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NATIONAL WEATHER SERVICE RIVER FORECAST SYSTEM FORECAST PROCEDURES

Staff, Hydrologic Research Laboratory

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CHAPTER 1. INTRODUCTION

1.1 NATIONAL WEATHER SERVICE RIVER FORECAST SYSTEM (NWSRFS)

The NWSRFS consists of several components such as data acquisition, forecast procedures, and forecast dissemination. This Technical Memorandum describes a complete river forecast procedure. The acronym NWSRFS is used throughout the text and computer programs.

The hydrologic forecasting service of the NWS is undergoing major change. Most forecast procedures used in the field are based on empirical graphical relations such as the Antecedent Precipitation Index method described by Linsley, Kohler, and Paulhus (1958). A few of the River Forecast Centers (RFC) have developed or adapted models for their own use, but no model has been adopted for general use. The Hydrologic Research Laboratory (HRL) of the Office of Hydrology in Silver Spring, Maryland, is responsible for research and development support for the river forecasting service. Work on conceptual models, as well as studies on the physical processes involved in the hydrologic cycle, has been conducted by the Laboratory for several years. In 1971 a decision was made that the Laboratory should prepare a package to illustrate the necessary steps for developing a river forecast system based on conceptual hydrologic models and to present the digital computer programs needed for implementation. This Technical Memorandum serves the following purposes:

a. A guide for implementation of conceptual river forecasting models by field offices,

b. a tool for use in testing and evaluating new concepts and procedures by the HRL, and

c. a vehicle for providing the results to others in the hydrologic community.

This Technical Memorandum describes the package which includes the techniques and programs needed for developing operational river forecasts based on the use of a continuous conceptual model, from the initial processing of basin data to the preparation of forecasts. The programs are written for a large-capacity digital computer and are generalized for use on any river system. Thus, they may or may not be the most efficient programs for use in a particular situation.

1.2 CONTENTS OF THE NWSRFS

a. Data requirements and availability. Records of precipitation, potential evapotranspiration, and streamflow are required. Precipitation records for the United States are maintained at the National Climatic Center (NCC), Environmental Data Service, NOAA, Asheville, North Carolina. It is recognized that hourly and daily precipitation records have not been readily available from NCC in a form suitable for hydrologic modeling. Arrangements have been made with NCC to provide hourly and daily precipitation data on tape in a format especially designed for use in hydrologic modeling. Information on the format and how the tapes may be obtained from NCC is included in this report (appendix B). Equations for computing potential evapotranspiration from meteorological factors, as well as programs for processing the summary tapes of the USGS containing all daily streamflow records for the United States are also included.

b. Computation of mean basin precipitation. A method of computing point precipitation from nearby observed values is described. This method is the basic portion of a computer program that estimates missing records or distributes cumulative precipitation records, as well as computing mean areal precipitation.

c. Parameter optimization. The optimization of conceptual model parameters is based on a direct-search optimization technique described by Monro (1971).

d. Verification and operational forecasting. The verification of model parameters and operational river forecasting are included in programs that can simulate an entire river system.

To permit the future incorporation of additions and improvements with a minimum of effort, the parameter optimization and the verification and operational river forecasting programs of the NWSRFS have been developed in a modular form.

1.3 COMPUTER REQUIREMENTS

The computer programs in the package are prepared for use on the CDC 6600 system and may be readily adapted to other large computer systems. Considerable modification and segmentation would be required to adapt the programs for use on computer systems with small storage capacity. The computer storage requirements of the main programs of the package are as follows:

a. The program for computing mean basin precipitation requires 50K (decimal) words (67K if the consistency check subroutine is included) of core storage when using 20 precipitation stations and 10 years of record. In addition, one K of mass storage (temporary random access disk storage) is required for each station year of precipitation data.

b. The parameter optimization program requires 30K core storage plus 40K for data storage (core or disk).

c. The parameter verification program requires 35K of core storage for a river system with five mean basin precipitation areas and five streamflow points.

d. The operational river forecasting program is currently dimensioned for 10 mean basin precipitation areas and 10 streamflow points and requires 25K of core storage.

1.4 CATCHMENT MODEL

An extensive testing program was conducted to select the hydrologic catchment model to be used in the package. A computerized model for simulating continuous streamflow based on the antecedent precipitation index (API) method was developed (3) as a basis for comparing other models. Three models were tested against the continuous API model. These were:

a. The SSARR Model used by the Portland, Oregon RFC in conjunction with the Corps of Engineers (1964),

b. the Sacramento RFC Hydrologic Model developed and used in the Sacramento RFC (Burnash 1971), and

c. a modified Stanford IV Model based on the work of Crawford and Linsley (1966).

The models were tested on the following six river basins representing various climatic and hydrologic regimes of the contiguous United States:

Mad River at Springfield, Ohio (485 mi^2)
Bird Creek near Sperry, Oklahoma (905 mi^2)
French Broad River at Rosman, North Carolina (68 mi^2)
Monocacy River above Jug Bridge near Frederick, Md. (817 mi^2)
Meramec River near Steelville, Missouri (781 mi^2)
South Yamhill River near Whiteson, Oregon (502 mi^2)

Based on the results of the statistical analyses of the tests completed as of August 1971, the modified Stanford IV Model was selected for use in the NWSRFS package. This does not imply that the Modified Stanford Model is the only acceptable model for use in the NWSRFS nor that it is the model that will be adopted for all future field use. Additional testing after the selection was made indicates that there is overall no statistical difference in the accuracy of model output between the Sacramento RFC Hydrologic Model and the modified Stanford Model for the six test basins and the Leaf River near Collins, Mississippi (752 mi^2) which is part of the river system used as the example for package results.

1.5 FUTURE ADDITIONS

The present package represents only the current programs for conceptual modeling as used by the Hydrologic Research Laboratory. Statements pertaining to a snowmelt routine are included in some of the present package programs. Snow subroutines have been developed, are in final review status, and will be included in the near future. Another addition being developed is a program for implicit numerical river routing. As these options are added to the package, other types of basic data input will be required.

1.6 COMPUTER PROGRAMS

The larger programs for mean basin precipitation, parameter optimization, parameter verification, and operational river forecasting are not included in this report because of space requirements. Small data processing programs are included in the appendices.

Information on availability and costs of program tapes can be obtained from the Office of Hydrology, National Weather Service, NOAA, Silver Spring, Maryland 20910.

1.7 ACKNOWLEDGMENTS

The forecast procedures described in this report were developed primarily through the efforts of the Research Hydrologists E. A. Anderson and J. C. Monro with contributions by V. C. Bissell, C. E. Schauss and W. T. Sittner. Dr. E. L. Peck, Acting Assistant Director of the Laboratory, acted as coordinator for the report, with general supervision by Mr. T. J. Nordenson, Acting Director of the Laboratory. Technical assistance was provided by other members of the Laboratory staff. Mrs. Doris B. Brown provided essential technical support and the manuscript was typed by Mrs. Michelle Scott.

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CHAPTER 2. DATA REQUIREMENTS

2.1 INTRODUCTION

Data requirements for a conceptual and continuous model differ from those for older types of procedure such as API in two ways. First, data for development purposes must be continuous. Second, some form of PE data may be involved in both development and operational work. Aside from these differences, all other considerations are about the same as for conventional forecast procedure.

2.2 STREAMFLOW DATA

2.2.1 DEVELOPMENT

Calibration of the catchment model is based on a record of mean daily discharge. Channel routing coefficients require instantaneous hydrographs of a few selected events.

2.2.2 OPERATIONAL

Observed data are used to update the model periodically. Requirements are the same as for any other type of forecast procedure. That is, observations from each flowpoint every 3 or 6 hours would be ideal. Any lesser quantity of data will decrease the quality of the final product, but no observed streamflow data are actually necessary to keep the system running.

2.3 PRECIPITATION DATA

2.3.1 DEVELOPMENT

A continuous record of 6-hour basin means is required. This can be derived (see sections 3.3 and 3.4) from any combination of recording and daily gages in and around the basin.

2.3.2 OPERATIONAL

The precipitation data requirement is identical to that which would be used with any basin analysis based on areal averages.

2.4 POTENTIAL EVAPOTRANSPIRATION

The catchment model uses for its evapotranspiration demand the product of PE and a seasonal correction curve that is optimized as part of the model. The PE record can be day-by-day computed PE or a curve representing the long term averages of these figures. There is some evidence, inconclusive at this time, that the use of day-by-day PE will yeild superior results. On the other hand, one can hypotehsize situations where use of day-by-day PE would produce a lesser degree of accuracy than would long term averages. Since the relative effects are not known, no recommendation can be made at this time. If average PE is to be used however, then no PE data are required. It is then only necessary to optimize the demand curve itself which is the product of two fixed seasonal curves.

2.5 PERIOD OF RECORD REQUIRED FOR DEVELOPMENT

Considerations here are the same as for the development of any other type of forecast procedure. It is desirable to sample the variation of each parameter over its maximum possible range, and so a long period is indicated. On the other hand, basin characteristics do change with time and for forecasting one is interested in parameters which express the future, not the past. Since the future cannot be sampled, a short record representing the present is the second choice. A suitable compromise seems to be the most recent 10 years of record.

CHAPTER 3. DATA PROCESSING

3.1 INTRODUCTION

Vast amounts of data are required to implement the NWSRFS throughout the United States. Thus, it becomes necessary to have the means for efficient data retrieval and the use of computerized data manipulation and processing routines. This chapter describes the data retrieval system and data processing programs used in the NWSRFS. In the final processed form, data are stored either on cards in the Office of Hydrology Standard Card Format (appendix A) or on magnetic tape in NWSRFS Standard Tape Format (section 3.7.2).

3.2 PRECIPITATION DATA FORMATING

3.2.1 DATA SOURCE

Hourly and daily precipitation data are retrieved from the National Climatic Center (NCC) Environmental Data Service, NOAA, Asheville, North Carolina.

3.2.2 HOURLY AND DAILY PRECIPITATION DATA

NCC stores the hourly precipitation data in a format described in their reference manual for Card Deck 488; daily precipitation data are stored according to Card Deck 486. Data may be retrieved from NCC on cards or on tape. Any other format used must be so specified.

Magnetic tape retrieval, formatted as defined in appendix B, is recommended. Tapes formatted in this manner can be processed efficiently by most large computer systems, in particular the IBM 360 series, the CDC 6000 series, and the UNIVAC 1100 series. Data tapes formatted as described in appendix B.1 are directly usable by the Mean Basin Precipitation (MBP) program. Section 3.4 describes MBP program computations.

If hourly data are on cards in NCC Card Deck 488 Format, then a "working" tape must be created. The format for the working tape is in order of monthly records and compatible for MBP program use. The program that creates working tapes is HRTAPE; a listing of this program is in appendix B.3. Daily precipitation data must be stored either on tape, as described in appendix B.2.3, or on cards in Office of Hydrology standard card format.

3.3 POINT VALUES AND AREAL MEANS OF PRECIPITATION

3.3.1 INTRODUCTION

The extraction of any hydrologic intelligence from precipitation data requires knowledge of its variation over an area. Since precipitation is normally measured as a point value, the use of the data requires an ability to estimate the value at other points. Any method of areal analysis, isohyets, Thiessen weights, etc. involves, implicitly or explicitly, inferences concerning the depth of precipitation at all points in the area of interest.

The procedure to be described is an objective formulation that produces an estimate of the precipitation at a point as a function of that at surrounding points. The method is the result of a great deal of unpublished development and experimentation over many years and has been verified on both an empirical and theoretical basis. Only the mechanics of the method will be given here.

3.3.2 THEORY OF ESTIMATION

Referring to Figure 3-1, let point A be the point at which it is desired to estimate the precipitation.

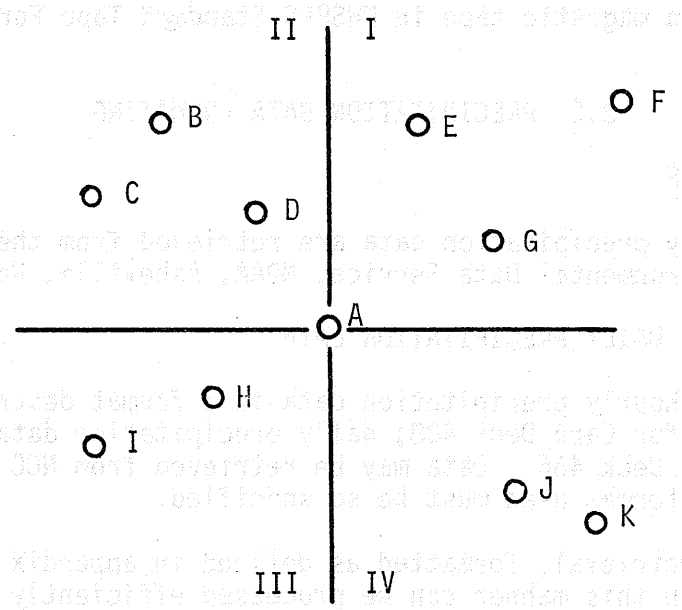

Figure 3-1.--The four quadrants surrounding precipitation station A.

North-South and East-West lines through point A divide the surrounding area into four quadrants, numbered as shown, counter clockwise from the northeast. Points B through K are points at which precipitation is known. Using the map coordinates of the stations, the closest to A in each quadrant is located. These are G, D, H and J. The estimate of precipitation at A is now computed as a weighted average of that at the other four points. The weight is equal to the reciprocal of the square of the distance from point A to the reference point. As an example, let the data be as shown in table 3-1.

Table 3-1.--Estimating the amount of precipitation at station A from surrounding station amounts.

Point	X	Y	Precip	ΔX	ΔY	D^2	$Wx10^3$	$PWx10^3$
A	75	50	----	--	--	--	----	----
G	92	59	2.61	17	9	370	2.7027	7.0540
D	67	62	1.78	8	12	208	4.8077	8.5577
H	63	43	0.56	12	7	193	5.1813	2.9015
J	94	33	2.19	19	17	650	1.5385	3.3693
Sums	--	--	----	--	--	---	14.2302	21.8825

The estimated precipitation at A is then equal to 21.8825/14.2302 or 1.538 inches.

If one or more quadrants contains no point of known precipitation, then the averaging computation involves only the remaining quadrants.

A variation of the method recognizes as a special case the situation where reference points are found in only two quadrants and those two are adjacent; that is, I and II, II and III, III and IV or IV and I. In this case, the estimate is given as ΣPW rather than $\Sigma PW/\Sigma W$. This has the effect of reducing estimates to zero as the points move from a precipitation area toward an area of no reports. This is probably the most logical treatment for this indeterminate rather unusual situation.

The estimating technique described can never result in a point estimate that is greater than the largest amount observed or less than the smallest. In some areas, particularly mountainous regions, precipitation patterns have known characteristics which might indicate higher or lower amounts at certain points. The following modification permits this to be taken into account.

This modification is designated as "station characteristic adjustment." The characteristic precipitation for a station is similar to its normal precipitation. The difference is that while station normals indicate the total accumulation at a station over an extended period, the station characteristics indicate the amount that might occur in one storm. In this application, the actual value of the characteristic precipitation is not important. What is used, in effect, is the ratio of one station characteristic to that of other stations. As defined, and as used, the characteristics are probably not equal to normals and there may be a separate set of characteristics for each of a number of storm types. Assuming that the appropriate set of station characteristics is known, the computation proceeds as follows: Using the example of figure 3-1 and table 3-1, let the characteristic precipitation for stations A, G, D, H, and J be as shown in table 3-2.

Table 3-2.--Adjusting the amount of precipitation at station A by the "station characteristic adjustment" method.

Point	Char.	W x 10^3	CxWx10^3
A	4.2	---	---
G	3.4	2.7027	9.1892
D	2.9	4.8077	13.9423
H	3.0	5.1813	15.5439
J	2.0	1.5385	3.0770
	---	14.2302	41.7524

Note that the characteristic for station A is considerably higher than for the estimator stations indicating an increase in the basic estimate. The computation in table 3-2 is essentially an estimate of the characteristic at station A based on those at stations G, D, H, and J and works out to 41.7524/14.2302, or 2.9341 inches. Since the known characteristic at station A is 4.2 inches, the estimate of precipitation for this event is 1.538 (4.2/2.9341) or 2.202 inches. It should be noted that unlike the basic estimating procedure, the characteristic adjustment method has had limited testing and verification. Provision for using it is included in the MBP program, but it should be used with caution.

Usually, in mountainous regions, there are no stations in the high precipitation areas. "Dummy" stations can be located at strategic points and their characteristic amounts estimated from known precipitation patterns. These stations of course will never report, but will be estimated in such a way as to define the proper pattern.

3.3.3 APPLICATIONS OF THE ESTIMATING TECHNIQUE--GENERAL

The basic estimating method can be used in a number of ways. The precipitation at network stations which fail to report in a particular event can be estimated. Then areal means may be computed by use of a pre-determined set of Thiessen weights.

If a fine grid is superimposed on an area, the precipitation at each grid point may be estimated. From the distribution so defined, depth-area studies can be made. Machine plotting of isohyets is also possible.

3.3.4 GRID POINT WEIGHTS.

The discussion so far has dealt with the analysis of an actual event in which precipitation amounts are the variables. Using the same concepts, it is possible to compute a set of station weights, similar to Thiessen weights, which can be used to compute areal averages. Consider a basin covered with a fine grid. In a particular event, the estimating procedure described could be used to compute the precipitation at each grid point that falls within the basin. The arithmetic average of all these grid point amounts would be the basin average. Station weights that will produce a basin average equal to one computed in this manner are known as "grid point weights". They can be determined as follows:

At each grid point falling within the basin, perform the estimating procedure only as far as locating the four reference stations and computing the weights. Then normalize (adjust to total unity) the weights, and assign each weight to the appropriate station. After this procedure has been repeated for each grid point, the total weight assigned to each station, after being normalized, is its grid point weight.

As an example, consider the basin shown in figure 3-2. The area is covered with a 10x10 grid, 47 points of which fall within the basin. The weight computations for these 47 points are shown in table 3-3. The weight shown is the reciprocal of the squared distance, but the weights for each grid point have been normalized to total unity. Note that a special case exists where a

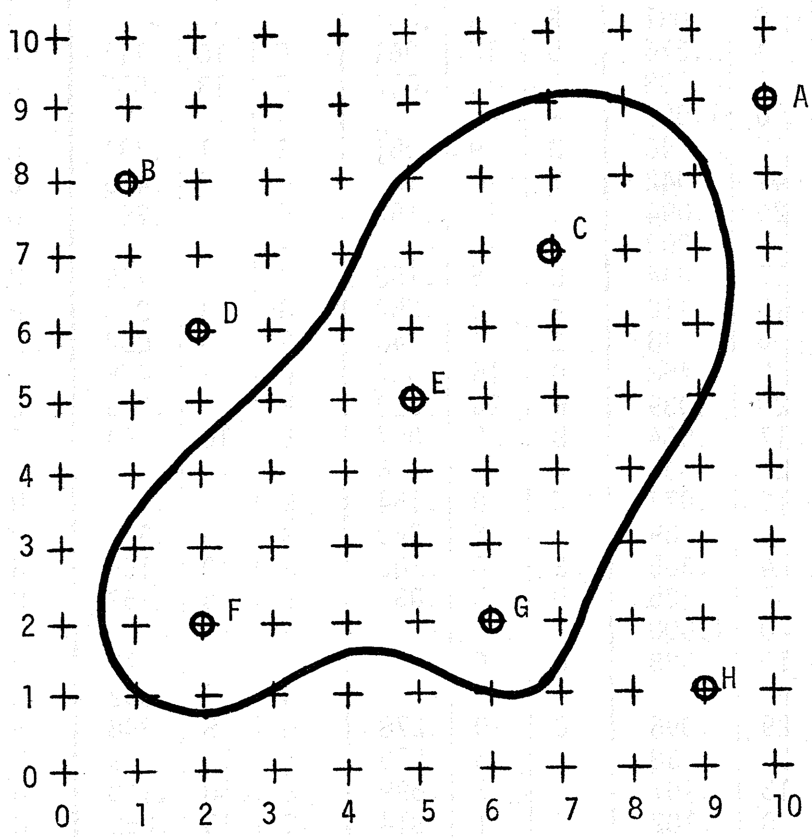

Figure 3-2.--Grid superimposed on an area for estimating grid point weights.

Table 3-3.--Normalized weights for each grid point.

		QUAD. I			QUAD. II			QUAD. III			QUAD. IV		
X	Y	Sta	D^2	W	Sta	D^2	W	Sta	D^2	W	Sta	D^2	W
1	2	D	17	.056	-	-	-	-	-	-	F	1	.944
1	3	D	10	.167	-	-	-	-	-	-	F	2	.833
2	1	F	1	.980	B	50	.020	-	-	-	-	-	-
2	2	F	0	1.000	-	-	-	-	-	-	-	-	-
2	3	D	9	.092	B	26	.032	F	1	.828	G	17	.048
2	4	D	4	.411	B	17	.096	F	4	.411	G	20	.082
3	1	G	10	.159	F	2	.797	-	-	-	H	36	.044
3	2	E	13	.065	F	1	.842	-	-	-	G	9	.093
3	3	E	8	.094	D	10	.076	F	1	.755	G	10	.075
3	4	E	5	.295	D	5	.295	F	5	.295	G	13	.115
3	5	C	20	.036	D	1	.714	F	10	.071	E	4	.179
4	2	E	10	.166	F	4	.417	-	-	-	G	4	.417
4	3	E	5	.295	D	13	.115	F	5	.295	G	5	.295
4	4	E	1	.727	D	8	.091	F	8	.091	G	8	.091
4	5	C	13	.057	D	5	.148	F	13	.057	E	1	.738
4	6	C	10	.111	D	4	.278	F	20	.056	E	2	.555
5	2	E	9	.091	F	9	.091	-	-	-	G	1	.818
5	3	E	4	.276	D	18	.061	F	10	.111	G	2	.552
5	4	E	1	.738	D	13	.057	F	13	.057	G	5	.148
5	5	E	0	1.000	-	-	-	-	-	-	-	-	-
5	6	C	5	.146	D	9	.081	E	1	.731	G	17	.042
5	7	A	41	.042	B	17	.101	E	4	.429	C	4	.428
5	8	A	26	.094	B	16	.152	E	9	.269	C	5	.485
6	2	G	0	1.000	-	-	-	-	-	-	-	-	-
6	3	C	17	.044	E	5	.150	G	1	.749	H	13	.057
6	4	C	10	.110	E	2	.552	G	4	.276	H	18	.062
6	5	C	5	.148	E	1	.740	G	9	.082	H	25	.030
6	6	C	2	.458	D	16	.057	E	2	.458	H	34	.027
6	7	A	20	.039	B	26	.030	E	5	.155	C	1	.776
6	8	A	17	.084	B	25	.057	E	10	.143	C	2	.716
7	2	C	25	.032	G	1	.806	-	-	-	H	5	.162
7	3	C	16	.077	E	8	.154	G	2	.615	H	8	.154
7	4	C	9	.189	E	5	.340	G	5	.340	H	13	.131
7	5	C	4	.385	E	4	.385	G	10	.154	H	20	.076
7	6	C	1	.785	D	25	.031	E	5	.157	H	29	.027
7	7	C	0	1.000	-	-	-	-	-	-	-	-	-
7	8	A	10	.088	B	36	.024	C	1	.872	H	53	.016
7	9	-	-	-	-	-	-	C	4	.692	A	9	.308
8	4	A	29	.096	C	10	.278	G	8	.348	H	10	.278
8	5	A	20	.130	C	5	.519	G	13	.199	H	17	.152
8	6	A	13	.107	C	2	.699	E	10	.140	H	26	.054
8	7	A	8	.102	C	1	.814	E	13	.062	H	37	.022
8	8	A	5	.270	B	49	.028	C	2	.675	H	50	.027
8	9	-	-	-	-	-	-	C	5	.444	A	4	.556
9	6	A	10	.279	C	5	.557	E	17	.164	-	-	-
9	7	A	5	.400	C	4	.500	E	20	.100	-	-	-
9	8	A	2	.699	B	64	.022	C	5	.279	-	-	-

station is located at the grid point. That station is given unit weight, and no other stations are used. To compute the grid point weights for the various stations, the total weight assigned to each station is determined. These totals are shown in table 3-4. Note that the grand total is 47, the number of grid points. Normalizing these figures results in the grid point weights.

Table 3-4.--Grid point weights for the various stations.

Station	Sum of weights	Grid point weight
A	3.294	0.0701
B	0.562	0.0119
C	12.312	0.2619
D	2.730	0.0581
E	10.348	0.2202
F	8.931	0.1900
G	7.504	0.1597
H	1.319	0.0281
	47.000	1.0000

To illustrate the application of the weights, see figure 3-3 which shows the basin with a precipitation pattern superimposed on it. Point amounts at the stations are:

A-1.0 B-0.2 C-4.6 D-1.0 E-3.2 F-1.9 G-2.1 H-1.0

Using these amounts and applying the grid point weights in table 3-4, the computed basin mean is 2.764 inches. If the computations in table 3-2 are continued, to determine, for this pattern, the precipitation at each of the 47 grid points in the basin, the computed basin mean is also 2.764.

3.3.5 THIESSEN WEIGHT COMPUTATIONS

The determination of Thiessen weights by machine can be done rather easily. A Thiessen polygon is defined as being formed by the perpendicular bisectors of the lines connecting stations. To program the equations of these lines and computations of the area bounded by them is extremely difficult. If, however, the polygon for a station is thought of as the boundary of all points which are closer to the subject station than to any other station, then the solution becomes obvious. Table 3-5 shows the stations, and, from figure 3-2, the number of grid points closest to each. These numbers, normalized, are the Thiessen weights.

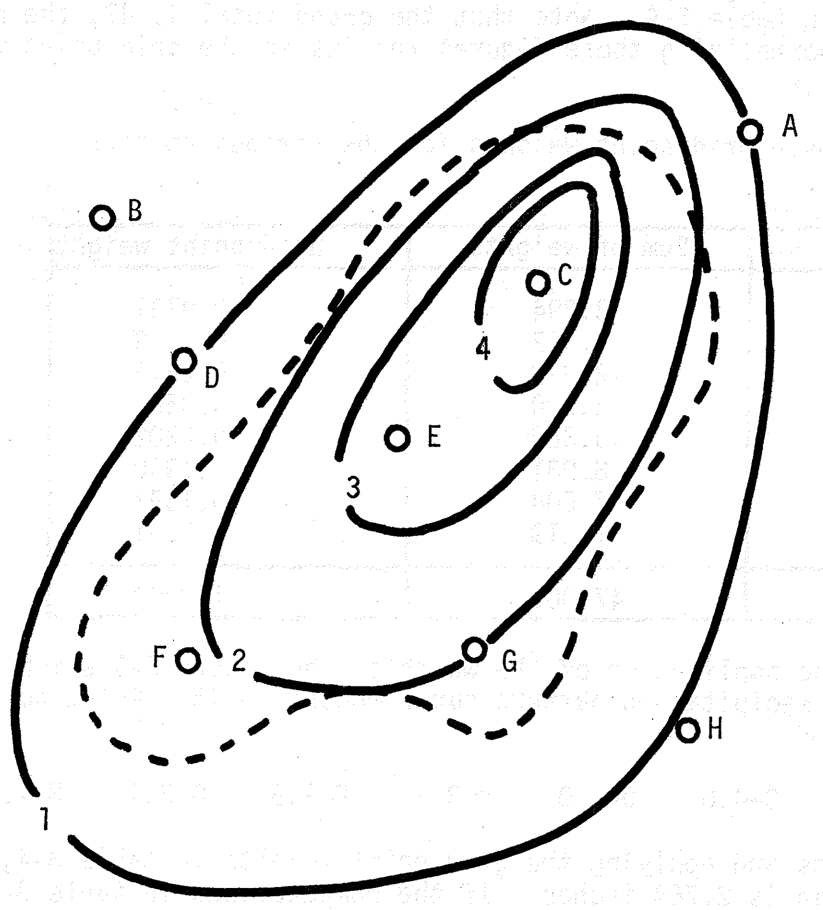

Figure 3-3.--Precipitation pattern superimposed on an area.

Table 3-5.--Grid points used to compute Thiessen weights.

Station	No. of points	Thiessen Weight
A	2	0.0426
B	0	--
C	16	0.3404
D	3	0.0638
E	10	0.2128
F	9	0.1915
G	7	0.1489
H	0	--

3.3.6 COMPARISON OF WEIGHTING METHODS

Figure 3-4 shows the network with conventional Thiessen polygons drawn. Weights determined from these are:

A - 0.0301	C - 0.3080	D - 0.0323
E - 0.2441	F - 0.2038	G - 0.1817

The agreement with the values of table 3-5 is good, considering the coarseness of the grid used. It is now possible, for this event, to compute the basin mean by a number of different methods. The computation has already been made using grid point weights and grid point averages and the results were, as expected, identical. The mean can also be determined by the use of Thiessen

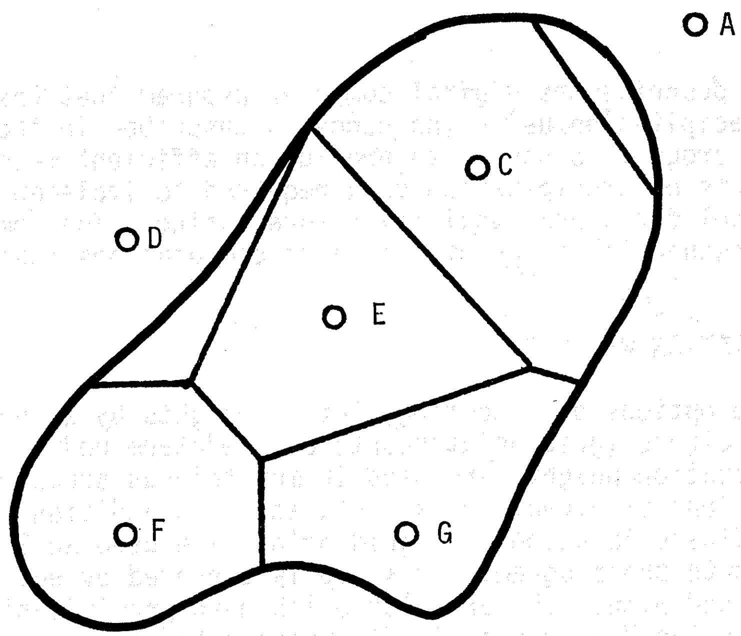

Figure 3-4.--Thiessen polygon network by the conventional method.

weights derived either from the polygons or the grid point count, or by an isohyetal analysis. A summary of results appears below:

Grid point method	2.76
Thiessen weights (Polygons)	3.03
Thiessen weights (Grid point count)	3.03
Isohyetal analysis	2.62

The isohyetal analysis would probably be considered as giving the best value, one which could be used as a standard for judging those derived by other methods. The fact that the grid point method yielded a value closer to this standard than that obtained from Thiessen weights indicates superior results in this case, but this should not be the basis for generalization.

Usually, the values of grid point weights for an area are quite close to those of Thiessen weights. The chief noticeable difference is that an outlying station often has a small non-zero grid point weight when its Thiessen weight would be zero. This was the case with stations B and H in the example.

3.3.7 SENSITIVITY

The use of a finite number of grid points in the analyses shown is of course an approximation to the exact solution. The greater the number of grid points, the closer the approximation. Sensitivity analyses for this type of computation have indicated that adequate results will be obtained if 100 or more grid points fall within the basin. Increasing the number of points above 100 refines results slightly, but beyond 150 points there is no perceptible change.

3.4 MEAN BASIN PRECIPITATION (MBP) PROGRAM

3.4.1 INTRODUCTION

The following sections describe the digital computer program that was written to compute mean basin precipitation using the concepts described in the preceding sections. Such a program is needed to provide an efficient means of processing the vast amounts of precipitation data required to implement a continuous hydrologic model for operational river forecasting. The computer program is described in sequential order of the major computations that are involved.

3.4.2 COMPUTATIONS OF STATION WEIGHTS

The MBP program has the options of computing station weights by either grid point weights, Thiessen weights (grid point count) or predetermined station weights. Predetermined station weights are used in mountainous areas where station weights are functions of elevation, aspect, etc., in addition to their two-dimension coordinate location. If grid points are used an 80-by-80-element grid map is input to the program. This map is prepared by putting a 1 at all grid points located within the area for which mean precipitation is to be computed. Currently the MBP program is dimensioned to compute mean areal (basin) precipitation for up to 10 areas during a single run. All areas must lie within the same 80-by-80-element grid map. Various size 80-by-80 grids can be prepared so that a grid system which will cover the entire area and meet the sensitivity requirements of section 3.3.7 can be selected.

3.4.3 INPUT OF PRECIPITATION DATA

In the MBP program precipitation data for the period for which MBP is being computed are input in order by stations. Hourly stations are input first. Hourly data can come from NWSRFS--National Climatic Center hourly precipitation tapes (appendix B.1 and B.2) or from working tapes created by program HRTAPE (appendix B.3) or from Office of Hydrology standard format cards. If NWSRFS-NCC tapes are used, the observation time of each daily station and any changes during the period in observation time must also be input to the program. Standard format cards contain the observation time. As each month of data is read, it is stored on mass storage (temporary disk storage). The information is later retrieved from mass storage as it is needed. The MBP program is currently programmed to store 4,800 months of hourly data on mass storage (daily data are stored in hourly form, i.e., each daily amount is stored in the hour of the observation time). This is approximately 3.5 million hours of precipitation data.

3.4.4 ESTIMATION OF MISSING OR ACCUMULATIVE HOURLY PRECIPITATION DATA

After all data are read, the program goes through the hourly precipitation stations, month by month, to estimate periods when the hourly data are missing or to distribute periods when only an accumulative value is recorded. One day from the preceding month and two days from the following month are also included to help estimate missing time distribution which overlaps months. Only hourly stations are used to estimate missing or accumulative hourly data. The equation used to estimate a missing hour of data is:

$$A_x = \frac{\sum_{i=1}^{i=n} \left[A_i \cdot \frac{N_x}{N_i} \cdot \frac{1}{(d_{i,x})^2} \right]}{\sum_{i=1}^{i=n} \frac{1}{(d_{i,x})^2}} \qquad (3\text{-}1)$$

where:

A_x = the hourly precipitation at the station being estimated.

i = the station being used as an estimator.

n = number of estimators. (The nearest station in each quadrant which has valid data is used as an estimator -- see section 3.3.2.)

A_i = the hourly precipitation at the estimator station.

N_x = the monthly characteristic precipitation at the station being estimated.

N_i = the monthly characteristic precipitation at the estimator station.

$d_{i,x}$ = the distance from the station being estimated to the estimator station.

Characteristic precipitation does not need to be included in flat terrain, but is necessary in mountainous areas. Monthly characteristic precipitation is used because individual storm data are not usually available and because storm types have a fairly strong correlation with season. The equation used to estimate each hour during a period when only the accumulative value is recorded is:

$$A_x = \frac{\sum_{i=1}^{i=n} \left[A_i \cdot \frac{T_x}{T_i} \cdot \frac{1}{(d_{i,x})^2} \right]}{\sum_{i=1}^{i=n} \frac{1}{(d_{i,x})^2}} \qquad (3\text{-}2)$$

where:

T_x = the accumulative precipitation amount at the station being distributed.

T_i = the total precipitation amount for the period of missing time distribution at the station being used to estimate the distribution.

Equations 3-1 and 3-2 will handle the general case of missing data or accumulative data. For special cases the following rules apply:

a. If no valid estimator station is available, the hourly precipitation for that hour is set to zero and a message is printed.

b. If missing time distribution extends more than 2 days into the succeeding month, then the entire period is set to missing data and a message printed. The missing data period is again estimated using equation 3-1.

c. If no station can be found to estimate a period of missing time distribution, then the accumulated amount is left in the last hour and again a message is printed.

At this point in the program all hourly precipitation stations have a complete record free of missing data and accumulative amount indicators.

3.4.5 DISTRIBUTION OF DAILY PRECIPITATION OBSERVATIONS

Daily precipitation is converted into hourly, month by month, by using the hourly precipitation stations to determine distribution of the daily values. Converting daily precipitation into hourly is a two-pass operation. On the first pass, daily precipitation observations are distributed but missing data are ignored. Equation 3-2 is used to distribute the daily observations, where T_x is now the daily precipitation observation and T_i is the total precipitation since the last daily observation at the hourly station being used to estimate the missing daily amount. Once the daily amount is estimated it is distributed as in pass one. The reason for a second pass is so that not only can hourly precipitation stations be used to estimate the missing daily amount, but so that the amount from a daily station will be used if it is the closest station, in a particular quadrant, to the station being estimated. In this case, A_x in equation 3-1 is now the daily precipitation at the station which is being estimated and A_i is the total precipitation since the last daily observation at the hourly or daily station used as an estimator. For special cases the following rules apply:

a. If no station can be found to distribute a daily observation, then the total amount is left in the hour of the time of observation and a message is printed.

b. If missing time distribution extends more than 2 days into the succeeding month, then the entire period is set to missing data and an appropriate message printed.

c. If no valid estimator station is available for a missing daily amount, the daily amount is set to zero and again a message is printed.

Now all the hourly precipitation stations are complete and all daily stations have been converted into an hourly record which is free of missing data and accumulative amount indicators.

3.4.6 COMPUTATION AND OUTPUT OF MEAN AREAL PRECIPITATION

Computation of mean areal precipitation is now simply accomplished by going through the entire period for each area, multiplying the hourly precipitation by the station weight for all stations within the area, and summing these results to create a mean areal hourly precipitation sequence. The MBP program has the option to output the results in 1-, 3- or 6-hour increments. The program also has the option to output results onto tape or in Office of Hydrology standard format cards. If tape output of 6-hour data is requested, the results are output in NWSRFS standard tape format (see section 3.7.2).

3.4.7 CONSISTENCY SUBROUTINE

Before using the results of the MBP program, some check on the consistency of the individual station records is needed. The MBP program contains a subroutine that performs this function. The subroutine uses the station records just prior to the computation of mean areal precipitation (i.e., hourly precipitation stations are complete and all daily stations have been converted into an hourly record) to prepare the following table and plots:

a. A table is prepared which lists for each station, month by month, the accumulated precipitation at that station, the double mass value from the group to which the station is assigned, and the double mass value from a group containing all other stations. Group assignments are made so that stations can be compared against other stations with the same geographical characteristics. If a station is not assigned to a group it will be compared to the group-one double mass. In this case, group one would be composed of stations judged to have the highest quality records.

b. In addition to a tabulation of monthly values, the subroutine plots the accumulative values for each station against the double mass of all other stations and against the double mass of the group to which the individual station is assigned.

3.4.8 INPUT SUMMARY

Appendix C.1 contains a listing of the data cards needed for operating the MBP program.

3.4.9 SAMPLE INPUT AND OUTPUT

A set of sample input for the computation of mean basin precipitation for January 1968 through September 1969 on three subareas of the Leaf River basin in Mississippi is listed in appendix C.2. Appendix C.3 contains examples of the output for that run.

3.5 POTENTIAL EVAPOTRANSPIRATION

3.5.1 INTRODUCTION

Thornthwaite defined potential evapotranspiration as "the water loss which will occur if at no time there is a deficiency of water in the soil for the use of vegetation". Many investigators have assumed that for practical purposes potential evapotranspiration can be considered equal to free-water (lake) evaporation. Theoretically, this assumption is not correct since the albedo of meadows and forest is 10-20%, crops 15-25% and soils 10-45% (Sellers, 1969). This difference in albedo would indicate that free-water evaporation should be somewhat greater than potential evapotranspiration. However, since the error associated with the computed free-water evaporation is 10-15% (root-mean-square), it is doubtful that use of a coefficient to reduce free-water evaporation to potential evapotranspiration is justified.

3.5.2 COMPUTATION METHODS

Many methods are described in the literature for the computation of potential evapotranspiration and free-water evaporation. The methods that require as input only air temperature (such as Thornthwaite) are very attractive due to the small data requirement. However, caution should be exercised in use of such methods since they yield very poor estimates of P.E. in many areas. Only the methods for computing free-water evaporation (E_L) developed in the Office of Hydrology will be described briefly:

a. Class A pan evaporation. The most reliable estimates of E_L can be obtained by adjusting the observed Class A pan evaporation for heat gain or loss through the sides and bottom of the pan. This can be accomplished by use of equation 14 or figure 7 in Kohler et al. (1955).

$$E_L = 0.70\ [E_p + 0.00051P\alpha_p(0.37 + 0.0041u_p)\ (T_o - T_a)^{0.88}] \quad (3\text{-}3)$$

The reader should refer to Kohler for units and meaning of symbols. The value of α_p (proportion of advected energy utilized for evaporation) is obtained from figure 5 as a function of pan wind movement and pan water temperature. This relationship has been converted to equation form for use in the computer program.

b. Meteorological factors. E_L can be computed from the meteorological factors of air temperature, dew point, daily wind movement, and solar radiation as described by equation 10 and figure 6 of Kohler et al. (1955). This relationship has been expressed in equation form by Lamoreaux (1962).

$$E_L = [\varepsilon^{(T_a-212)(0.1024-0.01066 \ln R)} - 0.0001 \qquad (3\text{-}4)$$

$$+ 0.0105(e_s-e_a)^{0.88}(0.37+0.0041U_p)] \times$$

$$[0.015+(T_a+398.36)^{-2}(6.8554\times10^{10})\varepsilon^{-7482.6/(T_a+398.36)}]^{-1}$$

See Lamoreaux's paper for units and symbols.

The solar radiation network in the United States unfortunately consists of a sparse network of only about 90 stations. Therefore, it is necessary at most first-order stations to estimate solar radiation from percent sunshine. This is accomplished by the relationship developed by Hamon et al. (1954) which has been converted to computer format. It will also be necessary at some first-order stations to estimate solar radiation from tenths of sky cover. A crude approximation of percent sunshine can be obtained by assuming it to be inversely related to sky cover, i.e., 1.00 minus 0.2 sky cover is 80% possible sunshine. In the development of evaporation maps for the United States (Kohler et al. 1959), percent sunshine at first-order stations with only sky cover was obtained from a relationship between tenths sky cover and percent sunshine developed for a nearby first-order station with similar climatic regime. A study is underway to develop a generalized relationship between sky cover and solar radiation. Evaporation computed on the basis of sky cover will not be reliable on a daily basis, but may be adequate on a weekly or monthly basis.

It is important to remember that the wind term in equation 3.4 is for the daily wind movement at Class A pan anemometer height (approx. 2 feet). The following equation is recommended for reducing observed wind to pan height.

$$\frac{U_1}{U_2} = \left(\frac{Z_1}{Z_2}\right)^{0.3} \qquad (3\text{-}5)$$

where U_1 = wind movement at pan height; U_2 = wind movement at station anemometer height; Z_1 = height of pan anemometer (2 feet); and Z_2 = height of first-order station anemometer. The literature indicates that the exponent in equation 3-5 should be 1/7. However, experience, and wind data at 2, 4, 8 and 16 meters for the Lake Hefner evaporation study indicate that 0.3 power is preferable when reducing wind to such a low height as 2 feet above the ground. It is also suggested that a cursory check be made of the computed 2-foot wind movement with observed wind movement at nearby Class A pan stations to ensure that a reasonable wind reduction has been achieved.

c. Kohler-Parmele equation. Kohler and Parmele (1967) present a modification of the basic Penman equation by providing for use of "incident minus reflected" all-wave radiation (Q_{ir}) and eliminating water temperature from the emitted radiation term.

$$E_L = \frac{(Q_{ir} - \varepsilon\sigma T_a^4)\Delta + E_a\,[\gamma + 4\varepsilon\sigma T_a^3/f(u)]}{\Delta + [\,\gamma + 4\varepsilon\sigma T_a^3/f(u)\,]} \qquad (3\text{-}6)$$

where

$$E_a = (0.181 + 0.00236U_4)\,(e_s - e_2) \qquad (3\text{-}7)$$

See paper for units and symbols.

Q_{ir} can be obtained from observed or computed solar radiation (short-wave) and observed or computed incoming long-wave radiation. Unfortunately, observed incoming long-wave radiation is rarely available, although recently Eppley has put on the market a new radiometer (pyrgeometer) to measure directly incoming long-wave radiation. Long-wave radiation can be computed by technique described by Anderson and Baker (1967). It is hoped that in the not too distant future Q_{ir} can be obtained from a network of X-3 pans. This is the experimental insulated pan developed and being tested by the Office of Hydrology. It is hoped that this pan will be an improved evaporimeter with a nearly constant pan-to-lake coefficient and will also serve as a radiation integrator. Q_{ir} can be computed by an energy budget analysis of the X-3 pan observations.

d. Other. At Class A stations where pan water temperature observations are not available, E_L can be computed by multiplying the observed pan evaporation by a coefficient obtained from Plate 3 of Kohler (1959). At stations where X-3 pan is being tested, E_L can also be computed by multiplying the observed X-3 evaporation by 0.73.

3.6 STREAMFLOW

3.6.1 INSTANTANEOUS DISCHARGE

USGS does not maintain instantaneous discharge records in automatic data processing (ADP) form (cards or magnetic tape). Instantaneous discharge records may, however, be obtained from USGS in two forms.

a. Tabulation of primary computation of gage height and discharge. Gives bi-hourly gage heights and daily maximum, minimum, and mean discharge. Corresponding rating curves are required to convert bi-hourly stages to discharge values. Bi-hourly stage tabulations are available only for more recent records where digital stage recorders have been installed.

b. Instantaneous stage data are available in strip chart form from Geological Survey. Again, appropriate rating tables must be used in converting stage to discharge. Also, timing and gage-height corrections must be made where appropriate in picking stage values from charts.

3.6.2 MEAN DAILY DISCHARGE

3.6.2.1 General

Mean daily discharge records are available from USGS on magnetic tape or IBM cards. Costs for copying selected portions depend on several factors. For example, the number of stations and their physical location on the USGS magnetic tape library, the type of output desired, and the request priority (governing turnaround time), all contribute to computation of the job cost. Briefly, three output formats are available to users as follows:

a. Nine-track magnetic tape (1636 byte record);

b. Seven-track magnetic tape (336 byte record); and

c. IBM cards (or card images on magnetic tape).

The program DAILYF described herein and in appendix D will read mean daily discharge data from the USGS seven-track magnetic tape and output selected portions in one of two modes:

a. Office of Hydrology standard card format (see appendix A for description) in station order;

b. NWSRFS tape format (binary, in month order, produced with Fortran unformatted write. See 3.7)

3.6.2.2 Input to DAILYF

Two items are required to specify the data portion to be output:

a. Which stations. Station identification numbers (USGS downstream order numbers) are required in output sequence. These are eight-character integers (example: 12-1422.10 is input as 12142210).

b. Period of Record. The same period of record must be output for all requested stations. This is specified by beginning year and month and ending year and month of the desired record.

Up to 20 input tapes may be used. The entire record for a particular station may be repeated on more than one input tape. If a station is encountered more than once, the program retains the requested portion the first time the station is encountered and ignores it at subsequent encounters. Also, the program has the option available to override parity errors in reading an input tape record and treating as missing data the information on such a record. More detailed information on program input is found in appendix D.

3.6.2.3 The Function of Program DAILYF

The data available from USGS are in station order. For input to NWSRFS the data must be in monthly order, with stations and various types of data for each properly ordered within each month (see 3.7). For large jobs, conversion from USGS station ordering to NWSRFS monthly ordering requires either the availability of mass storage in the computing system or time-consuming multiple passes on the input data tape. Program DAILYF will either produce a mean daily flow tape in month order which can be combined with other types of data using SUPERTP, or will produce a standard format card deck in station order appropriate for input to NWSRFS2. In either output mode, DAILYF takes advantage of the large random access storage available in the CDC 6600 system at NOAA Computer Division, Suitland, Maryland. See section 3.7 for SUPERTP and NWSRFS2 program descriptions.

What happens if requested data are not encountered on the input tape(s)? It is anticipated that an incomplete mean daily flow record would not be used in either optimization or verification jobs. Program DAILYF, however, will not abort a job in which all requested record is not found on input. Instead, a message is printed "missing data month xx station yyyy" and flow values of (-9.) are output if a tape is being produced, or appropriate missing data flags (see appendix A) if standard format cards are being produced. For any month in which one or more values are missing, the entire month of record will be treated as missing.

3.6.2.4 Output of DAILYF

Output for NWSRFS may be, as previously mentioned, (1) magnetic tape in binary format, without header records of any kind, or (2) standard format cards. Tape output will have data in order (month 1, station 1), (month 1, station 2). . . . (month 1, station N), (month 2, station 1), . . . etc. Standard format card output will be in order (month 1, station 1), (month 2, station 1), . . . , (month M, station 1), (month 1, station 2), . . . etc.

Listing of output data is a program option which may be specified on the job input card stream.

3.6.2.5 Job Input Stream and USGS Data Tape Formats are Detailed in appendix D.

3.7 MAGNETIC TAPE PREPARATION AND MANIPULATION

3.7.1 INTRODUCTION

The previous sections of this chapter have described the different types of data needed for the NWSRFS. The data, at this stage of processing, are either on cards in Office of Hydrology standard card format, or on tapes in NWSRFS standard tape format. The final phase of data processing is the conversion of card-stored data to tape storage, and the merging of tape data onto a lesser number of tapes. Section 3.7.2 describes NWSRFS standard tape formatting; section 3.7.3 briefly describes program NWSRFS2, which converts standard format cards to standard tape formats; and, section 3.7.4 introduces program SUPERTP, the tape-merging program.

3.7.2 NWSRFS STANDARD TAPE FORMAT

Data on the flow forecast model input tapes are blocked by monthly records, with each type of data in a specific sequence. A standard month length of 31 days is used with 124 values for 6-hour data and 31 values for daily data. These data values are in binary code. The data field on tape is "zeroed" for the excess days for months with less than 31 days.

The sequence in which each data type is entered for each monthly block is:

Sequence number	Types of data
1	mean 6-hour precipitation (MBP)
2	daily potential evaporation (PE)
3	mean 6-hour temperature (TA)
4	mean daily streamflow (OFW24)
5	instantaneous (6-hour) streamflow (OFW6)

Examples of how the data are entered are given below:

Case 1

One data tape with: 10 MBP stations

1 PE station

6 OFW24 stations

Month 1

[MBP(1)] . . . [MBP(10)] [PE] [OFW24(1)] . . . [OFW24(6)]

This sequence repeats for each month of the data recorded.

Case 2

Two data tapes: Tape 1: 5 MBP stations

3 TA stations

Tape 2: 1 PE station

2 OFW24 stations

The data tape sequence for each tape would be:

Tape 1

Month 1

[MBP(1)] . . . [MBP(5)] [TA(1)] . . . [TA(3)]

This sequence repeats for each month of the data record.

Tape 2

Month 1

[PE] [OFW24(1)] [OFW24(2)]

This sequence repeats for each month of the data record.

3.7.3 CONVERSION OF CARD-STORED DATA INTO MAGNETIC TAPE-STORED DATA

The computer program (NWSRFS2) that performs the data conversion, cards to tape, is listed in appendix E.1. This program reads data from Office of Hydrology standard format cards for the available period of record for each station, and stores this information in a mass storage device in the computer system. The data are rearranged into monthly records and written on tape in the sequence described in section 3.7.2.

3.7.4 MERGING NWSRFS STANDARD FORMAT TAPES

The final phase of data manipulation is the creation of as few NWSRFS standard format tapes as possible. For example, one can combine the data from four tapes (for the same period of record), perhaps two tapes of MBP stations, one for PE stations, and one for OFW24 stations, onto one tape. This is done simply for a more efficient tape storage. Program SUPERTP, listed in appendix E.2, performs this merging operation.

In addition to combining tape data covering the same period of record, SUPERTP has the flexibility of "piecing together" types of data from two different record periods. These record periods may overlap in time, but should not have a time gap between them. As an example, assume one tape has data for the period 10/1/51 to 12/31/58, and another tape has data for the same stations, but for the period 10/1/58 to 12/31/66. Then SUPERTP will create a tape for the combined period of 10/1/51 to 12/31/66.

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CHAPTER 4. SOIL MOISTURE ACCOUNTING

4.1 INTRODUCTION

Soil moisture accounting includes that portion of the hydrologic cycle from when rain hits the ground and vegetation, or runoff from the snow leaves the pack, until the water enters the stream channel. This can also be referred to as the land phase of the hydrologic cycle.

4.2 METHOD

The current version of NWSRFS uses a modified version of the Stanford Watershed Model IV (SWM IV) as described by Crawford and Linsley (1966) to model the land phase. This chapter will not discuss the soil-moisture accounting portion of SWM IV in detail. The reader should refer to chapter 4 (pp. 30-43) of Crawford and Linsley (1966) for this information. This chapter will describe the modifications which have been made to SWM IV (see section 4.5).

4.3 PARAMETERS

Following is a list of the soil moisture parameters used in NWSRFS and their definitions for use as a reference.

a.	K1	Ratio of average areal precipitation to the precipitation input.
b.	A	Percent impervious area
c.	EPXM	Maximum amount of interception storage (inches)
d.	UZSN	Nominal upper zone storage. An index to the magnitude of upper zone capacity (inches)
e.	LZSN	Nominal lower zone storage. An index to the magnitude of lower zone capacity (inches)
f.	CB	Infiltration index (inches/hour)
g.	POWER	Exponent in infiltration curve
h.	CC	Interflow index. Determines the ratio of interflow to surface runoff
i.	K24L	Percent of groundwater recharge assigned to deep percolation
j.	K3	Evaporation loss index for the lower zone (inches)

k. GAGEPE — Ratio of areal evapotranspiration to input evapotranspiration

l. EHIGH
m. ELOW
n. NEP
o. NDUR — Parameters to compute watershed potential evapotranspiration from free water potential evapotranspiration (defined in section 4.6)
EHIGH and ELOW can vary for each subarea
NEP and NDUR are regional parameters assigned to the evaporation input station

p. K24EL — Percent of watershed stream surfaces and riparian vegetation

q. SRC1 — Percent of surface detention reaching the channel each hour

r. LIRC6 — Percent of interflow detention reaching the channel each 6 hours

$$LIRC6 = 1.0-(IRC)^{1/4} \qquad (4\text{-}1)$$

where IRC is the SWM IV daily recession constant for interflow.

s. LKK6 — Percent of groundwater storage that reaches the channel each 6 hours when KV zero.

$$LKK6 = 1.0-(KK24)^{1/4} \qquad (4\text{-}2)$$

where KK24 is the SWM IV minimum observed daily groundwater recession constant.

t. KV — Weighting factor to allow variable groundwater recession rates.

NOTE: The basic 6-hour groundwater flow (GWF) equation is:

$$GWF = LKK6 \cdot (1.0+KV \cdot GWS) \cdot SGW \qquad (4\text{-}3)$$

where: GWS is the antecedent groundwater inflow index and SGW is storage in groundwater (inches).

u. KGS — Recession factor for antecedent groundwater inflow index.

4.4 FLOW CHART

Figure 4-1 shows the flow chart of the overall soil moisture accounting procedure used in NWSRFS. Parameters are associated with the components for which they are used.

4.5 MODIFICATIONS

Most of the computations in SWM IV are the same in NWSRFS. These include the following computations, with reference to the appropriate equation, figure or table number from Crawford and Linsley (1966).

a. Interception as described on page 30

b. Infiltration computations summarized by figure 4.3 and table 4.1 (p. 33)

c. Upper zone moisture retention; equations 4.4, 4.5, 4.6 and 4.7 and figure 4.7 (pp. 35 and 37)

d. The separation of interflow detention from surface detention as summarized by figures 4.3 and 4.6 and equation 4.3 (pp. 33, 35, 36)

e. The outflow from interflow as shown in equations 4.10 and 4.11 (p. 39) except that a 6-hour time interval is used

f. Percolation as shown in equation 4.8 (p. 38) except that a daily time interval is used; thus the coefficient becomes 0.072

g. Lower zone moisture retention; equations 4.12, 4.13 and 4.14 and figure 4.8 (pp. 39-40)

h. The outflow from groundwater as shown in equations 4.15 and 4.17 (pp. 40-41) except that a 6-hour time interval is used

i. Evapotranspiration from the lower zone as summarized by figure 4.10 and equations 4.18 and 4.19 (p. 42).

Following are the modifications which have been made to SWM IV for use in the National Weather Service River Forecast System.

4.5.1 COMPUTATION INTERVAL

The NWSRFS uses 6-hour input for precipitation. All computations are based on a 6-hour interval except:

a. Infiltration, upper zone retention, surface and interflow detention, and lower zone retention are computed on an hourly basis. This is necessary because soil moisture ratios can change significantly during a 6-hour period with heavy precipitation.

b. Percolation of water from upper zone to lower zone and groundwater storages is computed on a daily basis.

4.5.2 INFILTRATION CURVE

The value of the maximum infiltration capacity as a function of lower zone soil-moisture ratio is defined as

$$b = CB/(LZS/LZSN)^{POWER} \quad (4\text{-}4)$$

This replaces SWM IV equations 4.1 and 4.2 and figure 4.5 (pp. 35-36). Figure 4-2 illustrates this new relationship. This change was needed to give more flexibility to the shape of the infiltration curve. The shape of the infiltration curve is very important in most watersheds.

4.5.3 IMPERVIOUS AREA RUNOFF

It is assumed that most impervious areas are not subjected to interception storage; therefore, impervious area runoff is taken from the precipitation input rather than from precipitation in excess of interception storage as in SWM IV.

4.5.4 EVAPORATION FROM STREAM SURFACES AND EVAPOTRANSPIRATION FROM GROUNDWATER

These two calculations, which were handled separately in SWM IV, are computed jointly in NWSRFS. The parameter K24EL represents the percent of the watershed subject to evaporation from stream surfaces and riparian vegetation. The maximum amount of stream and riparian evaporation is equal to K24EL multiplied by the watershed potential evaporation for that day. The water available for stream and riparian evaporation is equal to the impervious area (A) multiplied by the watershed potential evaporation plus watershed evaporation demand which was not satisfied from soil moisture storage. The stream surface and adjacent moist areas make up a sizeable portion of impervious area in many watersheds though rock outcrops and paved surfaces; buildings which do not allow evaporation also constitute a portion of the impervious area. The computed stream and riparian vegetation evaporation is the smaller of the two quantities, the maximum or the available evaporation.

4.5.5 OVERLAND FLOW ROUTING

Because of the longer time interval used in NWSRFS, the overland flow routing equations of SWM IV involving slope, overland flow length, and roughness are not used. The equation for the amount of fast response runoff that reaches the channel during each hour (ROST) is:

$$ROST = SRC1 \cdot RX \quad (4\text{-}5)$$

where: SRC1 is the percent of the water in surface detention (RX) to reach the channel.

The Water that does not reach the channel is available to become infiltration, upper zone storage, or runoff during the next hour. The term overland flow may be misleading as some fast response runoff may be overland flow, but some may also be flow within the ground cover or upper layer of the soil. The soil moisture accounting in NWSRFS allows for three basic types of runoff: fast response (surface runoff), medium response (interflow) and slow response (groundwater).

4.5.6 ANTECEDENT INDEX TO GROUNDWATER INFLOW

NWSRFS computes the antecedent index of groundwater inflow (GWS) as:

$$GWS = KGS \cdot (GWS + GW\ inflow) \qquad (4\text{-}6)$$

where: GW inflow is the inflow to groundwater storage.
KGS is the antecedent index recession factor.

In SWM IV (equation 4.16, p. 41) the recession factor is a coefficient with a value of 0.97 on a daily basis.

4.6 WATERSHED POTENTIAL EVAPOTRANSPIRATION

The basic evapotranspiration input to NWSRFS is the evaporation from a free water surface with no heat storage. The potential evapotranspiration of a watershed may or may not be equal to free water evaporation because of radiation properties of the watershed such as reflectivity and absorption, roughness of vegetation, heat storage capacity of the soil, and other factors. In NWSRFS the watershed potential evapotranspiration for a given day (EP) is computed by:

$$EP = E \cdot PE \qquad (4\text{-}7)$$

where: PE is the free water potential evapotranspiration for the day. E is a factor that adjusts free water potential to watershed potential.

The adjustment factor (E) is assumed to vary seasonally to reflect the seasonal changes in vegetation. In order to reduce the number of parameters for optimization, the curve of the adjustment factor (E) versus time of year is defined by four parameters. In SWM IV an adjustment factor was used for each month. The four parameters are:

1. ELOW - The minimum value of the adjustment factor. The minimum is assumed to occur on February 15th.

2. EHIGH - The maximum value of the adjustment factor.

3. NEP - The Julian date when the adjustment factor reaches the maximum.

4. NDUR - The number of days during which the adjustment factor remains at the maximum.
   A sine curve is used for the transition between February 15th and the beginning of EHIGH and the end of EHIGH and February 15th.

Reference:

Crawford, N. H. and Linsley, R. K., "Digital Simulation in Hydrology: Stanford Watershed Model IV", Technical Report No. 39, Department of Civil Engineering, Stanford University, Stanford, California, July 1966, 210 pp.

Copies available through: University Microfilms
300 N. Zeeb Road
Ann Arbor, Michigan 48106

Reference Number: OP#55,431
Cost: $11.75 for Xerox copy

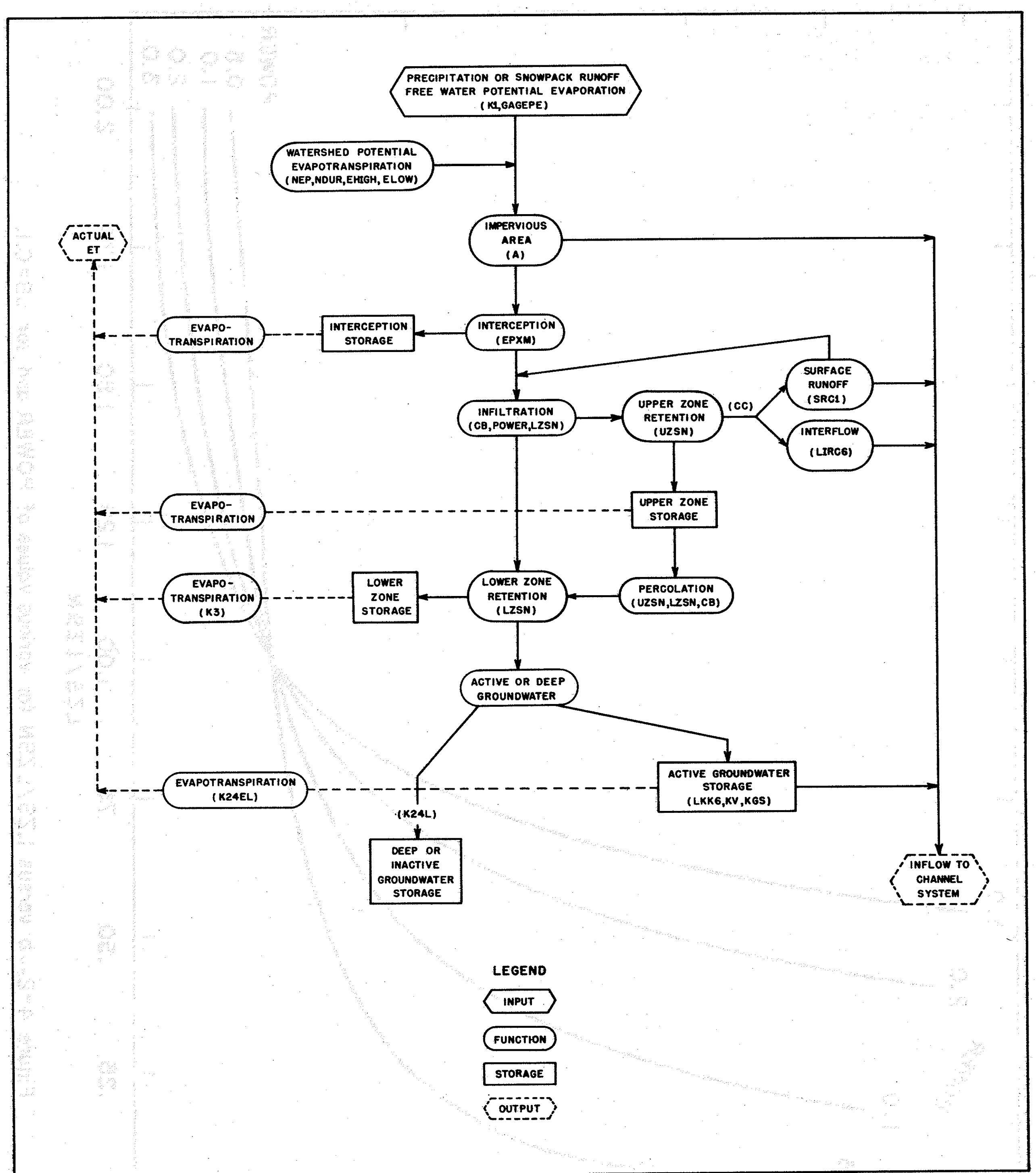


Figure 4-1.--Flowchart of soil moisture accounting portion of the National Weather Service River Forecasting System

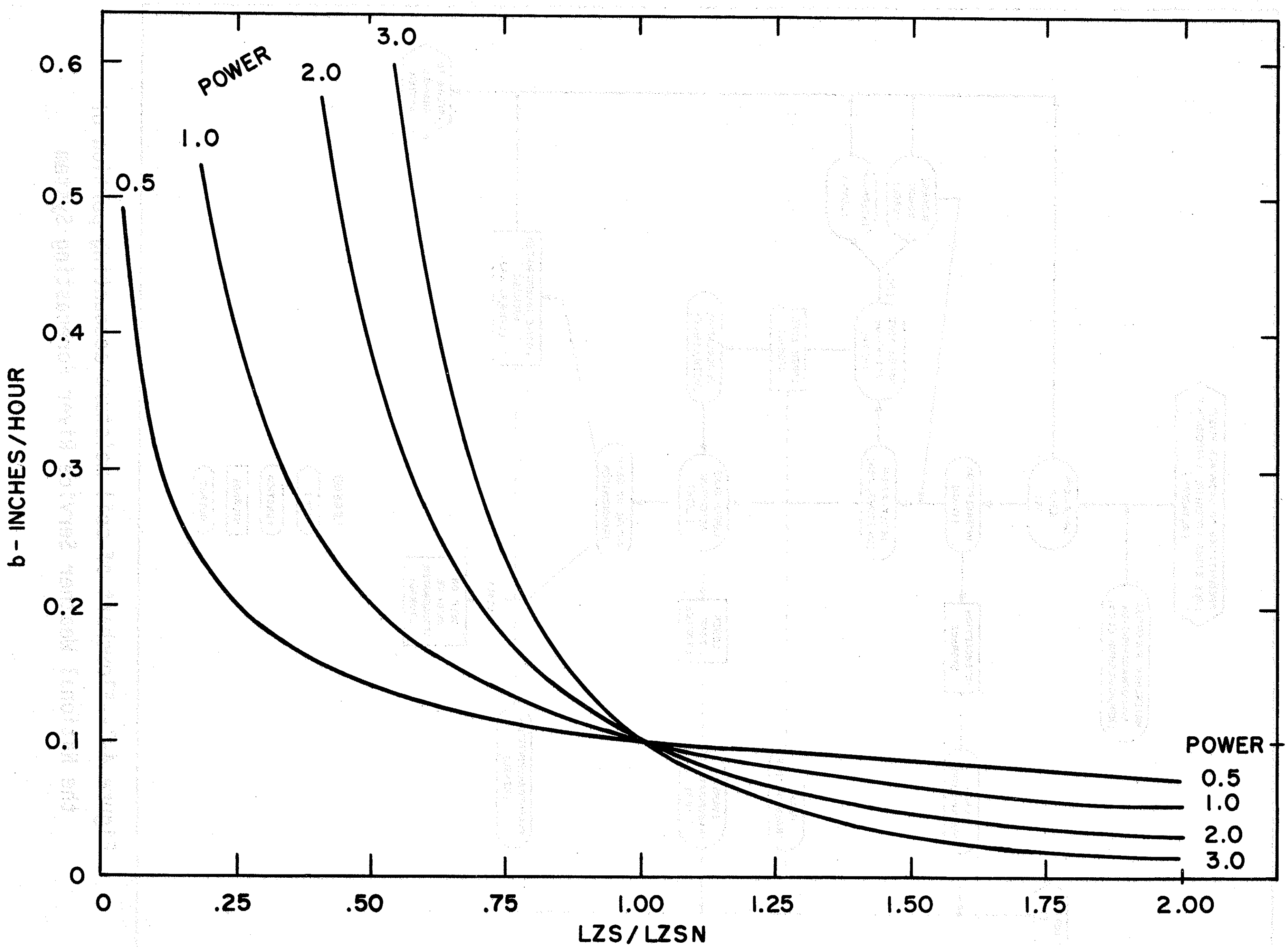


Figure 4-2.--b versus LZS/LZSN for various values of POWER and for CB=0.1.

CHAPTER 5. CHANNEL ROUTING

5.1 GENERAL

This chapter describes the model of the channel system that is currently used in the NWSRFS.

5.2 FLOW ROUTING PROCEDURE

Lag and K channel routing, as described by Linsley, Kohler and Paulhus in Hydrology for Engineers, is used. The essence of this procedure is to: (1) introduce a time delay (lag) to account for travel time of a wave through a reach, and (2) simulate wave attenuation in the reach caused by channel storage effects. The attenuation is simulated by routing the reach inflow, suitably lagged, through a hypothetical reservoir governed by the equation:

$$\frac{dS}{dt} = I(t)-Q(t) = K\frac{dQ}{dt} ,$$

in which the reservoir storage constant K gives rise to the second half of the method name "lag and K." The reservoir storage is given by S, and its inflow and outflow are given by I and Q, respectively.

5.2.1 CONSTANT LAG

5.2.1.1 Local Runoff

In the conceptual framework of the soil moisture accounting procedure, the runoff produced in a 6-hour interval is the flow volume delivered to the channel system in that period. The first step in channel routing is to apply a constant lag to this channel inflow. This is accomplished by the time-delay histogram. The channel system is divided into reaches which have equal travel time. Currently in NWSRFS a 6-hour time interval is used for routing computations; thus, the channel reaches have travel times that are multiples of 6 hours.

Each element of the time delay histogram is associated with a travel time zone. For example, element three is associated with a travel time between 12 and 18 hours. Each element of the time delay histogram is merely a summation of the fraction of the area contributing to all reaches with the same travel time. The total time-delay histogram is a tabulation of these summations and must equal unity. Figure 5-1 shows an example of a time-delay histogram containing seven elements.

To account for areal variation in runoff, each element of the time-delay histogram can have channel inflow from separate soil moisture accounting computations. In the example in figure 5-1, the first four elements have channel inflow computed using mean basin precipitation and soil moisture parameters from area number eight, while the last three elements use area five to get channel inflow.

The time-delay histogram (TDH) may be obtained in one of two ways. The first parallels unit hydrograph analysis and is described in section 7.6.1, part c. The second (more subjective) method is to divide the basin into isochrones of channel travel time, assuming wave speeds over various portions of the reach. Computation of the time-delay histogram for the local area at Hattiesburg, Mississippi as shown in figure 5-2 by the isochrone method is shown in table 5-1.

Table 5.1--Computing the time-delay histogram for the local area at Hattiesburg, Mississippi

Interval	Units of contributing area	Instantaneous channel time-delay histogram	Six-hour interval channel time-delay histogram	Comparison: Six-hour interval channel time-delay histogram from UHG method
0-6 hours	4	.007	.003	.053
6-12	40	.075	.041	.098
12-18	49	.091	.083	.098
18-24	52	.097	.094	.093
24-30	32	.059	.078	.083
30-36	60	.112	.085	.072
36-42	80	.149	.131	.070
42-48	115	.214	.181	.075
48-54	62	.115	.165	.081
54-60	34	.063	.089	.079
60-66	10	.018	.041	.074
66-72	0	0	.009	.064
72-78	0	0	0	.043
78-84	0	0	0	.017
	538.0	1.000	1.000	1.000

It should be noted that for channel systems where it is difficult to determine travel times a more reasonable first approximation to the TDH can usually be obtained by utilizing the unit hydrograph.

5.2.1.2 Upstream inflows

The constant lag of an upstream inflow is obtained as described in section 7.8.3, step a. This value represents the time in hours for a channel wave to travel from the upstream inflow point to the reach outlet. In figure 5.2, constant lags of 30 and 12 hours were obtained for upstream inflow points 1 and 2, respectively.

5.2.2 VARIABLE LAG

Some channel systems exhibit a lag that varies with inflow. In the NWSRFS the total lag consists of the constant lag component plus a variable component.

The variable lag is applied to upstream inflows and local runoff after constant lag has been applied and after these lagged flows have been added together.

An example of a variable lag curve is shown in figure 5-3. (It should be noted here that the method of inputing the variable lag curve varies between programs. The input for the verification and operational program is the same and is described on card 20C appendix F and card 21C appendix G. Variable lag input for the optimization program is described on card 37 appendix H.) As an example of the application of variable lag using figure 5-3, suppose I_C = 36,000 cfs. An increment of 5,000 cfs would be lagged 8.35 hours, an increment of 5,000 cfs would be lagged 6.25 hours, an increment of 10,000 cfs would be lagged 1.7 hours, and the last 6,000 cfs would be lagged 0.35 hours. This is illustrated in figure 5-4. The result is to allocate 16,063 cfs to the present period under consideration, 1,777 cfs to the next 6-hour interval, and the remaining 2,160 cfs to yet the next 6-hour interval.

A few appropriate comments:

a. No negative lags are allowed.

b. Large lag value jumps from one table entry to the next should be avoided.

c. The minimum lag value shown in figure 5-3 is zero. This is because it is expected that any further lagging will be done in the constant-lag operation.

d. The variably lagged flow values are "interval values" rather than instantaneous values. An interval flow value would be an average flow over a 6-hour interval (say midnight til 6 a.m.) whereas an instantaneous flow value would be appropriate at the end of a flow interval (say 6 a.m.).

e. The method of obtaining a variable lag curve is given in Hydrology for Engineers (section 10.10) by Linsley, Kohler and Paulhus.

5.2.3 ATTENUATION BY CHANNEL STORAGE

This is the "K" part of the routing. The attenuation by channel storage is simulated by routing the lagged flow through a hypothetical reservoir with storage constant K. The reservoir inflow will have undergone both constant lag and variable lag, so let's call it I_V to distinguish it from the constant lagged flow I_C of the previous section.

The hypothetical reservoir is governed by the equation:

$$\frac{dS}{dt} = I - Q = K \frac{dQ}{dt}$$

where S is the reservoir storage, K the reservoir storage constant, and I and Q are the reservoir inflow and outflow, respectively. The above equation is exact for instantaneous value, but is used to estimate the behavior of the hypothetical reservoir over a 6-hour interval. In particular, it is used as:

$$\bar{I} - \bar{Q} = \overline{K(\frac{dQ}{dt})}$$

This equation is not necessarily exact. $\bar{I}$ (identically the lagged inflow I_v) is the average inflow during the period. The interval values $\bar{Q}$ and $\overline{(dQ/dt)}$ are estimated by instantaneous outflow values as:

$$\bar{Q} = (Q_2 + Q_1)/2$$

$$\overline{(\frac{dQ}{dt})} = (Q_2 - Q_1)/\Delta t$$

Here Q_1 is the instantaneous flow at the flow point at the end of the last time period, a known quantity.

Solving for the desired instantaneous outflow at the end of the period (Δt = 6 hours) gives:

$$Q_2 = \bar{I}\ (\frac{6}{K+3}) + Q_1\ (\frac{K-3}{K+3})$$

For some channel reaches, the same K value is sufficient for all flow levels. Other channel reaches require K as a function of flow (variable K). Figure 5-5 shows a sample variable K curve. As an example of the use of this curve suppose the midnight flow (Q_1) was 33,000 cfs and the average lagged inflow for the 6-hour interval midnight-6 a.m. is computed as I_v = 26,000 cfs. The simulated 6 a.m. flow would be obtained as follows:

a. Interpolate between the K vs. outflow points to obtain K:

$$K = 15.0 + (11.3-15.0) \times \frac{(33,000-30,000)}{(37,000-30,000)}$$

$$= 13.41 \text{ hours}$$

b. Plug into routing equation

$$Q_{6\text{ a.m.}} = 26,000\ (\frac{6}{16.41}) + 33,000\ (\frac{10.41}{16.41})$$

$$= 30,440 \text{ cfs}$$

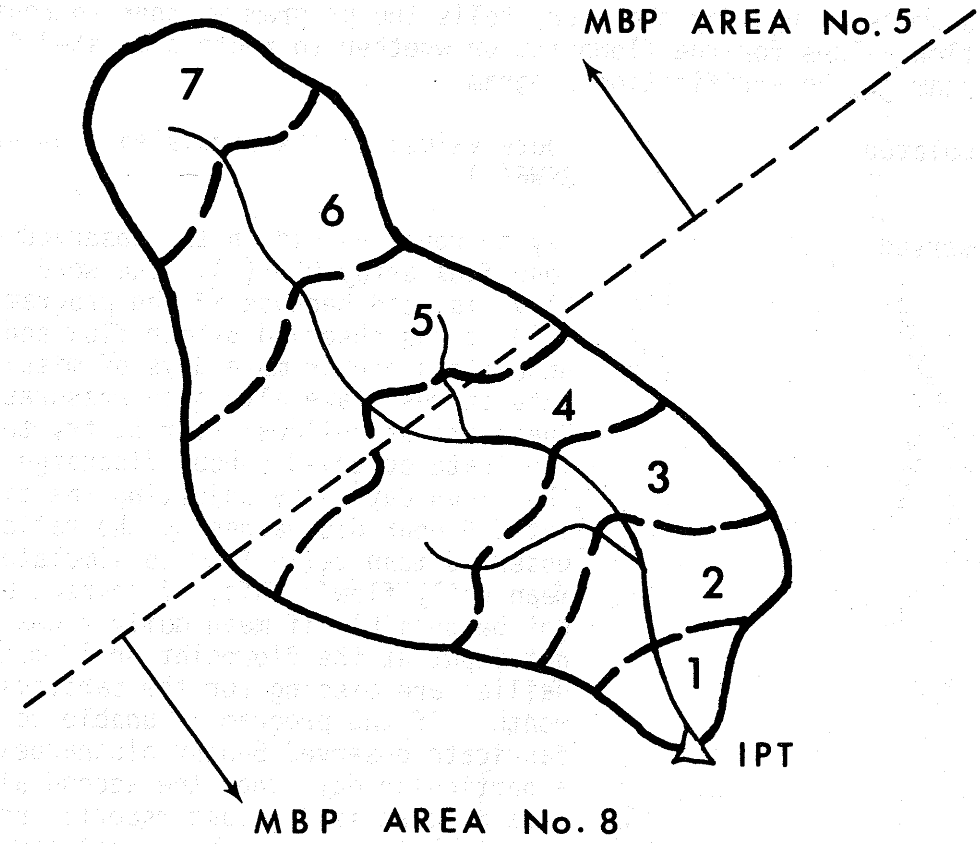
5.2.4 SUMMARY

Figure 5-6 summarizes the computations of constant lag, variable lag, constant K, and variable K that have been described in the preceding sections.

5.3 SELECTION OF FLOW VALUES

A control parameter, input by the user, tells the program whether to route the observed flow values for the flowpoint or whether to route simulated flow values downstream in the verification program.

Route Simulated	Route values in the simulated flow array SFW6( ).
Route Observed	Try to route values in the observed 6-hour flow array OFW6( ). The word "try" is used because if the program is told it has observed 6-hour flow and then encounters one or more days of missing data it must take alternate measures. These are as follows: first, try to fabricate observed 6-hour discharge for the given day(s) by adjusting the simulated 6-hour discharges by the ratio of observed mean daily flow to simulated mean daily flow. This, of course, would not be possible if mean daily flows are not input at the flowpoint or if mean dailies are missing for the particular month. If the program is unable to fabricate observed 6-hour discharges for a particular day, then the second alternate measure is the last resort: route the simulated flow array downstream.

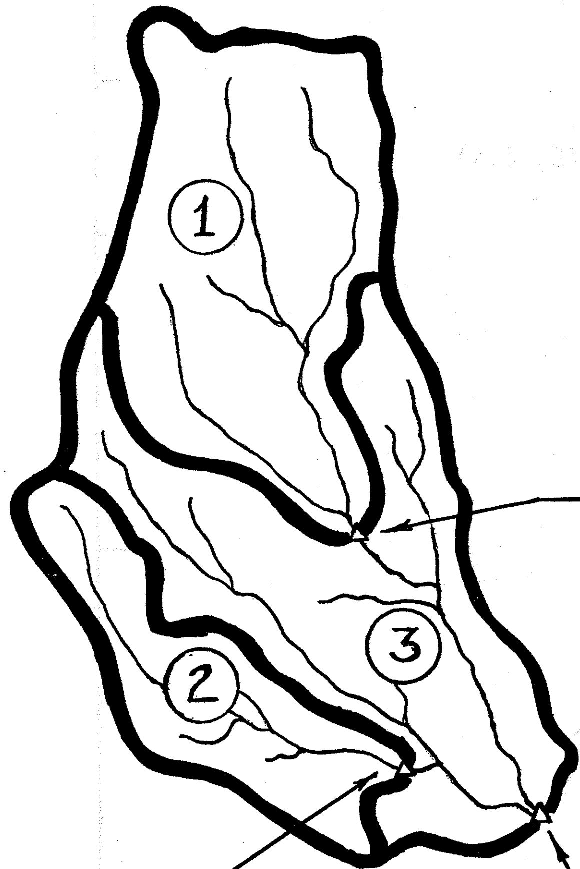


BASIN TIME-DELAY HISTOGRAM

ELEMENT NUMBER	1	2	3	4	5	6	7
FRACTION OF BASIN AREA	.05	.10	.15	.25	.20	.15	.10

ASSIGNMENT OF RUNOFF TO HISTOGRAM ELEMENT: AREA NO. 8 (elements 1–4) AREA NO. 5 (elements 5–7)

Figure 5-1.--Assignment of channel inflows to histogram elements.



Subarea #1: Leaf River above Collins, Mississippi.
[headwater, area = 752 mi^2]

Subarea #2: Bowie Creek above Hattiesburg, Mississippi.
[headwater, area = 304 mi^2]

Subarea #3: Leaf River at Hattiesburg, Mississippi.
[local, area = 704 mi^2]

Figure 5-2.--Channel lag values for flowpoints above Hattiesburg, Mississippi.

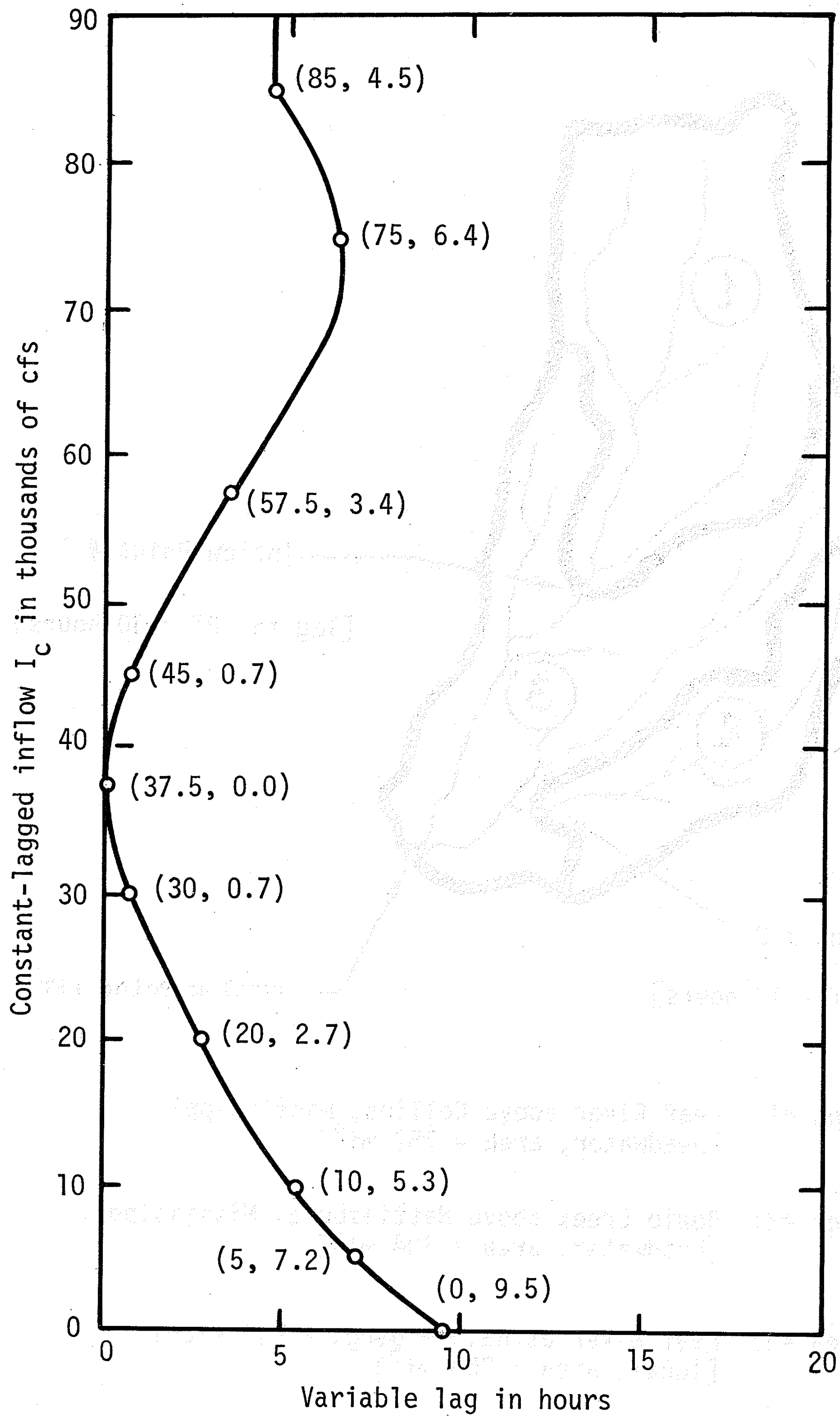
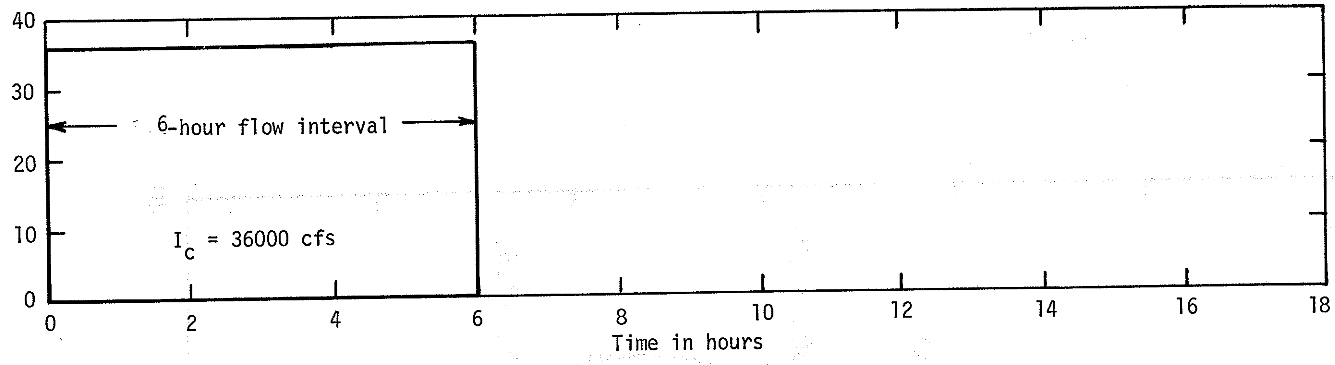
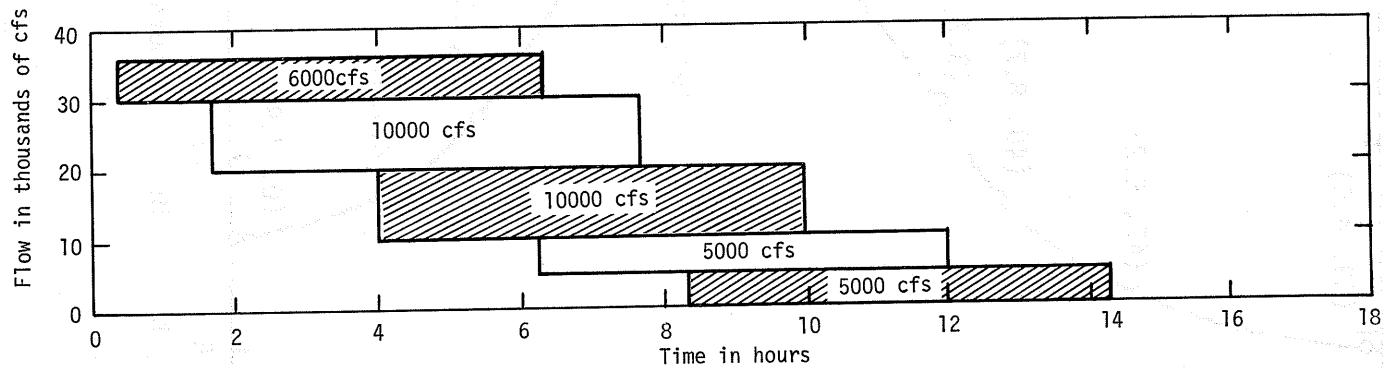


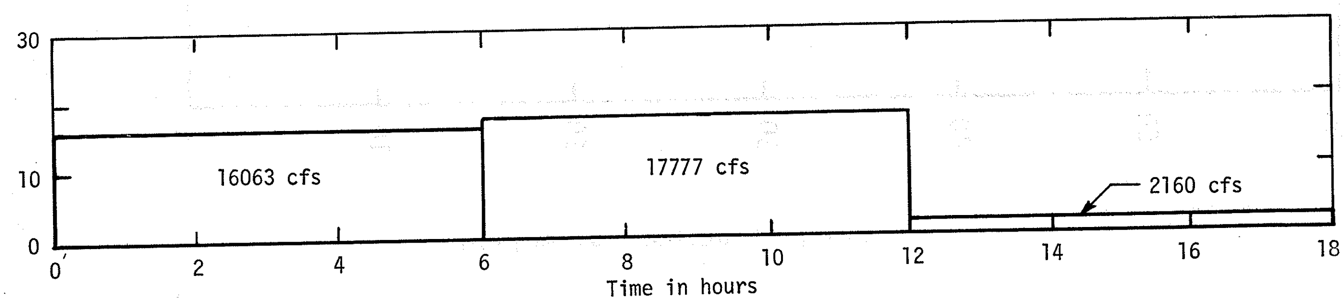
Figure 5-3.--Sample Variable Lag Curve.



(a) Constant-lagged flow for a 6-hour interval.



(b) Variably lagged increments of the constant lagged flow.



(c) Allocation of variably lagged flow among 6 -hour intervals

Figure 5-4.--Application of the variable lag method.

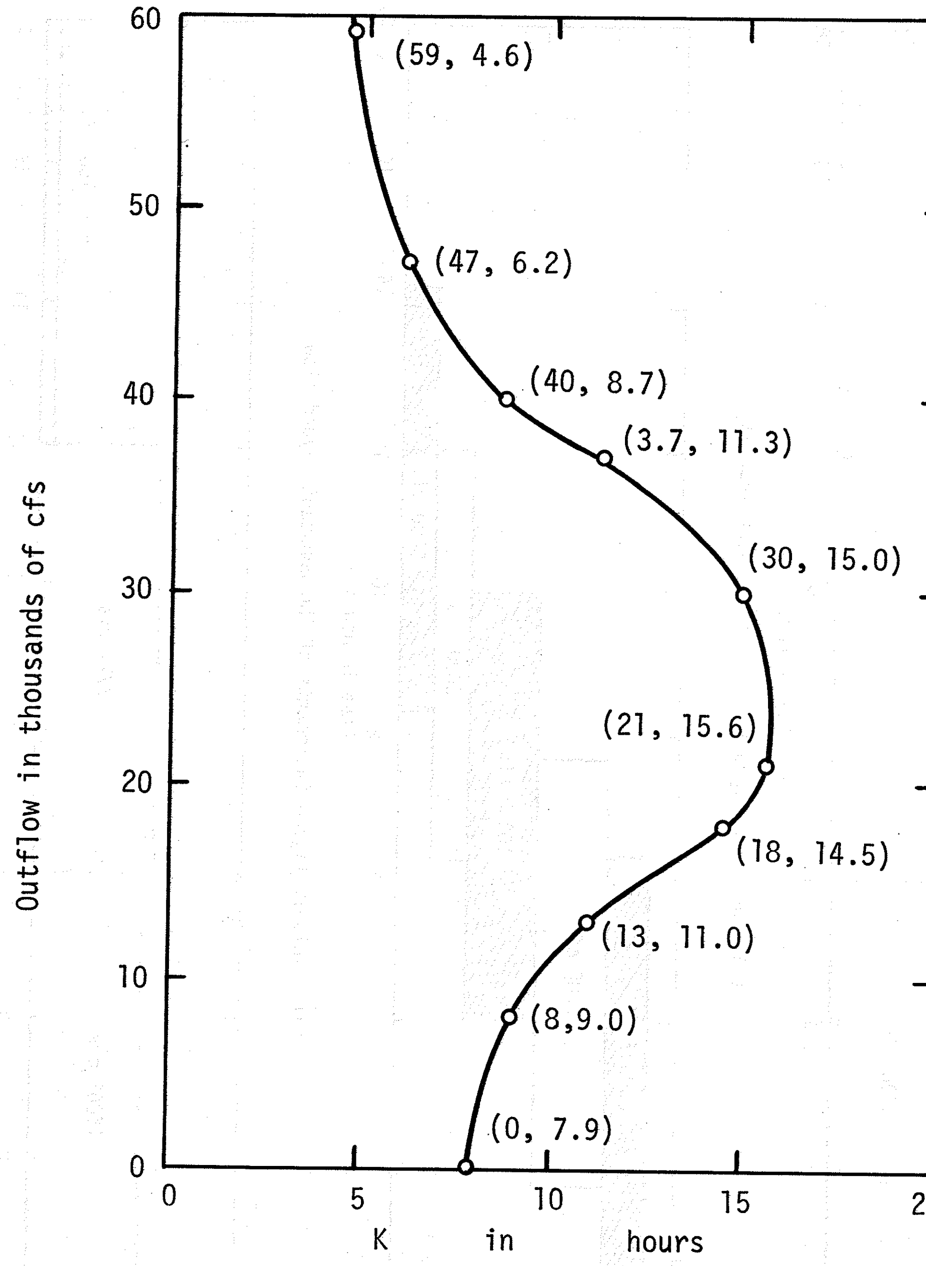


Figure 5.5--Sample variable-K curve.

ROUTING TO PRODUCE FLOW AT A FLOWPOINT

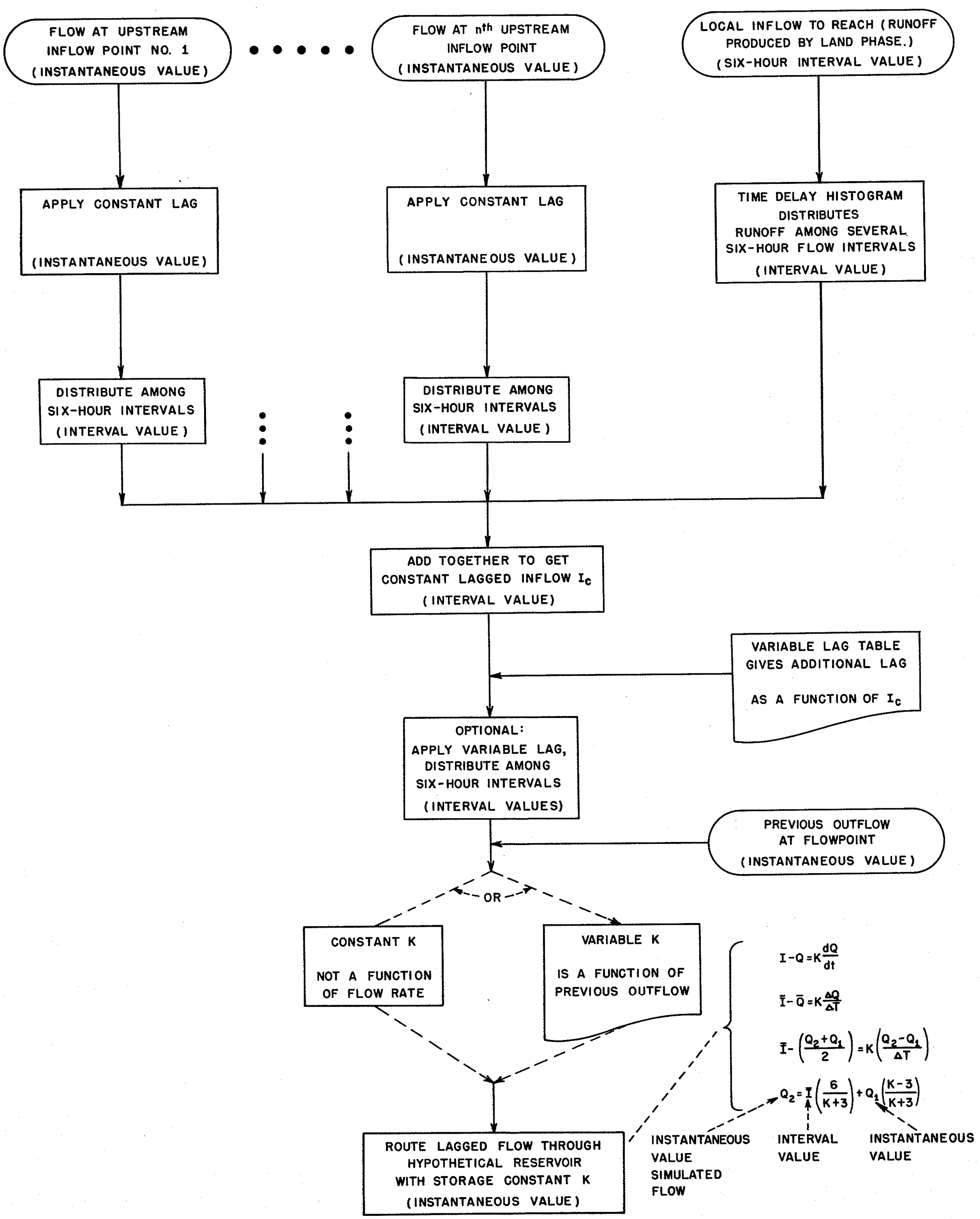
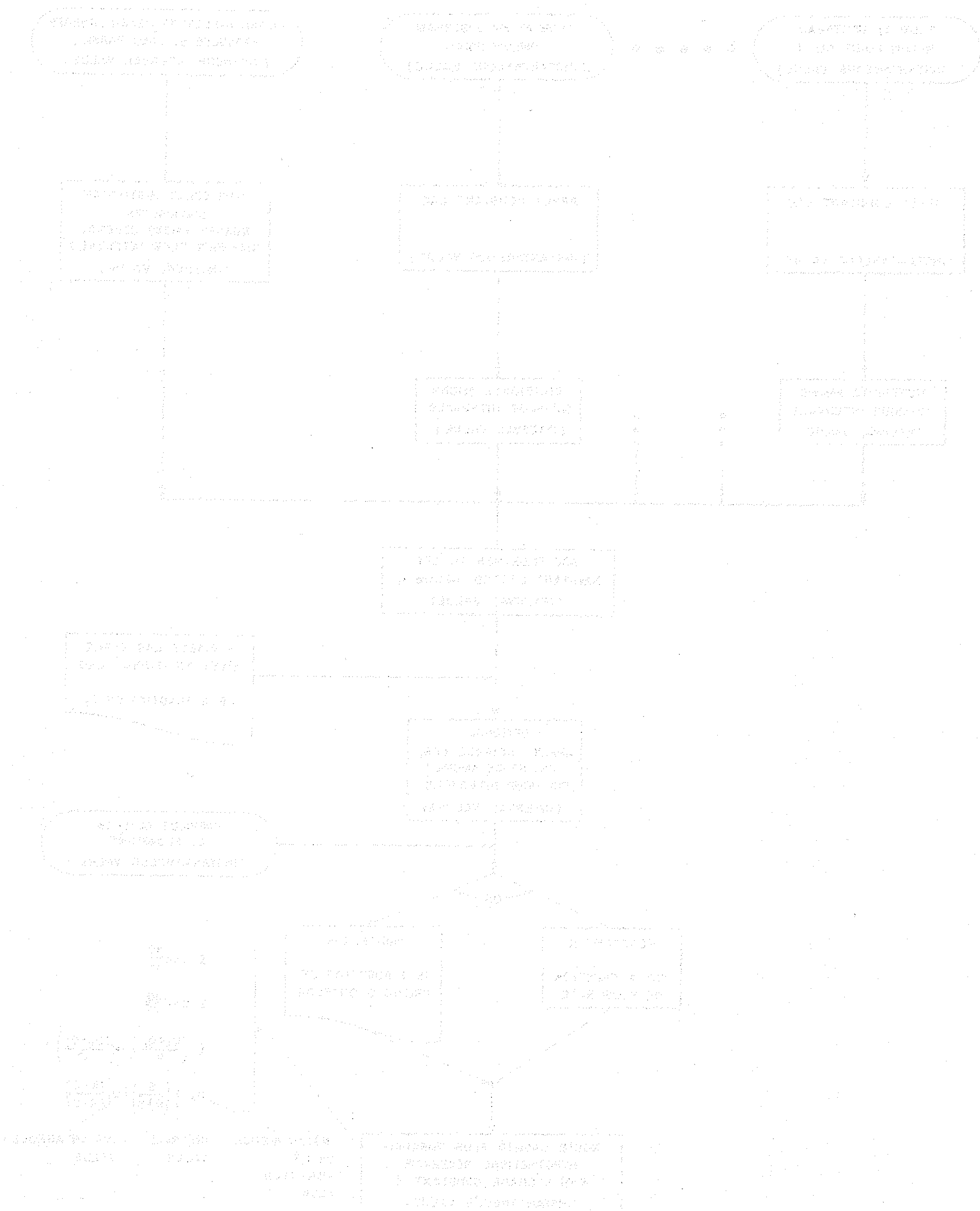


Figure 5-6.



CHAPTER 6. VERIFICATION AND OPERATIONAL PROGRAMS

6.1 INTRODUCTION

This chapter describes program 4 (NWSRFS4) and program 5 (NWSRFS5) of the NWSRFS. NWSRFS4 is used for verification of parameter values by hydrograph simulation. NWSRFS5 is used for operational river forecasting.

6.2 PROGRAM CONTENTS

The verification program and the operational river forecasting program use the same basic computation procedures; thus, they are described in the same chapter. They differ in the length of period that is run and in the method of input and type of output. Both programs consist of a main program and many subroutines. The main program basically inputs options and controls the computational sequence. The subroutines input parameter values, input data, perform soil moisture accounting and channel routing computations, perform statistical computations, and output results.

Following is a listing of the subroutines included in NWSRFS4 and NWSRFS5 and their function:

a. Subroutines included in both NWSRFS4 and NWSRFS5.

1) LANDPM inputs soil-moisture accounting parameters and initial moisture storages for each sub-area for which channel inflow is to be computed. The subroutine also outputs the parameters and initial storages for future reference.

2) FLOWPM inputs parameters for channel routing, initializes the arrays needed to carry channel routing computations over from one period to the next, and computes the size of the local area and the factor to convert inches of runoff to cfs days. This subroutine also inputs information to assign soil-moisture accounting areas to channel reaches. Like LANDPM, FLOWPM also outputs information for future reference.

3) LAND is the subroutine that does the soil-moisture accounting and outputs channel inflow. This subroutine is described in detail in chapter 4.

4) CHANEL is the subroutine which does channel routing by the lag and K (including variable) method. This subroutine is described in detail in chapter 5.

5) FLOWOT is the 6-hour discharge printer plot subroutine for both verification and operational forecast use. In the verification program, 6-hour observed versus simulated discharge is plotted when it is requested for those flowpoints and selected periods for which observed 6-hour discharge was read in. In the operational program, the simulated 6-hour discharge is always plotted. If observed flow was read in, it too is plotted, as well as whether the stage is rising,

falling, stationary, or tendency is not known. Also, when a forecast is made, the forecast is plotted. The forecast may be simulated flow or the forecast may be input by the hydrologist, depending on the program options selected.

b. Subroutines included only in NWSRFS4.

1) INTAPE is the basic data input routine for verification use. This subroutine inputs 6-hour precipitation, daily potential evapotranspiration, observed mean daily flow, observed 6-hour discharge, if available, and 6-hour discharge for upstream inflows from outside the current run area, from tape, if they are needed. The time interval for data input is one month. The data input is described in more detail at the end of appendix F.1. The subroutine contains the flexibility that all data need not be on one tape; plus, if more data are on tape than are needed for a particular run, only that information that is needed is read. Thus, one data tape can be set up for a large river system and used for running any segment of the system.

2) LANDOT is a short subroutine for verification use that outputs monthly runoff components (surface runoff, interflow, etc.), precipitation, total runoff, actual and potential watershed evapotranspiration, and end-of-the-month soil moisture storages plus a water balance for the month as a check on LAND subroutine computations.

3) CHANOT computes simulated mean daily flow from simulated 6-hourly, and the monthly sum of simulated and observed flow. In addition, CHANOT calls for 6-hour discharge plot subroutine when it is needed.

4) SUMARY prints a table of simulated mean daily flow, monthly simulated and observed flows, and water-year flow for each flowpoint for each water-year. In addition, summary calls the water-year mean daily flow plot subroutines (LPLOT, DAILY) and the water-year statistical summary subroutine (STASUM).

5) STASUM is a water-year statistical summary subroutine that computes several common statistics on a monthly, water-year, and flow-interval basis. In addition, a multi-year summary is computed at the end of a verification run. The sample output from a verification run in appendix F shows the statistics that are computed.

6) LPLOT and DAILY are observed versus simulated mean daily flow plot routines for each water-year. LPLOT is for a printer plot. DAILY computes scaled values for an auxiliary plot program. DAILY could be easily modified to plot directly if plot routines are available on the computer.

d. Subroutines included only in NWSRFS5.

1) DATAIN is the basic data input routine for operational river forecasting. This subroutine inputs the same information as INTAPE except for mean daily flows that are not used operationally. In addition, DATAIN inputs whether the stage is rising, falling, or stationary, when

such information is available. DATAIN inputs data for the period from the last forecast up to the current time, with 6 hours being the shortest time between forecasts. DATAIN will also input future data such as QPF (quantitative precipitation forecast) if instructed to do so. DATAIN is programmed to read from cards; however, in normal operational use, a separate program would be used to prepare the cards or, more likely, a tape that DATAIN could be programmed to read. This separate operational data program would compute mean areal precipitation from point values, potential evapotranspiration from meteorological factors, and convert observed stages to discharge.

2) NWDATA is used in operational river forecasting to input data for two rerun options. These data are:

   (a) Constant precipitation multipliers for any sub-area where precipitation input should be so adjusted.

   (b) Six-hour discharge forecasts for any flow-point where the hydrologist wishes to override the computer forecast.

3) WRITCO is a subroutine to prepare a carry-over tape in the operational program. A carry-over tape is a tape that contains the information (parameter values, storage values, etc.) needed to resume forecasting at a future time. The next forecast can begin at any time in the past for which a carry-over tape is available.

4) READCO is a subroutine that reads the information needed to resume operational forecasting from a tape prepared by subroutine WRITCO at some time in the past.

6.3 RIVER SYSTEM ORGANIZATION

NWSRFS4 and NWSRFS5 will simulate a complete river system. The size of the system that can be simulated is virtually unlimited. During a single pass through the programs, the system size is controlled by the dimensions of the precipitation input, land parameter and storage, and channel inflow (runoff from the land phase) arrays plus the dimensions of the channel reach parameter and storage, and the simulated and observed flow arrays. However, by recycling the program and using downstream outflows from one pass as upstream inflows for the next, a very large river system could be simulated for verification purposes or for operational forecasting.

A typical stream system is shown in figure 6-1 to illustrate the flow-point numbering system used in the programs. In this illustration, flow is being computed at seven points during this pass of the program; plus, there are two upstream inflows from outside the area. For points where flow is computed, the flowpoint number must be greater than that of the points upstream. This is to ensure that flows needed as inflows to a local area have previously been computed, since the program computes flows in sequential order. Since upstream inflows from outside the area have been computed previously, they are assigned numbers at the end of the string and can violate the rule that upstream inflow points must have a flowpoint number less than the downstream flowpoint.

The runoff from the land phase of the hydrologic cycle (channel inflow) is computed independently from the channel system. To unite the two systems, it is necessary to assign to each channel reach the area or areas from which it is to receive channel inflow. This assignment is part of the program input.

6.4 ALTERNATE REACH ROUTING

The present versions of NWSRFS4 and NWSRFS5 contain only one type of reach routing, as described in chapter 5. In use, it may be necessary to add additional types of reach-routing procedures due to reservoirs, backwater conditions, etc. Provisions have been made in the programs so that such additions can be made with a minimum of programing changes. The option variable CHECK ( ) determines the reach-routing subroutine to be used at each flow-point. CHECK ( ) equal to one for a given flow-point signifies use of lag and K (including variable) as described in chapter 5 and programed in subroutine CHANEL. Another value of CHECK ( ) would signify the use of a new subroutine, programed to handle another type of reach. The only other program changes would be to expand the flowpoint parameter input subroutine (FLOWPM) to read the parameters needed for the new type of reach and to add statements to output additional information such as reservoir level, flow depths and velocities which may be computed in the new reach-routing subroutine. As far as continuity with the rest of the program, it is only necessary that the array SFW6 ( ) contain the simulated flow at each flowpoint.

6.4.1 ADDITION OF RESERVOIRS - EXAMPLE ONE

Figure 6-2 shows examples of how to handle reservoirs in NWSRFS4 and NWSRFS5. In example one, flowpoint 4 would combine the inflows from flowpoints 1, 2, and 3 plus the local area to give inflow to the reservoir. The reach above flowpoint 5 would be the reservoir itself and a new subroutine would be needed to simulate the outflow. Since no observed flow would be available at flowpoint 4, simulated flow must be routed downstream. That is, the simulated flow at flowpoint 4 would be the inflow to the reservoir subroutine. At flowpoint 5, either simulated or observed flow could be routed downstream, depending on the circumstances.

6.4.2 ADDITION OF RESERVOIRS - EXAMPLE TWO

Example two of figure 6-2 could be used for two types of reservoirs: first, a reservoir where outflow was always completely controlled; and, second, a reservoir that was kept full all the time. In this example, the simulated flow at flowpoint 4 (consisting of inflows from flowpoints 1, 2, and 3, plus the local area) would be the inflow to the reservoir. The past observed flow at point 4, plus the forecast, would be routed downstream. The forecast for the first type of reservoir would be the hydrologist's estimate of future releases, the forecast for the second type would be the simulated outflow.

6.5 VERIFICATION PROGRAM

This section describes the options and input for the verification program NWSRFS4.

6.5.1 INPUT SUMMARY

A summary of the input needed for the verification program is given in appendix F.1.

6.5.2 OPTIONS

Several options are available in the verification program to save computer time when determining the parameters, especially in the case of a downstream local area. The following options are available (option variables are read in on verification input card 14, appendix F.1).

a. Store channel inflow on tape. On many downstream local areas, the LAND subroutine parameters can be obtained from nearby headwater areas. In some cases the estimates from the nearby headwaters will need to be modified slightly by several trial and error runs with NWSRFS4. However, it soon becomes evident from hydrograph examination and volume considerations that the values of the LAND parameters are satisfactory and that the remaining error lies with the channel routing parameters. In this case, the first option on card 14 will store the LAND subroutine output (channel inflow) in the tape specified by option 6, card 14. On subsequent runs, the second option on card 14 tells the program to by-pass the LAND subroutine and instead read channel inflow from the tape specified by option 6, card 14. These options can save considerable computer time when determining only channel-routing parameters.

b. Save 6-hour flow on tape. In determining parameter values for a channel system, there is no need to keep rerunning calibrated upstream flowpoints to provide inflows for downstream local areas. In this case, when upstream areas are satisfactorily calibrated, option 3, card 14, can be used to store the 6-hour discharge, which is to be routed downstream at each flow-point, on the tape specified by option 12, card 14. The discharge to be routed downstream, either simulated or observed, is specified on verification card 13. This tape can then be used on subsequent runs of the downstream local area as the tape which supplies upstream inflows from outside the run area (option variable 13, card 14). This tape can also be used to supply upstream inflows to the parameter optimization program (NWSRFS3) as discussed in chapter 7.

6.5.3 SAMPLE INPUTS

Sample inputs for two runs of the verification program are listed in appendix F.2. These are for the Leaf River Basin in Mississippi which is shown in figure 6-3.

The first set of sample input is for a run of the entire area above Hattiesburg. Observed flow is routed downstream at all flowpoints. The 6-hour discharges for each flowpoint are saved on tape 2. Six-hour observed discharges for selected periods, obtained from USGS records are input from tape 3. Thus, the flow routed downstream during these selected periods is the observed 6-hour discharge. During other periods, an estimate of the observed 6-hour discharge based on simulated 6-hour discharge and observed mean daily flow as described in chapter 5 is used.

The second set of sample input is for a run of the local area above Hattiesburg. This run uses the 6-hour discharges stored on tape during the previous run as upstream inflows.

6.5.4 SAMPLE OUTPUT

Appendix F.3 contains examples of output from NWSRFS4. To conserve space, the entire output is not listed, but examples are given of each type of printout.

6.6 OPERATIONAL RIVER FORECASTING PROGRAM

This section describes the options and input for the operational river forecasting program (NWSRFS5).

6.6.1 INPUT SUMMARY

A summary of the input needed for the operational river forecasting program is given in appendix G.1.

6.6.2 OPTIONS

A number of options are available in the operational program to make the program flexible and suitable for river forecasting under various circumstances. The following options are available:

a. Update and forecast period. The minimum time interval between forecasts is 6 hours. The maximum is controlled by the dimensions of the precipitation, channel inflow, and discharge arrays. The length of the update period (time since the last forecast) plus the length of the forecast (an input variable) cannot exceed the dimensions of these arrays.

b. Use of carryover tapes. An update period can begin at any time for which carryover information is available. Carryover information is written onto tape at the end of the program run. The program as written requires a new tape for each group of carryover information. In actual operational use, this could be modified depending on the particular computer system so that carryover information was placed sequentially on a single tape or on a disk file. Under such a system, carryover information might be kept for the preceding week or month so that the update period could be varied, depending on circumstances.

   In addition to the normal method of handling carryover information, the program has an option to store carryover information at the beginning of a storm. At the beginning of a storm, variable 10, card 2, is set to 1. This stores carryover information for the beginning of the storm on the carryover tape. This information is retained until the beginning of another storm is indicated. Therefore, the entire storm period can be run whenever it is desirable. To run the entire storm period, variable 11, card 2, is set to 1.

c. Flow routed downstream. At each flowpoint the program has the option, as discussed previously, of routing simulated or observed flow downstream. Operational program input card 5 makes it possible to change the flow to be routed downstream at any particular flowpoint. This could be used in cases where observations of stage are made only during periods of high flow. At such a flowpoint, simulated flow would normally be routed downstream; but, during times when observed flow is available, the option could be changed to route observed downstream. It should be noted that an unrealistic step may occur when shifting from the routing of simulated to observed, or vice versa, downstream. There is no provision for blending at the transition point.

d. Input observed flow. Operational input card 12 determines the discharge information that is to be read in at each flowpoint. Observed flow can be read in for a particular flowpoint even though it is not to be routed downstream. In this case, only those times when observations were made need be included (missing 6-hour values input as negative). When observed flow is to be routed downstream, 6-hour discharge is needed for every period.

e. Input of new parameters. Variable 5, card 1, is included so that new parameter values can be added without destroying the present carryover information. In this case, the new values are substituted for the old and are used in further computations and are included in future carryover information.

f. Hydrograph adjustment. Several methods of adjusting the simulated hydrograph are included in NWSRFS5. These are provided for use when the simulated hydrograph may deviate significantly from the observed. In this case, an adjustment can be made to correct the error. A major consideration is the determination of the cause of the error so that the adjustment applied will correct the error and will minimize future deviations of the hydrographs. A set of decision rules to accomplish this is an area for considerable future research. For the present, the program supplies only the method of adjusting; the hydrologist must decide which adjustment to use. The following adjustments are available:

   1) Precipitation timing can be adjusted only by changing the precipitation data input through subroutine DATAIN.

   2) Precipitation volume can be adjusted by a multiplying factor. A separate factor can be applied to each area where channel inflow is computed. Operational input cards 30 and 31 determine which areas are to be adjusted and the value of the multiplication factor. Another method of adjusting the hydrographs is to apply a correction factor to land runoff (channel inflow). However, this does not correct the basic reason for the error and does not result in updated soil-moisture accounting storages; thus, it is not included in NWSRFS5.

   3) Errors caused by initial soil-moisture storages can be corrected by using new initial values. Option variable 8, card 2, plus cards 3 and 4, allow for changing initial soil-moisture storages.

4) Errors at a downstream flowpoint caused by upstream forecasts can be corrected by inputting a forecast rather than using the computer forecast. Operational input cards 30, 32, and 33 determine at which flowpoints the forecast is to be changed and the hydrograph for the new forecast.

6.6.3 TIME INTERVAL FOR HYDROGRAPH ORDINATES

NWSRFS5 is programmed to use a Δt of 6 hours for routing computations; thus, 6 hours is the minimum possible time between hydrograph ordinates. In some cases, 6-hour ordinates are not adequate to define the hydrograph for operational river forecasting. In these cases, a shorter Δt is needed to produce hydrograph ordinates at a more frequent interval. In these cases, it would be necessary to modify the routing computations in subroutine CHANEL, to expand the observed (OFW6 ( )) and simulated (SFW6 ( )) flow arrays to contain more than four ordinates per day, and to expand the hydrograph plot subroutine (FLOWOT) to plot the additional hydrograph ordinates.

6.6.4 SAMPLE INPUT AND OUTPUT

Three examples of sample input and corresponding output for the operational river forecasting program are listed in appendix G.2. The Leaf River as shown in figure 6-3 is used as an example. The first example is for an initial run of the program for which no forecast is to be issued. Since the channel storages are initially set to zero, it takes some time for the simulated flow to build up.

The second example is for the preliminary run on a major flood.

The third example illustrates the use of adjustment methods (precipitation multiplication factors, changing initial soil-moisture storages, and inputting a forecast to replace the simulated forecast) to revise the preliminary run for the same major flood.

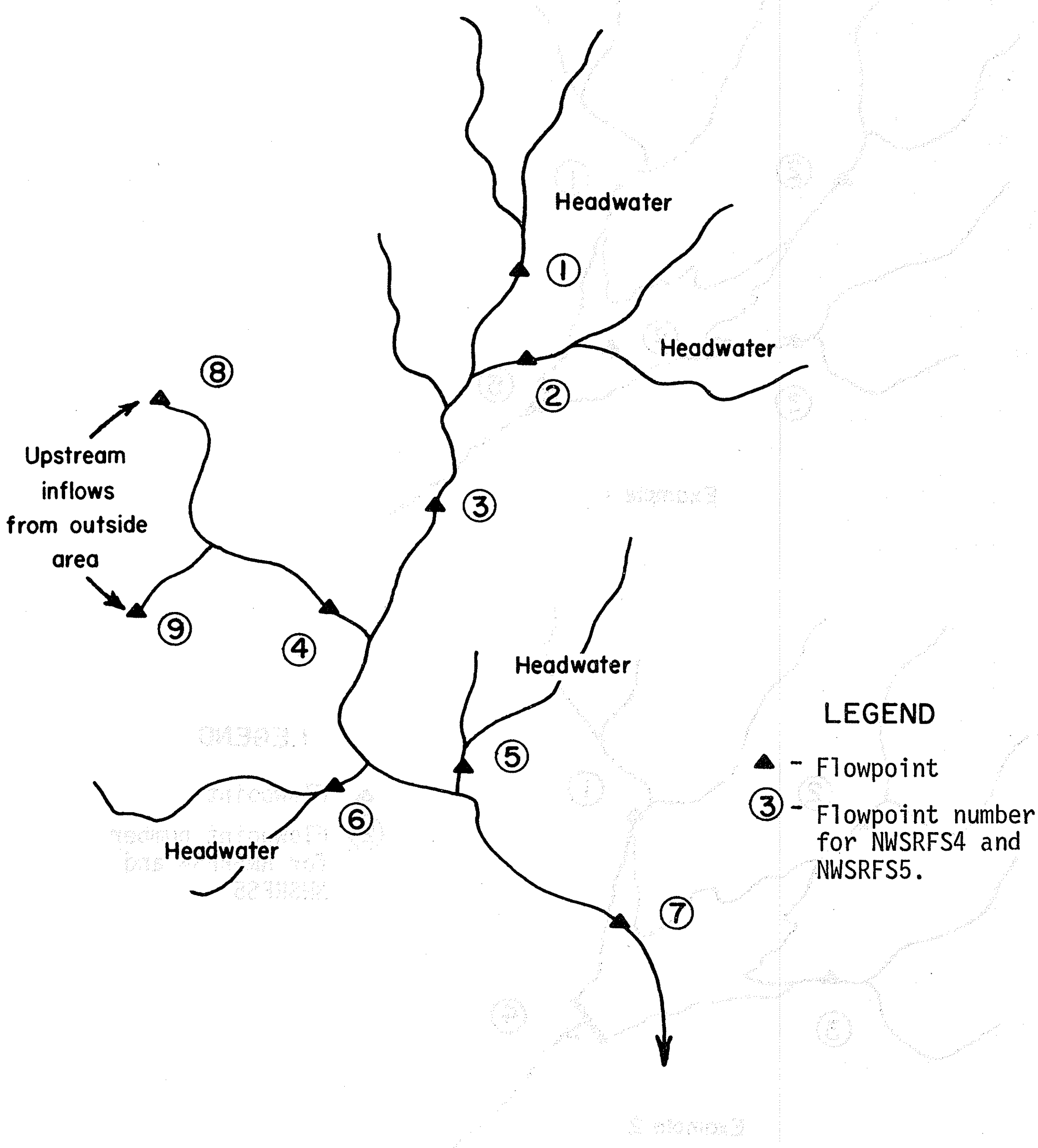


Figure 6-1.--Flowpoint numbering for river system simulation by NWSRFS4 and NWSRFS5.

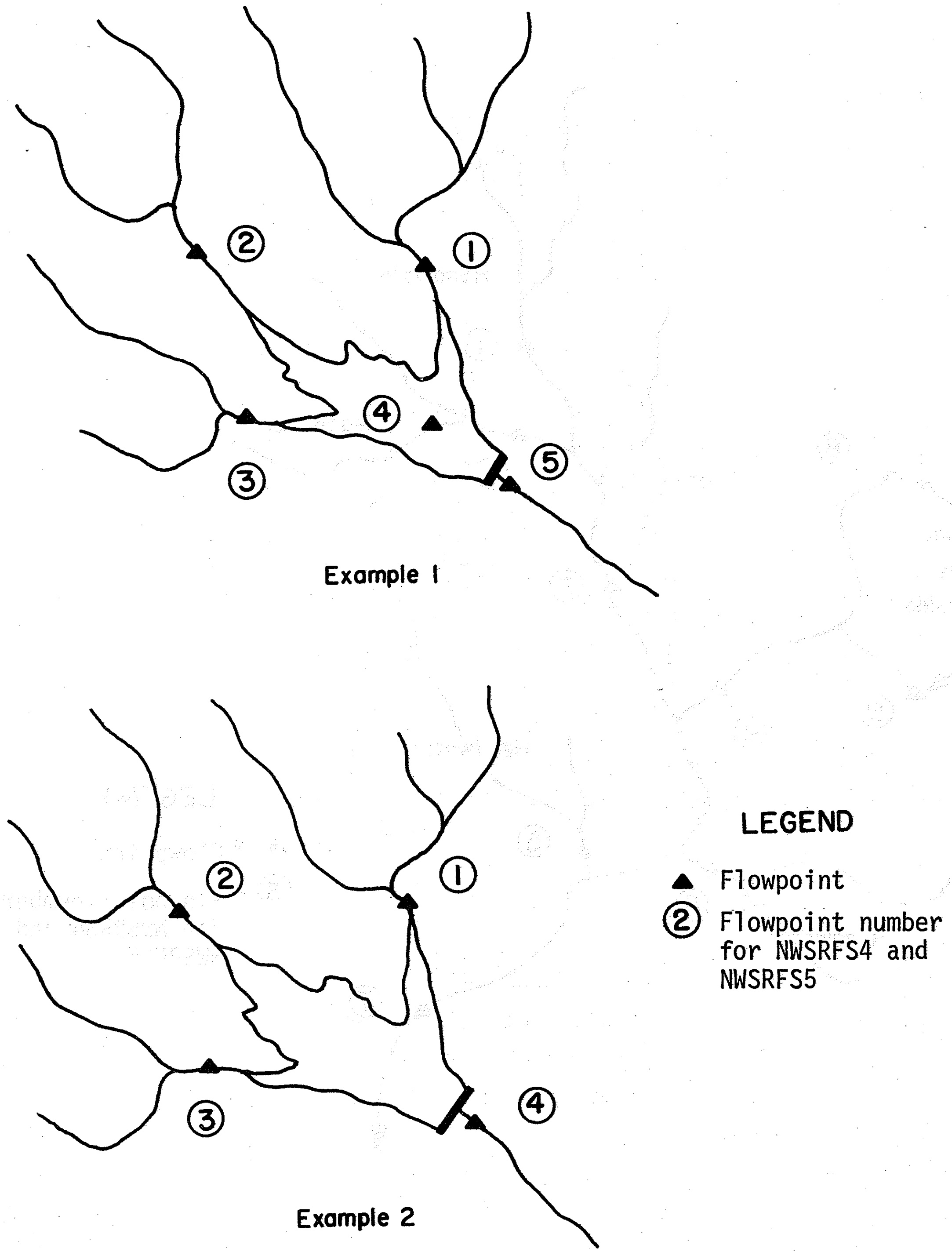


Figure 6-2.--Two examples of flowpoint numbering for NWSRFS4 and NWSRFS5 with reservoirs added.

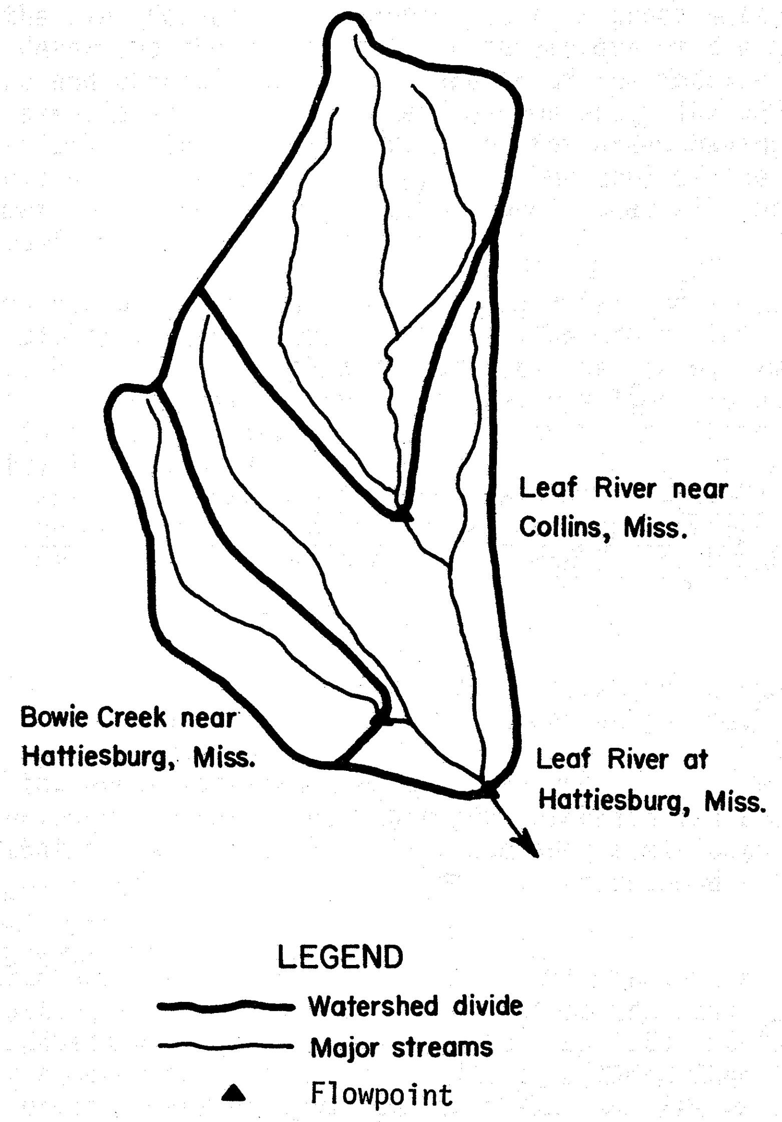


Figure 6-3.--Map of Leaf River Basin above Hattiesburg, Mississippi.

CHAPTER 7. MODEL CALIBRATION

7.1 INTRODUCTION

The utility of the Flow Forecast Model depends, to a great extent, on the methods that will determine the values for the parameters of the Model. The moisture accounting and channel routing components of the Model are composed of equations with associated coefficients and parameters. The parameters give the Model flexibility to simulate streamflow for areas having widely different hydrologic and meteorological regimes. The goal of the modeler is to determine parameter values (calibrating the Model) that will provide simulation of streamflow to the desired accuracy.

Model calibration can be accomplished by using a trial-and-error procedure, a direct-search optimization procedure, or both. The use of both procedures is recommended for the NWSRFS. Trial-and-error, as used here, simply means that the modeler is subjectively modifying parameter values and observing the resulting changes in the simulation results. Direct search (Pattern Search) is described briefly in section 7.2. A complete description of the algorithm is found in Monro (1971). To use the Calibration Model (NWSRFS3) efficiently and to understand the many suggestions for trial-and-error analysis, the modeler must have some experience using programs NWSRFS3 and NWSRFS4.

7.2 PATTERN SEARCH

In the application of the Pattern Search, it is necessary to specify an index upon which the best set of parameter values can be judged. This index is referred to as the "evaluation criterion" and, in NWSRFS3, it is the sum of the squares of the errors in simulated and observed mean daily streamflow values. Past experience indicates that this type of criterion produces parameter values that allow the model to simulate adequately both high and low streamflows. The best set of parameter values will correspond to the smallest criterion value.

The Pattern Search process consists of starting with an initial set of parameter values, adjusting them successively, and testing the results. There are two types of adjustments, known as Local Excursion (LE) and Pattern Move (PM). In an LE, the parameter increment (DELTA) is a fixed quantity, or a percentage of the present parameter value. In a PM, the size of the adjustment applied to each parameter is determined from the trend of its past LE's. The increment size [$\xi^i(I)$] for a given parameter can be calculated by the following equation:

$$\xi^i(I) = N(I) * DELTA(I)$$

and

$$N(I) = N_1(I) + N_2(I)$$

where: i = Pattern move i

$N_1(I)$ = The number of previous successful (+) LE's for parameter A (I)

$N_2(I)$ = The number of previous successful (-) LE's for parameter A (I)

7.3 COMPUTATION FEATURES

Several of the computational considerations in Pattern Search optimization are not described in Monro (1971); they are as follows:

a. Each parameter has an upper and lower constraint associated with it. The parameter values are allowed to fall only between the constraints. The constraints are determined by the modeler and may be set by physical considerations.

b. If a parameter value has not changed by at least 2*DELTA in the past three LE-PM cycles, then it is removed from the optimization process for the next three LE-PM cycles.

c. If a parameter has had a (+) DELTA applied to it in the last LE, then for the present LE, a (+) DELTA will be considered first. However, if during the last LE, a (-) DELTA was successfully applied to it, then for the present LE, a (-) DELTA will be considered first.

d. During selected times of the simulation period, contributions to the evaluation criterion can be suppressed. This action can be taken if, during certain periods, there appear to be large data errors in either the streamflow or precipitation record. It may be advantageous to suppress contributions to the evaluation criterion during months with snow on the ground.

e. The length of the simulation time period can be varied. The simulation time period generally is 50 months, including 48 months for which the evaluation criterion is computed, and a 2-month buffer period prior to the first year to be simulated. The buffer period allows the assumed initial moisture conditions of the model to adjust to "actual" field conditions. NWSRFS3, as now programed, can simulate a streamflow record of no more than 50 months. A record of 50 months generally contains enough "hydrologic" variety and plus-and-minus data errors to ensure calculating stable values for the parameters. This simulation period may be shortened because of limitations in data availability or computer time. The buffer period may be decreased or increased; this depends upon whether or not the initial moisture storage values appear to be adjusting to "actual" field conditions.

f. The optimization procedure terminates in three ways. (Refer to appendix H.1 for parameter definitions that follow). If SUBRØUTINE ØPT has been called MAXN times, the optimization process ends. It also terminates if there have been KC resolution maneuvers (DELTAs being halved). Termination also occurs if the evaluation criterion has not improved by at least PCENTØT (percent/100) in KSTØP LE-PM cycles.

7.4 THE CALIBRATION MODEL (NWSRFS3)

7.4.1 INTRODUCTION

The calibration computer program (NWSRFS3) is composed of a main program and many subroutines. The data input summary for NWSRFS3 is found in appendix H.1. Section 7.4.2 describes the computer program structure and the main purpose of each of the elements in NWSRFS3. Section 7.4.3 explains the different simulation configurations allowed in the program. There are two basic computation modes, the optimization mode and the sensitivity mode.

7.4.2 STRUCTURE

a. PRØGRAM NWSRFS3. The main function of this program is to read from cards the moisture-accounting parameter values, the channel routing function, simulation option values, and data tape parameters. Examples of input data for NWSRFS3 are found in appendices H.2 and H.4. This program reads (from cards) all necessary information for optimization or sensitivity analysis.

b. SUBRØUTINE INDATA. All necessary meteorological and streamflow data are read from magnetic tapes in this subroutine. These data are stored in central memory (extended core storage is employed on the CDC 6600 system). The typical data read are 6-hour (mean basin) precipitation, daily potential evaporation, and observed mean daily discharge. If upstream inflows are needed, then observed or simulated instantaneous (6-hour) discharges are read from tape. The 6-hour discharges can be created by the verification program (NWSRFS4).

c. SUBRØUTINE ECURVE. E curve computations adjust free water potential evaporation to potential evapotranspiration of the watershed. Refer to section 4.6 for a complete description of these computations. Subroutine ECURVE is initially called by Program NWSRFS3, and thereafter by subroutine LAND, whenever the parameters associated with the E curve are modified during the optimization or sensitivity analysis.

d. SUBRØUTINE LAND. Moisture accounting is performed in this subroutine. Chapter 4 gives the details of the moisture-accounting computations performed in NWSRFS3 and NWSRFS4. LAND functions as the "coordinator" for all the other subroutines. During optimization or sensitivity analysis, LAND "calls" the other necessary subroutines. Meteorological data are retrieved from computer storage by LAND.

e. SUBRØUTINE CHAØP CHAØP is not presently used. This subroutine merely serves as a "dummy" storage location in computer memory.

f. SUBRØUTINE CHANNEL. The channel inflows computed by subroutine LAND are routed to the gaging point by the computations in CHANNEL. The routed channel inflows represent the continuous simulated hydrograph trace at the gage. Chapter 5 contains the description of the channel routing computations.

   Although the computer statements in subroutine CHANEL of NWSRFS4 are quite different than those in subroutine CHANNEL of NWSRFS3, they are mathematically equivalent.

g. SUBRØUTINE ØPT. In subroutine ØPT parameter values are modified according to the Pattern Search algorithm. Section 7.2 describes the basic computations.

h. SUBRØUTINE SENSETV. Parameter values are modified by predetermined increments, (maximum of eight for each parameter), during a sensitivity analysis in SENSETV.

i. SUBRØUTINE WARP. The channel time-delay histogram is modified in this subroutine. Appendix I explains the computation logic of this routine.

7.4.3 OPTIONS

There are two basic computation modes in NWSRFS3, the optimization mode and the sensitivity mode. In the optimization mode, adjustments to the value of the parameters are determined by the strategy of the Pattern Search algorithm. In the sensitivity mode, the number of adjustments and the size of each adjustment applied to each parameter value, are predetermined by the modeler. The ability to determine what is an adequate number of adjustments, and what are appropriate adjustment sizes for each parameter, comes with experience. When running under the sensitivity mode, subroutine SENSETV, in a sense, replaces subroutine ØPT. There are several different simulation configurations under either mode.

a. Headwater Basin or Local Area. A local area as defined here is any area that has upstream inflows into it. The upstream inflows may be either observed 6-hour discharge or previously generated simulated 6-hour discharge. NWSRFS4 supplies the simulated 6-hour flow data. As presently programed, NWSRFS3 can model local areas having no more than four upstream inflows.

b. Two Sub-Areas. A headwater basin or local area may be subdivided into two parts for moisture-accounting purposes. The values for moisture-accounting parameters are the same for each area (AREA 1 and AREA 2). However, mean-basin precipitation differs between AREA 1 and AREA 2. Section 7.5.3 describes the channel routing procedure when two areas are considered.

c. Variable Channel Routing Function - Variable Lag and Variable K curves. Chapter 5 presents details on these channel routing functions.

7.5 PARAMETERS

7.5.1 INTRODUCTION

Meteorological, hydrologic, and topographic data are used to derive the values for some of the parameters. Some parameters, in general, may be treated as coefficients, and have arbitrarily fixed values. However, the majority of the values for the parameters must be determined by Pattern Search optimization or trial-and-error analysis.

7.5.2 MOISTURE-ACCOUNTING PARAMETERS

Moisture-accounting parameters are listed below. Definitions for these parameters are found in chapter 4.

UZSN	KGS	PEADJ*	ELØW
LZSN	K24EL	K3	NEP
CB	A	SRC1	NDUR
PØWER	K24L	LIRC6	
CC	EPXM	LKK6	
KV	K1	EHIGH	

*Same as GAGEPE in chapter 4

7.5.3 CHANNEL SYSTEM

The following functions and parameters are associated with channel routing. Chapter 5 should be referred to for a more detailed description of the channel system.

a. HIST (I,J). Six-hour channel time-delay histogram ordinate J for channel reach I. Channel inflows are translated to gage location I by the set of histogram ordinates. This function is similar in meaning to the commonly used time-area curve.

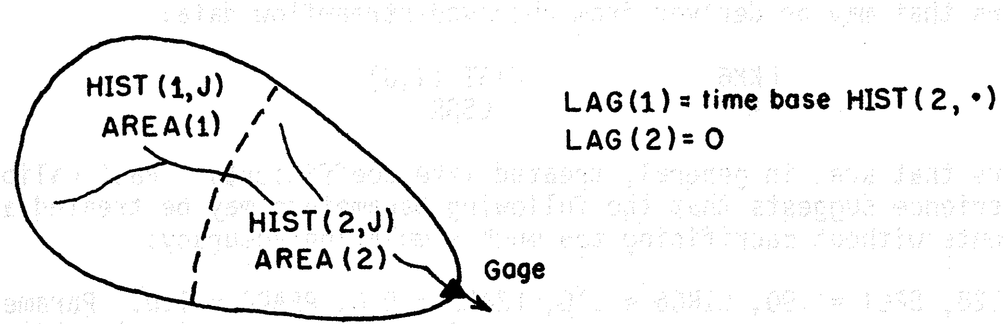
b. CSSR. CSSR is a linear reservoir storage constant, mathematically defined by the following equations (for a 6-hour period).

$$CSSR = \frac{K-3}{K+3}$$

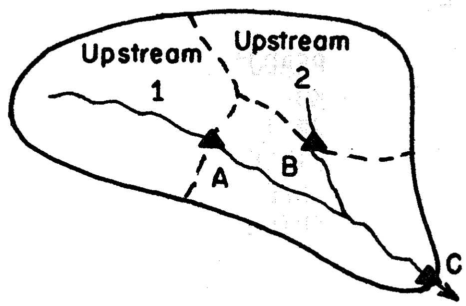
where K is given by
Reservoir Storage = K * [Reservoir Outflow]

The channel time-delay histogram is routed through the linear reservoir, producing the simulated hydrograph at the stream gage.

c. LAG (I). The fixed lag for channel reach I. The following explains the meaning of LAG (I):



d. LLAG (I). The fixed channel lag from upstream inflow point I to the downstream gage as shown below:



LLAG (1) = Channel wave travel time between points A and C

LLAG (2) = Channel wave travel time between points B and C

e. Variable Channel Lag Curve. The variable portion of the channel time-delay; refer to chapter 5 for a description.

f. Variable K Curve. A curve that relates the linear reservoir storage constant to outflow.

g. HWARP. A horizontal shift to the channel time-delay histogram is produced when the value of HWARP is modified. The histogram modification is performed in subroutine WARP.

h. VWARP. A vertical adjustment to the channel time-delay histogram is produced when the value of VWARP is modified. Appendix I describes horizontal and vertical modifications to functions such as the channel-delay histogram.

7.5.4 PARAMETER CATEGORIES

These categories should not be considered rigid divisions but merely suggested parameter groupings.

a. Parameters that may be derived from observed streamflow data:

LKK6	HIST (I,J)
A	CSSR

b. Parameters that are, in general, treated like coefficients: Past calibration experience suggests that the following parameters may be treated as coefficients without sacrificing too much simulation accuracy:

K3 = .28, SRC1 = .90, LIRC6 = .10, K24EL = 0.0, PEADJ = 1.0. Parameter K1, the constant adjustment to mean basin precipitation (MBP), should equal 1.0, if representative precipitation data are used in determining MBP.

c. Parameters that are determined from Pattern Search optimization or trial-and-error analysis:

UZSN	CC	EPXM	NDUR
LZSN	KV	EHIGH	HWARP*
CB	KGS	ELØW	VWARP*
PØWER	K24L	NEP	

*See appendix I

d. Parameters that are likely to be standardized by region:

EHIGH
ELØW
NEP
NDUR

If EHIGH, ELØW, NEP, and NDUR are standardized parameters, then parameter PEADJ should be considered under category c. Regionalized values for these parameters are assumed to exist for the NWSRFS4.

7.6 INITIAL PARAMETER VALUES

7.6.1 CATEGORY (a) PARAMETERS

a. The 6-hour groundwater recession, LKK6, may be determined from observed mean-daily discharge records. The value for LKK6 is calculated by:

$$LKK6 = 1.0 - (\text{daily recession})^{1/4}$$

where the "daily recession" is the minimum observed.

b. Fraction of the area (A) that produces impervious area runoff. Small amounts of precipitation following a dry period should be entirely abstracted, except for impervious area runoff. Therefore, increase to streamflow during these conditions should represent A * PRECIPITATION. An adequate value for A should be obtained from an average of several computations. The typical range for the value of A is 0.0 to 0.05 for non-urban watersheds.

c. The channel time-delay histogram, [HIST (I,·)] and the linear-reservoir constant (CSSR). There are two methods for determining the (first approximation) channel routing function. The first parallels unit hydrograph (UHG) analysis. The UHG for a basin, the area of which is over 75-100 square miles, basically represents the channel-response characteristics for that basin. An assumption inherent in the above statement is that interflow does not constitute a major portion of the streamflow. A normalized 6-hour UHG is derived in the standard manner. Base flow is separated from the storm hydrograph, so that the resulting UHG has a short time base. A mathematical expression can be used to convert the UHG to a HIST (I, ·) plus CSSR routing function.

The channel routing equation:

$$O_i = \overline{I}_{i-1} - \frac{(K - 3)}{(K + 3)} * (\overline{I}_{i-1} - O_{i-1}),$$

where

O_i: instantaneous outflow of the reservoir at time i.

$\overline{I}_{i-1}$: inflow to the reservoir and, for one inch of channel inflow, the channel time-delay histogram ordinate for the time interval i - 1 to i.

K: six-hour reservoir storage constant.

The above expression can be manipulated to give the histogram ordinates in terms of the UHG ordinates (O) and the reservoir constant (K).

$$\overline{I}_i = \frac{O_{i+1} - CSSR * O_i}{1 - CSSR},$$

where

$$CSSR = \frac{K - 3}{K + 3}$$

An example:

TIME	UHG	HISTOGRAM	REPRODUCTION OF THE UHG
1	0	.10	0
2	.05	.35	.05
3	.20	.30	.20
4	.25	.15	.25
5	.20	.10	.20
6	.15		.15
7	.10		.075
8	.05		.0375
9	0		⋮
	1.0	1.0	1.0

A value of 9 hours was assumed for K. In general, values between 6 and 12 hours are reasonable values for K. It will be noted that it is impossible to exactly duplicate the falling limb of a UHG by a HIST (I, ·) plus CSSR routing function.

For the second method, the channel-routing function can also be computed from a topographic map of the basin, and from assumed wave speeds for the channel system. Channel inflow may be lagged by dividing the basin into isochrones of channel travel time from the outlet. The fraction of the total basin area between isochrones is then measured, and an instantaneous channel time-delay histogram is plotted. A 6-hour channel time-delay histogram (HIST (I, ·)) results when ordinates 6 hours apart are averaged. An initial value for CSSR is assumed.

Since there is a great deal of subjectivity involved with the second method, the UHG method is recommended.

7.6.2 CATEGORY (b) PARAMETERS

The values for these parameters as suggested in section 7.5.4 (2) should be used, unless previous calibration studies indicate otherwise.

7.6.3 CATEGORY (c) PARAMETERS

Good starting values for the moisture-accounting parameters would be those values determined for a nearby basin. If there are no nearby calibrated basins, the guidelines in this section should be helpful. Table 7-1 summarizes a typical range of values for each parameter. Table 7-2 summarizes values for the parameters obtained for several basins in the U.S.

Table 7-1.--Typical range of values for parameters of the Model.

Parameter	Typical range
UZSN	.05 - 1.25
LZSN	4.0 - 10.0
CB	.05 - .75
POWER	.50 - 3.0
CC	.25 - 1.25
KV	.70 - 5.0
KGS	.85 - .97
K24L	.00 - .20
EPXM	.10 - .50
EHIGH	.90 - 1.20
ELOW	.10 - .60
NEP	90 - 200
NDUR	0 - 100

Table 7-2.--Values for the Model parameters obtained for several basins in the United States

	Monocacy River, Frederick, Md.	Bird Creek, Sperry, Okla.	French Broad River at Rosman, N. C.	Mad River at Springfield, Ohio	Meramec River, Steelville, Mo.	South Yamhill River, Whiteson, Ore.	Leaf River, Collins, Miss.	Upper Castle Creek Central Snow Lab.	Skyland Creek, Upper Columbia Snow Lab.	ARS W-3 Watershed Sleepers River, Vt.
UZSN	1.2	1.2	.01	.41	1.2	1.2	.05	.70	1.83	.25
LZSN	1.75	12.0	5.4	4.10	12.7	5.3	7.5	9.0	10.7	4.5
CB	.06	.08	.79	.125	.04	.24	.33	.08	.07	.40
PØWER	.63	.95	.35	.40	1.55	.37	2.85	1.5	.83	3.0
CC	1.0	.28	.25	.83	1.05	.50	.37	.67	5.6	.25
KV	2.4	4.8	.60	2.38	2.5	1.8	15.0	1.0	1.32	1.54
KGS	.80	.88	.95	.97	.97	.89	.92	.98	.95	.99
K24L	0.0	.37	.01	.01	.08	0.0	0.0	0.0	0.0	0.01
EPXM	.16	1.5	.15	.12	.23	.26	.50	.10	.41	.20
EHIGH	.90	.64	1.21	1.07	1.12	1.15	1.2	1.0	.78	1.02
ELØW	.55	.12	.16	.03	.41	.17	.60	1.0	0.0	.09
NEP	210	212	135	106	195	91	90	91	151	163
NDUR	15	1	30	105	2	122	60	90	122	102
A	.03	0.0	.01	.034	.03	.03	.035	.05	0.0	.08

7.7 INITIAL MOISTURE STORAGE

Seven initial (beginning of the simulation period) moisture storage values must be specified. They are:

UZSI = initial upper-zone storage
LZSI = initial lower-zone storage
SWGI = initial groundwater storage
GWSI = initial antecedent groundwater inflow index
SCEPI = initial interception storage
RESI = initial surface detention storage
SRGXI = initial interflow detention storage

Simulation usually is started in late summer or at the beginning of the water-year. At this time, the basin is often in a dry state with the stream in groundwater recession. When the moisture state of the basin is dry, the initial moisture storages are assumed equal to zero, with the exception of LZSI and SGWI.

Initial groundwater storage is calculated by the following equation:

$$SGWI = \frac{GWF}{LKK6 * 107.7 * AREA}$$

where:

GWF = observed mean daily flow (CFS) for the first day of the simulation run

An appropriate value for the initial lower zone storage, LZSI, is difficult to obtain. A procedure for determining a value for LZSI is deferred until section 7.8.2.

7.8 A RECOMMENDED CALIBRATION TECHNIQUE

7.8.1 INTRODUCTION

Three types of catchment areas are to be distinguished for calibration purposes: the headwater basin, and two types of local areas, (Type I and Type II). Type I: For Type I area, the local channel inflow represents a significant contribution to the downstream discharge, and therefore, both moisture-accounting parameters, as well as the channel system, must be considered during calibration. Type II: The amount of upstream inflow into a Type II area is substantially greater than the local channel inflow, and consequently, optimization of the moisture-accounting parameter values is not feasible. The main distinction between the calibration procedures (for each type of catchment) is the method for determining the channel response function. Pattern Search optimization can be applied to the channel system by including the parameters CSSR, HWARP, and VWARP in the optimization analysis. Changes in the values of these parameters produces changes to the channel response function. However, the degree of distortion to the channel function is limited, in part, because of computation limitations inherent in subroutine WARP, and for local areas LLAG (K) parameters and variable Lag and K curves are not considered in the optimization analysis.

Therefore, the channel system must be reasonably well defined before Pattern Search optimization is applied.

7.8.2 CALIBRATION OF HEADWATER AREAS

Initial values for the following are determined: moisture-accounting parameters,moisture storage values at the beginning of the simulation period,and channel time-delay histogram and linear-reservoir constant. Techniques and guidelines for determining initial parameter values including the channel time-delay histogram are described in section 7.6. The values for initial moisture storages, with the exception of lower-zone storage (LZSI),are defined in section 7.7. LZSI may be assumed equal to LZSN until the next stage of calibration.

If several nearby basins have been calibrated, the modeler has the option of using one of the following techniques to determine each parameter value:

1. arithmetic average
2. value from the most (hydrologically) similar basin
3. weighted average

It is recommended that prior to optimization, the verification model (NWSRFS4) be used to simulate the entire period of record. This simulation is recommended for several reasons: A comparison of the observed/simulated streamflow trace and the MBP trace will reveal any gross errors present in the data. For example, when a major precipitation event is indicated, with an increase in the simulated streamflow but no increase in the observed flow, a large error in the precipitation data is suspected. All such errors should be explained and corrected, if possible, prior to optimization. If data errors are not corrected, the computation of the criterion should be suppressed during the time periods associated with the errors (section 7.3).

The results from NWSRFS4 are used to check the adequacy of the previously determined channel-routing function. If, for example, simulated peak discharges are consistently leading observed peak discharges, then the channel time-delay histogram should be recalculated to peak later. A good value for LZSI can be determined from the NWSRFS4 results only when the simulated flows are reasonably well matched to the observed flows. Crawford and Linsley (1966) give some guidelines as to how to modify soil moisture parameter values to improve the match between simulated and observed flows.

The value of lower-zone storage (LZS), as indicated by NWSRFS4 for the date corresponding to the first day of the buffer period, is used to calculate LZSI for NWSRFS3. The volume discrepancy in inches of runoff between simulated and observed streamflow, for the first few months beyond the beginning of the buffer period, is added to LZS, and this then would be the value for LZSI:

$$LZSI = LZS + (\text{observed volume} - \text{simulated volume})$$

Once data errors have been documented, initial moisture storages determined, and an adequate channel-routing function obtained, a Pattern Search optimization is performed. An example of data input and corresponding output is found in appendix H.2 and H.3, respectively. It is suggested that this first optimization run be short, in the range of 75 to 100 runs (MAXN = 75 to 100); this number of runs allows about five LE-PM cycles. If the value of a parameter has changed little (less than 10 percent) during the five LE-PM cycles, the parameter should be removed from further optimization. The parameter KGS should be dropped only if the five LE-PM cycle change is less than 1 percent.

One must be cautious in dropping parameters from Pattern Search optimization. If, during further optimization, a parameter is included in the analysis that previously was not, then certain parameters that may have been dropped must be reintroduced because certain groups of parameters are highly interrelated. As an example, if parameter KGS is introduced into the analysis, then the following parameters should also be included: CB, LZSN, and KV -- even if some of these parameters were dropped previously.

At this stage of calibration, the modeler may wish to perform a sensitivity analysis. Sensitivity analysis is recommended if no nearby basins have been calibrated. For this analysis, several parameters should be included that normally are not optimized. These parameters are:

LKK6	CSSR	SRC1	K24EL	PEADJ
A	K3	LIRC6	K1	

(Examples of data input and computer output are found in appendices H.4 and H.5, respectively.) The results of sensitivity analysis should: 1) suggest that, possibly, an important (sensitive) parameter is presently not considered for optimization; and, 2) confirm which parameters should be dropped from further optimization.

The verification program is rerun, using the values of the parameters established during the first optimization analysis. If channel-routing deficiencies and seasonal flow bias are suggested by NWSRFS4 results, they are corrected at this time. Trial-and-error is used. Past experience indicates that seasonal streamflow bias can be removed by adjusting one or more of the following parameter values:

EPXM	NEP
ELØW	NDUR
EHIGH	K24L

NWSRFS3 (optimization) is now rerun. Information gained from the first optimization run, the sensitivity analysis, and the verification rerun, is reflected in:

a. the parameters to be included in optimization
b. the parameter values
c. the channel-routing function

The number of runs (MAXN) for this optimization run is optional; but the number should be larger than that used for the first optimization run. The resulting values for the parameters are used in the NWSRFS4 program to simulate the entire period of record. If seasonal bias is absent in the simulated streamflow trace, the calibration of the basin is considered complete. If bias is present, trial-and-error (with the appropriate parameters) is used to remove as much bias as possible; then the calibration process is considered complete.

7.8.3 CALIBRATION OF TYPE I LOCAL AREAS

The calibration procedure applied to Type I areas is the same as is used for headwater areas, with one exception: the method used to determine the local area channel-response function. To model the channel-response function, the local area time-delay histogram [HIST (I,J)], the reservoir constant (CSSR), and the fixed channel lags for the upstream flows [LLAG (K)], must be computed. A "variable channel lag curve" and a "variable channel K curve" must be specified for channels exhibiting a variable response to flow magnitude. An outline of the recommended calibration sequence and a discussion of each step follows:

Outline

a. Calculate lags for upstream inflows.
b. Calculate the local area time-delay histogram.
c. Determine values for initial moisture storages and moisture-accounting parameters.
d. Check for a variable channel response (if present, computational sequence continues with step f).
e. Complete the calibration procedure by following an optimization procedure which is similar to that for headwater areas [beginning with step c (section 7.8.5)].

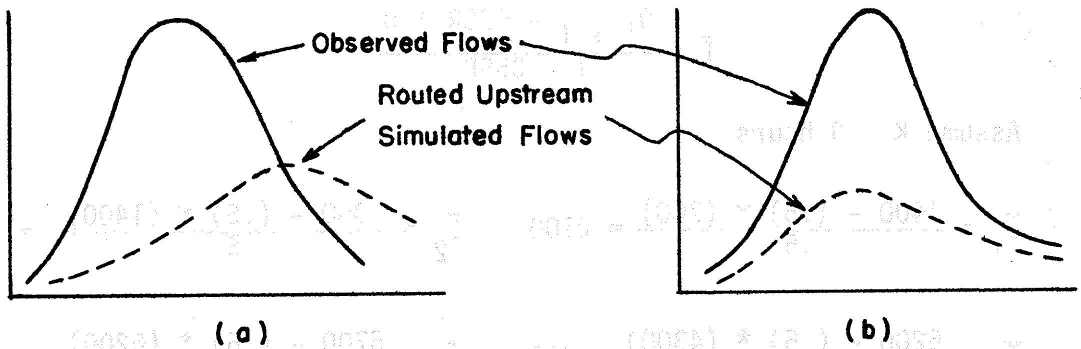
f. Calculate variable lag and K curve. Return to step e.

Discussion of each step:

a. The values for LLAG(K)'s are determined first. The channel lengths, from each inflow point to the outlet, are determined; and, with an assumed channel wave speed(s), the values for LLAG(K) are calculated. The verification program is run, simulating a short period of the record (1 or 2 years), with the values for LLAG(K) and the following parameter values:

   1) K1 = 0.0
   2) SGWI = 0.0

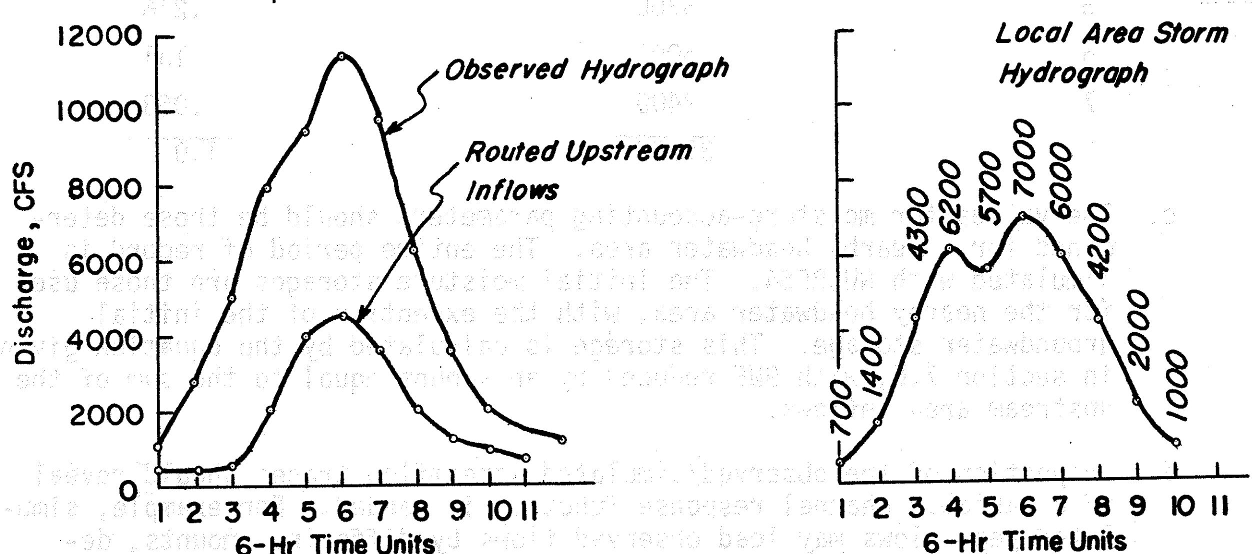
   With K1 and SGWI set to zero there is no inflow to the channel from the local area. Therefore, the NWSRFS4 simulated streamflow at the outlet represents only the lagged upstream inflows. A comparison of the observed and the simulated flows at the outlet will demonstrate the reasonableness of the LLAG(K) values. For example, below, in (a), inappropriate values for upstream inflows are suggested; whereas, for (b), this is not so.



Several simulation runs may be needed to calculate reasonable lag values.

b. A channel time-delay histogram for the local area: the verification program is run simulating a period of record, which includes several major storm events, with the previously determined LLAG(K) values for the upstream inflows and K1 and SGWI set to zero. Also, a one-element histogram equal to 1 and reservoir constant (K = 6 to 12 hours) are assumed for the simulation run. The routed upstream inflows are subtracted from the observed storm hydrograph. The resultant hydrograph is converted to a channel time-delay histogram in a manner described in section 7.6.1. An example is presented below. Since many types of errors (data, modeling, etc.) may be present in these computations, several storm periods should be analyzed to obtain a representative (first guess) local area delay histogram.

An example:



$$\overline{I} = \frac{O_{i+1} - CSSR * O_i}{1 - CSSR}$$

Assume K = 9 hours

$$\overline{I}_1 = \frac{1400 - (.5) * (700)}{.5} = 2100 \qquad \overline{I}_2 = \frac{4300 - (.5) * (1400)}{.5} = 7200$$

$$\overline{I}_3 = \frac{6200 - (.5) * (4300)}{.5} = 8100 \qquad \overline{I}_4 = \frac{5700 - (.5) * (6200)}{.5} = 5200$$

etc.

$\overline{I}_8$ produces a negative ordinate and therefore the computations should terminate.

Time	Histogram (cfs)	Histogram (normalized)
1	2100	.055
2	7200	.188
3	8100	.211
4	5200	.136
5	8300	.216
6	5000	.131
7	2400	.063
	38300	1.0

c. The values for moisture-accounting parameters should be those determined for a nearby headwater area. The entire period of record is simulated with NWSRFS4. The initial moisture storages are those used for the nearby headwater area, with the exception of the initial groundwater storage. This storage is calculated by the equation given in section 7.6, with GWF reduced by an amount equal to the sum of the upstream area inflows.

d. Inspection of the observed/simulated streamflow traces should reveal if a variable channel response function is needed. For example, simulated peak flows may lead observed flows by differing amounts, depending on the flow magnitude; attenuation of the simulated flows may be about right for high flows, but not for low flows. If variable response is suggested in the results, the next step is step f.

e. The calibration procedure is continued if the assumed values for the moisture-accounting parameters need to be modified to produce the desired simulation accuracy. The calibration procedure continues in a manner similar to that described for headwater areas (step c of section 7.8.5). For most local areas an adequate calibration is obtained by just performing a short Pattern Search optimization.

f. The variable lag and K curves are derived from simulated and observed streamflow data. Lag values are calculated from the simulated inflow and observed flows at the outlet. The simulated inflow is comprised of both the lagged upstream inflows and the flow contribution from the local area. The reader is referred to chapter 10 of Linsley et al. (1958) for details for calculating lag and K curves.

7.8.4 CALIBRATION OF TYPE II LOCAL AREAS

To define the channel system response of Type II areas, the methods in chapter 10 (Linsley et al. 1958) should be employed. Step f in section 7.8.3 gives additional information for calibrating the channel system. The values for moisture-accounting parameters should be those determined for a nearby headwater basin or Type I local area.

7.8.5 SUMMARY OF A CALIBRATION TECHNIQUE FOR HEADWATER AREAS

a. Obtain initial values (section 7.6)

   1) moisture accounting parameters
   2) moisture storages
   3) channel response function

b. Simulate the streamflow for the entire period with the verification program (section 7.8.2)

   1) check for and correct any data errors
   2) trial-and-error on values for moisture-accounting parameters
   3) check for and correct obvious channel-routing deficiencies
   4) make certain there is a reasonable lower-zone wetness ratio (LZSI/LZSN) for the first day of the buffer period

c. Perform a short optimization analysis, MAXN = 75 to 100 (section 7.8.2)

d. Perform a sensitivity analysis (section 7.8.2) (optional)

e. Resimulate (with the verification program) the calibration period, with parameter values established during step c above

f. Determine from steps c, d, and e above:

   1) the parameters to be included in the next optimization run and the "starting" values for these parameters
   2) a more appropriate channel-response function

g. Reoptimize with NWSRFS3

h. Simulate the period of record with the verification program; correct for any seasonal bias

References

Crawford, N. H., Linsley, R.K., "Digital Simulation in Hydrology: Stanford Watershed Model IV", Technical Paper No. 39, Civil Engineering Dept., Stanford University, Stanford, California, July 1966, 210 pp.

Linsley, R. K., Kohler, M. A., and Paulhus, J. L. H., Hydrology for Engineers, McGraw-Hill, New York, 1958, 340 pp.

Monro, J. C., "Direct Search Optimization in Mathematical Modeling and a Watershed Model Application", NOAA Technical Memorandum NWS Hydro-12, U. S. Department of Commerce, Washington, D.C., April 1971, 52 pp.

APPENDIX A

STANDARD DATA FORMAT FOR PUNCH CARDS

This format may be used for all raw hydrologic data and most computed data. Each card carries full identification as to type of data, physical location, time, and format of individual data entries.

The data fields are punched in 52 columns (29 to 80) and may be from two to nine digits in length. Field length may not vary within a card, but may vary within a data deck. The following table shows the maximum number of entries per card for various field lengths.

Field length	Maximum no. of entries
2	26
3	17
4	13
5	10
6	8
7	7
8	6
9	5

The card layout is as follows:

Col 1 to 4 contain a card number, 0001 to 9999. Cards are numbered consecutively in any one deck and input routines can check for proper sequencing and missing cards.

Col 5 contains the data field length, 2 to 9.

Col 6 contains one digit which indicates the number of digits following the decimal point. Digits 0 to 4 indicate actual decimal places. Numbers 5 to 9 indicate low order zeroes which are not punched. The following examples explain the notation.

Col 5	Col 6	Data field	Quantity
4	2	2631	26.31
3	2	631	6.31
3	1	631	63.1
3	0	631	631
3	5	631	6310
4	7	2631	2631000

Numbers 5 to 9 in col 6 would be used chiefly for streamflow data which often involves large quantities rounded off to three or four significant digits. The format may be selected on the basis of the range of values encountered in a particular set of data or on a particular card, so as to store the maximum number of entries on the card. Input routines would be written to decode this information and read and store the data entries correctly.

Col 7 to 15 contain a station or basin identifier. In the case of a climatological station, the two-digit state identifier and the four-digit station identifier appear in col 7 to 13 as follows: XX-XXXX. Col 14 and 15 are blank. For a stream gaging station, the nine-character identifier appears in col 7 to 15 as follows: XXXXXX.XX. Certain types of data such as precipitation may be either point amounts or basin averages. If the former, the climatological station identifier is used. If the latter, the identifier is that of the stream gaging station at the outlet of the basin. This portion of the card therefore denotes not only location but also distinguishes between point data and areal averages. Normally a computer program uses the information in these columns only as a Hollerith. Consequently, the programmer is accorded complete flexibility in its use and may insert any alpha-numeric data he pleases.

Col 16 to 18 contain the data time increment in hours. In the case of instantaneous data such as an individual temperature observation, a rate of discharge in cfs, a precipitation observation representing the accumulation since the previous observation, or a wind speed, this is the interval between data points. For data representing an integrated or average value over a period such as mean daily temperature, volume of discharge in cfs days, wind movement, it is the length of the period. If the interval involved is one month, each card will contain entries for months of various lengths. In this case, these columns would contain the figure 720 (30 days).

Col 19 to 20 contain a two-digit data code indicating the type of data on the card. The code appears below:

Code	Data	Units
00	Streamflow (rate)	cfs
01	Streamflow (volume)	cfs days
02-09	Not Assigned	
10	Precipitation (not adjusted for melt)	inches
11	Precipitation (adjusted for melt)	inches
12-19	Not Assigned	
20	Snow cover (depth)	inches
21	Snow cover (W.E.)	inches
22	Snow cover area	percent
23	Snow surf. temp. (mean)	°F
24	Snow surf. temp. (mean)	°C
25	Snow pack runoff	inches
26-29	Not Assigned	
30	Air temp. (instantaneous)	°F
31	Air temp. (instantaneous)	°C
32	Air temp. (maximum)	°F
33	Air temp. (maximum)	°C
34	Air temp. (minimum)	°F
35	Air temp. (minimum)	°C
36	Air temp. (mean)	°F
37	Air temp. (mean)	°C

38,39	Not Assigned	
40	Wet bulb temp. (instantaneous)	°F
41	Wet bulb temp. (instantaneous)	°C
42	Wet bulb temp. (maximum)	°F
43	Wet bulb temp. (maximum)	°C
44	Wet bulb temp. (minimum)	°F
45	Wet bulb temp. (minimum)	°C
46	Wet bulb temp. (mean)	°F
47	Wet bulb temp. (mean)	°C
48,49	Not Assigned	
50	Dew pt. temp. (instantaneous)	°F
51	Dew pt. temp. (instantaneous)	°C
52	Dew pt. temp. (maximum)	°F
53	Dew pt. temp. (maximum)	°C
54	Dew pt. temp. (minimum)	°F
55	Dew pt. temp. (minimum)	°C
56	Dew pt. temp. (mean)	°F
57	Dew pt. temp. (mean)	°C
58,59	Not Assigned	
60	Wind speed	mph
61	Wind movement	miles
62-69	Not Assigned	
70	Pan evaporation (Class A)	inches
71	Pan evaporation (X-3)	mm
72	Lake evaporation (Comp. met. factors)	inches
73	Lake evaporation (Comp. Eq. 14)	inches
74	Lake evaporation (Kohler-Parmele)	inches
75	Lake evaporation (X-3 coeff.)	inches
76-79	Not Assigned	
80	Duration of sunshine	percent
81	Albedo	percent
82	Insolation	langleys
83	Reflected solar radiation	langleys
84	Net radiation	langleys
85	Atmospheric long-wave radiation	langleys
86	Incident minus reflected all-wave radiation	langleys
87-99	Not Assigned	

Col 21 to 28 contain the time of the first data entry on the card in form HRDAMOYR. If it is instantaneous data, this is the time of the event. If it is data for a period, it is the end of the period. The following two examples illustrate the notation:

Col	5-6	16-18	19-20	21-28	29-32
	40	024	00	24051056	1286
	45	024	01	24051056	1286

In the first case, the rate of discharge at midnight on Oct. 5, 1956, is 1286 cfs. In the second case, the total flow for the 24-hr period, Oct. 5, 1956, is 12860 cfs days.

In all cases, missing data are indicated by filling the field with nines. To have a valid value that would be so represented would be most unlikely, since it would be the maximum quantity that could be represented by the specified format. Should it happen however, the low order digit would be changed to 8. In the case of precipitation data, the change would be to 7, since a 9---98 precipitation field has special meaning. A group of one or more such fields followed by a valid quantity indicates missing time distribution of that valid precipitation quantity.

Negative quantities will have a field length one column greater than that required for the digits. A minus sign may then be placed in the first column of the field.

From the standpoint of efficient card storage, it is desirable to have all cards in a deck filled. Other considerations however might make it desirable to terminate the entries on a card at the end of a time period such as a month, putting the first entry for the next period on a new card. Doing this may cause the last card in the time period to be incomplete. This is permissible even though the coding on the card does not indicate the number of data entries nor the time of the last entry. The input routine would read the blank fields as zero quantities and store them in sequence. The first card of the next time period, however, would overlay this storage area and insert the correct values.

Normally, all data fields for the period will have an entry. For some types of data, particularly hourly precipitation, space can be saved by not showing zero periods which would be the leading fields on the cards in which they appeared. That is, while all entries on a card must be in sequence and continuous, the next card may start with the next non-zero period. Input routines using such data must zero the input array before the data are stored.

Where data field formats are decided on the basis of an entire record and held constant throughout the deck, data can be manually punched in this format very easily. For many types of data, however, card storage requirements can be greatly reduced by varying the field format from card to card, depending on the data on that particular card. This is perfectly practical, but requires a more complex input routine in the using program. Manual punching with a varying format would be difficult. The likely solution would be to punch in a fixed format and have a computer program to convert. The task of scanning a record, selecting the most economical field format, and converting is the type of thing that is difficult to do manually, but simple for a computer. The choice between the two basic approaches is an option of the user. The method works equally well with either.

Storage and handling operations tend to be more efficient if data types are color coded. The following code is suggested:

Data code	Type of data	Color
00-09	Streamflow	White
10-19	Precipitation	Yellow
20-29	Snow data	Green
30-59	Temperature	Blue
60-79	Wind & evaporation	Orange
80-99	Miscellaneous	Red

APPENDIX B

DATA TAPES CONTAINING NCC DATA AND PROGRAM HRTAPE

B.1 ORDERING DATA TAPES

B.1.1 MAILING ADDRESS

All requests for data and related information should be addressed to:

National Climatic Center
Federal Building
Asheville, N.C. 28801

ATTN: Director, National Climatic Center

B.1.2 GENERAL INFORMATION

a. Requests should specify the use of the National Weather Service, Office of Hydrology data tape formating.

b. Requesting data formating that deviates from this formating will increase the data acquisition cost.

c. The Office of Hydrology (O/H) data tape formating stipulates the following. (Additional items are found under B.2.1):

1) Data must be requested by state.

2) Hourly precipitation data and the daily observation data are placed on different tapes for any given state.

3) For any given state <u>all</u> station records for the requested period are supplied. Requests for only a selected number of hourly or daily station records deviates from O/H formating.

d. Tapes containing daily observation data will have approximately 900 station years of record per tape (556 BPI).

e. Tapes containing hourly precipitation data will have approximately 450 station years of record per tape (556 BPI).

f. Beginning period of record. The NCC master data tape files for most states begin on:

1) January 1960 for hourly precipitation data

2) October 1963 for daily observation data

g. End of record. The end of the period of record, as of June 30, 1972, is December 1971.

h. Data may be obtained prior to 1/60 for hourly data or 10/63 for daily data. NCC should be contacted on the availability and cost of obtaining such data.

i. Data costs. The following cost figures are as of June 30, 1972:

If an individual is the first one to request data for a state in O/H tape format, then each data tape will cost $110 to $130. If the same O/H formated tape has been supplied previously to another user, the cost reduces to $45 to $55, since a permanent O/H formated backup tape is produced while fulfilling the first data request.

j. Data may be paid for on "accept billing on receipt of data."

B.1.3 A NEAR FUTURE ADDITION

With each data tape the NCC will soon be able to supply a comprehensive table of contents. Some of the items to be included will be: the station number, period of record, and the position of the record on tape for each station. There will also be documentation of extended missing data periods for each type of data for each station.

B.2 TAPE FORMATS FOR NCC DATA

B.2.1 GENERAL TAPE FORMATING FOR HOURLY PRECIPITATION AND DAILY OBSERVATIONS

a. Tapes have been tested to 1600 BPI.

b. There are two basic options on how data can be written on tape.

1) Written in 7-channel BCD even parity at a density of 556 or 800 BPI. This format is compatible to the CDC 6000 and UNIVAC 1100 systems.

2) Written in 9-channel EBCDIC even parity at 800 BPI. This format is especially suited to the IBM 360 and RCA SPECTRA systems.

c. There are no end-of-file (EOF) or tape labels at the beginning of a tape. Two EOF are at the end of a tape or at the end of data transfer, whichever occurred first.

d. A record consists of 960 characters (daily) or 2400 characters (hourly), representing a string of monthly data.

e. No non-integer character remains in the data field after NCC format conversion.

f. The data record for the last station on a tape is complete and not split between two tapes.

B.2.2 HOURLY PRECIPITATION

a. Character string (per record)

1 - 2	State index number
3 - 6	Climatological station number
7 - 8	Year
9 - 10	Month
11 - 2242	Hourly precipitation (744 values)
2243 - 2366	Total daily precipitation (31 daily values)
2367 - 2400	Blank

b. Hourly precipitation (fields of 3)

Characters 11 - 2242, 31 days of 24 values, field of 3. For months with less than 31 days remaining fields are 999.

Contents of Each Field

001 - 997	Hourly precipitation in hundredths of inches (if precipitation is equal to or greater than 9.98 it is set to 997)
000	No precipitation or trace
999	Missing data
998	Accumulative indicator

1) Hourly data sequence is as follows:

Day 1; hour 1 - 24
Day 2; hour 1 - 24
.
.
.
Day 31; hour 1 - 24

2) The accumulator indicator (998) is in the data fields for all hours between the beginning of a period of accumulative data and the end. For example, if hour 24, day 7 shows accumulative indicator and the next day with precipitation is day 12, all hours for days 8 through 11 are equal to the accumulator indicator (998).

3) The above formating is followed for missing data. All intervening hours are filled with missing data indicator (999).

4) For data from "Fischer Porter" precipitation gage, the 0.01-inch column is 0.

c. Daily total (fields of 4)

Characters 2243 - 2366, 31 days, field of 4. For months with less than 31 days, remaining fields are 9999.

Contents of Each Field

0001 - 9997	Daily precipitation in 0.01 in.
0000	No precipitation or trace
9999	Missing data
9998	Accumulative indicator

1) The accumulator indicator (9998) is in the data fields for all days between the beginning day of accumulative data and the end of that accumulative data.

2) The above formating is followed for missing daily data. All intervening days are filled with missing data indicator (9999).

3) For data from "Fischer Porter" precipitation gage the 0.01-inch column is 0.

B.2.3 DAILY OBSERVATIONS

a. Character string (per record)

1 - 2	State index number
3 - 6	Climatological station number
7 - 8	Year
9 - 10	Month
11 - 134	Precipitation (31 values)
135 - 227	Max temperature (31 values)
228 - 320	Min temperature (31 values)
321 - 413	Temperature at obs. time (31 values)
414 - 475	Snowfall (31 values)
476 - 568	Snow depth on ground (31 values)
569 - 661	Water equivalent of snow on ground (31 values)
662 - 785	Wind movement (31 values)
786 - 878	Evaporation (31 values)
879 - 909	Estimated precipitation (31 values)
910 - 940	Thunder (31 values)
941 - 960	Blank

b. Precipitation (fields of 4)

Characters 11 - 134, 31 values, field of 4. For months with less than 31 days, remaining fields are 9999.

Contents of each field

0001 - 9997	Daily precipitation in 0.01 in.
0000	No precipitation or trace
9998	Amount included in subsequent measurement
9999	Missing or not reported

c. Maximum temperature (fields of 3)

Characters 135 - 227, 31 values, field of 3. For months with less than 31 days, remaining fields are 999.

Contents of each field

001 - 299	-99 to 199°F. Each temperature value is biased by +100°F; thus, character string will contain values from 1 to 299.
999	Missing or not reported

d. Minimum temperature (fields of 3)

Characters 228 - 320

Contents of each field (same as for maximum temperature)

e. Temperature at time of observation (fields of 3)

Characters 321 - 413

Contents of each field (same as for maximum temperature)

f. Snowfall (fields of 2)

Characters 414 - 475, 31 values, field of 2. For months with less than 31 days, remaining fields are 99.

Contents of each field

01 - 97	1 to 97 inches (whole inches) (if over 97 inches code as 97)
00	No snowfall or trace
98	Amount included in subsequent measurement
99	Missing or not reported

g. Snowdepth on ground (fields of 3)

Characters 476 - 568, 31 values, field of 3. For months with less than 31 days, remaining fields are 999.

Contents of each field

001 - 998	1 - 998 inches (whole inches)
000	None or trace
999	Missing or not reported

h. Water equivalent of snow on ground* (fields of 3)

Characters 569 - 661, 31 values, field of 3. For months with less than 31 days, remaining fields are 999.

Contents of each field

000 - 998	00.0 to 99.8 inches of water
999	Missing or not reported

*NOTE. . .water equivalent data available only at first-order stations beginning October 1963

i. Wind movement (fields of 4)

Characters 662 - 785, 31 values, field of 4. For months with less than 31 days, remaining fields are 9999.

Contents of each field

0000 - 9997	Whole miles; if over 9997 miles it is set to 9997.
9998	Amount included in subsequent measurement
9999	Missing or not reported

j. Evaporation (fields of 3)

Characters 786 - 878, 31 values, field of 3. For months with less than 31 days, remaining fields are 999.

Contents of each field

001 - 997	0.01 - 9.97 (to hundredths)
998	Amount included in subsequent measurement
999	Missing or not reported

k. Estimated precipitation (fields of 1)

Characters 879 - 909, 31 values, field of 1. For months with less than 31 days, remaining fields are 9.

Contents of each field

9	When daily precipitation was not estimated or when it is missing or not reported
1	When daily precipitation was estimated

l. Thunder (fields of 1)

Characters 910 - 940, 31 values, field of 1. For months with less than 31 days, remaining fields are 9.

Contents of each field

9	No occurrence or missing or not reported
1	Occurrence reported

SECTION B. 3 PROGRAM HRTAPE PREPARE HOURLY PRECIPITATION DATA WORKING TAPE FOR MBP FROM NCC CARD DECK 488 OR STANDARD FORMAT CARDS

```
      PROGRAM HRTAPE(INPUT,OUTPUT,TAPE1,TAPE2,TAPE3)
C     PROGRAM TO PUT ASHEVILLE(NWRC) OR O/H STANDARD
C     FORMAT HOURLY PCPN CARDS ON TO TAPE FOR INPUT TO MBP.
*************************************************************************
*************************************************************************
*CARD NO.  FORMAT     CONTENTS
*************************************************************************
*   1        I5      NO. OF PRECIPITATION STATIONS IN THE RUN
*            I5      NO. OF RECORDS TO TRANSFER FROM A PREVIOUS OUTPUT TAPE(NTB)
*                         TO THE CURRENT OUTPUT TAPE (TAPE1) AT THE BEGINNING
*                         OF THE RUN.
*            I5      TAPE NO. OF PREVIOUS OUTPUT TAPE  (EITHER =2 OR 3 OR
*                         TAPE(NTR)                             =0 IF NONE)
*                         THIS A PREVIOUS OUTPUT TAPE WHICH NORMALLY WE ARE
*                              GOING TO ADD MORE STATIONS ON TO.
*            I5      TAPE NO. OF A PREVIOUS OUTPUT TAPE (TAPE(NTSB)) TO WHICH
*                         WE ARE GOING TO ADD MORE MONTHS OF DATA.
*                              (EITHER =2,3 OR =0 IF NONE)
*            I5      NO. OF RECORDS TO SKIP TO POSITION TAPE(NTSB) CORRECTLY
*************************************************************************
*************************************************************************
*   2       3A10     PRECIPITATION STATION NAME
*            I5      NWS STATE NUMBER
*            I5      NWS STATION NUMBER
*            I5      NO. OF FIRST MONTH TO BE PUT ON TAPE     *
*            I5      LAST TWO DIGITS OF FIRST YEAR            *  THESE INCLUDE
*            I5      NO. OF LAST MONTH                        *  MISSING DATA
*            I5      NO. OF LAST YEAR                         *     MONTHS
*            I5      =1 NATIONAL WEATHER RECORDS CENTER (ASHEVILLE) CARDS
*                    =0 O/H STANDARD FORMAT CARDS
*            I5      NO. OF RECORDS TO TRANSFER FROM TAPE(NTSB) TO CURRENT
*                         OUTPUT TAPE PRIOR TO ADDING DATA  IN THIS RUN.
*            I5      NO. OF MONTHS OF MISSING DATA TO PUT AT THE START.
*                         THIS AND THE NEXT NUMBER CAN BE USED SO THAT
*                         ALL STATIONS HAVE THE SAME LENGTH OF RECORD
*                         IF THIS IS DESIREABLE.
*            I5      NO. OF MONTHS OF MISSING DATA TO PUT AT THE END OF RECORD
*************************************************************************
*REST OF            HOURLY PCPN CARDS FOR STATION
* PCPN STATION            IF NWRC CARDS LAST CARD MUST HAVE 99 IN COL. 1-2
*                         IF O/H STD FMT CARDS LAST CARD MUST HAVE 9999 COL. 1-4
*************************************************************************
*************************************************************************
****NOTE***REPEAT CARDS NO. 2 ON FOR EACH PCPN STATION IN THE RUN.
*************************************************************************
*************************************************************************
*
```

```
*     EXAMPLE OF THE USE OF TAPE PARAMETERS.
*                                         NTB TO               MO. SKIP   NTSB TO TAPE1
*   RUN      NO. STA.      W.Y.      NTB    TAPE1     NTSB      NTSB      STA 1     2     3     4
*    1           2       55-57        0       0         0         0          0     0
*    2           2       55-57        2      72         0         0                      0     0
*    3           2       58-60        0       0         3         0         36    36
*    4           2       58-60        2     144         3        72                     36    36
*         TAPE 3 CONTAINS OUTPUT FROM RUN 2    WY 55-57 AT 4 STATIONS (144 RECDS)
*         FIRST TAPE 2 CONTAINS OUTPUT RUN 1   WY 55-57 AT 2 STATIONS (72  RECDS)
*         SECOND TAPE 2 CONTAINS OUTPUT RUN 3 WY 55-60 AT 2 STATIONS (144 RECDS)
*              OUTPUT FROM RUN 4 WILL CONTAIN WY 55-60 AT 4 STATIONS (288 RECDS)
************************************************************************************
************************************************************************************
      DIMENSION L(52),NDA(4),RGNAME(3)
      DIMENSION PX(749),ICH(31,2),A(12),APX(745),LASTDA(2,12)
      REAL MINUS,MBB,MISSING,MISSTD
      DATA LASTDA/31,31,28,29,31,31,30,30,31,31,30,30,31,31,31,31,30,30,
     131,31,30,30,31,31/
      DATA MINUS,MBB,BBB,MISSING,MISSTD,ZMB,ZZZ,DLO
     1/1H-,3H-   ,3H   ,3H999,3H998,3H0-  ,3H000,3H997/
      DATA NDA/52,26,17,13/
      READ 900,NSTA,NRTB,NTB,NTSB,NSKIP
      NRECS=NRTB
C     NMOS=NO OF MONTHS TO LOAD FROM EACH STATION (NSTA)
      PRINT 914
      DO 90 I=1,10
 90   PRINT 906
      PRINT 907
      PRINT 908,NSTA
      PRINT 909,NRTB,NTB
      PRINT 910,NTSB,NSKIP
      REWIND 1
      IF (NRTB.EQ.0) GO TO 100
      REWIND NTB
      DO 101 I=1,NRTB
      READ (NTB) PX
      WRITE (1) PX
  101 CONTINUE
  100 IF (NTSB.EQ.0) GO TO 109
      REWIND NTSB
      IF (NSKIP.EQ.0) GO TO 109
      DO 108 I=1,NSKIP
      READ (NTSB)
  108 CONTINUE
  109 DO 110 NUM=1,NSTA
      NMOSC=0
      READ 902,RGNAME,IST,ISTA,MONTH1,IYEAR1,MONTH2,IYEAR2,NWRC,NSRTB,
     1NMSG1,NMSG2
      NMOS=((IYEAR2-1)*12+MONTH2)-((IYEAR1-1)*12+MONTH1)+1
      PRINT 914
      DO 91 I=1,10
 91   PRINT 906
      PRINT 911,RGNAME,MONTH1,IYEAR1,MONTH2,IYEAR2
      PRINT 912,NSRTB,NTSB
```

```
      PRINT 913,NMSG1,NMSG2
      IF (NSRTB.EQ.0) GO TO 107
      DO 111 I=1,NSRTB
      READ (NTSB) PX
      WRITE (1) PX
      NRECS=NRECS+1
  111 CONTINUE
C     CHECK FOR MISSING MONTHS AT START OF RECORD
  107 IF (NMSG1.EQ.0) GO TO 102
      DO 103 I=1,NMSG1
      NYR=(I-1)/12
      IYR=IYEAR1+NYR
      MO=MONTH1+I-1-12*NYR
      IF (MO.LT.13) GO TO 105
      MO=MO-12
      IYR=IYR+1
  105 LEAPYR=0
      IF ((IYR-4*(IYR/4)).EQ.0) LEAPYR=1
      LAST=LASTDA((LEAPYR+1),MO)
      NN=LAST*24
      DO 104 J=1,NN
  104 PX(J)=99.99
      NN=NN+1
      DO 106 J=NN,745
  106 PX(J)=0.0
      PX(746)=IST
      PX(747)=ISTA
      PX(748)=IYR
      PX(749)=MO
      WRITE(1) PX
      NRECS=NRECS+1
      NMOSC=NMOSC+1
  103 CONTINUE
  102 IF(NWRC.NE.1) GO TO 150
C     NWRC(ASHEVILLE) HOURLY CARDS
      DO 121 MHR=1,745
  121 APX(MHR)=ZZZ
      DO 122 IDA=1,31
      DO 122 ICN=1,2
  122 ICH(IDA,ICN)=0
C     READ ASHEVILLE CARD
      READ 901,IST,ISTA,IYR,MO,IDA,ICN,A,CH,NC
      MO1=MO
      IST1=IST
      ISTA1=ISTA
      IYR1=IYR
      GO TO 124
  120 READ 901,IST,ISTA,IYR,MO,IDA,ICN,A,CH,NC
      IF (MO.NE.MO1) GO TO 130
      IF (ICH(IDA,ICN).EQ.1) GO TO 120
  124 IF (CH.EQ.MINUS) ICH(IDA,ICN)=1
      DO 125 I=1,12
      IF (A(I).NE.MBB) GO TO 126
      A(I)=ZZZ
```

```
      GO TO 125
  126 IF (A(I).NE.BBB) GO TO 127
      A(I)=MISSING
      GO TO 125
  127 IF (A(I).NE.ZMB) GO TO 128
      A(I)=MISSTD
      GO TO 125
  128 IF ((A(I).EQ.MISSING).OR.(A(I).EQ.MISSTD))A(I)=DLO
  125 CONTINUE
      DO 129 I=1,12
      MHR=(IDA-1)*24+(ICN-1)*12+I
  129 APX(MHR)=A(I)
      IF (ICN.NE.2) GO TO 120
      IF ((A(12).NE.MISSING).AND.(A(12).NE.MISSTD)) GO TO 120
      IF (NC.EQ.(IDA+1)) GO TO 120
      IF (NC.LT.IDA) GO TO 120
      MHR1=MHR+1
      MHR2=(NC-1)*24
      DO 123 MHR=MHR1,MHR2
  123 APX(MHR)=A(12)
      GO TO 120
C     DECODE MONTH OF DATA AND WRITE ON TAPE
  130 DO 132 MHR=1,745
      DECODE (10,1,APX(MHR)) PX(MHR)
    1 FORMAT (F3.2)
      IF (PX(MHR).EQ.9.99) PX(MHR)=99.99
      IF (PX(MHR).EQ.9.98) PX(MHR)=99.98
  132 CONTINUE
      LEAPYR=0
      IF ((IYR1-4*(IYR1/4)).EQ.0)LEAPYR=1
      LAST=LASTDA((LEAPYR+1),MO1)
      NN=LAST*24
      CALL OUTMO(PX,NN,IST1,ISTA1,IYR1,MO1,RGNAME,NMOSC,NRECS)
      IF (IST.EQ.99) GO TO 170
      IST1=IST
      ISTA1=ISTA
      MO1=MO
      IYR1=IYR
      DO 133 MHR=1,745
  133 APX(MHR)=ZZZ
      DO 134 ID=1,31
      DO 134 IC=1,2
 134  ICH(ID,IC)=0
      GO TO 124
C     O/H STANDARD FORMAT CARDS
  150 READ 903,ISEQ,IFL,IDP,IST,ISTA,IHR,IDA,MO,IYR,L
      ISEQCK=ISEQ
      MO1=MO
      IST1=IST
      ISTA1=ISTA
      IYR1=IYR
      DO 156 MHR=1,745
  156 PX(MHR)=0.0
      GO TO 154
```

```
      LAST=LASTDA((LEAPYR+1),MO)
      NN=LAST*24
      DO 173 J=1,NN
  173 PX(J)=99.99
      NN=NN+1
      DO 174 J=NN,745
  174 PX(J)=0.0
      PX (746)=IST1
      PX (747)=ISTA1
      PX (748)=IYR
      PX (749)=MO
      WRITE (1) PX
      NRECS=NRECS+1
      NMOSC=NMOSC+1
  171 CONTINUE
  175 IF (NMOSC.EQ.NMOS) GO TO 112
      PRINT 904,NMOSC,NMOS
      STOP
112   PRINT 915,NRECS
  110 CONTINUE
C     HRTAPE FORMAT STATEMENTS
  900 FORMAT (5I5)
  901 FORMAT (I2,I4,3I2,I1,12A3,20X,A1,8X,I2)
  902 FORMAT (3A10,10I5)
  903 FORMAT (I4,I1,I1,I2,1X,I4,7X,4I2,52I1)
  904 FORMAT (1H1,31HNUMBER OF MONTHS TRANSFERED IS=,I3,5X,
     131HNUMBER OF MONTHS CALLED FOR IS=,I3)
  905 FORMAT (1H1,55H O/H STANDARD FORMAT CARD IS OUT OF SEQUENCE--SEQ.
     1NO.=,I4,5X,16H SEQUENCE CHECK=,I4)
 906  FORMAT (1H0)
 907  FORMAT (1H0,20X,41HHOURLY PRECIPITATION DATA PUT ON TO TAPE1)
 908  FORMAT (1H0,25X,13HNO. OF GAGES=,I2)
 909  FORMAT (1H0,25X,I4,1X,28HRECORDS TRANSFERED FROM TAPE,I1,1X,21HTO
     1TAPE1 AT THE START)
 910  FORMAT (1H0,25X,29HSTATION TRANSFER TAPE IS TAPE,I1,5X,I4,1X,
     145HRECORDS SKIPPED AT THE START TO POSITION TAPE)
 911  FORMAT (1H0,20X,29HHOURLY PRECIPITATION DATA FOR,1X,3A10,5X,I2,
     11H/,I2,2X,2HTO,2X,I2,1H/,I2)
 912  FORMAT (1H0,20X,5X,I4,1X,26HRECORDS TRANSFER FROM TAPE,I1,1X,
     121HTO TAPE1 AT THE START)
 913  FORMAT (1H0,25X,I3,1X,31HMONTHS OF MISSING DATA AT START,5X,I3,1X,
     129HMONTHS OF MISSING DATA AT END)
 914  FORMAT (1H1)
 915  FORMAT (1H1,I5,1X,21HRECORDS NOW ON TAPE 1)
      STOP
      END
      SUBROUTINE OUTMO (PX,NN,IST,ISTA,IYR,MO,RGNAME,NMOSC,NRECS)
      DIMENSION PX(749),RGNAME(3),NUM(24)
      DATA NUM/1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,
     123,24/
      MTD=0
      DO 200 MHR=1,NN
      IF (PX(MHR).EQ.99.98) GO TO 201
      IF (MTD.EQ.0) GO TO 200
```

```
 155 READ 903,ISEQ,IFL,IDP,IST,ISTA,IHR,IDA,MO,IYR,L
     ISEQCK=ISEQCK+1
     IF (MO.NE.MO1) GO TO 160
 154 IF (ISEQ.EQ.ISEQCK) GO TO 158
     PRINT 905,ISEQ,ISEQCK
     STOP
 158 ND=NDA(IFL)
     MHR1=(IDA-1)*24+IHR
     MHR2=MHR1+ND-1
     LEAPYR=0
     IF ((IYR1-4*(IYR1/4)).EQ.0)LEAPYR=1
     LAST=LASTDA((LEAPYR+1),MO1)
     NN=LAST*24
     IF (MHR2.GT.NN) MHR2=NN
     DO 151 MHR=MHR1,MHR2
     J=(MHR-MHR1)*IFL
     K=0
     DO 152 I=1,IFL
     N=IFL-I
 152 K=K+(L(J+I)*(10**N))
     M=0
     DO 153 I=1,IFL
     N=I-1
 153 M=M+(9*(10**N))
     FACT=0.01
     IF (IDP.EQ.1) FACT=0.1
     PX(MHR)=K*FACT
     DM=M*FACT
     M=M-1
     TDM=M*FACT
     IF (PX(MHR).EQ.DM) PX(MHR)=99.99
     IF (PX(MHR).EQ.TDM) PX(MHR)=99.98
 151 CONTINUE
     GO TO 155
160  CALL OUTMO(PX,NN,IST1,ISTA1,IYR1,MO1,RGNAME,NMOSC,NRECS)
     IF (ISEQ.EQ.9999) GO TO 170
     IST1=IST
     ISTA1=ISTA
     MO1=MO
     IYR1=IYR
     DO 157 MHR=1,745
 157 PX(MHR)=0.0
     GO TO 154
C    CHECK FOR MISSING MONTHS AT END OF RECORD
 170 IF (NMSG2.EQ.0) GO TO 175
     DO 171 I=1,NMSG2
     NYR=(I-1)/12
     IYR=IYR1+NYR
     MO=MO1+I-12*NYR
     IF (MO.LT.13) GO TO 172
     MO=MO-12
     IYR=IYR+1
 172 LEAPYR=0
     IF ((IYR-4*(IYR/4)).EQ.0) LEAPYR=1
```

```
      IF (PX(MHR).EQ.99.99) GO TO 202
      MTD=0
      GO TO 200
  202 DO 203 I=MHR1,MHR
  203 PX(I)=PX(MHR)
      MTD=0
      GO TO 200
  201 IF (MTD.EQ.0) MHR1=MHR
      MTD=1
  200 CONTINUE
      PX(746)=IST
      PX(747)=ISTA
      PX(748)=IYR
      PX(749)=MO
      WRITE (1) PX
      NRECS=NRECS+1
      NMOSC=NMOSC+1
      PRINT 900
      PRINT 901,RGNAME,MO,IYR
      PRINT 902,NUM
      LAST=NN/24
      SUMPX=0.0
      DO 210 IDA=1,LAST
      DSUM=0.0
      MHR1=(IDA-1)*24+1
      MHR2=IDA*24
      DO 211 MHR=MHR1,MHR2
      IF((PX(MHR).GT.90.0).OR.(DSUM.GT.90.0)) GO TO 212
      DSUM=DSUM+PX(MHR)
      GO TO 211
  212 IF (PX(MHR).LT.99.99) GO TO 211
      DSUM=99.99
  211 CONTINUE
      IF (((IDA-1)-5*(IDA/5)).EQ.0) PRINT 903
      PRINT 904,IDA,(PX(MHR),MHR=MHR1,MHR2),DSUM
      IF (DSUM.EQ.99.99) SUMPX=99.99
      IF (SUMPX.LT.90.0) SUMPX=SUMPX+DSUM
  210 CONTINUE
      PRINT 905,SUMPX
C     OUTMO FORMAT STATEMENTS
  900 FORMAT (1H1)
  901 FORMAT (1H0,20X,29HHOURLY PRECIPITATION DATA FOR,2X,3A10,5X,I2,
     11H/,I2)
  902 FORMAT (1H0,3HDAY,I4,23I5,6X,5HTOTAL)
  903 FORMAT (1H )
  904 FORMAT (1H ,I3,24F5.2,F10.2)
  905 FORMAT (1H0,5X,51HMISSING DATA=99.99--MISSING TIME DISTRIBUTION=99
     1.98,55X,14HMONTHLY TOTAL=,F10.2)
      RETURN
      END
```

APPENDIX C

MEAN BASIN PRECIPITATION PROGRAM

SECTION C.1 MBP PROGRAM INPUT SUMMARY

SECTION C.2 SAMPLE INPUT FOR MBP PROGRAM

SECTION C.3 EXAMPLES OF OUTPUT FROM MBP PROGRAM

```
***                     MBP INPUT SUMMARY
***
***  THIS PROGRAM CALCULATES MEAN AREAL PRECIPITATION FOR ONE OR MORE AREAS OR
***  BASINS AT A TIME. THE PROGRAM IS PRESENTLY DIMENSIONED TO HANDLE UP
***  TO TEN (10) BASINS HAVING AS MANY AS TWENTY   (20)    PRECIPITATION
***  STATIONS.
***             NOTE... TO CONSERVE CORE MEMORY THE C(J,817) VARIABLE
***                     ARRAY SHOULD BE DIMENSIONED TO THE EXACT SIZE
***                     NEEDED. FOR EXAMPLE,    THE ARRAY C(J,817) SHOULD BE
***                     DIMENSIONED,
***                             C(10,817) FOR PROCESSING 10 PCPN STATIONS
***
***                     IN ANY CASE J CANNOT EXCEED 40.
***                         NUMBER OF YEARS--MAXIMUM.LE.(400/J)
***
***
***                     TO CHANGE THE NUMBER OF AREAS OR BASINS THE PROGRAM
***                     WILL HANDLE AT ONE TIME, CHANGE THE DIMENSION OF THE
***                     ARRAYS SWX(J,40) AND BASINID(J) ...WHERE J IS THE
***                     DESIRED NUMBER OF AREAS. AT PRESENT J=10.
***
***    INPUT... DESCRIBED AS FOUR (4) GROUPS.
***
***   GROUP (1) FIRST CARD - CONTAINS THE NUMBER OF BASINS (NBASIN) AND THE
***                     DESIRED OPTIONS PLUS (NTRANS) WHEN NEEDED IN 16I5 FMT.
***
***                  *** OPTION SELECTION DESCRIPTION ***
***    OPT1=0 -- COMPUTE GRID POINT WEIGHTS FOR EACH STATION.
***         1 -- COMPUTE THIESSEN WEIGHTS FOR EACH STATION.
***         2 -- READ IN PREDETERMINED STATION WEIGHTS AND (X,Y) GRID
***              COORDINATES.
***
***    OPT2=0 -- TERMINATE PROGRAM AFTER PRINTING OUT STATION WEIGHTS.
***        =1 -- CONTINUE PROGRAM AFTER PRINTING OUT STATION WEIGHTS.
***              READ IN PRECIPITATION DATA, PLACE
***              IN MASS STORAGE AND COMPUTE MEAN BASIN PRECIP.
***
***    OPT3=1 -- OUTPUT MBP IN HOURLY INCREMENTS
***        =2 -- OUTPUT MBP IN 3-HOUR INCREMENTS
***        =3 -- OUTPUT MBP IN 6-HOUR INCREMENTS
***
***    OPT4=1 -- PRINTOUT (ONLY) OF MBP IN STD. FORMAT.
***        =2 -- PRINTOUT AND PUNCH MBP IN STD. FORMAT.
***        =3 -- PRINTOUT AND PUT MBP ON TAPE1
***
***    OPT5 ---- METHOD OF INPUTING HOURLY PRECIPITATION DATA
***        =1 -- HOURLY FROM NWSRFS-NCC TAPES. (TAPE2)
***        =2 -- HOURLY FROM NWSRFS WORKING TAPE (TAPE6)
***        =3 -- HOURLY FROM STD. FMT. CARDS
```

```
***
***      OPT6=1 -- PREFORM PCPN CONSISTENCY COMPUTATIONS
***          =2 -- NO CONSISTENCY COMPUTATIONS
***
***       OPT7=1 -- DO NOT USE NORMALS
***           =2 -- USE MONTHLY NORMALS AS PART OF THE EST. OF MISSING DATA
***                *NOTE* OPT7=2 SHOULD BE USED IN MOUNTAINOUS AREAS
***
***      OPT8 ---- METHOD OF INPUTING NON-RECORDING PRECIPITATION DATA
***          =1 -- NON-RECORDING FROM NWSRFS-NCC TAPES. (TAPE3)
***          =2 -- NON-RECORDING FROM STD.FMT. CARDS
***
***      NTRANS     NO. OF RECORDS TO TRANSFER FROM TAPE4(PREVIOUS OUTPUT TAPE)
***                      TO TAPE1(CURRENT OUTPUT TAPE) AT START OF RUN (OPT4=3)
***
***
*********************************************************************************
***
***                       NEXT SET OF CARDS CONTAINS THE NUMBER OF
***                       HOURLY STATIONS, TOTAL NUMBER OF PCPN STATIONS
***                       PLUS PRECIPITATION STATION NAMES
***                       THEIR CORRESPONDING GRID COORDINATES, ONE CARD PER
***                       STATION. RECORDER (HOURLY) STATIONS MUST BE PLACED AHEAD
***                       OF NON-RECORDER (DAILY) STATIONS, USUALLY IN ALPHABETICAL
***                       ORDER.
***
***                          FIRST CARD     COLS, 01-05 NO. OF HOURLY STATIONS
***                                         COLS. 06-10 TOTAL NO. OF STATIONS
***
***                          REMAINING CARDS
***                           FORMAT FOR EACH CARD AS FOLLOWS...
***
***                                 COLS. 01-25  PCPN STATION NAME
***                                 COLS. 28-30  X COORDINATE
***                                 COLS. 38-40  Y COORDINATE
***                         NOTE....TWO STATIONS CAN NOT HAVE THE SAME COORDINATES
***
*********************************************************************************
***
***                       NEXT SET OF CARDS CONTAIN NORMALS   *** FOR OPT7=2 ONLY***
***                      1. ONE CARD PER STATION
***                      2. STATIONS IN ORDER AS ABOVE
***                      3. MONTHS IN ORDER JAN-DEC
***                             CARD FORMAT (12F5.2)
***
*********************************************************************************
***
***                  FOLLOWING WILL BE THE CARD DECK(S) DESCRIBING
***                  THE AREA(S) OR BASIN(S) TO BE PROCESSED. ONE DECK PER BASIN.
***
***
***
***     GROUP (2A) STRUCTURE OF BASIN DECK(S).  *** FOR OPT1=0 OR 1 ***
***                       FIRST CARD  COLS. 02-80 BASIN IDENTIFICATION.
```

```
***                  NEXT 80 CARDS - BASIN GRID MAP.
***                  CARD 82      COLS. 01-10 GRID SCALE(MI/GRID LENTH)
***                                                      IN FORM XXXX.XXXXXX
***
***
***     GROUP (2B)  STRUCTURE OF BASIN DECK(S).  *** FOR OPT1=2 ***
***                  FIRST CARD  COLS. 02-80 BASIN IDENTIFICATION.
***                 SECOND CARD COLS. 01-05 BASIN AREA IN SQ. MILES(INTEGER)
***
***                 NEXT SET OF CARDS CONTAIN PREDETERMINED STATION
***                 WEIGHTS. ONE CARD PER 16 STATIONS.
***                 STATIONS IN ORDER THAT THEY HAVE BEEN READ IN.
***                 FORMAT FOR EACH CARD IS AS FOLLOWS...
***
***                          16F5.2     PREDETERMINED STATION WEIGHT
***
***
***    GROUP (3)        NEXT CARDS CONTAIN THE BEGINNING AND ENDING DATES FOR THE
***               PCPN RECORDS, INITIAL SEQUENCE STD FMT CARD NUMBER AND THE
***               NUMERIC BASIN IDENT NUMBER (XX-XXXX.X) FOR EACH BASIN. THE
***               BASIN IDENT IS THE BASIN OUTFLOW POINT STATE AND STATION
***               INDEX NUMBER.
***
***                  FIRST CARD  COLS. 04-05 STARTING MONTH
***                                    09-10 STARTING YEAR
***                                    14-15 ENDING MONTH
***                                    19-20 ENDING YEAR
***                                    22-25 INITIAL STD FMT CARD
***                                          SEQUENCE NO. FOR OUTPUT
***           NOTE...WHEN USING NCC TAPES MISSING DATA IS FILLED IN  FOR ALL
***               MONTHS FOR WHICH A GAGE WAS NOT ACTIVE.
***
***                  SECOND CARD COLS. 01-09 BASIN IDENT NO. IN FORM XX-XXXX.X
***                                    10-18   (8 BASIN IDENT NOS. PER CARD)
***                                    19-27
***                                      .
***                                      .
***                                      .
***                                    64-72
***
***
***                 THIRD CARD   ONLY NEEDED IF OPT5=1 OR 2.  (16I5) FORMAT
***                    OPT5=1    NWS STATION NUMBERS( NOT INCLUD. STATE NO.)
***                         OF EACH RECORDING STATION TO BE USED ON TAPE2.
***                         NOTE...STATION NUMBERS .GT. 9999 SIGNIFY DUMMY
***                                   STATIONS AS DISCUSSED IN WRITE-UP(3.3.2)
***                         NUMBERS LISTED IN ORDER THAT THEY ARE ON TAPE(S).
***                    OPT5=2     NUMBER OF RECORDS TO SKIP BEFORE READING
***                               EACH RECORDING STATION FROM TAPE6.
***      NOTE....EXTRA SKIP IS NEEDED BETWEEN TWO STATIONS WHICH ARE ON
***                  DIFFERENT TAPES TO TAKE CARE OF EOF.
***
***
***           NOTE......EXTRA CARD GOES HERE WHEN HOURLY DATA IS TO BE READ
```

```
***                     FROM TAPE.  THIS CARD GIVES THE NUMBERS OF THE
***                    TAPES, IN SEQUENTIAL ORDER, WHICH CONTAIN THE DATA.
***                     FORMAT IS 8A10 LEFT JUSTIFIED.  CARD IS NOT USED IF
***                     ONLY ONE TAPE IS USED, BUT IT MUST STILL BE READ IN.
***                     TAPE CHANGING PROCEDURE MAY DIFFER ON OTHER SYSTEMS.
***
***
***               FOURTH CARD  ONLY NEEDED IF OPT8=1    (16I5) FORMAT
***                        NWS STATION NUMBERS (NOT INCLUD. STATE NO.) OF
***                       EACH NON-RECORDING STATION TO BE USED ON TAPE3.
***                        NOTE...STATION NUMBERS .GT. 9999 SIGNIFY DUMMY
***                                   STATIONS AS DISCUSSED IN WRITE-UP(3.3.2)
***                        NUMBERS LISTED IN ORDER THAT THEY ARE ON TAPE(S).
***
***
***          NOTE......EXTRA CARD GOES HERE WHEN DAILY  DATA IS TO BE READ
***                     FROM TAPE.  THIS CARD GIVES THE NUMBERS OF THE
***                    TAPES, IN SEQUENTIAL ORDER, WHICH CONTAIN THE DATA.
***                     FORMAT IS 8A10 LEFT JUSTIFIED.  CARD IS NOT USED IF
***                     ONLY ONE TAPE IS USED, BUT IT MUST STILL BE READ IN.
***                     TAPE CHANGING PROCEDURE MAY DIFFER ON OTHER SYSTEMS.
***
***
***               FIFTH CARD    NEEDED ONLY IF OPT8=1
***                             OBSERVATION TIME FOR EACH NON-RECORDING
***                                 STATION FOR THE FIRST MONTH OF THE RUN.
***                                 (16F5.0) FORMAT -- USE MILITARY TIME
***
***
***               REMAINING     CHANGES IN OBSERVATION TIME AT NON-RECORDING
***                 CARDS           STATIONS.  ONE CHANGE PER CARD.  MUST BE
***               (GROUP 3)         IN SEQUENTIAL ORDER IN TIME -- STATION
***                                 ORDER DOES NOT MATTER.
***
***                                 COL. 1- 5  STATION NO. IN RUN
***                                 COL. 6-10  YEAR (LAST 2 DIGITS)
***                                 COL.11-15  MONTH
***                                 COL.16-20  NEW OBSERVATION TIME
***
***                                 LAST CARD PUT 99 IN COL. 4-5.
***
***                                 **NOTE** MAXIMUM OF 9 CHANGES PER STATION
***                                      ARE ALLOWED.
***
***
***
***     GROUP (4)  PCPN DATA DECKS FOR EACH STATION. THE FIRST CARD FOR EACH
***                STATION MUST HAVE AN INITIAL SEQUENCE NO. EQUAL TO ONE (0001).
***                THE PCPN DECKS ARE PLACED BACK TO BACK,HOURLY STATIONS FIRST
***                FOLLOWED BY DAILY STATIONS. THESE DECKS MUST BE IN THE SAME
***                ORDER AS THE ABOVE MENTIONED STATION COORDINATE CARDS. THE
***                LAST PCPN DECK IS FOLLOWED BY A LAST CARD INDICATOR, IE. IN
***                COLS. 01 THRU 04 THE NUMBER 9999.
***                  **NOTE** GROUP (4) IS NOT NEEDED IF ALL PCPN DATA IS ON TAPE
```

```
*******************************************************************************
*          LAST SET OF CARDS (ONLY NEEDED IF CONSISTENCY SUBROUTINE IS USED)
*
*
*                    DOUBLE MASS PLOTS AND CALCULATIONS  ARE DONE FOR THE
*               FOLLOWING.  EACH STATION AGAINST ALL OTHER STATIONS AND
*               EACH STATION AGAINST OTHERS IN A GROUP TO WHICH IT IS ASSIGNED.
*               IF THE STATION IS NOT ASSIGNED TO A GROUP IT IS PLOTTED
*               AGAINST THE DOUBLE MASS OF GROUP ONE.
*
*          FIRST CARD.
*                    NUMBER OF GROUPS (NGROUPS). I5 FORMAT    MAX=3
*                    NUMBER OF STATIONS IN EACH GROUP. 3I5 FORMAT    MAX=32
*          REMAINING CARDS (ONE FOR EACH GROUP) (TWO IF MORE THAN 16 STA IN GRP)
*                    RUN NUMBERS (DETERMINED BY READ IN SEQUENCE) FOR EACH
*                         PRECIPITATION STATION IN THE GROUP.  16I5 FORMAT
*
*         *NOTE*  CONSISTENCY SUBROUTINE IS CURRENTLY DIMENSIONED FOR
*                    20 PRECIPITATION STATIONS AND 10 YEARS OF RECORD
*
*******************************************************************************
```

SECTION C.2   SAMPLE INPUT FOR MBP PROGRAM

```
    3    0    1    3    3    2    1    1    2    0
    7   18
 COLLINS,MISSISSIPPI        22        37
 FORREST,MISSISSIPPI        26        78
LEAKESVILLE,MISSISSIPPI     74         5
 SHUBUTA 2,MISSISSIPPI      67        49
 RALEIGH,MISSISSIPPI        24        61
 ROSE HILL 7SW,MISS.        46        63
 PURVIS,MISSISSIPPI         28         5
 MIZE,MISSISSIPPI           22        50
 LAUREL,MISSISSIPPI         44        40
 BAY SPRINGS,MISS.          36        57
 HATTIESBURG,MISS.          34        17
 COLUMBIA,MISS.              6        14
 WHITE OAK,MISS.            17        60
 SUMRALL,MISS               22        23
 PRENTISS,MISS.              5        36
 NEWTON,MISS.               43        79
 PAULDING,MISS.             49        60
 MONTROSE,MISS.             39        66
 LEAF RIVER NEAR COLLINS,MISSISSIPPI
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1.11
BOWIE CREEK NEAR HATTIESBURG,MISSISSIPPI

```
C
C              GRID MAP -- BOWIE CREEK NEAR HATTIESBURG,MISS.
C
     1.11
 LEAF RIVER LOCAL AT HATTIESBURG,MISSISSIPPI
C
C              GRID MAP -- LEAF RIVER LOCAL ABOVE HATTIESBURG,MISS.
C
     1.11
    1   68    9   69    1
02-4720.002-4725.002-4730.0
  195  204  140  356   52   52  356
E05820
C
C                   OFFICE OF HYDROLOGY STANDARD FORMAT
C                        DAILY PRECIPITATION CARDS
C
9999
    3    7    6    5
    1    2    5    8   10   13   15
    4    6    9   16   17   18
    3    7   11   12   14
```

LEAF RIVER NEAR COLLINS,MISSISSIPPI
BASIN AREA IS 726 SQ. MILES (590 GRID POINTS)

GRID POINT WEIGHTS FOR ALL STATIONS.

STATION NO. 1	COLLINS,MISSISSIPPI	WT. IS	.03
STATION NO. 2	FORREST,MISSISSIPPI	WT. IS	.15
STATION NO. 3	LEAKESVILLE,MISSISSIPPI	WT. IS	0.00
STATION NO. 4	SHUBUTA 2,MISSISSIPPI	WT. IS	0.00
STATION NO. 5	RALEIGH,MISSISSIPPI	WT. IS	.25
STATION NO. 6	ROSE HILL 7SW,MISS.	WT. IS	0.00
STATION NO. 7	PURVIS,MISSISSIPPI	WT. IS	0.00
STATION NO. 8	MIZE,MISSISSIPPI	WT. IS	.19
STATION NO. 9	LAUREL,MISSISSIPPI	WT. IS	.01
STATION NO. 10	BAY SPRINGS,MISS.	WT. IS	.10
STATION NO. 11	HATTIESBURG,MISS.	WT. IS	0.00
STATION NO. 12	COLUMBIA,MISS.	WT. IS	0.00
STATION NO. 13	WHITE OAK,MISS.	WT. IS	.09
STATION NO. 14	SUMRALL,MISS	WT. IS	0.00
STATION NO. 15	PRENTISS,MISS.	WT. IS	0.00
STATION NO. 16	NEWTON,MISS.	WT. IS	.04
STATION NO. 17	PAULDING,MISS.	WT. IS	0.00
STATION NO. 18	MONTROSE,MISS.	WT. IS	.14

DISTRIBUTION CAN NOT BE ESTIMATED FOR COLLINS,MISSISSIPPI HOURS 54 TO 63 ACCUM. LEFT IN LAST HOUR= .10
MISSING TIME DIST. SET TO MISSING DATA LEAKESVILLE,MISSISSIPPI HOURS 781 TO 792
MISSING TIME DIST. SET TO MISSING DATA ROSE HILL 7SW,MISS. HOURS 49 TO 72
DISTRIBUTION CAN NOT BE ESTIMATED FOR LAUREL,MISSISSIPPI HOURS 441 TO 464 ACCUM. LEFT IN LAST HOUR= .08
DISTRIBUTION CAN NOT BE ESTIMATED FOR BAY SPRINGS,MISS. HOURS 465 TO 488 ACCUM. LEFT IN LAST HOUR= .03
DISTRIBUTION CAN NOT BE ESTIMATED FOR HATTIESBURG,MISS. HOURS 178 TO 201 ACCUM. LEFT IN LAST HOUR= .01
DISTRIBUTION CAN NOT BE ESTIMATED FOR HATTIESBURG,MISS. HOURS 202 TO 225 ACCUM. LEFT IN LAST HOUR= .03
DISTRIBUTION CAN NOT BE ESTIMATED FOR HATTIESBURG,MISS. HOURS 442 TO 465 ACCUM. LEFT IN LAST HOUR= .02
DISTRIBUTION CAN NOT BE ESTIMATED FOR HATTIESBURG,MISS. HOURS 538 TO 561 ACCUM. LEFT IN LAST HOUR= .02
DISTRIBUTION CAN NOT BE ESTIMATED FOR COLUMBIA,MISS. HOURS 200 TO 223 ACCUM. LEFT IN LAST HOUR= .02
DISTRIBUTION CAN NOT BE ESTIMATED FOR COLUMBIA,MISS. HOURS 512 TO 535 ACCUM. LEFT IN LAST HOUR= .02
DISTRIBUTION CAN NOT BE ESTIMATED FOR COLUMBIA,MISS. HOURS 728 TO 751 ACCUM. LEFT IN LAST HOUR= .02
DISTRIBUTION CAN NOT BE ESTIMATED FOR COLUMBIA,MISS. HOURS 752 TO 775 ACCUM. LEFT IN LAST HOUR= .11
DISTRIBUTION CAN NOT BE ESTIMATED FOR WHITE OAK,MISS. HOURS 343 TO 366 ACCUM. LEFT IN LAST HOUR= .06
DISTRIBUTION CAN NOT BE ESTIMATED FOR SUMRALL,MISS HOURS 752 TO 775 ACCUM. LEFT IN LAST HOUR= .24
DISTRIBUTION CAN NOT BE ESTIMATED FOR NEWTON,MISS. HOURS 570 TO 593 ACCUM. LEFT IN LAST HOUR= .18
DISTRIBUTION CAN NOT BE ESTIMATED FOR NEWTON,MISS. HOURS 642 TO 665 ACCUM. LEFT IN LAST HOUR= .08
DISTRIBUTION CAN NOT BE ESTIMATED FOR PAULDING,MISS. HOURS 368 TO 391 ACCUM. LEFT IN LAST HOUR= .10
DISTRIBUTION CAN NOT BE ESTIMATED FOR PAULDING,MISS. HOURS 440 TO 463 ACCUM. LEFT IN LAST HOUR= .09
DISTRIBUTION CAN NOT BE ESTIMATED FOR PAULDING,MISS. HOURS 464 TO 487 ACCUM. LEFT IN LAST HOUR= .24
DISTRIBUTION CAN NOT BE ESTIMATED FOR MONTROSE,MISS. HOURS 636 TO 659 ACCUM. LEFT IN LAST HOUR= .09

MBP FOR 02-4720.0 1/69

1	0.00	0.00	0.00	0.00	0.00	0.00	.06	.01	0.00	0.00	.03	.00	0.00	0.00	0.00	0.00	0.00	0.00	.01	0.00	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.01	0.00	0.00	0.00	.07	.11	.08	.01	.09	.04	.04	.15
19	.09	0.00	0.00	0.00	0.00	.00	0.00	0.00	0.00	.00	0.00	0.00	.09	0.00	0.00	0.00	.08	.04	0.00	0.00	0.00	0.00	0.00	0.00
25	0.00	0.00	.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.01	.01	.00	.06	.14	0.00	0.00	0.00	0.00	.05	.00	.02
31	.17	.08	0.00	.04																				

MONTHLY TOTAL= 1.63

MBP FOR 02-4725.0 1/69

1	0.00	0.00	0.00	0.00	0.00	0.00	.05	.03	0.00	0.00	.06	.01	.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.00	0.00	0.00	0.00	.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.04	.01	.02	.04	.03	.05	.10	.10	.14
19	.07	0.00	0.00	0.00	0.00	.00	0.00	0.00	0.00	0.00	0.00	0.00	.05	0.00	0.00	0.00	.00	.00	0.00	0.00	0.00	.00	0.00	0.00
25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.03	.00	.00	.07	.05	0.00	0.00	0.00	0.00	.10	.03	.03
31	.00	0.00	0.00	.00																				

MONTHLY TOTAL= 1.14

MBP FOR 02-4730.0 1/69

1	0.00	0.00	0.00	0.00	0.00	0.00	.05	.02	0.00	0.00	.05	.01	.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.00	0.00	0.00	0.00	.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.00	0.00	0.00	.03	.03	.07	.11	.05	.11	.10	.13	.27
19	.13	0.00	0.00	0.00	0.00	.01	0.00	0.00	0.00	.00	0.00	0.00	.07	0.00	0.00	0.00	.01	0.00	0.00	0.00	0.00	.00	0.00	0.00
25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.03	.00	.01	.08	.06	0.00	0.00	0.00	0.00	.09	.03	.04
31	.03	.01	0.00	.01																				

MONTHLY TOTAL= 1.68

DISTRIBUTION CAN NOT BE ESTIMATED FOR MIZE,MISSISSIPPI HOURS 297 TO 320 ACCUM. LEFT IN LAST HOUR= .76
DISTRIBUTION CAN NOT BE ESTIMATED FOR BAY SPRINGS,MISS. HOURS 81 TO 104 ACCUM. LEFT IN LAST HOUR= .14
DISTRIBUTION CAN NOT BE ESTIMATED FOR BAY SPRINGS,MISS. HOURS 321 TO 344 ACCUM. LEFT IN LAST HOUR= .18
DISTRIBUTION CAN NOT BE ESTIMATED FOR HATTIESBURG,MISS. HOURS 274 TO 297 ACCUM. LEFT IN LAST HOUR= .03
DISTRIBUTION CAN NOT BE ESTIMATED FOR COLUMBIA,MISS. HOURS 248 TO 271 ACCUM. LEFT IN LAST HOUR= .02
DISTRIBUTION CAN NOT BE ESTIMATED FOR COLUMBIA,MISS. HOURS 272 TO 295 ACCUM. LEFT IN LAST HOUR= .02
DISTRIBUTION CAN NOT BE ESTIMATED FOR PAULDING,MISS. HOURS 320 TO 343 ACCUM. LEFT IN LAST HOUR= .05

STATION 2 FORREST,MISSISSIPPI MONTH 3 YEAR 69

DAY	HOURLY--TOTALS																							DAILY
23	0.00	0.00	0.00	0.00	0.00	0.00	.10	0.00	0.00	.30	.20	0.00	.10	.10	.10	.20	1.00	.20	0.00	0.00	0.00	0.00	0.00	0.00	2.30

STATION 5 RALEIGH,MISSISSIPPI MONTH 3 YEAR 69

DAY	HOURLY--TOTALS																							DAILY
23	0.00	0.00	0.00	0.00	.20	0.00	.10	0.00	0.00	0.00	.10	0.00	.10	.10	0.00	1.20	.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.20

STATION 6 ROSE HILL 7SW,MISS. MONTH 3 YEAR 69

DAY	HOURLY--TOTALS																							DAILY
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.10	0.00	.10	0.00	0.00	0.00	.10	.10	.10	0.00	.10	.40	1.10	0.00	0.00	0.00	0.00	2.10

STATION 7 PURVIS,MISSISSIPPI MONTH 3 YEAR 69

DAY	HOURLY--TOTALS																							DAILY
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.09	.27	.35	.56	.18	.12	.23	.86	.01	0.00	0.00	0.00	0.00	0.00	2.67

STATION 11 HATTIESBURG,MISS. MONTH 3 YEAR 69

DAY	HOURLY--TOTALS																							DAILY
23	0.00	0.00	0.00	0.00	.00	.00	.00	.00	.00	.03	.08	.25	.31	.47	.20	.21	.34	.85	.08	.01	0.00	0.00	0.00	0.00	2.86

STATION 16 NEWTON,MISS. MONTH 3 YEAR 69

DAY	HOURLY--TOTALS																							DAILY
23	0.00	0.00	0.00	0.00	0.00	0.00	.04	.19	0.00	.32	.08	0.00	.04	.24	.24	.28	.42	.61	.16	.43	0.00	0.00	0.00	0.00	3.05

MBP FOR 02-4720.0 3/69

1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.10	.05	0.00	0.00	0.00	0.00	.01	0.00	0.00	.01	0.00	.02	.94	.28	0.00	0.00
7	0.00	0.00	0.00	0.00	0.00	0.00	.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	0.00	0.00	0.00	0.00	0.00	.14	0.00	0.00	0.00	.05	.04	.19	.02	.01	.02	.00	0.00	0.00	.39	.57	.39	.09	.03	.01
19	0.00	.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.13	.33	1.41	.21	0.00	0.00	0.00	0.00
25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	0.00	.01	0.00	0.00																				

MONTHLY TOTAL= 5.57

MBP FOR 02-4725.0 3/69

1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.13	.09	.74	.17	0.00	0.00
7	0.00	0.00	0.00	0.00	0.00	0.00	.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.00	0.00	0.00
13	0.00	.00	0.00	0.00	0.00	.05	0.00	0.00	0.00	0.00	.00	.44	.10	.08	0.00	.01	0.00	0.00	1.22	.84	.36	.03	0.00	0.00
19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.19	.26	1.23	.02	0.00	0.00	0.00	0.00
25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	0.00	0.00	0.00	0.00																				

MONTHLY TOTAL= 6.14

MBP FOR 02-4730.0 3/69

1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.09	.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.01	.08	.06	.62	.31	0.00	0.00
7	0.00	0.00	0.00	0.00	0.00	0.00	.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	0.00	.00	0.00	0.00	0.00	.11	0.00	0.00	0.00	.02	.01	.35	.10	.08	.00	.02	0.00	0.00	.98	.81	.38	.05	.01	.01
19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.14	.25	1.42	.14	0.00	0.00	0.00	0.00
25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	0.00	0.00	0.00	0.00																				

MONTHLY TOTAL= 6.11

STATION ACCUMULATION AND DOUBLE MASS DATA

		COLLINS, MISSISSIPPI GROUP 1			FORREST, MISSISSIPPI GROUP 1			LEAKESVILLE, MISSISSIPPI GROUP 3			SHUBUTA 2, MISSISSIPPI GROUP 2		
MO	YEAR	ACCUM	GROUP D.M.	STA. D.M.	ACCUM	GROUP D.M.	STA. D.M.	ACCUM	GROUP D.M.	STA. D.M.	ACCUM	GROUP D.M.	STA. D.M.
1	68	2.1	3.4	3.1	3.8	3.2	3.0	2.6	2.2	3.1	2.8	3.5	3.1
2	68	4.4	6.4	5.9	6.4	6.0	5.8	5.0	5.3	5.8	5.1	6.1	5.8
3	68	7.0	10.8	9.5	12.9	9.8	9.1	7.5	8.5	9.4	7.4	9.5	9.4
4	68	12.6	16.6	15.1	17.8	15.8	14.8	11.5	13.7	15.2	14.1	15.3	15.0
5	68	15.2	21.1	18.4	24.0	19.7	17.9	13.6	15.6	18.5	17.4	18.7	18.3
6	68	20.7	24.6	21.6	28.0	23.4	21.2	15.3	19.3	21.9	19.6	21.6	21.7
7	68	25.7	27.4	24.8	32.3	26.3	24.4	19.2	22.8	25.1	20.9	25.0	25.0
8	68	29.8	31.8	30.5	39.0	30.3	30.0	25.9	29.3	30.7	27.6	31.4	30.6
9	68	33.7	35.5	34.0	41.7	34.1	33.5	30.4	33.0	34.2	30.2	34.6	34.2
10	68	35.1	37.2	35.5	42.9	35.9	35.1	34.7	33.9	35.5	31.2	35.9	35.7
11	68	40.0	42.1	40.4	48.3	40.7	39.9	38.5	38.8	40.4	36.1	40.8	40.6
12	68	51.0	51.7	50.1	58.9	50.4	49.6	45.0	49.5	50.4	46.6	50.3	50.3
1	69	52.2	53.1	52.0	61.1	51.6	51.5	48.0	51.5	52.2	49.0	52.4	52.2
2	69	55.8	56.1	55.4	64.2	54.7	54.9	51.3	55.8	55.6	52.0	55.7	55.6
3	69	61.9	61.9	61.2	70.5	60.5	60.7	58.4	62.1	61.4	57.3	61.0	61.5
4	69	71.6	70.9	69.3	77.0	70.0	69.0	62.0	68.3	69.9	63.3	70.8	69.8
5	69	74.6	75.3	73.4	82.0	74.1	73.0	65.5	72.4	74.0	68.6	74.6	73.8
6	69	76.3	76.2	74.7	83.1	75.1	74.3	66.6	74.4	75.3	70.3	75.8	75.1
7	69	82.8	82.8	81.7	91.8	81.3	81.2	74.8	81.5	82.2	75.2	83.2	82.2
8	69	89.5	87.3	87.2	96.6	86.2	86.8	80.8	90.8	87.7	79.8	86.8	87.7
9	69	92.9	89.5	89.1	98.1	88.6	88.8	81.5	91.9	89.7	82.8	89.1	89.7

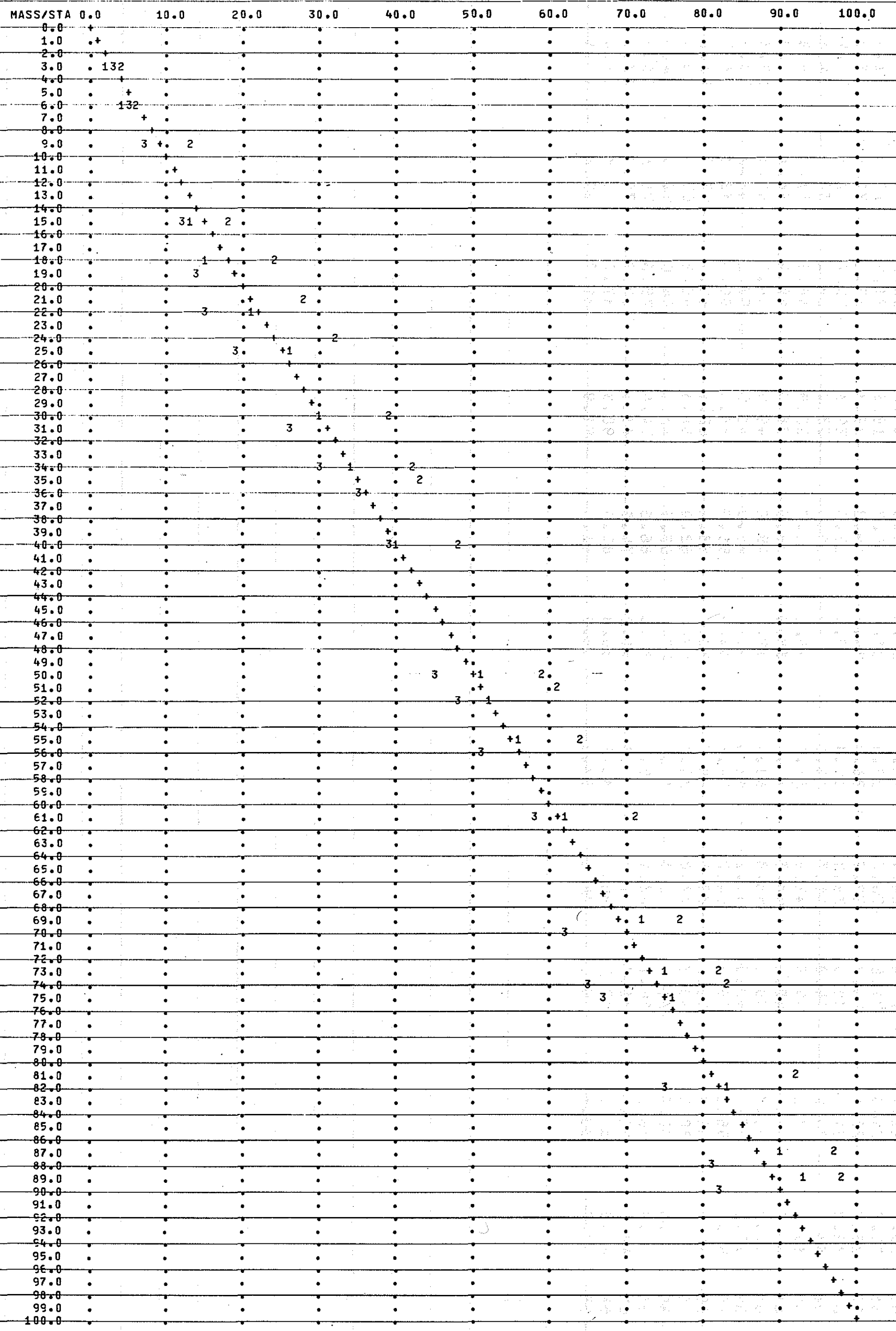
DOUBLE MASS PLOTS--INDIVIDUAL STATICN AGAINST ALL OTHER STATIONS

1 COLLINS,MISSISSIPPI

2 FORREST,MISSISSIPPI

3 LEAKESVILLE,MISSISSIPPI

+ IS 45 DEGREE LINE



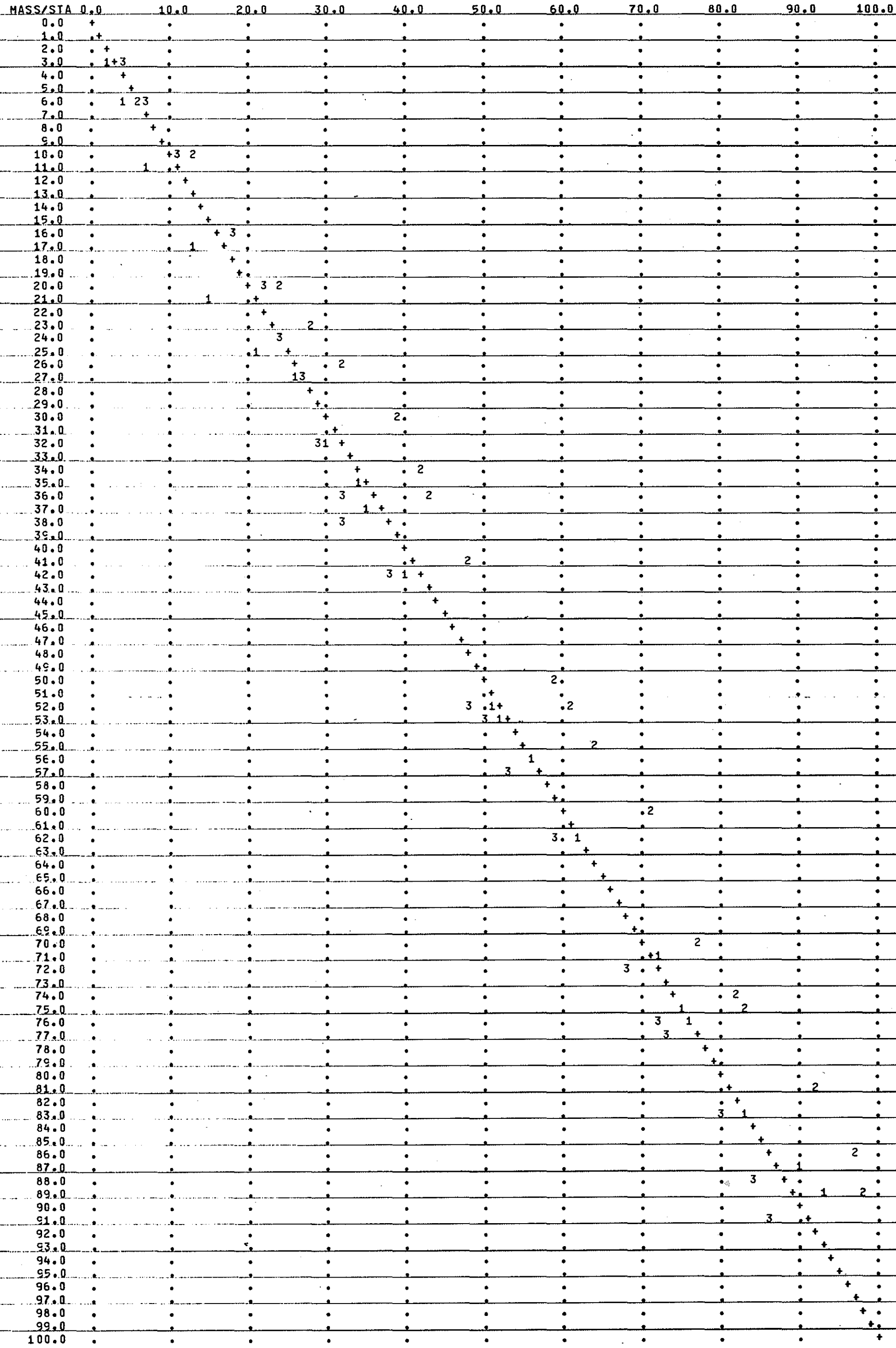
DOUBLE MASS PLOTS--INDIVIDUAL STATION AGAINST GROUP BASE--GROUP=1 GROUP BASE=1

1 COLLINS,MISSISSIPPI

2 FORREST,MISSISSIPPI

3 RALEIGH,MISSISSIPPI

+ IS 45 DEGREE LINE



APPENDIX D

PROCESSING USGS MEAN DAILY STREAMFLOW DATA

D.1 DESCRIPTION OF DATA AVAILABLE FROM USGS

Three output formats are available as follows:

a. Nine-track magnetic tape (1636 byte record)

b. Seven-track magnetic tape (336 byte record)

c. IBM cards (or card images on magnetic tape)

The basic data, retrieval options, and output formats available from USGS are described in the remainder of this section. Data should be requested from:

Chief Hydrologist ATTN: 4200-4014
U.S. Geological Sruvey, Water Resources Div.
Washington, D.C. 20242

D.1.1 RETRIEVAL OPTIONS

a. Retrieve by individual station number or a range of station numbers.

b. Retrieve by selected period of record. (If no date is specified, retrieve entire period of record.)

c. Specify cross section location and depth location. If cross-section is coded IGNORE, then cross section and depth are ignored.

d. Specify parameter code. If blank, retrieve all data for the station.

e. Specify statistic code. If blank, retrieve all records for each parameter retrieved.

D.1.2 PARAMETER CODE LIST FOR DAILY VALUES

The USGS parameter code list for daily values is given in table D-1.

D.1.3 STATISTIC CODES FOR DAILY VALUES

The USGS statistic codes for daily values are given in table D-2.

D.1.4 FORMATS OF USGS DATA

D.1.4.1 Format of 9-Channel Tape

The format of USGS 9-channel data tapes is given in table D-3. Additional information:

1. 1636 bytes per record, fixed block, one-half inch wide tape, 9 channels, 800 bpi, odd parity.

2. There are also two bytes at the end of each block that are used as a longitudinal check and one other hardware check. These two bytes are used as hardware check only, and system IBM 360 does not consider these as part of the block size, but they may be bothersome to other computer systems.

D.1.4.2 Format of 7-Channel Tape

The format of USGS 7-channel data tapes containing hydrologic daily value records is given in table D-4.

D.1.4.3 Format of Cards or Card-Image Tape

Retrieval may be onto IBM cards or as card images on 7-track, 556 bpi, BCD magnetic tape. The requestor may specify the blocking factor.

There are three different card forms in card data:

a. daily values code card (USGS form 9-1842)

b. station name card (USGS form 9-1843)

c. daily values data card (USGS form 9-1844)

The format of each of these card forms is given in table D-5. The forms are shown in figure D-1.

The code card (9-1842) and station name card (9-1843) appear only once at the beginning of each station. The data cards require 48 cards per year (4 per month).

In addition to card outputs, the user receives a printout showing the number of records retrieved with a line per record indicating which records have been retrieved.

D.2 PROGRAM "DAILYF" FOR CONVERSION OF USGS DATA TO NWSRFS FORMAT

The Fortran IV program DAILYF is written to convert data from the USGS 7-channel data tapes (D.1.4.2 and table D-4) to NWSRFS tape format or standard format cards. Program DAILYF has also been programmed to read USGS data tapes with record lengths other than the standard monthly 336-byte record. Data tapes from the USGS can be requested with monthly data blocked together. DAILYF can handle data tapes having up to 10 months of blocked data per logical record. A listing of DAILYF is found in table D-6.

Table D-1.--USGS parameter code list for daily values

Parameter Code	Parameter Name
00940	Chloride (MG/L as CL)
70290	Chloride (TONS/DAY)
00080	Color (Platinum - Cobalt Units)
00095	Conductivity (Micromhos at 25°C)
00300	Dissolved Oxygen (MG/L)
70301	Dissolved Solids (Sum of Constituents)
70302	Dissolved Solids (TONS/DAY)
72020	Elevation (Ft. above MSL)
00012	Evaporation Temperature (48 In. Pan Deg. C)
00013	Evaporation Temperature (24 In. Pan Deg. C)
00950	Fluoride, Dissolved (MG/L as F)
00400	Ph (Standard Units)
00650	Phosphate (MG/L as PO_4)
00045	Rainfall, Accumulated (In.)
00054	Reservoir Storage (Acre-Feet)
72021	Reservoir Storage (CFS-DAYS)
72022	Reservoir Storage (Million Gallons)
72023	Reservoir Storage (Million Cubic Feet)
00065	Stage (Ft. above Datum)
00060	Streamflow (CFS)
00945	Sulfate (MG/L as SO_4)
70291	Sulfate (TONS/DAY)
80154	Suspended-Sediment Concentration (MG/L)
80155	Suspended-Sediment Discharge (TONS/DAY)
00020	Temperature, Air (Deg. C)
00010	Temperature, Water (Deg. C)
80156	Total-Sediment Discharge (TONS/DAY)
00070	Turbidity (JTU)
00014	Wet Bulb Temperature (Deg. C)
00035	Wind Velocity (MPH)

Table D-2.--USGS statistic codes for daily values

Maximum	00001
Minimum	00002
Mean	00003
AM	00004
PM	00005
SUM	00006
MODE	00007
Median	00008
Standard deviation	00009
Variance	00010
Instantaneous (random)	00011
Reserved	00012-00999
Percentile Codes = (1000 + (Percentile X 10))	
0.5 Percentile	01005
1.0 Percentile	01010
67.0 Percentile	01670
99.9 Percentile	01999
Instantaneous Observation Code = 30000 + (HOUR)	
12:30 AM	30030
6:00 AM	30600
12:30 PM	31230
9:45 PM	32145

Table D-3.--Format of USGS 9-track tape

FORMAT OF DAILY FILE RECORDS ON MAGNETIC TAPE OR DISK
NOVEMBER 1971

IDENTIFIER	DATA TYPE	BYTE POSITIONS	REMARKS
DELETE CODE	CHAR (1)	1	
STATION ID	CHAR (15)	2-16	Latitude (position 2-7), longitude (position 8-14), sequence number (position 15-16) OR Blank (position 2-8), downstream order number (position 9-16).
XSEC LOCATOR	FLOAT (6)	17-20	Distance in feet from left bank (as determined by facing downstream), value of 999999 means no XSEC code stored.
DEPTH LOCATOR	FLOAT (6)	21-24	Depth in feet. Value of 999999 means no depth code stored. Top value stored with code 111111, and bottom value with code 888888. Positive value is measured down from water surface.
PARAMETER CODE	FIXED BIN (31)	25-28	Storet parameter code from attached list.
WATER YEAR	FIXED BIN (15)	29-30	Four-digit water year number.
STATISTIC CODE	FIXED BIN (15)	31-32	Statistical code from attached list.
NO VALUE INDICATOR	FLOAT (6)	33-36	Value that will be stored in place of a missing daily value. Will be 999999 for most types of data.
DAILY VALUES (12, 31)	FLOAT (6)	37-1524	Two dimensional array (12,31) * that will contain all of the daily values for one water year.
STATE CODE	FIXED BIN (15)	1525-1526	FIPS state code where station is located
DISTRICT CODE	FIXED BIN (15)	1527-1528	FIPS state code for district that operates station.
STATION NAME	CHAR (48)	1529-1576	
DRAINAGE AREA	FLOAT (6)	1577-1580	
PROCESS DATE	FIXED BIN (31)	1581-1584	
RESERVED INTERNAL USE	CHAR (52)	1585-1636	See program E303 for details.

RECORD LENGTH = 1636 bytes

* The first dimension of the array represents the month number (Jan. = 1, Dec. = 12). The second dimension represents the day number within the month (1-31). Since data for one water year are stored together in one record, the data stored in the array for October, November and December are for those months in the calendar year preceding the calendar year for which data for January to September are stored.

Table D-4.--Format of USGS 7-channel tape containing hydrologic daily values records

The data are recorded on IBM-compatible tape, 7-channel, 556 bpi, even parity in six-bit BCD (binary coded decimal) tape characters as follows:

Byte Positions	Number of BCD Characters	Identifier
1	15	Station identification number. Latitude (Pos. 1-6), Longitude (Pos. 7-13), Sequence number (Pos. 14-15), or Blank (Pos. 1-7), Downstream order number (Pos. 8-15).
16	7	Cross-section locator. Distance in feet from left bank (as determined by facing downstream). Value of 999999 means no cross-section locator code stored.
23	7	Depth locator. Depth in feet. Value of 999999 means no depth locator code stored. Top value stored with code 111111, and bottom value with 888888. Positive value is measured down from water surface.
30	5	Parameter code. See attached parameter code list.
35	4	Calendar year.
39	2	Month.
41	5	Statistic code. See attached statistic code list.
46	7	No value indicator. Value that is stored in place of a missing daily value. A value of 999999 is stored for most types of data.
53	217	Daily values (31). Thirty-one daily values (7 characters each). Decimal point is included when applicable.
270	2	State code. FIPS state code where station is located.
272	2	District code. FIPS state code for district that operates station.
274	48	Station name.
322	7	Drainage area in square miles. A value of 0 indicates no value stored.
329	8	Reserved space.

Record length is 336 bytes and is divisible by 4, 6, 8 to fit most word lengths.

Table D-5.--USGS card formats

1. Daily Values Code Card
(Form 9-1842)

Column(s)	
1	Card type - Always a '1.'
2-16	Station identification number.
17-22	Cross section location (ft.).
23-28	Sampling depth location (ft.).
29-33	Parameter code.
34-38	Statistic code.
39-40	State code.
41-42	District code.
43-49	Drainage area.
50-80	Blank.

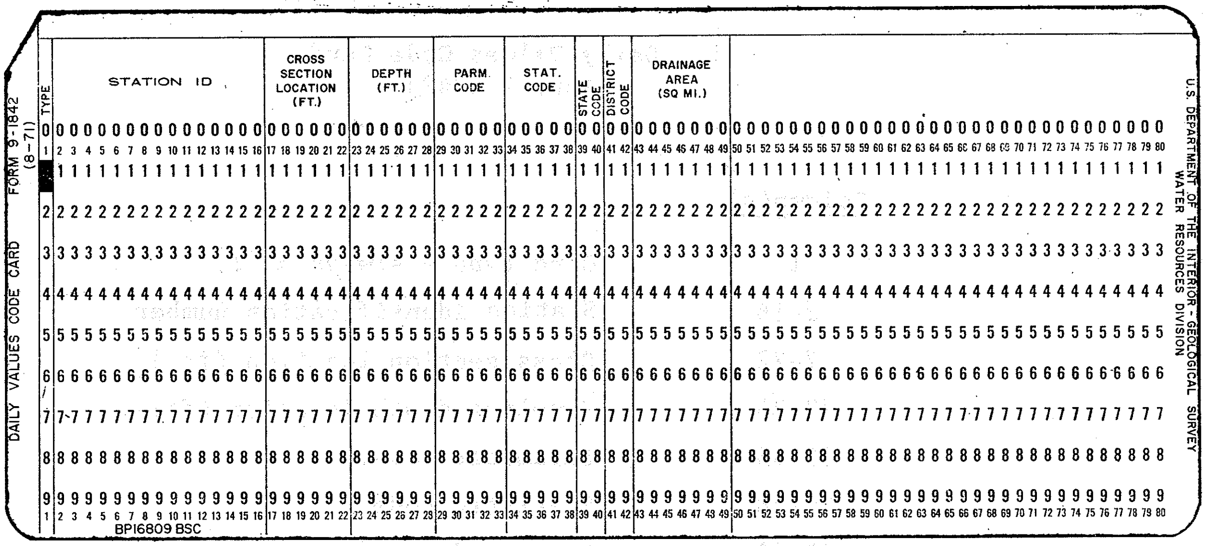
2. Station Name Card
(Form 9-1843)

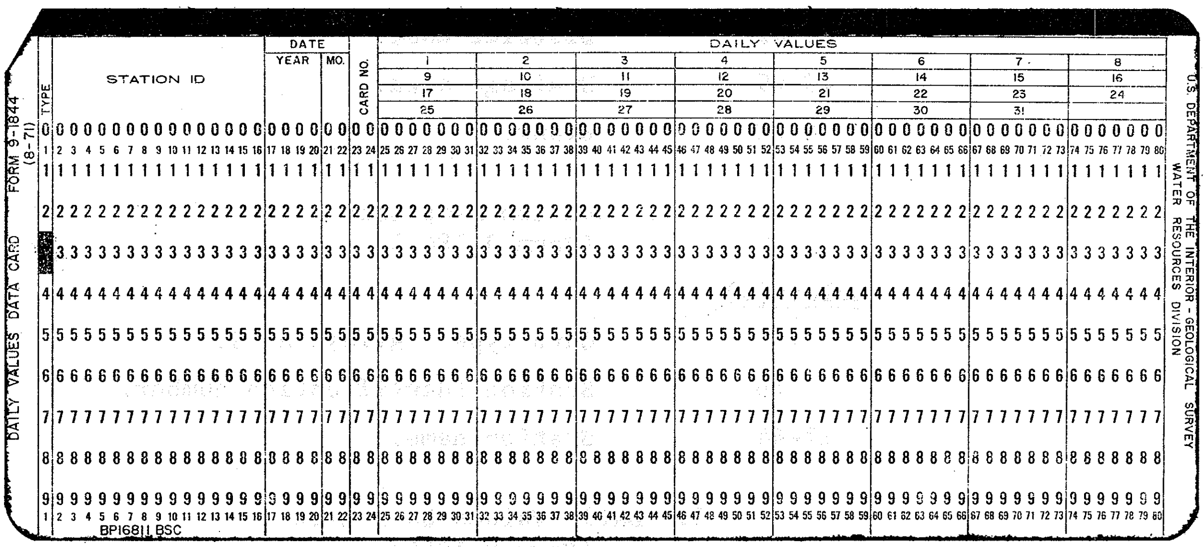
Column(s)	
1	Card type - Always a '2.'
2-16	Station identification number.
17-64	Station name.

3. Daily Values Data Card
(Form 9-1844)

Column(s)	
1	Card type - Always a '3.'
2-16	Station identification number.
17-20	Calendar year.
21-22	Month.
23-24	Card number.
25-28	Daily values - Eight seven-column fields in which the daily values are punched for the designated day.

Figure D-1.--USGS data card forms





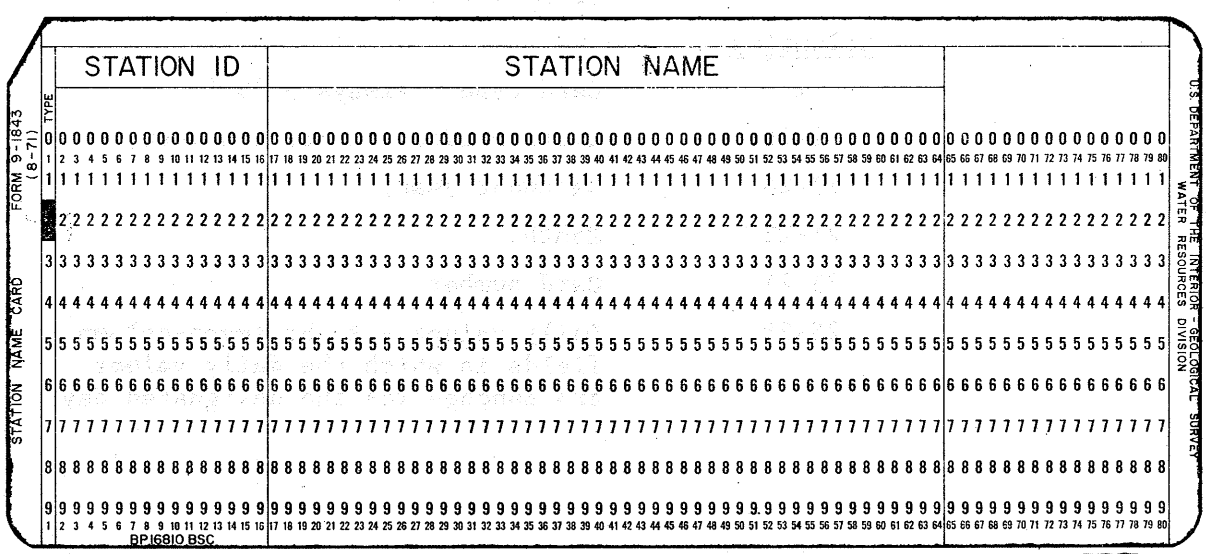


TABLE D-6

PROGRAM TO PROCESS U.S.G.S. MEAN DAILY FLOW TAPES FOR THE
NATIONAL WEATHER SERVICE RIVER FORECAST SYSTEM

```
      PROGRAM DAILYF (INPUT,OUTPUT,TAPE1,TAPE2,TAPE3=0,PUNCH)
C
C     PROGRAM TO PROCESS U.S.G.S. MEAN DAILY FLOW TAPES FOR THE
C           NATIONAL WEATHER SERVICE RIVER FORECAST SYSTEM
C
C     INPUT REQUIREMENTS...U.S.G.S. 7 TRACK MAGNETIC TAPE (336 BYTE RECORD).
C                  SEE TABLE D-4 FOR DESCRIPTION.  PROGRAM WILL HANDLE
C                  UP TO A 3360 BYTE RECORD (THAT IS UP TO A BLOCK OF TEN
C                  MONTHS OF DATA).
C
C     OUTPUT...CARDS --- OH STANDARD FORMAT CARDS
C              TAPE--NWSRFS TAPE FORMAT (31 WORDS PER RECORD, NO HEADER RECORDS,
C                    WRITTEN MONTH1(STA1,...,STAK),.....,MONTHM(STA1,...,STAK)
C              OUTPUT LISTING OPTIONAL
C
C     PROGRAM NOTES........(1)  IF ONE DAY DURING A MONTH IS MISSING THE DATA
C                  FOR THE MONTH ARE PRINTED FOR REFERENCE, HOWEVER, THE
C                  ENTIRE MONTH IS SET TO MISSING DATA FOR TAPE OR CARD OUTPUT.
C                        (2) THE PROGRAM CAN HANDLE UP TO 10150 MONTHS OF DATA
C
C*************************************************************************
C*************************************************************************
C             PROGRAM CONTROL CARD STREAM
C*************************************************************************
C      5I5    OTYPE = 1(TAPE OUTPUT) OR ZERO (CARDS OUTPUT)
C             LISTING = 1 (LIST OUTPUT) OR ZERO (DONT LIST OUTPUT)
C             NSTAOT = NUMBER OF STATIONS TO BE OUTPUT (NOT GREATER THAN 500)
C             NTAPSIN = NUMBER OF INPUT TAPES (NOT GREATER THAN 20)
C             PARPASS = 1 (OVERIDE PARITY ERROR ON READ)
C                     = 0 (BOMB JOB IF TAPE PARITY ERROR)
C*************************************************************************
C     8A10    TAPEID(J)  THIS CARD ONLY IF NTAPSIN GREATER THAN ONE
C                        IF NTAPSIN=1, OMIT THIS CARD (OR CARDS). THIS
C                        MAY BE UP TO THREE CARDS GIVING UP TO 20 TAPE NUMBERS.
C*************************************************************************
C     8I10    IDENTF(I)  STATION IDENTIFIERS (USGS DOWNSTREAM ORDER NUMBER)
C                        LISTED IN DESIRED ORDER OF OUTPUT. NO MORE THAN 500
C                        STATIONS.  (8 DIGIT NUMBERS AS DESCRIBED IN U.S.G.S.
C                        WATER SUPPLY PAPERS BEGINNING WITH WATER YEAR 1970.
C*************************************************************************
C     4I5     BEGYR = BEGINNING YEAR (FOUR DIGITS) OF REQUESTED OUTPUT
C             BEGNO = BEGINNING MONTH (JAN=1,DEC=12) OF REQUESTED RECORD
C             ENDYR = ENDING YEAR (FOUR DIGITS) OF REQUESTED RECORD
C             ENDMO = ENDING MONTH OF REQUESTED OUTPUT
C*************************************************************************
C*************************************************************************
C
```

```
C*****************************************************************************
C     FILE ASSIGNMENTS. TAPE1 INPUT TAPE(S), TAPE2 OUTPUT TAPE, TAPE3 MASS STORG
      INTEGER OTYPE,FILLED,PULLING,BEGYR,BEGMO,ENDYR,ENDMO,TAPEID,
     1 REKORD,PARPASS,YEAROT,CDSEQ ,FOUND,YEAR
      DIMENSION TAPEID(20),INDEX(10151),FILLED(10150),KWORD(10),
     1 OUTARAY(31),IDENTF(500),FLOW(31) ,BUFF(336),FOUND(500)
      COMMON /SCARD/ FLOW,MONTHOT,YEAROT,IDENTF,K,CDSEQ
      DATA (KWORD(J),J=1,10)/1,35,68,102,136,169,203,236,270,304/
      TAPE1=5LTAPE1
      READ 9005,OTYPE,LISTING,NSTAOT,NTAPSIN,PARPASS
C         OTYPE= 1(TAPE OUTPUT) OR ZERO(CARDS OUTPUT)
C         LISTING = 1 (LIST OUTPUT)  OR ZERO (NO LISTING)
C         NSTAOT = NUMBER OF STATIONS TO BE OUTPUT
C         NTAPSIN = NUMBER OF INPUT TAPES
C         PARPASS = 1 (OVERRIDE PARITY ERR ON READ), =0 BOMB ON PARITY
 9005 FORMAT (6I5)
      PRINT 9006,OTYPE,LISTING,NSTAOT,NTAPSIN,PARPASS
 9006 FORMAT (15H1PROGRAM DAILYF,5X,6HOTYPE=,I5,5X,8HLISTING=,I5,5X,
     1 7HNSTAOT=,I5,5X,8HNTAPSIN=,I5,5X,8HPARPASS=,I5)
    6 IF (NTAPSIN.EQ.1) GO TO 10
C         MORE THAN ONE INPUT TAPE. READ TAPE IDENTIFIERS IN INPUT ORDER (LE 20)
    7 READ 9007, (TAPEID(J),J=1,NTAPSIN)
 9007 FORMAT (8A10)
      PRINT 9008,((J,TAPEID(J)),J=1,NTAPSIN)
 9008 FORMAT (12H0INPUT TAPES,10(/5X,I5,A10))
   10 READ 9010,(IDENTF(I),I=1,NSTAOT)
C         STATION IDENTIFIERS (USGS DOWNSTREAM ORDER NUMBER) IN OUTPUT ORDER
 9010 FORMAT (8I10)
      PRINT 9011
 9011 FORMAT (9H0STATIONS  )
      PRINT 9012,((I,IDENTF(I)),I=1,NSTAOT)
 9012 FORMAT (10(/5X,I5,I10))
      READ 9005,BEGYR,BEGMO,ENDYR,ENDMO
C         REQUESTED PERIOD FOR OUTPUT. EXAMPLE  1948,10,1954,9
      PRINT 9015,BEGMO,BEGYR,ENDMO,ENDYR
 9015 FORMAT(22H0PERIOD REQUESTED FROM,2I5,2X,4HTHUR,2I5)
      PRINT 9000
 9000 FORMAT (1H1)
C
C         INITIALIZE
      MOSBEG = 12*BEGYR + BEGMO
      MOSEND = 12*ENDYR + ENDMO
      MOSOUT = MOSEND - MOSBEG + 1
      NFOUND = 0
C         NFOUND KEEP NUMBER OF REQUESTED STATIONS FOUND IN INPUT
      LASTID = -1
C         LASTID KEEPS IDENTIFIER OF STATION ON LAST INPUT RECORD
      ITPNOW = 1
C         ITPNOW TELLS WHICH INPUT TAPE CURRENTLY BEING PROCESSED
      PULLING = 0
C         PULLING TELLS IF PROCESSING A REQUESTED STATION
      REKORD=0
C         REKORD = 1,...,10    TELLS WHICH LOGICAL RECORD OF THE TEN
C              LOGICAL RECORD PHYSICAL RECORD IS BEING PROCESSED
```

```
      IF (OTYPE.EQ.1) REWIND 2
      REWIND 1
      DO 13 J=1,10150
      INDEX(J)=0
   13 FILLED(J)=0
      INDEX(10151)=0
      CALL OPENMS(3,INDEX,10151,0)
      DO 14 J=1,NSTAOT
   14 FOUND(J)=0
C
C  20      READ A RECORD OF THE INPUT TAPE INTO CORE
   20 IF (REKORD .GE. 1) GO TO 25
C          NEED ANOTHER RECORD FROM INPUT TAPE
   22 BUFFER IN (1,0) (BUFF(1),BUFF(336))
      REKORD = 1
      IF (UNIT(1)) 24,45,23
C          24.UNIT READY, 45. EOF, 23.PARITY
   23 IF (PARPASS.EQ.1) GO TO 22
      PRINT 9023
 9023 FORMAT (21H PARITY ERR ON INPUT )
      STOP
   24 LENG = LENGTH(1)
C   LENGTH( ) GIVES NUMBER OF CM WORDS IN RECORD. (CDC6600 HAS 10 CHAR./WORD)
      NREK =    LENG*10/336
   25 IDX = KWORD(REKORD)
      GO TO (31,32,33,34,35,31,32,33,34,35) ,REKORD
   31 DECODE (136,8031,BUFF(IDX))IDENT,YEAR,MONTH,MIS,(FLOW(JF),JF=1,12)
 8031 FORMAT (7X,I8,19X,I4,I2,5X,I7,12F7.0)
      IDXN=IDX+13
      DECODE (139,8131,BUFF(IDXN)) (FLOW(JF),JF=13,31)
 8131 FORMAT (6X,19F7.0)
      GO TO 37
   32 DECODE (132,8032,BUFF(IDX))IDENT,YEAR,MONTH,MIS,(FLOW(JF),JF=1,12)
 8032 FORMAT (3X,I8,19X,I4,I2,5X,I7,12F7.0)
      IDXN=IDX+13
      DECODE (135,8132,BUFF(IDXN)) (FLOW(JF),JF=13,31)
 8132 FORMAT (2X,19F7.0)
      GO TO 37
   33 DECODE (138,8033,BUFF(IDX))IDENT,YEAR,MONTH,MIS,(FLOW(JF),JF=1,12)
 8033 FORMAT (9X,I8,19X,I4,I2,5X,I7,12F7.0)
      IDXN=IDX+13
      DECODE (141,8133,BUFF(IDXN)) (FLOW(JF),JF=13,31)
 8133 FORMAT (8X,19F7.0)
      GO TO 37
   34 DECODE (134,8034,BUFF(IDX))IDENT,YEAR,MONTH,MIS,(FLOW(JF),JF=1,12)
 8034 FORMAT (5X,I8,19X,I4,I2,5X,I7,12F7.0)
      IDXN = IDX+13
      DECODE (137,8134,BUFF(IDXN)) (FLOW(JF),JF=13,31)
 8134 FORMAT (4X,19F7.0)
      GO TO 37
   35 DECODE (130,8035,BUFF(IDX))IDENT,YEAR,MONTH,MIS,(FLOW(JF),JF=1,12)
 8035 FORMAT (1X,I8,19X,I4,I2,5X,I7,12F7.0)
      IDXN= IDX+13
      DECODE (133,8135,BUFF(IDXN))(FLOW(JF),JF=13,31)
```

```
 8135 FORMAT (19F7.0)
   37 REKORD=REKORD+1
      IF (REKORD.GT.NREK) REKORD=0
      GO TO 50
C
   45 IF (ITPNOW.LT.NTAPSIN) GO TO 46
      IF (PULLING.EQ.1) PRINT 9158,MONTHP,IYEARP
      GO TO 100
 46   XFTAPE = TAPEID(ITPNOW)
      ITPNOW = ITPNOW + 1
      XTAPE = TAPEID(ITPNOW)
C     SEE NOAA CDC6600 USER HNDBK 7.22 FOR CHANGER SUBROUTINE
      CALL CHANGER(TAPE1,XFTAPE,XTAPE, 1)
      REWIND 1
      GO TO 20
   50 IF (IDENT.EQ.LASTID) GO TO 60
      IF (PULLING.EQ.1) PRINT 9158,MONTHP,IYEARP
 9158 FORMAT (1H ,50X,11HRECORD ENDS,3X,I2,1H/,I4)
      LASTID = IDENT
   52 DO 53 I=1,NSTAOT
      IF (IDENT.EQ.IDENTF(I)) GO TO 58
   53 CONTINUE
      IF (NFOUND.EQ.NSTAOT) GO TO 100
      PULLING = 0
      GO TO 20
   58 IF (FOUND (I).EQ.0) GO TO 59
      PULLING=0
      GO TO 20
   59 NFOUND=NFOUND+1
      PRINT 9159,I,IDENTF(I),MONTH,YEAR
 9159 FORMAT (14H0FOUND STATION,I4,10X,3HID=,I10,10X,13HRECORD BEGINS,
     11X,I2,1H/,I4)
      FOUND(I) = 1
      PULLING=1
      GO TO 64
   60 IF (PULLING.EQ.0) GO TO 20
   64 KMO = 12*YEAR + MONTH
      MONTHP=MONTH
      IYEARP=YEAR
      IF (KMO.LT.MOSBEG) GO TO 20
      IF (KMO.LE.MOSEND) GO TO 70
      IF (NFOUND.EQ.NSTAOT) GO TO 100
      PULLING = 0
      GO TO 20
   70 KEY = (I-1)*MOSOUT +KMO -MOSBEG +1
      NDAZ = MODAYS(MONTH,YEAR)
      MIZZ = 0
      DO 75 MZ=1,NDAZ
      MFL =FLOW(MZ)
      IF (MFL.NE.MIS) GO TO 75
      MIZZ =1
   75 CONTINUE
      IF (MIZZ.EQ.0) GO TO 80
      PRINT 9075,YEAR,MONTH,IDENTF(I),(FLOW(MZ),MZ=1,NDAZ)
```

```
 9075 FORMAT (20HOMISSING SYMB, YEAR ,I4,7H MONTH ,I2,5X,3HID=,I8,10X,
     1 4(/8F10.2))
C****
C          IF MISSING DAY(S), MAKE WHOLE MONTH MISSING
      GO TO 20
   80 FILLED(KEY) =1
      KEYP=KEY+1
      CALL WRITMS(3,FLOW,31,KEYP)
      GO TO 20
C
C          NOW FINISHED READING INPUT
100   IF(OTYPE.EQ.0) GO TO 205
      IF(LISTING.EQ.0) GO TO 105
      PRINT 9101,BEGMO,BEGYR,ENDMO,ENDYR
 9101 FORMAT (30H1MEAN DAILY FLOWS FROM (MO,YR) ,2I5,5X,2X,4HTHUR,2I5)
  105 MONTHOT = BEGMO
      YEAROT = BEGYR
      DO 130 J=1,MOSOUT
      MODAZ = MODAYS(MONTHOT,YEAROT)
      DO 140 K=1,NSTAOT
      IF (LISTING.EQ.1) PRINT 9106,  K,IDENTF(K),MONTHOT,YEAROT
 9106 FORMAT          (10X,10H  STATION ,I4,5X,5HIDENT,I10,10X,I2,1H/,I4)
      KEY=MOSOUT*(K-1)+J
      KEYP=KEY+1
      IF (FILLED(KEY).NE.0) GO TO 110
C          DATA MISSING THIS STATION MONTH
      DO 107 ND=1,MODAZ
  107 FLOW(ND)=-9.0
      PRINT 9108
 9108 FORMAT (20H MISSING DATA MONTH )
      GO TO 113
  110 CALL READMS(3,FLOW ,31,KEYP)
  113 IF (LISTING.EQ.1) PRINT 9113,(FLOW(IF),IF=1,MODAZ)
 9113 FORMAT (4 (/10F12.2))
      WRITE (2) FLOW
140   CONTINUE
      MONTHOT = MONTHOT +1
      IF (MONTHOT .LE. 12) GO TO 130
      MONTHOT = 1
      YEAROT = YEAROT +1
  130 CONTINUE
      GO TO 299
  205 DO 235 K=1,NSTAOT
      PRINT 9000
      MONTHOT = BEGMO
      YEAROT = BEGYR
      CDSEQ=0
      DO 230 J=1,MOSOUT
      MODAZ = MODAYS(MONTHOT,YEAROT)
      IF (LISTING.EQ.1) PRINT 9106,  K,IDENTF(K),MONTHOT,YEAROT
      KEY = MOSOUT*(K-1)+J
      KEYP = KEY+1
      IF (FILLED(KEY).NE.0) GO TO 210
C          DATA MISSING THIS STATION MONTH
```

```
      DO 207 ND=1,31
  207 FLOW(ND) = -9.0
      PRINT 9108
      GO TO 213
  210 CALL READMS(3,FLOW,31,KEYP)
  213 IF (LISTING.EQ.1) PRINT 9113,(FLOW(IF),IF=1,MODAZ)
      CALL STDCARD
      MONTHOT=MONTHOT+1
      IF (MONTHOT .LE. 12) GO TO 230
      MONTHOT = 1
      YEAROT = YEAROT +1
  230 CONTINUE
  235 CONTINUE
  299 STOP
      END


      FUNCTION MODAYS (M,NY)
      INTEGER DAYSINM
      DIMENSION DAYSINM(12)
      DATA DAYSINM /31,28,31,30,31,30,31,31,30,31,30,31/
      MODAYS = DAYSINM(M)
      IF (M.NE.2) RETURN
      MNY = 4*(NY/4)
      IF (MNY.EQ.NY) MODAYS = 29
      RETURN
      END


      SUBROUTINE STDCARD
C
C           NOTE...THIS ROUTINE TO PRODUCE STANDARD FORMAT CARDS IS SPECIFIC
C           FOR THE PROGRAM DAILYF DUE TO THE FACT THAT A MONTH HAVING ONE OR
C           MORE DAYS MISSING ON THE INPUT TAPE WILL BE TREATED AS HAVING THE
C           ENTIRE MONTH MISSING.
C
      COMMON /SCARD/FLOW,MONTHOT,YEAROT,IDENTF,K,CDSEQ
      INTEGER DAYSOT,YEAROT,CDSEQ,DIGFDEC,YEAR,HIGHSD,DFL
      DIMENSION FLOW(31),IFLOW(31),IDENTF(500),          MXENTRY(9),
     1 FMAT(4,8),FORMT(4),DIGFDEC(8),MIZVAL(9),MAXVAL(9)
      DATA (MIZVAL(MZ),MZ=1,9),(MAXVAL(MZ),MZ=1,9)/9,99,999,9999,99999,
     1 999999,9999999,99999999,999999999,8,98,998,9998,99998,999998,
     2 9999998,99999998,999999998 /
      DATA (FMAT(J,1),J=1,4)/31H(I4,2I1,I6,1H.,2I1,I3,5I2,26I2)/
      DATA (FMAT(J,2),J=1,4)/31H(I4,2I1,I6,1H.,2I1,I3,5I2,17I3)/
      DATA (FMAT(J,3),J=1,4)/31H(I4,2I1,I6,1H.,2I1,I3,5I2,13I4)/
      DATA (FMAT(J,4),J=1,4)/31H(I4,2I1,I6,1H.,2I1,I3,5I2,10I5)/
      DATA (FMAT(J,5),J=1,4)/31H(I4,2I1,I6,1H.,2I1,I3,5I2, 8I6)/
      DATA (FMAT(J,6),J=1,4)/31H(I4,2I1,I6,1H.,2I1,I3,5I2, 7I7)/
      DATA (FMAT(J,7),J=1,4)/31H(I4,2I1,I6,1H.,2I1,I3,5I2, 6I8)/
      DATA (FMAT(J,8),J=1,4)/31H(I4,2I1,I6,1H.,2I1,I3,5I2, 5I9)/
      DATA MXENTRY /0,26,17,13,10,8,7,6,5/
```

```
      DATA IFLCODE,I24,(DIGFDEC(J),J=1,8)/1,24,2,1,0,5,6,7,8,9/
      DATA IZERO,IONE,I2,I27 /0,1,2,27/
C            K IS THE STATION INDEX
      DAYSOT = MODAYS  (MONTHOT,YEAROT)
      IDDOUT = IDENTF(K)
      ID1=IDDOUT-100*(IDDOUT/100)
      N=ID1-10*(ID1/10)
      M=ID1-N
      ID=(IDDOUT/100)
      YEAR=YEAROT-100*(YEAROT/100)
      IF (FLOW(1).EQ.-9) GO TO 110
      HIGHF = FLOW(1)
      DO 30 L=2,DAYSOT
      IF (FLOW(L).GT.HIGHF) HIGHF=FLOW(L)
   30 CONTINUE
C                 NOW FIND NUMBER OF SIGNIFICANT DIGITS
C                 NOTE THIS SECTION ALLOWS MAXIMUM OF TWO SIG. DIGITS
C                 PAST DECIMAL POINT (CFS IN HUNDREDTHS). ALSO LOOKS
C                 FOR LOW ORDER ZEROS.
      DO 35 KEXP=1,8
      NPOW = 2-KEXP
      DO 35 KDAY = 1,DAYSOT
      IF (FLOW(KDAY).LT.0.01) GO TO 34
      FP = FLOW(KDAY)*10.0**NPOW+0.0001
      IFP = FP
      FIFP = IFP
      DELT = FP -FIFP
      IF (ABS(DELT).GT.0.001) GO TO 40
   34 CONTINUE
   35 CONTINUE
      KEXP=1
      NPOW=1
      GO TO 40
C
C               KEXP =       1    2    3    4    5    6    7    8
C               NPOW =       1    0   -1   -2   -3   -4   -5   -6
C             NDFDPT =       2    1    0    5    6    7    8    9
C               (NDFDPT GOES IN CARD COLUMN 6)
   41 PRINT 9041,MONTHOT,YEAROT,IDDOUT
 9041 FORMAT (26H1NEED SIGNIF DIGITS MONTH ,I3,4X,4HYEAR,I5,4X,
     1  7HSTATION,I10)
      STOP
C
C             NOW NEED NUMBER DIGITS FOR HIGHEST FLOW
   40 LOWNSD = KEXP
      IF (HIGHF.GT. 0.001) GO TO 43
      KEXP=0
      GO TO 50
   43 DO 45 KEXP=1,8
      FP = HIGHF * 10.**(-KEXP)
      IFP = FP
      IF (IFP.EQ.0) GO TO 50
   45 CONTINUE
      GO TO 41
```

```
   50 HIGHSD = KEXP
      DFL = HIGHSD +3 -LOWNSD
      IF ((DFL.LT.1).OR.(DFL.GT.9)) GO TO 41
      IF (DFL.EQ.1) DFL=2
      NDFDPT = DIGFDEC(LOWNSD)
      NPOW = 3-LOWNSD
      DO 55 L=1,DAYSOT
      IFLW=FLOW(L)*10.0**NPOW+0.1
      IF (IFLW.EQ.MIZVAL(DFL)) IFLW=MAXVAL(DFL)
      IFLOW(L) =IFLW
   55 CONTINUE
C
C                 OUTPUT ADJUSTED. NOW PUNCH IT
      NUMCDS = ((DAYSOT-1)/MXENTRY(DFL)) +1
      NUMLCD = DAYSOT - MXENTRY(DFL)*(NUMCDS-1)
C                 NUMCDS = NUMBER OF CARDS FOR MONTH
C                 NUMLCD = NUMBER OF DAYS ON LAST CARD
      KDF = DFL-1
      FORMT(1) = FMAT(1,KDF)
      FORMT(2) = FMAT(2,KDF)
      FORMT(3) = FMAT(3,KDF)
      FORMT(4)=FMAT(4,KDF)
      NUMCDM = NUMCDS-1
      MXENT = MXENTRY(DFL)
      DO 60 L=1,NUMCDM
      NFD = (L-1)*MXENT +1
      NLD = L*MXENT
      CDSEQ = CDSEQ +1
      PUNCH FORMT,CDSEQ,DFL,NDFDPT,ID,M,N,I24,IFLCODE,I24,NFD,MONTHOT,
     1 YEAR   ,(IFLOW(KIF),KIF=NFD,NLD)
   60 CONTINUE
      NFD = NUMCDM*MXENT +1
      CDSEQ=CDSEQ +1
      PUNCH FORMT,CDSEQ,DFL,NDFDPT,ID,M,N,I24,IFLCODE,I24,NFD,MONTHOT,
     1 YEAR   ,(IFLOW(KIF),KIF=NFD,DAYSOT)
      RETURN
  110 DO 112 JZ=1,DAYSOT
  112 IFLOW(JZ)=99
      CDSEQ=CDSEQ+1
      PUNCH 9112,CDSEQ,I2,IZERO,ID,M,N,I24,IFLCODE,I24,IONE,MONTHOT,
     1 YEAR   ,(IFLOW(KIF),KIF=1,26)
      CDSEQ=CDSEQ+1
      PUNCH 9112,CDSEQ,I2,IZERO,ID,M,N,I24,IFLCODE,I24,I27,MONTHOT,
     1 YEAR   , (IFLOW(KIF),KIF=27,DAYSOT)
 9112 FORMAT (I4,2I1,I6,1H.,2I1,I3,5I2,26I2 )
      RETURN
      END
```

APPENDIX E

TAPE PREPARATION PROGRAMS

SECTION E.1 PROGRAM NWSRFS2 STANDARD FORMAT CARDS TO MAGNETIC TAPE (IN NWSRFS STANDARD TAPE FORMAT)

```
      PROGRAM NWSRFS2(INPUT,OUTPUT,TAPE1,TAPE5)
***
***   THIS PROGRAM READS VARIOUS HYDROLOGIC DATA IN STATION OR SUB-AREA
***   RECORDS (STANDARD FORMAT), ARRANGES THE DATA INTO MONTH RECORDS,
***   THEN LOADS ON TO MAGNETIC TAPE AS STATION MONTH RECORDS. THE DATA
***   ON TAPE IS THEN IN THE APPROPRIATE FORMAT FOR INPUT TO NWS HYDROLOGIC
***   DEVELOPMENT PROGRAMS.
***
***
***       INPUT...
***                 FIRST CARD             I5   NUMBER OF BASINS
***
***                SECOND CARD             80H HEADER INFORMATION  (ZERO IN COL. 1)
***
***                 THIRD CARD             I5   BMO - BEGIN MONTH
***                                        I5   BYR - BEGIN YEAR
***
***
***                 FOURTH CARD            I5   TYPE(1)- NO. OF MEAN AREAL PCPN PER
***                                                      BASIN  TO BE LOADED ON TAPE
***                                        I5   TYPE(2)- NO. OF PE RECORDS PER
***                                                      BASIN TO BE LOADED ON TAPE.
***                                        I5   TYPE(3)- NO. OF TEMPERATURE (6-HR)
***                                                    RECORDS PER BASIN TO BE
***                                                    LOADED ON TAPE.
***                                        I5   TYPE(4)- NO. OF MEAN DAILY DISCH
***                                                    RECORDS PER BASIN TO BE
***                                                    LOADED ON TAPE.
***                                        I5   TYPE(5)- NO. OF 6-HR DISCH RECORDS
***                                                    PER BASIN TO BE
***                                                    LOADED ON TAPE.
***
***                CARD FOUR  IS FOLLOWED BY THE STD FMT DATA DECKS. EACH DATA
***                DECK HAS A LAST CARD INDICATOR, IE. COLS. 01-04  9999
***                WITH THE REMAINDER OF THE CARD BLANK. DATA DECK TYPE MUST
***                FOLLOW THE SAME SEQUENCE AS INDICATED ON CARD FOUR  ABOVE.
***
***
***                CYCLE BACK TO THE SECOND CARD FOR EACH OF THE BASINS
***
***
```

```
***                        GENERAL  REMARKS
***
***
***     (1) TEMPERATURE DATA MUST ALWAYS BE IN A FIELD OF THREE(3)
***         ON STANDARD FORMAT CARDS
***
***     (2) THERE CAN NEVER BE MISSING DATA IN TYPE(1) AND
***         TYPE(2) CARD RECORDS
***
***     (3) MISSING 6-HR AND 24-HR DISCH (TYPE(5) AND TYPE(4))
***         DATA ARE STORED ON TAPE AS A MINUS NUMBER (-9.0,-99.0, ETC)
***
***     (4) MISSING TEMPERATURE DATA (TYPE(3)) ARE STORED ON TAPE
***         AS 999.0
***
***
      DIMENSION DATA(52),X(125),TYPE(5),INDEX(4801),NDAYS(12)
      DIMENSION TDATA(52)
      INTEGER SEQN,F,D,CODE,HR,DA,YR,DATA,EVENTS,TYPE,STATOT
      INTEGER STANO,Z1,Z2,ZYR,BRANCH
      INTEGER BMO,BYR
      DATA (NDAYS(J),J=1,12)/31,28,31,30,31,30,31,31,30,31,30,31/
      MINUS=1R-
      REWIND 1
      DO 40 J=1,4801
   40 INDEX(J)=0
      CALL OPENMS(5,INDEX,4801,0)
      READ 1,NOBASIN
    1 FORMAT(I5)
      DO 2 JBAS=1,NOBASIN
***
***   READ HEADER INFORMATION COLS. 02 THRU 80  (LEAVE COL. 1 BLANK)
***
      READ 10
   10 FORMAT(49H
     131H
      READ 25,BMO,BYR
   25 FORMAT(2I5)
***
***   READ NUMBER OF AREAS OR STATIONS FOR EACH TYPE OF DATA.
***
***                     TYPE(1) - NUMBER OF MEAN AREA PRECIPITATION (6-HOUR
***                               INCREMENTS) ENTRIES.
***                     TYPE(2) - NUMBER OF POINT OR MEAN AREA P. E. ENTRIES.
***                     TYPE(3) - NUMBER OF POINT OR MEAN AREA TEMPERATURE
***                               ENTRIES.
***                     TYPE(4) - NUMBER OF MEAN DAILY DISCHARGE POINTS.
***                     TYPE(5) - NUMBER OF 6-HOUR DISCHARGE POINTS.
***
***   THE ABOVE DATA MUST BE IN O/H STANDARD FORMAT AND BE ENTERED IN THE
***   SEQUENCE DESCRIBED ABOVE. EACH POINT AND (OR) AREAL RECORD MUST
***   COVER IDENTICAL DATA PERIODS.
***
   16 READ 20,(TYPE(J),J=1,5)
```

```
 20 FORMAT(5I5)
    STATOT=TYPE(1)+TYPE(2)+TYPE(3)+TYPE(4)+TYPE(5)
    STANO=0
    Z1=TYPE(1)+TYPE(2)
    Z2=Z1+TYPE(3)
    DO 30 J=1,125
    X(J)=0.0
    IF(Z1.GT.0) GO TO 30
    IF(Z2.GT.0) GO TO 35
    X(J)=-9.0
    GO TO 30
 35 X(J)=999.0
 30 CONTINUE
 98 STANO=STANO+1
    NSEQN=0
    IF(STANO.GT.STATOT) GO TO 500
    IF(STANO.GT.Z1.AND.STANO.LE.Z2) GO TO 400
    BRANCH=0
 99 READ 100,SEQN,F,D,IDENT,INCR,CODE,HR,DA,MO,YR,(TDATA(J),J=1,52)
100 FORMAT(I4,2I1,A9,I3,5I2,52R1)
    IF(SEQN.EQ.9999) GO TO 301
    DO 3 I=1,52
    IF(TDATA(I).EQ.MINUS) TDATA(I)=1R0
    DECODE(10,4,TDATA(I)) DATA(I)
  3 CONTINUE
  4 FORMAT(9X,I1)
    NSEQN=NSEQN+1
    IF(NSEQN.EQ.SEQN) GO TO 12
    PRINT 11,IDENT,NSEQN,HR,DA,MO,YR
 11 FORMAT(* STATION *A9*  SEQUENCE NUMBER *I5,10X,4I5)
    STOP
 12 IF(SEQN.NE.1) GO TO 101
    NOMO=0
    MOX=MO
101 IF(MOX.NE.MO) GO TO 3001
1001 IF=(52/F)*F
    L=(52/F)-1
    MISS=0
    DO 7 I=1,F
    MISS=MISS*10+9
  7 CONTINUE
    IK=0
    DO 5 I=1,IF,F
    IK=IK+1
    ITD=0
    DO 6 J=1,F
    ITD=ITD*10+DATA(I+J-1)
  6 CONTINUE
    IF(STANO.LE.Z1) GO TO 38
    IF(ITD.EQ.MISS) ITD=-ITD
 38 DATA(IK)=ITD
  5 CONTINUE
200 IF(MO.NE.2) GO TO 201
```

```
      XYR=ZYR
      XYR=XYR*0.25
      ZYR=ZYR/4
      YYR=ZYR
      IF(XYR.NE.YYR) GO TO 202
      NDAYS(2)=29
      GO TO 201
  202 NDAYS(2)=28
  201 NDAY=NDAYS(MO)
      INC=24/INCR
      EVENTS=INC*NDAY
      J=(DA-1)*INC+1
      IF(INCR.GT.6) GO TO 2011
      M=HR/6-1
      J=J+M
 2011 M=J+L
      IF(M.GT.EVENTS) M=EVENTS
      NDIF=J-1
      IF(D.LT.5) EXP=-D
      IF(D.EQ.0) EXP=0.0
      IF(D.GT.4) EXP=D-4
      DO 203 K=J,M
      N=K-NDIF
      X(K)=DATA(N)
      X(K)=X(K)*10.0**EXP
  203 CONTINUE
      MOX=MO
      IF(BRANCH.EQ.2) GO TO 401
      GO TO 99
  300 IX=1
      IF(BRANCH.EQ.2) IX=4
      GO TO 303
 3001 IX=3
      IF(BRANCH.EQ.2) IX=5
      GO TO 303
  301 IX=2
  303 NOMO=NOMO+1
      JX=0
      N1=EVENTS
      IF(N1.GT.31) N1=124
      IF(N1.LT.32) N1=31
      N2=(NOMO-1)*STATOT+STANO
      CALL WRITMS(5,X,N1,N2)
      DO 304 J=1,125
      X(J)=0.0
      IF((STANO.GT.Z1).AND.(STANO.LE.Z2)) GO TO 36
      IF(STANO.GT.Z2) X(J)=-9.0
      GO TO 304
   36 X(J)=999.0
  304 CONTINUE
      MOX=MOX+1
      IF(MOX.GT.12) MOX=1
      GO TO (99,98,1001,401,200),IX
  400 BRANCH=2
```

```
      NSEQN=0
  401 READ 402,SEQN,F,D,IDENT,INCR,CODE,HR,DA,MO,YR,(DATA(J),J=1,17)
  402 FORMAT(I4,2I1,A9,I3,5I2,17I3)
      IF(SEQN.EQ.9999) GO TO 301
      L=17
      NSEQN=NSEQN+1
      IF(NSEQN.EQ.SEQN) GO TO 13
      PRINT 11,IDENT,NSEQN,HR,DA,MO,YR
      STOP
   13 IF(SEQN.NE.1) GO TO 403
      NOMO=0
      MOX=MO
  403 IF(MOX.NE.MO) GO TO 3001
      GO TO 200
***
***   LOAD DATA FROM MASS STORAGE ONTO MAGNETIC TAPE.
***
  500 K=N2-STATOT+1
      M=STATOT
      PRINT 505
  505 FORMAT(1H1)
      PRINT 10
      DO 510 J=1,K,STATOT
      IC=0
      DO 520 L=1,M
      M2=J-1+L
      NSTA1=TYPE(1)
      NSTA2=NSTA1+TYPE(2)
      NSTA3=NSTA2+TYPE(3)
      NSTA4=NSTA3+TYPE(4)
      IF(L.LE.NSTA1) GO TO 501
      IF(L.LE.NSTA2) GO TO 502
      IF(L.LE.NSTA3) GO TO 501
      IF(L.LE.NSTA4) GO TO 502
  501 M1=124
      GO TO 503
  502 M1=31
  503 CALL READMS(5,X,M1,M2)
      IF(M1.EQ.31) GO TO 31
      IC=IC+1
      WRITE (1) (X(N),N=1,M1)
      PRINT 325,IC,BMO,BYR
      ID=1
      LZ=1
      LLZ=16
   21 PRINT 22,ID,(X(N),N=LZ,LLZ)
      ID=ID+4
      LZ=LLZ+1
      LLZ=LLZ+16
      IF(LLZ.EQ.128) LLZ=124
      IF(LLZ.GT.128) GO TO 520
      GO TO 21
   31 IC=IC+1
      WRITE (1) (X(N),N=1,M1)
```

```
      PRINT 325,IC,BMO,BYR
      ID=1
      PRINT 23,ID,(X(N),N=1,10)
      ID=11
      PRINT 23,ID,(X(N),N=11,20)
      ID=21
      PRINT 23,ID,(X(N),N=21,31)
  520 CONTINUE
      BMO=BMO+1
      IF(BMO.NE.13) GO TO 510
      BMO=1
      BYR=BYR+1
  510 CONTINUE
    2 CONTINUE
   22 FORMAT(1X,I2,4(4F8.2,*/*))
   23 FORMAT(1X,I3,11F10.3)
  325 FORMAT(* DAY*22X*STATION *I3,5X*MONTH *I3,5X*YEAR *I5)
      REWIND 1
      STOP
      END
```

```
      PROGRAM SUPERTP (INPUT,OUTPUT,TAPE1,TAPE2,TAPE3,TAPE4)
************************************************************************
C        NATIONAL WEATHER SERVICE RIVER FORECAST SYSTEM (SUPER TAPE)
************************************************************************
C                                 INPUT SUMMARY
************************************************************************
*CARD NO. FORMAT    CONTENTS
************************************************************************
C   1       8A10    HEADER CARD  COLS 2-80 AVAILABLE
************************************************************************
C   2          I5   TOTAL NUMBER OF DATA TAPES PLUS ONE
C                   (TAPE1 IS FOR WRITING THE COMPLETE DATA SET)
C              I5   NUMBER OF MONTHS OF RECORD FOR PASS ONE  (MOSUB(1))
C                   PASS ONE TRANSFERS DATA FOR THE FOLLOWING PERIOD
C                         BEGINNING MONTH  UP TO  EARLEST TIME WHEN ONE OF
C                                            THE DATA-TAPE RECORDS ENDS
C              I5   NUMBER OF MONTHS OF RECORD FOR PASS TWO  (MOSUB(2))
C                   THIS EXTENDS THE DATA SET MOSUB(2) MONTHS BEYOND
C                   PASS ONE
C              I5   IF MORMO = 0   JUST ONE PASS
C                      MORMO = 1   TWO PASSES ARE REQUSTED
C              I5   BEGINNING MONTH
C              I5   BEGINNING YEAR (USE FOUR DIGITS)
************************************************************************
C   3         5I5   NUMBER OF RECORD  ADVANCES FOR EACH TAPE USED
C
************************************************************************
C   4         5I5   NUMBER OF MBP RECORDS/MONTH ON EACH TAPE USED  (PASS 1)
************************************************************************
C   5         5I5   NUMBER OF PE  RECORDS/MONTH ON EACH TAPE USED  (PASS 1)
************************************************************************
C   6         5I5   NUMBER OF TEMP RECORDS/MONTH ON EACH TAPE USED  (PASS 1)
************************************************************************
C   7         5I5   NUMBER DAILY Q RECORDS/MONTH ON EACH TAPE USED  (PASS 1)
************************************************************************
C   8         5I5   NUMBER 6-HR  Q RECORDS/MONTH ON EACH TAPE USED  (PASS 1)
************************************************************************
C  9-13             REPEAT CARDS 4 THUR 8  USE APPROPRIATE NUMBERS
C                   FOR PASS 2  (ONLY IF TWO PASSES ARE REQUESTED)
************************************************************************
      DIMENSION PX(4,31),PE(31),TA(4,31),OFW24(31),OFW6(4,31),A(8),IDAR
     1(5)
      DIMENSION IADV(5),MOSUB(2),TPXR(5),TPER(5),TTAR(5),TOFW24R(5),
     1TOFW6R(5)
      INTEGER TPXR,TPER,TTAR,TOFW24R,TOFW6R,BMO,BYR
      READ 319,(A(I),I=1,8)
      READ 1100,NTAPES,MOSUB(1),MOSUB(2),MORMO,BMO,BYR
      READ 1100,(IADV(I),I=1,5)
      READ 1100,(TPXR(I),I=1,5)
      READ 1100,(TPER(I),I=1,5)
```

```
      READ 1100,(TTAR(I),I=1,5)
      READ 1100,(TOFW24R(I),I=1,5)
      READ 1100,(TOFW6R(I),I=1,5)
 319  FORMAT(8A10)
1100  FORMAT(6I5)
      IDAR(1)=0
      IDAR(2)=0
      IDAR(3)=0
      IDAR(4)=0
      IDAR(5)=0
      DO 100 I=1,NTAPES
      REWIND I
      IDAR(1)=IDAR(1)+TPXR(I)
      IDAR(2)=IDAR(2)+TPER(I)
      IDAR(3)=IDAR(3)+TTAR(I)
      IDAR(4)=IDAR(4)+TOFW24R(I)
      IDAR(5)=IDAR(5)+TOFW6R(I)
 100  CONTINUE
      DO 101 I=1,NTAPES
      M=IADV(I)
      IF (M.EQ.0) GO TO 101
      DO 102 J=1,M
      READ (I)
 102  CONTINUE
 101  CONTINUE
      ML=1
      IF(MORMO.EQ.1) ML=2
      DO 200 KK=1,ML
      NMO=MOSUB(KK)
      DO 103 J=1,NMO
      DO 104 N=2,NTAPES
      K=TPXR(N)
      IF (K.EQ.0) GO TO 104
      DO 105 L=1,K
      READ(N) PX
      WRITE(1) PX
 105  CONTINUE
 104  CONTINUE
      DO 106 N=2,NTAPES
      K=TPER(N)
      IF (K.EQ.0) GO TO 106
      DO 107 L=1,K
      READ(N) PE
      WRITE(1) PE
 107  CONTINUE
 106  CONTINUE
      DO 108 N=2,NTAPES
      K=TTAR(N)
      IF (K.EQ.0) GO TO 108
      DO 109 L=1,K
      READ(N) TA
      WRITE(1) TA
 109  CONTINUE
 108  CONTINUE
```

```
      DO 110 N=2,NTAPES
      K=TOFW24R(N)
      IF(K.EQ.0) GO TO 110
      DO 111 L=1,K
      READ(N) OFW24
      WRITE(1) OFW24
  111 CONTINUE
  110 CONTINUE
      DO 112 N=2,NTAPES
      K=TOFW6R(N)
      IF(K.EQ.0) GO TO 112
      DO 113 L=1,K
      READ(N) OFW6
      WRITE(1) OFW6
  113 CONTINUE
  112 CONTINUE
  103 CONTINUE
      IF (MORMO.EQ.0) GO TO 200
      IF (KK.EQ.2) GO TO 200
      READ 1100,(TPXR(I),I=1,5)
      READ 1100,(TPER(I),I=1,5)
      READ 1100,(TTAR(I),I=1,5)
      READ 1100,(TOFW24R(I),I=1,5)
      READ 1100,(TOFW6R(I),I=1,5)
  200 CONTINUE
      M=MOSUB(1)
      IF (MORMO.EQ.1) M=M+MOSUB(2)
      REWIND 1
      PRINT 320
  320 FORMAT (1H1)
      PRINT 319,(A(I),I=1,8)
      DO 321 I=1,M
      IC=0
      DO 322 K=1,5
      IDA=IDAR(K)
      IF (IDA.EQ.0) GO TO 322
      GO TO (323,324,323,324,323)K
  323 DO 326 J=1,IDA
      IC=IC+1
      PRINT 325,IC,BMO,BYR
      L=1
      LL=4
      READ(1) PX
  500 PRINT 400,L,((PX(N,NN),N=1,4),NN=L,LL)
      L=LL+1
      LL=LL+4
      IF(LL.EQ.32) LL=31
      IF(LL.GT.32) GO TO 326
      GO TO 500
  326 CONTINUE
      GO TO 322
  324 DO 327 J=1,IDA
      IC=IC+1
      PRINT 325,IC,BMO,BYR
```

```
      L=1
      READ(1) PE
      PRINT 406,L,(PE(N),N=1,10)
      L=11
      PRINT 406,L,(PE(N),N=11,20)
      L=21
      PRINT 406,L,(PE(N),N=21,31)
  327 CONTINUE
  322 CONTINUE
      BMO=BMO+1
      IF (BMO.NE.13) GO TO 321
      BMO=1
      BYR=BYR+1
  321 CONTINUE
  325 FORMAT(* DAY*22X*STATION *I3,5X*MONTH *I3,5X*YEAR *I5)
  400 FORMAT(1X,I2,4(4F8.2,*/*))
  406 FORMAT(1X,I3,11F10.3)
      END
```

APPENDIX F

VERIFICATION PROGRAM - INPUT AND OUTPUT SAMPLES

SECTION F.1 PROGRAM NWSRFS4 INPUT SUMMARY FOR VERIFICATION

SECTION F.2 SAMPLE INPUT VERIFICATION ------- SET ONE

SAMPLE INPUT VERIFICATION ------- SET TWO

SECTION F.3 EXAMPLES OF OUTPUT FROM VERIFICATION

```
C          INPUT SUMMARY FOR VERIFICATION
***********************************************************************
*CARD NO. FORMAT    CONTENTS
***********************************************************************
C    1      20A4    BASIC RUN INFORMATION SUCH AS DATE,ETC.
***********************************************************************
C    2      20A4    BASIN NAME
***********************************************************************
C    3        I5    NO. OF MBP AREAS USED IN RUN (NGAGES)
C             I5    NO. OF PE STATIONS USED (NPEGS)
C             I5    NO. OF STREAM-FLOW-POINTS USED (NPTS)
C             I5    NO. OF UPSTREAM INFLOW POINTS NEEDED FROM OUTSIDE
C                       AREA BEING RUN (NPTSUP)
***********************************************************************
C    4        I5    NO. OF MBP AREAS ON INPUT TAPE
C             I5    NO. OF PE STATIONS ON TAPE
C             I5    NO. OF MEAN DAILY FLOW-POINTS ON TAPE
C             I5    NO. OF POINTS WITH OBSERVED SIX-HOUR DISCHARGE
C                       THAT ARE ON TAPE
C             I5    NO. OF UPSTREAM INFLOWS FROM OUTSIDE RUN AREA
C                       ON TAPE
***********************************************************************
C    5        I5    FIRST MONTH OF RUN
C             I5    FIRST YEAR OF RUN (LAST 2 DIGITS ONLY)
C             I5    LAST MONTH
C             I5    LAST YEAR
***********************************************************************
C    6      16I5    IDENTIFIES THE MBP AREAS ON TAPE TO BE USED IN THE RUN.
C                       ALSO DEFINES THE PRECIP. AREA ORDER FOR THE RUN.
C                       1 TO (NGAGES) VALUES ARE NEEDED.
C                   E.G.    5 MBP AREAS ON TAPE,(NGAGES)=3, CARD 7=4,1,5
C                           THEN THE 4 TH GAGE ON TAPE WILL BE GAGE 1 FOR RUN.
C                                    1 ST GAGE ON TAPE WILL BE GAGE 2 FOR RUN.
C                                    5 TH GAGE ON TAPE WILL BE GAGE 3 FOR RUN.
***********************************************************************
C    7      10A4    NAME OF PE STATION
C             I5    NEP
C             I5    NDUR
C     (REPEAT CARD 7 FOR EACH PE STATION(1 TO NPEGS))--ORDER OF READ DETERMINES
C                       PE STATION NUMBER FOR THE RUN)
***********************************************************************
C    8      16I5    SAME AS CARD 6 ONLY FOR PE STATIONS.
***********************************************************************
C    9      16I5    ASSOCIATES PE STATIONS TO MBP AREAS
C                       1 TO (NGAGES) VALUES ARE NEEDED
C                   E.G. (NGAGES)=3,(NPEGS)=2, CARD 10=2,1,2
C                           THEN THE 1ST PRECIP AREA WILL USE PE FROM NO.2
C                                                                PE STATION
C                                THE 2ND PRECIP AREA WILL USE PE FROM NO.1
```

```
C                                                              PE STATION
C                                   THE 3RD PRECIP AREA WILL USE PE FROM NO.2
C                                                              PE STATION
*************************************************************************
C  10      16I5     SAME AS CARD 6 ONLY FOR MEAN DAILY FLOW STATIONS
C                       (VALUE =0 IF NO M.D.F. FOR A PARTICULAR FLOW-POINT)
*************************************************************************
C  11      16I5     SAME AS CARD 6 ONLY FOR SIX HOUR OBSERVED DISCHARGE
C                       (VALUE =0 IF NO DISCHARGE FOR A PARTICULAR FLOW-POINT)
*************************************************************************
C  11A     16I5     SAME AS CARD 6 ONLY FOR UPSTREAM INFLOW STATIONS
C                      FROM OUTSIDE CURRENT RUN AREA
C                       (ONLY NEEDED IF NO. OF UPSTREAM INFLOWS ON TAPE.GT.0)
*************************************************************************
C  12      16I5     TYPE OF ROUTING TO BE APPLIED TO REACH ABOVE FLOW-
C                       POINT (1 TO NPTS) EQUAL TO 1 FOR NOW
C                   1 IS FOR LAG AND K ROUTING INCLUDING VARIABLE
C                   SEE CHAPTER 6 OF WRITE-UP FOR ADDING OTHER ROUTING
C                       PROCEDURES.
*************************************************************************
C  13      16I5     FLOW TO ROUTE DOWNSTREAM (1 TO NPTS)
C                   =1 ROUTE OBSERVED OR BEST ESTIMATE OF OBSERVED
C                   =0 ROUTE SIMULATED
*************************************************************************
C  14        I5     =1 STORE CHANNEL INFLOW ON TAPE     =0 NO
C            I5     =1 DO ROUTING ONLY USING CHANNEL INFLOWS PREVIOUSLY STORED
C                            ON TAPE    =0 NO
C            I5     =1 SAVE 6 HOUR FLOW AT EACH FLOW POINT ON TAPE FOR USE
C                       AS  UPSTREAM INFLOWS LATER     =0 NO
C            I5     =1 PLOT SIX HOUR FLOW FOR ALL PERIODS WHEN OBSERVED IS
C                            READ IN.          =0 NO
C            I5     =1 PLOT MEAN DAILY FLOWS BY WATER YEAR FOR FLOW-POINTS
C                       WHERE OBSERVED DATA IS READ IN AND PLOT IS WANTED.
C                       THIS IS A PRINTER PLOT.  =0 FOR CARD OUTPUT FOR
C                     CAL-COMP PLOT PROGRAM
C            I5     TAPE NO. OF CHANNEL INFLOW TAPE
C            I5     TAPE NO. OF PRECIPITATION TAPE
C            I5     TAPE NO. OF MEAN DAILY FLOW TAPE
C            I5     TAPE NO. OF SIX HOUR OBSERVED DISCHARGE TAPE
C            I5     TAPE NO. OF PE TAPE
C            I5     TAPE NO. OF SNOW DATA (TA,TD,U,QI,QA,QR,TS,WE)
C            I5     TAPE NO. FOR SAVING SIX HOUR FLOWS AS FUTURE
C                                          UPSTREAM INFLOWS
C            I5     TAPE NO. FOR UPSTREAM INFLOWS FROM OUTSIDE RUN AREA
C            I5     =0    NO  STATISTICAL SUMMARY
C                   =1    MULTIYEAR STATISTICAL SUMMARY PLUS PUNCH M.D.F. IN
C                                                STANDARD FORMAT
C                   =2    MULTIYEAR SUMMARY ONLY
C                   =3    YEARLY AND MULTIYEAR SUMMARY
C                   =4    YEARLY PLUS MULTIYEAR PLUS PUNCH M.D.F. CARDS
C            I5     =1 OUTPUT MONTHLY FLOW VOLUMES AND MOISTURE STORAGES, =0 NO
*************************************************************************
C  15        I5     =1 SNOW IS INCLUDED,  =0 NO SNOW
C            I5     =1 OUTPUT WATER YEAR MEAN DAILY FLOW SUMMARY TABLES,
```

```
C                          =0 NO TABLE OUTPUT
C                  I5    =1 OUTPUT DETAILED SOIL MOISTURE OUTPUT FOR SELECTED MONTHS,
C                          =0 NO DETAILED OUTPUT
*******************************************************************************
C  15A      16I5    MONTH AND YEAR (2 DIGITS) FOR WHICH DETAILED SOIL MOISTURE
C                          OUTPUT IS WANTED.  (UP TO 8 MONTHS CAN BE OBTAINED)
C                   (THIS CARD ONLY NEEDED IF DETAILED SOIL MOISTURE OUTPUT
C                          IS ASKED FOR)
*******************************************************************************
*******************************************************************************
C**NOTE**  REPEAT CARDS 16 THROUGH 19 FOR EACH MBP AREA (NGAGES)
C  16        5A4    NAME OF MBP AREA
C           4F5.2   SOIL-MOISTURE VOLUME PARAMETERS
C          ,F5.1,          MOD. STANFORD WATERSHED MODEL
C           F5.2,          ORDER OF PARAMETERS IS --
C          2F5.1,              K1,A,EPXM,UZSN,LZSN,CB,POWER,CC,K24L
C            F5.2         (PARAMETERS DEFINED IN SECTION 4.3 OF PACKAGE
C                             WRITE-UP)
*******************************************************************************
C  17       20X,    EVAPOTRANSPIRATION PARAMETERS FOR SOIL MOISTURE
C          5F5.2           ORDER IS  K3,GAGEPE,EHIGH,ELOW,K24EL
*******************************************************************************
C  18       20X,    SOIL MOISTURE  TIMING PARAMETERS
C          2F5.2,          ORDER IS---
C           F5.4,            SRC1,LIRC6,LKK6,KV,KGS
C          2F5.2
*******************************************************************************
C  19       20X,    SOIL MOISTURE INITIAL CONDITIONS
C          7F5.1           ORDER IS---UZSI,LZSI,SGWI,GWSI,RESI,SRGXI,SCEPI
C                              UZS=UPPER ZONE STORAGE
C                              LZS=LOWER ZONE STORAGE
C                              SGW=GROUNDWATER STORAGE
C                              GWS=ANTECEDENT GW INFLOW INDEX
C                              RES=SURFACE DETENTION
C                              SRGX=INTERFLOW DETENTION
C                              SCEP=INTERCEPTION STORAGE
*******************************************************************************
*******************************************************************************
C**NOTE**CARD 20A IS ONLY NEEDED WHEN THE NUMBER OF UPSTREAM INFLOWS
C         FROM OUTSIDE THE AREA BEING RUN IS.GT.0 (NPTSUP.GT.0)
C  20A       7A4    NAME OF UPSTREAM INFLOW POINT
C      2X,F10.0     AREA OF UPSTREAM INFLOW POINT  (TOTAL AREA ABOVE GAGE SQ.MI)
C        REPEAT CARD 20A FOR EACH UPSTREAM INFLOW POINT (1 TO NPTSUP))
C              ORDER OF CARDS DETERMINES FLOW-POINT NUMBER FOR RUN
C              FIRST UPSTREAM INFLOW POINT IS ASSIGNED FLOW-POINT NUMBER
C                   EQUAL TO (NPTS+1) ETC. E.G. IF NPTS=3 THEN THE FIRST
C                   UPSTREAM INFLOW POINT BECOMES FLOW-POINT 4 FOR
C                   THE RUN.
*******************************************************************************
*******************************************************************************
C**NOTE** REPEAT CARDS 20 THROUGH 23 (IF ALL NEEDED) FOR EACH FLOW-POINT
C         WITHIN RUN AREA (NPTS)
C        ORDER OF CARDS DETERMINES FLOW-POINT NUMBER FOR THE RUN.
C        NOTE...ALL FLOW-POINTS UPSTREAM FROM GAGE MUST HAVE A SMALLER RUN
```

```
C              NUMBER THAN THE GIVEN GAGE--EXCEPT FOR UPSTREAM INFLOW-POINTS
C              FROM OUTSIDE THE AREA BEING RUN(SEE CARD 20A)
C  20       7A4      NAME OF FLOW-POINT
C      2X,F10.0      TOTAL AREA ABOVE FLOW-POINT IN SQUARE MILES
C        ,F5.2,      CONSTANT K ROUTING FACTOR IN HOURS   =0.0 IF VAR. K USED
C            I5      =1 USE VARIABLE K    =0 NO
C            I5      =1 USE VARIABLE LAG =0 NO
C            I5      ROUTING INTERVAL IN HOURS  (MUST=6 FOR NOW)
C            I5      NO. OF VALUES  IN TIME-DELAY HISTOGRAM FOR LOCAL AREA
C            I5      NO. OF UPSTREAM  INFLOW POINTS TO LOCAL AREA (NUPIN)
C                          THESE CAN BE UPSTREAM INFLOWS FROM OUTSIDE OR
C                          INSIDE THE RUN AREA
C            I5      NO.OF POINTS TO DEFINE VARIABLE K VS OUTFLOW CURVE
C            I5      NO. OF POINTS TO DEFINE VARIABLE LAG VS INFLOW CURVE
************************************************************************
C  20B   8F10.0      VARIABLE K VS.OUTFLOW CURVE IF NEEDED    K IN HOURS
C                          MAXIMUM POINTS TO DEFINE CURVE IS 10 (THUS 3 CARDS)
C                          VALUES READ IN PAIRS  (FLOW,K)
C                                SO 4 PAIRS OF (FLOW,K) CAN GO ON A CARD
C                          K AT ZERO FLOW MUST BE FIRST POINT
C                          CALCULATIONS USING K ARE BASED ON A LINEAR
C                                INTERPOLATION BETWEEN POINTS
C                          K VALUE FOR HIGHEST DEFINED FLOW IS USED FOR
C                                ALL FLOWS ABOVE THAT DISCHARGE
************************************************************************
C  20C   8F10.0      VARIABLE LAG VS. INFLOW CURVE IF NEEDED   LAG IN HOURS
C                          MAX.PTS=10, VALUES IN PAIRS(FLOW,LAG), 4 PAIRS PER CARD
C                          LAG AT ZERO FLOW MUST BE FIRST POINT
C                          CALCULATIONS USING VARIABLE LAG ARE BASE ON
C                                LAGGING THE VOLUME OF FLOW IN THE INTERVAL
C                                FLOW(N) TO FLOW(N+1) BY THE AVERAGE LAG FOR
C                                THAT INTERVAL (LAG(N)+LAG(N+1))*0.5
C                          LAG VALUE FOR HIGHEST DEFINED FLOW IS USED FOR
C                                ALL FLOW ABOVE THAT DISCHARGE
************************************************************************
C  21     40X,I5     =1 IF M.D.F. PLOT WANTED FOR THE FLOW-POINT  =0 NO
C                          M.D. OBSERVED FLOW MUST BE READ IN TO GET PLOT
C         F10.0      MAXIMUM PLOT ORDINATE FOR M.D.F. PLOT
C         F10.0      BASE FOR FLOW INTERVAL CALCULATIONS IN STATISTICAL
C                          SUBROUTINE   (GUIDE--FLOW THAT IS EXCEEDED 25 PER
C                                                 CENT OF THE TIME)
C         1X,A9      USGS STATION IDENTICATION NUMBER  (NEEDED IF STD. FMT CARDS
C                                    ARE TO BE PUNCHED)
************************************************************************
C  22       30X,     TIME DELAY HISTOGRAM (MAX.NO OF POINTS=30)
C        10F5.2            HISTOGRAM IS FOR LOCAL AREA   SUMMATION OF VALUES=1.0
************************************************************************
C  23       30X,     MBP AREAS TO BE ASSIGNED TO EACH ELEMENT OF THE TIME-DELAY
C           10I5           HISTOGRAM ---  MBP AREAS DESIGNATED BY RUN NO. WHICH
C                          IS DETERMINED BY THE ORDER CARDS 16 TO 19 WERE READ.
************************************************************************
C  20D      30X,     RUN NO. OF EACH UPSTREAM INFLOW POINT TO LOCAL AREA
C            5I5                 NEEDED IF (NUPIN.GT.0)
************************************************************************
```

```
C  20E      30X,     CONSTANT LAG FOR EACH UPSTREAM INFLOW POINT
C           5F5.1        (LAG IN HOURS)
C                **NOTE** TOTAL LAG CONSISTS OF CONSTANT PLUS VARIABLE COMPONENT
********************************************************************************
********************************************************************************
C  24        4I5     NUMBER OF RECORDS TO SKIP ON TAPES 1 TO 4 TO POSITION
C                         THE TAPE CORRECTLY FOR THE INITIAL MONTH
********************************************************************************
********************************************************************************
********************************************************************************
C
C     DATA INPUT DESCRIPTION
C
C        A.    BASIC DATA  CAN BE ON MORE THAN ONE TAPE  (IN ORDER BY MONTHS)
C                         IF ON ONE TAPE MUST BE IN FOLLOWING ORDER
C              1.   MBP AREAS  RECORD SIZE=124    SIX HOUR PCPN IN SEQUENTIAL
C                                                ORDER FOR THE MONTH
C              2.   PE STATION RECORD SIZE=31     DAILY PE
C              3.   M.D.F STREAMGAGES  RECORD SIZE=31  DAILY FLOWS FROM
C                                                 USGS WATER SUPPLY PAPERS
C                        MISSING DATA IS READ IN AS NEGATIVE NUMBER
C                        ENTIRE MONTH MUST EITHER BE ALL VALID DATA OR
C                             ALL MISSING DATA.
C              4.   SIX HOUR DISCHARGES RECORD SIZE=124
C                        DISCHARGE AT 6 A.M.,NOON,6 P.M.,MID. FOR EACH DAY
C                             IN SEQ. ORDER FOR THE MONTH
C                        MISSING DATA IS READ IN AS NEGATIVE NUMBER
C
C        B.  OTHER DATA IS EITHER GENERATED BY THE PROGRAM IN A PREVIOUS
C              RUN OR IN THE CASE OF UPSTREAM INFLOWS, THESE CAN BE GENERATED
C              BY A PREVIOUS RUN OR THE TAPE COULD BE PREPARED.
C                   IF PREPARED IT IS THE SAME FORMAT AS SIX HOUR DISCHARGES
C                        EXCEPT NO MISSING DATA IS ALLOWED.
********************************************************************************
********************************************************************************
********************************************************************************
```

SECTION F.2   SAMPLE INPUT VERIFICATION   -------   SET ONE

```
NATIONAL WEATHER SERVICE  RIVER FORECAST SYSTEM  SAMPLE OUTPUT
LEAF RIVER BASIN-----MISSISSIPPI
    3    1    3    0
   10    1    6    6    0
   10   60    9   62
    3    8    9
   JACKSON,MISSISSIPPI                         90    60
    1
    1    1    1
    1    2    5
    2    3    1
    1    1    1
    1    1    0
    0    0    1    1    1    0    1    1    3    1    0    2    0    3    1
    0    1    1
    2   61    1   62
  MBP OF COLLINS,MISS   1.0 .035  .50  .05  7.5  .33 2.85  .37  0.0       VOL PAR
  MBP OF COLLINS,MISS   .28  1.0 1.20  .60  0.0                           ET PARM
  MBP OF COLLINS,MISS   .90   .1.0025 15.0  .925                        TIME PARM
  MBP OF COLLINS,MISS   0.0  5.0  .60  0.0  0.0  0.0  0.0                 INITIAL
MBP BOWIE CREEK         1.0 .037  .24 .212 5.85  .91  2.4 .417 .180      VOL PARM
MBP BOWIE CREEK         .28  1.0  1.1  .84  0.0                           ET PARM
MBP BOWIE CREEK          .9   .1.002010.25 .865                         TIME PARM
  MBP OF BOWIE CR       0.0  5.0  2.0  0.0  0.0  0.0  0.0                 INITIAL
HATTIESBURG LOCAL       1.0 .035  .50  .05  7.5  .33 2.85  .37  .00      VOL PARM
HATTIESBURG LOCAL       .28  1.0  1.2  .60  0.0                           ET PARM
HATTIESBURG LOCAL        .9   .1.0020  12.  .90                         TIME PARM
  MBP HATTIES LOCAL     0.0  5.0  1.5  0.0  0.0  0.0  0.0                 INITIAL
  LEAF RIVER NR COLLINS MISS.         752.  8.0    0    0    6   18    0    0    0
  LEAF RIVER NR COLLINS MISS.                 1   20000.      1500. 02-4720.0
  TIME DELAY   COLLINS MISS.     .030 .050 .055 .059 .061 .064 .069 .072 .080 .081
  TIME DELAY   COLLINS MISS.     .080 .073 .064 .052 .043 .032 .023 .014
  GAGE AREA    COLLINS MISS.        1    1    1    1    1    1    1    1    1    1
  GAGE AREA    COLLINS MISS.        1    1    1    1    1    1    1    1
  BOWIE CREEK NR HATTIESBURG          304. 12.6    0    0    6    8    0    0    0
  BOWIE CREEK NR HATTIESBURG                  1   10000.      1000. 02-4725.0
  TIME DELAY   BOWIE CREEK       .105 .140 .210 .170 .155 .095 .075 .050
  GAGE AREA    BOWIE CREEK          2    2    2    2    2    2    2    2
 LEAF RIVER AT HATTIESBURG          1760.    9.    0    0    6   14    2    0    0
 LEAF RIVER AT HATTIESBURG                    1   30000.      3000. 02-4730.0
  TIME DELAY   HATTIE LOCAL      .054 .097 .098 .093 .083 .073 .070 .075 .079 .077
  TIME DELAY   HATTIE LOCAL      .075 .064 .044 .018
  GAGE AREA    HATTIE LOCAL         3    3    3    3    3    3    3    3    3    3
  GAGE AREA    HATTIE LOCAL         3    3    3    3
  UPSTREAM INFLOW POINTS            1    2
  UPSTREAM LAG                    30.  12.
  1836    0  648    0                                                SKIP TAPE RECDS
```

SAMPLE INPUT VERIFICATION ------- SET TWO

```
NATIONAL WEATHER SERVICE  RIVER FORECAST SYSTEM  SAMPLE OUTPUT
LEAF RIVER BASIN-----MISSISSIPPI
    1    1    1    2
   10    1    6    0    3
   10   60    9   62
    9
   JACKSON,MISSISSIPPI                                 90   60
    1
    1
    5
    0
    1    2
    1
    0
    0    0    0    0    1    0    1    1    0    1    0    0    2    2    0
    0    1    0
HATTIESBURG LOCAL       1.0 .035  .50  .05  7.5  .33 2.85  .37  .00       VOL PARM
HATTIESBURG LOCAL       .28  1.0  1.2  .60  0.0                            ET PARM
HATTIESBURG LOCAL        .9   .1.0020  12.  .90                          TIME PARM
 MBP HATTIES LOCAL      0.0  5.0  1.5  0.0  0.0  0.0  0.0                  INITIAL
LEAF RIVER NR COLLINS,MISS            752.
BOWIE CREEK NR HATTIESBURG            304.
LEAF RIVER AT HATTIESBURG            1760.   9.    0    0    6   14    2    0    0
LEAF RIVER AT HATTIESBURG                    1   30000.   3000.  02-4730.0
 TIME DELAY     HATTIE LOCAL   .054 .097 .098 .093 .083 .073 .070 .075 .079 .077
 TIME DELAY     HATTIE LOCAL   .075 .064 .044 .018
 GAGE AREA      HATTIE LOCAL      1    1    1    1    1    1    1    1    1    1
 GAGE AREA      HATTIE LOCAL      1    1    1    1
 UPSTREAM INFLOW POINTS           2    3
 UPSTREAM LAG                    30.  12.
 1836    0    0    0                                                SKIP TAPE RECDS
```

LEAF RIVER BASIN-----MISSISSIPPI

NATIONAL WEATHER SERVICE RIVER FORECAST SYSTEM SAMPLE OUTPUT

BASIC RUN INFORMATION

RUN BEGINS OCT 1960   RUN ENDS SEPT 1962

NUMBER OF PRECIPITATION GAGES= 3   NUMBER OF FLOW-POINTS= 3   NUMBER OF POTENTIAL ET STATIONS= 1
EVAPORATION PARAMETERS ARE   JACKSON,MISSISSIPPI   NEP= 90   NDUR= 60

SIX HOUR FLOW TO BE ROUTED DOWNSTREAM FOR EACH FLOW-POINT STORED ON TAPE 2

LEAF RIVER BASIN-----MISSISSIPPI

NATIONAL WEATHER SERVICE RIVER FORECAST SYSTEM SAMPLE OUTPUT

SOIL MOISTURE VOLUME PARAMETERS

RG	PRECIP. GAGE NAME	K1	A	EPXM	UZSN	LZSN	CB	POWER	CC	K24L	K3	GAGEPE	EHIGH	ELOW	K24EL
1	MBP OF COLLINS,MISS	1.000	.035	.500	.050	7.500	.330	2.850	.370	0.000	.280	1.000	1.200	.600	0.000
2	MBP BOWIE CREEK	1.000	.037	.240	.212	5.850	.910	2.400	.417	.180	.280	1.000	1.100	.840	0.000
3	HATTIESBURG LOCAL	1.000	.035	.500	.050	7.500	.330	2.850	.370	0.000	.280	1.000	1.200	.600	0.000

SOIL MOISTURE TIMING PARAMETERS

RG	SRC1	LIRC6	LKK6	KV	KGS
1	.900	.100	.0025	15.000	.9200
2	.900	.100	.0020	10.250	.8650
3	.900	.100	.0020	12.000	.9000

SOIL MOISTURE INITIAL VALUES

RG	UZS	LZS	SGW	GWS	RES	SRGX	SCEP
1	0.00	5.00	.60	0.00	0.00	0.00	0.00
2	0.00	5.00	2.00	0.00	0.00	0.00	0.00
3	0.00	5.00	1.50	0.00	0.00	0.00	0.00

LEAF RIVER BASIN-----MISSISSIPPI

NATIONAL WEATHER SERVICE RIVER FORECAST SYSTEM SAMPLE OUTPUT

FLOW-POINT PARAMETERS

FP	FLOW-POINT NAME	AREA	KS1	OBSER	COMPAR	CHECK	SIXIN	HISTOGRAMS										
1	LEAF RIVER NR COLLINS MISS.	752.00	8.00	1	1	1	2	TIME-DELAY	.030	.050	.055	.059	.061	.064	.069	.072	.080	.081
									.080	.073	.064	.052	.043	.032	.023	.014		
								GAGE AREA	1	1	1	1	1	1	1	1	1	1
									1	1	1	1	1	1	1	1		
2	BOWIE CREEK NR HATTIESBURG	304.00	12.60	1	1	1	3	TIME-DELAY	.105	.140	.210	.170	.155	.095	.075	.050		
								GAGE AREA	2	2	2	2	2	2	2	2		
3	LEAF RIVER AT HATTIESBURG	1760.00	9.00	0	1	1	1	TIME-DELAY	.054	.097	.098	.093	.083	.073	.070	.075	.079	.077
									.075	.064	.044	.018						
								GAGE AREA	3	3	3	3	3	3	3	3	3	3
									3	3	3	3						
								INFLOW-PTS	1	2								
								INFLOW LAG	30.0	12.0								

SIX-HOUR SOIL MOISTURE OUTPUT FOR 1/62 MBP OF COLLINS,MISS ELKK6=LKK6*(1.0+KV*GWS) GWIN=INFLOW TO GROUNDWATER STORAGE

IDA	IP6	SCEP	UZS	LZS	SGW	RES	SRGX	ELKK6	INFIL	GWIN	IMPV-RO	SUR-RO	INTERFW	GW-FLOW	TOTAL-RO	PRECIP
1	1	.490	.125	10.428	1.243	0.0000	0.0000	.0117	0.0000	0.0000	0.0000	0.0000	0.0000	.0148	.0148	0.000
1	2	.487	.125	10.428	1.230	0.0000	0.0000	.0110	0.0000	0.0000	0.0000	0.0000	0.0000	.0137	.0137	0.000
1	3	.479	.123	10.428	1.218	0.0000	0.0000	.0103	.0015	.0012	0.0000	0.0000	0.0000	.0127	.0127	0.000
1	4	.479	.123	10.428	1.206	0.0000	0.0000	.0097	0.0000	0.0000	0.0000	0.0000	0.0000	.0119	.0119	0.000
2	1	.479	.123	10.428	1.195	0.0000	0.0000	.0092	0.0000	0.0000	0.0000	0.0000	0.0000	.0110	.0110	0.000
2	2	.467	.123	10.428	1.185	0.0000	0.0000	.0086	0.0000	0.0000	0.0000	0.0000	0.0000	.0103	.0103	0.000
2	3	.443	.122	10.429	1.176	0.0000	0.0000	.0081	.0014	.0011	0.0000	0.0000	0.0000	.0096	.0096	0.000
2	4	.443	.122	10.429	1.167	0.0000	0.0000	.0077	0.0000	0.0000	0.0000	0.0000	0.0000	.0091	.0091	0.000
3	1	.443	.122	10.429	1.159	0.0000	0.0000	.0073	0.0000	0.0000	0.0000	0.0000	0.0000	.0085	.0085	0.000
3	2	.428	.122	10.429	1.151	0.0000	0.0000	.0069	0.0000	0.0000	0.0000	0.0000	0.0000	.0080	.0080	0.000
3	3	.398	.121	10.429	1.144	0.0000	0.0000	.0066	.0013	.0010	0.0000	0.0000	0.0000	.0076	.0076	0.000
3	4	.398	.121	10.429	1.137	0.0000	0.0000	.0063	0.0000	0.0000	0.0000	0.0000	0.0000	.0072	.0072	0.000
4	1	.398	.121	10.429	1.130	0.0000	0.0000	.0060	0.0000	0.0000	0.0000	0.0000	0.0000	.0068	.0068	0.000
4	2	.390	.121	10.429	1.124	0.0000	0.0000	.0057	0.0000	0.0000	0.0000	0.0000	0.0000	.0064	.0064	0.000
4	3	.384	.119	10.429	1.119	0.0000	0.0000	.0054	.0012	.0009	.0004	0.0000	0.0000	.0061	.0065	.012
4	4	.490	.119	10.429	1.113	0.0000	0.0000	.0052	0.0000	0.0000	.0037	0.0000	0.0000	.0059	.0096	.106
5	1	.500	.163	10.513	1.379	.0233	0.0000	.0158	.3697	.2887	.0579	1.1538	0.0000	.0222	1.2340	1.656
5	2	.499	.168	10.593	1.621	.0223	0.0000	.0254	.3616	.2843	.0552	1.1575	0.0000	.0423	1.2550	1.578
5	3	.498	.160	10.616	1.656	0.0000	0.0000	.0264	.1009	.0797	.0029	.0079	0.0000	.0446	.0555	.084
5	4	.500	.161	10.685	1.845	.0030	0.0000	.0342	.3201	.2538	.0174	.1536	0.0000	.0653	.2364	.497
6	1	.500	.161	10.700	1.836	0.0000	0.0000	.0338	.0702	.0559	.0026	.0036	0.0000	.0642	.0703	.074
6	2	.494	.161	10.700	1.779	0.0000	0.0000	.0313	0.0000	0.0000	0.0000	0.0000	0.0000	.0574	.0574	0.000
6	3	.483	.154	10.701	1.733	0.0000	0.0000	.0290	.0064	.0051	0.0000	0.0000	0.0000	.0515	.0515	0.000
6	4	.483	.154	10.701	1.686	0.0000	0.0000	.0270	0.0000	0.0000	0.0000	0.0000	0.0000	.0468	.0468	0.000
7	1	.486	.154	10.701	1.644	0.0000	0.0000	.0251	0.0000	0.0000	.0001	0.0000	0.0000	.0423	.0424	.003
7	2	.493	.154	10.701	1.605	0.0000	0.0000	.0233	0.0000	0.0000	.0004	0.0000	0.0000	.0382	.0387	.013
7	3	.483	.149	10.703	1.575	0.0000	0.0000	.0216	.0051	.0040	.0001	0.0000	0.0000	.0347	.0348	.002
7	4	.483	.149	10.703	1.543	0.0000	0.0000	.0202	0.0000	0.0000	0.0000	0.0000	0.0000	.0319	.0319	0.000
8	1	.483	.149	10.703	1.514	0.0000	0.0000	.0188	0.0000	0.0000	0.0000	0.0000	0.0000	.0290	.0290	0.000
8	2	.472	.149	10.703	1.487	0.0000	0.0000	.0175	0.0000	0.0000	0.0000	0.0000	0.0000	.0265	.0265	0.000
8	3	.450	.145	10.703	1.466	0.0000	0.0000	.0163	.0042	.0033	0.0000	0.0000	0.0000	.0243	.0243	0.000
8	4	.450	.145	10.703	1.444	0.0000	0.0000	.0153	0.0000	0.0000	0.0000	0.0000	0.0000	.0225	.0225	0.000
9	1	.450	.145	10.703	1.423	0.0000	0.0000	.0143	0.0000	0.0000	0.0000	0.0000	0.0000	.0206	.0206	0.000
9	2	.447	.145	10.703	1.404	0.0000	0.0000	.0134	0.0000	0.0000	0.0000	0.0000	0.0000	.0190	.0190	0.000
9	3	.440	.141	10.704	1.389	0.0000	0.0000	.0125	.0035	.0028	0.0000	0.0000	0.0000	.0175	.0175	0.000
9	4	.500	.142	10.746	1.508	0.0000	0.0000	.0172	.1820	.1452	.0099	.0294	0.0000	.0265	.0658	.283
10	1	.500	.142	10.755	1.517	0.0000	0.0000	.0174	.0448	.0358	.0017	.0014	0.0000	.0269	.0299	.048
10	2	.492	.142	10.755	1.493	0.0000	0.0000	.0162	0.0000	0.0000	0.0000	0.0000	0.0000	.0246	.0246	0.000
10	3	.476	.139	10.756	1.473	0.0000	0.0000	.0151	.0031	.0025	0.0000	0.0000	0.0000	.0226	.0226	0.000
10	4	.476	.139	10.756	1.452	0.0000	0.0000	.0142	0.0000	0.0000	0.0000	0.0000	0.0000	.0209	.0209	0.000
11	1	.476	.139	10.756	1.432	0.0000	0.0000	.0133	0.0000	0.0000	0.0000	0.0000	0.0000	.0193	.0193	0.000
11	2	.471	.139	10.756	1.415	0.0000	0.0000	.0124	0.0000	0.0000	0.0000	0.0000	0.0000	.0178	.0178	0.000
11	3	.460	.136	10.756	1.400	0.0000	0.0000	.0116	.0027	.0022	0.0000	0.0000	0.0000	.0164	.0164	0.000
11	4	.460	.136	10.756	1.385	0.0000	0.0000	.0110	0.0000	0.0000	0.0000	0.0000	0.0000	.0154	.0154	0.000
12	1	.460	.136	10.756	1.371	0.0000	0.0000	.0103	0.0000	0.0000	0.0000	0.0000	0.0000	.0142	.0142	0.000
12	2	.454	.136	10.756	1.357	0.0000	0.0000	.0097	0.0000	0.0000	0.0000	0.0000	0.0000	.0132	.0132	0.000
12	3	.442	.134	10.757	1.347	0.0000	0.0000	.0091	.0024	.0019	0.0000	0.0000	0.0000	.0123	.0123	0.000
12	4	.442	.134	10.757	1.335	0.0000	0.0000	.0086	0.0000	0.0000	0.0000	0.0000	0.0000	.0116	.0116	0.000
13	1	.442	.134	10.757	1.325	0.0000	0.0000	.0081	0.0000	0.0000	0.0000	0.0000	0.0000	.0109	.0109	0.000
13	2	.432	.134	10.757	1.314	0.0000	0.0000	.0077	0.0000	0.0000	0.0000	0.0000	0.0000	.0102	.0102	0.000
13	3	.411	.131	10.757	1.307	0.0000	0.0000	.0073	.0021	.0017	0.0000	0.0000	0.0000	.0096	.0096	0.000
13	4	.411	.131	10.757	1.297	0.0000	0.0000	.0070	0.0000	0.0000	0.0000	0.0000	0.0000	.0091	.0091	0.000
14	1	.411	.131	10.757	1.289	0.0000	0.0000	.0066	0.0000	0.0000	0.0000	0.0000	0.0000	.0086	.0086	0.000
14	2	.403	.131	10.757	1.281	0.0000	0.0000	.0063	0.0000	0.0000	0.0000	0.0000	0.0000	.0081	.0081	0.000
14	3	.390	.129	10.758	1.275	0.0000	0.0000	.0060	.0019	.0015	.0002	0.0000	0.0000	.0076	.0078	.004
14	4	.500	.132	10.800	1.409	0.0000	0.0000	.0114	.1881	.1508	.0120	.0311	.0000	.0163	.0594	.344
15	1	.500	.140	10.859	1.613	.0023	.0008	.0195	.2930	.2357	.0153	.1180	.0001	.0321	.1655	.436
15	2	.490	.140	10.860	1.585	0.0000	.0007	.0182	.0022	.0018	0.0000	.0000	.0001	.0294	.0295	0.000
15	3	.470	.137	10.860	1.560	0.0000	.0006	.0170	.0027	.0022	0.0000	0.0000	.0001	.0269	.0270	0.000
15	4	.470	.137	10.860	1.536	0.0000	.0006	.0159	0.0000	0.0000	0.0000	0.0000	.0001	.0248	.0249	0.000
16	1	.470	.137	10.860	1.513	0.0000	.0005	.0148	0.0000	0.0000	0.0000	0.0000	.0001	.0228	.0228	0.000

16	2	.458	.137	10.860	1.492	0.0000	.0005	.0138	0.0000	0.0000	0.0000	0.0000	.0000	.0209	.0210	0.000
16	3	.434	.134	10.861	1.474	0.0000	.0004	.0129	.0024	.0019	0.0000	0.0000	.0000	.0193	.0193	0.000
16	4	.434	.134	10.861	1.457	0.0000	.0004	.0122	0.0000	0.0000	0.0000	0.0000	.0000	.0179	.0180	0.000
17	1	.434	.134	10.861	1.440	0.0000	.0003	.0114	0.0000	0.0000	0.0000	0.0000	.0000	.0166	.0166	0.000
17	2	.419	.134	10.861	1.425	0.0000	.0003	.0107	0.0000	0.0000	0.0000	0.0000	.0000	.0154	.0154	0.000
17	3	.389	.132	10.861	1.412	0.0000	.0003	.0100	.0021	.0017	0.0000	0.0000	.0000	.0143	.0143	0.000
17	4	.389	.132	10.861	1.399	0.0000	.0002	.0095	0.0000	0.0000	0.0000	0.0000	.0000	.0134	.0134	0.000
18	1	.458	.132	10.861	1.386	0.0000	.0002	.0089	0.0000	0.0000	.0024	0.0000	.0000	.0125	.0149	.069
18	2	.497	.145	10.927	1.622	.0053	.0036	.0184	.3298	.2666	.0239	.2674	.0004	.0304	.3221	.684
18	3	.494	.149	10.991	1.839	.0083	.0086	.0270	.3293	.2675	.0280	.4277	.0009	.0510	.5076	.800
18	4	.500	.158	11.052	2.026	.0124	.0149	.0350	.3194	.2607	.0357	.6385	.0016	.0735	.7492	1.019
19	1	.500	.159	11.105	2.166	.0024	.0174	.0411	.2835	.2324	.0148	.1292	.0019	.0928	.2387	.423
19	2	.498	.159	11.105	2.085	0.0000	.0156	.0381	.0023	.0019	0.0000	.0000	.0017	.0825	.0842	0.000
19	3	.495	.153	11.106	2.016	0.0000	.0141	.0352	.0055	.0045	0.0000	0.0000	.0015	.0735	.0750	0.000
19	4	.495	.153	11.106	1.950	0.0000	.0127	.0328	0.0000	0.0000	0.0000	0.0000	.0014	.0661	.0675	0.000
20	1	.495	.153	11.106	1.891	0.0000	.0114	.0304	0.0000	0.0000	0.0000	0.0000	.0012	.0592	.0604	0.000
20	2	.498	.153	11.107	1.841	0.0000	.0102	.0283	.0049	.0040	.0003	.0000	.0011	.0536	.0551	.010
20	3	.494	.149	11.108	1.796	0.0000	.0092	.0262	.0045	.0037	0.0000	0.0000	.0010	.0483	.0493	0.000
20	4	.494	.149	11.108	1.752	0.0000	.0083	.0245	0.0000	0.0000	0.0000	0.0000	.0009	.0439	.0448	0.000
21	1	.494	.149	11.108	1.713	0.0000	.0075	.0227	0.0000	0.0000	0.0000	0.0000	.0008	.0398	.0406	0.000
21	2	.485	.149	11.108	1.677	0.0000	.0067	.0211	0.0000	0.0000	0.0000	0.0000	.0007	.0361	.0368	0.000
21	3	.465	.145	11.108	1.647	0.0000	.0061	.0196	.0037	.0031	0.0000	0.0000	.0006	.0329	.0335	0.000
21	4	.465	.145	11.108	1.617	0.0000	.0054	.0183	0.0000	0.0000	0.0000	0.0000	.0006	.0302	.0308	0.000
22	1	.468	.145	11.108	1.589	0.0000	.0049	.0171	0.0000	0.0000	.0001	0.0000	.0005	.0276	.0282	.003
22	2	.464	.145	11.108	1.564	0.0000	.0044	.0159	0.0000	0.0000	0.0000	0.0000	.0005	.0253	.0258	0.000
22	3	.457	.142	11.109	1.543	0.0000	.0040	.0148	.0032	.0026	0.0000	0.0000	.0004	.0232	.0236	0.000
22	4	.457	.142	11.109	1.522	0.0000	.0036	.0140	0.0000	0.0000	0.0000	0.0000	.0004	.0215	.0219	0.000
23	1	.463	.142	11.109	1.502	0.0000	.0032	.0130	0.0000	0.0000	.0002	0.0000	.0003	.0198	.0204	.006
23	2	.497	.142	11.120	1.526	0.0000	.0030	.0139	.0555	.0456	.0034	.0023	.0003	.0215	.0275	.097
23	3	.494	.139	11.131	1.553	0.0000	.0028	.0148	.0620	.0510	.0024	.0026	.0003	.0233	.0286	.067
23	4	.496	.139	11.131	1.532	0.0000	.0025	.0139	0.0000	0.0000	.0001	0.0000	.0003	.0216	.0219	.002
24	1	.496	.139	11.131	1.512	0.0000	.0022	.0130	0.0000	0.0000	0.0000	0.0000	.0002	.0199	.0202	0.000
24	2	.488	.139	11.131	1.494	0.0000	.0020	.0122	0.0000	0.0000	0.0000	0.0000	.0002	.0184	.0186	0.000
24	3	.472	.136	11.132	1.479	0.0000	.0018	.0114	.0024	.0020	0.0000	0.0000	.0002	.0170	.0172	0.000
24	4	.472	.136	11.132	1.463	0.0000	.0016	.0108	0.0000	0.0000	0.0000	0.0000	.0002	.0159	.0161	0.000
25	1	.472	.136	11.132	1.448	0.0000	.0015	.0101	0.0000	0.0000	0.0000	0.0000	.0002	.0148	.0149	0.000
25	2	.464	.136	11.132	1.434	0.0000	.0013	.0095	0.0000	0.0000	0.0000	0.0000	.0001	.0137	.0139	0.000
25	3	.446	.134	11.132	1.423	0.0000	.0012	.0089	.0022	.0018	0.0000	0.0000	.0001	.0128	.0129	0.000
25	4	.446	.134	11.132	1.411	0.0000	.0011	.0085	0.0000	0.0000	0.0000	0.0000	.0001	.0121	.0122	0.000
26	1	.446	.134	11.132	1.400	0.0000	.0010	.0080	0.0000	0.0000	0.0000	0.0000	.0001	.0113	.0114	0.000
26	2	.487	.134	11.143	1.433	0.0000	.0010	.0093	.0569	.0469	.0040	.0024	.0001	.0135	.0200	.116
26	3	.474	.132	11.148	1.444	0.0000	.0009	.0097	.0304	.0250	.0015	.0006	.0001	.0141	.0162	.043
26	4	.500	.156	11.204	1.666	.0152	.0117	.0186	.3069	.2532	.0415	.7629	.0013	.0316	.8373	1.185
27	1	.500	.156	11.216	1.687	0.0000	.0107	.0194	.0664	.0549	.0021	.0043	.0011	.0334	.0409	.059
27	2	.498	.156	11.220	1.671	0.0000	.0096	.0187	.0194	.0160	.0007	.0003	.0010	.0318	.0338	.020
27	3	.496	.151	11.224	1.660	0.0000	.0087	.0179	.0229	.0190	.0007	.0002	.0009	.0302	.0321	.021
27	4	.500	.151	11.224	1.632	0.0000	.0078	.0168	0.0000	0.0000	.0001	0.0000	.0008	.0280	.0289	.004
28	1	.500	.151	11.224	1.607	0.0000	.0070	.0157	0.0000	0.0000	0.0000	0.0000	.0008	.0256	.0264	0.000
28	2	.483	.151	11.224	1.583	0.0000	.0063	.0146	0.0000	0.0000	0.0000	0.0000	.0007	.0235	.0242	0.000
28	3	.450	.147	11.225	1.565	0.0000	.0057	.0137	.0039	.0033	0.0000	0.0000	.0006	.0216	.0222	0.000
28	4	.450	.147	11.225	1.545	0.0000	.0051	.0129	0.0000	0.0000	0.0000	0.0000	.0005	.0202	.0207	0.000
29	1	.450	.147	11.225	1.526	0.0000	.0046	.0121	0.0000	0.0000	0.0000	0.0000	.0005	.0186	.0191	0.000
29	2	.433	.147	11.225	1.509	0.0000	.0042	.0113	0.0000	0.0000	0.0000	0.0000	.0004	.0172	.0177	0.000
29	3	.399	.143	11.225	1.496	0.0000	.0037	.0106	.0033	.0028	0.0000	0.0000	.0004	.0160	.0164	0.000
29	4	.399	.143	11.225	1.480	0.0000	.0034	.0101	0.0000	0.0000	0.0000	0.0000	.0004	.0150	.0154	0.000
30	1	.399	.143	11.225	1.466	0.0000	.0030	.0094	0.0000	0.0000	0.0000	0.0000	.0003	.0140	.0143	0.000
30	2	.375	.143	11.225	1.453	0.0000	.0027	.0089	0.0000	0.0000	0.0000	0.0000	.0003	.0130	.0133	0.000
30	3	.326	.140	11.226	1.444	0.0000	.0025	.0084	.0029	.0024	0.0000	0.0000	.0003	.0122	.0124	0.000
30	4	.326	.140	11.226	1.432	0.0000	.0022	.0080	0.0000	0.0000	0.0000	0.0000	.0002	.0115	.0118	0.000
31	1	.326	.140	11.226	1.421	0.0000	.0020	.0076	0.0000	0.0000	0.0000	0.0000	.0002	.0108	.0110	0.000
31	2	.307	.140	11.226	1.411	0.0000	.0018	.0072	0.0000	0.0000	0.0000	0.0000	.0002	.0102	.0104	0.000
31	3	.269	.138	11.226	1.404	0.0000	.0016	.0068	.0025	.0021	0.0000	0.0000	.0002	.0096	.0097	0.000
31	4	.269	.138	11.226	1.394	0.0000	.0014	.0065	0.0000	0.0000	0.0000	0.0000	.0002	.0091	.0093	0.000

MONTHLY SUMMARY FOR LEAF RIVER BASIN-----MISSISSIPPI

JAN 1962

PRECIPITATION GAGE SUMMARY

SOIL MOISTURE ACCOUNTING VOLUMES

RG	PRECIP GAGE NAME	TOTAL RO	SURFACE RO	IMPV RO	INTERFLOW	GW FLOW	RECHARGE	PRECIP	POTENTIAL-ET	ACTUAL-ET
1	MBP OF COLLINS,MISS	8.273	4.895	.342	.033	3.003	0.000	9.77	.816	.787
2	MBP BOWIE CREEK	5.811	1.070	.313	.375	4.053	.920	8.46	1.119	1.077
3	HATTIESBURG LOCAL	7.045	3.746	.295	.047	2.956	0.000	8.44	.816	.787

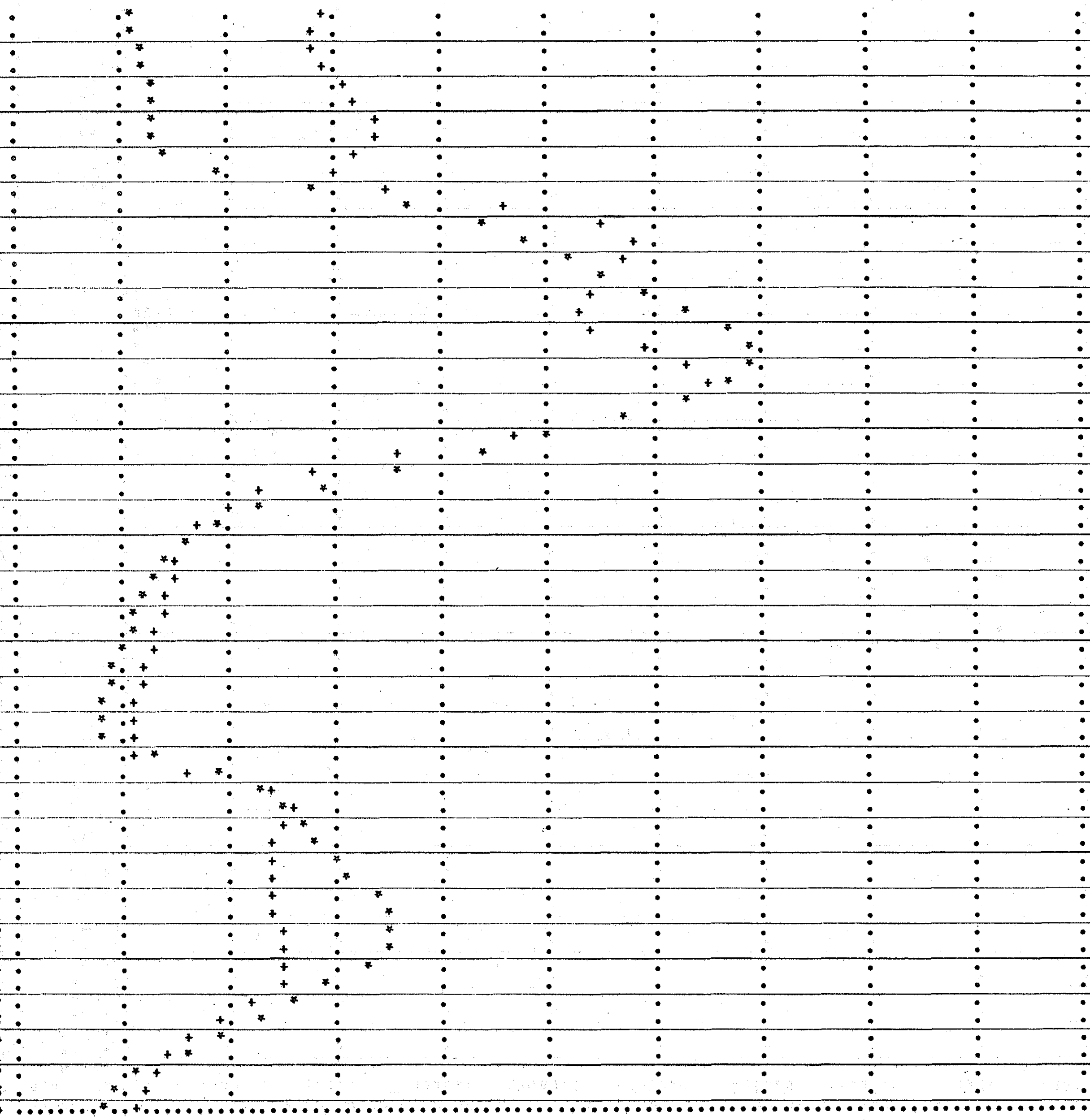
SOIL MOISTURE VARIABLES AT END OF MONTH

PRECIP GAGE NAME	UZS	LZS	SGW	GWS	RES	SRGX	SCEP	BALANCE
MBP OF COLLINS,MISS	.14	11.23	1.39	.10	0.00	.00	.27	-.000
MBP BOWIE CREEK	.44	10.09	4.20	.04	0.00	.01	0.00	-.000
HATTIESBURG LOCAL	.14	11.32	2.73	.07	0.00	.00	.27	-.000

SIX HOUR FLOW PLOT LEAF RIVER NR COLLINS MISS. JAN ,1962 *=SIMULATED +=OBSERVED

TIME 0.0 2000.0 4000.0 6000.0 8000.0 10000.0 12000.0 14000.0 16000.0 18000.0 20000.0

TIME	SIMULATED	OBSERVED
1-1	746.6	1465.0
1-2	813.9	1584.0
1-3	873.0	1559.0
1-4	932.7	1659.0
2-1	994.5	1775.0
2-2	1060.3	1840.0
2-3	1129.9	1857.0
2-4	1185.3	1834.0
3-1	1220.2	1784.0
3-2	1227.1	1719.0
3-3	1207.1	1654.0
3-4	1166.1	1654.0
4-1	1112.6	1419.0
4-2	1046.6	1275.0
4-3	974.5	1150.0
4-4	893.7	1073.0
5-1	2436.6	1094.0
5-2	5853.0	3912.0
5-3	8825.3	8400.0
5-4	11000.3	11320.0
6-1	12602.7	13319.0
6-2	13776.2	14470.0
6-3	14900.5	15060.0
6-4	15985.7	15200.0
7-1	17221.1	15499.0
7-2	18434.6	15920.0
7-3	19136.8	16599.0
7-4	19203.3	17559.0
8-1	18477.6	18319.0
8-2	17075.4	18239.0
8-3	15283.4	17319.0
8-4	13316.3	16020.0
9-1	11214.0	14139.0
9-2	9151.4	11139.0
9-3	6800.3	7859.0
9-4	4860.9	5907.0
10-1	3850.1	4728.0
10-2	3200.1	3992.0
10-3	2824.1	3470.0
10-4	2583.9	3105.0
11-1	2416.5	2846.0
11-2	2295.1	2629.0
11-3	2198.9	2463.0
11-4	2131.7	2313.0
12-1	2071.5	2151.0
12-2	2013.1	1912.0
12-3	1944.4	1739.0
12-4	1865.0	1595.0
13-1	1772.1	1525.0
13-2	1675.6	1510.0
13-3	1572.2	1475.0
13-4	1467.3	1405.0
14-1	1360.9	1400.0
14-2	1241.9	1405.0
14-3	1143.5	1405.0
14-4	1129.3	1489.0
15-1	1343.9	2541.0
15-2	1591.4	4431.0
15-3	1766.8	5818.0
15-4	1901.1	6151.0
16-1	2006.8	6052.0



16-2	2110.8	5790.0
16-3	2224.0	5647.0
16-4	2341.9	5682.0
17-1	2481.1	5701.0
17-2	2582.0	6124.0
17-3	2635.5	6465.0
17-4	2617.1	6730.0
18-1	2538.9	6760.0
18-2	2818.5	6394.0
18-3	3783.2	5980.0
18-4	5595.0	7060.0
19-1	7430.7	9220.0
19-2	8719.1	10999.0
19-3	9590.6	11660.0
19-4	10333.1	11440.0
20-1	11047.2	10979.0
20-2	11842.7	10760.0
20-3	12642.2	10560.0
20-4	13410.4	10900.0
21-1	13858.9	11739.0
21-2	13882.1	12600.0
21-3	13401.9	12940.0
21-4	12527.6	12609.0
22-1	11361.9	11340.0
22-2	10078.9	9329.0
22-3	8709.0	7209.0
22-4	7250.7	5611.0
23-1	5823.7	4568.0
23-2	4545.3	3928.0
23-3	3732.3	3483.0
23-4	3235.8	3231.0
24-1	2895.9	3085.0
24-2	2640.1	2945.0
24-3	2434.2	2819.0
24-4	2262.5	2706.0
25-1	2116.2	2595.0
25-2	1991.0	2505.0
25-3	1882.4	2445.0
25-4	1784.8	2367.0
26-1	1693.8	2271.0
26-2	1618.3	2187.0
26-3	1553.6	2127.0
26-4	2581.6	2151.0
27-1	3780.0	3266.0
27-2	4527.0	4765.0
27-3	5033.3	5161.0
27-4	5356.5	4999.0
28-1	5632.6	4864.0
28-2	5966.6	4801.0
28-3	6256.7	4791.0
28-4	6708.0	4791.0
29-1	6982.3	4836.0
29-2	7097.4	4936.0
29-3	6914.8	5035.0
29-4	6512.0	5061.0
30-1	5886.4	4927.0
30-2	5253.4	4431.0
30-3	4534.6	3744.0
30-4	3836.0	3287.0
31-1	3143.4	2888.0
31-2	2267.3	2547.0
31-3	1805.3	2307.0
31-4	1540.0	2176.0

WATER YEAR SUMMARY FOR-- LEAF RIVER NR COLLINS MISS.

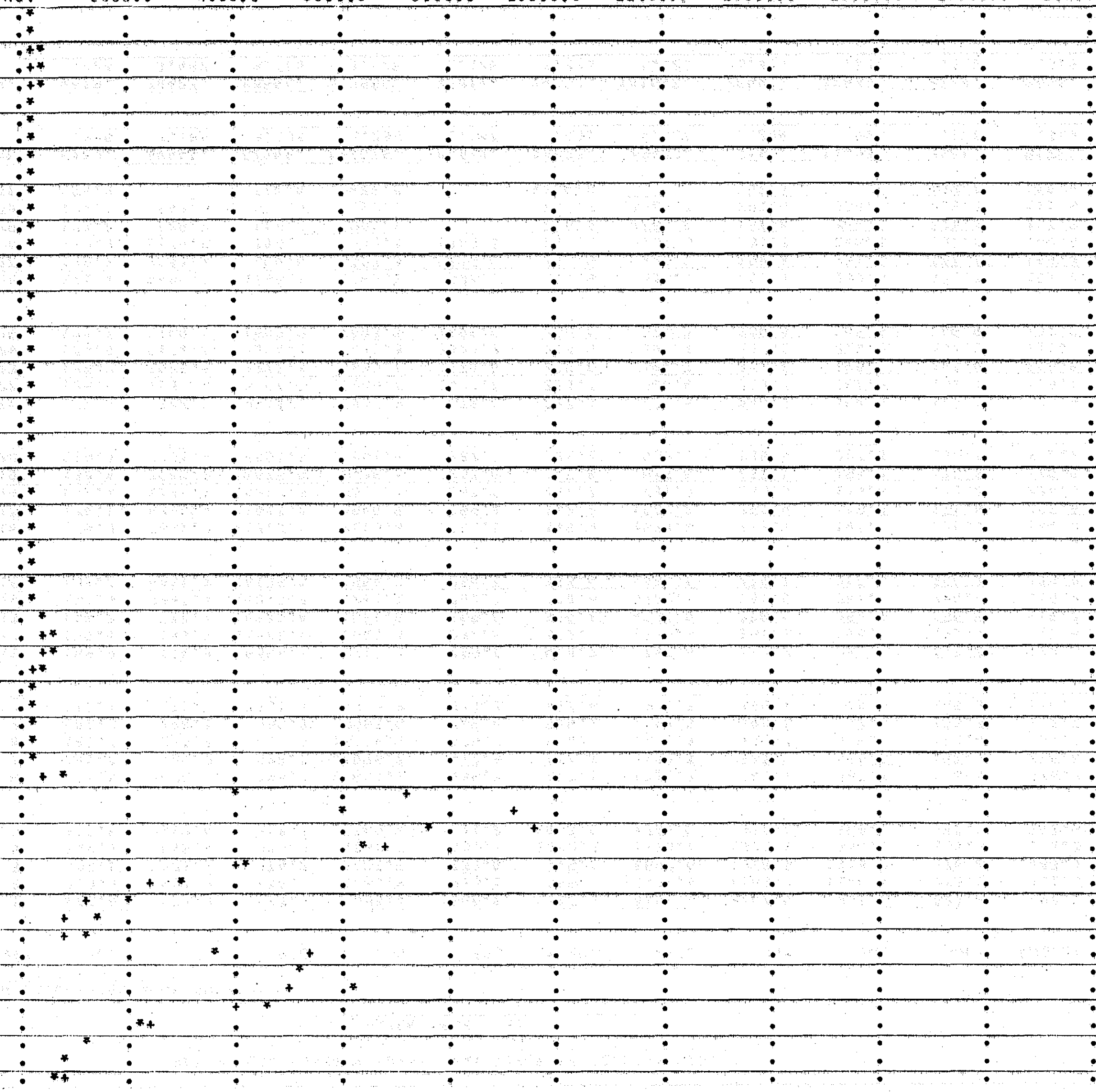
WATER YEAR 1962

MEAN DAILY DISCHARGE SUMMARY

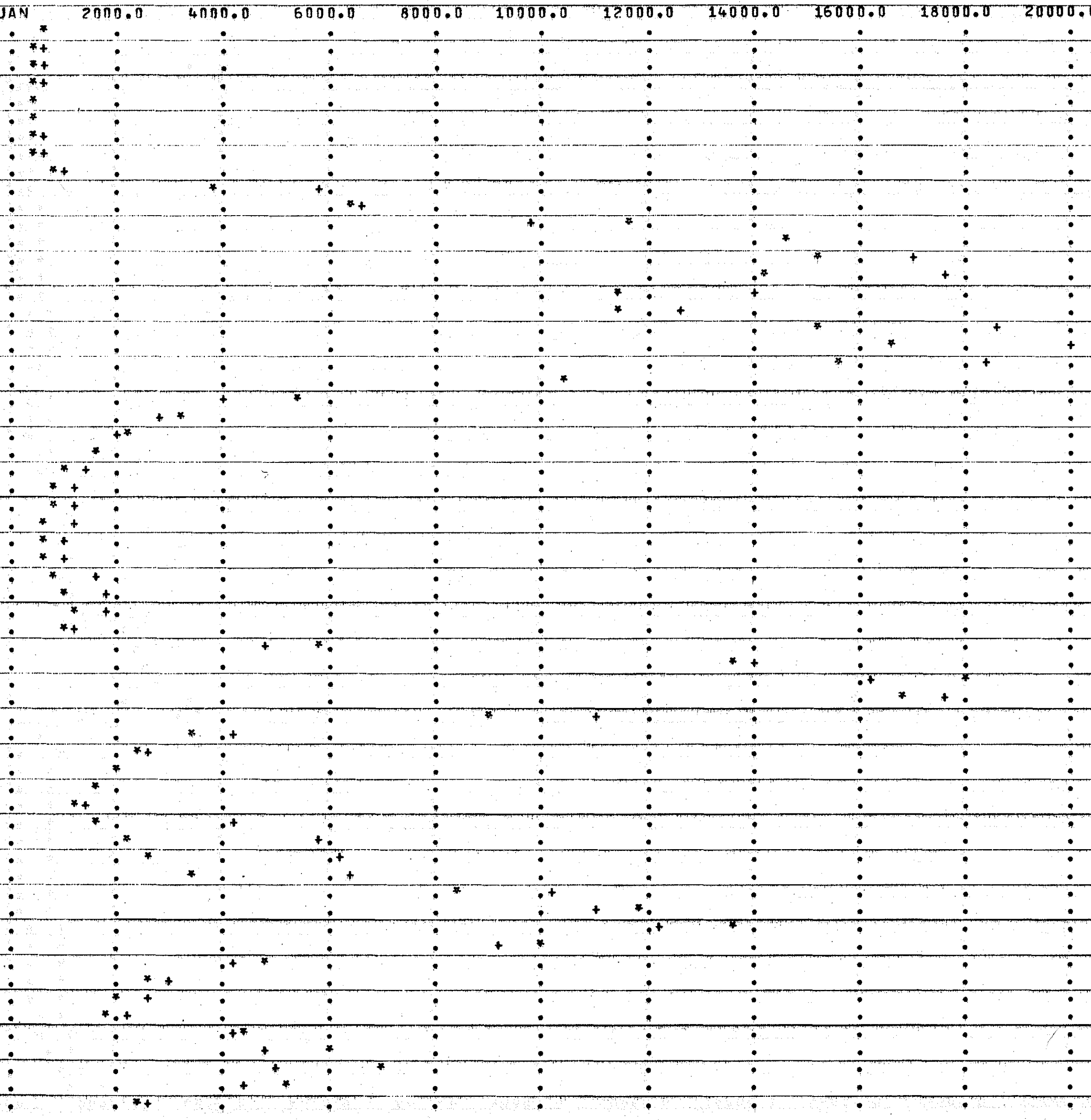
DAY	OCT	NOV	DEC	JAN	FEB	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPT	ANNUAL
1	173.6	123.0	523.9	808.4	1266.6	1112.1	8168.9	8707.4	935.6	223.2	192.0	111.0	
2	219.0	117.2	436.3	1060.9	938.1	955.1	10436.8	4169.0	1144.4	203.2	321.9	103.9	
3	307.1	225.7	374.2	1207.5	739.0	949.1	8697.6	1918.5	1018.2	176.8	483.3	98.8	
4	347.5	446.4	329.9	1040.9	601.8	1002.2	3978.7	1329.1	800.2	165.8	608.3	96.8	
5	337.6	619.4	318.5	5765.5	511.2	1043.4	1284.6	977.1	669.1	162.2	557.6	122.3	
6	267.6	635.2	345.7	13693.1	456.2	947.1	1021.9	742.4	557.3	156.6	376.2	220.6	
7	201.7	464.9	392.7	18096.7	412.9	777.7	1109.3	588.2	468.6	152.3	225.6	263.6	
8	180.7	278.8	428.0	16774.1	379.7	634.1	1221.8	482.7	375.0	150.4	167.9	268.4	
9	181.2	200.1	865.0	9063.6	345.4	534.1	1198.9	408.8	313.4	151.3	142.2	187.6	
10	177.0	171.5	3761.3	3399.2	318.0	467.4	974.5	356.4	278.9	165.3	126.1	138.6	
11	169.0	154.8	6356.5	2317.1	299.7	418.7	742.8	318.9	263.6	173.7	120.6	161.8	
12	155.6	145.9	11676.1	2006.8	282.3	372.1	2529.6	291.8	258.9	198.4	117.5	210.3	
13	144.7	737.7	14583.8	1671.5	269.2	325.8	4537.0	276.1	252.9	250.5	115.3	208.6	
14	140.4	3947.4	15243.0	1261.1	260.3	300.5	5702.1	281.5	241.0	264.4	116.4	209.2	
15	138.0	6061.2	14135.3	1554.3	254.3	333.4	4884.5	279.3	217.6	256.2	130.8	347.7	
16	135.9	7641.2	11315.1	2115.8	259.1	345.0	2528.4	272.6	197.7	205.5	184.3	404.0	
17	134.1	6364.4	11417.2	2544.5	259.8	342.9	1095.2	251.4	189.3	171.6	205.6	425.0	
18	132.4	4180.1	15249.5	3311.7	263.6	297.7	781.9	239.5	185.6	172.2	220.6	284.9	
19	130.8	2983.2	16625.9	8426.1	283.0	247.8	615.6	237.1	198.0	172.5	186.0	133.9	
20	129.3	2031.8	15560.6	11851.0	287.7	231.6	502.2	235.5	297.3	157.7	152.7	94.4	
21	127.9	1382.7	10489.7	13527.9	672.1	227.1	421.8	226.2	348.6	140.1	135.9	83.7	
22	126.6	1131.4	5397.7	10009.7	1427.7	223.7	364.4	215.0	367.0	136.1	125.0	80.1	
23	125.2	3535.5	3222.3	4836.1	2170.0	220.6	324.3	209.7	296.5	143.9	116.6	78.2	
24	124.0	5174.1	2154.1	2679.8	2803.2	217.6	308.9	207.1	216.2	147.2	118.8	76.7	
25	122.7	6149.1	1509.2	2003.3	2696.6	234.0	324.2	204.8	205.6	146.9	137.2	75.5	
26	121.4	4698.5	1095.1	1762.2	2308.2	250.5	328.4	202.5	239.3	151.3	151.8	74.8	
27	120.2	2233.4	844.4	4327.3	1855.8	257.6	499.1	200.4	251.2	187.8	159.3	74.6	
28	119.0	1129.0	709.5	5972.0	1388.3	244.8	5161.6	198.3	246.3	207.0	140.9	74.0	
29	120.2	829.7	618.2	6901.1		218.5	8764.7	197.8	240.2	214.0	117.2	73.1	
30	124.0	648.5	537.3	5212.1		205.7	10963.8	291.6	225.5	210.3	111.6	71.5	
31	125.0		524.0	2476.0		4084.8		652.0		189.7	110.4		
TOTAL	5150.	64444.	167040.	167678.	24010.	18023.	89473.	25169.	11499.	5604.	6176.	4854.	589129. CFSD
	.255	3.186	8.258	8.289	1.187	.891	4.423	1.244	.568	.277	.305	.240	29.12 INCHES
													1170010. ACRE-FT
OBSV.	4619.	70427.	188546.	179550.	43014.	24737.	101643.	20441.	12904.	6280.	7466.	4701.	664428. CFSD
	.228	3.482	9.326	8.876	2.126	1.223	5.025	1.010	.638	.310	.369	.232	32.85 INCHES
													1319554. ACRE-FT

MEAN DAILY FLOW PLOT   LEAF RIVER NR COLLINS MISS.   WATER YEAR 1962   *=SIMULATED   +=OBSERVED

OCT-NOV   2000.0   4000.0   6000.0   8000.0   10000.0   12000.0   14000.0   16000.0   18000.0   20000.0



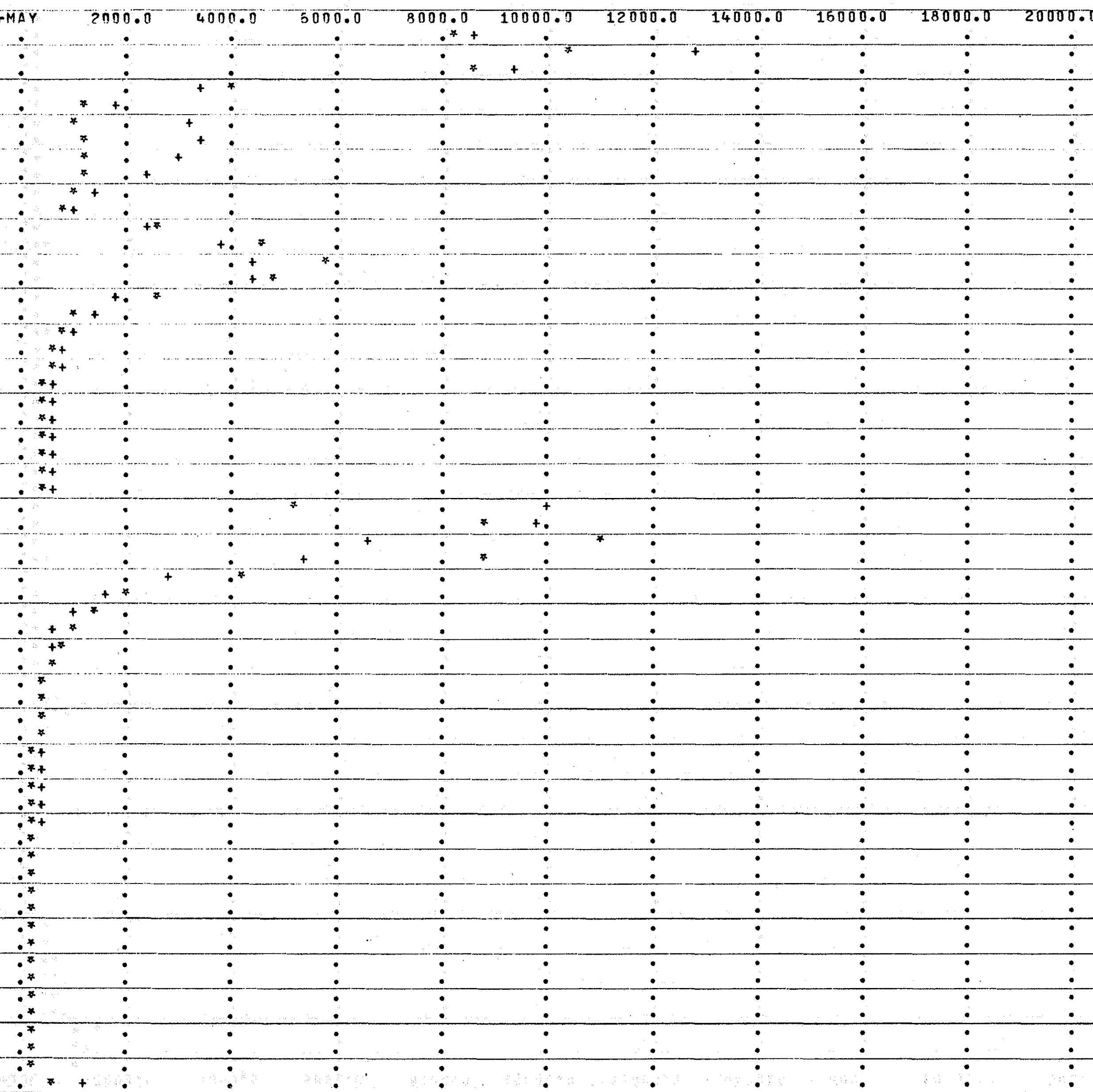
OCT-NOV	SIMULATED	OBSERVED	PRECIP
1	173.6	161.0	.24
2	219.0	167.0	.59
3	307.1	205.0	0.00
4	347.5	241.0	0.00
5	337.6	203.0	0.00
6	267.6	187.0	0.00
7	201.7	169.0	.03
8	180.7	169.0	.08
9	181.2	173.0	0.00
10	177.0	163.0	0.00
11	169.0	152.0	0.00
12	155.6	148.0	0.00
13	144.7	143.0	0.00
14	140.4	139.0	0.00
15	138.0	134.0	0.00
16	135.9	132.0	0.00
17	134.1	132.0	0.00
18	132.4	132.0	0.00
19	130.8	130.0	0.00
20	129.3	128.0	0.00
21	127.9	128.0	0.00
22	126.6	128.0	0.00
23	125.2	130.0	0.00
24	124.0	130.0	0.00
25	122.7	130.0	0.00
26	121.4	130.0	0.00
27	120.2	126.0	0.00
28	119.0	125.0	0.00
29	120.2	126.0	.05
30	124.0	128.0	0.00
31	125.0	130.0	0.00
1	123.0	130.0	0.00
2	117.2	132.0	.00
3	226.7	171.0	1.71
4	446.4	407.0	.48
5	619.4	461.0	.02
6	636.2	359.0	0.00
7	464.9	276.0	0.00
8	278.8	228.0	0.00
9	200.1	197.0	0.00
10	171.5	181.0	0.00
11	154.8	171.0	0.00
12	145.9	167.0	.26
13	737.7	459.0	4.79
14	3947.4	7230.0	.09
15	6061.2	9140.0	.97
16	7641.2	9680.0	.04
17	6364.4	6730.0	0.00
18	4180.1	4000.0	.00
19	2983.2	2420.0	.00
20	2031.8	1220.0	0.00
21	1382.7	846.0	0.00
22	1131.4	798.0	1.98
23	3535.5	5450.0	.07
24	5174.1	5230.0	.00
25	6149.1	5040.0	0.00
26	4698.5	3980.0	0.00
27	2233.4	2460.0	0.00
28	1129.0	1220.0	0.00
29	829.7	898.0	0.00
30	648.5	746.0	0.00



DEC-JAN	SIMULATED	OBSERVED	PRECIP
1	523.9	651.0	0.00
2	436.3	588.0	0.00
3	374.2	546.0	.00
4	329.9	517.0	0.00
5	318.5	493.0	.34
6	345.7	498.0	.24
7	392.7	560.0	0.00
8	428.0	580.0	.48
9	865.0	1020.0	2.00
10	3761.3	5830.0	.11
11	6356.5	6680.0	1.32
12	11676.1	9820.0	1.77
13	14583.8	14500.0	.07
14	15243.0	17000.0	1.09
15	14135.3	17500.0	.52
16	11315.1	14000.0	.56
17	11417.2	12600.0	2.49
18	15249.5	18700.0	0.00
19	16625.9	20400.0	0.00
20	15560.6	18400.0	0.00
21	10489.7	10300.0	0.00
22	5397.7	4060.0	.03
23	3222.3	2750.0	0.00
24	2154.1	2040.0	0.00
25	1509.2	1550.0	0.00
26	1095.1	1340.0	.00
27	844.4	1230.0	.31
28	709.5	1270.0	0.00
29	618.2	1180.0	0.00
30	537.3	1050.0	0.00
31	524.0	993.0	.55
1	808.4	1500.0	0.00
2	1060.9	1800.0	0.00
3	1207.5	1710.0	0.00
4	1040.9	1280.0	.12
5	5765.5	4800.0	3.82
6	13693.1	14000.0	.07
7	18096.7	16200.0	.02
8	16774.1	17600.0	0.00
9	9063.6	11000.0	.28
10	3399.2	4250.0	.05
11	2317.1	2680.0	0.00
12	2006.8	1920.0	0.00
13	1671.5	1510.0	0.00
14	1261.1	1410.0	.35
15	1554.3	4160.0	.44
16	2115.8	5870.0	0.00
17	2544.5	6150.0	0.00
18	3311.7	6490.0	2.58
19	8426.1	10200.0	.42
20	11851.0	10900.0	.01
21	13527.9	12100.0	0.00
22	10009.7	9280.0	.00
23	4836.1	4200.0	.17
24	2679.8	2940.0	0.00
25	2003.3	2520.0	0.00
26	1762.2	2210.0	1.35
27	4327.3	4190.0	.10
28	5972.0	4850.0	0.00
29	6901.1	4920.0	0.00
30	5212.1	4320.0	0.00
31	2476.0	2590.0	0.00

FEB-MAR 2000.0 4000.0 6000.0 8000.0 10000.0 12000.0 14000.0 16000.0 18000.0 20000.0

FEB-MAR	SIMULATED	OBSERVED	PRECIP
1	1266.6	1900.0	0.00
2	938.1	1430.0	0.00
3	739.0	1230.0	0.00
4	601.8	1130.0	0.00
5	511.2	1080.0	.12
6	456.2	1060.0	0.00
7	412.9	1030.0	0.00
8	379.7	986.0	.05
9	345.4	950.0	0.00
10	318.0	906.0	0.00
11	299.7	853.0	0.00
12	282.3	798.0	0.00
13	269.2	766.0	0.00
14	260.3	738.0	0.00
15	254.3	742.0	.09
16	259.1	823.0	0.00
17	259.8	766.0	.01
18	263.6	752.0	.26
19	283.0	802.0	0.00
20	287.7	982.0	.29
21	672.1	1670.0	.97
22	1427.7	3240.0	.10
23	2170.0	3420.0	.35
24	2803.2	4040.0	0.00
25	2696.6	4100.0	0.00
26	2308.2	2850.0	.25
27	1855.8	2250.0	0.00
28	1388.3	1720.0	.05
1	1112.1	1280.0	.13
2	955.1	1130.0	.23
3	949.1	1130.0	0.00
4	1002.2	1070.0	.07
5	1043.4	1040.0	0.00
6	947.1	966.0	0.00
7	777.7	849.0	0.00
8	634.1	776.0	.01
9	534.1	725.0	.15
10	467.4	711.0	.01
11	418.7	725.0	.00
12	372.1	742.0	.00
13	325.8	694.0	0.00
14	300.5	636.0	.44
15	333.4	776.0	0.00
16	345.0	780.0	0.00
17	342.9	721.0	0.00
18	297.7	656.0	0.00
19	247.8	592.0	0.00
20	231.6	556.0	.00
21	227.1	544.0	.00
22	223.7	529.0	0.00
23	220.6	505.0	0.00
24	217.6	486.0	0.00
25	234.0	494.0	.22
26	250.5	502.0	0.00
27	257.6	466.0	0.00
28	244.8	447.0	0.00
29	218.5	431.0	0.00
30	205.7	418.0	.21
31	4084.8	3360.0	2.72



APR-MAY	SIMULATED	OBSERVED	PRECIP
1	8168.9	8650.0	0.00
2	10436.8	12900.0	0.00
3	8697.6	9500.0	0.00
4	3978.7	3420.0	0.00
5	1284.6	1840.0	.20
6	1021.9	3100.0	.77
7	1109.3	3300.0	0.00
8	1221.8	2900.0	0.00
9	1198.9	2320.0	0.00
10	974.5	1450.0	.07
11	742.8	1010.0	.60
12	2529.6	2330.0	1.34
13	4537.0	3870.0	0.00
14	5702.1	4500.0	0.00
15	4884.5	4430.0	0.00
16	2528.4	1720.0	0.00
17	1095.2	1330.0	.01
18	781.9	922.0	.00
19	615.6	798.0	0.00
20	502.2	742.0	0.00
21	421.8	697.0	0.00
22	364.4	636.0	0.00
23	324.3	592.0	.06
24	308.9	571.0	.26
25	324.2	556.0	.03
26	328.4	550.0	0.00
27	499.1	559.0	2.53
28	5161.6	9950.0	1.02
29	8764.7	9860.0	0.00
30	10963.8	6640.0	.05
1	8707.4	5380.0	.12
2	4169.0	2830.0	0.00
3	1918.5	1560.0	0.00
4	1329.1	918.0	0.00
5	977.1	694.0	0.00
6	742.4	601.0	0.00
7	588.2	526.0	.00
8	482.7	477.0	0.00
9	408.8	434.0	0.00
10	356.4	398.0	0.00
11	318.9	374.0	0.00
12	291.8	357.0	0.00
13	276.1	337.0	.17
14	281.5	326.0	0.00
15	279.3	321.0	0.00
16	272.6	317.0	.00
17	251.4	300.0	.08
18	239.5	294.0	0.00
19	237.1	282.0	0.00
20	235.5	268.0	0.00
21	226.2	258.0	0.00
22	215.0	251.0	0.00
23	209.7	238.0	0.00
24	207.1	234.0	0.00
25	204.8	228.0	0.00
26	202.5	223.0	0.00
27	200.4	216.0	0.00
28	198.3	208.0	0.00
29	197.8	203.0	.13
30	291.6	258.0	2.24
31	652.0	1130.0	.02

JUN-JUL	2000.0 4000.0 6000.0 8000.0 10000.0 12000.0 14000.0 16000.0 18000.0 20000.0	SIMULATED	OBSERVED	PRECIP
1	*	935.6	1070.0	.47
2	+*	1144.4	962.0	.02
3	* +	1018.2	1310.0	.10
4	+*	800.2	662.0	.40
5	+*	669.1	480.0	0.00
6	+*	557.3	474.0	.09
7	*+	468.6	514.0	.00
8	*	375.0	383.0	.08
9	*	313.4	352.0	0.00
10	*	278.9	296.0	.02
11	*	263.6	276.0	.15
12	*	258.9	264.0	.04
13	*	252.9	258.0	0.00
14	*	241.0	241.0	0.00
15	*	217.6	228.0	0.00
16	*	197.7	214.0	0.00
17	*	189.3	205.0	0.00
18	*	185.6	198.0	0.00
19	*	198.0	194.0	.82
20	* +	297.3	610.0	0.00
21	* +	348.6	745.0	0.00
22	*+	367.0	659.0	0.00
23	*+	296.5	364.0	.01
24	*	216.2	282.0	.09
25	*	205.6	262.0	.30
26	*	239.3	253.0	.01
27	*	251.2	240.0	0.00
28	*	246.3	230.0	.25
29	*	240.2	292.0	.03
30	*+	225.5	386.0	0.00
1	*	223.2	284.0	.00
2	*	203.2	241.0	.03
3	*	176.8	217.0	0.00
4	*	165.8	203.0	0.00
5	*	162.2	190.0	0.00
6	*	156.6	185.0	0.00
7	*	152.3	176.0	0.00
8	*	150.4	171.0	0.00
9	*	151.3	167.0	.13
10	*	165.3	163.0	0.00
11	*	173.7	162.0	.11
12	*	198.4	191.0	.49
13	*+	250.5	405.0	.00
14	*	264.4	234.0	0.00
15	*	256.2	189.0	0.00
16	*	205.5	180.0	.15
17	*	171.6	199.0	.04
18	*+	172.2	357.0	0.00
19	*	172.5	274.0	0.00
20	*	157.7	207.0	0.00
21	*	140.1	180.0	0.00
22	*	136.1	169.0	.09
23	*	143.9	171.0	0.00
24	*	147.2	163.0	.01
25	*	146.9	156.0	.04
26	*	151.3	158.0	.37
27	*	187.8	165.0	.02
28	*	207.0	167.0	.02
29	*	214.0	169.0	.28
30	*	210.3	207.0	.01
31	*	189.7	180.0	.02

AUG-SEP		2000.0	4000.0	6000.0	8000.0	10000.0	12000.0	14000.0	16000.0	18000.0	20000.0	SIMULATED	OBSERVED	PRECIP
1	.*	.	.	.	.	.	.	.	.	.	.	192.0	165.0	1.12
2	. *	.	.	.	.	.	.	.	.	.	.	321.9	342.0	.87
3	. * +	.	.	.	.	.	.	.	.	.	.	483.3	1010.0	.37
4	. *+	.	.	.	.	.	.	.	.	.	.	608.3	704.0	.02
5	. +*	.	.	.	.	.	.	.	.	.	.	557.6	362.0	.11
6	.+*	.	.	.	.	.	.	.	.	.	.	376.2	268.0	0.00
7	.*	.	.	.	.	.	.	.	.	.	.	225.6	240.0	0.00
8	.*	.	.	.	.	.	.	.	.	.	.	167.9	219.0	0.00
9	.*	.	.	.	.	.	.	.	.	.	.	142.2	200.0	0.00
10	.*	.	.	.	.	.	.	.	.	.	.	126.1	180.0	.01
11	.*	.	.	.	.	.	.	.	.	.	.	120.6	170.0	0.00
12	.*	.	.	.	.	.	.	.	.	.	.	117.5	160.0	0.00
13	.*	.	.	.	.	.	.	.	.	.	.	115.3	156.0	.02
14	.*	.	.	.	.	.	.	.	.	.	.	116.4	172.0	.05
15	.*	.	.	.	.	.	.	.	.	.	.	130.8	178.0	.44
16	.*	.	.	.	.	.	.	.	.	.	.	184.3	170.0	0.00
17	.*	.	.	.	.	.	.	.	.	.	.	205.6	165.0	.16
18	.*	.	.	.	.	.	.	.	.	.	.	220.6	165.0	.00
19	.*	.	.	.	.	.	.	.	.	.	.	186.0	160.0	.05
20	.*	.	.	.	.	.	.	.	.	.	.	152.7	160.0	.01
21	.*	.	.	.	.	.	.	.	.	.	.	135.9	155.0	.05
22	.*	.	.	.	.	.	.	.	.	.	.	125.0	155.0	0.00
23	.*	.	.	.	.	.	.	.	.	.	.	116.6	150.0	.00
24	.*	.	.	.	.	.	.	.	.	.	.	118.8	150.0	.15
25	.*	.	.	.	.	.	.	.	.	.	.	137.2	250.0	.14
26	.*+	.	.	.	.	.	.	.	.	.	.	151.8	330.0	.05
27	.*	.	.	.	.	.	.	.	.	.	.	159.3	250.0	0.00
28	.*	.	.	.	.	.	.	.	.	.	.	140.9	200.0	0.00
29	.*	.	.	.	.	.	.	.	.	.	.	117.2	170.0	.08
30	.*	.	.	.	.	.	.	.	.	.	.	111.6	160.0	.01
31	.*	.	.	.	.	.	.	.	.	.	.	110.4	150.0	.01
1	.*	.	.	.	.	.	.	.	.	.	.	111.0	140.0	0.00
2	.*	.	.	.	.	.	.	.	.	.	.	103.9	135.0	.04
3	*+	.	.	.	.	.	.	.	.	.	.	98.8	130.0	.00
4	*+	.	.	.	.	.	.	.	.	.	.	96.8	130.0	0.00
5	.*	.	.	.	.	.	.	.	.	.	.	122.3	129.0	.87
6	.*	.	.	.	.	.	.	.	.	.	.	220.6	178.0	0.00
7	.*	.	.	.	.	.	.	.	.	.	.	263.6	201.0	.03
8	.*	.	.	.	.	.	.	.	.	.	.	268.4	156.0	0.00
9	.*	.	.	.	.	.	.	.	.	.	.	187.6	154.0	.25
10	.*	.	.	.	.	.	.	.	.	.	.	138.6	268.0	.15
11	.*	.	.	.	.	.	.	.	.	.	.	161.8	178.0	.30
12	.*	.	.	.	.	.	.	.	.	.	.	210.3	163.0	.00
13	.*	.	.	.	.	.	.	.	.	.	.	208.6	158.0	.01
14	.*	.	.	.	.	.	.	.	.	.	.	209.2	144.0	1.55
15	. *	.	.	.	.	.	.	.	.	.	.	347.7	394.0	.01
16	.+*	.	.	.	.	.	.	.	.	.	.	404.0	241.0	.07
17	.+*	.	.	.	.	.	.	.	.	.	.	425.0	189.0	0.00
18	.*	.	.	.	.	.	.	.	.	.	.	284.9	154.0	0.00
19	.*	.	.	.	.	.	.	.	.	.	.	133.9	140.0	0.00
20	*+	.	.	.	.	.	.	.	.	.	.	94.4	133.0	0.00
21	*+	.	.	.	.	.	.	.	.	.	.	83.7	126.0	0.00
22	*+	.	.	.	.	.	.	.	.	.	.	80.1	122.0	0.00
23	*+	.	.	.	.	.	.	.	.	.	.	78.2	122.0	0.00
24	*+	.	.	.	.	.	.	.	.	.	.	76.7	120.0	0.00
25	*+	.	.	.	.	.	.	.	.	.	.	75.5	119.0	0.00
26	*+	.	.	.	.	.	.	.	.	.	.	74.8	119.0	.01
27	*+	.	.	.	.	.	.	.	.	.	.	74.6	117.0	0.00
28	*+	.	.	.	.	.	.	.	.	.	.	74.0	115.0	0.00
29	*+	.	.	.	.	.	.	.	.	.	.	73.1	114.0	0.00
30	*+	.	.	.	.	.	.	.	.	.	.	71.5	112.0	0.00

STATISTICAL SUMMARY

FLOW POINT = LEAF RIVER NR COLLINS MISS.   WATER YEAR = 1962

MONTH	SIMULATED MEAN	OBSERVED MEAN	BIAS (SIM MEAN -OBS MEAN)	PERCENT BIAS	1ST MOMENT (SIM)-1ST MOMENT(OBS)	MAXIMUM ERROR	STANDARD ERROR	PERCENT STANDARD ERROR	CORREL. COEFF	BEST FIT LINE OBS = A + B *SIM A	B
OCTOBER	166.438	149.000	17.438	11.703	-1.222	134.640	7.045	4.728	.968	77.236	.431
NOVEMBER	2148.135	2347.567	-199.432	-8.495	.413	-3282.589	917.380	39.078	.946	-194.917	1.184
DECEMBER	5388.383	6085.355	-696.972	-11.453	-.050	-3774.138	1076.863	17.696	.987	16.127	1.126
JANUARY	5408.954	5791.935	-382.982	-6.612	.425	-3754.225	1338.158	23.104	.955	978.413	.890
FEBRUARY	857.501	1536.214	-678.713	-44.181	1.162	-1812.299	277.476	18.062	.962	473.501	1.239
MARCH	581.385	797.968	-216.582	-27.142	-.099	724.805	77.323	9.690	.989	373.209	.731
APRIL	2982.446	3388.100	-405.654	-11.973	.619	-4788.399	1427.846	42.143	.908	581.186	.941
MAY	811.891	659.387	152.504	23.128	-2.293	3327.402	120.845	18.327	.993	162.227	.612
JUNE	383.306	430.133	-46.827	-10.887	-1.260	-396.435	130.558	30.353	.881	69.991	.940
JULY	180.777	202.581	-21.803	-10.763	.546	-184.789	50.648	25.001	.447	69.141	.738
AUGUST	199.224	240.839	-41.615	-17.279	-.667	-526.705	109.905	45.634	.781	29.990	1.058
SEPTEMBER	161.786	156.700	5.086	3.246	-.705	235.964	42.270	26.975	.675	94.719	.383
WATER YEAR	1614.052	1820.351	-206.299	-11.333	.024	-4788.399	823.528	45.240	.971	136.434	1.043

NOTE...SUM OF (SIM-OBS)2 = 270108859......ROOT MEAN OF SUM OF (SIM-OBS)**2 = 860.247...**

FLOW INTERVAL		NUMBER OF CASES OBSERVED	OBSERVED MEAN	SIMULATED MEAN	BIAS	PERCENT BIAS	MAXIMUM ERROR	STANDARD ERROR	PERCENT STANDARD ERROR	CORREL. COEFF	BEST FIT LINE OBS = A + B *SIM A	B
0 -	11	NO OBSERVED FLOW IN THIS INTERVAL										
11 -	67	NO OBSERVED FLOW IN THIS INTERVAL										
67 -	242	132	168.523	168.624	.101	.060	235.964	24.870	14.757	.700	103.259	.387
242 -	660	80	421.112	326.375	-94.737	-22.497	-358.290	115.492	27.425	.385	304.173	.358
660 -	1500	67	964.090	687.481	-276.608	-28.691	811.846	179.730	18.642	.561	729.495	.341
1500 -	3000	27	2166.296	1942.127	-224.169	-10.348	-1678.187	372.518	17.196	.615	1441.949	.373
3000 -	5471	26	4215.769	4239.463	23.694	.562	3327.402	455.971	10.816	.722	3117.219	.259
5471 -	9295	11	7153.636	5782.287	-1371.349	-19.170	4323.756	987.866	13.809	.582	5714.314	.249
9295 -	14933	15	11420.667	10449.702	-970.965	-8.502	-4788.399	1180.006	10.332	.724	6136.734	.506
ABOVE	14933	7	17971.429	15955.010	-2016.419	-11.220	-3774.138	1242.236	6.912	-.151	20482.961	-.157
ABOVE	1500	86	6324.419	5752.317	-572.102	-9.046	-4788.399	1629.234	25.761	.942	595.571	.996

MULTIYEAR STATISTICAL SUMMARY

FLOWPOINT = LEAF RIVER NR COLLINS MISS. WATER YEARS 1961 TO 1962

MONTH	SIMULATED MEAN	OBSERVED MEAN	BIAS (SIM MEAN -OBS MEAN)	PERCENT BIAS	1ST MOMENT (SIM)-1ST MOMENT(OBS)	MAXIMUM ERROR	STANDARD ERROR	PERCENT STANDARD ERROR	CORREL. COEFF	BEST FIT LINE OBS = A + B *SIM A	B
OCTOBER	223.545	202.516	21.029	10.384	.070	170.956	52.471	25.909	.962	-13.627	.967
NOVEMBER	1210.632	1272.267	-61.635	-4.844	-.065	-3282.589	657.907	51.711	.957	-144.495	1.170
DECEMBER	2872.342	3196.677	-324.335	-10.146	.015	-3774.138	765.748	23.954	.991	-53.929	1.132
JANUARY	3376.284	3409.984	-33.700	-.988	.499	-3754.225	1087.381	31.888	.963	178.368	.957
FEBRUARY	3971.505	4352.464	-380.959	-8.753	.694	-9557.838	1691.691	38.867	.983	152.297	1.058
MARCH	2050.265	2247.984	-197.718	-8.795	.703	-3775.363	698.038	31.052	.974	507.992	.849
APRIL	2953.789	3341.483	-387.694	-11.602	-.236	-4788.399	1173.572	35.121	.973	313.413	1.025
MAY	558.588	485.258	73.330	15.111	-1.371	3327.402	103.411	21.310	.990	142.062	.614
JUNE	1185.481	893.017	292.465	32.750	1.318	3873.348	348.018	38.971	.960	153.882	.623
JULY	725.232	890.226	-164.994	-18.534	-.647	-1948.562	449.599	50.504	.890	197.458	.955
AUGUST	286.294	311.484	-25.190	-8.087	-.372	-526.705	119.169	38.259	.707	96.557	.751
SEPTEMBER	213.260	194.317	18.943	9.749	.018	235.964	50.142	25.804	.780	72.301	.572
WATER YEAR	1619.085	1714.985	-95.900	-5.592	-10.293	-9557.838	873.381	50.926	.976	43.946	1.032

NOTE...SUM OF (SIM-OBS)2 = 574318820......ROOT MEAN OF SUM OF (SIM-OBS)**2 = 886.983...**

FLOW INTERVAL	NUMBER OF CASES OBSERVED	OBSERVED MEAN	SIMULATED MEAN	BIAS	PERCENT BIAS	MAXIMUM ERROR	STANDARD ERROR	PERCENT STANDARD ERROR	CORREL. COEFF	BEST FIT LINE OBS = A + B *SIM A	B
0 - 11	NO OBSERVED FLOW IN THIS INTERVAL										
11 - 67	NO OBSERVED FLOW IN THIS INTERVAL										
67 - 242	231	168.788	180.201	11.413	6.762	235.964	24.635	14.596	.716	100.441	.379
242 - 660	210	411.505	390.262	-21.243	-5.162	495.347	107.064	26.018	.421	295.463	.297
660 - 1500	132	979.720	791.341	-188.378	-19.228	1263.505	194.741	19.877	.439	799.985	.227
1500 - 3000	62	2147.903	1943.424	-204.479	-9.520	2559.338	413.879	19.269	.390	1750.540	.204
3000 - 5471	43	4109.767	4445.353	335.586	8.166	3873.348	498.671	12.134	.599	3204.447	.204
5471 - 9295	18	6830.000	6211.074	-618.926	-9.062	4323.756	1055.497	15.454	.318	5989.130	.135
9295 - 14933	20	11444.000	11190.923	-253.077	-2.211	-4788.399	1231.949	10.765	.651	7227.210	.377
ABOVE 14933	14	23964.286	21902.389	-2061.896	-8.604	-9557.838	2852.953	11.905	.944	-514.123	1.118
ABOVE 1500	157	6351.656	6075.756	-275.900	-4.344	-9557.838	1832.878	28.857	.963	98.627	1.029

APPENDIX G

OPERATIONAL PROGRAM - INPUT AND OUTPUT SAMPLES

SECTION G.1 PROGRAM NWSRFS5 INPUT SUMMARY FOR THE OPERATIONAL RIVER FORECAST PROGRAM

SECTION G.2-SAMPLE INPUT AND OUTPUT FROM OPERATIONAL PROGRAM--EXAMPLE ONE

SAMPLE INPUT AND OUTPUT FROM OPERATIONAL PROGRAM--EXAMPLE TWO

SAMPLE INPUT AND OUTPUT FROM OPERATIONAL PROGRAM--EXAMPLE THREE

```
C         INPUT SUMMARY FOR OPERATIONAL PROGRAM
*******************************************************************************
*CARD NO. FORMAT     CONTENTS
*******************************************************************************
C    1          I5       PUNCH 1 IN COLUMN 5
C               I5       =1 IF THE INITIAL RUN, =0 IF STARTING FROM PREVIOUS DATE
C                             (INITIAL)
C               I5       TAPE NO. OF PREVIOUS CARRYOVER TAPE(TAPE THAT CONTAINS
C                             PARAMETER VALUES AND INITIAL STORAGES)
C               I5       TAPE NO. OF CARRYOVER TAPE TO BE USED AT THE END OF THE RUN
C               I5       =1 INPUT NEW PARAMETER VALUES,   =0 NO    (INPM)
*******************************************************************************
C    2          I5       YEAR(LAST TWO DIGITS)
C               I5       MONTH NUMBER -- MONTH NO. OF INITIAL DAY
C               I5       DAY NUMBER OF INITIAL DAY
C               I5       PERIOD NUMBER OF INITIAL PERIOD (4 SIX HOUR PERIODS USED)
C               I5       CURRENT DAY NUMBER (IF IN NEXT MONTH USE DAY NO.=(DAYS IN
C                             PREVIOUS MONTH PLUS DAY NO.))
C               I5       PERIOD NUMBER OF CURRENT PERIOD
C               I5       =1 THIS IS A RERUN TO ADJUST PRECIPITATION VOLUME OR TO
C                             ROUTE NON-COMPUTER MADE FORECASTS DOWNSTREAM,
C                             =0 NO RERUN FOR ABOVE REASONS (RERUN)
C               I5       =1 INPUT NEW INITIAL SOIL MOISTURE STORAGES, =0 NO (INSTOR)
C               I5       =1 CHANGE FLOWS TO BE ROUTED DOWNSTREAM, =0 NO (INOBSER)
C               I5       =1 BEGINNING OF STORM, =0 NO
C               I5       =1 RUN TOTAL STORM INSTEAD OF JUST CURRENT UPDATE, =0 NO
*******************************************************************************
CARDS 3-4 NEEDED ONLY IF (INITIAL.EQ.0.AND.INSTOR.EQ.1)
*******************************************************************************
C    3          I5       NO. OF MBP AREAS AT WHICH TO CHANGE INITIAL SOIL MOISTURE
C                             (NGCHGE)
*******************************************************************************
C    4          I5       MBP AREA NUMBER FOR THE RUN
C           7F5.2        INITIAL SOIL MOISTURE VALUES
C                             (UZSI,LZSI,SGWI,GWSI,RESI,SRGXI,SCEPI)
C                             REPEAT CARD 4 FOR (NGCHGE) MBP AREAS)
*******************************************************************************
CARD 5  ONLY NEEDED IF (INITIAL.EQ.0).AND.(INOBSER.EQ.1)
*******************************************************************************
C     5       16I5       FLOW TO BE ROUTED DOWNSTREAM (1 TO NPTS)
C                             =1 ROUTE OBSERVED
C                             =0 ROUTE SIMULATED
*******************************************************************************
CARD 6 ONLY NEEDED IF (INITIAL.EQ.0.AND.INPM.EQ.0)
*******************************************************************************
C    6          I5       =1 OUTPUT PARAMETER VALUES, =0 NO
C               I5       LENGTH OF FORECAST IN DAYS -- THUS LAST FORECAST DAY WILL
C                             BE CURRENT DAY PLUS LENGTH     =0 IF NO FORECAST NEEDED
C               I5       =1 SNOW INCLUDED, =0 NO SNOW      SNOW NOT YET IN OPERATIONAL
```

```
*************************************************************************
*    CARDS 7 THROUGH 23 ARE ONLY NEEDED IF (INITIAL.EQ.1.OR.INPM.EQ.1)
*************************************************************************
C   7      20A4     BASIC RUN INFORMATION SUCH AS DATE,ETC.
*************************************************************************
C   8      20A4     BASIN NAME
*************************************************************************
C   9          I5   NO. OF MBP AREAS USED IN RUN (NGAGES)
C              I5   NO. OF PE STATIONS USED (NPEGS)
C              I5   NO. OF STREAM-FLOW-POINTS USED (NPTS)
C              I5   NO. OF UPSTREAM INFLOW POINTS NEEDED FROM OUTSIDE
C                       AREA BEING RUN (NPTSUP)
*************************************************************************
C  10      10A4     NAME OF PE STATION
C              I5   NEP
C              I5   NDUR
C    (REPEAT CARD 10 FOR EACH PE STATION(1 TO NPEGS))--ORDER OF READ DETERMINES
C                         PE STATION NUMBER FOR THE RUN)
*************************************************************************
C  11      16I5     ASSOCIATES PE STATIONS TO MBP AREAS
C                         1 TO (NGAGES) VALUES ARE NEEDED
C                   E.G. (NGAGES)=3,(NPEGS)=2, CARD 11=2,1,2
C                             THEN THE 1ST PRECIP AREA WILL USE PE FROM NO.2
C                                                                PE STATION
C                                  THE 2ND PRECIP AREA WILL USE PE FROM NO.1
C                                                                PE STATION
C                                  THE 3RD PRECIP AREA WILL USE PE FROM NO.2
C                                                                PE STATION
*************************************************************************
C  12      16I5     DESCRIBES OBSERVED DISCHARGE TO BE READ IN AT EACH
C                        FLOW-POINT (1-NPTS)
C                   =0 NO OBSERVED SIX HOUR DISCHARGE
C                   =1 OBSERVED SIX HOUR DISCHARGE IN THE PAST (INITIAL DAY,
C                        INITIAL PERIOD TO CURRENT DAY,CURRENT PERIOD)
C                   =2 OBSERVED SIX HOUR Q IN PAST PLUS EST. OF SIX HOUR Q IN
C                        THE FUTURE (THROUGH CURRENT DAY PLUS LENGTH)
C                        IF FUTURE Q IS MISSING (NEGATIVE), THEN SIMULATED
C                        FORECAST IS USED.
*************************************************************************
C  13      16I5     TYPE OF ROUTING TO BE APPLIED TO REACH ABOVE FLOW-
C                        POINT (1 TO NPTS) EQUAL TO 1 FOR NOW
C                   1 IS FOR LAG AND K ROUTING INCLUDING VARIABLE
C                   SEE CHAPTER 6 OF WRITE-UP FOR ADDING OTHER ROUTING
C                        PROCEDURES.
*************************************************************************
C  14      16I5     FLOW TO ROUTE DOWNSTREAM (1 TO NPTS)
C                   =1 ROUTE OBSERVED
C                   =0 ROUTE SIMULATED
*************************************************************************
C  15          I5   =1 OUTPUT PARAMETER VALUES, =0 NO
C              I5   LENGTH OF FORECAST IN DAYS -- THUS LAST FORECAST DAY WILL
C                        BE CURRENT DAY PLUS LENGTH      =0 IF NO FORECAST NEEDED
C              I5   =1 SNOW INCLUDED, =0 NO SNOW      SNOW NOT YET IN OPERATIONAL
C              I5   =1 IN COLUMN 20
```

```
*******************************************************************************
C  16          I5      NUMBER OF FUTURE(QPF) AREAS TO BE USED  (NFPXGS)
*******************************************************************************
C  16A      16I5      ASSOCIATES QPF AREAS TO MBP AREAS -- SAME TYPE AS CARD 11
C          CARD 16A NEEDED ONLY IF (NFPXGS.ET.0)
C               IF (NFPXGS.EQ.0) THEN FUTURE PRECIP AND PE IS SET TO 0.0
C               IF FUTURE PRECIP IS INPUT THEN FUTURE PE MUST ALSO BE INPUT
C               FOR EACH PE STATION.
*******************************************************************************
C**NOTE**  REPEAT CARDS 17 THROUGH 20 FOR EACH MBP AREA (NGAGES)
C  17         5A4     NAME OF MBP AREA
C           4F5.2     SOIL-MOISTURE VOLUME PARAMETERS
C          ,F5.1,            MOD. STANFORD WATERSHED MODEL
C           F5.2,            ORDER OF PARAMETERS IS --
C          2F5.1,                  K1,A,EPXM,UZSN,LZSN,CB,POWER,CC,K24L
C            F5.2          (PARAMETERS DEFINED IN SECTION 4.3 OF PACKAGE
C                                WRITE-UP)
*******************************************************************************
C  18        20X,     EVAPOTRANSPIRATION PARAMETERS FOR SOIL MOISTURE
C           5F5.2            ORDER IS  K3,GAGEPE,EHIGH,ELOW,K24EL
*******************************************************************************
C  19        20X,     SOIL MOISTURE  TIMING PARAMETERS
C          2F5.2,            ORDER IS---
C            F5.4,            SRC1,LIRC6,LKK6,KV,KGS
C          2F5.2
*******************************************************************************
C  20        20X,     SOIL MOISTURE INITIAL CONDITIONS
C          7F5.1             ORDER IS---UZSI,LZSI,SGWI,GWSI,RESI,SRGXI,SCEPI
C                                 UZS=UPPER ZONE STORAGE
C                                 LZS=LOWER ZONE STORAGE
C                                 SGW=GROUNDWATER STORAGE
C                                 GWS=ANTECEDENT GW INFLOW INDEX
C                                 RES=SURFACE DETENTION
C                                 SRGX=INTERFLOW DETENTION
C                                 SCEP=INTERCEPTION STORAGE
***    *NOTE*................CARD 20 IS NOT NEEDED IF(INITIAL.EQ.0)
C              INITIAL MOISTURE STORAGES ARE CARRIED OVER FROM PREVIOUS RUN
C                                                             IN THIS CASE
*******************************************************************************
C**NOTE**CARD 21A IS ONLY NEEDED WHEN THE NUMBER OF UPSTREAM INFLOWS
C          FROM OUTSIDE THE AREA BEING RUN IS.GT.0 (NPTSUP.GT.0)
C  21A        7A4     NAME OF UPSTREAM INFLOW POINT
C       2X,F10.0      AREA OF UPSTREAM INFLOW POINT  (TOTAL AREA ABOVE GAGE SQ.MI)
C         REPEAT CARD 21A FOR EACH UPSTREAM INFLOW POINT (1 TO NPTSUP))
C              ORDER OF CARDS DETERMINES FLOW-POINT NUMBER FOR RUN
C              FIRST UPSTREAM INFLOW POINT IS ASSIGNED FLOW-POINT NUMBER
C                   EQUAL TO (NPTS+1) ETC. E.G. IF NPTS=3 THEN THE FIRST
C                   UPSTREAM INFLOW POINT BECOMES FLOW-POINT 4 FOR
C                   THE RUN.
*******************************************************************************
C**NOTE** REPEAT CARDS 21 THROUGH 23 (IF ALL NEEDED) FOR EACH FLOW-POINT
C          WITHIN RUN AREA (NPTS)
C         ORDER OF CARDS DETERMINES FLOW-POINT NUMBER FOR THE RUN.
C         NOTE...ALL FLOW-POINTS UPSTREAM FROM GAGE MUST HAVE A SMALLER RUN
```

```
C             NUMBER THAN THE GIVEN GAGE--EXCEPT FOR UPSTREAM INFLOW-POINTS
C             FROM OUTSIDE THE AREA BEING RUN(SEE CARD 21A)
C  21      7A4      NAME OF FLOW-POINT
C     2X,F10.0      TOTAL AREA ABOVE FLOW-POINT IN SQUARE MILES
C        ,F5.2,     CONSTANT K ROUTING FACTOR IN HOURS   =0.0 IF VAR. K USED
C          I5       =1 USE VARIABLE K    =0 NO
C          I5       =1 USE VARIABLE LAG =0 NO
C          I5       ROUTING INTERVAL IN HOURS  (MUST=6 FOR NOW)
C          I5       NO. OF VALUES  IN TIME-DELAY HISTOGRAM FOR LOCAL AREA
C          I5       NO. OF UPSTREAM  INFLOW POINTS TO LOCAL AREA (NUPIN)
C                        THESE CAN BE UPSTREAM INFLOWS FROM OUTSIDE OR
C                        INSIDE THE RUN AREA
C          I5       NO.OF POINTS TO DEFINE VARIABLE K VS OUTFLOW CURVE
C          I5       NO. OF POINTS TO DEFINE VARIABLE LAG VS INFLOW CURVE
*********************************************************************************
C  21B   8F10.0     VARIABLE K VS.OUTFLOW CURVE IF NEEDED     K IN HOURS
C                        MAXIMUM POINTS TO DEFINE CURVE IS 10 (THUS 3 CARDS)
C                        VALUES READ IN PAIRS  (FLOW,K)
C                             SO 4 PAIRS OF (FLOW,K) CAN GO ON A CARD
C                        K AT ZERO FLOW MUST BE FIRST POINT
C                        CALCULATIONS USING K ARE BASED ON A LINEAR
C                             INTERPOLATION BETWEEN POINTS
C                        K VALUE FOR HIGHEST DEFINED FLOW IS USED FOR
C                             ALL FLOWS ABOVE THAT DISCHARGE
*********************************************************************************
C  21C   8F10.0     VARIABLE LAG VS. INFLOW CURVE IF NEEDED   LAG IN HOURS
C                        MAX.PTS=10, VALUES IN PAIRS(FLOW,LAG), 4 PAIRS PER CARD
C                        LAG AT ZERO FLOW MUST BE FIRST POINT
C                        CALCULATIONS USING VARIABLE LAG ARE BASE ON
C                             LAGGING THE VOLUME OF FLOW IN THE INTERVAL
C                             FLOW(N) TO FLOW(N+1) BY THE AVERAGE LAG FOR
C                             THAT INTERVAL (LAG(N)+LAG(N+1))*0.5
C                        LAG VALUE FOR HIGHEST DEFINED FLOW IS USED FOR
C                             ALL FLOW ABOVE THAT DISCHARGE
*********************************************************************************
C  22      30X,     TIME DELAY HISTOGRAM (MAX.NO OF POINTS=30)
C        10F5.2          HISTOGRAM IS FOR LOCAL AREA    SUMMATION OF VALUES=1.0
*********************************************************************************
C  23      30X,     MBP AREAS TO BE ASSIGNED TO EACH ELEMENT OF THE TIME-DELAY
C          10I5          HISTOGRAM ---  MBP AREAS DESIGNATED BY RUN NO. WHICH
C                        IS DETERMINED BY THE ORDER CARDS 17 TO 20 WERE READ.
*********************************************************************************
C  21D     30X,     RUN NO. OF EACH`UPSTREAM INFLOW POINT TO LOCAL AREA
C          5I5                NEEDED IF (NUPIN.GT.0)
*********************************************************************************
C  21E     30X,     CONSTANT LAG FOR EACH UPSTREAM INFLOW POINT
C         5F5.1          (LAG IN HOURS)
C             **NOTE** TOTAL LAG CONSISTS OF CONSTANT PLUS VARIABLE COMPONENT
*********************************************************************************
*********************************************************************************
*NEXT GROUP OF CARDS INPUTS DATA FOR THE PERIOD FROM (INITIAL DAY-INITIAL PERIOD
*             TO CURRENT DAY-CURRENT PERIOD)  FROM SUBROUTINE DATAIN
*********************************************************************************
*********************************************************************************
```

```
C  24          I5      MONTH NUMBER
C              I5      DAY NUMBER
C           4F5.2      PRECIPITATION FOR EACH SIX HOUR PERIOD
C                 (REPEAT CARD 24 FOR EACH DAY THAT PRECIPITATION IS .GT.0.0
C                      PLUS ALWAYS HAVE A CARD FOR THE CURRENT DAY)
C            (REPEAT CARD 24 FOR EACH MBP AREA AFTER IT IS REPEATED FOR EACH DAY)
********************************************************************************
C  25        10X,      PE FOR EACH PE STATION (1-NPEGS)
C          14F5.3
C                 (REPEAT CARD 25 FOR EACH DAY(INITIAL DAY THROUGH CURRENT DAY)
********************************************************************************
C  26        10X,      STAGE TENDENCY PLUS DISCHARGE AT END OF EACH SIX HOUR PERIOD
C      4(F1.0,F9.0)       STAGE TENDENCY-- ZERO OR BLANK (NO REPORT)
C                         =1 (RISING)  =2 (FALLING)  =3 (STATIONARY)
C                 (REPEAT CARD 26 FOR EACH DAY (INITIAL THROUGH CURRENT))
C            NOTE.GROUPS OF CARD 26 ARE NEEDED AT EACH FLOW-POINT WHERE SIX-HOUR
C                DISCHARGE IS TO BE READ IN--(SEE CARD 12)
C                PLUS ALL UPSTREAM FLOW-POINTS FROM OUTSIDE THE BASIN
C                     FOR UPSTREAM INFLOWS STAGE TENDENCY CAN BE BLANK
C        NOTE..INPUT OF CARD 26 GROUPS IS IN ORDER OF FLOW-POINT RUN NUMBER
C        NOTE.IF OBSERVED FLOW IS TO BE ROUTED DOWNSTREAM THEN A FLOW VALUE
C             MUST BE SUPPLIED FOR EACH SIX HOURS -- IF SIMULATED ROUTED
C             DOWNSTREAM FLOW VALUES DO NOT HAVE TO BE SUPPLIED EACH SIX HOURS
C             BUT ONLY WHEN READINGS ARE AVAILABLE.
********************************************************************************
********************************************************************************
*NEXT GROUP OF CARDS ONLY NEEDED IF(LENGTH.GT.0.)
********************************************************************************
********************************************************************************
C        CARDS 27 AND 28 ONLY NEEDED IF (NFPXGS.GT.0)
********************************************************************************
C  27     SAME AS CARD 24 GROUP ONLY FOR (CURRENT DAY TO CURRENT DAY PLUS LENGTH
C               AND FOR QPF AREAS INSTEAD OF MBP AREAS)
********************************************************************************
C  28     SAME AS CARD 25 GROUP ONLY FOR FUTURE PE DATA
********************************************************************************
***                       CARD 29 NEEDED IF THERE ARE FLOW POINTS WITH A CARD
C             12 VALUE EQUAL 2 OR UPSTREAM FLOW-POINTS FROM OUTSIDE THE BASIN
********************************************************************************
C  29      SAME AS CARD 26 GROUP ONLY FOR FORECAST FLOWS FROM ALL FLOW-POINTS
C              WITH A CARD 12 VALUE OF 2 OR UPSTREAM INFLOWS FROM OUTSIDE THE
C               CURRENT RUN AREA (IN ORDER OF THEIR RUN NUMBER) (TENDENCY=BLANK)
********************************************************************************
********************************************************************************
*NEXT GROUP OF CARDS ONLY NEEDED IF RERUN.EQ.1
********************************************************************************
********************************************************************************
C  30          I5      NO. OF MBP AREAS TO ADJUST PRECIP BY A MULTIPICATION FACTOR
C              I5      NO. OF FLOW-POINTS TO INPUT A FORECAST (THESE ARE
C                          POINTS WHERE THE HYDROLOGIST WANTS TO CHANGE THE
C                          COMPUTER FORECAST)
********************************************************************************
C  31          I5      MBP AREA NUMBER
C            F5.2      ADJUSTMENT MULTIPLYING FACTOR
```

```
C              (REPEAT CARD 31 FOR EACH MBP AREA TO BE ADJUSTED)
C           NOTE..CARD 31 NEEDED ONLY IF AT LEAST ONE MBP AREA IS ADJUSTED
*********************************************************************************
CARDS  32,33 ONLY NEEDED IF HYDROLOGIST WANTS TO CHANGE A COMPUTER FORECAST
*********************************************************************************
C  32       16I5      FLOW-POINT NUMBERS WHERE FORECAST IS TO BE CHANGED
C                        NOTE..A HIGHER NUMBER CANNOT PRECEED A LOWER NUMBER
*********************************************************************************
C  33       10X,      HYDROLOGIST FORECAST (CFS) FOR EACH SIX HOURS
C         4F10.0
C                (REPEAT CARD 33 FOR EACH DAY (CURRENT DAY-CURRENT DAY+LENGTH))
C                (REPEAT CARD 31 GROUPS FOR EACH FLOW-POINT WHERE FORECAST
C                   IS TO BE CHANGED -- IN ORDER GIVEN BY CARD 32)
*********************************************************************************
*********************************************************************************
```

SECTION G.2-SAMPLE INPUT AND OUTPUT FROM OPERATIONAL PROGRAM--EXAMPLE ONE

```
    1    1    0    1    0
   61    2    1    1    7    4    0    0    0    0    0
SAMPLE OUTPUT-NWSRFS OPERATIONAL RIVER FORECASTING PROGRAM
 LEAF RIVER ABOVE HATTIESBURG,MISSISSIPPI
    3    1    3    0
 JACKSON,MISSISSIPPI                          90   60
    1    1    1
    1    1    1
    1    1    1
    0    0    0
    1    0    0    1
    0
 MBP OF COLLINS,MISS   1.0 .035  .50  .05  7.5  .33 2.85  .37  0.0        VOL PAR
 MBP OF COLLINS,MISS   .28  1.0 1.20  .60  0.0                             ET PARM
 MBP OF COLLINS,MISS   .90   .1.0025 15.0  .925                           TIME PARM
 MBP OF COLLINS,MISS   .12 8.82 1.26  .10  0.0  0.0  .39                   INITIAL
MBP BOWIE CREEK        1.0 .037  .24 .212 5.85  .91  2.4 .417 .180        VOL PARM
MBP BOWIE CREEK        .28  1.0  1.1  .84  0.0                             ET PARM
MBP BOWIE CREEK         .9   .1.002010.25 .865                            TIME PARM
 MBP OF BOWIE CR       .42 8.01 2.94  .03  0.0  0.0  .08                   INITIAL
HATTIESBURG LOCAL      1.0 .035  .50  .05  7.5  .33 2.85  .37  .00        VOL PARM
HATTIESBURG LOCAL      .28  1.0  1.2  .60  0.0                             ET PARM
HATTIESBURG LOCAL       .9   .1.0020  12.  .90                            TIME PARM
 MBP HATTIES LOCAL     .12 9.27 2.22  .08  0.0  0.0  .38                   INITIAL
 LEAF RIVER NR COLLINS MISS.          752.  8.0    0    0    6   18    0    0    0
 TIME DELAY    COLLINS MISS.     .030 .050 .055 .059 .061 .064 .069 .072 .080 .081
 TIME DELAY   COLLINS MISS.      .080 .073 .064 .052 .043 .032 .023 .014
 GAGE AREA --COLLINS                1    1    1    1    1    1    1    1    1    1
 GAGE AREA --COLLINS                1    1    1    1    1    1    1    1
 BOWIE CREEK NR HATTIESBURG           304. 12.6    0    0    6    8    0    0    0
 TIME DELAY    BOWIE CREEK       .105 .140 .210 .170 .155 .095 .075 .050
 GAGE AREA --BOWIE                  2    2    2    2    2    2    2    2
LEAF RIVER AT HATTIESBURG            1760.   9.    0    0    6   14    2    0    0
 TIME DELAY    HATTIE LOCAL      .054 .097 .098 .093 .083 .073 .070 .075 .079 .077
 TIME DELAY    HATTIE LOCAL      .075 .064 .044 .018
 GAGE AREA --HATTIESBURG            3    3    3    3    3    3    3    3    3    3
 GAGE AREA --HATTIESBURG            3    3    3    3
 UPSTREAM INFLOW POINTS             1    2
 UPSTREAM LAG                     30.  12.
    2    2  .00  .10  .25  .11
    2    6  .12  .02  .00  .00
    2    7  .13  .05  .00  .00
    2    2  .00  .11  .34  .04
    2    6  .24  .04  .00  .00
    2    7  .09  .01  .00  .00
    2    2  .00  .04  .37  .06
    2    6  .23  .04  .00  .00
    2    7  .11  .02  .00  .00
    2    1 .050
```

2	2	.022				
2	3	.064				
2	4	.071				
2	5	.075				
2	6	.021				
2	7	.011				
2	1		721	697	678	658
2	2		639	626	626	645
2	3		694	780	914	1055
2	4		1150	1245	1345	1389
2	5		1410	1400	1360	1300
2	6		1214	1086	979	902
2	7		847	816	795	784
2	1		351	340	334	327
2	2		324	315	318	338
2	3		397	465	490	499
2	4		495	476	451	418
2	5		393	374	351	334
2	6		327	327	346	425
2	7		427	431	440	451
2	1		2380	2236	2167	2167
2	2		2100	2040	2023	2040
2	3		2125	2261	2439	2508
2	4		2567	2645	2718	2753
2	5		2780	2816	2816	2789
2	6		2772	2726	2708	2708
2	7		2691	2637	2567	2533

G-10

LEAF RIVER ABOVE HATTIESBURG,MISSISSIPPI

SAMPLE OUTPUT-NWSRFS OPERATIONAL RIVER FORECASTING PROGRAM

BASIC RUN INFORMATION

NUMBER OF PRECIPITATION GAGES= 3   NUMBER OF FLOW-POINTS= 3   NUMBER OF POTENTIAL ET STATIONS= 1
EVAPORATION PARAMETERS ARE   JACKSON,MISSISSIPPI   NEP= 90   NDUR= 60
OPERATIONAL FORECAST MODE   FEB ,1961   DAY 1-1 TO DAY 7-4   FORECAST 0 DAYS

LEAF RIVER ABOVE HATTIESBURG,MISSISSIPPI

SAMPLE OUTPUT-NWSRFS OPERATIONAL RIVER FORECASTING PROGRAM

SOIL MOISTURE VOLUME PARAMETERS

RG	PRECIP. GAGE NAME	K1	A	EPXM	UZSN	LZSN	CB	POWER	CC	K24L	K3	GAGEPE	EHIGH	ELOW	K24EL
1	MBP OF COLLINS,MISS	1.000	.035	.500	.050	7.500	.330	2.850	.370	0.000	.280	1.000	1.200	.600	0.000
2	MBP BOWIE CREEK	1.000	.037	.240	.212	5.850	.910	2.400	.417	.180	.280	1.000	1.100	.840	0.000
3	HATTIESBURG LOCAL	1.000	.035	.500	.050	7.500	.330	2.850	.370	0.000	.280	1.000	1.200	.600	0.000

SOIL MOISTURE TIMING PARAMETERS

RG	SRC1	LIRC6	LKK6	KV	KGS
1	.900	.100	.0025	15.000	.9200
2	.900	.100	.0020	10.250	.8650
3	.900	.100	.0020	12.000	.9000

SOIL MOISTURE INITIAL VALUES

RG	UZS	LZS	SGW	GWS	RES	SRGX	SCEP
1	.12	8.82	1.26	.10	0.00	0.00	.39
2	.42	8.01	2.94	.03	0.00	0.00	.08
3	.12	9.27	2.22	.08	0.00	0.00	.38

LEAF RIVER ABOVE HATTIESBURG,MISSISSIPPI

SAMPLE OUTPUT-NWSRFS OPERATIONAL RIVER FORECASTING PROGRAM

FLOW-POINT PARAMETERS

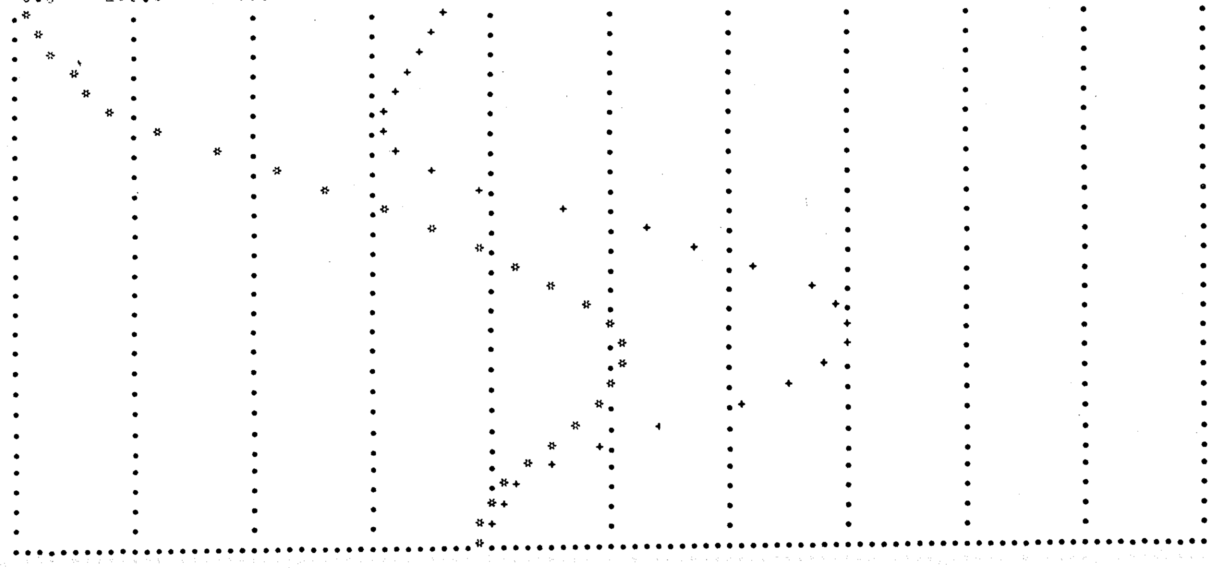
FP	FLOW-POINT NAME	AREA	KS1	OBSER	SIXIN	CHECK
1	LEAF RIVER NR COLLINS MISS.	752.00	8.00	0	1	1
2	BOWIE CREEK NR HATTIESBURG	304.00	12.60	0	1	1
3	LEAF RIVER AT HATTIESBURG	1760.00	9.00	0	1	1

```
HISTOGRAMS
TIME-DELAY .030 .050 .055 .059 .061 .064 .069 .072 .080 .08
           .080 .073 .064 .052 .043 .032 .023 .014
GAGE AREA     1    1    1    1    1    1    1    1    1
              1    1    1    1    1    1    1    1
TIME-DELAY .105 .140 .210 .170 .155 .095 .075 .050
GAGE AREA     2    2    2    2    2    2    2    2
TIME-DELAY .054 .097 .098 .093 .083 .073 .070 .075 .079 .07
           .075 .064 .044 .018
GAGE AREA     3    3    3    3    3    3    3    3    3
              3    3    3    3
INFLOW-PTS    1    2
INFLOW LAG 30.0 12.0
```

SIX HOUR FLOW PLOT   LEAF RIVER NR COLLINS MISS.   FEB ,1961   *=SIMULATED   +=OBSERVED $=FORECAST

STAGE TENDENCY (+) NOT REPORTED (+>) RISING (<+) FALLING (<+>) STATIONARY

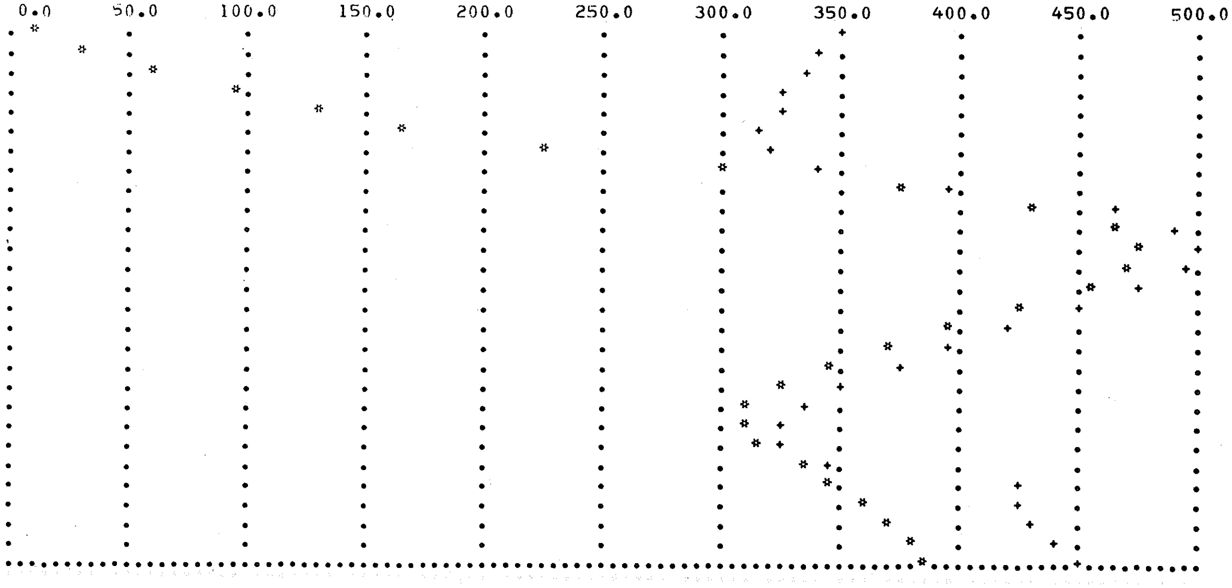
TIME 0.0 200.0 400.0 600.0 800.0 1000.0 1200.0 1400.0 1600.0 1800.0 2000.0



TIME	SIMULATED	OBS-FORE
1-1	10.4	721.0
1-2	32.0	697.0
1-3	59.4	678.0
1-4	90.1	658.0
2-1	122.2	639.0
2-2	159.6	626.0
2-3	235.4	626.0
2-4	336.2	645.0
3-1	436.2	694.0
3-2	529.5	780.0
3-3	615.9	914.0
3-4	695.9	1055.0
4-1	771.5	1150.0
4-2	839.9	1245.0
4-3	905.7	1345.0
4-4	961.1	1389.0
5-1	1002.1	1410.0
5-2	1023.4	1400.0
5-3	1022.3	1360.0
5-4	1003.0	1300.0
6-1	978.5	1214.0
6-2	946.7	1086.0
6-3	906.7	979.0
6-4	859.5	902.0
7-1	818.3	847.0
7-2	795.9	816.0
7-3	783.4	795.0
7-4	775.0	784.0

SIX HOUR FLOW PLOT BOWIE CREEK NR HATTIESBURG FEB ,1961 *=SIMULATED +=OBSERVED $=FORECAST

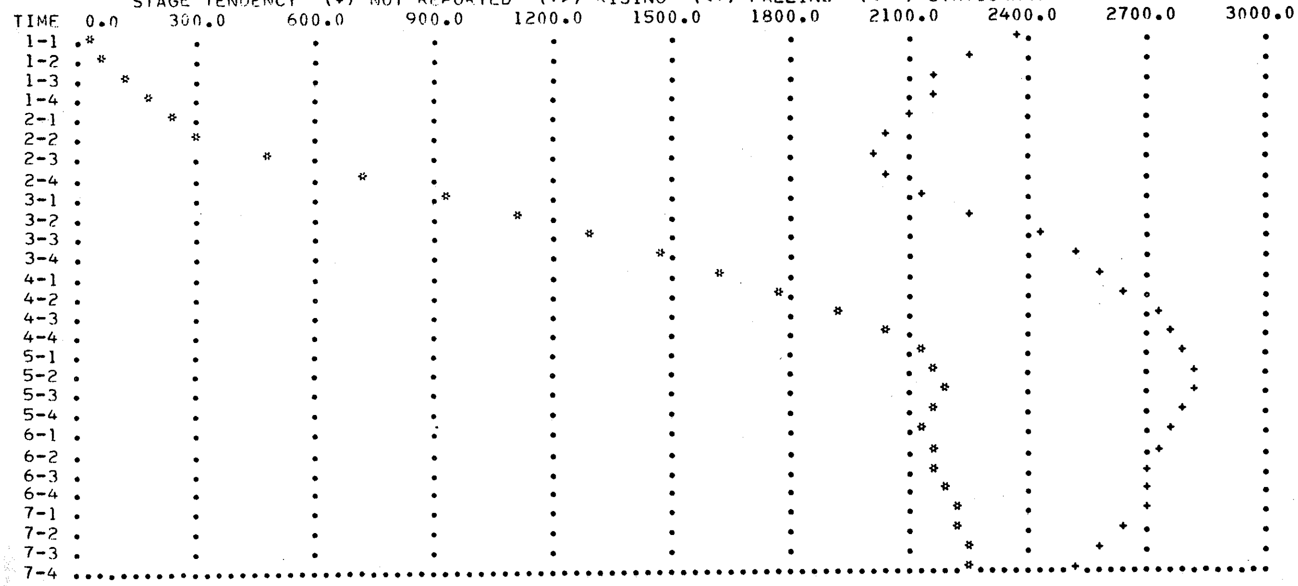
STAGE TENDENCY (+) NOT REPORTED (+>) RISING (<+) FALLING (<+>) STATIONARY



TIME	SIMULATED	OBS-FORE
1-1	10.2	351.0
1-2	29.6	340.0
1-3	61.1	334.0
1-4	95.7	327.0
2-1	130.4	324.0
2-2	164.6	315.0
2-3	227.2	318.0
2-4	297.7	338.0
3-1	375.0	397.0
3-2	428.8	465.0
3-3	464.6	490.0
3-4	473.9	499.0
4-1	471.1	495.0
4-2	456.3	476.0
4-3	425.9	451.0
4-4	396.7	418.0
5-1	370.6	393.0
5-2	347.5	374.0
5-3	327.1	351.0
5-4	309.4	334.0
6-1	309.1	327.0
6-2	317.0	327.0
6-3	334.9	346.0
6-4	346.7	425.0
7-1	362.2	427.0
7-2	371.3	431.0
7-3	381.8	440.0
7-4	385.4	451.0

SIX HOUR FLOW PLOT   LEAF RIVER AT HATTIESBURG   FEB ,1961   *=SIMULATED   +=OBSERVED $=FORECAST

STAGE TENDENCY (+) NOT REPORTED (+>) RISING (<+) FALLING (<+>) STATIONARY



TIME	SIMULATED	OBS-FORE
1-1	17.8	2380.0
1-2	57.7	2236.0
1-3	110.0	2167.0
1-4	170.3	2167.0
2-1	235.6	2100.0
2-2	308.4	2040.0
2-3	479.1	2023.0
2-4	710.0	2040.0
3-1	923.5	2125.0
3-2	1119.0	2261.0
3-3	1295.4	2439.0
3-4	1458.5	2508.0
4-1	1620.0	2567.0
4-2	1778.7	2645.0
4-3	1918.9	2718.0
4-4	2031.5	2753.0
5-1	2117.5	2780.0
5-2	2167.4	2816.0
5-3	2176.6	2816.0
5-4	2146.6	2789.0
6-1	2131.4	2772.0
6-2	2152.6	2726.0
6-3	2174.7	2708.0
6-4	2187.1	2708.0
7-1	2207.0	2691.0
7-2	2229.7	2637.0
7-3	2241.1	2567.0
7-4	2242.5	2533.0

MOISTURE STORAGES AND VOLUMES AT THE CURRENT TIME

PRECIP GAGE NAME	UZS	LZS	SGW	GWS	RES	SRGX	SCEP	PRECIP	TOTAL RO	GW RO	PXC
MBP OF COLLINS,MISS	.11	8.99	1.30	.12	0.00	0.00	.49	.78	.306	.259	1.00
MBP BOWIE CREEK	.41	8.12	2.94	.06	0.00	0.00	.23	.87	.317	.280	1.00
HATTIESBURG LOCAL	.12	9.44	2.28	.12	0.00	0.00	.49	.87	.364	.303	1.00

SAMPLE INPUT AND OUTPUT FROM OPERATIONAL PROGRAM--EXAMPLE TWO

```
 1    0    1    2    0
61    2   16    2   22    1    0    0    0    0    0
 1    5    0
 2   17  .03  .25  .55  .41
 2   18  .25  .50  .01  .00
 2   19  .65  .21  .16  .52
 2   20  .09  .03  .61 1.56
 2   21  .18 1.23  .91 1.30
 2   22  .98
 2   17  .05  .68 1.11  .96
 2   18  .50  .61  .01  .00
 2   19  .03  .37  .19  .20
 2   20  .00  .00  .60 1.36
 2   21  .24 1.01 1.28 1.46
 2   22  .86
 2   17  .03  .43 1.13 1.09
 2   18  .60  .65  .13  .00
 2   19  .13  .35  .20  .30
 2   20  .03  .01  .65 1.45
 2   21  .32  .97 1.10 1.25
 2   22  .76
 2   16 .095
 2   17 .027
 2   18 .098
 2   19 .038
 2   20 .025
 2   21 .011
 2   22 .022
 2   16         394         383         380         375
 2   17        372.        383.        490.       1931.
 2   18        3458        4131        4875        4907
 2   19        4403        4115        4419        4571
 2   20        5361        6244        6631        6889
 2   21        7863       10810       16009       19559
 2   22       26680
 2   16         236         233         232         232
 2   17        230.        236.       1711.       3268.
 2   18        4215        4650        4480        4080
 2   19        3691        3350        2984        2511
 2   20        2902        2882        2595        3049
 2   21        3687        4729        6895       10339
 2   22       17420
 2   16        1267        1239        1225        1225
 2   17       1218.       1225.       1275.       7017.
 2   18       14071       17059       18179       18640
 2   19       18559       17919       17359       16419
 2   20       15144       13928       13287       13800
 2   21       15126       18939       23351       26960
 2   22       30089
```

LEAF RIVER ABOVE HATTIESBURG,MISSISSIPPI

SAMPLE OUTPUT-NWSRFS OPERATIONAL RIVER FORECASTING PROGRAM

BASIC RUN INFORMATION

NUMBER OF PRECIPITATION GAGES= 3   NUMBER OF FLOW-POINTS= 3   NUMBER OF POTENTIAL ET STATIONS= 1
EVAPORATION PARAMETERS ARE   JACKSON,MISSISSIPPI   NEP= 90   NDUR= 60
OPERATIONAL FORECAST MODE   FEB ,1961   DAY 16-2 TO DAY 22-1   FORECAST 5 DAYS

LEAF RIVER ABOVE HATTIESBURG,MISSISSIPPI

SAMPLE OUTPUT-NWSRFS OPERATIONAL RIVER FORECASTING PROGRAM

SOIL MOISTURE VOLUME PARAMETERS

RG	PRECIP. GAGE NAME	K1	A	EPXM	UZSN	LZSN	CB	POWER	CC	K24L	K3	GAGEPE	EHIGH	ELOW	K24EL
1	MBP OF COLLINS,MISS	1.000	.035	.500	.050	7.500	.330	2.850	.370	0.000	.280	1.000	1.200	.600	0.000
2	MBP BOWIE CREEK	1.000	.037	.240	.212	5.850	.910	2.400	.417	.180	.280	1.000	1.100	.840	0.000
3	HATTIESBURG LOCAL	1.000	.035	.500	.050	7.500	.330	2.850	.370	0.000	.280	1.000	1.200	.600	0.000

SOIL MOISTURE TIMING PARAMETERS

RG	SRC1	LIRC6	LKK6	KV	KGS
1	.900	.100	.0025	15.000	.9200
2	.900	.100	.0020	10.250	.8650
3	.900	.100	.0020	12.000	.9000

SOIL MOISTURE INITIAL VALUES

RG	UZS	LZS	SGW	GWS	RES	SRGX	SCEP
1	.10	8.99	1.14	.01	0.00	0.00	.14
2	.14	8.12	2.73	.00	0.00	0.00	0.00
3	.11	9.44	2.08	.01	0.00	0.00	.14

```
                LEAF RIVER ABOVE HATTIESBURG,MISSISSIPPI

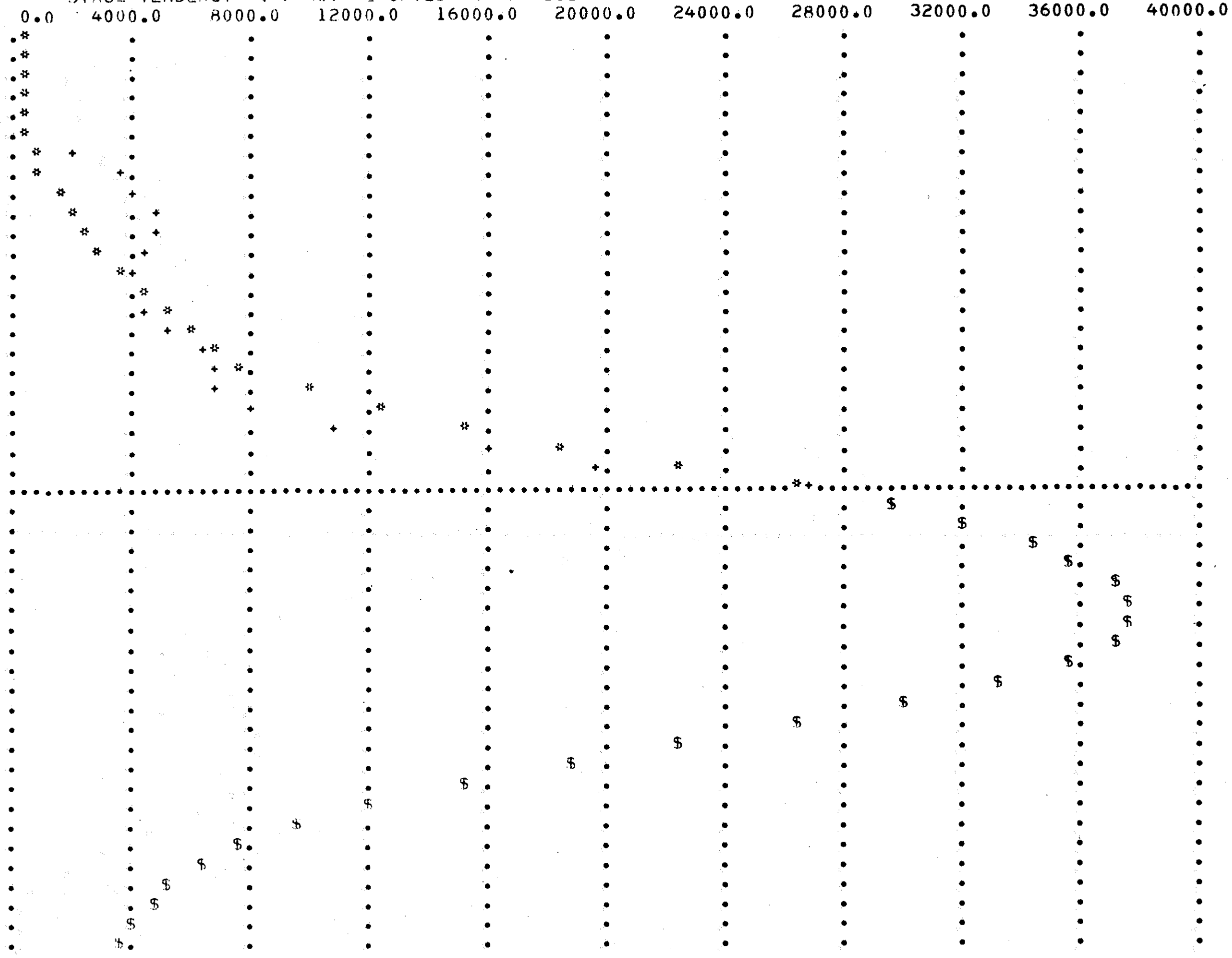
SAMPLE OUTPUT-NWSRFS OPERATIONAL RIVER FORECASTING PROGRAM

                                              FLOW-POINT PARAMETERS

FP       FLOW-POINT NAME              AREA  KS1 OBSER  SIXIN  CHECK       HISTOGRAMS
 1  LEAF RIVER NR COLLINS MISS.     752.00   8.00    0      1      1      TIME-DELAY .030 .050 .055 .059 .061 .064 .069 .072 .080 .0
                                                                                     .080 .073 .064 .052 .043 .032 .023 .014
                                                                          GAGE AREA     1    1    1    1    1    1    1    1    1
                                                                                        1    1    1    1    1    1    1    1
 2  BOWIE CREEK NR HATTIESBURG      304.00 12.60    0      1      1      TIME-DELAY .105 .140 .210 .170 .155 .095 .075 .050
                                                                          GAGE AREA     2    2    2    2    2    2    2    2
 3 LEAF RIVER AT HATTIESBURG       1760.00   9.00    0      1      1      TIME-DELAY .054 .097 .098 .093 .083 .073 .070 .075 .079 .0
                                                                                     .075 .064 .044 .018
                                                                          GAGE AREA     3    3    3    3    3    3    3    3    3
                                                                                        3    3    3    3
                                                                          INFLOW-PTS    1    2
                                                                          INFLOW LAG 30.0 12.0
```

SIX HOUR FLOW PLOT LEAF RIVER NR COLLINS MISS. FEB ,1961 *=SIMULATED +=OBSERVED $=FORECAST

STAGE TENDENCY (+) NOT REPORTED (+>) RISING (<+) FALLING (<+>) STATIONARY



TIME	SIMULATED	OBS-FORE
16-2	304.1	383.0
16-3	298.2	380.0
16-4	292.8	375.0
17-1	289.2	372.0
17-2	297.7	383.0
17-3	408.5	490.0
17-4	652.7	1931.0
18-1	952.1	3458.0
18-2	1408.5	4131.0
18-3	1871.1	4875.0
18-4	2251.9	4907.0
19-1	2865.4	4403.0
19-2	3571.4	4115.0
19-3	4248.7	4419.0
19-4	5109.4	4571.0
20-1	5965.8	5361.0
20-2	6721.6	6244.0
20-3	7662.4	6631.0
20-4	10033.3	6889.0
21-1	12508.5	7863.0
21-2	15336.6	10810.0
21-3	18569.9	16009.0
21-4	22368.6	19559.0
22-1	26471.9	26680.0
22-2	29788.8	29788.8
22-3	32191.0	32191.0
22-4	34234.3	34234.3
23-1	35731.8	35731.8
23-2	37020.4	37020.4
23-3	37619.7	37619.7
23-4	37730.9	37730.9
24-1	37032.1	37032.1
24-2	35488.4	35488.4
24-3	33025.5	33025.5
24-4	29945.5	29945.5
25-1	26274.5	26274.5
25-2	22215.1	22215.1
25-3	18665.7	18665.7
25-4	15193.7	15193.7
26-1	12197.4	12197.4
26-2	9560.4	9560.4
26-3	7546.2	7546.2
26-4	6255.1	6255.1
27-1	5347.8	5347.8
27-2	4660.0	4660.0
27-3	4109.8	4109.8
27-4	3653.9	3653.9

SIX HOUR FLOW PLOT   BOWIE CREEK NR HATTIESBURG   FEB ,1961   *=SIMULATED   +=OBSERVED $=FORECAST

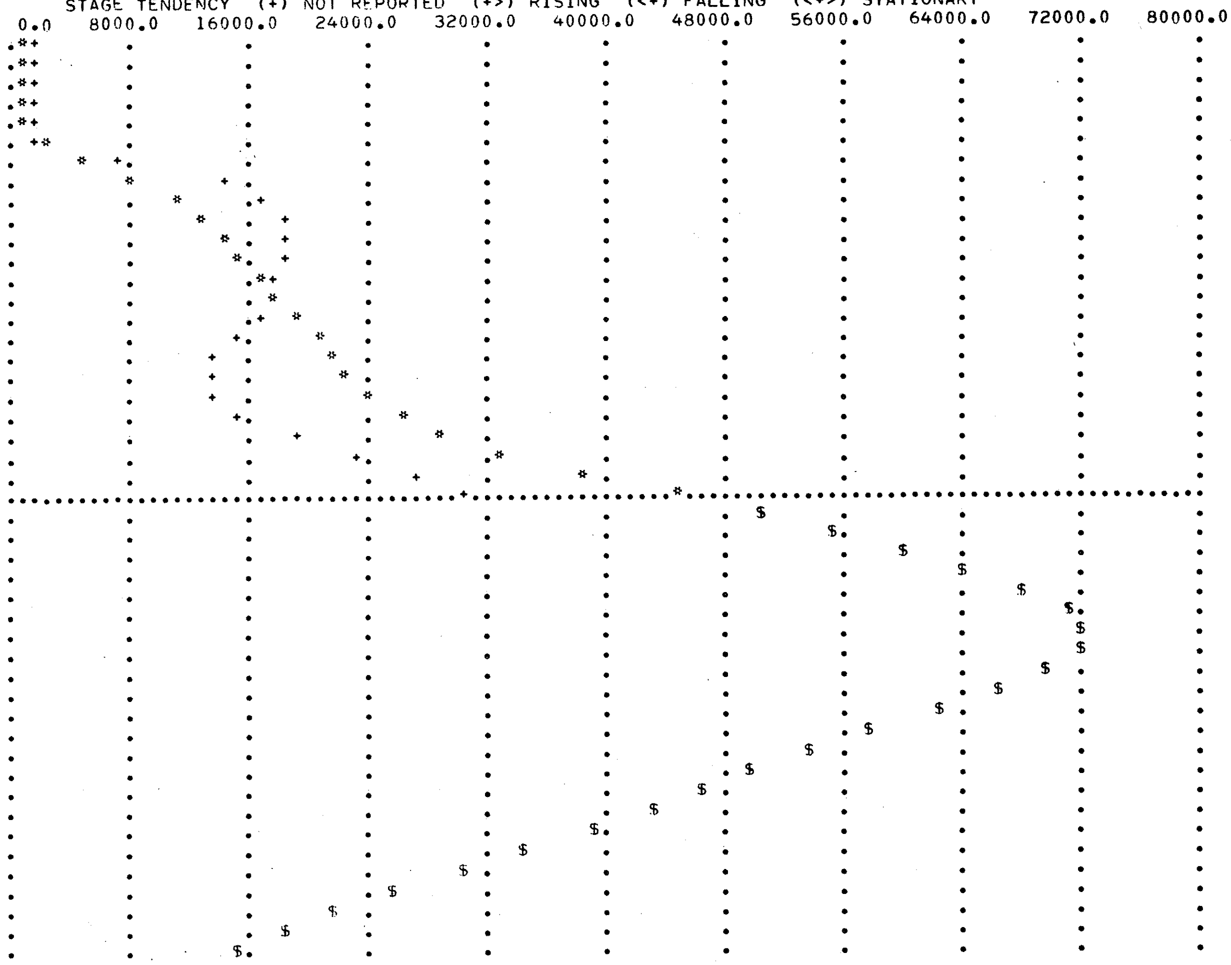
STAGE TENDENCY (+) NOT REPORTED (+>) RISING (<+) FALLING (<+>) STATIONARY

TIME 0.0 2000.0 4000.0 6000.0 8000.0 10000.0 12000.0 14000.0 16000.0 18000.0 20000.0

TIME	SIMULATED	OBS-FORE
16-2	182.9	233.0
16-3	182.2	232.0
16-4	181.5	232.0
17-1	183.3	230.0
17-2	241.2	236.0
17-3	444.4	1711.0
17-4	911.7	3268.0
18-1	1572.2	4215.0
18-2	2426.0	4650.0
18-3	3178.8	4480.0
18-4	3784.8	4080.0
19-1	4082.6	3691.0
19-2	4213.9	3350.0
19-3	4153.3	2984.0
19-4	4025.1	2511.0
20-1	3834.2	2902.0
20-2	3596.7	2882.0
20-3	3479.8	2595.0
20-4	3960.3	3049.0
21-1	4611.0	3687.0
21-2	5808.1	4729.0
21-3	7246.9	6895.0
21-4	9418.7	10339.0
22-1	11612.3	17420.0
22-2	13539.5	13539.5
22-3	14497.4	14497.4
22-4	14356.9	14356.9
23-1	13563.0	13563.0
23-2	12291.5	12291.5
23-3	10753.7	10753.7
23-4	9089.2	9089.2
24-1	7601.4	7601.4
24-2	6398.9	6398.9
24-3	5420.0	5420.0
24-4	4618.0	4618.0
25-1	3956.5	3956.5
25-2	3408.7	3408.7
25-3	2951.5	2951.5
25-4	2568.1	2568.1
26-1	2244.8	2244.8
26-2	1971.6	1971.6
26-3	1739.3	1739.3
26-4	1541.1	1541.1
27-1	1371.5	1371.5
27-2	1226.3	1226.3
27-3	1101.1	1101.1
27-4	993.3	993.3

SIX HOUR FLOW PLOT LEAF RIVER AT HATTIESBURG FEB ,1961 *=SIMULATED +=OBSERVED $=FORECAST

STAGE TENDENCY (+) NOT REPORTED (+>) RISING (<+) FALLING (<+>) STATIONARY



TIME	SIMULATED	OBS-FORE
16-2	898.8	1239.0
16-3	884.1	1225.0
16-4	870.5	1225.0
17-1	860.1	1218.0
17-2	886.2	1225.0
17-3	2160.0	1275.0
17-4	5126.0	7017.0
18-1	8304.1	14071.0
18-2	11073.2	17059.0
18-3	13121.8	18179.0
18-4	14346.0	18640.0
19-1	15260.1	18559.0
19-2	16448.1	17919.0
19-3	17954.8	17359.0
19-4	19516.3	16419.0
20-1	20843.2	15144.0
20-2	21619.0	13928.0
20-3	22199.8	13287.0
20-4	24300.3	13800.0
21-1	26465.8	15126.0
21-2	28838.3	18939.0
21-3	32771.5	23351.0
21-4	38281.1	26960.0
22-1	44598.1	30089.0
22-2	50362.3	50362.3
22-3	55311.8	55311.8
22-4	59703.5	59703.5
23-1	63782.8	63782.8
23-2	67725.9	67725.9
23-3	70825.7	70825.7
23-4	72238.9	72238.9
24-1	71632.3	71632.3
24-2	69543.5	69543.5
24-3	66514.3	66514.3
24-4	62464.7	62464.7
25-1	57977.2	57977.2
25-2	53711.8	53711.8
25-3	49986.1	49986.1
25-4	46493.7	46493.7
26-1	42830.0	42830.0
26-2	38857.3	38857.3
26-3	34550.9	34550.9
26-4	30163.0	30163.0
27-1	25926.8	25926.8
27-2	21943.3	21943.3
27-3	18327.5	18327.5
27-4	15169.3	15169.3

MOISTURE STORAGES AND VOLUMES AT THE CURRENT TIME

PRECIP GAGE NAME	UZS	LZS	SGW	GWS	RES	SRGX	SCEP	PRECIP	TOTAL RO	GW RO	PXC
MBP OF COLLINS.MISS	.17	10.43	2.75	1.97	.01	0.00	.50	10.43	6.833	2.047	1.00
MBP BOWIE CREEK	.61	9.52	5.68	2.17	.00	.30	.24	11.52	4.782	2.602	1.00
HATTIESBURG LOCAL	.17	10.76	3.98	1.70	.01	0.00	.50	11.58	7.820	2.003	1.00

SAMPLE INPUT AND OUTPUT FROM OPERATIONAL PROGRAM--EXAMPLE THREE

```
  1    0    1    2    0
 61    2   16    2   22    1    1    1    0    0    0
  1
  2  .25  9.0 2.73  0.0  0.0  0.0  .20
  1    5    0
  2   17  .03  .25  .55  .41
  2   18  .25  .50  .01  .00
  2   19  .65  .21  .16  .52
  2   20  .09  .03  .61 1.56
  2   21  .18 1.23  .91 1.30
  2   22  .98
  2   17  .05  .68 1.11  .96
  2   18  .50  .61  .01  .00
  2   19  .03  .37  .19  .20
  2   20  .00  .00  .60 1.36
  2   21  .24 1.01 1.28 1.46
  2   22  .86
  2   17  .03  .43 1.13 1.09
  2   18  .60  .65  .13  .00
  2   19  .13  .35  .20  .30
  2   20  .03  .01  .65 1.45
  2   21  .32  .97 1.10 1.25
  2   22  .76
  2   16 .095
  2   17 .027
  2   18 .098
  2   19 .038
  2   20 .025
  2   21 .011
  2   22 .022
  2   16        394       383       380       375
  2   17       372.      383.      490.     1931.
  2   18       3458      4131      4875      4907
  2   19       4403      4115      4419      4571
  2   20       5361      6244      6631      6889
  2   21       7863     10810     16009     19559
  2   22      26680
  2   16        236       233       232       232
  2   17       230.      236.     1711.     3268.
  2   18       4215      4650      4480      4080
  2   19       3691      3350      2984      2511
  2   20       2902      2882      2595      3049
  2   21       3687      4729      6895     10339
  2   22      17420
  2   16       1267      1239      1225      1225
  2   17      1218.     1225.     1275.     7017.
  2   18      14071     17059     18179     18640
  2   19      18559     17919     17359     16419
  2   20      15144     13928     13287     13800
```

2	21	15126	18939	23351	26960
2	22	30089			
2	1				
2	1.3				
3	.75				
1					
2	22		35000	40000	43000
2	23	45000	45000	43000	40000
2	24	37030	35490	33025	29950
2	25	26275	22220	18665	15190
2	26	12200	9560	7550	6250
2	27	5350	4660	4110	3650

LEAF RIVER ABOVE HATTIESBURG,MISSISSIPPI

SAMPLE OUTPUT-NWSRFS OPERATIONAL RIVER FORECASTING PROGRAM

BASIC RUN INFORMATION

NUMBER OF PRECIPITATION GAGES= 3 NUMBER OF FLOW-POINTS= 3 NUMBER OF POTENTIAL ET STATIONS= 1

EVAPORATION PARAMETERS ARE JACKSON,MISSISSIPPI NEP= 90 NDUR= 60

OPERATIONAL FORECAST MODE FEB ,1961 DAY 16-2 TO DAY 22-1 FORECAST 5 DAYS

LEAF RIVER ABOVE HATTIESBURG,MISSISSIPPI

SAMPLE OUTPUT-NWSRFS OPERATIONAL RIVER FORECASTING PROGRAM

SOIL MOISTURE VOLUME PARAMETERS

RG	PRECIP. GAGE NAME	K1	A	EPXM	UZSN	LZSN	CB	POWER	CC	K24L	K3	GAGEPE	EHIGH	ELOW	K24EL
1	MBP OF COLLINS,MISS	1.000	.035	.500	.050	7.500	.330	2.850	.370	0.000	.280	1.000	1.200	.600	0.000
2	MBP BOWIE CREEK	1.000	.037	.240	.212	5.850	.910	2.400	.417	.180	.280	1.000	1.100	.840	0.000
3	HATTIESBURG LOCAL	1.000	.035	.500	.050	7.500	.330	2.850	.370	0.000	.280	1.000	1.200	.600	0.000

SOIL MOISTURE TIMING PARAMETERS

RG	SRC1	LIRC6	LKK6	KV	KGS
1	.900	.100	.0025	15.000	.9200
2	.900	.100	.0020	10.250	.8650
3	.900	.100	.0020	12.000	.9000

SOIL MOISTURE INITIAL VALUES

RG	UZS	LZS	SGW	GWS	RES	SRGX	SCEP
1	.10	8.99	1.14	.01	0.00	0.00	.14
2	.25	9.00	2.73	0.00	0.00	0.00	.20
3	.11	9.44	2.08	.01	0.00	0.00	.14

LEAF RIVER ABOVE HATTIESBURG,MISSISSIPPI

SAMPLE OUTPUT-NWSRFS OPERATIONAL RIVER FORECASTING PROGRAM

FLOW-POINT PARAMETERS

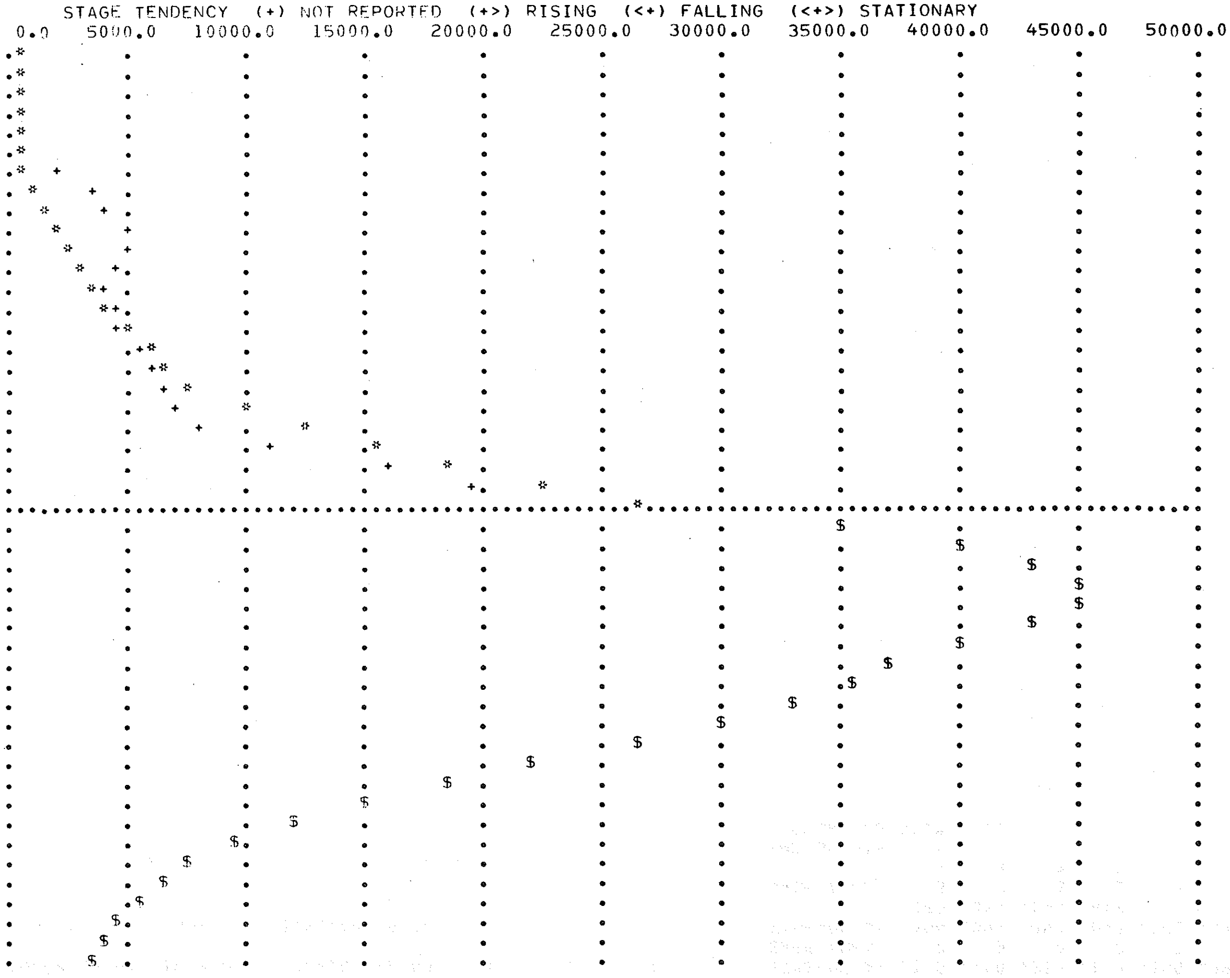
FP	FLOW-POINT NAME	AREA	KS1	OBSER	SIXIN	CHECK
1	LEAF RIVER NR COLLINS MISS.	752.00	8.00	0	1	1
2	BOWIE CREEK NR HATTIESBURG	304.00	12.60	0	1	1
3	LEAF RIVER AT HATTIESBURG	1760.00	9.00	0	1	1

HISTOGRAMS

TIME-DELAY	.030	.050	.055	.059	.061	.064	.069	.072	.080	.081
	.080	.073	.064	.052	.043	.032	.023	.014		
GAGE AREA	1	1	1	1	1	1	1	1	1	1
	1	1	1	1	1	1	1	1		
TIME-DELAY	.105	.140	.210	.170	.155	.095	.075	.050		
GAGE AREA	2	2	2	2	2	2	2	2		
TIME-DELAY	.054	.097	.098	.093	.083	.073	.070	.075	.079	.077
	.075	.064	.044	.018						
GAGE AREA	3	3	3	3	3	3	3	3	3	3
	3	3	3	3						
INFLOW-PTS	1	2								
INFLOW LAG	30.0	12.0								

SIX HOUR FLOW PLOT LEAF RIVER NR COLLINS MISS. FEB .1961 *=SIMULATED +=OBSERVED $=FORECAST

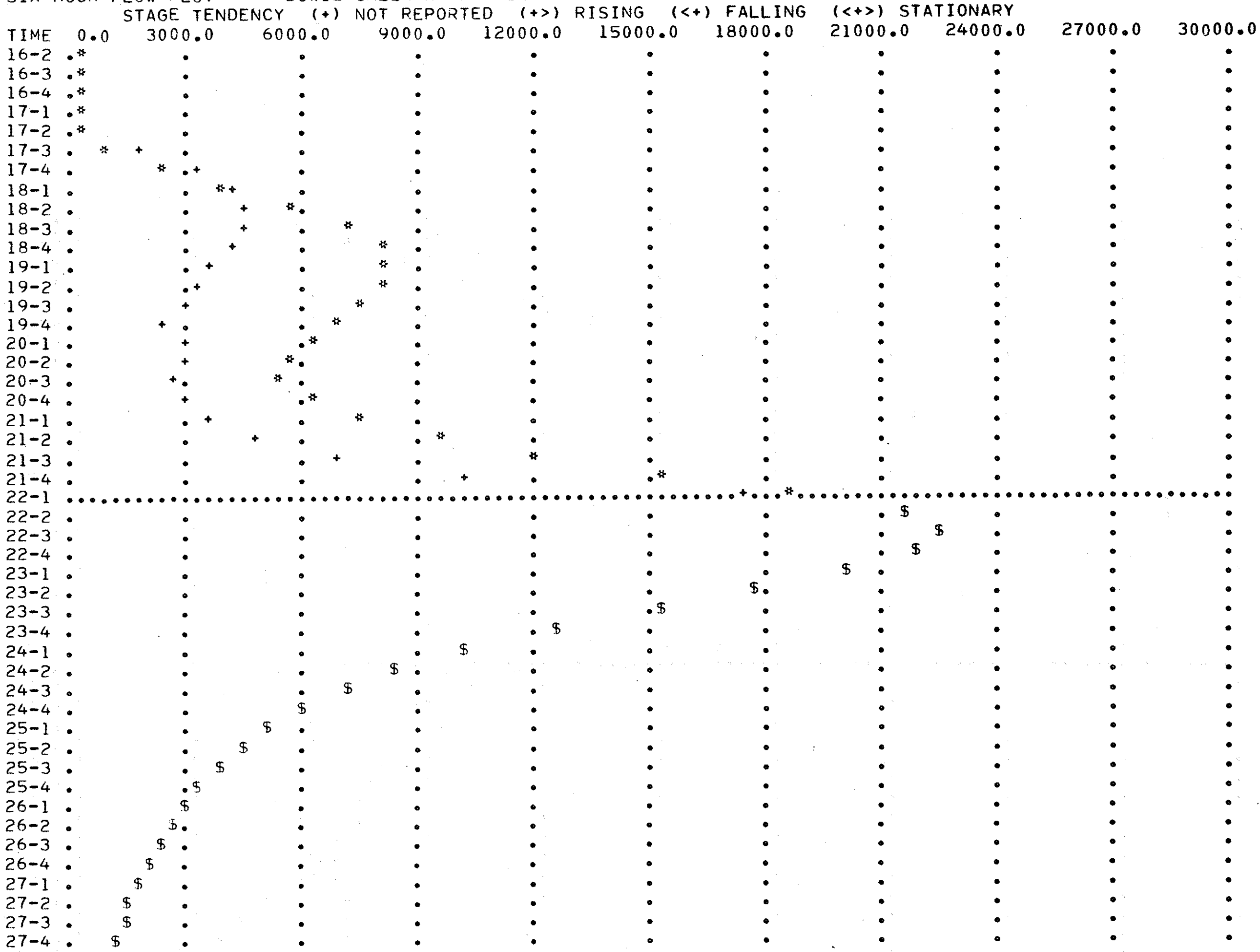
STAGE TENDENCY (+) NOT REPORTED (+>) RISING (<+) FALLING (<+>) STATIONARY



TIME	SIMULATED	OBS-FORE
16-2	304.1	383.0
16-3	298.2	380.0
16-4	292.8	375.0
17-1	289.2	372.0
17-2	297.7	383.0
17-3	408.5	490.0
17-4	652.7	1931.0
18-1	952.1	3458.0
18-2	1408.5	4131.0
18-3	1871.1	4875.0
18-4	2251.9	4907.0
19-1	2865.4	4403.0
19-2	3571.4	4115.0
19-3	4248.7	4419.0
19-4	5109.4	4571.0
20-1	5965.8	5361.0
20-2	6721.6	6244.0
20-3	7662.4	6631.0
20-4	10033.3	6889.0
21-1	12508.5	7863.0
21-2	15336.6	10810.0
21-3	18569.9	16009.0
21-4	22368.6	19559.0
22-1	26471.9	26680.0
22-2	-.0	35000.0
22-3	-.0	40000.0
22-4	-.0	43000.0
23-1	-.0	45000.0
23-2	-.0	45000.0
23-3	-.0	43000.0
23-4	-.0	40000.0
24-1	-.0	37030.0
24-2	-.0	35490.0
24-3	-.0	33025.0
24-4	-.0	29950.0
25-1	-.0	26275.0
25-2	-.0	22220.0
25-3	-.0	18665.0
25-4	-.0	15190.0
26-1	-.0	12200.0
26-2	-.0	9560.0
26-3	-.0	7550.0
26-4	-.0	6250.0
27-1	-.0	5350.0
27-2	-.0	4660.0
27-3	-.0	4110.0
27-4	-.0	3650.0

SIX HOUR FLOW PLOT BOWIE CREEK NR HATTIESBURG FEB ,1961 *=SIMULATED +=OBSERVED $=FORECAST

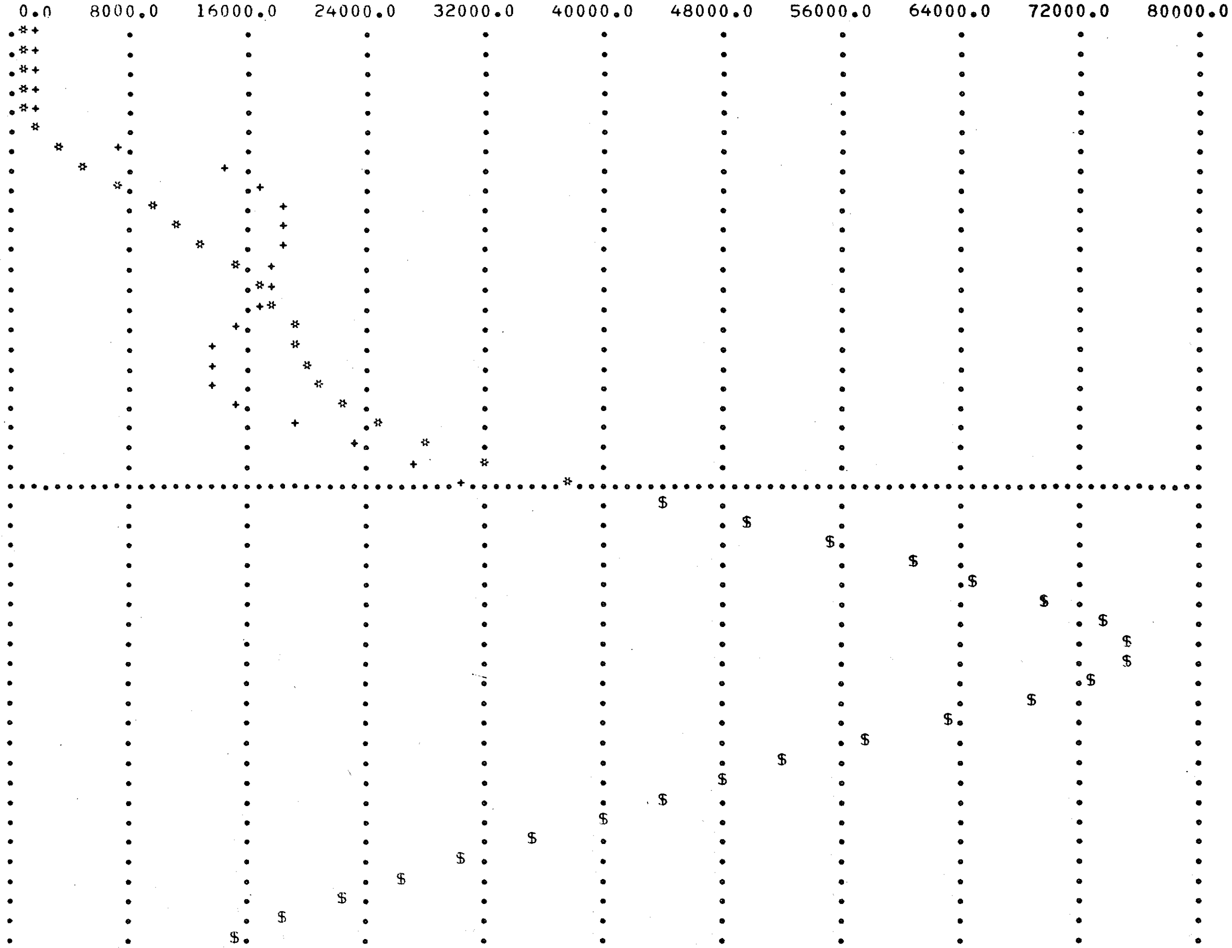
STAGE TENDENCY (+) NOT REPORTED (+>) RISING (<+) FALLING (<+>) STATIONARY



TIME	SIMULATED	OBS-FORE
16-2	182.8	233.0
16-3	182.0	232.0
16-4	181.2	232.0
17-1	183.6	230.0
17-2	301.0	236.0
17-3	988.4	1711.0
17-4	2297.3	3268.0
18-1	4003.7	4215.0
18-2	5806.4	4650.0
18-3	7140.1	4480.0
18-4	7950.4	4080.0
19-1	8098.8	3691.0
19-2	7955.3	3350.0
19-3	7402.9	2984.0
19-4	6816.3	2511.0
20-1	6256.8	2902.0
20-2	5710.7	2882.0
20-3	5452.8	2595.0
20-4	6328.0	3049.0
21-1	7465.5	3687.0
21-2	9519.0	4729.0
21-3	11856.3	6895.0
21-4	15357.3	10339.0
22-1	18702.4	17420.0
22-2	21499.2	21499.2
22-3	22577.0	22577.0
22-4	21837.5	21837.5
23-1	20154.7	20154.7
23-2	17843.1	17843.1
23-3	15234.0	15234.0
23-4	12537.3	12537.3
24-1	10250.8	10250.8
24-2	8494.1	8494.1
24-3	7119.8	7119.8
24-4	6027.5	6027.5
25-1	5146.4	5146.4
25-2	4427.7	4427.7
25-3	3833.8	3833.8
25-4	3338.6	3338.6
26-1	2921.9	2921.9
26-2	2569.7	2569.7
26-3	2269.4	2269.4
26-4	2012.4	2012.4
27-1	1791.2	1791.2
27-2	1600.9	1600.9
27-3	1435.9	1435.9
27-4	1292.8	1292.8

SIX HOUR FLOW PLOT LEAF RIVER AT HATTIESBURG FEB .1961 *=SIMULATED +=OBSERVED $=FORECAST

STAGE TENDENCY (+) NOT REPORTED (+>) RISING (<+) FALLING (<+>) STATIONARY



TIME	SIMULATED	OBS-FORE
16-2	898.8	1239.0
16-3	884.1	1225.0
16-4	870.5	1225.0
17-1	859.5	1218.0
17-2	873.1	1225.0
17-3	1484.0	1275.0
17-4	3058.5	7017.0
18-1	5020.4	14071.0
18-2	7163.3	17059.0
18-3	9311.8	18179.0
18-4	11269.9	18640.0
19-1	13079.4	18559.0
19-2	14840.3	17919.0
19-3	16474.0	17359.0
19-4	17848.7	16419.0
20-1	18812.2	15144.0
20-2	19277.4	13928.0
20-3	19601.3	13287.0
20-4	20993.6	13800.0
21-1	22566.3	15126.0
21-2	24458.1	18939.0
21-3	27636.1	23351.0
21-4	32229.2	26960.0
22-1	37836.3	30089.0
22-2	43702.1	43702.1
22-3	49564.0	49564.0
22-4	55234.5	55234.5
23-1	60473.2	60473.2
23-2	65024.1	65024.1
23-3	69578.0	69578.0
23-4	73595.2	73595.2
24-1	75288.8	75288.8
24-2	74871.0	74871.0
24-3	72705.3	72705.3
24-4	68594.6	68594.6
25-1	63106.1	63106.1
25-2	57265.3	57265.3
25-3	52218.9	52218.9
25-4	47996.0	47996.0
26-1	43913.6	43913.6
26-2	39688.9	39688.9
26-3	35221.4	35221.4
26-4	30723.3	30723.3
27-1	26404.9	26404.9
27-2	22359.6	22359.6
27-3	18694.9	18694.9
27-4	15496.0	15496.0

MOISTURE STORAGES AND VOLUMES AT THE CURRENT TIME

PRECIP GAGE NAME	UZS	LZS	SGW	GWS	RES	SRGX	SCEP	PRECIP	TOTAL RO	GW RO	PXC
MBP OF COLLINS.MISS	.17	10.43	2.75	1.97	.01	0.00	.50	10.43	6.833	2.047	1.00
MBP BOWIE CREEK	.64	10.11	5.85	2.30	.01	.78	.24	14.98	7.986	3.226	1.30
HATTIESBURG LOCAL	.16	10.66	3.90	1.60	.00	0.00	.50	8.68	5.107	1.714	.75

APPENDIX H

CALIBRATION PROGRAM - INPUT AND OUTPUT SAMPLES

SECTION H.1 CALIBRATION MODEL (NWSRFS3) INPUT SUMMARY

SECTION H.2 SAMPLE INPUT (OPTIMIZATION)

SECTION H.3 SAMPLE OUTPUT (OPTIMIZATION)

SECTION H.4 SAMPLE INPUT (SENSITIVITY ANALYSIS)

SECTION H.5 SAMPLE OUTPUT (SENSITIVITY ANALYSIS)

SECTION H.1 CALIBRATION MODEL (NWSRFS3) INPUT SUMMARY

```
      PROGRAM NWSRFS3(INPUT,OUTPUT,TAPE1,TAPE2,TAPE3,TAPE4)
*****************************************************************************
*****************************************************************************
C       NATIONAL WEATHER SERVICE RIVER FORECAST SYSTEM (OPTIMIZATION)
C                                                      (SENSITIVITY)
C                                                         (WARP)
C                         INPUT SUMMARY
*****************************************************************************
*CARD NO. FORMAT    CONTENTS
*****************************************************************************
C   1          I5    TAPE NO. OF PRECIPITATION TAPE
C              I5    TAPE NO. OF PE TAPE
C              I5    TAPE NO. OF TEMPERATURE TAPE(SAME AS  PE  IF NO TEMP DATA)
C              I5    TAPE NO. OF MEAN DAILY FLOW TAPE
C              I5    TAPE NO. OF 6-HOUR FLOWS(SAME AS DAILY IF NO 6 FLOW DATA)
*****************************************************************************
C   2          I5    NO. RECORD SKIPS FOR TAPE WHICH HAS PRECIP. DATA
C              I5    NO. RECORD SKIPS FOR TAPE WHICH HAS PE     DATA
C              I5    NO. RECORD SKIPS FOR TAPE WHICH HAS TEMP. DATA
C              I5    NO. RECORD SKIPS FOR TAPE WHICH HAS DAILY FLOW DATA
C              I5    NO. RECORD SKIPS FOR TAPE WHICH HAS 6-HOUR FLOW DATA
*****************************************************************************
C   3          I5    NO. OF MBP AREAS ON INPUT TAPE
C              I5    NO. OF PE STATIONS ON TAPE
C              I5    NO. OF TEMP STATIONS ON TAPE
C              I5    NO. OF MEAN DAILY FLOW-POINTS ON TAPE
C              I5    NO. OF 6-HOUR FLOW-POINTS ON TAPE
*****************************************************************************
C   4          I5    NO. OF MBP AREAS USED (NGAGES)
C              I5    NO. OF PE STATIONS USED (NPEGS)
C              I5    NO. OF TEMP STATIONS USED (NTAS) (NTAS=1 FOR 0 OR 1 STA)
C              I5    NO. OF STREAM-FLOW POINTS USED (NPTS)   OR
C                    NO. OF UPSTREAM INFLOW POINTS NEEDED
*****************************************************************************
C   5         5I5    IDENTIFIES THE MBP AREAS ON TAPE TO BE USED IN THE RUN
C                           ALSO DEFINES THE PRECIP. AREA ORDER FOR THE RUN
C                           1 TO NGAGES  VALUES ARE NEEDED
C                    E.G.      5 MBP AREAS ON TAPE,(NGAGES=2) CARD 5, 1,4
C                              THEN THE 1 ST GAGE ON TAPE WILL BE GAGE 1 FOR RUN
C                                       4 TH GAGE ON TAPE WILL BE GAGE 2 FOR RUN
*****************************************************************************
C   6         5I5    SAME AS CARD 5 ONLY FOR PE STATIONS
*****************************************************************************
C   7         2I5    IPEA(1)=1 , IPEA(2)=1  WHEN ONE PE STATION IS USED
C                    IPEA(1)=1 , IPEA(2)=2  WHEN TWO PE STATIONS ARE USED
*****************************************************************************
C   8         5I5    SAME AS CARD 5 ONLY FOR TEMPERATURE STATIONS
*****************************************************************************
C   9         2I5    SAME AS CARD 7 ONLY FOR TEMPERATURE STATIONS
```

```
C                    (INCLUDE ITAA(1)=1,ITAA(2)=1 EVEN IF NO STA)
******************************************************************************
C  10        5I5     SAME AS CARD 5 ONLY FOR DAILY Q
******************************************************************************
C  11        5I5     SAME AS CARD 5 ONLY FOR 6-HR Q
******************************************************************************
C  12         I5     NUMBER OF MONTHS FOR THE RUN (USUALLY 50)
C             I5     BEGINNING YEAR FOR THE RUN(4DIGITS) FIRST  DAY OF
C             I5     BEGINNING MONTH FOR THE RUN         BUFFER PERIOD
C             I5     CALENDAR DAY NUMBER FOR THE RUN     DEFINES THE START
C                    (BASED ON A 365 DAY YEAR)           OF THE RUN
C             I5     SNOW=0
******************************************************************************
C  13     8F10.4     LAND PARAMETERS
C                    MOD. STANFORD WATERSHED MODEL
C                    A,EPXM,UZSN,LZSN,CB,POWER,CC
******************************************************************************
C  14     2F10.4     AREA OF AREA(1),  AREA OF AREA(2)
******************************************************************************
C  15     8F10.4     LAND PARAMETERS     K1 FOR EACH AREA()
******************************************************************************
C  16     2F10.4     LAND PARAMETERS
C                    K24L,K3
******************************************************************************
C  17       F5.3     UPPER LIMIT OF E CURVE (EHIGH)
C           F5.3     LOWER LIMIT OF E CURVE (ELOW)
C             I5     CALENDAR DAY NUMBER WHEN E CURVE REACHES
C                       EHIGH  (IF JUNE 1  NEP=152)
C             I5     NO. DAYS E CURVE REMAINS AT EHIGH (MINUS ONE)
C                    (IF JUNE 1 TO JULY 31, NDUR=212-152=60 )
C           F5.3     LAND PARAMETER    K24EL
******************************************************************************
C  18     2F10.4     CONSTANT TIMES PE FOR AREAS 1 AND 2
******************************************************************************
C  19     5F10.4     TIMING  PARAMETERS
C                    SRC1, OVERLAND FLOW (ONE HR)
C                    LIRC6, INTERFLOW    (SIX HR)
C                    LKK6, GROUNDWATER   (SIX HR)
C                    KV
C                    KGS
******************************************************************************
C  20     8F10.4     SOIL MOISTURE INITIAL CONDITIONS
C                    UZSI,LZSI,SGWI,GWSI,RESI,SRGI,SCEPI
******************************************************************************
C  21    7I5     PARAMETERS FOR OPTIMIZATION OR SENSITIVITY ROUTINE
C         I5     NDAY=NUMBER OF DAYS IN RUN (USUALLY 1522)
C         I5     IBUF=NUMBER OF DAYS IN BUFFER PERIOD (USUALLY 61)
C                                     (ADD OR DELETE BY WHOLE MONTHS)
C         I5     NUMA= NO OF PARAMETERS TO BE CONSIDERED
C         I5     NPER  IF=1 DDELTA(I) MUST BE IN PERCENT/100
C                      IF=0 DDELTA(I) MUST BE AN ABSOLUTE VALUE
C         I5     KC= MAXIMUM NUMBER OF RESOLUTIONS BEFORE OPTIMIZATION
C                      IS TERMINATED
C         I5     MAXN= MAXIMUM NUMBER OF  RUNS  BEFORE OPTIMIZATION IS
```

```
C                   ABORTED (MAXN OVER-RIDES KC)
C        I5    MAXIN=3
********************************************************************************
C  22  16I5    PARAMETERS TO BE OPTIMIZED OR USED IN SENSITIVITY ANALYSIS SEE
C              PARM( ) ARRAY BELOW FOR PARAMETER NUMBERS (E.G. A IS NO. 9)
C
C    NOTE      TO ACCOMODATE (IN THE NEAR FUTURE) THE SNOWMELT SUBROUTINES
C              A NUMBER OF STATEMENTS AND ARRAYS PERTAINING TO SNOWMELT
C              ARE INCLUDED IN THE PRESENT VERSION OF NWSRFS3
C
C              AT PRESENT THE FOLLOWING PARAMETERS CAN ONLY BE CONSIDERED
C              FOR OPTIMIZATION OR SENSITIVITY ANALYSIS
C                                PARAMETERS 1 THRU 22
C                                      AND
C                                PARAMETERS 47 THRU 50
C                      (SEE PARM( ) ARRAY BELOW FOR CORRESPONDING NAMES)
C
C              THE MAXIMUM NUMBER OF PARAMETERS THAT CAN BE OPTIMIZED IS 16
C              THE MAXIMUM NUMBER OF PARAMETERS THAT CAN BE CONSIDERED FOR
C              SENSITIVITY ANALYSIS IS 50
C              THE ORDER OF THE PARAMETER NUMBERS IS NOT FIXED
C                                EXCEPT
C                                ******
C              THE  E  CURVE PARAMETERS, IF CONSIDERED, MUST BE LAST AND
C              ORDERED FROM LOW PARAMETER NUMBER TO HIGH PARAMETER
C              NUMBER (47,48,49,50)
C              REPEAT THIS CARD IF NUMA GT 16
********************************************************************************
C  23   2I5    NEPDEL IS THE FIXED SIZE DELTA FOR PARAMETER NEP (IN DAYS)
C              NDURDEL IS THE FIXED SIZE DELTA FOR PARAMETER NDUR (IN DAYS)
C                  (IF NEP AND NDUR ARE NOT TO BE OPTIMIZED
C                      STILL INCLUDE THIS CARD)
********************************************************************************
C  24          I5    NUMBER OF PERIODS TO BE REMOVED FROM CALCULATING
C                    THE VALUE OF THE OPTIMIZATION CRITERION--EXCLUDING
C                    THE BUFFER PERIOD. FROM ZERO(0) TO A MAXIMUM OF
C                                            TEN(10) PERIODS
********************************************************************************
C  25         6I5    IF OUTPER=0  THIS CARD IS NOT NEEDED
C             3I5    MONTH-DAY-YEAR(FOUR DIGITS) STOP CAL. CRITERION
C             3I5    MONTH-DAY-YEAR              BEGIN CAL. CRITERION
C
C                    REPEAT THIS CARD FOR EACH PERIOD TO BE DROPPED
********************************************************************************
C 25B          I5    ISENSE=0   NO SENSITIVITY ANALYSIS  WE THEREFORE ARE
C                               IN THE OPTIMIZATION MODE (IF ISENSE=0 THE
C                               MAX VALUE FOR NUMA IS 16)
C
C                          =1   SENSITIVITY  ANALYSIS (MAX VALUE FOR
C                                                  NUMA IS 50    )
********************************************************************************
C 25C                IF ISENSE=0 THIS CARD IS NOT NEEDED
C           16I5     NUMBER OF + AND/OR - PERTUBATIONS FOR EACH PARAMETER
C
```

```
C                       REPEAT THIS CARD IF NUMA GT 16
************************************************************************
C 25D                   IF ISENSE=0 THIS CARD IS NOT NEEDED
C         8F10.4        PERTUBATION VALUES FOR EACH PARAMETER I
C
C                       REPEAT THIS CARD FOR EACH OF THE NUMA PARAMETERS.
************************************************************************
C                       IF ISENSE=1 THIS CARD IS NOT NEEDED
C  26     8F10.4        DDELTA(I)  WHEN NPER=1  DELTA(I)=ABS(DDELTA(I)*A(I))
C                                       NPER=1  DELTA(I)=DDELTA(I)
C                       (IF MORE THAN 8  PARAMETERS IN OPT REPEAT CARD)
************************************************************************
C                       IF ISENSE=1 THIS CARD IS NOT NEEDED
C  27     8F10.4        CHECKL(I)= LOWER CONSTRAINT ON A(I)
C                       (IF MORE THAN 8  PARAMETERS IN OPT REPEAT CARD)
************************************************************************
C                       IF ISENSE=1 THIS CARD IS NOT NEEDED
C  28     8F10.4        CHECKH(I)= UPPER CONSTRAINT ON A(I)
C                       (IF MORE THAN 8  PARAMETERS IN OPT REPEAT CARD)
************************************************************************
C                       IF ISENSE=1 THIS CARD IS NOT NEEDED
C  28B     F10.5        PCENTOT=  PERCENT/100 CRITERION MUST AT LEAST CHANGE
C                         IN KSTOP TRIALS OR ANALYSIS IS STOPPED
C              I5       KSTOP  (SEE ABOVE)
************************************************************************
C  29         2I5       NUMBER OF NON ZERO ORDINATES IN THE CHANNEL
C                         DELAY HISTOGRAM FOR EACH FLOW POINT (6 HR INT)
************************************************************************
C   30      2I5         FIXED LAG (IN HOURS) FOR EACH AREA() SEE CARDS 29,32,
C                       32A THE UPSTREAM AREA() FIXED LAG TRANSLATES ITS
C                       HISTOGRAM TO THE DOWNSTREAM FLOW POINT.  THE DOWNSTREAM
C                       AREA() HAS A FIXED LAG OF 0
************************************************************************
C   31        I5        INWARP=0  THEN THE CHANNEL DELAY HISTOGRAM WILL NOT BE
C                       MODIFIED DURING THE OPTIMIZATION OR SENITIVITY ANALYSIS
C                             .GT. 0 THEN VERTICAL AND HORIZONTAL WARPING OF
C                                    THE HISTOGRAM WILL BE DONE DURING OPTIMIZATION
C                                    OR SENITIVITY
C
C             I5        NOWARP=  SEQUENCE NUMBER FOR HWARP PARAMETER.  IF
C                       HWARP PARAMETER NUMBER IS TH 5 TH NUMBER ON CARD 22
C                       THEN NOWARP=5.  (VWARP PARAMETER NUMBER MUST ALLWAYS
C                       FOLLOW HWARP PARAMETER NUMBER ON CARD 22)
************************************************************************
C   32                  IF INWARP=0 THIS CARD IS NOT NEEDED
C       20F4.4          G(I)  2-HOUR INSTANTANEOUS ORDINATES OF THE MODIFIED
C                             CHANNEL DELAY HISTOGRAM.  THESE ORDINATES COME
C   NOTE-- THE 2 HR           FROM A CONTINUOUS CURVE FITTED TO THE ORIGINAL
C     HISTOGRAM IS FOR        6 HOUR DELAY HISTOGRAM.  G(1) SHOULD EQUAL 0
C     THE TOTAL AREA. IF
C              TWO AREAS ARE ANA.
C              COMBINE THEIR HIST
C
C                                (READ IN (NELEM(1)+NELEM(2))*3+1 G(I) ORDINATES
```

```
C                               IF MORE THAN 20 REPEAT THIS CARD)
***********************************************************************
C  32A                 IF INWARP = 0 THIS CARD IS NEEDED
C        20F4.4        DIMENSIONALESS ORDINATES OF THE CHANNEL DELAY
C                      HISTOGRAM FOR FLOW POINT 1 -- 6-HR INT.
C                       (REPEAT IF 2 FLOW POINTS,  IF   2 AREAS THEN BE SURE
C                        HIST(1,I)+HIST(2,I) ORDINATES EQUAL 1.0)
***********************************************************************
***********************************************************************
C  32B          I5     VARL= 0  IF VARIABLE LAG IS NOT REQUESTED
C                          = 1  IF VARIABLE LAG IS REQUESTED
C               I5     VARK= 0  IF VARIABLE   K IS NOT REQUESTED
C                          = 1  IF VARIABLE   K    IS REQUESTED
C               I5     LOCAL= 0 HEADWATER OPTIMIZATION
C                           = 1 OR 2 LOCAL AREA OPTIMIZATION (LAND PARM)
C                      LOCAL= 3 LOCAL AREA OPTIMIZATION OF JUST CHANNEL PARM
C                             (OPTION 3 IS NOT PROGRAMED AS YET)
C               I5     NHWA  IS THE NUMBER OF UPSTREAM INFLOWS WHEN RUNNING
C                            UNDER LOCAL= 1 OR 2
***********************************************************************
C  33          4I5     IF LOCAL= 0 THIS CARD IS NOT NEEDED
C                      FIXED LAG (IN HOURS) FOR EACH UPSTREAM INFLOW
C                      WHEN RUNNING UNDER LOCAL= 1 OR 2
***********************************************************************
C  34         F4.4     FUNCTION OF CONSTANT K ROUTING FACTOR
C                         CSSR= (K-3)/(K+3)
***********************************************************************
C  35           I5     IF VARL= 0 THIS CARD IS NOT NEEDED
C                      NUMBER OF LAG VS Q POINTS TO DEFINE CURVE (MAX=15)
***********************************************************************
C  36       8F10.2     IF VARL= 0 THIS CARD IS NOT NEEDED
C                      FLOW VALUES DEFINING THE ABSCISSA OF THE
C                      LAG VS Q CURVE (FROM LOW TO HIGH Q AND FQLAG(1)
C                      USUALLY EQUALS 0.0)
C                                  REPEAT CARD IF NVL GT 8
***********************************************************************
C  37       8F10.2     IF VARL= 0 THIS CARD IS NOT NEEDED
C                      LAG VALUES (IN HOURS) DEFINING THE ORDINATE OF
C                      THE LAG VS Q CURVE. THEY MUST CORRESPOND TO THE
C                      ABOVE FQLAG( ) VALUES
C                      CALCULATIONS USING VARIABLE LAG ARE BASED ON
C                           LAGGING THE VOLUME OF FLOW IN THE INTERVAL
C                           FQLAG(N) TO FQLAG(N+1) BY VL(N+1)
C                      (NOTE DIFFERENCE BETWEEN THIS AND NWSRFS4 ROUTINE)
C                      LAG VALUE FOR HIGHEST DEFINED FLOW IS USED FOR
C                           ALL FLOW ABOVE THAT DISCHARGE
C                                   REPEAT CARD IF NVL GT 8
***********************************************************************
C  38-40               IF VARK= 0 THESE CARDS ARE NOT NEEDED
C                      IF VARK= 1 SEE CARDS 35-37 FOR FORMAT DESCRIPTION
C
C                      CALCULATION USING K ARE BASED ON A LINEAR
C                           INTERPOLATION BETWEEN POINTS
C                      K VALUE FOR HIGHEST DEFINED FLOW IS USED FOR
```

```
C                         ALL FLOWS ABOVE THAT DISCHARGE
C                  (NOTE THIS ROUTINE IS THE SAME AS NWSRFS4 ROUTINE)
*****************************************************************************
C  41       8A10       HEADER CARD   (USE COLS 2 THUR 80)
*****************************************************************************
*****************************************************************************
*****************************************************************************
C
      COMMON/OHG/X(50),OPTIM,NUMA,KKK,IZY,NSTART,NDAY,IBUF,TRO,MZERO,
     1LOCAL,RO(31,4),AREA(2),MO(60),NMO,NGAGES,SNOW,RCOF,
     2NHWA,JDAYST,PARM(50),IPARMA(50),NEPDEL,NDURDEL,NXNEP,NXNDUR,NXC,
     3PEROUT(11),PERIN(11),ISENSE,INWARP,NOWARP
      COMMON/OHMI/TPX,TPE,TTA,TFW24,TFW6,IPXS,IPES,ITAS,IF24S,IF6S,
     1PXIN,PEIN,TAIN,PTSIN,FW6IN,NPEGS,NTAGS,NPTS,
     2RGIN(2),PEGIN(2),TAGIN(2),SGIN(4),SIXIN(4),LYR,MOS,MOOUT(10),
     3DAYOUT(10),YROUT(10),MOIN(10),DAYIN(10),YRIN(10),OUTPER
      COMMON/OHML/A,PA,EPXM,UZSN,LZSN,CB,POWER,CC,K24L,K3,EHIGH,ELOW,
     1K24EL,SRC1,LIRC6,LKK6,KV,KGS,UZSI,LZSI,SGWI,GWSI,RESI,SRGXI,SCEPI,
     2RATIOL,RATIOS,RATIOU,RATIOE,IPEA(2),ITAA(2),K1(2),PEADJ(2),
     3E(1530),NEP,NDUR,NCOE,MONTH1
      COMMON/OHMO/DDELTA(18),CHECKL(18),CHECKH(18),MAXIN,NPER,KC,MAXN,
     1PCENTOT,KSTOP
      COMMON/OHMC/NELEM(2),HIST(2,35),CSSR,VARL,VARK,LAG(2),LLAG(4),
     1NVK,FQK(15),VVK(15),NVL,FQLAG(15),VL(15)
      COMMON/OHMS/LPARM(60),INCOEF(50),PERTUR(50),SENDEL(50,8)
      COMMON/OHMW/G(107),ELMRAT
      INTEGER TPX,TPE,TTA,TFW24,TFW6,PXIN,PEIN,TAIN,PTSIN,FW6IN,
     1RGIN,PEGIN,TAGIN,SGIN,SIXIN,DAYOUT,YROUT,DAYIN,YRIN,OUTPER
      INTEGER SNOW,PEROUT,PERIN
      INTEGER VARK,VARL
      INTEGER PERTUR
      REAL LZSN,K24L,K3,K24EL,LIRC6,LKK6,KV,KGS,LZSI
      REAL K1
      COMMON/XYZ/PXEC(12500),PEEC(3200),EPEC(3200),Q24EC(3200),
     1ROEC(12500),Q6EC(25000),TAEC(12500),TDEC(12500),UEC(12500),
     2QIEC(6250),QAEC(6250),TOEC(6250),QREC(6250)
      ECS PXEC,PEEC,EPEC,Q24EC,Q6EC,TAEC,ROEC,TDEC,UEC,QIEC,QAEC,TOEC,
     1QREC
      DIMENSION HEAD(8)
C     READ PARAMETERS FOR DATA INPUT
      READ 1110,TPX,TPE,TTA,TFW24,TFW6
      READ 1110,IPXS,IPES,ITAS,IF24S,IF6S
      READ 1110,PXIN,PEIN,TAIN,PTSIN,FW6IN
      READ 1110,NGAGES,NPEGS,NTAS,NPTS
      READ 1110,(RGIN(I),I=1,NGAGES)
      READ 1110,(PEGIN(I),I=1,NPEGS)
      READ 1110,IPEA(1),IPEA(2)
      READ 1110,(TAGIN(I),I=1,NTAS)
      READ 1110,ITAA(1),ITAA(2)
      READ 1110,(SGIN(I),I=1,NPTS)
      READ 1110,(SIXIN(I),I=1,NPTS)
      READ 1110,NMO,LYR,MOS,JDAYST,SNOW
 1110 FORMAT(5I5)
      K1(2)=0.0
```

```
      PEADJ(2)=0.0
      NELEM(2)=0
C     READ LAND PARAMETERS AND ET COEF
      READ 1003,A,EPXM,UZSN,LZSN,CB,POWER,CC
      READ 1003,AREA(1),AREA(2)
      READ 1003,(K1(I),I=1,NGAGES)
      READ 1003,K24L,K3
      READ 1004,EHIGH,ELOW,NEP,NDUR,K24EL
      READ 1003,(PEADJ(I),I=1,NPEGS)
      READ 1003,SRC1,LIRC6,LKK6,KV,KGS
      READ 1003,UZSI,LZSI,SGWI,GWSI,RESI,SRGXI,SCEPI
 1003 FORMAT(8F10.4)
 1004 FORMAT(2F5.3,2I5,F5.3)
      IF(SNOW.GT.0) CALL SNOWPM(TAIN,NGAGES,PARM)
C     READ PARAMETERS FOR OPTIMIZATION ROUTINE
      READ 1001,NDAY,IBUF,NUMA,NPER,KC,MAXN,MAXIN
      READ 1,(IPARMA(I),I=1,NUMA)
      READ 1,NEPDEL,NDURDEL
      READ 1001,OUTPER
      IF(OUTPER.EQ.0) GO TO 10
      READ 6,(MOOUT(J),DAYOUT(J),YROUT(J),MOIN(J),DAYIN(J),YRIN(J),
     1J=1,OUTPER)
   10 READ 1,ISENSE
      IF(ISENSE.EQ.0) GO TO 12
      READ 1,(PERTUR(I),I=1,NUMA)
      DO 14 J=1,NUMA
      K=PERTUR(J)
      READ 1003,(SENDEL(J,L),L=I,K)
   14 CONTINUE
      GO TO 15
   12 READ 1002,(DDELTA(I),I=1,NUMA)
      READ 1002,(CHECKL(I),I=1,NUMA)
      READ 1002,(CHECKH(I),I=1,NUMA)
    1 FORMAT(16I5)
      READ 1005,PCENTOT,KSTOP
 1005 FORMAT(F10.5,I5)
 1001 FORMAT(7I5)
    6 FORMAT(6I5)
 1002 FORMAT(8F10.4)
C     READ PARAMETERS FOR CHANNEL
   15 READ 1110,(NELEM(I),I=1,NGAGES)
      READ 1110,LAG(1),LAG(2)
      READ 1110,INWARP,NOWARP
      IF(INWARP.EQ.0) GO TO 41
      FNEL=NELEM(1)
      ELMRAT=FNEL/(NELEM(1)+NELEM(2))
      IL=(NELEM(1)+NELEM(2))*3+1
      DO 43 I=1,107
      G(I)=0.0
   43 CONTINUE
      READ 1112,(G(I),I=1,IL)
      DO 40 I=1,NGAGES
      N=NELEM(I)
      IJ=LAG(I)
```

```
      DO 40 J=1,N
      K=J*3+(IJ/2)
      HIST(I,J)=(G(K-2)+G(K+1)+2.0*(G(K-1)+G(K)))/6.0
   40 CONTINUE
      GO TO 44
   41 DO 1111 I=1,NGAGES
      N=NELEM(I)
      READ 1112,(HIST(I,K),K=1,N)
 1111 CONTINUE
   44 READ 1110,VARL,VARK,LOCAL,NHWA
      IF(LOCAL.EQ.0) GO TO 2500
      READ 1110,(LLAG(I),I=1,NHWA)
 2500 READ 1112,CSSR
 1112 FORMAT(20F4.4)
      IF(VARL.EQ.0) GO TO 2501
      READ 1110,NVL
      READ 3002,(FQLAG(I),I=1,NVL)
      READ 1002,(VL(I),I=1,NVL)
 2501 IF(VARK.EQ.0) GO TO 2502
      READ 1110,NVK
      READ 3002,(FQK(I),I=1,NVK)
      READ 1002,(VVK(I),I=1,NVK)
 3002 FORMAT (10F8.1)
C     READ HEADER CARD
 2502 READ 200,(HEAD(I),I=1,8)
  200 FORMAT(8A10)
      PRINT 201
  201 FORMAT(1H1)
      PRINT 200,(HEAD(I),I=1,8)
      I=NMO/12
      K=NMO-12*I
      LYEND=LYR+I
      MOEND=MOS+K-1
      IF(MOEND.LT.13) GO TO 50
      MOEND=MOEND-12
      LYEND=LYEND+1
   50 PRINT 51,MOS,LYR,MOEND,LYEND,IBUF
   51 FORMAT(/* THE PERIOD OF RECORD BEING ANALYZED IS FROM*2I5* THRU *I
     12,I5,3X*  THE BUFFER PERIOD IS THE FIRST *I3* DAYS*)
      MZERO=0
      MONTH1=MOS
      CALL INDATA
      CALL ECURVE
C
C     AREA ADJUSTMENT SO THAT CONVERSION FACTOR IN CHANNEL
C     IS CORRECT WHEN TWO AREAS ARE ANALYZED
      AREATOT=0.0
      DO 45 I=1,NGAGES
      AREATOT=AREATOT+AREA(I)
   45 CONTINUE
      AREA(1)=AREATOT
      IF(NGAGES.EQ.2) AREA(2)=AREATOT
      HWARP=1.0
      VWARP=1.0
```

```
      PARM(1)=UZSN
      PARM(2)=LZSN
      PARM(3)=CB
      PARM(4)=POWER
      PARM(5)=CC
      PARM(6)=KV
      PARM(7)=KGS
      PARM(8)=K24EL
      PARM(9)=A
      PARM(10)=K24L
      PARM(11)=EPXM
      PARM(12)=K1(1)
      PARM(13)=K1(2)
      PARM(14)=PEADJ(1)
      PARM(15)=PEADJ(2)
      PARM(16)=K3
      PARM(17)=SRC1
      PARM(18)=LIRC6
      PARM(19)=LKK6
      PARM(20)=CSSR
      PARM(21)=HWARP
      PARM(22)=VWARP
      PARM(47)=EHIGH
      PARM(48)=ELOW
      PARM(49)=NEP
      PARM(50)=NDUR
      DO 17 I=1,50
      INCOEF(I)=0
   17 CONTINUE
      NXNDUR=0
      NXNEP=0
      NCOE=0
      DO 2 I=1,NUMA
      J=IPARMA(I)
      IF (J.EQ.0) GO TO 2
      X(I)=PARM(J)
      INCOEF(J)=I
      IF(J.GT.46) NCOE=NCOE+1
      IF(J.EQ.49) NXNEP=1
      IF(J.EQ.50) NXNDUR=1
    2 CONTINUE
      LPARM(1)=4RUZSN
      LPARM(2)=4RLZSN
      LPARM(3)=2RCB
      LPARM(4)=5RPOWER
      LPARM(5)=2RCC
      LPARM(6)=2RKV
      LPARM(7)=3RKGS
      LPARM(8)=5RK24EL
      LPARM(9)=1RA
      LPARM(10)=4RK24L
      LPARM(11)=4REPXM
      LPARM(12)=5RK1(1)
      LPARM(13)=5RK1(2)
```

```
      LPARM(14)=8RPEADJ(1)
      LPARM(15)=8RPEADJ(2)
      LPARM(16)=2RK3
      LPARM(17)=4RSRC1
      LPARM(18)=5RLIRC6
      LPARM(19)=4RLKK6
      LPARM(20)=4RCSSR
      LPARM(21)=5RHWARP
      LPARM(22)=5RVWARP
      LPARM(23)=9RFOREST(1)
      LPARM(24)=9RFOREST(2)
      LPARM(25)=6RSCF(1)
      LPARM(26)=6RSCF(2)
      LPARM(27)=8RMFMAX(1)
      LPARM(28)=8RMFMAX(2)
      LPARM(29)=8RMFMIN(1)
      LPARM(30)=8RMFMIN(2)
      LPARM(31)=6RNMF(1)
      LPARM(32)=6RNMF(2)
      LPARM(33)=7RUADJ(1)
      LPARM(34)=7RUADJ(2)
      LPARM(35)=9RFUCOEF(1)
      LPARM(36)=9RFUCOEF(2)
      LPARM(37)=5RSI(1)
      LPARM(38)=5RSI(2)
      LPARM(39)=8RDAYGM(1)
      LPARM(40)=8RDAYGM(2)
      LPARM(41)=5RPLWHC
      LPARM(42)=4RTOPM
      LPARM(43)=2RAK
      LPARM(44)=2RAN
      LPARM(45)=4RRAIX
      LPARM(46)=4RSAIX
      LPARM(47)=5REHIGH
      LPARM(48)=4RELOW
      LPARM(49)=3RNEP
      LPARM(50)=4RNDUR
      LPARM(51)=4RUZSI
      LPARM(52)=4RLZSI
      LPARM(53)=4RSGWI
      LPARM(54)=4RGWSI
      LPARM(55)=4RRESI
      LPARM(56)=5RSRGXI
      LPARM(57)=5RSCEPI
      PRINT 20
   20 FORMAT(5(/),55X*PARAMETER  VALUES*/)
      PRINT 22,(INCOEF(I),I=1,12)
   22 FORMAT(1X,12I10)
      PRINT 21,(LPARM(I),I=1,12)
   21 FORMAT(1X,12A10)
      PRINT 24,(PARM(I),I=1,12)
   24 FORMAT(1X,12F10.4)
      PRINT 20
      IF(SNOW.EQ.0) GO TO 35
```

```
      PRINT 22,(INCOEF(I),I=13,24)
      PRINT 21,(LPARM(I),I=13,24)
      PRINT 24,(PARM(I),I=13,24)
      GO TO 36
   35 PRINT 22,(INCOEF(I),I=13,22),INCOEF(47),INCOEF(48)
      PRINT 21,(LPARM(I),I=13,22),LPARM(47),LPARM(48)
      PRINT 24,(PARM(I),I=13,22),PARM(47),PARM(48)
      GO TO 37
   36 PRINT 20
      PRINT 22,(INCOEF(I),I=25,36)
      PRINT 21,(LPARM(I),I=25,36)
      PRINT 24,(PARM(I),I=25,36)
      PRINT 20
      PRINT 22,(INCOEF(I),I=37,48)
      PRINT 21,(LPARM(I),I=37,48)
      PRINT 24,(PARM(I),I=37,48)
   37 PRINT 20
      PRINT 22,INCOEF(49),INCOEF(50)
      PRINT 21,LPARM(49),LPARM(50)
      PRINT 24,PARM(49),PARM(50)
      PRINT 23
   23 FORMAT(//,30X*(NOTE  ABOVE INUMBERS CORRESPOND TO A ( ) SUBSCRIPT
     1NUMBERS)*)
      PRINT 5
    5 FORMAT(//,10X*THE FOLLOWING PERIODS WILL BE REMOVED FROM CALCULATI
     1NG THE VALUE FOR THE OPTIMIZATION CRITERION AND (MEAN Q , R)*)
      IF(OUTPER.EQ.0) GO TO 11
      PRINT 7,IBUF
    7 FORMAT(/,15X*THE  BUFFER PERIOD (     THE FIRST *I4*  DAYS     )
     1       DATE                     DAY NO.*)
      PRINT 8,(MOOUT(J),DAYOUT(J),YROUT(J),MOIN(J),DAYIN(J),YRIN(J),
     1PEROUT(J),PERIN(J),J=1,OUTPER)
    8 FORMAT(65X,2I3,I5* TO*2I3,I5,4X,I5* TO*I5)
      GO TO 9
   11 PRINT 7,IBUF
    9 PRINT 25
   25 FORMAT(5(/),30X*INITIAL  STORAGE  VALUES*/)
      PRINT 21,(LPARM(I),I=51,57)
      PRINT 24,UZSI,LZSI,SGWI,GWSI,RESI,SRGXI,SCEPI
      PRINT 26
   26 FORMAT(5(/),21X*FIXED LAG*30X*CHANNEL DELAY HISTOGRAM*)
      DO 27 J=1,NGAGES
      N=NELEM(J)
      NN=N
      IF(N.GT.12) N=12
      PRINT 28,J,LAG(J),(HIST(J,K),K=1,N)
      IF(NN.LE.12) GO TO 27
      PRINT 28,J,LAG(J),(HIST(J,K),K=13,NN)
   27 CONTINUE
   28 FORMAT(10X*GAGE*I6,5X,I5,12F8.4)
      IF (LOCAL.EQ.0) GO TO 30
      PRINT 29
   29 FORMAT(/,5X*NUMBER OF HEADWATER AREAS*5X*CORRESPONDING FIXED LAGS*
     1)
```

```
      PRINT 31,NHWA,(LLAG(I),I=1,NHWA)
   31 FORMAT(14X,I3,5X,5I5)
      IF(VARL.EQ.0) GO TO 30
      PRINT 32,(VL(I),I=1,NVL)
   32 FORMAT(5(/),10X*VARIABLE LAG*11F10.2)
      PRINT 33,(FQLAG(I),I=1,NVL)
   33 FORMAT(10X*UPPER FLOW *11F10.2)
      IF (VARK.EQ.0) GO TO 30
      PRINT 34,(VVK(I),I=1,NVK)
   34 FORMAT(5(/),10X*VARIABLE   K*11F10.2)
      PRINT 33,(FQK(I),I=1,NVK)
   30 PRINT 201
      PRINT 200,(HEAD(I),I=1,8)
      PRINT 3
    3 FORMAT(//,40X*NDAY  WATER  BALANCE  QUANTITIES  (FOR   RUN   1)*)
      PRINT 4
    4 FORMAT(10X*SURFACE RO  INTERFLOW  IMPERVIOUS RO  GROUNDWATER  INTE
     1RCEPTION  ACT. ET LOSS       PREC.      P.E.  AVAIL ET   BALANCE*)
      RATIOE=SCEPI/EPXM
      RATIOL=LZSI/LZSN
      RATIOS=SGWI*LKK6*(1.0+KV*GWSI)
      RATIOU=UZSI/UZSN
      NCOE=NUMA-NCOE+1
      NXC=NXNEP+NXNDUR
      IZY=0
      NSTART=0
      KKK=0
      CALL LAND
      END
```

SECTION H.2   SAMPLE INPUT (OPTIMIZATION)

```
   1    1    1    1    1
  40    0    0    0    0
   1    1    0    1    1
   1    1    1    1
   1    1
   1
   1    1
   0
   1    1
   1
   1
  50 1961    8  213    0
      .03       .30       .20       6.0       .25       2.0       .75
    752.0
      1.0
      .01       .28
 1.0  .50   91   60  0.0
      1.0
      .90       .10     .0025       5.0       .92
      0.0       6.0       1.4       0.0       0.0       0.0       0.0
1522   61   16    1    3  200    3
   1    2    3    4    5    6    7    9   10   11   21   22   47   48   49   50
   1    1
   0
   0
      .03       .01       .03       .02       .02       .01      .002       .05
      .05       .03       .02       .02       .02       .02       .02       .02
      .01       3.0       .10       .75       .25       .50       .85      .001
     .001       .01       .25       .70       .80       .10      61.0       1.0
      .50      10.0       .50       4.0       3.0      20.0       .99       .06
      .10       .75       2.0       2.0       1.3       .80     150.0     120.0
     .005    3
  18
   0    0
   1   11
.000.023.036.044.049.051.053.055.056.057.058.059.060.061.062.062.063.064.066.067
.069.070.072.074.076.078.080.081.082.082.081.080.079.077.075.072.068.064.061.057
.054.050.047.044.040.037.033.030.027.024.021.018.015.012.010
   0    0    0    0
.500
NWS OPTIMIZATION LEAF RIVER NR COLLINS,MISS.  WYRS 62-65  (BUFFER 8/61-9/61)
```

NWS OPTIMIZATION LEAF RIVER NR COLLINS,MISS. WYRS 62-65 (BUFFER 8/61-9/61)

THE PERIOD OF RECORD BEING ANALYZED IS FROM 8 1961 THRU 9 1965 THE BUFFER PERIOD IS THE FIRST 61 DAYS

PARAMETER VALUES

1	2	3	4	5	6	7	0	8	9	10	0
UZSN	LZSN	CB	POWER	CC	KV	KGS	K24EL	A	K24L	EPXM	K1(1)
.2000	6.0000	.2500	2.0000	.7500	5.0000	.9200	0.0000	.0300	.0100	.3000	1.0000

PARAMETER VALUES

0	0	0	0	0	0	0	0	11	12	13	14
K1(2)	PEADJ(1)	PEADJ(2)	K3	SRC1	LIRC6	LKK6	CSSR	HWARP	VWARP	EHIGH	ELOW
0.0000	1.0000	0.0000	.2800	.9000	.1000	.0025	.5000	1.0000	1.0000	1.0000	.5000

PARAMETER VALUES

15	16
NEP	NDUR
91.0000	60.0000

(NOTE ABOVE INUMBERS CORRESPOND TO A ( ) SUBSCRIPT NUMBERS)

THE FOLLOWING PERIODS WILL BE REMOVED FROM CALCULATING THE VALUE FOR THE OPTIMIZATION CRITERION AND (MEAN Q , R)

THE BUFFER PERIOD (THE FIRST 61 DAYS) DATE DAY NO.

INITIAL STORAGE VALUES

UZSI	LZSI	SGWI	GWSI	RESI	SRGXI	SCEPI
0.0000	6.0000	1.4000	0.0000	0.0000	0.0000	0.0000

		FIXED LAG	CHANNEL DELAY HISTOGRAM											
GAGE	1	0	.0270	.0495	.0553	.0585	.0613	.0637	.0680	.0730	.0788	.0817	.0793	.0732
GAGE	1	0	.0625	.0520	.0420	.0317	.0225	.0137						

NWS OPTIMIZATION LEAF RIVER NR COLLINS,MISS. WYRS 62-65 (BUFFER 8/61-9/61)

NDAY WATER BALANCE QUANTITIES (FOR RUN 1)

SURFACE RO	INTERFLOW	IMPERVIOUS RO	GROUNDWATER	INTERCEPTION	ACT. ET LOSS	PREC.	P.E.	AVAIL ET	BALANCE
21.321	12.560	6.569	43.582	65.502	134.931	218.970	206.423	180.141	-.000

MEAN DAILY FLOWS (FOR RUN 1 BUFFER PER NOT INC)

```
 *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *
HISTOGRAM   27  50  56  59  62  64  68  73  79  82  80  74  63  52  42  32  23  14   2
 *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *
   251.60    287.91    366.82    409.79    408.34    350.33    290.14    266.18    262.32    256.31
   247.72    235.10    224.68    219.54    216.16    213.22    210.54    208.05    205.69    203.45
   201.28    199.17    197.12    195.11    193.13    191.18    189.25    187.36    187.51    190.35
   190.66
   188.22    182.09    266.81    454.16    603.41    621.51    479.84    322.40    254.03    229.47
   215.71    207.93    831.21   4563.52   7109.03   8780.31   7087.84   4372.42   2950.46   2055.24
  1469.94   1217.40   3365.50   5129.04   6256.54   5110.56   2843.85   1620.29   1195.76    939.65
   190.66
   767.47    649.73    568.26    510.74    485.15    507.68    581.07    645.73    938.79   2941.88
  4933.30   8809.25  11338.95  12198.97  11616.58   9694.27   9372.23  11833.25  13210.15  13069.34
 10092.41   6535.77   4485.15   3259.87   2446.84   1893.95   1539.80   1352.46   1236.43   1141.91
  1079.66
  1270.19   1489.91   1642.13   1528.18   4797.50  11303.48  15541.77  15480.20  10081.95   5349.57
  3807.05   3096.64   2540.68   2015.89   1996.44   2348.73   2692.12   3149.78   6365.55   9279.62
 11232.83   9760.25   6440.95   4336.69   3282.24   2693.02   4084.75   5408.00   6335.97   5486.47
  3592.04
  2383.36   1830.36   1474.92   1232.09   1067.48    959.23    878.55    818.61    767.36    727.84
   699.79    675.35    656.13    641.62    630.42    629.57    626.00    624.91    637.98    640.67
   927.18   1584.57   2282.60   2867.55   2864.88   2553.04   2192.63   1817.16   6335.97   5486.47
  3592.04
  1552.06   1375.91   1322.94   1337.51   1354.79   1266.25   1114.53    976.45    875.58    806.45
   755.11    706.98    660.01    630.59    674.62    729.09    773.10    755.92    694.06    642.42
   608.14    582.67    563.23    548.05    551.12    557.87    557.60    541.69    514.96    498.99
  3527.04
  7239.13   9397.60   8212.92   4349.40   1866.23   1544.00   1680.92   1833.88   1772.34   1430.56
  1107.15   2033.22   3460.91   4457.92   4246.92   2878.03   1781.88   1343.32   1078.01    898.34
   773.89    687.22    627.06    594.42    594.01    588.61    705.00   4610.79   8103.52  10347.06
  3527.04
  8690.13   4809.95   2577.51   1842.15   1401.00   1105.62    909.99    777.41    686.08    622.51
   577.72    545.67    525.32    525.15    519.86    511.04    489.69    476.04    470.75    466.62
   456.12    444.08    436.83    432.08    427.61    423.24    418.95    414.72    411.59    483.19
   799.19
  1065.69   1274.64   1190.46   1008.56    890.14    787.60    703.58    612.95    546.85    505.19
   482.29    470.73    460.26    445.99    423.08    402.50    391.43    385.13    391.77    478.86
   533.98    560.27    504.45    430.45    409.51    429.10    433.24    424.04    415.19    401.64
   799.19
   396.99    377.03    351.06    337.98    332.59    326.37    320.92    317.30    315.79    325.51
   330.99    348.97    390.95    403.10    395.95    352.85    322.83    319.62    317.68    303.23
   286.66    281.18    286.54    288.15    286.53    287.14    316.14    330.63    334.86    330.32
   312.52
   311.85    415.29    557.17    668.36    632.77    482.10    349.83    294.48    268.10    251.57
   244.47    239.92    236.05    234.38    243.36    287.17    306.03    319.35    290.46    261.27
   244.45    233.39    224.39    224.15    238.25    250.55    255.82    239.17    217.06    210.24
   208.07
   207.48    200.66    195.70    192.65    210.36    292.88    331.38    337.44    269.60    225.21
   241.11    282.20    282.13    279.56    396.75    449.91    472.07    355.89    226.20    185.03
   172.54    167.09    163.81    161.10    158.73    157.01    156.01    154.62    152.78    150.27
   208.07
```

165.68	206.93	227.27	222.58	183.07	149.83	147.95	200.73	326.80	384.41
371.72	261.43	166.18	142.97	138.64	139.44	165.62	179.70	183.58	165.42
242.06	334.79	386.27	332.72	214.06	148.55	136.80	132.40	129.21	129.38
130.25									
129.87	126.67	127.92	165.20	188.00	194.80	165.03	131.49	129.65	133.13
134.42	176.72	201.09	215.58	182.51	132.43	113.61	143.82	176.06	280.99
372.05	409.69	365.22	257.94	179.73	153.18	142.51	135.40	130.07	125.97
130.25									
122.72	120.08	118.34	133.72	161.80	187.31	186.91	161.80	131.94	117.09
113.26	111.46	110.07	108.49	106.33	105.36	104.67	103.83	102.14	100.61
104.03	115.92	120.79	156.00	252.16	314.68	344.27	321.37	409.96	523.76
587.84									
518.16	387.13	305.19	263.95	241.63	236.88	228.71	215.95	193.88	176.09
210.93	404.56	571.72	687.37	628.30	493.41	408.58	453.09	1011.08	2571.48
3638.63	3937.89	2992.81	1861.07	1344.50	1122.36	1345.47	1591.31	1772.76	1865.55
1909.99									
2020.28	1994.11	2073.68	2102.01	2148.74	1850.60	1380.91	1069.84	880.88	750.97
674.11	668.83	673.44	669.48	621.64	558.55	517.08	570.66	1252.49	1877.00
2318.42	2104.49	1530.05	1319.76	1366.70	1445.67	1383.32	1148.83	1772.76	1865.55
1909.99									
1131.19	1374.82	1675.10	1763.41	1556.35	1300.78	1122.26	1003.96	885.38	769.86
698.06	817.16	1288.37	1660.78	1843.53	1586.83	1214.92	983.13	819.18	732.17
670.49	622.89	570.73	522.72	503.07	557.47	641.27	709.95	709.83	644.89
578.57									
534.16	502.53	479.06	461.23	448.13	477.98	531.75	576.36	578.21	532.33
486.63	474.97	477.40	472.00	451.80	419.18	397.07	388.74	382.91	389.41
399.03	401.63	391.60	373.16	366.78	377.40	398.27	413.47	408.62	391.35
578.57									
369.30	354.13	342.77	330.56	323.81	326.26	325.92	323.42	315.69	307.75
303.54	300.44	297.44	294.48	291.55	288.64	285.77	282.92	280.63	280.90
279.57	278.82	280.53	278.84	276.06	268.98	261.55	261.38	262.55	262.99
259.17									
252.12	245.52	241.37	238.66	237.69	243.47	244.98	243.58	236.08	228.74
227.13	225.06	221.73	217.49	214.36	215.01	227.21	279.25	348.21	415.93
483.10	557.21	561.12	505.61	418.46	334.60	304.63	262.39	222.98	218.35
259.17									
221.52	241.55	253.36	286.35	301.00	288.99	253.62	221.77	237.87	250.75
247.25	212.94	196.97	221.91	255.56	262.83	262.93	280.59	288.09	288.79
243.77	199.23	175.14	163.14	183.78	235.02	272.52	281.92	238.92	190.54
165.78									
156.05	153.71	149.50	142.91	138.58	137.10	147.21	159.59	173.42	184.47
178.07	174.48	159.44	198.73	303.77	349.25	331.50	224.46	140.27	145.77
182.78	200.46	191.79	152.44	123.02	120.61	121.93	126.35	181.33	275.00
340.17									
324.82	233.62	148.56	118.85	127.69	133.37	133.62	119.99	110.27	116.37
119.77	122.07	152.19	238.84	291.20	289.77	211.48	132.88	102.99	95.54
93.60	92.34	91.21	90.15	89.15	88.18	99.23	127.56	140.11	136.04
340.17									
108.64	86.49	82.28	81.25	80.42	79.62	78.82	78.03	77.26	76.49
75.72	74.97	75.65	83.46	87.50	88.07	81.07	73.02	70.10	69.21
68.51	67.83	67.15	66.48	65.82	65.16	64.91	67.24	68.15	68.02
65.25									
77.18	110.59	125.81	120.60	90.34	70.38	68.72	67.16	69.90	84.99
92.84	89.62	70.84	56.11	53.51	52.85	52.31	51.79	51.27	56.08
72.08	85.70	202.13	261.71	286.46	209.08	99.02	71.98	122.36	148.89
65.25									
149.15	114.64	112.40	125.68	132.34	101.20	68.46	77.28	95.64	106.83
115.64	249.59	369.86	549.58	573.08	490.94	370.90	237.83	168.11	149.10
175.35	215.67	324.98	376.75	382.10	319.97	240.55	200.73	180.45	166.41
156.86									
181.74	214.50	235.32	238.58	242.32	280.21	386.48	487.84	1665.98	2573.55
3152.04	2792.41	1876.49	1427.60	1198.66	1012.68	1265.61	1523.82	1686.07	1460.25
1058.23	815.61	708.70	828.99	1624.62	2222.58	2520.34	2089.90	1411.66	1039.97
879.70									
805.18	760.83	698.09	606.81	544.18	535.27	528.88	513.75	473.29	432.97
411.91	397.35	404.82	496.15	653.85	959.95	1164.17	2177.46	2920.47	3363.05
2923.56	1936.30	1300.20	1009.61	1293.34	1871.33	2321.30	2300.49	1760.96	1039.97

879.70									
1311.78	2896.12	6157.30	8378.37	8560.25	6040.80	3634.67	2605.01	1973.05	1654.71
1461.14	1330.60	1146.35	1310.60	4179.79	6502.20	7942.27	6605.79	4094.04	2892.36
2427.66	2131.99	1769.24	1391.78	1128.33	1025.08	997.84	994.18	939.18	830.34
734.37									
670.65	625.67	593.86	569.50	834.38	9278.56	16599.49	21198.22	17547.09	9336.91
4843.35	3418.98	2931.44	3547.82	4049.32	4095.52	3194.55	2160.48	1624.58	1296.66
1073.58	918.88	810.45	755.12	933.68	1609.52	4715.70	7319.51	8758.22	7465.50
734.37									
4816.79	3148.35	2349.44	1826.39	1455.74	1187.13	1003.57	882.01	797.02	736.38
692.56	685.22	781.95	881.53	948.84	909.40	810.71	735.56	683.75	645.80
617.45	596.23	583.56	581.19	588.16	584.07	569.50	548.61	549.58	552.69
647.71									
796.29	933.18	967.95	869.14	741.16	657.84	605.50	568.35	543.81	542.31
537.01	530.29	510.05	487.14	475.57	493.70	604.24	671.68	693.90	614.92
520.09	504.14	559.61	624.69	764.04	815.70	804.55	733.03	730.83	796.83
647.71									
872.89	852.42	794.42	812.53	815.40	788.64	696.21	597.04	632.72	758.14
853.72	865.29	779.26	674.88	619.56	573.14	522.01	490.93	454.95	422.94
408.60	413.21	441.70	459.94	479.91	466.96	443.40	428.98	416.93	473.10
507.01									
530.48	545.31	551.22	553.90	516.81	462.84	440.73	449.07	440.93	415.88
387.57	388.80	415.96	428.84	420.53	390.72	372.65	369.11	358.87	336.53
319.32	342.49	374.49	401.61	385.00	347.51	316.65	303.85	299.18	295.59
286.41									
278.41	272.15	266.27	262.10	259.85	261.19	276.55	285.36	285.17	269.44
250.14	241.42	238.34	235.91	233.55	231.22	246.98	381.17	559.10	648.13
597.16	426.56	304.09	262.77	245.64	236.57	231.14	237.49	312.42	480.23
286.41									
604.64	624.22	507.41	1341.99	6070.05	8844.63	9843.37	6676.65	2902.39	1601.24
1154.52	879.53	695.17	573.08	489.75	431.59	388.29	356.30	334.61	319.63
308.58	300.14	293.48	288.02	283.32	279.18	275.60	305.58	370.52	412.94
415.18									
363.52	314.53	295.50	284.03	275.34	268.45	263.25	259.49	255.87	252.17
248.07	244.40	241.50	238.86	237.23	235.33	233.19	230.22	260.40	434.71
550.71	607.19	509.36	513.02	1124.70	1559.44	1769.53	3163.50	4936.05	6151.11
415.18									
5529.93	3258.48	1741.85	3268.41	4685.09	5619.42	4650.43	2696.13	1594.53	1185.26
2782.03	5665.69	7752.96	7736.99	5333.78	3134.68	2213.42	2233.45	2426.93	2624.10
2392.95	1856.74	1477.87	1237.99	1032.62	876.51	764.10	683.33	624.39	685.23
1953.29									
3163.27	4045.14	3694.85	2590.22	1837.09	1440.31	1163.20	966.69	844.11	1046.29
1299.12	1504.38	1428.89	1142.95	928.04	843.95	808.14	783.56	737.16	672.60
617.66	669.33	2758.07	5360.40	7243.40	6913.38	4704.66	2945.55	2139.20	1635.82
1296.06									
1063.82	907.94	797.23	717.34	654.97	675.76	906.45	1133.53	1287.81	1927.02
3179.53	7838.07	10861.84	11753.82	8957.94	4953.36	3570.69	3917.04	4382.71	4217.38
3307.13	2406.55	1848.04	1508.84	1434.31	1431.70	1427.46	1291.35	2139.20	1635.82
1296.06									
1388.78	2221.80	2968.37	3319.20	2829.44	2052.70	1578.67	1279.20	1074.66	1035.04
1113.71	1633.33	2967.47	3846.84	4107.24	3262.75	2212.90	1795.78	1588.95	1452.31
1262.03	1050.11	900.21	801.28	742.61	718.13	697.69	671.11	651.91	970.46
1455.83									
1899.45	1986.94	1697.69	1365.73	1134.39	970.34	846.88	754.11	689.55	644.64
611.77	587.77	578.28	581.98	577.86	563.81	537.47	516.96	520.13	599.04
671.20	722.35	695.83	627.90	585.32	559.57	566.76	565.91	555.60	523.02
1455.83									
483.58	463.51	455.57	449.35	443.72	438.49	433.54	428.81	424.25	419.82
415.49	411.25	407.08	402.97	398.92	394.92	390.97	387.06	383.19	379.37
376.40	379.59	390.77	408.12	410.31	398.23	378.19	388.91	415.77	426.75
407.80									
366.72	340.60	333.27	329.03	325.22	342.32	468.58	572.10	617.89	545.26
431.95	378.80	367.43	462.40	650.93	877.11	958.26	860.79	673.57	528.31
453.96	411.52	381.58	364.48	368.24	365.82	358.26	344.40	343.05	343.45

407.80									
350.08	340.38	337.07	367.71	378.08	379.37	385.61	490.13	579.46	645.10
616.09	539.24	481.13	412.20	367.92	362.30	359.88	338.56	309.33	286.93
277.29	266.86	258.17	269.88	350.02	397.68	456.98	515.08	527.96	547.89
478.12									
394.61	337.22	297.52	275.88	262.24	256.44	293.70	382.42	582.89	698.53
706.48	582.54	468.04	435.42	424.21	386.57	350.18	372.23	398.70	446.23
459.38	474.15	466.08	432.18	396.55	358.37	331.02	317.08	365.43	397.11
404.97									
354.29	298.03	275.64	274.10	275.59	272.02	260.96	241.86	228.78	255.20
403.42	594.12	720.10	693.27	549.66	426.06	361.42	324.81	300.82	297.92
304.79	307.94	331.27	359.10	370.55	353.38	301.35	261.45	250.13	359.91
404.97									

TRIAL	RUN	CRITERION	MEAN Q	R	A(1) / A(9)	A(2) / A(10)	A(3) / A(11)	A(4) / A(12)	A(5) / A(13)	A(6) / A(14)	A(7) / A(15)	A(8) / A(16)
		INITIAL VALUES OF THE PARAMETERS										
1	1	.7767E+09	1146.3	.9551	.2000	6.0000	.2500	2.0000	.7500	5.0000	.9200	.0300
					.0100	.3000	1.0000	1.0000	1.0000	.5000	91.0000	60.0000
1	2	.7788E+09	1145.1	.9551	.2060	6.0000	.2500	2.0000	.7500	5.0000	.9200	.0300
					.0100	.3000	1.0000	1.0000	1.0000	.5000	91.0000	60.0000
1	3	.7747E+09	1147.4	.9551	.1940	6.0000	.2500	2.0000	.7500	5.0000	.9200	.0300
					.0100	.3000	1.0000	1.0000	1.0000	.5000	91.0000	60.0000
1	4	.7759E+09	1145.5	.9551	.1940	6.0600	.2500	2.0000	.7500	5.0000	.9200	.0300
					.0100	.3000	1.0000	1.0000	1.0000	.5000	91.0000	60.0000
1	5	.7735E+09	1149.4	.9551	.1940	5.9400	.2500	2.0000	.7500	5.0000	.9200	.0300
					.0100	.3000	1.0000	1.0000	1.0000	.5000	91.0000	60.0000
1	6	.7829E+09	1148.5	.9549	.1940	5.9400	.2575	2.0000	.7500	5.0000	.9200	.0300
					.0100	.3000	1.0000	1.0000	1.0000	.5000	91.0000	60.0000
1	7	.7650E+09	1150.3	.9552	.1940	5.9400	.2425	2.0000	.7500	5.0000	.9200	.0300
					.0100	.3000	1.0000	1.0000	1.0000	.5000	91.0000	60.0000
1	8	.7598E+09	1150.6	.9554	.1940	5.9400	.2425	2.0400	.7500	5.0000	.9200	.0300
					.0100	.3000	1.0000	1.0000	1.0000	.5000	91.0000	60.0000
1	9	.7660E+09	1150.7	.9551	.1940	5.9400	.2425	2.0400	.7650	5.0000	.9200	.0300
					.0100	.3000	1.0000	1.0000	1.0000	.5000	91.0000	60.0000
1	10	.7533E+09	1150.6	.9557	.1940	5.9400	.2425	2.0400	.7350	5.0000	.9200	.0300
					.0100	.3000	1.0000	1.0000	1.0000	.5000	91.0000	60.0000
1	11	.7512E+09	1150.7	.9558	.1940	5.9400	.2425	2.0400	.7350	5.0500	.9200	.0300
					.0100	.3000	1.0000	1.0000	1.0000	.5000	91.0000	60.0000
1	12	.7494E+09	1150.7	.9558	.1940	5.9400	.2425	2.0400	.7350	5.0500	.9218	.0300
					.0100	.3000	1.0000	1.0000	1.0000	.5000	91.0000	60.0000
1	13	.7484E+09	1153.5	.9559	.1940	5.9400	.2425	2.0400	.7350	5.0500	.9218	.0315
					.0100	.3000	1.0000	1.0000	1.0000	.5000	91.0000	60.0000
1	14	.7486E+09	1153.2	.9559	.1940	5.9400	.2425	2.0400	.7350	5.0500	.9218	.0315
					.0105	.3000	1.0000	1.0000	1.0000	.5000	91.0000	60.0000
1	15	.7482E+09	1153.8	.9559	.1940	5.9400	.2425	2.0400	.7350	5.0500	.9218	.0315
					.0095	.3000	1.0000	1.0000	1.0000	.5000	91.0000	60.0000
1	16	.7480E+09	1151.9	.9559	.1940	5.9400	.2425	2.0400	.7350	5.0500	.9218	.0315
					.0095	.3090	1.0000	1.0000	1.0000	.5000	91.0000	60.0000

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HISTOGRAM 19 47 55 58 61 63 67 72 78 82 80 75 65 54 44 34 24 15 4

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TRIAL	RUN	CRITERION	MEAN Q	R	A(1) / A(9)	A(2) / A(10)	A(3) / A(11)	A(4) / A(12)	A(5) / A(13)	A(6) / A(14)	A(7) / A(15)	A(8) / A(16)
1	17	.7766E+09	1151.9	.9539	.1940	5.9400	.2425	2.0400	.7350	5.0500	.9218	.0315
					.0095	.3090	1.0200	1.0000	1.0000	.5000	91.0000	60.0000

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HISTOGRAM   32  51  57  60  62  65  70  75  80  82  79  72  61  51  40  30  21  12   1
 * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
  1  18  .7285E+09 1151.9 .9572       .1940     5.9400      .2425     2.0400      .7350     5.0500      .9218      .0315
                                            .0095      .3090      .9800     1.0000     1.0000      .5000    91.0000    60.0000

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HISTOGRAM   31  51  56  59  62  65  70  75  81  83  80  72  61  50  40  29  20  11   1
 * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
  1  19  .7280E+09 1151.9 .9571       .1940     5.9400      .2425     2.0400      .7350     5.0500      .9218      .0315
                                            .0095      .3090      .9800     1.0200     1.0000      .5000    91.0000    60.0000

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HISTOGRAM   31  51  56  59  62  65  70  75  81  83  80  72  61  50  40  29  20  11   1
 * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
  1  20  .7304E+09 1144.2 .9571       .1940     5.9400      .2425     2.0400      .7350     5.0500      .9218      .0315
                                            .0095      .3090      .9800     1.0200     1.0200      .5000    91.0000    60.0000

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HISTOGRAM   31  51  56  59  62  65  70  75  81  83  80  72  61  50  40  29  20  11   1
 * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
  1  21  .7272E+09 1160.0 .9570       .1940     5.9400      .2425     2.0400      .7350     5.0500      .9218      .0315
                                            .0095      .3090      .9800     1.0200      .9800      .5000    91.0000    60.0000

  1  22  .7274E+09 1156.0 .9570       .1940     5.9400      .2425     2.0400      .7350     5.0500      .9218      .0315
                                            .0095      .3090      .9800     1.0200      .9800      .5100    91.0000    60.0000

  1  23  .7271E+09 1164.0 .9569       .1940     5.9400      .2425     2.0400      .7350     5.0500      .9218      .0315
                                            .0095      .3090      .9800     1.0200      .9800      .4900    91.0000    60.0000

  1  24  .7271E+09 1164.2 .9569       .1940     5.9400      .2425     2.0400      .7350     5.0500      .9218      .0315
                                            .0095      .3090      .9800     1.0200      .9800      .4900    92.0000    60.0000

  1  25  .7270E+09 1163.8 .9569       .1940     5.9400      .2425     2.0400      .7350     5.0500      .9218      .0315
                                            .0095      .3090      .9800     1.0200      .9800      .4900    90.0000    60.0000

  1  26  .7270E+09 1163.3 .9569       .1940     5.9400      .2425     2.0400      .7350     5.0500      .9218      .0315
                                            .0095      .3090      .9800     1.0200      .9800      .4900    90.0000    61.0000

  1  27  .7270E+09 1164.4 .9569       .1940     5.9400      .2425     2.0400      .7350     5.0500      .9218      .0315
                                            .0095      .3090      .9800     1.0200      .9800      .4900    90.0000    59.0000

  1  27  .7270E+09 1164.4 .9569       .1940     5.9400      .2425     2.0400      .7350     5.0500      .9218      .0315
                                            .0095      .3090      .9800     1.0200      .9800      .4900    90.0000    60.0000

                   PATTERN  MOVE
 * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
HISTOGRAM   35  52  57  60  63  66  71  78  84  84  80  71  59  48  37  27  18   9
 * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
  2  28  .7041E+09 1181.8 .9575       .1880     5.8800      .2350     2.0800      .7200     5.1000      .9237      .0330
                                            .0090      .3180      .9600     1.0400      .9600      .4800    89.0000    60.0000

TRIAL RUN  CRITERION MEAN Q   R       A( 1)      A( 2)      A( 3)      A( 4)      A( 5)      A( 6)      A( 7)      A( 8)
                                            A( 9)      A(10)      A(11)      A(12)      A(13)      A(14)      A(15)      A(16)
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -

  2  29  .7044E+09 1182.9 .9574       .1822     5.8800      .2350     2.0800      .7200     5.1000      .9237      .0330
                                            .0090      .3180      .9600     1.0400      .9600      .4800    89.0000    60.0000

  2  30  .7037E+09 1180.8 .9575       .1938     5.8800      .2350     2.0800      .7200     5.1000      .9237      .0330
                                            .0090      .3180      .9600     1.0400      .9600      .4800    89.0000    60.0000

  2  31  .7041E+09 1182.6 .9575       .1938     5.8206      .2350     2.0800      .7200     5.1000      .9237      .0330
                                            .0090      .3180      .9600     1.0400      .9600      .4800    89.0000    60.0000
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 2 32  .7034E+09 1178.9 .9576   .1938  5.9394   .2350   2.0800   .7200   5.1000   .9237   .0330
                                     .0090    .3180    .9600   1.0400    .9600    .4800  89.0000  60.0000
 2 33  .7047E+09 1179.9 .9573   .1938  5.9394   .2277   2.0800   .7200   5.1000   .9237   .0330
                                     .0090    .3180    .9600   1.0400    .9600    .4800  89.0000  60.0000
 2 34  .7035E+09 1178.1 .9578   .1938  5.9394   .2423   2.0800   .7200   5.1000   .9237   .0330
                                     .0090    .3180    .9600   1.0400    .9600    .4800  89.0000  60.0000
 2 35  .6999E+09 1179.3 .9577   .1938  5.9394   .2350   2.1208   .7200   5.1000   .9237   .0330
                                     .0090    .3180    .9600   1.0400    .9600    .4800  89.0000  60.0000
 2 36  .6980E+09 1179.3 .9578   .1938  5.9394   .2350   2.1208   .7053   5.1000   .9237   .0330
                                     .0090    .3180    .9600   1.0400    .9600    .4800  89.0000  60.0000
 2 37  .6963E+09 1179.3 .9578   .1938  5.9394   .2350   2.1208   .7053   5.1505   .9237   .0330
                                     .0090    .3180    .9600   1.0400    .9600    .4800  89.0000  60.0000
 2 38  .6946E+09 1179.4 .9579   .1938  5.9394   .2350   2.1208   .7053   5.1505   .9255   .0330
                                     .0090    .3180    .9600   1.0400    .9600    .4800  89.0000  60.0000
 2 39  .6951E+09 1182.2 .9579   .1938  5.9394   .2350   2.1208   .7053   5.1505   .9255   .0346
                                     .0090    .3180    .9600   1.0400    .9600    .4800  89.0000  60.0000
 2 40  .6943E+09 1176.5 .9579   .1938  5.9394   .2350   2.1208   .7053   5.1505   .9255   .0314
                                     .0090    .3180    .9600   1.0400    .9600    .4800  89.0000  60.0000
 2 41  .6941E+09 1176.8 .9579   .1938  5.9394   .2350   2.1208   .7053   5.1505   .9255   .0314
                                     .0085    .3180    .9600   1.0400    .9600    .4800  89.0000  60.0000
 2 42  .6935E+09 1174.9 .9579   .1938  5.9394   .2350   2.1208   .7053   5.1505   .9255   .0314
                                     .0085    .3273    .9600   1.0400    .9600    .4800  89.0000  60.0000
 * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
HISTOGRAM  38  54  58  61  64  68  73  80  85  85  80  69  57  46  35  25  17   6
 * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
 2 43  .6882E+09 1174.9 .9582   .1938  5.9394   .2350   2.1208   .7053   5.1505   .9255   .0314
                                     .0085    .3273    .9404   1.0400    .9600    .4800  89.0000  60.0000
 * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
HISTOGRAM  38  53  58  61  64  68  73  80  86  86  80  69  57  46  35  25  16   6
 * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
 2 44  .6903E+09 1174.9 .9580   .1938  5.9394   .2350   2.1208   .7053   5.1505   .9255   .0314
                                     .0085    .3273    .9404   1.0604    .9600    .4800  89.0000  60.0000
 * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
HISTOGRAM  39  54  58  61  64  68  72  79  83  83  79  69  57  47  36  26  17   7
 * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
 2 45  .6859E+09 1174.9 .9584   .1938  5.9394   .2350   2.1208   .7053   5.1505   .9255   .0314
                                     .0085    .3273    .9404   1.0196    .9600    .4800  89.0000  60.0000
 * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
HISTOGRAM  39  54  58  61  64  68  72  79  83  83  79  69  57  47  36  26  17   7
 * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
 2 46  .6911E+09 1184.1 .9581   .1938  5.9394   .2350   2.1208   .7053   5.1505   .9255   .0314
                                     .0085    .3273    .9404   1.0196    .9404    .4800  89.0000  60.0000
 * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
HISTOGRAM  39  54  58  61  64  68  72  79  83  83  79  69  57  47  36  26  17   7
 * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
 2 47  .6827E+09 1166.3 .9587   .1938  5.9394   .2350   2.1208   .7053   5.1505   .9255   .0314
                                     .0085    .3273    .9404   1.0196    .9796    .4800  89.0000  60.0000
 2 48  .6838E+09 1170.2 .9586   .1938  5.9394   .2350   2.1208   .7053   5.1505   .9255   .0314
                                     .0085    .3273    .9404   1.0196    .9796    .4702  89.0000  60.0000
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  2  49   .6817E+09 1162.4 .9588       .1938    5.9394     .2350     2.1208     .7053     5.1505     .9255     .0314
                                               .0085     .3273     .9404     1.0196     .9796     .4898    89.0000    60.0000

  2  50   .6818E+09 1162.1 .9588       .1938    5.9394     .2350     2.1208     .7053     5.1505     .9255     .0314
                                               .0085     .3273     .9404     1.0196     .9796     .4898    88.0000    60.0000

  2  51   .6816E+09 1162.6 .9588       .1938    5.9394     .2350     2.1208     .7053     5.1505     .9255     .0314
                                               .0085     .3273     .9404     1.0196     .9796     .4898    90.0000    60.0000

  2  52   .6814E+09 1162.0 .9588       .1938    5.9394     .2350     2.1208     .7053     5.1505     .9255     .0314
                                               .0085     .3273     .9404     1.0196     .9796     .4898    90.0000    61.0000

  2  52   .6814E+09 1162.0 .9588       .1938    5.9394     .2350     2.1208     .7053     5.1505     .9255     .0314
                                               .0085     .3273     .9404     1.0196     .9796     .4898    90.0000    61.0000

                    PATTERN  MOVE
 *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *
 HISTOGRAM   44   58   61   64   66   70   75   81   84   82   76   65   55   45   34   25   15    2
 *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *
  3  53   .6681E+09 1160.4 .9589       .1936    5.9388     .2275     2.2016     .6756     5.2510     .9292     .0313
                                               .0075     .3455     .9008     1.0192     .9792     .4896    90.0000    62.0000

 TRIAL RUN  CRITERION MEAN Q    R       A( 1)     A( 2)     A( 3)     A( 4)     A( 5)     A( 6)     A( 7)     A( 8)
                                               A( 9)     A(10)     A(11)     A(12)     A(13)     A(14)     A(15)     A(16)
                                 - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -

  3  54   .6675E+09 1159.3 .9590       .1995    5.9388     .2275     2.2016     .6756     5.2510     .9292     .0313
                                               .0075     .3455     .9008     1.0192     .9792     .4896    90.0000    62.0000

  3  55   .6668E+09 1157.5 .9590       .1995    5.9982     .2275     2.2016     .6756     5.2510     .9292     .0313
                                               .0075     .3455     .9008     1.0192     .9792     .4896    90.0000    62.0000

  3  56   .6726E+09 1158.4 .9585       .1995    5.9982     .2204     2.2016     .6756     5.2510     .9292     .0313
                                               .0075     .3455     .9008     1.0192     .9792     .4896    90.0000    62.0000

  3  57   .6627E+09 1156.5 .9595       .1995    5.9982     .2345     2.2016     .6756     5.2510     .9292     .0313
                                               .0075     .3455     .9008     1.0192     .9792     .4896    90.0000    62.0000

  3  58   .6610E+09 1156.9 .9595       .1995    5.9982     .2345     2.2440     .6756     5.2510     .9292     .0313
                                               .0075     .3455     .9008     1.0192     .9792     .4896    90.0000    62.0000

  3  59   .6621E+09 1156.9 .9594       .1995    5.9982     .2345     2.2440     .6615     5.2510     .9292     .0313
                                               .0075     .3455     .9008     1.0192     .9792     .4896    90.0000    62.0000

  3  60   .6604E+09 1156.9 .9597       .1995    5.9982     .2345     2.2440     .6897     5.2510     .9292     .0313
                                               .0075     .3455     .9008     1.0192     .9792     .4896    90.0000    62.0000

  3  61   .6587E+09 1157.0 .9597       .1995    5.9982     .2345     2.2440     .6897     5.3025     .9292     .0313
                                               .0075     .3455     .9008     1.0192     .9792     .4896    90.0000    62.0000

  3  62   .6571E+09 1157.0 .9598       .1995    5.9982     .2345     2.2440     .6897     5.3025     .9311     .0313
                                               .0075     .3455     .9008     1.0192     .9792     .4896    90.0000    62.0000

  3  63   .6567E+09 1154.2 .9598       .1995    5.9982     .2345     2.2440     .6897     5.3025     .9311     .0298
                                               .0075     .3455     .9008     1.0192     .9792     .4896    90.0000    62.0000

  3  64   .6565E+09 1154.4 .9598       .1995    5.9982     .2345     2.2440     .6897     5.3025     .9311     .0298
                                               .0071     .3455     .9008     1.0192     .9792     .4896    90.0000    62.0000

  3  65   .6562E+09 1152.4 .9598       .1995    5.9982     .2345     2.2440     .6897     5.3025     .9311     .0298
                                               .0071     .3554     .9008     1.0192     .9792     .4896    90.0000    62.0000

 *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *
 HISTOGRAM   46   59   62   65   67   71   76   82   83   81   74   64   54   44   33   24   14    1
 *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *
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   3  66   .6587E+09 1152.4  .9596      .1995     5.9982     .2345     2.2440     .6897     5.3025     .9311      .0298
                                              .0071      .3554      .8820     1.0192      .9792      .4896    90.0000    62.0000
 *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *
HISTOGRAM   42  56  60  63  65  69  74  80  83  82  77  67  56  46  35  26  16   4
 *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *
   3  67   .6559E+09 1152.4  .9599      .1995     5.9982     .2345     2.2440     .6897     5.3025     .9311      .0298
                                              .0071      .3554      .9196     1.0192      .9792      .4896    90.0000    62.0000
 *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *
HISTOGRAM   42  57  60  63  65  69  73  78  82  81  76  67  57  47  36  27  17   5
 *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *
   3  68   .6537E+09 1152.4  .9602      .1995     5.9982     .2345     2.2440     .6897     5.3025     .9311      .0298
                                              .0071      .3554      .9196      .9988      .9792      .4896    90.0000    62.0000
 *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *
HISTOGRAM   42  57  60  63  65  69  73  78  82  81  76  67  57  47  36  27  17   5
 *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *
   3  69   .6531E+09 1144.1  .9603      .1995     5.9982     .2345     2.2440     .6897     5.3025     .9311      .0298
                                              .0071      .3554      .9196      .9988      .9988      .4896    90.0000    62.0000

   3  70   .6527E+09 1140.2  .9603      .1995     5.9982     .2345     2.2440     .6897     5.3025     .9311      .0298
                                              .0071      .3554      .9196      .9988      .9988      .4994    90.0000    62.0000

   3  71   .6527E+09 1140.5  .9603      .1995     5.9982     .2345     2.2440     .6897     5.3025     .9311      .0298
                                              .0071      .3554      .9196      .9988      .9988      .4994    91.0000    62.0000

   3  72   .6527E+09 1139.9  .9603      .1995     5.9982     .2345     2.2440     .6897     5.3025     .9311      .0298
                                              .0071      .3554      .9196      .9988      .9988      .4994    91.0000    63.0000

   3  73   .6526E+09 1141.0  .9603      .1995     5.9982     .2345     2.2440     .6897     5.3025     .9311      .0298
                                              .0071      .3554      .9196      .9988      .9988      .4994    91.0000    61.0000

   3  73   .6526E+09 1141.0  .9603      .1995     5.9982     .2345     2.2440     .6897     5.3025     .9311      .0298
                                              .0071      .3554      .9196      .9988      .9988      .4994    91.0000    61.0000

                           PATTERN  MOVE
 *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *
HISTOGRAM   45  58  61  64  66  70  74  79  82  80  75  65  55  46  35  26  16   2
 *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *
   4  74   .6383E+09 1137.4  .9606      .1995     5.9982     .2345     2.3672     .6741     5.4545     .9366      .0298
                                              .0057      .3834      .8988      .9988      .9988      .4994    91.0000    61.0000

TRIAL RUN  CRITERION MEAN Q    R         A( 1)      A( 2)      A( 3)      A( 4)      A( 5)      A( 6)      A( 7)      A( 8)
                                              A( 9)      A(10)      A(11)      A(12)      A(13)      A(14)      A(15)      A(16)
                                - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -

PARAMETER  A( 1) =      .199  REMOVED FROM OPTIMIZATION
PARAMETER  A( 2) =     5.998  REMOVED FROM OPTIMIZATION
PARAMETER  A( 3) =      .235  REMOVED FROM OPTIMIZATION
   4  75   .6373E+09 1137.7  .9606      .1995     5.9982     .2345     2.4121     .6741     5.4545     .9366      .0298
                                              .0057      .3834      .8988      .9988      .9988      .4994    91.0000    61.0000

   4  76   .6370E+09 1137.7  .9607      .1995     5.9982     .2345     2.4121     .6879     5.4545     .9366      .0298
                                              .0057      .3834      .8988      .9988      .9988      .4994    91.0000    61.0000

   4  77   .6356E+09 1137.8  .9608      .1995     5.9982     .2345     2.4121     .6879     5.5075     .9366      .0298
                                              .0057      .3834      .8988      .9988      .9988      .4994    91.0000    61.0000

   4  78   .6349E+09 1137.9  .9608      .1995     5.9982     .2345     2.4121     .6879     5.5075     .9385      .0298
                                              .0057      .3834      .8988      .9988      .9988      .4994    91.0000    61.0000

PARAMETER  A( 8) =      .030  REMOVED FROM OPTIMIZATION
   4  79   .6348E+09 1138.1  .9608      .1995     5.9982     .2345     2.4121     .6879     5.5075     .9385      .0298
                                              .0054      .3834      .8988      .9988      .9988      .4994    91.0000    61.0000
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    4  80   .6345E+09 1136.1 .9608         .1995     5.9982      .2345      2.4121      .6879      5.5075      .9385      .0298
                                              .0054      .3941      .8988      .9988      .9988      .4994    91.0000    61.0000

  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *
 HISTOGRAM    43   57   60   63   65   69   73   78   82   80   76   67   57   47   36   27   17    4
  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *
    4  81   .6340E+09 1136.1 .9609         .1995     5.9982      .2345      2.4121      .6879      5.5075      .9385      .0298
                                              .0054      .3941      .9172      .9988      .9988      .4994    91.0000    61.0000

  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *
 HISTOGRAM    43   57   60   63   65   69   73   78   82   80   76   67   57   47   36   27   17    4
  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *
 PARAMETER   A(12) =       .999  REMOVED FROM OPTIMIZATION
  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *
 HISTOGRAM    43   57   60   63   65   69   73   78   82   80   76   67   57   47   36   27   17    4
  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *
 PARAMETER   A(13) =       .999  REMOVED FROM OPTIMIZATION
 PARAMETER   A(14) =       .499  REMOVED FROM OPTIMIZATION
 PARAMETER   A(15) =     91.000  REMOVED FROM OPTIMIZATION
 PARAMETER   A(16) =     61.000  REMOVED FROM OPTIMIZATION
    4  81   .6340E+09 1136.1 .9609         .1995     5.9982      .2345      2.4121      .6879      5.5075      .9385      .0298
                                              .0054      .3941      .9172      .9988      .9988      .4994    91.0000    61.0000

                          PATTERN  MOVE
  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *
 HISTOGRAM    43   57   60   63   65   69   73   78   82   80   76   67   57   47   36   27   17    4
  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *
    5  82   .6264E+09 1131.6 .9610         .1995     5.9982      .2345      2.5802      .6879      5.7126      .9459      .0298
                                              .0036      .4329      .9172      .9988      .9988      .4994    91.0000    61.0000

 TRIAL RUN  CRITERION MEAN Q    R          A( 1)      A( 2)      A( 3)      A( 4)      A( 5)      A( 6)      A( 7)      A( 8)
                                              A( 9)      A(10)      A(11)      A(12)      A(13)      A(14)      A(15)      A(16)
                                 -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -

 PARAMETER   A( 1) =       .199  REMOVED FROM OPTIMIZATION
 PARAMETER   A( 2) =      5.998  REMOVED FROM OPTIMIZATION
 PARAMETER   A( 3) =       .235  REMOVED FROM OPTIMIZATION
    5  83   .6259E+09 1132.0 .9610         .1995     5.9982      .2345      2.6285      .6879      5.7126      .9459      .0298
                                              .0036      .4329      .9172      .9988      .9988      .4994    91.0000    61.0000

 PARAMETER   A( 5) =       .688  REMOVED FROM OPTIMIZATION
    5  84   .6250E+09 1132.0 .9610         .1995     5.9982      .2345      2.6285      .6879      5.7676      .9459      .0298
                                              .0036      .4329      .9172      .9988      .9988      .4994    91.0000    61.0000

    5  85   .6261E+09 1132.1 .9609         .1995     5.9982      .2345      2.6285      .6879      5.7676      .9477      .0298
                                              .0036      .4329      .9172      .9988      .9988      .4994    91.0000    61.0000

    5  86   .6242E+09 1131.9 .9611         .1995     5.9982      .2345      2.6285      .6879      5.7676      .9440      .0298
                                              .0036      .4329      .9172      .9988      .9988      .4994    91.0000    61.0000

 PARAMETER   A( 8) =       .030  REMOVED FROM OPTIMIZATION
    5  87   .6242E+09 1132.0 .9611         .1995     5.9982      .2345      2.6285      .6879      5.7676      .9440      .0298
                                              .0033      .4329      .9172      .9988      .9988      .4994    91.0000    61.0000

    5  88   .6240E+09 1130.0 .9611         .1995     5.9982      .2345      2.6285      .6879      5.7676      .9440      .0298
                                              .0033      .4447      .9172      .9988      .9988      .4994    91.0000    61.0000

 PARAMETER   A(11) =       .917  REMOVED FROM OPTIMIZATION
  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *
 HISTOGRAM    43   57   60   63   65   69   73   78   82   80   76   67   57   47   36   27   17    4
  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *
 PARAMETER   A(12) =       .999  REMOVED FROM OPTIMIZATION
  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *
 HISTOGRAM    43   57   60   63   65   69   73   78   82   80   76   67   57   47   36   27   17    4
  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *
 PARAMETER   A(13) =       .999  REMOVED FROM OPTIMIZATION
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 PARAMETER  A(14) =      .499  REMOVED FROM OPTIMIZATION
 PARAMETER  A(15) =    91.000  REMOVED FROM OPTIMIZATION
 PARAMETER  A(16) =    61.000  REMOVED FROM OPTIMIZATION
    5  88   .6240E+09 1130.0 .9611      .1995     5.9982      .2345     2.6285      .6879     5.7676      .9440      .0298
                                                  .0033      .4447      .9172      .9988      .9988      .4994    91.0000    61.0000

                       PATTERN  MOVE
  *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *
 HISTOGRAM   43  57  60  63  65  69  73  78  82  80  76  67  57  47  36  27  17   4
  *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *
    6  89   .6259E+09 1125.5 .9607      .1995     5.9982      .2345     2.8448      .6879     6.0277      .9495      .0298
                                                  .0013      .4953      .9172      .9988      .9988      .4994    91.0000    61.0000

 TRIAL RUN  CRITERION MEAN Q   R        A( 1)      A( 2)      A( 3)      A( 4)      A( 5)      A( 6)      A( 7)      A( 8)
                                                  A( 9)      A(10)      A(11)      A(12)      A(13)      A(14)      A(15)      A(16)
                             - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -

 PARAMETER  A( 1) =      .199  REMOVED FROM OPTIMIZATION
 PARAMETER  A( 2) =     5.998  REMOVED FROM OPTIMIZATION
 PARAMETER  A( 3) =      .235  REMOVED FROM OPTIMIZATION
    6  90   .6263E+09 1126.0 .9607      .1995     5.9982      .2345     2.8974      .6879     6.0277      .9495      .0298
                                                  .0013      .4953      .9172      .9988      .9988      .4994    91.0000    61.0000

    6  91   .6253E+09 1125.1 .9608      .1995     5.9982      .2345     2.7922      .6879     6.0277      .9495      .0298
                                                  .0013      .4953      .9172      .9988      .9988      .4994    91.0000    61.0000

 PARAMETER  A( 5) =      .688  REMOVED FROM OPTIMIZATION
    6  92   .6254E+09 1125.6 .9608      .1995     5.9982      .2345     2.8448      .6879     6.0854      .9495      .0298
                                                  .0013      .4953      .9172      .9988      .9988      .4994    91.0000    61.0000

    6  93   .6265E+09 1125.5 .9607      .1995     5.9982      .2345     2.8448      .6879     5.9701      .9495      .0298
                                                  .0013      .4953      .9172      .9988      .9988      .4994    91.0000    61.0000

    6  94   .6244E+09 1125.4 .9608      .1995     5.9982      .2345     2.8448      .6879     6.0277      .9476      .0298
                                                  .0013      .4953      .9172      .9988      .9988      .4994    91.0000    61.0000

    6  95   .6279E+09 1125.6 .9606      .1995     5.9982      .2345     2.8448      .6879     6.0277      .9514      .0298
                                                  .0013      .4953      .9172      .9988      .9988      .4994    91.0000    61.0000

 PARAMETER  A( 8) =      .030  REMOVED FROM OPTIMIZATION
    6  96   .6259E+09 1125.6 .9607      .1995     5.9982      .2345     2.8448      .6879     6.0277      .9495      .0298
                                                  .0011      .4953      .9172      .9988      .9988      .4994    91.0000    61.0000

    6  97   .6259E+09 1125.5 .9607      .1995     5.9982      .2345     2.8448      .6879     6.0277      .9495      .0298
                                                  .0015      .4953      .9172      .9988      .9988      .4994    91.0000    61.0000

    6  98   .6272E+09 1123.7 .9606      .1995     5.9982      .2345     2.8448      .6879     6.0277      .9495      .0298
                                                  .0013      .5086      .9172      .9988      .9988      .4994    91.0000    61.0000

    6  99   .6249E+09 1127.5 .9608      .1995     5.9982      .2345     2.8448      .6879     6.0277      .9495      .0298
                                                  .0013      .4819      .9172      .9988      .9988      .4994    91.0000    61.0000
 PARAMETER  A(11) =      .917  REMOVED FROM OPTIMIZATION
  *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *
 HISTOGRAM   43  57  60  63  65  69  73  78  82  80  76  67  57  47  36  27  17   4
  *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *
 PARAMETER  A(12) =      .999  REMOVED FROM OPTIMIZATION
  *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *
 HISTOGRAM   43  57  60  63  65  69  73  78  82  80  76  67  57  47  36  27  17   4
  *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *
 PARAMETER  A(13) =      .999  REMOVED FROM OPTIMIZATION
 PARAMETER  A(14) =      .499  REMOVED FROM OPTIMIZATION
 PARAMETER  A(15) =    91.000  REMOVED FROM OPTIMIZATION
 PARAMETER  A(16) =    61.000  REMOVED FROM OPTIMIZATION
  *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *
 HISTOGRAM   43  57  60  63  65  69  73  78  82  80  76  67  57  47  36  27  17   4
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PATTERN= 1 RESOLUTION= 0

TRIAL	RUN	CRITERION	MEAN Q	R	A(1) / A(9)	A(2) / A(10)	A(3) / A(11)	A(4) / A(12)	A(5) / A(13)	A(6) / A(14)	A(7) / A(15)	A(8) / A(16)
6	99	.6240E+09	1127.5	.9608	.1995	5.9982	.2345	2.6285	.6879	5.7676	.9440	.0298
					.0033	.4447	.9172	.9988	.9988	.4994	91.0000	61.0000
6	100	.6250E+09	1128.8	.9610	.2054	5.9982	.2345	2.6285	.6879	5.7676	.9440	.0298
					.0033	.4447	.9172	.9988	.9988	.4994	91.0000	61.0000
6	101	.6230E+09	1131.1	.9611	.1935	5.9982	.2345	2.6285	.6879	5.7676	.9440	.0298
					.0033	.4447	.9172	.9988	.9988	.4994	91.0000	61.0000
6	102	.6220E+09	1129.2	.9612	.1935	6.0582	.2345	2.6285	.6879	5.7676	.9440	.0298
					.0033	.4447	.9172	.9988	.9988	.4994	91.0000	61.0000
6	103	.6217E+09	1128.3	.9613	.1935	6.0582	.2416	2.6285	.6879	5.7676	.9440	.0298
					.0033	.4447	.9172	.9988	.9988	.4994	91.0000	61.0000
6	104	.6211E+09	1128.7	.9613	.1935	6.0582	.2416	2.6810	.6879	5.7676	.9440	.0298
					.0033	.4447	.9172	.9988	.9988	.4994	91.0000	61.0000
6	105	.6218E+09	1128.7	.9613	.1935	6.0582	.2416	2.6810	.7017	5.7676	.9440	.0298
					.0033	.4447	.9172	.9988	.9988	.4994	91.0000	61.0000
6	106	.6207E+09	1128.7	.9613	.1935	6.0582	.2416	2.6810	.6741	5.7676	.9440	.0298
					.0033	.4447	.9172	.9988	.9988	.4994	91.0000	61.0000
6	107	.6197E+09	1128.7	.9613	.1935	6.0582	.2416	2.6810	.6741	5.8253	.9440	.0298
					.0033	.4447	.9172	.9988	.9988	.4994	91.0000	61.0000
6	108	.6193E+09	1128.6	.9614	.1935	6.0582	.2416	2.6810	.6741	5.8253	.9421	.0298
					.0033	.4447	.9172	.9988	.9988	.4994	91.0000	61.0000
6	109	.6195E+09	1125.8	.9614	.1935	6.0582	.2416	2.6810	.6741	5.8253	.9421	.0283
					.0033	.4447	.9172	.9988	.9988	.4994	91.0000	61.0000
6	110	.6191E+09	1131.4	.9614	.1935	6.0582	.2416	2.6810	.6741	5.8253	.9421	.0313
					.0033	.4447	.9172	.9988	.9988	.4994	91.0000	61.0000
6	111	.6191E+09	1131.5	.9614	.1935	6.0582	.2416	2.6810	.6741	5.8253	.9421	.0313
					.0032	.4447	.9172	.9988	.9988	.4994	91.0000	61.0000
6	112	.6191E+09	1129.4	.9614	.1935	6.0582	.2416	2.6810	.6741	5.8253	.9421	.0313
					.0032	.4580	.9172	.9988	.9988	.4994	91.0000	61.0000

HISTOGRAM 40 55 59 62 64 68 72 77 82 81 77 68 58 48 37 28 18 6

TRIAL	RUN	CRITERION	MEAN Q	R	A(1) / A(9)	A(2) / A(10)	A(3) / A(11)	A(4) / A(12)	A(5) / A(13)	A(6) / A(14)	A(7) / A(15)	A(8) / A(16)
6	113	.6193E+09	1129.4	.9614	.1935	6.0582	.2416	2.6810	.6741	5.8253	.9421	.0313
					.0032	.4580	.9356	.9988	.9988	.4994	91.0000	61.0000

HISTOGRAM 45 58 61 64 66 70 74 79 82 80 75 65 55 46 35 26 16 2

TRIAL	RUN	CRITERION	MEAN Q	R	A(1) / A(9)	A(2) / A(10)	A(3) / A(11)	A(4) / A(12)	A(5) / A(13)	A(6) / A(14)	A(7) / A(15)	A(8) / A(16)
6	114	.6210E+09	1129.4	.9612	.1935	6.0582	.2416	2.6810	.6741	5.8253	.9421	.0313
					.0032	.4580	.8989	.9988	.9988	.4994	91.0000	61.0000

HISTOGRAM 43 57 61 63 65 68 72 77 80 79 75 66 57 48 37 28 18 5

TRIAL	RUN	CRITERION	MEAN Q	R	A(1) / A(9)	A(2) / A(10)	A(3) / A(11)	A(4) / A(12)	A(5) / A(13)	A(6) / A(14)	A(7) / A(15)	A(8) / A(16)
6	115	.6165E+09	1129.4	.9616	.1935	6.0582	.2416	2.6810	.6741	5.8253	.9421	.0313
					.0032	.4580	.9172	.9788	.9988	.4994	91.0000	61.0000

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*  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *
HISTOGRAM   43  57  61  63  65  68  72  77  80  79  75  66  57  48  37  28  18   5
*  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *
   6 116   .6184E+09 1121.1 .9615      .1935    6.0582     .2416    2.6810     .6741    5.8253     .9421     .0313
                                          .0032     .4580     .9172     .9788    1.0188     .4994   91.0000   61.0000

*  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *
HISTOGRAM   43  57  61  63  65  68  72  77  80  79  75  66  57  48  37  28  18   5
*  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *
   6 117   .6162E+09 1138.0 .9617      .1935    6.0582     .2416    2.6810     .6741    5.8253     .9421     .0313
                                          .0032     .4580     .9172     .9788     .9788     .4994   91.0000   61.0000

   6 118   .6152E+09 1134.0 .9617      .1935    6.0582     .2416    2.6810     .6741    5.8253     .9421     .0313
                                          .0032     .4580     .9172     .9788     .9788     .5094   91.0000   61.0000

   6 119   .6153E+09 1134.2 .9617      .1935    6.0582     .2416    2.6810     .6741    5.8253     .9421     .0313
                                          .0032     .4580     .9172     .9788     .9788     .5094   92.0000   61.0000

   6 120   .6151E+09 1133.7 .9617      .1935    6.0582     .2416    2.6810     .6741    5.8253     .9421     .0313
                                          .0032     .4580     .9172     .9788     .9788     .5094   90.0000   61.0000

   6 121   .6151E+09 1134.2 .9617      .1935    6.0582     .2416    2.6810     .6741    5.8253     .9421     .0313
                                          .0032     .4580     .9172     .9788     .9788     .5094   90.0000   60.0000

   6 122   .6151E+09 1133.2 .9617      .1935    6.0582     .2416    2.6810     .6741    5.8253     .9421     .0313
                                          .0032     .4580     .9172     .9788     .9788     .5094   90.0000   62.0000

   6 122   .6151E+09 1133.2 .9617      .1935    6.0582     .2416    2.6810     .6741    5.8253     .9421     .0313
                                          .0032     .4580     .9172     .9788     .9788     .5094   90.0000   62.0000

                    PATTERN  MOVE
*  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *
HISTOGRAM   44  58  61  63  65  68  72  76  79  78  74  66  58  48  38  29  19   5
*  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *
   7 123   .6088E+09 1137.1 .9622      .1875    6.1182     .2486    2.7336     .6604    5.8830     .9402     .0328
                                          .0030     .4714     .9172     .9589     .9588     .5194   89.0000   63.0000

TRIAL RUN  CRITERION MEAN Q    R       A( 1)     A( 2)     A( 3)     A( 4)     A( 5)     A( 6)     A( 7)     A( 8)
                                          A( 9)     A(10)     A(11)     A(12)     A(13)     A(14)     A(15)     A(16)
                                  - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -

   7 124   .6077E+09 1138.2 .9622      .1817    6.1182     .2486    2.7336     .6604    5.8830     .9402     .0328
                                          .0030     .4714     .9172     .9589     .9588     .5194   89.0000   63.0000

   7 125   .6071E+09 1136.4 .9623      .1817    6.1787     .2486    2.7336     .6604    5.8830     .9402     .0328
                                          .0030     .4714     .9172     .9589     .9588     .5194   89.0000   63.0000

   7 126   .6066E+09 1135.5 .9624      .1817    6.1787     .2559    2.7336     .6604    5.8830     .9402     .0328
                                          .0030     .4714     .9172     .9589     .9588     .5194   89.0000   63.0000

   7 127   .6058E+09 1135.9 .9624      .1817    6.1787     .2559    2.7872     .6604    5.8830     .9402     .0328
                                          .0030     .4714     .9172     .9589     .9588     .5194   89.0000   63.0000

   7 128   .6055E+09 1135.9 .9624      .1817    6.1787     .2559    2.7872     .6469    5.8830     .9402     .0328
                                          .0030     .4714     .9172     .9589     .9588     .5194   89.0000   63.0000

   7 129   .6045E+09 1135.9 .9624      .1817    6.1787     .2559    2.7872     .6469    5.9412     .9402     .0328
                                          .0030     .4714     .9172     .9589     .9588     .5194   89.0000   63.0000

   7 130   .6045E+09 1135.8 .9625      .1817    6.1787     .2559    2.7872     .6469    5.9412     .9383     .0328
                                          .0030     .4714     .9172     .9589     .9588     .5194   89.0000   63.0000

   7 131   .6048E+09 1136.0 .9624      .1817    6.1787     .2559    2.7872     .6469    5.9412     .9421     .0328
                                          .0030     .4714     .9172     .9589     .9588     .5194   89.0000   63.0000
```

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7 132  .6046E+09 1138.9 .9625   .1817   6.1787   .2559   2.7872   .6469   5.9412   .9402   .0343
                                 .0030   .4714    .9172   .9589    .9588   .5194   89.0000  63.0000

7 133  .6045E+09 1133.0 .9624   .1817   6.1787   .2559   2.7872   .6469   5.9412   .9402   .0312
                                 .0030   .4714    .9172   .9589    .9588   .5194   89.0000  63.0000

7 134  .6045E+09 1133.1 .9624   .1817   6.1787   .2559   2.7872   .6469   5.9412   .9402   .0312
                                 .0028   .4714    .9172   .9589    .9588   .5194   89.0000  63.0000

7 135  .6050E+09 1131.2 .9624   .1817   6.1787   .2559   2.7872   .6469   5.9412   .9402   .0312
                                 .0028   .4851    .9172   .9589    .9588   .5194   89.0000  63.0000

7 136  .6040E+09 1135.2 .9625   .1817   6.1787   .2559   2.7872   .6469   5.9412   .9402   .0312
                                 .0028   .4576    .9172   .9589    .9588   .5194   89.0000  63.0000

HISTOGRAM  42  56  60  62  64  67  71  75  79  78  75  67  58  49  39  30  20  7

7 137  .6048E+09 1135.2 .9624   .1817   6.1787   .2559   2.7872   .6469   5.9412   .9402   .0312
                                 .0028   .4576    .9356   .9589    .9588   .5194   89.0000  63.0000

HISTOGRAM  46  59  62  64  66  69  73  77  79  78  73  65  57  47  37  27  17  2

7 138  .6058E+09 1135.2 .9623   .1817   6.1787   .2559   2.7872   .6469   5.9412   .9402   .0312
                                 .0028   .4576    .8989   .9589    .9588   .5194   89.0000  63.0000

HISTOGRAM  45  58  61  63  65  68  71  75  77  76  73  66  58  49  39  29  19  5

7 139  .6030E+09 1135.2 .9626   .1817   6.1787   .2559   2.7872   .6469   5.9412   .9402   .0312
                                 .0028   .4576    .9172   .9393    .9588   .5194   89.0000  63.0000

HISTOGRAM  45  58  61  63  65  68  71  75  77  76  73  66  58  49  39  29  19  5

7 140  .6048E+09 1144.7 .9625   .1817   6.1787   .2559   2.7872   .6469   5.9412   .9402   .0312
                                 .0028   .4576    .9172   .9393    .9393   .5194   89.0000  63.0000

HISTOGRAM  45  58  61  63  65  68  71  75  77  76  73  66  58  49  39  29  19  5

7 141  .6032E+09 1126.2 .9625   .1817   6.1787   .2559   2.7872   .6469   5.9412   .9402   .0312
                                 .0028   .4576    .9172   .9393    .9784   .5194   89.0000  63.0000

7 142  .6023E+09 1131.0 .9626   .1817   6.1787   .2559   2.7872   .6469   5.9412   .9402   .0312
                                 .0028   .4576    .9172   .9393    .9588   .5296   89.0000  63.0000

7 143  .6022E+09 1130.8 .9626   .1817   6.1787   .2559   2.7872   .6469   5.9412   .9402   .0312
                                 .0028   .4576    .9172   .9393    .9588   .5296   88.0000  63.0000

7 144  .6022E+09 1130.3 .9626   .1817   6.1787   .2559   2.7872   .6469   5.9412   .9402   .0312
                                 .0028   .4576    .9172   .9393    .9588   .5296   88.0000  64.0000

7 145  .6022E+09 1131.3 .9626   .1817   6.1787   .2559   2.7872   .6469   5.9412   .9402   .0312
                                 .0028   .4576    .9172   .9393    .9588   .5296   88.0000  62.0000

7 145  .6022E+09 1131.3 .9626   .1817   6.1787   .2559   2.7872   .6469   5.9412   .9402   .0312
                                 .0028   .4576    .9172   .9393    .9588   .5296   88.0000  63.0000

                PATTERN MOVE

HISTOGRAM  46  59  62  64  65  67  70  73  74  74  71  66  59  51  42  32  21  6

8 146  .5929E+09 1129.4 .9633   .1699   6.2993   .2702   2.8934   .6197   6.0572   .9383   .0311
                                 .0025   .4572    .9172   .8997    .9389   .5497   86.0000  64.0000
```

TRIAL	RUN	CRITERION	MEAN Q	R	A(1) / A(9)	A(2) / A(10)	A(3) / A(11)	A(4) / A(12)	A(5) / A(13)	A(6) / A(14)	A(7) / A(15)	A(8) / A(16)
8	147	.5910E+09	1130.4	.9634	.1644	6.2993	.2702	2.8934	.6197	6.0572	.9383	.0311
					.0025	.4572	.9172	.8997	.9389	.5497	86.0000	64.0000
8	148	.5910E+09	1128.6	.9634	.1644	6.3611	.2702	2.8934	.6197	6.0572	.9383	.0311
					.0025	.4572	.9172	.8997	.9389	.5497	86.0000	64.0000
8	149	.5917E+09	1127.8	.9634	.1644	6.3611	.2778	2.8934	.6197	6.0572	.9383	.0311
					.0025	.4572	.9172	.8997	.9389	.5497	86.0000	64.0000
8	150	.5910E+09	1129.4	.9633	.1644	6.3611	.2625	2.8934	.6197	6.0572	.9383	.0311
					.0025	.4572	.9172	.8997	.9389	.5497	86.0000	64.0000
8	151	.5902E+09	1129.0	.9634	.1644	6.3611	.2702	2.9491	.6197	6.0572	.9383	.0311
					.0025	.4572	.9172	.8997	.9389	.5497	86.0000	64.0000
8	152	.5897E+09	1129.1	.9634	.1644	6.3611	.2702	2.9491	.6067	6.0572	.9383	.0311
					.0025	.4572	.9172	.8997	.9389	.5497	86.0000	64.0000
8	153	.5887E+09	1129.1	.9634	.1644	6.3611	.2702	2.9491	.6067	6.1166	.9383	.0311
					.0025	.4572	.9172	.8997	.9389	.5497	86.0000	64.0000
8	154	.5889E+09	1129.0	.9634	.1644	6.3611	.2702	2.9491	.6067	6.1166	.9364	.0311
					.0025	.4572	.9172	.8997	.9389	.5497	86.0000	64.0000
8	155	.5887E+09	1129.2	.9634	.1644	6.3611	.2702	2.9491	.6067	6.1166	.9402	.0311
					.0025	.4572	.9172	.8997	.9389	.5497	86.0000	64.0000
8	156	.5887E+09	1126.2	.9634	.1644	6.3611	.2702	2.9491	.6067	6.1166	.9383	.0296
					.0025	.4572	.9172	.8997	.9389	.5497	86.0000	64.0000
8	157	.5887E+09	1132.0	.9634	.1644	6.3611	.2702	2.9491	.6067	6.1166	.9383	.0327
					.0025	.4572	.9172	.8997	.9389	.5497	86.0000	64.0000
8	158	.5886E+09	1129.2	.9634	.1644	6.3611	.2702	2.9491	.6067	6.1166	.9383	.0311
					.0024	.4572	.9172	.8997	.9389	.5497	86.0000	64.0000
8	159	.5882E+09	1131.2	.9634	.1644	6.3611	.2702	2.9491	.6067	6.1166	.9383	.0311
					.0024	.4435	.9172	.8997	.9389	.5497	86.0000	64.0000

HISTOGRAM 44 58 61 63 64 66 69 72 74 74 72 67 60 52 43 33 22 8

8	160	.5893E+09	1131.2	.9634	.1644	6.3611	.2702	2.9491	.6067	6.1166	.9383	.0311
					.0024	.4435	.9356	.8997	.9389	.5497	86.0000	64.0000

HISTOGRAM 48 61 63 65 66 68 71 73 74 73 71 65 58 50 41 31 20 3

8	161	.5891E+09	1131.2	.9633	.1644	6.3611	.2702	2.9491	.6067	6.1166	.9383	.0311
					.0024	.4435	.8989	.8997	.9389	.5497	86.0000	64.0000

HISTOGRAM 46 60 62 64 65 67 69 71 73 72 70 66 59 52 43 33 22 6

8	162	.5887E+09	1131.2	.9635	.1644	6.3611	.2702	2.9491	.6067	6.1166	.9383	.0311
					.0024	.4435	.9172	.8809	.9389	.5497	86.0000	64.0000

HISTOGRAM 45 59 61 63 65 68 71 74 76 75 72 66 59 50 41 31 20 5

8	163	.5885E+09	1131.2	.9634	.1644	6.3611	.2702	2.9491	.6067	6.1166	.9383	.0311
					.0024	.4435	.9172	.9185	.9389	.5497	86.0000	64.0000

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 *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *
HISTOGRAM   46  59  62  64  65  67  70  73  74  74  71  66  59  51  42  32  21   6
 *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *
  8 164  .5908E+09 1141.2 .9633      .1644    6.3611    .2702    2.9491    .6067    6.1166    .9383    .0311
                                           .0024     .4435    .9172     .8997    .9197     .5497   86.0000   64.0000

 *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *
HISTOGRAM   46  59  62  64  65  67  70  73  74  74  71  66  59  51  42  32  21   6
 *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *
  8 165  .5880E+09 1121.7 .9635      .1644    6.3611    .2702    2.9491    .6067    6.1166    .9383    .0311
                                           .0024     .4435    .9172     .8997    .9580     .5497   86.0000   64.0000

  8 166  .5881E+09 1117.5 .9635      .1644    6.3611    .2702    2.9491    .6067    6.1166    .9383    .0311
                                           .0024     .4435    .9172     .8997    .9580     .5603   86.0000   64.0000

  8 167  .5881E+09 1126.0 .9635      .1644    6.3611    .2702    2.9491    .6067    6.1166    .9383    .0311
                                           .0024     .4435    .9172     .8997    .9580     .5391   86.0000   64.0000

  8 168  .5878E+09 1121.5 .9635      .1644    6.3611    .2702    2.9491    .6067    6.1166    .9383    .0311
                                           .0024     .4435    .9172     .8997    .9580     .5497   85.0000   64.0000

  8 169  .5879E+09 1121.0 .9635      .1644    6.3611    .2702    2.9491    .6067    6.1166    .9383    .0311
                                           .0024     .4435    .9172     .8997    .9580     .5497   85.0000   65.0000

  8 170  .5877E+09 1122.0 .9635      .1644    6.3611    .2702    2.9491    .6067    6.1166    .9383    .0311
                                           .0024     .4435    .9172     .8997    .9580     .5497   85.0000   63.0000

  8 170  .5877E+09 1122.0 .9635      .1644    6.3611    .2702    2.9491    .6067    6.1166    .9383    .0311
                                           .0024     .4435    .9172     .8997    .9580     .5497   85.0000   63.0000

                    PATTERN  MOVE
 *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *
HISTOGRAM   47  60  62  64  65  67  68  70  71  71  69  66  60  53  44  34  23   6
 *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *
  9 171  .5786E+09 1110.9 .9640      .1472    6.5434    .2844    3.1111    .5665    6.2919    .9364    .0311
                                           .0019     .4435    .9172     .8602    .9580     .5699   82.0000   63.0000

TRIAL RUN  CRITERION MEAN Q    R     A( 1)     A( 2)     A( 3)     A( 4)     A( 5)     A( 6)     A( 7)     A( 8)
                                           A( 9)     A(10)    A(11)     A(12)    A(13)     A(14)    A(15)     A(16)

  9 172  .5767E+09 1111.8 .9641      .1423    6.5434    .2844    3.1111    .5665    6.2919    .9364    .0311
                                           .0019     .4435    .9172     .8602    .9580     .5699   82.0000   63.0000

  9 173  .5769E+09 1110.0 .9641      .1423    6.6071    .2844    3.1111    .5665    6.2919    .9364    .0311
                                           .0019     .4435    .9172     .8602    .9580     .5699   82.0000   63.0000

  9 174  .5767E+09 1113.7 .9641      .1423    6.4798    .2844    3.1111    .5665    6.2919    .9364    .0311
                                           .0019     .4435    .9172     .8602    .9580     .5699   82.0000   63.0000

  9 175  .5768E+09 1112.9 .9642      .1423    6.4798    .2925    3.1111    .5665    6.2919    .9364    .0311
                                           .0019     .4435    .9172     .8602    .9580     .5699   82.0000   63.0000

  9 176  .5774E+09 1114.5 .9640      .1423    6.4798    .2763    3.1111    .5665    6.2919    .9364    .0311
                                           .0019     .4435    .9172     .8602    .9580     .5699   82.0000   63.0000

  9 177  .5768E+09 1114.1 .9640      .1423    6.4798    .2844    3.1701    .5665    6.2919    .9364    .0311
                                           .0019     .4435    .9172     .8602    .9580     .5699   82.0000   63.0000

  9 178  .5768E+09 1113.2 .9641      .1423    6.4798    .2844    3.0521    .5665    6.2919    .9364    .0311
                                           .0019     .4435    .9172     .8602    .9580     .5699   82.0000   63.0000

  9 179  .5769E+09 1113.6 .9640      .1423    6.4798    .2844    3.1111    .5544    6.2919    .9364    .0311
                                           .0019     .4435    .9172     .8602    .9580     .5699   82.0000   63.0000
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    9 180   .5769E+09 1113.7 .9641       .1423    6.4798     .2844     3.1111     .5787    6.2919     .9364     .0311
                                                .0019     .4435     .9172     .8602     .9580     .5699   82.0000   63.0000

    9 181   .5755E+09 1113.7 .9641       .1423    6.4798     .2844     3.1111     .5665    6.3531     .9364     .0311
                                                .0019     .4435     .9172     .8602     .9580     .5699   82.0000   63.0000

    9 182   .5762E+09 1113.6 .9641       .1423    6.4798     .2844     3.1111     .5665    6.3531     .9345     .0311
                                                .0019     .4435     .9172     .8602     .9580     .5699   82.0000   63.0000

    9 183   .5752E+09 1113.8 .9641       .1423    6.4798     .2844     3.1111     .5665    6.3531     .9383     .0311
                                                .0019     .4435     .9172     .8602     .9580     .5699   82.0000   63.0000

PARAMETER  A( 8) =      .031  REMOVED FROM OPTIMIZATION
    9 184   .5751E+09 1113.9 .9641       .1423    6.4798     .2844     3.1111     .5665    6.3531     .9383     .0311
                                                .0018     .4435     .9172     .8602     .9580     .5699   82.0000   63.0000

PARAMETER  A(10) =      .443  REMOVED FROM OPTIMIZATION
PARAMETER  A(11) =      .917  REMOVED FROM OPTIMIZATION
 *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *
HISTOGRAM   48  61  63  64  65  66  68  69  70  69  68  65  60  54  45  35  24   6
 *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *
    9 185   .5768E+09 1113.9 .9641       .1423    6.4798     .2844     3.1111     .5665    6.3531     .9383     .0311
                                                .0018     .4435     .9172     .8422     .9580     .5699   82.0000   63.0000

 *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *
HISTOGRAM   47  60  62  64  65  67  69  71  72  72  70  66  60  52  43  33  22   6
 *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *
    9 186   .5742E+09 1113.9 .9642       .1423    6.4798     .2844     3.1111     .5665    6.3531     .9383     .0311
                                                .0018     .4435     .9172     .8782     .9580     .5699   82.0000   63.0000

 *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *
HISTOGRAM   47  60  62  64  65  67  69  71  72  72  70  66  60  52  43  33  22   6
 *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *
PARAMETER  A(13) =      .958  REMOVED FROM OPTIMIZATION
    9 187   .5746E+09 1109.5 .9642       .1423    6.4798     .2844     3.1111     .5665    6.3531     .9383     .0311
                                                .0018     .4435     .9172     .8782     .9580     .5809   82.0000   63.0000

    9 188   .5742E+09 1118.2 .9642       .1423    6.4798     .2844     3.1111     .5665    6.3531     .9383     .0311
                                                .0018     .4435     .9172     .8782     .9580     .5589   82.0000   63.0000

    9 189   .5739E+09 1118.0 .9642       .1423    6.4798     .2844     3.1111     .5665    6.3531     .9383     .0311
                                                .0018     .4435     .9172     .8782     .9580     .5589   81.0000   63.0000

PARAMETER  A(16) =    63.000  REMOVED FROM OPTIMIZATION
    9 189   .5739E+09 1118.0 .9642       .1423    6.4798     .2844     3.1111     .5665    6.3531     .9383     .0311
                                                .0018     .4435     .9172     .8782     .9580     .5589   81.0000   63.0000

                      PATTERN  MOVE
 *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *
HISTOGRAM   47  60  62  64  65  67  68  70  71  70  69  66  60  53  44  34  23   6
 *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *
   10 190   .5634E+09 1114.6 .9647       .1201    6.5986     .2987     3.2730     .5264    6.5896     .9383     .0311
                                                .0012     .4435     .9172     .8566     .9580     .5681   77.0000   63.0000

TRIAL RUN  CRITERION MEAN Q   R          A( 1)     A( 2)     A( 3)     A( 4)     A( 5)     A( 6)     A( 7)     A( 8)
                                                A( 9)     A(10)     A(11)     A(12)     A(13)     A(14)     A(15)     A(16)
 - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -

   10 191   .5623E+09 1115.5 .9648       .1158    6.5986     .2987     3.2730     .5264    6.5896     .9383     .0311
                                                .0012     .4435     .9172     .8566     .9580     .5681   77.0000   63.0000

   10 192   .5628E+09 1117.3 .9647       .1158    6.5338     .2987     3.2730     .5264    6.5896     .9383     .0311
                                                .0012     .4435     .9172     .8566     .9580     .5681   77.0000   63.0000

   10 193   .5619E+09 1113.7 .9648       .1158    6.6634     .2987     3.2730     .5264    6.5896     .9383     .0311
                                                .0012     .4435     .9172     .8566     .9580     .5681   77.0000   63.0000
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 10 194   .5604E+09 1112.8 .9649       .1158     6.6634     .3073     3.2730      .5264     6.5896      .9383      .0311
                                                .0012     .4435     .9172     .8566     .9580     .5681   77.0000   63.0000

 10 195   .5609E+09 1113.3 .9649       .1158     6.6634     .3073     3.3352      .5264     6.5896      .9383      .0311
                                                .0012     .4435     .9172     .8566     .9580     .5681   77.0000   63.0000

 10 196   .5600E+09 1112.4 .9650       .1158     6.6634     .3073     3.2108      .5264     6.5896      .9383      .0311
                                                .0012     .4435     .9172     .8566     .9580     .5681   77.0000   63.0000

 10 197   .5607E+09 1112.4 .9649       .1158     6.6634     .3073     3.2108      .5150     6.5896      .9383      .0311
                                                .0012     .4435     .9172     .8566     .9580     .5681   77.0000   63.0000

 10 198   .5597E+09 1112.4 .9651       .1158     6.6634     .3073     3.2108      .5377     6.5896      .9383      .0311
                                                .0012     .4435     .9172     .8566     .9580     .5681   77.0000   63.0000

 10 199   .5587E+09 1112.4 .9651       .1158     6.6634     .3073     3.2108      .5377     6.6531      .9383      .0311
                                                .0012     .4435     .9172     .8566     .9580     .5681   77.0000   63.0000

PARAMETER  A( 7) =      .938  REMOVED FROM OPTIMIZATION
PARAMETER  A( 8) =      .031  REMOVED FROM OPTIMIZATION
 10 200   .5587E+09 1112.5 .9651       .1158     6.6634     .3073     3.2108      .5377     6.6531      .9383      .0311
                                                .0011     .4435     .9172     .8566     .9580     .5681   77.0000   63.0000

PARAMETER  A(10) =      .443  REMOVED FROM OPTIMIZATION
PARAMETER  A(11) =      .917  REMOVED FROM OPTIMIZATION
 *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *
HISTOGRAM   47  60  62  64  65  67  69  71  72  72  70  66  60  52  43  33  22   6
 *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *
```

SECTION H.4   SAMPLE INPUT (SENSITIVITY ANALYSIS)

```
       1       1       1       1       1
      40       0       0       0       0
       1       1       0       1       1
       1       1       1       1
       1       1
       1
       1       1
       0
       1       1
       1
       1
      50    1961       8     213       0
             .03             .30             .20             6.0             .25             2.0             .75
           752.0
             1.0
             .01             .28
     1.0     .50      91      60     0.0
             1.0
             .90             .10           .0025             5.0             .92
             0.0             6.0             1.4             0.0             0.0             0.0             0.0
     522      61      24       1       3     100       3
       1       2       3       4       5       6       7       8       9      10      11      12      14      16      17      18
      19      20      21      22      47      48      49      50
       1       1
       0
       1
       4       4       4       4       4       4       4       4       4       4       4       4       4       4       4       4
       4       4       4       4       4       4       4       4
            -.10            -.15             .10             .20
            -2.5            -1.0             1.0             2.5
            -.15            -.05             .05             .15
            -1.0            -.50             .50             1.0
            -.25            -.40             .25             .50
            -4.0            -2.0             5.0            10.0
            -.07            -.04             .02             .05
             .01             .05             .10             .20
           -.025           -.015            .015            .025
           -.009             .04             .09             .19
            -.25            -.10             .15             .30
            -.10            -.05             .05             .10
            -.10            -.05             .05             .10
            -.13            -.08             .07             .22
            -.30            -.20            -.10             .09
            -.09            -.05             .10             .20
          -.0015          -.0005           .0015           .0075
            -.40            -.20             .20             .40
            -.20            -.10             .10             .20
            -.20            -.10             .10             .20
            -.30            -.20            -.10             .20
```

```
     -.30       -.20       -.10        .20
    -30.0       30.0       60.0       90.0
    -59.0      -30.0       30.0       60.0
  18
   0    0
   1   19
.000.023.036.044.049.051.053.055.056.057.058.059.060.061.062.062.063.064.066.067
.069.070.072.074.076.078.080.081.082.082.081.080.079.077.075.072.068.064.061.057
.054.050.047.044.040.037.033.030.027.024.021.018.015.012.010
   0    0    0    0
 .500
 NWS SENSITIVITY  LEAF RIVER NR COLLINS,MISS.  WYRS 62-65  (BUFFER 8/61-9/61)
```

NWS SENSITIVITY LEAF RIVER NR COLLINS,MISS. WYRS 62-65 (BUFFER 8/61-9/61)

THE PERIOD OF RECORD BEING ANALYZED IS FROM 8 1961 THRU 9 1965 THE BUFFER PERIOD IS THE FIRST 61 DAYS

PARAMETER VALUES

1	2	3	4	5	6	7	8	9	10	11	12
UZSN	LZSN	CB	POWER	CC	KV	KGS	K24EL	A	K24L	EPXM	K1(1)
.2000	6.0000	.2500	2.0000	.7500	5.0000	.9200	0.0000	.0300	.0100	.3000	1.0000

PARAMETER VALUES

0	13	0	14	15	16	17	18	19	20	21	22
K1(2)	PEADJ(1)	PEADJ(2)	K3	SRC1	LIRC6	LKK6	CSSR	HWARP	VWARP	EHIGH	ELOW
0.0000	1.0000	0.0000	.2800	.9000	.1000	.0025	.5000	1.0000	1.0000	1.0000	.5000

PARAMETER VALUES

23	24
NEP	NDUR
91.0000	60.0000

(NOTE ABOVE INUMBERS CORRESPOND TO A ( ) SUBSCRIPT NUMBERS)

THE FOLLOWING PERIODS WILL BE REMOVED FROM CALCULATING THE VALUE FOR THE OPTIMIZATION CRITERION AND (MEAN Q , R)

THE BUFFER PERIOD (THE FIRST 61 DAYS) DATE DAY NO.

INITIAL STORAGE VALUES

UZSI	LZSI	SGWI	GWSI	RESI	SRGXI	SCEPI
0.0000	6.0000	1.4000	0.0000	0.0000	0.0000	0.0000

		FIXED LAG	CHANNEL DELAY HISTOGRAM											
GAGE	1	0	.0270	.0495	.0553	.0585	.0613	.0637	.0680	.0730	.0788	.0817	.0793	.0732
GAGE	1	0	.0625	.0520	.0420	.0317	.0225	.0137						

SENSITIVITY ANALYSIS

INITIAL OPT	PRESENT OPT	PERCENT	R COEF	MEAN Q	NAME	VALUE	PERCENT
.7766557E+09	.7766557E+09	0.00000	.9551051	1146.26			
.7766557E+09	.7595287E+09	2.20522	.9544076	1168.57	UZSN	.10000	-50.00000
.7766557E+09	.7555989E+09	2.71122	.9541453	1184.20	UZSN	.05000	-75.00000
.7766557E+09	.8294635E+09	-6.79938	.9545717	1127.94	UZSN	.30000	50.00000
.7766557E+09	.9195013E+09	-18.39240	.9516911	1110.59	UZSN	.40000	100.00000
.7766557E+09	.8439650E+09	-8.66655	.9494415	1250.81	LZSN	3.50000	-41.66667
.7766557E+09	.7702381E+09	.82632	.9540825	1181.58	LZSN	5.00000	-16.66667
.7766557E+09	.8082128E+09	-4.06320	.9549867	1116.85	LZSN	7.00000	16.66667
.7766557E+09	.8809049E+09	-13.42283	.9534962	1081.14	LZSN	8.50000	41.66667
.7766557E+09	.1098604E+10	-41.45319	.9377881	1180.67	CB	.10000	-60.00000
.7766557E+09	.7389776E+09	4.85134	.9548228	1153.31	CB	.20000	-20.00000
.7766557E+09	.8545768E+09	-10.03290	.9528714	1141.08	CB	.30000	20.00000
.7766557E+09	.1037409E+10	-33.57389	.9451474	1134.33	CB	.40000	60.00000
.7766557E+09	.9735137E+09	-25.34688	.9456297	1138.03	POWER	1.00000	-50.00000
.7766557E+09	.8596516E+09	-10.68631	.9515055	1142.16	POWER	1.50000	-25.00000
.7766557E+09	.7208246E+09	7.18866	.9571471	1150.34	POWER	2.50000	25.00000
.7766557E+09	.6860905E+09	11.66092	.9582332	1154.48	POWER	3.00000	50.00000
.7766557E+09	.7024651E+09	9.55257	.9572855	1145.94	CC	.50000	-33.33333
.7766557E+09	.6967002E+09	10.29485	.9567829	1145.63	CC	.35000	-53.33333
.7766557E+09	.9031871E+09	-16.29182	.9484931	1146.46	CC	1.00000	33.33333
.7766557E+09	.1024434E+10	-31.90317	.9411841	1146.59	CC	1.25000	66.66667
.7766557E+09	.1211722E+10	-56.01784	.9386618	1141.79	KV	1.00000	-80.00000
.7766557E+09	.9166802E+09	-18.02916	.9504223	1144.54	KV	3.00000	-40.00000
.7766557E+09	.6813168E+09	12.27558	.9575894	1148.36	KV	10.00000	100.00000
.7766557E+09	.6962993E+09	10.34647	.9567355	1149.08	KV	15.00000	200.00000
.7766557E+09	.8841317E+09	-13.83830	.9516311	1144.13	KGS	.85000	-7.60870
.7766557E+09	.8343368E+09	-7.42685	.9534856	1144.86	KGS	.88000	-4.34783
.7766557E+09	.7678449E+09	1.13445	.9545135	1147.26	KGS	.94000	2.17391
.7766557E+09	.8266459E+09	-6.43659	.9489008	1149.16	KGS	.97000	5.43478
.7766557E+09	.7684060E+09	1.06221	.9551635	1122.43	K24EL	.01000	
.7766557E+09	.7556646E+09	2.70276	.9552870	1050.48	K24EL	.05000	
.7766557E+09	.7603904E+09	2.09428	.9553150	1006.92	K24EL	.10000	
.7766557E+09	.7754710E+09	.15254	.9551479	968.05	K24EL	.20000	
.7766557E+09	.8144891E+09	-4.87132	.9529934	1100.11	A	.00500	-83.33333
.7766557E+09	.7964946E+09	-2.55440	.9539954	1118.57	A	.01500	-50.00000
.7766557E+09	.7654074E+09	1.44830	.9557605	1173.96	A	.04500	50.00000
.7766557E+09	.7626851E+09	1.79882	.9559553	1192.42	A	.05500	83.33333
.7766557E+09	.7724689E+09	.53909	.9552216	1151.56	K24L	.00100	-90.00000
.7766557E+09	.7982431E+09	-2.77953	.9545253	1122.70	K24L	.05000	400.00000
.7766557E+09	.8318358E+09	-7.10483	.9536545	1093.27	K24L	.10000	900.00000
.7766557E+09	.9194787E+09	-18.38948	.9514110	1034.44	K24L	.20000	1900.00000
.7766557E+09	.8290061E+09	-6.74049	.9532420	1238.33	EPXM	.05000	-83.33333
.7766557E+09	.7808283E+09	-.53725	.9548321	1171.20	EPXM	.20000	-33.33333
.7766557E+09	.7789767E+09	-.29884	.9553500	1116.75	EPXM	.45000	50.00000
.7766557E+09	.8012087E+09	-3.16137	.9545790	1095.99	EPXM	.60000	100.00000
.7766557E+09	.1286635E+10	-65.66345	.9508853	935.29	K1(1)	.90000	-10.00000
.7766557E+09	.9530441E+09	-22.71127	.9540839	1039.51	K1(1)	.95000	-5.00000
.7766557E+09	.7710683E+09	.71942	.9543638	1255.79	K1(1)	1.05000	5.00000
.7766557E+09	.9465503E+09	-21.87514	.9523241	1368.00	K1(1)	1.10000	10.00000
.7766557E+09	.7882217E+09	-1.48920	.9533334	1213.80	PEADJ(1)	.90000	-10.00000
.7766557E+09	.7729013E+09	.48341	.9546146	1177.99	PEADJ(1)	.95000	-5.00000
.7766557E+09	.7938083E+09	-2.20852	.9550359	1118.08	PEADJ(1)	1.05000	5.00000
.7766557E+09	.8202912E+09	-5.61837	.9546092	1092.03	PEADJ(1)	1.10000	10.00000
.7766557E+09	.8529458E+09	-9.82289	.9495581	1230.31	K3	.15000	-46.42857
.7766557E+09	.8007485E+09	-3.10212	.9529555	1185.88	K3	.20000	-28.57143
.7766557E+09	.7753230E+09	.17160	.9556661	1126.49	K3	.35000	25.00000
.7766557E+09	.7861180E+09	-1.21834	.9556388	1103.10	K3	.50000	78.57143
.7766557E+09	.8299203E+09	-6.85819	.9527243	1143.49	SRC1	.60000	-33.33333

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                                     .7766557E+09   .8076328E+09  -3.98852  .9537767   1144.36     SRC1    .70000 -22.22222
                                     .7766557E+09   .7912860E+09  -1.88375  .9544871   1145.34     SRC1    .80000 -11.11111
                                     .7766557E+09   .7642055E+09   1.60306  .9556621   1147.24     SRC1    .99000  10.00000
                                     .7766557E+09   .1032869E+10 -32.98935  .9518777   1146.27    LIRC6    .01000 -90.00000
                                     .7766557E+09   .8593653E+09 -10.64944  .9539591   1146.27    LIRC6    .05000 -50.00000
                                     .7766557E+09   .7269309E+09   6.40244  .9557833   1146.25    LIRC6    .20000 100.00000
                                     .7766557E+09   .7117061E+09   8.36273  .9561343   1146.24    LIRC6    .30000 200.00000
                                     .7766557E+09   .9896044E+09 -27.41867  .9481530   1134.62     LKK6    .00100 -60.00000
                                     .7766557E+09   .8233124E+09  -6.00738  .9537165   1145.18     LKK6    .00200 -20.00000
                                     .7766557E+09   .7096651E+09   8.62553  .9567810   1146.34     LKK6    .00400  60.00000
                                     .7766557E+09   .7110241E+09   8.45054  .9558198   1145.20     LKK6    .01000 300.00000
                                     .7766557E+09   .6969750E+09  10.25946  .9598625   1146.29     CSSR    .10000 -80.00000
                                     .7766557E+09   .7112062E+09   8.42710  .9591166   1146.28     CSSR    .30000 -40.00000
                                     .7766557E+09   .1054010E+10 -35.71139  .9371890   1146.24     CSSR    .70000  40.00000
                                     .7766557E+09   .2608473E+10-235.85962  .8274690   1146.17     CSSR    .90000  80.00000
 *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *
HISTOGRAM  51  64  67  69  74  80  86  89  87  81  69  58  47  35  25  16   3
 *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *
                                     .7766557E+09   .7250283E+09   6.64741  .9569240   1146.30    HWARP    .80000 -20.00000
 *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *
HISTOGRAM  44  57  61  64  66  70  76  82  85  83  76  65  54  44  33  24  14   2
 *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *
                                     .7766557E+09   .7088826E+09   8.72628  .9590881   1146.28    HWARP    .90000 -10.00000
 *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *
HISTOGRAM   0  28  50  56  59  62  64  68  74  79  82  80  73  62  52  42  31  22  13   2
 *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *
                                     .7766557E+09   .9860398E+09 -26.95970  .9401740   1146.23    HWARP   1.10000  10.00000
 *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *
HISTOGRAM   0   1  29  50  56  59  62  64  69  74  80  82  79  73  62  52  41  31  22  13   1
 *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *
                                     .7766557E+09   .1330446E+10 -71.30448  .9155356   1146.20    HWARP   1.20000  20.00000
 *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *
HISTOGRAM  36  57  60  61  62  63  64  65  65  65  65  65  63  58  52  43  33  21   3
 *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *
                                     .7766557E+09   .8331469E+09  -7.27364  .9529126   1146.27    VWARP    .80000 -20.00000
 *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *
HISTOGRAM  31  53  58  60  62  64  66  69  72  74  73  69  63  55  47  37  27  17   2
 *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *
                                     .7766557E+09   .7953180E+09  -2.40290  .9547005   1146.27    VWARP    .90000 -10.00000
 *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *
HISTOGRAM  23  46  54  58  61  64  70  77  86  90  86  77  63  49  38  27  18  10   1
 *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *
                                     .7766557E+09   .7744528E+09    .28365  .9543966   1146.26    VWARP   1.10000  10.00000
 *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *
HISTOGRAM  20  43  51  56  61  64  72  81  92  97  93  81  63  47  34  23  14   8   1
 *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *
                                     .7766557E+09   .7860436E+09  -1.20876  .9528236   1146.25    VWARP   1.20000  20.00000
 *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *
HISTOGRAM  27  50  56  59  62  64  68  73  79  82  80  74  63  52  42  32  23  14   2
 *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *
                                     .7766557E+09   .1010452E+10 -30.10298  .9422629   1336.49    EHIGH    .70000 -30.00000
 *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *
HISTOGRAM  27  50  56  59  62  64  68  73  79  82  80  74  63  52  42  32  23  14   2
 *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *
                                     .7766557E+09   .8484561E+09  -9.24481  .9498325   1254.31    EHIGH    .80000 -20.00000
 *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *
HISTOGRAM  27  50  56  59  62  64  68  73  79  82  80  74  63  52  42  32  23  14   2
 *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *
                                     .7766557E+09   .7817562E+09   -.65672  .9538515   1192.71    EHIGH    .90000 -10.00000
 *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *
HISTOGRAM  27  50  56  59  62  64  68  73  79  82  80  74  63  52  42  32  23  14   2
 *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *
                                     .7766557E+09   .8497898E+09  -9.41653  .9533753   1082.47    EHIGH   1.20000  20.00000
                                     .7766557E+09   .8339146E+09  -7.37249  .9510554   1269.96     ELOW    .20000 -60.00000
                                     .7766557E+09   .7921586E+09  -1.99610  .9530906   1227.56     ELOW    .30000 -40.00000
                                     .7766557E+09   .7737756E+09    .37084  .9544396   1186.34     ELOW    .40000 -20.00000
```

.7766557E+09	.8353748E+09	-7.56050	.9548320	1069.93	ELOW	.70000	40.00000
.7766557E+09	.7747372E+09	.24702	.9550932	1137.42	NEP	61.00000	-32.96703
.7766557E+09	.7817744E+09	-.65906	.9546067	1152.22	NEP	121.00000	32.96703
.7766557E+09	.8039269E+09	-3.51136	.9530946	1155.52	NEP	151.00000	65.93407
.7766557E+09	.8366761E+09	-7.72806	.9510619	1157.06	NEP	181.00000	98.90110
.7766557E+09	.7816249E+09	-.63982	.9537714	1178.79	NDUR	1.00000	-98.33333
.7766557E+09	.7731345E+09	.45339	.9547529	1162.51	NDUR	30.00000	-50.00000
.7766557E+09	.7923534E+09	-2.02119	.9547598	1130.47	NDUR	90.00000	50.00000
.7766557E+09	.8174693E+09	-5.25504	.9538532	1114.74	NDUR	120.00000	100.00000

APPENDIX I

THE OPTIMIZATION OF NON-MATHEMATICAL FUNCTIONS THROUGH THE USE OF WARPING COEFFICIENTS

In recent years, advances in hydrology and other fields have resulted in the development of rather complex mathematical models. A problem which has grown at perhaps a more rapid rate than the models themselves is the fitting of the models to specific real world situations, i.e., the determination of optimum values of the model parameters. As the models have increased in complexity and as more powerful computing equipment has become available, a group of methods known as "hill climbing" have become popular. The basic concept behind all these is trial-and-error experimentation with the various parameters, each perturbation being followed by a run of the model with the new set of parameters. Some arbitrarily selected error criterion or "objective function" is evaluated after each run, and the next adjustment to the parameters depends on the effect that previous adjustments have had on the objective function.

One difficulty which often arises in this process is that some of the relationships in a complex model may be non-mathematical in nature. That is, instead of a mathematical function defined by one or more coefficients, a relationship within the model may be a curve which the model interrogates through a table look-up process. Since a curve or table cannot be optimized as described above, past practice has been to express the curve mathematically, and therefore approximately, or to optimize a series of discrete points on the curve as independent parameters. Neither of these approaches is wholly satisfactory. The first method usually distorts the relationship by using a mathematical function which does not have the capability of fitting the curve closely. The second permits the selected points to vary more or less independently when they are not actually independent parameters.

The idea behind the use of warping coefficients is that the relationship will be expressed within the model in tabular form. Involved in the process will be an algorithm, the warp subroutine, which, by the use of one or more warp coefficients will warp or distort the relationship. The warp coefficients are the parameters which will be operated upon by hill climbing routine or "optimizer".

Figure I-1 illustrates the optimizing procedure. The model inputs a data set and outputs another data set. During the optimizing process, however, the model must be thought of differently. The normal input data set and the observed values of the output are stored permanently within the model. The set of parameters must now be considered the input, and the output is the objective function. As shown in figure 1, the process begins by supplying both the model and the optimizer with an initial set of values for the parameters.

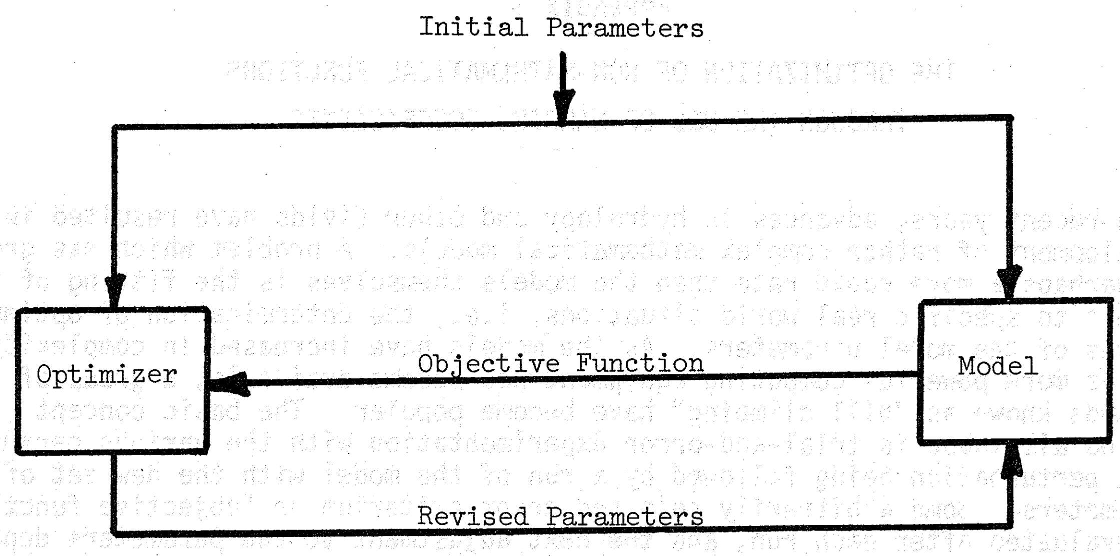


Figure I-1.--Flow diagram of the optimization procedure when there are no non-mathematical functions present in the model

The model then computes the objective function and feeds it to the optimizer. The optimizer adjusts the parameters and furnishes the model with the new values. The cycle then continues.

Figure I-2 illustrates the same process, but involving a warp routine. Note that this is identical to figure I-1 except for the inclusion of the warp routine and the tabular function. In this process, the model receives initially not only the beginning values of the numerical parameters, but also the beginning tabular function. The beginning values of the warp coefficients are established within the optimizer at a value (probably either zero or unity) which produces no distortion of the tabular function. During the optimizing procedure, the optimizer treats the warp coefficients in precisely the same manner as any other parameter. After each perturbation of a warp coefficient, however, the warp routine is called to revise the tabular function accordingly. Note that the optimizer never "sees" the tabular function and the model never "sees" the warp coefficients. The following two points should be emphasized: First, there can be no generalized warping algorithm; each application must be tailored to the particular relation involved and be formulated to produce the type of distortion desired. Second, the degree of distortion is necessarily limited. This requires that the initial tabular function be somewhere near the optimum value. This should not be considered a limitation of this technique alone, however, since it is a limitation of hill climbing methods in general.

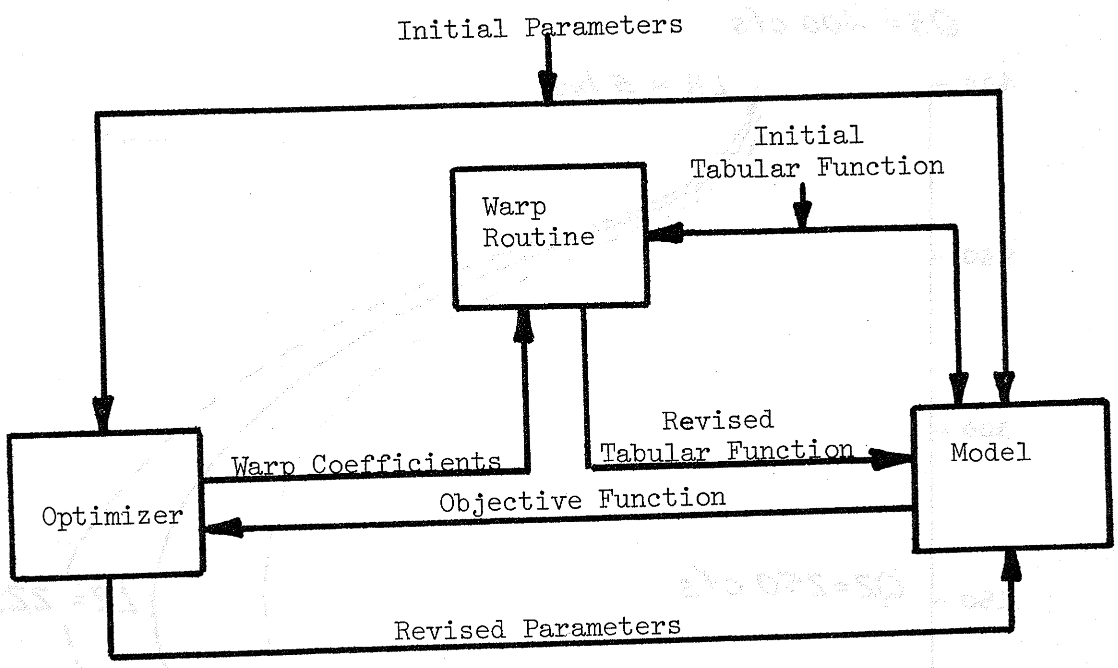


Figure I-2.--Flow diagram of the optimization procedure when there are non-mathematical functions present in the model

A very simple example of a warping algorithm is illustrated by figure I-3. The curve represents the variable lag function in a routing reach. L1 is the lag at minimum discharge, Q1. L2 is the maximum lag at discharge Q2. L3 is the lag at the maximum discharge, Q3. The algorithm is to involve one coefficient. It is not to affect L1 or L3 nor the discharge value at the curve along with it but leaving it "anchored" at L1 and L3. If it is established that the coefficient, CW, is to represent the ratio of the adjusted L2 minus L1 to the original L2 minus L1, then the adjustment, DL is given by:

$$DL = (L2 - L1)\ (CW - 1) \text{ at discharge } Q2$$

For any other discharge, Q the shift is prorated along the curve from zero at L1 or L3 to the full value at L2. Thus, where $Q1 \leq Q \leq Q2$,

$$DL = (L2 - L1)\ (CW - 1)\ \frac{Q - Q1}{Q2 - Q1}$$

where $Q2 \leq Q \leq Q3$,

$$DL = (L2 - L1)\ (CW - 1)\ \frac{Q3 - Q}{Q3 - Q2}$$

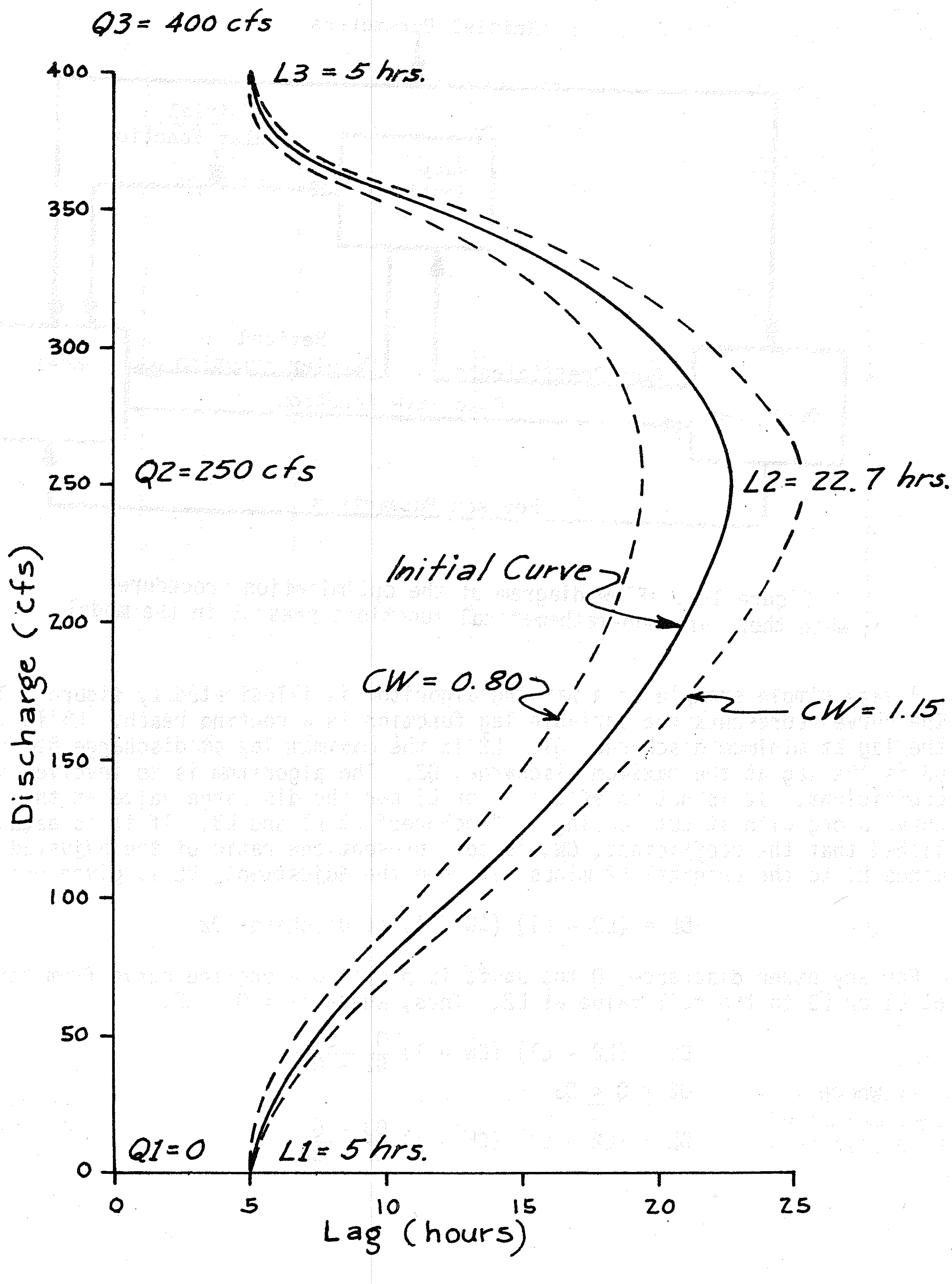


Figure I-3.--Warping algorithm applied to a variable lag function where L1=L3

A tabulation of the curve in figure I-3 along with the results of the algorithm using warp coefficients of 0.80 and 1.15 is shown below. The warped curves are plotted in figure I-3.

Discharge		Lag Values		
		Initial	CW=0.80	CW=1.15
Q1	0	L1 5.0	5.0	5.0
	25	5.8	5.4	6.1
	50	7.5	6.8	8.0
	75	9.7	8.6	10.5
	100	12.5	11.1	13.6
	125	15.1	13.3	16.4
	150	17.4	15.3	19.0
	175	19.4	16.9	21.3
	200	21.0	18.2	23.1
	225	22.1	18.9	24.5
Q2	250	L2 22.7	19.2	25.3
	275	22.0	19.1	24.2
	300	20.1	17.7	21.9
	325	16.8	15.0	18.1
	350	11.8	10.6	12.7
	375	6.2	5.6	6.6
Q3	400	L3 5.0	5.0	5.0

As was noted, this is a simplified case since L1 = L3. If L1 and L3 are not equal, the problem is complicated slightly. The basic shift (at Q2) may then be based on the mean of (L2 - L1) and (L2 - L3) and the formulas become:

Where $Q1 \le Q \le Q2$,

$$DL = \left(L2 - \frac{L1+L3}{2}\right)(CW-1)\frac{Q-Q1}{Q2-Q1}$$

Where $Q2 \le Q \le Q3$,

$$DL = \left(L2 - \frac{L1+L3}{2}\right)(CW-1)\frac{Q3-Q}{Q3-Q2}$$

Figure I-4 shows the curve of figure I-3 with L3 increased to 15 hours. The same values of CW are used and the adjusted curve is shown in the figure and tabulated on page I-7.

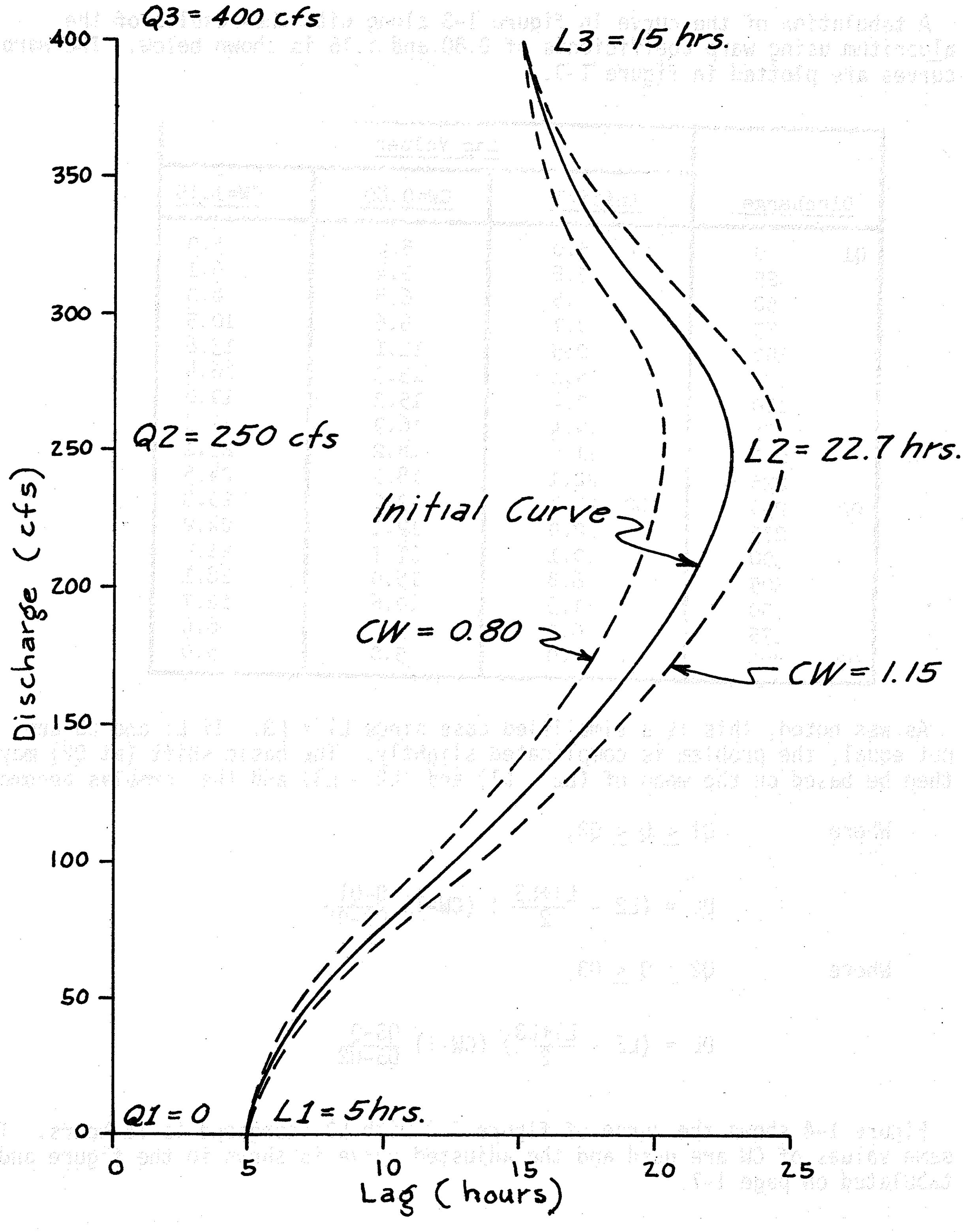


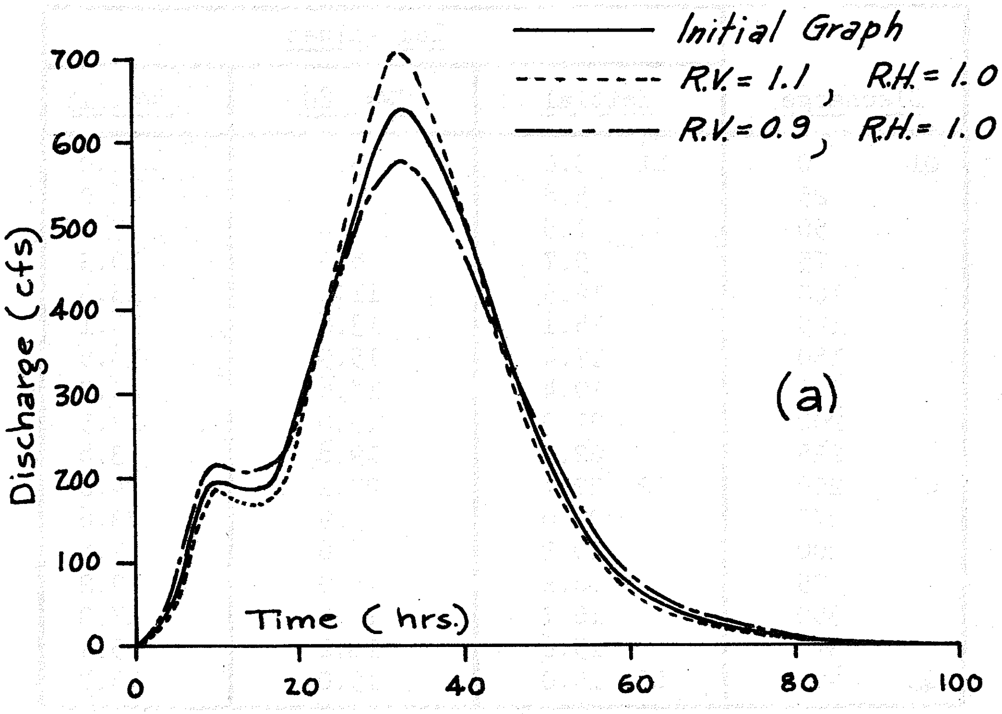
Figure I-4.--Warping algorithm applied to a variable lag function where L1 ≠ L3.

Discharge		Lag Values		
		Initial	CW=0.80	CW=1.15
Q1	0	L1 5.0	5.0	5.0
	25	5.8	5.5	6.0
	50	7.5	7.0	7.9
	75	9.7	8.9	10.3
	100	12.5	11.5	13.3
	125	15.1	13.8	16.1
	150	17.4	15.9	18.5
	175	19.4	17.6	20.7
	200	21.0	19.0	22.5
	225	22.1	19.8	23.8
Q2	250	L2 22.7	20.2	24.6
	275	22.0	19.9	23.6
	300	20.3	18.6	21.6
	325	18.2	16.9	19.2
	350	16.7	15.9	17.3
	375	15.6	15.2	15.9
Q3	400	L3 15.0	15.0	15.0

The foregoing illustrates one of the simplest applications of the warping technique. The curve has simple properties and only one warp coefficient is involved. A second coefficient could be introduced to change L1, or L3. Another could change the value of Q2. The optimizer could then vary the coefficients singly or in combination, producing major changes in the shape and position of the curve.

A second example is an algorithm for warping a unit hydrograph, which is an ideal subject for the warp technique. Where it represents one relationship within a hydrologic model, it must be optimized simultaneously with the model's numerical parameters. It cannot be expressed satisfactorily by a mathematical formulation. A reasonably close approximation to its optimum shape is always available prior to the optimizing run.

An algorithm for warping a unit graph is shown beginning on page I-13 as a computer program titled "Unit Hydrograph Warping." It involves two coefficients. The vertical warp coefficient, RV, raises or lowers the peak and the horizontal warp coefficient, RH, shifts it right or left. The algorithm generates the hydrograph in such a way that it passes through the new peak, has the same general shape as the original graph, and maintains unit volume. The warped hydrograph is expressed both as instantaneous ordinates and as a "time distribution" graph. The program contains comment cards which completely explain the algorithm and no further explanation will be given here. The following examples illustrate the procedure. Figures I-5 to I-7 show the effect of operating on the same unit hydrograph with various combinations of RV and RH, and demonstrate the characteristics of the algorithm. Figure I-5a shows the application of RV slightly greater and slightly less than unity. Note that



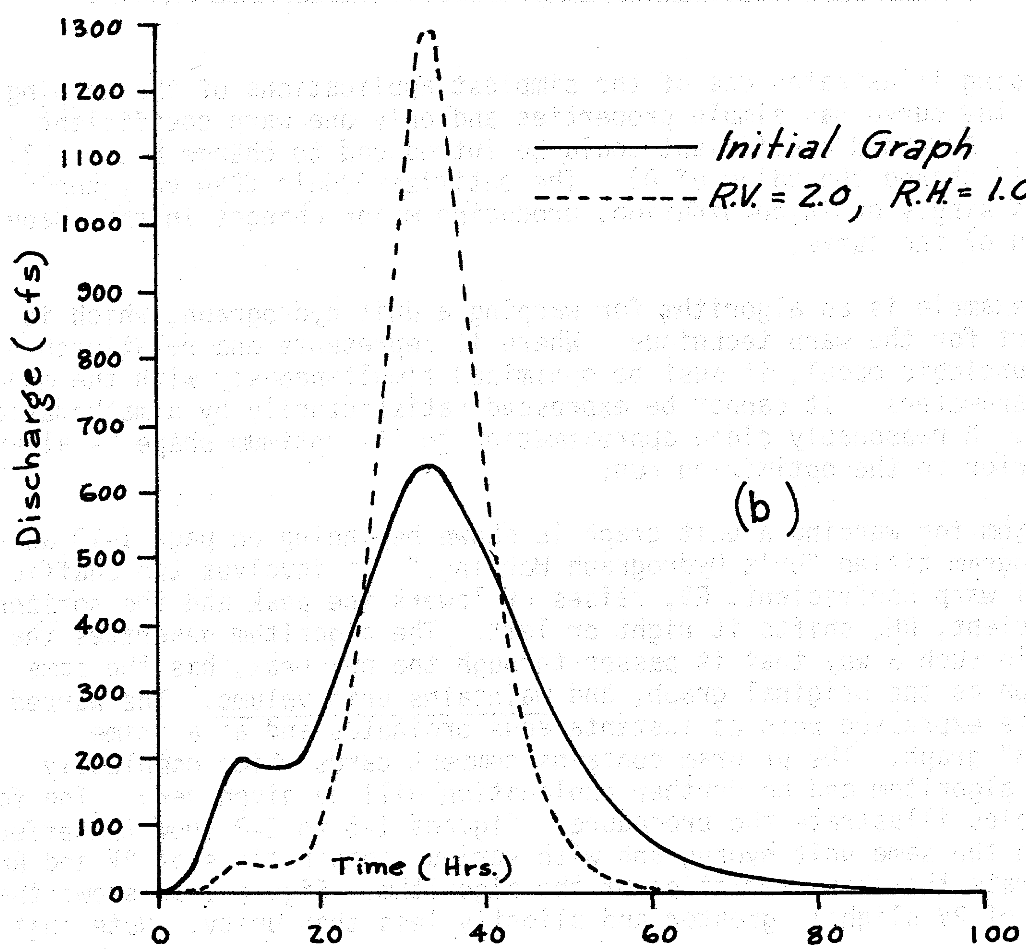


Figure I-5.--Vertical distortion applied to the unit hydrograph by the warping algorithm when the peak increases, the lower portions of the graph decrease and that unit volume is always maintained. In figure I-5b, an extreme value of RV (2.0) is applied. Note that volume is maintained by pulling in the sides and shortening the base. Figure I-6a shows the effect of a small vertical warp coefficient, 0.7. Note that the peak has become very flat. If RV had been even smaller, the algorithm, in order to maintain volume, would have generated ordinates to the left and right of the peak which would have been higher than the peak. For this reason, the minimum value of RV that can be used without producing undue distortion is about 0.7, and the lower constraint in the optimizing routine should be about this value. Normally, the initial unit graph will be close enough to the optimum so that RV values less than 0.7 would not occur. If an initial unit graph is believed to be particularly weak, it might be well to shade the peak low since the algorithm can raise it further than it can lower it.

Figure I-6b shows the effect of RH values greater and less than unity, which produce pure translation. Note that where RH = 0.7, a small amount of volume (5 percent) has been lost. This case, RH < 1 and RV = 1, is the only situation in which the routine does not maintain unit volume. This is not particularly important since the usual application would involve values other than unity for both coefficients. Where RV ≠ 1, the vertical warp routine restores the volume lost by the action of RH less than one.

The warp routine always operates on the original unit graph and not on the one resulting from the previous warp. Consequently, if RV appears before RH in the optimizer parameter array, the loss in volume would probably not occur. If it does, the loss would be small. If the model uses the unit graph in "time distribution" form, there would be no loss since this is normalized to unity. Figure I-7a illustrates this. Application of RH = 0.8 reduces the volume, but the vertical warp with RV = 1.1 restores it, and the area under the warped hydrograph is equal to that under the original. Figure I-7b illustrates the effect of RV < 1 and RH > 1.

As noted previously, the routine presents the hydrograph not only in the form of ordinates, but also as a 6-hour time distribution graph. The distribution figures for the initial graph and for the eight examples presented are shown on page I-12.

This algorithm has been used with great success in the optimization of both the NWS and the Sacramento RFC hydrologic models. Runs were made in which the optimizer controlled sixteen numerical model parameters plus the two warp coefficients.

Starting on page I-18 is subroutine WARP, which is the same algorithm expressed as a program subroutine.

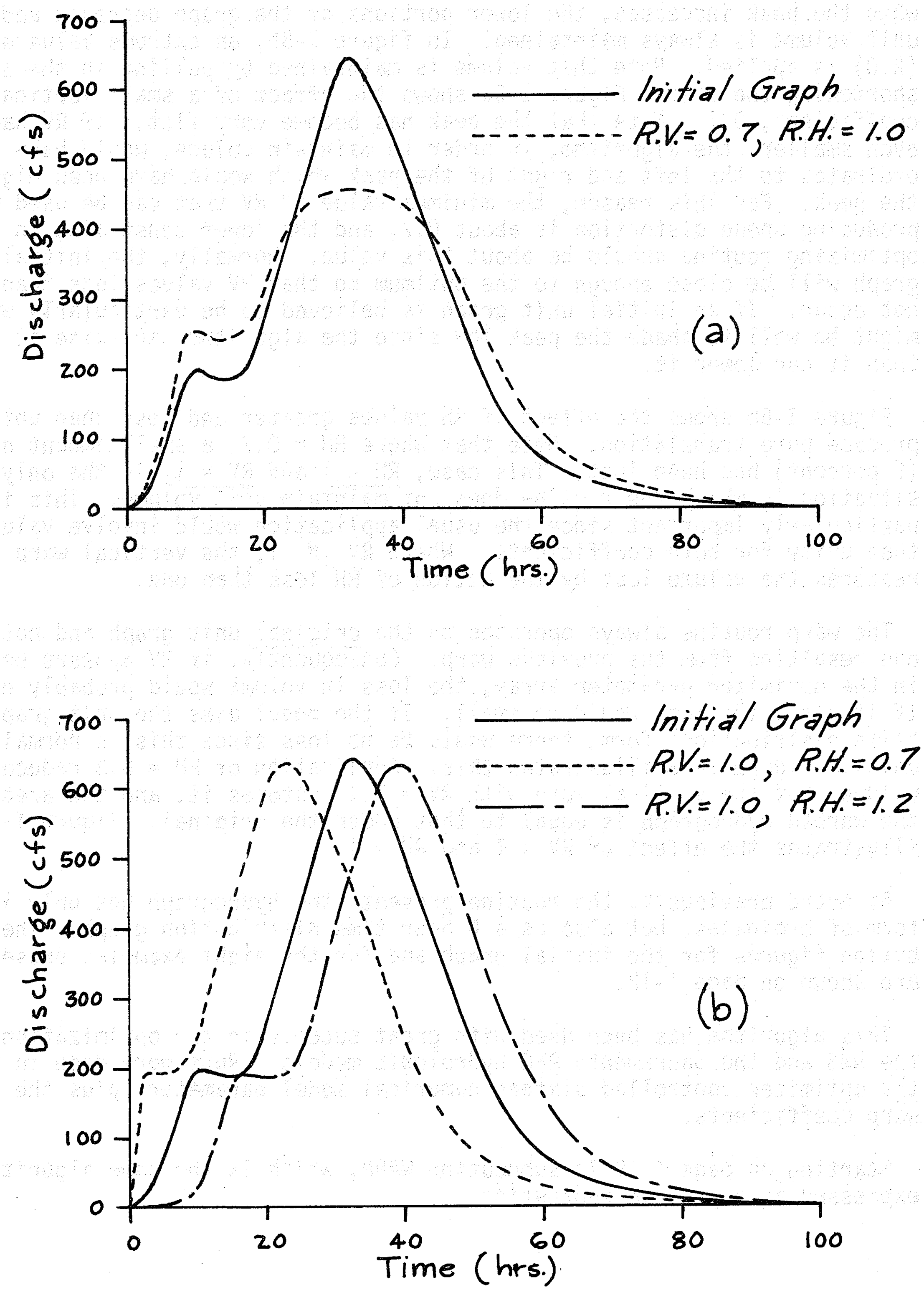


Figure I-6.--Vertical distortion (a) horizontal distortion (b) applied to unit hydrographs by the warping algorithm

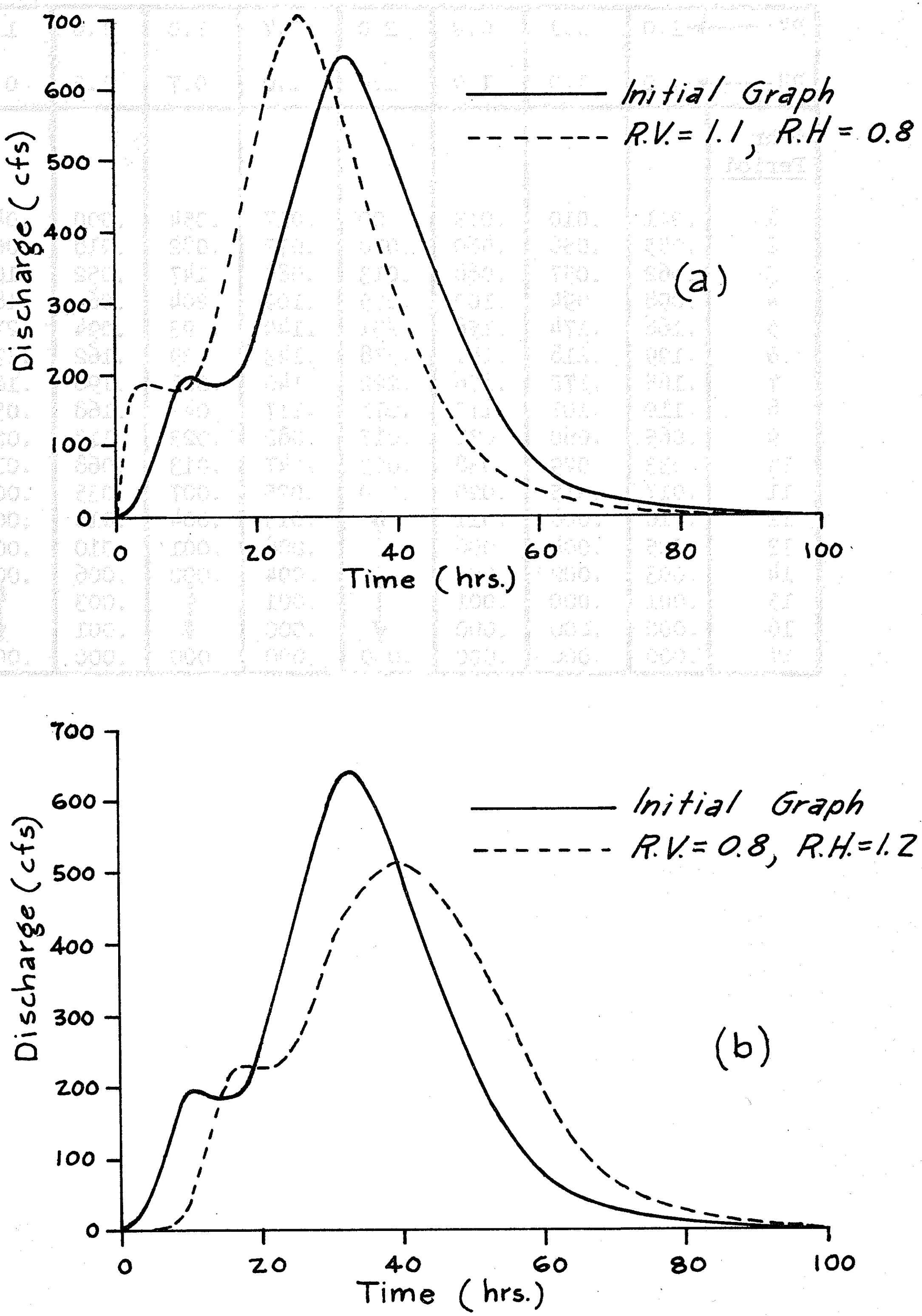


Figure I-7.--Horizontal and vertical distortion applied to the unit hydrograph

RV →	1.0	1.1	0.9	2.0	0.7	1.0	1.0	1.1	0.8
RH →	1.0	1.0	1.0	1.0	1.0	0.7	1.2	0.8	1.2
6-hr Period									
1	.011	.010	.013	.000	.017	.054	.000	.047	.000
2	.055	.050	.060	.010	.072	.082	.010	.060	.013
3	.062	.057	.068	.013	.080	.147	.052	.102	.063
4	.098	.094	.102	.055	.109	.204	.062	.180	.074
5	.166	.174	.158	.231	.140	.193	.094	.217	.103
6	.199	.218	.181	.378	.143	.139	.162	.170	.146
7	.165	.172	.156	.222	.140	.086	.198	.106	.160
8	.110	.107	.112	.071	.117	.047	.168	.059	.148
9	.065	.060	.071	.017	.082	.023	.113	.029	.118
10	.033	.029	.038	.003	.047	.013	.068	.015	.079
11	.017	.015	.020	.000	.025	.007	.035	.008	.045
12	.010	.008	.011	↑	.015	.004	.018	.005	.024
13	.005	.004	.006		.008	.001	.010	.002	.014
14	.003	.002	.003		.004	.000	.006	.000	.008
15	.001	.000	.001		.001	↑	.003	↑	.004
16	.000	.000	.000	↓	.000	↓	.001	↓	.001
17	.000	.000	.000	.000	.000	.000	.000	.000	.000

```
C     UNIT HYDROGRAPH WARPING.
C
C
C     HORIZONTAL WARP IS ACCOMPLISHED BY TRANSLATING HYDROGRAPH RIGHT OR
C     LEFT SO AS TO ADJUST THE TIME OF THE MAXIMUM ORDINATE BY THE
C     AMOUNT INDICATED BY THE HORIZONTAL WARPING COEFFICIENT, RH.
C     THAT IS, SHFT=(RH-1.)*GPT
C     WHERE SHFT IS THE NUMBER OF HOURS THE HYDROGRAPH IS SHIFTED TO THE
C     RIGHT AND GPT IS THE TIME OF THE MAXIMUM ORDINATE. FOLLOWING THE
C     SHIFT, THE FIRST AND LAST ORDINATES ARE SET TO ZERO. THIS MAY
C     RESULT IN A REDUCTION IN VOLUME UNDER THE HYDROGRAPH. THE VOLUME
C     WILL BE RESTORED HOWEVER DURING THE VERTICAL WARP.
C
C     VERTICAL WARP IS ACCOMPLISHED BY ADJUSTING THE MAXIMUM ORDINATE,
C     QMX BY THE VERTICAL WARPING COEFFICIENT, RV. ALL OTHER ORDINATES
C     ARE ADJUSTED BY OTHER AMOUNTS SO THAT THE HYDROGRAPH CO-INCIDES
C     WITH THE ORIGINAL AT THE INFLECTION POINTS AND HAS THE VOLUME OF
C     THE ORIGINAL.
C
C     THE ADJUSTMENT FORMULA IS
C
C               QI(K)=QI(K)*RV*((1.+ATS*(1.-CRV))/RV)**B
C
C     WHERE     ATS AND B ARE COEFFICIENTS
C               CRV IS THE CURVATURE OF THE HYDROGRAPH AT THE ORDINATE
C               BEING ADJUSTED. IT IS DEFINED BY
C                                   CRV=2.*QI(K)/(QI(K-1)+QI(K+1))
C               CRV IS EQUAL TO UNITY AT INFLECTION POINTS, GREATER THAN
C               ONE WHERE THE GRAPH IS CONCAVE DOWNWARD AND LESS THAN ONE
C               WHERE CONCAVE UPWARD.
C
C               WHERE QI(K) IS EQUAL TO THE MAXIMUM ORDINATE, THEN,
C                                   QI(K)=QI(K)*RV
C               CONSEQUENTLY, IF THE CURVATURE AT THE MAXUMUM ORDINATE IS
C               CMX, THE COEFFICIENT ATS IS GIVEN BY
C                                   ATS=(RV-1.)/(1.-CMX)
C
C               THE EXPONENT B IS DETERMINED BY ITERATION SO THAT THE
C               VOLUME OF THE ADJUSTED HYDROGRAPH IS EQUAL TO THAT OF THE
C               ORIGINAL.
C
C
C     SINCE THE COMPUTATION IS SENSITIVE TO THE VALUE OF CRV WHERE CRV
C     IS CLOSE TO UNITY, ROUNDOFF ERRORS IN THE INPUT ORDINATES MAY
C     PRODUCE AN UNEVEN ADJUSTED HYDROGRAPH IF THE ABOVE FORMULA IS USED
C     TO COMPUTE CRV. IN THE PROGRAM, AN ALTERNATE METHOD IS USED. FOR
C     EACH ORDINATE WHICH EXCEEDS TWENTY PERCENT OF THE MAXIMUM, THE
C     CURVATURE IS COMPUTED. ALL INFLECTION POINTS (UNITY CURVATURE) ARE
C     DETERMINED AND THE AVERAGE OF ALL INFLECTION POINT DISCHARGES IS
C     COMPUTED. THE RECIPROCAL OF THIS DISHCARGE IS QM. THE QUANTITY
C     THEN USED AS CURVATURE IS THE PRODUCT OF QM AND THE DISCHARGE AT
C     THE POINT IN QUESTION. THESE VALUES HAVE PROPERTIES SIMILAR TO THE
C     TRUE CURVATURE BUT RESULT IN A SMOOTH ADJUSTED HYDROGRAPH.
C
```

```
C
C
C     INPUT - 106 UNIT HYDROGRAPH ORDINATES, TIME 0 TO 210 HOURS. ELEVEN
C             ORDINATES IN F6.0 FORMAT ON EACH OF NINE CARDS. SEVEN ORDI-
C             NATES ON LAST CARD.
C             RH AND RV IN 2F6.3 FORMAT.
C
      DIMENSION Q(107),QI(110)
C
C     READ UNIT HYDROGRAPH ORDINATES.
C
 01   DO 04 K=1,10
      READ 02,Q(1),Q(2),Q(3),Q(4),Q(5),Q(6),Q(7),Q(8),Q(9),Q(10),Q(11)
      J=11*(K-1)
      DO 03 N=1,11
      M=N+J
 03   QI(M)=Q(N)
 04   CONTINUE
C
C     READ WARPING COEFFICIENTS, RH AND RV.
C
      READ 05,RH,RV
C
C     DETERMINE GRO, VOLUME UNDER ORIGINAL HYDROGRAPH. DETERMINE QMX,
C     THE MAXIMUM ORDINATE AND ITS LOCATION IN THE ARRAY. SET ARRAY, Q
C     EQUAL TO THE ORIGINAL HYDROGRAPH.
C
      GRO=0.
      QMX=0.
      DO 07 K=1,107
      X=QI(K)
      Q(K)=X
      GRO=GRO+X
      IF (QMX-X) 06,07,07
 06   QMX=X
      GPT=2*(K-1)
 07   CONTINUE
C
C     COMPUTE THE HORIZONTAL SHIFT.
C
      SHFT=RH*GPT-GPT
      L=-1
      IF (SHFT) 09,20,11
 09   SHFT=SHFT*(-1.)
      L=1
 11   IF (SHFT-2.) 16,12,12
C
C     SHIFT THE HYDROGRAPH RIGHT OR LEFT AN INTEGRAL NUMBER OF TWO-HOUR
C     PERIODS UNTIL THE RESIDUAL SHIFT IS LESS THAN TWO HOURS.
C
 12   DO 15 J=1,106
      K=J
      IF (L) 13,13,14
 13   K=108-J
```

```
 14    M=K+L
 15    QI(K)=QI(M)
       SHFT=SHFT-2.
       GO TO 11
C
C      APPLY THE RESIDUAL SHIFT OF LESS THAN TWO HOURS BY INTERPOLATING
C      BETWEEN ORDINATES.
C
 16    SHFT=SHFT*.5
       DO 19 J=1,106
       K=J
       IF (L) 17,17,18
 17    K=108-J
 18    M=K+L
 19    QI(K)=QI(K)+SHFT*(QI(M)-QI(K))
       QI(1)=0.
       QI(107)=0.
C
C      HORIZONTAL WARP IS COMPLETE. BEGIN VERTICAL WARPING PROCESS BY
C      DETERMINING THE MAXIMUM ORDINATE ON THE TRANSLATED HYDROGRAPH.
C
 20    QMX=0.
       DO 22 K=1,107
       IF (QMX-QI(K)) 21,22,22
 21    QMX=QI(K)
 22    CONTINUE
C
C      COMPUTE CURVATURE AT EACH ORDINATE AND DETERMINE THE DISCHARGE AT
C      EACH INFLECTION POINT WHERE THE DISCHARGE IS GREATER THAN 0.2*QMX
C
       QMX=QMX*.2
       QM=0.
       ER=0.
       DO 31 K=2,105
       BA=QI(K)
       BB=QI(K+1)
       IF (BA-QMX) 31,31,23
 23    X=2.*BA/(QI(K-1)+BB)
       IF (X-1.) 24,30,24
 24    Y=2.*BB/(BA+QI(K+2))
       IF (Y-X) 25,31,25
 25    X=(BA*(Y-1.)+BB*(1.-X))/(Y-X)
       IF (X-BA) 27,28,26
 26    IF (X-BB) 28,31,31
 27    IF (X-BB) 31,31,28
 28    QM=QM+X
       ER=ER+1.
       GO TO 31
 30    X=BA
       GO TO 28
 31    CONTINUE
C
C      COMPUTE QM, THE RECIPROCAL OF THE AVERAGE INFLECTION POINT
C      DISCHARGE.
```

```
C
      QM=ER/QM
C
C     COMPUTE COEFFICIENT ATS.
C
      ATS=(RV-1.)/(1.-5.*QMX*QM)
C
C     FIRST TRIAL VALUE OF COEFFICIENT B IS ZERO. THIS MULTIPLIES THE
C     ENTIRE HYDROGRAPH BY RV
C
      BA=0.
      RA=RV
      NT=0
C
C     SECOND TRIAL VALUE OF B IS 1.0
C
      B=1.
 32   X=0.
C
C     SOLVE ADJUSTMENT FORMULA AT EACH ORDINATE, USING TRIAL VALUE OF B,
C     AND COMPUTE VOLUME UNDER ADJUSTED HYDROGRAPH.
C
      DO 36 K=1,106
 33   QMX=(1.+ATS*(1.-QI(K)*QM))/RV
      IF (QMX) 34,35,35
 34   QMX=0.
 35   QMX=QI(K)*RV*(QMX)**B
      IF (NT) 42,36,36
 36   X=X+QMX
      NT=NT+1
      BB=B
C
C     COMPUTE ERROR FUNCTION, RB WHICH IS RATIO OF VOLUME UNDER ADJUSTED
C     HYDROGRAPH TO THAT UNDER ORIGINAL.
C
      RB=X/GRO
C
C     IF RB IS EQUAL TO VALUE AT PREVIOUS ITERATION, OR IF MORE THAN
C     FIFTEEN TRIALS HAVE BEEN MADE, OR IF RB IS WITHIN 0.01 OF UNITY,
C     SOLUTION HAS BEEN REACHED.
C
      IF (RB-RA) 37,41,37
 37   IF (NT-15) 38,38,41
 38   ER=RB-.99
      IF (ER) 40,41,39
 39   IF (ER-.02) 41,41,40
C
C     TO CONTINUE ITERATION, COMPUTE NEXT TRIAL VALUE OF B BY INTERPO-
C     LATING BETWEEN LAST TWO VALUES.
C
 40   B=(BA-BB+RA*BB-RB*BA)/(RA-RB)
      RA=RB
      BA=BB
      GO TO 32
```

```
41    NT=-1
C
C     IF SOLUTION HAS BEEN REACHED, COMPUTE ADJUSTED HYDROGRAPH.
C
      DO 42 K=1,106
      GO TO 33
42    QI(K)=QMX
C
C     PUNCH ADJUSTED HYDROGRAPH.
C
      PUNCH 48,
      PUNCH 49,RV,RH
      PUNCH 50,
      DO 55 K=1,107
      L=2*(K-1)
      X=QI(K)+.5
      PUNCH 51,L,Q(K),X
      IF (K-5) 55,52,52
52    X=Q(K-1)+QI(K-1)
      IF (X-.1) 58,55,55
55    CONTINUE
58    X=0.
C
C     COMPUTE TIME DISTRIBUTION GRAPH.
C
      DO 59 K=1,35
      J=3*K
      Q(K)=QI(J-2)+QI(J+1)+2.*(QI(J-1)+QI(J))
59    X=X+Q(K)
      PUNCH 61,
      PUNCH 62,
      DO 63 K=1,35
      J=6*(K-1)
      L=J+6
      BA=Q(K)/X+.0005
C
C     PUNCH TIME DISTRIBUTION GRAPH.
C
63    PUNCH 64,J,L,BA
      PAUSE
      GO TO 01
02    FORMAT (F6.0,F6.0,F6.0,F6.0,F6.0,F6.0,F6.0,F6.0,F6.0,F6.0,F6.0)
05    FORMAT (F6.3,F6.3)
48    FORMAT (28H  UNIT HYDROGRAPH ADJUSTMENT)
49    FORMAT (4X,3HRV=F6.3,4X,3HRH=F6.3/)
50    FORMAT (5H TIME4X,8HORIGINAL6X,8HADJUSTED/)
51    FORMAT (I4,F12.0,F13.0)
61    FORMAT (26H   TIME DISTRIBUTION GRAPH/)
62    FORMAT (30HFROM  TO      PERCENT OF VOLUME/)
64    FORMAT (I4,I4,F15.3)
      END
```

```
      SUBROUTINE WARP
      COMMON/WRAP/G(107),UG(35),RH,RV
      DIMENSION QI(107),C(106),JP(35)
C
C     COMPUTE RO VOLUME, GRO AND HORIZONTAL SHIFT, SHFT.
C
      GRO=0.
      QMX=0.
      DO 01 K=1,107
      QI(K)=G(K)
      GRO=GRO+G(K)
      IF (G(K).LT.QMX) GO TO 01
      J=K
      QMX=G(K)
 01   CONTINUE
      GPT=2*(J-1)
      SHFT=RH*GPT-GPT
C
C     SHIFT HYDROGRAPH RIGHT OR LEFT.
C
      IF (SHFT) 02,13,08
 02   SHFT=SHFT*(-1.)
 03   IF (SHFT-2.) 06,04,04
 04   DO 05 K=1,106
 05   QI(K)=QI(K+1)
      QI(107)=0.
      SHFT=SHFT-2.
      GO TO 03
 06   SHFT=SHFT*.5
      DO 07 K=1,106
 07   QI(K)=QI(K)+SHFT*(QI(K+1)-QI(K))
      QI(1)=0.
      QI(107)=0.
      GO TO 13
 08   IF (SHFT-2.) 11,09,09
 09   DO 10 K=1,106
      J=108-K
 10   QI(J)=QI(J-1)
      QI(1)=0.
      SHFT=SHFT-2.
      GO TO 08
 11   SHFT=SHFT*.5
      DO 12 K=1,106
      J=108-K
 12   QI(J)=QI(J)+SHFT*(QI(J-1)-QI(J))
      QI(1)=0.
      QI(107)=0.
C
C      WARP HYDROGRAPH VERTICALLY.
C     COMPUTE CURVATURE, C(K).
C
 13   QMX=0.
      DO 14 K=1,106
      IF (QI(K).GT.QMX) QMX=QI(K)
```

```
      X=0.
      IF (K.GT.1) X=QI(K-1)
      Y=X+QI(K+1)
      C(K)=0.
      IF (Y.EQ.0.) GO TO 14
      C(K)=2.*QI(K)/Y
 14   CONTINUE
      IF (RV.NE.1.) GO TO 16
      DO 15 K=1,106
 15   C(K)=1.
      B=1.
      GO TO 26
C
C     LOCATE INFLECTION POINTS.
C
 16   NT=0
      X=0
      QMX=QMX*.2
      DO 21 K=1,107
      IF (QI(K).LT.QMX) GO TO 21
      IF (C(K)-1.)  17,19,20
 17   IF (C(K+1).LT.1.) GO TO 21
 18   NT=NT+1
      X=X+QI(K)+(QI(K+1)-QI(K))*(1.-C(K))/(C(K+1)-C(K))
      GO TO 21
 19   NT=NT+1
      X=X+QI(K)
      GO TO 21
 20   IF (C(K+1)-1.) 18,21,21
 21   CONTINUE
      Y=NT
      X=Y/X
C
C     X IS AVERAGE OF ALL INFLECTION POINT DISCHARGES. RE-COMPUTE C(K)
C     AS A LINEAR FUNCTION OF DISCHARGE SO THAT WHEN QI=0, C(K)=0 AND
C     WHEN QI=X, C(K)=1.
C
      DO 22 K=1,106
 22   C(K)=QI(K)*X
C
C     VERTICAL WARP EQUATION IS - Q(K)=Q(K)*RV*((1.+A*(1.-C(K)))/RV)**B
C     COMPUTE COEFFICIIENT, A.
      CMX=QMX*X*5.
      ATS=(RV-1.)/(1.-CMX)
      DO 23 K=1,106
      C(K)=(1.+ATS*(1.-C(K)))/RV
      IF (C(K).LT.0.) C(K)=0.
 23   CONTINUE
C
C     BY ITERATION, DETERMINE A VALUE FOR THE EXPONENT, B, WHICH WILL
C     CAUSE THE VOLUME OF THE ADJUSTED HYDROGRAPH TO BE EQUAL TO GRO.
C
      BA=0.
      RA=RV
```

```
      NT=0
      B=1.
 24   X=0.
      DO 25 K=1,106
 25   X=X+QI(K)*RV*(C(K))**B
      NT=NT+1
      BB=B
      RB=X/GRO
      IF (RB.EQ.RA) GO TO 26
      IF (NT.GT.15) GO TO 26
      ER=ABS(RB-1.)
      IF (ER.LT..01) GO TO 26
      B=(BA-BB+RA*BB-RB*BA)/(RA-RB)
      RA=RB
      BA=BB
      GO TO 24
C
C     COMPUTE ADJUSTED HYDROGRAPH
C
 26   DO 27 K=1,106
 27   QI(K)=QI(K)*RV*(C(K))**B
C
C     COMPUTE TIME DISTRIBUTION GRAPH.
C
      X=0.
      DO 28 K=1,35
      J=3*K
      UG(K)=QI(J-2)+QI(J+1)+2.*(QI(J-1)+QI(J))
 28   X=X+UG(K)
      X=1./X
      DO 29 K=1,35
      UG(K)=X*UG(K)
 29   JP(K)=1000.*(UG(K)+.0005)
      PRINT 30,(JP(K),K=1,31)
 30   FORMAT (* UNIT GRAPH*31I4)
      RETURN
      END
```