1-1977

Effects of Stream Channel Improvements on Downstream Floods

Digital Object Identifier: https://doi.org/10.13023/kwrri.rr.102

Yang H. Huang
University of Kentucky

Ronald K. Gaynor
University of Kentucky

Research Report No. 102

EFFECTS OF STREAM CHANNEL IMPROVEMENTS ON DOWNSTREAM FLOODS

Dr. Yang H. Huang
Principal Investigator

Ronald K. Gaynor
Graduate Student Assistant

Project Number B-042-KY (Completion Report)
Agreement Number 14-31-0001-5076
Period of Project - July, 1974-December, 1976

University of Kentucky
Water Resources Research Institute
Lexington, Kentucky

The work on which this report is based was supported in part by funds provided by the Office of Water Research and Technology, United States Department of the Interior, as authorized under the Water Resources Act of 1964.

January 1977

ABSTRACT

This report presents a self-calibrating watershed model for predicting the effect of channel improvements on downstream floods. The model is called MOPSET because it is a modified version of OPSET developed several years ago at the University of Kentucky. OPSET is a computerized procedure for determining an optimum set of parameter values by matching synthesized flows with recorded flows. Major modifications include the replacement of the modified Muskingum method of channel routing by a kinematic finite difference method, the division of the watershed into a number of segments, and the inclusion of a storage routing procedure to take care of any reservoirs or flood control structures located in the watershed. The computer program is well documented and can be used not only as a flood predicting model but also as a general model for hydrologic simulations.

The model was applied to three different watersheds in Kentucky. It was found that the optimum set of parameter values obtained automatically by the model was not unique and might not yield the most desirable solution. For this reason, new features were added so that the user can exercise his judgment in selecting the most desirable parameter values.

The synthesized flows obtained from these watersheds are presented and compared with the recorded flows. The effects of channel improvements, flood control structures, and routing procedures on the synthesized flows are discussed.

KEY WORDS: Channel improvement*; computer programs*; downstream floods; finite difference method; flood routing*; hydrographs; model studies*; multiple segments; parameter optimization; rainfall-runoff relationships; streamflow*.

ACKNOWLEDGMENTS

The authors acknowledge the assistance given by Don Griffin of the U.S. Soil Conservation Service at Lexington, Kentucky, for providing the information on the North Fork Nolin River Watershed. Thanks are due R.L. Mullins of the Corps of Engineers at Louisville, Kentucky, for furnishing the data on the South Fork Beargrass Creek and the Floyds Fork Watersheds for use in the HEC-2 computer program. Most of the input data were prepared by Harry Chen, a graduate student at the University of Kentucky, whose assistance is appreciated.

Appreciation is expressed to the University of Kentucky Computing Center for the use of the IBM computer and the related technical service. The support given by the Office of Research and Engineering Services and the Water Resources Institute, University of Kentucky, for the preparation and publication of this report is also acknowledged.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

As stated in the original proposal, the purpose of this study was to determine the effect of channel improvements on downstream floods through the use of a computer program called the Kentucky Watershed Model with OPSET, a self-calibrating version of the Standford Watershed Model. OPSET is a computerized optimization procedure developed at the University of Kentucky [Liou, 1970] to determine an optimum set of parameter values by matching synthesized flows with recorded flows. The model was applied to twenty watersheds in Kentucky, and the parameter values selected by the model were correlated with the measurable physical characteristics of the watersheds [Ross, 1970].

Although OPSET is useful in determining the general effects of watershed changes on stream flows, it is not adequate for predicting the effect of channel improvements on downstream floods because the actual channel cross sections, which may vary continually in a watershed, were not considered. The model used a time-area histogram and a modified Muskingum method for flood routing, which was not reflective of channel changes. Therefore, a major effort was directed in this study to develop a kinematic method of channel routing, in which the actual channel cross sections were taken into account. As any changes in channel cross sections are reflected directly in the routed hydrographs, this modified version of OPSET, hereafter referred to as MOPSET, can be used for determining the effect of channel improvements on downstream floods.

In addition to the channel routing, other changes have been made to increase the versatility of MOPSET not only as a flood predicting model but also as a general model for hydrologic simulations.

In this report, only MOPSET will be presented. A modified version of the Kentucky Watershed Model, which provides more options but requires more experience to calibrate manually, will be described by Gaynor in his master's thesis.

CHAPTER II

REVIEW OF OPSET

2.1 History

Due to the prolific interest in the ecologic and economic aspects of watershed use, a flood of new hydrologic models programmed in digital electronic computers have appeared in recent years. One of the pioneering works is the Stanford Watershed Model developed by Crawford and Linsley [1966]. In spite of its great potential as a design tool, the Stanford Watershed Model has the limitations that the program was written in a seldom used language (BALGOL) and that the numerous imput parameters are difficult to calibrate to achieve satisfactory results. At the University of Kentucky, James [1970] translated the model into Fortran IV and called his translated, revised and expanded version the Kentucky Watershed Model (KWM). At the same time, a self-calibrating watershed model, based on the KWM, was developed [Liou, 1970]. This model was named OPSET because its objective was to determine the optimum set of parameter values for the watershed.

An outstanding feature in OPSET as well as in KWM is the use of mnemonic names for all variables. With a computer program as bulky as OPSET, the use of mnemonics greatly helps the reader in understanding the program. The same feature is preserved in MOPSET, and a dictionary of all variables is presented in Appendix B.

In the following sections, the limitations of OPSET and the changes made in MOPSET are described. Readers not familiar with OPSET should refer to the report by Liou [1970].

2.2 Watershed Segmentation

One drawback of OPSET is that it does not allow watershed segmentation. Precipitation is assumed to be uniform, channel routing is performed for the watershed as a whole, and output is only available at the mouth of the watershed. All these severely limit its applicability only to small watersheds. When applying the Kentucky Watershed Model in conjunction with a sediment model to a large watershed, David and Beer [1975] indicated that it was impossible to obtain representative hourly overland flow and pointed toward the need for watershed segmentation, which was not provided for in the Kentucky Watershed Model.

The use of only one segment in OPSET is probably due to the conception that a self-calibrating model is impractical for a multisegment basin. Linsley et al [1975] have indicated that if all segments have different parameters, the number of iterations increases exponentially as the number of segments and the computer time becomes too great. However, the segmentation of watershed is made possible in MOPSET because of the assumption that the parameter values at different segments be varied but kept at constant ratios. In the optimization process, the seven land phase parameters are specified as base values for the entire watershed. The individual segment values are read in as ratios to the base values. For a given set of base values, the individual values for each segment are computed from the given ratios, and a year of flow as well as the various moisture storages in each segment is simulated. The moisture storages are weighted by areas to calcualte the average moisture storage of the entire watershed, thus allowing MOPSET to print the same moisture summary as OPSET.

The assumption of constant ratios in parameter values among different segments is a step forward in extending the applicability of the model to a large watershed. The base values of these land phase parameters are difficult to estimate, but the parameter ratios between two widely different segments can usually be estimated with more certainty. Gross [1970] related these parameter values to the measurable physical characteristics of the watershed, and his results can be used as a guide in determining these ratios.

The use of multiple segments in a watershed requires the independent calculation of both the direct runoff and the base flow in each segment and thus increases greatly the computer time. As only the monthly flows are matched in the optimizing procedure, it may be more economical to consider the watershed as a single segment by using the weighted parameter values at the outset. Therefore, an option is provided in MOPSET such that either single or multiple segments can be used for optimization purposes. If a single segment is specified, the optimum set of parameter values is determined by considering the watershed as one segment, but the channel routing is performed on the basis of multiple segments.

2.3 Parameter Optimization

In OPSET, each computer run consists of three trips. Trip 1 optimizes the seven land phase parameters, trip 2 optimizes the four channel routing parameters, and trip 3 is the final run using the optimum set of parameters. Because the actual channel dimensions are specified in MOPSET, the optimization of channel parameters is no longer necessary, and only two trips are needed. The procedures for determining the two recession constants and optimizing the seven land phase parameters remain the same.

A major difficulty in the use of the Stanford or the Kentucky Watershed Model is the determination of the seven land phase parameters. The effects of these parameters on monthly flow are not clearly defined and may be highly overlapped. Consequently, satisfactory matching between synthesized and recorded monthly flows can be achieved by different combinations of these parameters. Based on the preset initial parameter values, OPSET will adjust the parameters according to a set of empirical rules until the sum of squares for the monthly deviation index is a minimum. However, the solution is not unique in that a different set of parameter values will be obtained if different initial values are assumed. It has also been found that the solution does not converge and may oscillate back and forth, and that the set of parameter values for the minimum sum of squares may not yield the most satisfactory solution. For these reasons, MOPSET was made more flexible by incorporating new features such that the user can assume any initial values, specify the number of adjustment cycles desired, and inspect the results before final selection of the parameter values being made.

In OPSET, the adjustment of LZC, SUZC, ETLF, BUZC, and SIAC is based on the monthly flow deviation index, MFDI, defined as

$$MFDI = \frac{TMSTF + 20}{TMRTF + 20} - 1 \quad \text{(when TMSTF > TMRTF)} \qquad (1)$$

$$MFDI = 1 - \frac{TMRTF + 20}{TMSTF + 20} \quad \text{(when TMSTF < TMRTF)} \qquad (2)$$

in which TMSTF is the synthesized monthly total flow volume and TMRTF is the recorded monthly total flow volume, both in Sfd. When the synthesized monthly flow volume exceeds the recorded, Eq. 1 is used, and the index is positive. When the synthesized monthly total is smaller, Eq. 2 is used, and the index is negative. The indices of a few arbitrarily selected months are used for adjusting each of the above parameters. For example, LZC is related to the overland flow months; SUZC to the two months between April and November with the greatest rainfall plus August and September, if they are base flow months; ETLF to summer months when the precipitation exceeds 2 in.; BUZC to either the three months of September, October and December or the three months of June, July and August, depending on the value of BUZC; and SIAC to either the first three summer months, when the rainfall is less than the potential evapotranspiration, or the first three winter months, when the rainfall is greater than the potential evapotranspiration, depending on the value of SIAC. If the adjustments based on the empirical rules cannot yield resasonable parameter values, alternate procedures will be evoked. These adjustment rules were developed from the sensitivity study of a few watersheds and may not work well in other watersheds. The adjustment of BMIR and BIVF was based on the matching between synthesized and recorded base flow and interflow during the first three days of each recession sequence.

Although the same optimization procedures are incorporated in MOPSET and both trips can be executed in the same computer run, it is suggested that the two trips be run separately for the following two reasons:

1. The automatic parameter-determination routines may not yield the most desirable solution. If found unsatisfactory, a new set of

initial parameter values should be assumed and each adjustment cycle inspected, so that the best set of parameter values can be selected.

2. One year of data is usually not enough for parameter determinations. Several years of records should be used and the results averaged to obtain the optimum set of parameters to be used for trip 2.

2.4 Channel Routing

In OPSET, each watershed is assumed to have only one segment, or one reach. By the use of a time-area histogram, it is possible to route the flow down a channel consisting of several reaches or branches. However, this method of routing is not only inaccurate but also difficult to perform, especially for large watersheds where a great number of branches exist.

In MOPSET, the watershed is divided into a number of segments. Each segment has one reach. The overland flow, interflow, and base flow from each segment are simulated and used as lateral flow distributed uniformly over the reach. Starting from the first day, the flow is routed from the uppermost reach to the lowest reach by a finite difference method. At the end of each day, the data for each reach are saved until all reaches have been routed for the same day. The procedure is then repeated for the next day, using the data stored in the previous day. Details of channel routing will be presented in Chapter III.

2.5 Storage Routing

Due to the numerous dams, weirs, and other hydraulic structures in Kentucky, it became evident that a storage routing routine would increase the power of the model. Therefore, a new subroutine STORRT was added. Only one structure may be routed for any one reach, and it must be located at the end of the reach. The subroutine takes the periodic flow, which has been channel routed, and adjusts it for the effects of storage and evaporation. This subroutine will be discussed in Chapter IV.

2.6 Orographic Influence

OPSET assumes that all rainfalls occur uniformly over the entire watershed. This assumption is probably quite reasonable for a small watershed but not for a large watershed. The model requires one recording precipitation gage and allows one storage gage to be used with a weighting factor for the purpose of adjusting the precipitation. In MOPSET, each segment can have its own rainfall pattern by estimating the precipitation from a given recording gage and any one storage gage representative of the segment. Thus, every segment may utilize a different storage gage. The capability for allowing the change in location and reading time of storage gages is preserved. The subroutine PRECHK, which was used in OPSET for checking precipitation-streamflow anomalies and adjusting precipitation where necessary, are also used in MOPSET when the number of watershed travel hours, NWSTH, is less than 12. the dated recording gage precipitation multipliers, DRGPM, of all segments are weighted by areas to obtain an average DRGPM to be used as an imput to PRECHK.

Since snowmelt is relatively insignificant in Kentucky, the snowmelt subroutine and all related calculations were removed from MOPSET for economy.

CHAPTER III

CHANNEL ROUTING

3.1 Governing Equations

The two equations used for channel routing are the continuity equation and the discharge-flow area relation. The equation of continuity can be expressed as

$$\frac{\partial A}{\partial t} + \frac{\partial Q}{\partial x} = q \tag{3}$$

in which A = flow area; Q = discharge; q = rate of inflow per unit length of channel; t = time; and x = downslope distance along the channel. Note that both A and Q vary with x and t, and that in a given segment q is a function of t independent of x.

In general, the discharge can be expressed as a power function of the flow cross-sectional area, hereafter called end area, or

$$Q = \alpha A^{m} \tag{4}$$

in which α and m are coefficients whose values depend on the shape and roughness of the channel.

3.2 Linear Routing

Schaake [1971] suggests the use of a finite difference equation which converges to Eq. 3 as the step size decreases. Substituting Eq. 4 into Eq. 3 and assuming α and m as constants independent of x

$$\frac{\partial A}{\partial t} + \alpha m A^{m-1} \frac{\partial A}{\partial x} = q \tag{5}$$

In the finite difference method, both t and x are divided into finite increments, Δt and Δx. In MOPSET, Δx may vary from reach to reach but Δt is the same for all reaches (either 15 min or 1 hr).

The requirement that α and m be constant over the distance x implies that each reach can only have one set of α and m, or one discharge-end area rating curve. This severely limits the applicability of the model because actual channels may consist of a large number of different cross sections within a reach. For this reason, each reach is further divided into a number of finite sections, each with a different length and a different set of α and m. The finite section is then further divided equally into one or more finite differences. The routing procedure described here is applied to one finite section.

Terms in Eq. 5 can be expressed in the following finite difference forms:

$$\frac{\partial A}{\partial t} = \frac{A(x + \Delta x, t + \Delta t) - A(x + \Delta X, t)}{\Delta t} \tag{6}$$

$$\frac{\partial A}{\partial x} = \frac{A(x + \Delta x, t + \Delta t) - A(x, t + \Delta t)}{\Delta x} \tag{7}$$

$$A^{m-1} = \left[\frac{A(x, t + \Delta t) + A(x + \Delta x, t)}{2}\right]^{m-1} \tag{8}$$

$$q = \frac{q(t + \Delta t) + q(t)}{2} \tag{9}$$

Substituting Eqs. 6 through 9 into Eq. 5

$$A(x + \Delta x, t + \Delta t) = \{\frac{q(t + \Delta t) + q(t)}{2} + \frac{A(x + \Delta x, t)}{\Delta t}$$

$$+ \frac{\alpha m\, A(x, t + \Delta t)}{\Delta x} \left[\frac{A(x, t + \Delta t) + A(x + \Delta x, t)}{2}\right]^{m-1}\}$$

$$/ \{\frac{1}{\Delta t} + \frac{\alpha m}{\Delta x} \left[\frac{A(x, t + \Delta t) + A(x + \Delta x, t)}{2}\right]^{m-1}\} \tag{10}$$

The solution obtained from Eq. 10 is called linear because all terms on the right hand side are known, and no iterations are needed. At the initial time, or t = 0, all end areas are assumed to be zero. The solution is approximate due to the use of Eq. 8. Theoretically, A^{m-1} should depend also on $A(x + \Delta x, t + \Delta t)$, but its inclusion will make the equation nonlinear and more difficult to solve. The linear solution is quite satisfactory for relatively flat channel slopes. When greater accuracy is desired, or channel slopes are steep and flows change rapidly, a nonlinear iterative method, as described in the next section, may be used.

Eq. 10 can be used directly to determine the end area at each finite difference point. The end area at the first, or the most upstream, point in a finite section can be determined from Eq. 4 based on the inflow from the previous finite section. Repeated applications of Eq. 8 down the stream will give the end area at the last, or the most downstream, point of the finite section. Knowing the end area, the discharge from the finite section can be determined from Eq. 4.

3.3 Nonlinear Routing

The nonlinear procedure was developed by Li et al. [1975]. The finite difference form of Eq. 3 can be represented by

$$\frac{A(x+\Delta x,\ t+\Delta t) - A(x+\Delta x,\ t)}{\Delta t} + \frac{Q(x+\Delta x,\ t+\Delta t) - Q(x,\ t+\Delta t)}{\Delta x}$$

$$= \frac{q(t+\Delta t) + q(t)}{2} \qquad (11)$$

From Eq. 4

$$Q(x+\Delta x,\ t+\Delta t) = \alpha[A(x+\Delta x,\ t+\Delta t)]^m \qquad (12)$$

$$Q(x,\ t+\Delta t) = \alpha[A(x,\ t+\Delta t)]^m \qquad (13)$$

Note that the same α and m are used in Eqs. 12 and 13. Substituting Eqs. 12 and 13 into Eq. 11 yields

$$\frac{\Delta x}{\Delta t} \cdot A(x+\Delta x,\ t+\Delta t) + \alpha[A(x+\Delta x,\ t+\Delta t)]^m = \frac{\Delta x}{\Delta t} \cdot A(x+\Delta x,\ t)$$

$$+ \alpha[A(x,\ t+\Delta t)]^m + \Delta x\left[\frac{q(t+\Delta t) + q(t)}{2}\right] \qquad (14)$$

The right side of Eq. 14 consists of known quantities and can be represented by

$$\Omega = \frac{\Delta x}{\Delta t} \cdot A(x+\Delta x,\ t) + \alpha[A(x,\ t+\Delta t)]^m + \Delta x\left[\frac{q(t+\Delta t) + q(t)}{2}\right] \qquad (15)$$

Letting $r = A(x+\Delta x,\ t+\Delta t)$ and $\Theta = \Delta x/\Delta t$, Eq. 14 can be written as

$$f(r) = \Theta r + \alpha r^m = \Omega \qquad (16)$$

The Taylor series expansion of f(r) is

$$f(r) = f(r^k) + (r - r^k)\ f'(r^k) + \frac{1}{2}(r - r^k)^2\ f''(r^k) + \ldots\ldots \qquad (17)$$

where r^k is the value of r at the kth iteration, and $f'(r^k)$ and $f''(r^k)$ are the first and second derivatives of $f(r^k)$. Neglecting all higher order terms, it is possible to find a solution r^{k+1} such that

$$f(r^{k+1}) = f(r^k) + (r^{k+1} - r^k)\ f'(r^k) + \frac{1}{2}(r^{k+1} - r^k)^2\ f''(r^k) = \Omega \qquad (18)$$

Eq. 18 is a quadratic equation in terms of $(r^{k+1} - r^k)$ and the solution is

$$r^{k+1} = r^k - \frac{f'(r^k)}{f''(r^k)} \pm \left\{[\frac{f'(r^k)}{f''(r^k)}]^2 - \frac{2[f(r^k)-\Omega]}{f''(r^k)}\right\}^{\frac{1}{2}} \qquad (19)$$

where

$$f(r^k) = \Theta r^k + \alpha(r^k)^m \qquad (20)$$

$$f'(r^k) = \Theta + \alpha m(r^k)^{m-1} \qquad (21)$$

$$f''(r^k) = \alpha m(m-1)(r^k)^{m-2} \qquad (22)$$

Eq. 19 is used to determine the value of r at (k+1)th iteration from that at kth iteration. The process is repeated until

$$\left| \frac{f(r^{k+1}) - \Omega}{\Omega} \right| \leqslant 0.01 \qquad (23)$$

During the iteration, Ω is a constant and need not be changed. By using the linear solution as the first approximation, the procedure converges very rapidly, usually within three iterations. The iterative scheme is quite stable until Ω approaches zero. However, when $\Omega < 10^{-8}$, the end area is set to zero and the nonlinear procedure is bypassed for that particular point.

3.4 Direct Method for Determining Routing Parameters

In the linear or nonlinear channel routing, a prior knowledge of the two routing parameters, α and m, is needed for each finite section. The values of these parameters can be determined from Manning's formula, or

$$Q = \frac{1.49}{n} AR^{\frac{2}{3}} S^{\frac{1}{2}} \qquad (24)$$

in which n = roughness coefficient; S = slope of channel; and R = hydraulic radius = Area/wetted perimeter. For a rectangular cross section of width, B, with the depth of water much smaller than B,

$$R = A/B \qquad (25)$$

Substituting Eq. 25 into 24 and comparing with Eq. 4

$$\alpha = \frac{1.49S^{\frac{1}{2}}}{nB^{\frac{2}{3}}} \tag{26}$$

$$m = 1.67 \tag{27}$$

Eqs. 26 and 27 can be used for rectangular cross sections when the water is shallow. For a triangular cross section with a width, w, at a depth of one ft , as shown in Figure 1a, the flow area for a depth, H, is

$$A = \frac{1}{2} wH^2 \tag{28}$$

or

$$H = \sqrt{\frac{2A}{w}} \tag{29}$$

If the side slopes are very flat, the wetted perimeter is equal to wH, and the hydraulic radius becomes

$$R = \frac{\frac{1}{2}wH^2}{wH} = \frac{1}{2}H \tag{30}$$

From Eqs. 29 and 30

$$R = \sqrt{\frac{A}{2w}} \tag{31}$$

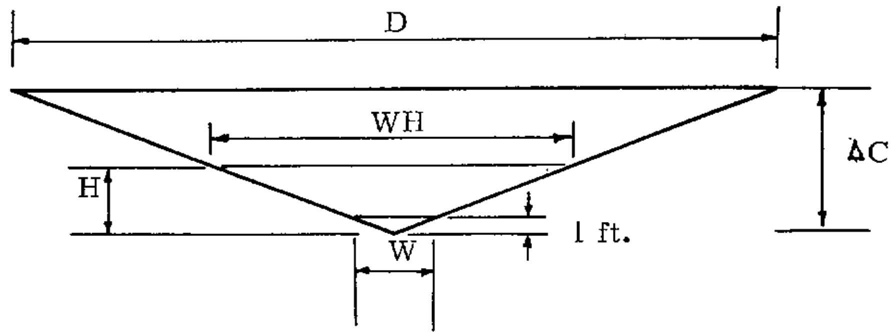
Substituting Eq. 31 into 24 and comparing with Eq. 4

$$\alpha = \frac{1.49S^{\frac{1}{2}}}{n(2w)^{\frac{1}{3}}} \tag{32}$$

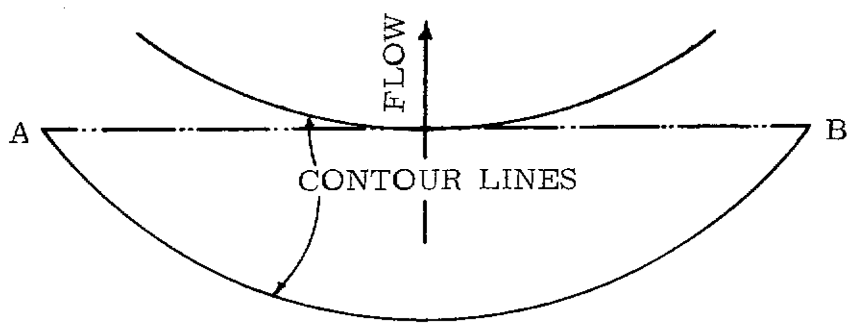
$$m = 1.33 \tag{33}$$

Eq. 32 can be used for determining the value of α from a topographic map, as shown in Figure 1.

Figure 1b is an exploded view of a contour map with a contour interval, ΔC. By measuring the length D on the map, which is the distance between A and B, the cross section of the channel can be determined, as shown in Figure 1a. Since $w = D/\Delta C$, from Eq. 32



(a) Section A-B



(b) PLAN VIEW

Figure 1. Determination of α and m from Topographic Map

$$\alpha = \frac{1.49S^{\frac{1}{2}}}{n(\frac{2D}{\Delta C})^{\frac{1}{3}}} \tag{34}$$

Eqs. 26, 27, 33, and 34 are useful for determining α and m when the flow volume is small. When the flow volume is large, the channel cross section becomes more irregular, and Eq. 4 may be valid only over a limited range. Consequently, the discharge-end area method as described below should be used instead.

3.5 Discharge - End Area Method for Determining Routing Parameters

In this method, channel characteristics are represented by the discharge-end area relationship. This relationship at a particular cross section can be obtained from the water surface profile computer programs, such as the WSP2 program by the Soil Conservation Service [1976] and the HEC-2 program by the Corps of Engineers [1973]. Figure 2 shows a plot of log Q versus log A for a cross section in the North Fork Nolin River Watershed, as obtained from the WSP2 program.

If Eq. 4 is valid, the plot should result in a straight line. However, Figure 2 shows that the data do not lie on a straight line but can be approximated by three straight lines, each having a different α and m, where α is the vertical intercept at A = 1 sq ft and m is the slope of the straight line. Therefore, instead of one set of α and m, three sets must be specified together with the values of A separating each set. After the end area at each finite difference point has been determined from channel routing, the average end area is computed, and the proper set of α and m selected. If the average end area indicates that α and m should be changed from one set to the other, the average of the two sets will be used to prevent a sudden change and the resulting oscillations.

The above procedure requires the plotting of log Q versus log A and the determination of several sets of α and m for each finite section. If the number of finite sections is large, a substantial time will be

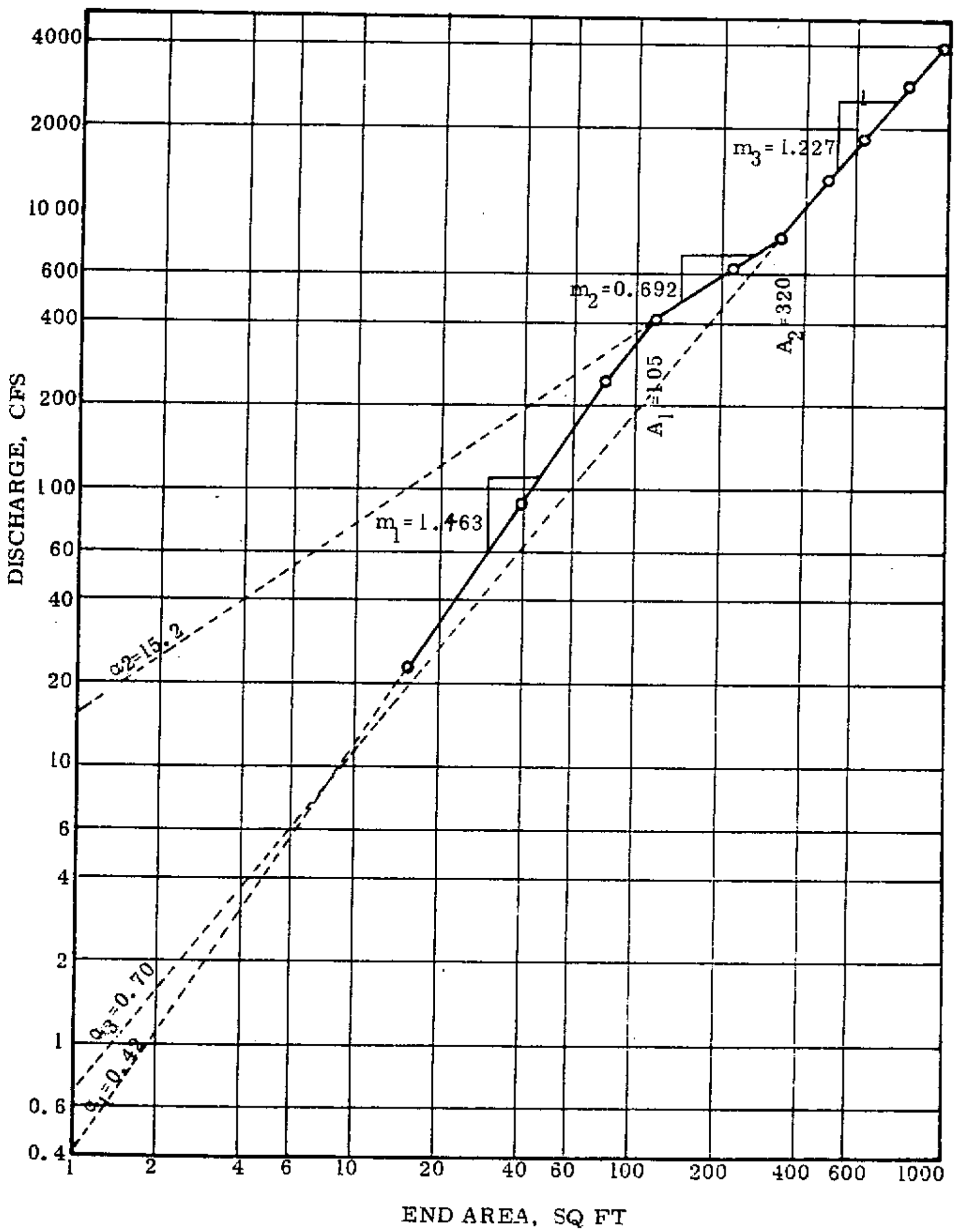


Figure 2. Determination of α and m from Discharge- End Area Relationships

needed for preparing the input data. To save the data preparation time, a subroutine ROUTAB was developed for determining α and m directly from the discharge-end area relationship, as will be described in the next chapter.

CHAPTER IV

PROGRAM DESCRIPTION

4.1 Main Program

The structure of MOPSET follows essentially that of OPSET except that a reach loop is imbedded between the day loop and the hour loop for the purpose of segmenting the watershed. It was attempted to make the model somewhat more modular in an effort to facilitate understanding. The channel routing and several related procedures were placed in subroutines, thus shortening the main program. Figure 3 is a simplified flow chart showing the general structure of the model.

The purpose of the flow chart is to show the several major loops in operation. Some of the detailed procedures, which are important for the control of the program but are not shown in the flow chart, will be described as follows.

1. Although the flow chart shows trips 1 and 2 to be run at the same time, it is more desirable to run trip 1 first and inspect the data before proceeding to trip 2.

2. The gaged reach is not necessarily to be located at the mouth of the watershed. In trip 1, the synthesized flow is computed from the first reach to the gaged reach; but in trip 2, it is to the last reach.

3. Within the hour loop is a period loop. In trip 1, the period is 1 hour for the coarse adjustment cycle and 20 min for the fine adjustment cycle. In trip 2, the period is 15 min.

4. Since the optimization procedure requires a comparison between the synthesized and the recorded daily and monthly flows, flows are summed from the first reach to the gaged reach at the end of each day and each month.

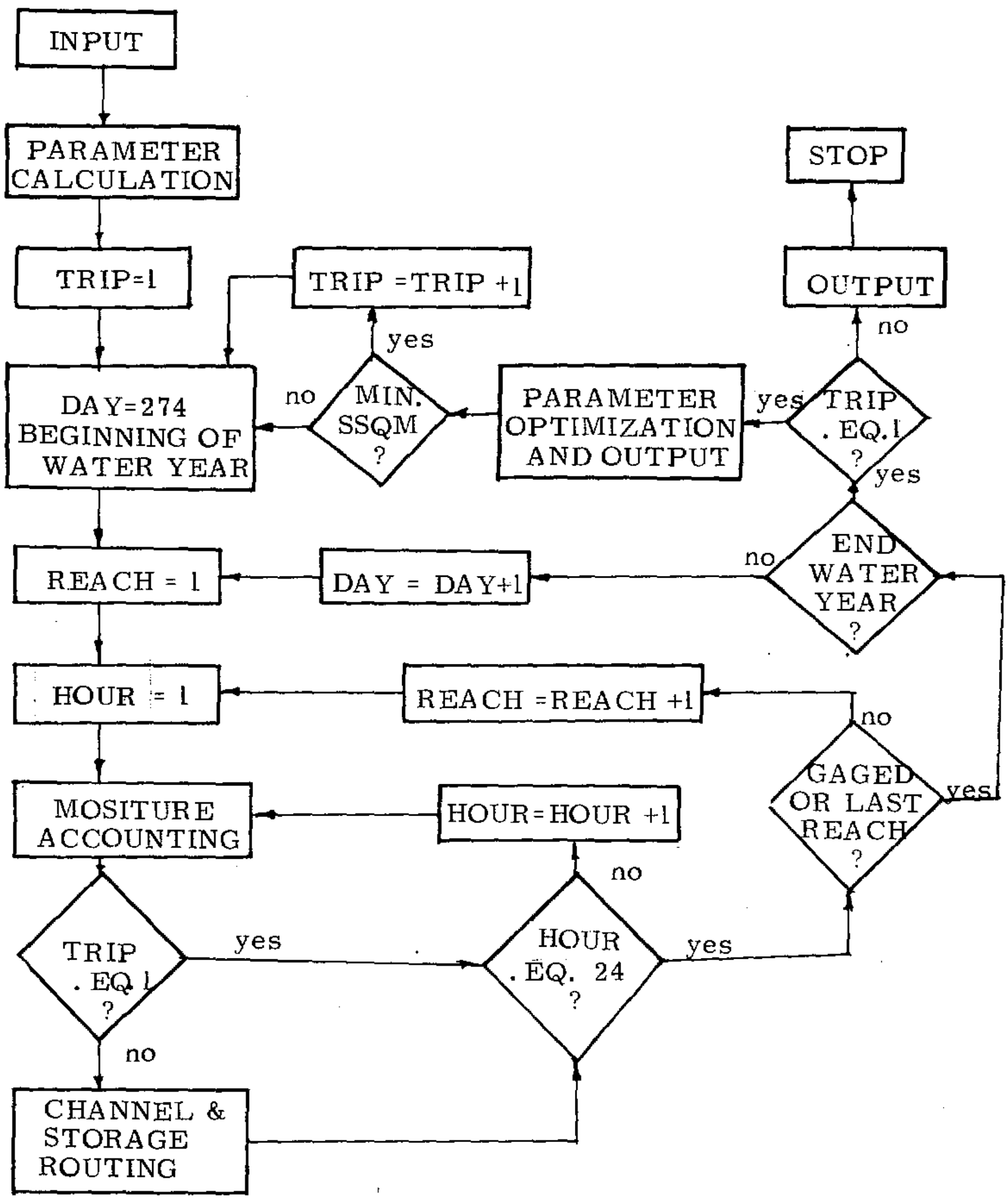


Figure 3. Simplified Flow Chart for MOPSET

5. An option is provided that during trip 1 the parameters used for different reaches are weighted over the areas, so the whole watershed is considered as one reach. This procedure may save considerable computer time without affecting significantly the accuracy of the results.

6. For the purpose of channel routing, each reach is divided into one or more finite sections. The lateral inflow per unit length of channel is the same for all finite sections in the same reach and equals to the total flow divided by the channel length in the reach. The outflow from different reaches can be added to form the inflow to the downstream reach. In other words, hydrographs can be added only at the junction of reach but not at the junction of finite sections in the same reach.

7. MOPSET used the same moisture accounting process as in the Stanford Watershed Model. The process was described by Crawford and Linsley [1966], Balk [1968], Ross [1970], and Ricca [1972]. The simulation procedures involving the seven land phase parameters are shown in Figure 4 as a flow chart. In actual simulations, each procedure can have several alternatives depending on the outcome of the results. However, these alternatives are not shown in the flow chart. The variables related directly to the land phase parameters are followed by a bracket in which the relevant parameters are shown.

4.2 Subroutines

Summary of Subroutines

MOPSET consists of a total of 18 subroutines, 4 of which were newly developed while the remaining 14 were borrowed from OPSET. Those borrowed from OPSET (including DAYNXT, DAYOUT, DAYSUM, EVPDAY, PRECHK, PREPRD, RECESS, SET2RC, SET1RC, SETBIV, SETBMI, SETFDI, SETFVP, and SETRBF) were described by Liou [1970] and will not be discussed here. Only the four new subroutines (including ROUTAB, RTGPAR, CHROUT, and STORRT) will be described. Table 1 is a summary of the subroutines used.

All subroutines are made self contained in that the input parameters are transferred from the main program to the subroutine by arguments.

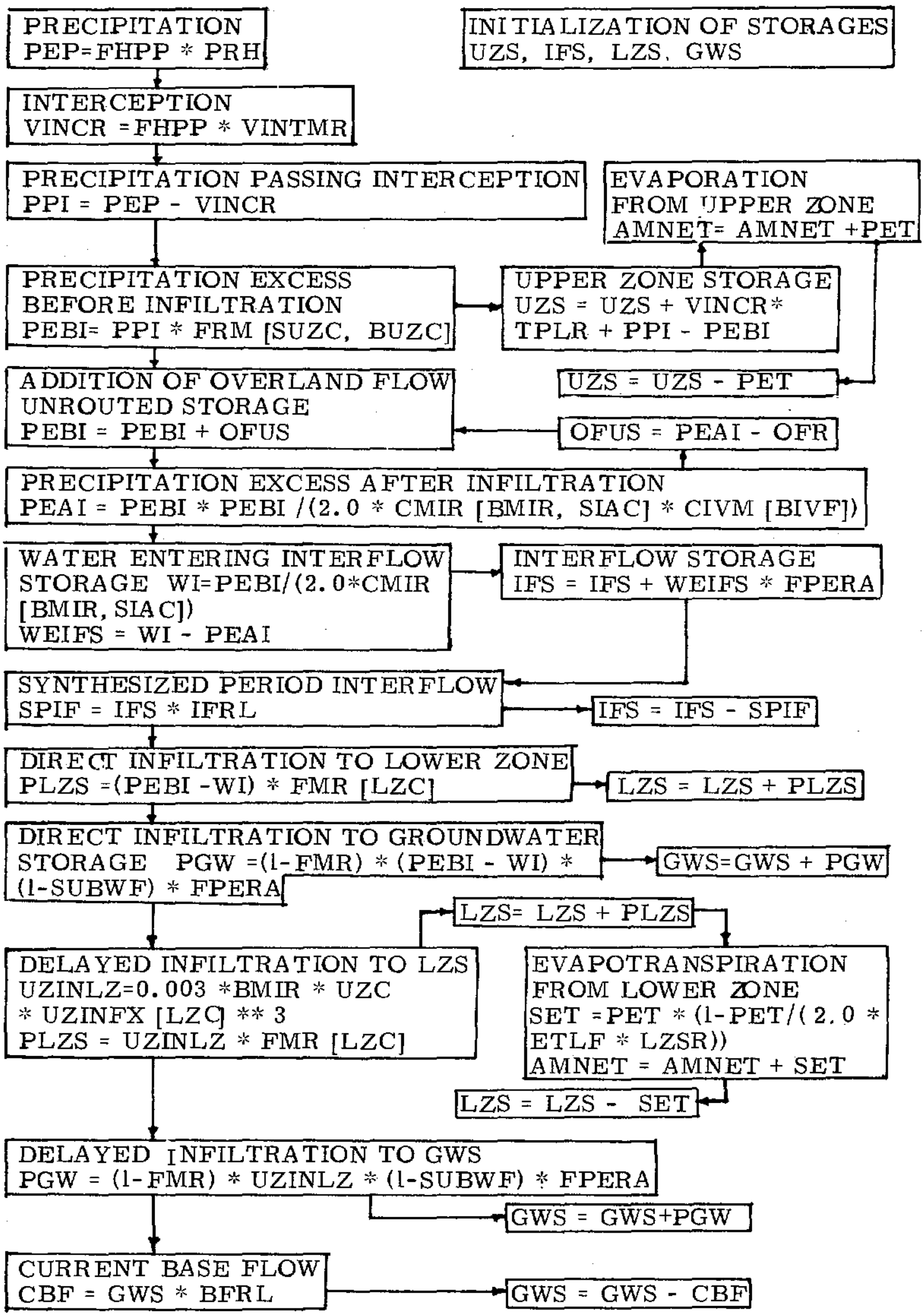


Figure 4. Flow Chart for Moisture Accounting Procedures

TABLE 1. SUMMARY OF SUBROUTINES

SUBROUTINE NAME	PURPOSE
A. ACCOUNTING SUBROUTINES	
DAYNXT	Determines next day of the year
DAYSUM	Sums daily values for monthly and yearly total
DAYOUT	Prints out daily values in tabular form
EVPDAY	Determines dated pan evaporation totals
PRECHK	Checks precipitation-streamflow anomalies
PREPRD	Divides hourly precipitation over 15 minute periods
B. RECESSION CONSTANT SUBROUTINES	
RECESS	Establishes recession sequences
SET2RC	Sets 2 recession constants
SET1RC	Sets 1 recession constant
C. LAND PHASE PARAMETER SUBROUTINES	
SETFVP	Sets new values of flow volume parameters
SETFDI	Sets values of flow deviation indices
SETBMI	Sets new values of basic maximum infiltration rate
SETRBF	Sets interflow and base flow at recession beginning
SETBIV	Sets new value of basic interflow volume factor
D. ROUTING SUBROUTINES	
ROUTAB	Establishes routing table
RTGPAR	Determines routing parameters for each time period
CHROUT	Performs channel routing through each finite section
STORRT	Performs storage routing through each structure

TABLE 2. RELATIONSHIPS BETWEEN AVERAGE END AREA AND ROUTING PARAMETERS

END AREA sq. ft	26.7	57.4	95.6	165.0	259.0	384.0	551.0	754.0	1020.0
α	0.46	0.42	0.79	21.2	6.40	1.58	1.89	0.21	0.77
m	1.45	1.47	1.32	0.63	0.85	1.09	1.06	1.41	1.21

This arrangement not only makes the subroutines more easily understandable but also facilitates the modification of the program, if needed. The user may like to replace some of the arguments by common statements in order to save the computer time.

Subroutine ROUTAB

This subroutine is called when the discharge-end area rating curve is read in for channel routing. A straight line is passed through every two successive points on the rating curve in logarithmic scales. The values of α and m, which are the vertical intercept and the slope, respectively, are computed and assigned to the average end area.

Table 2 shows the relationship between the average end area and the values of α and m for the data shown in Figure 2. There are a total of 10 data points, or nine sets of α and m. It can be seen that α and m do not change gradually but may jump back and forth. This is particularly true if any data point is erroneously out of line. Therefore, data on discharges and end areas should be carefully checked. Otherwise, the resulting hydrograph may oscillate up and down, and inaccurate results may be obtained. In view of the fact that channel routing is quite expensive, it is preferable to plot log Q versus log A and determine the several sets of α and m as input, thus any irregularity in the discharge-end area rating curve can be detected. Although subroutine ROUTAB was used for all three watersheds presented herein, it was found that the hydrographs sometimes oscillated up and down. These oscillations were completely eliminated when the several sets of α and m were determined from the logarithmic plot.

The subroutine consists of the following arguments:

DISCH (1000) - Values of discharges in the rating curve. Theoretically, the dimension required is only NP + 1, where NP is the number of points on the rating curve. However, a large dimension of 1000 is used because DISCH is also employed in subroutine STORRT, which requires a larger dimension. DISCH may be destroyed after the routing table is generated.

DAREA (150,50) - Values of end areas in the rating curve. The first subscript indicates the maximum number of finite sections, each with a different rating curve, and the second subscript indicates the maximum number of points on the rating curve. The original values of DAREA are destroyed and replaced with the average end area of two successive points on the rating curve.

KRKFS - Counter for finite section number. The number starts from the most upstream finite section of the first reach and ends at the most downstream finite section of the last reach.

NP - Number of points in the rating curve.

ALPH (150, 50) and EXPT (150, 50) - Values of α and m respectively. ALPH (KRKFS, 1) and EXPT (KRKFS, 1) are reserved exclusively for storing α and m for use in low volume flows, as will be described in subroutine RTGPAR. If these values are not read in, they are initialized as zero. The first point in the routing table is represented by ALPH (KRKFS, 2) and EXPT (KRKFS, 2).

<u>Subroutine RTGPAR</u>

This subroutine is called to determine the routing parameters, α and m, to be used at a given time increment. The average end area for a finite section during the previous time increment is computed, and the corresponding α and m are selected.

If several sets of α, m and the limiting end area are read in directly, the subroutine will compute the average end area for the finite section, check the average end area with the limiting areas, and determine the set of α and m to be used.

If the discharge-end area relationship is specified for a finite section, subroutine ROUTAB should be called first to generate a routing table, as shown in Table 2. If the average area for a finite section is smaller than the smallest end area in the routing table, α and m corresponding to the smallest area will be used. If the average end area is greater than the largest area, α and m corresponding to the largest area will be used. A straight line interpolation is used for determining α and m when the average end area falls between two successive areas in the table.

In view of the fact that the discharge-end area rating curve obtained from the water surface profile is mostly based on high volume flows and may not be applicable to low volume flows, an option is provided that the user can specify α and m when the average end area is smaller than the first point on the rating curve. If the average end area is greater than the first point on the rating curve but less than the first point in the routing table, a straight line interpolation is used for determining α and m.

The subroutine has the following arguments:

XAREA (150, 21) - End area at each finite difference point. The first subscript indicates the maximum number of finite sections and the second subscript indicates the maximum number of finite difference points in a finite section. This is an input parameter for computing the average end area.

KFS - Counter for finite section number in each reach.

KRKFS - Counter for finite section number in the entire watershed.

ALPH (150, 50), EXPT (150, 50), and DAREA (150, 50) - Values in the routing table obtained by calling subroutine ROUTAB.

ALPHA and EXPM - α and m used for channel routing, which are the output of the subroutine.

NOFD (150) - Number of finite difference division in each finite section.

NSC (150) - Number of slope changes in the rating curve. If the three sets of α and m are read in directly, NSC = 3. If all data points on the rating curve are read in, NSC = 0.

Subroutine CHROUT

The procdeures for channel routing, both linear and nonlinear as described in Chapter III, are programmed in this subroutine. In searching for the best routing method, the convex method used in the TR-20 program by the Soil Conservation Service [1965] was considered. However, it was ruled to be impractical and insufficient for use in MOPSET because no satisfactory method could be found for calculating the routing coefficient, nor did the procedure lend itself well to the moisture accounting by daily looping. The convex method requires that the entire rainfall hydrograph be known prior to routing; whereas MOPSET treats each periodic rainfall as it occurs in the simulation.

The subroutine has the following arguments:

XAREA (150,21) - End area at each finite difference point, which is the output desired.

ROLF1 (15) and ROLF2 (15) - Local inflow per linear ft of channel during the previous and the current time intervals, respectively. The subscript indicates the maximum number of reaches. ROLF1 and ROLF2 are computed by dividing the sum of direct runoff and base flow in each reach with the length of channel in that reach.

DELTAT - Routing time interval, or Δt.

DELTAX - Finite difference length, or Δx.

ALPHA and EXPM - routing parameters α and m.

N - Number of finite difference points.

KR - Counter for reach number.

KFS - Counter for finite section number in each reach.

INLR - Index for linear or nonlinear routing, 0 for linear routing and 1 for nonlinear routing.

Subroutine STORRT

This subroutine is used to account for the storage effect of any structure encountered in the watershed. It is used at the end of a reach with the simulated outflow from the reach as the inflow to the structure. The procedure is similar to that used in the TR-20 program by the Soil Conservation Service [1964, 1965]. The TR-20 program is concerned mainly with high volume flows, so the water in the structure is assumed to be full and the effect of evaporation on water level is neglected. Since MOPSET is designed to simulate flows throughout the year, the water in the structure at the beginning of the year is not necessarily to be full. By specifying the initial storage of the structure and considering the effect of evaporation, the storage and outflow can be simulated.

The basic equation for storage routing can be written as

$$\frac{(I_1 + I_2)}{2} \Delta t - \frac{(O_1 + O_2)}{2} \Delta t = S_2 - S_1 \tag{35}$$

in which I_1 = inflow at time t_1; I_2 = inflow at time t_2; O_1 = outflow at t_1; O_2 = outflow at t_2; S_1 = storage at t_1; S_2 = storage at t_2; and $\Delta t = t_2 - t_1$. The term involving known quantities is designated as

$$C_4 = (I_1 + I_2 - O_1)\Delta t + 2S_1. \tag{36}$$

The term involving unknown qualities is designated as

$$C_5 = O_2 \Delta t + 2S_2 \tag{37}$$

Note that $C_5 = C_4$ and Eq. 37 is a linear function of O_2 and S_2. O_2 and S_2 are also related by the discharge-storage rating curve for the structure.

Therefore, the required values of O_2 and S_2 occur at the intersection of Eq. 37 and the rating curve, as indicated in Figure 5.

To find the intersection, the subroutine selects two "bracketing" points on the rating curve. These bracketing points are located by substituting two corresponding values of discharge and storage near the beginning of the rating curve into Eq. 37 and obtaining C_5. If $C_5 < C_4$, the next set of discharge and storage is used and the same comparison is made between C_5 and C_4. This is repeated until $C_5 > C_4$, thus the bracketing points are those which cause a change in sign for $C_5 - C_4$. A straight line is passed through these two bracketing points and its intersection with Eq. 37 yields the unknown O_2 and S_2.

S_2 obtained at the end of one time period will be used as S_1 at the beginning of the next time period. Due to the effect of evaporation, S_2 must be reduced before being used for S_1. The volume of water evaporated can be computed from the daily potential evaporation and the elevation-storage rating curve. The elevation and storage at the two bracketing points is used to convert the evaporation in in. to the storage in cu ft. If there is no outflow, or the structure is not filled, the slope of the line connecting the first two points on the elevation-storage rating curve is used for the conversion.

The subroutine has the following arguments:

TFCFS - Total inflow, I_2, at t_2.

KR - Reach number.

DELTAT - Time increment, Δt.

ELEV (1000), DISCH (1000) and STORAG (1000) - Values of elevation, discharge and storage in the structure rating curve. The subscript indicates the maximum number of points in the rating curves for all structures in the watershed. For example, if there are twenty structures, each rating curve can have 50 points.

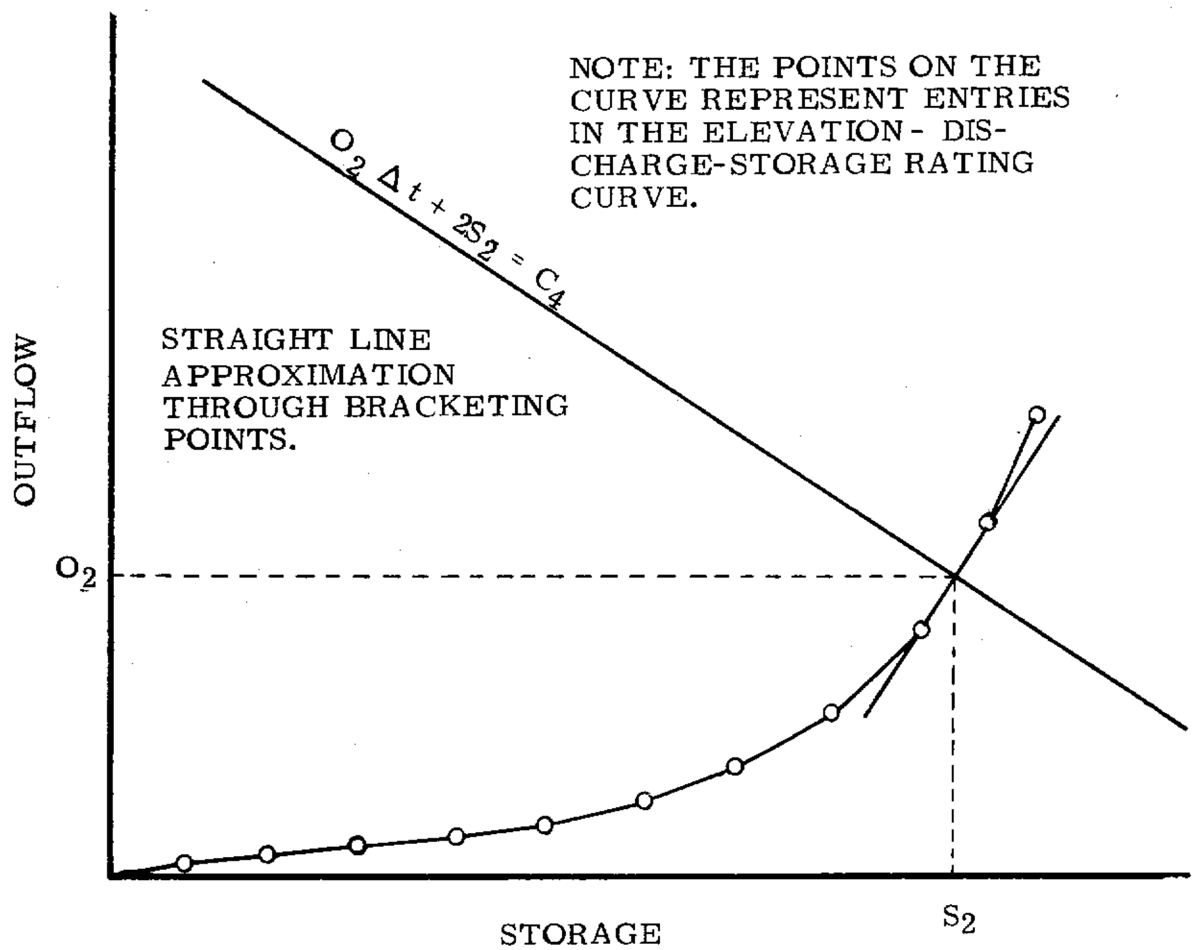


Figure 5. Solution of Storage Equation

IFST - Storage location of the first element in the rating curve.

ILST - Storage location of the last element in the rating curve.

INLST (15) - Inflow, I_1, at t_1. The subscript indicates the total number of reaches.

OUTLST (15) - Outflow, O_2, at t_2. O_2 is used as O_1 at the next time period.

STOLST (15) - Storage, S_2, at t_2. S_2 is used as S_1 at the next time period.

PET - Current daily potential evapotranspiration.

CHAPTER V

USER'S INFORMATION

5.1 Storage Requirement

The computer program was written in Fortran IV for an IBM 370 computer, model 165, which is used presently by the University of Kentucky. Because of the huge storage capacity of the computer, liberal storage locations were assigned to various variables. As a result, the program in its present form requires a storage of 360K. The user can reduce the required storage by following the suggestions described below:

1. If the total number of reaches is less than 15, the dimension of all variables having a subscript of 15 can be reduced to the number of reaches actually used.

2. If the number of data points in the discharge-end area rating curves is less than 50, all variables having a subscript of 50 can be reduced to a number equal to the number of data points plus one.

3. The dimension of ELEV (1000), DISCH (1000) and STORAG (1000) in the structure rating curves can be reduced to a number which is equal to the number of structures multiplied by the maximum number of data points in a rating curve.

4. If the maximum number of finite difference points in a finite section is fewer than 21, the second subscript in XAREA (150, 21) and EDAREA (150, 21) can be reduced to the number of points actually used.

5. If the total number of finite sections in the entire watershed is less than 150, the dimension of all variables having a subscript of 150 can be reduced to the number of finite sections actually used.

5.2 Data Preparation

Source of Information

MOPSET requires the same climatological and streamflow data as used in OPSET. Both Ross [1970] and Ricca [1974] suggest that a representative three to five year's record be available for calibration. Stream gage data and climatological data are published annually by the U.S. Geological Survey and the U.S. Weather Bureau respectively. Since the amount of required data is quite large, it is suggested that computer tapes containing these data be acquired so that the required data can be punched from the tapes.

Physical data of the watershed may be determined from topographic maps, aerial photos, and field surveys. The soil maps published by the Soil Conservation Service, which consist of soil boundaries superimposed on aerial photographs, are particularly useful. The available source of information and the procedures for obtaining physical data are discussed by Ross [1970].

Segmentation of Watershed

The first step in using MOPSET is to locate the stream gage on a topographic map and delineate the boundary of the watershed. The watershed is then divided into a number of reaches. The use of more reaches can approximate the watershed more closely but requires more computer times. Therefore, accuracy must be weighed carefully against economy in determining the number of reaches to be used.

The reaches are numbered from upstream to downstream, as shown in Figure 6. A basic principle in numbering is that the number of a reach must be greater than the number of the reaches, or branches, above it. Each reach is then divided into a number of finite sections, depending on the number of channel cross sections available. Each finite section is divided into a number of finite differences.

For more accurate results, it is desirable to consider each branch as a separate reach. However, economy may dictate that several small

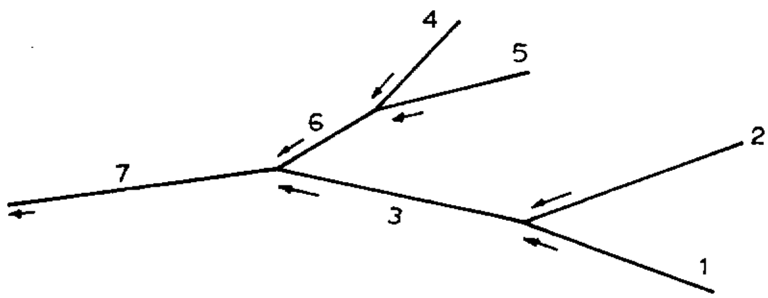


Figure 6. Numbering of Reaches

TABLE 3. ESTIMATES OF ETLF AND BUZC

Watershed Cover	Slope	ETLF	BUZC
Fallow	S	0.10	0.2
	M	0.15	0.4
	F	0.20	0.7
Cropland	S	0.13	0.8
	M	0.18	1.1
	F	0.23	1.6
Pasture	S	0.15	0.9
	M	0.20	1.3
	F	0.25	2.0
Woods	S	0.25	1.3
	M	0.30	1.7
	F	0.35	2.6

TABLE 4. ESTIMATES OF SIAC BY PERCENT OF WOODED AREA

Percent of Wooded Area	SIAC
0 - 20	0.15
21 - 40	0.30
41 - 60	0.50
61 - 100	0.70

branches be combined together and the channel in the largest branch be used for routing.

Determination of OFSL and OFSS

Two parameters most difficult to determine for each reach are the overland flow surface length, OFSL, and the overland flow surface slope, OFSS. Procedures were developed to measure these two parameters directly from a topographic map. By measuring with a chartometer the length of all discernible streams, as indicated by blue lines or V-shape contours, OFSL can be computed by

$$\mathrm{OFSL} = \frac{\text{area of the reach}}{\text{2x total length of streams in the reach}} \tag{38}$$

DeWiest [1965] suggests a method for determining OFSS. A grid consisting of two sets of perpendicular lines is drawn on a transparent paper and superimposed on the topographic map. By measuring the length of each line within the boundary of the reach and counting the number of intersections with the contour lines, OFSS along each line can be determined by

$$\mathrm{OFSS} = \frac{\text{Number of intersections x contour interval}}{\text{length of line}} \tag{39}$$

The average of OFSS over the two sets of perpendicular lines gives the overland flow surface slope for the whole reach.

Estimation of parameter ratios.

When the watershed is divided into a number of reaches, it is necessary to specify the ratios of the seven land phase parameters to a set of base values. If the parameters for a given reach are used as the base values, all ratios for that reach will be assigned unity. The following information can be used to estimate the seven ratios.

1. LZC is related to the available water capacity, AWC, by

$$\mathrm{LZC} = -0.7016 + 1.2404\ \mathrm{AWC}. \tag{40}$$

The available water capacity of Kentucky soils are tabulated in Appendix D.

2. BMIR is related to the permeability of A-horizon, P_A, by

$$BMIR = 2.3595\ P_A. \qquad (41)$$

The permeability of Kentucky soils are also tabulated in Appendix D. Eqs. 40 and 41 were developed by Ross [1970].

3. In the absence of more reliable information, use of a ratio of 1 for SUZC.

4. ETLF is related to the watershed cover and the overland flow surface slope and can be estimated from Table 3. In the table, S indicates steep slope with OFSS > 0.2, M indicates moderate slope with OFSS between 0.05 and 0.2, and F indicates flat slope with OFSS < 0.05.

5. BUZC is also related to watershed cover and OFSS and can be estimated from Table 3.

6. SIAC is related to the percent of wooded area and can be estimated from Table 4.

7. Use a ratio of 1 for BIVF due to the lack of more reliable information.

Although the estimated parameter values based on the above information are quite crude and may not agree with the values determined from MOPSET, their use as a guide for determining the parameter ratios among different reaches will greatly facilitate the application of the model.

5.3 Required Input

Each input parameter will be explained in the order as it appears in the computer program.

Number of Cases and Title Card

NSYT - Total number of station years included in a computer run. Several years of data, not necessarily to be consecutive, may be run for trip 1, so the optimum set of parameter values for each year can be determined and averaged. NSYT can also be used to indicate the total number of cases to be run, as long as all necessary data are read in for each case.

TITLE(20) - Title card with any number of characters punched in one card.

Control Options

Seven control options are used to control the program.

CONOPT(1) = 0 if daily evaporation values are to be read, 1 if evaporation data is in 10-day totals, and 2 if annual total evaporation is to be read.

CONOPT(2) = 0 if channel routing is to be done every 15 min, 1 if channel routing is to be done hourly.

CONOPT(3) = 0 if channel routing is linear, 1 if channel routing is nonlinear.

CONOPT(4) = 0 if initial parameter values are preset and not to be read, 1 if initial parameters are to be read. These parameters may be obtained from a previous run and used for trip 2 or the continuation of trip 1. They may also be any initial values arbitrarily assigned by the user.

CONOPT(5) = 0 if ALPH and EXPT for low volume flows are not to be read, and 1 if ALPH and EXPT for low volume flows are to be read.

CONOPT(6) = 0 if more than one reach is used for trip 1, and 1 if only one reach is used for trip 1. In the latter case, the parameters are averaged over all the reaches above the gage and used for trip 1.

CONOPT(7) = 0 if the fine adjustment cycle stops automatically when the sum of squares becomes greater. After checking the results, if it is desired to run a few more fine adjustment cycles, assign CONOPT(4) to one and CONOPT(7) to the number of cycles desired.

Other Control Data

MNRC - Minimum number of rough cycles. Ross [1970] suggested the use of 12 rough cycles as the minimum. However, it was found that in many cases the use of fewer cycles would yield the same results. It is therefore suggested that 6 be used for MNRC. If the results are not satisfactory, the user can always rerun the program for a few more rough cycles, starting from the sixth cycle.

NFTR - Number of first trip to be run. Assign 1 if trip 1 is to be run, 2 if only trip 2 is to be run.

NLTR - Number of last trip to be run. Assign 1 if only trip 1 is to be run, and 2 if trip 2 is to be run.

NDCR - Day number for terminating channel routing. The day begins at 274. For example, assign 275 if only the first day of flow is to be routed, 305 if the first month of flow is to be routed, and any number greater than 366 if the entire year of flow is to be routed. The program will stop whenever DAY = NDCR. This feature is useful in cases where it is not necessary to obtain the hydrographs for the entire year.

NR - Total number of reaches.

NGR - Identifying number of the gaged reach. The stream gage can be located at the end of any reach, not necessarily to be at the mouth of the watershed.

NFS(KR) - Total number of finite sections in each reach, where KR ranges from 1 to NR.

NUBR(KR) - Total number of upstream branches above reach KR, or the number of hydrographs to be added. Assign 0 for the most upstream reach or reaches, to which inflow is zero.

IUH(KR, N) - Identifying number of upstream reaches, where KR ranges from 1 to NR and N from 1 to NUBR(KR). IUH is skipped if NUBR = 0.

NWSTH - Number of watershed travel hours, which can be estimated by

$$NWSTH = 0.00013 \ [L/\sqrt{S}\,]^{0.77} \tag{42}$$

in which L = the horizontal length in ft from the most distant point in the watershed to the stream gage, and S = the slope in ft per ft between these two points calculated by dividing the difference in elevation by L.

NOUT - Total number of reaches whose outflow is to be printed.

IROUT(I) - Reaches whose outflow is to be presented, where I ranges from 1 to NOUT.

RMPF - Requested minimum peak flow to be printed. If the flow at each routing time increment is desired, set RMPF to 0.0.

Channel Cross Sections

The channel cross section is represented either by a discharge-end area rating curve or sets of α and m. If NLTR = 1, no data on channel cross sections are read.

NP - Number of points in a channel rating curve. Assign 2 if α and m are read and a rating curve is not used.

NSC(KRKFS) - Number of slope changes in a rating curve, applicable only when α and m are to be read. Assign 0 if discharge and end area are to be read. KRKFS is an index for finite section.

NOFD(KRKFS) - Total number of finite difference divisions for the finite section identified as KRKFS. For short finite section, use 1 for NOFD.

FSLTH(KRKFS) - Length of finite section.

DISCH(I) and DAREA(KRKFS,I) - Values of discharge and end area in a rating curve, where I ranges from 1 to NP. These values are read only when NP $\neq$ 2.

ALPH(KRKFS, 1) and EXPT(KRKFS, 1) - Values of α and m for low volume flows. These values are read only when NP $\neq$ 2 and CONOPT(5) = 1.

ALPH(KRKFS, I), EXPT(KRKFS, I), DAREA(KRKFS, I) - Values of α, m, and the limiting end area, where I ranges from 1 to NSC(KRKFS). Assign a large value for DAREA when I = NSC(KRKFS).

Hydraulic Structures

The hydraulic structures can be numbered in any order so long as the data are referred to the reach in which the structure is located. If NLTR = 1, no data on structures are read.

NSTR - Total number of structures. Assign 0 if there is no structure in the watershed. If NSTR = 0, no structure data are needed.

NELV - Number of points, or elevations, in a structure rating curve.

ELEV(IE), DISCH(IE), and STORAG(IE) - Values of elevation, discharge, and storage in a rating curve, where IE is the storage location computed automatically by the program. Discharge for the first point in each rating curve is always 0.

IRSTR(KS) - Reach number in which the structure is located, where KS ranges from 1 to NSTR.

INLST(KR), OUTLST(KR), STOLST(KR) - Initial values of inflow, outflow, and storage, where KR ranges fron 1 to NR. If the initial storage is less than the storage of the first point in the rating curve, OUTLST(KR) should be assigned 0.

Reach Parameters

RCHLTH(I) - Reach length, where I ranges from one to NR. The reach length can be measured in the field or from the topographic map by a chartometer.

SAREA(I) - Area of each segment, or reach. This can be measured from the topographic map by a planimeter.

OFSS(I) - Overland flow surface slope.

OFMN(I) - Overland flow Manning's coefficient, n. Table 5 gives the values for various types of surfaces [Chow, 1959].

OFSL(I) - Overland flow surface length.

OFMNIS(I) - Overland flow Manning's n for impervious surfaces.

FIMPA(I) - Fraction of area being impervious.

FWTRA(I) - Fraction of area being water.

RLZC(I), RBMIR(I), RSUZC(I), RETLF(I), RBUZC(I), RSIAC(I), and RBIVF(I) - Ratios of the seven land phase parameters to their respective base values. Methods for estimating these ratios are described in Section 5.2.

RGPMB(I) - Basic recording gage precipitation multiplier. If only a recording precipitation gage is used, RGPBM is the ratio of the average annual rainfall over the watershed to the annual rainfall recorded at the gage. If a storage gage is used in conjunction with the recording gage, RGPMB should be set to 1.0.

GWETF - Groundwater evapotranspiration factor, which is assumed to be constant for the entire watershed.

DIV - Division into basin, which is assumed to be constant for the entire watershed.

TABLE 5. MANNING'S ROUGHNESS COEFFICIENT FOR OVERLAND FLOW

Watershed Surface	Manning's n
Smooth Asphalt	.013
Concrete (trowel finish)	.013
Rough Asphalt	.016
Concrete (unfinished)	.017
Smooth Earth	.018
Firm Gravel	.020
Cemented Rubble Masonry	.025
Pasture (short grass)	.030
Pasture (high grass)	.035
Cultivated Area (row crops)	.035
Cultivated Area (field crops)	.040
Scattered Brush, Heavy Weeds	.050
Light Brush and Trees (winter)	.050
Light Brush and Trees (summer)	.060
Dense Brush (winter)	.070
Dense Brush (summer)	.100
Heavy Timber	.100

TABLE 6. INTERCEPTION VALUES FOR VARIOUS TYPES OF COVER

Watershed Cover	VINMRA(in.)
Grassland	0.10
Moderate Forest Cover	0.15
Heavy Forest Cover	0.20

VINMRA(I) - Maximum rate of vegetative interception. This value can be estimated by Table 6 [Crawford and Linsley, 1966].

SUBWFA(I) - Surface water flow out of basin. This parameter allows the user to account for any known subsurface loss such as sinkhole drainage.

Climatological Data

YR1 - The 2 digit integer specifying the first year of the water year.

YR2 - The 2 digit integer specifying the second year of the water year. YR2 is also used to determine whether the year has 366 days.

DPET(KRD) - Daily potential evapotranspiration, where KRD ranges from 274 to 365 and then from one to 273. If YR2 is a leap year, February 29 is read last as day 366. If CONOPT(1) = 0, daily values of DPET are read. If CONOPT(1) = 1, average evapotranspirations for each ten day period are read and the program assigns the same value to the remaining nine days. If CONOPT(1) = 2, EPAET and MNRD are read.

EPCM - Evaporation pan coefficient. This coefficient is read if CONOPT(1) = 0 or 1 to account for the difference between pan and lake evaporations.

EPAET and MNRD - Estimated potential annual evapotranspiration and mean number of rainy days, respectively. These two parameters are used in conjunction with subroutine EVPDAY to estimate the evaporation for each day of the year.

DRSF(DAY) - Daily recorded flow, where DAY ranges the same as KRD in DPET(KRD).

NSG - Total number of storage gages used. Each reach can have its own storage gage. If NSG = 0, all data related to storage gages are omitted.

NSGRD - Number of storage gage rainfall days.

ISGM (KG) - Index of storage gage movement during the year, where KG ranges from 1 to NSG. Assign 1 if the gage was moved, and 0 if not moved.

SGRT (KG) - Hour of day (24 hour clock) at which the storage gage was read.

SGRT2 (KG) - The new hour at which the storage gage was read. This parameter is read only if the storage gage was moved during the year.

SGMD (KG) - Storage gage moving day. This parameter is read only if the storage gage was moved during the year.

ISGRD - Storage gage rainfall day.

DRSGP (KG, ISGRD) - Daily recorded storage gage precipitation, where ISGRD ranges from 1 to NSGRD.

ISGA (KR) - Identity of the storage gage to be used for reach KR, where KR ranges from 1 to NR.

WSG (KR) - Storage gage weighting factor to be used for reach KR. This factor can be determined by dividing the distance between the centroid of the reach and the recording gage by the sum of the two distances, one from the centroid to the recording gage and the other from the centroid to the storage gage.

WSG2 (KR) - New storage gage weighting factor. This parameter is read only if the storage gage was moved during the year.

IWBG - 4 digit index number of Weather Bureau recording gage. All reaches must use the same recording gage.

YEAR - Last two-digits of current year.

MONTH - Current month, two digits.

DATE - Day of the month.

CN - 1 for A.M., 2 for P.M.

DRHP (DAY, HOUR) - Daily recorded hourly precipitation for calendar day, DAY, and 24 hour clock time, HOUR.

Continuation of Trip 1

Trip 1 can be continued at any adjustment cycle by simply reading in the following parameters, the values of which have been printed out in the previous run.

LZC, BMIR, SUZC, ETLF, BUZC, SIAC, BIVF - base values of the seven land phase parameters.

LZS - Initial value of lower zone storage. In MOPSET, it is assumed that the initial upper zone storage is always zero, and that the initial lower zone storage and the initial groundwater storage are the same for all reaches.

KRC - Counter of current adjustment cycle.

KBRC - Counter of rough cycles since best one. When CONOPT(7) = 0 and KBRC = 2, the program shifts from the rough to the fine adjustment cycle.

SSSQM - Current smallest estimate of the sum of squares of monthly flow deviations.

FTX - Fall trouble index. Initial value is 1.0. When the sum of the monthly deviation indices for November and December is greater than 2 , FTX is set to 0.9. When the sum is less than -2, FTX is set to 1.1.

LRC - Logical variable set TRUE for rough adjustment cycle.

LLZC, LBUZC, LBMIR, and LETLF - Logical variably set TRUE when exercising substitute approach for evaluating LZC, BUZC, BMIR, and ETLF, respectively. Initially, these variables are set FALSE.

Input of the above variables also allows the user to change the initial parameter values or the optimization procedures. For example, KRC can be set to 1, LRC to FALSE, and CONOPT(7) to the number of adjustment cycles desired. The user can then inspect the results of each fine adjustment cycle and select the land phase parameters which give the best results.

Separate Run for Trip 2

Because trip 2, which involves channel routing, is quite expensive, it is preferable to inspect the results of trip 1 and then read in the following parameters for trip 2.

LZC, BMIR, SUZC, ETLF, BUZC, SIAC, BIVF - Base values of the seven land phase parameters obtained from trip 1.

LZS - Initial value of lower zone storage.

IFRC and BFRC - Interflow and base flow recession constants determined from trip 1.

5.4 PRINTED OUTPUT

General Description

All input data, except climatological information, are printed so they can be checked for correctness. The climatological data are not printed because they are too voluminous. In fact, they can be read or punched from computer tapes, and the possibility for errors is minimum.

A table of recorded flows is printed showing the daily flow in cfs and the monthly and annual totals in sfd. Information in the table can be compared with the synthesized flow to ascertain how satisfactory a match exists.

Trip 1

In trip 1, data related to the two recession constants are printed once, but those related to the optimization procedures are printed during each adjustment cycle. The following recession data are printed:

1. Flow sequences used to estimate recession constants.

2. BFRC and IFRC for each sequence.

3. Sequence not used for determining the average BFRC and IFRC because of their unreasonable values.

4. Number of base flow days and number of interflow days.

5. Amount of base flow, interflow and total flow at the first day of each recession sequence.

6. Rejected value of IFRC if it is smaller than 0.3.

The following optimization data are printed for each cycle:

1. Values of seven land phase parameters and two recession constants used for simulations.

2. Initial moisture storages, LZS and GWS.

3. Data used for continuation run, if needed, including KRC, KBRC, SSSQM, FTX, LRC, LLZC, LBUZC, LBMIR, and LETLF.

4. Summary table showing the monthly total in inches of overland flow, interflow, base flow, stream evaporation, precipitation, evapotranspiration, and the various storages and indices at the end of each month.

5. Monthly synthesized flows and annual total in sfd and the annual moisture balance error.

6. Monthly flow deviation indices, MFDI, and the sum of squares, SSQM.

7. New values of LZC, SUZC, ETLF, BUZC, and SIAC to be used for the next cycle and the index months upon which the new values are based.

8. New values of BMIR and BIVF to be used for the next cycle and a listing of synthesized and recorded base flow and interflow during the first three days of recession sequence.

<u>Trip 2</u>

In trip 2, the following data are printed:

1. Seven land phase parameters and two recession constants to be used for trip 2.

2. Initial moisture storages, LZS and GWS.

3. Hourly flows, maximum flow, and daily average of those days when the flow at any time exceeds RMPF.

4. Daily flows and monthly total at the end of each month.

5. Table of synthesized flows at the end of the year showing the daily flow in cfs and the monthly and annual totals in sfd.

6. Summary table showing the monthly total in inches of overland flow, interflow, base flow, stream evaporation, precipitation, evapotranspiration, and the various storages and indices at the end of each month.

7. Monthly synthesized flows and annual total in sfd and the annual moisture balance error.

CHAPTER VI

DATA AND RESULTS

To illustrate the application of MOPSET, three watersheds of widely different characteristics were selected for analyses. They are the South Fork Beargrass Creek Watershed, the Floyds Fork Watershed, and the North Fork Nolin River Watershed. Due to the exhaust of the computer fund, each watershed was analyzed only for one year. Any error or inaccuracy in the recorded precipitation or streamflow data in that year will certainly affect the performance of the model. Therefore, the limited data presented in this chapter should not be used as a criterion to judge the adequacy of the model. However, this study did indicate that MOPSET could be applied to complex watersheds with variable channel characteristics. Further refinements are needed as more experience is gained in the application of the model.

6.1 South Fork Beargrass Creek Watershed

General Information

This watershed lies in the eastern portion of Louisville in Jefferson County. The U.S. Geological Survey has maintained a stream gaging station at Trevilian Way intermittently since 1939. The watershed has a drainage area of 17.2 sq mi. The downstream valley has very steep walls, the upstream section is hilly, and the majority of the basin is flat to gently rolling. The land use is primarily residential with some small vegetable farms. Much of the land is being held idle in anticipation of future urban development. A few sinkholes, ponds, and small wooded areas are scattered throughout the basin. The basin is transversed by numerous 4-lane state and interstate highways, city streets, and county roads. The soils in the watershed belong mostly to the Crider-Corydon association with level to sloping soils on broad ridges and steep, shallow soils over limestone on hillsides.

The watershed is located in the Louisville East and the Jeffersontown quadrangles of the 7.5 minute topographic map published in 1971 by the

U.S. Geological Survey. The map has a contour interval of 10 ft in rolling terrain and 5 ft in flat urban areas. Based on the topography indicated in the map, the watershed was divided into three reaches. Figure 7 shows a plan view of the the watershed. The reason that three reaches were used is because there are two major branches at the upstream. It is possible to combine the two upstream reaches and assume that all water in reach 2 be uniformly distributed along the stream in reach 1; however, this will result in a less accurate simulation. On the topographic map, each reach was measured for drainage area by a planimeter and for channel length by a chartometer. The overland flow surface length, OFSL, and the overland flow surface slope, OFSS, were determined by the method described in section 5.2 The percentage of urban area was measured, and the impervious area was assumed to be one-fifth of the urban area.

The soil survey maps of Jefferson County was issued in 1966 by the Soil Conservation Service [1966]. These maps, which indicate the boundary between different soils superimposed on aerial photographs, are very useful for determining the parameter ratios described in section 5.2. The area in each reach occupied by each major soil series was estimated. LZC and BMIR were computed for each series by Eqs. 40 and 41 and weighted over the area to obtain those for the reach. The areas in each reach covered by fallow, cropland, pasture and woods were estimated from the aerial photographs. By averaging the values listed in Table 3 for each watershed cover, ETLF and BUZC were also determined. SIAC was estimated from Table 4. The parameters for each reach were weighted by areas to obtain the base values. A division of the reach values by the base values provided the parameter ratios to be used as input.

The Louisville District of the Corps of Engineers has made an extensive study on the water surface profile in this watershed by the use of HEC-2 computer program. The profile was determined from the gage station up the stream through reaches 3 and 1, and no profile was run for reach 2. A total of 92 cross sections were used in reach 1 and 42 in reach 3. The output of the program included the discharge and end area for each of the 134 cross sections. The use of so many cross sections,

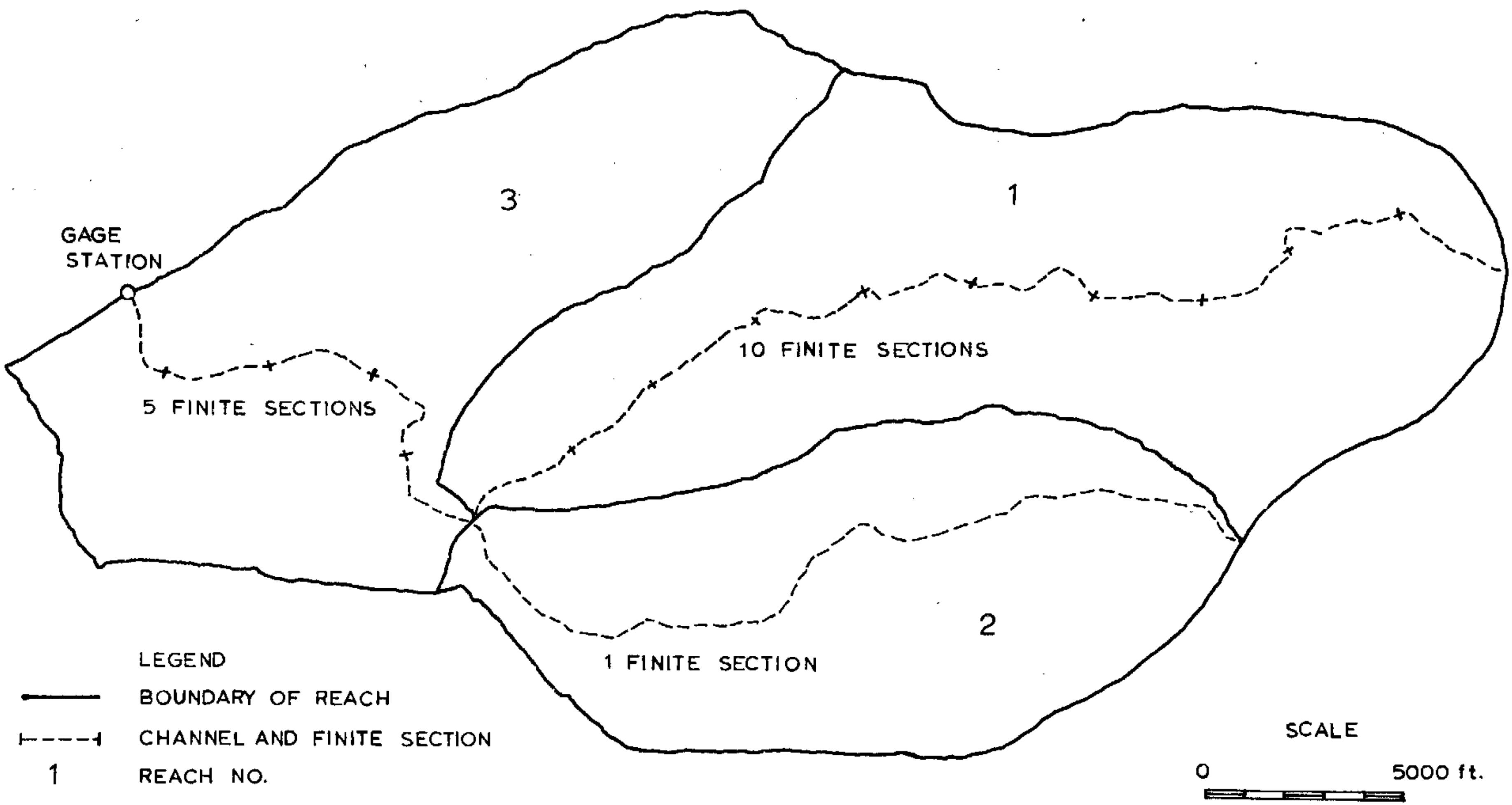


Figure 7. South Fork Beargrass Creek Watershed

some spaced as close as 5 ft apart, is neither economical nor necessary for MOPSET, in view of the many uncertainties involved in flood simulations. Therefore, the number of cross sections, one representing each finite section, was reduced to ten in reach 1 and five in reach 3. Each finite section consisted of only one finite difference division, i.e. the finite section was not further divided into finite differences. The discharge-end area rating curve for each cross section was the weighted average of all curves within the finite section. It will be shown that the use of fewer cross sections does not affect significantly the routed hydrograph. The α and m were determined at a number of points in reach 2 by the method described in section 3.4 and then averaged. Only one finite section was used in reach 2, which was divided into five finite differences. The α and m for low volume flows in reaches 1 and 3 were determined by the same method.

The climatological data for the 1971 water year was selected because they corresponded well with the information in the maps. One recording gage (No. 4954 at Louisville airport) and one storage gage (No. 0155 at Anchorage) were used. All the input data for this watershed are presented in Appendix C. The data shows that trips 1 and 2 are run at the same time. In reality, they were performed at two separate computer runs.

Comparison Between Synthesized and Recorded Flows

The synthesized flows presented herein were obtained by MOPSET, using the preset initial values for the land phase parameters. The sum of squares, SSQM, during the rough adjustment cycle was successively 166.466, 39.737, 9.434, 8.443, 9.061 and 9.538. Since the number of rough cycles had reached six, which was the minimum number specified, and since the SSQM had become greater twice, the program shifted to the fine adjustment cycle using the parameter values of the 4th rough cycle, which had the minimum SSQM. The SSQM during the fine adjustment cycle was successively 13.079, 12.517, and 12.605. Consequently, the program would shift to trip 2 using the parameter values of the 2nd fine cycle, should NLTR be set to 2.

Table 7 shows the optimized parameter values during the three fine adjustment cycles. Due to the insignificant amount of interflow, BIVF was set to 0. It can be seen that the parameter values

TABLE 7. PARAMETER VALUES DURING FINE ADJUSTMENT CYCLES FOR SOUTH FORK BEARGRASS CREEK WATERSHED

CYCLE NO.	LZC	BMIR	SUZC	ETLF	BUZC	SIAC	ANNUAL sfd
1	2.0000	8.2726	0.3000	0.0507	0.2864	0.1125	9775.5
2	3.9530	5.2540	0.1500	0.0568	0.2586	0.0562	10691.1
3	7.7819	3.8379	0.2019	0.1136	0.3393	0.0519	9598.9

TABLE 8. COMPARISON OF RECORDED AND SYNTHESIZED PEAKS FOR SOUTH FORK BEARGRASS CREEK WATERSHED

RECORDED PEAK			SYNTHESIZED PEAK		
DATE	TIME	CFS	DATE	TIME	CFS
12-22	0245	854	12-22	0200	491
2-22	0245	1,740	2-22	0100	3,168
5-6	1515	828	5-6	1100	910
5-25	0115	918	5-24	2400	1,886
6-15	1445	776	6-15	2100	1,896
6-21	1630	1,000	6-21	1500	718
7-18	2030	2,930	7-18	1700	4,263

had not converged when the program shifted to trip 2. It was suspected that this difficulty was due to the small number of rough cycles specified. However, after changing MNRC to 12, the same results were obtained because the SSQM at the fourth cycle was still the smallest, even though twelve rough cycles were run. The inability to converge certainly posed a serious problem in determining which set of parameter values were to be used. For example, cycle 2 had a SSQM of 12.517, which was not too much different from the 12.605 in cycle 3, then why should the optimum set of parameters be based on cycle 2 but not on cycle 3. In fact, the synthesized annual flow was 10,691 sfd in cycle 2 and 9,599 sfd in cycle 3; while the recorded flow was 9,260 sfd, which checked more closely with cycle 3 than with cycle 2. Should the slight difference in SSQM outweigh the large difference in annual flow? It is therefore recommended that the optimum set of parameter values be based not on the SSQM alone. A major contribution of MOPSET is its ability to generate a variety of adjustment cycles, each with a different set of parameter values. It is up to the user to inspect the data and determine which set of parameter values are to be used for trip 2.

Figure 8 gives a comparison between synthesized and recorded monthly flows. Unless noted otherwise, all the flows presented in this report are referred to those at the gaging station, which is located at the mouth of the watershed. The synthesized flow was obtained from trip 1, using the parameter values of the second fine adjustment cycle. Also shown in the figure is the monthly precipitation and evapotranspiration. It can be seen that in some months the synthesized flow is greater than the recorded flow, while in other months the reverse is true. Even though the match is not considered very good, both flows have the same general trend and respond well with the climatological data. The figure also shows that the synthesized monthly flow before routing is not too much different from that after routing. The former used a 20 min loop and considered the watershed as one reach, while the latter used a 15 min loop and divided the watershed into three reaches. The channel routing was performed by the linear procedure with one hour looping.

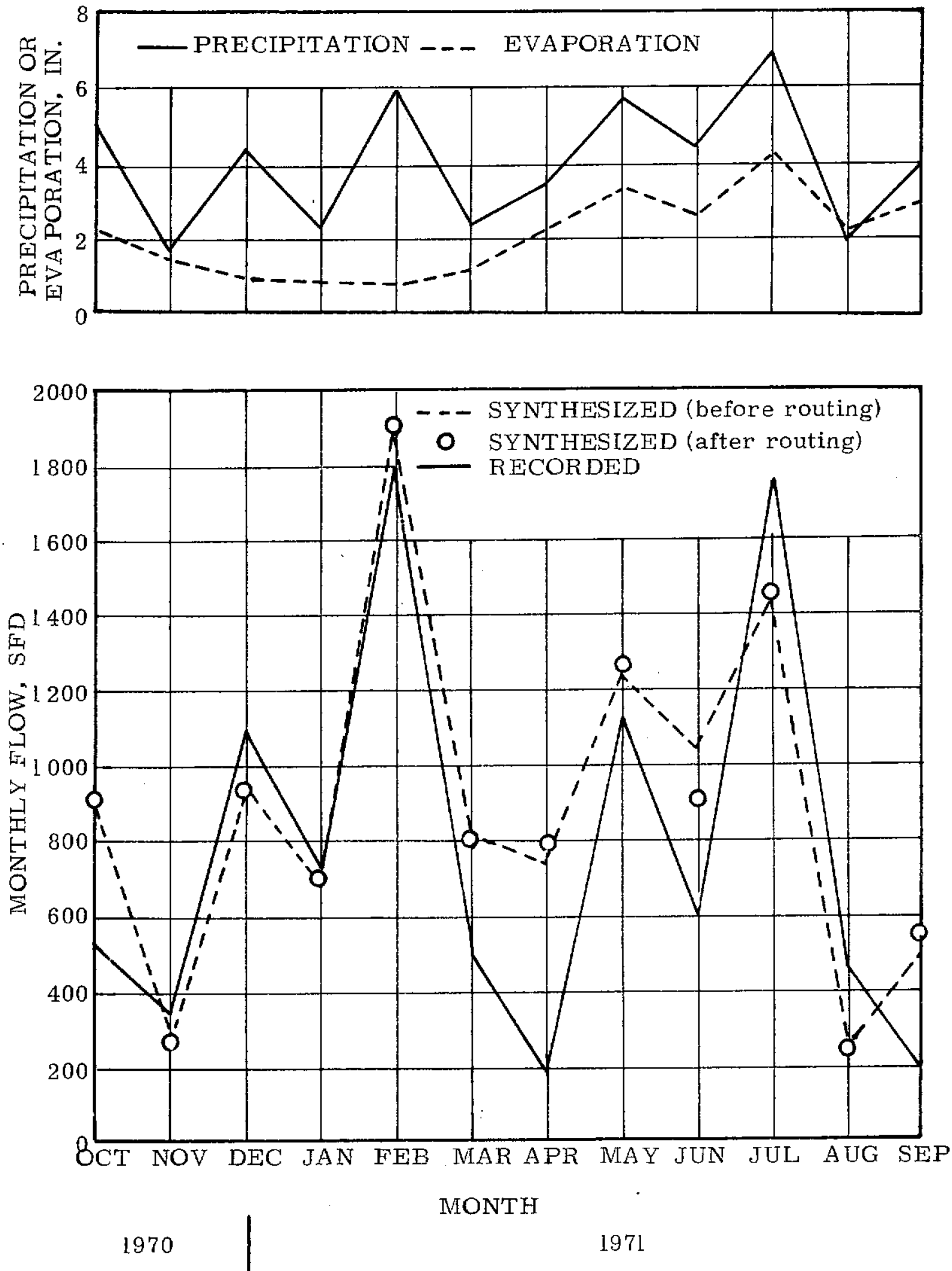


Figure 8. Comparison of Synthesized and Recorded Monthly Flows for South Fork Beargrass Creek Watershed

Figure 9 shows a comparison between the synthesized and recorded daily flows during February and July in 1971, the two months with the largest precipitation and runoff. The synthesized flow was obtained from trip 2, in which channel routing was performed. As can be seen, both flows check quite well. The computer time for trip 1 was 16 sec, and that for trip 2 with one year of channel routing was 60 sec, excluding the compiling time.

Table 8 gives a comparison of recorded and synthesized peak flows. Although the synthesized peaks are mostly much greater than the recorded peaks, the timings of both peaks are nearly the same.

<u>Effect of Routing Procedures</u>

Figure 10 shows the effect of number of cross sections used in channel routing on the synthesized hourly flow at the end of reaches 1 and 3. The solid curves represent the result of channel routing by the use of 16 finite sections, as shown in Figure 7, while the dashed curves use 135 finite sections. It can be seen that the results are not significantly different. The computer time for one month of channel routing was 6 sec for the former but 31 sec for the latter.

Figure 11 presents a comparison among three different routing procedures, viz. linear routing with 1 hour time increments, linear routing with 15 min time increments, and nonlinear routing with 15 min time increments. It can be seen that there is very little difference between 1 hr and 15 min routings, and that the nonlinear routing checks very well with the linear routing at all times except at the peak. The computer time for one month of channel routing is 6 sec for the linear 1 hr routing, 17 sec for the linear 15 min routing, and 38 sec for the nonlinear 15 min routing. In view of the good agreement between 1 hr and 15 min routings and the large increase in computer times for the nonlinear routing, only the linear 1 hr routing was used for the two other watersheds described in this chapter.

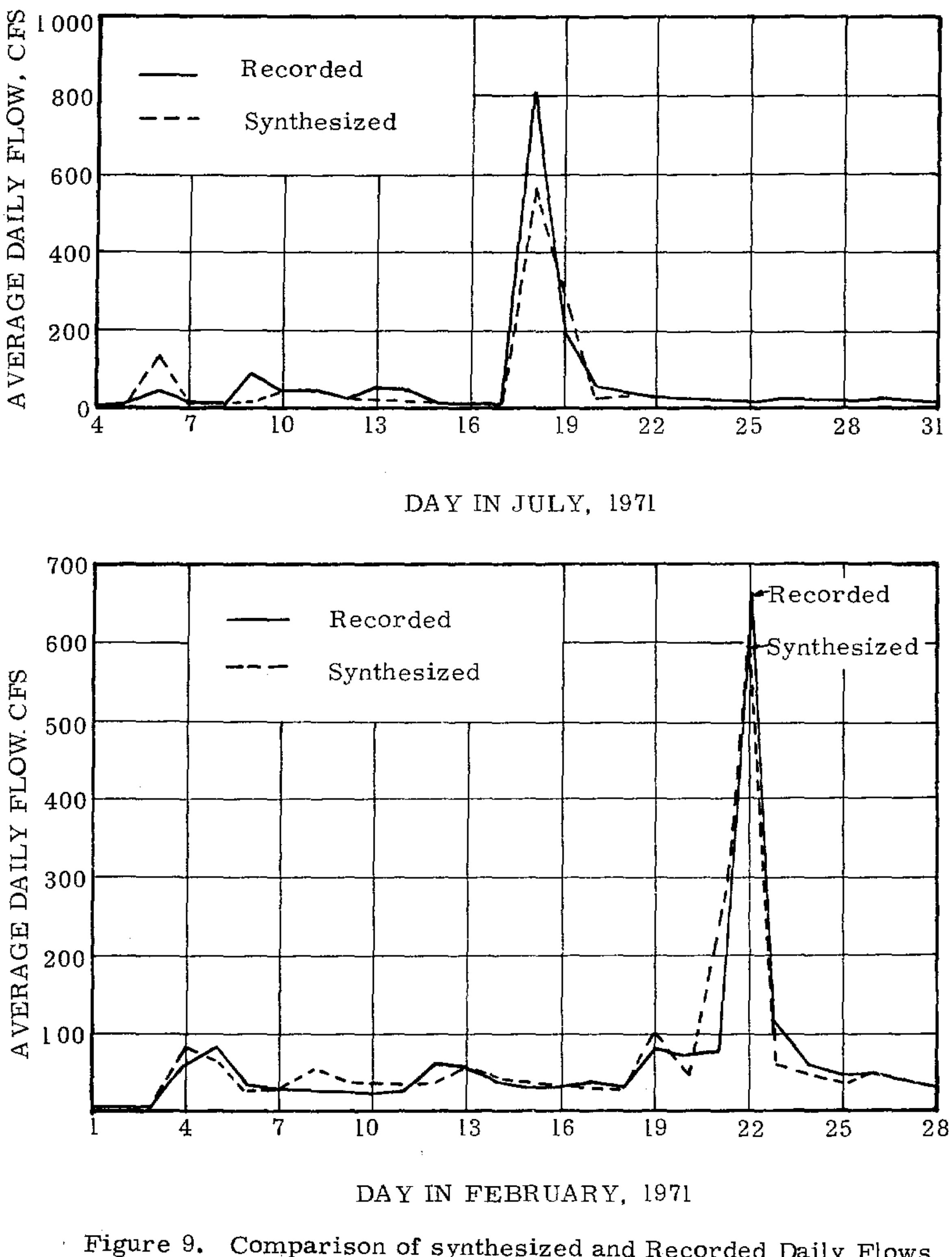


Figure 9. Comparison of synthesized and Recorded Daily Flows for South Fork Beargrass Creek Watershed

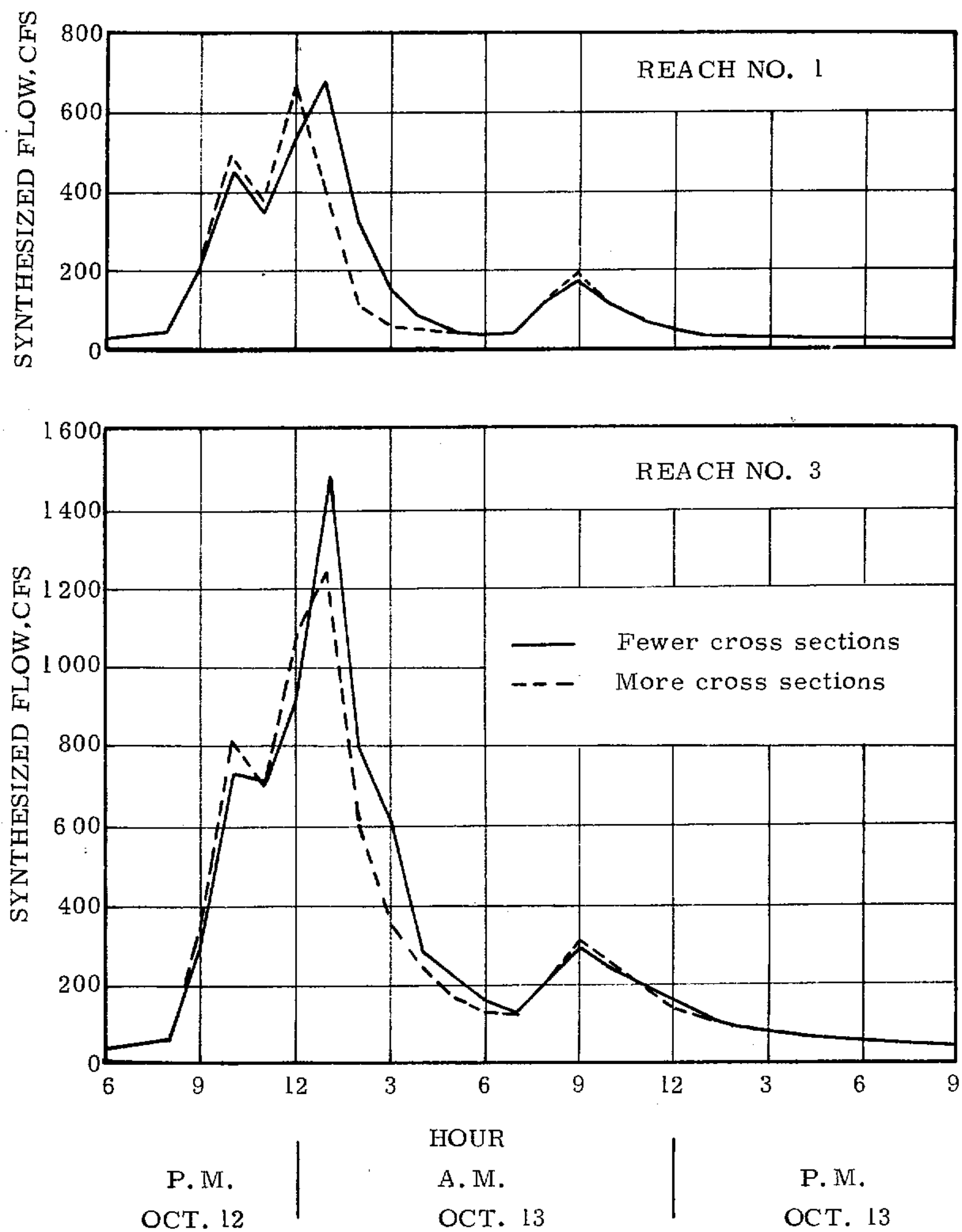


Figure 10. Effect of Number of Cross Sections on Synthesized Flow

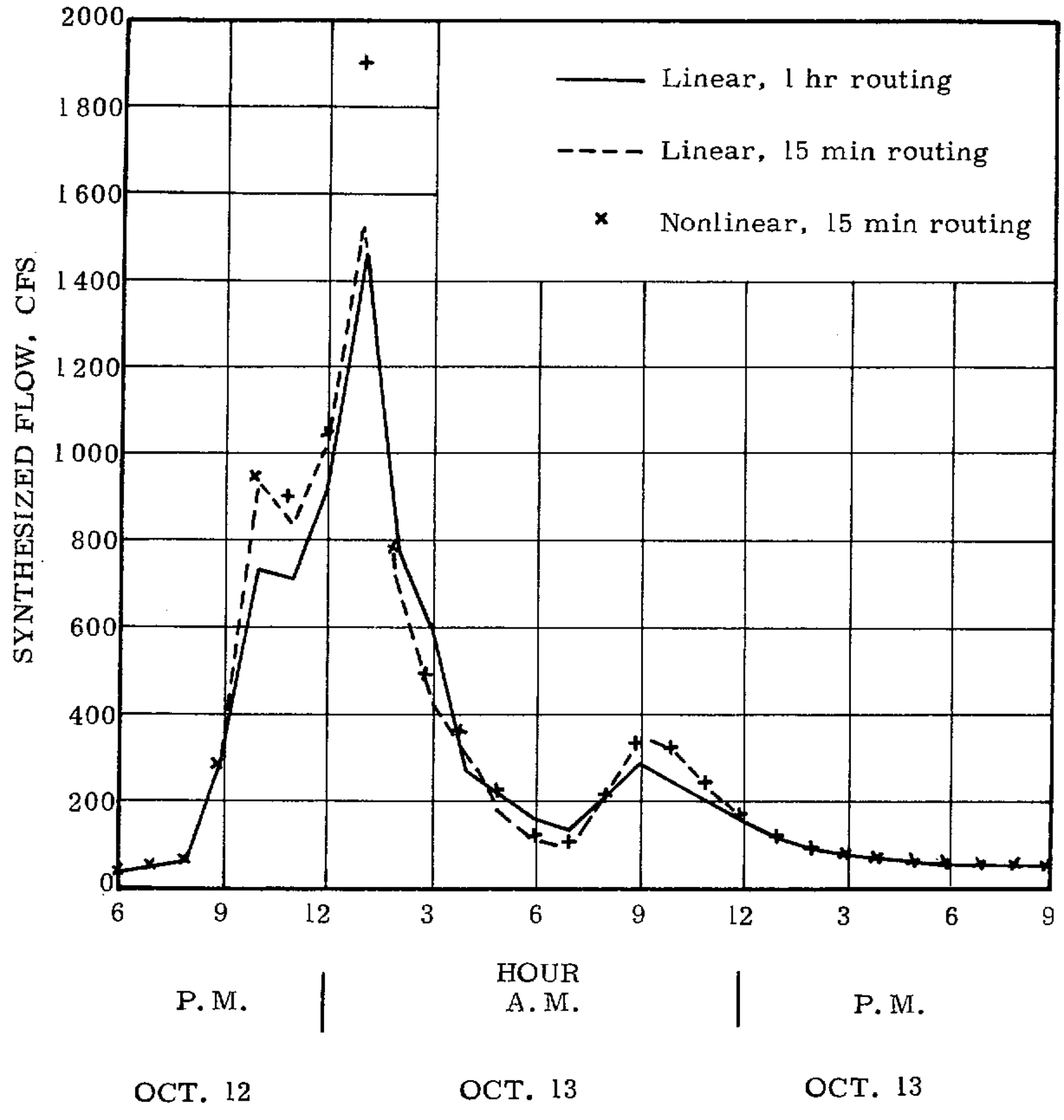


Figure 11. Comparison of Synthesized Flow Among Different Routing Procedures

6.2 Floyds Fork Watershed

General Information

This watershed lies in a four county area, including Jefferson, Shelby, Oldham, and Henry, with a drainage area of 138 sq mi. The U.S. Geological Survey has maintained a stream gaging station in the vicinity of Fisherville since 1944. The area is more hilly with an average overland flow surface slope of 6.1 percent, compared to the 2.1 percent for the Beargrass Creek. Figure 12 shows a plan view of the watershed. The gaging station is located at the mouth of the watershed.

Very little information is known about the watershed other than the 7.5 min topographic maps issued by the U.S. Geological Survey. The watershed is located in the following quadrangles: Jeffersontown, Fisherville, Crestwood, La Grange, Simpsonville, Ballardsville, Smithfield, Eminence, and New Castle. The maps have a contour interval of 10 ft. The watershed was divided into 5 reaches. The drainage area, OFSL, OFSS, and the channel length of each reach were measured from the map.

The Louisville District of the Corps of Engineers has run a water surface profile by the HEC-2 program in the Jefferson County area, which covers the entire reach 5 and the major part of reach 3. The discharge-end area rating curves of 37 cross sections obtained from the HEC-2 program were used in this study. The values of α and m for reaches 1, 2, and 4 as well as those for low volume flows in reaches 3 and 5 were measured from the topographic map as described in section 3.4. Due to the lack of information, the parameter ratios were assigned unity for each reach.

The rainfall data were obtained from one recording gage (NO. 4954 at Louisville airport) and two storage gages (NO. 4595 at La Grange and NO. 7324 at Shelbyville). Gage 4595 was used for reaches 1, 2 and 3, while gage 7324 was used for reaches 4 and 5. The program was run for the 1958 water year. An

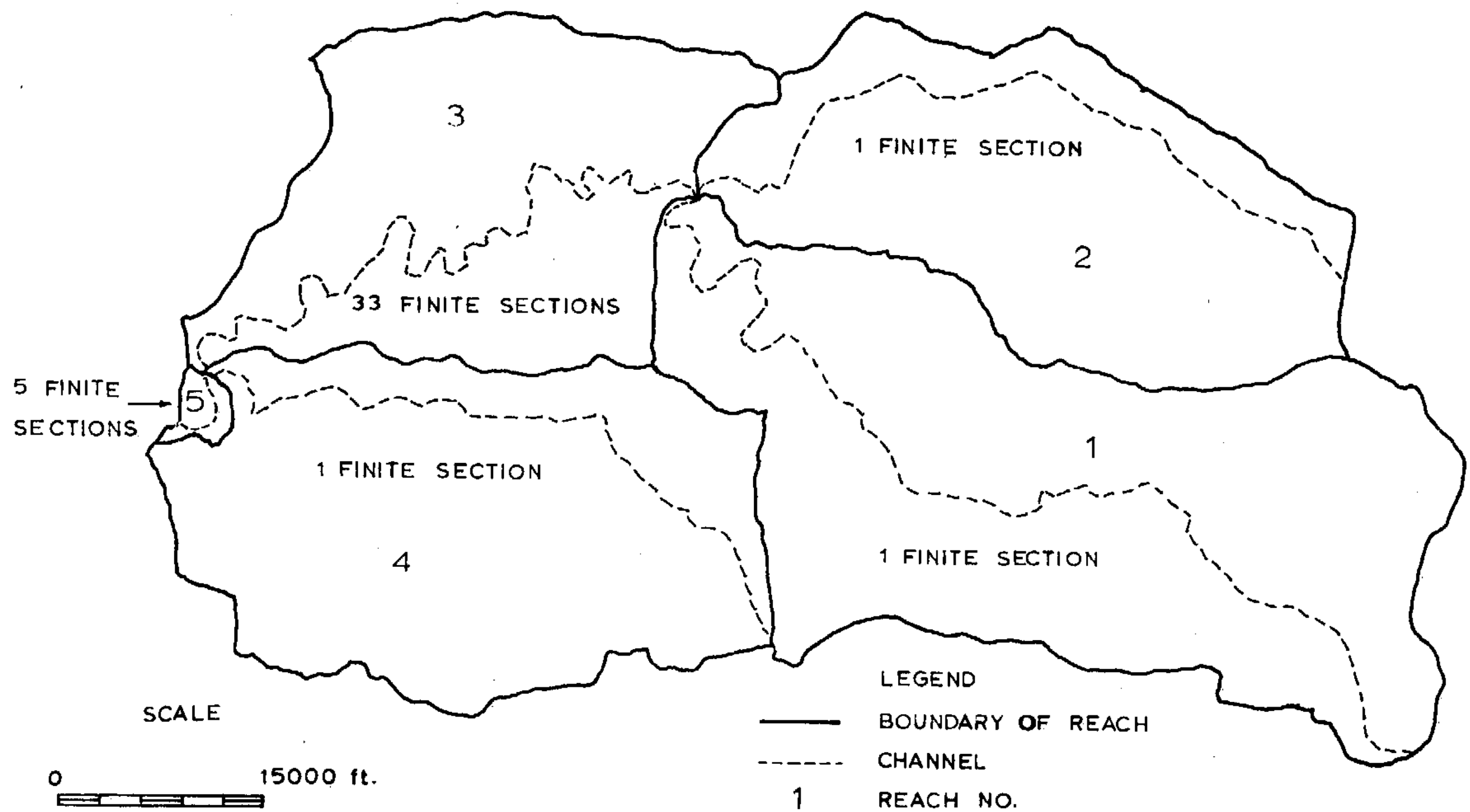


Figure 12. Floyds Fork Watershed

estimated potential annual evapotranspiration, EPAET, of 35.2 in. and a mean annual number of rainy days, MNRD, of 120 days were used for generating the daily potential evapotranspiration.

Comparison Between Synthesized and Recorded Flows

Trip 1 was run using the preset initial parameter values. The sum of squares, SSQM, during the rough adjustment cycle was successively 100.867, 12.755, 91.478, 9.528, 109.673, 8.165, 75.673, 8.161, 118.628, 8.140, 142.357, and 8.229. Because the minimum SSQM occurred at the 10th rough cycle and the result was worsened twice, the program then shifted to the fine adjustment cycle using the parameter values of the 10th rough cycle. The SSQM for the first fine cycle was 9.228, and that for the second cycle was 133.488. As the SSQM had become greater, the program stopped at the second cycle. This is undesirable because more cycles are needed to obtain better parameter values. It was found that the oscillation in SSQM was caused by the cyclic change in the values of SUZC, ETLF and SIAC. For example, the adjustment of SUZC was based on FSUZC, which is the sum of the monthly flow deviation indices of November, July, August and September. If FSUZC was positive, SUZC was increased by multiplying with (1 + FSUZC) to decrease the flow of the index months. If FSUZC was negative, SUZC was decreased by dividing with (1 - FSUZC). To prevent too much of a change, the absolute value of FSUZC was limited to a maximum of 1.0. If FSUZC exceeded 1.0, it was set equal to 1.0; if it was less than -1.0, it was set equal to -1.0. The sum of monthly flow deviation indices during the rough adjustment cycle was successively -11.777, +2.33, -13.302, + 0.768, -15.170, +0.388, -11.353, +1.882, -15.31, +1.766, -17.492, and +1.777, and the corresponding SUZC was 1.300, 0.650, 1.300, 0.650, 1.149, 0.575, 0.797, 0.399, 0.797, 0.399, 0.797 and 0.399. The same phenomenon also persisted in the adjustment of ETLF and SIAC. This ocsillation was due to the large values of the monthly flow deviation indices. It is not known if the very large indices were the results of inaccurate data, because only data of the 1958 water year were used. It is suggested that, when ocsillations occur, other initial values be tried. However, due to the limit of the computer fund, this was not done in this investigation.

Figure 13 shows a comparison between the synthesized and recorded monthly flows. The parameters of the first fine adjustment cycle was used to obtain the synthesized flow. It can be seen that there is a large difference between the synthesized and recorded flows for the month of November. The large amount of precipitation in November does not seem commensurate with the recorded flow. This may indicate that the precipitation recorded at the gages was not representative of what actually fell in the watershed. Due to this data difficulty, MOPSET would over adjust, thus resulting in larger monthly flow deviation indices and a greater sum of squares.

Figure 14 shows a comparison between the synthesized and recorded daily flows from January through April. Because the synthesized monthly flow during this period was smaller than the recorded flow, the synthesized daily flow was also smaller. Nevertheless, the general shape of the two hydrographs was quite similar. The maximum length of finite difference divisions used for channel routing was 10,000 ft. It was found that the result was not too much different when the maximum length was reduced to 5,000 ft.

Effects of Channel Improvements

The values of α and m for reaches 1, 2 and 4 were determined from the topographic map by assuming the channel as triangular with m=1.33. It will be interesting to find the effect of channel improvements on downstream floods by increasing the value of m for these reaches to 1.67, which is the case for a rectangular cross section. In both cases, the same values of α (i.e. 0.35 for reach 1, 0.44 for reach 2, and 0.52 for reach 4) were used.

Figure 15 shows the effect of channel improvements on the synthesized hydrograph at the mouth of the watershed. It can be seen that channel improvements increase the hydrograph peak and cause the peak flow to occur earlier, as would be expected.

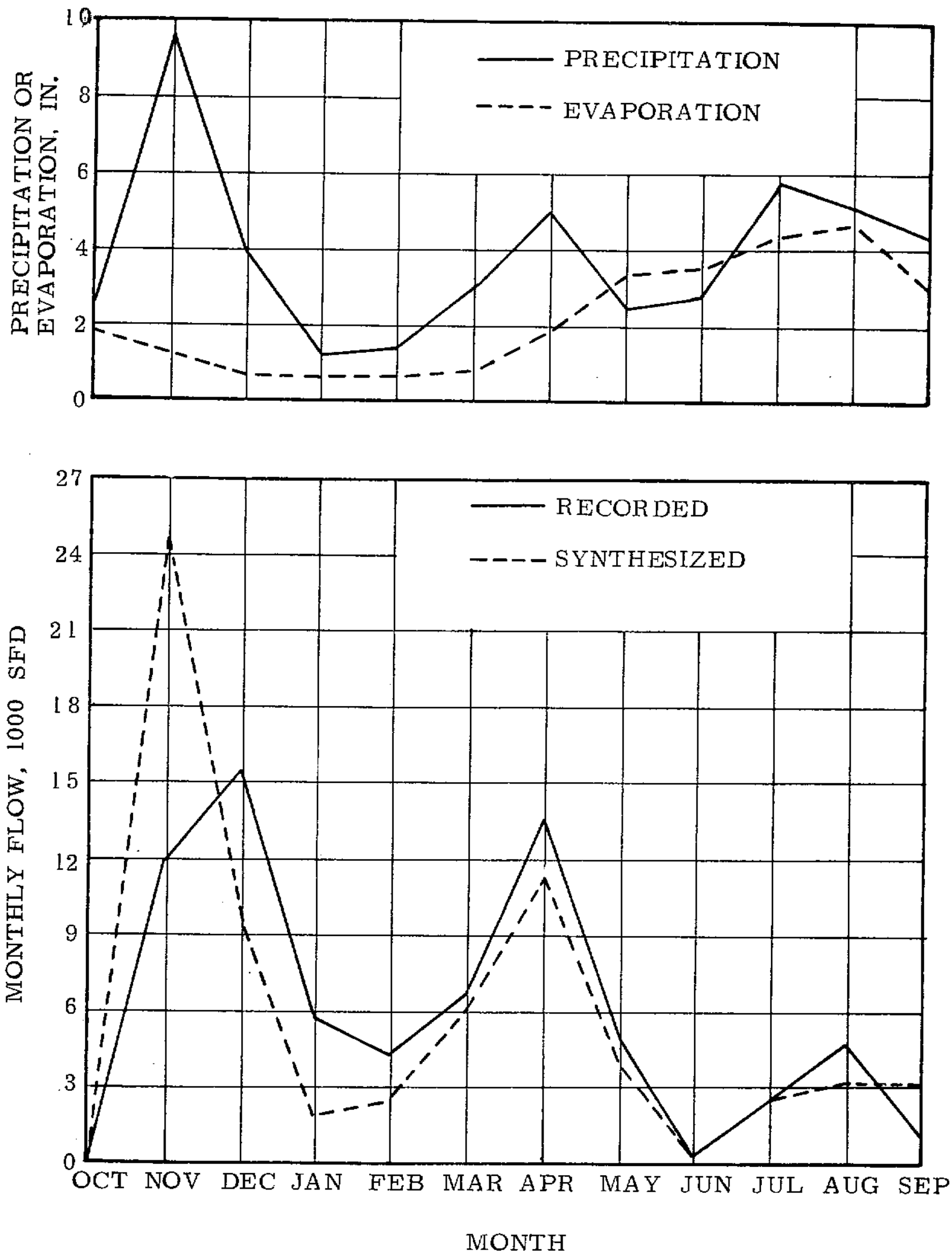


Figure 13. Comparison of Synthesized and Recorded Monthly Flows for Floyds Fork Watershed

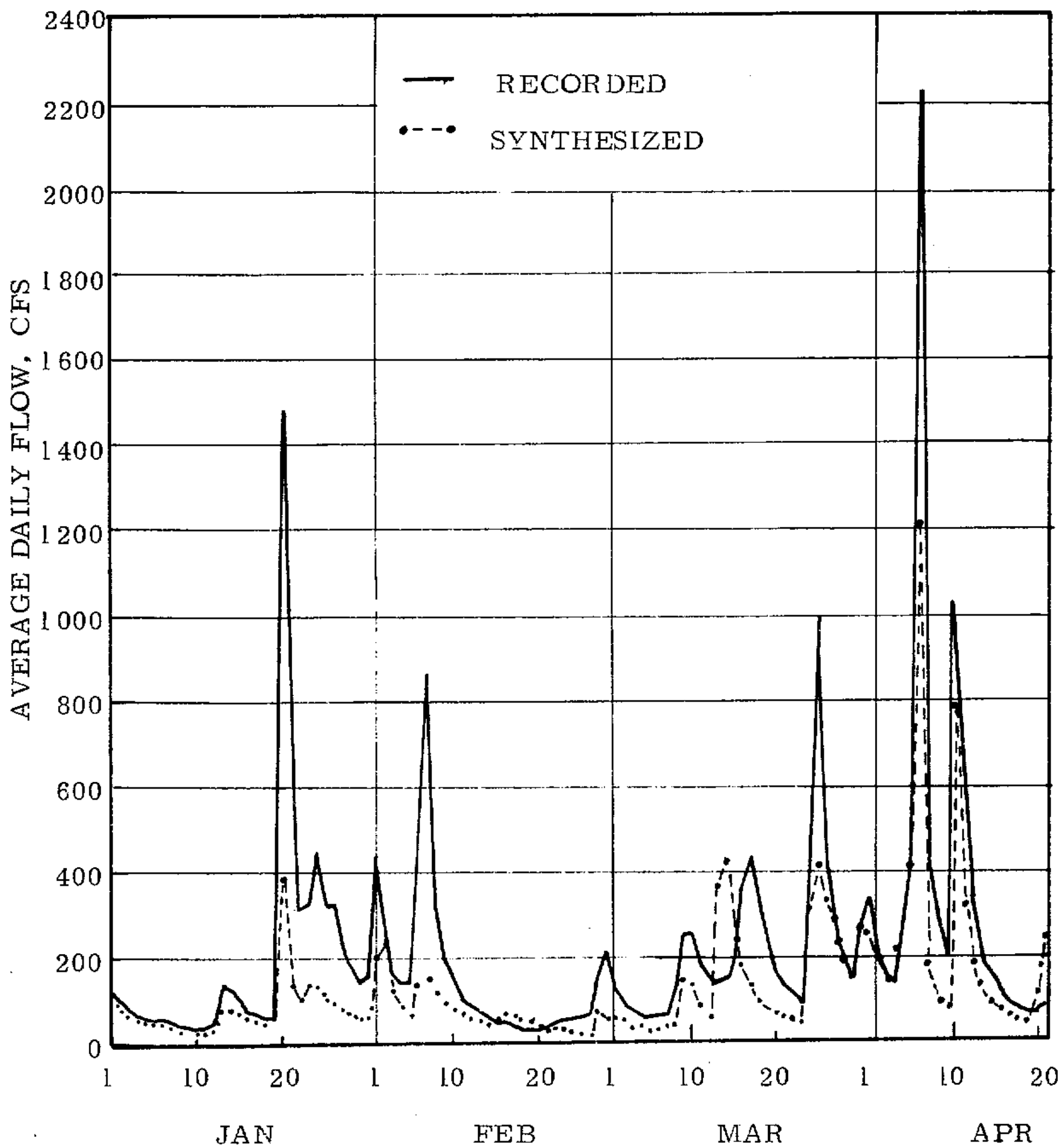


Figure 14. Comparison of Synthesized and Recorded Daily Flows for Floyds Fork Watershed

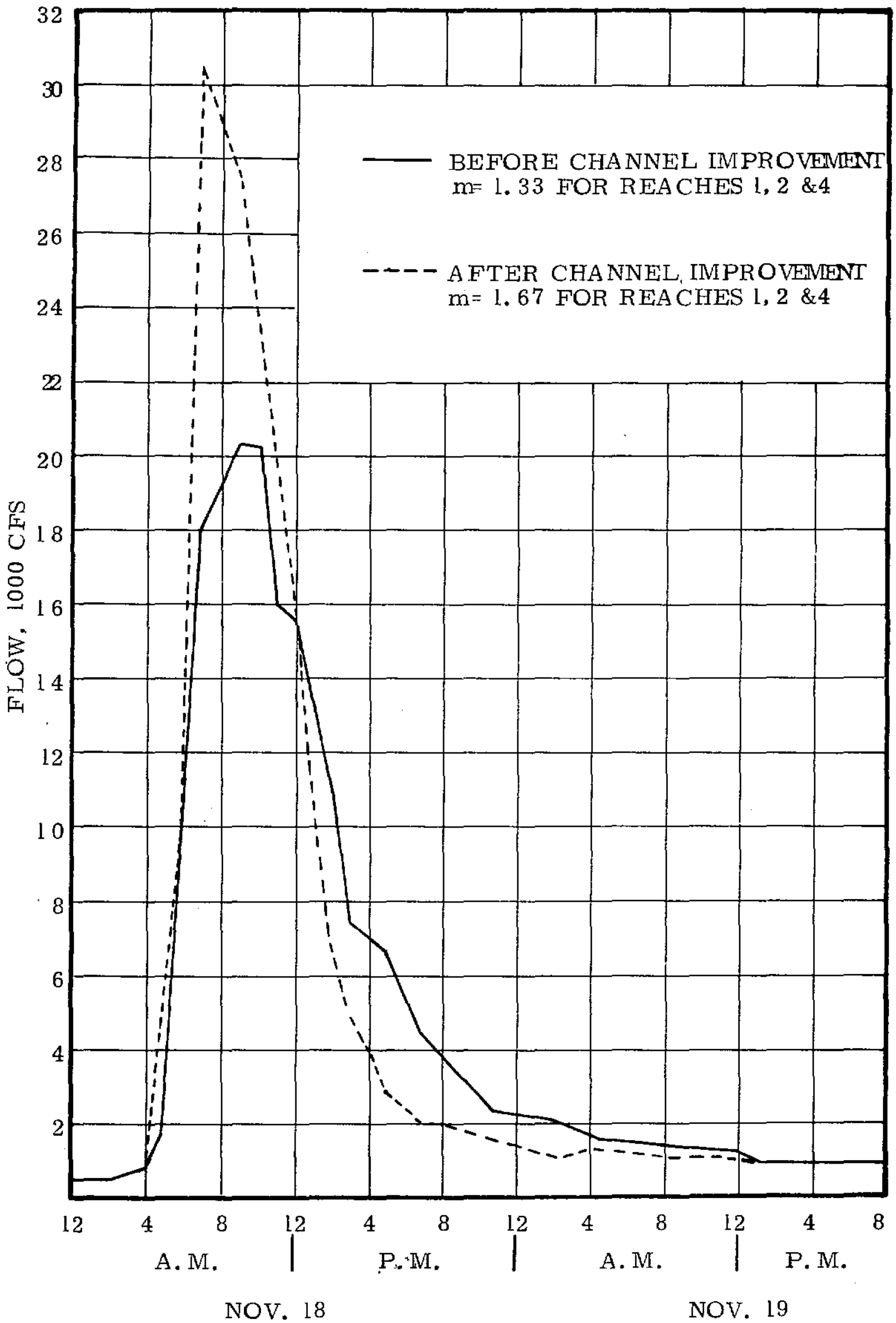


Figure 15. Effect of Channel Improvement on Downstream Floods

6.3 North Fork Nolin River Watershed

<u>General Information</u>

Figure 16 shows a plan view of the North Fork Nolin River Watershed located in Larue County. Two stream gaging stations have been maintained in this watershed. One gage, located at Hodgenville, has been recorded since 1941 and the other gage, located on McDougal Creek at the end of reach 1, has been recorded since 1953. In this study, only the gage at Hodgenville was employed for the optimization purpose. The watershed has a drainage area of 36.4 sq mi and is located in the Hodgenville, Magnolia, Hibernia, Howardstown and Nelsonville quadrangles of the 15 min topographic map with a contour interval of 20 ft. This watershed was selected because the Soil Conservation Service [1972] has made a study of this watershed and many of their data can be used as input to test the capability of MOPSET.

The watershed was divided into 15 reaches. Each reach was divided into one or more finite sections, as can be seen from Figure 16. Each finite section was divided into one or more finite differences. The maximum length of a finite difference division was about 5,000 ft. Each finite section had either a discharge-end area rating curve obtained from the WSP-2 computer program or a set of α and m measured from the topographic map. The total number of finite sections for the entire watershed was 38, of which 30 involved the use of discharge-end area rating curves. Because all the rating curves started from a small discharge, CONOPT(5) was set to 0, and no input of α and m for low volume flows was needed. Based on the information of soil type and watershed cover, the parameter ratios for each reach were estimated.

Also shown in Figure 16 is the location of six proposed flood control structures. The reason that these structures were included was due to the fact that their elevation-discharge-storage rating curves were reported by the Soil Conservation Service [1972]. The purposes

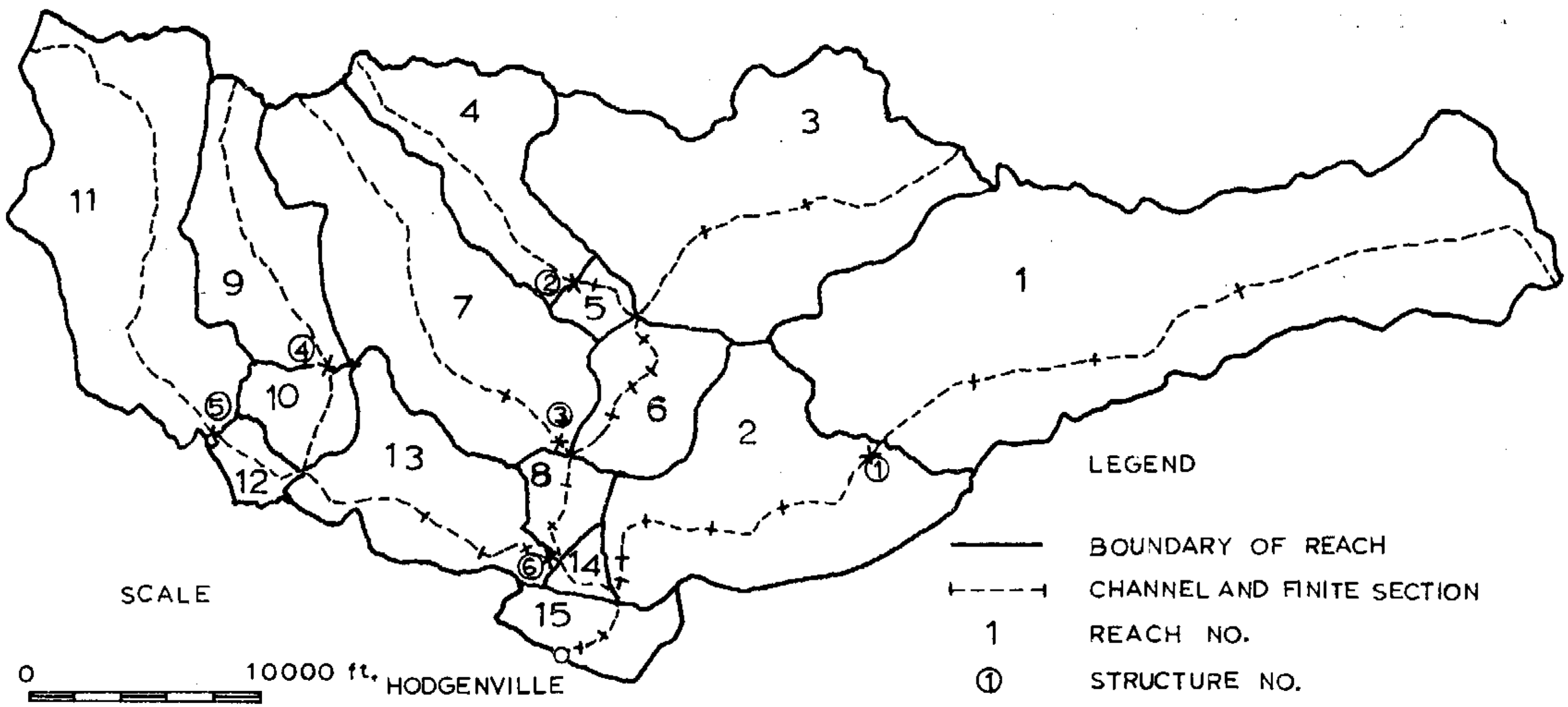


Figure 16. North Fork Nolin River Watershed

of including these structures were to check the capability of MOPSET in handling real data and also to illustrate the effect of structures on routed hydrographs.

The analyses were made for the 1965 water year. The rainfall data were obtained from a recording gage (NO. 3929 at Hodgenville), and no storage gage was used. The daily potential evapotranspiration was estimated by assuming 36 in. for EPAET and 116 days for MNRD.

Comparison Between Synthesized and Recorded Flows

Trip 1 was run using the preset initial parameter values. The SSQM during the rough adjustment cycle was successively 65.383, 4.134, 3.245, 3.278, 4.465, and 3.689, and that during the fine adjustment cycle was 1.706 and 3.288. A SSQM of 1.706 was much smaller than that obtained for the two previous watersheds. However, a closer inspection of the data revealed that the optimization procedure yielded a BMIR of 15.667 in./hr. As a result, more than three-fourths of the total flow was composed of the base flow, and the synthesized daily flow during the peak day was much less than the recorded flow. This further substantiates the previous contention that the optimum set of parameter values should not be based solely on SSQM. A number of fine adjustment cycles should be run and the best set of parameter values selected, even though the resulting SSQM may not be a minimum.

Figure 17 shows a comparison between the synthesized monthly flow obtained from trip 1 and the recorded flow. Two sets of parameter values were used. Synthesized flow NO. 1 was the result given by the first fine adjustment cycle with a SSQM of 1.706. Because BMIR was considered too large, the program was rerun by setting LBMIR to TRUE, so the alternate procedure for adjusting BMIR was evoked. The values of BMIR was reduced 10 percent each time, and synthesized flow NO. 2 was the result given by the 9th fine adjustment cycle with a SSMQ of 4.343. The parameter values used for these two synthesized flows, as well as synthesized flow NO. 3, are listed in

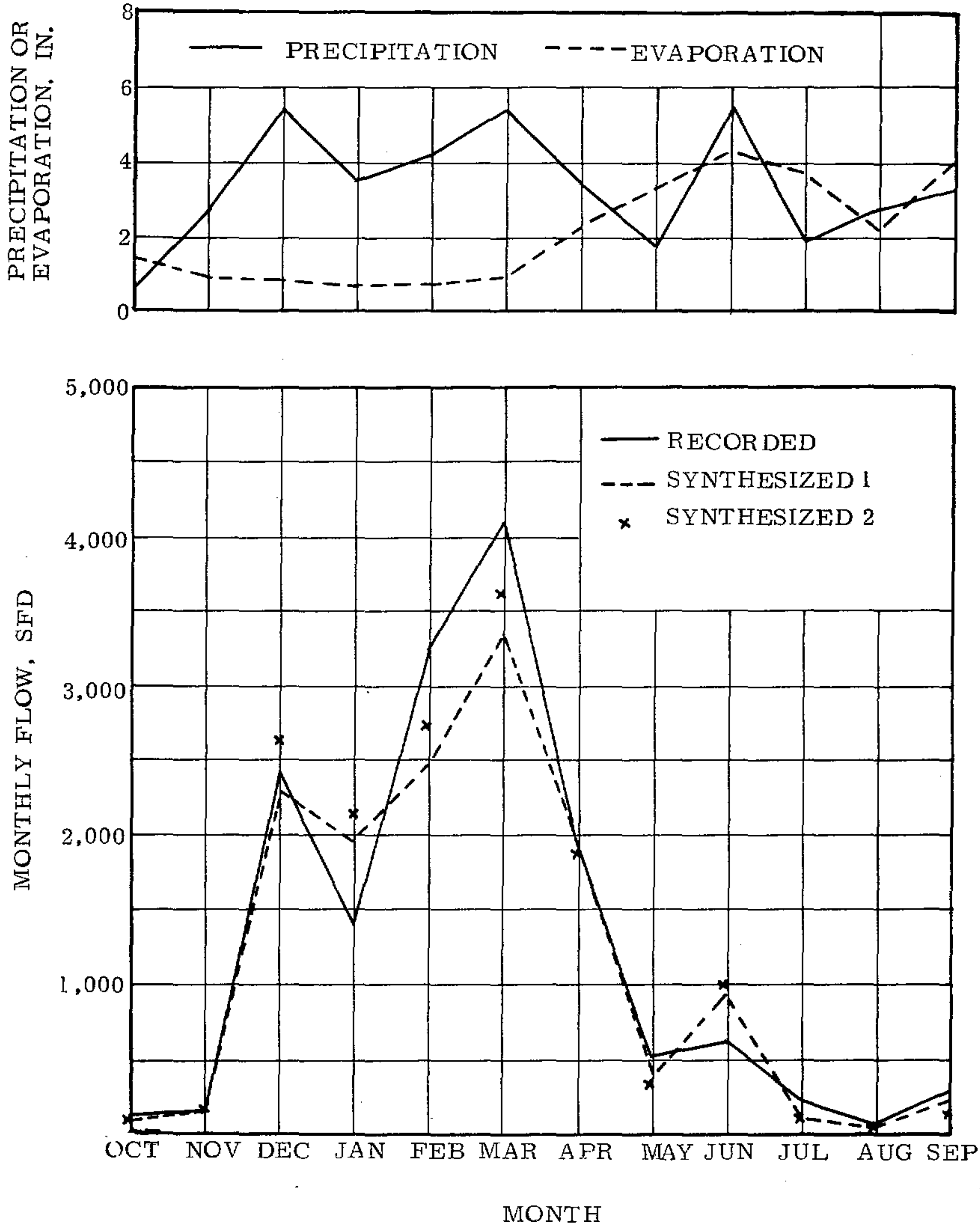


Figure 17. Comparison of Synthesized and Recorded Monthly Flows for North Fork Nolin River Watershed

Table 9. Even though flow NO. 2 has a larger SSQM, it checks better with the recorded flow not only in monthly variations but also in the total annual runoff. The recorded annual flow volume is 15,070 sfd, compared to 14,616 sfd for flow NO. 2 and 13,823 for flow NO. 1.

Figure 18 shows a comparison between the synthesized and recorded daily flows. The synthesized flow was obtained from trip 2 without the six structures. It can be seen that synthesized flow NO. 1 with a large BMIR does not match the recorded flow. The match is improved if synthesized flow NO. 2 with a much smaller BMIR is used. The large difference between the recorded and synthesized flows during December 11 and 12 may be the result of data errors, because it does not appear that the volume of recorded flow should be that large compared to the volume of precipitation. In order to compensate for any data difficulty, several years of data should be used.

Effect of Hydraulic Structures

Figure 19 shows the effect of flood control structures on daily flows. The location of the six structures are shown in Figure 16. It was arbitrarily assumed that the storages of all structures were only half full on October 1. To increase the flow peaks, synthesized flow NO. 3, having the parameter values listed in Table 9, were used. It can be seen that these structures have a significant effect in reducing the flow during peak days. The large difference of flow on December 4 was due to the fact that some of the structures were not completely filled. For example, the outflow from structure NO. 1, which has a storage capacity of 670 ac ft, started at 2 am, December 4, while the outflow from structure NO. 6 with a capacity of 401 ac ft did not start until 11 am on the same day. The significant difference in total flow during December was caused by this storage effect as well as the evaporation of water from the structure.

Figure 20 shows the effect of these six structures on the flood hydrograph. The structures decrease considerably the flood peak but increase the flow after the peak. These figures clearly demonstrate

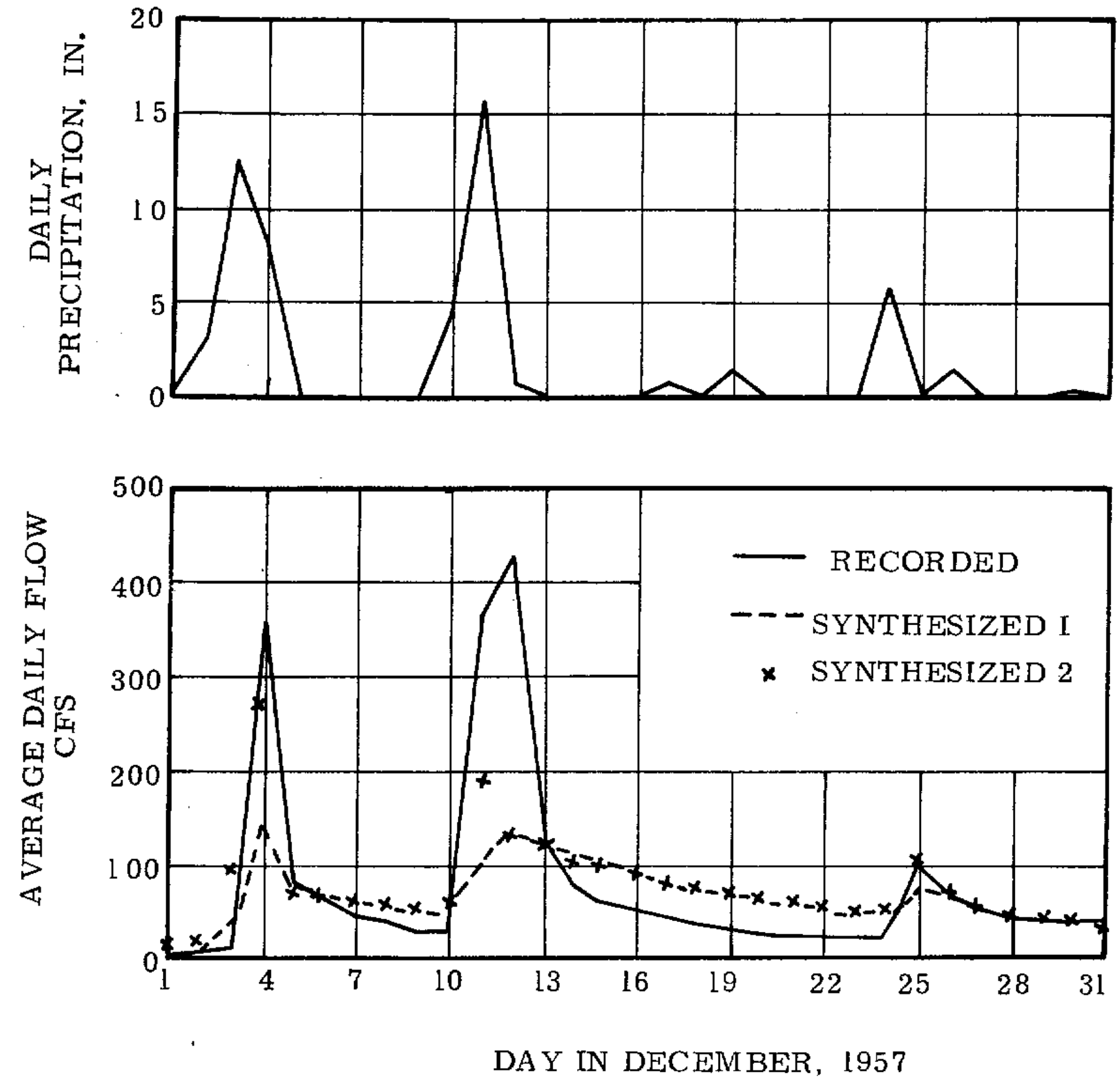


Figure 18. Comparison of Synthesized and Recorded Daily Flows for North Fork Nolin River Watershed

the effectiveness of using flood control structures to reduce downstream floods.

TABLE 9. PARAMETERS USED FOR SIMULATION OF NORTH FORK NOLIN RIVER WATERSHED

NO.	SSQM	LZC	BMIR	SUZC	ETLF	BUZC	SIAC	LZC	ANNUAL SFD
1	1.706	4.251	15.667	0.764	0.010	0.474	0.388	3.839	13.823
2	4.343	3.149	6.744	0.744	0.120	0.294	0.018	2.933	14.616
3.	8.263	1.740	4.920	0.990	0.070	0.160	0.010	1.400	15.725

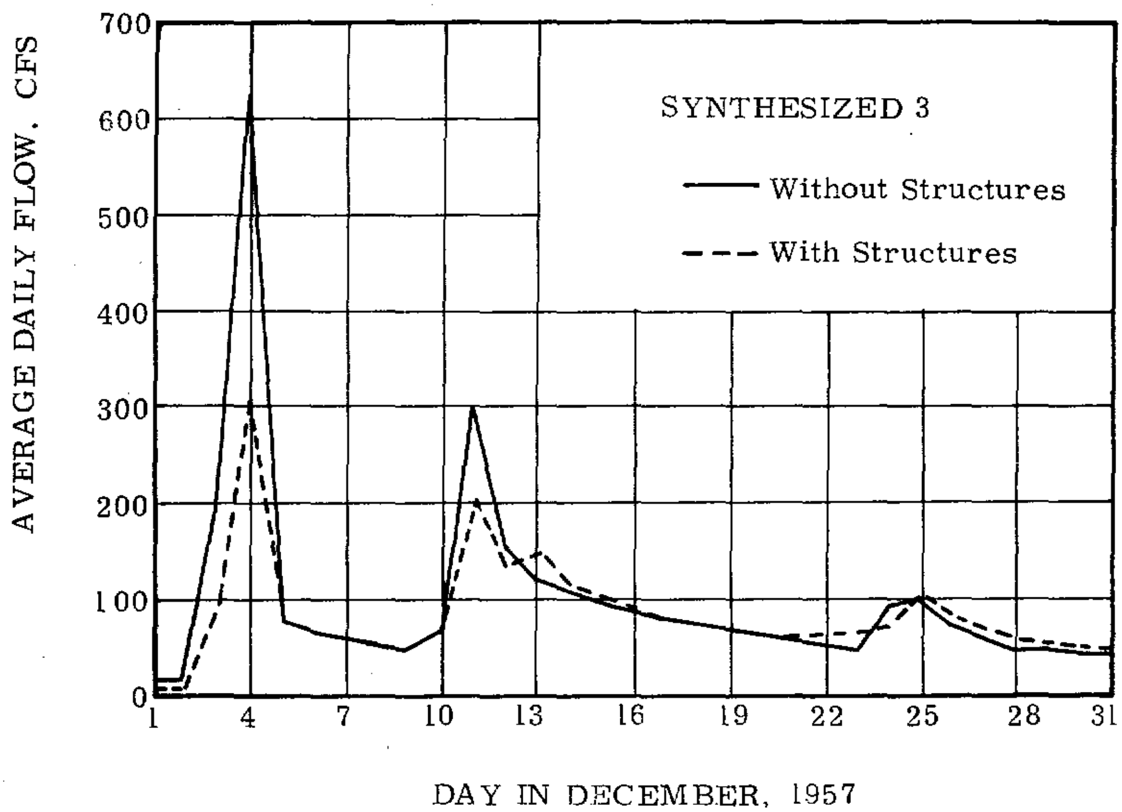


Figure 19. Effect of Flood Control Structures on Daily Flow

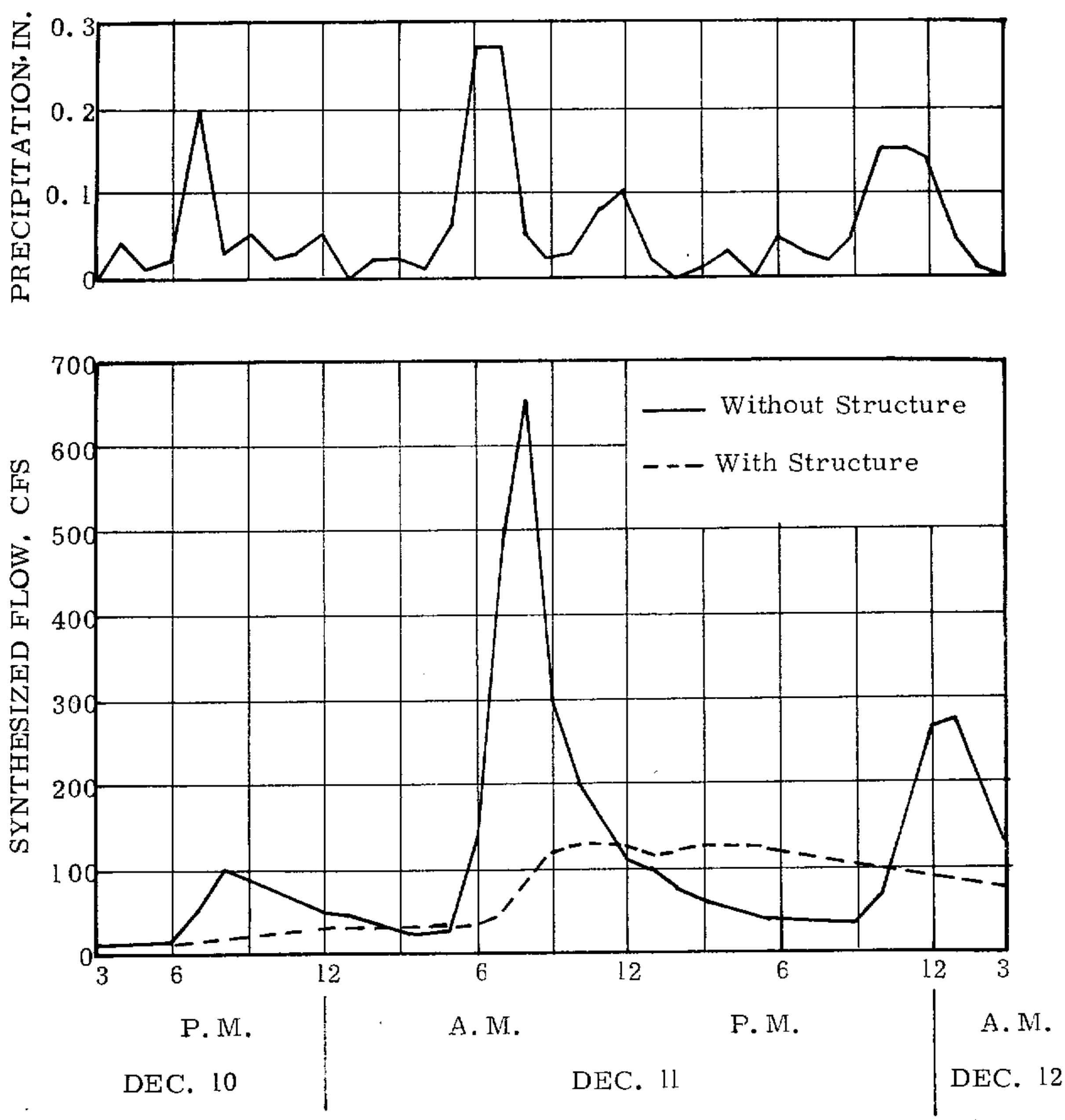


Figure 20. Effect of Flood Control Structures on Flood Hydrograph

CHAPTER VII

SUMMARY AND CONCLUSIONS

It is well known that the improvement of stream channels by straightening, lining, leveeing, or clearing and snagging generally increases the downstream peak flows. However, because of the unpredictable nature of hydrologic events, the effects of these improvements on downstream floods have not been evaluated quantitatively. The purpose of this research was to modify OPSET, a self-calibrating version of the Kentucky Watershed Model, and make it more suitable for evaluating the effect of channel improvements on downstream floods. This modified version of OPSET, which is given the name MOPSET, includes the following major changes:

1. A kinematic method of channel routing based on a finite difference scheme was used in place of the modified Muskingum method.

2. The watershed was divided into a number of segments, each subjected to different watershed characteristics and rainfall patterns.

3. The optimization of the seven land phase parameter values was achieved by assuming that the values in each segment bear fixed ratios to a set of base values, thus only the seven base values were optimized.

4. New options were provided that the user can specify the initial parameter values to be used for optimization and the number of rough or fine adjustment cycles desired, and that computations can be continued for additional cycles by simply reading in the data obtained from the previous cycle.

5. A storage routing subroutine was incorporated so that the model can be applied to large watersheds in which a number of reservoirs or flood control structures are located.

Procedures were developed for determining the routing parameters, α and m, either from a topographic map or from a discharge-end area rating curve. Methods were presented for estimating the parameter ratios to be used as input to the model. The program was well documented, together with a dictionary which defines every variable used in the main program as well as the subroutines.

The program was applied to three different watersheds, viz. the South Fork Beargrass Creek, the Floyds Fork, and the North Fork Nolin River. An inspection of the results obtained from these watersheds leads to the following conclusions:

1. The synthesized daily and monthly flows obtained from MOPSET checked favorably with the recorded flows in a qualitative sense. The large discrepancy in flow peaks at Floyd Fork Watershed was attributed to data errors because the recorded rainfall was simply not commensurate with the recorded streamflow. Therefore, several years of data must be used for calibration in order to balance the effects of positive and negative errors.

2. The adjustment rules used in MOPSET for optimizing the seven land phase parameter values were exactly the same as those in OPSET. It was found that the solution was not unique, because a slight difference in the assumed initial values yielded a set of optimized parameter values which were completely different. Furthermore, the parameters did not converge, and the values obtained from one adjustment cycle were quite different from the next cycle. This posed a serious problem in determining which cycle of values should be considered as optimum. It was also found that the cycle which resulted in a minimum sum of squares for the monthly flow deviation index might not give the most desirable solution. In the Nolin River Watershed, the optimum set of parameter values based on the minimum sum of squares produced such a large base flow and a small overland flow that the synthesized daily flow could not match the recorded peak. It is therefore suggested that the optimum set of

parameter values be based not on the minimum sum of squares but on a visual comparison between the synthesized and recorded flows. A major contribution of MOPSET is its ability to generate a variety of adjustment cycles, each with a different set of parameter values. It is up to the user to inspect the data and select the values to be used.

3. The use of one segment with an average set of parameter values weighted by areas and a 20 min looping yielded about the same monthly flow as when multiple segments and 15 min looping were used. Because most of the land phase parameters are optimized on the basis of the monthly flow, it is suggested that the entire watershed be considered as one segment in trip 1 but multiple segments in trip 2.

4. For the Beargrass Creek with a time of concentration of 4 hr, there existed very little difference in the simulated hydrograph whether a time increment of 1 hr or 15 min be used for channel routing. In view of the large amount of computer time required for nonlinear routing, it is suggested that linear and 1 hr routing be used unless local conditions indicate otherwise.

5. The finite difference method used in MOPSET for channel routing is unconditionally stable. Each finite difference division can be of any length. For the Floyds Fork Watershed, the results obtained from a maximum finite difference division of 10,000 ft were not too much different from those of 5,000 ft.

6. The computer time required for channel routing increases with the number of cross sections. The use of a large number of cross sections is unwarranted, because the results from the Beargrass Creek indicated that fewer cross sections could yield approximately the same results.

7. The values of α and m increase with the degree of channel improvements. Results from the Floyds Fork showed that channel

improvements increased the hydrograph peak downstream and caused the peak flow to occur earlier.

8. The use of flood control structures or reservoirs is an effective means of reducing downstream floods.

In this research, much emphasis was placed on the development of MOPSET. It is believed that if MOPSET is adequate to simulate stream flows, it can certainly be used to evaluate the effect of channel improvements on downstream floods, because the actual channel characteristics are employed in flood routing. Due to budget limitations and the exhaust of the computer fund, MOPSET has not been applied to watersheds where channel improvements have been documented. It is hoped that the publication of this report will promote its use, so that MOPSET can be constantly improved and updated to serve as an enviable tool for hydrologic simulations.

REFERENCES

Balk, E.L., Application of the Stanford Watershed Model to the Coshocton Hydrologic Station Data, Master's Thesis, Department of Civil Engineering, The Ohio State University, 1968.

Chow, V.T., Open Channel Hydraulics, McGraw-Hill, New York, 1959.

Corps of Engineers, Generalized Computer Program HEC-2 Water Surface Profiles, Users Manual, Hydrologic Engineering Center, October 1973.

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, 1966.

David, W.P., and Beer, C.E., "Simulation of Soil Erosion--Part II. Streamflow and Suspended Sediments Simulation Results," Transactions of ASAE, 1975, PP. 130-133.

DeWiest, R.J.M., Geohydrology, John Wiley, New York, 1965.

James, L.C., An Evaluation of Relationships Between Streamflow Patterns and Watershed Characteristics Through the Use of OPSET, A Self Calibrating Version of the Stanford Watershed Model, Research Report NO. 36, University of Kentucky Water Resources Research Institute, Lexington, Kentucky,1970.

Li, R.M., Simons, D.B., and Stevens, M.A., "Nonlinear Kinematic Wave Approximation for Water Routing," Water Resources Research, Vol. 11, No. 2, April 1975, PP. 245-252.

Linsley, R.K., Kohler, M.A., and Paulhus, J.L.H., Hydrology for Engineers, McGraw-Hill, 1975.

Liou, E.Y., OPSET Program for Computerized Selection of Watershed Parameter Values for the Stanford Watershed Model, Research Report No. 34, University of Kentucky Water Resources Research Institute, Lexington, Kentucky 1970.

Ricca, V.T., The Ohio State University Version of the Stanford Streamflow Simulation Model, Parts I & II, State of Ohio Water Resources Center, Ohio State University, 1972.

Ross, G.A., The Stanford Watershed Model: The Correlation of Parameter Values Selected by a Computerized Procedure with Measurable Physical Characteristics of the Watershed, Research Report No. 35, University of Kentucky Water Resources Research Institute, Lexington, Kentucky, 1970.

Schaake, J.C., "Deterministic Urban Runoff Model," Treatise on Urban Water Systems, Colorado State University, 1971.

Soil Conservation Service, Computer Program for Project Formulation, Hydrology, Contract No. 12-10-001-723, Prepared by C-E-I-R, Inc., January 1964.

Soil Conservation Service, Computer Program for Project Formulation, Hydrology, Technical Release No. 20, Central Technical Unit, Engineering Division, May 1965.

Soil Conservation Service, Soil Survey, Jefferson County, Kentucky, Issued June 1966.

Soil Conservation Service, North Fork Nolin River Watershed, Larue County, Kentucky, Unpublished Report, Lexington, Kentucky, 1972.

Soil Conservation Service, WSP2 Computer Program, Technical Release No. 61, Engineering Division, May 1976.

APPENDIX A

LISTING OF MOPSET

```
C   MOPSET-- A MODIFIED VERSION OF OPSET, WHICH IS A SELF-CALIBRATING      MAIN0001
C   KENTUCKY WATERSHED MODEL WITH CAPABILITY OF ESTIMATING AN OPTIMUM      MAIN0002
C   SET OF WATERSHED PARAMETERS,UPDATED DECEMBER 1976                      MAIN0003
      DIMENSION ADBF(15),ADIF(15),ALPH(150,50),AMBF(15),AMIF(15),          MAIN0004
     1 AMNET(15),AMSE(15),ARHF(15),CONOPT(7),CVWINA(15),DARFA(150,50),     MAIN0005
     2 DISCH(1000),DPET(366),DRGPM(15,366),DRHP(366,24),DRSF(366),         MAIN0006
     3 DRSGP(5,366),DSSF(366),EDAREA(150,21),EMGWS(12),EMIFS(12),          MAIN0007
     4 EMLZS(12),EMSIAM(12),EMUZC(12),EMUZS(12),EPCM(12),EQDF(15),         MAIN0008
     5 EQDFIS(15),EXPT(150,50),FIMPA(15),FWTRA(15),GAFL(366),GWSA(15),     MAIN0009
     6 HYDSTO(150,96),IFSA(15),IFST(15),ILST(15),INLST(15),IROUT(15),      MAIN0010
     7IRSTR(15),ISGA(15),ISGM(5),IUH(15,5),LZSA(15),MEDCY(12),MEDWY(12),MAIN0011
     8 NOFD(150),NUBR(15),OFMN(15),OFMNIS(15),OFRF(15),OFRFIS(15),         MAIN0012
     9 OFSL(15),OFSS(15),OFUS(15),OFUSIS(15),OUTLST(15),PALPHA(150)        MAIN0013
      DIMENSION PEXPM(150),RB1VF(15),RBMIR(15),RBUZC(15),RCHLTH(15),       MAIN0014
     1 RETLF(15),RGPM(15),RGPMB(15),RHF(15),RLZC(15),                      MAIN0015
     2 ROLF1(15),ROLF2(15),RSBBF(20),RSBD(20),RSBIF(20),RSIAC(15),         MAIN0016
     3 RSUZC(15),SAREA(15),SBFRS(3,20),SGMD(5),SGRT(5),SGRT2(5),           MAIN0017
     4S1FRS(3,20),STOLST(15),STORAG(1000),SUBWFA(15),THSF(24),TITLE(20),MAIN0018
     5 TMBF(12),TMIF(12),TMNET(12),TMOF(12),TMPFT(12),TMPREC(12),          MAIN0019
     6 TMRTF(12),TMSE(12),TMSTF(12),TMSTF1(12),TPLR(15),UZSA(15),          MAIN0020
     7 VINCR(15),VINMRA(15),VWINA(15), WCFSA(15),WSG(15),WSG2(15),         MAIN0021
     8 XAREA(150,21),XMPFT(12)                                             MAIN0022
      DIMENSION ADRGPM(366),CWCFSA(15),DRGPM1(366),ELEV(1000),FPERA(15),MAIN0023
     1 FSLTH(150),NFS(15),NFSEPR(15),NSC(150)                              MAIN0024
      REAL  IFPRC,IFRC,IFRL,IFS,IFSA,INLST,LZC,LZC1,LZRX,LZS,LZSA,LZSR,    MAIN0025
     1 MNRD                                                                MAIN0026
      LOGICAL LBMIR,LBUZC,LETLF,LLZC,LNPR,LRC,LSTR,SAVE                    MAIN0027
      INTEGER CN, CONOPT, DATE, DAY, DPY, EHSGD, HOUR, HRF, HRL, PDAY,     MAIN0028
```

```
     1  PRD, RHPD, RHPH, RSBD, SGMD, SGRT, SGRT2, TRIP, YEAR, YR1,          MAIN0029
     2  YR2                                                                  MAIN0030
      INTEGER DPRD                                                           MAIN0031
      DATA MEDCY/0,31,59,90,120,151,181,212,243,273,304,334/                 MAIN0032
      DATA MEDWY/304,334,365,31,59,90,120,151,181,212,243,273/               MAIN0033
C  SPECIFY NUMBER OF STATION-YEARS INCLUDED IN COMPUTER RUN                  MAIN0034
      NSYC=0                                                                 MAIN0035
      READ(5,10)NSYT                                                         MAIN0036
   10 FORMAT(16I5)                                                           MAIN0037
   20 NSYC= NSYC+1                                                           MAIN0038
      SMF=0.0                                                                MAIN0039
C ASSUME 15 MINUTE ROUTING TIME INTERVAL                                     MAIN0040
      DELTAT=900.                                                            MAIN0041
      NPPH=4                                                                 MAIN0042
C  READ TITLE TO COMPUTER RUN                                                MAIN0043
      READ (5,30) TITLE                                                      MAIN0044
   30 FORMAT(20A4)                                                           MAIN0045
      WRITE(6,40)(TITLE(KTA),KTA=1,20)                                       MAIN0046
   40 FORMAT(1H1, 25X,20A4)                                                  MAIN0047
C  READ CONTROL OPTIONS                                                      MAIN0048
      READ(5,10) (CONOPT(I),I=1,7)                                           MAIN0049
      IF(CONOPT(2) .NE. 1) GO TO 50                                          MAIN0050
C  USE ONE HOUR ROUTING TIME INTERVAL WHEN SPECIFIED                         MAIN0051
      DELTAT=3600.                                                           MAIN0052
      NPPH=1                                                                 MAIN0053
C  READ TRIP NUMBER AND CONTROL DATA FOR REACH AND CHANNEL                   MAIN0054
   50 READ(5,10)MNRC,NFTR,NLTR,NDCR                                          MAIN0055
      READ(5,10) NR,NGR,(NFS(KR),KR=1,NR)                                    MAIN0056
      WRITE(6,60)(CONOPT(I),I=1,7),MNRC,NFTR,NLTR,NR,NGR                     MAIN0057
   60 FORMAT(5X,10HCONOPT(1)=,I2,5X,10HCONOPT(2)=,I2,5X,10HCONOPT(3)=,I2MAIN0058
     1 ,5X,10HCONOPT(4)=,I2,5X,10HCONOPT(5)=,I2,5X,   10HCONOPT(6)=,I2, MAIN0059
     2 5X,10HCONOPT(7)=,I2,/,10X,5HMNRC=,I2,10X,5HNFTR=,I2,10X,5HNLTR=, MAIN0060
     3 I2,12X,3HNR=,I2,11X,4HNGR=,I2)                                        MAIN0061
C  READ NUMBER OF BRANCHES IN UPSTREAM REACHES                               MAIN0062
      READ(5,10) (NUBR(KR),KR=1,NR)                                          MAIN0063
```

```
      DO 80 KR=1,NR                                                     MAIN0064
      NB=NUBR(KR)                                                       MAIN0065
      IF(NB.LE.0) GO TO 80                                              MAIN0066
C READ IDENTIFYING NUMBER OF UPSTREAM REACHES                             MAIN0067
      READ(5,10) (IUH(KR,N),N=1,NB)                                     MAIN0068
      WRITE(6,70)KR,(IUH(KR,N),N=1,NB)                                  MAIN0069
   70 FORMAT(5X,25HUPSTREAM REACHES OF REACH,I3,15H ARE AS FOLLOW:,5I5) MAIN0070
   80 CONTINUE                                                          MAIN0071
C  READ NUMBER OF WATERSHED TRAVEL HOURS AND OUTPUT REACHES              MAIN0072
      READ(5,10) NWSTH,NOUT                                             MAIN0073
      READ(5,10) (IROUT(I),I=1,NOUT)                                    MAIN0074
      READ(5,90) RMPF                                                   MAIN0075
   90 FORMAT(8F10.2)                                                    MAIN0076
      WRITE(6,100)NWSTH,NOUT,(IROUT(I),I=1,NOUT)                        MAIN0077
  100 FORMAT(5X,6HNWSTH=,I5,5X,5HNOUT=,I2,55H  REACHES AT WHICH FLOW IS MAIN0078
     1TO BE PRINTED ARE AS FOLLOW:,5I5)                                 MAIN0079
     KNFS=0                                                             MAIN0080
C  SKIP READING CHANNEL AND STRUCTURE PARAMETERS IF TRIP 2 IS NOT RUN   MAIN0081
      IF(NLTR .NE. 2) GO TO 290                                         MAIN0082
C  READ CHANNEL PARAMETERS                                              MAIN0083
      DO 230 KR=1,NR                                                    MAIN0084
      NFSEPR(KR)=KNFS                                                   MAIN0085
      NFSKR = NFS(KR)                                                   MAIN0086
      WRITE(6,110)KR,NFS(KR)                                            MAIN0087
  110 FORMAT(/,5X,9HREACH NO.,I3,4H HAS,I3,16H FINITE SECTIONS)         MAIN0088
      DO 220 KFS=1,NFSKR                                                MAIN0089
      KNFS=KNFS+1                                                       MAIN0090
      KRKFS=NFSEPR(KR)+KFS                                              MAIN0091
      ALPH(KRKFS,1)=0.0                                                 MAIN0092
      EXPT(KRKFS,1)=0.0                                                 MAIN0093
C  READ CONTROL DATA FOR EACH FINITE SECTION                            MAIN0094
      READ(5,120)NP,NSC(KRKFS),NOFD(KRKFS),FSLTH(KRKFS)                 MAIN0095
  120 FORMAT(3I5,F10.4)                                                 MAIN0096
      WRITE(6,130)KFS,NP,NSC(KRKFS),NOFD(KRKFS),FSLTH(KRKFS)            MAIN0097
  130 FORMAT(5X,24HCHANNEL DATA FOR SECTION,I3,25H ARE TABULATED AS FOLLMAIN0098
```

```
     1OW:,/,5X,3HNP=,I3,5X,4HNSC=,I2,5X,5HNOFD=,I3,5X,6HFSLTH=,F10.4)  MAIN0099
      DAREA(KRKFS,NP+1)=0.0                                            MAIN0100
      IF(NP .EQ. 2) GO TO 180                                          MAIN0101
C   READ DISCHARGE-END AREA CURVE FOR EACH FINITE SECTION              MAIN0102
      READ(5,140)(DISCH(I),DAREA(KRKFS,I),I=1,NP)                      MAIN0103
  140 FORMAT(8F10.2)                                                   MAIN0104
      IF(CONOPT(5).EQ.1) READ(5,190)ALPH(KRKFS,1),EXPT(KRKFS,1)        MAIN0105
      DISCH(NP+1)=0.0                                                  MAIN0106
      WRITE(6,150)                                                     MAIN0107
  150 FORMAT (5X,41HDISCHARGE AND END AREA RELATIONSHIPS ARE:)         MAIN0108
      WRITE(6,160)(DISCH(I),DAREA(KRKFS,I),I=1,NP)                     MAIN0109
  160 FORMAT(8F15.2)                                                   MAIN0110
      WRITE(6,170)ALPH(KRKFS,1),EXPT(KRKFS,1)                          MAIN0111
  170 FORMAT(5X,25HFOR LOW FLOW VOLUME,ALPH=,F10.3,5X,5HEXPT=,F10.3)   MAIN0112
C   GENERATE DAREA VS ALPH AND DAREA VS EXPT FROM DISCHARGE AREA CURVE MAIN0113
      IF(NLTR.EQ.2) CALL ROUTAB(DISCH,DAREA,KRKFS,NP,ALPH,EXPT)        MAIN0114
      GO TO 220                                                        MAIN0115
  180 NSCS=NSC(KRKFS)                                                  MAIN0116
C   IF DISCHARGE-END AREA CURVE IS NOT AVAILABLE,READ ALPH AND EXPT    MAIN0117
      READ(5,190)(ALPH(KRKFS,I),EXPT(KRKFS,I),DAREA(KRKFS,I),I=1,NSCS) MAIN0118
  190 FORMAT(3F10.3)                                                   MAIN0119
      DAREA(KRKFS,NSCS+1)=0.0                                          MAIN0120
      WRITE(6,200)NSCS                                                 MAIN0121
  200  FORMAT(5X,27HALPH,EXPT,AND DAREA FOR THE,I2,18H SLOPE CHAGES ARE:MAIN0122
     1)                                                                MAIN0123
      WRITE(6,210)(ALPH(KRKFS,I),EXPT(KRKFS,I),DAREA(KRKFS,I),I=1,NSCS) MAIN0124
  210 FORMAT(3(5X,F10.2))                                              MAIN0125
      IF (NSC(KRKFS).LE.1) GO TO 220                                   MAIN0126
      PALPHA(KRKFS) = ALPH(KRKFS,1)                                    MAIN0127
      PEXPM(KRKFS) = EXPT(KRKFS,1)                                     MAIN0128
  220 CONTINUE                                                         MAIN0129
  230 CONTINUE                                                         MAIN0130
C   READ STRUCTURE PARAMETERS                                          MAIN0131
      READ(5,10) NSTR                                                  MAIN0132
C   SKIP READING STRUCTURE DATA IF NONE EXISTS                         MAIN0133
```

```
      IF(NSTR.EQ.0) GO TO 290                                           MAIN0134
      IFIELD=1000/NSTR                                                  MAIN0135
      DO 280 KS=1,NSTR                                                  MAIN0136
      READ(5,10) NELV                                                   MAIN0137
      IEF=(KS-1)*IFIELD+1                                               MAIN0138
      IEL=IEF+NELV-1                                                    MAIN0139
C  READ ELEVATION-DISCHARGE-STORAGE CURVE AND LOCATION OF STRUCTURES    MAIN0140
      READ(5,240)(ELEV(IE),DISCH(IE),STORAG(IE),IE=IEF,IEL)             MAIN0141
  240 FORMAT(9F8.2)                                                     MAIN0142
      READ(5,10) IRSTR(KS)                                              MAIN0143
      KR=IRSTR(KS)                                                      MAIN0144
C  READ INITIAL CONDITIONS OF STRUCTURE                                 MAIN0145
      READ(5,140) INLST(KR),OUTLST(KR),STOLST(KR)                       MAIN0146
      WRITE(6,250) KS,KR,NELV,INLST(KR),OUTLST(KR),STOLST(KR)           MAIN0147
  250 FORMAT(/,5X,13HSTRUCTURE NO.,I2,30H IS LOCATED AT BOTTOM OF REACH,MAIN0148
     1 I3,/,5X,5HNELV=,I3,5X,6HINLST=,F10.2,5X,7HOUTLST=,F10.2,5X,7HSTOLMAIN0149
     2ST=,F10.2)                                                        MAIN0150
       WRITE(6,260)                                                     MAIN0151
  260 FORMAT(5X,50HELEVATION DISCHARGE AND STORAGE RELATIONSHIPS ARE:)  MAIN0152
      WRITE(6,240) (ELEV(IE),DISCH(IE),STORAG(IE),IE=IEF,IEL)           MAIN0153
      IFST(KR)=IEF                                                      MAIN0154
      ILST(KR)=IEL                                                      MAIN0155
      DO 270 IE=IEF,IEL                                                 MAIN0156
  270 STORAG(IE)=43560.*STORAG(IE)                                      MAIN0157
      STOLST(KR)=43560.*STOLST(KR)                                      MAIN0158
  280 CONTINUE                                                          MAIN0159
C  READ REACH PARAMETERS                                                MAIN0160
  290 READ(5,300) (RCHLTH(I),SAREA(I),OFSS(I),OFMN(I),OFSL(I),          MAIN0161
     1OFMNIS(I),FIMPA(I),FWTRA(I),I=1,NR)                               MAIN0162
  300 FORMAT(8F10.4)                                                    MAIN0163
      WRITE(6,310)                                                      MAIN0164
  310 FORMAT(/,5X,3HNO.,9X,6HRCHLTH,10X,5HSAREA,11X,4HOFSS,11X,4HOFMN,  MAIN0165
     1 11X,4HOFSL,9X,6HOFMNIS,10X,5HFIMPA,10X,5HFWTRA)                  MAIN0166
      WRITE(6,320)(I,RCHLTH(I),SAREA(I),OFSS(I),OFMN(I),OFSL(I),        MAIN0167
     1OFMNIS(I),FIMPA(I),FWTRA(I),I=1,NR)                               MAIN0168
```

```
  320 FORMAT(6X,I2,8F15.4)
      READ(5,330) (RLZC(I),RBMIR(I),RSUZC(I),RETLF(I),RBUZC(I),RSIAC(I),
     1RBIVF(I),I=1,NR)
  330 FORMAT(7F10.3)
      WRITE(6,340)
  340 FORMAT(/,5X,3HNO.,11X,4HRLZC,10X,5HRBMIR,10X,5HRSUZC,10X,5HRETLF,
     1 10X,5HRBUZC,10X,5HRSIAC,10X,5HRBIVF)
      WRITE(6,350)(I,RLZC(I),RBMIR(I),RSUZC(I),RETLF(I),RBUZC(I),
     1RSIAC(I),RBIVF(I),I=1,NR)
  350 FORMAT(6X,I2,7F15.3)
C  SET INITIAL CONDITIONS
      SGRT(1)=0.0
      IFT = 1
      LRC = .TRUE.
      LLZC = .FALSE.
      LBUZC = .FALSE.
      LBMIR = .FALSE.
      LETLF = .FALSE.
      LNPR = .FALSE.
      IF(CONOPT(2).EQ.0)LNPR=.TRUE.
      ICYC=0
      KRC = 1
      KBRC = 0
      KFFC = 0
      SSSQM = 950.0
C  READ OTHER PARAMETERS
      READ(5,90) (RGPMB(I),I=1,NR)
      READ(5,90) GWETF,DIV
      READ(5,90) (VINMRA(I),SUBWFA(I),I=1,NR)
      WRITE(6,360)RMPF,GWETF,DIV
  360 FORMAT(/,5X,5HRMPF=,F10.2,5X,6HGWETF=,F10.2,5X,4HDIV=,F10.2)
      WRITE(6,370)
  370 FORMAT(/,5X,3HNO.,10X,5HRGPMB ,9X,6HVINMRA,9X,6HSUBWFA)
      WRITE(6,380)(I,RGPMB(I),VINMRA(I),SUBWFA(I),I=1,NR)
  380 FORMAT(6X,I2,3F15.2)
```

```
C  CALCULATE CONSTANTS SET BY REACH PARAMETERS
      AREA=0.0
      VWIN =0.0
      WCFS=0.0
      EPAET=0.0
      DO 430 KR=1,NR
      AREA=AREA+SAREA(KR)
      FPERA(KR)=1.0-FIMPA(KR)-FWTRA(KR)
      IF(FPERA(KR).GT.0.01) GO TO 390
      TPLR(KR)=100.0
      FPERA(KR)=0.01
      GO TO 400
  390 TPLR(KR)=(1.0-FWTRA(KR))/FPERA(KR)
  400 VWINA(KR)=26.8888*SAREA(KR)
      VWIN=VWIN+VWINA(KR)
      WCFSA(KR)=VWINA(KR)*24.0
      WCFS=WCFS+WCFSA(KR)
      CWCFSA(KR)=WCFSA(KR)
      CVWINA(KR)=VWINA(KR)
      IF(NUBR(KR).EQ.0) GO TO 420
      N=NUBR(KR)
      DO 410 I=1,N
      CWCFSA(KR)=CWCFSA(KR)+CWCFSA(IUH(KR,I))
      CVWINA(KR)=CVWINA(KR)+CVWINA(IUH(KR,I))
  410 CONTINUE
  420 ROLF1(KR)=0.0
      ROLF2(KR)=0.0
      RHF(KR)=0.0
      ISGA(KR)=1
      SSRT = SQRT(OFSS(KR))
      OFRF(KR) = 1020.0*SSRT/(OFMN(KR)*OFSL(KR))
      OFRFIS(KR) = 1020.0*SSRT/(OFMNIS(KR)*OFSL(KR))
      EQDF(KR) = 0.00982*((OFMN(KR)*OFSL(KR)/SSRT)**0.6)
      EQDFIS(KR) = 0.00982*((OFMNIS(KR)*OFSL(KR)/SSRT)**0.6)
  430 CONTINUE
```

```
      GAREA=CVWINA(NGR)/26.8888                                         MAIN0239
C  STORE PARAMETERS OF REACH 1 FOR USE IN TRIP 2                        MAIN0240
      NGR1=NGR                                                          MAIN0241
      IF (NGR .EQ. 1 .OR. NFTR .EQ. 2 .OR. CONOPT(6) .EQ. 0) GO TO 460  MAIN0242
      NR1=NR                                                            MAIN0243
      VWINA1=VWINA(1)                                                   MAIN0244
      VINMR1=VINMRA(1)                                                  MAIN0245
      SUBWF1=SUBWFA(1)                                                  MAIN0246
      FPERA1=FPERA(1)                                                   MAIN0247
      SAREA1=SAREA(1)                                                   MAIN0248
      FIMPA1=FIMPA(1)                                                   MAIN0249
      FWTRA1=FWTRA(1)                                                   MAIN0250
      TPLR1=TPLR(1)                                                     MAIN0251
      WCFSA1=WCFSA(1)                                                   MAIN0252
      CWCFS1=CWCFSA(1)                                                  MAIN0253
      CVWIN1=CVWINA(1)                                                  MAIN0254
      OFRF1=OFRF(1)                                                     MAIN0255
      OFRFI1=OFRFIS(1)                                                  MAIN0256
      EQDF1=EQDF(1)                                                     MAIN0257
      EQDFI1=EQDFIS(1)                                                  MAIN0258
      RLZC1=RLZC(1)                                                     MAIN0259
      RBMIR1=RBMIR(1)                                                   MAIN0260
      RSUZC1=RSUZC(1)                                                   MAIN0261
      RETLF1=RETLF(1)                                                   MAIN0262
      RBUZC1=RBUZC(1)                                                   MAIN0263
      RSIAC1=RSIAC(1)                                                   MAIN0264
      RBIVF1=RBIVF(1)                                                   MAIN0265
C  COMPUTE AVERAGE PARAMETERS OF ALL REACHES ABOVE THE GAGE FOR TRIP 1  MAIN0266
  440 FIMPA(1)=0.0                                                      MAIN0267
      FWTRA(1)=0.0                                                      MAIN0268
      TPLR(1)=0.0                                                       MAIN0269
      OFRF(1)=0.0                                                       MAIN0270
      OFRFIS(1)=0.0                                                     MAIN0271
      EQDF(1)=0.0                                                       MAIN0272
      EQDFIS(1)=0.0                                                     MAIN0273
```

```
      RLZC(1)=0.0                                                       MAIN0274
      RBMIR(1)=0.0                                                      MAIN0275
      RSUZC(1)=0.0                                                      MAIN0276
      RETLF(1)=0.0                                                      MAIN0277
      RBUZC(1)=0.0                                                      MAIN0278
      RSIAC(1)=0.0                                                      MAIN0279
      RBIVF(1)=0.0                                                      MAIN0280
      VINMRA(1)=0.0                                                     MAIN0281
      SUBWFA(1)=0.0                                                     MAIN0282
      FPERA(1)=0.0                                                      MAIN0283
      DO 450 KR=2,NGR                                                   MAIN0284
      FIMPA(1)=FIMPA(1)+FIMPA(KR)*SAREA(KR)                             MAIN0285
      FWTRA(1)=FWTRA(1)+FWTRA(KR)*SAREA(KR)                             MAIN0286
      TPLR(1)=TPLR(1)+TPLR(KR)*SAREA(KR)                                MAIN0287
      OFRF(1)=OFRF(1)+OFRF(KR)*SAREA(KR)                                MAIN0288
      OFRFIS(1)=OFRFIS(1)+OFRFIS(KR)*SAREA(KR)                          MAIN0289
      EQDF(1)=EQDF(1)+EQDF(KR)*SAREA(KR)                                MAIN0290
      EQDFIS(1)=EQDFIS(1)+EQDFIS(KR)*SAREA(KR)                          MAIN0291
      RLZC(1)=RLZC(1)+RLZC(KR)*SAREA(KR)                                MAIN0292
      RBMIR(1)=RBMIR(1)+RBMIR(KR)*SAREA(KR)                             MAIN0293
      RSUZC(1)=RSUZC(1)+RSUZC(KR)*SAREA(KR)                             MAIN0294
      RETLF(1)=RETLF(1)+RETLF(KR)*SAREA(KR)                             MAIN0295
      RBUZC(1)=RBUZC(1)+RBUZC(KR)*SAREA(KR)                             MAIN0296
      RSIAC(1)=RSIAC(1)+RSIAC(KR)*SAREA(KR)                             MAIN0297
      VINMRA(1)=VINMRA(1)+VINMRA(KR)*SAREA(KR)                          MAIN0298
      SUBWFA(1)=SUBWFA(1)+SUBWFA(KR)*SAREA(KR)                          MAIN0299
      FPERA(1)=FPERA(1)+FPERA(KR)*SAREA(KR)                             MAIN0300
  450 RBIVF(1)=RBIVF(1)+RBIVF(KR)*SAREA(KR)                             MAIN0301
      FIMPA(1)=(FIMPA(1)+FIMPA1*SAREA(1))/GAREA                         MAIN0302
      FWTRA(1)=(FWTRA(1)+FWTRA1*SAREA(1))/GAREA                         MAIN0303
      TPLR(1)=(TPLR(1)+TPLR1*SAREA(1))/GAREA                            MAIN0304
      OFRF(1)=(OFRF(1)+OFRF1*SAREA(1))/GAREA                            MAIN0305
      OFRFIS(1)=(OFRFIS(1)+OFRFI1*SAREA(1))/GAREA                       MAIN0306
      EQDF(1)=(EQDF(1)+EQDF1*SAREA(1))/GAREA                            MAIN0307
      EQDFIS(1)=(EQDFIS(1)+EQDFI1*SAREA(1))/GAREA                       MAIN0308
```

```
      RLZC(1)=(RLZC(1)+RLZC1*SAREA(1))/GAREA
      RBMIR(1)=(RBMIR(1)+RBMIR1*SAREA(1))/GAREA
      RSUZC(1)=(RSUZC(1)+RSUZC1*SAREA(1))/GAREA
      RETLF(1)=(RETLF(1)+RETLF1*SAREA(1))/GAREA
      RBUZC(1)=(RBUZC(1)+RBUZC1*SAREA(1))/GAREA
      RSIAC(1)=(RSIAC(1)+RSIAC1*SAREA(1))/GAREA
      RBIVF(1)=(RBIVF(1)+RBIVF1*SAREA(1))/GAREA
      VINMRA(1)=(VINMRA(1)+VINMR1*SAREA(1))/GAREA
      SUBWFA(1)=(SUBWFA(1)+SUBWF1*SAREA(1))/GAREA
      FPERA(1)=(FPERA(1)+FPERA1*SAREA(1))/GAREA
C  READ WATER YEAR
  460 READ(5,10) YR1,YR2
      DPY = 365
      IF(MOD(YR2,4) .EQ. 0) DPY = 366
C  READ EVAPORATION DATA
      IF(CONOPT( 1) .NE. 1) GO TO 500
      READ(5,470) (DPET(KRD),KRD=274,365,10),(DPET(KRD),KRD=1,273,10)
  470 FORMAT(10F5.2)
      DO 490 IDAY2 = 1,9
      DO 480 IDAY1 = 274,360,10
      DAY = IDAY1 + IDAY2
  480 DPET(DAY) = DPET(IDAY1)
      DO 490 IDAY1 = 1,273,10
      DAY = IDAY1 + IDAY2
      IF(DAY .GT. 273) GO TO 490
      DPET(DAY) = DPET(IDAY1)
  490 CONTINUE
      DPET(366) = DPET(59)
      DPET(365) = DPET(363)
      DPET(364) = DPET(363)
      GO TO 510
  500 IF(CONOPT( 1) .EQ. 2) GO TO 530
      DAY = 274
      READ(5,470) (DPET(KRD),KRD=274,365),(DPET(KRD),KRD=1,273)
      IF(DPY.EQ.366) READ(5,470) DPET(366)
```

```
  510 READ(5,470) EPCM                                                  MAIN0344
      DO 520 DAY = 1,DPY                                                MAIN0345
  520 EPAET = EPAET + DPET(DAY)                                         MAIN0346
      IF(EPCM(6) .NE. 1.0) EPAET = 0.7*EPAET                            MAIN0347
      GO TO 540                                                         MAIN0348
  530 READ(5,90) EPAET,MNRD                                             MAIN0349
      EMAET = EPAET*(365.0 + MNRD)/404.0                                MAIN0350
      CALL EVPDAY(DPET,EMAET)                                           MAIN0351
C  READ DAILY FLOW DATA                                                 MAIN0352
  540 DRSF(366) = 0.0                                                   MAIN0353
      DAY=274                                                           MAIN0354
      READ(5,550) (DRSF(DAY),DAY=274,365),(DRSF(DAY),DAY=1,273)         MAIN0355
  550 FORMAT(10F8.2)                                                    MAIN0356
      IF(DPY.EQ.366) READ(5,550) DRSF(366)                              MAIN0357
      IF(DIV .EQ. 0.0) GO TO 580                                        MAIN0358
      DO 570 DAY = 1,DPY                                                MAIN0359
      IF(DRSF(DAY) .GT. DIV) GO TO 560                                  MAIN0360
      DRSF(DAY) = 0.0                                                   MAIN0361
      GO TO 570                                                         MAIN0362
  560 DRSF(DAY) = DRSF(DAY) - DIV                                       MAIN0363
  570 CONTINUE                                                          MAIN0364
C  SUM DAILY FLOW AND PRINT FLOW TABLE                                  MAIN0365
  580 CALL DAYSUM(DRSF,MEDCY,DPY,RATFV,TMRTF)                           MAIN0366
      WRITE(6,590)                                                      MAIN0367
  590 FORMAT(1H0,42X,'RECORDED        FLOWS')                           MAIN0368
      CALL DAYOUT(DRSF,MEDWY,DPY)                                       MAIN0369
      WRITE(6,600) (TMRTF(KWD), KWD = 1,12),RATFV                       MAIN0370
  600 FORMAT(6X,'TOTAL',2X,12F8.1,2X,F10.1,2X,3HSFD)                    MAIN0371
C  INITIALIZE PRECIPITION DATA ARRAYS                                   MAIN0372
      DO 620 DAY=1,366                                                  MAIN0373
      DO 610 KR=1,NR                                                    MAIN0374
  610 DRGPM(KR,DAY)=RGPMB(KR)                                           MAIN0375
      DO 620 HOUR=1,24                                                  MAIN0376
  620 DRHP(DAY,HOUR)=0.0                                                MAIN0377
C  READ NUMBER OF STORAGE GAGES                                         MAIN0378
```

```
      READ(5,10) NSG                                                    MAIN0379
C  SKIP READING STORAGE GAGE DATA IF NO STORAGE GAGE IS USED            MAIN0380
      IF(NSG.EQ.0) GO TO 710                                            MAIN0381
      DO 660 KG=1,NSG                                                   MAIN0382
      DO 630 DAY=1,366                                                  MAIN0383
  630 DRSGP(KG,DAY)=0.0                                                 MAIN0384
C  READ DATA FOR STORAGE GAGES                                          MAIN0385
      READ(5,10) NSGRD,ISGM(KG),SGRT(KG)                                MAIN0386
      IF(ISGM(KG).EQ.0) GO TO 640                                       MAIN0387
      READ(5,10) SGRT2(KG),SGMD(KG)                                     MAIN0388
  640 READ(5,650) (ISGRD,DRSGP(KG,ISGRD),KRD=1,NSGRD)                   MAIN0389
  650 FORMAT(5(I5,F7.2))                                                MAIN0390
  660 CONTINUE                                                          MAIN0391
      WRITE(6,670)                                                      MAIN0392
  670 FORMAT(/,5X,9HREACH NO.,5X,16HSTORAGE GAGE NO.,5X,16HWEIGHTING FACMAIN0393
     *TOR)                                                              MAIN0394
C  READ STORAGE GAGE NUMBER FOR EACH REACH AND ITS WEIGHTING FACTOR     MAIN0395
      DO 700 KR=1,NR                                                    MAIN0396
      READ(5,680) ISGA(KR),WSG(KR)                                      MAIN0397
  680 FORMAT(I5,F10.2)                                                  MAIN0398
      WRITE(6,690)KR,ISGA(KR),WSG(KR)                                   MAIN0399
  690 FORMAT(12X,I2,19X,I2,13X,F8.2)                                    MAIN0400
      IF(ISGM(ISGA(KR)).EQ.0) GO TO 700                                 MAIN0401
      READ(5,550) WSG2(KR)                                              MAIN0402
  700 CONTINUE                                                          MAIN0403
C  READ RECORDING RAIN GAGE HOURLY TOTALS                               MAIN0404
  710 READ(5,720) IWBG,YEAR,MONTH,DATE,CN                               MAIN0405
  720 FORMAT(I5,I4,I4,I4,I3)                                            MAIN0406
C  LAST CARD OF HOURLY PRECIPITATION HAS YEAR 98                        MAIN0407
      IF(YEAR .GE. 98) GO TO 750                                        MAIN0408
      HRF = 12*(CN-1) + 1                                               MAIN0409
      HRL = 12*(CN-1) + 12                                              MAIN0410
      DAY = MEDCY(MONTH) + DATE                                         MAIN0411
      READ(5,730) (DRHP(DAY,HOUR),HOUR=HRF,HRL)                         MAIN0412
  730 FORMAT(1X,12F6.2)                                                 MAIN0413
```

```
      IF(DPY .NE. 366 .OR. MONTH .NE. 2 .OR. DATE .NE. 29) GO TO 710
      DO 740  HOUR = HRF,HRL
      DRHP(366,HOUR) = DRHP(60,HOUR)
  740 DRHP(60,HOUR) = 0.0
      GO TO 710
C   CALCULATE PRECIPITATION WEIGHTING FACTORS
  750 IF(NSG.EQ.0) GO TO 830
      DO 820 KR=1,NR
      KG=ISGA(KR)
      DAY = 274
      PDAY = 274
      RDPT = 0.0
  760 IF(ISGM(KG).NE.1) GO TO 770
      IF(SGMD(KG).NE.DAY) GO TO 770
      WSG(KR)=WSG2(KR)
      SGRT(KG)=SGRT2(KG)
  770 EHSGD=SGRT(KG)
      IF(SGRT(KG).EQ.0)EHSGD=24
      EHSGDF = EHSGD
      DO 810  HOUR = 1,24
      RDPT = RDPT + DRHP(DAY,HOUR)
      IF (HOUR .NE. EHSGD)  GO TO 810
      IF (RDPT .LE. 0.0)  GO TO 780
      IF(SGRT(KG).EQ.0) PDAY=DAY
      DRGPM(KR,PDAY)=(DRSGP(KG,DAY)*WSG(KR)+RDPT*(1.0-WSG(KR)))/
     1 RDPT
C  REDUCE DATED POTENTIAL EVAPORATION TO ONE HALF FOR RAINY DAYS
      IF(CONOPT(1) .NE. 0 .AND. KR .EQ. 1) DPET(PDAY)=0.5*DPET(PDAY)
      IF(SGRT(KG).NE.0)PDAY=DAY
      RDPT = 0.0
      GO TO 810
  780 IF(DRSGP(KG,DAY).LE.0.0) GO TO 800
      IF(KR.NE.NR) GO TO 800
      DO 790  KHOUR = 1,EHSGD
  790 DRHP(DAY,KHOUR)=(WSG(KR)*DRSGP(KG,DAY))/EHSGDF
```

```
  800 IF(SGRT(KG).NE.0)PDAY=DAY                                            MAIN0449
  810 CONTINUE                                                             MAIN0450
      CALL DAYNXT(DAY,DPY)                                                 MAIN0451
      IF(DAY.NE.274) GO TO 760                                             MAIN0452
  820 CONTINUE                                                             MAIN0453
C  STORE DRGPM OF REACH 1 FOR USE IN TRIP 2                                MAIN0454
  830 IF (NGR.EQ.1 .OR. NFTR.EQ.2 .OR. NLTR.EQ.1 .OR. CONOPT(6).EQ.0)      MAIN0455
     1 GO TO 850                                                           MAIN0456
      DO 840 DAY=1,366                                                     MAIN0457
  840 DRGPM1(DAY)=DRGPM(1,DAY)                                             MAIN0458
  850 IF(NFTR.EQ.2 .OR. CONOPT(4).EQ.1) GO TO 860                          MAIN0459
C  SET INITIAL VALUES OF FLOW VOLUME PARAMETERS TO BE OPTIMIZED            MAIN0460
      LZC = 12.0                                                           MAIN0461
      BMIR = 1.2                                                           MAIN0462
      SUZC = 1.3                                                           MAIN0463
      ETLF = 0.25                                                          MAIN0464
      BUZC = 1.50                                                          MAIN0465
      SIAC = 0.90                                                          MAIN0466
      BIVF = 0.90                                                          MAIN0467
  860 IF(NFTR .EQ. 2) GO TO 900                                            MAIN0468
      IF(CONOPT(4).EQ.0) GO TO 880                                         MAIN0469
C  READ DATA FROM PREVIOUS RUN AND CONTINUE TRIP 1                         MAIN0470
      READ(5,910) LZC,BMIR,SUZC,ETLF,BUZC,SIAC,BIVF,LZS                    MAIN0471
      READ(5,870) KRC,KBRC,SSSQM,FTX,LRC,LLZC,LBUZC,LBMIR,LETLF             MAIN0472
  870 FORMAT(2I5,2F10.3,5L5)                                               MAIN0473
      BLZC=LZC                                                             MAIN0474
      BBMIR=BMIR                                                           MAIN0475
      BSUZC=SUZC                                                           MAIN0476
      BETLF=ETLF                                                           MAIN0477
      BBUZC=BUZC                                                           MAIN0478
      BSIAC=SIAC                                                           MAIN0479
      BBYLZS=LZS                                                           MAIN0480
      KBRC=KBRC-1                                                          MAIN0481
C  ESTIMATE BASE AND INTERFLOW RECESSION CONSTANTS                         MAIN0482
  880 CALL RECESS(DRSF,DPY,BFRC,IFRC,GAREA,RSBD,RSBIF,NRS,RSBBF)           MAIN0483
```

```
      IF(IFRC .GE. 0.3) GO TO 900
      WRITE(6,890) IFRC
  890 FORMAT(/10X,'REJECTED IFRC =',F8.4)
      IFRC = 0.1
      BIVF = 0.0
C  READ FLOW VOLUME PARAMETERS AND RECESSION CONSTANTS IF ONLY TRIP 2 IS
C  RUN
  900 IF(NFTR.GE.2) READ(5,910) LZC,BMIR,SUZC,ETLF,BUZC,SIAC,BIVF,
     1LZS,IFRC,BFRC
  910 FORMAT(9F8.4)
C  COMPUTE AVERAGE DRGPM FOR ALL REACHES ABOVE THE GAGE
      DO 920 DAY=1,366
      ADRGPM(DAY)=0.0
      DO 920 KR=1,NGR
  920 ADRGPM(DAY)=ADRGPM(DAY)+DRGPM(KR,DAY)*SAREA(KR)/GAREA
C  ADJUST RAINFALL ANOMALIES
  930 IF(NWSTH.LT.12)CALL PRECHK(ADRGPM,DRHP,DRSF,CVWINA(NGR),SGRT(1),
     1 NWSTH)
      BFHRC = BFRC**(1.0/24.0)
      BFRL = -ALOG(BFHRC)
      TRIP = NFTR
      KHYD = 1
C INITIALIZE DAILY HYDROGRAPH FOR OUTFLOW FROM EACH FINITE SECTION
      IF(TRIP .EQ. 1) GO TO 970
      DO 960 KR=1,NR
      NFSKR=NFS(KR)
      DO 960 KFS=1,NFSKR
      KRKFS=NFSEPR(KR)+KFS
      DO 940 DPRD=1,96
  940 HYDSTO(KRKFS,DPRD)=0.0
C  INITIALIZE END AREAS OF CHANNEL CROSS SECTIONS
      N=NOFD(KRKFS)+1
      DO 950 NX=1,N
  950 EDAREA(KRKFS,NX)=0.0
  960 CONTINUE
```

```
C  POINT OF RETURN FOR NEW TRIP
 970 IF(KRC .LE. 5) FTX = 1.0
C  RESTORE DATA OF REACH 1 FOR USE IN TRIP 2
      IF (NGR1.EQ.1 .OR. NFTR.EQ.2 .OR. TRIP.EQ.1 .OR. CONOPT(6).EQ.0)
     1 GO TO 990
      NR=NR1
      NGR=NGR1
      VWINA(1)=VWINA1
      WCFSA(1)=WCFSA1
      VWINA(1)=VWINA1
      CVWINA(1)=CVWIN1
      VINMRA(1)=VINMR1
      SUBWFA(1)=SUBWF1
      FPERA(1)=FPERA1
      SAREA(1)=SAREA1
      FIMPA(1)=FIMPA1
      FWTRA(1)=FWTRA1
      TPLR(1)=TPLR1
      WCFSA(1)=WCFSA1
      CWCFSA(1)=CWCFS1
      CVWINA(1)=CVWIN1
      OFRF(1)=OFRF1
      OFRFIS(1)=OFRFI1
      EQDF(1)=EQDF1
      EQDFIS(1)=EQDFI1
      RLZC(1)=RLZC1
      RSUZC(1)=RSUZC1
      RETLF(1)=RETLF1
      RBUZC(1)=RBUZC1
      RSIAC(1)=RSIAC1
      RBIVF(1)=RBIVF1
      DO 980 DAY=1,366
 980  DRGPM(1,DAY)=DRGPM1(DAY)
 990  ICYC= ICYC+1
      IF(TRIP.EQ.2 .OR. CONOPT(6).EQ.0) GO TO 1000
```

```
      SAREA(1)=GAREA
      NR=1
      VWINA(1)=CVWINA(NGR)
      WCFSA(1)=CWCFSA(NGR)
      CWCFSA(1)=CWCFSA(NGR)
      CVWINA(1)=CVWINA(NGR)
      NGR=1
 1000 DO 1010 DAY=1,366
 1010 GAFL(DAY)=0.0
      KBRC=KBRC+1
C  STORE FLOW VOLUME PARAMETERS REPRESENTING THE ENTIRE WATERSHED
      LZC1=LZC
      BMIR1=BMIR
      SUZC1=SUZC
      ETLF1=ETLF
      BUZC1=BUZC
      SIAC1=SIAC
      BIVF1=BIVF
      IF(DPY .EQ. 366) MEDWY(5) = 366
C  SET TIME INCREMENT FOR SIMULATION
      PPH = 1.0
      IF(.NOT. LRC) PPH = 3.0
      IF(TRIP .NE. 1) PPH = 4.0
      IPPH = PPH
      FHPP = 1.0/PPH
      IFPRC = IFRC**(FHPP/24.0)
      IFRL = -ALOG(IFPRC)
C  INITIALIZE PARAMETERS
      HOURL=0
      HSE = 0.0
      PEAI = 0.0
      SPIF = 0.0
      DO 1020 KR=1,NR
      IFSA(KR)=0.0
      OFUS(KR)=0.0
```

```
      OFUSIS(KR)=0.0
      AMIF(KR)=0.0
      AMNET(KR)=0.0
      AMBF(KR) = 0.0
      AMSE(KR) = 0.0
 1020 CONTINUE
      AMPET = 0.0
      AMPREC = 0.0
      DO 1030 MONTH=1,12
      TMPREC(MONTH) = 0.0
      TMBF(MONTH) = 0.0
      TMIF(MONTH) = 0.0
      TMSE(MONTH) = 0.0
      TMPET(MONTH) = 0.0
      TMNET(MONTH) = 0.0
 1030 CONTINUE
      KRS = 1
      KDRS = 400
      UZS = 0.0
      IFS = 0.0
      IF(NFTR .EQ. 2) GO TO 1060
      IF(KRC .NE. 1) GO TO 1040
C  ADJUST BEGINNING YEAR LOWER ZONE STORAGE
      BYLZS = 6.00
      IF(CONOPT(4) .EQ. 0) LZS=BYLZS
      GO TO 1060
 1040 IF(ICYC .EQ. 1) GO TO 1060
      IF(EMLZS(11) .LT. LZS) LZS= EMLZS(11)
      LZS = LZS*LZC/PLZC
      IF(LLZC) LZS = LZC - (LZC-LZS)*(SATFV/RATFV)
      IF(ABS(FTX - 1.0) .LT. 0.02) GO TO 1050
      LZS = FTX*BBYLZS*LZC/BLZC
      IF(LRC .AND. LZC-LZS .LT. 2.0) LZC = LZS + 2.0
 1050 IF(TRIP .EQ. 2 .OR. KFFC .EQ. 1) LZS = BBYLZS
      KFFC = 0
```

```
C  DETERMINE BEGINNING YEAR GROUNDWATER STORAGE
 1060 OCT1BF = 0.05*TMRTF(1)
      IF(DRSF(274) .LT. 0.05*TMRTF(1)) OCT1BF = DRSF(274)
      IF(DRSF(276) .LT. OCT1BF*BFRC**2) OCT1BF = DRSF(276)/BFRC**2
      BYGWS = OCT1BF/(WCFS*BFRL*SQRT(BFRC))
      GWS = BYGWS
      BYLZS = LZS
      WRITE(6,1070) TRIP,LZC,BMIR,SUZC,ETLF,BUZC,SIAC,BIVF,BFRC,IFRC
 1070 FORMAT(1H1,3X,'TRIAL RUN NUMBER',I3/5X,'PARAMETER VALUES'/10X,
     1  5HLZC =,3X,F8.4,2X,6HBMIR =,2X,F8.4,2X,6HSUZC =,2X,F8.4,2X,
     2  6HETLF =,2X,F8.4,2X,6HBUZC =,2X,F8.4,2X,6HSIAC =,2X,F8.4/10X,
     3  6HBIVF =,2X,F8.4,2X,6HBFRC =,2X,F8.4,2X,6HIFRC =,2X,F8.4)
      WRITE(6,1080) LZS,GWS
 1080 FORMAT(/5X,'INITIAL MOISTURE STORAGES,  LZS =',F9.4,5X,'GWS =',
     1 F9.4)
      IF(TRIP .EQ. 1) WRITE(6,1090) KRC,KBRC,SSSQM,FTX,LRC,LLZC,LBUZC,
     1     LBMIR,LETLF
 1090 FORMAT(5X,'DATA USED FOR CONTINUATION RUN: KRC =',I5,5X,'KBRC =',
     2 I5,5X,'SSSQM =',F10.3,5X,'FTX =',F10.3,5X,'LRC =',L3,/,36X,
     3 'LLZC =',L3,6X,'LBUZC =',L3,7X,'LBMIR =',L3,10X,'LETLF =',L3)
      AETX = 24.0*EPAET/365.0
      AEX96 = 1.2*AETX
      AEX90 = 0.3*AETX
      PAEX90=AEX90
      PAEX96=AEX96
      SIAM = 1.2**SIAC
      DO 1100 KR=1,NR
      UZSA(KR)=UZS
      LZSA(KR) = LZS
      GWSA(KR)=GWS
      VINCR(KR)=FHPP*VINMRA(KR)
      OFUS(KR) = 0.0
      OFUSIS(KR) = 0.0
 1100 CONTINUE
      MONTH = 1
```

```
      MDAY = 273
      IF(TRIP .EQ. 1) GO TO 1130
      WRITE(6,1110) YR1,YR2
 1110 FORMAT(03X,61HOPTIMIZATION OF MODEL INPUT PARAMETERS BASED ON WATE
     1R YEAR 19,I2,1H-,I2)
      WRITE(6,1120)
 1120 FORMAT(8H OCTOBER)
C  BEGIN DAY LOOP
 1130 DAY = 274
      LDAY=DAY
 1140 NNJ=1
C  CHECK THE SPECIFIED DAY NUMBER AND DETERMINE IF TRIP 2 SHOULD STOP
      IF (TRIP .EQ. 2 .AND. DAY .EQ. NDCR) GO TO 2460
      KR=0
C  BEGIN REACH LOOP
 1150 KR=KR+1
      IF(TRIP .EQ. 1) GO TO 1200
C  CHECK WHETHER FLOW AT  REACH IS TO BE PRINTED
      SAVE=.FALSE.
      DO 1160 I=1,NOUT
      J=I
      IF(KR.EQ.IROUT(I))GO TO 1170
 1160 CONTINUE
      GO TO 1180
 1170 SAVE=.TRUE.
      KOUT=J
C  CHECK WHETHER A STRUCTURE EXISTS AT THE BOTTOM OF REACH
 1180 LSTR=.FALSE.
      IF(NSTR.EQ.0) GO TO 1200
      DO 1190 I=1,NSTR
      IF(KR.NE.IRSTR(I)) GO TO 1190
      LSTR=.TRUE.
      GO TO 1200
 1190 CONTINUE
 1200 CONTINUE
```

```
C  COMPUTE FLOW VOLUME PARAMETERS FOR EACH REACH BASED ON GIVEN RATIOS  MAIN0694
      SUBWF=SUBWFA(KR)                                                  MAIN0695
      LZC=RLZC(KR)*LZC1                                                 MAIN0696
      BMIR=RBMIR(KR)*BMIR1                                              MAIN0697
      SUZC=RSUZC(KR)*SUZC1                                              MAIN0698
      ETLF=RETLF(KR)*ETLF1                                              MAIN0699
      BUZC=RBUZC(KR)*BUZC1                                              MAIN0700
      SIAC=RSIAC(KR)*SIAC1                                              MAIN0701
      BIVF=RBIVF(KR)*BIVF1                                              MAIN0702
      AEX90=PAEX90                                                      MAIN0703
      AEX96=PAEX96                                                      MAIN0704
      IF(TRIP .EQ. 2) GO TO 1210                                        MAIN0705
C  INITIALIZE FIRST THREE DAYS OF RECESSION SEQUENCE FOR BASE AND       MAIN0706
C  INTERFLOW                                                            MAIN0707
      IF(KR.NE.1) GO TO 1210                                            MAIN0708
      KDRS=KDRS+1                                                       MAIN0709
      IF(KDRS.LE.3) SBFRS(KDRS,KRS-1)=0.0                               MAIN0710
      IF(KDRS.LE.3) SIFRS(KDRS,KRS-1)= 0.0                              MAIN0711
      IF(RSBD(KRS) .NE. DAY) GO TO 1210                                 MAIN0712
      KDRS = 1                                                          MAIN0713
      KRS = KRS + 1                                                     MAIN0714
      SBFRS(KDRS,KRS-1)=0.0                                             MAIN0715
      SIFRS(KDRS,KRS-1)=0.0                                             MAIN0716
 1210 ADIF(KR)= 0.0                                                     MAIN0717
      ADBF(KR) = 0.0                                                    MAIN0718
      TDSF = 0.0                                                        MAIN0719
      PET = DPET(DAY)                                                   MAIN0720
      IF(CONOPT(1) .NE. 2) PET = PET*EPCM(MONTH)                        MAIN0721
      PETU = PET                                                        MAIN0722
      TFMAX = 0.0                                                       MAIN0723
      TDFP24=0.0                                                        MAIN0724
      IF(TRIP .EQ. 1) GO TO 1230                                        MAIN0725
C  ASSIGN CHANNEL FLOW END AREAS AT BEGINNING OF EACH DAY               MAIN0726
      NFSKR=NFS(KR)                                                     MAIN0727
      DO 1220 KFS=1,NFSKR                                               MAIN0728
```

```
      KRKFS=NFSEPR(KR)+KFS                                              MAIN0729
      N=NOFD(KRKFS)+1                                                   MAIN0730
      DO 1220 NX=1,N                                                    MAIN0731
      XAREA(KFS,NX)=EDAREA(KRKFS,NX)                                    MAIN0732
 1220 CONTINUE                                                          MAIN0733
C  BEGIN HOUR LOOP                                                      MAIN0734
 1230 DO 1610 HOUR = 1,24                                               MAIN0735
      CBF=GWSA(KR)*BFRL                                                 MAIN0736
      URHF=0.0                                                          MAIN0737
      IF(NSG.EQ.0 .AND. DRHP(DAY,HOUR).NE.0.0 .AND. PET.EQ.PETU .AND.   MAIN0738
     1 CONOPT(1).NE.0) PET=0.5*PET                                      MAIN0739
C  COMPUTE HOURLY PRECIPITATION FOR EACH REACH                          MAIN0740
      IF(DAY .EQ. 274) RGPM(KR)= DRGPM(KR,DAY)                          MAIN0741
      IF(HOUR.EQ.SGRT(ISGA(KR))+1) RGPM(KR)= DRGPM(KR,DAY)              MAIN0742
      IF(HOUR.EQ.9) HSE = (FWTRA(KR)*PET)/12.0                          MAIN0743
      IF(HOUR .EQ. 21) HSE = 0.0                                        MAIN0744
      PRH= RGPM(KR)*DRHP(DAY,HOUR)                                      MAIN0745
      IF(KR.LE.NGR)AMPREC=AMPREC+PRH*SAREA(KR)                          MAIN0746
      ARHF(KR)=0.0                                                      MAIN0747
C  15 MIN ACCOUNTING AND ROUTING LOOP (60 MINUTES USED FOR ROUGH        MAIN0748
C    ADJUSTMENT, AND 20 MINUTES FOR FINE ADJUSTMENT IN TRIP 1)          MAIN0749
      DO 1550 PRD=1,IPPH                                                MAIN0750
      DPRD=IPPH*(HOUR-1)+PRD                                            MAIN0751
      PEP=FHPP*PRH                                                      MAIN0752
      PEBI = 0.0                                                        MAIN0753
      PPI = 0.0                                                         MAIN0754
      OFR = 0.0                                                         MAIN0755
      OFRIS = 0.0                                                       MAIN0756
      WI = 0.0                                                          MAIN0757
      WEIFS = 0.0                                                       MAIN0758
C  USE NONUNIFORM RAIN DISTRIBUTION WHEN NEEDED                         MAIN0759
      IF(TRIP.EQ.2.AND.LNPR) CALL PREPRD(RGPM(KR),DRHP,DAY,HOUR,DPY,PRD,MAIN0760
     1 PEP,PRH)                                                         MAIN0761
      IF(PEP .GT. 0.0) GO TO 1240                                       MAIN0762
      IF(OFUS(KR).GT.0.0) GO TO 1260                                    MAIN0763
```

```
      IF(IFSA(KR).GT.0.0) GO TO 1350                                    MAIN0764
      IF(TRIP .EQ. 1) GO TO 1540                                        MAIN0765
      IF(RHF(KR).GT. 0.0) GO TO 1370                                    MAIN0766
      IF(CONOPT(2) .EQ. 1 .AND. PRD .NE. 4) GO TO 1540                  MAIN0767
      TFCFS=0.0                                                         MAIN0768
      IF(CBF .GT. HSE) TFCFS=(CBF-HSE)*WCFSA(KR)                        MAIN0769
      GO TO 1510                                                        MAIN0770
C  RAINFALL UPPER ZONE INTERACTION                                      MAIN0771
 1240 IF(PEP.GE.VINCR(KR))GO TO 1250                                    MAIN0772
      UZSA(KR) = UZSA(KR)+PEP*TPLR(KR)                                  MAIN0773
      VINCR(KR)=VINCR(KR)-PEP                                           MAIN0774
      PPI=0.0                                                           MAIN0775
      PEBI = 0.0                                                        MAIN0776
      IF(OFUS(KR).GT.0.0) GO TO 1260                                    MAIN0777
      GO TO 1350                                                        MAIN0778
 1250 PPI = PEP-VINCR(KR)                                               MAIN0779
      UZSA(KR) = UZSA(KR)+VINCR(KR)*TPLR(KR)                            MAIN0780
      VINCR(KR)=0.0                                                     MAIN0781
      LZSR=LZSA(KR)/LZC                                                 MAIN0782
      UZC = SUZC*AEX90 + BUZC*EXP(-2.7*LZSR)                            MAIN0783
      IF(UZC .LT. 0.25) UZC = 0.25                                      MAIN0784
      UZRX=2.0*ABS(UZSA(KR)/UZC-1.0) + 1.0                              MAIN0785
      FMR=(1.0/(1.0+UZRX))**UZRX                                        MAIN0786
      IF(UZSA(KR).GT.UZC) FMR=1.0-FMR                                   MAIN0787
      PEBI=PPI*FMR                                                      MAIN0788
      UZSA(KR)=UZSA(KR)+PPI-PEBI                                        MAIN0789
C  LOWER ZONE AND GROUNDWATER INFILTRATION                              MAIN0790
 1260 LZSR=LZSA(KR)/LZC                                                 MAIN0791
      EID = 4.0*LZSR                                                    MAIN0792
      IF(LZSR .LE. 1.0) GO TO 1270                                      MAIN0793
      EID = 4.0 + 2.0*(LZSR - 1.0)                                      MAIN0794
      IF(LZSR .LE. 2.0) GO TO 1270                                      MAIN0795
      EID = 6.0                                                         MAIN0796
 1270 PEBI=PEBI+OFUS(KR)                                                MAIN0797
      CMIR = FHPP*SIAM*BMIR/(2.0**EID)                                  MAIN0798
```

```
      CIVM = BIVF*2.0**LZSR                                             MAIN0799
      IF(CIVM .LT. 1.0) CIVM = 1.0                                      MAIN0800
      PEAI = PEBI*PEBI/(2.0*CMIR*CIVM)                                  MAIN0801
      WI = PEBI*PEBI/(2.0*CMIR)                                         MAIN0802
      IF (PEBI .GE. CMIR) WI = PEBI-0.5*CMIR                            MAIN0803
      IF (PEBI .GE. CMIR*CIVM) PEAI = PEBI-0.5*CMIR*CIVM                MAIN0804
      WEIFS = WI - PEAI                                                 MAIN0805
C  OVERLAND RUNOFF                                                      MAIN0806
      IF((PEAI-OFUS(KR)).GT.0.0) GO TO 1280                             MAIN0807
      EQD= (OFUS(KR)+PEAI)/2.0                                          MAIN0808
      GO TO 1290                                                        MAIN0809
 1280 EQD=EQDF(KR)*((PEAI-OFUS(KR))**0.6)                               MAIN0810
 1290 IF((OFUS(KR)+PEAI).GT.(2.0*EQD)) EQD=0.5*(OFUS(KR)+PEAI)          MAIN0811
      IF((OFUS(KR)+PEAI).LE.0.001) GO TO 1300                           MAIN0812
      OFR    =FHPP*OFRF(KR)*(((OFUS(KR)+PEAI)*0.5)**1.67)*((1.0+0.6*    MAIN0813
     1 ((OFUS(KR)+PEAI)/(2.0*EQD))**3.0)**1.67)                         MAIN0814
      IF(OFR .GT. (0.75*PEAI)) OFR = 0.75*PEAI                          MAIN0815
 1300 IF(FIMPA(KR).EQ.0) GO TO 1330                                     MAIN0816
C  OVERLAND RUNOFF ON IMPERVIOUS SURFACE                                MAIN0817
      PEIS=PPI+OFUSIS(KR)                                               MAIN0818
      IF((PEIS-OFUSIS(KR)).GT.0.0) GO TO 1310                           MAIN0819
      EQDIS=(OFUSIS(KR)+PEIS)/2.0                                       MAIN0820
      GO TO 1320                                                        MAIN0821
 1310 EQDIS=EQDFIS(KR)*((PEIS-OFUSIS(KR))**0.6)                         MAIN0822
 1320 IF((OFUSIS(KR)+PEIS).GT.(2.0*EQDIS))EQDIS=0.5*(OFUSIS(KR)+PEIS)   MAIN0823
      IF((OFUSIS(KR)+PEIS).LE.0.01) GO TO 1330                          MAIN0824
      OFRIS = FHPP*OFRFIS(KR)*(((OFUSIS(KR)+PEIS)*0.5)**1.67)*((1.0+0.6*MAIN0825
     1 ((OFUSIS(KR)+PEIS)/(2.0*EQDIS))**3.0)**1.67)                     MAIN0826
      IF(OFRIS .GT. PEIS) OFRIS = PEIS                                  MAIN0827
 1330 OFUSIS(KR) = PEIS-OFRIS                                           MAIN0828
      OFUS(KR)=PEAI-OFR                                                 MAIN0829
      IF(OFUS(KR).GE.0.001) GO TO 1340                                  MAIN0830
      LZSA(KR)=LZSA(KR)+OFUS(KR)                                        MAIN0831
      OFUS(KR)=0.0                                                      MAIN0832
      OFRIS=OFRIS+OFUSIS(KR)                                            MAIN0833
```

```
      OFUSIS(KR)=0.0
C  PERCOLATION TO GROUNDWATER
 1340 LZRX=1.5*ABS(LZSA(KR)/LZC-1.0)+1.0
      FMR = (1.0/(1.0 + LZRX))**LZRX
      IF(LZSA(KR).LT.LZC)FMR=1.0-FMR*(LZSA(KR)/LZC)
      PLZS = FMR*(PEBI-WI)
      PGW = (1.0 -FMR)*(PEBI - WI)*(1.0 - SUBWF)*FPERA(KR)
      GWSA(KR)=GWSA(KR)+PGW
      LZSA(KR)=LZSA(KR)+PLZS
      IFSA(KR)=IFSA(KR)+WEIFS*FPERA(KR)
 1350 SPIF=IFRL*IFSA(KR)
      AMIF(KR)=AMIF(KR)+SPIF
      ADIF(KR)=ADIF(KR)+SPIF
      IFSA(KR)=IFSA(KR)-SPIF
      IF(IFSA(KR).GE.0.0001)GO TO 1360
      LZSA(KR)=LZSA(KR)+IFSA(KR)
      IFSA(KR)=0.0
 1360 SPDR=FPERA(KR)*OFR+PPI*FWTRA(KR)+FIMPA(KR)*OFRIS+SPIF
      IF(TRIP .EQ. 2) GO TO 1380
      ARHF(KR)=ARHF(KR)+SPDR*WCFSA(KR)
      GO TO 1540
 1370 SPDR=0.0
C  ROUTING
 1380 IF(CONOPT(2) .NE. 1) GO TO 1390
C  HOURLY ROUTING
      URHF=URHF+SPDR
      IF(PRD.NE.4)GO TO 1540
C  SPDR MUST BE IN INCHES PER QUARTER HOUR
      SPDR = URHF/4.
 1390 IF(NUBR(KR).LE.0) GO TO 1410
C  IF THE CURRENT REACH IS THE FIRST REACH AFTER A JUNCTION, THEN
C  ADD THE PREVIOUS JUNCTION'S HYDROGRAPHS TO OBTAIN INFLOW TO REACH
      NSUM=IUH(KR,1)
      IF(NUBR(KR).EQ.1) GO TO 1410
      NB=NUBR(KR)
```

```
      DO 1400 NH=2,NB
      IH=IUH(KR,NH)
 1400 HYDSTO(NFSEPR(NSUM)+NFS(NSUM),DPRD)=HYDSTO(NFSEPR(NSUM)+NFS(NSUM),
     1 DPRD)+HYDSTO(NFSEPR(IH)+NFS(IH),DPRD)
C  CALCULATE LOCAL INFLOW PER LINEAR FT ALONG THE REACH
 1410 ROLF2(KR)=(SPDR*4.*WCFSA(KR))/RCHLTH(KR)
      DO 1500 KFS=1,NFSKR
      KRKFS=NFSEPR(KR)+KFS
      DELTAX=FSLTH(KRKFS)/NOFD(KRKFS)
C  DETERMINE ALPHA AND EXPM TO BE USED FOR ROUTING
      CALL RTGPAR(XAREA,KFS,KRKFS,ALPH,EXPT,DAREA,ALPHA,EXPM,NOFD,NSC)
      IF(NSC(KRKFS) .LE. 1) GO TO 1420
      ALPHA1=ALPHA
      EXPM1=EXPM
      IF(PALPHA(KRKFS) .EQ. ALPHA) GO TO 1420
      ALPHA=(PALPHA(KRKFS)+ALPHA)/2.0
      EXPM= (PEXPM(KRKFS)+EXPM)/2.0
      PALPHA(KRKFS) = ALPHA1
      PEXPM(KRKFS) = EXPM1
 1420 IF(NUBR(KR) .LE. 0 .AND. KFS .EQ. 1) GO TO 1450
      IF(KFS .EQ. 1) GO TO 1430
      NLR=KR
      NLS = KFS-1
      GO TO 1440
 1430 NLR = NSUM
      NLS = NFS(NSUM)
 1440 IF(HYDSTO(NFSEPR(NLR)+NLS,DPRD)/ALPHA .LE. 0.) GO TO 1450
C  CALCULATE XAREA AT HEAD OF REACH FROM INFLOW HYDROGRAPH
      XAREA(KFS,1)=(HYDSTO(NFSEPR(NLR)+NLS,DPRD)/ALPHA)**(1./EXPM)
      GO TO 1460
 1450 XAREA(KFS,1)=0.0
C  FINITE DIFFERENCE ROUTING THROUGH STREAM REACH
 1460 N=NOFD(KRKFS)+1
      IF(EXPM .GE. 0.0) GO TO 1480
      WRITE(6,1470) EXPM,KR,KFS
```

```
 1470 FORMAT(5X,6HEXPM= ,E10.3,2X,13HAT REACH NO. ,I2,2X,12HSECTION NO. MAIN0904
     1 ,I2)                                                             MAIN0905
      GO TO 2460                                                        MAIN0906
 1480 CALL  CHROUT(XAREA,ROLF1,ROLF2,DELTAT,DELTAX,ALPHA,EXPM,N,KR,KFS,  MAIN0907
     1 CONOPT(3))                                                       MAIN0908
C  CALCULATE CURRENT ROUTED OUTFLOW FROM THE REACH                      MAIN0909
      RHF(KR)=ALPHA*XAREA(KFS,N)**EXPM                                  MAIN0910
C  CALCULATE TOTAL OUTFLOW                                              MAIN0911
      IF(KFS .NE. NFSKR) GO TO 1490                                     MAIN0912
      TFCFS=RHF(KR)+(CBF-HSE)*WCFSA(KR)                                 MAIN0913
      IF(TFCFS .LT. 0.0) TFCFS=0.0                                      MAIN0914
      GO TO 1500                                                        MAIN0915
 1490 HYDSTO(KRKFS,DPRD)=RHF(KR)                                        MAIN0916
 1500 CONTINUE                                                          MAIN0917
 1510 IF(.NOT. LSTR) GO TO 1520                                         MAIN0918
      CALL  STORRT(TFCFS,KR,DELTAT,ELEV,DISCH,STORAG,IFST(KR),          MAIN0919
     1 ILST(KR),INLST,OUTLST,STOLST,PET)                                MAIN0920
      TFCFS=OUTLST(KR)                                                  MAIN0921
C  STORE FLOW FOR INFLOW TO NEXT LOWER REACH                            MAIN0922
 1520 HYDSTO(NFSEPR(KR)+NFSKR,DPRD)=TFCFS                               MAIN0923
C  CHECK TO SEE IF DAY'S FLOWS SHOULD BE PRINTED                        MAIN0924
      IF(TFCFS .LE. TFMAX) GO TO 1530                                   MAIN0925
      PRDF = PRD                                                        MAIN0926
      TDFP24 = HOUR                                                     MAIN0927
      IF(PRD .LE. 3) TDFP24 = (TDFP24 - 1.0) + 0.15*PRDF                MAIN0928
      TFMAX = TFCFS                                                     MAIN0929
 1530 ARHF(KR)=ARHF(KR)+TFCFS/NPPH                                      MAIN0930
      ROLF1(KR)=ROLF2(KR)                                               MAIN0931
 1540 IF(VINCR(KR).LT.FHPP*VINMRA(KR))  VINCR(KR)=VINCR(KR)+DPET(DAY)/  MAIN0932
     1  (24.0/FHPP)                                                     MAIN0933
 1550 CONTINUE                                                          MAIN0934
C  END OF 15 MINUTE LOOP                                                MAIN0935
C  ADDING GROUNDWATER FLOW                                              MAIN0936
      GWSA(KR)=GWSA(KR)-CBF                                             MAIN0937
      AMBF(KR)=AMBF(KR)+CBF                                             MAIN0938
```

```
      IF(TRIP .EQ. 1) ARHF(KR)=ARHF(KR)+CBF*WCFSA(KR)                   MAIN0939
C  EVAPORATION FROM STREAM SURFACE                                      MAIN0940
      IF(HSE*WCFSA(KR) .GT. ARHF(KR)) HSE=ARHF(KR)/WCFSA(KR)            MAIN0941
      IF(CBF.GT.HSE)ADBF(KR)=ADBF(KR)+CBF-HSE                           MAIN0942
      AMSE(KR)=AMSE(KR)+HSE                                             MAIN0943
      THSF(HOUR)=ARHF(KR)                                               MAIN0944
      IF(TRIP .EQ. 1) THSF(HOUR)=ARHF(KR)-(HSE*WCFSA(KR))               MAIN0945
      IF(TFMAX .LE. 0.0) TFMAX = THSF(HOUR)                             MAIN0946
      TDSF = TDSF + THSF(HOUR)                                          MAIN0947
C  DRAINING OF UPPER ZONE STORAGE                                       MAIN0948
      UZINFX=(UZSA(KR)/UZC)-(LZSA(KR)/LZC)                              MAIN0949
      IF(UZINFX .LE. 0.0) GO TO 1560                                    MAIN0950
      LZSR=LZSA(KR)/LZC                                                 MAIN0951
      UZINLZ = 0.003*BMIR*UZC*UZINFX**3.0                               MAIN0952
      IF(UZINLZ.GT.UZSA(KR))UZINLZ=UZSA(KR)                             MAIN0953
      UZSA(KR)=UZSA(KR)-UZINLZ                                          MAIN0954
      LZRX = 1.5*ABS(LZSR - 1.0) + 1.0                                  MAIN0955
      FMR = (1.0/(1.0 + LZRX))**LZRX                                    MAIN0956
      IF(LZSA(KR).LT.LZC)FMR=1.0-FMR*LZSR                               MAIN0957
      PGW = (1.0-FMR)*UZINLZ*(1.0 - SUBWF)*FPFRA(KR)                    MAIN0958
      PLZS     =FMR*UZINLZ                                              MAIN0959
      LZSA(KR)=LZSA(KR)+PLZS                                            MAIN0960
      GWSA(KR)=GWSA(KR)+PGW                                             MAIN0961
C  4 PM ADJUSTMENTS OF VARIOUS VALUES                                   MAIN0962
 1560 IF(HOUR .NE. 16) GO TO 1610                                       MAIN0963
      PAEX90=AEX90                                                      MAIN0964
      PAEX96=AEX96                                                      MAIN0965
      AEX90 = 0.9*(AEX90 + PET)                                         MAIN0966
      AEX96 = 0.96*(AEX96 + PET)                                        MAIN0967
      IF(KR.NE.NR) GO TO 1570                                           MAIN0968
      PAEX90=AEX90                                                      MAIN0969
      PAEX96=AEX96                                                      MAIN0970
C  INFILTRATION CORRECTION                                              MAIN0971
 1570 SIAM = (AEX96/AETX)**SIAC                                         MAIN0972
      IF(SIAM .LT. 0.33) SIAM = 0.33                                    MAIN0973
```

```
      IF(PET .EQ. 0.0) GO TO 1610                                       MAIN0974
C  EVAP-TRANS LOSS FROM GROUNDWATER                                     MAIN0975
      GWET=GWSA(KR)*GWETF*PET*FPERA(KR)                                 MAIN0976
      GWSA(KR)=GWSA(KR)-GWET                                            MAIN0977
      IF(KR.EQ.1)AMPET=AMPET+PET                                        MAIN0978
      IF(PET.GE.UZSA(KR))GO TO 1580                                     MAIN0979
      UZSA(KR)=UZSA(KR)-PET                                             MAIN0980
      AMNET(KR)=AMNET(KR)+PET                                           MAIN0981
      GO TO 1610                                                        MAIN0982
 1580 PET=PET-UZSA(KR)                                                  MAIN0983
      AMNET(KR)=AMNET(KR)+UZSA(KR)                                      MAIN0984
      UZSA(KR)=0.0                                                      MAIN0985
      LZSR=LZSA(KR)/LZC                                                 MAIN0986
      IF(PET .GE. ETLF*LZSR) GO TO 1590                                 MAIN0987
      SET = PET*(1.0 - PET/(2.0*ETLF*LZSR))                             MAIN0988
      GO TO 1600                                                        MAIN0989
 1590 SET = 0.5*ETLF*LZSR                                               MAIN0990
 1600 LZSA(KR)=LZSA(KR)-SET                                             MAIN0991
      AMNET(KR)=AMNET(KR)+SET                                           MAIN0992
 1610 CONTINUE                                                          MAIN0993
C  END OF HOUR LOOP                                                     MAIN0994
      IF(TRIP .EQ. 1) GO TO 1630                                        MAIN0995
C  STORE END AREA OF EACH FINITE DIFFERENCE SECTION FOR USE IN NEXT DAY MAIN0996
      DO 1620 KFS=1,NFSKR                                               MAIN0997
      KRKFS=NFSEPR(KR)+KFS                                              MAIN0998
      N=NOFD(KRKFS)+1                                                   MAIN0999
      DO 1620 NX=1,N                                                    MAIN1000
      EDAREA(KRKFS,NX)=XAREA(KFS,NX)                                    MAIN1001
 1620 CONTINUE                                                          MAIN1002
 1630 DSSF(DAY)=TDSF/24.0                                               MAIN1003
      IF(TRIP.EQ.1.AND.KR.LE.NGR) GAFL(DAY)=GAFL(DAY)+DSSF(DAY)         MAIN1004
      IF(TRIP .EQ. 1) GO TO 1730                                        MAIN1005
      IF(KR.NE.NGR)GO TO 1640                                           MAIN1006
C  DETERMINE SYNTHESIZED DAILY AND MONTHLY FLOW AT GAGED REACH          MAIN1007
      GAFL(DAY)=DSSF(DAY)                                               MAIN1008
```

```
      SMF=SMF+DSSF(DAY)
 1640 IF(.NOT.SAVE .OR. TFMAX.LE. RMPF) GO TO 1730
C  PRINT HOURLY,DAILY AND PEAK FLOW FOR DAY WHEN PEAK FLOW EXCEEDS RMPF
      WRITE(6,1650)KR,RMPF
 1650 FORMAT(1H/,'***  FLOW FROM REACH = ',I2,' (REQUESTED MINIMUM PEAK
     1= ',F5.1,'CFS)  ***')
      IF(DAY .EQ. 366) MDAY = 337
      DATE = MOD(DAY,MDAY)
      WRITE(6,1660) DATE, (THSF(HOUR),HOUR=1,12)
 1660 FORMAT(1H/,1X/,1X,I4,2X,2HAM,1X,6F8.1,3X,6F8.1)
      WRITE(6,1670) (THSF(HOUR),HOUR=13,24), DSSF(DAY)
 1670 FORMAT(1HJ,6X,2HPM,1X,6F8.1,3X,7F8.1)
      IF(TDFP24 .LT. 12.0) GO TO 1690
      TDFP12 = TDFP24 - 12.0
      WRITE(6,1680) TFMAX, TDFP12
 1680 FORMAT(1H/,10X,8HMAXIMUM=,F8.1,2X,6HC.F.S.,5X,4HTIME,3X,F5.2,2X,
     1  4HP.M.)
      GO TO 1710
 1690 WRITE(6,1700) TFMAX,TDFP24
 1700 FORMAT(1H/,10X,8HMAXIMUM=,F8.1,2X,6HC.F.S.,5X,4HTIME,3X,F5.2,2X,
     1  4HA.M.)
 1710 WRITE(6,1720)
 1720 FORMAT(1H/,120('_')/)
 1730 IF(TRIP .EQ. 1 .AND. .NOT. LRC .AND. KDRS .LE. 3 .AND. IFRC .GT.
     1  0.1) SIFRS(KDRS,KRS-1) = SIFRS(KDRS,KRS-1)+ADIF(KR)*VWINA(KR)
      IF(TRIP.EQ.1.AND.KDRS.LE.3) SBFRS(KDRS,KRS-1)=SBFRS(KDRS,KRS-1)+
     1  ADBF(KR)*VWINA(KR)
C  MONTHLY SUMMARY STORAGE
      IF(DAY .NE. MEDWY(MONTH)) GO TO 2080
      IF(KR.GT.NGR)GO TO 1840
      IF(KR.NE.NGR)GO TO 1820
      IF(TRIP .EQ. 1) GO TO 1810
C  PRINT SYNTHESIZED DAILY FLOW AND MONTHLY TOTAL
      IF(MONTH-1) 1740,1740,1750
 1740 MEDWYP=MEDWY(12)
```

```
      GO TO 1760                                                        MAIN1044
 1750 MEDWYP=MEDWY(MONTH-1)                                             MAIN1045
      IF(MONTH .EQ. 4) MEDWYP=0                                         MAIN1046
      IF(MONTH.EQ.5) MEDWY(5)=59                                        MAIN1047
 1760 NDPM=MEDWY(MONTH)-MEDWYP                                          MAIN1048
      WRITE(6,1770)                                                     MAIN1049
 1770 FORMAT(/,5X,49HDAILY SYNTHESIZED FLOWS ARE TABULATED AS FOLLOWS:) MAIN1050
      WRITE(6,1780)(I,DSSF(MEDWYP+I),I=1,NDPM)                          MAIN1051
 1780 FORMAT(8(I5,F10.3))                                               MAIN1052
      IF(MONTH .EQ. 5 .AND. DPY .EQ. 366) WRITE(6,1790) DSSF(366)       MAIN1053
 1790 FORMAT(2X,3H366,F10.3)                                            MAIN1054
      WRITE(6,1800)MONTH,SMF                                            MAIN1055
 1800 FORMAT(5X,6HMONTH=,I3,5X,20HSUM OF MOMTHLY FLOW=,F10.3)           MAIN1056
      SMF=0.0                                                           MAIN1057
 1810 TMPET(MONTH) = AMPET                                              MAIN1058
      AMPET = 0.0                                                       MAIN1059
 1820 IF(KR.GT.NGR) GO TO 1840                                          MAIN1060
      TMPREC(MONTH)=TMPREC(MONTH)+AMPREC                                MAIN1061
      AMPREC=0.0                                                        MAIN1062
      TMBF(MONTH)=TMBF(MONTH)+AMBF(KR)*SAREA(KR)                        MAIN1063
      AMBF(KR)=0.0                                                      MAIN1064
      TMIF(MONTH)=TMIF(MONTH)+AMIF(KR)*SAREA(KR)                        MAIN1065
      AMIF(KR)=0.0                                                      MAIN1066
      TMSE(MONTH)=TMSE(MONTH)+AMSE(KR)*SAREA(KR)                        MAIN1067
      AMSE(KR)=0.0                                                      MAIN1068
      TMNET(MONTH)=TMNET(MONTH)+AMNET(KR)*SAREA(KR)                     MAIN1069
      AMNET(KR)=0.0                                                     MAIN1070
      UZC=SUZC*AEX90+BUZC*EXP(-2.7*LZSA(KR)/LZC)                        MAIN1071
      IF(UZC .LT. 0.25) UZC = 0.25                                      MAIN1072
      IF(KR.NE.1) GO TO 1830                                            MAIN1073
      EMGWS(MONTH)=GWSA(KR)*SAREA(KR)                                   MAIN1074
      EMUZC(MONTH)=UZC*SAREA(KR)                                        MAIN1075
      EMUZS(MONTH)=UZSA(KR)*SAREA(KR)                                   MAIN1076
      EMSIAM(MONTH)=SIAM*SAREA(KR)                                      MAIN1077
      EMLZS(MONTH)=LZSA(KR)*SAREA(KR)                                   MAIN1078
```

```
      EMIFS (MONTH)=IFSA(KR)*SAREA(KR)
      GO TO 1840
 1830 EMUZC(MONTH)=EMUZC(MONTH)+UZC*SAREA(KR)
      EMUZS(MONTH)=EMUZS(MONTH)+UZSA(KR)*SAREA(KR)
      EMSIAM(MONTH)=EMSIAM(MONTH)+SIAM*SAREA(KR)
      EMLZS(MONTH)=EMLZS(MONTH)+LZSA(KR)*SAREA(KR)
      EMIFS(MONTH)=EMIFS(MONTH)+IFSA(KR)*SAREA(KR)
      EMGWS(MONTH)=EMGWS(MONTH)+GWSA(KR)*SAREA(KR)
 1840 IF(KR.NE.NR) GO TO 1150
C  END OF REACH LOOP
      IF(MONTH .EQ. 5) MEDWY(5) = 59
      MDAY = MEDWY(MONTH)
      IF(TRIP .EQ. 1) GO TO 2070
      GO TO (1850,1870,1890,1910,1930,1950,1970,1990,2010,2030,2050,
     1              2070),MONTH
 1850 WRITE(6,1860)
 1860 FORMAT(1H/,8HNOVEMBER)
      GO TO 2070
 1870 WRITE(6,1880)
 1880 FORMAT(1H/,8HDECEMBER)
      GO TO 2070
 1890 WRITE(6,1900)
 1900 FORMAT(1H/,7HJANUARY)
      GO TO 2070
 1910 WRITE(6,1920)
 1920 FORMAT(1H/,8HFEBRUARY)
      GO TO 2070
 1930 WRITE(6,1940)
 1940 FORMAT(1H/,5HMARCH)
      GO TO 2070
 1950 WRITE(6,1960)
 1960 FORMAT(1H/,5HAPRIL)
      GO TO 2070
 1970 WRITE(6,1980)
 1980 FORMAT(1H/,3HMAY)
```

```
      GO TO 2070                                                        MAIN1114
 1990 WRITE(6,2000)                                                     MAIN1115
 2000 FORMAT(1H/,4HJUNE)                                                MAIN1116
      GO TO 2070                                                        MAIN1117
 2010 WRITE(6,2020)                                                     MAIN1118
 2020 FORMAT(1H/,4HJULY)                                                MAIN1119
      GO TO 2070                                                        MAIN1120
 2030 WRITE(6,2040)                                                     MAIN1121
 2040 FORMAT(1H/,6HAUGUST)                                              MAIN1122
      GO TO 2070                                                        MAIN1123
 2050 WRITE(6,2060)                                                     MAIN1124
 2060 FORMAT(1H/,9HSEPTEMBER)                                           MAIN1125
 2070 IF(KR.EQ.NR) MONTH=MONTH+1                                        MAIN1126
      LDAY=DAY                                                          MAIN1127
C  END OF DAY LOOP                                                      MAIN1128
 2080 IF(KR .NE. NR) GO TO 1150                                         MAIN1129
      CALL DAYNXT(DAY,DPY)                                              MAIN1130
      IF(DAY .NE. 274) GO TO 1140                                       MAIN1131
      DO 2090 MONTH=1,12                                                MAIN1132
      TMPREC(MONTH)=TMPREC(MONTH)/GAREA                                 MAIN1133
      TMBF(MONTH)=TMBF(MONTH)/GAREA                                     MAIN1134
      TMIF(MONTH)=TMIF(MONTH)/GAREA                                     MAIN1135
      TMSE(MONTH)=TMSE(MONTH)/GAREA                                     MAIN1136
      TMNET(MONTH)=TMNET(MONTH)/GAREA                                   MAIN1137
      EMGWS(MONTH)=EMGWS(MONTH)/GAREA                                   MAIN1138
      EMUZC(MONTH)=EMUZC(MONTH)/GAREA                                   MAIN1139
      EMUZS(MONTH)=EMUZS(MONTH)/GAREA                                   MAIN1140
      EMSIAM(MONTH)=EMSIAM(MONTH)/GAREA                                 MAIN1141
      EMLZS(MONTH)=EMLZS(MONTH)/GAREA                                   MAIN1142
      EMIFS(MONTH)=EMIFS(MONTH)/GAREA                                   MAIN1143
 2090 CONTINUE                                                          MAIN1144
      IF(TRIP .NE. 1) WRITE(6,2100)   (TITLE(KTA), KTA=1,20,1)          MAIN1145
 2100 FORMAT(1H1,25X,20A4)                                              MAIN1146
C  ANNUAL SUMMARY                                                       MAIN1147
      APREC = 0.0                                                       MAIN1148
```

```
      ABFV = 0.0
      ASEV = 0.0
      ANET = 0.0
      APET = 0.0
      AIFV = 0.0
      DO 2110 MONTH = 1,12
      APREC = APREC + TMPREC(MONTH)
      ABFV = ABFV + TMBF(MONTH)
      ASEV = ASEV + TMSE(MONTH)
      ANET = ANET + TMNET(MONTH)
      APET = APET + TMPET(MONTH)
 2110 AIFV = AIFV + TMIF(MONTH)
      WRITE(6,2120)
 2120 FORMAT(1H///44X,23HSYNTHESIZED       FLOWS)
      IF(TRIP .EQ. 1) WRITE(6,2130)
 2130 FORMAT(//5X,'SUMMARY WHILE OPTIMIZING VOLUME VARIABLES')
      CALL DAYSUM(GAFL,MEDCY,DPY,SATFV,TMSTF)
      IF(TRIP .EQ. 1) GO TO 2140
      CALL DAYOUT(GAFL,MEDWY,DPY)
 2140 WRITE(6,2150) (TMSTF(KWD), KWD=1,12),SATFV
 2150 FORMAT(1X, 9HSYNTHETIC,3X,12F8.1,2X,F10.1,2X,3HSFD)
      DO 2160 MONTH = 1,12
 2160 TMSTFI(MONTH) = TMSTF(MONTH)/CVWINA(NGR)
      SATFVI = SATFV/CVWINA(NGR)
      WRITE(6,2170) (TMSTFI(KWD),KWD=1,12),SATFVI
 2170 FORMAT(1X,5HTOTAL,8X,12F8.3,4X,F7.3,2X,6HINCHES)
      DO 2180 MONTH = 1,12
      TMOF(MONTH) = TMSTFI(MONTH)- TMIF(MONTH) - TMBF(MONTH) +
     1  TMSE(MONTH)
 2180 IF(TMOF(MONTH) .LT. 0.0) TMOF(MONTH) = 0.0
      AOFV = SATFVI - AIFV - ABFV + ASEV
      IF(AOFV .LT.0.0) AOFV = 0.0
      WRITE(6,2190) (TMOF(KWD), KWD=1,12), AOFV
 2190 FORMAT(1X,8HOVERLAND ,5X,12F8.3,4X,F7.3,2X,6HINCHES)
      WRITE(6,2200) (TMIF(KWD), KWD=1,12),AIFV
```

```
 2200 FORMAT(1X,9HINTERFLOW,4X,12F8.3,4X,F7.3,2X,6HINCHES)
      WRITE(6,2210) (TMBF(KWD), KWD=1,12),ABFV
 2210 FORMAT(1X,4HBASE,9X,12F8.3,4X,F7.3,2X,6HINCHES)
      WRITE(6,2220) (TMSE(KWD), KWD=1,12), ASEV
 2220 FORMAT(1X,9HSTRM EVAP,4X,12F8.3,4X,F7.3,2X,6HINCHES)
      WRITE(6,2230) (TMPREC(KWD), KWD=1,12),APREC
 2230 FORMAT( 1X,6HPRECIP,7X,12F8.2,3X,F8.2,2X,6HINCHES)
      WRITE(6,2240) (TMNET(KWD), KWD=1,12),ANET
 2240 FORMAT(1X,12HEVP/TRAN-NET,2X,12F8.3,3X,F7.3,2X,6HINCHES)
      WRITE(6,2250) (TMPET(KWD), KWD=1,12),APET
 2250 FORMAT(3X,10H-POTENTIAL,2X,12F8.3,3X,F7.3,2X,6HINCHES)
      WRITE(6,2260) (EMUZS(KWD), KWD=1,12)
 2260 FORMAT(1X,12HSTORAGES-UZS,2X,12F8.3,12X,6HINCHES)
      WRITE(6,2270) (EMLZS(KWD), KWD=1,12)
 2270 FORMAT(10X,3HLZS,2X,12F8.3,12X,6HINCHES)
      WRITE(6,2280) (EMIFS(KWD), KWD=1,12)
 2280 FORMAT(10X,3HIFS,2X,12F8.3,12X,6HINCHES)
      WRITE(6,2290) (EMGWS(KWD), KWD=1,12)
 2290 FORMAT(10X,3HGWS,2X,12F8.3,12X,6HINCHES)
      WRITE(6,2300) (EMUZC(KWD), KWD=1,12)
 2300 FORMAT(1X,12HINDICES- UZC,2X,12F8.3)
      WRITE(6,2310) (EMSIAM(KWD), KWD=1,12)
 2310 FORMAT(9X,4HSIAM,2X,12F8.3)
      LZS=EMLZS(12)
      UZS=EMUZS(12)
      IFS=EMIFS(12)
      GWS=EMGWS(12)
      AMBER=(LZS-BYLZS)*FPERA(NGR)+(UZS+IFS+GWS-BYGWS)*(1.0-FWTRA(NGR))+
     1 SATFVI+ANET*FPERA(NGR)+ASEV-APREC
      WRITE(6,2320) AMBER
 2320 FORMAT(1H/,7HBALANCE,5X,F10.4,2X,6HINCHES)
C  ESTABLISH WHETHER MONTH IS PREDOMINATELY BASE FLOW OR DIRECT RUNOFF
      NOFM = 0
      MONTH1 = 1
      IF(FTX .LT. 0.95) MONTH1 = 4
```

```
      LZC=LZC1
      BMIR=BMIR1
      SUZC=SUZC1
      ETLF=ETLF1
      BUZC=BUZC1
      SIAC=SIAC1
      BIVF=BIVF1
      DO 2340 MONTH = 1,12
      XMPFT(MONTH) = 0.0
      IF(MONTH .LT. MONTH1) GO TO 2340
      IF(TMSTFI(MONTH) .GT. 0.001) GO TO 2330
      XMPFT(MONTH) = 1.0
      GO TO 2340
 2330 IF(TMBF(MONTH)/TMSTFI(MONTH) .GT. 0.5) XMPFT(MONTH) = 1.0
      IF(TMOF(MONTH)/TMSTFI(MONTH) .LT. 0.5) GO TO 2340
      NOFM = NOFM + 1
      XMPFT(MONTH) = 2.0
 2340 CONTINUE
C  NATURE OF TRIPS
C    TRIP 1  OPTIMIZE VOLUME VARIABLES WHILE BYPASSING ROUTING
C     TRIP 2 FINAL RUN WITH OPTIMIZED VALUES
      IF(TRIP .EQ. 1) GO TO 2350
      GO TO 2460
C SYSTEMATIC ADJUSTMENT OF VOLUME VARIABLES CONVERGING ON OPTIMUM VALUES
 2350 KRC = KRC + 1
      PLZC = LZC
      PBMIR = BMIR
      PSUZC = SUZC
      PETLF = ETLF
      PBUZC = BUZC
      PSIAC = SIAC
C  ADJUST FIVE VOLUME VARIABLES: LZC,SUZC,ETLF,BUZC,SIAC
      CALL SETFVP(LZC,SUZC,ETLF,BUZC,SIAC,TMSTF,TMRTF,TMPREC,TMPET,
     1  EMLZS,SSQM,LRC,XMPFT,FTX,NOFM,LBUZC,LETLF,LLZC,APREC,APET)
C  ADJUST INTERFLOW VOLUME CONSTANT DURING FINE ADJUSTMENT PHASE
```

```
      FNWSTH=NWSTH                                                      MAIN1254
      IF(.NOT. LRC .AND. IFRC .GT. 0.1) CALL SETBIV(BIVF,NRS,IFRC,RSBIF,MAIN1255
     1  SIFRS,FNWSTH)                                                   MAIN1256
C  ADJUST INFILTRATION RATE CONSTANT: BMIR                              MAIN1257
      IF(.NOT. LBMIR) GO TO 2360                                        MAIN1258
      BMIR = 0.9*BMIR                                                   MAIN1259
      GO TO 2370                                                        MAIN1260
 2360 IF(ABS(FTX-1.0) .GT. 0.02 .AND. KRC .GT. 5) IFT = 2               MAIN1261
      CALL SETBMI(BMIR,NRS,BFRC,RSBBF,SBFRS,FNWSTH,IFT)                 MAIN1262
 2370 IF((KRC .GT. 6) .AND. (LZC .GT. 29.0)) LLZC = .TRUE.              MAIN1263
      IF((KRC .GT. 6) .AND. (ETLF .GT. 0.59)) LETLF = .TRUE.            MAIN1264
      IF((KRC .GT. 6) .AND. (BUZC .GT. 3.9)) LBUZC = .TRUE.             MAIN1265
      IF(.NOT. LLZC) GO TO 2390                                         MAIN1266
      LZC = PLZC*SATFV/RATFV                                            MAIN1267
      WRITE(6,2380) LZC                                                 MAIN1268
 2380 FORMAT(/2X,'LZC WAS CHANGED TO',F6.2,' BASED ON ANNUAL RUNOFF VOLUMAIN1269
     1ME')                                                              MAIN1270
 2390 IF(KRC .LT. 6 .OR. BMIR .LT. 20.0) GO TO 2400                     MAIN1271
      LBMIR = .TRUE.                                                    MAIN1272
      BMIR = 20.0                                                       MAIN1273
 2400 IF (CONOPT(7) .EQ. 0) GO TO 2410                                  MAIN1274
      IF(KRC .EQ. CONOPT(7)+1) GO TO 2460                               MAIN1275
      GO TO 970                                                         MAIN1276
 2410 IF(SSSQM .LE. SSQM .AND. ((KRC .GT. MNRC .AND. KBRC .GE. 2) .OR.  MAIN1277
     1  (.NOT. LRC))) GO TO 2440                                        MAIN1278
      IF(SSSQM .LE. SSQM) GO TO 970                                     MAIN1279
      BLZC = PLZC                                                       MAIN1280
      BBMIR = PBMIR                                                     MAIN1281
      BSUZC = PSUZC                                                     MAIN1282
      BETLF = PETLF                                                     MAIN1283
      BBUZC = PBUZC                                                     MAIN1284
      BSIAC = PSIAC                                                     MAIN1285
      SSSQM = SSQM                                                      MAIN1286
      BBYLZS = BYLZS                                                    MAIN1287
      KBRC = 0                                                          MAIN1288
```

```
      IF(SSQM .LT. 0.15 .AND. LRC) GO TO 2420                           MAIN1289
      GO TO 970                                                         MAIN1290
 2420 LRC = .FALSE.                                                     MAIN1291
      WRITE(6,2430)                                                     MAIN1292
 2430 FORMAT(/5X,'SHIFT TO FINE ADJUSTMENT BEGINNING AT BEST ROUGH ADJUSMAIN1293
     1TMENT POINT')                                                     MAIN1294
      SSSQM = 1000.0                                                    MAIN1295
      GO TO 2450                                                        MAIN1296
 2440 CONTINUE                                                          MAIN1297
      IF(LRC) GO TO 2420                                                MAIN1298
      IF(TRIP .EQ. NLTR) GO TO 2460                                     MAIN1299
      TRIP = TRIP + 1                                                   MAIN1300
 2450 LZC = BLZC                                                        MAIN1301
      BMIR = BBMIR                                                      MAIN1302
      SUZC = BSUZC                                                      MAIN1303
      ETLF = BETLF                                                      MAIN1304
      BUZC = BBUZC                                                      MAIN1305
      SIAC = BSIAC                                                      MAIN1306
      KFFC = 1                                                          MAIN1307
      GO TO 970                                                         MAIN1308
 2460 CONTINUE                                                          MAIN1309
      IF(NSYC .LT. NSYT) GO TO 20                                       MAIN1310
      STOP                                                              MAIN1311
      END                                                               MAIN1312
```

```
      SUBROUTINE ROUTAB(DISCH,DAREA,KRKFS,NP,ALPH,EXPT)                 RTAB0001
C   THIS SUBROUTINE PRODUCES A TABLE OF ROUTING PARAMETERS FOR EACH     RTAB0002
C   FINITE SECTION IN EACH REACH OF THE WATERSHED FROM THE DISCHARGE-END RTAB0003
C   AREA RELATIONSHIPS                                                  RTAB0004
      DIMENSION DISCH(1000),DAREA(150,50),ALPH(150,50),EXPT(150,50)     RTAB0005
      REAL LDIS1,LDIS2,LDAR1,LDAR2                                      RTAB0006
      AREA1=DAREA(KRKFS,1)                                              RTAB0007
      DO 10 I=2,NP                                                      RTAB0008
```

```
      AREA2= DAREA(KRKFS,I)                                             RTAB0009
      LDIS2=ALOG10(DISCH(I))                                            RTAB0010
      LDIS1=ALOG10(DISCH(I-1))                                          RTAB0011
      LDAR2=ALOG10(AREA2)                                               RTAB0012
      LDAR1=ALOG10(AREA1)                                               RTAB0013
      EXPT(KRKFS,I) = (LDIS2-LDIS1)/(LDAR2-LDAR1)                       RTAB0014
      ALPH(KRKFS,I) = 10.**(LDIS2-EXPT(KRKFS,I)*LDAR2)                  RTAB0015
      DAREA(KRKFS,I)= (AREA1+AREA2)/2.                                  RTAB0016
      AREA1=AREA2                                                       RTAB0017
   10 CONTINUE                                                          RTAB0018
      RETURN                                                            RTAB0019
      END                                                               RTAB0020
```

```
      SUBROUTINE RTGPAR(XAREA,KFS,KRKFS,ALPH,EXPT,DAREA,ALPHA,EXPM,     RPAR0001
     1 NOFD,NSC)                                                        RPAR0002
C  THIS SUBROUTINE READS THE PROPER TABLE PRODUCED BY SUBROUTINE ROUTAB,RPAR0003
C  AND RETURNS THE CURRENT VALUES OF ALPHA ANE THE EXPONENT M TO BE     RPAR0004
C  USED IN THE STREAM ROUTING FOR ONE TIME INCREMENT.                   RPAR0005
      DIMENSION XAREA(150,21),ALPH(150,50),EXPT(150,50),DAREA(150,50),  RPAR0006
     1 NOFD(150),NSC(150)                                               RPAR0007
      AVXAR=0.0                                                         RPAR0008
      NL=NOFD(KRKFS)+1                                                  RPAR0009
      DO 10 N=2,NL                                                      RPAR0010
   10 AVXAR = AVXAR+XAREA(KFS,N)                                        RPAR0011
      AVXAR=AVXAR+0.5*(XAREA(KFS,1)-XAREA(KFS,NL))                      RPAR0012
      AVXAR= AVXAR/NOFD(KRKFS)                                          RPAR0013
      DO 20 J=1,50                                                      RPAR0014
      I=J                                                               RPAR0015
      IF(AVXAR .LE. DAREA(KRKFS,J)) GO TO 40                            RPAR0016
      IF(DAREA(KRKFS,J) .LE. 0.) GO TO 30                               RPAR0017
   20 CONTINUE                                                          RPAR0018
   30 ALPHA= ALPH(KRKFS,I-1)                                            RPAR0019
      EXPM= EXPT(KRKFS,I-1)                                             RPAR0020
```

```
      RETURN                                                            RPAR0021
   40 IF(I.LE.2 .AND. ALPH(KRKFS,1) .EQ. 0.0) GO TO 60                  RPAR0022
      IF(I .EQ. 1 .OR. NSC(KRKFS) .NE. 0) GO TO 50                      RPAR0023
C  INTERPOLATE BETWEEN VALUES                                           RPAR0024
      RAT=(AVXAR-DAREA(KRKFS,I-1))/(DAREA(KRKFS,I)-DAREA(KRKFS,I-1))    RPAR0025
      ALPHA=ALPH(KRKFS,I-1)+(ALPH(KRKFS,I)-ALPH(KRKFS,I-1))*RAT         RPAR0026
      EXPM=EXPT(KRKFS,I-1)+(EXPT(KRKFS,I)-EXPT(KRKFS,I-1))*RAT          RPAR0027
      RETURN                                                            RPAR0028
   50 ALPHA=ALPH(KRKFS,I)                                               RPAR0029
      EXPM=EXPT(KRKFS,I)                                                RPAR0030
      RETURN                                                            RPAR0031
   60 ALPHA=ALPH(KRKFS,2)                                               RPAR0032
      EXPM=EXPT(KRKFS,2)                                                RPAR0033
      RETURN                                                            RPAR0034
      END                                                               RPAR0035
```

```
      SUBROUTINE CHROUT(XAREA,ROLF1,ROLF2,DELTAT,DELTAX,ALPHA,EXPM,N,KR,CHRT0001
     1 KFS,INLR)                                                        CHRT0002
C  THIS SUBROUTINE ROUTES STREAMFLOW THROUGH THE REACHES OF THE         CHRT0003
C  WATERSHED USING THE KINEMATIC METHODS.                               CHRT0004
      DIMENSION XAREA(150,21),ROLF1(15),ROLF2(15)                       CHRT0005
C  LINEAR SOLUTION                                                      CHRT0006
      DO 70 NX=2,N                                                      CHRT0007
      PXAREA = XAREA(KFS,NX)                                            CHRT0008
      AX=0.5*(XAREA(KFS,NX-1)+PXAREA)                                   CHRT0009
      IF(AX .GT. 1.0E-20) GO TO 10                                      CHRT0010
      XAREA(KFS,NX)=DELTAT*(ROLF1(KR)+ROLF2(KR))/2.+PXAREA              CHRT0011
      GO TO 20                                                          CHRT0012
   10 CONTINUE                                                          CHRT0013
      XAREA(KFS,NX) = (ROLF1(KR)+ROLF2(KR))/2.+PXAREA/DELTAT+XAREA(KFS, CHRT0014
     1 NX-1)/DELTAX*ALPHA*EXPM*AX**(EXPM-1)                             CHRT0015
      XAREA(KFS,NX) = XAREA(KFS,NX)/((1./DELTAT)+(1./DELTAX)*ALPHA*EXPM*CHRT0016
     1 AX**(EXPM-1))                                                    CHRT0017
```

```
   20 IF(XAREA(KFS,NX) .LT. 1.0E-20) XAREA(KFS,NX)=0.0                  CHRT0018
      IF(INLR.NE.1) GO TO 70                                             CHRT0019
C  ITERATION FOR NON-LINEAR SOLUTION USING LINEAR SOLUTION AS FIRST      CHRT0020
C  ESTIMATE                                                              CHRT0021
      IF(XAREA(KFS,NX) .LE. 0.) GO TO 70                                 CHRT0022
      THETA = DELTAX/DELTAT                                              CHRT0023
      CONST = THETA*PXAREA+DELTAX*(ROLF1(KR)+ROLF2(KR))/2.0              CHRT0024
      OMEGA = CONST+ALPHA*XAREA(KFS,NX-1)**EXPM                          CHRT0025
      IF(OMEGA.GT.0.001/1000) GO TO 30                                   CHRT0026
      XAREA(KFS,NX) = 0.                                                 CHRT0027
      GO TO 70                                                           CHRT0028
   30 CONTINUE                                                           CHRT0029
      NI=0                                                               CHRT0030
   40 FUNC = THETA*XAREA(KFS,NX)+ALPHA*XAREA(KFS,NX)**EXPM               CHRT0031
      NI=NI+1                                                            CHRT0032
      IF(NI.LT.10.OR.OMEGA.GT.1.0) GO TO 50                              CHRT0033
      XAREA(KFS,NX) = 0.                                                 CHRT0034
      GO TO 70                                                           CHRT0035
   50 CONTINUE                                                           CHRT0036
      FUNC1 = THETA+ALPHA*EXPM*XAREA(KFS,NX)**(EXPM-1)                   CHRT0037
      FUNC2 = ALPHA*EXPM*(EXPM-1)*XAREA(KFS,NX)**(EXPM-2)                CHRT0038
      IF(FUNC2.EQ.0.0) GO TO 70                                          CHRT0039
      XAREA1 = XAREA(KFS,NX)-FUNC1/FUNC2+((FUNC1/FUNC2)**2-2.*(FUNC-     CHRT0040
     1 OMEGA)/FUNC2)**0.5                                                CHRT0041
      XAREA2 = XAREA(KFS,NX)-FUNC1/FUNC2-((FUNC1/FUNC2)**2-2.*(FUNC-     CHRT0042
     1 OMEGA)/FUNC2)**0.5                                                CHRT0043
      IF(XAREA2.LT.0) XAREA2=XAREA1                                      CHRT0044
      FUNC1 = THETA*XAREA1+ALPHA*XAREA1**EXPM                            CHRT0045
      FUNC2 = THETA*XAREA2+ALPHA*XAREA2**EXPM                            CHRT0046
      DEV1=ABS(FUNC1-OMEGA)                                              CHRT0047
      DEV2=ABS(FUNC2-OMEGA)                                              CHRT0048
      XAREA(KFS,NX) = XAREA1                                             CHRT0049
      FUNC=FUNC1                                                         CHRT0050
      IF(DEV2.GE.DEV1) GO TO 60                                          CHRT0051
      XAREA(KFS,NX) = XAREA2                                             CHRT0052
```

```
      FUNC=FUNC2                                                        CHRT0053
   60 CONTINUE                                                          CHRT0054
      IF(NI.GT.20) GO TO 80                                             CHRT0055
      IF(ABS((FUNC-OMEGA)/OMEGA).GT.0.01) GO TO 40                      CHRT0056
   70 CONTINUE                                                          CHRT0057
      RETURN                                                            CHRT0058
   80 WRITE(6,90)NI                                                     CHRT0059
   90 FORMAT(' ',' EXECUTION TERMINATING DUE TO EXCESSIVE ITERATIONS IN CHRT0060
     1NONLINEAR ROUTING DETERMINATION.  NI = ',I2)                      CHRT0061
      WRITE(6,100)                                                      CHRT0062
  100 FORMAT(' ',' CONDITIONS AT TERMINATION: ')                        CHRT0063
      WRITE(6,110)KR,KFS,NX,XAREA(KFS,NX),PXAREA                        CHRT0064
  110 FORMAT(' ','CURRENT REACH =',I2,5X,' NUMBER OF FINITE SECTIONS =',CHRT0065
     2 I2,/,' NUMBER OF ENDAREA =',I3,/,' ENDAREA =',F12.4,' PREVIOUS ENCHRT0066
     2DAREA =',E12.4)                                                   CHRT0067
      WRITE(6,120)ROLF2(KR),ROLF1(KR),DELTAT,DELTAX,ALPHA,EXPM          CHRT0068
  120 FORMAT(' ',' LOCAL INFLOW =',E12.4,' PREVIOUS LOCAL INFLOW =',    CHRT0069
     1 E12.4,/,' DELTAT =',F5.0,' DELTAX=',F5.0,/,' ALPHA =',F8.4,      CHRT0070
     2 ' EXPONENT M =',F8.4)                                            CHRT0071
      WRITE(6,130) CONST,OMEGA,FUNC,FUNC1,FUNC2                         CHRT0072
  130 FORMAT('CONST',E12.4,'OMEGA',E12.4,'FUNC',E12.4,'FUNC1',E12.4,    CHRT0073
     1 'FUNC2',E12.4)                                                   CHRT0074
      STOP                                                              CHRT0075
      END                                                               CHRT0076
```

```
      SUBROUTINE STORRT(TFCFS,KR,DELTAT,ELEV,DISCH,STORAG,IFST,ILST,    STOR0001
     1 INLST,OUTLST,STOLST,PET)                                         STOR0002
C     THIS SUBROUTINE ADJUSTS THE CHANNEL ROUTED FLOWS FOR ANY REACH    STOR0003
C     TO ACCOUNT FOR THE EFFECTS OF ANY EXISTING STRUCTURE.             STOR0004
      DIMENSION DISCH(1000),STORAG(1000),INLST(15),OUTLST(15),STOLST(15)STOR0005
     1          ,ELEV(1000)                                             STOR0006
      REAL INLST                                                        STOR0007
      IF(STOLST(KR) .GE. STORAG(IFST)) GO TO 10                         STOR0008
```

```
      J=IFST+1                                                          STOR0009
      OUTLST(KR)=0.0                                                    STOR0010
      STOLST(KR)=STOLST(KR)+(INLST(KR)+TFCFS)*DELTAT/2.0                STOR0011
      GO TO 40                                                          STOR0012
   10 C4 = (INLST(KR)+TFCFS-OUTLST(KR))*DELTAT+2.*STOLST(KR)            STOR0013
      J = IFST                                                          STOR0014
   20 J = J+1                                                           STOR0015
      IF(J .GT. ILST-1) GO TO 30                                        STOR0016
      C5 = DISCH(J)*DELTAT+2.*STORAG(J)                                 STOR0017
      IF(C5-C4) 20,30,30                                                STOR0018
C     SOLUTION OF SIMULTANEOUS EQUATIONS                                STOR0019
   30 A2 = DISCH(J)-DISCH(J-1)                                          STOR0020
      B2 = STORAG(J-1)-STORAG(J)                                        STOR0021
      C2 = DISCH(J-1)*STORAG(J)-STORAG(J-1)*DISCH(J)                    STOR0022
      AZ = 2.*B2-A2*DELTAT                                              STOR0023
      OUTLST(KR) = (-C4*A2-2.0*C2)/AZ                                   STOR0024
      STOLST(KR) = (DELTAT*C2+C4*B2)/AZ                                 STOR0025
   40 SLOPE = (STORAG (J)-STORAG(J-1))/(ELEV(J)-ELEV(J-1))              STOR0026
      STOLST(KR) = STOLST(KR)-PET*DELTAT*SLOPE/1036800.                 STOR0027
      INLST(KR)=TFCFS                                                   STOR0028
      RETURN                                                            STOR0029
      END                                                               STOR0030


      SUBROUTINE DAYNXT(DAY,DPY)                                        DYNX0001
C   DETERMINES NUMBER OF NEXT DAY OF THE YEAR                           DYNX0002
      INTEGER  DAY,DPY                                                  DYNX0003
      DAY = DAY + 1                                                     DYNX0004
      IF(DAY .EQ. 366) DAY = 1                                          DYNX0005
      IF(DAY .EQ. 60 .AND. DPY .EQ. 366) DAY = 366                      DYNX0006
      IF(DAY .EQ. 367) DAY = 60                                         DYNX0007
      RETURN                                                            DYNX0008
      END                                                               DYNX0009
```

```
      SUBROUTINE DAYSUM(DRSF,MEDCY,DPY,ATFV,TMTFWY)                     DYSM0001
C   SUMS DAILY VALUES TO GET MONTHLY AND ANNUAL TOTALS                  DYSM0002
      DIMENSION  DRSF(366),EMATF(13),MEDCY(12),TMTFCY(12),TMTFWY(12)    DYSM0003
      INTEGER  DAY,DPY                                                  DYSM0004
C   SUM ANNUAL AND CUMULATIVE MONTHLY FLOWS                             DYSM0005
      EMATF(1) = 0.0                                                    DYSM0006
      ATF = 0.0                                                         DYSM0007
      DO 101 DAY = 1,365                                                DYSM0008
      ATF = ATF + DRSF(DAY)                                             DYSM0009
      DO 100 KMO = 2,12                                                 DYSM0010
  100 IF(DAY .EQ. MEDCY(KMO)) EMATF(KMO) = ATF                          DYSM0011
  101 CONTINUE                                                          DYSM0012
      EMATF(13) = ATF                                                   DYSM0013
      ATFV = ATF + DRSF(366)                                            DYSM0014
C   CALCULATE MONTHLY FLOWS                                             DYSM0015
      DO 102 KMO = 1,12                                                 DYSM0016
  102 TMTFCY(KMO) = EMATF(KMO + 1) - EMATF(KMO)                         DYSM0017
      TMTFCY(2) = TMTFCY(2) + DRSF(366)                                 DYSM0018
C   CONVERT MONTHLY FLOWS TO A WATER YEAR ORDER                         DYSM0019
      DO 103 KMO = 1,9                                                  DYSM0020
  103 TMTFWY(KMO+3) = TMTFCY(KMO)                                       DYSM0021
      DO 104 KMO = 10,12                                                DYSM0022
  104 TMTFWY(KMO-9) = TMTFCY(KMO)                                       DYSM0023
      RETURN                                                            DYSM0024
      END                                                               DYSM0025


      SUBROUTINE DAYOUT(VDCY,MEDWY,DPY)                                 DYOT0001
C   PRINTS TABLE OF DAILY VALUES                                        DYOT0002
      DIMENSION  MEDWY(12),VDCY(366),VDMD(12)                           DYOT0003
      INTEGER  DATE,DAY,DPY                                             DYOT0004
  100 WRITE(6,1)                                                        DYOT0005
```

```
    1 FORMAT(7X,3HDAY,7X,3HOCT,5X,3HNOV,5X,3HDEC,5X,3HJAN,5X,3HFEB,5X,
     1  3HMAR,5X,3HAPR,5X,3HMAY,5X,3HJUN,5X,3HJUL,5X,3HAUG,5X,4HSEPT)
      MEDWY(3) = 0
      DO 104 DATE = 1,28,1
      IF(MOD(DATE,5) .NE. 1) GO TO 102
      DO 101 KMO = 1,12
      DAY = MEDWY(KMO) + DATE
  101 VDMD(KMO) = VDCY(DAY)
      WRITE(6,2) DATE,VDMD(12),(VDMD(KWD), KWD=1,11)
    2 FORMAT(1H0,3X,I6,3X,12F8.1)
      GO TO 104
  102 DO 103 KMO = 1,12
      DAY = MEDWY(KMO) + DATE
  103 VDMD(KMO) = VDCY(DAY)
      WRITE(6,3) DATE,VDMD(12),(VDMD(KWD), KWD = 1,11)
    3 FORMAT(1X,3X,I6,3X,12F8.1)
  104 CONTINUE
      IF(DPY .NE. 366) GO TO 106
      DATE = 29
      VDCY(60) = VDCY(366)
      DO 105 KMO = 1,12
      DAY = MEDWY(KMO) + DATE
  105 VDMD(KMO) = VDCY(DAY)
      WRITE(6,3) DATE,VDMD(12),(VDMD(KWD), KWD=1,11)
      GO TO 107
  106 CONTINUE
      WRITE(6,4) VDCY(302),VDCY(333),VDCY(363),VDCY(29),VDCY(88),
     1  VDCY(119),VDCY(149),VDCY(180),VDCY(210),VDCY(241),VDCY(272)
    4 FORMAT(1X,7X,2H29,3X,4F8.1,8X,7F8.1)
  107 CONTINUE
  108 WRITE(6,5) VDCY(303),VDCY(334),VDCY(364),VDCY(30),VDCY(89),
     1  VDCY(120),VDCY(150),VDCY(181),VDCY(211),VDCY(242),VDCY(273)
    5 FORMAT(1X,7X,2H30,3X,4F8.1,8X,7F8.1)
      WRITE(6,6) VDCY(304),VDCY(365),VDCY(31),VDCY(90),VDCY(151),
     1  VDCY(212),VDCY(243)
```

```
    6 FORMAT(1H/,7X,2H31,3X,F8.1,8X,2F8.1,8X,F8.1,8X,F8.1,8X,2F8.1)        DYOT0041
      MEDWY(3) = 365                                                     DYOT0042
      RETURN                                                             DYOT0043
      END                                                                DYOT0044


      SUBROUTINE EVPDAY(DPET, EMAET)                                     EVDY0001
C     DETERMINES DATED PAN EVAPORATION TOTALS                            EVDY0002
      DIMENSION  DPET(366)                                               EVDY0003
      INTEGER DAY                                                        EVDY0004
      DO 100  DAY = 1,5                                                  EVDY0005
  100 DPET(DAY) = 0.00060*EMAET                                          EVDY0006
      DPET(  6) = 0.00059*EMAET                                          EVDY0007
      DPET(  7) = DPET(  6)                                              EVDY0008
      DO 101 DAY = 8,10                                                  EVDY0009
  101 DPET(DAY) = 0.00058*EMAET                                          EVDY0010
      DO 102 DAY = 11,16                                                 EVDY0011
  102 DPET(DAY) = 0.00057*EMAET                                          EVDY0012
      DPET( 17) = DPET(  8)                                              EVDY0013
      DO 103 DAY = 18,20                                                 EVDY0014
  103 DPET(DAY) = DPET(  6)                                              EVDY0015
      DO 104 DAY = 21,32                                                 EVDY0016
  104 DPET(DAY) = DPET(  1)                                              EVDY0017
      DPET( 33) = 0.00061*EMAET                                          EVDY0018
      DO 105 DAY = 34,38                                                 EVDY0019
  105 DPET(DAY) = 0.00062*EMAET                                          EVDY0020
      DPET( 39) = 0.00063*EMAET                                          EVDY0021
      DPET( 40) = DPET( 39)                                              EVDY0022
      DPET( 41) = 0.00064*EMAET                                          EVDY0023
      DPET( 42) = 0.00065*EMAET                                          EVDY0024
      DPET( 43) = 0.00066*EMAET                                          EVDY0025
      DO 106 DAY = 44,50                                                 EVDY0026
  106 DPET(DAY) = 0.00067*EMAET                                          EVDY0027
      DO 107 DAY = 51,55                                                 EVDY0028
```

```
107 DPET(DAY) = 0.00068*EMAET                                        EVDY0029
    DPET( 56) = 0.00069*EMAET                                        EVDY0030
    DO 108 DAY = 57,61                                               EVDY0031
108 DPET(DAY) = 0.00070*EMAET                                        EVDY0032
    DPET( 62) = 0.00071*EMAET                                        EVDY0033
    DPET( 63) = 0.00072*EMAET                                        EVDY0034
    DPET( 64) = DPET( 63)                                            EVDY0035
    DPET( 65) = 0.00073*EMAET                                        EVDY0036
    DPET( 66) = 0.00074*EMAET                                        EVDY0037
    DPET( 67) = 0.00075*EMAET                                        EVDY0038
    DPET( 68) = 0.00076*EMAET                                        EVDY0039
    DPET( 69) = 0.00077*EMAET                                        EVDY0040
    DPET( 70) = DPET( 69)                                            EVDY0041
    DPET( 71) = 0.00078*EMAET                                        EVDY0042
    DPET( 72) = DPET( 71)                                            EVDY0043
    DPET( 73) = 0.00079*EMAET                                        EVDY0044
    DPET( 74) = DPET( 73)                                            EVDY0045
    DPET( 75) = 0.00080*EMAET                                        EVDY0046
    DPET( 76) = 0.00081*EMAET                                        EVDY0047
    DPET( 77) = 0.00082*EMAET                                        EVDY0048
    DPET( 78) = 0.00084*EMAET                                        EVDY0049
    DPET( 79) = 0.00086*EMAET                                        EVDY0050
    DPET( 80) = 0.00088*EMAET                                        EVDY0051
    DPET( 81) = 0.00090*EMAET                                        EVDY0052
    DPET( 82) = 0.00092*EMAET                                        EVDY0053
    DPET( 83) = 0.00094*EMAET                                        EVDY0054
    DPET( 84) = 0.00097*EMAET                                        EVDY0055
    DPET( 85) = 0.00099*EMAET                                        EVDY0056
    DPET( 86) = 0.00102*EMAET                                        EVDY0057
    DPET( 87) = 0.00106*EMAET                                        EVDY0058
    DPET( 88) = 0.00109*EMAET                                        EVDY0059
    DPET( 89) = 0.00113*EMAET                                        EVDY0060
    DPET( 90) = 0.00118*EMAET                                        EVDY0061
    DPET( 91) = 0.00122*EMAET                                        EVDY0062
    DPET( 92) = 0.00128*EMAET                                        EVDY0063
```

```
      DPET( 93) = 0.00132*EMAET                                          EVDY0064
      DPET( 94) = 0.00137*EMAET                                          EVDY0065
      DPET( 95) = 0.00142*EMAET                                          EVDY0066
      DPET( 96) = 0.00147*EMAET                                          EVDY0067
      DPET( 97) = 0.00151*EMAET                                          EVDY0068
      DPET( 98) = 0.00157*EMAET                                          EVDY0069
      DPET( 99) = 0.00163*EMAET                                          EVDY0070
      DPET(100) = 0.00168*EMAET                                          EVDY0071
      DPET(101) = 0.00173*EMAET                                          EVDY0072
      DPET(102) = 0.00178*EMAET                                          EVDY0073
      DPET(103) = 0.00185*EMAET                                          EVDY0074
      DPET(104) = 0.00193*EMAET                                          EVDY0075
      DPET(105) = 0.00201*EMAET                                          EVDY0076
      DPET(106) = 0.00208*EMAET                                          EVDY0077
      DPET(107) = 0.00214*EMAET                                          EVDY0078
      DPET(108) = 0.00221*EMAET                                          EVDY0079
      DPET(109) = 0.00227*EMAET                                          EVDY0080
      DPET(110) = 0.00234*EMAET                                          EVDY0081
      DPET(111) = 0.00241*EMAET                                          EVDY0082
      DPET(112) = 0.00249*EMAET                                          EVDY0083
      DPET(113) = 0.00256*EMAET                                          EVDY0084
      DPET(114) = 0.00262*EMAET                                          EVDY0085
      DPET(115) = 0.00268*EMAET                                          EVDY0086
      DPET(116) = 0.00276*EMAET                                          EVDY0087
      DPET(117) = 0.00281*EMAET                                          EVDY0088
      DPET(118) = 0.00287*EMAET                                          EVDY0089
      DPET(119) = 0.00293*EMAET                                          EVDY0090
      DPET(120) = 0.00299*EMAET                                          EVDY0091
      DPET(121) = 0.00305*EMAET                                          EVDY0092
      DPET(122) = 0.00310*EMAET                                          EVDY0093
      DPET(123) = 0.00317*EMAET                                          EVDY0094
      DPET(124) = 0.00322*EMAET                                          EVDY0095
      DPET(125) = 0.00328*EMAET                                          EVDY0096
      DPET(126) = 0.00333*EMAET                                          EVDY0097
      DPET(127) = 0.00338*EMAET                                          EVDY0098
```

```
DPET(128) = 0.00344*EMAET
DPET(129) = 0.00348*EMAET
DPET(130) = 0.00354*EMAET
DPET(131) = 0.00359*EMAET
DPET(132) = 0.00365*EMAET
DPET(133) = 0.00370*EMAET
DPET(134) = 0.00374*EMAET
DPET(135) = 0.00378*EMAET
DPET(136) = 0.00382*EMAET
DPET(137) = 0.00387*EMAET
DPET(138) = 0.00391*EMAET
DPET(139) = 0.00394*EMAET
DPET(140) = 0.00399*EMAET
DPET(141) = 0.00402*EMAET
DPET(142) = 0.00407*EMAET
DPET(143) = 0.00411*EMAET
DPET(144) = 0.00417*EMAET
DPET(145) = 0.00420*EMAET
DPET(146) = 0.00426*EMAET
DPET(147) = 0.00430*EMAET
DPET(148) = 0.00436*EMAET
DPET(149) = 0.00440*EMAET
DPET(150) = 0.00446*EMAET
DPET(151) = 0.00450*EMAET
DPET(152) = 0.00455*EMAET
DPET(153) = 0.00460*EMAET
DPET(154) = 0.00466*EMAET
DPET(155) = 0.00470*EMAET
DPET(156) = 0.00473*EMAET
DPET(157) = 0.00478*EMAET
DPET(158) = 0.00482*EMAET
DPET(159) = 0.00487*EMAET
DPET(160) = 0.00491*EMAET
DPET(161) = 0.00495*EMAET
DPET(162) = 0.00500*EMAET
```

```
      DPET(163) = 0.00504*EMAET                                         EVDY0134
      DPET(164) = 0.00508*EMAET                                         EVDY0135
      DPET(165) = 0.00510*EMAET                                         EVDY0136
      DPET(166) = 0.00512*EMAET                                         EVDY0137
      DPET(167) = 0.00514*EMAET                                         EVDY0138
      DPET(168) = 0.00515*EMAET                                         EVDY0139
      DPET(169) = 0.00517*EMAET                                         EVDY0140
      DPET(170) = 0.00519*EMAET                                         EVDY0141
      DPET(171) = 0.00520*EMAET                                         EVDY0142
      DPET(172) = 0.00521*EMAET                                         EVDY0143
      DPET(173) = DPET(172)                                             EVDY0144
      DPET(174) = DPET(172)                                             EVDY0145
      DPET(175) = 0.00522*EMAET                                         EVDY0146
      DPET(176) = 0.00523*EMAET                                         EVDY0147
      DPET(177) = 0.00524*EMAET                                         EVDY0148
      DPET(178) = 0.00525*EMAET                                         EVDY0149
      DPET(179) = 0.00527*EMAET                                         EVDY0150
      DPET(180) = 0.00528*EMAET                                         EVDY0151
      DPET(181) = DPET(180)                                             EVDY0152
      DPET(182) = 0.00529*EMAET                                         EVDY0153
      DPET(183) = 0.00530*EMAET                                         EVDY0154
      DPET(184) = DPET(183)                                             EVDY0155
      DPET(185) = 0.00531*EMAET                                         EVDY0156
      DPET(186) = 0.00532*EMAET                                         EVDY0157
      DPET(187) = 0.00533*EMAET                                         EVDY0158
      DPET(188) = 0.00534*EMAET                                         EVDY0159
      DPET(189) = DPET(188)                                             EVDY0160
      DPET(190) = 0.00535*EMAET                                         EVDY0161
      DPET(191) = 0.00536*EMAET                                         EVDY0162
      DPET(192) = 0.00537*EMAET                                         EVDY0163
      DPET(193) = 0.00538*EMAET                                         EVDY0164
      DPET(194) = DPET(193)                                             EVDY0165
      DPET(195) = 0.00539*EMAET                                         EVDY0166
      DPET(196) = 0.00540*EMAET                                         EVDY0167
      DPET(197) = DPET(196)                                             EVDY0168
```

```
      DPET(198) = 0.00541*EMAET                                          EVDY0169
      DPET(199) = 0.00542*EMAET                                          EVDY0170
      DPET(200) = 0.00543*EMAET                                          EVDY0171
      DPET(201) = 0.00545*EMAET                                          EVDY0172
      DPET(202) = 0.00546*EMAET                                          EVDY0173
      DPET(203) = 0.00547*EMAET                                          EVDY0174
      DPET(204) = 0.00548*EMAET                                          EVDY0175
      DPET(205) = 0.00549*EMAET                                          EVDY0176
      DPET(206) = 0.00550*EMAET                                          EVDY0177
      DPET(207) = 0.00551*EMAET                                          EVDY0178
      DPET(208) = 0.00552*EMAET                                          EVDY0179
      DPET(209) = 0.00553*EMAET                                          EVDY0180
      DPET(210) = 0.00555*EMAET                                          EVDY0181
      DPET(211) = 0.00557*EMAET                                          EVDY0182
      DPET(212) = 0.00558*EMAET                                          EVDY0183
      DPET(213) = 0.00560*EMAET                                          EVDY0184
      DPET(214) = DPET(213)                                              EVDY0185
      DPET(215) = 0.00561*EMAET                                          EVDY0186
      DPET(216) = 0.00562*EMAET                                          EVDY0187
      DPET(217) = 0.00563*EMAET                                          EVDY0188
      DPET(218) = 0.00565*EMAET                                          EVDY0189
      DPET(219) = 0.00567*EMAET                                          EVDY0190
      DPET(220) = DPET(219)                                              EVDY0191
      DO 109 DAY = 221,226                                               EVDY0192
  109 DPET(DAY) = 0.00568*EMAET                                          EVDY0193
      DO 110 DAY = 227,229                                               EVDY0194
  110 DPET(DAY) = DPET(219)                                              EVDY0195
      DPET(230) = 0.00566*EMAET                                          EVDY0196
      DPET(231) = 0.00564*EMAET                                          EVDY0197
      DPET(232) = DPET(217)                                              EVDY0198
      DPET(233) = DPET(216)                                              EVDY0199
      DPET(234) = DPET(213)                                              EVDY0200
      DPET(235) = 0.00559*EMAET                                          EVDY0201
      DPET(236) = DPET(211)                                              EVDY0202
      DPET(237) = DPET(210)                                              EVDY0203
```

```
      DPET(238) = DPET(209)                                             EVDY0204
      DPET(239) = DPET(206)                                             EVDY0205
      DPET(240) = DPET(203)                                             EVDY0206
      DPET(241) = DPET(199)                                             EVDY0207
      DPET(242) = DPET(193)                                             EVDY0208
      DPET(243) = DPET(190)                                             EVDY0209
      DPET(244) = DPET(185)                                             EVDY0210
      DPET(245) = DPET(179)                                             EVDY0211
      DPET(246) = DPET(175)                                             EVDY0212
      DPET(247) = DPET(169)                                             EVDY0213
      DPET(248) = 0.00511*EMAET                                         EVDY0214
      DPET(249) = DPET(163)                                             EVDY0215
      DPET(250) = 0.00497*EMAET                                         EVDY0216
      DPET(251) = 0.00490*EMAET                                         EVDY0217
      DPET(252) = DPET(158)                                             EVDY0218
      DPET(253) = 0.00476*EMAET                                         EVDY0219
      DPET(254) = 0.00468*EMAET                                         EVDY0220
      DPET(255) = 0.00461*EMAET                                         EVDY0221
      DPET(256) = 0.00454*EMAET                                         EVDY0222
      DPET(257) = DPET(150)                                             EVDY0223
      DPET(258) = 0.00437*EMAET                                         EVDY0224
      DPET(259) = 0.00427*EMAET                                         EVDY0225
      DPET(260) = 0.00418*EMAET                                         EVDY0226
      DPET(261) = DPET(142)                                             EVDY0227
      DPET(262) = 0.00397*EMAET                                         EVDY0228
      DPET(263) = DPET(137)                                             EVDY0229
      DPET(264) = 0.00377*EMAET                                         EVDY0230
      DPET(265) = 0.00367*EMAET                                         EVDY0231
      DPET(266) = 0.00356*EMAET                                         EVDY0232
      DPET(267) = 0.00347*EMAET                                         EVDY0233
      DPET(268) = 0.00337*EMAET                                         EVDY0234
      DPET(269) = 0.00329*EMAET                                         EVDY0235
      DPET(270) = DPET(124)                                             EVDY0236
      DPET(271) = 0.00315*EMAET                                         EVDY0237
      DPET(272) = 0.00308*EMAET                                         EVDY0238
```

```
      DPET(273) = 0.00303*EMAET                                          EVDY0239
      DPET(274) = 0.00300*EMAET                                          EVDY0240
      DPET(275) = 0.00298*EMAET                                          EVDY0241
      DPET(276) = 0.00294*EMAET                                          EVDY0242
      DPET(277) = 0.00290*EMAET                                          EVDY0243
      DPET(278) = 0.00286*EMAET                                          EVDY0244
      DPET(279) = 0.00283*EMAET                                          EVDY0245
      DPET(280) = 0.00279*EMAET                                          EVDY0246
      DPET(281) = DPET(116)                                              EVDY0247
      DPET(282) = 0.00271*EMAET                                          EVDY0248
      DPET(283) = DPET(115)                                              EVDY0249
      DPET(284) = DPET(114)                                              EVDY0250
      DPET(285) = 0.00259*EMAET                                          EVDY0251
      DPET(286) = 0.00254*EMAET                                          EVDY0252
      DPET(287) = 0.00252*EMAET                                          EVDY0253
      DPET(288) = 0.00247*EMAET                                          EVDY0254
      DPET(289) = 0.00244*EMAET                                          EVDY0255
      DPET(290) = 0.00239*EMAET                                          EVDY0256
      DPET(291) = DPET(110)                                              EVDY0257
      DPET(292) = 0.00230*EMAET                                          EVDY0258
      DPET(293) = 0.00225*EMAET                                          EVDY0259
      DPET(294) = 0.00222*EMAET                                          EVDY0260
      DPET(295) = 0.00217*EMAET                                          EVDY0261
      DPET(296) = 0.00213*EMAET                                          EVDY0262
      DPET(297) = 0.00210*EMAET                                          EVDY0263
      DPET(298) = 0.00206*EMAET                                          EVDY0264
      DPET(299) = 0.00200*EMAET                                          EVDY0265
      DPET(300) = 0.00197*EMAET                                          EVDY0266
      DPET(301) = 0.00194*EMAET                                          EVDY0267
      DPET(302) = 0.00189*EMAET                                          EVDY0268
      DPET(303) = 0.00186*EMAET                                          EVDY0269
      DPET(304) = 0.00183*EMAET                                          EVDY0270
      DPET(305) = 0.00180*EMAET                                          EVDY0271
      DPET(306) = 0.00177*EMAET                                          EVDY0272
      DPET(307) = 0.00174*EMAET                                          EVDY0273
```

```
      DPET(308) = 0.00172*EMAET                                        EVDY0274
      DPET(309) = DPET(100)                                            EVDY0275
      DPET(310) = DPET( 99)                                            EVDY0276
      DPET(311) = 0.00160*EMAET                                        EVDY0277
      DPET(312) = 0.00156*EMAET                                        EVDY0278
      DPET(313) = 0.00152*EMAET                                        EVDY0279
      DPET(314) = 0.00149*EMAET                                        EVDY0280
      DPET(315) = 0.00146*EMAET                                        EVDY0281
      DPET(316) = DPET( 95)                                            EVDY0282
      DPET(317) = 0.00138*EMAET                                        EVDY0283
      DPET(318) = 0.00135*EMAET                                        EVDY0284
      DPET(319) = 0.00131*EMAET                                        EVDY0285
      DPET(320) = 0.00127*EMAET                                        EVDY0286
      DPET(321) = 0.00124*EMAET                                        EVDY0287
      DPET(322) = 0.00120*EMAET                                        EVDY0288
      DPET(323) = DPET( 90)                                            EVDY0289
      DPET(324) = 0.00116*EMAET                                        EVDY0290
      DPET(325) = DPET( 89)                                            EVDY0291
      DPET(326) = 0.00110*EMAET                                        EVDY0292
      DPET(327) = 0.00107*EMAET                                        EVDY0293
      DPET(328) = 0.00104*EMAET                                        EVDY0294
      DPET(329) = DPET( 86)                                            EVDY0295
      DPET(330) = 0.00100*EMAET                                        EVDY0296
      DPET(331) = 0.00098*EMAET                                        EVDY0297
      DPET(332) = 0.00097*EMAET                                        EVDY0298
      DPET(333) = 0.00095*EMAET                                        EVDY0299
      DPET(334) = 0.00093*EMAET                                        EVDY0300
      DPET(335) = DPET( 81)                                            EVDY0301
      DPET(336) = DPET( 80)                                            EVDY0302
      DPET(337) = 0.00087*EMAET                                        EVDY0303
      DPET(338) = DPET( 79)                                            EVDY0304
      DPET(339) = DPET( 78)                                            EVDY0305
      DPET(340) = DPET( 77)                                            EVDY0306
      DPET(341) = DPET( 75)                                            EVDY0307
      DPET(342) = DPET( 73)                                            EVDY0308
```

```
      DPET(343) = DPET( 71)                                             EVDY0309
      DPET(344) = DPET( 71)                                             EVDY0310
      DPET(345) = DPET( 69)                                             EVDY0311
      DPET(346) = DPET( 68)                                             EVDY0312
      DPET(347) = DPET( 66)                                             EVDY0313
      DPET(348) = DPET( 63)                                             EVDY0314
      DPET(349) = DPET( 62)                                             EVDY0315
      DPET(350) = DPET( 57)                                             EVDY0316
      DPET(351) = DPET( 57)                                             EVDY0317
      DPET(352) = DPET( 56)                                             EVDY0318
      DO 111 DAY = 353,355                                              EVDY0319
  111 DPET(DAY) = DPET( 51)                                             EVDY0320
      DPET(356) = DPET( 44)                                             EVDY0321
      DPET(357) = DPET( 44)                                             EVDY0322
      DPET(358) = DPET( 42)                                             EVDY0323
      DPET(359) = DPET( 41)                                             EVDY0324
      DPET(360) = DPET( 39)                                             EVDY0325
      DPET(361) = DPET( 34)                                             EVDY0326
      DPET(362) = DPET( 33)                                             EVDY0327
      DO 112 DAY = 363,365                                              EVDY0328
  112 DPET(DAY) = DPET(  1)                                             EVDY0329
      DPET(366) = DPET( 57)                                             EVDY0330
      RETURN                                                            EVDY0331
      END                                                               EVDY0332


      SUBROUTINE PRECHK(DRGPM,DRHP,DRSF,VWIN,SGRT,NATRH)                PRCK0001
C  CHECKS PRECIPITATION-STREAMFLOW ANOMALIES AND ADJUSTS PRECIPITATION  PRCK0002
C     WHERE NECESSARY                                                   PRCK0003
      DIMENSION  DRGPM(366),DRHP(366,24),DRSF(366)                      PRCK0004
      INTEGER  DAY,HOUR,SGRT                                            PRCK0005
      AHP = 0.0                                                         PRCK0006
      NRHA = 24 - NATRH                                                 PRCK0007
      RGPM = DRGPM(90)                                                  PRCK0008
```

```
      DAY = 90
      RMWR = 1.25
  100 DAY = DAY + 1
      IF(DAY .GT. 200 .OR. VWIN .GT. 750.0) RMWR = 2.00
      RFRISE = (DRSF(DAY) - DRSF(DAY-1))/VWIN
      DO 101 HOUR = 1,24
      IF(HOUR .EQ. SGRT+1) RGPM = DRGPM(DAY)
      AHP = AHP + DRHP(DAY,HOUR)*RGPM
      IF(HOUR .NE. NRHA) GO TO 101
      RWRAIN = AHP
      AHP = 0.0
  101 CONTINUE
      IF(RFRISE .GT. RWRAIN .AND. RFRISE .GT. 0.1) GO TO 102
      IF((RWRAIN .GT. RMWR .AND. RFRISE .LT. 0.02*RWRAIN) .OR. (RWRAIN
     1 .GT. 3.00 .AND. RFRISE .LT. 0.05*RWRAIN)) GO TO 104
      GO TO 108
  102 IF(RWRAIN .GT. 0.05) GO TO 103
      RAA = RFRISE*2.0 - RWRAIN + 1.0
      DRHP(DAY,13) = RAA
      WRITE(6,1) DAY, RAA
    1 FORMAT(/10X,'FOR DAY',I4,1X,'RAIN ADDED OF',F7.2)
      GO TO 108
  103 RAM = 2.0*RFRISE/RWRAIN
      GO TO 105
  104 RAM = 10.0*RFRISE/RWRAIN
  105 IF(RAM .LT. 0.0) GO TO 108
      WRITE(6,2) DAY,RAM,RWRAIN
    2 FORMAT(/5X,'FOR DAY',I4,1X,'RAIN ADJUSTMENT MULTIPLIER IS',F8.4,
     1  1X,'RECORDED RAIN IS',F7.2)
      DO 106 HOUR = 1,NRHA
  106 DRHP(DAY,HOUR) = DRHP(DAY,HOUR)*RAM
      IF(NATRH .EQ. 0) GO TO 108
      NFRHA = NRHA + 1
      DO 107 HOUR = NFRHA,24
  107 DRHP(DAY-1,HOUR) = DRHP(DAY-1,HOUR)*RAM
```

```
108 IF(DAY .NE. 273) GO TO 100
    RETURN
    END


    SUBROUTINE PREPRD(RGPM,DRHP,DAY,HOUR,DPY,PRD,PEP,PRH)
C   DIVIDES HOURLY PRECIPITATION TOTALS AMONG PERIODS FOR SMALL BASINS
    DIMENSION DRHP(366,24), PE4P(4)
    INTEGER DAY,DPY,HOUR,PRD
    PEP = 0.0
    IF(PRH .EQ. 0.0) RETURN
    IF(PRD .EQ. 1) GO TO 100
    PEP = PE4P(PRD)
    RETURN
100 LHOUR = HOUR - 1
    LDAY = DAY
    IF(LHOUR .GE. 1) GO TO 101
    LHOUR = 24
    LDAY = DAY - 1
    IF(LDAY .EQ. 0) LDAY = 365
    IF(LDAY .EQ. 365) LDAY = 59
    IF(LDAY .EQ. 59 .AND. DPY .EQ. 366) LDAY = 366
101 PRLH = RGPM*DRHP(LDAY,LHOUR)
    NHOUR = HOUR + 1
    NDAY = DAY
    IF(NHOUR .LE. 24) GO TO 102
    NHOUR = 1
    CALL DAYNXT(NDAY,DPY)
102 PRNH = RGPM*DRHP(NDAY,NHOUR)
    IF(PRH .GT. PRLH .AND. PRH .GT. PRNH) GO TO 103
    GO TO 104
103 PE4P(1) = 0.10
    PE4P(2) = 0.28
    PE4P(3) = 0.46
```

```
      PE4P(4) = 0.16                                                    PREP0030
      GO TO 108                                                         PREP0031
  104 IF(PRH .LT. PRLH .AND. PRH .LT. PRNH) GO TO 105                  PREP0032
      GO TO 106                                                         PREP0033
  105 PE4P(1) = 0.28                                                    PREP0034
      PE4P(2) = 0.10                                                    PREP0035
      PE4P(3) = 0.16                                                    PREP0036
      PE4P(4) = 0.46                                                    PREP0037
      GO TO 108                                                         PREP0038
  106 IF(PRNH .GE. PRLH) GO TO 107                                      PREP0039
      PE4P(1) = 0.46                                                    PREP0040
      PE4P(2) = 0.16                                                    PREP0041
      PE4P(3) = 0.28                                                    PREP0042
      PE4P(4) = 0.10                                                    PREP0043
      GO TO 108                                                         PREP0044
  107 PE4P(1) = 0.10                                                    PREP0045
      PE4P(2) = 0.28                                                    PREP0046
      PE4P(3) = 0.16                                                    PREP0047
      PE4P(4) = 0.46                                                    PREP0048
  108 DO 109 KPRD = 1,4                                                 PREP0049
  109 PE4P(KPRD) = PE4P(KPRD)*PRH                                       PREP0050
      PEP = PE4P(1)                                                     PREP0051
      RETURN                                                            PREP0052
      END                                                               PREP0053


      SUBROUTINE RECESS(DRSF,DPY,EFRC,IFRC,AREA,RSBD,RSBIF,NRS,RSBBF)   RCSS0001
C  ESTABLISHES RECESSION SEQUENCES                                      RCSS0002
      DIMENSION  DRSF(366),LBFO(20),NDRS(20),RSBBF(20),RSBD(20),        RCSS0003
     1  RSBFRC(20),RSBIF(20),RSIFRC(20),RSTF(50,20)                     RCSS0004
      LOGICAL  LBFO                                                     RCSS0005
      INTEGER  DAY,DPY,RSBD,RSL                                         RCSS0006
      REAL  IFRC                                                        RCSS0007
      MRSL = 9                                                          RCSS0008
```

```
      BFRC = 0.9
      IFRC = 0.05
      FRERS = 0.1*SQRT(AREA)
  100 DO 101 KSD = 1,50
      DO 101 KRS = 1,20
  101 RSTF(KSD,KRS) = 0.0
      KRS = 0
      DAY = 274
C   BEGIN NEW SEQUENCE
  102 IF(KRS .GE. 20) GO TO 109
      KRS = KRS + 1
      KSD = 1
      RSF1 = DRSF(DAY)
      CALL DAYNXT(DAY,DPY)
      IF(DAY .EQ. 274) GO TO 107
      RSF2 = DRSF(DAY)
      RSBD(KRS) = DAY
      IF(RSF2 .LT. RSF1+FRERS .AND. (RSF2 .GT. 0.4*AREA .OR. RSF2 .GT.
     1  10.0)) GO TO 103
      KRS = KRS - 1
      GO TO 102
  103 RSTF(1,KRS) = RSF2
      RSFM = RSF2
  104 KSD = KSD + 1
      CALL DAYNXT(DAY,DPY)
      IF(DAY .EQ. 274) GO TO 107
      RSFN = DRSF(DAY)
      IF(RSFN .LT. (RSFM + FRERS) .AND. RSFN .GT. 0.0) GO TO 106
      IF(KSD .GE. MRSL) GO TO 102
      NDRS(KRS) = 0
      DO 105 KSD = 1,MRSL
  105 RSTF(KSD,KRS) = 0.0
      KRS = KRS - 1
      GO TO 102
  106 IF(RSFN .LT. RSFM) RSFM = RSFN
```

```
      RSTF(KSD,KRS) = RSFN
      NDRS(KRS) = KSD
      IF(KSD .GE. 50) GO TO 102
      GO TO 104
  107 IF(KSD .GE. MRSL) GO TO 109
      NTRS = KRS - 1
      DO 108 KSD = 1,MRSL
  108 RSTF(KSD,KRS) = 0.0
      GO TO 110
  109 NTRS = KRS
  110 CONTINUE
      IF(NTRS .GE. 3) GO TO 111
      IF(MRSL .LT. 7) RETURN
      MRSL = 6
      GO TO 100
C  WRITE OUT ESTABLISHED ARRAY OF FLOW SEQUENCES
  111 WRITE(6,1)
    1 FORMAT(/5X,'FLOW SEQUENCES USED TO ESTIMATE RECESSION CONSTANTS')
      DO 113 KRS = 1,NTRS
      NDRSC = NDRS(KRS)
      DO 112 KSD = 2,NDRSC
  112 RSTF(KSD-1,KRS) = RSTF(KSD,KRS)
      NDRS(KRS) = NDRS(KRS) - 1
      NDRSC = NDRSC - 1
      WRITE(6,2) KRS,(RSTF(KSD,KRS),KSD=1,NDRSC)
    2 FORMAT(/10X,I2,5(10F8.1/12X))
  113 CONTINUE
C  DETERMINE RECESSION CONSTANTS FROM EACH SEQUENCE
  114 DO 116 KRS = 1,NTRS
      IF((RSTF(1,KRS) .LT. 0.4*AREA) .AND. (RSTF(2,KRS) .GT. 0.8*
     1 (RSTF(1,KRS)))) GO TO 115
      LBFO(KRS) = .FALSE.
      CALL SET2RC(RSTF,KRS,NDRS(KRS),RSIFRC(KRS),RSBFRC(KRS),LBFO(KRS))
      IF(LBFO(KRS) .OR. RSBFRC(KRS) .GT. 1.2 .OR. RSBFRC(KRS) .LT. 0.6
     1 .OR. RSIFRC(KRS) .GT. 0.8 .OR. RSIFRC(KRS) .LT. -0.4) GO TO 115
```

```
      GO TO 116
  115 LBFO(KRS) = .TRUE.
      CALL SETIRC(RSTF,KRS,NDRS(KRS),RSBFRC(KRS))
  116 CONTINUE
C  CALCULATE WEIGHTED AVERAGE RECESSION CONSTANTS
      BFRC = 0.0
      IFRC = 0.0
      ABFSL = 0.0
      AIFSL = 0.0
      DO 118 KRS = 1,NTRS
      IF(RSBFRC(KRS) .GT. 1.2 .OR. RSBFRC(KRS) .LT. 0.7) GO TO 117
      RSL = NDRS(KRS)
      BFRC = BFRC + RSBFRC(KRS)*RSL
      ABFSL = ABFSL + RSL
      IF(LBFO(KRS)) GO TO 118
      IF(RSL .GE. 20.0) RSL = 20.0
      IFRC = IFRC + RSIFRC(KRS)*RSL
      AIFSL = AIFSL + RSL
      GO TO 118
  117 WRITE(6,3) KRS
    3 FORMAT(10X,'SEQUENCE',I3,1X,'OMITTED IN AVERAGING')
  118 CONTINUE
      WRITE(6,4) ABFSL,AIFSL
    4 FORMAT(10X,'BASE FLOW DAYS =',F5.0,2X,'INTERFLOW DAYS =',F5.0)
      BFRC = BFRC/ABFSL
      IFRC = IFRC/AIFSL
      IF(BFRC .GT. 0.99) BFRC = 0.99
      IF(BFRC .LT. 0.70) BFRC = 0.70
      KSQ = 0
      DO 119 KRS = 1,NTRS
      IF(LBFO(KRS)) GO TO 119
      CALL SETRBF(RSTF,NDRS,KRS,BFRC,IFRC,CRSBIF,CRSBBF)
      IF(CRSBIF .GT. 95000.0 .OR. CRSBBF .LT. 0.0) GO TO 119
      IF(CRSBIF .LT. 0.0) CRSBIF = 0.0
      KSQ  = KSQ + 1
```

```
      RSBD(KSQ) = RSBD(KRS)                                             RCSS0114
      RSBIF(KSQ) = CRSBIF                                               RCSS0115
      RSBBF(KSQ) = CRSBBF                                               RCSS0116
  119 CONTINUE                                                          RCSS0117
      NRS = KSQ                                                         RCSS0118
      DO 120 KSQ = 1,NRS                                                RCSS0119
      DAY = RSBD(KSQ)                                                   RCSS0120
      CALL DAYNXT(DAY,DPY)                                              RCSS0121
  120 RSBD(KSQ) = DAY                                                   RCSS0122
      DO 121 KSQ = 1,NRS                                                RCSS0123
      CRSBTF = RSBIF(KSQ) + RSBBF(KSQ)                                  RCSS0124
  121 WRITE(6,5) KSQ,RSBD(KSQ),RSBIF(KSQ),RSBBF(KSQ),CRSBTF.            RCSS0125
    5 FORMAT(/10X,'REVISED FLOW SEQUENCE',I3,1X,1X,'BEGINS ON DAY',I4,  RCSS0126
     1  1X,'AT INTERFLOW =',F7.2,1X,'CFS,  BASE FLOW =',F7.2,1X,'CFS,   RCSS0127
     1  TOTAL =',F7.2,1X,'CFS')                                         RCSS0128
      RETURN                                                            RCSS0129
      END                                                               RCSS0130
```



```
      SUBROUTINE SET2RC(RSTF,KRS,NDRSC,IFRC,BFRC,LBFO)                  ST2R0001
C   SETS BEST VALUES FOR TWO RECESSION CONSTANTS                        ST2R0002
      DIMENSION  RSTF(50,20)                                            ST2R0003
      LOGICAL  LBFO                                                     ST2R0004
      REAL  IFRC                                                        ST2R0005
      REAL*8  RA1,RA2,RA3,RA4,RA5,CRSTF(50),RA6,DBFRC,DIFRC,RA,RB,RD    ST2R0006
      DO 100 KSD = 1,NDRSC                                              ST2R0007
  100 CRSTF(KSD) = RSTF(KSD,KRS)                                        ST2R0008
      NDRSC2 = NDRSC - 2                                                ST2R0009
      RA1 = 0.0                                                         ST2R0010
      RA2 = 0.0                                                         ST2R0011
      RA3 = 0.0                                                         ST2R0012
      DO 101 KSD = 1,NDRSC2                                             ST2R0013
      RA1 = RA1 + CRSTF(KSD)**2                                         ST2R0014
      RA2 = RA2 + CRSTF(KSD)*CRSTF(KSD+1)                               ST2R0015
```

```
  101 RA3 = RA3 + CRSTF(KSD)*CRSTF(KSD+2)                                  ST2R0016
      RA4 = RA1 + CRSTF(NDRSC-1)**2 - CRSTF(1)**2                          ST2R0017
      RA5 = RA2 + CRSTF(NDRSC-1)*CRSTF(NDRSC) - CRSTF(1)*CRSTF(2)          ST2R0018
      RA6 = RA4*RA1 - RA2**2                                               ST2R0019
      IF(RA6 .EQ. 0.0) GO TO 102                                           ST2R0020
      RA5 = RA5/RA6                                                        ST2R0021
      RA3 = RA3/RA6                                                        ST2R0022
      RA = RA1*RA5 - RA2*RA3                                               ST2R0023
      RB = RA4*RA3 - RA2*RA5                                               ST2R0024
      RD = RA**2 + 4.0*RB                                                  ST2R0025
      IF(RD .LT. 0.0) GO TO 102                                            ST2R0026
      DBFRC = (RA + RD**0.5)/2.0                                           ST2R0027
      DIFRC = RA - DBFRC                                                   ST2R0028
      BFRC = DBFRC                                                         ST2R0029
      IFRC = DIFRC                                                         ST2R0030
      WRITE(6,1) KRS,BFRC,IFRC                                             ST2R0031
    1 FORMAT(15X,'KRS =',I3,5X,'BFRC =',F8.4,5X,'IFRC =',F8.4)             ST2R0032
      GO TO 103                                                            ST2R0033
  102 LBFO = .TRUE.                                                        ST2R0034
      WRITE(6,2) KRS                                                       ST2R0035
    2 FORMAT(/15X,'IMAGINARY VALUES ENCOUNTERED IN SET2RC, SEQUENCE =',    ST2R0036
     1 I3)                                                                 ST2R0037
  103 RETURN                                                               ST2R0038
      END                                                                  ST2R0039


      SUBROUTINE SET1RC(RSTF,KRS,NDRSC,BFRC)                               ST1R0001
C     SETS BEST VALUE FOR ONE RECESSION CONSTANT                           ST1R0002
      DIMENSION  RSTF(50,20)                                               ST1R0003
      RA1 = 0.0                                                            ST1R0004
      RA2 = 0.0                                                            ST1R0005
      NDRSC1 = NDRSC - 1                                                   ST1R0006
      DO 100 KSD = 1,NDRSC1                                                ST1R0007
      RA1 = RA1 + RSTF(KSD,KRS)**2                                         ST1R0008
```

```
  100 RA2 = RA2 + RSTF(KSD,KRS)*RSTF(KSD+1,KRS)                        ST1R0009
      BFRC = RA2/RA1                                                   ST1R0010
      WRITE(6,1) KRS,BFRC                                              ST1R0011
    1 FORMAT(15X,'KRS =',I3,5X,'BFRC =',F8.4)                          ST1R0012
      RETURN                                                           ST1R0013
      END                                                              ST1R0014


      SUBROUTINE SETFVP(LZC,SUZC,ETLF,BUZC,SIAC,TMSTF,TMRTF,TMPREC,    STFV0001
     1 TMPET,EMLZS,SSQM,LRC,XMPFT,FTX,NOFM,LBUZC,LETLF,LLZC,APREC,APET) STFV0002
C  SETS BEST VALUES OF FLOW VOLUME PARAMETERS                           STFV0003
      DIMENSION  EMLZS(12),MFDP(12),MXA(12),TMPET(12),TMPREC(12),      STFV0004
     1  TMRTF(12),TMSTF(12),XMPFT(12)                                   STFV0005
      LOGICAL  LBUZC,LETLF,LLZC,LRC                                     STFV0006
      REAL  LZC,MFDP                                                    STFV0007
      CALL SETFDI(MFDP,TMSTF,TMRTF,SSQM)                                STFV0008
      IF((MFDP(2) + MFDP(3)) .GT. 2.0 .AND. FTX .LT. 1.05) FTX = 0.9   STFV0009
      IF((MFDP(2) + MFDP(3)) .LT. -2.0 .AND. FTX .GT. 0.95) FTX = 1.1  STFV0010
C  ADJUSTMENT OF LZC BASED ON MONTHS WHERE OVER HALF OF TOTAL           STFV0011
C     SYNTHESIZED RUNOFF IS OVERLAND FLOW, MINIMUM OF TWO MONTHS        STFV0012
C     WITH GREATEST RUNOFF USED                                         STFV0013
      PLZC = LZC                                                        STFV0014
      FNOFM = NOFM                                                      STFV0015
      IF(NOFM .GT. 2) GO TO 103                                         STFV0016
      M1R = 2                                                           STFV0017
      M2R = 1                                                           STFV0018
      IF(TMRTF(2) .GT. TMRTF(1)) GO TO 100                              STFV0019
      M1R = 1                                                           STFV0020
      M2R = 2                                                           STFV0021
  100 DO 102 MONTH = 3,12                                               STFV0022
      IF(TMRTF(MONTH) .LT. TMRTF(M2R)) GO TO 102                        STFV0023
      IF(TMRTF(MONTH) .GT. TMRTF(M1R)) GO TO 101                        STFV0024
      M2R = MONTH                                                       STFV0025
      GO TO 102                                                         STFV0026
```

```
  101 M2R = M1R
      M1R = MONTH
  102 CONTINUE
      IF(LLZC) GO TO 106
      FLZC = (MFDP(M1R) + MFDP(M2R))/2.0
      GO TO 105
  103 SOFMD = 0.0
      KM1 = 0
      DO 104 MONTH = 1,12
      IF(XMPET(MONTH) .LT. 1.5) GO TO 104
      SOFMD = SOFMD + MFDP(MONTH)
      KM1 = KM1 + 1
      MXA(KM1) = MONTH
  104 CONTINUE
      FLZC = SOFMD/(FNOFM*0.75)
  105 IF(FLZC .GT. 1.0) FLZC = 1.0
      IF(FLZC .LT. -1.0) FLZC = -1.0
      IF(FLZC .GT. 0.0) LZC = (FLZC + 1.0)*LZC
      IF(FLZC .LE. 0.0) LZC = LZC/(1.0 + ABS(FLZC))
      IF(NOFM .LE. 2) WRITE(6,1) LZC,M1R,M2R
    1 FORMAT(/5X,'LZC WAS CHANGED TO',F6.2,' BASED ON MONTHS',2I3)
      IF(NOFM .GT. 2) WRITE(6,2) LZC,(MXA(KWD), KWD = 1,NOFM)
    2 FORMAT(/5X,'LZC WAS CHANGED TO',F6.2,' BASED ON MONTHS',12I3)
      IF(LZC .LT. 2.0 .AND. LRC) LZC = 2.0
      IF(LZC .GT. 30.0 .AND. LRC) LZC = 30.0
C   SELECTION OF MONTHS BEGINNING WET AND BEGINNING DRY SEASONS
  106 MBWS = 0
      MBDS = 0
      DO 109 MONTH = 2,10
      IF(TMPET(MONTH) .GT. TMPREC(MONTH)) GO TO 108
      IF(MBWS .NE. 0) GO TO 107
      MBWS = MONTH
      GO TO 109
  107 MBDS = MONTH + 1
      GO TO 109
```

```
  108 IF(MBDS .NE. 0) GO TO 110
  109 CONTINUE
  110 MBDS = MBDS + 1
C  ADJUSTMENT OF SUZC BASED ON TWO WETTEST SUMMER MONTHS AND LAST TWO
C     BASE FLOW MONTHS
      M11 = 0
      M12 = 0
      PRM1 = 0.0
      M1SP = 0
      DO 112 MNX = 7,14
      MONTH = MNX
      IF(MNX .GT. 12) MONTH = MNX - 12
      IF(TMPREC(MONTH) .LE. PRM1) GO TO 111
      M2SP = M1SP
      PRM2 = PRM1
      M1SP = MONTH
      PRM1 = TMPREC(MONTH)
      GO TO 112
  111 IF(TMPREC(MONTH) .LE. PRM2) GO TO 112
      M2SP = MONTH
      PRM2 = TMPREC(MONTH)
  112 CONTINUE
      FSUZC = MFDP(M1SP) + MFDP(M2SP)
      IF(ABS(XMPFT(12) - 1.0) .GT. 0.2) GO TO 113
      FSUZC = FSUZC + MFDP(12)
      M12 = 12
  113 IF(ABS(XMPFT(11) - 1.0) .GT. 0.2) GO TO 114
      FSUZC = FSUZC + MFDP(11)
      M11 = 11
  114 IF(FSUZC .GT. 1.0) FSUZC = 1.0
      IF(FSUZC .LT. -1.0) FSUZC = -1.0
      IF(FSUZC .GT. 0.0) SUZC = (FSUZC + 1.0)*SUZC
      IF(FSUZC .LE. 0.0) SUZC = SUZC/(1.0 + ABS(FSUZC))
      WRITE(6,3) SUZC,M1SP,M2SP,M11,M12
    3 FORMAT(4X,'SUZC WAS CHANGED TO',F6.2,' BASED ON MONTHS',4I3)
```

```
      IF(SUZC .LT. 0.3 .AND. LRC) SUZC = 0.3
      IF(SUZC .GT. 3.0 .AND. LRC) SUZC = 3.0
C  ADJUSTMENT OF ETLF BASED ON SUMMER MONTHS OF RAINFALL EXCEEDING TWO
C     INCHES OR NEED TO PREVENT MOISTURE BUILDUP
      IF(EMLZS(12) .LT. PLZC .OR. EMLZS(11) .LT. PLZC .OR. APREC .GT.
     1  1.5*APET) GO TO 115
      FETLF = 1.0
      MXA(1) = 13
      KWSM = 1
      GO TO 120
  115 SWSMD = 0.0
      KWSM = 0
      DO 116 MONTH = 1,12
      IF((MONTH .GT. MBWS .OR. MONTH .GT. 2) .AND. (MONTH .LT. MBDS
     1  .AND. MONTH .LT. 9)) GO TO 116
      IF(TMPREC(MONTH) .LT. 2.0) GO TO 116
      SWSMD = SWSMD + MFDP(MONTH)
      KWSM = KWSM + 1
      MXA(KWSM) = MONTH
  116 CONTINUE
      IF(KWSM .GE. 1) GO TO 117
      MXA(1) = M1R
      KWSM = 1
      FETLF = 5.0*MFDP(M1R)
      GO TO 120
  117 WSM = KWSM
      IF(.NOT. LETLF .OR. KWSM .EQ. 1) GO TO 119
      EMFDP = 0.0
      DO 118 MONTH = 1,KWSM
      KM1 = MXA(MONTH)
      IF(MFDP(KM1) .LT. EMFDP) GO TO 118
      EMFDP= MFDP(KM1)
      KM2 = MONTH
  118 CONTINUE
      MXA(KM2) = 0
```

```
      SWSMD = SWSMD - EMFDP
      WSM = WSM - 1.0
  119 FETLF = 1.2*SWSMD/WSM
  120 IF(FETLF .GT. 1.0) FETLF = 1.0
      IF(FETLF .LT. -1.0) FETLF = -1.0
      IF(FETLF .GT. 0.0) ETLF = (FETLF + 1.0)*ETLF
      IF(FETLF .LT. 0.0) ETLF = ETLF/(1.0 + ABS(FETLF))
      WRITE(6,4) ETLF,(MXA(KWD), KWD = 1,KWSM)
    4 FORMAT(4X,'ETLF WAS CHANGED TO',F6.2,' BASED ON MONTHS',12I3)
      IF(ETLF .LT. 0.05 .AND. LRC) ETLF = 0.05
      IF(ETLF .GT. 0.6 .AND. LRC) ETLF = 0.6
C  ADJUSTMENT OF BUZC BASED ON SEPTEMBER, NOVEMBER, AND DECEMBER
      KM1 = 12
      KM2 = 2
      KM3 = 3
      FBUZC = 0.4*(MFDP(12) + MFDP(2) + MFDP(3))
      IF(.NOT. LBUZC) GO TO 121
      FBUZC = 0.4*(MFDP(9) + MFDP(10) + MFDP(11))
      KM1 = 9
      KM2 = 10
      KM3 = 11
  121 IF(FBUZC .GT. 1.0) FBUZC = 1.0
      IF(FBUZC .LT. -1.0) FBUZC = -1.0
      IF(FBUZC .GT. 0.0) BUZC = (FBUZC + 1.0)*BUZC
      IF(FBUZC .LE. 0.0) BUZC = BUZC/(1.0 + ABS(FBUZC))
      WRITE(6,5) BUZC,KM1,KM2,KM3
    5 FORMAT(4X,'BUZC WAS CHANGED TO',F6.2,' BASED ON MONTHS',3I3)
      IF(BUZC .LT. 0.2 .AND. LRC) BUZC = 0.2
      IF(BUZC .GT. 4.0 .AND. LRC) BUZC = 4.0
C  ADJUSTMENT OF SIAC BASED ON THREE FIRST MOISTURE EXCESS AND THREE
C     FIRST MOISTURE DEFICIENT MONTHS
      KM1 = MBDS
      KM2 = MBDS + 1
      KM3 = MBDS - 1
      KM4 = 0
```

```
      KM5 = 0                                                           STFV0167
      KM6 = 0                                                           STFV0168
      WFDX = 0.0                                                        STFV0169
      IF(SIAC .GT. 1.0) GO TO 122                                       STFV0170
      WFDX = (MFDP(MBWS) + MFDP(MBWS+1) + MFDP(MBWS+2))/3.0             STFV0171
      IF(SIAC .GT. 0.6) WFDX = WFDX*(1.0 - SIAC)/0.4                    STFV0172
      KM4 = MBWS                                                        STFV0173
      KM5 = MBWS + 1                                                    STFV0174
      KM6 = MBWS + 2                                                    STFV0175
  122 SFDX = (MFDP(MBDS) + MFDP(MBDS+1) + MFDP(MBDS-1))/3.0             STFV0176
      FSIAC = 1.5*(SFDX - WFDX)                                         STFV0177
      IF(FSIAC .GT. 1.0) FSIAC = 1.0                                    STFV0178
      IF(FSIAC .LE. -1.0) FSIAC = -1.0                                  STFV0179
      IF(SIAC .LT. 0.02) SIAC = 0.02                                    STFV0180
      IF(FSIAC .GT. 0.0) SIAC = (FSIAC + 1.0)*SIAC                      STFV0181
      IF(FSIAC .LE. 0.0) SIAC = SIAC/(1.0 + ABS(FSIAC))                 STFV0182
      WRITE(6,6) SIAC,KM4,KM5,KM6,KM3,KM1,KM2                           STFV0183
    6 FORMAT(4X,'SIAC WAS CHANGED TO',F6.2,' BASED ON MONTHS',6I3)      STFV0184
      IF(SIAC .LT. 0.02 .AND. LRC) SIAC = 0.00                          STFV0185
      IF(SIAC .GT. 4.0 .AND. LRC) SIAC = 4.0                            STFV0186
      RETURN                                                            STFV0187
      END                                                               STFV0188


      SUBROUTINE SETFDI(MFDP,TMSTF,TMRTF,SSQM)                          STFD0001
C   SETS VALUES OF FLOW DEVIATION INDICES                               STFD0002
      DIMENSION MFDP(12),TMRTF(12),TMSTF(12)                            STFD0003
      REAL   MFDP                                                       STFD0004
      DO 101 MONTH = 1,12                                               STFD0005
      IF(MONTH .LE. 2) SSQM = 0.0                                       STFD0006
      SMFX = TMSTF(MONTH) + 20.0                                        STFD0007
      RMFX = TMRTF(MONTH) + 20.0                                        STFD0008
      MFDP(MONTH) = SMFX/RMFX - 1.0                                     STFD0009
      IF(MFDP(MONTH) .GT. 8.0) MFDP(MONTH) = 8.0                        STFD0010
```

```
      IF(MFDP(MONTH) .LT. 0.0) MFDP(MONTH) = 1.0 - RMFX/SMFX           STFD0011
      IF(MFDP(MONTH) .LT. -8.0) MFDP(MONTH) = -8.0                     STFD0012
  100 SSQM = SSQM + MFDP(MONTH)*MFDP(MONTH)                            STFD0013
  101 CONTINUE                                                         STFD0014
      WRITE(6,1) (MFDP(MONTH), MONTH=1,12), SSQM                       STFD0015
    1 FORMAT(//2X,'MONTHLY DEVIATIONS',/16X,12(F7.3,1X),'SSQM =',F7.3) STFD0016
      RETURN                                                           STFD0017
      END                                                              STFD0018


      SUBROUTINE SETBMI(BMIR,NRS,BFRC,RSBBF,SBFRS,FNCTRH,IFT)          STBM0001
C   SETS BEST VALUE OF BASIC MAXIMUM INFILTRATION RATE WITHIN WATERSHED STBM0002
      DIMENSION  RSBBF(20),SBFRS(3,20)                                 STBM0003
      ARSTR = 0.0                                                      STBM0004
      DO 101 KRS = IFT,NRS                                             STBM0005
      RBF = RSBBF(KRS)/BFRC                                            STBM0006
      DO 100 KDY = 1,3                                                 STBM0007
      RBF = RBF*BFRC                                                   STBM0008
      SBF = SBFRS(KDY,KRS)*BFRC**(FNCTRH/48.0)                         STBM0009
      RSTR = SBF/RBF                                                   STBM0010
      IF(RSTR .GT. 3.0) RSTR = 3.0                                     STBM0011
      ARSTR = ARSTR + RSTR                                             STBM0012
      WRITE(6,1) KRS,KDY,SBF,RBF                                       STBM0013
    1 FORMAT(10X,'KRS =',I3,2X,'KDY =',I2,2X,'SBF =',F7.1,5X,'RBF =',  STBM0014
     1  F7.1)                                                          STBM0015
  100 CONTINUE                                                         STBM0016
  101 CONTINUE                                                         STBM0017
      TBRD = NRS*3                                                     STBM0018
      ARSTR = ARSTR/TBRD                                               STBM0019
      ARSTR = ARSTR**1.3                                               STBM0020
      PBMIR = BMIR                                                     STBM0021
      BMIR = PBMIR/ARSTR                                               STBM0022
      WRITE(6,2) PBMIR,BMIR                                            STBM0023
    2 FORMAT(5X,'BMIR CHANGED FROM',F6.2,2X,'TO',F6.2//)               STBM0024
```

```
      RETURN
      END


      SUBROUTINE SETRBF(RSTF,NDRS,KRS,BFRC,IFRC,CRSBIF,CRSBBF)
C   SETS VALUES OF INTERFLOW AND BASE FLOW AT RECESSION BEGINNING
      DIMENSION  RSTF(50,20),NDRS(20)
      REAL*8  RA1,RA2,RA3,RA4,RA5,RA6
      REAL  IFRC
      RA1 = 0.0
      RA2 = 0.0
      RA3 = 0.0
      RA4 = 0.0
      RA5 = 0.0
      MNDRS = 12
      IF(NDRS(KRS) .LT. 12) MNDRS = NDRS(KRS)
      IF(IFRC .GE. 0.3) GO TO 101
      CRSBIF = 0.0
      DO 100 KSD = 1,MNDRS
      RA1 = RA1 + BFRC**(2*KSD)
  100 RA4 = RA4 + RSTF(KSD,KRS)*(BFRC**KSD)
      CRSOBF = RA4/RA1
      CRSBBF = CRSOBF*BFRC
      RETURN
  101 CRSBIF = 100000.0
      DO 102 KSD = 1,MNDRS
      RA1 = RA1 + BFRC**(2*KSD)
      RA2 = RA2 + IFRC**(2*KSD)
      RA3 = RA3 + (BFRC*IFRC)**KSD
      RA4 = RA4 + RSTF(KSD,KRS)*(BFRC**KSD)
      RA5 = RA5 + RSTF(KSD,KRS)*(IFRC**KSD)
  102 CONTINUE
      RA6 = RA1*RA2 - RA3**2
      IF(RA6 .EQ. 0.0) RETURN
```

```
      CRSOIF = -(RA3/RA6)*RA4 + (RA1/RA6)*RA5                           STRB0031
      CRSBIF = CRSOIF*IFRC                                              STRB0032
      CRSOBF = (RA2/RA6)*RA4 - (RA3/RA6)*RA5                            STRB0033
      CRSBBF = CRSOBF*BFRC                                              STRB0034
      RETURN                                                            STRB0035
      END                                                               STRB0036


      SUBROUTINE SETBIV(BIVF,NRS,IFRC,RSBIF,SIFRS,FNCTRH)               STBV0001
C  SETS BEST VALUE OF BASIC INTERFLOW VOLUME FACTOR                     STBV0002
      DIMENSION  RSBIF(20),SIFRS(3,20)                                  STBV0003
      REAL  IFRC                                                        STBV0004
      ARSTR = 0.0                                                       STBV0005
      DO 101 KRS = 1,NRS                                                STBV0006
      RIF = RSBIF(KRS)/IFRC                                             STBV0007
      DO 100 KDY = 1,3                                                  STBV0008
      RIF = RIF*IFRC                                                    STBV0009
      SIF = SIFRS(KDY,KRS)*IFRC**(FNCTRH/48.0)                          STBV0010
      RSTR = 0.0                                                        STBV0011
      IF(RIF .GT. 0.0) RSTR = SIF/RIF                                   STBV0012
      IF(RSTR .GT. 3.0 .OR. (SIF .GT. 0.0 .AND. RIF .EQ. 0.0))RSTR=3.0  STBV0013
      ARSTR = ARSTR + RSTR                                              STBV0014
      WRITE(6,1) KRS,KDY,SIF,RIF                                        STBV0015
    1 FORMAT(10X,'KRS =',I3,2X,'KDY =',I2,2X,'SIF =',F7.1,5X,'RIF =',   STBV0016
     1  F7.1)                                                           STBV0017
  100 CONTINUE                                                          STBV0018
  101 CONTINUE                                                          STBV0019
      TIRD = NRS*3                                                      STBV0020
      PBIVF = BIVF                                                      STBV0021
      BIVF = 0.40                                                       STBV0022
      IF(ARSTR .GT. 0.0) BIVF = ((PBIVF - 0.40)*TIRD)/ARSTR + 0.40      STBV0023
      WRITE(6,2) PBIVF,BIVF                                             STBV0024
    2 FORMAT(5X,'BIVF CHANGED FROM',F6.2,2X,'TO',F6.2//)                STBV0025
      RETURN                                                            STBV0026
      END                                                               STBV0027
```

APPENDIX B

DICTIONARY OF VARIABLES USED IN MOPSET

ITEM 1 - VARIABLE NAME

ITEM 2 - WHETHER VARIABLE IS REAL, INTEGER, OR LOGICAL

ITEM 3 - VARIABLE DIMENSIONS

ITEM 4 - UNITS

ITEM 5 - DEFINITION OF THE VARIABLE

1	2	3	4	5
ABFSL	R	1	DAY	ACCUMULATED BASE FLOW SEQUENCE LENGTH
ABFV	R	1	IN	ANNUAL BASE FLOW VOLUME
ADBF	R	15	IN	ACCUMULATED DAILY BASE FLOW
ADIF	R	15	IN	ACCUMULATED DAILY INTERFLOW
ADRGPM	R	366	-	AVERAGE DATED RECORDING GAGE PRECIPITATION MULTIPLIER ABOVE GAGED REACH
AETX	R	1	IN	ANNUAL EVAPOTRANSPIRATION INDEX
AEX90	R	1	IN	ANTECEDENT EVAPORATION INDEX, DECAY RATE = 0.9
AEX96	R	1	IN	ANTECEDENT EVAPORATION INDEX, DECAY RATE = 0.96
AHP	R	1	IN	ACCUMULATED HOURLY PRECIPITATION
AIFSL	R	1	DAY	ACCUMULATED INTERFLOW SEQUENCE LENGTH
AIFV	R	1	IN	ANNUAL INTERFLOW VOLUME
ALPH	R	150,50	-	TABLE OF ALPHA VALUES
ALPHA	R	1	-	CURRENT ROUTING PARAMETER ALPHA
ALPHA1	R	1	-	TEMPORARY STORAGE OF ALPHA

AMBER	R	1	IN	ANNUAL MOISTURE BALANCE ERROR
AMBF	R	15	IN	ACCUMULATED MONTHLY BASE FLOW
AMIF	R	15	IN	ACCUMULATED MONTHLY INTERFLOW
AMNET	R	15	IN	ACCUMULATED MONTHLY NET EVAPOTRANSPIRATION
AMPET	R	1	IN	ACCUMULATED MONTHLY POTENTIAL EVAPOTRANSPIRATION
AMPREC	R	1	IN	ACCUMULATED MONTHLY PRECIPITATION
AMSE	R	15	IN	ACCUMULATED MONTHLY STREAM EVAPORATION
ANET	R	1	IN	ANNUAL NET EVAPOTRANSPIRATION
AOFV	R	1	IN	ANNUAL OVERLAND FLOW VOLUME
APET	R	1	IN	ANNUAL POTENTIAL EVAPOTRANSPIRATION
APREC	R	1	IN	ANNUAL PRECIPITATION
AREA	R	1	SQ MI	AREA OF WATERSHED
AREA1	R	1	SQ FT	TEMPORARY STORAGE FOR 1ST END AREA DURING ROUTING
AREA2	R	1	SQ FT	TEMPORARY STORAGE FOR 2ND END AREA DURING ROUTING
ARHF	R	15	CFS	ACCUMULATED ROUTED HYDROGRAPH FLOW
ARSTR	R	1	-	ACCUMULATED RATIO OF SYNTHESIZED TO RECORDED FLOWS
ASEV	R	1	IN	ANNUAL STREAM EVAPORATION VOLUME
ATF	R	1	SFD	ACCUMULATED TOTAL FLOW
ATFV	R	1	SFD	ANNUAL TOTAL FLOW VOLUME
AVXAR	R	1	SQ FT	AVERAGE FLOW END AREA FOR CURRENT REACH
AX	R	1	SQ FT	AVERAGE END AREA AT TWO SUCCESSIVE ROUTING TIMES
AZ	R	1	CU FT	DUMMY VARIABLE USED IN STORAGE ROUTING
A2	R	1	CFS	DIFFERENCE IN DISCHARGE BETWEEN TWO SUCCESSIVE POINTS IN STORAGE RATING TABLE
BBMIR	R	1	IN/HR	CURRENT BEST ESTIMATE OF BASIC MAXIMUM INFILTRATION RATE
BBUZC	R	1	-	CURRENT BEST ESTIMATE OF BASIC UPPER ZONE STORAGE CAPACITY FACTOR
BBYLZS	R	1	IN	CURRENT BEST ESTIMATE OF BEGINNING OF YEAR LOWER ZONE STORAGE
BETLF	R	1	-	CURRENT BEST ESTIMATE OF EVAPOTRANSPIRATION LOSS FACTOR
BFHRC	R	1	-	BASE FLOW HOURLY RECESSION CONSTANT
BFRC	R	1	-	BASE FLOW RECESSION CONSTANT
BFRL	R	1	-	BASE FLOW RECESSION LOGARITHM
BIVF	R	1	-	BASIC INTERFLOW VOLUME FACTOR
BIVF1	R	1	-	STORAGE FOR AVERAGE BIVF

BLZC	R	1	IN	CURRENT BEST ESTIMATE OF LOWER ZONE STORAGE CAPACITY
BMIR	R	1	IN/HR	BASIC MAXIMUM INFILTRATION RATE WITHIN WATERSHED
BMIR1	R	1	IN/HR	STORAGE FOR AVERAGE BMIR
BSIAC	R	1	-	CURRENT BEST ESTIMATE OF SEASONAL INFILTRATION ADJUSTMENT FACTOR
BSUZC	R	1	-	CURRENT BEST ESTIMATE OF SEASONAL UPPER ZONE STORAGE CAPACITY FACTOR
BUZC	R	1	-	BASIC UPPER ZONE STORAGE CAPACITY FACTOR
BUZC1	R	1	-	STORAGE FOR AVERAGE BUZC
BYGWS	R	1	IN	BEGINNING OF YEAR GROUNDWATER STORAGE
BYLZS	R	1	IN	BEGINNING OF YEAR LOWER ZONE STORAGE
B2	R	1	CF	DIFFERENCE IN STORAGE BETWEEN TWO SUCCESSIVE POINTS
CBF.	R	1	IN/HR	CURRENT BASE FLOW
CIVM	R	1	-	CURRENT INTERFLOW VOLUME MULTIPLIER
CMIR	R	1	IN	CURRENT MAXIMUM INFILTRATION RATE DURING PERIOD
CN	I	1	-	1 = A. M., 2 = P. M.
CONOPT	I	7	-	CONTROL OPTION
CONST	R	1	-	NONLINEAR ROUTING ITERATION CONSTANT
CRSBBF	R	1	CFS	CURRENT RECESSION SEQUENCE BEGINNING BASE FLOW
CRSBIF	R	1	CFS	CURRENT RECESSION SEQUENCE BEGINNING INTERFLOW
CRSBTF	R	1	CFS	CURRENT RECESSION SEQUENCE BEGINNING TOTAL FLOW
CRSTF	R	50	CFS	CURRENT RECESSION SEQUENCE TOTAL FLOWS
CRSOBF	R	1	CFS	CURRENT RECESSION SEQUENCE BASE FLOW ON DAY ZERO
CRSOIF	R	1	CFS	CURRENT RECESSION SEQUENCE INTERFLOW ON DAY ZERO
CVWINA	R	15	SFD	CUMULATIVE VWINA FOR PREVIOUS REACHES
CVWIN1	R	1	SFD	TEMPORARY STORAGE OF CVWINA FOR REACH 1
CWCFSA	R	15	CFS	CUMULATIVE WCFSA FOR PREVIOUS REACHES
CWCFS1	R	1	CFS	TEMPORARY STORAGE OF CWCFSA FOR REACH 1
C2	R	1	-	DUMMY VARIABLE USED IN STORAGE ROUTING
C4	R	1	CUFT	FUNCTION OF KNOWN QUANTITIES IN STORAGE ROUTING EQUATION
C5	R	1	CUFT	FUNCTION OF UNKNOWN QUANTITIES IN STORAGE ROUTING EQUATION
DAREA	R	150,50	SQFT	TABLE OF END AREAS FOR CHANNEL ROUTING
DATE	I	1	-	CURRENT DAY OF THE MONTH

DAY	I	1	-	CURRENT DAY OF THE YEAR
DBFRC	R	1	-	DOUBLE PRECISION BFRC
DELTAT	R	1	SEC	ROUTING TIME INTERVAL
DELTAX	R	1	FT	FINITE DIFFERENCE LENGTH FOR CURRENT REACH
DEV1	R	1	-	DEVIATION BETWEEN 1ST TRIAL VALUE AND EXPECTED SOLUTION
DEV2	R	1	-	DEVIATION BETWEEN 2ND TRIAL VALUE AND EXPECTED SOLUTION
DIFRC	R	1	-	DOUBLE PRECISION IFRC
DISCH	R	1000	CFS	TABLE OF DISCHARGES
DIV	R	1	CFS	DIVERSION INTO BASIN, MEAN DAILY FLOW
DPET	R	366	IN	DATED POTENTIAL EVAPOTRANSPIRATION
DPRD	I	1	-	CURRENT DAILY 15-MINUTE PERIOD
DPY	I	1	-	DAYS PER YEAR
DRGPM	R	15,366	-	DATED RECORDING GAGE PRECIPITATION MULTIPLIER
DRGPM1	R	366	-	TEMPORARY STORAGE OF DRGPM FOR REACH 1
DRHP	R	366,24	IN	DATED RECORDED HOURLY PRECIPITATION
DRSF	R	366	CFS	DATED RECORDED STREAMFLOW
DRSGP	R	5,366	IN	DATED RECORDED STORAGE GAGE PRECIPITATION
DSSF	R	366	CFS	DATED SYNTHESIZED STREAMFLOW
EDAREA	R	150,21	SQ FT	END OF DAY FLOW END AREA
EHSGD	I	1	-	ENDING HOUR OF STORAGE GAGE DAY
EHSGDF	R	1	-	ENDING HOUR OF STORAGE GAGE DAY - FLOATING POINT
EID	R	1	-	EXPONENT OF INFILTRATION RATE DECAY WITH INCREASED SOIL MOISTURE CONTENT
ELEV	'R	1000	FT	ELEVATION OF STORAGE ROUTING TABLE
EMAET	R	1	IN	ESTIMATED MAXIMUM ANNUAL EVAPOTRANSPIRATION
EMATF	R	13	SFD	END OF MONTH ACCUMULATED TOTAL FLOWS
EMFDP	R	1	-	EXTREME MONTHLY FLOW DEVIATION PARAMETER
EMGWS	R	12	IN	END OF MONTH GROUNDWATER STORAGE
EMIFS	R	12	IN	END OF MONTH INTERFLOW STORAGE
EMLZS	R	12	IN	END OF MONTH LOWER ZONE STORAGE
EMSIAM	R	12	-	END OF MONTH SEASONAL INFILTRATION ADJUSTMENT MULTIPLIER
EMUZC	R	12	IN	END OF MONTH UPPER ZONE STORAGE CAPACITY
EMUZS	R	12	IN	END OF MONTH UPPER ZONE STORAGE
EPAET	R	1	IN	ESTIMATED POTENTIAL ANNUAL EVAPOTRANSPIRATION
EPCM	R	12	-	EVAPORATION PAN COEFFICIENT FOR MONTH

EQD	R	1	IN	EQUILIBRIUM DEPTH OF OVERLAND FLOW
EQDF	R	15	-	EQUILIBRIUM DEPTH FACTOR FOR OVERLAND FLOW
EQDF1	R	1	-	TEMPORARY STORAGE OF EQDF FOR REACH 1
EQDFIS	R	15	-	EQUILIBRIUM DEPTH FACTOR FOR OVERLAND FLOW,IMPERVIOUS
				SURFACES
EQDFI1	R	1	-	TEMPORARY STORAGE OF EQDFIS FOR REACH 1
EQDIS	R	1	IN	EQUILIBRIUM DEPTH OF OVERLAND FLOW ON IMPERVIOUS SURFACES
ETLF	R	1	-	EVAPOTRANSPIRATION LOSS FACTOR
ETLF1	R	1	-	STORAGE FOR AVERAGE ETLF
EXPM	R	1	-	CURRENT ROUTING EXPONENT - M
EXPT	R	150,50	-	TABLE OF M EXPONENTS
FBUZC	R	1	-	ADJUSTMENT FACTOR FOR BUZC
FETLF	R	1	-	ADJUSTMENT FACTOR FOR ETLF
FHPP	R	1	-	FRACTIONAL HOUR PER PERIOD
FIMPA	R	15	-	FRACTION OF SUBAREA BEING IMPERVIOUS
FIMPA1	R	1	-	TEMPORARY STORAGE OF FIMPA FOR REACH 1
FLZC	R	1	-	ADJUSTMENT FACTOR FOR LZC
FMR	R	1	-	FRACTION OF MOISTURE NOT RETAINED IN UPPER ZONE
FNCTRH	R	1	HR	FLOATING POINT NUMBER OF CURRENT TIME ROUTING HOUR,
				WHICH IS EQUIVALENT TO FNWSTH IN MAIN PROGRAM
FNOFM	R	1	-	FLOATING POINT NUMBER OF OVERLAND FLOW MONTHS
FNWSTH	R	1	HR	FLOATING POINT NUMBER OF WATERSHED TRAVEL HOUR
FPERA	R	15	-	FRACTION OF SUBAREA BEING PERVIOUS
FPERA1	R	1	-	TEMPORARY STORAGE OF FPERA FOR REACH 1
FRERS	R	1	CFS	FLOW RISE ENDING RECESSION SEQUENCE
FSIAC	R	1	-	ADJUSTMENT FACTOR FOR SIAC
FSLTH	I	150	FT	LENGTH OF FINITE SECTION
FSUZC	R	1	-	ADJUSTMENT FACTOR FOR SUZC
FTX	R	1	-	FALL TROUBLE INDEX
FUNC	R	1	-	FUNCTION USED IN NONLINEAR ROUTING
FUNC1	R	1	-	FIRST DERVIATIVE OF FUNCTION USED IN NONLINEAR ROUTING
FUNC2	R	1	-	2ND DERVIATIVE OF FUNCTION USED IN NONLINEAR ROUTING
FWTR	R	1	-	FRACTION OF WATERSHED BEING WATER
FWTRA	R	15	-	FRACTION OF SUBAREA BEING WATER
FWTRA1	R	1	-	TEMPORARY STORAGE OF FWTRA FOR REACH 1

GAFL	R	366	CFS	DAILY SYNTHESIZED STREAM FLOW FROM GAGED REACH
GAREA	R	1	SQ MI	DRAINAGE AREA ABOVE THE GAGE
GWET	R	1	IN	CURRENT HOURLY GROUNDWATER EVAPOTRANSPIRATION
GWETF	R	1	-	GROUNDWATER EVAPOTRANSPIRATION FACTOR
GWS	R	1	IN	CURRENT GROUNDWATER STORAGE
GWSA	R	15	IN	GWS FOR SUBAREA
HOUR	I	1	-	CURRENT HOUR OF THE DAY
HOURL	I	1	-	LAST HOUR
HRF	I	1	-	FIRST HOUR OF LOOP
HRL	I	1	-	LAST HOUR OF LOOP
HSE	R	1	IN	CURRENT HOURLY STREAM EVAPORATION
HYDSTO	R	150,96	CFS	DAILY STORAGE FOR OUTFLOW HYDROGRAPHS TO BE USED AS INFLOW HYDROGRAPHS TO THE NEXT LOWER REACH
I	I	1	-	DO-LOOP COUNTER
ICYC	I	1	-	IDENTIFICATION OF CYCLE NUMBER IN TRIP 1
IDAY1	I	1	-	INDEX TO 10-DAY PERIOD
IDAY2	I	1	-	INDEX WITHIN 10-DAY PERIOD
IE	I	1	-	STORAGE ELEMENT COUNTER
IEF	I	1	-	FIRST ELEMENT IN STRUCTURE RATING CURVE
IEL	I	1	-	LAST ELEMENT IN STRUCTURE RATING CURVE
IFIELD	I	1	-	LENGTH OF AVAILABLE ARRAY FOR STORAGE ROUTING
IFPRC	R	1	-	INTERFLOW PERIOD RECESSION CONSTANT
IFRC	R	1	-	INTERFLOW RECESSION CONSTANT
IFRL	R	1	-	INTERFLOW RECESSION LOGARITHM
IFS	R	1	IN	INTERFLOW STORAGE
IFSA	R	15	IN	IFS FOR SUBAREA
IFST	I	15	-	FIRST ELEMENT IN STRUCTURE RATING CURVE STORAGE ARRAY
IFT	I	1	-	INDICATOR OF FALL TROUBLE (SKIP FIRST RECESSION IN EVALUATION OF BMIR)
IH	I	1	-	UPSTREAM HYDROGRAPH COUNTER
ILST	I	15	-	LAST ELEMENT IN STRUCTURE RATING CURVE STORAGE ARRAY
INLR	I	1	-	INDEX EQUAL TO 1 FOR NONLINEAR ROUTING
INLST	R	15	CFS	INITIAL STRUCTURE INFLOW
IP	I	1	-	RATING CURVE POINT COUNTER
IPPH	I	1	-	INTEGER PERIODS PER HOUR

IROUT	I	15 -	REACHES WHOSE OUTFLOW IS TO BE PRINTED
IRSTR	I	15 -	IDENTITY OF REACH CONTAINING STRUCTURE
ISGA	I	15 -	STORAGE GAGE DESIGNATION
ISGM	I	5 -	INDEX OF STORAGE GAGE MOVEMENT DURING THE YEAR
ISGRD	I	1 -	CURRENT STORAGE GAGE RAINFALL DAY
IUH	I	15,5 -	IDENTITY OF UPSTREAM HYDROGRAPHS TO BE ADDED
IWBG	I	1 -	INDEX NUMBER OF WEATHER BUREAU PRECIPITATION GAGE
J	I	1 -	DO-LOOP COUNTER
KBRC	I	1 -	COUNTER OF ROUGH CYCLES SINCE BEST ONE
KDRS	I	1 -	COUNTER OF CURRENT DAY IN RECESSION SEQUENCE
KDY	I	1 -	COUNTER FOR DAY
KFFC	I	1 -	COUNTER EQUALLING ONE ON FIRST FINE ADJUSTMENT CYCLE
KFS	I	1 -	COUNTER FOR FINITE SECTION
KG	I	1 -	STORAGE GAGE COUNTER
KHOUR	I	1 -	COUNTER FOR HOUR OF DAY
KHYD	I	1 -	COUNTER SPECIFYING CURRENT HYDROGRAPH
KMO	I	1 -	COUNTER INDEXING MONTH OF THE YEAR
KM1-6	I	1 -	MONTH COUNTERS
KNFS	I	1 -	COUNTER FOR FINITE SECTION FROM HEAD OF 1ST REACH
KOUT	I	1 -	COUNTER FOR REACH OUTPUT
KPRD	I	1 -	COUNTER FOR PERIOD
KR	I	1 -	REACH COUNTER
KRC	I	1 -	COUNTER OF CURRENT ADJUSTMENT CYCLE
KRD	I	1 -	COUNTER FOR READING DATA ARRAYS
KRKFS	I	1 -	ONE DIMENSIONAL ARRAY FOR (KR,KFS)
KRS	I	1 -	COUNTER FOR RECESSION SEQUENCE NUMBER
KS	I	1 -	STRUCTURE COUNTER
KSD	I	1 -	COUNTER FOR RECESSION SEQUENCE DAYS
KSQ	I	1 -	COUNTER FOR REVISED SEQUENCES
KTA	I	1 -	COUNTER FOR TITLE ARRAY
KWD	I	1 -	COUNTER FOR WRITING DATA ARRAYS
KWSM	I	1 -	COUNTER OF WET SUMMER MONTHS
LBFO	L	20 -	LOGICAL VARIABLE SET TRUE WHERE BASE FLOW ONLY ENCOUNTERED
LBMIR	L	1 -	LOGICAL VARIABLE SET TRUE WHEN EXERCISING SUBSTITUTE

				APPROACH FOR EVALUATING BMIR
LBUZC	L	1	-	LOGICAL VARIABLE SET TRUE WHEN EXERCISING SUBSTITUTE APPROACH FOR EVALUATING BUZC
LDAR1	R	1	-	LOG OF END AREA FOR POINT 1
LDAR2	R	1	-	LOG OF END AREA FOR POINT 2
LDAY	I	1	-	LAST DAY OF YEAR
LDIS1	R	1	-	LOG OF DISCHARGE FOR POINT 1
LDIS2	R	1	-	LOG OF DISCHARGE FOR POINT 2
LETLF	L	1	-	LOGICAL VARIABLE SET TRUE WHEN EXERCISING SUBSTITUTE APPROACH FOR EVALUATING ETLF
LHOUR	I	1	-	LAST HOUR OF DAY
LLZC	L	1	-	LOGICAL VARIABLE SET TRUE WHEN EXERCISING SUBSTITUTE APPROACH FOR EVALUATING LZC
LNPR	L	1	-	LOGICAL VARIABLE SET TRUE FOR NONEQUAL PERIOD RAINFALL
LRC	L	1	-	LOGICAL VARIABLE SET TRUE DURING ROUGH ADJUSTMENT CYCLES
LSTR	L	1	-	SET TRUE WHEN CURRENT REACH CONTAINS STRUCTURE
LZC	R	1	IN	LOWER ZONE STORAGE CAPACITY
LZC1	R	1	IN	STORAGE FOR AVERAGE LZC
LZRX	R	1	-	LOWER ZONE MOISTURE RETENTION INDEX
LZS	R	1	IN	CURRENT LOWER ZONE STORAGE
LZSA	R	15	IN	LZS FOR SUBAREA
LZSR	R	1	-	CURRENT LOWER ZONE STORAGE RATIO (LZS/LZC)
MBDS	I	1	-	MONTH BEGINNING DRY SEASON
MBWS	I	1	-	MONTH BEGINNING WET SEASON
MDAY	I	1	-	DAY OF YEAR OF LAST DAY OF PREVIOUS MONTH
MEDCY	I	12	-	MONTH END DATES - CALENDAR YEAR
MEDWY	I	12	-	MONTH END DATES - WATER YEAR
MEDWYP	I	1	-	MEDWY OF PREVIOS MONTH
MFDP	R	12	-	MONTHLY FLOW DEVIATION PARAMETER
MNDRS	I	1	-	MAXIMUM NUMBER OF DAYS IN RECESSION SEQUENCE
MNRC	I	1	-	MINIMUM NUMBER OF ROUGH CYCLES
MNRD	R	1	-	MEAN ANNUAL NUMBER OF RAINY DAYS
MNX	I	1	-	MONTH INDEX
MONTH	I	1	-	CURRENT MONTH OF THE YEAR
MONTH1	I	1	-	COUNTER FOR BEGINNING MONTH

MRSL	I	1 DAY	MINIMUM RECESSION SEQUENCE LENGTH
MXA	I	12 -	MONTH INDEX ARRAY (SPECIFYING MONTHS USED IN PARAMETER ADJUSTMENT)
M1R	I	1 -	MONTH WITH MOST RUNOFF
M1SP	I	1 -	MONTH WITH MOST SUMMER PRECIPITATION
M11	I	1 -	SET AT 11 IF AUGUST IS A BASE FLOW MONTH
M12	I	1 -	SET AT 12 IF SEPTEMBER IS A BASE FLOW MONTH
M2R	I	1 -	MONTH WITH SECOND MOST RUNOFF
M2SP	I	1 -	MONTH WITH SECOND MOST SUMMER PRECIPITATION
N	I	1 -	DO-LOOP COUNTER
NATRH	I	1 HR	NUMBER OF ANTICEPPATED TIME ROUTING HOURS, WHICH IS EQUIVALENT TO NWSTH IN MAIN PROGRAM
NB	I	1 -	NUMBER OF CURRENT UPSTREAM BRANCHES
NDAY	I	1 -	NEXT DAY OF YEAR
NDCR	I	1 -	DAY NUMBER FOR TERMINATING CHANNEL ROUTING
NDPM	I	1 DAY	NUMBER OF DAYS PER MONTH
NDRS	I	20 DAY	NUMBER OF DAYS IN RECESSION SEQUENCE
NDRSC	I	1 DAY	NUMBER OF DAYS IN CURRENT RECESSION SEQUENCE
NDRSC1	I	1 DAY	NUMBER OF DAYS IN CURRENT RECESSION SEQUENCE LESS 1
NDRSC2	I	1 DAY	NUMBER OF DAYS IN CURRENT RECESSION SEQUENCE LESS 2
NELV	I	1 -	NUMBER OF ELEVATIONS IN STRUCTURE RATING CURVE
NFRHA	I	1 -	NUMBER OF FIRST RAINFALL HOUR ADJUSTED, PREVIOUS DAY
NFS	I	150 -	NUMBER OF FINITE SECTIONS IN EACH REACH
NFSKR	I	1 -	NUMBER OF FINITE SECTION FOR REACH KR
NFSEPR	I	15 -	NUMBER OF FINITE SECTIONS AT THE END OF PRERIOUS REACH
NFTR	I	1 -	NUMBER OF FIRST TRIP TO BE RUN FOR A GIVEN STATION YEAR
NGR	R	1 -	IDENTIFYING NUMBER OF GAGED REACH
NGR1	I	1 -	TEMPORARY STORAGE FOR NGR
NH	I	1 -	NUMBER OF HYDROGRAPHS
NHOUR	I	1 -	NEXT HOUR OF DAY
NI	I	1 -	COUNTER FOR NUMBER OF ITERATIONS IN NONLINEAR ROUTING
NL	I	1 -	NUMBER OF FINITE DIFFERENCE PLUS 1
NLR	I	1 -	NUMBER OF LAST REACH
NLS	I	1 -	NUMBER OF LAST SECTION
NLTR	I	1 -	NUMBER OF LAST TRIP TO BE RUN FOR A GIVEN STATION YEAR

NNJ	I	1	-	ARRAY NUMBER OF NEXT JUNCTION TO BE CALCULATED
NOFD	I	150	-	NUMBER OF FINITE DIFFERENCE DIVISION FOR EACH FINITE SECTION
NOFM	I	1	-	NUMBER OF OVERLAND FLOW MONTHS
NOUT	I	1	-	NUMBER OF REACHES WHOSE OUTFLOWS ARE TO BE PRINTED
NP	I	1	-	NUMBER OF POINTS IN RATING CURVE
NPPH	I	1	-	NUMBER OF PERIODS PER HOUR OF ROUTING
NR	I	1	-	NUMBER OF REACHES IN WATERSHED LAYOUT
NRHA	I	1	-	NUMBER OF RAINFALL HOURS ADJUSTED, CURRENT DAY
NRS	I	1	-	NUMBER OF RECESSION SEQUENCES
NR1	I	1	-	TEMPORARY STORAGE FOR NR
NSC	I	150	-	NUMBER OF SLOPE CHANGE IN RATING CURVE
NSCS	I	1	-	NSC FOR (KR,KFS)
NSG	I	1	-	NUMBER OF STORAGE GAGES
NSGRD	I	1	-	NUMBER OF STORAGE GAGE RAINFALL DAYS
NSTR	I	1	-	NUMBER OF STRUCTURES
NSUM	I	1	-	NUMBER OF SUM HYDROGRAPH
NSYC	I	1	-	NUMBER OF STATION YEAR, CURRENT ONE BEING RUN
NSYT	I	1	-	NUMBER OF STATION YEARS, TOTAL INCLUDED IN A GIVEN JOB
NTRS	I	1	-	NUMBER OF TENTATIVE RECESSION SEQUENCES
NUBR	I	15	-	NUMBER OR UPSTREAM HYDROGRAPHS TO BE ADDED
NWSTH	I	1	HR	NUMBER OF WATERSHED TRAVEL HOURS
NX	I	1	-	NUMBER OF CURRENT XAREA BEING CALCULATED
OCT1BF	R	1	-	OCTOBER FIRST BASE FLOW
OFMN	R	15	-	OVERLAND FLOW MANNING'S N
OFMNIS	R	15	-	OVERLAND FLOW MANNING'S N , IMPERVIOUS SURFACES
OFR	R	1	IN	CURRENT OVERLAND FLOW RUNOFF
OFRF	R	15	-	OVERLAND FLOW ROUTING FACTOR
OFRF1	R	1	-	TEMPORARY STORAGE OF OFRF FOR REACH 1
OFRFIS	R	15	-	OVERLAND FLOW ROUTING FACTOR, IMPERVIOUS SURFACES
OFRFI1	R	1	-	TEMPORARY STORAGE OF OFRFIS FOR REACH 1
OFRIS	R	1	IN	CURRENT OVERLAND FLOW RUNOFF, IMPERVIOUS SURFACES
OFSL	R	15	FT	OVERLAND FLOW SURFACE LENGTH
OFSS	R	15	-	OVERLAND FLOW SURFACE SLOPE
OFUS	R	15	IN	CURRENT OVERLAND FLOW UNROUTED STORAGE

OFUSIS	R	15	IN	CURRENT OVERLAND FLOW UNROUTED STORAGE, IMPERVIOUS SURFACES
OMEGA	R	1	-	NONLINEAR ROUTING ITERATION VARIABLE
OUTLST	R	15	CFS	INITIAL OUTFLOW FROM STRUCTURE
PAEX90	R	1	IN	PRESENT VALUE OF AEX90
PAEX96	R	1	IN	PRESENT VALUE OF AEX96
PALPHA	R	150	-	VALUE OF ALPHA AT PREVIOUS TIME
PBIVF	R	1	-	PREVIOUS VALUE OF BIVF
PBMIR	R	1	IN/HR	PREVIOUS VALUE OF BMIR
PBUZC	R	1	-	PREVIOUS ESTIMATE OF BASIC UPPER ZONE STORAGE CAPACITY FACTOR
PDAY	I	1	-	PREVIOUS DAY OF THE YEAR
PEAI	R	1	IN	PRECIPITION EXCESS AFTER INFILTRATION
PEBI	R	1	IN	PRECIPITATION EXCESS BEFORE INFILTRATION
PEIS	R	1	IN	PRECIPITATION EXCESS ON IMPERVIOUS SURFACES
PEP	R	1	IN	PRECIPITATION ESTIMATED FOR PERIOD
PET	R	1	IN	CURRENT DAILY POTENTIAL EVAPOTRANSPIRATION
PETLF	R	1	-	PREVIOUS ESTIMATE OF EVAPOTRANSPIRATION LOSS FACTOR
PETU	R	1	IN	UNADJUSTED CURRENT DAILY POTENTIAL EVAPOTRANSPIRATION
PEXPM	R	150	-	VALUE OF EXPM AT PREVIOUS TIME
PE4P	R	4	IN	PRECEPITATION ESTIMATES FOR 4 PERIODS
PGW	R	1	IN	PERCOLATION TO GROUND WATER
PLZC	R	1	IN	PREVIOUS ESTIMATE OF LZC
PLZS	R	1	IN	PERCOLATION TO LOWER ZONE STORAGE
PPH	R	1	-	PERIODS PER HOUR
PPI	R	1	IN	PRECIPITATION PASSING INTERCEPTION
PRD	I	1	-	CURRENT PERIOD OF THE HOUR
PRDF	R	1	-	CURRENT PERIOD OF THE HOUR-FLOATING POINT
PRH	R	1	IN	PRECIPITATION RECORDED FOR HOUR
PRLH	R	1	IN	PRECIPITATION RECORDED FOR LAST HOUR
PRM1	R	1	IN	PRECIPITATION DURING WETTEST MONTH
PRM2	R	1	IN	PRECIPITATION DURING SECOND WETTEST MONTH
PRNH	R	1	IN	PRECEPITATION RECORDED FOR NEXT HOUR
PSIAC	R	1	-	PREVIOUS ESTIMATE OF SEASONAL INFILTRATION ADJUSTMENT
PSUZC	R	1	-	PREVIOUS ESTIMAFD OF SEASONAL UPPER ZONE STORAGE CAPACITY FACTOR

PXAREA	R	1 SQ FT	PREVIOUS FLOW END AREA AT CURRENT SECTION
RA	R	1 -	RECESSION ALPHA
RAA	R	1 IN	RAINFALL ADJUSTMENT ADDITION
RAM	R	1 -	RAINFALL ADJUSTMENT MULTIPLIER
RAT	R	1 -	INTERPOLATING RATIO
RATFV	R	1 SFD	RECORDED ANNUAL TOTAL FLOW VOLUME
RA1-6	R	1 -	REGRESSION ACCUMULATORS
RB	R	1 -	RECESSION BETA
RBF	R	1 CFS	RECORDED BASE FLOW
RBIVF	R	15 -	RATIO OF BIVF FOR SUBAREA TO AVERAGE BIVF
RBIVF1	R	1 -	TEMPORARY STORAGE OF RBIVF FOR REACH 1
RBMIR	R	15 -	RATIO OF BMIR FOR SUBAREA TO AVERAGE BMIR
RBMIR1	R	1 -	TEMPORARY STORAGE OF RBMIR FOR REACH 1
RBUZC	R	15 -	RATIO OF BUZC FOR SUBAREA TO AVERAGE BUZC
RBUZC1	R	1 -	TEMPORARY STORAGE OF RBUZC FOR REACH 1
RCHLTH	R	15 FT	REACH LENGTH
RD	R	1 -	RECESSION DISCRIMINANT
RDPT	R	1 IN	RECORDED DAILY PRECIPITATION TOTAL
RETLF	R	15 -	RATIO OF ETLF FOR SUBAREA TO AVERAGE ETLF
RETLF1	R	1 -	TEMPORARY STORAGE OF RETLF FOR REACH 1
RFRISE	R	1 IN	RECORDED FLOW RISE
RGPM	R	15 -	RECORDING GAGE PRECIPITATION MULTIPLIER
RGPMB	R	15 -	RECORDING GAGE PRECIPITATION MULTIPLIER - BASIC
RHF	R	1 CFS	ROUTED HYDRAGRAPH FLOW
RIF	R	1 CFS	RECORDED INTERFLOW
RLZC	R	15 -	RATIO OF LZC FOR SUBAREA TO AVERRE LZC
RLZC1	R	1 -	TEMPORARY STORAGE OF RLZC FOR REACH 1
RMFX	R	1 -	RECORDED MONTHLY FLOW INDEX
RMPF	R	1 CFS	REQUESTED MINIMUM DAILY PEAK FLOW TO BE PRINTED
RMWR	R	1 IN	RAINFALL MAXIMUM WITHOUT RUNOFF
ROLF1	R	15 CFS/FT	RUNOFF (LOCAL INFLOW) PER LINEAR FOOT OF STREAM FOR THE PREVIOUS TIME INTERVAL
ROLF2	R	15 CFS/FT	RUN OFF (LOCAL INFLOW) PER LINEAR FOOT OF STREAM FOR THE CURRENT TIME INTERVAL
RSBBF	R	20 CFS	ESTIMATED BASE FLOW AT BEGINNING OF RECESSION SEQUENCE
RSBD	I	20 -	RECESSION SEQUENCE BEGINNING DAY

RSBFRC	R	20	-	RECESSION SEQUENCE BASE FLOW RECESSION CONSTANT
RSBIF	R	20	CFS	ESTIMATED INTERFLOW AT BEGINNING OF RECESSION SEQUENCE
RSFM	R	1	CFS	RECESSION SEQUENCE FLOW MINIMUM
RSFN	R	1	CFS	RECORDED STREAMFLOW ON NEW DAY
RSF1	R	1	CFS	RECORDED STREAMFLOW ON DAY 1
RSF2	R	1	CFS	RECORDED STREAMFLOW ON DAY 2
RSIAC	R	15	-	RATIO OF SIAC FOR SUBAREA TO AVERAGE SIAC
RSIAC1	R	1	-	TEMPORARY STORAGE OF RSIAC FOR REACH 1
RSIFRC	R	20	-	RECESSION SEQUENCE INTERFLOW RECESSION CONSTANT
RSL	I	1	DAY	CURRENT RECESSION SEQUENCE LENGTH
RSTF	R	50,20	CFS	RECESSION SEQUENCE TOTAL FLOWS
RSTR	R	1	-	RATIO OF SYNTHESIZED TO RECORDED FLOW
RSUZC	R	15	-	RATIO OF SUZC FOR SUBAREA TO AVERAGE SUZC
RSUZC1	R	1	-	TEMPORARY STORAGE OF RSUZC FOR REACH 1
RWRAIN	R	1	IN	RECORDED WATERSHED RAINFALL
SAREA	R	15	SQ MI	SUBAREA AREA IN SQUARE MILES
SAREA1	R	1	SQ MI	TEMPORARY STORAGE OF SAREA FOR REACH 1
SATFV	R	1	SFD	SYNTHESIZED ANNUAL TOTAL FLOW VOLUME
SATFVI	R	1	IN	SYNTHESIZED ANNUAL TOTAL FLOW VOLUME IN INCHES
SAVE	L	1	-	SET TRUE WHEN CURRENT REACH OUTFLOW IS SUBJECT TO PRINT
SBF	R	1	CFS	SYNTHESIZED BASE FLOW
SBFRS	R	3,20	CFS	SYNTHESIZED BASE FLOW DURING THE FIRST THREE DAYS OF EACH RECESSION SEQUENCE
SET	R	1	IN	CURRENT HOURLY SOIL EVAPOTRANSPIRATION
SFDX	R	1	-	SUMMER FLOW DEVIATION INDEX
SGMD	I	5	-	STORAGE GAGE MOVING DAY (WHEN IT IS MOVED DURING WATER YEAR)
SGRT	I	5	-	STORAGE GAGE READING TIME
SGRT2	I	5	-	SECOND STORAGE GAGE READING TIME
SIAC	R	1	-	SEASONAL INFILTRATION ADJUSTMENT CONSTANT
SIAC1	R	1	-	STORAGE FOR AVERAGE SIAC
SIAM	R	1	-	SEASONAL INFILTRATION ADJUSTMENT MULTIPLIER
SIF	R	1	CFS	SYNTHESIZED INTERFLOW
SIFRS	R	3,20	CFS	SYNTHESIZED INTERFLOW DURING THE FIRST THREE DAYS OF EACH RECESSION SEQUENCE
SLOPE	R	1	-	SLOPE OF STORAGE OVER ELEVATION

SMF	R	1	SFD	SUM OF MONTHLY SYNTHESIZED FLOW
SMFX	R	1	-	SYNTHESIZED MONTHLY FLOW INDEX
SOFMD	R	1	-	SUM OF OVERLAND FLOW MONTH DEVIATIONS
SSQM	R	1	-	SUM OF THE SQUARES OF THE MONTHLY FLOW DEVIATIONS
SSRT	R	1	-	SQUARE ROOT OF OVERLAND FLOW SURFACE SLOPE
SSSQM	R	1	-	CURRENT SMALLEST ESTIMATE OF SSQM
STOLST	R	15	CU FT	INITIAL STORAGE IN STRUCTURE
STORAG	R	1000	AC FT	TABLE OF STRUCTURE STORAGES FROM RATING CURVE
SUBWF	R	1		SUBSURFACE WATER FLOW OUT OF BASIN
SUBWFA	R	15	IN	SUBWF FROM SUBAREA
SUBWF1	R	1	IN	TEMPORARY STORAGE OF SUBWFA FOR REACH 1
SUZC	R	1	-	SEASONAL UPPER ZONE STORAGE CAPACITY FACTOR
SUZC1	R	1	-	STORAGE FOR AVERAGE SUZC
SWSMD	R	1	-	SUM OF WET SUMMER MONTH DEVIATIONS
TBRD	R	1	-	TOTAL BASE FLOW RECESSION DAYS
TDFP12	R	1	-	TIME OF DAILY FLOOD PEAK, 12-HOUR CLOCK
TDFP24	R	1	-	TIME OF DAILY FLOOD PEAK, 24-HOUR CLOCK
TDSF	R	1	CFS	TOTAL DAILY STREAMFLOW
TFCFS	R	1	CFS	CURRENT TOTAL FLOW
TFMAX	R	1	CFS	MAXIMUM TOTAL FLOW DURING CURRENT DAY
THETA	R	1	FT/SEC	DELTAX/DELTAT
THSF	R	24	CFS	TOTAL HOURLY STREAMFLOW
TIRD	R	1	-	TOTAL INTERFLOW RECESSION DAYS
TITLE	A	20	-	TITLE OF CURRENT STATION YEAR (STREAM GAGE LOCATION AND DATE)
TMBF	R	12	IN	TOTALS OF MONTHLY BASE FLOW
TMIF	R	12	IN	TOTALS OF MONTHLY INTERFLOW
TMNET	R	12	IN	TOTALS OF MONTHLY NET EVAPOTRANSPIRATION
TMOF	R	12	IN	TOTALS OF MONTHLY OVERLAND FLOW
TMPET	R	12	IN	TOTALS OF MONTHLY POTENTIAL EVAPOTRANSPIRATION
TMPREC	R	12	IN	TOTALS OF MONTHLY PRECIPITATION
TMRTF	R	12	SFD	TOTALS OF MONTHLY RECORDED TOTAL FLOW
TMSE	R	12	IN	TOTALS OF MONTHLY STREAM EVAPORATION
TMSTF	R	12	SFD	TOTALS OF MONTHLY SYNTHESIZED TOTAL FLOW
TMSTFI	R	12	IN	TOTALS OF MONTHLY SYNTHESIZED TOTAL FLOW IN INCHES
TMTFCY	R	12	SFD	TOTALS OF MONTHLY TOTAL FLOW BY CALENDAR YEAR

TMTFWY	R	12	SFD	TOTALS OF MONTHLY TOTAL FLOW BY WATER YEAR
TOFR	R	1	IN	CURRENT TOTAL OVERLAND FLOW RUNOFF
TPLR	R	15	-	TOTAL TO PERVIOUS LAND RATIO
TPLR1	R	1	-	TEMPORARY STORAGE OF TPLR FOR REACH 1
TRIP	I	1	-	COUNTER SPECIFYING PROGRAM PORTIONS
URHF	R	1	IN	CURRENT UNROUTED HYDROGRAPH FLOW
UZC	R	1	IN	UPPER ZONE STORAGE CAPACITY
UZINLZ	R	1	IN/HR	CURRENT UPPER ZONE INFILTRATION TO LOWER ZONE
UZRX	R	1	-	UPPER ZONE MOISTURE RETENTION INDEX
UZS	R	1	IN	CURRENT UPPER ZONE STORAGE
UZSA	R	15	IN	UZS FOR SUBAREA
VDCY	R	366	-	VALUE DATED BY CALENDAR DAY
VDMD	R	12	-	VALUE DATED BY MONTH DAY
VINCR	R	15	IN	VEGETATIVE INTERCEPTION - CURRENT RATE PER PERIOD
VINMRA	R	15	IN/HR	VEGETATIVE INTERCEPTION - MAXIMUM RATE
VINMR1	R	1	IN/HR	TEMPORARY STORAGE OF VINMRA FOR REACH 1
VWIN	R	1	SFD	VOLUME OF AN INCH OF RUNOFF FROM WATERSHED
VWINA	R	15	SFD	VWIN FOR SUBAREA
VWINA1	R	1	SFD	TEMPORARY STORAGE OF VWINA FOR REACH 1
WCFS	R	1	CFS	WATERSHED CFS EQUALLING ONE INCH PER HOUR
WCFSA	R	15	CFS	WCFS FOR SUBAREA
WCFSA1	R	1	CFS	TEMPORARY STORAGE OF WCFSA FOR REACH 1
WEIFS	R	1	IN	WATER ENTERING INTERFLOW STORAGE
WFDX	R	1	-	WINTER FLOW DEVIATION INDEX
WI	R	1	IN	WATER REMAINING AFTER INFILTRATION INCLUDING INTERFLOW
WSG	R	15	-	WEIGHTING FACTOR FOR STORAGE RAIN GAGE
WSG2	R	15	-	SECOND WEIGHTING FACTOR FOR STORAGE RAIN GAGE
WSM	R	1	-	NUMBER OF WET SUMMER MONTHS
XAREA	R	150,21	SQ FT	END AREA OF WATER DURING ROUTING
XAREA1	R	1	SQ FT	1ST SOLUTION OF END AREA DURING NONLINEAR ROUTING
XAREA2	R	1	SQ FT	2ND SOLUTION OF END AREA DURING NONLINEAR ROUTING
XMPFT	R	12	-	INDEX OF MONTHLY PREDOMINATE FLOW TYPE
YEAR	I	1	-	LAST TWO DIGITS OF CURRENT YEAR
YR1	I	1	-	LAST TWO DIGITS OF FIRST CALENDAR YEAR IN WATER YEAR
YR2	I	1	-	LAST TWO DIGITS OF SECOND CALENDAR YEAR IN WATER YEAR

APPENDIX C

INPUT DATA FOR SOUTH FORK BEARGRASS CREEK AT LOUISVILLE, KY.
1970 WATER YEAR

```
**********************************
* NUMBER OF CASES AND TITLE CARD *
**********************************
    1
SOUTH FORK BEARGRASS CREEK
*******************
* CONTROL OPTIONS *
*******************
    2    1    0    0    1    1    0
**********************
* OTHER CONTROL DATA *
**********************
    6    1    2  400
    3    3   10    1    5
    0    0    2
    1    2
    4    2
    1    3
     50.00
**************************
* CHANNEL CROSS SECTIONS *
**************************
    5    0    1 2300.0000
```

3.2	1.27	33.	32.42	66.	44.02	132.	78.39
264.	128.23						
1.39	1.33						
5 0	1 3000.0000						
5.	40.27	57.5	66.22	102.	73.19	204.	96.52
408.	126.72						
0.57	1.67						
5 0	1 3000.0000						
11.	6.11	106.67	37.31	213.6	80.24	429.	148.53
858.	270.68						
1.14	1.33						
5 0	1 3000.0000						
24.6	18.69	246.	61.81	492.	116.09	984.	232.24
1968.	519.82						
0.47	1.67						
5 0	1 3000.0000						
29.5	18.26	296.2	133.06	592.5	231.05	1185.	465.42
2370.	978.65						
0.32	1.67						
5 0	1 3000.0000						
30.	15.44	300.	75.45	600.	125.96	1200.	229.47
2400.	449.58						
0.3	1.67						
5 0	1 3000.0000						
35.6	26.3	356.6	96.51	713.3	153.63	1426.6	285.99
2520.	544.28						
1.5	1.33						
5 0	1 3000.0000						
40.4	27.5	415.	145.96	830.	238.55	1660.	485.66
3320.	1038.69						
0.3	1.67						
5 0	1 3000.0000						
46.	29.9	460.	623.87	920.	714.24	2828.	1039.27
3680.	2153.66						
0.22	1.67						

```
    5     0      1 3000.0000
     65.          40.43     650.         202.26    1301.82      357.08    2596.          917.86
   5207.        2374.64
     0.66         1.33
    2     1      522400.
     0.46         1.33 999999.
    5     0      1 2800.0000
     79.          52.01     790.         234.47    1580.        402.44    3160.         1051.03
   6320.        2005.65
     0.1          1.67
    5     0      1 2800.0000
     79.          41.50     790.         204.66    1580.        370.64    3160.          759.87
   6320.        1773.33
     0.3          1.67
    5     0      1 2800.0000
     84.          51.89     840.         269.44    1980.        465.13    3360.          932.30
   6720.        1825.93
     0.11         1.67
    5     0      1 2800.0000
     84.          54.65     840.         253.55    1680.        427.51    3360.          943.14
   6720.        2225.86
     0.25         1.67
    5     0      1 3300.
     86.          39.95     860.         204.43    1720.        525.24    3440.         2171.87
   6880.        5696.58
     0.8          1.33
************************
* HYDRAULIC STRUCTURES *
************************
    0
********************
* REACH PARAMETERS *
********************
29300.          7.2         0.023        0.035  1119.4890      0.015       0.068        0.005
22400.          4.66        0.017        0.035   918.3501      0.015       0.034        0.005
```

14500.	5.35	0.023	0.035	803.02	0.015	0.0082	0.005
1.03	0.96	1.	1.	1.	1.	1.	
0.97	1.05	1.	1.	1.	1.	1.	
0.99	1.02	1.	1.	1.	1.	1.	
1.	1.	1.					
0.	0.						
0.12	0.00	0.11	0.00	0.10	0.00		

****

* CLIMATOLOGICAL DATA *

****

70 71

46.31 105.

RECORDED DAILY STREAM FLOW

****

3.20	2.20	1.80	1.60	1.60	1.50	1.30	4.40	18.00	17.00
3.00	48.00	146.00	48.00	29.00	21.00	15.00	12.00	7.80	40.00
22.00	11.00	8.00	6.20	5.40	4.90	6.60	17.00	11.00	8.00
5.20	8.00	7.00	6.00	5.00	4.30	3.80	3.20	3.50	4.00
4.70	3.90	3.30	2.90	21.00	19.00	11.00	9.30	7.80	7.00
94.00	24.00	20.00	15.00	12.00	11.00	9.30	7.80	5.50	5.10
4.80	4.20	3.40	5.30	7.00	4.10	3.60	3.30	3.00	2.90
2.70	11.00	55.00	17.00	13.00	11.00	62.00	38.00	29.00	24.00
19.00	153.00	321.00	77.00	48.00	39.00	32.00	27.00	23.00	19.00
17.00	15.00	13.00	12.00	16.00	91.00	30.00	23.00	21.00	19.00
16.00	14.00	12.00	11.00	112.00	71.00	41.00	32.00	27.00	23.00
20.00	18.00	14.00	14.00	12.00	11.00	10.00	7.80	6.30	7.80
7.50	8.60	8.40	6.80	4.40	4.10	53.00	79.00	33.00	26.00
23.00	22.00	20.00	22.00	59.00	58.00	36.00	29.00	29.00	36.00
29.00	91.00	69.00	72.00	664.00	113.00	59.00	45.00	49.00	38.00
30.00	25.00	21.00	23.00	18.00	15.00	34.00	26.00	20.00	17.00
43.00	30.00	23.00	20.00	17.00	58.00	23.00	19.00	17.00	29.00
19.00	0.42	0.29	0.08	0.04	0.02	0.01	0.14	0.03	0.03
0.0	0.0	0.0	0.0	0.07	0.46	0.07	0.04	0.07	0.02
0.0	0.0	0.06	57.00	1.40	20.00	4.10	4.10	3.70	3.30
2.70	2.40	3.10	4.20	2.80	2.30	1.90	2.00	26.00	22.00

7.80	4.20	2.60	12.00	2.60	2.00	3.00	278.00	132.00	50.00
34.00	26.00	24.00	27.00	62.00	32.00	24.00	19.00	15.00	12.00
15.00	9.30	7.00	5.30	4.80	17.00	180.00	21.00	41.00	22.00
16.00	14.00	11.00	9.30	12.00	6.30	5.00	4.20	2.90	2.20
2.70	1.70	1.60	1.60	6.30	1.70	33.00	170.00	29.00	12.00
7.00	4.80	3.90	179.00	33.00	16.00	9.30	6.30	4.80	4.10
3.90	3.90	4.10	24.00	6.30	3.40	2.70	5.30	46.00	16.00
8.50	87.00	43.00	48.00	24.00	52.00	42.00	13.00	7.80	5.30
840.00	198.00	50.00	36.00	27.00	21.00	17.00	18.00	22.00	18.00
14.00	25.00	17.00	10.00	3.50	11.00	103.00	113.00	46.00	31.00
23.00	17.00	12.00	11.00	7.00	5.10	4.40	3.20	2.70	2.20
1.80	19.00	3.50	1.80	1.60	2.90	1.80	1.70	1.60	12.00
1.60	1.40	1.30	1.30	13.00	1.70	1.80	1.20	1.10	0.97
80.00	4.20	2.50	1.70	1.10	7.00	5.30	1.30	0.71	0.57
0.54	0.53	0.51	0.53	58.00	3.40	2.60	1.70	1.40	2.10
7.00	3.40	1.40	1.40	1.20					

STROAGE GAGE
****

1

100 0 17

281	0.52	283	0.27	286	2.55	287	0.24	288	0.26
293	1.00	294	0.05	298	0.05	301	0.15	302	0.33
306	0.24	313	0.07	314	0.18	318	0.45	319	0.17
324	0.65	338	0.35	345	0.30	346	0.47	350	0.74
351	0.23	355	0.95	356	1.08	357	0.06	365	0.05
4	1.15	14	0.44	23	0.07	28	0.03	30	0.25
34	0.29	35	0.52	36	0.26	38	0.01	39	0.54
43	0.17	44	0.05	48	0.06	51	0.54	53	2.68
57	0.38	62	0.26	65	0.41	66	0.04	69	0.58
74	0.72	78	0.34	85	0.13	91	0.28	92	0.32
96	0.38	104	0.17	113	0.20	118	0.87	122	0.26
125	0.02	126	1.30	127	0.99	128	0.07	131	0.11
132	0.22	133	0.58	140	0.28	144	0.06	145	0.77
147	0.57	153	0.25	163	0.13	164	0.12	165	0.42
166	1.05	167	2.20	172	1.46	173	0.17	182	0.17

186	0.14	187	0.97	191	0.04	192	1.02	193	0.32
195	0.24	200	2.43	205	0.10	207	0.90	210	0.61
211	0.16	214	0.30	215	0.28	216	0.62	231	0.16
234	0.03	238	0.51	243	0.31	245	0.58	249	0.48
254	1.03	260	0.07	263	0.90	269	0.19	270	0.05
1	0.51								
2	0.42								
3	0.27								

RECORDING GAGE
****

4954	70	10	8	1							
0.0	0.01	0.07	0.05	0.03	0.01	0.01	0.02	0.04	0.01	0.0	0.0
4954	70	10	8	2							
0.03	0.07	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4954	70	10	9	2							
0.01	0.0	0.0	0.08	0.02	0.14	0.0	0.09	0.03	0.0	0.0	0.0
4954	70	10	12	1							
0.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.01	0.01
4954	70	10	12	2							
0.0	0.0	0.0	0.0	0.60	0.13	0.04	0.12	0.35	0.20	0.02	0.45
4954	70	10	13	1							
0.03	0.0	0.0	0.04	0.0	0.0	0.17	0.18	0.02	0.03	0.01	0.0
4954	70	10	13	2							
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.01
4954	70	10	14	1							
0.05	0.04	0.10	0.13	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4954	70	10	14	2							
0.0	0.0	0.0	0.0	0.0	0.0	0.02	0.0	0.0	0.0	0.0	0.0
4954	70	10	19	2							
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.01	0.03	0.05
4954	70	10	20	1							
0.07	0.13	0.13	0.09	0.02	0.02	0.05	0.0	0.0	0.03	0.01	0.03
4954	70	10	20	2							
0.02	0.01	0.02	0.0	0.0	0.0	0.0	0.01	0.03	0.0	0.0	0.0
4954	70	10	28	1							

0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.01	0.03	0.04
4954	70	10	28	2							
0.07	0.01	0.03	0.03	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.01
4954	70	10	29	1							
0.02	0.02	0.01	0.08	0.05	0.10	0.01	0.0	0.01	0.0	0.0	0.01
4954	70	11	2	1							
0.0	0.0	0.0	0.0	0.0	0.0	0.01	0.07	0.08	0.04	0.0	0.0
4954	70	11	9	2							
0.0	0.0	0.05	0.01	0.03	0.03	0.0	0.0	0.0	0.0	0.06	0.03
4954	70	11	10	1							
0.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4954	70	11	14	1							
0.0	0.0	0.0	0.0	0.0	0.03	0.03	0.04	0.06	0.09	0.05	0.02
4954	70	11	14	2							
0.05	0.03	0.03	0.01	0.04	0.08	0.05	0.02	0.01	0.01	0.01	0.0
4954	70	11	19	2							
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.02	0.01	0.08	0.18
4954	70	11	20	1							
0.08	0.17	0.03	0.0	0.0	0.0	0.0	0.01	0.0	0.0	0.0	0.0
4954	70	11	22	1							
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.02	0.04	0.0	0.0
4954	70	11	23	1							
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.02	0.0	0.0	0.0
4954	70	11	29	2							
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.01	0.0	0.0	0.0	0.0
4954	70	12	3	1							
0.0	0.0	0.09	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4954	70	12	3	2							
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.14	0.0	0.0
4954	70	12	11	2							
0.01	0.13	0.18	0.0	0.02	0.0	0.0	0.0	0.0	0.02	0.03	0.14
4954	70	12	12	1							
0.16	0.06	0.09	0.02	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4954	70	12	16	1							
0.0	0.05	0.10	0.10	0.10	0.04	0.07	0.08	0.01	0.04	0.02	0.01

4954	70	12	16	2							
0.0	0.0	0.0	0.06	0.05	0.07	0.0	0.0	0.01	0.02	0.0	0.0
4954	70	12	21	1							
0.01	0.02	0.03	0.04	0.01	0.18	0.17	0.05	0.14	0.13	0.14	0.14
4954	70	12	21	2							
0.02	0.0	0.0	0.0	0.0	0.0	0.02	0.08	0.06	0.09	0.13	0.22
4954	70	12	22	1							
0.15	0.09	0.01	0.08	0.06	0.11	0.0	0.0	0.0	0.0	0.0	0.0
4954	70	12	23	1							
0.0	0.0	0.0	0.0	0.0	0.02	0.0	0.0	0.0	0.0	0.0	0.0
4954	70	12	31	1							
0.0	0.0	0.01	0.01	0.02	0.01	0.0	0.01	0.0	0.0	0.0	0.0
4954	71	1	3	2							
0.0	0.0	0.0	0.0	0.10	0.05	0.03	0.0	0.02	0.27	0.09	0.03
4954	71	1	4	1							
0.01	0.10	0.18	0.07	0.10	0.04	0.0	0.01	0.0	0.0	0.0	0.0
4954	71	1	13	1							
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.01	0.04	0.10
4954	71	1	13	2							
0.15	0.20	0.15	0.05	0.20	0.05	0.03	0.09	0.0	0.0	0.0	0.0
4954	71	1	14	1							
0.03	0.01	0.04	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4954	71	1	22	2							
0.0	0.0	0.0	0.0	0.01	0.03	0.02	0.01	0.0	0.0	0.0	0.0
4954	71	1	24	1							
0.0	0.0	0.0	0.01	0.0	0.0	0.0	0.0	0.0	0.0	0.01	0.0
4954	71	1	28	1							
0.0	0.0	0.0	0.01	0.0	0.01	0.0	0.0	0.0	0.01	0.0	0.0
4954	71	1	30	1							
0.0	0.0	0.05	0.03	0.0	0.0	0.0	0.02	0.04	0.06	0.05	0.02
4954	71	2	3	1							
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.02	0.06	0.06
4954	71	2	3	2							
0.0	0.04	0.06	0.06	0.01	0.0	0.0	0.0	0.0	0.01	0.03	0.06
4954	71	2	4	1							

0.22	0.03	0.03	0.01	0.01	0.02	0.04	0.01	0.0	0.0	0.0	0.0
4954	71	2	4	2							
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.27	0.05
4954	71	2	5	1							
0.02	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4954	71	2	7	1							
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.01	0.0	0.0	0.0	0.0
4954	71	2	7	2							
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.02	0.01
4954	71	2	8	1							
0.01	0.05	0.03	0.04	0.06	0.03	0.04	0.02	0.08	0.07	0.10	0.08
4954	71	2	8	2							
0.05	0.04	0.03	0.0	0.01	0.01	0.0	0.0	0.0	0.0	0.0	0.0
4954	71	2	12	1							
0.01	0.0	0.01	0.0	0.01	0.0	0.0	0.02	0.0	0.01	0.02	0.01
4954	71	2	12	2							
0.0	0.01	0.0	0.09	0.06	0.09	0.08	0.10	0.10	0.09	0.07	0.03
4954	71	2	13	1							
0.04	0.03	0.02	0.03	0.01	0.01	0.0	0.0	0.02	0.01	0.01	0.0
4954	71	2	17	1							
0.0	0.0	0.0	0.0	0.0	0.03	0.0	0.0	0.0	0.0	0.0	0.0
4954	71	2	19	2							
0.0	0.0	0.0	0.02	0.03	0.10	0.30	0.07	0.0	0.0	0.0	0.0
4954	71	2	21	2							
0.0	0.0	0.0	0.0	0.0	0.0	0.08	0.22	0.20	0.21	0.37	0.50
4954	71	2	22	1							
0.32	0.26	0.14	0.20	0.03	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4954	71	2	26	1							
0.0	0.0	0.02	0.08	0.01	0.03	0.0	0.0	0.0	0.0	0.0	0.0
4954	71	2	26	2							
0.0	0.08	0.08	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4954	71	3	2	2							
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.02
4954	71	3	3	1							
0.05	0.05	0.01	0.0	0.0	0.0	0.03	0.08	0.04	0.01	0.02	0.03

4954	71	3	3	2							
0.0	0.01	0.02	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4954	71	3	6	1							
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.11
4954	71	3	6	2							
0.13	0.01	0.01	0.03	0.0	0.03	0.01	0.02	0.0	0.0	0.0	0.0
4954	71	3	10	1							
0.0	0.0	0.01	0.03	0.04	0.06	0.08	0.07	0.06	0.06	0.03	0.03
4954	71	3	10	2							
0.02	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4954	71	3	15	1							
0.0	0.0	0.0	0.0	0.47	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4954	71	3	18	2							
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.08	0.06	0.03
4954	71	3	19	1							
0.04	0.01	0.02	0.02	0.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4954	71	3	19	2							
0.01	0.0	0.0	0.0	0.01	0.0	0.01	0.01	0.01	0.01	0.01	0.0
4954	71	3	20	1							
0.0	0.0	0.0	0.0	0.0	0.0	0.01	0.0	0.0	0.0	0.0	0.0
4954	71	3	25	2							
0.0	0.0	0.0	0.0	0.0	0.0	0.01	0.01	0.03	0.0	0.01	0.0
4954	71	3	26	1							
0.0	0.0	0.0	0.0	0.0	0.02	0.0	0.01	0.0	0.0	0.0	0.0
4954	71	4	1	1							
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.02	0.03	0.0
4954	71	4	1	2							
0.10	0.10	0.04	0.05	0.06	0.03	0.01	0.15	0.05	0.02	0.0	0.0
4954	71	4	6	1							
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.04	0.02	0.04	0.09
4954	71	4	6	2							
0.01	0.05	0.01	0.03	0.03	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4954	71	4	13	2							
0.0	0.0	0.0	0.0	0.0	0.0	0.07	0.08	0.0	0.0	0.0	0.0
4954	71	4	21	2							

0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.15	0.03	0.0	0.0	0.0
4954	71	4	27	2							
0.0	0.0	0.0	0.0	0.0	0.0	0.22	0.60	0.0	0.03	0.0	0.0
4954	71	5	1	2							
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.01
4954	71	5	2	1							
0.04	0.13	0.01	0.0	0.0	0.02	0.01	0.0	0.0	0.0	0.0	0.0
4954	71	5	5	1							
0.0	0.0	0.04	0.0	0.0	0.0	0.0	0.0	0.01	0.01	0.0	0.0
4954	71	5	5	2							
0.0	0.0	0.0	0.0	0.0	0.01	0.0	0.03	0.0	0.0	0.0	0.0
4954	71	5	6	1							
0.0	0.0	0.0	0.08	0.03	0.0	0.0	0.0	0.28	0.40	0.0	0.0
4954	71	5	6	2							
0.26	0.03	0.01	0.0	0.0	0.40	0.13	0.15	0.02	0.03	0.01	0.01
4954	71	5	7	1							
0.0	0.0	0.0	0.0	0.0	0.0	0.01	0.04	0.01	0.0	0.02	0.19
4954	71	5	7	2							
0.0	0.0	0.0	0.02	0.0	0.0	0.0	0.0	0.0	0.01	0.01	0.02
4954	71	5	8	1							
0.0	0.0	0.0	0.0	0.0	0.0	0.03	0.0	0.02	0.0	0.0	0.0
4954	71	5	11	1							
0.0	0.0	0.0	0.0	0.0	0.0	0.01	0.09	0.01	0.0	0.0	0.0
4954	71	5	11	2							
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.01	0.02	0.0
4954	71	5	12	1							
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.08	0.0	0.0
4954	71	5	12	2							
0.0	0.10	0.05	0.08	0.04	0.01	0.01	0.02	0.0	0.04	0.04	0.05
4954	71	5	13	1							
0.02	0.06	0.08	0.07	0.05	0.03	0.01	0.01	0.0	0.0	0.0	0.0
4954	71	5	19	2							
0.0	0.0	0.0	0.02	0.50	0.01	0.0	0.0	0.0	0.0	0.0	0.0
4954	71	5	24	1							
0.0	0.0	0.0	0.05	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

4954	71	5 24	2								
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.02	0.58	0.79	0.05
4954	71	5 27	1								
0.0	0.0	0.0	0.02	0.22	0.12	0.05	0.01	0.01	0.14	0.03	0.0
4954	71	6 1	2								
0.0	0.0	0.0	0.0	0.02	0.01	0.0	0.01	0.01	0.0	0.0	0.0
4954	71	6 8	1								
0.0	0.0	0.0	0.0	0.02	0.03	0.02	0.01	0.0	0.0	0.0	0.0
4954	71	6 12	1								
0.0	0.0	0.0	0.0	0.0	0.03	0.07	0.0	0.0	0.0	0.0	0.0
4954	71	6 14	1								
0.14	0.06	0.02	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4954	71	6 14	2								
0.0	0.0	0.0	0.0	0.0	0.0	0.50	0.20	0.15	0.01	0.0	0.0
4954	71	6 15	1								
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.01	0.17
4954	71	6 15	2								
0.0	0.0	0.0	0.0	0.02	0.0	0.04	0.10	0.01	0.0	0.0	0.0
4954	71	6 21	2								
0.36	0.25	0.06	0.03	0.0	0.0	0.0	0.0	0.0	0.0	0.02	0.01
4954	71	6 22	1								
0.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4954	71	6 30	2								
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.07	0.14	0.03
4954	71	7 5	1								
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.02	0.08
4954	71	7 5	2								
0.02	0.02	0.0	0.0	0.0	0.0	0.0	0.0	0.20	0.0	0.0	0.0
4954	71	7 6	1								
0.0	0.0	0.0	0.0	0.0	0.68	0.18	0.01	0.0	0.0	0.0	0.0
4954	71	7 9	2								
0.0	0.0	0.05	0.29	0.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4954	71	7 10	2								
0.0	0.0	0.0	0.0	0.0	0.02	0.20	0.36	0.02	0.01	0.0	0.0
4954	71	7 11	2								

0.0	0.0	0.0	0.0	0.0	0.0	0.18	0.0	0.0	0.0	0.0	0.0
4954	71	7	13	2							
0.0	0.0	0.0	0.0	0.0	0.0	0.01	0.45	0.01	0.0	0.0	0.0
4954	71	7	14	1							
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.01	0.01	0.0	0.0
4954	71	7	18	2							
0.0	0.0	0.95	2.40	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4954	71	7	19	1							
0.0	0.01	0.0	0.03	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4954	71	7	24	1							
0.0	0.01	0.01	0.0	0.0	0.0	0.0	0.0	0.01	0.0	0.0	0.0
4954	71	7	25	2							
0.0	0.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4954	71	7	26	2							
0.0	0.01	0.04	0.03	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4954	71	7	28	2							
0.0	0.01	0.0	0.0	0.0	0.0	0.0	0.12	0.01	0.03	0.01	0.0
4954	71	7	30	1							
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.01	0.0	0.0
4954	71	7	30	2							
0.02	0.01	0.14	0.01	0.02	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4954	71	8	2	2							
0.0	0.36	0.07	0.16	0.01	0.02	0.0	0.01	0.0	0.0	0.0	0.0
4954	71	8	3	1							
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.21	0.02	0.04
4954	71	8	3	2							
0.0	0.0	0.0	0.0	0.0	0.0	0.04	0.02	0.0	0.0	0.02	0.06
4954	71	8	4	1							
0.02	0.03	0.0	0.01	0.0	0.01	0.01	0.01	0.0	0.0	0.14	0.03
4954	71	8	4	2							
0.0	0.01	0.03	0.04	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.03
4954	71	8	5	1							
0.01	0.0	0.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4954	71	8	18	2							
0.0	0.0	0.01	0.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

4954	71	8 22	1								
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.03	0.01
4954	71	8 25	2								
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.01	0.07
4954	71	8 26	1								
0.03	0.0	0.09	0.12	0.02	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4954	71	9 1	2								
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.01	0.01	0.0
4954	71	9 2	2								
0.0	0.20	0.0	0.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4954	71	9 6	1								
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.14
4954	71	9 6	2								
0.86	0.15	0.07	0.06	0.05	0.02	0.0	0.0	0.01	0.0	0.0	0.0
4954	71	9 11	1								
0.0	0.0	0.0	0.0	0.0	0.22	0.46	0.27	0.04	0.03	0.05	0.0
4954	71	9 11	2								
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.66
4954	71	9 16	1								
0.0	0.08	0.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4954	71	9 20	1								
0.0	0.0	0.16	0.16	0.04	0.12	0.38	0.09	0.0	0.0	0.0	0.0
4954	71	9 25	2								
0.0	0.0	0.0	0.0	0.0	0.0	0.18	0.0	0.03	0.0	0.0	0.0
4954	71	9 26	1								
0.0	0.0	0.0	0.0	0.08	0.01	0.0	0.0	0.06	0.0	0.0	0.0
4954	98										

APPENDIX D

PERMEABILITY AND AVAILABILITY WATER CAPACITY OF KENTUCKY SOILS

Soil Series	Perm. in./hr	AWC in.
Adler	2.53	7.54
Allegheny	2.93	7.17
Armour	0.91	10.26
Ashton	2.53	10.25
Ashwood	0.50	2.97
Atkins	3.12	9.11
Barbourville	5.50	5.99
Baxter	2.08	6.87
Beasley	1.74	7.75
Bedford	1.19	11.18
Belknap	1.32	9.50
Berks	3.47	3.22
Beulah	7.50	3.90
Bewleyville	3.75	5.84
Birds	1.48	11.66
Blago	3.75	8.19
Bondine	4.34	2.64
Bonnie	1.30	12.13
Brandon	1.40	7.41
Brashear	0.91	8.56
Braxton	1.36	7.11
Brookside	1.30	8.52
Bruno	7.77	3.95
Burgin	0.13	7.22
Calloway	1.43	10.19
Caneyville	2.22	5.26
Captina	1.62	8.65
Chagrin	1.30	6.90
Chavies	4.15	9.10
Christian	2.77	7.09
Clarksville	2.76	5.09
Clifty	2.02	5.55
Clymer	4.15	5.29
Colbert	0.86	6.61
Collins	1.95	10.20
Colyer	2.26	1.92
Commerce	1.08	9.72
Cookeville	3.75	13.53
Corydon	1.36	4.04
Cotaco	4.12	7.15
Cranston	4.15	8.75
Crevasse	10.00	4.22
Crider	1.34	11.25
Cruze	2.11	8.27
Cuba	1.31	13.39
Culleoka	2.07	5.68
Cumberland	1.31	8.47
Cynthiana	1.32	3.17
Danridge	1.32	3.02
Dekalb	3.79	3.70
Dekoven	1.32	8.40
Dewey	1.32	8.06
Dickson	1.84	10.04
Donahue	4.15	4.37
Donerail	1.32	8.73
Dowellton	1.32	8.76
Dubbs	1.65	8.94
Dundee	1.65	8.88
Dunning	1.09	7.82
Eden	0.88	5.14
Egan	1.40	8.12
Elk	1.47	9.19
Enders	1.40	6.24
Ennsi	3.50	5.40
Epley	1.30	9.74
Etowah	2.12	9.86
Fairmount	1.20	2.57
Falaya	1.16	11.37
Faywood	1.32	6.12
Fleming	1.88	5.32
Forestdale	0.50	7.75
Frankstown	3.78	4.72
Frederick	1.30	16.36
Fredonia	1.10	4.54
Frondort	1.31	4.64
Garmon	1.31	3.47
Gilpin	1.35	4.71
Ginat	1.34	8.20
Grenada	1.42	10.10
Guthrie	1.98	8.39

Soil Series	Perm. in./hr	AWC in.
Hagerstown	2.88	9.63
Hamblen	1.32	10.28
Hampshire	0.95	9.66
Hartsells	4.12	4.54
Hayter	2.45	9.55
Heitt	1.32	6.18
Henry	0.50	13.54
Henshaw	1.32	10.45
Holston	2.45	8.47
Humphreys	3.88	5.46
Huntington	3.35	7.98
Jacob	0.42	6.71
Jefferson	4.53	5.72
Johnsburg	1.94	9.64
Karnak	0.13	7.35
Lakin	6.90	4.07
Landisburg	2.61	7.96
Lanton	0.66	8.85
Latham	1.31	5.42
Lawrence	1.39	9.93
Lindside	1.54	9.26
Linker	4.00	6.40
Litz	2.04	4.71
Loradale	2.04	8.94
Loring	1.42	9.96
Loudon	1.32	8.55
Lowell	1.74	6.21
Markland	1.34	6.75
Maury	3.93	11.51
McAfee	3.79	3.68
McGary	1.36	7.51
Melvin	1.37	9.74
Memphis	1.35	10.91
Mercer	2.04	8.79
Monogahela	2.77	8.40
Montevallo	7.50	1.92
Montgomery	0.42	7.42
Morehead	1.32	10.97
Morganfield	1.32	9.24
Mountview	1.92	9.44
Mullins	1.87	8.90
Muse	1.90	8.42
Muskingum	5.23	4.76
Needmore	1.82	5.72
Newark	2.03	8.99
Nicholson	2.53	7.70
Nolickucky	3.54	11.58
Nolin	1.30	12.98
Otway	1.01	3.38
Otwell	1.32	8.49
Patton	1.33	11.16
Pembroke	1.73	10.69
Philo	2.86	8.49
Pickwick	1.30	13.97
Pope	4.70	7.28
Purdy	1.22	8.73
Ramsey	5.68	1.57
Rarden	1.97	5.45
Renox	2.26	7.63
Righley	4.15	5.87
Robertsville	1.43	8.90
Robinsonville	3.22	6.82
Rockcastle	0.99	4.44
Roellen	1.32	7.61
Russellville	1.37	11.81
Sadler	1.30	9.93
Sango	2.13	8.60
Salvisa	2.77	3.91
Sciotoville	1.34	8.16
Sees	1.65	7.86
Sequatchie	3.95	6.44
Sharkey	0.39	8.59
Shelbyville	2.88	8.20
Shelocta	1.31	8.06
Shrouts	1.03	3.91
Skidmore	4.15	4.31
Staser	3.14	6.77
Steff	1.30	7.79
Steinsburg	4.15	2.21
Stendal	4.11	7.76
Taft	1.60	8.62
Talbott	1.66	6.96
Torklin	1.31	6.52
Tate	3.47	7.68
Tilsit	1.27	9.15
Trappist	2.07	5.45
Trimble	1.31	11.74
Tunica	0.13	7.35

Soil Series	Perm. in./hr	AWC in.
Tyler	2.68	8.92
Uniontown	1.32	9.77
Upshur	0.13	6.54
Vicksburg	2.45	10.06
Wakeland	1.43	11.47
Waverly	1.42	9.84
Waynesboro	1.30	14.85
Weibach	1.04	8.44
Weikert	1.32	1.58
Wellston	1.64	7.33
Westmoreland	3.63	3.24
Wheeling	1.34	8.35
Whitley	1.31	8.91
Whitewell	4.10	8.28
Wilbour	1.32	9.50
Wolftever	1.75	7.46
Woolper	1.29	7.76
Zaleski	1.40	8.05
Zanesville	1.34	10.54
Zipp	0.50	6.02