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PB-288 127

# Unsteady Streamflow Simulation Using a Linear Implicit Finite-Difference Model



(U.S.) Geological Survey, Bay Saint Louis, MS

May 78

PB 288127

# Unsteady Streamflow Simulation Using a Linear Implicit Finite-Difference Model

## U.S. GEOLOGICAL SURVEY

Water-Resources Investigations 78-59

| BIBLIOGRAPHIC DATA SHEET | 1. Report No. USGS/WRD/WRI-78/078 | 2. | 3. Recipient's Accession No. PB288127 |
|---|---|---|---|
| 4. Title and Subtitle<br>UNSTEADY STREAMFLOW SIMULATION USING A LINEAR IMPLICIT FINITE-DIFFERENCE MODEL (Final report) | | | 5. Report Date<br>May 1978<br>6. |
| 7. Author(s)<br>Larry F. Land | | | 8. Performing Organization Rept. No. USGS/WRI-78-59 |
| 9. Performing Organization Name and Address<br>U.S. Geological Survey, Water Resources Division<br>Gulf Coast Hydroscience Center<br>National Space Technology Laboratories<br>NSTL Station, Mississippi 39529 | | | 10. Project/Task/Work Unit No.<br>11. Contract/Grant No. |
| 12. Sponsoring Organization Name and Address<br>U.S. Geological Survey, Water Resources Division<br>Gulf Coast Hydroscience Center<br>National Space Technology Laboratories<br>NSTL Station, Mississippi 39529 | | | 13. Type of Report & Period Covered<br>Final<br>14. |

15. Supplementary Notes

16. Abstracts A computer program for simulating one-dimensional subcritical, gradually varied, unsteady flow in a stream has been developed and documented. Given upstream and downstream boundary conditions and channel geometry data, roughness coefficients, stage, and discharge can be calculated anywhere within the reach as a function of time. The program uses a linear implicit finite-difference technique that discritizes the partial differential equations. Then it arranges the coefficients of the continuity and momentum equations into a pentadiagonal matrix for solution. Because it is a reasonable compromise between computational accuracy, speed and ease of use, the technique is one of the most commonly used. The upstream boundary condition is a depth hydrograph. However, options also allow the boundary condition to be discharge or water-surface elevation. The downstream boundary condition is a depth which may be constant, self-setting, or unsteady. The reach may be divided into uneven increments and the cross sections may be nonprismatic and may vary from one to the other. Tributary and lateral inflow may enter the reach. The digital model will simulate such common problems as (1) flood waves, (2) releases from dams, and (3) channels where storage is a consideration. It may also supply the needed flow information for mass-transport simulation.

17. Key Words and Document Analysis. 17a. Descriptors

*Streams, *Model studies, Computer models, Backwater, Depth, Discharge, Hydraulic properties, Hydrographs, Manning's equation, Unsteady flow

17b. Identifiers/Open-Ended Terms

*Unsteady streamflow simulation, Digital model development

17c. COSATI Field/Group

| 18. Availability Statement | 19. Security Class (This Report) | |
|---|---|---|
| No restriction on distribution.<br>Prepared for NTIS by U.S. Geological Survey, WRD | UNCLASSIFIED | |
| | 20. Security Class (This Page) UNCLASSIFIED | 22. Price MF A01 PC A04 |

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May 1978

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NSTL Station, Mississippi  39529

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ILLUSTRATION



FACTORS FOR CONVERTING U.S. CUSTOMARY UNITS TO INTERNATIONAL SYSTEM (SI) UNITS

| Multiply U.S. Customary units | By | To obtain metric units |
|---|---|---|
| feet (ft) | 0.3048 | meters (m) |
| cubic feet per second ($ft^3/s$) | $2.832 \times 10^{-2}$ | cubic meters per second ($m^3/s$) |

# UNSTEADY STREAMFLOW SIMULATION USING A LINEAR IMPLICIT FINITE-DIFFERENCE MODEL

By Larry F. Land

## ABSTRACT

A computer program for simulating one-dimensional subcritical, gradually varied, unsteady flow in a stream has been developed and documented. Given upstream and downstream boundary conditions and channel geometry data, roughness coefficients, stage, and discharge can be calculated anywhere within the reach as a function of time.

The program uses a linear implicit finite-difference technique that discritizes the partial differential equations. Then it arranges the coefficients of the continuity and momentum equations into a pentadiagonal matrix for solution. Because it is a reasonable compromise between computational accuracy, speed and ease of use, the technique is one of the most commonly used.

The upstream boundary condition is a depth hydrograph. However, options also allow the boundary condition to be discharge or water-surface elevation. The downstream boundary condition is a depth which may be constant, self-setting, or unsteady. The reach may be divided into uneven increments and the cross sections may be nonprismatic and may vary from one to the other. Tributary and lateral inflow may enter the reach.

The digital model will simulate such common problems as (1) flood waves, (2) releases from dams, and (3) channels where storage is a consideration. It may also supply the needed flow information for mass-transport simulation.

## INTRODUCTION

A number of digital models for simulating gradually varied unsteady streamflow have been developed by the U.S. Geological Survey and others. However, few are being used at the field level, possibly because of the lack of documentation in a form appropriate for the user. The purpose of this report is to document for field use one of the simpler yet powerful digital models.

The numerical analysis technique used to state the continuity and momentum equations governing streamflow generally include difference methods, method of characteristics, and weighted residuals (finite elements). Each technique has many variations with each having some specific advantage or disadvantage. Probably the most common solution, and the one used for this model, is the linear implicit finite-difference technique. It offers a reasonable compromise between computational accuracy and speed and ease of use.

The computer program (J879) presented in this report is designed to compute discharge and depth hydrographs at any point in a one-dimensional channel. The model is driven by depth and velocity at the upstream boundary and may be controlled at the downstream boundary by a steady or unsteady depth function. Options available in the model include tributary inflow, storage of main stem water in a tributary, and lateral inflow from ground-water seepage or overland flow.

## ACKNOWLEDGMENT

The author wishes to express appreciation to T. N. Keefer of SUTRON, Inc., formerly U.S. Geological Survey, for formulating, developing, and testing the basic model used in this documentation.

## BASIS FOR MODEL DEVELOPMENT

The continuity and momentum equations for flow in a one-dimensional channel have been developed by Strelkoff (1969). Amein and Fang (1970) formulated a nonlinear finite-difference form of the equations. Strelkoff (1970) presented the linear implicit form of the finite-difference equations. The matrix solver routine, an algorithm for a pentadiagonal matrix, is presented by Von Rosenberg (1969).

Briefly, the basic forms of the continuity and momentum equations used in the model are, respectively:

$$U \frac{\partial A}{\partial x} + A \frac{\partial U}{\partial x} + \frac{\partial A}{\partial t} - q = 0 \qquad (1)$$

and

$$\frac{\partial U}{\partial t} + U \frac{\partial U}{\partial x} + g \frac{\partial y}{\partial x} = g\,(S_o - S_f) + D_L \qquad (2)$$

where

$U$ = cross-section average velocity
$A$ = cross-section area
$q$ = tributary and lateral inflow
$x$ = distance along channel
$t$ = time
$y$ = depth
$g$ = acceleration of gravity
$S_o$ = channel bottom slope
$S_f$ = friction slope defined by Manning's equation
$D_L$ = momentum changes caused by tributary and lateral inflow (assumed zero).

Upstream and downstream boundary conditions must be specified or estimated to complete a set of 2N equations and 2N unknowns.

Refer to Keefer (1976) for the transformation of the above partial differential equations into the finite-difference form used in this report.

## GENERAL MODEL DESIGN AND OPERATION

A generalized program flow chart is given in attachment A. A program listing is given in attachment B. The program first reads the control parameters and data from punched cards. To begin the flow computations, a steady-state step-backwater subprogram is executed for the initial steady flow discharges. This subprogram computes the velocity and water depth values at all cross sections at time = 0. Since the datum at each cross section is the lowest point (thalweg) of that cross section, all depth values are referenced to the lowest point and the water surface of the cross section. Next, the computer begins moving the simulation in time. At each time step the depth and velocity are calculated at all cross sections. Selected results are printed and saved on a disk storage device. At the end of the simulation, line-printer plots of depth and discharge may be made at selected cross sections.

The primary step in applying the model to a field problem is to design a grid or cross-section network that represents the stream. The distance between cross sections in the field and the length of time step used in the model are related by the inequality

$$\Delta t \leq K \frac{\Delta x}{|U| + \sqrt{gy}} \quad \text{where } K \leq 10 \qquad (3)$$

$K$ is a factor expressing the number of times the Courant conditions (Courant and Reese, 1952) are exceeded. When $K$ is equal to 1, the relationship is known as the Courant condition. Errors in the solution will increase as the Courant conditions are exceeded but remain small when $K$ is less than 10 and negligible when less than 5. These determinations should be made at several locations in the reach. However, a very rapid change in discharge relative to time will require smaller time steps and more cross sections for computational stability. The duration of a time step ($\Delta t$) is constant, but the cross sections may be unequally spaced ($\Delta x$). An example of a reach design and the numbering system is given in figure 1.

## MODEL OPTIONS

### Upstream Boundary Conditions

Four options are available for inputing hydrograph data at the upstream boundary. They include (1) discharge with self-setting depth, (2) discharge with a unique depth-discharge rating table, (3) depth, and (4) water-surface elevation. Since the model must be driven by depth and velocity at the upstream boundary, the missing data must be computed or estimated. The

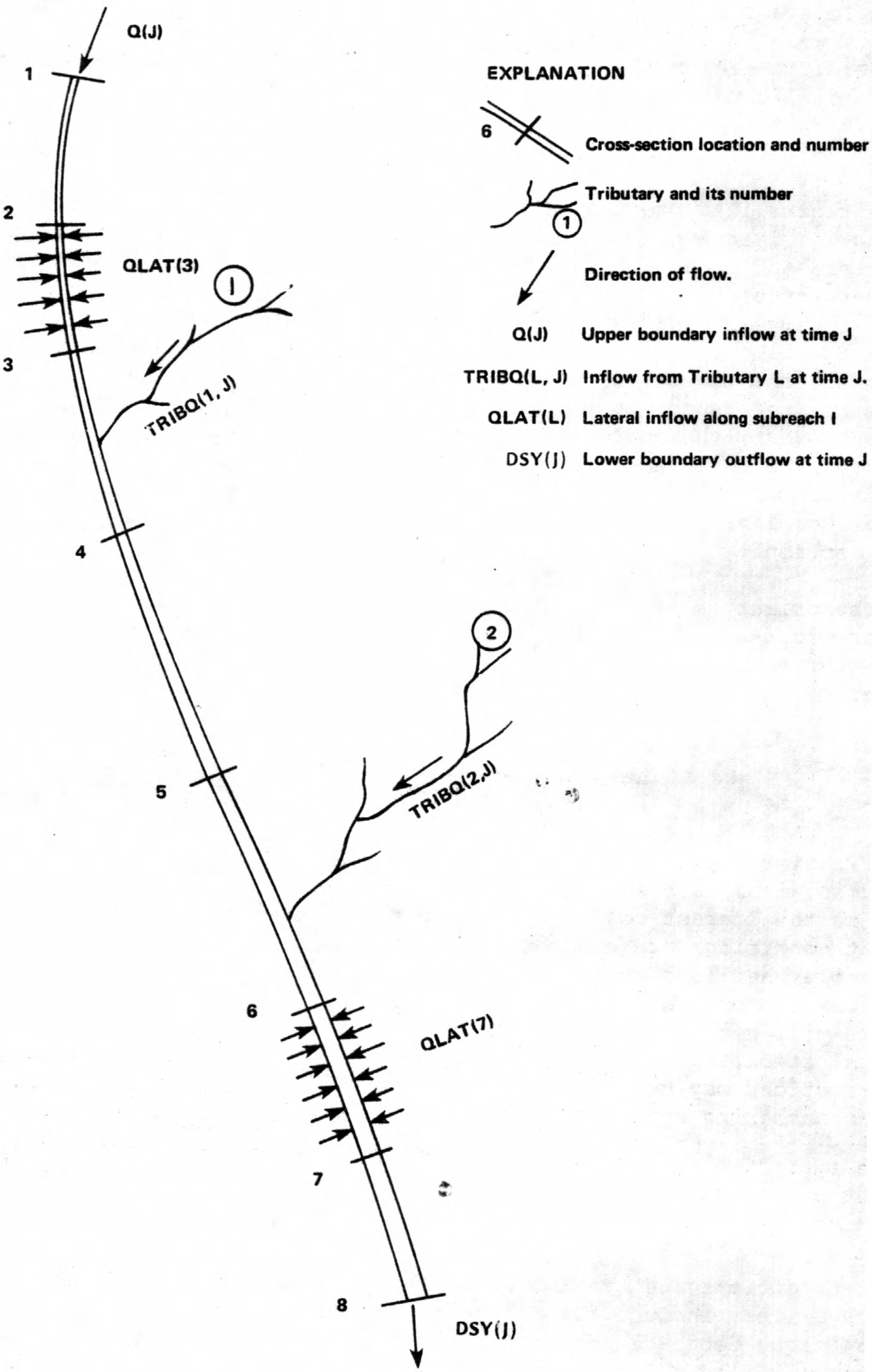


Figure 1.--Schematic diagram of grid design and numbering system.

velocity is computed from discharge and area values for options 1 and 2 and is estimated from matrix coefficients at nearby cross sections for options 3 and 4. The depth is set to the value computed at the previous time step for option 1, computed from a depth-discharge rating table for option 2, input directly for option 3, and computed by subtracting thalweg elevation from water-surface elevation for option 4. For accuracy and for calibration and verification purposes, it is preferable to input discharge and compare depth data. It is also acceptable to input depth data and compare discharge data.

### Downstream Boundary Conditions

Four options are available for specifying the downstream boundary. They include (1) self-setting depth, (2) constant depth, (3) depth, and (4) water-surface elevation. The self-setting depth option locally linearizes a depth-velocity rating curve that is based on normal flow. This procedure automatically produces a unique depth-velocity relationship. For options 1 and 2 it is suggested that the downstream boundary be moved a distance downstream from the reach under study to minimize problems with traveltime and the effects of loop ratings. If possible, the downstream boundary should be specified by one of the other options (3 or 4). Controlling the downstream boundary with velocities is not available in the model.

### Tributary Inflow

The program is coded to allow up to three tributaries to enter the reach. These inflows may be unsteady. In order to ignore the momentum or energy effects, they are assumed to enter the stream at a 90° angle. The tributary is assumed to enter the subreach at its downstream cross section.

### Lateral Inflow

A constant rate of lateral inflow can be added to the streamflow in any subreach. The inflow is in cubic feet per second per lateral foot of channel in the subreach. A steady tributary flow may be treated as lateral inflow.

### Storage in Tributaries

If a significant amount of main channel water is temporarily stored or released from tributary channels, an account can be made for these effects. The procedure is to compute an adjusted or net tributary flow that is equal to the specified flow plus the amount of water released from the tributary's channel due to the change in stage of the main channel during the previous time step. A cubic equation is used to describe the area-depth relationship of each tributary.

### Disk Storage of Results

In the event of future computational needs for intermediate values, an option can be selected to store (1) top width, (2) velocity, (3) area, (4) net tributary flow, (5) lateral inflow, and (6) depth. This is done at each time step and at each cross section.

## Output

Printed output is obtained at selected time steps and for selected cross sections. Punch card output can be obtained for stage and discharge data at selected cross sections. Line printer plots of depth and discharge can also be obtained for selected cross sections.

## Observed Data Plot

An option is available for plotting the observed hydrograph data on the printer with the same scale as used for the simulated hydrograph. This facilitates a quick comparison of modeled and observed results which can be very helpful in the calibration phase.

# PROGRAM RUN PREPARATIONS

## Data

One of the first steps in applying the model to a reach is subdividing the reach with cross sections and selecting a time increment. An upper limit for $\Delta t$ and $\Delta x$ values can be derived from equation 3. Normally, a $\Delta t$ value is selected and $\Delta x$ values are computed at several locations to establish a relationship between $\Delta x$ and reach and flow characteristics. If this reach subdivision produces too many or too few grids, another $\Delta t$ should be selected. But, if very rapid changes in stage occur, additional cross sections and smaller time steps may be necessary for computational stability. Cross sections should appear at the natural changes in the channel geometry, roughness, and bed profile. Each cross section is assumed to be representative of the channel to a point midway to adjacent cross sections. For consideration of computer cost, the number of cross sections should be kept to less than 50.

Use of finite-difference flow models carries a rather heavy demand for good channel geometry and vertical control data. For each cross section selected a bottom elevation and several sets of corresponding depths and top widths are required. It is suggested that depth profiles be obtained at steady flow to estimate the elevations of intermediate cross sections between the cross sections with good vertical control. This technique was discussed by Jobson and Keefer (1976). Considerable cross-section geometry data can be obtained at little expense by making soundings and distance measurements for that part of the cross section lying below the water surface and by scaling topographic maps for that part lying above the water surface. Preparation of cross-section geometry data for model input requires summarizing the data into a table relating depth and top width. This is best done by plotting the x-y coordinates of the cross section and then determining the depths and top widths at breaks with an engineering scale.

Unsteady flow data are entered into the model in card format and at the $\Delta t$ selected above. These data include inflow at the upstream boundary, all major tributaries with unsteady flow, and the downstream boundary, when not using the self-setting or constant depth options. The first 16 columns of the cards are not utilized by the program; therefore, they may be used to identify location and date of flow data.

Data for steady flows, such as lateral inflow and steady tributary flow, are entered as constants.

Channel roughness data in the form of Manning *n* is required at each cross section. The *n* value is allowed to vary linearly with depth.

The option to allow the storage of main channel water in tributary channels is controlled by a cubic equation relating depth in the main channel and water surface area in the tributary. A set of coefficients, usually obtained by regression, is needed for each tributary.

## Computer Program

The computer program is written in Fortran IV programing language and was developed and tested on IBM 360/91 equipment[1/]. Some changes may be required when using other equipment.

The program is dimensioned for 50 cross sections and 999 time steps. For simulations requiring more cross sections or time steps, the dimensioning must be increased. The program as dimensioned requires 250 K bytes of core storage on IBM 360 or 370 equipment. Compiling the program takes 15 to 20 seconds. Execution time for production runs requires 50 to 70 seconds for a reach with 50 cross sections and 1,000 time steps. These estimates are for the Fortran IV H-level compiler using Opt=2. For larger production or calibration runs, this compiler reduces computation time about 40 percent in comparison to the Fortran IV G-level compiler.

A schematic diagram showing the arrangement of the input cards for a model run is given in attachment C. A listing of an example data set is given in attachment D.

# DATA INPUT SPECIFICATIONS

Data input for the model is by computer cards. The information on the control cards is input with the NAMELIST command. Other data are generally entered in fields 8 columns wide with 10 fields per card. All variables are real (number with a decimal) or integer according to standard notation, that is, A-H, O-Z for real and I-N for integer. All integers and real numbers without decimals must be right justified. The variables in the NAMELIST name block have the form

```
 &name          VALUE1=1.0,          VALUE2=2.0,      VALUE3=3.0     &END
```

The first ampersand must be in column 2 and commas must be used to separate data items.

---

[1/] The use of brand names in this report is for identification purposes only and does not imply endorsement by the U.S. Geological Survey.

A description of the data input, sequence, and arrangement follows.

---

SET NO. I PARAMETERS

| Card No. | Variable | Description | Columns |
|---|---|---|---|
| 1 | INFO(20) | Information card. Generally with basin name, period of record, date of run, and so forth. | 1-80 |
| 2 | CODE | Block name for selected codes | 3-6 |
| | IUBC | Upstream boundary condition selector code<br>1 = discharge with self-setting depth<br>2 = discharge with depth from rating curve<br>3 = depth<br>4 = water-surface elevation | --- |
| | IDBC | Downstream boundary condition selector code<br>1 = self-setting depth<br>2 = constant depth<br>3 = depth<br>4 = water-surface elevation | --- |
| | IOFS | Allow storage of water in tributaries?<br>0 = no<br>1 = yes | --- |
| | NZPLOT | Plot observed data only?<br>0 = no<br>1 = yes | --- |
| 3 | SIZE | Block name for defining size of run | 3-6 |
| | NX | Number of cross sections | --- |
| | NTS | Number of time steps | --- |
| | NTRIB | Number of tributaries with unsteady flow. Maximum of 3. | --- |
| | DT | Length of time step, seconds | --- |
| 4 | INIT | Block name for defining initial boundary values | 3-6 |
| | QINIT | Initial discharge of upstream boundary, used only when IUBC = 3 or 4. | --- |
| | DSDEP | Constant downstream depth, used only when IDBC = 2 | --- |
| 5 | CTRL | Block name for program controls | 3-6 |
| | NPRNT | Number of cross sections with results to be printed<br>0 = all<br>N, N=1,2,3,..., NX = number of selected cross sections | --- |

| Card No. | Variable | Description | Columns |
| --- | --- | --- | --- |
| | IPNT | Number of time steps between printouts | --- |
| | NPLOT | Number of cross sections with depths and discharges plotted on printer. Maximum of 5. | --- |
| | IPLT | Number of time steps between adjacent points on plot. | --- |
| | NPNCH | Number of cross sections with discharge and water-surface elevation results punched on cards. Maximum of 5. | --- |
| | ITRAN | Store results on disk device?<br>0 = no<br>1 = yes | --- |
| 6 | DATE | Block name of starting date | 3-6 |
| | IYR | Starting date - year | --- |
| | IMON | - month | --- |
| | IDY | - day | --- |
| | IHR | - hour (military) | --- |

SET NO. II CROSS-SECTION OUTPUT

| Card No. | Variable | Description | Columns |
| --- | --- | --- | --- |
| 1,... | NP(I) | Cross-section numbers for which results are to be printed. Number of values equals NPRNT. Omit when NPRNT=0. | 1-8,<br>9-16,...<br>73-80 |
| 1,... | NPP(I) | Cross-section numbers for which results are to be plotted or punched on cards. Number of values equals the larger of NPNCH and NPLOT. Maximum of 5. Omit when NPNCH and NPLOT=0. If NPNCH and NPLOT are not equal, the parameter with the smaller value uses only as many NPP values as needed, beginning with the first one. | 1-8,<br>9-16,<br>....,<br>33-40 |

SET NO. III RATING TABLE

| Card No. | Variable | Description | Columns |
| --- | --- | --- | --- |
| 1,2 | YPT(20) | Depth values of rating table. Two cards required. Code only as many values as needed. Maximum of 20. Omit when IUBC ≠ 2. | 1-8,<br>9-16,...<br>73-80 |
| 3,4 | QPT(20) | Corresponding discharge values of YPT(20). Two cards required. Use Cards 1-4 only when IUBC = 2. | 1-8<br>9-16,...<br>73-80 |

## SET NO. IV CROSS-SECTION DATA

| Card No. | Variable | Description | Columns |
|---|---|---|---|
| 1,5,9,... | X(I) | Channel length in downstream direction from reference to cross section (I). | 1-8 |
| | Z(I) | Elevation of low-point in cross section (I). | 9-16 |
| | FNO(I) | Manning *n* coefficient of roughness at depth YFN(I). | 17-24 |
| | FN1(I) | Change in *n* per foot change in depth. | 25-32 |
| | YFN(I) | Depth at which FNO(I) equals channel's roughness. Generally depth at base flow. *n* (I)=FNO(I)+FN1(I)*(Y(I)-YFN(I)) | 33-40 |
| | QLAT(I) | Lateral inflow or steady tributary flow between cross section (I-1) and cross section (I). Values are in cubic feet per second per foot of channel length between cross sections. | 41-48 |
| | THETA(I) | Symmetry coefficient for cross section (I). Using bank width data THETA(I) is determined from the equation: THETA(I)=ABS(Rt-Lf)/(Rt+Lf). For perfect symmetry, THETA=0.0; for no symmetry THETA=1.0. The parameter is used to compute the wetted perimeter. Select top width data at most common depth. | 49-56 |
| | NPTS(I) | Number of coordinates used to describe geometry of cross section (I). Maximum of 20. | 73-76 |
| | LTRIB(I) | Tributary number entering subreach above cross section (I). Only one tributary per subreach. Maximum of three tributaries. Number consecutively in downstream direction. | 77-80 |
| 2,6,10,... | YPNT(I,N) | Depth values of table describing cross section (I). Entries are made at breaks in the cross section. The first value is at the channel bottom (0.0). Succeeding values must increase in the upward direction. Number of entries equals NPTS(I). | 1-8, 9-16, ...., 73-80 |

| Card No. | Variable | Description | Columns |
|---|---|---|---|
| 3,7,11,... | TPNT(I,N) | Corresponding top width values to preceding depth YPNT(I,N) values. | 1-8, 9-16, ...., 73-80 |
| 4,8,12,... | ACOEF(L,1-4) | Coefficients of a cubic equation that describes the relationship between the depth in the main channel and a corresponding water-surface area in the tributary. Area(I)=ACOEF(L,1)+ACOEF(L,2)Y +ACOEF(L,3)$Y^2$ + ACOEF(L,4)$Y^3$. L is the tributary number, Y is depth. Use only when IOFS = 1 and when tributaries exist. | 1-8, 9-16, 17-24, 25-32 |

SET NO. V[1/] INFLOW HYDROGRAPH

| Card No. | Variable | Description | Columns |
|---|---|---|---|
| 1,2,3,4,... | Q(J) | Inflow hydrograph. Discharge when IUBC = 1 or 2. Depth when IUBC=3. Elevation when IUBC=4. The first value corresponds to time DT. NTS VALUES ARE REQUIRED. | 17-24, 25-32, ...., 73-80 |

SET NO. VI[1/] TRIBUTARY INFLOW HYDROGRAPH

| Card No. | Variable | Description | Columns |
|---|---|---|---|
| 1,2,3,4,...<br>1,2,3,4,...<br>1,2,3,4,... | TRIBQ(L,J) | Discharge hydrograph of tributary (L). First value corresponds to time DT. NTS values required for each tributary. Number of card sets=NTRIB. | 17-24, 25-32, ...., 73-80 |

SET NO. VII[1/] OUTFLOW HYDROGRAPH

| Card No. | Variable | Description | Columns |
|---|---|---|---|
| 1,2,3,4,... | DSY(J) | Outflow hydrograph. Depth when IDBC=3. Elevation when IDBC=4. First value corresponds to time DT. NTS values required. | 17-24, 25-32, ...., 73-80 |

SET NO. VIII[2/] PLOT DATA

| Card No. | Variable | Description | Columns |
|---|---|---|---|
| 1,2,3,4,... | QSAV(K,J) | Observed discharge data. | 17-24, 25-32, ....., 73-80 |

Footnote:

1/ Omit these sets when NZPLOT=1
2/ Omit this set when NZPLOT=0

| Card No. | Variable | Description | Columns |
|---|---|---|---|
| 1,2,3,4,... | DSAV(K,J) | Observed depth or water-surface elevation data. Assumed later when IDBC=4. Plot will be in depth terms. | 17-24, 25-32, ...., 73-80 |

Repeat discharge and depth card decks in pairs until the number of pairs equals NPLOT, maximum of five.

---

Summary of card requirements:

Set No. I. Required.

II. Print Card required when NOUT > 0. Punch/Plot card required when NPNCH or NPLOT > 0.

III. Required when IUBC = 2.

IV. One set required for each cross section. Area coefficients card required when IOFS = 1 and LTRIB > 0.

V. Required when NZPLOT = 0.

VI. Required when NZPLOT = 0 and NTRIB > 0. Number of sets equals NTRIB.

VII. Required when NZPLOT = 0 and IDBC = 3 or 4.

VIII. Required when NZPLOT = 1. Number of sets of discharge and depth data equals NPLOT.

## PROGRAM OUTPUT

Results of calculations are printed at selected cross sections and selected time steps. Top width, velocity, area, tributary flow, lateral inflow, and depth may be stored on disk. These values are stored for all cross sections and time steps. Printer plots of depth and discharge are available for a visual presentation. Punched computer cards may be obtained if needed.

An example of the printer output of listings and plots is given in attachment E.

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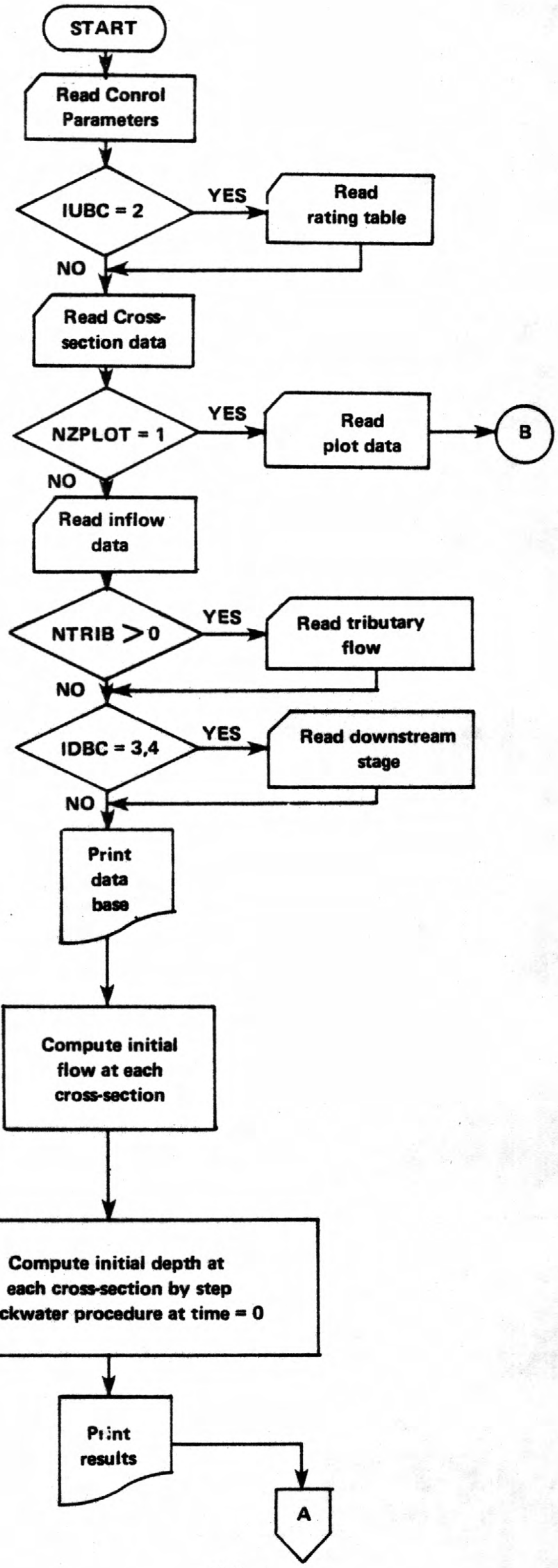
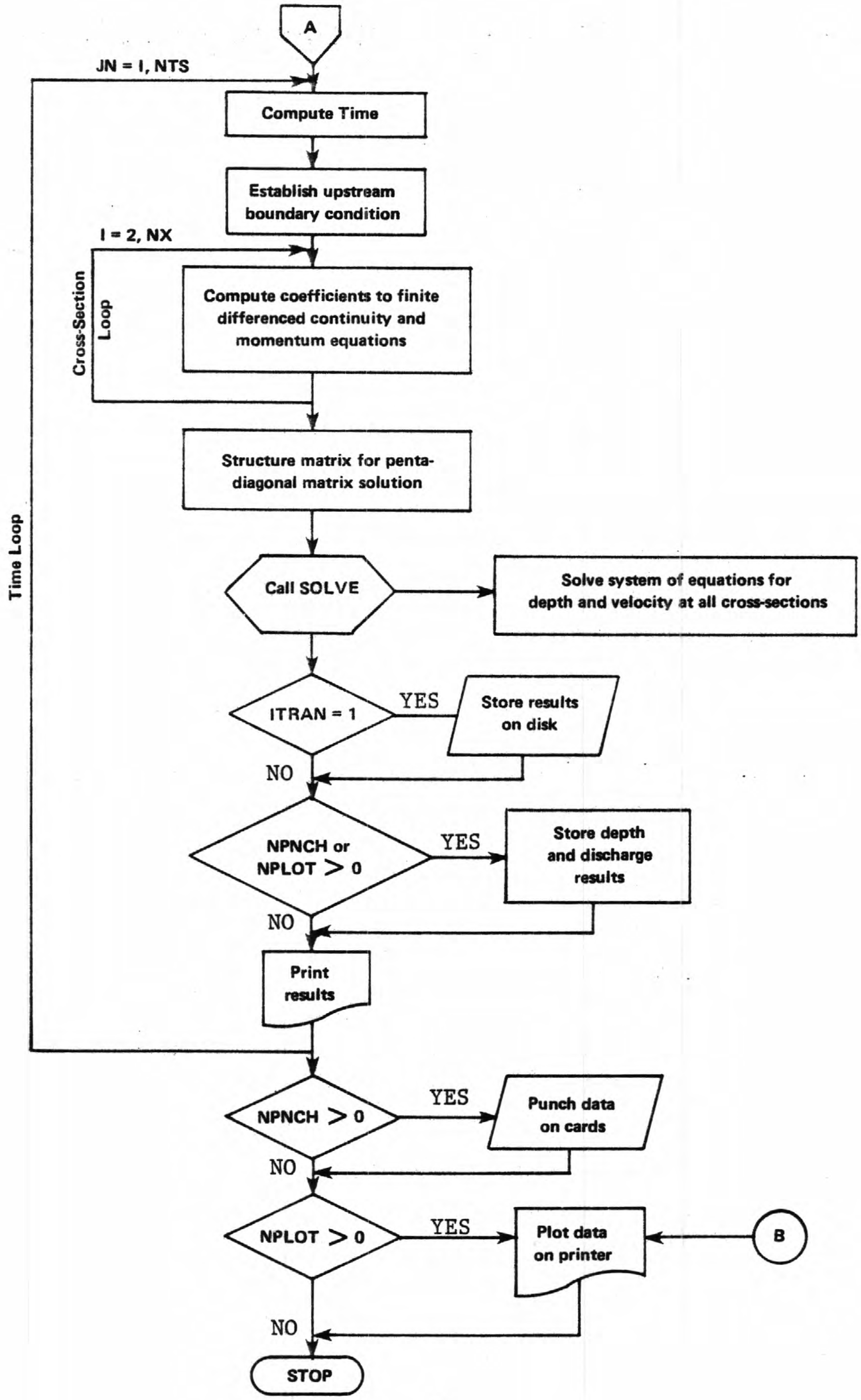
ATTACHMENTS

## A. GENERALIZED FLOW CHART


START
Read Conrol Parameters
IUBC = 2
YES
Read rating table
NO
Read Cross-section data
NZPLOT = 1
YES
Read plot data
B
NO
Read inflow data
NTRIB > 0
YES
Read tributary flow
NO
IDBC = 3,4
YES
Read downstream stage
NO
Print data base
Compute initial flow at each cross-section
Compute initial depth at each cross-section by step Backwater procedure at time = 0
Print results
A


A
JN = I, NTS
Compute Time
Establish upstream boundary condition
I = 2, NX
Cross-Section Loop
Compute coefficients to finite differenced continuity and momentum equations
Structure matrix for penta-diagonal matrix solution
Time Loop
Call SOLVE
Solve system of equations for depth and velocity at all cross-sections
ITRAN = 1
YES
Store results on disk
NO
NPNCH or NPLOT > 0
YES
Store depth and discharge results
NO
Print results
NPNCH > 0
YES
Punch data on cards
NO
NPLOT > 0
YES
Plot data on printer
B
NO
STOP

## B. COMPUTER PROGRAM

| Subprogram identification code | Subprogram name | Description |
|---|---|---|
| A | MAIN | Executive program with instructions for data input, primary computations and outputs results. |
| B | SOLVE | Routine for solution of a pentadiagonal matrix. |
| C | TABL | Computes depth from a given discharge using a rating table. |
| D | XPROP | Computes cross-section parameters. |
| E | HEAD | Computes velocity and friction heads. |
| F | PRPLOT | Compilation of ENTRY subprograms for plotting hydrograph data on line printer. |

```
C     ****************************************************************
C     *                                                              *
C     *  J879--UNSTEADY STREAMFLOW SIMULATION USING A                *
C     *                      LINEAR IMPLICIT FINITE DIFFERENCE MODEL *
C     *                                                              *
C     *                   OPERATIONAL MODELS PROJECT                 *
C     *                 GULF COAST HYDROSCIENCE CENTER               *
C     *                  U. S. GEOLOGICAL SURVEY - WRD               *
C     *            DATE OF LAST PROGRAM REVISION: JAN 20, 1978       *
C     *                                                              *
C     ****************************************************************
C
      DEFINE FILE 20(1000,1200,L,ID3)
C
      COMMON /A/ A(100,5),F(100),DEL(100),RLAM(100),GAM(100),RMU(100),BE
     1TA(100),Y(200),YN(200)
      COMMON /B/ NPTS(50),THETA(50),YPNT(50,20),TPNT(50,20)
      COMMON /C/ YPT(20),QPT(20)
      COMMON /D/ NX,JX,IUBC,IDBC,IDY,IHR
      COMMON /E/ YDSJ,SLOPE,FY2
C
      DIMENSION Q(1000), TRIBQ(3,1000), DSY(1000)
      DIMENSION QSAV(5,1000), DSAV(5,1000), NPP(5)
      DIMENSION X(50), Z(50), FN0(50), FN1(50), YFN(50), ELEV(50)
      DIMENSION R(50), NP(50), DATA(6,50)
      DIMENSION QLAT(50), QOUT(50), LTRIB(50)
      DIMENSION YJM1(3), STORQ(3), ACOEF(3,4), MONTH(12), INFO(20)
      DIMENSION IMAGE(2450), IRNG1(6), IRNG2(10), NSCALE(5)
      LOGICAL*1 LETTER(5)
      DATA IRNG1/10,20,25,40,50,100/
      DATA IRNG2/1000,2000,2500,4000,5000,10000,25000,50000,100000,20000
     10/
      DATA NSCALE/1,0,3,0,1/
      DATA LETTER/'A','B','C','D','E'/
      DATA MONTH/31,28,31,30,31,30,31,31,30,31,30,31/
      DATA NZPLOT/0/
C
C
C                       DEFINITION OF INPUT PARAMETERS
C
C     INFO   :  INFORMATION CARD
C
C                            NAMELIST PARAMETERS
C                            -------------------
C     CODE ----
C     IUBC   :  UPSTREAM BOUNDARY CONDITION SELECTOR CODE
C                1=DISCHARGE WITH SELF-SETTING DEPTH
C                2=DISCHARGE WITH DEPTH FROM RATING CURVE
C                3=DEPTH
C                4=ELEVATION
C     IDBC   :  DOWNSTREAM BOUNDARY CONDITION SELECTOR CODE
C                1=SELF-SETTING
C                2=CONSTANT DEPTH
C                3=DEPTH
C                4=ELEVATION
C     IOFS   :  ALLOW STORAGE IN TRIBUTARIES?  NO(0)   YES(1)
C     NZPLOT:   RUN TO PLOT OBSERVED DATA ONLY?  NO(0)   YES(1)
```

```
C      SIZE ----
C      NX     :  NUMBER OF CROSS-SECTIONS
C      NTS    :  NUMBER OF TIME STEPS
C      NTRIB  :  NUMBER OF TRIBUTARIES
C      DT     :  LENGTH OF TIME STEP IN SECONDS
C      INIT ----
C      QINIT  :  INITIAL DISCHARGE; USED WHEN IUBC =>3
C      DSDEP  :  CONSTANT DOWNSTREAM DEPTH; USED WHEN IDBC=2
C      CTRL ----
C      NPRNT  :  NUMBER OF X-SECTIONS PRINTED CODE;  ALL(0)   LIMIT(=)
C      IPNT   :  NUMBER OF TIME STEPS BETWEEN PRINTOUTS
C      NPLOT  :  NUMBER OF X-SECTIONS WITH DISCHARGE AND DEPTH PLOTS
C      IPLT   :  NUMBER OF TIME STEPS BETWEEN POINTS ON PLOT
C      NPNCH  :  NUMBER OF X-SECTIONS WITH DISCHARGE AND DEPTH PUNCH CRD O
C      ITRAN  :  STORE RESULTS ON DISK?  NO(0)   YES(1)
C      DATE ----
C      IYR    :  STARTING DATE - YEAR
C      IMON   :                  MONTH
C      IDY    :                  DAY
C      IHR    :                  HOUR
C
C                        SELECTING OUTPUT
C                        ----------------
C      NP(K)       :  X-SEC NOS. WITH RESULTS PRINTED
C      NPP(K)      :  X-SEC NOS. WITH DEPTH AND DISCH PUNCHED AND/OR PLOTT
C                   NOTE:  IF NPNCH AND NPLOT ARE NOT EQUAL, THE LEADING
C                          NUMBERS WILL BE USED FOR THE SMALLER PARAMETER
C
C                        RATING TABLE
C                        ------------
C      YPT(M) + QPT(M):  CORRESPONDING DEPTH AND DISCHARGE VALUES,
C                    USED WHEN IUBC=2.
C
C                        CROSS-SECTION PARAMETERS
C                        ------------------------
C      X(I)        :  CHANNEL LENGTH FROM BEGINNING TO X-SEC(I)
C      Z(I)        :  ELEVATION OF LOW-POINT IN X-SEC(I)
C      FNO(I),FN1(I):  A AND B COEFS OF A LINEAR EQUATION DESCRIBING
C                     MANNINGS N WITH DEPTH.  THE EQUATION IS
C                     N=FNO+FN1*(Y-YFN) WHERE YFN IS DEFINED AS
C      YFN(I)    :  DEPTH, GENERALLY AT BASE FLOW, AT WHICH THE FNO VALUE
C                   IS EQUAL TO THE STREAM'S N VALUE.
C      QLAT(I)     :  LATERAL INFLOW IN CFS/FT BETWEEN X-SEC(I-1) + X-SEC(
C      THETA(I)    :  X-SEC SYMMETRY COEF:  0.0=100( SYMMETRY
C                                           1.0=  0( SYMMETRY
C      NPTS(I)     :  NUMBER OF COORDINATES DESCRIBING GEOMETRY
C      LTRIB(I)    :  TRIB NO. AT X-SEC(I); NO. CONSEC.IN D S DIRECTION
C
C      YPNT(I,N) + TPNT(I,N):  CORRESPONDING DEPTHS AND TOP WIDTHS AT
C                              X-SEC(I).  DATUM OF DEPTH IS 0.0
C      ACOEF(L,1-4):  COEF OF CUBIC EQUATION DESCRIBING
C                     AREA-DEPTH RELATIONSHIP OF STORAGE IN TRIB(L)
C                     AREA=ACOEF(L,1)+ACOEF(L,2)*Y+...+ACOEF(L,4)*Y**3
C
C                        TIME-SERIES DATA
C                        ----------------
C      Q(J)      :  INFLOW DISCHARGE HYDROGRAPH;        IUBC=1 OR 2
C                :  UPSTREAM DEPTH HYDORGRAPH;          IUBC=3
C                :  UPSTREAM ELEVATION HYDROGRAPH;      IUBC=4
C      TRIBQ(L,J):  DISCHARGE HYDROGRAPH FROM TRIB(L)
```

```
C     DSY(J)      :  DOWNSTREAM DEPTH HYDROGRAPH;          IDBC=3
C                 :  DOWNSTREAM ELEVATION HYDROGRAPH;      IDBC=4
C
C     QSAV(1-5,J):  OBSERVED DISCHARGE DATA AT SELECTED X-SECTIONS
C     DSAV(1-5,J):  OBSERVED STAGE DATA AT SELECTED X-SECTIONS
C                     DEPTH                       IDBC=1,2 OR 3
C                     ELEVATION                   IDBC=4
C
C                          MISC. PARAMETER DEFINITION
C                          --------------------------
C     Y(IODD)     :  VELOCITY AT S-SEC(IODD/2+.5) - OLD
C     Y(IEVEN)    :  DEPTH AT X-SEC(IEVEN/2) - OLD
C     YN(IODD)    :  VELOCITY - NEW
C     YN(IEVEN)   :  DEPTH -NEW
C     STORQ(L)    :  NET FLUX FROM TRIB(L)
C     DATA(1-6,I):  SELECTED RESULTS AT X-SEC(I)
C                     1=TOP WIDTH
C                     2=VELOCITY
C                     3=AREA
C                     4=NET TRIBUTARY FLOW
C                     5=LATERAL INFLOW
C                     6=DEPTH
C
C                            MODEL UNITS
C                            -----------
C     LENGTH       FEET
C     TIME         SECONDS
C     FLOW RATE    CUBIC FEET PER SECOND
C
C
      NAMELIST /CODE/ IUBC,IDBC,IOFS,NZPLOT
      NAMELIST /SIZE/ NX,NTS,NTRIB,DT
      NAMELIST /INIT/ QINIT,DSDEP
      NAMELIST /CTRL/ NPRNT,IPNT,NPLOT,IPLT,NPNCH,ITRAN
      NAMELIST /DATE/ IYR,IMON,IDY,IHR
C
C                             READ DATA CARDS
C                             ---------------
C                                  MISC.
      READ (5,1070) INFO
      READ (5,CODE)
      READ (5,SIZE)
      READ (5,INIT)
      READ (5,CTRL)
      READ (5,DATE)
      IF (IUBC.LT.0.OR.IUBC.GT.4) IUBC=1
      IF (IDBC.LT.0.OR.IDBC.GT.4) IDBC=1
      IF (NPRNT.LT.0.OR.NPRNT.GT.NX) NPRNT=0
      IF (NPLOT.GT.5) NPLOT=5
      IF (NPNCH.GT.5) NPNCH=5
      IF (IPNT.LE.0) IPNT=1
      IF (IPLT.LE.0) IPLT=1
      IF (NPRNT.GT.0) READ (5,1060) (NP(I),I=1,NPRNT)
      IF (NPNCH.GT.0.OR.NPLOT.GT.0) READ (5,1060) (NPP(I),I=1,5)
      IF (IUBC.EQ.2) READ (5,880) (YPT(I),I=1,20)
      IF (IUBC.EQ.2) READ (5,880) (QPT(I),I=1,20)
      IF (MOD(IYR,4).EQ.0) MONTH(2)=29
      NTSP1=NTS+1
```

```
C                                    CROSS-SECTION
      DO 10 I=1,NX
      READ (5,1010) X(I),Z(I),FN0(I),FN1(I),YFN(I),QLAT(I),THETA(I),NPTS
     1(I),LTRIB(I)
      N1=NPTS(I)
      READ (5,880) (YPNT(I,J),J=1,N1)
      READ (5,880) (TPNT(I,J),J=1,N1)
      IF (LTRIB(I).EQ.0.OR.IOFS.EQ.0) GO TO 10
      READ (5,880) (ACOEF(LTRIB(I),J),J=1,4)
   10 CONTINUE
      IF (NZPLOT.GT.0) GO TO 90
C                                    UPSTREAM HYDROGRAPH
      READ (5,1000) (Q(I),I=2,NTSP1)
      Q(1)=Q(2)
      IF (NTRIB.EQ.0) GO TO 30
C                                    TRIBUTARY HYDROGRAPH
      DO 20 I=1,NTRIB
      READ (5,1000) (TRIBQ(I,J),J=2,NTSP1)
   20 TRIBQ(I,1)=TRIBQ(I,2)
   30 CONTINUE
      IF (IDBC.LE.2) GO TO 40
C                                    DOWNSTREM HYDROGRAPH
      READ (5,1000) (DSY(I),I=2,NTSP1)
      DSY(1)=DSY(2)
   40 CONTINUE
      IF (IUBC.NE.4) GO TO 60
      DO 50 I=1,NTSP1
   50 Q(I)=Q(I)-Z(1)
   60 CONTINUE
      IF (IDBC.NE.4) GO TO 80
      DO 70 I=1,NTSP1
   70 DSY(I)=DSY(I)-Z(NX)
   80 CONTINUE
      GO TO 110
   90 CONTINUE
C                                    OBSERVED DATA FOR PLOTTING
      DO 100 L=1,NPLOT
      READ (5,1000) (QSAV(L,J),J=2,NTSP1)
  100 READ (5,1000) (DSAV(L,J),J=2,NTSP1)
C
  110 HR=FLOAT(IHR)
      JX=2*NX
      DTMIN=DT/60.
      R(1)=0.0
      DO 120 I=2,NX
  120 R(I)=(X(I)-X(I-1))/DT
      DO 130 I=1,JX
      Y(I)=0.0
      DO 130 J=1,5
  130 A(I,J)=0.0
      IF (NPRNT.GT.0) GO TO 150
      DO 140 I=1,NX
  140 NP(I)=I
      NPRNT=NX
  150 CONTINUE
      G=32.2
      SLOPE=(Z(NX-1)-Z(NX))/(X(NX)-X(NX-1))
      IF (SLOPE.LE.0.0) SLOPE=(Z(1)-Z(NX))/(X(NX)-X(1))
      IYEAR=IYR
      IMONTH=IMON
```

```
      IDAY=IDY
      IHOUR=IHR
      IF (NZPLOT.EQ.0) GO TO 170
      DO 160 JN=1,NTS
      HR=HR+DT/60.
      IHR=INT(HR)
      IF (MOD(IHR,100).LT.60) GO TO 160
      IHR=IHR/100*100+100
      HR=FLOAT(IHR)
      IF (IHR.LE.2400) GO TO 160
      HR=HR-2400.
      IHR=MOD(IHR,2400)
      IDY=IDY+1
      IF (IDY.LE.MONTH(IMON)) GO TO 160
      IDY=1
      IMON=IMON+1
      IF (IMON.LE.12) GO TO 160
      IMON=1
      IYR=IYR+1
  160 CONTINUE
  170 CONTINUE
C                                      PRINT DATA
C                                      ----------
      WRITE (6,890)
      WRITE (6,1080) INFO
      WRITE (6,1090) IUBC,IDBC,IOFS,ITRAN
      WRITE (6,1100) IMONTH,IDAY,IYEAR
      WRITE (6,1110) NX,NTS,DTMIN,NTRIB
      IF (NZPLOT.EQ.0) GO TO 190
      WRITE (6,1210)
      DO 180 N=1,NPLOT
      WRITE (6,1230) NPP(N)
      WRITE (6,1240) (QSAV(N,J),J=2,NTSP1)
  180 WRITE (6,1250) (DSAV(N,J),J=2,NTSP1)
      IF (IDBC.LE.3) GO TO 650
      GO TO 630
  190 IF (IUBC.GE.3) WRITE (6,1120) QINIT
      IF (IDBC.EQ.2) WRITE (6,1130) DSDEP
      IF (IUBC.EQ.2) WRITE (6,1140) (YPT(I),QPT(I),I=1,20)
      IF (IOFS.EQ.0) GO TO 210
      WRITE (6,1020)
      DO 200 N=1,NTRIB
  200 WRITE (6,1030) N,(ACOEF(N,L),L=1,4)
  210 WRITE (6,1180)
      DO 230 I=1,NX
      WRITE (6,1190) I,X(I),Z(I),FN0(I),FN1(I),YFN(I),QLAT(I),LTRIB(I),T
     1HETA(I)
      M1=1
      M2=4
  220 IF (M2.GT.NPTS(I)) M2=NPTS(I)
      WRITE (6,1200) (YPNT(I,M),TPNT(I,M),M=M1,M2)
      IF (M2.EQ.NPTS(I)) GO TO 230
      M1=M2+1
      M2=M2+4
      GO TO 220
  230 CONTINUE
      DO 240 I=2,NX
      DX=X(I)-X(I-1)
      IF (DX.GT.0.0) GO TO 240
      WRITE (6,1220) I
```

```
      STOP
  240 CONTINUE
      WRITE (6,1150) (Q(I),I=2,NTSP1)
      IF (NTRIB.EQ.0) GO TO 260
      DO 250 K=1,NTRIB
  250 WRITE (6,1170) K,(TRIBQ(K,I),I=2,NTSP1)
  260 IF (IDBC.GE.3) WRITE (6,1160) (DSY(I),I=2,NTSP1)
      WRITE (6,1260)
C
C        *    *    *    *    *    *    *    *    *    *    *    *    *
C
C                    STEP-BACKWATER PROGRAM -
C                        USED TO ESTABLISH INITIAL FLOW CONDITIONS
      IF (IDBC.EQ.2) Y(2*NX)=DSDEP
      IF (IDBC.GE.3) Y(2*NX)=DSY(1)
      IF (IUBC.GE.3) QOUT(1)=QINIT
      IF (IUBC.LE.2) QOUT(1)=Q(1)
      DO 270 I=2,NX
      QOUT(I)=QOUT(I-1)+QLAT(I)*(X(I)-X(I-1))
      IF (LTRIB(I).NE.0) QOUT(I)=QOUT(I)+TRIBQ(LTRIB(I),1)
  270 CONTINUE
      IF (IDBC.NE.1) GO TO 300
      Q2=QOUT(NX)*QOUT(NX)/G
      YC=0.0
      DO 280 I=1,1000
      YC=YC+0.1
      CALL XPROP (YC,NX,DUMA,DUMT,AOVRT,POVRA,H)
      RHS=YC*YC*YC*DUMT*DUMT
      IF (RHS.GT.Q2) GO TO 290
  280 CONTINUE
  290 Y(2*NX)=YC*3.
C     ++++++BEGIN COMPUTATIONS FOR WATER DEPTH AT EACH X-SEC++++++++++++
  300 ELEV(NX)=Z(NX)+Y(2*NX)
      Z2=ELEV(NX)
      CALL HEAD (NX,Y(2*NX),QOUT(NX),HV2,HF2,Y(2*NX-1),FN0(NX),FN1(NX),Y
     1FN(NX))
      CVAY2=QOUT(NX)/SQRT(HF2)
      NXM1=NX-1
      L=NX
      DO 360 I=1,NXM1
      L=L-1
      XDEL=X(L+1)-X(L)
      Y(2*L)=Y(2*(L+1))
      DO 340 NIT=1,100
      J=0
  310 ELEV(L)=Z(L)+Y(2*L)
      Z1=ELEV(L)
      CALL HEAD (L,Y(2*L),QOUT(L),HV1,HF1,Y(2*L-1),FN0(L),FN1(L),YFN(L))
      CVAY1=QOUT(L)/SQRT(HF1)
      FSLOPE=(HF1+HF2)/2.
      HLOSS=FSLOPE*XDEL
      ELOSS=0.1*ABS(HV2-HV1)
      DSHED=Z2+HV2+HLOSS+ELOSS
      USHED=Z1+HV1
      ERNOW=USHED-DSHED
      IF (ABS(ERNOW).LE.0.01) GO TO 350
      IF (NIT.GT.1.AND.ABS(ERNOW).LT.100.) GO TO 330
      IF (NIT.GT.1) GO TO 320
      OLDY=Y(2*L)
      EROLD=ERNOW
```

```
      Y(2*L)=Y(2*L)+0.25*Y(2*L)
      GO TO 340
  320 J=J+1
      Y(2*L)=Y(2*L)-SIGN(0.100,ERNOW)*Y(2*L)
      IF (J.GT.50) WRITE (6,1300) L
      IF (J.GT.50) GO TO 350
      GO TO 310
  330 OLY2L=Y(2*L)
      Y(2*L)=Y(2*L)-ERNOW*((Y(2*L)-OLDY)/(ERNOW-EROLD))
      IF (Y(2*L).LE.0.0) Y(2*L)=0.25
      EROLD=ERNOW
      OLDY=OLY2L
  340 CONTINUE
  350 CONTINUE
      Z2=Z1
      HV2=HV1
      HF2=HF1
      CVAY2=CVAY1
  360 CONTINUE
C     *************END OF BACKWATER COMPUTATIONS************************
      IF (NTRIB.EQ.0) GO TO 380
      DO 370 I=1,NX
      IF (LTRIB(I).NE.0) YJM1(LTRIB(I))=Y(2*I)
  370 CONTINUE
  380 YDSJ=Y(2*NX-2)+0.1
      IF (IUBC.EQ.1) YCHK=Y(2)
C                   SAVE DATA ON DISK
      IF (ITRAN.NE.1) GO TO 400
      DO 390 I=1,NX
      CALL XPROP (Y(2*I),I,ARIA,TOP,AOVRT,POVRA,4)
      DATA (1,I)=TOP
      DATA (2,I)=Y(2*I-1)
      DATA (3,I)=ARIA
      DATA (4,I)=0.0
      IF (LTRIB(I).NE.0) DATA(4,I)=TRIBQ(LTRIB(I),1)
      DATA (5,I)=QLAT(I)
      DATA (6,I)=Y(2*I)
      WRITE (20'1) DATA
  390 CONTINUE
C                    PRINT RESULTS AT SELECTED X-SECTIONS
  400 WRITE (6,900)
      WRITE (6,930) IMON,IDY,IYR,IHR
      M1=1
      M2=13
  410 IF (M2.GT.NPRNT) M2=NPRNT
      WRITE (6,940) (NP(I),I=M1,M2)
      WRITE (6,950) (ELEV(NP(I)),I=M1,M2)
      WRITE (6,960) (Y(2*NP(I)),I=M1,M2)
      WRITE (6,970) (QOUT(NP(I)),I=M1,M2)
      WRITE (6,980) (Y(2*NP(I)-1),I=M1,M2)
      WRITE (6,990)
      IF (M2.EQ.NPRNT) GO TO 420
      M1=M2+1
      M2=M2+13
      GO TO 410
  420 CONTINUE
```

```
C
C           *     *     *     *     *     *     *     *     *     *     *     *     *
C
C                BEGIN LINEAR IMPLICIT FINITE DIFFERENCE ALGORITHM
C
C     --------- BEGIN LOOPING THROUGH MODEL IN TIME --------------------
      DO 590 JN=1,NTS
      JNP1=JN+1
      K=JNP1
      HR=HR+DT/60.
      IHR=INT(HR)
      IF (MOD(IHR,100).LT.60) GO TO 430
      IHR=IHR/100*100+100
      HR=FLOAT(IHR)
      IF (IHR.LE.2400) GO TO 430
      HR=HR-2400.
      IHR=MOD(IHR,2400)
      IDY=IDY+1
      IF (IDY.LE.MONTH(IMON)) GO TO 430
      IDY=1
      IMON=IMON+1
      IF (IMON.LE.12) GO TO 430
      IMON=1
      IYR=IYR+1
  430 CONTINUE
      A(1,3)=1.0
C                    ESTABLISH UPSTREAM BOUNDARY CONDITIONS
      IF (IUBC.NE.1) GO TO 440
C                          TYPE 1 = SELF-SETTING
      CALL XPROP (YCHK,1,AR,DUMT,AOVRT,POVRA,H)
      F(1)=Q(K)/AR
      YN(1)=F(1)
      GO TO 460
  440 IF (IUBC.NE.2) GO TO 450
C                          TYPE 2 = RATING CURVE
      CALL TABL (Q(K),YCHK)
      CALL XPROP (YCHK,1,AR,DUMT,AOVRT,POVRA,H)
      F(1)=Q(K)/AR
      YN(1)=F(1)
      YN(2)=YCHK
      GO TO 460
  450 CONTINUE
C                          TYPE 3 = DEPTH
C                          TYPE 4 = ELEVATION
C     DATA INPUT DIRECTLY
  460 CONTINUE
C                    X-SEC PROPERTY CALCULATIONS
C                          FILL COEF MATRIX
      I2=2
      FY=FN0(1)+FN1(1)*(Y(I2)-YFN(1))
      FPRMY=FN1(1)
      CALL XPROP (Y(I2),1,AR,TOP,AOVRT,POVRA,H)
      DO 490 I=2,NX
      I0=2*I
      I1=2*I-1
      I2=2*I-2
      I3=2*I-3
      DX=X(I)-X(I-1)
C             COMPUTE MANNINGS N
      FY2=FN0(I)+FN1(I)*(Y(I0)-YFN(I))
```

```
      FPRMY2=FN1(I)
      CALL XPROP (Y(I0),I,AR2,TOP2,AOVRT2,POVRA2,H2)
C              COEFFICIENTS OF L.H.S. OF MOMENTUM EQUATION
      A(I2,2)=-ABS(Y(I1))-ABS(Y(I3))+.906*G*ABS(Y(I3))*DX*FY*FY*POVRA**(
     14./3.)+R(I)
      A(I2,3)=.906*G*ABS(Y(I3))*Y(I3)*FY*POVRA**(4./3.)*FPRMY*DX-2*G+.60
     14*G*ABS(Y(I3))*Y(I3)*FY*FY*POVRA**(1./3.)*H*DX
      A(I2,4)=+ABS(Y(I1))+ABS(Y(I3))+.906*G*ABS(Y(I1))*FY2*FY2*POVRA2**(
     14./3.)*DX+R(I)
      A(I2,5)=2.*G+.604*G*ABS(Y(I1))*Y(I1)*FY2*FY2*POVRA2**(1./3.)*H2*DX
     1+.906*G*ABS(Y(I1))*Y(I1)*FY2*POVRA2**(4./3.)*FPRMY2*DX
C              COEFFICIENTS OF L.H.S. OF CONTINUITY EQUATION
      A(I1,1)=-(AR+AR2)
      A(I1,2)=TOP*(R(I)-(Y(I1)+Y(I3)))
      A(I1,3)=-A(I1,1)
      A(I1,4)=TOP2*(R(I)+(Y(I1)+Y(I3)))
C              COEFFICIENT OF R.H.S. OF MOMENTUM EQUATION
      F(I2)=R(I)*Y(I3)+(.604*G*ABS(Y(I3))*Y(I3)*FY*FY*POVRA**(1./3.)*H*D
     1X+.906*G*ABS(Y(I3))*Y(I3)*FY*POVRA**(4./3.)*FPRMY*DX)*Y(I2)+R(I)*Y
     2(I1)+(.604*G*ABS(Y(I1))*Y(I1)*FY2*FY2*POVRA2**(1./3.)*H2*DX+.906*G
     3*ABS(Y(I1))*Y(I1)*FY2*POVRA2**(4./3.)*FPRMY2*DX)*Y(I0)-2.*G*(Z(I)-
     4Z(I-1))+(.45*G*FY*FY*POVRA**(4./3.)*DX)*ABS(Y(I3))*Y(I3)+(.45*G*FY
     52*FY2*POVRA2**(4./3.)*DX)*ABS(Y(I1))*Y(I1)
C              COEFFICIENT OF R.H.S. OF CONTINUITY EQUATION
      F(I1)=R(I)*(AR+AR2)-(R(I)-(Y(I1)+Y(I3)))*(AR-TOP*Y(I2))-(R(I)+(Y(I
     11)+Y(I3)))*(AR2-TOP2*Y(I0))+2.*QLAT(I)*DX
      IF (LTRIB(I).EQ.0) GO TO 480
      IF (IOFS.EQ.0) GO TO 470
C              COMPUTE OFF CHANNEL STORAGE
C                  COMPUTE TRIBUTARY INFLOW VOLUME
      FLO=TRIBQ(LTRIB(I),K)*DT
C                  INTEGRATE DEL VOLUME DUE TO CHANGE IN Y IN MAIN CHANNEL
      DELS=ACOEF(LTRIB(I),1)*(Y(2*I)-YJM1(LTRIB(I)))
      DELS=DELS+(ACOEF(LTRIB(I),2)/2.)*(Y(2*I)**2.-YJM1(LTRIB(I))**2.)
      DELS=DELS+(ACOEF(LTRIB(I),3)/3.)*(Y(2*I)**3.-YJM1(LTRIB(I))**3.)
      DELS=DELS+(ACOEF(LTRIB(I),4)/4.)*(Y(2*I)**4.-YJM1(LTRIB(I))**4.)
      STORQ(LTRIB(I))=(FLO-DELS)/DT
      F(I1)=F(I1)+2.*STORQ(LTRIB(I))
      GO TO 480
  470 F(I1)=F(I1)+2.*TRIBQ(LTRIB(I),K)
  480 CONTINUE
C              EXCHANGE UPSTREAM AND DOWNSTREAM X-SEC PROPERTIES
      FY=FY2
      FPRMY=FPRMY2
      AR=AR2
      TOP=TOP2
      AOVRT=AOVRT2
      POVRA=POVRA2
      H=H2
  490 CONTINUE
C                        STRUCTURE MATRIX
C                              UPSTREAM BOUNDARY CONDITION
      IF (IUBC.NE.1) GO TO 500
C                                     TYPE 1 = SELF SETTING
      GO TO 520
  500 IF (IUBC.NE.2) GO TO 510
C                                     TYPE 2 = RATING CURVE
      A(2,1)=0.0
      A(2,2)=0.0
      A(2,3)=1.0
```

```
      A(2,4)=0.0
      A(2,5)=0.0
      F(2)=YCHK
      GO TO 520
  510 CONTINUE
C                                   TYPE 3 = DEPTH
C                                   TYPE 4 = ELEVATION
      ZRATIO=A(2,5)/A(3,4)
      A(1,3)=A(2,2)-ZRATIO*A(3,1)
      A(1,4)=A(2,3)-ZRATIO*A(3,2)
      A(1,5)=A(2,4)-ZRATIO*A(3,3)
      F(1)=F(2)-ZRATIO*F(3)
      A(2,1)=0.0
      A(2,2)=0.0
      A(2,3)=1.0
      A(2,4)=0.0
      A(2,5)=0.0
      F(2)=Q(K)
  520 CONTINUE
C                             DOWNSTREAM BOUNDARY CONDITION
      A(2*NX,3)=1.0
      IF (IDBC.EQ.1) F(2*NX)=1.0
      IF (IDBC.EQ.2) F(2*NX)=DSDEP
      IF (IDBC.GE.3) F(2*NX)=DSY(K)
C                             SOLVE MATRIX FOR DEPTHS AND VELOCITIES
      CALL SOLVE
C                             PREPARE FOR NEXT TIME STEP
      IF (IUBC.EQ.1) YCHK=YN(2)
      DO 550 I=1,NX
      CALL XPROP (YN(2*I),I,ARIA,TOP,AOVRT,POVRA,H)
      QOUT(I)=YN(2*I-1)*ARIA
      ELEV(I)=Z(I)+YN(2*I)
      IF (LTRIB(I).NE.0) YJM1(LTRIB(I))=Y(2*I)
      IF (ITRAN.NE.1) GO TO 530
      DATA (1,I)=TOP
      DATA (2,I)=YN(2*I-1)
      DATA (3,I)=ARIA
      DATA (4,I)=0.0
      IF (LTRIB(I).NE.0.AND.IOFS.EQ.0) DATA(4,I)=TRIBQ(LTRIB(I),K)
      IF (LTRIB(I).NE.0.AND.IOFS.NE.0) DATA(4,I)=STORQ(LTRIB(I))
C     DATA (5,I) QLAT         QLAT IS STEADY .  IT WAS DEFINED EARLIER.
      DATA (6,I)=YN(2*I)
  530 CONTINUE
      IF (NPNCH.LE.0.AND.NPLOT.LE.0) GO TO 550
      N=MAX0(NPNCH,NPLOT)
      DO 540 L=1,N
      K=NPP(L)
      QSAV(L,JNP1)=QOUT(K)
  540 DSAV(L,JNP1)=ELEV(K)
  550 CONTINUE
C                           WRITE MODEL RESULTS ON DISK
      IF (ITRAN.EQ.1) WRITE (20'JNP1) DATA
C                           PRINT MODEL RESULTS AT SELECTED TIME STEPS
      IF (MOD(JN,IPNT).NE.0) GO TO 570
      WRITE (6,930) IMON,IDY,IYR,IHR
      M1=1
      M2=13
  560 IF (M2.GT.NPRNT) M2=NPRNT
      WRITE (6,940) (NP(I),I=M1,M2)
      WRITE (6,950) (ELEV(NP(I)),I=M1,M2)
```

```
      WRITE (6,960) (YN(2*NP(I)),I=M1,M2)
      WRITE (6,970) (WOUT(NP(I)),I=M1,M2)
      WRITE (6,980) (YN(2*NP(I)-1),I=M1,M2)
      WRITE (6,990)
      IF (M2.EQ.NPRNT) GO TO 570
      M1=M2+1
      M2=M2+13
      GO TO 560
  570 CONTINUE
C                EXCHANGE OLD AND NEW TIME LINES
      YDSJ=YN(2*NX-2)
      DO 580 I=1,JX
  580 Y(I)=YN(I)
  590 CONTINUE
C     -------------------END TIME LOOP---------------------------------
C
C        *     *     *     *     *     *     *     *     *     *     *     *     *
C
C                                   PUNCH DATA ON CARDS
      IF (NPNCH.EQ.0) GO TO 620
      DO 600 I=1,NPNCH
  600 WRITE (7,1050) (QSAV(I,L),L=2,NTSP1)
      DO 610 I=1,NPNCH
  610 WRITE (7,1040) (DSAV(I,L),L=2,NTSP1)
  620 CONTINUE
  630 CONTINUE
C                                   PLOT DATA ON PRINTER
      IF (NPLOT.LE.0) GO TO 870
      DO 640 K=1,NPLOT
      DO 640 I=1,NTSP1
      L=NPP(K)
  640 DSAV(K,I)=DSAV(K,I)-Z(L)
C
  650 DPI=DT/86400.*IPLT
      IPLT1=IPLT+1
      XMXQ=QSAV(1,2)
      XMNQ=XMXQ
      XMXE=DSAV(1,2)
      XMNE=XMXE
      DO 670 I=1,NPLOT
      K1=0
      DO 660 K=IPLT1,NTSP1,IPLT
      K1=K1+1
      QSAV(I,K1)=QSAV(I,K)
      DSAV(I,K1)=DSAV(I,K)
      IF (QSAV(I,K1).GT.XMXQ) XMXQ=QSAV(I,K1)
      IF (QSAV(I,K1).LT.XMNQ) XMNQ=QSAV(I,K1)
      IF (DSAV(I,K1).GT.XMXE) XMXE=DSAV(I,K1)
      IF (DSAV(I,K1).LT.XMNE) XMNE=DSAV(I,K1)
  660 CONTINUE
  670 CONTINUE
C                           COMPUTE MAXS AND MINS
      IXMIN=(INT(XMNQ)/1000)*1000
      IXMAX=(INT(XMXQ)/1000+1)*1000
      DO 680 I=1,10
      IUP=IXMIN+IRNG2(I)
      IF (IUP.GE.IXMAX) GO TO 690
  680 CONTINUE
```

```
  690 IF (IRNG2(I).LT.IXMAX) GO TO 700
      XMAXQ=IRNG2(I)
      XMINQ=0.0
      GO TO 710
  700 XMAXQ=IUP
      XMINQ=IXMIN
  710 CONTINUE
      IXMIN=(INT(XMNE)/5)*5
      IXMAX=(INT(XMXE)/5+1)*5
      DO 720 I=1,6
      IUP=IXMIN+IRNG1(I)
      IF (IUP.GE.IXMAX) GO TO 730
  720 CONTINUE
  730 XMAXE=IUP
      XMINE=IXMIN
C                        BEGIN PLOTTING
      CALL PLOT1 (NSCALE,8,12,10,10)
      DO 860 LOOP=1,2
      WRITE (6,1260)
      M1=1
      M2=96
  740 IF (M2.GT.K1) M2=K1
      NOPTS=M2-M1+1
      DO 750 I=1,NOPTS
  750 Y(I)=(I+M1-1)*DPI
      IF (M1.GT.1) GO TO 770
      YMIN=Y(M1)-DPI
      YMAX=Y(M2)
      IF (LOOP.EQ.2) GO TO 760
      XMAX=XMAXQ
      XMIN=XMINQ
      WRITE (6,910) IMONTH,IDAY,IYEAR,IHOUR,IMON,IDY,IYR,IHR
      GO TO 770
  760 XMAX=XMAXE
      XMIN=XMINE
      WRITE (6,920) IMONTH,IDAY,IYEAR,IHOUR,IMON,IDY,IYR,IHR
  770 CONTINUE
      CALL PLOT2 (IMAGE,XMAX,XMIN,YMIN,YMAX,6)
      DO 840 I=1,NPLOT
      DO 780 K=1,NOPTS
      IF (LOOP.EQ.1) YN(K)=QSAV(I,K+M1-1)
      IF (LOOP.EQ.2) YN(K)=DSAV(I,K+M1-1)
  780 CONTINUE
      GO TO (790,800,810,820,830), I
  790 CALL PLOT3 ('A',YN,Y,NOPTS)
      GO TO 840
  800 CALL PLOT3 ('B',YN,Y,NOPTS)
      GO TO 840
  810 CALL PLOT3 ('C',YN,Y,NOPTS)
      GO TO 840
  820 CALL PLOT3 ('D',YN,Y,NOPTS)
      GO TO 840
  830 CALL PLOT3 ('E',YN,Y,NOPTS)
  840 CONTINUE
      IF (M2.GE.K1) GO TO 850
      CALL OMIT (5)
      CALL PLOT4 (17,'      TIME IN DAYS')
      M1=M2+1
      M2=M2+96
      YDEL=YMAX-YMIN
```

```
      YMIN=YMAX
      YMAX=YMAX+YDEL
      GO TO 740
  850 CALL OMIT (-3)
      CALL PLOT4 (17,'      TIME IN DAYS')
      IF (LOOP.EQ.1) WRITE (6,1270)
      IF (LOOP.EQ.2) WRITE (6,1280)
      WRITE (6,1290) (LETTER(I),NPP(I),I=1,NPLOT)
  860 CONTINUE
  870 STOP
C
C        *     *     *     *     *     *     *     *     *     *     *
C
C                         FORMAT STATEMENTS
C
  880 FORMAT (10F8.0)
  890 FORMAT ('1'////1X,130(1H*)//25X,'J879--UNSTEADY STREAMFLOW SIMULAT
     1ION USING A LINEAR IMPLICIT FINITE DIFFERENCE MODEL'//1X,130(1H*))
  900 FORMAT (' ',30X,'FLOW RESULTS AT SELECTED CROSS-SECTIONS'/1X,130(1
     1H-)/1X)
  910 FORMAT (' ',20X,'DISCHARGE HYDROGRAPH',5X,I2,'/',I2,'/',I4,':',I4,
     1' TO ',I2,'/',I2,'/',I4,':',I4/1X)
  920 FORMAT (' ',20X,'DEPTH HYDROGRAPH',5X,I2,'/',I2,'/',I4,':',I4,' TO
     1 ',I2,'/',I2,'/',I4,':',I4/1X)
  930 FORMAT (' ',I2,'/',I2,'/',I4,3X,I4,2X,13(5(1H-),3X))
  940 FORMAT (' ',12X,'XSEC',13(3X,I2,3X))
  950 FORMAT (1H ,12X,'ELEV',13F8.2)
  960 FORMAT (1H ,11X,'DEPTH',13F8.2)
  970 FORMAT (1H ,7X,'DISCHARGE',13F8.0)
  980 FORMAT (1H ,8X,'VELOCITY',13F8.2)
  990 FORMAT (1H )
 1000 FORMAT (16X,8F8.2)
 1010 FORMAT (7F8.0,16X,2I4)
 1020 FORMAT (1H0,'TRIBUTARIES HAVE VARIABLE STORAGE'/21X,'  TRIB. NO.
     1  A0        A1        A2        A3'/)
 1030 FORMAT (1H ,28X,I3,F10.1,3F10.2)
 1040 FORMAT (12F6.2)
 1050 FORMAT (12F6.0)
 1060 FORMAT (10I8)
 1070 FORMAT (20A4)
 1080 FORMAT ('0'//10X,20A4//1X)
 1090 FORMAT ('0','SELECTED INPUT DATA'/11X,'UPSTREAM BOUNDARY CONDITION
     1 CODE',6(1H-),2X,I1/11X,'DOWNSTREAM BOUNDARY CONDITION CODE',4(1H-
     2),2X,I1/11X,'TRIBUTARY STORAGE    YES(1)    NO(0)',4(1H-),2X,I1/11X,
     3'RESULTS STORED ON DISK    YES(1)    NO(0)  ',I1)
 1100 FORMAT (' ',10X,'STARTING DATE',23(1H-),I2,'/',I2,'/',I4)
 1110 FORMAT (' ',10X,'NUMBER OF CROSS-SECTIONS',12(1H-),2X,I3/11X,'NUMB
     1ER OF TIME STEPS',16(1H-),I5/11X,'LENGTH OF TIME STEP (MINUTES)',7
     2(1H-),1X,F6.1/11X,'NUMBER OF TRIBUTARIES',15(1H-),1X,I4)
 1120 FORMAT (' ',10X,'INITIAL DISCHARGE (CFS)',9(1H-),2X,F9.0)
 1130 FORMAT (' ',10X,'CONSTANT DOWNSTREAM DEPTH (FT)',3X,F11.2)
 1140 FORMAT (' ',10X,'RATING TABLE',20(1H-),'DEPTH   DISCHARGE'/43X,F5.2
     1,5X,F6.0/(43X,F5.2,5X,F6.0))
 1150 FORMAT ('1',40X,'VALUES OF PARAMETER DRIVING MODEL'/1X,120(1H-)/1X
     1,12F10.2/(1X,12F10.2))
 1160 FORMAT ('1',30X,'VALUES OF PARAMETER CONTROLLING DOWNSTREAM BOUNDA
     1RY'/1X,125(1H-)/1X,12F10.2/(1X,12F10.2))
 1170 FORMAT ('1',40X,'TRIBUTARY FLOW FOR TRIB. NO. ',I2/1X,120(1H-)/1X,
     112F10.2/(1X,12F10.2))
 1180 FORMAT ('1',55X,'CROSS-SECTION DATA'/1X,125(1H-)//1X,'X-SEC      X
```

```
     1       Z          N0      N1     YFN       QLAT       TRIB   SKEW
     2X-SEC COORDINATES:  DEPTH(FT)  TOP WIDTH(FT)'/1X,'  N0     (FT)
     3 (FT)    N=N0+N1*(Y-YFN) (FT)   (CFS/FT)      N0     COEF',5X,50(1H-)
     4)
1190 FORMAT ('0',I4,F10.0,F8.2,F8.3,F7.3,F7.2,F12.6,I6,F8.2)
1200 FORMAT ('+',71X,4(4X,F4.1,F6.0),/,1X)
1210 FORMAT ('0',/////,21X,'OBJECTIVE OF THIS COMPUTER RUN IS TO PLOT O
    1BSERVED HYDROGRAPH DATA')
1220 FORMAT ('0','JOB ABORTED.  INCORRECT CHANNEL LENGTH AT CROSS-SECTI
    1ON',I4)
1230 FORMAT ('1',40X,'OBSERVED DATA AT CROSS-SECTION NUMBER',I3/1X,130(
    11H-))
1240 FORMAT ('0','DISCHARGE'/1X,12F10.2/(1X,12F10.2))
1250 FORMAT ('0','WATER DEPTH OR WATER SURFACE ELEVATION'/1X,12F10.2/(1
    1X,12F10.2))
1260 FORMAT ('1')
1270 FORMAT ('0',50X,'DISCHARGE IN CFS')
1280 FORMAT ('0',50X,'DEPTH IN FEET')
1290 FORMAT (' ',10X,'EXPLANATION:  SYMBOL    X-SECT'/28X,A1,8X,I3/(28X
    1,A1,8X,I3))
1300 FORMAT ('0',////,1X,'NOTE:  STEP-BACKWATER PROGRAM DID NO REACH A
    1CORRECT SOLUTION AT CROSS SECTION ',I3)
     END
```

```
      SUBROUTINE SOLVE
C
C              PENTADIAGONAL MATRIX SOLVER -- OUT OF VON ROSENBERG
C
      COMMON /A/ A(100,5),F(100),DEL(100),RLAM(100),GAM(100),RMU(100),BE
     1TA(100),Y(200),YN(200)
      COMMON /D/ NX,JX,IUBC,IDBC,IDY,IHR
      COMMON /E/ YDSJ,SLOPE,FY2
C
      BETA(1)=0.0
      BETA(2)=0.0
      DEL(1)=A(1,4)/A(1,3)
      RLAM(1)=A(1,5)/A(1,3)
      GAM(1)=F(1)/A(1,3)
      RMU(2)=A(2,3)-A(2,2)*DEL(1)
      DEL(2)=(A(2,4)-A(2,2)*RLAM(1))/RMU(2)
      RLAM(2)=A(2,5)/RMU(2)
      GAM(2)=(F(2)-A(2,2)*GAM(1))/RMU(2)
      LX=2*(NX-1)
      DO 10 I=3,LX
      BETA(I)=A(I,2)-A(I,1)*DEL(I-2)
      RMU(I)=A(I,3)-BETA(I)*DEL(I-1)-A(I,1)*RLAM(I-2)
      DEL(I)=(A(I,4)-BETA(I)*RLAM(I-1))/RMU(I)
      RLAM(I)=A(I,5)/RMU(I)
      GAM(I)=(F(I)-BETA(I)*GAM(I-1)-A(I,1)*GAM(I-2))/RMU(I)
   10 CONTINUE
      BETA(JX-1)=A(JX-1,2)-A(JX-1,1)*DEL(JX-3)
      RMU(JX-1)=A(JX-1,3)-BETA(JX-1)*DEL(JX-2)-A(JX-1,1)*RLAM(JX-3)
      DEL(JX-1)=(A(JX-1,4)-BETA(JX-1)*RLAM(JX-2))/RMU(JX-1)
      GAM(JX-1)=(F(JX-1)-BETA(JX-1)*GAM(JX-2)-A(JX-1,1)*GAM(JX-3))/RMU(J
     1X-1)
      BETA(JX)=A(JX,2)-A(JX,1)*DEL(JX-2)
      RMU(JX)=A(JX,3)-BETA(JX)*DEL(JX-1)-A(JX,1)*RLAM(JX-2)
      GAM(JX)=(F(JX)-BETA(JX)*GAM(JX-1)-A(JX,1)*GAM(JX-2))/RMU(JX)
      RLAM(JX)=0.0
      DEL(JX)=0.0
      IF (IDBC.NE.1) GO TO 20
      C667=-0.6667
      DELH=ABS(Y(2*NX-2)-YDSJ)
      IF (DELH.LT.0.1) DELH=0.1
      H1=Y(2*NX)+DELH
      CALL XPROP (H1,NX,A,T,AOVRT,POVRA,H)
      U1=1.486/FY2*POVRA**C667*SLOPE**0.5
      H2=Y(2*NX)-DELH
      CALL XPROP (H2,NX,A,T,AOVRT,POVRA,H)
      U2=1.486/FY2*POVRA**C667*SLOPE**0.5
      AA=(H1-H2)/(U1-U2)
      B=H1-AA*U1
      YN(JX-1)=(GAM(JX-1)-B*DEL(JX-1))/(1+AA*DEL(JX-1))
      YN(JX)=AA*YN(JX-1)+B
      GO TO 30
   20 CONTINUE
      YN(JX)=GAM(JX)
      YN(JX-1)=GAM(JX-1)-DEL(JX-1)*YN(JX)
   30 CONTINUE
      KX=JX-2
      IF (IUBC.EQ.1) IKX=JX-3
      IF (IUBC.EQ.2) IKX=JX-4
      IF (IUBC.GE.3) IKX=JX-2
      DO 40 I=1,IKX
      J=KX-I+1
      YN(J)=GAM(J)-DEL(J)*YN(J+1)-RLAM(J)*YN(J+2)
   40 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE TABL (X1,Y1)
C
C     TABL - USED TO COMPUTE STAGE FOR A GIVEN DISCHARGE FROM A
C            RATING TABLE.
C
      COMMON /C/ Y(20),X(20)
C
      IF (X1.LE.0.0) GO TO 50
      IF (X1.LT.X(1)) GO TO 30
      DO 10 I=1,19
      IF (X(I+1).LE.0.0) GO TO 50
      IF (X1.GE.X(I).AND.X1.LT.X(I+1)) GO TO 20
   10 CONTINUE
   20 Y1=Y(I)+(((Y(I+1)-Y(I))/(X(I+1)-X(I)))*(X1-X(I)))
      GO TO 40
   30 Y1=(Y(1)/X(1))*X1
   40 RETURN
   50 WRITE (6,60)
      Y1=Y(20)
      RETURN
C
C
   60 FORMAT (1H ,'VARIABLE OUT OF RANGE OF TABLE')
      END
```

```
      SUBROUTINE XPROP (Y,I,A,T,AOVRT,POVRA,H)
C
C     XPROP - USED TO COMPUTE X-SECTION PROPERTIES
C             Y=DEPTH
C             I=X-SECTION NUMBER
C             A=AREA
C             T=TOP WIDTH
C             AOVRT= HYDRAULIC DEPTH (A OVER T)
C             POVRA= 1/HYDRAULIC RADIUS (P OVER A)
C             H=
C
      COMMON /B/ NPTS(50),THETA(50),YPNT(50,20),TPNT(50,20)
      COMMON /D/ NX,JX,IUBC,IDBC,IDY,IHR
      DATA ICNT/0/
C
      N1=NPTS(I)-1
      DO 10 L=1,N1
      J=NPTS(I)-L
      IF (Y.GT.YPNT(I,J)) GO TO 20
   10 CONTINUE
      GO TO 50
   20 CONTINUE
C             COMPUTE TOP WIDTH
      DELY=YPNT(I,J+1)-YPNT(I,J)
      DELT=TPNT(I,J+1)-TPNT(I,J)
      YPRIM=Y-YPNT(I,J)
      T=TPNT(I,J)+(YPRIM/DELY)*DELT
C             COMPUTE AREA AND WETTED PERIMETER
      EPSL=0.5-0.5*THETA(I)
      EPSR=-EPSL+1.
      JM1=J-1
      WPSUM=TPNT(I,1)
      ARSUM=0.0
      IF (J.EQ.1) GO TO 40
      DO 30 K=1,JM1
      DDT=TPNT(I,K+1)-TPNT(I,K)
      DDY=YPNT(I,K+1)-YPNT(I,K)
      ARSUM=ARSUM+((TPNT(I,K)+TPNT(I,K+1))*0.5*DDY)
      WPSUM=WPSUM+SQRT(EPSL*DDT*EPSL*DDT+DDY*DDY)+SQRT(EPSR*DDT*EPSR*DDT
     1+DDY*DDY)
   30 CONTINUE
   40 A=ARSUM+YPRIM*TPNT(I,J)+(YPRIM*YPRIM/(2.*DELY))*DELT
      DPDY=(1./DELY)*(SQRT(EPSL*DELT*EPSL*DELT+DELY*DELY)+SQRT(EPSR*DELT
     1*EPSR*DELT+DELY*DELY))
      P=WPSUM+YPRIM*DPDY
      AOVRT=A/T
      POVRA=P/A
      H=-(P*T/(A*A))+(DPDY/A)
      IF (Y.LE.YPNT(I,NPTS(I))) GO TO 60
      WRITE (6,90) I,IDY,IHR,Y,YPNT(I,NPTS(I))
      GO TO 60
   50 CONTINUE
      A=0.0
      T=0.0
      AOVRT=0.0
      POVRA=0.0
      H=0.0
      ICNT=ICNT+1
      WRITE (6,70) I,IDY,IHR,Y
      IF (ICNT.LE.10) GO TO 60
```

```
      WRITE (6,80)
      STOP
   60 RETURN
C
C
C
   70 FORMAT (1H0,'COMPUTED WATER SURFACE IS BELOW STREAM BOTTOM AT CROS
     1S-SECTION',I4,' AT TIME =',I4,I6,'.',5X,'WATER DEPTH=',F8.2)
   80 FORMAT ('0',10X,'****JOB ABORTED IN SUBROUTINE XPROP*****',10X,'COM
     1PUTED WATER SURFACE WAS BELOW STREAM BED MORE THAN 10 TIMES.')
   90 FORMAT (1H0,'WATER SURFACE ABOVE TOP OF CROSS-SECTION',I4,' AT TIM
     1E=',I6,I6/5X,'WATER DEPTH=',F8.2,'     DISTANCE TO TOP OF CROSS-SE
     2CTION=',F8.1)
      END
```

```
      SUBROUTINE HEAD (I,Y,Q,HV,HF,U,FN0,FN1,YFN)
C
C     HEAD - USED TO COMPUTE VELOCITY AND FRICTION HEADS
C
      ALPHA=1.1
      ELC=0.1
      CALL XPROP (Y,I,AREA,TWID,AOVRT,POVRA,H)
      R=1./POVRA
      U=Q/AREA
      HV=ALPHA*ABS(U)*U/(62.348)
      FN=FN0+FN1*(Y-YFN)
      IF (FN.LT.0.005) FN=0.005
      HF=(FN*FN*ABS(U)*U)/(2.22*R**(4./3.))
      RETURN
      END
```

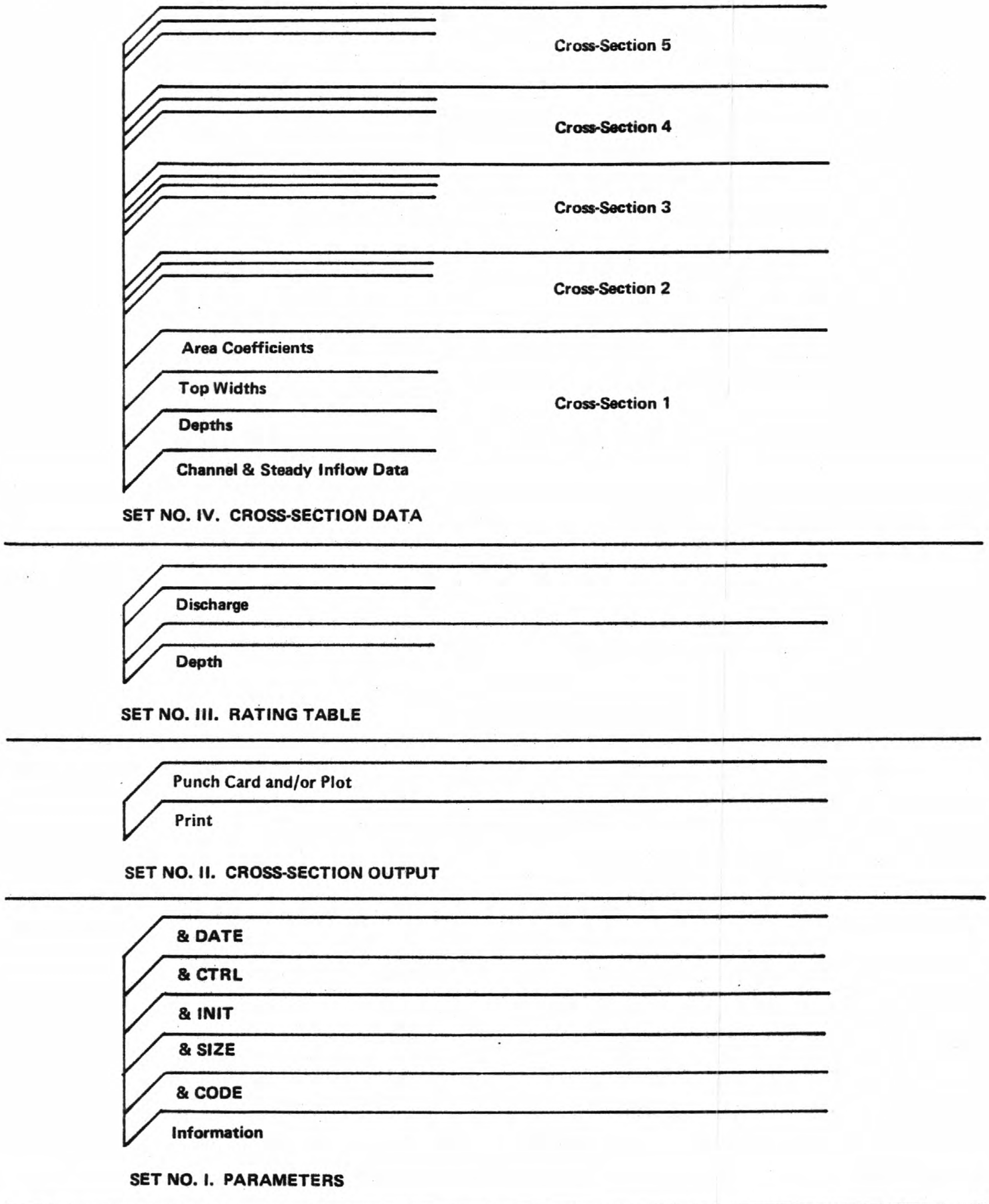
```
      SUBROUTINE PRPLOT
C
C     PRPLOT- SUBPROGRAM OF ENTRIES TO CONSTRUCT A CONTINUOUS
C             PRINTER PLOT OF TIME SERIES DATA.
C
      IMPLICIT LOGICAL*1(W),LOGICAL*1(K)
      DIMENSION NSCALE(5), ABNOS(26), X(1), Y(1)
      LOGICAL*1 NOS(10)/'0','1','2','3','4','5','6','7','8','9'/
      LOGICAL*1 IMAGE(1),CH,LABEL(1),ERR1,ERR3,ERR5
      LOGICAL*1 VC,HC,FOR1(19),FOR2(15),FOR3(19),NC,BL,HF,HF1
      REAL*8 FOX1(3),FOX2(2),FOX3(3)
      INTEGER*2 VCR
      EQUIVALENCE (FOR1(1),FOX1(1)), (FOR2(1),FOX2(1)), (FOR3(1),FOX3(1)
     1), (VC,VCR)
      INTEGER FILE
      DATA HC/'-'/,NC/'+'/,BL/' '/,HF/'F'/,HF1/'.'/
      DATA FOX1/'(1XA1,F9','.2,  121','A1)      '/
      DATA FOX2/'(1XA1, 9','X121A1) '/
      DATA FOX3/'(1H0F  .',' ,  F    ','. )      '/
      DATA VCR/Z4F00/
      DATA KPLOT1/.FALSE./,KPLOT2/.FALSE./
      DATA KABSC,KORD,KBOTGL/3*.FALSE./
C
      ENTRY PLOT1(NSCALE,NHL,NSBH,NVL,NSBV)
      IFL=FILE
      ERR1=.FALSE.
      ERR3=.FALSE.
      ERR5=.FALSE.
      KPLOT1=.TRUE.
      KPLOT2=.FALSE.
      NH=IABS(NHL)
      NSH=IABS(NSBH)
      NV=IABS(NVL)
      NSV=IABS(NSBV)
      NSCL=NSCALE(1)
      IF (NH*NSH*NV*NSV.NE.0) GO TO 10
      KPLOT=.FALSE.
      ERR1=.TRUE.
      RETURN
   10 KPLOT=.TRUE.
      IF (NV.LE.25) GO TO 20
      KPLOT=.FALSE.
      ERR3=.TRUE.
      RETURN
   20 CONTINUE
      NVM=NV-1
      NVP=NV+1
      NDH=NH*NSH
      NDHP=NDH+1
      NDV=NV*NSV
      NDVP=NDV+1
      NIMG=(NDHP*NDVP)
      IF (NDV.LE.120) GO TO 30
      KPLOT=.FALSE.
      ERR5=.TRUE.
      RETURN
   30 CONTINUE
      IF (NSCL.EQ.0) GO TO 40
      FSY=10.**NSCALE(2)
      FSX=10.**NSCALE(4)
```

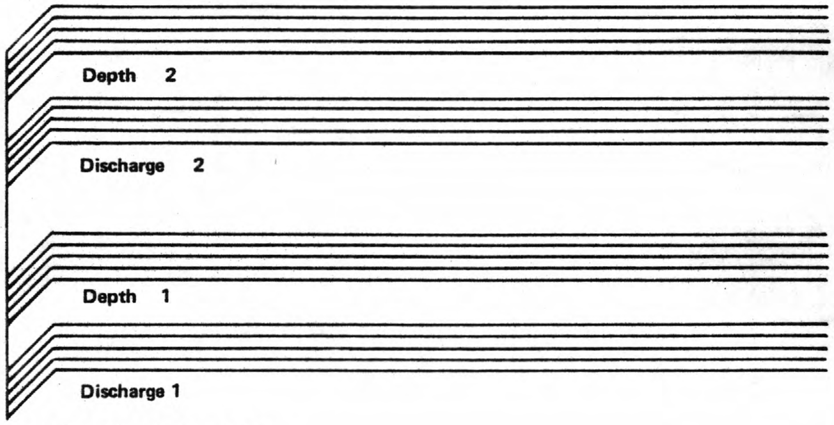
```
      IY=MINO(IABS(NSCALE(3)),7)+1
      IX=MINO(IABS(NSCALE(5)),9)+1
      GO TO 50
   40 FSY=1.
      FSX=1.
      IY=4
      IX=4
   50 FOR1(10)=NOS(IY)
      NA=MINO(IX,NSV)-1
      NS=NA-MINO(NA,120-NDV)
      NB=11-NS+NA
      I1=NB/10
      I2=NB-I1*10
      FOR3(6)=NOS(I1+1)
      FOR3(7)=NOS(I2+1)
      FOR3(9)=NOS(NA+1)
      IF (NV.GT.0) GO TO 70
      DO 60 J=11,18
   60 FOR3(J)=BL
      GO TO 80
   70 I1=NV/10
      I2=NV-I1*10
      FOR3(11)=NOS(I1+1)
      FOR3(12)=NOS(I2+1)
      FOR3(13)=HF
      I1=NSV/100
      I3=NSV-I1*100
      I2=I3/10
      I3=I3-I2*10
      FOR3(14)=NOS(I1+1)
      FOR3(15)=NOS(I2+1)
      FOR3(16)=NOS(I3+1)
      FOR3(17)=HF1
      FOR3(18)=FOR3(9)
   80 IF (KPLOT1) RETURN
      KPLOT1=.TRUE.
C
      ENTRY PLOT2(IMAGE,XMAX,XMIN,YMAX,YMIN,FILE)
      IFL=FILE
      KPLOT2=.TRUE.
      IF (KPLOT1) GO TO 90
      NSCL=0
      NH=5
      NSH=10
      NV=10
      NSV=10
      GO TO 10
   90 CONTINUE
      IF (KPLOT) GO TO 100
      IF (ERR1) WRITE (IFL,300)
      IF (ERR3) WRITE (IFL,310)
      IF (ERR5) WRITE (IFL,320)
      RETURN
  100 YMX=YMAX
      DH=(YMAX-YMIN)/FLOAT(NDH)
      DV=(XMAX-XMIN)/FLOAT(NDV)
      DO 110 I=1,NVP
  110 ABNOS(I)=(XMIN+FLOAT((I-1)*NSV)*DV)*FSX
      DO 120 I=1,NIMG
  120 IMAGE(I)=BL
```

```
      DO 160 I=1,NDHP
      I2=I*NDVP
      I1=I2-NDV
      KNHOR=MOD(I-1,NSH).NE.0
      IF (KNHOR) GO TO 140
      DO 130 J=I1,I2
  130 IMAGE(J)=HC
  140 CONTINUE
      DO 160 J=I1,I2,NSV
      IF (KNHOR) GO TO 150
      IMAGE(J)=NC
      GO TO 160
  150 IMAGE(J)=VC
  160 CONTINUE
      XMIN1=XMIN-DV/2.
      YMIN1=YMIN-DH/2.
      RETURN
C
      ENTRY PLOT3(CH,X,Y,N3)
      IF (KPLOT2) GO TO 180
  170 WRITE (IFL,330)
  180 CONTINUE
      IF (.NOT.KPLOT) RETURN
      IF (N3.GT.0) GO TO 190
      KPLOT=.FALSE.
      WRITE (IFL,340)
      RETURN
  190 DO 260 I=1,N3
      IF (DV) 210,200,210
  200 DUM1=0
      GO TO 220
  210 CONTINUE
      DUM1=(X(I)-XMIN1)/DV
  220 IF (DH) 240,230,240
  230 DUM2=0
      GO TO 250
  240 CONTINUE
      DUM2=(Y(I)-YMIN1)/DH
  250 CONTINUE
      IF (DUM1.LT.0..OR.DUM2.LT.0.) GO TO 260
      IF (DUM1.GE.NDVP.OR.DUM2.GE.NDHP) GO TO 260
      NX=1+INT(DUM1)
      NY=1+INT(DUM2)
      J=(NDHP-NY)*NDVP+NX
      IMAGE(J)=CH
  260 CONTINUE
      RETURN
C
      ENTRY PLOT4(NL,LABEL)
      ENTRY FPLOT4(NL,LABEL)
      IF (.NOT.KPLOT) RETURN
      IF (.NOT.KPLOT2) GO TO 170
      DO 280 I=1,NDHP
      IF (I.EQ.NDHP.AND.KBOTGL) GO TO 280
      WL=BL
      IF (I.LE.NL) WL=LABEL(I)
      I2=I*NDVP
      I1=I2-NDV
      IF (MOD(I-1,NSH).EQ.0.AND..NOT.KORD) GO TO 270
      WRITE (IFL,FOR2) WL,(IMAGE(J),J=I1,I2)
```

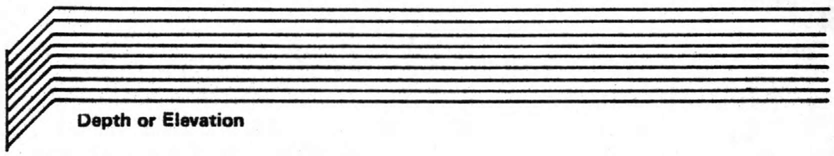
```
      GO TO 280
  270 CONTINUE
      ORDNO=(YMX-FLOAT(I-1)*DH)*FSY
      IF (I.EQ.NDHP) ORDNO=YMIN
      WRITE (IFL,FOR1) WL,ORDNO,(IMAGE(J),J=I1,I2)
  280 CONTINUE
      IF (KABSC) GO TO 290
      WRITE (IFL,FOR3) (ABNOS(J),J=1,NVP)
  290 RETURN
C
      ENTRY OMIT(LSW)
      KABSC=MOD(LSW,2).EQ.1
      KORD=MOD(LSW,4).GE.2
      KBOTGL=LSW.GE.4
      RETURN
C
C
  300 FORMAT (T5,'SOME PLOT1 ARG. ILLEGALLY 0')
  310 FORMAT (T5,'NO. OF VERTICAL LINES >25')
  320 FORMAT (T5,'WIDTH OF GRAPH >121')
  330 FORMAT (T5,'PLOT2 MUST BE CALLED')
  340 FORMAT (T5,'PLOT3, ARG2 ) 0')
      END
```

C. SCHEMATIC DIAGRAM OF INPUT CARD DECK

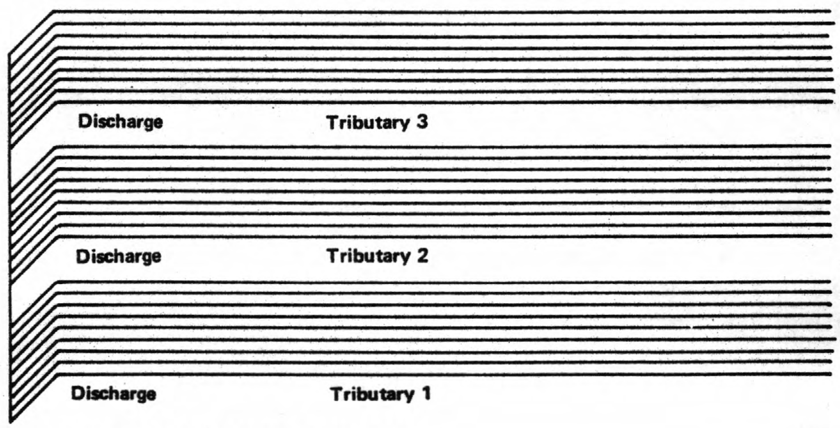

Cross-Section 5
Cross-Section 4
Cross-Section 3
Cross-Section 2
Area Coefficients
Top Widths
Depths
Channel & Steady Inflow Data
Cross-Section 1
SET NO. IV. CROSS-SECTION DATA
Discharge
Depth
SET NO. III. RATING TABLE
Punch Card and/or Plot
Print
SET NO. II. CROSS-SECTION OUTPUT
& DATE
& CTRL
& INIT
& SIZE
& CODE
Information
SET NO. I. PARAMETERS



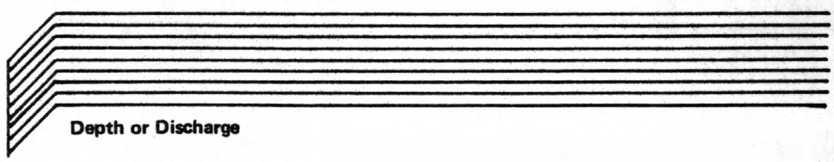

SET NO. VIII. PLOT DATA




SET NO. VII. OUTFLOW HYDROGRAPH




SET NO. VI. TRIBUTARY HYDROGRAPH(S)




SET NO. V. INFLOW HYDROGRAPH

REQUIREMENT NOTES:

| | |
|---|---|
| Set No. I. | Required. |
| II. | Print card required when NOUT > 0.<br>Punch/Plot card required when NPNCH or NPLOT 0. |
| III. | Required. |
| IV. | Required when NZPLOT = 0. |
| V. | Required when NZPLOT = 0 and NTRIB 0. Number of sets equals NTRIB. |
| VI. | Required when NZPLOT = 0 and ISS = 1. |
| VII. | Required when NZPLOT = 1. Number of sets equals NPLOT. |

D. LISTING OF INPUT CARD DECK

```
    J879.--FLOW SIMULATION MODEL FOR UPPER CHATTAHOOCHEE RIVER    FEB 1978
 &CODE     IUBC=2,    IDBC=1,    IOFS=1,    NZPLOT=0                                    &END
 &SIZE     NX=30,     NTS=288,   NTRIB=1,   DT=300.                                     &END
 &INIT     QINIT=550.,           DSDEP=10.                                              &END
 &CTRL     NPRNT=13, IPNT=6,     NPLOT=3,   IPLT=3,    NPNCH=0,   ITRAN=0               &END
 &DATE     IYR=1976, IMON=4,     IDY=2,     IHR=0                                       &END
       1          2         4          7         10         13         16         19         22         25
      28         29        30
       1         15        30
2.7       3.4       4.2       6.6       11.0

430.      1030.     1850.     4700.     10880.

   1584.   910.54    0.060    0.0       0.0       0.0       1.000                          9
    0.0      2.50     5.00     7.50     10.00     12.50     15.00     17.50     20.00
  250.00   250.00   250.00   250.00    250.00    250.00    250.00    250.00    250.00
   2217.   909.53    0.086    0.0       0.0       0.0       1.000                          9
    0.0      2.50     5.00     7.50     10.00     12.50     15.00     17.50     20.00
  204.00   205.27   209.07   215.42    224.30    235.72    249.67    266.17    285.20
   3000.   908.10    0.054    0.0       0.0       0.0       1.000                          9
    0.0      2.50     5.00     7.50     10.00     12.50     15.00     17.50     20.00
  180.00   180.00   180.00   180.00    180.00    180.00    180.00    180.00    180.00
   4000.   906.13    0.056    0.0       0.0       0.0       1.000                          9
    0.0      2.50     5.00     7.50     10.00     12.50     15.00     17.50     20.00
  180.00   180.00   180.00   180.00    180.00    180.00    180.00    180.00    180.00
   5121.   903.76    0.051    0.0       0.0       0.0       1.000                          9
    0.0      2.50     5.00     7.50     10.00     12.50     15.00     17.50     20.00
  162.00   164.58   172.32   185.23    203.30    226.53    254.92    288.48    327.20
   6969.   901.15    0.038    0.0       0.0       0.0       1.000                          9
    0.0      2.50     5.00     7.50     10.00     12.50     15.00     17.50     20.00
  120.00   120.86   123.45   127.76    133.80    141.56    151.05    162.26    175.20
   9873.   898.04    0.026    0.0       0.0       0.0       1.000                          9
    0.0      2.50     5.00     7.50     10.00     12.50     15.00     17.50     20.00
  144.00   144.74   146.95   150.64    155.80    162.44    170.55    180.14    191.20
  12302.   896.96    0.025    0.0       0.0       0.0       1.000                          9
    0.0      2.50     5.00     7.50     10.00     12.50     15.00     17.50     20.00
  128.00   129.54   134.17   141.89    152.70    166.59    183.57    203.64    226.80
  13675.   895.97    0.035   -0.001     0.0       0.0       1.000                          9
    0.0      2.50     5.00     7.50     10.00     12.50     15.00     17.50     20.00
  210.00   210.83   213.32   217.48    223.30    230.78    239.92    250.73    263.20
  14361.   895.87    0.048   -0.001     0.0       0.0       1.000                          9
    0.0      2.50     5.00     7.50     10.00     12.50     15.00     17.50     20.00
  160.00   160.87   163.50   167.87    174.00    181.87    191.50    202.87    216.00
  15153.   894.16    0.037   -0.001     0.0       0.0       1.000                          9    1
    0.0      2.50     5.00     7.50     10.00     12.50     15.00     17.50     20.00
  120.00   121.19   124.77   130.74    139.10    149.84    162.97    178.49    196.40
  5000.0   5000.0
  17793.   897.65    0.021    0.0       0.0       0.0       1.000                          9
    0.0      2.50     5.00     7.50     10.00     12.50     15.00     17.50     20.00
  152.00   153.89   159.55   168.99    182.20    199.19    219.95    244.49    272.80
  18585.   897.55    0.021    0.0       0.0       0.0       1.000                          9
    0.0      2.50     5.00     7.50     10.00     12.50     15.00     17.50     20.00
  120.00   121.25   125.00   131.25    140.00    151.25    165.00    181.25    200.00
  19536.   897.45    0.018    0.0       0.0       0.0       1.000                          9
    0.0      2.50     5.00     7.50     10.00     12.50     15.00     17.50     20.00
  112.00   113.67   118.67   127.02    138.70    153.72    172.07    193.77    218.80
  22334.   897.03    0.018    0.0       0.0       0.0       1.000                          9
```

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 0.0 | 2.50 | 5.00 | 7.50 | 10.00 | 12.50 | 15.00 | 17.50 | 20.00 | |
| 136.00 | 136.94 | 139.75 | 144.44 | 151.00 | 159.44 | 169.75 | 181.94 | 196.00 | |
| 25291. | 900.52 | 0.030 | 0.0 | 0.0 | 0.0 | 1.000 | | | 9 |
| 0.0 | 2.50 | 5.00 | 7.50 | 10.00 | 12.50 | 15.00 | 17.50 | 20.00 | |
| 208.00 | 209.67 | 214.67 | 223.02 | 234.70 | 249.72 | 268.07 | 289.77 | 314.80 | |
| 27350. | 899.61 | 0.030 | 0.0 | 0.0 | 0.0 | 1.000 | | | 9 |
| 0.0 | 2.50 | 5.00 | 7.50 | 10.00 | 12.50 | 15.00 | 17.50 | 20.00 | |
| 160.00 | 161.29 | 165.17 | 171.64 | 180.70 | 192.34 | 206.57 | 223.39 | 242.80 | |
| 30888. | 898.90 | 0.030 | -0.002 | 0.0 | 0.0 | 1.000 | | | 9 |
| 0.0 | 2.50 | 5.00 | 7.50 | 10.00 | 12.50 | 15.00 | 17.50 | 20.00 | |
| 136.00 | 143.06 | 164.25 | 199.56 | 249.00 | 312.56 | 390.25 | 482.06 | 588.00 | |
| 32419. | 897.49 | 0.065 | -0.005 | 0.0 | 0.0 | 1.000 | | | 9 |
| 0.0 | 2.50 | 5.00 | 7.50 | 10.00 | 12.50 | 15.00 | 17.50 | 20.00 | |
| 136.00 | 137.25 | 141.00 | 147.25 | 156.00 | 167.25 | 181.00 | 197.25 | 216.00 | |
| 33686. | 895.59 | 0.099 | -0.005 | 0.0 | 0.015785 | 1.000 | | | 9 |
| 0.0 | 2.50 | 5.00 | 7.50 | 10.00 | 12.50 | 15.00 | 17.50 | 20.00 | |
| 140.00 | 141.11 | 144.45 | 150.01 | 157.80 | 167.81 | 180.05 | 194.51 | 211.20 | |
| 35481. | 894.48 | 0.107 | -0.004 | 0.0 | 0.0 | 1.000 | | | 9 |
| 0.0 | 2.50 | 5.00 | 7.50 | 10.00 | 12.50 | 15.00 | 17.50 | 20.00 | |
| 152.00 | 153.06 | 156.25 | 161.56 | 169.00 | 178.56 | 190.25 | 204.06 | 220.00 | |
| 37066. | 893.27 | 0.110 | 0.0 | 0.0 | 0.015773 | 1.000 | | | 9 |
| 0.0 | 2.50 | 5.00 | 7.50 | 10.00 | 12.50 | 15.00 | 17.50 | 20.00 | |
| 168.00 | 169.21 | 172.85 | 178.91 | 187.40 | 198.31 | 211.65 | 227.41 | 245.60 | |
| 39758. | 891.46 | 0.088 | 0.0 | 0.0 | 0.0 | 1.000 | | | 9 |
| 0.0 | 2.50 | 5.00 | 7.50 | 10.00 | 12.50 | 15.00 | 17.50 | 20.00 | |
| 140.00 | 140.39 | 141.57 | 143.54 | 146.30 | 149.84 | 154.17 | 159.29 | 165.20 | |
| 43349. | 890.85 | 0.058 | 0.0 | 0.0 | 0.0 | 1.000 | | | 9 |
| 0.0 | 2.50 | 5.00 | 7.50 | 10.00 | 12.50 | 15.00 | 17.50 | 20.00 | |
| 144.00 | 144.43 | 145.72 | 147.88 | 150.90 | 154.78 | 159.52 | 165.13 | 171.60 | |
| 45038. | 887.84 | 0.026 | 0.0 | 0.0 | 0.0 | 1.000 | | | 9 |
| 0.0 | 2.50 | 5.00 | 7.50 | 10.00 | 12.50 | 15.00 | 17.50 | 20.00 | |
| 130.00 | 131.94 | 137.77 | 147.49 | 161.10 | 178.59 | 199.97 | 225.24 | 254.40 | |
| 46517. | 888.26 | 0.016 | 0.0 | 0.0 | 0.0 | 1.000 | | | 9 |
| 0.0 | 2.50 | 5.00 | 7.50 | 10.00 | 12.50 | 15.00 | 17.50 | 20.00 | |
| 160.00 | 161.85 | 167.40 | 176.65 | 189.60 | 206.25 | 226.60 | 250.65 | 278.40 | |
| 48101. | 890.39 | 0.019 | 0.0 | 0.0 | 0.0 | 1.000 | | | 9 |
| 0.0 | 2.50 | 5.00 | 7.50 | 10.00 | 12.50 | 15.00 | 17.50 | 20.00 | |
| 155.00 | 156.87 | 162.50 | 171.87 | 185.00 | 201.87 | 222.50 | 246.87 | 275.00 | |
| 49685. | 890.21 | 0.023 | 0.0 | 0.0 | 0.0 | 1.000 | | | 9 |
| 0.0 | 2.50 | 5.00 | 7.50 | 10.00 | 12.50 | 15.00 | 17.50 | 20.00 | |
| 151.00 | 154.32 | 164.30 | 180.92 | 204.20 | 234.12 | 270.70 | 313.92 | 363.80 | |
| 51533. | 889.44 | 0.023 | 0.0 | 0.0 | 0.0 | 1.000 | | | 9 |
| 0.0 | 2.50 | 5.00 | 7.50 | 10.00 | 12.50 | 15.00 | 17.50 | 20.00 | |
| 170.00 | 170.96 | 173.85 | 178.66 | 185.40 | 194.06 | 204.65 | 217.16 | 231.60 | |
| 52747. | 889.36 | 0.026 | 0.0 | 0.0 | 0.0 | 1.000 | | | 9 |
| 0.0 | 2.50 | 5.00 | 7.50 | 10.00 | 12.50 | 15.00 | 17.50 | 20.00 | |
| 160.00 | 161.00 | 164.00 | 169.00 | 176.00 | 185.00 | 196.00 | 209.00 | 224.00 | |
| 4 276 1H | SPRING | 550. | 550. | 550. | 550. | 550. | 550. | 550. | 550. |
| 4 276 2H | SPRING | 550. | 550. | 550. | 550. | 550. | 550. | 550. | 550. |
| 4 276 3H | SPRING | 550. | 550. | 550. | 550. | 550. | 550. | 550. | 550. |
| 4 276 4H | SPRING | 550. | 550. | 550. | 550. | 550. | 550. | 550. | 550. |
| 4 276 5H | SPRING | 550. | 550. | 550. | 550. | 550. | 550. | 550. | 550. |
| 4 276 6H | SPRING | 550. | 550. | 550. | 550. | 550. | 550. | 550. | 550. |
| 4 276 7H | SPRING | 550. | 550. | 550. | 550. | 550. | 550. | 550. | 550. |
| 4 276 8H | SPRING | 550. | 550. | 550. | 550. | 550. | 550. | 550. | 550. |
| 4 276 9H | SPRING | 550. | 550. | 550. | 550. | 550. | 550. | 550. | 550. |
| 4 27610H | SPRING | 550. | 550. | 550. | 550. | 550. | 550. | 550. | 550. |
| 4 27611H | SPRING | 550. | 550. | 550. | 661. | 1676. | 2871. | 3465. | 3691. |
| 4 27612H | SPRING | 3809. | 3881. | 3916. | 3940. | 3964. | 3964. | 3964. | 3964. |
| 4 27613H | SPRING | 3988. | 3988. | 3999. | 3988. | 3999. | 3988. | 3988. | 3999. |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 4 27614H SPRING | 3999. | 3999. | 4011. | 4011. | 4011. | 4011. | 4011. | 4011. |
| 4 27615H SPRING | 4011. | 4011. | 4023. | 4011. | 4023. | 4023. | 4023. | 4023. |
| 4 27616H SPRING | 4035. | 4035. | 4035. | 4035. | 4035. | 4035. | 4035. | 4023. |
| 4 27617H SPRING | 4035. | 4035. | 4035. | 4035. | 4035. | 4047. | 4035. | 4035. |
| 4 27618H SPRING | 4035. | 4035. | 4035. | 4035. | 4035. | 4035. | 4035. | 4035. |
| 4 27619H SPRING | 4035. | 4035. | 4035. | 4035. | 4035. | 4035. | 4035. | 4035. |
| 4 27620H SPRING | 4035. | 4035. | 4047. | 4035. | 4035. | 4047. | 4047. | 4047. |
| 4 27621H SPRING | 4047. | 4035. | 4035. | 4035. | 4035. | 4047. | 4047. | 4047. |
| 4 27622H SPRING | 4047. | 4047. | 4035. | 4047. | 4047. | 4047. | 4047. | 4047. |
| 4 27623H SPRING | 4047. | 4047. | 4047. | 4047. | 4047. | 4047. | 4047. | 4035. |
| 4 27624H SPRING | 4035. | 4047. | 4047. | 4047. | 4035. | 4047. | 4047. | 4035. |
| 4 27625H SPRING | 4047. | 4047. | 4059. | 4059. | 4059. | 4059. | 4071. | 4059. |
| 4 27626H SPRING | 4071. | 4071. | 4071. | 4106. | 4130. | 4142. | 4154. | 4154. |
| 4 27627H SPRING | 4166. | 4166. | 4166. | 4178. | 4166. | 4178. | 4166. | 4154. |
| 4 27628H SPRING | 4142. | 4130. | 4130. | 4130. | 4130. | 4130. | 4130. | 4130. |
| 4 27629H SPRING | 4130. | 4130. | 4130. | 4118. | 4083. | 4071. | 4059. | 4059. |
| 4 27630H SPRING | 4047. | 4047. | 4047. | 4047. | 4047. | 4047. | 4035. | 4047. |
| 4 27631H SPRING | 4035. | 4047. | 4047. | 4047. | 4035. | 4047. | 4047. | 4047. |
| 4 27632H SPRING | 4035. | 4035. | 4035. | 4035. | 4047. | 4047. | 4047. | 4047. |
| 4 27633H SPRING | 4035. | 4035. | 4047. | 4035. | 4035. | 4035. | 3833. | 2871. |
| 4 27634H SPRING | 2064. | 1543. | 1245. | 1030. | 867. | 764. | 687. | 644. |
| 4 27635H SPRING | 610. | 584. | 567. | 559. | 550. | 550. | 550. | 550. |
| 4 27636H SPRING | 550. | 550. | 550. | 550. | 550. | 550. | 550. | 550. |
| 4 276 1JAMES CR | 40. | 40. | 40. | 40. | 40. | 40. | 40. | 40. |
| 4 276 2JAMES CR | 40. | 40. | 40. | 40. | 40. | 40. | 40. | 40. |
| 4 276 3JAMES CR | 40. | 40. | 40. | 40. | 40. | 40. | 40. | 40. |
| 4 276 4JAMES CR | 40. | 40. | 40. | 40. | 40. | 40. | 40. | 40. |
| 4 276 5JAMES CR | 40. | 40. | 40. | 40. | 40. | 40. | 40. | 40. |
| 4 276 6JAMES CR | 40. | 40. | 40. | 40. | 40. | 40. | 40. | 40. |
| 4 276 7JAMES CR | 40. | 40. | 40. | 40. | 40. | 40. | 40. | 40. |
| 4 276 8JAMES CR | 40. | 40. | 40. | 40. | 40. | 40. | 40. | 40. |
| 4 276 9JAMES CR | 40. | 40. | 40. | 40. | 40. | 40. | 40. | 40. |
| 4 27610JAMES CR | 40. | 40. | 40. | 40. | 40. | 40. | 40. | 40. |
| 4 27611JAMES CR | 40. | 40. | 40. | 40. | 40. | 40. | 40. | 40. |
| 4 27612JAMES CR | 40. | 40. | 40. | 40. | 40. | 40. | 40. | 40. |
| 4 27613JAMES CR | 40. | 40. | 40. | 40. | 40. | 40. | 40. | 40. |
| 4 27614JAMES CR | 40. | 40. | 40. | 40. | 40. | 40. | 40. | 40. |
| 4 27615JAMES CR | 40. | 40. | 40. | 40. | 40. | 40. | 40. | 40. |
| 4 27616JAMES CR | 40. | 40. | 40. | 40. | 40. | 40. | 40. | 40. |
| 4 27617JAMES CR | 40. | 40. | 40. | 40. | 40. | 40. | 40. | 40. |
| 4 27618JAMES CR | 40. | 40. | 40. | 40. | 40. | 40. | 40. | 40. |
| 4 27619JAMES CR | 40. | 40. | 40. | 40. | 40. | 40. | 40. | 40. |
| 4 27620JAMES CR | 40. | 40. | 40. | 40. | 40. | 40. | 40. | 40. |
| 4 27621JAMES CR | 40. | 40. | 40. | 40. | 40. | 40. | 40. | 40. |
| 4 27622JAMES CR | 40. | 40. | 40. | 40. | 40. | 40. | 40. | 40. |
| 4 27623JAMES CR | 40. | 40. | 40. | 40. | 40. | 40. | 40. | 40. |
| 4 27624JAMES CR | 40. | 40. | 40. | 40. | 40. | 40. | 40. | 40. |
| 4 27625JAMES CR | 40. | 40. | 40. | 40. | 40. | 40. | 40. | 40. |
| 4 27626JAMES CR | 40. | 40. | 40. | 40. | 40. | 40. | 40. | 40. |
| 4 27627JAMES CR | 40. | 40. | 40. | 40. | 40. | 40. | 40. | 40. |
| 4 27628JAMES CR | 40. | 40. | 40. | 40. | 40. | 40. | 40. | 40. |
| 4 27629JAMES CR | 40. | 40. | 40. | 40. | 40. | 40. | 40. | 40. |
| 4 27630JAMES CR | 40. | 40. | 40. | 40. | 40. | 40. | 40. | 40. |
| 4 27631JAMES CR | 40. | 40. | 40. | 40. | 40. | 40. | 40. | 40. |
| 4 27632JAMES CR | 40. | 40. | 40. | 40. | 40. | 40. | 40. | 40. |
| 4 27633JAMES CR | 40. | 40. | 40. | 40. | 40. | 40. | 40. | 40. |
| 4 27634JAMES CR | 40. | 40. | 40. | 40. | 40. | 40. | 40. | 40. |
| 4 27635JAMES CR | 40. | 40. | 40. | 40. | 40. | 40. | 40. | 40. |
| 4 27636JAMES CR | 40. | 40. | 40. | 40. | 40. | 40. | 40. | 40. |

E. OUTPUT EXAMPLE

**********************************************************************************

J879--UNSTEADY STREAMFLOW SIMULATION USING A LINEAR IMPLICIT FINITE DIFFERENCE MODEL

**********************************************************************************

J879.--FLOW SIMULATION MODEL FOR UPPER CHATTAHOOCHEE RIVER   FEB 1978

SELECTED INPUT DATA

UPSTREAM BOUNDARY CONDITION CODE------ 2
DOWNSTREAM BOUNDARY CONDITION CODE---- 1
TRIBUTARY STORAGE   YES(1)   NO(0)---- 1
RESULTS STORED ON DISK   YES(1)   NO(0) 0
STARTING DATE---------------------- 4/ 2/1976
NUMBER OF CROSS-SECTIONS------------ 30
NUMBER OF TIME STEPS--------------- 288
LENGTH OF TIME STEP (MINUTES)------- 5.0
NUMBER OF TRIBUTARIES-------------- 1
RATING TABLE--------------------DEPTH DISCHARGE

| DEPTH | DISCHARGE |
|---|---|
| 2.70 | 430. |
| 3.40 | 1030. |
| 4.20 | 1850. |
| 6.60 | 4700. |
| 11.00 | 10880. |
| 0.0 | 0. |
| 0.0 | 0. |
| 0.0 | 0. |
| 0.0 | 0. |
| 0.0 | 0. |
| 0.0 | 0. |
| 0.0 | 0. |
| 0.0 | 0. |
| 0.0 | 0. |
| 0.0 | 0. |
| 0.0 | 0. |
| 0.0 | 0. |
| 0.0 | 0. |
| 0.0 | 0. |
| 0.0 | 0. |

TRIBUTARIES HAVE VARIABLE STORAGE

| TRIB. NO. | A0 | A1 | A2 | A3 |
|---|---|---|---|---|
| 1 | 5000.0 | 5000.00 | 0.0 | 0.0 |

## CROSS-SECTION DATA

| X-SEC NO | X (FT) | Z (FT) | N0 N=N0+N1*(Y-YFN) | N1 | YFN (FT) | QLAT (CFS/FT) | TRIB NO | SKEW COEF | X-SEC COORDINATES: DEPTH(FT) | TOP WIDTH(FT) | DEPTH(FT) | TOP WIDTH(FT) | DEPTH(FT) | TOP WIDTH(FT) | DEPTH(FT) | TOP WIDTH(FT) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1584. | 910.54 | 0.060 | 0.0 | 0.0 | 0.0 | 0 | 1.00 | 0.0 | 250. | 2.5 | 250. | 5.0 | 250. | 7.5 | 250. |
| | | | | | | | | | 10.0 | 250. | 12.5 | 250. | 15.0 | 250. | 17.5 | 250. |
| | | | | | | | | | 20.0 | 250. | | | | | | |
| 2 | 2217. | 909.53 | 0.086 | 0.0 | 0.0 | 0.0 | 0 | 1.00 | 0.0 | 204. | 2.5 | 205. | 5.0 | 209. | 7.5 | 215. |
| | | | | | | | | | 10.0 | 224. | 12.5 | 236. | 15.0 | 250. | 17.5 | 266. |
| | | | | | | | | | 20.0 | 285. | | | | | | |
| 3 | 3000. | 908.10 | 0.054 | 0.0 | 0.0 | 0.0 | 0 | 1.00 | 0.0 | 180. | 2.5 | 180. | 5.0 | 180. | 7.5 | 180. |
| | | | | | | | | | 10.0 | 180. | 12.5 | 180. | 15.0 | 180. | 17.5 | 180. |
| | | | | | | | | | 20.0 | 180. | | | | | | |
| 4 | 4000. | 906.13 | 0.056 | 0.0 | 0.0 | 0.0 | 0 | 1.00 | 0.0 | 180. | 2.5 | 180. | 5.0 | 180. | 7.5 | 180. |
| | | | | | | | | | 10.0 | 180. | 12.5 | 180. | 15.0 | 180. | 17.5 | 180. |
| | | | | | | | | | 20.0 | 180. | | | | | | |
| 5 | 5121. | 903.76 | 0.051 | 0.0 | 0.0 | 0.0 | 0 | 1.00 | 0.0 | 162. | 2.5 | 165. | 5.0 | 172. | 7.5 | 185. |
| | | | | | | | | | 10.0 | 203. | 12.5 | 227. | 15.0 | 255. | 17.5 | 288. |
| | | | | | | | | | 20.0 | 327. | | | | | | |
| 6 | 6969. | 901.15 | 0.038 | 0.0 | 0.0 | 0.0 | 0 | 1.00 | 0.0 | 120. | 2.5 | 121. | 5.0 | 123. | 7.5 | 128. |
| | | | | | | | | | 10.0 | 134. | 12.5 | 142. | 15.0 | 151. | 17.5 | 162. |
| | | | | | | | | | 20.0 | 175. | | | | | | |
| 7 | 9873. | 898.04 | 0.026 | 0.0 | 0.0 | 0.0 | 0 | 1.00 | 0.0 | 144. | 2.5 | 145. | 5.0 | 147. | 7.5 | 151. |
| | | | | | | | | | 10.0 | 156. | 12.5 | 162. | 15.0 | 171. | 17.5 | 180. |
| | | | | | | | | | 20.0 | 191. | | | | | | |
| 8 | 12302. | 896.96 | 0.025 | 0.0 | 0.0 | 0.0 | 0 | 1.00 | 0.0 | 128. | 2.5 | 130. | 5.0 | 134. | 7.5 | 142. |
| | | | | | | | | | 10.0 | 153. | 12.5 | 167. | 15.0 | 184. | 17.5 | 204. |
| | | | | | | | | | 20.0 | 227. | | | | | | |
| 9 | 13675. | 895.97 | 0.035 | -0.001 | 0.0 | 0.0 | 0 | 1.00 | 0.0 | 210. | 2.5 | 211. | 5.0 | 213. | 7.5 | 217. |
| | | | | | | | | | 10.0 | 223. | 12.5 | 231. | 15.0 | 240. | 17.5 | 251. |
| | | | | | | | | | 20.0 | 263. | | | | | | |
| 10 | 14361. | 895.87 | 0.048 | -0.001 | 0.0 | 0.0 | 0 | 1.00 | 0.0 | 160. | 2.5 | 161. | 5.0 | 164. | 7.5 | 168. |
| | | | | | | | | | 10.0 | 174. | 12.5 | 182. | 15.0 | 192. | 17.5 | 203. |
| | | | | | | | | | 20.0 | 216. | | | | | | |
| 11 | 15153. | 894.16 | 0.037 | -0.001 | 0.0 | 0.0 | 1 | 1.00 | 0.0 | 120. | 2.5 | 121. | 5.0 | 125. | 7.5 | 131. |
| | | | | | | | | | 10.0 | 139. | 12.5 | 150. | 15.0 | 163. | 17.5 | 178. |
| | | | | | | | | | 20.0 | 196. | | | | | | |

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 20 | 33686. | 895.59 | 0.099 | -0.005 | 0.0 | 0.015785 | 0 | 1.00 | 0.0 | 140. | 2.5 | 141. | 5.0 | 144. | 7.5 | 150. |
| | | | | | | | | | 10.0 | 158. | 12.5 | 168. | 15.0 | 180. | 17.5 | 195. |
| | | | | | | | | | 20.0 | 211. | | | | | | |
| 21 | 35481. | 894.48 | 0.107 | -0.004 | 0.0 | 0.0 | 0 | 1.00 | 0.0 | 152. | 2.5 | 153. | 5.0 | 156. | 7.5 | 162. |
| | | | | | | | | | 10.0 | 169. | 12.5 | 179. | 15.0 | 190. | 17.5 | 204. |
| | | | | | | | | | 20.0 | 220. | | | | | | |
| 22 | 37066. | 893.27 | 0.110 | 0.0 | 0.0 | 0.015773 | 0 | 1.00 | 0.0 | 168. | 2.5 | 169. | 5.0 | 173. | 7.5 | 179. |
| | | | | | | | | | 10.0 | 187. | 12.5 | 198. | 15.0 | 212. | 17.5 | 227. |
| | | | | | | | | | 20.0 | 246. | | | | | | |
| 23 | 39758. | 891.46 | 0.088 | 0.0 | 0.0 | 0.0 | 0 | 1.00 | 0.0 | 140. | 2.5 | 140. | 5.0 | 142. | 7.5 | 144. |
| | | | | | | | | | 10.0 | 146. | 12.5 | 150. | 15.0 | 154. | 17.5 | 159. |
| | | | | | | | | | 20.0 | 165. | | | | | | |
| 24 | 43349. | 890.85 | 0.058 | 0.0 | 0.0 | 0.0 | 0 | 1.00 | 0.0 | 144. | 2.5 | 144. | 5.0 | 146. | 7.5 | 148. |
| | | | | | | | | | 10.0 | 151. | 12.5 | 155. | 15.0 | 160. | 17.5 | 165. |
| | | | | | | | | | 20.0 | 172. | | | | | | |
| 25 | 45038. | 887.84 | 0.026 | 0.0 | 0.0 | 0.0 | 0 | 1.00 | 0.0 | 130. | 2.5 | 132. | 5.0 | 138. | 7.5 | 147. |
| | | | | | | | | | 10.0 | 161. | 12.5 | 179. | 15.0 | 200. | 17.5 | 225. |
| | | | | | | | | | 20.0 | 254. | | | | | | |
| 26 | 46517. | 888.26 | 0.016 | 0.0 | 0.0 | 0.0 | 0 | 1.00 | 0.0 | 160. | 2.5 | 162. | 5.0 | 167. | 7.5 | 177. |
| | | | | | | | | | 10.0 | 190. | 12.5 | 206. | 15.0 | 227. | 17.5 | 251. |
| | | | | | | | | | 20.0 | 278. | | | | | | |
| 27 | 48101. | 890.39 | 0.019 | 0.0 | 0.0 | 0.0 | 0 | 1.00 | 0.0 | 155. | 2.5 | 157. | 5.0 | 163. | 7.5 | 172. |
| | | | | | | | | | 10.0 | 185. | 12.5 | 202. | 15.0 | 223. | 17.5 | 247. |
| | | | | | | | | | 20.0 | 275. | | | | | | |
| 28 | 49685. | 890.21 | 0.023 | 0.0 | 0.0 | 0.0 | 0 | 1.00 | 0.0 | 151. | 2.5 | 154. | 5.0 | 164. | 7.5 | 181. |
| | | | | | | | | | 10.0 | 204. | 12.5 | 234. | 15.0 | 271. | 17.5 | 314. |
| | | | | | | | | | 20.0 | 364. | | | | | | |
| 29 | 51533. | 889.44 | 0.023 | 0.0 | 0.0 | 0.0 | 0 | 1.00 | 0.0 | 170. | 2.5 | 171. | 5.0 | 174. | 7.5 | 179. |
| | | | | | | | | | 10.0 | 185. | 12.5 | 194. | 15.0 | 205. | 17.5 | 217. |
| | | | | | | | | | 20.0 | 232. | | | | | | |
| 30 | 52747. | 889.36 | 0.026 | 0.0 | 0.0 | 0.0 | 0 | 1.00 | 0.0 | 160. | 2.5 | 161. | 5.0 | 164. | 7.5 | 169. |
| | | | | | | | | | 10.0 | 176. | 12.5 | 185. | 15.0 | 196. | 17.5 | 209. |
| | | | | | | | | | 20.0 | 224. | | | | | | |

VALUES OF PARAMETER DRIVING MODEL

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 550.00 | 550.00 | 550.00 | 550.00 | 550.00 | 550.00 | 550.00 | 550.00 | 550.00 | 550.00 | 550.00 | 550.00 |
| 550.00 | 550.00 | 550.00 | 550.00 | 550.00 | 550.00 | 550.00 | 550.00 | 550.00 | 550.00 | 550.00 | 550.00 |
| 550.00 | 550.00 | 550.00 | 550.00 | 550.00 | 550.00 | 550.00 | 550.00 | 550.00 | 550.00 | 550.00 | 550.00 |
| 550.00 | 550.00 | 550.00 | 550.00 | 550.00 | 550.00 | 550.00 | 550.00 | 550.00 | 550.00 | 550.00 | 550.00 |
| 550.00 | 550.00 | 550.00 | 550.00 | 550.00 | 550.00 | 550.00 | 550.00 | 550.00 | 550.00 | 550.00 | 550.00 |
| 550.00 | 550.00 | 550.00 | 550.00 | 550.00 | 550.00 | 550.00 | 550.00 | 550.00 | 550.00 | 550.00 | 550.00 |
| 550.00 | 550.00 | 550.00 | 550.00 | 550.00 | 550.00 | 550.00 | 550.00 | 550.00 | 550.00 | 550.00 | 661.00 |
| 1676.00 | 2871.00 | 3465.00 | 3691.00 | 3809.00 | 3881.00 | 3916.00 | 3940.00 | 3964.00 | 3964.00 | 3964.00 | 3964.00 |
| 3988.00 | 3988.00 | 3999.00 | 3988.00 | 3999.00 | 3988.00 | 3988.00 | 3999.00 | 3999.00 | 3999.00 | 4011.00 | 4011.00 |
| 4011.00 | 4011.00 | 4011.00 | 4011.00 | 4011.00 | 4011.00 | 4023.00 | 4011.00 | 4023.00 | 4023.00 | 4023.00 | 4023.00 |
| 4035.00 | 4035.00 | 4035.00 | 4035.00 | 4035.00 | 4035.00 | 4035.00 | 4023.00 | 4035.00 | 4035.00 | 4035.00 | 4035.00 |
| 4035.00 | 4047.00 | 4035.00 | 4035.00 | 4035.00 | 4035.00 | 4035.00 | 4035.00 | 4035.00 | 4035.00 | 4035.00 | 4035.00 |
| 4035.00 | 4035.00 | 4035.00 | 4035.00 | 4035.00 | 4035.00 | 4035.00 | 4035.00 | 4035.00 | 4035.00 | 4047.00 | 4035.00 |
| 4035.00 | 4047.00 | 4047.00 | 4047.00 | 4047.00 | 4035.00 | 4035.00 | 4035.00 | 4035.00 | 4047.00 | 4047.00 | 4047.00 |
| 4047.00 | 4047.00 | 4035.00 | 4047.00 | 4047.00 | 4047.00 | 4047.00 | 4047.00 | 4047.00 | 4047.00 | 4047.00 | 4047.00 |
| 4047.00 | 4047.00 | 4047.00 | 4035.00 | 4035.00 | 4047.00 | 4047.00 | 4047.00 | 4035.00 | 4047.00 | 4047.00 | 4035.00 |
| 4047.00 | 4047.00 | 4059.00 | 4059.00 | 4059.00 | 4059.00 | 4071.00 | 4059.00 | 4071.00 | 4071.00 | 4071.00 | 4106.00 |
| 4130.00 | 4142.00 | 4154.00 | 4154.00 | 4166.00 | 4166.00 | 4166.00 | 4178.00 | 4166.00 | 4178.00 | 4166.00 | 4154.00 |
| 4142.00 | 4130.00 | 4130.00 | 4130.00 | 4130.00 | 4130.00 | 4130.00 | 4130.00 | 4130.00 | 4130.00 | 4130.00 | 4118.00 |
| 4083.00 | 4071.00 | 4059.00 | 4059.00 | 4047.00 | 4047.00 | 4047.00 | 4047.00 | 4047.00 | 4047.00 | 4035.00 | 4047.00 |
| 4035.00 | 4047.00 | 4047.00 | 4047.00 | 4035.00 | 4047.00 | 4047.00 | 4047.00 | 4035.00 | 4035.00 | 4035.00 | 4035.00 |
| 4047.00 | 4047.00 | 4047.00 | 4047.00 | 4035.00 | 4035.00 | 4047.00 | 4035.00 | 4035.00 | 4035.00 | 3833.00 | 2871.00 |
| 2064.00 | 1543.00 | 1245.00 | 1030.00 | 867.00 | 764.00 | 587.00 | 644.00 | 610.00 | 584.00 | 567.00 | 559.00 |
| 550.00 | 550.00 | 550.00 | 550.00 | 550.00 | 550.00 | 550.00 | 550.00 | 550.00 | 550.00 | 550.00 | 550.00 |

TRIBUTARY FLOW FOR TRIB. NO. 1

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 |
| 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 |
| 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 |
| 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 |
| 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 |
| 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 |
| 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 |
| 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 |
| 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 |
| 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 |
| 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 |
| 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 |
| 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 |
| 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 |
| 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 |
| 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 |
| 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 |
| 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 |
| 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 |
| 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 |
| 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 |
| 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 |
| 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 |
| 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 |

FLOW RESULTS AT SELECTED CROSS-SECTIONS

4/ 2/1976 0

| XSEC | 1 | 2 | 4 | 7 | 10 | 13 | 16 | 19 | 22 | 25 | 28 | 29 | 30 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ELEV | 912.56 | 911.55 | 907.83 | 903.24 | 903.20 | 903.15 | 902.72 | 900.36 | 897.60 | 893.00 | 892.42 | 892.03 | 891.76 |
| DEPTH | 2.02 | 2.02 | 1.70 | 5.20 | 7.33 | 5.60 | 2.20 | 2.87 | 4.33 | 5.16 | 2.21 | 2.59 | 2.40 |
| DISCHARGE | 550. | 550. | 550. | 550. | 550. | 590. | 590. | 590. | 635. | 635. | 635. | 635. | 635. |
| VELOCITY | 1.09 | 1.33 | 1.80 | 0.73 | 0.46 | 0.86 | 1.28 | 1.50 | 0.87 | 0.92 | 1.89 | 1.44 | 1.65 |

4/ 2/1976 30

| XSEC | 1 | 2 | 4 | 7 | 10 | 13 | 16 | 19 | 22 | 25 | 28 | 29 | 30 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ELEV | 913.38 | 911.55 | 907.82 | 903.24 | 903.19 | 903.14 | 902.72 | 900.36 | 897.60 | 893.05 | 892.70 | 892.52 | 892.45 |
| DEPTH | 2.84 | 2.02 | 1.69 | 5.20 | 7.32 | 5.59 | 2.20 | 2.87 | 4.33 | 5.21 | 2.49 | 3.08 | 3.09 |
| DISCHARGE | 550. | 550. | 542. | 531. | 535. | 580. | 585. | 588. | 633. | 614. | 561. | 510. | 477. |
| VELOCITY | 0.77 | 1.33 | 1.78 | 0.70 | 0.45 | 0.85 | 1.27 | 1.50 | 0.86 | 0.89 | 1.48 | 0.97 | 0.96 |

4/ 2/1976 100

| XSEC | 1 | 2 | 4 | 7 | 10 | 13 | 16 | 19 | 22 | 25 | 28 | 29 | 30 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ELEV | 913.38 | 911.55 | 907.83 | 903.24 | 903.19 | 903.14 | 902.72 | 900.35 | 897.60 | 893.18 | 892.87 | 892.71 | 892.64 |
| DEPTH | 2.84 | 2.02 | 1.70 | 5.20 | 7.32 | 5.59 | 2.20 | 2.86 | 4.33 | 5.34 | 2.66 | 3.27 | 3.28 |
| DISCHARGE | 550. | 550. | 550. | 546. | 546. | 584. | 583. | 586. | 633. | 617. | 571. | 544. | 527. |
| VELOCITY | 0.77 | 1.33 | 1.79 | 0.72 | 0.46 | 0.85 | 1.27 | 1.50 | 0.86 | 0.87 | 1.40 | 0.97 | 1.00 |

4/ 2/1976 130

| XSEC | 1 | 2 | 4 | 7 | 10 | 13 | 16 | 19 | 22 | 25 | 28 | 29 | 30 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ELEV | 913.38 | 911.55 | 907.84 | 903.24 | 903.19 | 903.14 | 902.72 | 900.35 | 897.59 | 893.27 | 892.98 | 892.84 | 892.76 |
| DEPTH | 2.84 | 2.02 | 1.71 | 5.20 | 7.32 | 5.59 | 2.20 | 2.86 | 4.32 | 5.43 | 2.77 | 3.40 | 3.41 |
| DISCHARGE | 550. | 550. | 550. | 549. | 548. | 587. | 585. | 585. | 632. | 622. | 589. | 571. | 560. |
| VELOCITY | 0.77 | 1.33 | 1.79 | 0.73 | 0.46 | 0.86 | 1.28 | 1.50 | 0.86 | 0.86 | 1.39 | 0.99 | 1.02 |

4/ 2/1976 200

| XSEC | 1 | 2 | 4 | 7 | 10 | 13 | 16 | 19 | 22 | 25 | 28 | 29 | 30 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ELEV | 913.38 | 911.55 | 907.84 | 903.25 | 903.19 | 903.14 | 902.72 | 900.35 | 897.58 | 893.33 | 893.06 | 892.92 | 892.85 |
| DEPTH | 2.84 | 2.02 | 1.71 | 5.21 | 7.32 | 5.59 | 2.20 | 2.86 | 4.31 | 5.49 | 2.85 | 3.48 | 3.49 |
| DISCHARGE | 550. | 550. | 550. | 549. | 549. | 588. | 586. | 585. | 631. | 624. | 602. | 590. | 582. |
| VELOCITY | 0.77 | 1.33 | 1.79 | 0.73 | 0.46 | 0.86 | 1.28 | 1.50 | 0.87 | 0.85 | 1.38 | 0.99 | 1.04 |

4/ 2/1976 230

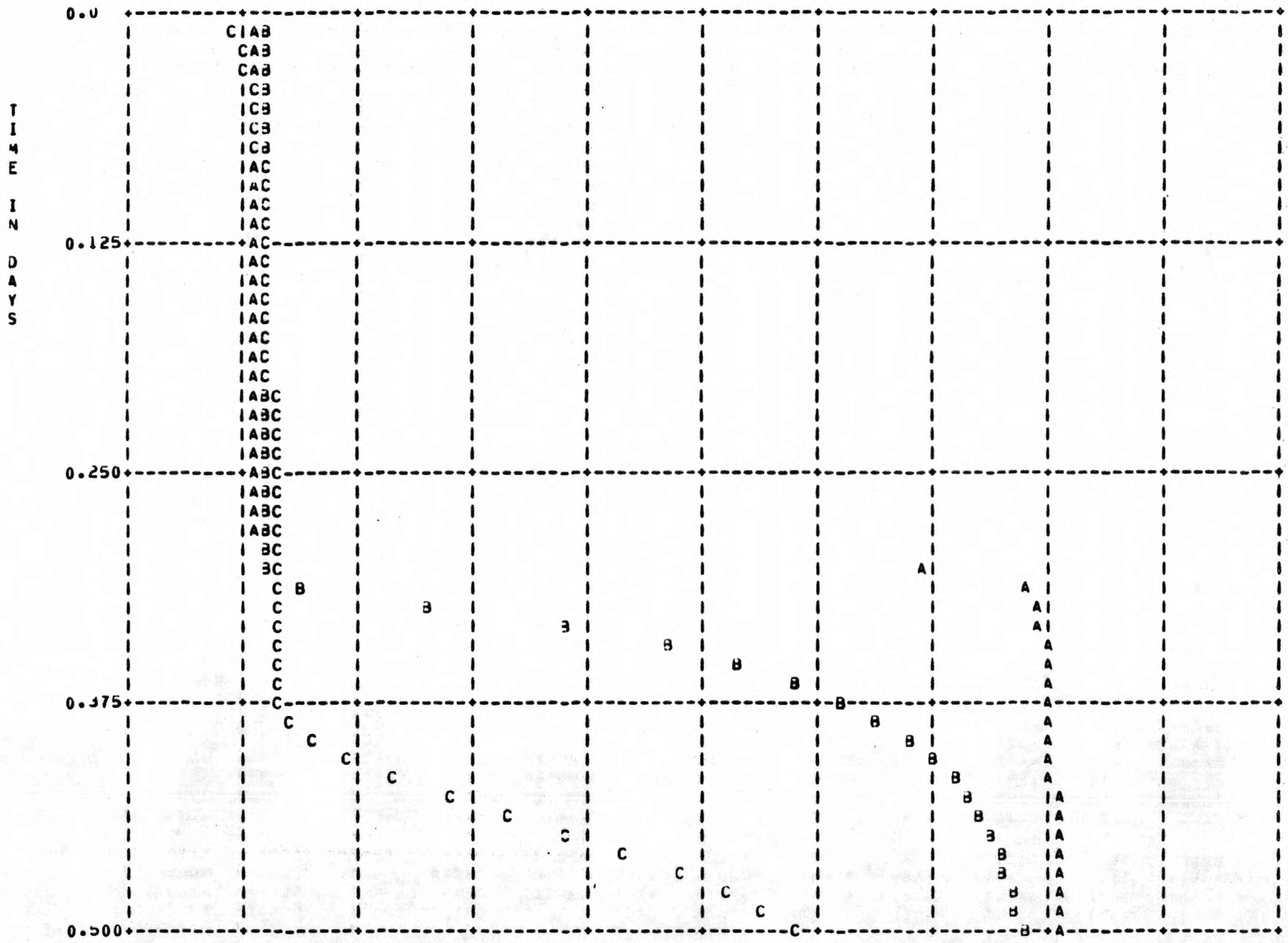
| XSEC | 1 | 2 | 4 | 7 | 10 | 13 | 16 | 19 | 22 | 25 | 28 | 29 | 30 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ELEV | 913.38 | 911.55 | 907.84 | 903.25 | 903.20 | 903.15 | 902.72 | 900.35 | 897.57 | 893.38 | 893.11 | 892.97 | 892.90 |
| DEPTH | 2.84 | 2.02 | 1.71 | 5.21 | 7.33 | 5.60 | 2.20 | 2.86 | 4.30 | 5.54 | 2.90 | 3.53 | 3.54 |
| DISCHARGE | 550. | 550. | 550. | 550. | 549. | 588. | 587. | 586. | 631. | 626. | 610. | 602. | 597. |
| VELOCITY | 0.77 | 1.33 | 1.79 | 0.73 | 0.46 | 0.86 | 1.28 | 1.50 | 0.87 | 0.85 | 1.38 | 1.00 | 1.05 |

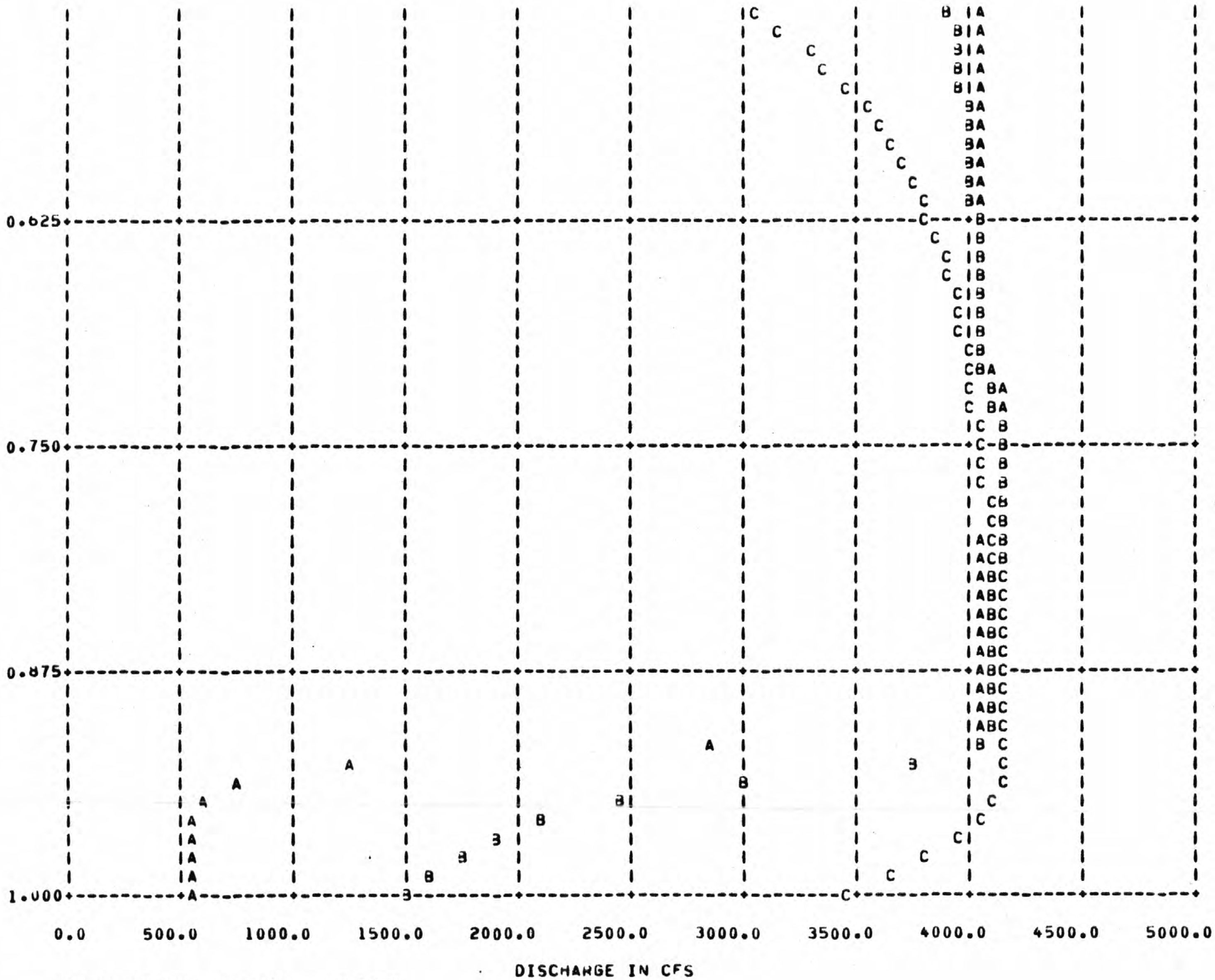
4/ 2/1976 300

| XSEC | 1 | 2 | 4 | 7 | 10 | 13 | 16 | 19 | 22 | 25 | 28 | 29 | 30 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ELEV | 913.38 | 911.55 | 907.84 | 903.25 | 903.20 | 903.15 | 902.72 | 900.35 | 897.57 | 893.41 | 893.15 | 893.01 | 892.94 |
| DEPTH | 2.84 | 2.02 | 1.71 | 5.21 | 7.33 | 5.60 | 2.20 | 2.86 | 4.30 | 5.57 | 2.94 | 3.57 | 3.58 |
| DISCHARGE | 550. | 550. | 550. | 550. | 549. | 589. | 588. | 587. | 632. | 627. | 617. | 611. | 608. |
| VELOCITY | 0.77 | 1.33 | 1.79 | 0.73 | 0.46 | 0.86 | 1.28 | 1.50 | 0.87 | 0.84 | 1.37 | 1.00 | 1.06 |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 4/ 2/1976 2100 | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- |
| XSEC | 1 | 2 | 4 | 7 | 10 | 13 | 16 | 19 | 22 | 25 | 28 | 29 | 30 |
| ELEV | 916.58 | 916.08 | 912.85 | 909.56 | 909.32 | 909.05 | 908.56 | 907.52 | 906.22 | 901.35 | 901.14 | 901.05 | 900.97 |
| DEPTH | 6.04 | 6.55 | 6.72 | 11.52 | 13.45 | 11.50 | 8.04 | 10.03 | 12.95 | 13.51 | 10.93 | 11.61 | 11.61 |
| DISCHARGE | 4035. | 4035. | 4036. | 4041. | 4045. | 4088. | 4093. | 4097. | 4145. | 4147. | 4146. | 4146. | 4146. |
| VELOCITY | 2.67 | 2.97 | 3.34 | 2.35 | 1.78 | 2.75 | 2.38 | 2.86 | 1.79 | 2.06 | 2.20 | 2.02 | 2.13 |
| 4/ 2/1976 2130 | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- |
| XSEC | 1 | 2 | 4 | 7 | 10 | 13 | 16 | 19 | 22 | 25 | 28 | 29 | 30 |
| ELEV | 916.58 | 916.08 | 912.85 | 909.56 | 909.32 | 909.05 | 908.55 | 907.51 | 906.21 | 901.35 | 901.14 | 901.05 | 900.97 |
| DEPTH | 6.04 | 6.55 | 6.72 | 11.52 | 13.45 | 11.50 | 8.03 | 10.02 | 12.94 | 13.51 | 10.93 | 11.61 | 11.61 |
| DISCHARGE | 4035. | 4036. | 4039. | 4044. | 4046. | 4088. | 4090. | 4093. | 4140. | 4143. | 4145. | 4145. | 4145. |
| VELOCITY | 2.67 | 2.97 | 3.34 | 2.35 | 1.78 | 2.76 | 2.38 | 2.86 | 1.79 | 2.05 | 2.20 | 2.02 | 2.13 |
| 4/ 2/1976 2200 | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- |
| XSEC | 1 | 2 | 4 | 7 | 10 | 13 | 16 | 19 | 22 | 25 | 28 | 29 | 30 |
| ELEV | 915.60 | 915.42 | 912.53 | 909.51 | 909.29 | 909.03 | 908.55 | 907.51 | 906.20 | 901.35 | 901.14 | 901.04 | 900.97 |
| DEPTH | 5.06 | 5.89 | 6.40 | 11.47 | 13.42 | 11.48 | 8.03 | 10.02 | 12.94 | 13.51 | 10.93 | 11.60 | 11.61 |
| DISCHARGE | 2871. | 3173. | 3587. | 3924. | 3977. | 4060. | 4079. | 4089. | 4137. | 4141. | 4142. | 4143. | 4143. |
| VELOCITY | 2.27 | 2.61 | 3.11 | 2.29 | 1.76 | 2.74 | 2.37 | 2.86 | 1.79 | 2.05 | 2.19 | 2.02 | 2.13 |
| 4/ 2/1976 2230 | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- |
| XSEC | 1 | 2 | 4 | 7 | 10 | 13 | 16 | 19 | 22 | 25 | 28 | 29 | 30 |
| ELEV | 913.63 | 912.25 | 909.75 | 908.49 | 908.47 | 908.38 | 908.12 | 907.30 | 906.06 | 901.33 | 901.12 | 901.03 | 900.95 |
| DEPTH | 3.09 | 2.72 | 3.62 | 10.45 | 12.60 | 10.83 | 7.60 | 9.81 | 12.79 | 13.49 | 10.91 | 11.59 | 11.59 |
| DISCHARGE | 764. | 851. | 1171. | 1783. | 2186. | 2759. | 3277. | 3747. | 3971. | 4101. | 4123. | 4131. | 4136. |
| VELOCITY | 0.99 | 1.53 | 1.80 | 1.15 | 1.04 | 1.99 | 2.02 | 2.68 | 1.74 | 2.04 | 2.19 | 2.01 | 2.13 |
| 4/ 2/1976 2300 | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- |
| XSEC | 1 | 2 | 4 | 7 | 10 | 13 | 16 | 19 | 22 | 25 | 28 | 29 | 30 |
| ELEV | 913.39 | 911.61 | 908.58 | 907.55 | 907.52 | 907.45 | 907.22 | 906.53 | 905.35 | 901.14 | 900.95 | 900.86 | 900.79 |
| DEPTH | 2.85 | 2.08 | 2.45 | 9.51 | 11.65 | 9.90 | 6.70 | 9.04 | 12.08 | 13.30 | 10.74 | 11.42 | 11.43 |
| DISCHARGE | 559. | 570. | 652. | 1052. | 1413. | 1833. | 2347. | 2971. | 3398. | 3791. | 3944. | 4003. | 4039. |
| VELOCITY | 0.78 | 1.34 | 1.48 | 0.75 | 0.73 | 1.46 | 1.65 | 2.32 | 1.58 | 1.92 | 2.13 | 1.98 | 2.11 |
| 4/ 2/1976 2330 | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- |
| XSEC | 1 | 2 | 4 | 7 | 10 | 13 | 16 | 19 | 22 | 25 | 28 | 29 | 30 |
| ELEV | 913.38 | 911.56 | 908.15 | 906.78 | 906.75 | 906.68 | 906.44 | 905.69 | 904.47 | 900.70 | 900.51 | 900.43 | 900.35 |
| DEPTH | 2.84 | 2.04 | 2.02 | 8.74 | 10.88 | 9.13 | 5.92 | 8.20 | 11.20 | 12.86 | 10.30 | 10.99 | 10.99 |
| DISCHARGE | 550. | 550. | 567. | 881. | 1183. | 1519. | 1938. | 2471. | 2885. | 3359. | 3622. | 3729. | 3792. |
| VELOCITY | 0.77 | 1.32 | 1.56 | 0.68 | 0.66 | 1.32 | 1.55 | 2.14 | 1.46 | 1.77 | 2.06 | 1.92 | 2.07 |
| 4/ 2/1976 2400 | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- |
| XSEC | 1 | 2 | 4 | 7 | 10 | 13 | 16 | 19 | 22 | 25 | 28 | 29 | 30 |
| ELEV | 913.38 | 911.56 | 907.98 | 906.14 | 906.11 | 906.04 | 905.79 | 904.94 | 903.65 | 900.11 | 899.93 | 899.84 | 899.77 |
| DEPTH | 2.84 | 2.03 | 1.85 | 8.10 | 10.24 | 8.49 | 5.27 | 7.45 | 10.38 | 12.27 | 9.72 | 10.40 | 10.41 |
| DISCHARGE | 550. | 550. | 555. | 800. | 1050. | 1330. | 1674. | 2120. | 2494. | 2974. | 3274. | 3398. | 3472. |
| VELOCITY | 0.77 | 1.32 | 1.67 | 0.67 | 0.62 | 1.25 | 1.51 | 2.03 | 1.37 | 1.66 | 2.00 | 1.86 | 2.01 |

DISCHARGE HYDROGRAPH      4/ 2/1976:   0 TO  4/ 2/1976:2400






EXPLANATION: SYMBOL X-SECT

| SYMBOL | X-SECT |
|---|---|
| A | 1 |
| B | 15 |
| C | 30 |