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US Army Corps
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The Hydrologic
Engineering Center

GENERALIZED COMPUTER PROGRAM

HEC-2

Water Surface Profiles

Users Manual

September 1982

10 December 1984

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16. Abstract (Limit: 200 words)

The program computes water surface profiles for one-dimensional steady, gradually varied flow in rivers of any cross section. Flow may be subcritical or supercritical. Various routines are available for modifying input cross-section data, for example, for locating encroachments or inserting a trapezoidal excavation on cross sections. The water surface profile through structures such as bridges, culverts and weirs can be computed. Variable channel roughness and variable reach length between adjacent cross sections can be accomodated. The computational procedure is based on the solution of the one-dimensional energy equation with energy loss due to friction evaluated with Manning's equation (Standard Step Method). The program is also designed for application in flood plain management and flood insurance studies to evaluate floodway encroachments and to designate flood hazard zones. Also, capabilities are available for assessing the effects of channel improvements and levees on water surface profiles. Printer plots can be made of the river cross sections and computed profiles. Input may be in either English or metric units.

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HEC-2

Water Surface Profiles

Users Manual

September 1982

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Water Resources Support Center

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FOREWORD

This edition of the HEC-2 Users Manual provides input description for the November 1976 version of computer program HEC-2 with modifications 50 through 56. This edition is an update of the January 1981 Users Manual with revisions to correct typographical errors, update references and to provide instruction for program capabilities added by modification 55.

Major revisions to the January 1981 edition are the following:

(1) The input description of the CI and BT cards has been updated to describe the enhanced capabilities added by modification 55.

(2) Input instructions have been added for the optional ice analysis and split flow analysis capabilities added by modification 55.

Source code modifications to the November 1976 version of HEC-2 are described in the following:

MODIFICATION NUMBER	DESCRIPTION
50	Provides an option which enables the program user to specify which of the five alternative procedures are to be used to estimate friction losses.
51	Enables a program user to use system control cards to bypass the normal HEC-2 output routines.
52	Changed trace numbers to correspond with the format statements used by HEC-2 trace options.
53	Added the archival tape output option and two new optimizing encroachment methods.
54	Provided improvements to the Flood Hazard Factor and channel improvement capabilities of the program, added new routines to enhance the readability of program output, and reduced the size of the largest subroutine to facilitate easier compilation on smaller computer systems.
55	Provided a new flow under ice option, new split flow option, and several improvements to the channel improvement option. The 100 comment card limit was removed and an optional input format for the BT cards was added.
56	Program enhancements were added to make HEC-2 more adaptable to a variety of computer systems.

May 1985

HEC-2 is the second in a special series of comprehensive programs, each of which is intended to be a major computational aid for solving problems associated with a particular area of hydrologic engineering. The programs currently in this series are:

HEC-1, Flood Hydrograph Package

HEC-2, Water Surface Profiles

HEC-3, Reservoir System Analysis (for Conservation)

HEC-4, Monthly Streamflow Simulation

HEC-5, Simulation of Flood Control and Conservation Systems

HEC-6, Scour and Deposition in Rivers and Reservoirs

Up-to-date information and copies of source statement cards for the programs are available from the Center. While the Government is not responsible for the results obtained when using the programs, assistance in resolving malfunctions in the programs will be furnished to the extent that time and funds are available. It is desired that users notify the Center of inadequacies in, or desirable modifications to, the program.

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HEC-2
WATER SURFACE PROFILES
USERS MANUAL

Chapter 1

INTRODUCTION

1. PROGRAM DEVELOPMENT

The HEC-2 computer program was developed in the Hydrologic Engineering Center by Bill S. Eichert. The version documented herein, dated November 1976, is intended to replace all earlier versions. The basic computational capabilities for calculating water surface profiles and the data input requirements remain essentially unchanged. However, capabilities have been added for a) encroachment analysis (methods 5 and 6), b) summarizing output with pre-defined or user-defined summary tables, c) creating a permanent record of study results on an "archival" tape and d) calculating friction loss with one of five alternative approaches. The version also has reduced storage requirements and increased potential for usage on interactive computer terminals.

2. OVERVIEW OF PROGRAM CAPABILITIES

The program is intended for calculating water surface profiles for steady gradually varied flow in natural or man-made channels. Both subcritical and supercritical flow profiles can be calculated. The effects of various obstructions such as bridges, culverts, weirs, and structures in the flood plain may be considered in the computations. The computational procedure is based on the solution of the one-dimensional energy equation with energy loss due to friction evaluated with Manning's equation. The computational procedure is generally known as the Standard Step Method. The program is also designed for application in flood plain management and flood insurance studies to evaluate floodway encroachments and to designate flood hazard zones. Also, capabilities are available for assessing the effects of channel improvements and levees on water surface profiles. Input and output units may be either English or Metric.

3. SUPPLEMENTARY PROGRAMS

A data edit program (EDIT-2) which checks the data cards for various input errors is available. EDIT-2 is described in Appendix VIII.

A **Fortran graphics program** (Hydraulics Graphics Package) which produces HEC-2 cross section and profile plots in interactive or batch modes is also available. Documentation for the Hydraulics Graphics Package may be obtained from the Hydrologic Engineering Center.

4. COMPUTER EQUIPMENT REQUIREMENTS

Two versions of HEC-2 have been developed by the Hydrologic Engineering Center (HEC). A standard version of HEC-2 has been developed on the CDC 6600 computer. It may be used with minor modifications on most medium to large computers. A microcomputer version of HEC-2 has been developed for use on the IBM PC/XT microcomputer. FORTRAN source code for both versions and an executable module for the micro version are available from HEC. The following table shows the approximate memory requirements, and compilation and execution times for various computers.

TABLE 1
COMPUTER MEMORY AND TIME REQUIREMENTS

		Time Requirements	
Computer	Memory Requirement Words (Decimal)	Compile	Standard Tests* Execution
************************ STANDARD HEC-2 VERSION **************************			
Honeywell 6620	56,000	2 min 03 sec	2 min 19 sec
HARRIS 500	80,000	8 min 54 sec	1 min 36 sec
Hewlett Packard 9000	90,000	7 min 13 sec	2 min 12 sec
******************** MICROCOMPUTER HEC-2 VERSION ************************			
IBM PC/AT (with math coprocessor)	512,000		12 min
IBM PC/XT (with math coprocessor)	512,000	1 hr 30 min	36 min
IBM PC/XT (w/o math coprocessor)	512,000		1 hr 15 min

*Standard tests are contained in Exhibit 1 of the HEC-2 Water Surface Profiles, Programmers Manual.

Chapter 2

THEORETICAL BASIS FOR PROFILE CALCULATION

1. GENERAL

This section describes methodology used in HEC-2 for the calculation of water surface profiles. Topics discussed include equations used for basic profile calculation, cross section subdivision for determining conveyance and velocity distribution, friction loss evaluation, iterative procedure for solving the basic equations and critical depth determination. Computational methodology for calculating flow through bridges is presented in Appendix IV. Methodology used by HEC-2 to determine and evaluate flood plain encroachments is contained in Appendix II.

2. EQUATIONS FOR BASIC PROFILE CALCULATION

The following two equations are solved by an iterative procedure (the standard step method) to calculate an unknown water surface elevation at a cross section:

$$WS_2 + \frac{\alpha_2 V_2^2}{2g} = WS_1 + \frac{\alpha_1 V_1^2}{2g} + h_e \qquad (1)$$

$$h_e = L\,\bar{S}_f + C\left|\frac{\alpha_2 V_2^2}{2g} - \frac{\alpha_1 V_1^2}{2g}\right| \qquad (2)$$

where:

WS_1, WS_2 = water surface elevations at ends of reach (see Figure 1)

V_1, V_2 = mean velocities (total discharge ÷ total flow area) at ends of reach

α_1, α_2 = velocity coefficients for flow at ends of reach

g = acceleration of gravity

h_e = energy head loss

L = discharge-weighted reach length

$\bar{S}_f$ = representative friction slope for reach

C = expansion or contraction loss coefficient

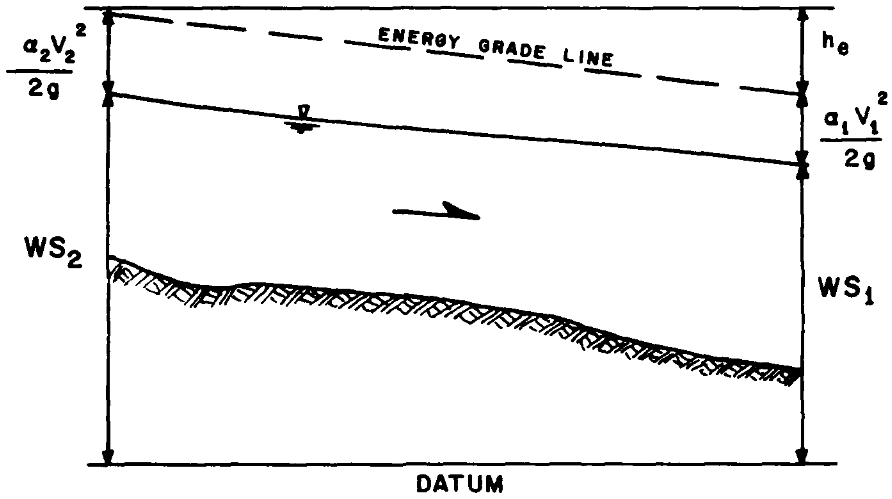

Figure 1. Representation of Terms in Energy Equation

The discharge-weighted reach length, L, is calculated as:

$$L = \frac{L_{lob}\bar{Q}_{lob} + L_{ch}\bar{Q}_{ch} + L_{rob}\bar{Q}_{rob}}{\bar{Q}_{lob} + \bar{Q}_{ch} + \bar{Q}_{rob}} \qquad (3)$$

where:

L_{lob}, L_{ch}, L_{rob} = reach lengths specified for flow in the left overbank, main channel and right overbank, respectively

$\bar{Q}_{lob}$, $\bar{Q}_{ch}$, $\bar{Q}_{rob}$ = arithmetic average of flows at the ends of the reach for the left overbank, main channel, and right overbank, respectively

Determination of a representative friction slope, $\bar{S}_f$, is discussed in section 4 of this chapter. Selection of appropriate magnitudes for expansion and contraction coefficients is discussed in Chapter 3, Section 5 and Appendix IV.

3. CROSS SECTION SUBDIVISION

The determination of total conveyance and the velocity coefficient for a cross section requires that flow be subdivided into units for which the velocity is uniformly distributed. The approach used in HEC-2 is to subdivide flow in the overbank areas using the input cross section stations (X-coordinates) as the basis for subdivision. Conveyance is calculated within each subdivision by the equation (based on English units):

$$k = \frac{1.486}{n} a r^{2/3} \tag{4}$$

where:

k = conveyance for subdivision

n = Manning's 'n' for subdivision

a = flow area for subdivision

r = hydraulic radius for subdivision (area divided by wetted perimeter)

Flow in the main channel is not subdivided in normal applications. The total conveyance for the cross section is obtained by summing the incremental conveyances.

The velocity coefficient, α, is obtained with the following equation:

$$\alpha = \frac{(A_t)^2 \left[(K_{lob})^3/(A_{lob})^2 + (K_{ch})^3/(A_{ch})^2 + (K_{rob})^3/(A_{rob})^2\right]}{(K_t)^3} \tag{5}$$

where:

A_t = total flow area of cross section

A_{lob}, A_{ch}, A_{rob} = flow areas of left overbank, main channel and right overbank, respectively

K_t = total conveyance of cross section

K_{lob}, K_{ch}, K_{rob} = conveyances of left overbank, main channel and right overbank, respectively

4. FRICTION LOSS EVALUATION

Friction loss is evaluated in HEC-2 as the product of $\bar{S}_f$, and L, where $\bar{S}_f$ is the representative friction slope for a reach and L is defined with equation (3). Alternative expressions for $\bar{S}_f$ available in HEC-2 are as follows:

Average Conveyance Equation

$$\bar{S}_f = \left(\frac{Q_1 + Q_2}{K_1 + K_2} \right)^2 \tag{6}$$

Average Friction Slope Equation

$$\bar{S}_f = \frac{S_{f_1} + S_{f_2}}{2} \tag{7}$$

Geometric Mean Friction Slope Equation

$$\bar{S}_f = \sqrt{S_{f_1} \cdot S_{f_2}} \tag{8}$$

Harmonic Mean Friction Slope Equation

$$\bar{S}_f = \frac{2\, S_{f_1} \cdot S_{f_2}}{S_{f_1} + S_{f_2}} \tag{9}$$

Equation (6), which has been used in HEC-2 since 1971, is the 'default' equation used by the program; that is, it is used automatically unless use of a different equation is requested by input. The program also contains an option by which one of the above equations is automatically selected on a reach by reach basis depending on flow regime and profile type (e.g., S1, M1, etc.). Further discussion of the alternative methods for evaluating friction loss is contained in Chapter 4, Optional Capabilities.

5. COMPUTATION PROCEDURE

The unknown water surface elevation at a cross section is determined by an iterative solution of equations (1) and (2). The computational procedure is as follows:

1. Assume a water surface elevation at the upstream cross section (or downstream cross section if a supercritical profile is being calculated).

2. Based on the assumed water surface elevation, determine the corresponding total conveyance and velocity head.

3. With values from step 2, compute $\bar{S}_f$ and solve equation (2) for h_e.

4. With values from steps 2 and 3, solve equation (1) for WS_2.

5. Compare the computed value of WS_2 with the values assumed in step 1; repeat steps 1 through 5 until the values agree to within .01 feet (or .01 meters).

Criteria used to assume water surface elevations in the iterative procedure varies from trial to trial. Generally the first trial is based on projecting the previous cross section's water surface elevation on the average of the friction slopes from the previous two cross sections. The second trial is an arithmetic average of the computed and assumed elevations from the first trial. The third and subsequent trials are generally based on a "secant" method of projecting the rate of change of the difference between computed and assumed elevations for the previous two trials to zero. The change from one trial to the next is constrained to a maximum of ±50% of the assumed depth from the previous trial.

Once a 'balanced' water surface elevation has been obtained for a cross section, checks are made to ascertain that the elevation is on the 'right' side of the critical water surface elevation (e.g., above the critical elevation if a subcritical profile is being calculated). If the balanced elevation is on the 'wrong' side of the critical water surface elevation, critical depth is assumed for the cross section and a message to that effect is printed by the program. The program user should be aware of critical depth assumptions and determine the reasons for their occurrence, because in many cases they result from reach lengths being too long or from misrepresentation of the effective flow areas of cross sections.

For a subcritical profile, a preliminary check for proper flow regime involves the following equation:

$$\left(\alpha \frac{V^2}{2g}\right)_{test} = \frac{A_t}{2T} \tag{10}$$

where:

$\left(\alpha \frac{V^2}{2g}\right)_{test}$ = velocity head that would exist if critical conditions existed at the balanced water surface elevation.

A_t = total flow area

T = water surface width

If the calculated velocity head, $\alpha \frac{V^2}{2g}$, is less than 94% of $\left(\alpha \frac{V^2}{2g}\right)_{test}$ the balanced water surface elevation will be accepted for the cross section. If the calculated velocity head is greater than 94% of the test value, the critical water surface elevation will be determined (by a procedure discussed in section 6) so that a direct comparison of balanced elevation versus critical elevation can be made.

For a supercritical profile, critical depth is automatically calculated for every cross section, which enables a direct comparison between balanced and critical elevations.

6. CRITICAL DEPTH DETERMINATION

Critical depth for a cross section will be determined if any of the following conditions are satisfied:

(1) The supercritical flow regime has been specified.

(2) Calculation of critical depth has been requested with the program's critical depth option.

(3) This is the first cross section and critical depth starting conditions have been specified.

(4) The critical depth check for a subcritical profile indicates that critical depth needs to be determined to verify the flow regime associated with the balanced elevation.

The total energy head for a cross section is defined by:

$$H = WS + \frac{\alpha V^2}{2g} \tag{11}$$

where:

H = total energy head

WS = water surface elevation

$\frac{\alpha V^2}{2g}$ = velocity head

The critical water surface elevation is the elevation for which the total energy head is a minimum. The critical elevation is determined with an iterative procedure whereby values of WS are assumed and corresponding values of H are determined with equation (11) until a minimum value for H is reached.

To speed the iteration process, a parabolic interpolation procedure is followed. The procedure basically involves determining values of H for three values of WS that are spaced at equal ΔWS intervals. The WS corresponding to the minimum value for H defined by a parabola passing through the three points (on the H versus WS plane) is used as the basis for the next assumption of a value for WS.

It is presumed that critical depth has been obtained when there is less than a 2.5% change in depth from one iteration to the next and provided the energy head has either decreased or has not increased by more than .01 feet. The tolerance of 2.5% may be changed by program input.

7. PROGRAM LIMITATIONS

The following assumptions are implicit in the analytical expressions used in the program:

(1) Flow is steady

(2) Flow is gradually varied

(3) Flow is one dimensional (i.e., velocity components in directions other than the direction of flow are not accounted for)

(4) River channels have 'small' slopes, say less than 1:10

Flow is assumed to be steady because time-dependent terms are not included in the energy equation (1). Flow is assumed to be gradually varied because equation (1) is based on the premise that a hydrostatic pressure distribution exists at each cross section. Flow is assumed to be one-dimensional because equation (4) is based on the premise that the total energy head is the same for all points in a cross section. Small channel slopes are assumed because the pressure head which is a component of WS in equation (1) is represented by the water depth measured vertically.

The program does not have the capability to deal with movable boundaries (i.e., sediment transport) and requires that energy losses be definable with the terms contained in equation (2) or by using criteria described in Appendix IV for bridge, culvert or weir flow.

Chapter 3

BASIC DATA REQUIREMENTS

1. GENERAL

A major portion of the programming in HEC-2 is devoted to providing a large variety of input and data manipulation options. The program objective is quite simple -- compute water surface elevations at all locations of interest for given flow values. The data needed to perform these computations include: flow regime, starting elevation, discharge, loss coefficients, cross section geometry, and reach lengths. The options available for providing and manipulating input are discussed in the following sections.

2. FLOW REGIME

Profile computations begin at a cross section with known or assumed starting conditions and proceed upstream for subcritical flow or downstream for supercritical flow. The direction of flow is specified on the J1 card (first job card) by setting variable IDIR equal to one for supercritical flow or zero (or blank) for subcritical flow. Subcritical profiles computed by the program (IDIR = 0) are constrained to critical depth or above, and supercritical profiles (IDIR = 1) are constrained to critical depth or below. The program will not allow profile computations to cross critical depth except for certain bridge analysis problems. In cases where flow passes from one flow regime to another as shown in Figure 2 below, it is necessary to compute the profile twice, alternately assuming subcritical and supercritical flow. Results of a subcritical profile, (shown as ⊙ in Figure 2) computed for the example stream would plot at critical depth (above the actual water surface profile) in the steep reach of stream. Results from a supercritical profile computation (shown as x in Figure 2)

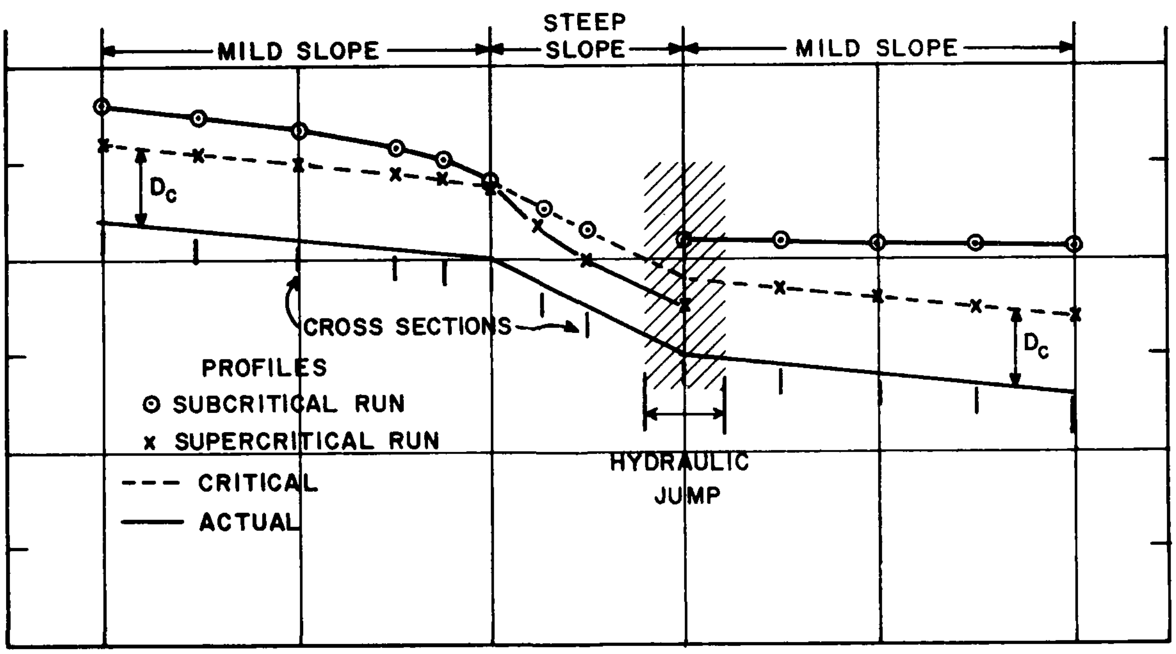

Figure 2. Profiles Calculated for Subcritical and Supercritical Flows

would plot at critical depth (below the actual water surface profile) for both mild reaches of the stream. The final plotted profile should incorporate computed results from both computations and an analysis of the hydraulic jump. HEC-2 does not contain the capability to determine the position of the hydraulic jump or energy losses associated with the jump.

3. STARTING ELEVATION

The water surface elevation for the beginning cross section may be specified in one of three ways: (1) as critical depth, (2) as a known elevation, (3) by the slope area method. By setting the variable STRT on the J1 card equal to minus one, critical depth will be computed and used as the starting water surface elevation. This method is appropriate at locations where critical or near critical conditions are known to exist for the range of discharges being computed, e.g., a waterfall, weir or a section of rapids. When a rating curve is available, the appropriate starting elevation can be specified by variable WSEL on the J1 card.

For beginning by the slope area method, STRT is set equal to the estimated slope of the energy grade line (must be a positive value) and WSEL is used as the initial estimate of the water surface elevation. The flows computed for the fixed slope are compared with the starting flow and the depth is adjusted until the computed flow is within one percent of the starting flow. The water surface elevation thus determined is used as the starting water surface elevation for subsequent water surface profile computations.

4. DISCHARGE

Discharge may be specified and altered in several ways. The Variable Q on the first job card (J1 card) specifies the starting discharge for single profile runs. When it is desired to change the discharge for a single profile run, the variable QNEW on the X2 card can be used to permanently change the discharge at any cross section.

An alternate procedure utilizes the QT cards (discharge table) and may be used to specify from one to nineteen discharge values for single or multiple profile runs. QT cards may be used to specify starting discharges and to permanently change discharges at any cross section in a data set. Variable INQ on the J1 card directs the program to the field of the QT card that contains the discharge for that profile. When a value of FQ is entered, all discharges on the X2 cards and discharges in the specified INQ of the QT cards are multiplied by the value.

5. ENERGY LOSS COEFFICIENTS

Several types of loss coefficients are utilized by the program to evaluate head losses: (1) Manning's 'n' values for friction loss, (2) contraction and expansion coefficients to evaluate transition (shock) losses, and (3) bridge loss coefficients to evaluate losses related to weir shape, pier configuration, and pressure flow.

Because Manning's coefficient of roughness 'n' depends on such factors as type and amount of vegetation, channel configuration and stage, several options are available to vary 'n'. When three 'n' values are sufficient to describe the channel and overbank roughness, the first three fields of the NC card ('n' value change) are used. Any of the 'n' values may be permanently changed at any cross section by using another NC card. Often three values are not enough to adequately describe the lateral roughness variation in the cross section; in this case the NH card ('n' value - horizontal) is used. The number of 'n' values used to describe the roughness is entered as variable NUMNH in the first field and the 'n' values and corresponding cross section stations are entered in subsequent fields. These 'n' values will be used for all subsequent cross sections unless changed by another NH card. Normally the NH card 'n' values should be redefined for each cross section with new geometry.

Data indicating the variation of Manning's 'n' with river stage may be used in the program. Manning's 'n' and the corresponding stage elevation (beginning with the lowest elevation) are entered on the NV card ('n' value - vertical), beginning in the second and third fields, respectively. Variable NUMNV in field one is the number of 'n' values input on the NV cards. This 'n' value option applies only to the channel area.

If for subsequent jobs of the same run it is desired to modify the 'n' values specified on the NC, NH, and NV cards by a factor, variable FN on the J2 card may be used. The desired factor is entered as variable FN for each job. If the value of FN is negative, the factor is multiplied by the channel 'n' values on the NC card but the overbank 'n' values are not changed.

Reference 1 shows Manning's 'n' values for average channels. A more extensive compilation of 'n' values for streams and flood plains is listed in reference 2. References 3 and 4 use pictures of selected streams as a guide to 'n' value determination.

Contraction or expansion of flow due to changes in the channel cross section is a common cause of energy losses within a reach. Whenever this occurs, the loss may be computed by specifying the contraction and expansion coefficients as variables CCHV and CEHV, respectively, on the NC card. The coefficients are multiplied by the absolute difference in velocity heads between the cross sections to give the energy loss caused by the transition. Where the change in river cross section is small, coefficients CCHV and CEHV are typically on the order of 0.1 and 0.3, respectively. When the change in effective cross section area is abrupt such as at bridges, CCHV and CEHV may be as high as 0.6 and 1.0, respectively. These values may be changed at any cross section by inserting a new NC card. These new values will be used until changed again by another NC card. For additional information concerning transition losses and for information on bridge loss coefficients see Appendix IV.

6. CROSS SECTION GEOMETRY

Boundary geometry for the analysis of flow in natural streams is specified in terms of ground surface profiles (cross sections) and the measured distances between them (reach lengths). Cross sections are located at intervals along a stream to characterize the flow carrying capability of the stream and its adjacent flood plains. They should extend across the entire flood plain and should be perpendicular to the anticipated flow lines (approximately perpendicular to contour lines). Occasionally it is necessary to layout cross sections in a curved or dog-leg alignment ot meet this requirement. Every effort should be made to obtain cross sections that accurately represent the stream and flood plain geometry. However, ineffective flow areas of the flood plain such as stream inlets, small ponds or indents in the valley floor should generally not be included in the cross section geometry.

Cross sections are required at representative locations throughout a stream reach and at locations where changes occur in discharge, slope, shape, or roughness, at locations where levees begin or end and at bridges or control structures such as weirs. Where abrupt changes occur, several cross sections should be used to describe the change regardless of the distance. Cross section spacing is also a function of stream size, slope, and the uniformity of cross section shape. In general, large uniform rivers of flat slope normally require the fewest number of cross sections per mile. The purpose of the study also affects spacing of cross sections. For instance, navigation studies on large relatively flat streams may require closely spaced (e.g., five hundred feet) cross sections to analyze the effect of local conditions on low flow depths, whereas cross sections for sedimentation studies to determine deposition in reservoirs may be spaced at intervals of up to five or ten miles.

The choice of friction loss equation may also influence the spacing of cross sections. For instance, cross section spacing may be maximized when calculating an M1 profile with the average friction slope equation or when the harmonic mean friction slope equation is used to compute M2 profiles.

Each cross section in an HEC-2 data set is identified and described by X1 and GR cards. Variable SECNO on the X1 card is the cross section identification number which may correspond to stationing along the channel, mile points, or any fictitious numbering system, since it is only used to identify output and is not used in the computations. Each data point in the cross section is given a station number corresponding to the horizontal distance from a zero point on the left. The elevation and a corresponding station number of each data point are input as variables EL(I) and STA(I) on GR cards. Up to one hundred data points may be used to describe cross section geometry for most program applications. When the encroachment options are utilized, no more than ninety-five data points should be used, since they generate additional data points automatically to define the encroachment limits. The channel improvement option also should be used with few than one hundred data points since it will generate data points (four or more depending on the geometry).

Cross section data is traditionally oriented looking downstream since the program considers the left side of the stream to have the lowest station numbers and the right side to have the highest. The left and right stations separating the channel from the overbank areas are specified as variables STCHL and STCHR on the X1 card. End points of a cross section that are too low (below the computed water surface elevation) will automatically be extended vertically and a note indicating the extension amount will be printed.

Numerous program options are available to allow the user to easily add or modify cross section data. For example, when the user wishes to repeat a surveyed cross section, a single X1 card may be input to identify the cross section and to provide reach length information. X1 card variables, PXSECR and PXSECE, allow the user to modify the horizontal and vertical dimensions of the repeated cross section data. Other program options to modify cross section data to model improved channel sections, encroachments and ineffective flow areas are described in detail in the following chapter.

7. REACH LENGTHS

The measured distances between cross sections are referred to as reach lengths. The reach lengths for the left overbank, right overbank and channel used in computations are specified on the X1 card by variables *XLOBL, XLOBR, and XLCH, respectively. Channel reach lengths are typically* measured along the thalweg. Overbank reach lengths should be measured along the anticipated path of the center of mass of the overbank flow. Often these three values will be equal. There are, however, conditions where they will differ, such as at river bends, or where the channel meanders considerably and the overbanks are straight. Where the distances between cross sections for channel and overbanks are different, a discharge-weighted reach length is determined based on the discharges in the main channel and left and right overbank segments of the reach (see Equation 3, page 4).

Chapter 4

OPTIONAL CAPABILITIES

1. GENERAL

HEC-2 has numerous optional capabilities that allow the program user to determine flood plains, floodways, and flood hazard zones; to evaluate energy losses at obstructions such as weirs, culverts, and bridges; and to analyze improvements to drainage systems. Detailed descriptions of options associated with encroachments, determination of flood hazard zones, and bridges are contained in Appendices II, III, and IV, respectively. Other program options include the capability to select from alternative friction loss equations; calculate critical depth; solve directly for Manning's 'n'; automatically insert program generated cross sections; specify ineffective flow areas; analyze tributary streams; and perform multiple profile analysis in a single execution of the program. These options are described in detail in the following sections.

2. MULTIPLE PROFILE ANALYSIS

HEC-2 can in a single run compute up to fourteen profiles using the same cross sectional data. Variables NPROF on the J2 card controls the reading of data cards. For a multiple profile run, the NPROF for the first profile is set equal to one or left blank to read in cross section data cards. For all remaining profiles NPROF equals the profile number, i.e., 2, 3, 4, ..., and only T1, T2, T3, J1 and J2 are required (cards NC through EJ are omitted). If NPROF is set equal to fifteen for the last profile of a multiple profile run, a summary printout will be generated which provides a concise summary of results for all profiles for each cross section. If a summary printout is required for a single profile run, NPROF should be set equal to minus one.

3. CRITICAL DEPTH

Several options related to the computation of critical depth are available in HEC-2. Critical depth may be requested for <u>each</u> cross section of a sub-critical run by coding a value of -1 for variable ALLDC of the J2 card. As described previously in section 6 of Chapter 2, the normal tolerance used to terminate critical depth trial calculations is 2.5 percent of the depth. Other tolerances may be specified by coding a <u>minus</u> percent value for variable ALLDC. For instance, if a user desires critical depth to be computed at each cross section with a tolerance of 1.5 percent, a value of -1.5 should be entered for ALLDC.

As indicated in section 5 of Chapter 2, critical depth is calculated automatically for cross sections of subcritical profiles whenever the calculated velocity head exceeds a test velocity head. The tolerance normally used is also 2.5 percent of the depth. The user can specify an alternative tolerance to be used for the automatic calculation of critical depth by indicating a positive value for ALLDC.

4. EFFECTIVE FLOW OPTIONS

A series of program capabilities are available to restrict flow to the effective flow areas of cross sections. Among these capabilities are options to simulate sediment deposition, to confine flows to leveed channels, to block out road fills and bridge decks, and to analyze flood plain encroachments. These program options are illustrated in Figure 3 below.

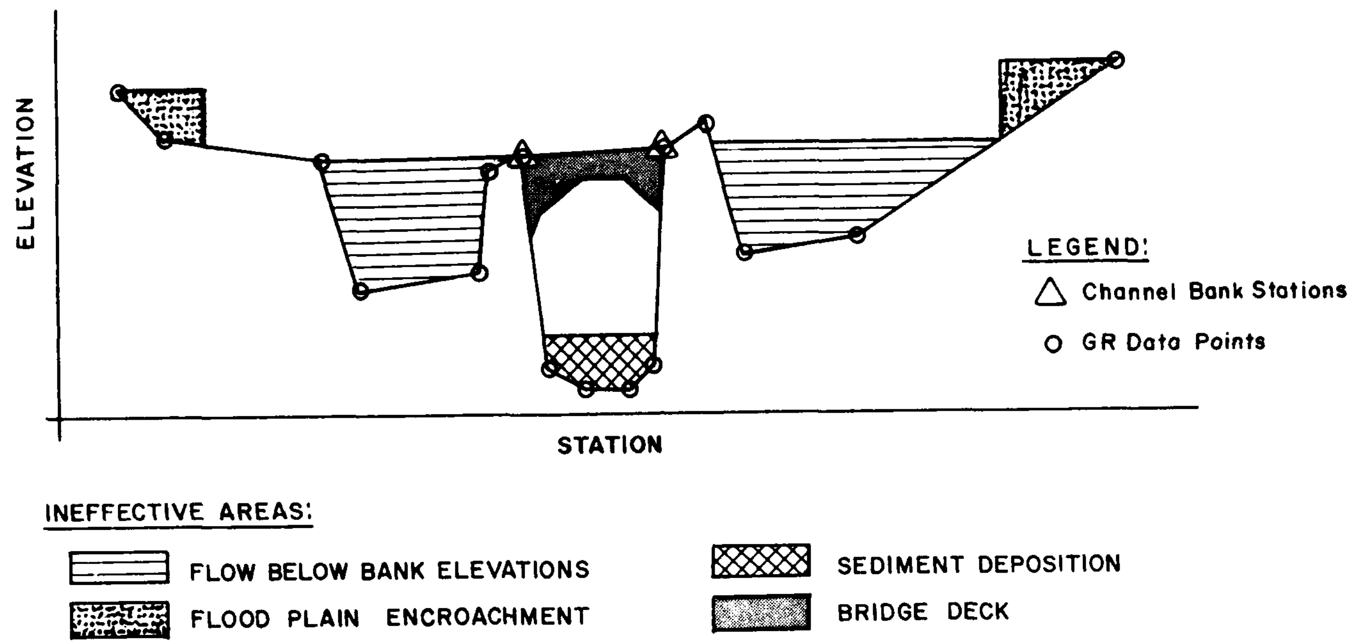

Figure 3. Types of Effective Flow Options

Sediment deposition may be specified by variable ELSED on the X3 card. The specified elevation (ELSED) is extended horizontally across the cross section and the area below this elevation is not considered by the program to carry flow.

Cross sections with low overbank areas or levees, require special consideration in computing water surface profiles because of possible overflow into areas outside the main channel. Normally the computations are based on the assumption that all area below the water surface elevation is effective in passing the discharge. However, if the water surface elevation at a particular cross section is less than the top of levee elevations, and if the water cannot enter or leave the overbanks upstream of that cross section, then the flow areas in these overbanks should not be used in the computations. Variable IEARA on the X3 card and the bank stations coded in fields three and four on the X1 card are used for this condition. By setting IEARA equal to ten the program will consider only flow confined by the levees, unless the water surface elevation is above the top of one or both of the levees; in this case flow area or areas outside the levee(s) will be included. If this option is employed and the water surface elevation is close to the top of a levee, it may not be possible to balance the assumed and computed water surface elevations due to the changing assumptions of flow area when just above and below the levee top. When this condition occurs, a note will be printed that states that the assumed and computed water surface elevations for the cross section cannot be balanced. A water surface elevation equal to the elevation which came closest to balancing will be adopted. It is then up to the program user to determine the appropriateness of the assumed water surface elevation and start the computation over again at that cross section if required.

It is important for the user to study carefully the flow pattern of the river where levees exist. If, for example, a levee were open at both ends and flow passed behind the levee without overtopping it, IEARA equals zero or blank should be used. Also, assumptions regarding effective flow areas may change with changes in flow magnitude. Where cross section elevations outside the levee are considerably lower than the channel bottom, it may be necessary to set IEARA equal to ten to confine the flow to the channel. For further information on this option see Appendix IV, paragraph 8, Effective Area Option. The effective flow capabilities of the bridge and encroachment routines are described in the following paragraphs and in Appendices IV and II, respectively.

5. BRIDGE LOSSES

Energy losses caused by structures such as bridges and culverts are computed in two parts. First, the losses due to expansion and contraction of the cross section on the upstream and downstream sides of the structure are computed in the standard step calculations. Secondly, the loss through the structure itself is computed by either the normal bridge or the special bridge methods.

The normal bridge method handles the cross section at the bridge just as it would any river cross section with the exception that the area of the bridge below the water surface is subtracted from the total area and the wetted perimeter is increased where the water surface elevation exceeds the low chord. The normal bridge method is particularly applicable for bridges without piers, bridges under high submergence, and for low flow through circular and arch culverts. Whenever flow crosses critical depth in a structure, the special bridge method should be used. The normal bridge method is automatically used by the computer, even though data was prepared for the special bridge method, for bridges without piers and under low flow control.

The special bridge method can be used for any bridge, but should be used for bridges with piers where low flow controls, for pressure flow, and whenever flow passes through critical depth when going through the structure. The special bridge method computes losses through the structure for low flow, weir flow and pressure flow or for any combination of these. Refer to Appendix IV for a detailed explanation of HEC-2 bridge capabilities.

6. ENCROACHMENT OPTIONS

Six methods of specifying encroachments for floodway studies can be used. Stations and elevations of the left and/or right encroachment (method 1) can be specified for individual cross sections as desired. A floodway with a fixed top width (method 2) can be specified which will be used for all cross sections until changed. The left and right encroachment stations are made equidistant from the centerline of the channel, which is half-way between the left and right banks stations. Encroachments can be specified by percentages (method 3) which indicate the desired proportional reduction in the natural discharge carrying capacity of each cross section.

Encroachments can be determined so that each modified cross section will have the same discharge carrying capacity (at some higher elevation) as the natural cross section (method 4). This higher elevation is specified as a fixed amount above the natural (e.g., 100-year) profile. The encroachments are determined so that an equal loss of conveyance (at higher elevation) occurs on each side of the channel, if possible.

Encroachment method 5 is an optimization solution of encroachment method 4. It determines water surfaces elevation differences between the natural and encroached conditions such that the target difference is obtained as near as possible.

Encroachment method 6 is an optimization solution similar to method 5; however, method 6 optimizes on differences in the energy grade line elevations. Refer to Appendix II for a detailed explanation of encroachment methods 1 through 6.

7. OPTIONAL FRICTION LOSS EQUATIONS

The friction loss between adjacent cross sections is computed as the product of the representative rate of friction loss (friction slope) and the weighted reach length. The program allows the user to select from the following previously defined (see page 6) friction loss equations:

(1) Average Conveyance

(2) Average Friction Slope

(3) Geometric Mean Friction Slope

(4) Harmonic Mean Friction Slope

Any of the above friction loss equations will produce satisfactory estimates provided that reach lengths are not too long. The advantage sought in alternative friction loss formulations is to be able to maximize reach lengths without sacrificing profile accuracy.

Equation (1), the Average Conveyance equation, is the friction loss formulation that has been standard in all HEC-2 source decks since 1971. Previous HEC-2 source decks utilized equation (2), the Average Friction Slope equation. Research by Reed and Wolfkill (reference 5), indicates that equation (2) is the most suitable for M1 profiles. (Suitability as indicated by Reed and Wolfkill is the most accurate determination of a known profile with the least number of cross sections.) Equation (3) is the friction loss formulation presently used in the U.S.G.S. Step-Backwater programs E431 amd J635. Equation (4) has been shown by Reed and Wolfkill to be the most suitable for M2 profiles.

Another feature of this option is the capability of the program to select the most appropriate of the preceding four equations on a reach by reach basis depending on flow conditions (e.g., M1, S1, etc.) within the reach. It is anticipated that this capability may be incorporated into the program as a standard feature at sometime in the future. At present, however, the criteria shown in Table 2 below, do not select the best equation for friction loss analysis in reaches with significant lateral expansion, such as the reach below a contracted bridge opening.

TABLE 2
CRITERIA UTILIZED TO SELECT FRICTION EQUATION

Profile Type	Is friction slope at current cross section greater than friction slope at preceding cross section?	Equation Used
Subcritical (M1, S1)	Yes	(2)
Subcritical (M2)	No	(4)
Supercritical (S2)	Yes	(2)
Supercritical (M3, S3)	No	(3)

The friction loss equation is controlled by variable IHLEQ on the J6 card as follows:

Value of IHLEQ (J6.1)	Friction Loss Equation Used
0	(1) Average Conveyance
1	Program selects equation based on flow conditions (see Table 2).
2	(2) Average Friction Slope
3	(3) Geometric Mean Friction Slope
4	(4) Harmonic Mean Friction Slope

When using this option, it is appropriate to also use a J3 card to request printout of the variable IHLEQ to identify the equation used for each reach.

8. CHANNEL IMPROVEMENT

Cross section data may be modified automatically by the CHIMP option of the program to analyze improvements made to natural stream sections. The CHIMP option simulates channel improvement by trapezoidal excavation. This option is requested by the CI card which specifies the location of the centerline (CLSTA), the elevation of the improved invert (CELCH), a new channel reach length (XLCH), a new 'n' value (CNCH), the left side slope (XLSS), the right side slope (RSS) and a bottom width (BW). Up to five different bottom widths may be specified for the execution of a single run on each CI card. A maximum of three CI cards may be used at each cross section. By using more than one CI card, a pilot channel can be defined. Figure 4 shows a sample application of the CHIMP option; note that improved section is modified only by excavation and not by fill. The old channel can be filled prior to the excavation by entering a negative channel bottom width.

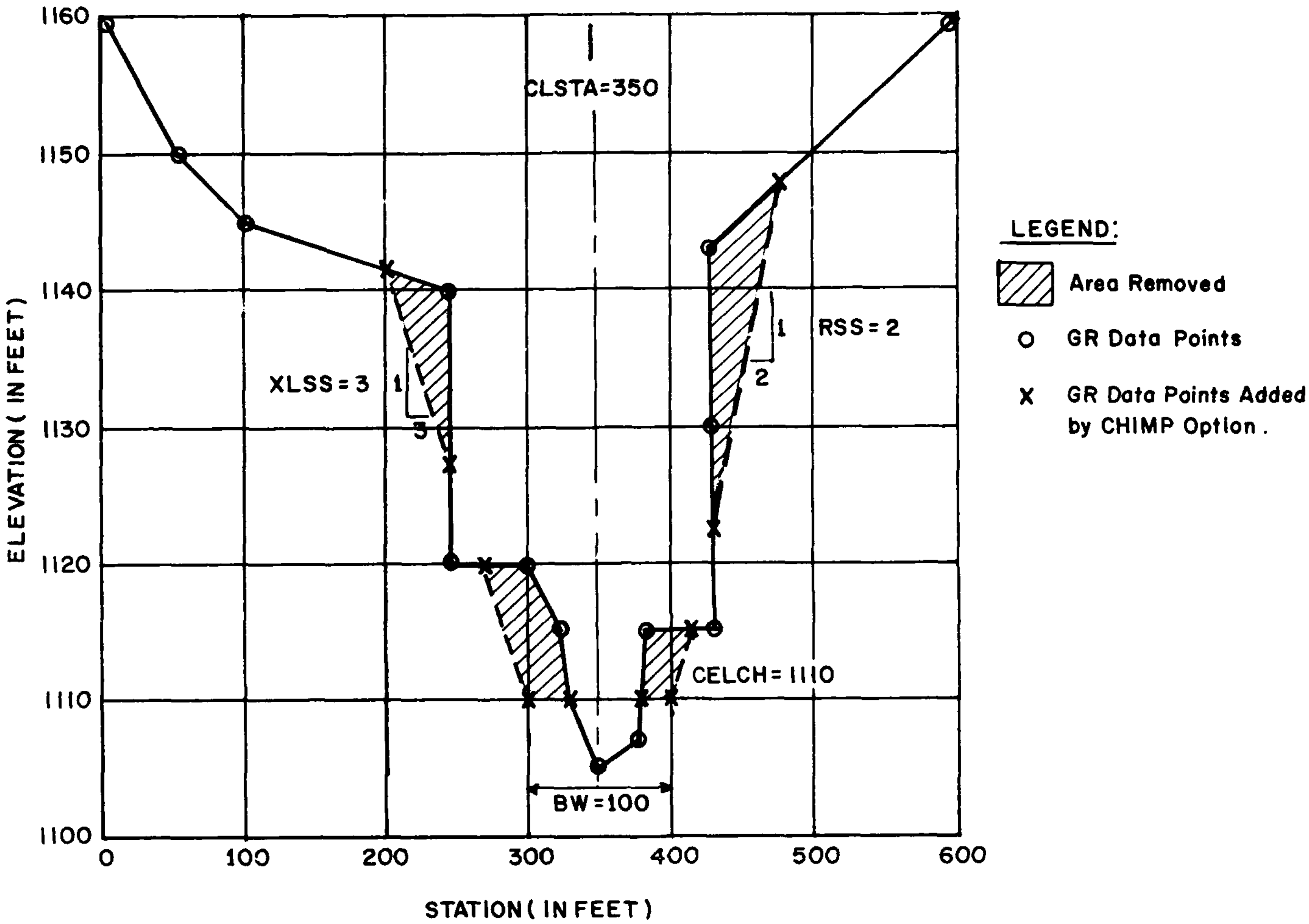

Figure 4. A Stream Cross Section Before and After CHIMP Modification

9. INTERPOLATED CROSS SECTIONS

Occasionally it is necessary to insert cross sections between those specified by input, because the change in velocity head (ΔHV) is too great to accurately determine the energy gradient. Additional cross sections may be coded manually or a program option may be requested to input interpolated cross sections. The option specified by the variable HVINS on the J1 card will insert up to three interpolated cross sections between two adjacent input cross sections. HVINS is the user specified maximum allowable change in velocity head between adjacent cross sections. When the program determines that ΔHV between the current cross section and the previous cross section exceeds the user specified criterion, the program will automatically insert one to three cross sections (depending on the magnitude of (ΔHV/HVINS) - 1).

Interpolated cross sections are determined by raising or lowering and expanding or contracting the current cross section's shape. They are inserted uniformly between the two input cross sections. A proportion of the elevation difference determined from the minimum elevations of the two input cross sections is added (or subtracted) to the elevation coordinates (on GR cards) of the current cross section.

The modification of the horizontal coordinates is a function of the ratio of the channel areas of the two input cross sections. The channel area (between bank stations) of the current cross section is determined with the depth of flow from the previous cross section.

Interpolated cross sections will be identified in the output by section numbers of 1.01, 1.02, and 1.03. The option will not add interpolated cross sections in the following cases: 1) if reach lengths between input cross sections are less than fifty feet, 2) if encroachments have been encountered in the run, or 3) if the previous cross section is a special bridge cross section.

When there is a substantial difference in shape between the previous and current cross sections, interpolated cross sections generated automatically by the program may not be representative of the actual stream geometry. The user should always check the **reasonableness of interpolated** cross sections.

The number of interpolated cross sections added to each profile may vary with discharge; **therefore, it is advisable not to request them for** multiple profile runs because analysis should be made using exactly the same cross section data.

10. TRIBUTARY STREAM PROFILES

Subcritical profiles may be computed for tributary stream systems for single or multiple profiles in a single execution of the program. In general data sets are arranged to compute profiles for the main stream (reach 1) from the most downstream point to the study limit on the main stream. Data for a tributary stream (reach 2), whose starting water surface elevation was determined when reach 1 was calculated, follows the data for reach 1. The first section number for reach 2 is negative and refers to the section number in reach 1 where the starting water surface elevation for reach 2 was determined. When a negative section number (on the X1 card) is encountered the program will search its memory for the computed water surface elevation that corresponds to the negative section number. The program will then start computing the profile for reach 2 with the previously determined water surface elevation.

Occasionally it may be desireable to calculate, in a single run, a profile for a stream system with a second order tributary (a tributary to a tributary). This may be accomplished if data for the tributary with the tributary is treated as a portion of the main stream and the main stream beyond the junction of the two streams is treated as a tributary. This is illustrated in the following figure on the next page; numbers one through eight locate cross sections on the main stream, numbers eleven through sixteen are cross sections on the first order tributary and numbers twenty-one through twenty-two are cross sections on the second order tributary.

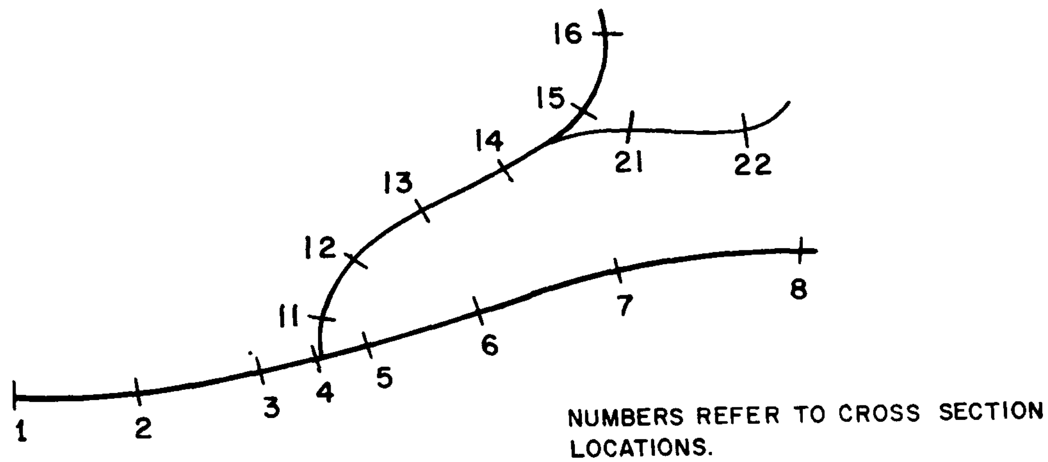

Figure 5. Second Order Stream System

The arrangement of cross section data (X1 and GR cards) for the stream system in Figure 5 for a tributary analysis in a single execution of the program is as follows: 1, 2, 3, 4, 11, 12, 13, 14, 15, 16, -4, 5, 6, 7, 8, -14, 21, and 22.

Tributary stream profiles should not be calculated simultaneously with encroachment methods 3 - 6.

11. SOLVING FOR MANNING'S 'n'

The program can be utilized in two ways to solve for Manning's 'n'. HEC-2 can compute 'n' values automatically from high water data if the discharge, relative ratios of the 'n' values for the channel and overbanks and the water surface elevation at each cross section are known. The "best estimate" of 'n' for the first cross section must be entered on the NC card since it is not possible to compute an 'n' value for this cross section. The relative ratio of 'n' between channel and overbank is set by the first cross section and will be used for all subsequent cross sections unless another NC card is used to change this ratio. High water marks are used for the computed water surface elevation by setting variable NINV on the J1 card equal to one and entering the known water surface elevation as variable WSELK on the X2 card for each cross section. The average friction slope equation (see J6 card description) is utilized by the program to solve for 'n' values. If one of the other friction equations is to be utilized for profile analysis then the program-determined 'n' values should be verified using the appropriate friction equation. Because of the sensitivity of calculated results to slight errors in observed high water marks, a weighted 'n' (WTN) value is also calculated at each cross section. WTN is the length weighted channel 'n' calculated from the first cross section to the current cross section. When an adverse slope is encountered, computations restart using 'n' values from the previous section, but WTN computations continue.

Another method is to specify the discharge and an assumed set of 'n' values, and have the program compute a water surface profile which can be compared with the high water profile. For this method WSELK may be input on the X2 card, without entering the computations, so that it can be easily compared with the computed water surface elevation on the output. The variable FN (J2.6 card) may be utilized to vary the assumed 'n' values for multiple profile trails.

12. STORAGE-OUTFLOW DATA

Punched cards can be obtained from HEC-2 for stream routing by the Modified Puls Method using program HEC-1. The cards punched are Y, 2, and 3 cards (see program description for HEC-1). This option can be used only if multiple profiles are computed from the same cross sectional data and if the summary printout is requested. Interpolated cross sections determined by the computer may be used. However, it may not be wise to use interpolated cross sections since a different number of cross sections might be interpolated between two given cross sections for different magnitudes of discharge which could cause inconsistencies in the incremental storage volumes. The ability to repeat the previous cross section by using only an X1 card (i.e., field two on the X1 card is blank) can be used where additional cross sections are needed at the ends of routing reaches and in place of the interpolated cross sections. The J4 card calls for this option.

13. SPLIT FLOW OPTION

The addition of the split flow option (Modification 55) to HEC-2 allows the automatic determination of channel discharges and profiles in situations where flow is lost from the main channel. Split flow modeling situations which may be encountered include bifurcations caused by islands, flow over levees or weirs, overtopping of watershed divides, and flow splits created by diversion structures. This option allows the user to determine flow splits with weir, or normal depth analyses or by direct input of rating curves. Use of the split flow option is described in HEC Training Document 18, Application of the HEC-2 Split Flow Option. The split flow option is compatible with all HEC-2 options except encroachment methods 3-6.

14. ICE COVERED STREAMS

The addition of the ice cover analysis option (Modification 55) to HEC-2 provides the user with the capability to determine water surface profiles for streams with stationary floating ice cover. The option allows the user to input different ice thickness in the channel and left and right overbanks. A composite Manning's 'n' value is determined by the Belokon-Sabaneeve formula (Reference 6). In addition to hydraulic analysis the option determines the potential for ice jams through the application of Pariset's ice stability function (Reference 7).

Chapter 5

PROGRAM INPUT

1. GENERAL

Twenty-seven different cards may be utilized to specify the many options and data input requirements for computer program HEC-2. These cards are described in detail in Appendix VII. In general the various cards may be classified into the following five categories: documentation, job control, change, cross section and bridge data cards. Cards in each of the five categories are described briefly in the following sections.

2. CARD FORMAT

Data cards are laid out in ten fields of eight columns each. One variable is used for each field except the first field, where the first two card columns are used for the card identification characters (i.e., T1, J1, GR). The format specification for each data card is A2, F6.0, 9F8.0. If decimal points are not indicated in the data, all numbers must be right justified within the field. Where the user desires to punch a decimal point it may appear anywhere within the field. All blank fields are read as zeroes. The program uses -1, 1, 10 and 15 to specify certain program options. Any number without a sign is considered positive.

Besides the fixed field format described above, the HEC program has been modifed to allow the use of free-formt input. See Appendix VIII for a detailed description of the free-format input. This option is being included with all HEC-2 source code acquired after August 1983.

3. DATA ORGANIZATION

Data sets for HEC-2 have a range encompassing, at a minimum, a single job (profile) with one cross section, to a run consisting of fourteen profiles with eight hundred cross sections. The minimum data set would require cards T1, T2, T3, J1, NC, X1, GR, EJ, three blanks, and ER. Multiple profile data sets using the same cross sections are constructed by inputting successive sets of T1, T2, T3, J1, and J2 cards for each profile immediately following the EJ card. Table 3 illustrates the organization of data for a typical multiple profile run.

4. STACKED JOBS

Occasionally it is desirable to enter several jobs for computation at the same time. This can be accomplished by removing the three blank cards and the ER cards from all but the last job. The jobs can then be stacked and entered for computation at the same time.

5. DOCUMENTATION CARDS: AC, C, T1 - T3

These cards allow the user to document HEC-2 output to identify such items as stream name, study location, discharge frequency, data sources, or other pertinent information that will identify the unique character of a particular HEC-2 application.

AC: Archival Option. The optional AC card allows the user to document and create a computer readable record of input data and computed results in a compact form on a magnetic tape. The Archival tape could be utilized with appropriate software to generate profile or cross section plots and to create new output tables using any of the ninety variables available for summary printout. Multiple AC cards may be utilized to provide alphanumeric comments on the magnetic tape to document data sources, study assumptions or other pertinent information.

C: Comment Cards. These optional cards can be used to provide alphanumeric commentary in the data input list and in the standard cross section output.

T1, T2, & T3: Title Cards. These cards are required for each job (profile). Title information provided by these cards is printed at the beginning of each job. A portion of the T3 card is reserved for title information for summary printout tables and cross section and profile plots.

6. JOB CONTROL CARDS: J1, JR, JS, J2 - J6, EJ & ER

These cards control the processing of data, specify the level of printout, select various computation options, and terminate execution of the program. J1, JR, JS and J2 cards apply only to a particular profile and must be input for each profile of a run. Job control cards J3 through J6 pertain to all profiles in a run and are only input with job cards for the first profile.

J1: Required Job Card. This job card is required for each profile to specify starting conditions, i.e., dishcarges, flow regime, water surface elevation, or energy slope. The J1 card also controls the printing of the data input list and options related to metric units, computer generated cross sections and the calculation of Manning's 'n' from high water marks.

JR: Optional Job Card. This optional job card can be used to input a starting rating curve; up to twenty discharge-elevation values may be used.

JS: Optional Job Card. This optional job card may be used to specify assumed lost discharges for each reach defined in a split flow model. Normally this option is only used when the split flow option has experienced convergence problems.

J2: Required Job Card. This job card is required for each profile except the first of a multi-profile run. The use of the J2 card is optional for the first profile of a multiple profile run or for a single profile run. This card controls the reading of data cards, the plotting of cross sections and profiles, modification of Manning's 'n', the calculation of critical depth and simulates channel modification by trapezoidal excavation. The J2 card also controls the trace option, requests flow distribution data, and requests summary tables.

J3: Optional Job Card. This job card is used on the first profile to select variables for summary printout. The user may select from a list of ninety variables to define summary output tables. The user also may choose from seven pre-defined tables to summarize data for bridges, encroachments, channel improvements, floodways and flood hazard zones.

J4: Optional Job Card. This job card is used on the first profile to request punched cards for Modified Puls routing in the format required by computer program HEC-1.

J5: Optional Card. This job card is used to provide various levels of suppression of the cross-section data and summary tables. This card is used with job cards for the first profile.

J6: Optional Job Card. This job card is used to select various equations for computation of friction loss and to provide for transfer of control of disk/tape output units to system control cards.

EJ: End of Job Card. This required job control card follows data for the last cross section to be read. It serves to terminate the reading of data cards. A single EJ card is required for both single or multiple profile (job) runs.

ER: End of Run Card. This required job control card preceded by three blank cards terminates the execution of the program. The three blank cards and the ER card follow the EJ card of a single job run or follow the last J2 card of a multiple job run.

7. CHANGE CARDS: IC, NC, NH, NV, QT, ET & CI

These cards provide options to initialize and change values related to ice analysis, Manning's 'n', discharge, cross section modification by encroachment, and channel improvement options. When initial values are changed they remain changed for all subsequent cross sections until another change card is encountered. Change cards, IC - ET become effective at the cross section (X1 card) immediately following. The CI card is input in the data set following the X1 card where the channel improvement option is to be initialized or changed.

IC: Ice Analysis Data. This optional card is used to specify ice thicknesses, 'n' values, and specific gravity for the ice analysis option.

NC: Manning's 'n' Description. This card is required to initialize 'n' values and transition (shock) loss coefficients prior to data for the first cross section. Subsequent NC cards may be utilized to permanently change values at any cross section within the job.

NH: Horizontal Description of Manning's 'n'. This optional card can be utilized to specify up to twenty 'n' values that vary with horizontal distance across the cross section. Normally NH cards apply to a single cross section and 'n' values should be redefined by either another set of NH cards or by an NC card for subsequent cross sections.

NV: Vertical Description of Manning's 'n'. This optional card may be used to specify channel 'n' values that vary with elevation.

QT: Discharge Table. This optional card allows the user to input a table of up to nineteen discharges for multiple profile runs. Subsequent QT cards may be used to change discharge values at any cross section. The discharge value to be used for a particular run is specified by a variable on the J1 card.

ET: Encroachment Table. This optional card allows the user to input a table of up to nine encroachment specifications for multiple profile runs. The encroachment specification to be utilized for a particular profile corresponds with the field of the QT card selected by the J1 card.

CI: Optional Channel Improvement Card. This optional card allows a user to simulate the improvement of channels by excavation. Invert elevations, side slopes, 'n' values and bottom widths may be specified by this option. Up to five different bottom widths may be specified for analysis during the execution of a multiple profile run. Up to three CI cards may be used at a cross section. By using more than one CI card a pilot channel may be modeled.

8. CROSS SECTION CARDS: X1, RC, X2 - X5 & GR

These cards are the basic data that describe the geometric properties of a stream. Each set of X1 through X5 and GR cards defines a single stream cross section. X1 and GR are required cards that provide the basic geometric representation for a reach of stream. X2 through X5 cards provide a series of options related to bridges, effective flow areas, additional geometric data, and high water elevations.

X1: Required Cross Section Card. An X1 card is required to input data for each cross section. Values on the X1 indicate the number of GR data points to be read on the following GR cards and locate the cross section by indicating the distance to the immediate downstream cross section. Other values input on the X1 card locate the bank stations, raise or lower elevations on the GR cards, allow skewing (expansion or contraction of the GR data, and request a line printer plot of the cross section data).

RC: Optional Rating Curve Card. This optional card provides the capability to input a rating curve. With this option the water surface elevation at the cross section where the option is employed is not determined by standard step computations but is based upon the input rating curve.

X2: Optional Cross Section Card. This card provides an array of options related to discharge, bridges, program traces, and calculation of Manning's 'n'. An X2 card is required for each application of the special bridge option.

X3: Optional Cross Section Card. The X3 card provides various options to remove portions of the GR data from flow calculations. The removed or blocked out areas are referred to as ineffective flow areas. The X3 card allows the specification of such ineffective flow areas as: areas behind levees prior to overtopping; areas below a specified sediment elevation; filled areas; and areas behind specified encroachment stations.

X4: Optional Cross Section Card. This card allows additional ground points to be added to the elevation station data contained on the GR cards. This option is useful when modifying GR data repeated from the previous cross section or when the effects of proposed obstructions such as levees, piers or buildings are to be examined.

X5: Optional Cross Section Card. This card is used to input water surface elevations at a cross section. Elevations or increments of elevation to be added to the water surface elevation of the previous cross section may be specified. The elevation specified for a particular profile corresponds with the field of the QT card selected by the J1 card.

GR: Ground Profile Card. This card inputs data that represents a profile of a stream taken perpendicular to the direction of flow. Up to one hundred pairs of elevation-station data may be utilized to describe the ground profile.

9. BRIDGE CARDS: SB & BT

These cards are utilized to input data for bridge analysis by the normal bridge and the special bridge methods.

SB: Special Bridge Card. This card is required to input coefficients for pier shape, orifice flow and weir flow for use by the special bridge method. Geometric properties of the bridge such as weir length, width of piers, and net area of the opening of the bridge can also be input on the SB card.

BT: Bridge Profile Card. The BT card is used to input bridge geometry for both normal bridge and special bridge analysis. For analysis by the normal bridge method, BT cards are utilized to describe the flow areas of the cross section that are blocked out by the bridge peirs, bridge deck and approach fill. For the special bridge method the BT cards are used to define the weir profile.

10. SPLIT FLOW CARDS: SF, JC, JP, TW, WS, WC, TN, NS, NG, TC, CR, & EE

These cards are used to specify input data for the split flow analysis capability added to the November 1976 version of HEC-2 by Modification 55. The split flow cards are always entered ahead of all other HEC-2 data cards (AC,C,T1 etc.).

SF: Split Flow Card. The card is required when the split flow option is used. It must be the first card in the HEC-2 input deck.

JC & JP: Optional Split Flow Job Cards. These cards may be used to input titles or initialize parameters for split flow analysis.

TW, WS, & WC: Weir Analysis Cards. These cards provide input for weir coefficients, elevation-station coordinates, and other data required for loss determination using the weir assumption.

TN, NS & NG: Normal Depth Analysis Cards. These cards provide input for normal depth parameters, elevation-station coordinates and other data required for loss determination using the normal depth assumption.

TC, CS, & CR: Rating Curve Analysis Card. These cards provide input for analysis of split flows by input rating curves.

EE: End of Split Flow Analysis Card. This card is required to terminate a split flow analysis. The EE card is the last of the split flow cards; it is input just ahead of the first regular HEC-2 data card (AC,C,T1 etc.).

TABLE 3
TYPICAL HEC-2 DATA ORGANIZATION

(Multiple Profile Run)

CARD TYPE	CARD IDENTIFICATION	APPLICATION
Documentation	AC, C	All profiles
Documentation	T1* - T3*	1st profile
Job Control	J1*, J2	
Job Control	J3 - J6	All profiles
Change	NC*, NH, NV, QT, ET	
Cross Section	X1*, CI, X2, X3, X4, X5, GR*	
Bridge (Special Bridge)	SB*	
Cross Section	X1*, X2*, X3, X4, X5, BT, GR	
Change	NC, NH, NV, QT, ET	
Cross Section	X1*, CI, X2, X3, X4, X5, GR	
Cross Section	X1*, CI, X2, X3, X4, X5, GR	
Job Control	EJ*	
Documentation	T1* - T3*	2nd profile
Job Control	J1*, J2*	
Documentation	T1* - T3*	Last profile
Job Control	J1*, J2*	
Job Control	3 blank cards*	Terminate run
Job Control	ER*	

*Indicates required cards

Chapter 6

PROGRAM OUTPUT

1. GENERAL

Computer program HEC-2 provides the user with a wide variety of output control options. Program output is generally by line printer, although some output can be directed to card punch or magnetic tape devices. Commonly used output options are shown in Appendix I, Sample Application of HEC-2. Table 4 (at the end of this section) summarizes output control options.

2. PROGRAM IDENTIFICATION BLOCK

Each execution of the program will print a program identification block in the upper left corner of the first page of output. Information contained in the block includes program release date, date of latest updating, and a list of error corrections and program modifications.

3. JOB CONTROL DATA

The first three lines of output following the program identification block are title cards (T1 - T3) for the first profile. Following the title information, input data on the J1 card and optional job cards J2 through J6 (if used) are printed. Subsequent sets of T1 through J2 data are printed prior to execution of the respective profiles.

4. INPUT DATA

A listing of the input data (cards NC through EJ) is printed following the job control data for the first profile. This listing may be suppressed by coding a minus ten for variable ICHECK(J1.1) on the J1 card for the first profile.

5. COMMENTARY

Comments to document data sources, study assumptions, or to label specific cross sections may be input with the data set. These comments will appear immediately ahead of the cross section they refer to in the input data listing and the cross section data.

6. OUTPUT LABELS

In order to assist users with interactive terminals, unique labels are generated by the program at the beginning of each profile (e.g., *PROF 2) and at each cross section (e.g., *SECNO 21.100). With commonly available system text editors, these labels allow easy location of calculated data within the cross section data printout. The J5 card can be utilized to suppress all or portions of the cross section data printout to further facilitate the use of the program on interactive terminals.

7. CROSS SECTION DATA

Computed results are printed for each cross section following the data input list for the first profile and following the job control data for subsequent profiles. Headings listing the names of each of the forty variables arranged in the same spatial order are printed periodically throughout the data. Appendix VI contains definitions of these variables.

8. FLOW DISTRIBUTION

The cross section data printout shows the distribution of flow in three subdivisions of the cross section: left overbank, channel and right overbank. Additional output showing the distribution of flow in overbanks of the cross section may be requested by the user. When the flow distribution option is requested, the program prints out the lateral distribution of area, velocity and percent of total discharge for up to thirteen subdivisions of the cross section. This program output is requested for all cross sections of a profile by setting variable ITRACE on the J2 equal to fifteen. Flow distribution for a single cross section may be requested by setting ITRACE on the X2 card equal to fifteen. For additional information and an example of this output see Appendix II.

9. SPECIAL NOTES

Special notes and error messages are printed at various locations in the cross section data to inform the user of various assumptions or options that have been used during computations. These notes should be carefully reviewed to assure an accurate profile. Special notes are described in Appendix V.

10. PROGRAM TRACE

It is sometimes useful to print out important variables as they are computed to aid in checking, debugging and understanding the program. Two levels of program trace are available for this purpose. The minor trace prints values of variables, for each trial, used in the following computations:

(1) Interpolated cross sections

(2) Manning's 'n' from known water surface elevations

(3) Computed water surface elevation

(4) Weir flow

(5) Critical water surface elevation

The major trace, in addition to data printed for the minor trace, prints values of variables used in the computation of the hydraulic properties of each subarea of a cross section.

ITRACE on the J2 and X2 cards is used to specify the desired level of trace. The minor trace may be called separately, ITRACE = 1, or in combination with the major trace, ITRACE = 10. If all cross sections are to be traced, the J2 card is used. If only individual cross sections are to be traced, the X2 cards are used.

11. PROFILE PLOTS

Profile plots are printed following the cross section data for jobs having five or more cross sections. These plots show the location of cross sections and elevations of critical depth, water surface, energy grade line, channel invert, left and right bank elevations, and the lowest of the end stations of the cross section. The vertical and horizontal scales of a profile may be specified by J2 card variables PRFVS and XSECH, respectively. If these variables are omitted the program will automatically determine the appropriate scale values.

12. CROSS SECTION PLOTS

Printer plots of any or all of the stream cross sections to any scale may be requested by using the J2 and X1 cards. If all cross sections are to be plotted, set variable IPLOT on the J2.2 card equal to one or ten. If only certain cross sections are desired, IPLOT on the J2.2 card should be left blank and variable IPLOT on the X1.10 card should be set equal to one or ten for the cross section to be plotted. Vertical and horizontal scales of the plot may be specified constant for all cross sections in the job using variables XSECV(J2.4) and XSECH(J2.5). If the scale is not specified, the largest scale which is a multiple of one, two or five that produces three pages of output or less will be used. For some deep river cross sections, flow may occupy only a small portion of the total cross section. In this case it may be desirable to enlarge the scale and to print only the cross section points up to the water surface elevation. This may be done by using a value of ten for IPLOT instead of one.

13. SUMMARY DATA

Tables may be requested to summarize data in a tabular form for either single or multiple profile runs. The J3 card may be used to specify user- and pre-defined tables. User-defined tables of one to thirteen variables may be specified from a list of sixty-three variables. User-defined tables may be specified to permit summary output that will conveniently print on seventy-two or eighty column terminals. Seven pre-defined tables are available to summarize data for bridges, encroachments, channel improvements, and flood hazard zones.

14. TAPES

A magnetic tape can be created by the program to document data input and computed results in a compact computer readable form. The Archival Option, (see AC card) creates a tape that records data input and stores sixty-three variables per cross section for each profile. The Archival Option also stores the program identification block and provides a capability to record alphanumeric comments to document such pertinent information as study location, data sources, and study assumptions.

An Archival tape can be used, with appropriate software, as a basis for further analysis. For example, additional profile plots can be generated; new output tables can be produced using any of the variables available for summary printout (J3 card); and cross section data can be verified. This may be particularly valuable when analysis is required to determine encroachment or floodways within the study area.

The Archival tape is structured as follows:

Section a. Input data cards

Section b. Header block showing program version

Section c. Number of output variables and cross sections

Section d. Alphanumeric names of output variables

Section e. Output variables for each cross section

Sections of the output defined above are separated by numeric delineators. Section a is terminated by a 130 character line of 1's. Sections b, c, and d are terminated, respectively by lines of 2's, 3's, and 4's. This is followed by the values of all sixty-three variables for each cross section. Each profile is terminated by a line of 5's. The tape is terminated by a line of 6's. This is illustrated by the example on pages 36 - 37.

At the beginning of the normal output for Archival executions the following line will appear:

```
THIS IS AN ARCHIVAL RUN ALL DATA AND RESULTS ARE SAVED ON UNIT    96
```

This indicates the unit number (in this example unit 96) on which the file is written. It is the user's responsibility to provide the required job control statements to insure that the file written on unit 96 will appear on magnetic tape or otherwise be saved by the system after execution.

The information written to the tape is formatted 130 character lines. This will allow the tape to be listed directly on a line printer. It should be noted that the tape will contain characters in column one that are not intended as line printer carriage control. Thus for direct tape listing, the lines should be shifted one column.

On an Archival execution, cross section plots should not be requested. Also the maximum number of summary tables is reduced by two for an Archival run. The example on the following page shows the type of information that may be appropriate.

```
AC
AC               AC CARDS ARE UTILIZED TO EMPLOY THE ARCHIVAL TAPE OPTION
AC               THEY MAY ALSO BE USED TO PROVIDE ADDITIONAL DOCUMENTATION
AC                              (FOR INSTANCE)
AC                          RED FOX RIVER INVESTIGATION
AC                     THE STOUTT COUNTY PLANNING COMMISSION
AC                     A.B.C.ENGINEERS,INC.SALT WELLS,NEVADA
AC               ANALYSIS PERFORMED BETWEEN RIVER MILE 9.2 TO 25.6
AC                          NOVEMBER 12,1976
AC
T1      ARCHIVAL EXAMPLE
T2      2 PROFILES. 3 CROSS SECTIONS
T3      RED FOX RIVER
J1     -1       2                                                     5709
NC                              0.1      0.3
QT      3    5000    7500    10000
NH      5     0.1     415     0.05     650    0.03     710    0.05    1020     0.1
NH   1635
X1      1      26     650     710
GR   5726      20    5724      30    5722      45    5720      60    5718     110
GR   5717     415    5716     630    5714     650  5713.7     655    5713     660
GR   5702     670    5701     675    5700     690  5700.1     697  5700.8     700
GR   5701     710    5713     710  5713.5     940    5714    1020    5714    1215
GR   5712    1235    5712    1575    5714    1590    5716    1615    5720    1630
GR   5725    1635
NH      4     0.1     415    0.05     575    0.03     640     0.1    1250
X1      2      22     575     640     500     500     500
GR   5725      30    5724      40    5722      50    5720     110    5720     200
GR   5718     295    5717     415    5716     455    5713     505  5709.5     575
GR   5705     585  5704.2     595  5704.5     615    5716     635    5718     640
GR5718.5      980    5718    1130    5718    1195    5720    1205    5722    1225
GR   5724    1245    5725    1250
NH      4     0.1     260     0.1     370   0.036     600    0.05     875
X1      3      16     260     600     400     400     400
GR   5725      40    5724      90    5722     260    5720     330  5718.7     370
GR   5715     420  5711.2     460  5707.1     500  5707.5     530    5712     550
GR5717.3      580    5719     590    5720     600    5722     650    5724     865
GR   5725     875
EJ
T1      RED FOX RIVER  TEST DATA
T2      Q=7500CFS
T3      RED FOX RIVER
J1    -10       3                      0.0072                           5710
J2     15


ER
1111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111
1


 ****************************************************
   HEC2 RELEASE DATED NOV 76 UPDATED  AUG1977
   ERROR CORR - 01.02
   MODIFICATION -  50,51,52,53
 ****************************************************
```

```
222222222222222222222222222222222222222222222222222222222222222222222222222222222222222222222222222222222
      65        3
333333333333333333333333333333333333333333333333333333333333333333333333333333333333333333333333333333333
         CWSEL         CRIWS           EG            TOPWID         10K*S          TIME           VOL            DEPTH
         WSELK         HV              HL            OLOSS          QLOB           QCH            QROB           K*XNL
         K*XNCH        K*XNR           K*WTN         CASE           STCHL          STCHR          XLBEL          RBEL
         AREA          VCH             STENCL        STENCR         CLSTA          BW             ELENCL         ELENCR
         K*CHSL        .01K            QCHS          PERENC         TWA            SECNO          XLCH           ELTRD
         ELLC          ELMIN           Q             EGPRS          EGLWC          QWEIR          QPR            H3
         CLASS         DIFWSP          DIFWSX        DIFKWS         SSTA           ENDST          VLOB           VROB
         ALPHA         KRATIO          QLOBS         OROBS          DIFEG          IHLEQ          TELMX
444444444444444444444444444444444444444444444444444444444444444444444444444444444444444444444444444444444
 .57090000E+04  0.             .57120532E+04  .46363636E+02  .70619315E+02  0.             0.             .90000000E+01
 .57090000E+04  .30532170E+01  0.             0.             0.             .49999992E+04  0.             .10000000E-01
 .10000000E-01  .10000000E-01  0.             0.             .65000000E+03  .71000000E+03  .57140000E+04  .57130000E+04
 .35657273E+03  .14022382E+02  0.             0.             0.             0.             0.             0.
0.              .59498806E+03  0.             0.             0.             .10000000E+01  0.             0.
0.              .57000000E+04  .50000000E+04  0.             0.             0.             0.             0.
0.              0.             0.             0.             .66363636E+03  .71000000E+03  0.             0.
 .99999950E+00  0.             0.             .99999983E+02  0.             0.             .57250000E+04  0.
0.
 .57129264E+04  .57127879E+04  .57151600E+04  .12321240E+03  .52403591E+02  .11823766E-01  .48636510E+01  .87264280E+01
0.              .22335684E+01  .30248146E+01  .81964861E-01  .36173204E+03  .46382672E+04  0.             .10000000E-01
 .10000000E-01  .10000000E-01  .99800399E-02  0.             .57500000E+03  .64000000E+03  .57095000E+04  .57180000E+04
 .49086982E+03  .12422587E+02  0.             0.             0.             0.             0.             0.
 .84000000E+01  .69070004E+03  .72346409E+01  0.             .97323256E+00  .20000000E+01  .50000000E+03  0.
0.              .57042000E+04  .50000000E+04  0.             0.             0.             0.             0.
0.              0.             .39264280E+01  0.             .50644459E+03  .62965699E+03  .30786725E+01  0.
 .13863656E+01  .11608637E+01  0.             .92765345E+02  0.             0.             .57250000E+04  0.
0.
 .57161464E+04  0.             .57166800E+04  .16899919E+03  .23536903E+02  .30777046E-01  .11033381E+02  .90463543E+01
0.              .53365481E+00  .13500212E+01  .16999136E+00  0.             .49999995E+04  0.             .10000000E-01
 .10000000E-01  .10000000E-01  .99778271E-02  0.             .26000000E+03  .60000000E+03  .57220000E+04  .57200000E+04
 .85289741E+03  .58623692E+01  0.             0.             0.             0.             0.             0.
 .72500000E+01  .10306124E+04  0.             0.             .23148836E+01  .30000000E+01  .40000000E+03  0.
0.              .57071000E+04  .50000000E+04  0.             0.             0.             0.             0.
0.              0.             .32199262E+01  0.             .40448195E+03  .57348114E+03  0.             0.
 .99999971E+00  .14921273E+01  0.             .99999990E+02  0.             0.             .57250000E+04  0.
0.
555555555555555555555555555555555555555555555555555555555555555555555555555555555555555555555555555555555
 .57113488E+04  0.             .57153371E+04  .48498950E+02  .72519471E+02  0.             0.             .11348845E+02
 .57100000E+04  .39882209E+01  0.             0.             0.             .74999991E+04  0.             .10000000E-01
 .10000000E-01  .10000000E-01  0.             0.             .65000000E+03  .71000000E+03  .57140000E+04  .57130000E+04
 .46798107E+03  .16026274E+02  0.             0.             0.             0.             0.             0.
0.              .88071207E+03  0.             0.             0.             .10000000E+01  0.             0.
0.              .57000000E+04  .75000000E+04  0.             0.             0.             0.             0.
0.              0.             0.             .13488446E+01  .66150105E+03  .71000000E+03  0.             0.
 .99999960E+00  0.             0.             .99999989E+02  0.             0.             .57250000E+04  0.
0.
 .57162105E+04  0.             .57175630E+04  .18887949E+03  .24552593E+02  .15555574E-01  .83994277E+01  .12010499E+02
0.              .13525414E+01  .19624074E+01  .26356795E+00  .16653138E+04  .58346857E+04  0.             .10000000E-01
 .10000000E-01  .10000000E-01  .99800399E-02  0.             .57500000E+03  .64000000E+03  .57095000E+04  .57180000E+04
 .99553482E+03  .10380335E+02  0.             0.             0.             0.             0.             0.
 .84000000E+01  .15136051E+04  .22204184E+02  0.             .13623648E+01  .20000000E+01  .50000000E+03  0.
0.              .57042000E+04  .75000000E+04  0.             0.             0.             0.             0.
0.              0.             .48616548E+01  0.             .44664284E+03  .63552232E+03  .38420461E+01  0.
 .15347118E+01  .17186151E+01  0.             .77795809E+02  0.             0.             .57250000E+04  0.
0.
 .57179573E+04  0.             .57185739E+04  .20383931E+03  .22388061E+02  .33187114E-01  .18434614E+02  .10857480E+02
0.              .61666411E+00  .93731539E+00  .73587732E-01  0.             .74999995E+04  0.             .10000000E-01
 .10000000E-01  .10000000E-01  .99778271E-02  0.             .26000000E+03  .60000000E+03  .57220000E+04  .57200000E+04
 .11901288E+04  .63018387E+01  0.             0.             0.             0.             0.             0.
 .72500000E+01  .15850867E+04  0.             0.             .31654814E+01  .30000000E+01  .40000000E+03  0.
0.              .57071000E+04  .75000000E+04  0.             0.             0.             0.             0.
0.              0.             .17467804E+01  0.             .38002999E+03  .58386930E+03  0.             0.
 .99999981E+00  .10472261E+01  0.             .99999994E+02  0.             0.             .57250000E+04  0.
0.
555555555555555555555555555555555555555555555555555555555555555555555555555555555555555555555555555555555
666666666666666666666666666666666666666666666666666666666666666666666666666666666666666666666666666666666
```

Control of the six disk/tape units that the program uses for storing summary data may be transferred from the program to system control cards by the J6 card. See the HEC-2 Programmers Manual for information regarding these units.

15. PUNCHED CARDS

Storage-discharge data in a format for Modified Puls routing using program HEC-1 may be directed to an online card punch by the J4 card. The J3 card must be used simultaneously to request variables 6 (TIME) and 7 (VOLUME) for summary output.

TABLE 4
CONTROL OF PROGRAM OUTPUT

OUTPUT	CONTROL (CARDS)
Commentary	C
Input Data Listing*	J1.1
Detailed Output by Cross Section*	J5
Flow Distribution	J2.10, X2.10
Traces	J2.10, X2.10
Summary Tables*	J2.1, J3, J5
Profile Plots*	J2.3
Cross Section Plots	J2.2, X1.10
Archival Tape	AC
Program Storage Tapes	J6
Punched Cards	J4

*These data are normal program output, but may be suppressed.

REFERENCES

1. U.S. Army Corps of Engineers, EM-1110-2-1409, "Backwater Curves in River Channels," 7 December 1959.

2. Chow, Ven Te, "Open-Channel Hydraulics," 1959.

3. Fasken, Guy B., "Guide for Selecting Roughness Coefficient "n" Values for Channels," Soil Conservation Service, December 1963.

4. Barnes, Harry H., Jr., "Roughness Characteristics of Natural Channels," Geological Survey Water-Supply Paper 1849, 1967.

5. Reed, J.R. and Wolfkill, A.J., "Evaluation of Friction Slopes Models," River 76, Symposium on Inland Waterways for Navigation Flood Control and Water Diversions, Colorado State University.

6. U.S. Army Corps of Engineers, EC 1110-2-220, Draft Ice Engineering Manual, 16 March 1981.

7. Pariset, E., Hausser, R., and Gagon, A., 1966, "Formation of Ice Covers and Ice Jams in Rivers," Journal of the Hydraulics Division, ASCE 92:1-24.

SUPPLEMENTAL MATERIAL

The following supporting publications and illustrations are available from HEC for computer program HEC-2, Water Surface Profiles:

a. HEC-2, Water Surface Profiles, Programmers Manual, September 1982.

b. HEC Technical Paper No. 11, Survey of Programs for Water Surface Profiles (1968)by Bill S. Eichert. (Published in the Journal of the Hydraulics Division, ASCE, Vol. 96, No. HY 2, February 1970).

c. HEC Technical Paper No. 20, Computer Determination of Flow Through Bridges (1970) by Bill S. Eichert and John Peters. (Published in the Journal of the Hydraulics Division, ASCE, Vol. 96, No. HY 7, July 1970).

d. HEC Training Document No. 5, Floodway Determination Using Computer Program HEC-2, May 1974.

e. "Water Surface Profiles," IHD Volume 6, The Hydrologic Engineering Center, 1975.

f. HEC Technical Paper No. 69, Critical Water Surface by Minimum Specific Energy Using the Parabolic Method, Bill S. Eichert, 1969.

g. Hydraulics Graphics Package (HGP), Users Manual, August 1980.

h. HEC Training Document No. 18, Application of the HEC-2 Split Flow Option, April 1982.

i. HEC Training Document No. 20, Analysis of Flow in Ice Covered Streams Using HEC-2, August 1982.

APPENDIX I

SAMPLE APPLICATIONS OF HEC-2

Example No.	Sample HEC-2 Application	Page
1	Single profile run, cross section plot, and user defined summary table requested.	I-1
2	Multiple profile run with tributaries, special and normal bridge applications.	I-10
3	Multiple profile run with channel improvement.	I-37
4	Multiple profile run with floodway analysis by encroachment methods 1, 4, and 5.	I-48
5	Multiple profile run with Flood Hazard Factor determination.	I-63

NOTE: For three other bridge examples, see Appendix IV, pages IV-40 - IV-61.

```
                                                                THIS RUN EXECUTED 29 JUL 82     9:26:42
*****************************************************
  HEC2 RELEASE DATED NOV 76 UPDATED MARC 1982
  ERROR CORR -  01,02,03,04,05
  MODIFICATION -  50,51,52,53,54,55
*****************************************************

T1      EXAMPLE 1 SUBCRITICAL PROFILE, XSEC 4  PLOTTED
T2      USER DEFINED SUMMARY TABLE   J3 CARD
T3      BEAR CREEK

J1  ICHECK     INQ       NINV      IDIR      STRT     METRIC    HVINS      Q        WSEL       FQ

       0.       4.         0.        0.  0.009200     0.00      0.0    7800.  1755.000    0.000

J2  NPROF     IPLOT     PRFVS     XSECV     XSECH      FN       ALLDC     IBW      CHNIM     ITRACE

    -1.000    0.000     0.000     0.000     0.000     0.000     0.000     0.000     0.000     0.000

J3  VARIABLE CODES FOR SUMMARY PRINTOUT

    38.000    1.000     2.000     3.000    10.000    11.000    12.000    33.000     5.000    58.000

    57.000   43.000    14.000     0.000     0.000     0.000     0.000     0.000     0.000     0.000

NC      0.100      0.100      0.040      0.100      0.300      0.000      0.000      0.000      0.000      0.000
QT      4.000   4500.000   7400.000   9000.000  11500.000      0.000      0.000      0.000      0.000      0.000
X1      1.000     61.000    767.000    815.000      0.000      0.000      0.000      0.000      0.000      0.000
GR   1767.000      0.000   1765.400     23.000   1763.500     49.000   1762.000     69.000   1759.100     87.000
GR   1758.100    103.000   1756.900    113.000   1756.900    122.000   1753.200    127.000   1753.100    131.000
GR   1757.700    140.000   1757.700    152.000   1755.000    160.000   1755.600    168.000   1755.600    171.000
GR   1755.600    174.000   1754.700    177.000   1755.900    183.000   1756.000    190.000   1754.900    208.000
GR   1754.700    220.000   1753.700    247.000   1753.300    282.000   1752.700    321.000   1750.900    352.000
GR   1748.600    373.000   1747.200    391.000   1748.300    404.000   1752.100    434.000   1753.600    452.000
GR   1753.700    477.000   1752.600    499.000   1753.200    532.000   1753.400    572.000   1753.900    613.000
GR   1753.300    644.000   1754.400    677.000   1754.700    698.000   1755.600    728.000   1756.200    750.000
GR   1755.700    767.000   1749.900    772.000   1749.300    775.000   1748.000    775.000   1747.400    778.000
GR   1749.300    785.000   1749.700    789.000   1752.900    797.000   1755.500    807.000   1756.900    815.000
GR   1755.300    827.000   1756.300    847.000   1756.200    866.000   1756.900    871.000   1759.500    877.000
GR   1760.700    893.000   1762.000    918.000   1763.200    936.000   1764.300    963.000   1766.200    990.000
GR   1766.700   1006.000      0.000      0.000      0.000      0.000      0.000      0.000      0.000      0.000

X1      2.000     61.000    768.000    816.000    500.000    480.000    510.000      0.000      0.000      0.000
GR   1774.100      0.000   1769.500     30.000   1765.800     59.000   1762.900     89.000   1761.400    116.000
GR   1760.000    150.000   1759.900    165.000   1760.500    185.000   1761.500    213.000   1761.300    218.000
GR   1759.500    220.000   1759.200    224.000   1762.800    232.000   1763.400    240.000   1762.500    245.000
GR   1759.200    248.000   1759.800    255.000   1761.400    260.000   1761.400    263.000   1761.400    267.000
GR   1759.300    271.000   1758.500    285.000   1758.700    298.000   1758.600    315.000   1757.700    326.000
GR   1755.800    336.000   1755.700    347.000   1755.800    358.000   1757.300    374.000   1757.300    411.000
GR   1756.500    433.000   1756.400    459.000   1755.200    482.000   1753.500    508.000   1755.100    539.000
GR   1755.800    550.000   1758.000    578.000   1759.000    606.000   1759.100    632.000   1760.100    666.000
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GR	1759.600	693.000	1759.400	718.000	1760.200	748.000	1759.500	760.000	1759.800	768.000
GR	1755.500	771.000	1754.600	773.000	1753.600	776.000	1754.600	788.000	1755.400	795.000
GR	1762.600	816.000	1761.900	828.000	1761.900	851.000	1762.500	893.000	1761.900	919.000
GR	1763.500	944.000	1764.600	973.000	1766.700	1009.000	1769.000	1034.000	1771.300	1065.000
GR	1773.900	1100.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
X1	3.000	69.000	1017.000	1068.000	520.000	450.000	510.000	0.000	0.000	0.000
GR	1779.000	0.000	1776.900	18.000	1775.300	41.000	1774.400	69.000	1773.700	92.000
GR	1773.400	112.000	1773.500	130.000	1773.400	156.000	1772.500	175.000	1771.700	193.000
GR	1772.300	211.000	1772.700	231.000	1772.700	254.000	1771.800	274.000	1771.200	295.00.
GR	1771.500	315.000	1771.500	345.000	1771.300	386.000	1771.800	417.000	1769.200	423.000
GR	1769.200	428.000	1771.300	434.000	1771.500	444.000	1770.100	470.000	1770.100	476.000
GR	1770.100	481.000	1768.500	486.000	1765.400	502.000	1767.100	513.000	1768.100	534.000
GR	1767.600	557.000	1764.800	591.000	1764.200	619.000	1762.300	647.000	1760.300	666.000
GR	1760.500	684.000	1762.400	707.000	1765.300	735.000	1765.800	766.000	1766.000	796.000
GR	1765.800	825.000	1765.600	860.000	1765.600	906.000	1765.800	940.000	1765.800	980.000
GR	1766.100	991.000	1765.800	1017.000	1763.100	1025.000	1762.400	1032.000	1761.300	1034.000
GR	1759.400	1053.000	1761.300	1059.000	1763.500	1068.000	1765.100	1093.000	1765.600	1116.000
GR	1765.500	1134.000	1766.900	1156.000	1770.000	1169.000	1770.500	1188.000	1770.900	1218.000
GR	1771.500	1234.000	1771.200	1258.000	1771.100	1290.000	1770.600	1330.000	1770.100	1365.000
GR	1770.900	1390.000	1773.500	1415.000	1777.000	1442.000	1778.600	1465.000	0.000	0.000
X1	4.000	85.000	1248.000	1285.000	480.000	500.000	520.000	0.000	0.000	1.000
GR	1789.300	0.000	1785.200	18.000	1781.500	44.000	1780.000	70.000	1778.800	94.000
GR	1778.400	126.000	1778.100	150.000	1777.700	178.000	1777.400	212.000	1777.800	243.000
GR	1775.900	254.000	1775.200	274.000	1775.000	314.000	1774.600	358.000	1774.500	373.000
GR	1774.600	388.000	1773.800	437.000	1775.000	424.000	1775.000	441.000	1775.700	461.000
GR	1775.700	465.000	1774.000	466.000	1774.000	474.000	1776.900	482.000	1775.000	488.000
GR	1774.700	503.000	1773.500	506.000	1773.900	509.000	1773.900	512.000	1773.900	516.000
GR	1772.200	518.000	1773.900	527.000	1772.500	543.000	1772.800	554.000	1772.900	565.000
GR	1771.900	587.000	1771.300	619.000	1770.400	641.000	1770.600	658.000	1769.200	680.000
GR	1765.900	697.000	1763.000	709.000	1763.700	713.000	1767.000	733.000	1768.500	747.000
GR	1769.400	765.000	1769.400	798.000	1769.300	833.000	1768.900	865.000	1769.100	889.000
GR	1769.000	907.000	1769.600	941.000	1769.200	974.000	1769.900	1006.000	1769.800	1032.000
GR	1769.600	1060.000	1770.100	1088.000	1770.200	1126.000	1770.500	1159.000	1770.500	1187.000
GR	1771.000	1198.000	1768.500	1207.000	1769.300	1221.000	1769.200	1248.000	1764.000	1257.000
GR	1763.000	1263.000	1764.000	1267.000	1764.000	1275.000	1773.700	1285.000	1781.400	1302.000
GR	1789.600	1320.000	1789.700	1332.000	1790.500	1352.000	1790.200	1373.000	1788.700	1396.000
GR	1789.600	1412.000	1790.200	1428.000	1790.500	1458.000	1790.800	1492.000	1789.900	1511.000
GR	1787.200	1517.000	1788.900	1525.000	1788.600	1538.000	1791.000	1549.000	1797.800	1562.000
X1	5.000	16.000	880.000	931.000	500.000	600.000	570.000	0.000	0.000	0.000
GR	1780.000	0.000	1780.000	290.000	1778.000	310.000	1782.000	315.000	1782.000	325.000
GR	1778.000	335.000	1776.000	380.000	1774.000	480.000	1773.000	635.000	1774.000	880.000
GR	1768.800	910.000	1768.500	918.000	1768.800	925.000	1776.200	931.000	1776.600	944.000
GR	1780.900	965.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
X1	6.000	55.000	605.000	684.000	450.000	350.000	430.000	0.000	0.000	0.000
GR	1798.100	0.000	1796.800	20.000	1795.100	38.000	1794.900	58.000	1795.800	80.000
GR	1795.100	88.000	1797.600	98.000	1796.900	106.000	1794.700	115.000	1793.900	139.000
GR	1792.900	164.000	1792.000	191.000	1791.600	222.000	1790.400	257.000	1789.900	280.000
GR	1789.100	300.000	1787.300	301.000	1786.700	310.000	1789.600	317.000	1788.000	323.000
GR	1785.400	330.000	1782.900	339.000	1783.400	343.000	1783.400	346.000	1783.400	350.000
GR	1782.800	353.000	1785.100	362.000	1786.000	369.000	1785.400	395.000	1783.900	398.000

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GR    1783.200     422.000    1782.100      452.000     1780.700      476.000     1779.200      499.000     1779.800      522.000
GR    1780.000     550.000    1778.900      579.000     1780.600      605.000     1776.600      613.000     1775.100      626.000
GR    1774.500     635.000    1775.300      643.000     1783.800      684.000     1784.300      705.000     1784.700      730.000
GR    1785.900     785.000    1786.700      809.000     1787.700      817.000     1788.200      854.000     1788.500      878.000
GR    1789.800     907.000    1792.000      937.000     1794.000      961.000     1795.300      987.000     1797.300     1015.000
EJ       0.000       0.000       0.000        0.000        0.000        0.000        0.000        0.000        0.000        0.000

     SECNO      DEPTH      CWSEL      CRIWS      WSELK      EG         HV         HL         OLOSS    BANK ELEV
     Q          QLOB       QCH        QROB       ALOB       ACH        AROB       VOL        TWA    LEFT/RIGHT
     TIME       VLOB       VCH        VROB       XNL        XNCH       XNR        WTN        ELMIN        SSTA
     SLOPE      XLOBL      XLCH       XLOBR      ITRIAL     IDC        ICONT      CORAR      TOPWID       ENDST

*PROF 1

CCHV=   0.100 CEHV=   0.300
*SECNO 1.000

3265 DIVIDED FLOW

      1.00       9.16    1756.36       0.00    1755.00    1756.82       0.46       0.00       0.00    1755.70
     9000.      7009.      1976.        15.      1921.       212.        18.         0.         0.     1756.90
      0.00       3.65       9.33       0.88      0.100      0.040      0.100      0.000    1747.20     122.73
  0.009281         0.         0.         0.          0          0          4       0.00     718.66     867.14

*SECNO 2.000

3265 DIVIDED FLOW

      2.00       7.58    1761.08       0.00       0.00    1761.64       0.56       4.79       0.03    1759.80
     9000.      6795.      2205.         0.      1805.       217.         0.        24.         8.     1762.60
      0.03       3.76      10.17       0.00      0.100      0.040      0.100      0.000    1753.50     123.70
  0.009818       500.       510.       480.          2          0          0       0.00     644.24     811.57

*SECNO 3.000

3265 DIVIDED FLOW

3301 HV CHANGED MORE THAN HVINS

7185 MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED
      3.00       7.90    1767.30    1767.30       0.00    1768.69       1.40       6.06       0.25    1765.80
     9000.      4582.      3889.       529.      1155.       283.       176.        45.        15.     1763.50
      0.04       3.97      13.73       3.01      0.100      0.040      0.100      0.000    1759.40     492.21
  0.014394       520.       510.       450.          3          8          0       0.00     621.94    1157.67

*SECNO 4.000

3265 DIVIDED FLOW
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  SECNO     DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS    BANK ELEV
  Q         QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA     LEFT/RIGHT
  TIME      VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN       SSTA
  SLOPE     XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID      ENDST


3301 HV CHANGED MORE THAN HVINS

     4.00      9.77   1772.77      0.00      0.00   1773.32      0.54      4.54      0.09   1769.20
    9000.     6401.     2599.        0.     2234.      258.        0.       68.       23.    1773.70
     0.07      2.86     10.06      0.00     0.100     0.040     0.100     0.000   1763.00    517.32
 0.006350      480.      520.      500.         3         0         0      0.00    733.37   1284.05

*SECNO 5.000

3301 HV CHANGED MORE THAN HVINS

     5.00      8.26   1776.76      0.00      0.00   1777.97      1.[illegible]  4.45   0.20   1774.00
    9000.     5064.     3932.        4.     1487.      308.        5.       94.       30.    1776.20
     0.09      3.40     12.76      0.81     0.100     0.040     0.100     0.000   1768.50    362.86
 0.011855      500.      570.      600.         3         0         0      0.00    581.93    944.79

*SECNO 6.000

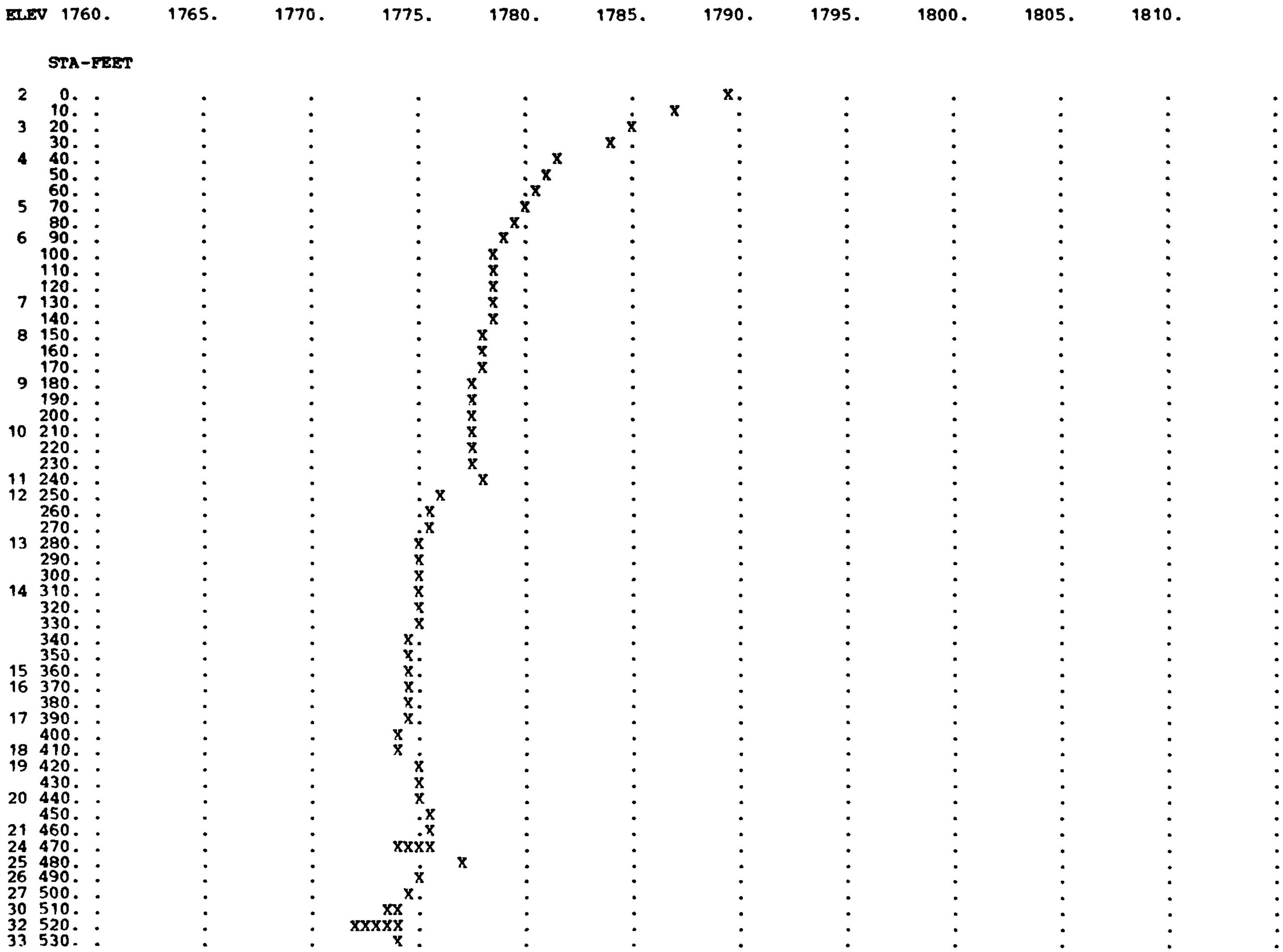
3265 DIVIDED FLOW

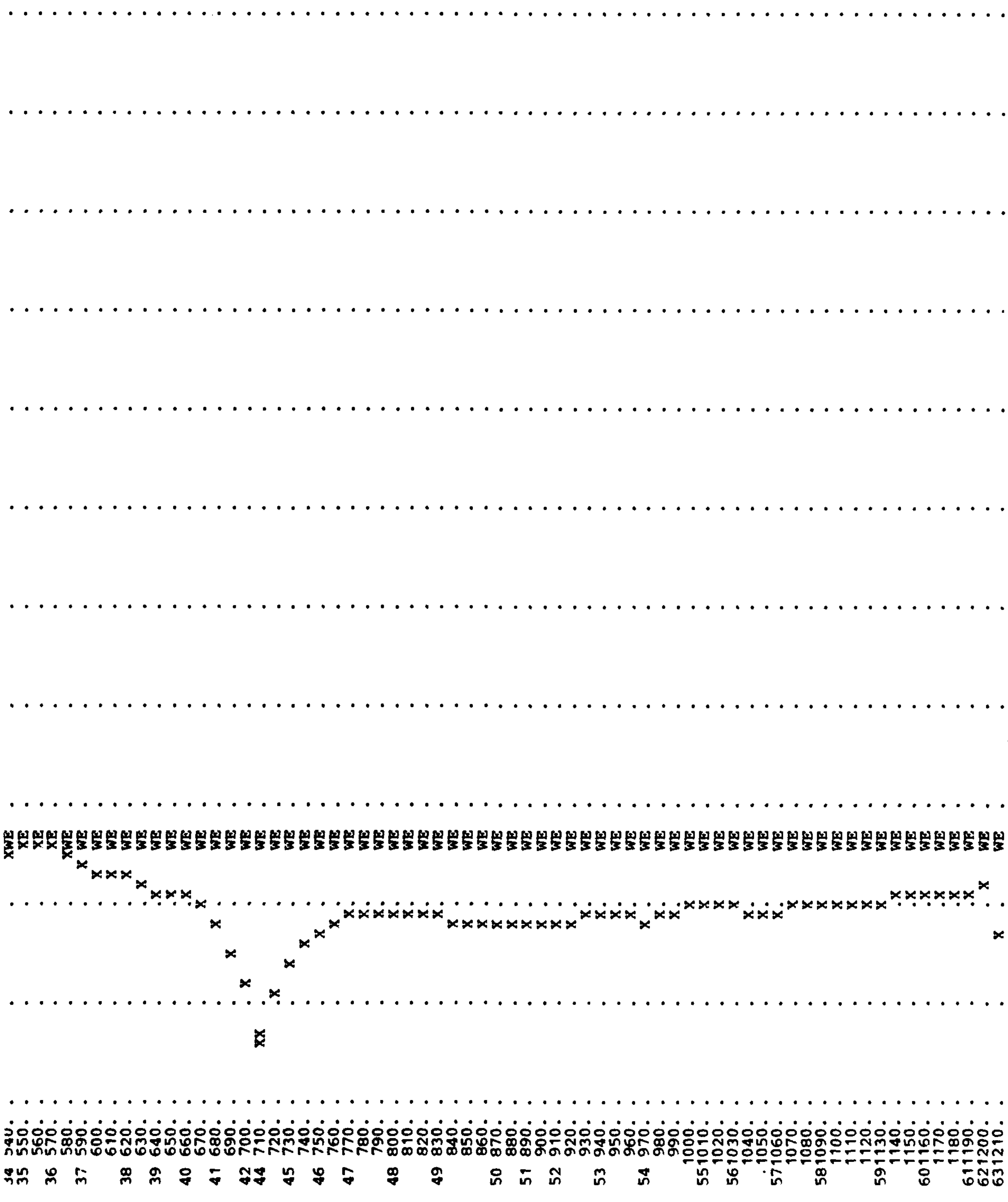
3301 HV CHANGED MORE THAN HVINS

7185 MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED
     6.00      9.38   1783.88   1783.88      0.00   1785.96      2.08      5.30      0.26   1780.60
    9000.     2571.     6429.        0.      654.      477.        0.      108.       35.    1783.80
     0.10      3.93     13.47      0.19     0.100     0.040     0.100     0.000   1774.50    335.49
 0.012340      450.      430.      350.         7         8         0      0.00    310.03    687.16
```

CROSS SECTION 4.00
STREAM BEAR CREEK
DISCHARGE= 9000.

PLOTTED POINTS (BY PRIORITY)-B=BOTTOM BRIDGE,T=TOP BRIDGE,X=GROUND,W=WATER SUR,E=ENERGY GRADIENT,C=CRITICAL WSEL





```
641220. .         .        X.      WE .         .         .         .         .         .         .         .         .
  1230. .         .        X.      WE .         .         .         .         .         .         .         .         .
  1240. .         .       X .      WE .         .         .         .         .         .         .         .         .
651250. .         .       X .      WE .         .         .         .         .         .         .         .     BANK.
671260. .     XXX .         .      WE .         .         .         .         .         .         .         .         .
681270. .       X .         .      WE .         .         .         .         .         .         .         .         .
691280. .       X .         .      WE .         .         .         .         .         .         .         .         .
701290. .         .         .      X  .         .         .         .         .         .         .         .     BANK.
711300. .         .         .         .         .  X      .         .         .         .         .         .         .
  1310. .         .         .         .         .         . X       .         .         .         .         .         .
721320. .         .         .         .         .         .        X.         .         .         .         .         .
731330. .         .         .         .         .         .        X.         .         .         .         .         .
  1340. .         .         .         .         .         .         X         .         .         .         .         .
741350. .         .         .         .         .         .         .X        .         .         .         .         .
  1360. .         .         .         .         .         .         .X        .         .         .         .         .
751370. .         .         .         .         .         .         X         .         .         .         .         .
  1380. .         .         .         .         .         .        X.         .         .         .         .         .
  1390. .         .         .         .         .         .       X .         .         .         .         .         .
761400. .         .         .         .         .         .      X  .         .         .         .         .         .
771410. .         .         .         .         .         .        X.         .         .         .         .         .
  1420. .         .         .         .         .         .         X         .         .         .         .         .
781430. .         .         .         .         .         .         X         .         .         .         .         .
  1440. .         .         .         .         .         .         .X        .         .         .         .         .
  1450. .         .         .         .         .         .         .X        .         .         .         .         .
791460. .         .         .         .         .         .         .X        .         .         .         .         .
  1470. .         .         .         .         .         .         .X        .         .         .         .         .
  1480. .         .         .         .         .         .         .X        .         .         .         .         .
801490. .         .         .         .         .         .         . X       .         .         .         .         .
  1500. .         .         .         .         .         .         .X        .         .         .         .         .
811510. .         .         .         .         .         .         X         .         .         .         .         .
821520. .         .         .         .         .         .   X     .         .         .         .         .         .
831530. .         .         .         .         .         .       X .         .         .         .         .         .
841540. .         .         .         .         .         .      X  .         .         .         .         .         .
851550. .         .         .         .         .         .         . X       .         .         .         .         .
861560. .         .         .         .         .         .         .         .     X   .         .         .         .

NRD=        0 ELLC=  9999999.00 ELTRD=  9999999.00

  EL(I),STA(I)
    1789.30        0.00     1785.20       18.00     1781.50       44.00     1780.00       70.00     1778.80       94.00
    1778.40      126.00     1778.10      150.00     1777.70      178.00     1777.40      212.00     1777.80      243.00
    1775.90      254.00     1775.20      284.00     1775.00      314.00     1774.60      358.00     1774.50      373.00
    1774.60      388.00     1773.80      407.00     1775.00      424.00     1775.00      441.00     1775.70      461.00
    1775.70      465.00     1774.00      466.00     1774.00      474.00     1776.90      482.00     1775.00      488.00
    1774.70      503.00     1773.50      506.00     1773.90      509.00     1773.90      512.00     1773.90      516.00
    1772.20      518.00     1773.90      527.00     1772.50      543.00     1772.80      554.00     1772.90      565.00
    1771.90      587.00     1771.30      619.00     1770.40      641.00     1770.60      658.00     1769.20      680.00
    1765.90      697.00     1763.00      709.00     1763.70      713.00     1767.00      733.00     1768.50      747.00
    1769.40      765.00     1769.40      798.00     1769.30      833.00     1768.90      865.00     1769.10      889.00
    1769.00      907.00     1769.60      941.00     1769.20      974.00     1769.90     1006.00     1769.80     1032.00
    1769.60     1060.00     1770.10     1088.00     1770.20     1126.00     1770.50     1159.00     1770.50     1187.00
    1771.00     1198.00     1768.50     1207.00     1769.30     1221.00     1769.20     1248.00     1764.00     1257.00
    1763.00     1263.00     1764.00     1267.00     1764.00     1275.00     1773.70     1285.00     1781.40     1302.00
    1789.60     1320.00     1789.70     1332.00     1790.50     1352.00     1790.20     1373.00     1788.70     1396.00
    1789.60     1412.00     1790.20     1428.00     1790.50     1458.00     1790.80     1492.00     1789.90     1511.00
    1787.20     1517.00     1788.90     1525.00     1788.60     1538.00     1791.00     1549.00     1797.80     1562.00
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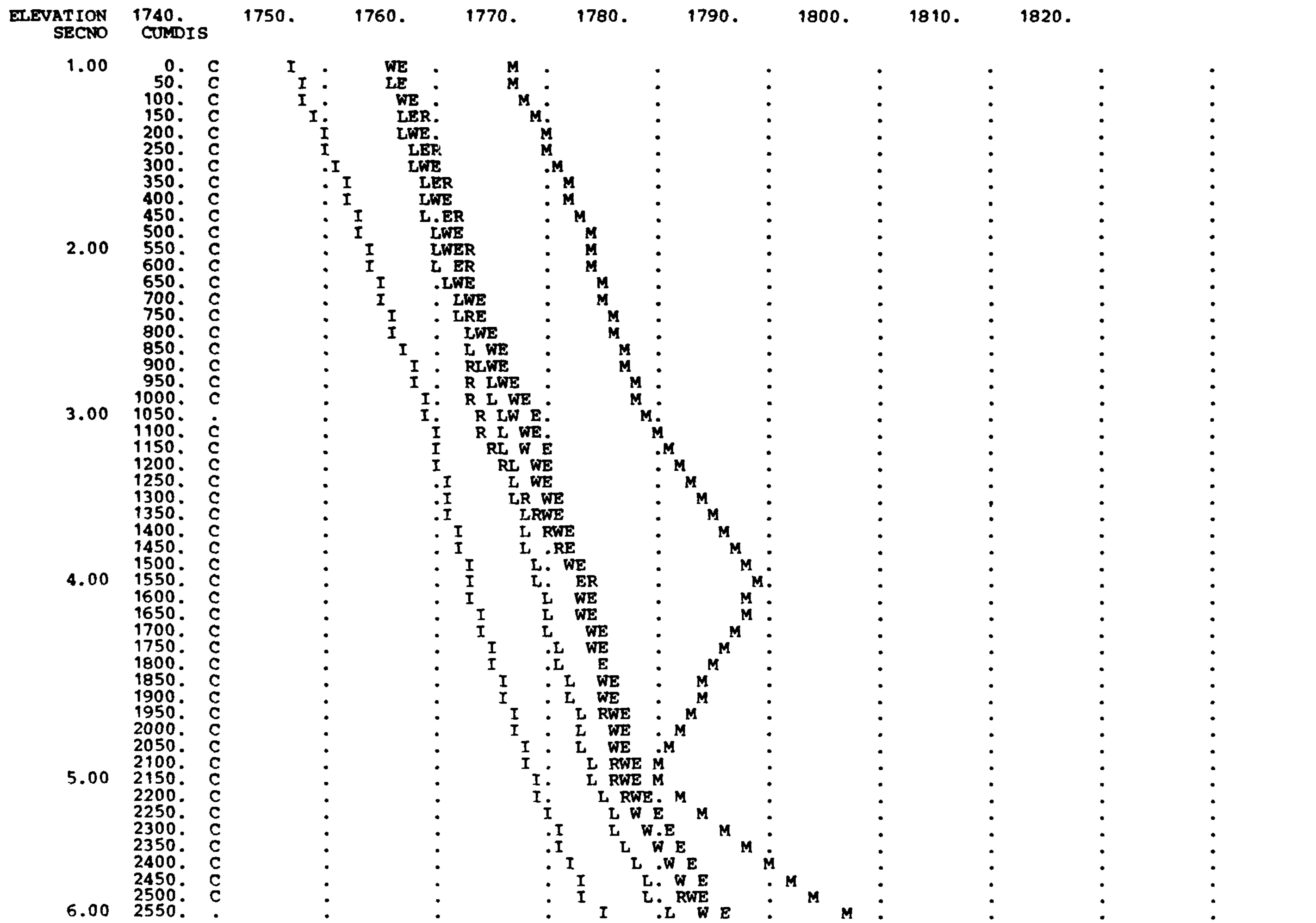
PROFILE FOR STREAM BEAR CREEK

PLOTTED POINTS (BY PRIORITY)-E-ENERGY,W-WATER SURFACE,I-INVERT,C-CRITICAL W.S.,L-LEFT BANK,R-RIGHT BANK,M-LOWER END STA



THIS RUN EXECUTED 29 JUL 82   9:27:59

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****************************************************
  HEC2 RELEASE DATED NOV 76 UPDATED MARC 1982
  ERROR CORR -  01,02,03,04,05
  MODIFICATION -  50,51,52,53,54,55
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NOTE- ASTERISK (*) AT LEFT OF CROSS-SECTION NUMBER INDICATES MESSAGE IN SUMMARY OF ERRORS LIST

BEAR CREEK

SUMMARY PRINTOUT

	SECNO	CWSEL	CRIWS	EG	HV	HL	OLOSS	K*CHSL	10K*S	KRATIO	ALPHA	Q	QCH
	1.000	1756.36	0.00	1756.82	0.46	0.00	0.00	0.00	92.81	0.00	1.68	9000.00	1975.98
	2.000	1761.08	0.00	1761.64	0.56	4.79	0.03	12.35	98.18	0.97	1.82	9000.00	2204.68
*	3.000	1767.30	1767.30	1768.69	1.40	6.06	0.25	11.57	143.94	0.83	2.89	9000.00	3888.69
	4.000	1772.77	0.00	1773.32	0.54	4.54	0.09	6.92	63.50	1.51	2.69	9000.00	2599.50
	5.000	1776.76	0.00	1777.97	1.21	4.45	0.20	9.65	118.55	0.73	3.11	9000.00	3931.79
*	6.000	1783.88	1783.88	1785.96	2.08	5.30	0.26	13.95	123.40	0.98	2.12	9000.00	6429.34

SUMMARY OF ERRORS AND SPECIAL NOTES

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CAUTION  SECNO=    3.000  PROFILE= 1  CRITICAL DEPTH ASSUMED
CAUTION  SECNO=    3.000  PROFILE= 1  MINIMUM SPECIFIC ENERGY

CAUTION  SECNO=    6.000  PROFILE= 1  CRITICAL DEPTH ASSUMED
CAUTION  SECNO=    6.000  PROFILE= 1  MINIMUM SPECIFIC ENERGY
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                                                                     THIS RUN EXECUTED 29 JUL 82    11:30:51

**************************************************
 HEC2 RELEASE DATED NOV 76 UPDATED MARC 1982
 ERROR CORR -  01,02,03,04,05
 MODIFICATION -  50,51,52,53,54,55
**************************************************

C
T1      EXAMPLE 2 SPECIAL AND NORMAL BRIDGES
T2      TRIBUTARY STREAMS JOIN MAIN STEM AT CROSS SECTION 3
T3      WOODY CREEK               6000 CFS  LOW FLOW

J1  ICHECK    INQ     NINV     IDIR     STRT     METRIC    HVINS     Q       WSEL     FQ

      0.       2.       0.       0.  0.001600    0.00      0.0      0.     45.000    0.000

J2  NPROF    IPLOT    PRFVS    XSECV    XSECH     FN      ALLDC     IBW     CHNIM    ITRACE

     1.000    0.000   -1.000    0.000    0.000    0.000    0.000    0.000    0.000    0.000

J3  VARIABLE CODES FOR SUMMARY PRINTOUT

   100.000  105.000    0.000    0.000    0.000    0.000    0.000    0.000    0.000    0.000

QT     9.000  6000.000 10000.000 14000.000 14000.000 16000.000 18000.000 20000.000 24000.000 28000.000
NC     0.060     0.060     0.035     0.100     0.300     0.000     0.000     0.000     0.000     0.000
            X3 CARD UTILIZED TO SPECIFY SEDIMENT ELEVATION (X3.2)
X1     1.000    15.000   550.000   670.000     0.000     0.000     0.000     0.000     0.000     0.000
X3    10.000    36.000     0.000     0.000     0.000     0.000     0.000     0.000     0.000     0.000
GR    55.000     0.000    50.000   100.000    45.000   250.000    44.000   500.000    43.000   550.000
GR    35.000   570.000    33.000   575.000    38.000   600.000    39.000   640.000    45.000   670.000
GR    46.000   750.000    43.500   800.000    44.000  1050.000    49.000  1100.000    55.000  1200.000

            X5 CARD UTILIZED TO SPECIFY WATER SURFACE ELEVATIONS
X1     2.000    14.000   450.000   540.000  1700.000  2050.000  1900.000     0.000     0.000     0.000
X3    10.000    37.500     0.000     0.000     0.000     0.000     0.000     0.000     0.000     0.000
X5     9.000    48.500    49.590    51.000    51.000    51.200    51.500    51.700    52.400    53.000
GR    60.000     0.000    50.000   100.000    47.000   200.000    46.000   400.000    45.000   450.000
GR    36.800   460.000    37.000   480.000    38.000   510.000    47.000   540.000    49.000   700.000
GR    48.000   750.000    46.000   800.000    49.000  1000.000    60.000  1200.000     0.000     0.000

            JUNCTION WITH 2 TRIBUTARIES
X1     3.000    14.000   650.000   745.000  1900.000  1900.000  2000.000     0.000     0.000     0.000
GR    65.000     0.000    55.000    50.000    52.000   100.000    53.000   300.000    55.000   400.000
GR    52.000   600.000    50.000   650.000    45.000   660.000    40.800   700.000    41.000   740.000
GR    53.000   745.000    51.000   890.000    52.000  1000.000    65.000  1200.000     0.000     0.000
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                  X5 CARD UTILIZED TO S"ECIFY DIFFERENCE IN CWSEL BETWEEN
                  SECTIONS 3 AND 3.1
X1     3.100      0.000     0.000     0.000   400.000   400.000   400.000     0.950     0.500     0.000
X5    -9.000      0.600     1.000     1.050     1.100     1.150     1.300     1.300     1.350     1.400

NC     0.060      0.060     0.035     0.300     0.500     0.000     0.000     0.000     0.000     0.000
                  EFFECTIVE AREA OPTION USED TO CONFINE FLOW TO BRIDGE OPENING
                  UNTIL WEIR FLOW CAN BE EXPECTED (X3.8,X3.9=58)
X1     4.000     21.000   600.000   700.000  1600.000  1600.000  1600.000     0.000     0.000     0.000
X3    10.000      0.000     0.000     0.000     0.000     0.000     0.000    58.000    58.000     0.000
GR    70.000      0.000    63.000   100.000    57.500   250.000    55.000   400.000    54.000   500.000
GR    53.500    600.000    45.000   610.000    44.000   625.000    44.500   640.000    46.000   650.000
GR    47.500    660.000    47.000   670.000    47.000   695.000    55.000   700.000    55.500   750.000
GR    54.500    775.000    53.000   825.000    55.000   900.000    57.500   950.000    63.000  1000.000
GR    70.000   1100.000     0.000     0.000     0.000     0.000     0.000     0.000     0.000     0.000

SB     1.250      1.500     3.000     0.000    82.500     6.000  1014.000     0.670    45.000    45.000
                  BT CARDS DEFINE WEIR PROFILE ONLY ,SINCE PIER IS SPECIFIED THIS
                  SPECIAL BRIDGE CAN NOT REVERT TO A NORMAL BRIDGE
X1     5.000      0.000     0.000     0.000    50.000    50.000    50.000     0.000     0.000     0.000
X2     0.000      0.000     1.000    57.000    60.000     0.000     0.000     0.000     0.000     0.000
X3    10.000      0.000     0.000     0.000     0.000     0.000     0.000    61.000    61.000     0.000
BT     7.000      0.000    65.000     0.000   500.000    61.000     0.000   600.000    60.000     0.000
BT   700.000     60.000     0.000   800.000    61.000     0.000  1000.000    63.000     0.000  1100.000
BT    70.000      0.000     0.000     0.000     0.000     0.000     0.000     0.000     0.000     0.000

                  HIGH WATER ELEVATION OF 59.6 (X2.2)
X1     6.000     12.000   350.000   440.000   250.000   250.000   250.000     0.000    -0.300     0.000
X2     0.000     59.600     0.000     0.000     0.000     0.000     0.000     0.000     0.000     0.000
X3    10.000      0.000     0.000     0.000     0.000     0.000     0.000     0.000     0.000     0.000
GR    75.000      0.000    60.000    50.000    56.000   300.000    54.500   350.000    45.000   370.000
GR    46.000    400.000    48.000   420.000    56.000   440.000    58.000   600.000    55.000   650.000
GR    56.000    700.000    75.000   850.000     0.000     0.000     0.000     0.000     0.000     0.000

NC     0.060      0.060     0.035     0.100     0.300     0.000     0.000     0.000     0.000     0.000
X1    -3.000     14.000   650.000   745.000     0.000     0.000     0.000     0.000     0.000     0.000
X3    10.000      0.000     0.000     0.000     0.000     0.000     0.000     0.000     0.000     0.000
GR    65.000      0.000    55.000    50.000    52.000   100.000    53.000   300.000    55.000   400.000
GR    52.000    600.000    50.000   650.000    45.000   660.000    40.800   700.000    41.000   740.000
GR    53.000    745.000    51.000   890.000    52.000  1000.000    65.000  1200.000     0.000     0.000

                  FIRST TRIBUTARY
X1    13.100      0.000     0.000     0.000   400.000   400.000   400.000     0.950     0.500     0.000
X5    -9.000      0.600     1.000     1.050     1.100     1.150     1.300     1.300     1.350     1.400

NC     0.060      0.060     0.035     0.300     0.500     0.000     0.000     0.000     0.000     0.000
X1    14.000     21.000   600.000   700.000  1600.000  1600.000  1600.000     0.000     0.000     0.000
X3    10.000      0.000     0.000     0.000     0.000     0.000     0.000    58.000    58.000     0.000
GR    70.000      0.000    63.000   100.000    57.500   250.000    55.000   400.000    54.000   500.000
GR    53.500    600.000    45.000   610.000    44.000   625.000    44.500   640.000    46.000   650.000
GR    47.500    660.000    47.000   670.000    47.000   695.000    55.000   700.000    55.500   750.000
GR    54.500    775.000    53.000   825.000    55.000   900.000    57.500   950.000    63.000  1000.000
GR    70.000   1100.000     0.000     0.000     0.000     0.000     0.000     0.000     0.000     0.000
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SB      0.000      1.500      3.000    300.000     76.500      0.000   1014.000      0.670     45.000     45.000
                 WEIR LENGTH  DEFINED BY SB.4, BT CARDS ARE NOT REQUIRED
                 NO PIER DEFINED ON SB CARD,NORMAL BR. TO BE USED FOR LOW FLOW
                 X4 CARDS ARE USED TO ADD PIER TO GR DATA
X1     15.000      0.000      0.000      0.000     50.000     50.000     50.000      0.000      0.000      0.000
X2      0.000      0.000      1.000     57.000     60.000      0.000      0.000      0.000      0.000      0.000
X3     10.000      0.000      0.000      0.000      0.000      0.000      0.000     61.000     61.000      0.000
X4     10.000     44.000    622.900     57.000    623.000     57.000    624.900     46.000    647.900     57.000
X4    648.000     57.000    649.900     47.000    674.000     57.000    674.100     57.000    676.000     47.000
X4    676.100      0.000      0.000      0.000      0.000      0.000      0.000      0.000      0.000      0.000

                 HIGH WATER ELEVATION OF 59.06 (X2.2)
X1     16.000     12.000    350.000    440.000    250.000    250.000    250.000      0.000     -0.300      0.000
X2      0.000     59.600      0.000      0.000      0.000      0.000      0.000      0.000      0.000      0.000
X3     10.000      0.000      0.000      0.000      0.000      0.000      0.000      0.000      0.000      0.000
GR     75.000      0.000     60.000     50,000     56.000    300.000     54.500    350.000     45.000    370.000
GR     46.000    400.000     48.000    420.000     56.000    440.000     58.000    600.000     55.000    650.000
GR     56.000    700.000     75.000    850.000      0.000      0.000      0.000      0.000      0.000      0.000

NC      0.060      0.060      0.035      0.100      0.300      0.000      0.000      0.000      0.000      0.000
X1     -3.000     14.000    650.000    745.000      0.000      0.000      0.000      0.000      0.000      0.000
X3     10.000      0.000      0.000      0.000      0.000      0.000      0.000      0.000      0.000      0.000
GR     65.000      0.000     55.000     50.000     52.000    100.000     53.000    300.000     55.000    400.000
GR     52.000    600.000     50.000    650.000     45.000    660.000     40.800    700.000     41.000    740.000
GR     53.000    745.000     51.000    890.000     52.000   1000.000     65.000   1200.000      0.000      0.000

                 SECOND TRIBUTARY
X1     23.100      0.000      0.000      0.000    400.000    400.000    400.000      0.950      0.500      0.000
X5     -9.000      0.600      1.000      1.050      1.100      1.150      1.300      1.300      1.350      1.400

NC      0.060      0.060      0.035      0.300      0.500      0.000      0.000      0.000      0.000      0.000
X1     24.000     23.000    600.000    700.000   1600.000   1600.000   1600.000      0.000      0.000      0.000
X3     10.000      0.000      0.000      0.000      0.000      0.000      0.000     58.000     58.000      0.000
GR     70.000      0.000     63.000    100.000     57.500    250.000     55.000    400.000     54.000    500.000
GR     53.500    600.000     53.500    600.100     45.000    610.000     44.000    625.000     44.500    640.000
GR     46.000    650.000     47.500    660.000     47.000    670.000     47.000    695.000     55.000    699.900
GR     55.000    700.000     55.500    750.000     54.500    775.000     53.000    825.000     55.000    900.000
GR     57.500    950.000     63.000   1000.000     70.000   1100.000      0.000      0.000      0.000      0.000

                 X4 CARD PROVIDES ADDITIONAL GR DATA TO MODEL BRIDGE PIERS
X1     24.100      0.000      0.000      0.000      1.000      1.000      1.000      0.000      0.000      0.000
X4     10.000     44.000    622.900     57.000    623.000     57.000    624.900     46.000    647.900     57.000
X4    648.000     57.000    649.900     47.000    674.000     57.000    674.100     57.000    676.000     47.000
X4    676.100      0.000      0.000      0.000      0.000      0.000      0.000      0.000      0.000      0.000
BT     16.000      0.000     70.000     70.000    100.000     63.000     63.000    250.000     62.000     57.500
BT    400.000     61.500     55.000    500.000     61.000     54.000    600.000     60.000     53.500    600.100
BT     60.000     57.000    699.900     60.000     57.000    700.000     60.000     55.000    750.000     60.500
BT     55.500    775.000     60.500     54.500    825.000     61.000     53.000    900.000     62.000     55.000
BT    950.000     62.500     57.500   1000.000     63.000     63.000   1100.000     70.000     70.000      0.000
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               X1 REPEATS GR AND X4 DATA, X2 CARD REPEATS BT DATA
X1     24.200     0.000     0.000     0.000    50.000    50.000    50.000     0.000     0.000     0.000
X2      0.000     0.000     0.000     0.000     0.000     0.000     1.000     0.000     0.000     0.000

X1     25.000    21.000   600.000   700.000     1.000     1.000     1.000     0.000     0.000     0.000
X3     10.000     0.000     0.000     0.000     0.000     0.000     0.000    61.000    61.000     0.000
GR     70.000     0.000    63.000   100.000    57.500   250.000    55.000   400.000    54.000   500.000
GR     53.500   600.000    45.000   610.000    44.000   625.000    44.500   640.000    46.000   650.000
GR     47.500   660.000    47.000   670.000    47.000   695.000    55.000   700.000    55.500   750.000
GR     54.500   775.000    53.000   825.000    55.000   900.000    57.500   950.000    63.000  1000.000
GR     70.000  1100.000     0.000     0.000     0.000     0.000     0.000     0.000     0.000     0.000

               HIGH WATER ELEVATION OF 59.6 (X2.2)
X1     26.000    12.000   350.000   440.000   250.000   250.000   250.000     0.000    -0.300     0.000
X2      0.000    59.600     0.000     0.000     0.000     0.000     0.000     0.000     0.000     0.000
X3     10.000     0.000     0.000     0.000     0.000     0.000     0.000     0.000     0.000     0.000
GR     75.000     0.000    60.000    50.000    56.000   300.000    54.500   350.000    45.000   370.000
GR     46.000   400.000    48.000   420.000    56.000   440.000    58.000   600.000    55.000   650.000
GR     56.000   700.000    75.000   850.000     0.000     0.000     0.000     0.000     0.000     0.000
EJ      0.000     0.000     0.000     0.000     0.000     0.000     0.000     0.000     0.000     0.000
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  SECNO     DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS     BANK ELEV
  Q         QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA     LEFT/RIGHT
  TIME      VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN       SSTA
  SLOPE     XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID      ENDST

*PROF 1

CCHV=   0.100 CEHV=    0.300
*SECNO 1.000

3265 DIVIDED FLOW

             X3 CARD UTILIZED TO SPECIFY SEDIMENT ELEVATION (X3.2)
     1.00      9.69     45.69      0.00     45.00     46.12      0.43      0.00      0.00     43.00
    6000.      519.     4659.      822.      414.      788.      566.        0.        0.     45.00
     0.00      1.25      5.91      1.45     0.060     0.035     0.060     0.000     36.00    229.31
 0.001511        0.        0.        0.         0         0         4      0.00    806.57   1066.90

*SECNO 2.000
 WATER EL=X5 CARD=     48.500

3265 DIVIDED FLOW

             X5 CARD UTILIZED TO SPECIFY WATER SURFACE ELEVATIONS
     2.00     11.00     48.50      0.00      0.00     48.96      0.46      2.59      0.01     45.00
    6000.      831.     4815.      354.      588.      795.      380.       76.       34.     47.00
     0.10      1.41      6.06      0.93     0.060     0.035     0.060     0.000     37.50    150.00
 0.001178     1700.     1900.     2050.         0         0         0      0.00    751.67    966.67

*SECNO 3.000

3265 DIVIDED FLOW

             JUNCTION WITH 2 TRIBUTARIES
     3.00     10.41     51.21      0.00      0.00     52.07      0.86      2.99      0.12     50.00
    6000.       14.     5985.        1.       18.      803.        4.      135.       54.     53.00
     0.18      0.78      7.45      0.24     0.060     0.035     0.060     0.000     40.80    619.91
 0.001979     1900.     2000.     1900.         1         0         0      0.00    161.49    912.39

*SECNO 3.100
 WATER EL=X5 CARD=     51.809

3265 DIVIDED FLOW

             X5 CARD UTILIZED TO SPECIFY DIFFERENCE IN CWSEL BETWEEN
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                  SECTIONS 3 AND 3.1
     3.10     10.51     51.81      0.00      0.00     52.74      0.93      0.82      0.02     50.50
    6000.       17.     5980.        3.       20.      772.        8.      142.       55.      53.50
     0.19      0.86      7.74      0.33     0.060     0.035     0.060     0.000     41.30    586.42
 0.002122      400.      400.      400.         0         0         0      0.00    174.18    877.76

CCHV=   0.300 CEHV=    0.500
*SECNO 4.000

3495 OVERBANK AREA ASSUMED NON-EFFECTIVE,ELLEA=       58.00 ELREA=       58.00

                  EFFECTIVE AREA OPTION USED TO CONFINE FLOW TO BRIDGE OPENING
                  UNTIL WEIR FLOW CAN BE EXPECTED (X3.8,X3.9=58)
     4.00     11.06     55.06      0.00      0.00     55.82      0.76      3.03      0.05     53.50
    6000.        0.     6000.        0.        0.      860.        0.      173.       61.      55.00
     0.26      0.00      6.98      0.00     0.060     0.035     0.060     0.000     44.00    600.00
 0.001697     1600.     1600.     1600.         2         0         0      0.00    100.00    700.00


SPECIAL BRIDGE

SB   XK         XKOR       COFQ       RDLEN      BWC        BWP       BAREA      SS         ELCHU      ELCHD
     1.25       1.50       3.00       0.00      82.50       6.00    1014.00      0.67      45.00      45.00

*SECNO 5.000
CLASS A LOW FLOW

3420 BRIDGE W.S.=     54.93 BRIDGE VELOCITY=,       7.27     CALCULATED CHANNEL AREA=,       826.

 EGPRS      EGLWC       H3       QWEIR      QLOW       BAREA    TRAPEZOID     ELLC      ELTRD
                                                                   AREA
     0.00     55.96      0.18         0.     6000.     1014.     1014.       57.00     60.00


3495 OVERBANK AREA ASSUMED NON-EFFECTIVE,ELLEA=       61.00 ELREA=       61.00

                  BT CARDS DEFINE WEIR PROFILE ONLY ,SINCE PIER IS SPECIFIED THIS
                  SPECIAL BRIDGE CAN NOT REVERT TO A NORMAL BRIDGE
     5.00     11.24     55.24      0.00      0.00     55.96      0.73      0.15      0.00     53.50
    6000.        0.     6000.        0.        0.      878.        0.      174.       61.      55.00
     0.26      0.00      6.84      0.00     0.060     0.035     0.060     0.000     44.00    600.00
 0.001584       50.       50.       50.         0         0         0      0.00    100.00    700.00

*SECNO 6.000

3495 OVERBANK AREA ASSUMED NON-EFFECTIVE,ELLEA=       54.20 ELREA=       55.70
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                 HIGH WATER ELEVATION OF 59.6 (X2.2)
     6.00    10.84    55.54     0.00    59.60    56.71     1.17     0.53     0.22    54.20
    6000.      31.    5969.       0.      30.     686.       0.     178.      61.    55.70
     0.27     1.03     8.70     0.00    0.060    0.035    0.060    0.000    44.70   305.24
 0.002942     250.     250.     250.        2        0        0     0.00   134.36   439.61

CCHV=    0.100 CEHV=    0.300
*SECNO -3.000
START TRIB COMP
   -3.000      3.000     51.209

3495 OVERBANK AREA ASSUMED NON-EFFECTIVE,ELLEA=       50.00 ELREA=       53.00

    -3.00    10.41    51.21     0.00     0.00    52.07     0.86     0.00     0.00    50.00
    6000.      14.    5986.       0.      18.     803.       0.     178.      61.    53.00
     0.27     0.79     7.45     0.00    0.060    0.035    0.060    0.000    40.80   619.78
 0.001976       0.       0.       0.        0        0        0     0.00   124.47   744.25

*SECNO 13.100
 WATER EL=X5 CARD=    51.809

3265 DIVIDED FLOW

                 FIRST TRIBUTARY
    13.10    10.51    51.81     0.00     0.00    52.74     0.93     0.82     0.02    50.50
    6000.      17.    5980.       3.      20.     772.       8.     186.      63.    53.50
     0.28     0.86     7.74     0.33    0.060    0.035    0.060    0.000    41.30   586.42
 0.002122     400.     400.     400.        0        0        0     0.00   174.18   877.76

CCHV=    0.300 CEHV=    0.500
*SECNO 14.000

3495 OVERBANK AREA ASSUMED NON-EFFECTIVE,ELLEA=       58.00 ELREA=       58.00

    14.00    11.06    55.06     0.00     0.00    55.82     0.76     3.03     0.05    53.50
    6000.       0.    6000.       0.       0.     860.       0.     216.      68.    55.00
     0.34     0.00     6.98     0.00    0.060    0.035    0.060    0.000    44.00   600.00
 0.001697    1600.    1600.    1600.        2        0        0     0.00   100.00   700.00

SPECIAL BRIDGE
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    SECNO      DEPTH      CWSEL      CRIWS      WSELK      EG         HV         HL         OLOSS     BANK ELEV
    Q          QLOB       QCH        QROB       ALOB       ACH        AROB       VOL        TWA     LEFT/RIGHT
    TIME       VLOB       VCH        VROB       XNL        XNCH       XNR        WTN        ELMIN        SSTA
    SLOPE      XLOBL      XLCH       XLOBR      ITRIAL     IDC        ICONT      CORAR      TOPWID       ENDST

SB  XK         XKOR       COFQ       RDLEN      BWC        BWP        BAREA      SS         ELCHU      ELCHD
     0.00       1.50       3.00     300.00      76.50       0.00    1014.00       0.67      45.00      45.00

*SECNO 15.000

6070,LOW FLOW BY NORMAL BRIDGE

EGPRS=     0.000  EGLWC=     56.754  ELLC=     57.000  PCWSE=     55.058  ELTRD=     60.000

3265 DIVIDED FLOW

3370 NORMAL BRIDGE,NRD=  0 MIN ELTRD=   60.00 MAX ELLC=   57.00

3495 OVERBANK AREA ASSUMED NON-EFFECTIVE,ELLEA=       61.00 ELREA=       61.00

                WEIR LENGTH  DEFINED BY SB.4, BT CARDS ARE NOT REQUIRED
                NO PIER DEFINED ON SB CARD,NORMAL BR. TO BE USED FOR LOW FLOW
                X4 CARDS ARE USED TO ADD PIER TO GR DATA
     15.00      11.13      55.13       0.00       0.00      55.98       0.85       0.12       0.05      53.50
     6000.         0.      6000.         0.         0.       809.         0.       217.        68.      55.00
      0.35       0.00       7.42       0.00      0.060      0.035      0.060      0.000      44.00     600.00
  0.003472        50.        50.        50.          3          0          0       0.00      94.20     700.00

*SECNO 16.000

3265 DIVIDED FLOW

                HIGH WATER ELEVATION OF 59.06 (X2.2)
     16.00      11.07      55.77       0.00      59.60      56.85       1.08       0.75       0.11      54.20
     6000.        46.      5921.        33.        41.       707.        38.       222.        69.      55.70
      0.35       1.11       8.38       0.86      0.060      0.035      0.060      0.000      44.70     295.44
  0.002638       250.       250.       250.          0          0          0       0.00     218.86     700.58

CCHV=    0.100 CEHV=    0.300
*SECNO -3.000
START TRIB COMP
    -3.000      3.000     51.209

3495 OVERBANK AREA ASSUMED NON-EFFECTIVE,ELLEA=       50.00 ELREA=       53.00

     -3.00      10.41      51.21       0.00       0.00      52.07       0.86       0.00       0.00      50.00
     6000.        14.      5986.         0.        18.       803.         0.       222.        69.      53.00
      0.35       0.79       7.45       0.00      0.060      0.035      0.060      0.000      40.80     619.78
  0.001976         0.         0.         0.          0          0          0       0.00     124.47     744.25
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  SECNO      DEPTH      CWSEL      CRIWS      WSELK      EG         HV         HL         OLOSS     BANK ELEV
  Q          QLOB       QCH        QROB       ALOB       ACH        AROB       VOL        TWA      LEFT/RIGHT
  TIME       VLOB       VCH        VROB       XNL        XNCH       XNR        WTN        ELMIN        SSTA
  SLOPE      XLOBL      XLCH       XLOBR      ITRIAL     IDC        ICONT      CORAR      TOPWID       ENDST

*SECNO 23.100
 WATER EL=X5 CARD=     51.809

3265 DIVIDED FLOW

                 SECOND TRIBUTARY
    23.10     10.51      51.81       0.00       0.00      52.74       0.93       0.82       0.02      50.50
    6000.       17.      5980.         3.        20.       772.         8.       229.        70.       53.50
     0.37      0.86       7.74       0.33      0.060      0.035      0.060      0.000      41.30     586.42
 0.002122      400.       400.       400.          0          0          0       0.00     174.18     877.76

CCHV=    0.300 CEHV=     0.500
*SECNO 24.000

3495 OVERBANK AREA ASSUMED NON-EFFECTIVE,ELLEA=       58.00 ELREA=       58.00

    24.00     11.06      55.06       0.00       0.00      55.82       0.76       3.03       0.05      53.50
    6000.        0.      6000.         0.         0.       859.         0.       260.        75.       55.00
     0.43      0.00       6.98       0.00      0.060      0.035      0.060      0.000      44.00     600.00
 0.001702     1600.      1600.      1600.          2          0          0       0.00     100.00     700.00

*SECNO 24.100

3265 DIVIDED FLOW

3370 NORMAL BRIDGE,NRD= 16 MIN ELTRD=    60.00 MAX ELLC=    70.00

                X4 CARD PROVIDES ADDITIONAL GR DATA TO MODEL BRIDGE PIERS
    24.10     11.00      55.00      51.36       0.00      55.88       0.88       0.00       0.06      53.50
    6000.        0.      6000.         0.         0.       796.         0.       260.        75.       55.00
     0.43      0.00       7.54       0.00      0.060      0.035      0.060      0.000      44.00     399.89
 0.003684        1.         1.         1.          4         18          0    -316.30     432.08     900.04

*SECNO 24.200

3265 DIVIDED FLOW
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 SECNO     DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS    BANK ELEV
 Q         QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA     LEFT/RIGHT
 TIME      VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN       SSTA
 SLOPE     XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID      ENDST


3370 NORMAL BRIDGE,NRD= 16 MIN ELTRD=   60.00 MAX ELLC=   70.00

               X1 REPEATS GR AND X4 DATA, X2 CARD REPEATS BT DATA
   24.20     11.24     55.24     51.36      0.00     56.08      0.83      0.18      0.01     53.50
   6000.        0.     6000.        0.        0.      819.        0.      260.       76.      55.00
    0.43      0.00      7.33      0.00     0.060     0.035     0.060     0.000     44.00    385.50
0.003410       50.       50.       50.         4        18         0   -403.22    481.25    904.83

*SECNO 25.000

3495 OVERBANK AREA ASSUMED NON-EFFECTIVE,ELLEA=      61.00 ELREA=       61.00

   25.00     11.42     55.42      0.00      0.00     56.12      0.70      0.00      0.04     53.50
   6000.        0.     6000.        0.        0.      896.        0.      260.       76.      55.00
    0.43      0.00      6.70      0.00     0.060     0.035     0.060     0.000     44.00    600.00
0.001477        1.        1.        1.         2         0         0      0.00    100.00    700.00

*SECNO 26.000

3265 DIVIDED FLOW

              HIGH WATER ELEVATION OF 59.6 (X2.2)
   26.00     11.01     55.71      0.00     59.60     56.81      1.10      0.49      0.20     54.20
   6000.       41.     5931.       28.       38.      701.       34.      265.       77.      55.70
    0.44      1.08      8.46      0.82     0.060     0.035     0.060     0.000     44.70    299.26
0.002716      250.      250.      250.         2         0         0      0.00    208.65    700.09
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THIS RUN EXECUTED 29 JUL 82   11:31:33

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******************************************************
 HEC2 RELEASE DATED NOV 76 UPDATED MARC 1982
 ERROR CORR -  01,02,03,04,05
 MODIFICATION -  50,51,52,53,54,55
******************************************************

T1      EXAMPLE 2 SPECIAL AND NORMAL BRIDGES
T2      TRIBUTARY STREAMS JOIN MAIN STEM AT CROSS SECTION 3
T3      WOODY CREEK                10000 CFS   PRESSURE FLOW

J1  ICHECK     INQ      NINV      IDIR      STRT     METRIC    HVINS      Q        WSEL       FQ
        0.       3.       0.        0.  0.001600      0.00       0.0       0.    48.000    0.000

J2  NPROF     IPLOT    PRFVS     XSECV     XSECH       FN      ALLDC     IBW      CHNIM     ITRACE
     2.000    0.000   -1.000     0.000     0.000     0.000     0.000    0.000     0.000     0.000
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 SECNO      DEPTH      CWSEL      CRIWS      WSELK      EG         HV         HL         OLOSS   BANK ELEV
 Q          QLOB       QCH        QROB       ALOB       ACH        AROB       VOL        TWA    LEFT/RIGHT
 TIME       VLOB       VCH        VROB       XNL        XNCH       XNR        WTN        ELMIN       SSTA
 SLOPE      XLOBL      XLCH       XLOBR      ITRIAL     IDC        ICONT      CORAR      TOPWID      ENDST

*PROF 2

CCHV=    0.100 CEHV=    0.300
*SECNO 1.000
                 X3 CARD UTIL' ED TO SPECIFY SEDIMENT ELEVATION (X3.2)
     1.00     11.00      47.00      0.00      48.00      47.44      0.45      0.00       0.00      43.00
   10000.     1589.      6254.     2157.       859.       945.     1088.        0.         0.       45.00
     0.00      1.85       6.62      1.98      0.060      0.035     0.060     0.000      36.00     190.11
 0.001586        0.         0.        0.          0          0         4      0.00     889.85    1079.96

*SECNO 2.000
 WATER EL=X5 CARD=     49.590
                 X5 CARD UTILIZED TO SPECIFY WATER SURFACE ELEVATIONS
     2.00     12.09      49.59      0.00       0.00      50.21      0.62      2.99       0.05      45.00
   10000.     1933.      6757.     1310.       934.       893.      860.      121.        39.      47.00
     0.09      2.07       7.57      1.52      0.060      0.035     0.060     0.000      37.50     113.67
 0.001574     1700.      1900.     2050.          0          0         0      0.00     897.06    1010.73

*SECNO 3.000

3265 DIVIDED FLOW

3301 HV CHANGED MORE THAN HVINS

                 JUNCTION WITH 2 TRIBUTARIES
     3.00     12.22      53.02     49.66       0.00      54.30      1.28      3.89       0.20      50.00
   10000.      318.      9215.      467.       248.       975.      323.      215.        74.      53.00
     0.15      1.28       9.45      1.45      0.060      0.035     0.060     0.000      40.80      83.01
 0.002521     1900.      2000.     1900.          4         12         0      0.00     701.57    1015.68

*SECNO 3.100
 WATER EL=X5 CARD=     54.016

3265 DIVIDED FLOW

                 X5 CARD UTILIZED TO SPECIFY DIFFERENCE IN CWSEL BETWEEN
                 SECTIONS 3 AND 3.1
     3.10     12.72      54.02      0.00       0.00      55.11      1.09      0.93       0.02      50.50
   10000.      568.      8713.      719.       410.       971.      436.      231.        81.      53.50
     0.17      1.39       8.97      1.65      0.060      0.035     0.060     0.000      41.30      71.00
 0.002153      400.       400.      400.          0          0         0      0.00     736.66     972.15
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   SECNO      DEPTH      CWSEL      CRIWS      WSELK      EG         HV         HL         OLOSS    BANK ELEV
   Q          QLOB       QCH        QROB       ALOB       ACH        AROB       VOL        TWA    LEFT/RIGHT
   TIME       VLOB       VCH        VROB       XNL        XNCH       XNR        WTN        ELMIN       SSTA
   SLOPE      XLOBL      XLCH       XLOBR      ITRIAL     IDC        ICONT      CORAR      TOPWID      ENDST

CCHV=    0.300 CEHV=    0.500
*SECNO 4.000

3495 OVERBANK AREA ASSUMED NON-EFFECTIVE,ELLEA=        58.00 ELREA=        58.00

                  EFFECTIVE AREA OPTION USED TO CONFINE FLOW TO BRIDGE OPENING
                  UNTIL WEIR FLOW CAN BE EXPECTED (X3.8,X3.9=58)
      4.00      13.35      57.35       0.00       0.00      58.66       1.31       3.44       0.11      53.50
    10000.         0.     10000.         0.         0.      1088.         0.       284.        96.      55.00
      0.22       0.00       9.19       0.00      0.060      0.035      0.060      0.000      44.00     600.00
  0.002147      1600.      1600.      1600.          2          0          0       0.00     100.00     700.00


SPECIAL BRIDGE

SB  XK         XKOR        COFQ        RDLEN       BWC         BWP        BAREA        SS          ELCHU       ELCHD
     1.25        1.50        3.00        0.00       82.50        6.00     1014.00        0.67       45.00       45.00

*SECNO 5.000
PRESSURE FLOW

  EGPRS       EGLWC       H3        QWEIR       QPR         BAREA     TRAPEZOID      ELLC        ELTRD
                                                                         AREA
    59.61       58.95       0.37        0.      10000.       1014.       1014.       57.00       60.00


3495 OVERBANK AREA ASSUMED NON-EFFECTIVE,ELLEA=        61.00 ELREA=        61.00

                  BT CARDS DEFINE WEIR PROFILE ONLY ,SINCE PIER IS SPECIFIED THIS
                  SPECIAL BRIDGE CAN NOT REVERT TO A NORMAL BRIDGE
      5.00      14.55      58.55       0.00       0.00      59.61       1.06       0.95       0.00      53.50
    10000.         0.     10000.         0.         0.      1209.         0.       285.        96.      55.00
      0.22       0.00       8.27       0.00      0.060      0.035      0.060      0.000      44.00     600.00
  0.001513        50.        50.        50.          3          0          0       0.00     100.00     700.00

*SECNO 6.000
                  HIGH WATER ELEVATION OF 59.6 (X2.2)
      6.00      14.80      59.50       0.00      59.60      60.08       0.58       0.32       0.15      54.20
    10000.      1087.      7335.      1578.       680.      1042.       886.       296.        98.      55.70
      0.23       1.60       7.04       1.78      0.060      0.035      0.060      0.000      44.70      62.26
  0.001107       250.       250.       250.          3          0          0       0.00     667.77     730.03
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   SECNO      DEPTH      CWSEL      CRIWS      WSELK      EG         HV         HL         OLOSS     BANK ELEV
   Q          QLOB       QCH        QROB       ALOB       ACH        AROB       VOL        TWA     LEFT/RIGHT
   TIME       VLOB       VCH        VROB       XNL        XNCH       XNR        WTN        ELMIN        SSTA
   SLOPE      XLOBL      XLCH       XLOBR      ITRIAL     IDC        ICONT      CORAR      TOPWID       ENDST

CCHV=    0.100 CEHV=    0.300
*SECNO -3.000
START TRIB COMP
     -3.000      3.000     53.016

3265 DIVIDED FLOW

3301 HV CHANGED MORE THAN HVINS

     -3.00     12.22      53.02      49.65       0.00      54.30       1.28       0.00       0.00      50.00
    10000.      317.      9218.       465.       247.       975.       322.       296.        98.      53.00
      0.23      1.28       9.46       1.45      0.060      0.035      0.060      0.000      40.80      83.07
  0.002525        0.         0.         0.          0         14          0       0.00     701.07    1015.63

*SECNO 13.100
 WATER EL=X5 CARD=      54.016

3265 DIVIDED FLOW

               FIRST  TRIBUTARY
     13.10     12.72      54.02       0.00       0.00      55.11       1.09       0.93       0.02      50.50
    10000.      568.      8713.       719.       410.       971.       436.       312.       105.      53.50
      0.24      1.39       8.97       1.65      0.060      0.035      0.060      0.000      41.30      71.00
  0.002153      400.       400.       400.          0          0          0       0.00     736.66     972.15

CCHV=    0.300 CEHV=    0.500
*SECNO 14.000

3495 OVERBANK AREA ASSUMED NON-EFFECTIVE,ELLEA=       58.00 ELREA=       58.00

     14.00     13.35      57.35       0.00       0.00      58.66       1.31       3.44       0.11      53.50
    10000.        0.     10000.         0.         0.      1088.         0.       365.       120.      55.00
      0.29      0.00       9.19       0.00      0.060      0.035      0.060      0.000      44.00     600.00
  0.002147     1600.      1600.      1600.          2          0          0       0.00     100.00     700.00
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   SECNO      DEPTH      CWSEL      CRIWS      WSELK      EG         HV         HL         OLOSS    BANK ELEV
   Q          QLOB       QCH        QROB       ALOB       ACH        AROB       VOL        TWA     LEFT/RIGHT
   TIME       VLOB       VCH        VROB       XNL        XNCH       XNR        WTN        ELMIN       SSTA
   SLOPE      XLOBL      XLCH       XLOBR      ITRIAL     IDC        ICONT      CORAR      TOPWID      ENDST


 SPECIAL BRIDGE

 SB  XK        XKOR       COFQ       RDLEN      BWC        BWP        BAREA      SS         ELCHU      ELCHD
       0.00       1.50       3.00     300.00      76.50       0.00    1014.00       0.67      45.00      45.00

 *SECNO 15.000
 PRESSURE FLOW

  EGPRS      EGLWC        H3        QWEIR       QPR        BAREA     TRAPEZOID     ELLC       ELTRD
                                                                       AREA
     59.61      59.59       0.00         0.     10000.      1014.      1014.      57.00      60.00


 3495 OVERBANK AREA ASSUMED NON-EFFECTIVE,ELLEA=       61.00 ELREA=       61.00

                  WEIR LENGTH  DEFINED BY SB.4, BT CARDS ARE NOT REQUIRED
                  NO PIER DEFINED ON SB CARD,NORMAL BR. TO BE USED FOR LOW FLOW
                  X4 CARDS ARE USED TO ADD PIER TO GR DATA
     15.00      14.38      58.38       0.00       0.00      59.61       1.23       0.95       0.00      53.50
    10000.         0.     10000.         0.         0.      1124.         0.       366.       120.      55.00
      0.29       0.00       8.90       0.00      0.060      0.035      0.060      0.000      44.00     600.00
  0.003690        50.        50.        50.          3          0          0       0.00     100.00     700.00

 *SECNO 16.000

 3301 HV CHANGED MORE THAN HVINS

                  HIGH WATER ELEVATION OF 59.06 (X2.2)
     16.00      15.04      59.74       0.00      59.60      60.26       0.52       0.43       0.21      54.20
    10000.      1167.      7157.      1676.       749.      1064.       955.       378.       123.      55.70
      0.31       1.56       6.73       1.76      0.060      0.035      0.060      0.000      44.70      49.87
  0.000986       250.       250.       250.          3          0          0       0.00     682.03     731.89

 CCHV=    0.100 CEHV=    0.300
 *SECNO -3.000
 START TRIB COMP
      -3.000      3.000      53.016

 3265 DIVIDED FLOW
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29 JUL 82     11:30:50

   SECNO      DEPTH      CWSEL      CRIWS      WSELK      EG         HV         HL         OLOSS    BANK ELEV
   Q          QLOB       QCH        QROB       ALOB       ACH        AROB       VOL        TWA    LEFT/RIGHT
   TIME       VLOB       VCH        VROB       XNL        XNCH       XNR        WTN        ELMIN        SSTA
   SLOPE      XLOBL      XLCH       XLOBR      ITRIAL     IDC        ICONT      CORAR      TOPWID      ENDST


3301 HV CHANGED MORE THAN HVINS

    -3.00      12.22      53.02      49.65       0.00      54.30       1.28       0.00       0.00      50.00
   10000.       317.      9218.       465.       247.       975.       322.       378.       123.      53.00
     0.31       1.28       9.46       1.45      0.060      0.035      0.060      0.000      40.80      83.07
 0.002525         0.         0.         0.          0         14          0       0.00     701.07    1015.63


*SECNO 23.100
 WATER EL=X5 CARD=    54.016

3265 DIVIDED FLOW

               SECOND TRIBUTARY
    23.10      12.72      54.02       0.00       0.00      55.11       1.09       0.93       0.02      50.50
   10000.       568.      8713.       719.       410.       971.       436.       393.       129.      53.50
     0.32       1.39       8.97       1.65      0.060      0.035      0.060      0.000      41.30      71.00
 0.002153       400.       400.       400.          0          0          0       0.00     736.66     972.15


CCHV=   0.300 CEHV=    0.500
*SECNO 24.000

3495 OVERBANK AREA ASSUMED NON-EFFECTIVE,ELLEA=       58.00 ELREA=       58.00

    24.00      13.35      57.35       0.00       0.00      58.66       1.31       3.44       0.11      53.50
   10000.         0.     10000.         0.         0.      1088.         0.       446.       145.      55.00
     0.37       0.00       9.19       0.00      0.060      0.035      0.060      0.000      44.00     600.00
 0.002152      1600.      1600.      1600.          2          0          0       0.00     100.00     700.00


*SECNO 24.100

3370 NORMAL BRIDGE,NRD= 16 MIN ELTRD=    60.00 MAX ELLC=    70.00

               X4 CARD PROVIDES ADDITIONAL GR DATA TO MODEL BRIDGE PIERS
    24.10      13.21      57.21      53.52       0.00      58.81       1.60       0.00       0.15      53.50
   10000.         0.     10000.         0.         0.       984.         0.       446.       145.      55.00
     0.37       0.00      10.16       0.00      0.060      0.035      0.060      0.000      44.00     267.43
 0.010173         1.         1.         1.          4         19          0   -1400.26     676.75     944.19
```

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 SECNO     DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS    BANK ELEV
 Q         QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA     LEFT/RIGHT
 TIME      VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN       SSTA
 SLOPE     XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID      ENDST

*SECNO 24.200

3370 NORMAL BRIDGE,NRD= 16 MIN ELTRD=   60.00 MAX ELLC=   70.00

                 X1 REPEATS GR AND X4 DATA, X2 CARD REPEATS BT DATA
    24.20     13.72     57.72     53.52      0.00     59.32      1.60      0.51      0.00     53.50
   10000.        0.    10000.        0.        0.      984.        0.      448.      145.     55.00
     0.37      0.00     10.16      0.00     0.060     0.035     0.060     0.000     44.00    244.05
 0.010173       50.       50.       50.         4        19         0  -1753.78    707.93    951.98

*SECNO 25.000

3301 HV CHANGED MORE THAN HVINS

3495 OVERBANK AREA ASSUMED NON-EFFECTIVE,ELLEA=       61.00 ELREA=       61.00

    25.00     14.39     58.39      0.00      0.00     59.48      1.09      0.00      0.15     53.50
   10000.        0.    10000.        0.        0.     1194.        0.      448.      145.     55.00
     0.37      0.00      8.38      0.00     0.060     0.035     0.060     0.000     44.00    600.00
 0.001578        1.        1.        1.         2         0         0      0.00    100.00    700.00

*SECNO 26.000
                 HIGH WATER ELEVATION OF 59.6 (X2.2)
    26.00     14.64     59.34      0.00     59.60     59.96      0.62      0.34      0.14     54.20
   10000.     1038.     7451.     1511.      637.     1029.      842.      458.      148.     55.70
     0.38      1.63      7.24      1.79     0.060     0.035     0.060     0.000     44.70     71.79
 0.001194      250.      250.      250.         2         0         0      0.00    657.04    728.83
```

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                                                    THIS RUN EXECUTED 29 JUL 82   11:32:02
**************************************************
  HEC2 RELEASE DATED NOV 76 UPDATED MARC 1982
  ERROR CORR -  01,02,03,04,05
  MODIFICATION -  50,51,52,53,54,55
**************************************************

T1       EXAMPLE 2 SPECIAL AND NORMAL BRIDGE, TRIBUTARY BACKWATER
T2       X2,X3,X4,X5,AND COMMENT CARDS  BRIDGE SUMMARY TABLES 100 AND 105
T3       WOODY CREEK              16000 CFS  PRESSURE AND WEIR FLOW

J1  ICHECK    INQ      NINV     IDIR      STRT    METRIC    HVINS     Q       WSEL     FQ
        0.       6.       0.       0.  0.001600    0.00      0.0       0.    50.000   0.000
J2  NPROF     IPLOT    PRFVS    XSECV    XSECH     FN       ALLDC    IBW     CHNIM    ITRACE
    15.000    0.000   -1.000    0.000    0.000    0.000    0.000    0.000    0.000    0.000
```

```
  SECNO      DEPTH      CWSEL      CRIWS      WSELK      EG         HV         HL         OLOSS    BANK ELEV
  Q          QLOB       QCH        QROB       ALOB       ACH        AROB       VOL        TWA     LEFT/RIGHT
  TIME       VLOB       VCH        VROB       XNL        XNCH       XNR        WTN        ELMIN       SSTA
  SLOPE      XLOBL      XLCH       XLOBR      ITRIAL     IDC        ICONT      CORAR      TOPWID      ENDST

*PROF 3

CCHV=    0.100 CEHV=    0.300
*SECNO 1.000
                X3 CARD UTILIZED TO SPECIFY SEDIMENT ELEVATION (X3.2)
     1.00      12.43      48.43       0.00      50.00      48.92       0.49       0.00       0.00      43.00
   16000.      3382.      8301.      4317.      1406.      1117.      1687.         0.         0.      45.00
     0.00       2.41       7.43       2.56      0.060      0.035      0.060      0.000      36.00     147.07
 0.001598         0.         0.         0.          0          0          4       0.00     947.24    1094.31

*SECNO 2.000
 WATER EL=X5 CARD=    51.200
                X5 CARD UTILIZED TO SPECIFY WATER SURFACE ELEVATIONS
     2.00      13.70      51.20       0.00       0.00      51.79       0.59       2.93       0.03      45.00
   16000.      3917.      8492.      3592.      1502.      1038.      1641.       182.        41.      47.00
     0.10       2.61       8.18       2.19      0.060      0.035      0.060      0.000      37.50      88.00
 0.001506      1700.      1900.      2050.          0          0          0       0.00     952.00    1040.00

*SECNO 3.000

3265 DIVIDED FLOW

3301 HV CHANGED MORE THAN HVINS

                JUNCTION WITH 2 TRIBUTARIES
     3.00      13.75      54.55      54.14       0.00      55.97       1.43       3.93       0.25      50.00
   16000.      1888.     12210.      1902.       919.      1120.       756.       337.        83.      53.00
     0.16       2.05      10.90       2.52      0.060      0.035      0.060      0.000      40.80      57.48
 0.002783      1900.      2000.      1900.          4          8          0       0.00     929.41    1039.25

*SECNO 3.100
 WATER EL=X5 CARD=    55.696
                X5 CARD UTILIZED TO SPECIFY DIFFERENCE IN CWSEL BETWEEN
                SECTIONS 3 AND 3.1
     3.10      14.40      55.70       0.00       0.00      56.79       1.09       0.98       0.03      50.50
   16000.      2555.     11157.      2288.      1228.      1123.       901.       364.        91.      53.50
     0.17       2.08       9.94       2.54      0.060      0.035      0.060      0.000      41.30      46.57
 0.002177       400.       400.       400.          0          0          0       0.00     950.14     996.71
```

```
  SECNO     DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS    BANK ELEV
  Q         QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA     LEFT/RIGHT
  TIME      VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN      SSTA
  SLOPE     XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID     ENDST

CCHV=   0.300 CEHV=    0.500
*SECNO 4.000
                  EFFECTIVE AREA OPTION USED TO CONFINE FLOW TO BRIDGE OPENING
                  UNTIL WEIR FLOW CAN BE EXPECTED (X3.8,X3.9=58)
     4.00    14.98     58.98      0.00      0.00     59.64      0.67      2.73      0.13     53.50
   16000.    3312.    10079.     2609.     1409.     1251.     1067.      493.      122.      55.00
     0.25     2.35      8.05      2.45     0.060     0.035     0.060     0.000     44.00    209.71
 0.001369    1600.     1600.     1600.         2         0         0      0.00    753.72    963.43


SPECIAL BRIDGE

SB  XK         XKOR       COFQ       RDLEN      BWC        BWP        BAREA      SS         ELCHU      ELCHD
     1.25       1.50       3.00       0.00      82.50       6.00    1014.00       0.67      45.00      45.00

*SECNO 5.000
PRESSURE AND WEIR FLOW

 EGPRS       EGLWC       H3         QWEIR       QPR         BAREA     TRAPEZOID       ELLC       ELTRD
                                                                        AREA
    64.78       61.59       0.12       3492.      12443.      1014.      1014.          57.00      60.00

                  BT CARDS DEFINE WEIR PROFILE ONLY ,SINCE PIER IS SPECIFIED THIS
                  SPECIAL BRIDGE CAN NOT REVERT TO A NORMAL BRIDGE
     5.00    18.29     62.29      0.00      0.00     62.48      0.20      2.84      0.00     53.50
   16000.    4802.     7667.     3531.     2850.     1582.     1988.      498.      123.      55.00
     0.25     1.69      4.85      1.78     0.060     0.035     0.060     0.000     44.00    119.48
 0.000363      50.       50.       50.         2         0         2      0.00    874.03    993.51


*SECNO 6.000
                  HIGH WATER ELEVATION OF 59.6 (X2.2)
     6.00    17.59     62.29      0.00     59.60     62.74      0.45      0.13      0.12     54.20
   16000.    3202.     8931.     3867.     1526.     1293.     1725.      530.      128.      55.70
     0.27     2.10      6.91      2.24     0.060     0.035     0.060     0.000     44.70     41.36
 0.000800     250.      250.      250.         2         0         0      0.00    710.68    752.04

CCHV=   0.100 CEHV=    0.300
*SECNO -3.000
START TRIB COMP
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  SECNO     DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS    BANK ELEV
  Q         QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA    LEFT/RIGHT
  TIME      VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN       SSTA
  SLOPE     XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID      ENDST

    -3.000      3.000     54.546

3265 DIVIDED FLOW

3301 HV CHANGED MORE THAN HVINS

    -3.00     13.75     54.55     54.14      0.00     55.98      1.43      0.00      0.00     50.00
   16000.     1883.    12219.     1898.      916.     1120.      754.      530.      128.      53.00
     0.27      2.05     10.91      2.52     0.060     0.035     0.060     0.000     40.80     57.57
 0.002792        0.        0.        0.         0        16         0      0.00    928.61   1039.17

*SECNO 13.100
 WATER EL=X5 CARD=     55.696
                FIRST TRIBUTARY
    13.10     14.40     55.70      0.00      0.00     56.79      1.09      0.98      0.03     50.50
   16000.     2555.    11157.     2288.     1228.     1123.      901.      558.      137.      53.50
     0.28      2.08      9.94      2.54     0.060     0.035     0.060     0.000     41.30     46.57
 0.002177      400.      400.      400.         0         0         0      0.00    950.14    996.71

CCHV=    0.300 CEHV=    0.500
*SECNO 14.000
    14.00     14.98     58.98      0.00      0.00     59.64      0.67      2.73      0.13     53.50
   16000.     3312.    10079.     2609.     1409.     1251.     1067.      686.      168.      55.00
     0.35      2.35      8.05      2.45     0.060     0.035     0.060     0.000     44.00    209.71
 0.001369     1600.     1600.     1600.         2         0         0      0.00    753.72    963.43

SPECIAL BRIDGE

SB   XK         XKOR       COFQ      RDLEN       BWC        BWP       BAREA      SS        ELCHU      ELCHD
     0.00       1.50       3.00     300.00      76.50       0.00    1014.00      0.67      45.00      45.00

*SECNO 15.000

3301 HV CHANGED MORE THAN HVINS

PRESSURE AND WEIR FLOW
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   SECNO     DEPTH     CWSEL     CRIWS     WSELK      EG        HV        HL       OLOSS    BANK ELEV
   Q         QLOB      QCH       QROB      ALOB       ACH       AROB      VOL      TWA     LEFT/RIGHT
   TIME      VLOB      VCH       VROB      XNL        XNCH      XNR       WTN      ELMIN       SSTA
   SLOPE     XLOBL     XLCH      XLOBR     ITRIAL     IDC       ICONT     CORAR    TOPWID      ENDST

  EGPRS      EGLWC       H3       QWEIR       QPR       BAREA   TRAPEZOID    ELLC      ELTRD
                                                                  AREA
    64.78      62.39      0.00     3538.     12454.     1014.     1014.      57.00     60.00

               WEIR LENGTH  DEFINED BY SB.4, BT CARDS ARE NOT REQUIRED
               NO PIER DEFINED ON SB CARD,NORMAL BR. TO BE USED FOR LOW FLOW
               X4 CARDS ARE USED TO ADD PIER TO GR DATA
     15.00     18.36     62.36      0.00      0.00     62.49      0.13      2.85      0.00     53.50
   16000.      5720.     6079.     4201.     2884.     1521.     2009.      692.      169.      55.00
      0.36      1.98      4.00      2.09     0.060     0.035     0.060     0.000     44.00    117.54
  0.000497       50.       50.       50.         2         0         2      0.00    876.61    994.15

*SECNO 16.000
               HIGH WATER ELEVATION OF 59.06 (X2.2)
     16.00     17.66     62.36      0.00     59.60     62.79      0.43      0.15      0.15     54.20
   16000.      3229.     8881.     3890.     1547.     1299.     1747.      723.      173.      55.70
      0.37      2.09      6.83      2.23     0.060     0.035     0.060     0.000     44.70     41.13
  0.000779      250.      250.      250.         2         0         0      0.00    711.45    752.58

CCHV=     0.100 CEHV=     0.300
*SECNO -3.000
START TRIB COMP
     -3.000      3.000     54.546

3265 DIVIDED FLOW

3301 HV CHANGED MORE THAN HVINS

     -3.00     13.75     54.55     54.14      0.00     55.98      1.43      0.00      0.00     50.00
   16000.      1883.    12219.     1898.      916.     1120.      754.      723.      173.      53.00
      0.37      2.05     10.91      2.52     0.060     0.035     0.060     0.000     40.80     57.57
  0.002792        0.        0.        0.         0        16         0      0.00    928.61   1039.17

*SECNO 23.100
 WATER EL=X5 CARD=     55.696
               SECOND TRIBUTARY
     23.10     14.40     55.70      0.00      0.00     56.79      1.09      0.98      0.03     50.50
   16000.      2555.    11157.     2288.     1228.     1123.      901.      751.      182.      53.50
      0.39      2.08      9.94      2.54     0.060     0.035     0.060     0.000     41.30     46.57
  0.002177      400.      400.      400.         0         0         0      0.00    950.14    996.71
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29 JUL 82    11:30:50

   SECNO      DEPTH      CWSEL      CRIWS      WSELK      EG         HV         HL         OLOSS     BANK ELEV
   Q          QLOB       QCH        QROB       ALOB       ACH        AROB       VOL        TWA     LEFT/RIGHT
   TIME       VLOB       VCH        VROB       XNL        XNCH       XNR        WTN        ELMIN        SSTA
   SLOPE      XLOBL      XLCH       XLOBR      ITRIAL     IDC        ICONT      CORAR      TOPWID       ENDST

CCHV=    0.300 CEHV=    0.500
*SECNO 24.000
    24.00      14.98      58.98       0.00       0.00      59.65       0.67       2.73       0.13      53.50
   16000.      3316.     10071.      2612.      1410.      1251.      1067.       879.       213.      55.00
     0.46       2.35       8.05       2.45      0.060      0.035      0.060      0.000      44.00     209.65
 0.001371      1600.      1600.      1600.          2          0          0       0.00     753.80     963.45

*SECNO 24.100

3301 HV CHANGED MORE THAN HVINS

3370 NORMAL BRIDGE,NRD= 16 MIN ELTRD=    60.00 MAX ELLC=    70.00

              X4 CARD PROVIDES ADDITIONAL GR DATA TO MODEL BRIDGE PIERS
    24.10      13.26      57.26      56.43       0.00      61.37       4.10       0.00       1.72      53.50
   16000.         0.     16000.         0.         0.       984.         0.       879.       213.      55.00
     0.46       0.00      16.26       0.00      0.060      0.035      0.060      0.000      44.00     264.16
 0.026042         1.         1.         1.          4         12          0   -1437.32     681.12     945.28

*SECNO 24.200

3370 NORMAL BRIDGE,NRD= 16 MIN ELTRD=    60.00 MAX ELLC=    70.00

              X1 REPEATS GR AND X4 DATA, X2 CARD REPEATS BT DATA
    24.20      14.57      58.57      56.43       0.00      62.67       4.10       1.30       0.00      53.50
   16000.         0.     16000.         0.         0.       984.         0.       880.       214.      55.00
     0.46       0.00      16.26       0.00      0.060      0.035      0.060      0.000      44.00     220.92
 0.026042        50.        50.        50.          4         12          0   -2367.22     738.77     959.69

*SECNO 25.000

3301 HV CHANGED MORE THAN HVINS

    25.00      19.73      63.73       0.00       0.00      63.86       0.13       0.00       1.19      53.50
   16000.      5259.      6974.      3767.      3570.      1727.      2423.       880.       214.      55.00
     0.46       1.47       4.04       1.55      0.060      0.035      0.060      0.000      44.00      89.55
 0.000224         1.         1.         1.          5          0          0       0.00     920.91    1010.45
```

```
 SECNO     DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS    BANK ELEV
 Q         QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA     LEFT/RIGHT
 TIME      VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN       SSTA
 SLOPE     XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID      ENDST

*SECNO 26.000
               HIGH WATER ELEVATION OF 59.6 (X2.2)
    26.00     19.04     63.74      0.00     59.60     64.01      0.27      0.08      0.07     54.20
   16000.     3707.     8003.     4290.     1979.     1424.     2188.      919.      219.     55.70
     0.48      1.87      5.62      1.96     0.060     0.035     0.060     0.000     44.70     36.51
 0.000466      250.      250.      250.         2         0         0      0.00    727.03    763.53
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THIS RUN EXECUTED 29 JUL 82 11:32:22

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**************************************************
 HEC2 RELEASE DATED NOV 76 UPDATED MARC 1982
 ERROR CORR -  01,02,03,04,05
 MODIFICATION -  50,51,52,53,54,55
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NOTE- ASTERISK (*) AT LEFT OF CROSS-SECTION NUMBER INDICATES MESSAGE IN SUMMARY OF ERRORS LIST

WOODY CREEK

SUMMARY PRINTOUT TABLE 100

SECNO	EGLWC	ELLC	EGPRS	ELTRD	QPR	QWEIR	CLASS	H3	DEPTH	CWSEL	VCH	EG
5.000	55.96	57.00	0.00	60.00	6000.00	0.00	1.00	0.18	11.24	55.24	6.84	55.96
5.000	58.95	57.00	59.61	60.00	10000.00	0.00	10.00	0.37	14.55	58.55	8.27	59.61
5.000	61.59	57.00	64.78	60.00	12442.84	3492.10	30.00	0.12	18.29	62.29	4.85	62.48
15.000	56.75	57.00	0.00	60.00	6000.00	0.00	59.00	0.00	11.13	55.13	7.42	55.98
15.000	59.59	57.00	59.61	60.00	10000.00	0.00	10.00	0.00	14.38	58.38	8.90	59.61
15.000	62.39	57.00	64.78	60.00	12454.19	3537.53	30.00	0.00	18.36	62.36	4.00	62.49

WOODY CREEK

SUMMARY PRINTOUT TABLE 105

	SECNO	CWSEL	HL	OLOSS	TOPWID	QLOB	QCH	QROB
*	3.100	51.81	0.82	0.02	174.18	17.48	5979.81	2.71
*	3.100	54.02	0.93	0.02	736.66	567.82	8713.23	718.94
*	3.100	55.70	0.98	0.03	950.14	2554.55	11157.46	2287.99
	4.000	55.06	3.03	0.05	100.00	0.00	6000.00	0.00
	4.000	57.35	3.44	0.11	100.00	0.00	10000.00	0.00
	4.000	58.98	2.73	0.13	753.72	3311.76	10079.42	2608.82
	5.000	55.24	0.15	0.00	100.00	0.00	6000.00	0.00
	5.000	58.55	0.95	0.00	100.00	0.00	10000.00	0.00
	5.000	62.29	2.84	0.00	874.03	4802.09	7667.22	3530.70
	6.000	55.54	0.53	0.22	134.36	30.94	5969.06	0.00
	6.000	59.50	0.32	0.15	667.77	1087.49	7334.53	1577.98
	6.000	62.29	0.13	0.12	710.68	3201.85	8931.07	3867.08
*	13.100	51.81	0.82	0.02	174.18	17.48	5979.81	2.71
*	13.100	54.02	0.93	0.02	736.66	567.82	8713.23	718.94
*	13.100	55.70	0.98	0.03	950.14	2554.55	11157.46	2287.99
	14.000	55.06	3.03	0.05	100.00	0.00	6000.00	0.00
	14.000	57.35	3.44	0.11	100.00	0.00	10000.00	0.00
	14.000	58.98	2.73	0.13	753.72	3311.76	10079.43	2608.81
	15.000	55.13	0.12	0.05	94.20	0.00	6000.00	0.00
	15.000	58.38	0.95	0.00	100.00	0.00	10000.00	0.00
	15.000	62.36	2.85	0.00	876.61	5720.42	6078.84	4200.74
	16.000	55.77	0.75	0.11	218.86	45.97	5920.81	33.21
	16.000	59.74	0.43	0.21	682.03	1166.80	7156.73	1676.47
	16.000	62.36	0.15	0.15	711.45	3229.03	8880.98	3889.99

SUMMARY OF ERRORS AND SPECIAL NOTES

```
NOTE    SECNO=    2.000  PROFILE= 1  WSEL BASED ON X5 CARD
NOTE    SECNO=    2.000  PROFILE= 2  WSEL BASED ON X5 CARD
NOTE    SECNO=    2.000  PROFILE= 3  WSEL BASED ON X5 CARD

NOTE    SECNO=    3.100  PROFILE= 1  WSEL BASED ON X5 CARD
NOTE    SECNO=    3.100  PROFILE= 2  WSEL BASED ON X5 CARD
NOTE    SECNO=    3.100  PROFILE= 3  WSEL BASED ON X5 CARD

NOTE    SECNO=   13.100  PROFILE= 1  WSEL BASED ON X5 CARD
NOTE    SECNO=   13.100  PROFILE= 2  WSEL BASED ON X5 CARD
NOTE    SECNO=   13.100  PROFILE= 3  WSEL BASED ON X5 CARD

NOTE    SECNO=   23.100  PROFILE= 1  WSEL BASED ON X5 CARD
NOTE    SECNO=   23.100  PROFILE= 2  WSEL BASED ON X5 CARD
NOTE    SECNO=   23.100  PROFILE= 3  WSEL BASED ON X5 CARD
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                                                              THIS RUN EXECUTED 29 JUL 82    9:37:56
**************************************************
  HEC2 RELEASE DATED NOV 76 UPDATED MARC 1982
  ERROR CORR -  01,02,03,04,05
  MODIFICATION -  50,51,52,53,54,55
**************************************************

T1      EXAMPLE 3  CHANNEL IMPROVEMENT OPTION
T2      NATURAL CHANNEL     NO IMPROVEMENT
T3      RABBIT CREEK

J1  ICHECK     INQ      NINV      IDIR      STRT      METRIC     HVINS      Q        WSEL      FQ

       0.       4.        0.        0.  0.000000      0.00       0.0       0.   689.300    0.000

J2  NPROF     IPLOT     PRFVS     XSECV     XSECH       FN      ALLDC      IBW      CHNIM     ITRACE

     1.000     0.000    -1.000     0.000     0.000     0.000     0.000     0.000     0.000     0.000

J3  VARIABLE CODES FOR SUMMARY PRINTOUT

   120.000     0.000     0.000     0.000     0.000     0.000     0.000     0.000     0.000     0.000

NC      0.120      0.120      0.055      0.100      0.300      0.000      0.000      0.000      0.000      0.000
QT      5.000   1910.000   5700.000   8000.000  12500.000  22000.000      0.000      0.000      0.000      0.000
X1      1.000     23.000    460.000    508.000      0.000      0.000      0.000      0.000      0.000      0.000
GR    712.000      0.000    708.000     10.000    703.200     28.000    701.200     35.000    699.200     42.000
GR    697.200     57.000    695.200     71.000    693.200    110.000    691.200    150.000    691.000    400.000
GR    689.200    460.000    681.200    470.000    681.200    495.000    689.200    508.000    691.200    512.000
GR    693.200    530.000    695.200    563.000    697.200    570.000    699.200    580.000    701.200    595.000
GR    703.200    601.000    709.000    612.000    712.000    630.000      0.000      0.000      0.000      0.000

X1      2.000     22.000    245.000    285.000   3000.000   3000.000   3800.000      0.000      0.000      0.000
CI     -1.000     -1.000      0.025      2.000      2.000      0.000    -20.000     40.000      0.000      0.000
GR    713.000      0.000    709.200     20.000    705.200     35.000    703.200     50.000    701.200     63.000
GR    699.200     75.000    697.200     90.000    695.200    130.000    695.200    240.000    693.200    245.000
GR    685.000    250.000    685.000    280.000    693.200    285.000    695.200    292.000    695.200    410.000
GR    697.200    457.000    699.200    500.000    701.200    510.000    703.200    535.000    705.200    560.000
GR    708.700    573.000    713.000    590.000      0.000      0.000      0.000      0.000      0.000      0.000

X1      3.000     19.000    115.000    150.000   1000.000   1500.000   1400.000      0.000      0.000      0.000
CI     -1.000     -1.000      0.025      2.000      2.000      0.000    -20.000     40.000      0.000      0.000
GR    714.000      0.000    710.100     23.000    706.700     36.000    705.200     48.000    703.200     64.000
GR    701.200     76.000    699.200     92.000    689.200    115.000    686.000    116.000    686.000    136.000
GR    689.200    140.000    691.200    145.000    693.200    150.000    695.200    160.000    695.200    360.000
GR    697.200    370.000    699.200    375.000    709.200    395.000    714.200    410.000      0.000      0.000
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X1	4.000	22.000	193.000	233.000	1600.000	1600.000	1850.000	0.000	0.000	0.000
CI	-1.000	-1.000	0.025	2.000	2.000	0.000	-20.000	40.000	0.000	0.000
GR	715.000	0.000	709.200	25.000	707.200	31.000	705.200	40.000	703.200	50.000
GR	701.200	61.000	699.200	87.000	697.200	180.000	693.200	193.000	688.000	198.000
GR	688.000	228.000	693.200	233.000	695.200	245.000	697.200	250.000	697.200	290.000
GR	699.200	310.000	701.200	370.000	703.200	410.000	705.200	445.000	707.200	465.000
GR	709.200	500.000	715.200	512.000	0.000	0.000	0.000	0.000	0.000	0.000
X1	5.000	0.000	0.000	0.000	50.000	50.000	50.000	0.000	0.000	0.000
X1	6.000	0.000	0.000	0.000	110.000	110.000	110.000	0.000	0.200	0.000
X1	7.000	22.000	95.000	145.000	2800.000	2800.000	3040.000	0.000	0.000	0.000
CI	-1.000	-1.000	0.025	2.000	2.000	0.000	-20.000	40.000	0.000	0.000
GR	720.200	0.000	719.200	22.000	717.200	30.000	715.200	40.000	713.200	50.000
GR	711.200	58.000	709.200	70.000	699.200	95.000	693.000	105.000	693.000	135.000
GR	699.200	145.000	701.200	150.000	701.200	220.000	703.200	240.000	705.200	255.000
GR	707.200	270.000	709.200	290.000	711.200	310.000	713.200	325.000	715.200	350.000
GR	717.200	370.000	719.200	390.000	0.000	0.000	0.000	0.000	0.000	0.000
X1	8.000	0.000	0.000	0.000	650.000	650.000	650.000	0.000	3.000	0.000
CI	0.000	0.000	0.000	0.000	0.000	0.000	0.010	0.010	0.000	0.000
EJ	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

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   SECNO      DEPTH      CWSEL      CRIWS      WSELK      EG         HV         HL         OLOSS     BANK ELEV
   Q          QLOB       QCH        QROB       ALOB       ACH        AROB       VOL        TWA     LEFT/RIGHT
   TIME       VLOB       VCH        VROB       XNL        XNCH       XNR        WTN        ELMIN         SSTA
   SLOPE      XLOBL      XLCH       XLOBR      ITRIAL     IDC        ICONT      CORAR      TOPWID       ENDST

*PROF  1

CCHV=    0.100 CEHV=    0.300
*SECNO 1.000
3720 CRITICAL DEPTH ASSUMED
     1.00     12.22     693.42     693.42     689.30     695.18       1.76      0.00       0.00     689.20
    8000.     1911.      6025.        64.       829.       495.        35.        0.         0.      689.20
     0.00      2.31      12.18       1.83      0.120      0.055      0.120     0.000     681.20     105.71
 0.010365        0.         0.         0.          0         10          0      0.00     427.93     533.63

*SECNO 2.000

3301 HV CHANGED MORE THAN HVINS

     2.00     18.36     703.36       0.00       0.00     703.55       0.19      8.22       0.16     693.20
    8000.     2064.      3490.      2446.      1360.       693.      1646.      185.        32.      693.20
     0.32      1.52       5.03       1.49      0.120      0.055      0.120     0.000     685.00      48.81
 0.001020     3000.      3800.      3000.          7          0          0      0.00     488.16     536.98

*SECNO 3.000
     3.00     18.81     704.81       0.00       0.00     705.04       0.24      1.48       0.01     689.20
    8000.      579.      3357.      4065.       360.       598.      2179.      291.        45.      693.20
     0.43      1.61       5.61       1.87      0.120      0.055      0.120     0.000     686.00      51.11
 0.001140     1000.      1400.      1500.          3          0          0      0.00     335.12     386.22

*SECNO 4.000
     4.00     18.65     706.65       0.00       0.00     706.90       0.26      1.85       0.01     693.20
    8000.     1879.      3984.      2137.      1179.       719.      1407.      414.        59.      693.20
     0.56      1.59       5.54       1.52      0.120      0.055      0.120     0.000     688.00      33.53
 0.001025     1600.      1850.      1600.          1          0          0      0.00     425.84     459.37

*SECNO 5.000
     5.00     18.70     706.70       0.00       0.00     706.95       0.25      0.05       0.00     693.20
    8000.     1885.      3968.      2147.      1189.       722.      1421.      417.        60.      693.20
     0.57      1.59       5.50       1.51      0.120      0.055      0.120     0.000     688.00      33.25
 0.001005       50.        50.        50.          0          0          0      0.00     426.75     460.00
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29 JUL 82 9:37:55

SECNO Q TIME SLOPE	DEPTH QLOB VLOB XLOBL	CWSEL QCH VCH XLCH	CRIWS QROB VROB XLOBR	WSELK ALOB XNL ITRIAL	EG ACH XNCH IDC	HV AROB XNR ICONT	HL VOL WTN CORAR	OLOSS TWA ELMIN TOPWID	BANK ELEV LEFT/RIGHT SSTA ENDST
*SECNO 6.000									
6.00	18.61	706.81	0.00	0.00	707.07	0.26	0.11	0.00	693.40
8000.	1877.	3990.	2134.	1175.	719.	1402.	426.	61.	693.40
0.58	1.60	5.55	1.52	0.120	0.055	0.120	0.000	688.20	33.64
0.001033	110.	110.	110.	0	0	0	0.00	425.49	459.13
*SECNO 7.000									
7.00	17.46	710.46	0.00	0.00	710.98	0.52	3.84	0.08	699.20
8000.	260.	5530.	2210.	161.	811.	1076.	602.	82.	699.20
0.73	1.61	6.82	2.05	0.120	0.055	0.120	0.000	693.00	62.43
0.001698	2800.	3040.	2800.	2	0	0	0.00	240.19	302.62
*SECNO 8.000									
8.00	15.68	711.68	0.00	0.00	712.47	0.79	1.41	0.08	702.20
8000.	199.	5898.	1902.	112.	722.	811.	629.	86.	702.20
0.76	1.77	8.17	2.34	0.120	0.055	0.120	0.000	696.00	71:29
0.002846	650.	650.	650.	2	0	0	0.00	213.53	284.83

THIS RUN EXECUTED 29 JUL 82 9:38:03

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**************************************************
  HEC2 RELEASE DATED NOV 76 UPDATED MARC 1982
  ERROR CORR -  01,02,03,04,05
  MODIFICATION -  50,51,52,53,54,55
**************************************************

T1      EXAMPLE 3  CHANNEL IMPROVEMENT OPTION
T2      FILL CHANNEL PRIOR TO EXCAVATION  CI.7=-20
T3      RABBIT ^REEK

J1  ICHECK    INQ     NINV     IDIR     STRT     METRIC   HVINS    Q        WSEL     FQ
      0.       4.      0.       0.  0.000000   0.00     0.0      0.     689.300   0.000

J2  NPROF     IPLOT   PRFVS    XSECV    XSECH    FN       ALLDC    IBW      CHNIM    ITRACE
     2.000    0.000   -1.000   0.000    0.000    0.000    0.000    7.000    0.000    0.000
```

```
   SECNO      DEPTH      CWSEL      CRIWS      WSELK      EG         HV         HL         OLOSS    BANK ELEV
   Q          QLOB       QCH        QROB       ALOB       ACH        AROB       VOL        TWA    LEFT/RIGHT
   TIME       VLOB       VCH        VROB       XNL        XNCH       XNR        WTN        ELMIN        SSTA
   SLOPE      XLOBL      XLCH       XLOBR      ITRIAL     IDC        ICONT      CORAR      TOPWID      ENDST

*PROF 2

CCHV=    0.100 CEHV=    0.300
*SECNO 1.000
3720 CRITICAL DEPTH ASSUMED
     1.00      12.22     693.42     693.42     689.30     695.18       1.76       0.00       0.00     689.20
    8000.      1911.      6025.        64.       829.       495.        35.         0.         0.     689.20
     0.00       2.31      12.18       1.83      0.120      0.055      0.120      0.000     681.20     105.71
 0.010365         0.         0.         0.          0         10          0       0.00     427.93     533.63

*SECNO 2.000
CHIMP CLSTA=      265.00 CELCH=      685.00 BW=      20.00 STCHL=      234.60 STCHR=      295.40
EXCAVATION DATA        AEX=       33.SQ-FT       VEXR=          0.K*CU-YD        VEXT=         0.K*CU-YD

3301 HV CHANGED MORE THAN HVINS

     2.00      15.93     700.93       0.00       0.00     701.73       0.80       6.46       0.10     695.20
    8000.       840.      6180.       980.       839.       761.      1004.       148.        31.     695.20
     0.15       1.00       8.12       0.98      0.120      0.025      0.120      0.000     685.00      64.61
 0.000712      3000.      3800.      3000.          7          0          0       0.00     444.06     508.66

*SECNO 3.000
CHIMP CLSTA=      132.50 CELCH=      686.00 BW=      20.00 STCHL=      115.00 STCHR=      160.90
EXCAVATION DATA        AEX=       52.SQ-FT       VEXR=          2.K*CU-YD        VEXT=         2.K*CU-YD

     3.00      15.83     701.83       0.00       0.00     702.89       1.06       1.08       0.08     689.20
    8000.       245.      5989.      1765.       203.       628.      1401.       224.        43.     695.20
     0.21       1.21       9.54       1.26      0.120      0.025      0.120      0.000     686.00      72.24
 0.000854      1000.      1400.      1500.          3          0          0       0.00     308.01     380.25

*SECNO 4.000
CHIMP CLSTA=      213.00 CELCH=      688.00 BW=      20.00 STCHL=      191.96 STCHR=      233.60
EXCAVATION DATA        AEX=      -24.SQ-FT       VEXR=          1.K*CU-YD        VEXT=         3.K*CU-YD

     4.00      15.27     703.27       0.00       0.00     704.75       1.49       1.74       0.13     693.52
    8000.       798.      6335.       867.       657.       577.       709.       304.        55.     693.30
     0.26       1.21      10.98       1.22      0.120      0.025      0.120      0.000     688.00      49.66
 0.001109      1600.      1850.      1600.          2          0          0       0.00     361.51     411.17
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   SECNO      DEPTH      CWSEL      CRIWS      WSELK      EG         HV         HL         OLOSS      BANK ELEV
   Q          QLOB       QCH        QROB       ALOB       ACH        AROB       VOL        TWA      LEFT/RIGHT
   TIME       VLOB       VCH        VROB       XNL        XNCH       XNR        WTN        ELMIN        SSTA
   SLOPE      XLOBL      XLCH       XLOBR      ITRIAL     IDC        ICONT      CORAR      TOPWID       ENDST

*SECNO 5.000
CHIMP CLSTA=     213.00 CELCH=     688.00 BW=       20.00 STCHL=     191.96 STCHR=     233.60
EXCAVATION DATA        AEX=      -24.SQ-FT      VEXR=        -0.K*CU-YD       VEXT=        3.K*CU-YD

      5.00      15.37     703.37       0.00       0.00     704.81       1.45       0.05       0.00     693.52
     8000.       811.      6307.       882.       671.       581.       726.       306.        56.     693.30
      0.26       1.21      10.85       1.21      0.120      0.025      0.120      0.000     688.00      49.17
  0.001073        50.        50.        50.          2          0          0       0.00     363.73     412.90

*SECNO 6.000
CHIMP CLSTA=     213.00 CELCH=     688.20 BW=       20.00 STCHL=     191.96 STCHR=     233.60
EXCAVATION DATA        AEX=      -24.SQ-FT      VEXR=        -0.K*CU-YD       VEXT=        3.K*CU-YD

      6.00      15.25     703.45       0.00       0.00     704.95       1.49       0.12       0.01     693.72
     8000.       796.      6339.       865.       655.       577.       707.       311.        57.     693.50
      0.27       1.21      10.99       1.22      0.120      0.025      0.120      0.000     688.20      49.73
  0.001113       110.       110.       110.          2          0          0       0.00     361.21     410.94

*SECNO 7.000
CHIMP CLSTA=     120.00 CELCH=     693.00 BW=       20.00 STCHL=      95.00 STCHR=     145.00
EXCAVATION DATA        AEX=      -47.SQ-FT      VEXR=        -4.K*CU-YD       VEXT=       -1.K*CU-YD

      7.00      14.10     707.10       0.00       0.00     708.98       1.89       3.92       0.12     699.20
     8000.        90.      7008.       902.        78.       596.       602.       417.        75.     699.20
      0.35       1.16      11.76       1.50      0.120      0.025      0.120      0.000     693.00      75.26
  0.001553      2800.      3040.      2800.          2          0          0       0.00     193.96     269.22

*SECNO 8.000

3301 HV CHANGED MORE THAN HVINS

      8.00      11.63     707.63     706.87       0.00     710.66       3.02       1.33       0.34     702.20
     8000.        45.      7493.       461.        37.       520.       319.       434.        77.     702.20
      0.36       1.22      14.41       1.44      0.120      0.025      0.120      0.000     696.00      81.40
  0.002837       650.       650.       650.          4         15          0       0.00     169.38     250.79
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THIS RUN EXECUTED 29 JUL 82   9:38:10

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**************************************************
 HEC2 RELEASE DATED NOV 76 UPDATED MARC 1982
 ERROR CORR -  01,02,03,04,05
 MODIFICATION -  50,51,52,53,54,55
**************************************************

T1      EXAMPLE 3  CHANNEL IMPROVEMENT OPTION
T2
T3      RABBIT CREEK              40 FOOT BOTTOM WIDTH SPECIFIED (CI.8)
J1  ICHECK    INQ      NINV     IDIR     STRT     METRIC   HVINS    Q        WSEL     FQ
       0.       4.       0.       0.  0.000000    0.00     0.0       0.  689.300   0.000
J2  NPROF     IPLOT    PRFVS    XSECV    XSECH    FN       ALLDC    IBW      CHNIM    ITRACE
    15.000    0.000   -1.000    0.000    0.000    0.000    0.000    8.000    0.000    0.000
```

```
  SECNO      DEPTH      CWSEL      CRIWS      WSELK      EG         HV         HL         OLOSS    BANK ELEV
  Q          QLOB       QCH        QROB       ALOB       ACH        AROB       VOL        TWA    LEFT/RIGHT
  TIME       VLOB       VCH        VROB       XNL        XNCH       XNR        WTN        ELMIN        SSTA
  SLOPE      XLOBL      XLCH       XLOBR      ITRIAL     IDC        ICONT      CORAR      TOPWID      ENDST

*PROF 3

CCHV=    0.100 CEHV=    0.300
*SECNO 1.000
3720 CRITICAL DEPTH ASSUMED
     1.00      12.22     693.42     693.42     689.30     695.18       1.76       0.00       0.00     689.20
    8000.      1911.      6025.        64.       829.       495.        35.         0.         0.     689.20
     0.00       2.31      12.18       1.83      0.120      0.055      0.120      0.000     681.20     105.71
 0.010365         0.         0.         0.          0         10          0       0.00     427.93     533.63

*SECNO 2.000
CHIMP CLSTA=     265.00 CELCH=     685.00 BW=      40.00 STCHL=     224.60 STCHR=     305.40
EXCAVATION DATA       AEX=     237.SQ-FT      VEXR=         0.K*CU-YD        VEXT=         0.K*CU-YD

3301 HV CHANGED MORE THAN HVINS

     2.00      14.84     699.84       0.00       0.00     700.52       0.68       5.23       0.11     695.20
    8000.       460.      7007.       533.       610.       991.       727.       141.        31.     695.20
     0.16       0.75       7.07       0.73      0.120      0.025      0.120      0.000     685.00      71.18
 0.000541      3000.      3800.      3000.          6          0          0       0.00     432.01     503.18

*SECNO 3.000
CHIMP CLSTA=     132.50 CELCH=     686.00 BW=      40.00 STCHL=      84.13 STCHR=     170.90
EXCAVATION DATA       AEX=     253.SQ-FT      VEXR=        13.K*CU-YD        VEXT=        13.K*CU-YD

     3.00      14.63     700.63       0.00       0.00     701.32       0.69       0.80       0.00     700.18
    8000.         0.      6987.      1013.         1.       984.      1086.       211.        42.     695.20
     0.22       0.11       7.10       0.93      0.120      0.025      0.120      0.000     686.00      80.52
 0.000608      1000.      1400.      1500.          3          0          0       0.00     297.35     377.87

*SECNO 4.000
CHIMP CLSTA=     213.00 CELCH=     688.00 BW=      40.00 STCHL=     174.36 STCHR=     251.40
EXCAVATION DATA       AEX=     129.SQ-FT      VEXR=        13.K*CU-YD        VEXT=        26.K*CU-YD

     4.00      13.69     701.69       0.00       0.00     702.72       1.04       1.30       0.11     697.32
    8000.       263.      7468.       269.       339.       883.       334.       283.        54.     697.20
     0.29       0.78       8.46       0.80      0.120      0.025      0.120      0.000     688.00      58.33
 0.000844      1600.      1850.      1600.          2          0          0       0.00     321.40     379.73
```

```
    SECNO      DEPTH      CWSEL      CRIWS      WSELK      EG         HV         HL         OLOSS    BANK ELEV
    Q          QLOB       QCH        QROB       ALOB       ACH        AROB       VOL        TWA     LEFT/RIGHT
    TIME       VLOB       VCH        VROB       XNL        XNCH       XNR        WTN        ELMIN       SSTA
    SLOPE      XLOBL      XLCH       XLOBR      ITRIAL     IDC        ICONT      CORAR      TOPWID      ENDST

  *SECNO 5.000
  CHIMP CLSTA=     213.00 CELCH=     688.00 BW=      40.00 STCHL=     174.36 STCHR=     251.40
  EXCAVATION DATA       AEX=     129.SQ-FT      VEXR=        0.K*CU-YD      VEXT=      26.K*CU-YD

      5.00     13.74     701.74       0.00       0.00     702.77       1.02       0.04       0.00     697.32
     8000.      268.      7457.       274.       345.       887.       342.       284.        54.     697.20
      0.29      0.78       8.40       0.80      0.120      0.025      0.120      0.000     688.00      58.01
  0.000827       50.        50.        50.          2          0          0       0.00     322.89     380.89

  *SECNO 6.000
  CHIMP CLSTA=     213.00 CELCH=     688.20 BW=      40.00 STCHL=     174.36 STCHR=     251.40
  EXCAVATION DATA       AEX=     129.SQ-FT      VEXR=        1.K*CU-YD      VEXT=      27.K*CU-YD

      6.00     13.61     701.81       0.00       0.00     702.87       1.06       0.09       0.01     697.52
     8000.      256.      7482.       262.       330.       877.       325.       288.        55.     697.40
      0.29      0.77       8.53       0.81      0.120      0.025      0.120      0.000     688.20      58.72
  0.000865      110.       110.       110.          2          0          0       0.00     319.55     378.28

  *SECNO 7.000
  CHIMP CLSTA=     120.00 CELCH=     693.00 BW=      40.00 STCHL=      66.40 STCHR=     156.40
  EXCAVATION DATA       AEX=     140.SQ-FT      VEXR=       15.K*CU-YD      VEXT=      42.K*CU-YD

      7.00     11.96     704.96       0.00       0.00     706.51       1.54       3.49       0.15     709.80
     8000.        0.      7652.       348.         0.       751.       306.       376.        72.     701.20
      0.38      0.00      10.19       1.13      0.120      0.025      0.120      0.000     693.00      76.07
  0.001613     2800.      3040.      2800.          2          0          0       0.00     177.17     253.24

  *SECNO 8.000

  3301 HV CHANGED MORE THAN HVINS

  3685 20 TRIALS ATTEMPTED WSEL,CWSEL
  3693 PROBABLE MINIMUM SPECIFIC ENERGY
  3720 CRITICAL DEPTH ASSUMED
      8.00     10.87     706.87     706.87       0.00     710.58       3.71       1.54       0.65     702.20
     8000.       35.      7622.       343.        27.       482.       241.       389.        74.     702.20
      0.39      1.28      15.82       1.42      0.120      0.025      0.120      0.000     696.00      83.31
  0.003786      650.       650.       650.         20         11          0       0.00     161.74     245.06
```

THIS RUN EXECUTED 29 JUL 82   9:38:17

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**************************************************
 HEC2 RELEASE DATED NOV 76 UPDATED MARC 1982
 ERROR CORR -  01,02,03,04,05
 MODIFICATION -  50,51,52,53,54,55
**************************************************
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NOTE- ASTERISK (*) AT LEFT OF CROSS-SECTION NUMBER INDICATES MESSAGE IN SUMMARY OF ERRORS LIST

RABBIT CREEK

SUMMARY PRINTOUT TABLE 120

	SECNO	CWSEL	EG	VCH	10K*S	DEPTH	TOPWID	CLSTA	BW	STCHL	XLBEL	STCHR	RBEL
*	1.000	693.42	695.18	12.18	103.65	12.22	427.93	0.00	0.01	460.00	689.20	508.00	689.20
*	1.000	693.42	695.18	12.18	103.65	12.22	427.93	0.00	0.01	460.00	689.20	508.00	689.20
*	1.000	693.42	695.18	12.18	103.65	12.22	427.93	0.00	0.01	460.00	689.20	508.00	689.20
	2.000	703.36	703.55	5.03	10.20	18.36	488.16	0.00	0.01	245.00	693.20	285.00	693.20
	2.000	700.93	701.73	8.12	7.12	15.93	444.06	265.00	20.00	234.60	695.20	295.40	695.20
	2.000	699.84	700.52	7.07	5.41	14.84	432.01	265.00	40.00	224.60	695.20	305.40	695.20
	3.000	704.81	705.04	5.61	11.40	18.81	335.12	0.00	0.01	115.00	689.20	150.00	693.20
	3.000	701.83	702.89	9.54	8.54	15.83	308.01	132.50	20.00	115.00	689.20	160.90	695.20
	3.000	700.63	701.32	7.10	6.08	14.63	297.35	132.50	40.00	84.13	700.18	170.90	695.20
	4.000	706.65	706.90	5.54	10.25	18.65	425.84	0.00	0.01	193.00	693.20	233.00	693.20
	4.000	703.27	704.75	10.98	11.09	15.27	361.51	213.00	20.00	191.96	693.52	233.60	693.30
	4.000	701.69	702.72	8.46	8.44	13.69	321.40	213.00	40.00	174.36	697.32	251.40	697.20
	5.000	706.70	706.95	5.50	10.05	18.70	426.75	0.00	0.01	193.00	693.20	233.00	693.20
	5.000	703.37	704.81	10.85	10.73	15.37	363.73	213.00	20.00	191.96	693.52	233.60	693.30
	5.000	701.74	702.77	8.40	8.27	13.74	322.89	213.00	40.00	174.36	697.32	251.40	697.20
	6.000	706.81	707.07	5.55	10.33	18.61	425.49	0.00	0.01	193.00	693.40	233.00	693.40
	6.000	703.45	704.95	10.99	11.13	15.25	361.21	213.00	20.00	191.96	693.72	233.60	693.50
	6.000	701.81	702.87	8.53	8.65	13.61	319.55	213.00	40.00	174.36	697.52	251.40	697.40
	7.000	710.46	710.98	6.82	16.98	17.46	240.19	0.00	0.01	95.00	699.20	145.00	699.20
	7.000	707.10	708.98	11.76	15.53	14.10	193.96	120.00	20.00	95.00	699.20	145.00	699.20
	7.000	704.96	706.51	10.19	16.13	11.96	177.17	120.00	40.00	66.40	709.80	156.40	701.20
	8.000	711.68	712.47	8.17	28.46	15.68	213.53	0.00	0.01	95.00	702.20	145.00	702.20
	8.000	707.63	710.66	14.41	28.37	11.63	169.38	0.00	0.01	95.00	702.20	145.00	702.20
*	8.000	706.87	710.58	15.82	37.86	10.87	161.74	0.00	0.01	95.00	702.20	145.00	702.20

SUMMARY OF ERRORS AND SPECIAL NOTES

```
CAUTION  SECNO=    1.000  PROFILE= 1  CRITICAL DEPTH ASSUMED
CAUTION  SECNO=    1.000  PROFILE= 2  CRITICAL DEPTH ASSUMED
CAUTION  SECNO=    1.000  PROFILE= 3  CRITICAL DEPTH ASSUMED

CAUTION  SECNO=    8.000  PROFILE= 3  CRITICAL DEPTH ASSUMED
CAUTION  SECNO=    8.000  PROFILE= 3  PROBABLE MINIMUM SPECIFIC ENERGY
CAUTION  SECNO=    8.000  PROFILE= 3  20 TRIALS ATTEMPTED TO BALANCE WSEL
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                                                                THIS RUN EXECUTED 29 JUL 82    9:38:48
**************************************************
  HEC2 RELEASE DATED NOV 76 UPDATED MARC 1982
  ERROR CORR -  01,02,03,04,05
  MODIFICATION -  50,51,52,53,54,55
**************************************************

T1      EXAMPLE 4  FLOODWAY ANALYSIS, METHODS 4 AND 5
T2      FLOW DISTRIBUTION REQUESTED
T3      NORTH BUFFALO CREEK -- 100 YEAR FLOOD NATURAL PROFILE

J1  ICHECK     INQ       NINV      IDIR      STRT      METRIC     HVINS      Q        WSEL       FQ

       0.        2.        0.        0.  0.000000     0.00       0.0        0.    698.300     0.000

J2  NPROF      IPLOT     PRFVS     XSECV     XSECH      FN        ALLDC      IBW       CHNIM     ITRACE

     1.000     0.000    -1.000     0.000     0.000     0.000     0.000     0.000     0.000     15.000

J3  VARIABLE CODES FOR SUMMARY PRINTOUT

    110.000   200.000     0.000     0.000     0.000     0.000     0.000     0.000     0.000     0.000

NC       0.120      0.120      0.055      0.100      0.300      0.000      0.000      0.000      0.000      0.000
QT       7.000   8000.000   8000.000   8000.000   8000.000   8000.000   8000.000   8000.000      0.000      0.000
ET       0.000      0.000      0.000      0.000      0.000     10.410     10.510      0.000      0.000      0.000
X1   29900.000     23.000    460.000    508.000      0.000      0.000      0.000      0.000      0.000      0.000
GR     712.000      0.000    708.000     10.000    703.200     28.000    701.200     35.000    699.200     42.000
GR     697.200     57.000    695.200     71.000    693.200    110.000    691.200    150.000    691.000    400.000
GR     689.200    460.000    681.200    470.000    681.200    495.000    689.200    508.000    691.200    512.000
GR     693.200    530.000    695.200    563.000    697.200    570.000    699.200    580.000    701.200    595.000
GR     703.200    601.000    709.000    612.000    712.000    630.000      0.000      0.000      0.000      0.000

NH       5.000      0.120     75.000      0.100    245.000      0.055    285.000      0.100    457.000      0.120
NH     590.000      0.000      0.000      0.000      0.000      0.000      0.000      0.000      0.000      0.000
X1   33700.000     22.000    245.000    285.000   3000.000   3000.000   3800.000      1.000      0.000      0.000
GR     713.000      0.000    709.200     20.000    705.200     35.000    703.200     50.000    701.200     63.000
GR     699.200     75.000    697.200     90.000    695.200    130.000    695.200    240.000    693.200    245.000
GR     685.000    250.000    685.000    280.000    693.200    285.000    695.200    292.000    695.200    410.000
GR     697.200    457.000    699.200    500.000    701.200    510.000    703.200    535.000    705.200    560.000
GR     708.700    573.000    713.000    590.000      0.000      0.000      0.000      0.000      0.000      0.000

NH       6.000      0.120     48.000      0.100    115.000      0.040    140.000      0.060    160.000      0.100
NH     360.000      0.120    410.000      0.000      0.000      0.000      0.000      0.000      0.000      0.000
X1   35100.000     19.000    115.000    150.000   1000.000   1500.000   1400.000      0.000      0.000      0.000
GR     714.000      0.000    710.100     23.000    706.700     36.000    705.200     48.000    703.200     64.000
GR     701.200     76.000    699.200     92.000    689.200    115.000    686.000    116.000    686.000    136.000
GR     689.200    140.000    691.200    145.000    693.200    150.000    695.200    160.000    695.200    360.000
GR     697.200    370.000    699.200    375.000    709.200    395.000    714.200    410.000      0.000      0.000
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NC	0.120	0.120	0.055	0.100	0.300	0.000	0.000	0.000	0.000	0.000
X1	36950.000	22.000	193.000	233.000	1600.000	1600.000	1850.000	0.000	0.000	0.000
X3	10.000	0.000	0.000	0.000	0.000	0.000	0.000	705.500	705.500	0.000
GR	715.000	0.000	709.200	25.000	707.200	31.000	705.200	40.000	703.200	50.000
GR	701.200	61.000	699.200	87.000	697.200	180.000	693.200	193.000	688.000	198.000
GR	688.000	228.000	693.200	233.000	695.200	245.000	697.200	250.000	697.200	290.000
GR	699.200	310.000	701.200	370.000	703.200	410.000	705.200	445.000	707.200	465.000
GR	709.200	500.000	715.200	512.000	0.000	0.000	0.000	0.000	0.000	0.000
SB	0.900	1.500	2.900	0.000	28.000	1.500	1050.000	2.400	688.000	688.000
X1	37000.000	0.000	0.000	0.000	50.000	50.000	50.000	0.000	0.000	0.000
X2	0.000	0.000	1.000	704.000	706.000	0.000	0.000	0.000	0.000	0.000
X3	10.000	0.000	0.000	0.000	0.000	0.000	0.000	706.000	706.000	0.000
BT	16.000	0.000	715.000	715.000	25.000	712.000	709.200	31.000	710.000	707.200
BT	40.000	709.000	705.200	50.000	709.000	703.200	61.000	708.500	701.200	87.000
BT	706.500	699.200	180.000	706.000	697.200	290.000	706.000	697.200	310.000	706.000
BT	699.200	370.000	708.000	701.200	410.000	708.500	703.200	445.000	709.000	705.200
BT	465.000	710.000	707.200	500.000	712.000	709.200	512.000	715.200	715.200	0.000
X1	37110.000	0.000	0.000	0.000	110.000	110.000	110.000	0.000	0.200	0.000
X1	40150.000	22.000	95.000	145.000	2800.000	2800.000	3040.000	0.000	0.000	0.000
GR	720.200	0.000	719.200	22.000	717.200	30.000	715.200	40.000	713.200	50.000
GR	711.200	58.000	709.200	70.000	699.200	95.000	693.000	105.000	693.000	135.000
GR	699.200	145.000	701.200	150.000	701.200	220.000	703.200	240.000	705.200	255.000
GR	707.200	270.000	709.200	290.000	711.200	310.000	713.200	325.000	715.200	350.000
GR	717.200	370.000	719.200	390.000	0.000	0.000	0.000	0.000	0.000	0.000
X1	40800.000	0.000	0.000	0.000	650.000	650.000	650.000	0.000	3.000	0.000
EJ	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

```
 SECNO      DEPTH      CWSEL      CRIWS      WSELK      EG         HV         HL         OLOSS    BANK ELEV
 Q          QLOB       QCH        QROB       ALOB       ACH        AROB       VOL        TWA    LEFT/RIGHT
 TIME       VLOB       VCH        VROB       XNL        XNCH       XNR        WTN        ELMIN       SSTA
 SLOPE      XLOBL      XLCH       XLOBR      ITRIAL     IDC        ICONT      CORAR      TOPWID      ENDST

*PROF 1

CCHV=   0.100 CEHV=   0.300
*SECNO 29900.000
 29900.00     17.10     698.30      0.00     698.30     698.50      0.20       0.00       0.00     689.20
    8000.     4002.     3654.       344.      2730.       729.       295.        0.         0.      689.20
     0.00      1.47      5.01       1.16      0.120      0.055      0.120      0.000     681.20      48.75
 0.001047       0.        0.         0.          0          0          0       0.00     526.75     575.50

FLOW DISTRIBUTION FOR SECNO=  29900.00          CWSEL=     698.30

STA=        49.       57.       71.      110.      150.      400.      460.      508.      512.      530.      563.      570.      576.
  PER Q=        0.0       0.2       2.1       4.1      33.6      10.0      45.7       0.6       1.8       1.7       0.1       0.0
   AREA=        4.5      29.4     159.9     244.0    1800.0     492.0     728.8      32.4     109.8     135.3      14.7       3.0
    VEL=        0.3       0.7       1.0       1.3       1.5       1.6       5.0       1.5       1.3       1.0       0.6       0.3

1490 NH CARD USED
*SECNO 33700.000
 33700.00     17.17     702.17      0.00       0.00     702.40      0.23       3.89       0.01     693.20
    8000.     2092.     3490.      2418.      1132.       646.      1355.       250.        35.      693.20
     0.28      1.85      5.40       1.78      0.100      0.055      0.102      0.000     685.00      56.69
 0.001292     3000.     3800.      3000.          2          0          0       0.00     465.45     522.14

FLOW DISTRIBUTION FOR SECNO=  33700.00          CWSEL=     702.17

STA=        57.      130.      240.      245.      285.      410.      457.      522.
  PER Q=        6.5      18.7       1.0      43.6      21.5       6.2       2.6
   AREA=      325.1     766.8      39.9     645.8     878.4     280.6     196.4
    VEL=        1.6       1.9       2.0       5.4       2.0       1.8       1.0

1490 NH CARD USED
*SECNO 35100.000
 35100.00     17.67     703.67      0.00       0.00     704.01      0.34       1.57       0.03     689.20
    8000.      507.     3667.      3826.       292.       558.      1910.       342.        47.      693.20
     0.37      1.74      6.57       2.00      0.100      0.060      0.097      0.000     686.00      60.27
 0.001021     1000.     1400.      1500.          2          0          0       0.00     323.66     383.93

FLOW DISTRIBUTION FOR SECNO=  35100.00          CWSEL=     703.67

STA=        60.      115.      150.      160.      360.      384.
  PER Q=        6.3      45.8       4.1      41.7       1.9
   AREA=      291.6     558.3      94.7    1693.2     121.9
    VEL=        1.7       6.6       3.5       2.0       1.3
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   SECNO      DEPTH      CWSEL      CRIWS      WSELK      EG         HV         HL         OLOSS    BANK ELEV
   Q          QLOB       QCH        QROB       ALOB       ACH        AROB       VOL        TWA    LEFT/RIGHT
   TIME       VLOB       VCH        VROB       XNL        XNCH       XNR        WTN        ELMIN       SSTA
   SLOPE      XLOBL      XLCH       XLOBR      ITRIAL     IDC        ICONT      CORAR      TOPWID      ENDST

CCHV=    0.100 CEHV=    0.300
*SECNO 36950.000
 36950.00     17.70     705.70       0.00       0.00     706.04       0.34       2.04       0.00     693.20
    8000.     1779.      4235.      1986.      1032.       682.      1200.       449.        61.     693.20
     0.49      1.72       6.21       1.66      0.120      0.055      0.120      0.000     688.00      37.73
 0.001383     1600.      1850.      1600.          2          0          0       0.00     412.30     450.03

FLOW DISTRIBUTION FOR SECNO=  36950.00          CWSEL=      705.70

STA=        38.        87.       180.       193.       233.       245.       290.       310.       370.       450.
  PER Q=        3.2       15.4        3.7       52.9        4.0        9.3        3.3        5.9        2.3
   AREA=      197.2      697.8      136.5      682.1      138.0      387.7      150.1      330.2      194.0
    VEL=        1.3        1.8        2.1        6.2        2.3        1.9        1.8        1.4        0.9

SPECIAL BRIDGE

SB  XK          XKOR       COFQ       RDLEN      BWC        BWP        BAREA      SS         ELCHU      ELCHD
     0.90       1.50       2.90       0.00      28.00       1.50    1050.00       2.40     688.00     688.00

*SECNO 37000.000
PRESSURE AND WEIR FLOW

  EGPRS       EGLWC        H3        QWEIR        QPR        BAREA    TRAPEZOID     ELLC       ELTRD
                                                                         AREA
    706.91     706.44       0.11       501.      7565.      1050.      1038.     704.00     706.00

 37000.00     18.66     706.66       0.00       0.00     706.91       0.25       0.87       0.00     693.20
    8000.     1881.      3978.      2141.      1182.       720.      1412.       453.        61.     693.20
     0.49      1.59       5.52       1.52      0.120      0.055      0.120      0.000     688.00      33.43
 0.001018       50.        50.        50.          2          0          2       0.00     426.16     459.60

FLOW DISTRIBUTION FOR SECNO=  37000.00          CWSEL=      706.66

STA=       33.        87.       180.       193.       233.       245.       290.       310.       370.       445.       460.
  PER Q=        3.8       16.1        3.6       49.7        3.9        9.5        3.5        6.6        3.2        0.0
   AREA=      246.4      786.7      149.0      720.4      149.5      430.7      169.2      387.6      264.5       10.7
    VEL=        1.2        1.6        1.9        5.5        2.1        1.8        1.6        1.4        1.0        0.3

*SECNO 37110.000
 37110.00     18.57     706.77       0.00       0.00     707.03       0.26       0.11       0.00     693.40
    8000.     1872.      4001.      2127.      1168.       717.      1391.       461.        62.     693.40
     0.50      1.60       5.58       1.53      0.120      0.055      0.120      0.000     688.20      33.84
 0.001047      110.       110.       110.          2          0          0       0.00     424.84     458.68
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   SECNO      DEPTH      CWSEL      CRIWS      WSELK      EG         HV         HL         OLOSS     BANK ELEV
   Q          QLOB       QCH        QROB       ALOB       ACH        AROB       VOL        TWA     LEFT/RIGHT
   TIME       VLOB       VCH        VROB       XNL        XNCH       XNR        WTN        ELMIN        SSTA
   SLOPE      XLOBL      XLCH       XLOBR      ITRIAL     IDC        ICONT      CORAR      TOPWID       ENDST

 FLOW DISTRIBUTION FOR SECNO=  37110.00           CWSEL=     706.77

 STA=       34.       87.       180.      193.       233.       245        290.       310.       370.       445.       459.
   PER Q=       3.7       16.1        3.6       50.0        3.9        9.5        3.4        6.6        3.1        0.0
    AREA=     241.5      778.2      147.8      716.7      148.4      426.6      167.4      382.1      257.6        9.4
     VEL=       1.2        1.7        2.0        5.6        2.1        1.8        1.6        1.4        1.0        0.3

*SECNO 40150.000
 40150.00     17.46     710.46       0.00       0.00     710.98       0.52       3.87       0.08     699.20
    8000.      260.      5531.      2209.       161.       811.      1075.       637.        84.      699.20
     0.65      1.61       6.82       2.06      0.120      0.055      0.120      0.000     693.00      62.46
 0.001701     2800.      3040.      2800.          2          0          0       0.00     240.09     302.56

 FLOW DISTRIBUTION FOR SECNO=  40150.00           CWSEL=     710.46

 STA=       62.       70.       95.       145.       150.       220.       240.       255.       270.       290.       303.
   PER Q=       0.0        3.2       69.1        1.5       18.2        4.3        2.0        1.1        0.5        0.0
    AREA=       4.7      156.4      810.8       51.3      647.9      165.1       93.8       63.8       45.1        7.9
     VEL=       0.4        1.7        6.8        2.3        2.3        2.1        1.7        1.3        0.9        0.4

*SECNO 40800.000
 40800.00     15.68     711.68       0.00       0.00     712.46       0.79       1.41       0.08     702.20
    8000.      199.      5899.      1902.       112.       722.       811.       664.        87.      702.20
     0.68      1.77       8.17       2.35      0.120      0.055      0.120      0.000     696.00      71.30
 0.002849      650.       650.       650.          2          0          0       0.00     213.48     284.79

 FLOW DISTRIBUTION FOR SECNO=  40800.00           CWSEL=     711.68

 STA=       71.       95.       145.      150.       220.       240.       255.       270.       285.
   PER Q=       2.5       73.7        1.4       16.5        3.7        1.5        0.6        0.1
    AREA=     112.3      721.9       42.4      523.5      129.6       67.2       37.2       10.9
     VEL=       1.8        8.2        2.6        2.5        2.3        1.8        1.2        0.5
```

THIS RUN EXECUTED 29 JUL 82 9:39:01

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*****************************************************
  HEC2 RELEASE DATED NOV 76 UPDATED MARC 1982
  ERROR CORR -  01,02,03,04,05
  MODIFICATION -  50,51,52,53,54,55
*****************************************************
```

T1 EXAMPLE 4 FLOODWAY ANALYSIS, METHODS 4 AND 5
T2 100 YEAR FLOOD METHOD 4 ENCROACHMENT
T3 NORTH BUFFALO CREEK

J1	ICHECK	INQ	NINV	IDIR	STRT	METRIC	HVINS	Q	WSEL	FQ
	0.	6.	0.	0.	0.000000	0.00	0.0	0.	699.300	0.000

J2	NPROF	IPLOT	PRFVS	XSECV	XSECH	FN	ALLDC	IBW	CHNIM	ITRACE
	2.000	0.000	-1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

```
 SECNO      DEPTH      CWSEL      CRIWS      WSELK      EG         HV         HL         OLOSS    BANK ELEV
 Q          QLOB       QCH        QROB       ALOB       ACH        AROB       VOL        TWA     LEFT/RIGHT
 TIME       VLOB       VCH        VROB       XNL        XNCH       XNR        WTN        ELMIN        SSTA
 SLOPE      XLOBL      XLCH       XLOBR      ITRIAL     IDC        ICONT      CORAR      TOPWID       ENDST

*PROF 2

CCHV=    0.100 CEHV=    0.300
*SECNO 29900.000
 2800 NAT Q1=    2472.20  WSEL=     698.30  ENC Q1=    2472.20  WSEL=     699.30  RATIO=   0.0000
 NAT Q1=    2950.  RATIOS LOB,CH,ROB=   0.5250   0.4258   0.0492  WSEL=     699.30

3470 ENCROACHMENT STATIONS=       172.9      508.0  TYPE=      4  TARGET=         0.162
 29900.00     18.10     699.30      0.00     698.30     699.50      0.20       0.00       0.00     689.20
    8000.     4171.      3829.        0.      2416.       777.        0.         0.         0.     689.20
     0.00      1.73       4.93      0.00      0.120      0.055     0.120      0.000     681.20     172.90
 0.001173        0.         0.        0.          0          0         0       0.00     335.10     508.00

1490 NH CARD USED
*SECNO 33700.000
 2800 NAT Q1=    2225.67  WSEL=     702.17  ENC Q1=    2225.67  WSEL=     703.17  RATIO=   0.0000
 NAT Q1=    2677.  RATIOS LOB,CH,ROB=   0.2769   0.4009   0.3221  WSEL=     703.17

3470 ENCROACHMENT STATIONS=       131.7      420.9  TYPE=      4  TARGET          0.169
 33700.00     18.33     703.33      0.00     702.17     703.60      0.26       4.07       0.02     693.20
    8000.     1872.      3833.     2295.       926.       692.     1109.       217.        22.     693.20
     0.25      2.02       5.54      2.07      0.100      0.055     0.100      0.000     685.00     131.68
 0.001237     3000.      3800.     3000.          2          0         0       0.00     289.24     420.92

1490 NH CARD USED
*SECNO 35100.000
 2800 NAT Q1=    2504.19  WSEL=     703.67  ENC Q1=    2504.19  WSEL=     704.67  RATIO=   0.0000
 NAT Q1=    2910.  RATIOS LOB,CH,ROB=   0.0685   0.4352   0.4963  WSEL=     704.67

3470 ENCROACHMENT STATIONS=       115.0      343.6  TYPE=      4  TARGET=         0.139
 35100.00     19.01     705.01      0.00     703.67     705.28      0.28       1.68       0.00     689.20
    8000.        0.      3502.     4498.         0.       605.     1908.       301.        30.     693.20
     0.35      0.00       5.79      2.36      0.100      0.060     0.096      0.000     686.00     115.00
 0.001174     1000.      1400.     1500.          2          0         0       0.00     228.61     343.61

CCHV=    0.100 CEHV=    0.300
*SECNO 36950.000
 2800 NAT Q1=    2150.88  WSEL=     705.70  ENC Q1=    2150.88  WSEL=     706.70  RATIO=   0.0000
 NAT Q1=    2525.  RATIOS LOB,CH,ROB=   0.2357   0.4959   0.2685  WSEL=     706.70
```

```
 SECNO     DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS   BANK ELEV
 Q         QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA    LEFT/RIGHT
 TIME      VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN     SSTA
 SLOPE     XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID    ENDST


3470 ENCROACHMENT STATIONS=    105.1     332.4  TYPE=     4  TARGET=         0.148
 36950.00    19.04    707.04     0.00    705.70    707.42     0.37      2.11     0.03    693.20
  8000.      1552.    4602.     1846.     831.      736.      946.      397.      39.    693.20
    0.46     1.87      6.25      1.95     0.120     0.055     0.120     0.000   688.00   105.09
 0.001269    1600.     1850.     1600.       2         0         0      0.00    227.30   332.38


SPECIAL BRIDGE

SB  XK        XKOR       COFQ       RDLEN      BWC        BWP       BAREA      SS         ELCHU      ELCHD
     0.90      1.50       2.90       0.00      28.00       1.50    1050.00      2.40     688.00     688.00

*SECNO 37000.000
     3700.   BRIDGE STENCL=    105.09    STENCR=    332.38
 2800 NAT Q1=    2507.76  WSEL=    706.66  ENC Q1=    2507.76  WSEL=    707.66  RATIO=  0.0000
 NAT Q1=    2915.  RATIOS LOB,CH,ROB=  0.2462  0.4680  0.2857  WSEL=    707.66
PRESSURE AND WEIR FLOW

 EGPRS      EGLWC       H3        QWEIR      QPR        BAREA    TRAPEZOID     ELLC       ELTRD
                                                                   AREA
  708.40    707.42      0.01      1559.      6429.      1050.     1038.       704.00     706.00


3470 ENCROACHMENT STATIONS=    105.1     332.4  TYPE=     4  TARGET=         0.140
 37000.00    19.58    707.58     0.00    706.66    707.92     0.34      0.50     0.00    693.20
  8000.      1587.    4524.     1889.     878.      757.     1000.      400.      39.    693.20
    0.47     1.81      5.97      1.89     0.120     0.055     0.120     0.000   688.00   105.09
 0.001115     50.       50.       50.        2         0         3      0.00    227.30   332.38

*SECNO 37110.000
 2800 NAT Q1=    2472.19  WSEL=    706.77  ENC Q1=    2472.19  WSEL=    707.77  RATIO=  0.0000
 NAT Q1=    2877.  RATIOS LOB,CH,ROB=  0.2453  0.4705  0.2841  WSEL=    707.77

3470 ENCROACHMENT STATIONS=     98.2     347.4  TYPE=     4  TARGET=         0.141
 37110.00    19.53    707.73     0.00    706.77    708.04     0.31      0.12     0.00    693.40
  8000.      1633.    4378.     1989.     933.      755.     1104.      407.      40.    693.40
    0.47     1.75      5.80      1.80     0.120     0.055     0.120     0.000   688.20    98.22
 0.001053    110.      110.      110         2         0         0      0.00    249.14   347.36
```

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   SECNO     DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS   BANK ELEV
   Q         QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA   LEFT/RIGHT
   TIME      VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN       SSTA
   SLOPE     XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID      ENDST

*SECNO 40150.000
 2800 NAT Q1=    1939.81  WSEL=      710.46  ENC Q1=    1939.81  WSEL=     711.46  RATIO=  0.0000
 NAT Q1=    2219.  RATIOS LOB,CH,ROB=  0.0371  0.6678  0.2951  WSEL=     711.46

3470 ENCROACHMENT STATIONS=        95.0      221.5  TYPE=      4  TARGET=        0.126
 40150.00     18.73    711.73      0.00    710.46    712.27      0.55      4.16      0.07    699.20
    8000.        0.     5885.     2115.        0.      874.      810.      555.       52.    699.20
     0.62      0.00      6.73      2.61     0.120     0.055     0.120     0.000    693.00     95.00
 0.001982     2800.     3040.     2800.         2         0         0      0.00    126.45    221.45

*SECNO 40800.000
 2800 NAT Q1=    1498.82  WSEL=      711.68  ENC Q1=    1498.82  WSEL=     712.68  RATIO=  0.0000
 NAT Q1=    1738.  RATIOS LOB,CH,ROB=  0.0289  0.7110  0.2602  WSEL=     712.68

3470 ENCROACHMENT STATIONS=        95.0      210.0  TYPE=      4  TARGET=        0.138
 40800.00     17.13    713.13      0.00    711.68    713.95      0.83      1.60      0.08    702.20
    8000.        0.     6396.     1604.        0.      794.      585.      578.       54.    702.20
     0.64      0.00      8.05      2.74     0.120     0.055     0.120     0.000    696.00     95.00
 0.003120      650.      650.      650.         2         0         0      0.00    115.01    210.01
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29 JUL 82     9:38:45                                                                PAGE   10

                                                          THIS RUN EXECUTED 29 JUL 82    9:39:10
**************************************************
  HEC2 RELEASE DATED NOV 76 UPDATED MARC 1982
  ERROR CORR -  01,02,03,04,05
  MODIFICATION -  50,51,52,53,54,55
**************************************************

T1       EXAMPLE 4  FLOODWAY ANALYSIS, METHODS 4 AND 5
T2       100 YEAR FLOOD METHOD 5 ENCROACHMENT
T3       NORTH BUFFALO CREEK

J1  ICHECK     INQ      NINV      IDIR      STRT     METRIC    HVINS     Q        WSEL      FQ
        0.         7.        0.        0.  0.000000     0.00       0.0        0.   699.300    0.000

J2  NPROF     IPLOT     PRFVS     XSECV     XSECH     FN        ALLDC     IBW       CHNIM     ITRACE
     15.000     0.000    -1.000     0.000     0.000     0.000     0.000     0.000     0.000     0.000
```

```
  SECNO      DEPTH      CWSEL      CRIWS      WSELK      EG         HV         HL         OLOSS    BANK ELEV
  Q          QLOB       QCH        QROB       ALOB       ACH        AROB       VOL        TWA    LEFT/RIGHT
  TIME       VLOB       VCH        VROB       XNL        XNCH       XNR        WTN        ELMIN        SSTA
  SLOPE      XLOBL      XLCH       XLOBR      ITRIAL     IDC        ICONT      CORAR      TOPWID       ENDST

*PROF 3

CCHV=    0.100 CEHV=    0.300
*SECNO 29900.000
 2800 NAT Q1=    2472.20  WSEL=      698.30  ENC Q1=     2410.40  WSEL=      698.30  RATIO=   0.0250
 NAT Q1=    2472.  RATIOS LOB,CH,ROB=  0.5002  0.4568  0.0430  WSEL=      698.30

3470 ENCROACHMENT STATIONS=       91.3      540.8  TYPE=      5  TARGET=         0.025
 29900.00     18.10    699.30      0.00    698.30    699.46      0.16      0.00      0.00    689.20
    8000.     4205.     3527.      268.     2991.      777.      226.        0.        0.     689.20
     0.00      1.41      4.54      1.18     0.120     0.055     0.120     0.000    681.20     91.27
 0.000789        0.        0.        0.         0         0         3      0.00    449.51    540.77

1490 NH CARD USED
*SECNO 33700.000
 2800 NAT Q1=    2226.36  WSEL=      702.17  ENC Q1=     1522.70  WSEL=      702.17  RATIO=   0.3161
 NAT Q1=    2226.  RATIOS LOB,CH,ROB=  0.2615  0.4362  0.3023  WSEL=      702.17

3470 ENCROACHMENT STATIONS=      180.7      373.2  TYPE=      5  TARGET=         0.316
 33700.00     18.17    703.17      0.00    702.17    703.69      0.52      4.13      0.11    693.20
    8000.     1298.     4883.     1819.      518.      686.      710.      217.       23.     693.20
     0.18      2.51      7.12      2.56     0.100     0.055     0.100     0.000    685.00    180.67
 0.002070     3000.     3800.     3000.         2         0         6      0.00    192.52    373.19

1490 NH CARD USED
*SECNO 35100.000

3470 ENCROACHMENT STATIONS=       70.8      378.7  TYPE=      5  TARGET=         0.001
 35100.00     19.02    705.02      0.00    703.67    705.26      0.24      1.54      0.03    689.20
    8000.      545.     3436.     4019.      344.      606.     2212.      298.       31.     693.20
     0.29      1.59      5.67      1.82     0.100     0.060     0.097     0.000    686.00     70.77
 0.000689     1000.     1400.     1500.         2         0         4      0.00    307.97    378.74

CCHV=    0.100 CEHV=    0.300
*SECNO 36950.000
     4190. ITRY7 EXCEEDS 4
 2800 NAT Q1=    2151.19  WSEL=      705.70  ENC Q1=     1548.72  WSEL=      705.70  RATIO=   0.2801
 NAT Q1=    2151.  RATIOS LOB,CH,ROB=  0.2224  0.5293  0.2483  WSEL=      705.70
```

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29 JUL 82      9:38:45

   SECNO      DEPTH     CWSEL     CRIWS     WSELK      EG        HV        HL       OLOSS   BANK ELEV
   Q          QLOB      QCH       QROB      ALOB       ACH       AROB      VOL      TWA    LEFT/RIGHT
   TIME       VLOB      VCH       VROB      XNL        XNCH      XNR       WTN      ELMIN      SSTA
   SLOPE      XLOBL     XLCH      XLOBR     ITRIAL     IDC       ICONT     CORAR    TOPWID     ENDST


3301 HV CHANGED MORE THAN HVINS

3470 ENCROACHMENT STATIONS=      153.1      282.7   TYPE=      5  TARGET=        0.280
  36950.00     18.63    706.63      0.00    705.70    707.38      0.76      1.97      0.15    693.20
     8000.      935.     5800.     1265.      394.      719.      509.      389.       39.    693.20
      0.36      2.37      8.07      2.49     0.120     0.055     0.120     0.000    688.00    153.15
  0.002177     1600.     1850.     1600.         2         0        13      0.00    129.53    282.68


SPECIAL BRIDGE

SB  XK        XKOR        COFQ        RDLEN       BWC        BWP        BAREA       SS         ELCHU      ELCHD
     0.90      1.50        2.90        0.00       28.00       1.50     1050.00       2.40     688.00     688.00

*SECNO 37000.000
      3700.   BRIDGE STENCL=     153.15    STENCR=     282.68
  2800 NAT Q1=    2507.59  WSEL=     706.66  ENC Q1=    2382.21  WSEL=     706.66  RATIO=  0.0500
  NAT Q1=    2508.  RATIOS LOB,CH,ROB=  0.2351  0.4973  0.2676  WSEL=     706.66
 PRESSURE AND WEIR FLOW

 EGPRS      EGLWC        H3        QWEIR       QPR        BAREA     TRAPEZOID      ELLC       ELTRD
                                                                       AREA
   707.98     707.40      0.02        817.      7171.      1050.      1038.       704.00     706.00


3470 ENCROACHMENT STATIONS=      153.1      282.7   TYPE=      5  TARGET=        0.050
  37000.00     19.00    707.00      0.00    706.66    707.71      0.72      0.33      0.00    693.20
     8000.      950.     5765.     1285.      409.      734.      528.      391.       39.    693.20
      0.37      2.33      7.86      2.43     0.120     0.055     0.120     0.000    688.00    153.15
  0.002009       50.       50.       50.         2         0         0      0.00    129.53    282.68

*SECNO 37110.000

3301 HV CHANGED MORE THAN HVINS

3470 ENCROACHMENT STATIONS=       41.2      445.6   TYPE=      5  TARGET=        0.001
  37110.00     19.49    707.69      0.00    706.77    707.89      0.20      0.13      0.05    693.40
     8000.     1951.     3791.     2258.     1302.      754.     1579.      398.       40.    693.40
      0.38      1.50      5.03      1.43     0.120     0.055     0.120     0.000    688.20     41.25
  0.000795      110.      110.      110.         2         0         4      0.00    404.35    445.60
```

```
 SECNO      DEPTH      CWSEL      CRIWS      WSELK      EG         HV         HL         OLOSS   BANK ELEV
 Q          QLOB       QCH        QROB       ALOB       ACH        AROB       VOL        TWA    LEFT/RIGHT
 TIME       VLOB       VCH        VROB       XNL        XNCH       XNR        WTN        ELMIN       SSTA
 SLOPE      XLOBL      XLCH       XLOBR      ITRIAL     IDC        ICONT      CORAR      TOPWID      ENDST

*SECNO 40150.000

3301 HV CHANGED MORE THAN HVINS

3470 ENCROACHMENT STATIONS=      95.0      145.4  TYPE=       5  TARGET=        0.308
 40150.00     18.38     711.38      0.00    710.46    712.73      1.35      4.49      0.34    699.20
    8000.        0.      7998.        2.        0.      857.        5.      547.       55.    699.20
     0.46      0.00      9.33       0.44     0.120     0.055     0.120     0.000    693.00     95.00
 0.003889     2800.     3040.      2800.         2         0        16      0.00     50.45    145.45

*SECNO 40800.000

3301 HV CHANGED MORE THAN HVINS

3470 ENCROACHMENT STATIONS=      76.7      271.9  TYPE=       5  TARGET=        0.001
 40800.00     17.84     713.84      0.00    711.68    714.34      0.49      1.52      0.09    702.20
    8000.      238.     5518.      2244.      146.      830.     1077.      569.       57.    702.20
     0.50      1.63      6.65       2.08     0.120     0.055     0.120     0.000    696.00     76.74
 0.001565      650.      650.       650.         2         0         4      0.00    195.17    271.91
```

THIS RUN EXECUTED 29 JUL 82 9:39:26

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*****************************************************
HEC2 RELEASE DATED NOV 76 UPDATED MARC 1982
ERROR CORR - 01,02,03,04,05
MODIFICATION - 50,51,52,53,54,55
*****************************************************
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NOTE- ASTERISK (*) AT LEFT OF CROSS-SECTION NUMBER INDICATES MESSAGE IN SUMMARY OF ERRORS LIST

NORTH BUFFALO CREEK -- 1

SUMMARY PRINTOUT TABLE 110

SECNO	CWSEL	DIFKWS	EG	TOPWID	QLOB	QCH	QROB	PERENC	STENCL	STCHL	STCHR	STENCR
29900.000	698.30	0.00	698.50	526.75	4001.78	3654.36	343.86	0.00	0.00	460.00	508.00	0.00
29900.000	699.30	1.00	699.50	335.10	4170.61	3829.39	0.00	0.16	172.90	460.00	508.00	508.00
29900.000	699.30	1.00	699.46	449.51	4205.01	3527.29	267.69	0.03	91.27	460.00	508.00	540.77
33700.000	702.17	0.00	702.40	465.45	2091.73	3490.14	2418.13	0.00	0.00	245.00	285.00	0.00
33700.000	703.33	1.16	703.60	289.24	1872.40	3832.94	2294.66	0.17	131.68	245.00	285.00	420.92
33700.000	703.17	1.00	703.69	192.52	1297.82	4883.07	1819.12	0.32	180.67	245.00	285.00	373.19
35100.000	703.67	0.00	704.01	323.66	507.39	3667.00	3825.61	0.00	0.00	115.00	150.00	0.00
35100.000	705.01	1.34	705.28	228.61	0.00	3501.72	4498.28	0.14	115.00	115.00	150.00	343.61
35100.000	705.02	1.35	705.26	307.97	544.75	3436.07	4019.18	0.00	70.77	115.00	150.00	378.74
36950.000	705.70	0.00	706.04	412.30	1779.04	4234.97	1985.99	0.00	0.00	193.00	233.00	0.00
36950.000	707.04	1.34	707.42	227.30	1551.58	4602.05	1846.37	0.15	105.09	193.00	233.00	332.38
36950.000	706.63	0.92	707.38	129.53	934.77	5799.82	1265.41	0.28	153.15	193.00	233.00	282.68
37000.000	706.66	0.00	706.91	426.16	1881.13	3978.06	2140.82	0.00	0.00	193.00	233.00	0.00
37000.000	707.58	0.92	707.92	227.30	1587.46	4523.90	1888.64	0.14	105.09	193.00	233.00	332.38
37000.000	707.00	0.34	707.71	129.53	950.46	5764.95	1284.59	0.05	153.15	193.00	233.00	282.68
37110.000	706.77	0.00	707.03	424.84	1872.14	4001.14	2126.73	0.00	0.00	193.00	233.00	0.00
37110.000	707.73	0.96	708.04	249.14	1632.90	4378.35	1988.75	0.14	98.22	193.00	233.00	347.36
37110.000	707.69	0.92	707.89	404.35	1951.16	3790.87	2257.97	0.00	41.25	193.00	233.00	445.60
40150.000	710.46	0.00	710.98	240.09	259.86	5530.98	2209.15	0.00	0.00	95.00	145.00	0.00
40150.000	711.73	1.27	712.27	126.45	0.00	5884.67	2115.33	0.13	95.00	95.00	145.00	221.45
40150.000	711.38	0.92	712.73	50.45	0.00	7997.62	2.38	0.31	95.00	95.00	145.00	145.45
40800.000	711.68	0.00	712.46	213.48	199.34	5899.13	1901.53	0.00	0.00	95.00	145.00	0.00
40800.000	713.13	1.45	713.95	115.01	0.00	6395.59	1604.41	0.14	95.00	95.00	145.00	210.01
40800.000	713.84	2.17	714.34	195.17	238.08	5518.26	2243.67	0.00	76.74	95.00	145.00	271.92

SUMMARY OF ERRORS AND SPECIAL NOTES

FLOODWAY DATA,   NORTH BUFFALO CREEK -- 1
PROFILE NO. 2

STATION	------- FLOODWAY ------- WIDTH	SECTION AREA	MEAN VELOCITY	WATER SURFACE ELEVATION WITH FLOODWAY	WITHOUT FLOODWAY	DIFFERENCE
29900.000	335.	3193.	2.5	699.3	698.3	1.0
33700.000	289.	2728.	2.9	703.4	702.2	1.2
35100.000	229.	2513.	3.2	705.0	703.7	1.3
36950.000	227.	2513.	3.2	707.0	705.7	1.3
37000.000	227.	2635.	3.0	707.6	706.7	0.9
37110.000	249.	2793.	2.9	707.8	706.8	1.0
40150.000	126.	1684.	4.8	711.8	710.5	1.3
40800.000	115.	1380.	5.8	713.1	711.7	1.4

FLOODWAY DATA,   NORTH BUFFALO CREEK -- 1
PROFILE NO. 3

STATION	------- FLOODWAY ------- WIDTH	SECTION AREA	MEAN VELOCITY	WATER SURFACE ELEVATION WITH FLOODWAY	WITHOUT FLOODWAY	DIFFERENCE
29900.000	450.	3994.	2.0	699.3	698.3	1.0
33700.000	193.	1914.	4.2	703.2	702.2	1.0
35100.000	308.	3161.	2.5	705.1	703.7	1.4
36950.000	130.	1622.	4.9	706.6	705.7	0.9
37000.000	130.	1670.	4.8	707.0	706.7	0.3
37110.000	404.	3635.	2.2	707.7	706.8	0.9
40150.000	50.	862.	9.3	711.4	710.5	0.9
40800.000	195.	2053.	3.9	713.9	711.7	2.2

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                                                            THIS RUN EXECUTED 29 JUL 82    9:41:11
*************************************************
  HEC2 RELEASE DATED NOV 76 UPDATED MARC 1982
  ERROR CORR -  01,02,03,04,05
  MODIFICATION -  50,51,52,53,54,55
*************************************************

T1      EXAMPLE 5  FIA FLOOD HAZARD FACTOR ANALYSIS  (J3 = 201 AND 202)
T2
T3      SILLER CANYON CREEK       10 YEAR FLOOD

J1  ICHECK     INQ      NINV      IDIR      STRT     METRIC    HVINS     Q       WSEL      FQ

       0.       2.        0.        0.  0.000000     0.00      0.0       0.  4531.080   0.000

J2  NPROF     IPLOT    PRFVS     XSECV     XSECH      FN       ALLDC     IBW      CHNIM    ITRACE

     1.000    0.000   -1.000     0.000     0.000     0.000     0.000    0.000    0.000    0.000

J3  VARIABLE CODES FOR SUMMARY PRINTOUT

   201.000    0.000    0.000     0.000     0.000     0.000     0.000    0.000    0.000    0.000

J5  LPRNT    NUMSEC              ********REQUESTED SECTION NUMBERS********

   -10.000  -10.000    0.000     0.000     0.000     0.000     0.000    0.000    0.000    0.000

NC      0.050      0.050      0.035      0.100      0.300      0.000      0.000      0.000      0.000      0.000
QT      5.000    390.000    680.000    715.000   1315.000   1790.000      0.000      0.000      0.000      0.000
X1    500.000     10.000    100.000    158.000      0.000      0.000      0.000      0.000   4500.000      0.000
X3     10.000      0.000      0.000      0.000      0.000      0.000      0.000      0.000      0.000      0.000
GR     36.000      0.000     34.000    100.000     32.000    107.000     30.000    115.000     28.000    125.000
GR     27.000    132.000     28.000    142.000     30.000    150.000     32.000    158.000     32.000    260.000

X1   1000.000      9.000    100.000    158.000    500.000    500.000    500.000      0.000   4500.000      0.000
GR     36.000      0.000     35.000    100.000     32.000    115.000     30.000    125.000     29.000    132.000
GR     30.000    140.000     32.000    149.000     34.000    158.000     36.000    220.000      0.000      0.000

X1   1500.000     10.000    100.000    165.000    500.000    500.000    500.000      0.000   4500.000      0.000
GR     37.000      0.000     36.000    100.000     34.000    110.000     32.000    118.000     30.000    125.000
GR     30.000    142.000     32.000    152.000     34.000    161.000     36.000    165.000     36.500    250.000

X1   1960.000     11.000    118.000    136.000    460.000    460.000    460.000      0.000   4500.000      0.000
X3     10.000      0.000      0.000      0.000      0.000      0.000      0.000   4538.000   4538.000      0.000
GR     40.000      0.000     40.000    100.000     38.000    108.000     36.000    110.000     34.000    118.000
GR     32.000    125.000     32.000    131.000     34.000    136.000     36.000    142.000     37.000    160.000
GR     40.000    200.000      0.000      0.000      0.000      0.000      0.000      0.000      0.000      0.000
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NC	0.000	0.000	0.020	0.000	0.000	0.000	0.000	0.000	0.000	0.000
X1	2010.000	13.000	104.000	112.000	50.000	50.000	50.000	0.000	4500.000	0.000
X3	10.000	0.000	0.000	0.000	0.000	0.000	0.000	4541.500	4541.500	0.000
GR	42.500	0.000	42.500	100.000	36.500	104.000	33.850	105.000	33.040	106.000
GR	32.630	107.000	32.500	108.000	32.630	109.000	33.040	110.000	33.850	111.000
GR	36.500	112.000	42.500	116.000	42.500	200.000	0.000	0.000	0.000	0.000
SB	0.000	1.500	3.000	0.000	6.280	0.000	50.270	0.000	0.000	0.000
X1	2040.000	0.000	0.000	0.000	30.000	30.000	30.000	0.000	0.000	0.000
X2	0.000	0.000	1.000	4540.500	4542.500	0.000	0.000	0.000	0.000	0.000
X3	10.000	0.000	0.000	0.000	0.000	0.000	0.000	4542.500	4542.500	0.000
BT	13.000	0.000	4542.500	4542.500	100.000	4542.500	4542.500	104.000	4542.500	4536.500
BT	105.000	4542.500	4539.150	106.000	4542.500	4539.960	107.000	4542.500	4540.370	108.000
BT	4542.500	4540.500	109.000	4542.500	4542.370	110.000	4542.500	4539.960	111.000	4542.500
BT	4539.100	112.000	4542.500	4536.500	116.000	4542.500	4542.500	200.000	4542.500	4542.500
NC	0.000	0.000	0.035	0.000	0.000	0.000	0.000	0.000	0.000	0.000
X1	2070.000	11.000	100.000	160.000	30.000	30.000	30.000	0.000	4500.000	0.000
X3	10.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
GR	38.500	0.000	41.000	100.000	38.000	108.000	36.000	110.000	34.000	118.000
GR	33.000	125.000	33.000	131.000	34.000	136.000	36.000	142.000	41.000	160.000
GR	42.000	200.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
NC	0.000	0.000	0.015	0.000	0.000	0.000	0.000	0.000	0.000	0.000
X1	2100.000	6.000	100.000	112.000	30.000	30.000	30.000	0.000	4500.000	0.000
X3	10.000	0.000	0.000	0.000	0.000	0.000	0.000	4543.000	4543.000	0.000
GR	45.500	0.000	45.500	100.000	34.000	100.000	34.000	112.000	45.500	112.000
GR	45.500	200.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SB	0.000	1.500	2.600	200.000	12.000	0.000	84.000	0.000	0.000	0.000
X1	2120.000	0.000	0.000	0.000	20.000	20.000	20.000	0.000	0.000	0.000
X2	0.000	0.000	1.000	4541.000	4545.500	0.000	0.000	0.000	0.000	0.000
X3	10.000	0.000	0.000	0.000	0.000	0.000	0.000	4545.500	4545.500	0.000
NC	0.000	0.000	0.035	0.000	0.000	0.000	0.000	0.000	0.000	0.000
X1	2190.000	12.000	100.000	158.000	80.000	60.000	70.000	0.000	4500.000	0.000
GR	44.000	65.000	42.000	100.000	40.000	115.000	38.000	122.000	36.000	126.000
GR	35.000	132.000	36.000	134.000	38.000	140.000	40.000	145.000	42.000	158.000
GR	44.000	180.000	45.000	200.000	0.000	0.000	0.000	0.000	0.000	0.000
X1	2260.000	6.000	100.000	164.000	50.000	80.000	70.000	0.640	4500.000	0.000
X3	10.000	0.000	0.000	0.000	0.000	0.000	0.000	4545.000	4545.000	0.000
GR	45.500	0.000	45.500	100.000	35.250	117.000	35.250	147.000	45.500	164.000
GR	45.500	200.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SB	0.000	1.500	2.800	200.000	30.000	0.000	246.300	1.700	4535.750	4535.250
X1	2440.000	0.000	0.000	0.000	180.000	180.000	180.000	0.000	0.500	0.000
X2	0.000	0.000	1.000	4541.750	4545.750	0.000	0.000	0.000	0.000	0.000
X3	10.000	0.000	0.000	0.000	0.000	0.000	0.000	4545.750	4545.750	0.000

QT	5.000	0.000	610.000	670.000	0.000	0.000	0.000	0.000	0.000	0.000
X1	2515.000	6.000	100.000	164.000	75.000	75.000	75.000	0.000	4500.000	0.000
GR	42.000	0.000	42.000	100.000	36.000	117.000	36.000	147.000	42.000	164.000
GR	43.000	200.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
QT	5.000	0.000	700.000	760.000	800.000	0.000	0.000	0.000	0.000	0.000
X1	2595.000	6.000	100.000	130.000	80.000	80.000	80.000	0.000	4500.000	0.000
X3	10.000	0.000	0.000	0.000	0.000	0.000	0.000	4544.000	4544.000	0.000
GR	44.500	0.000	44.500	100.000	36.500	100.000	36.500	130.000	44.500	130.000
GR	44.500	190.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SB	0.000	1.500	2.800	190.000	30.000	0.000	210.000	0.000	0.000	0.000
X1	2625.000	0.000	0.000	0.000	30.000	30.000	30.000	0.000	0.000	0.000
X2	0.000	0.000	1.000	4543.500	4545.000	0.000	0.000	0.000	0.000	0.000
X3	10.000	0.000	0.000	0.000	0.000	0.000	0.000	4545.000	4545.000	0.000
QT	5.000	0.000	655.000	750.000	0.000	0.000	0.000	0.000	0.000	0.000
X1	2675.000	8.000	100.000	145.000	50.000	50.000	50.000	0.000	4500.000	0.000
GR	43.000	0.000	42.000	100.000	40.000	109.000	37.000	120.000	37.000	126.000
GR	40.000	135.000	44.000	145.000	44.000	170.000	0.000	0.000	0.000	0.000
QT	5.000	0.000	570.000	590.000	855.000	0.000	0.000	0.000	0.000	0.000
X1	3000.000	9.000	100.000	154.000	325.000	325.000	325.000	0.000	4500.000	0.000
GR	44.000	0.000	43.000	100.000	42.000	115.000	40.000	125.000	38.000	130.000
GR	40.000	136.000	44.000	145.000	46.000	154.000	46.000	190.000	0.000	0.000
QT	5.000	0.000	615.000	650.000	825.000	0.000	0.000	0.000	0.000	0.000
X1	3500.000	7.000	100.000	150.000	500.000	500.000	500.000	0.000	4500.000	0.000
GR	45.000	0.000	44.000	100.000	42.000	118.000	39.000	130.000	44.000	135.000
GR	47.000	150.000	47.000	200.000	0.000	0.000	0.000	0.000	0.000	0.000
QT	5.000	0.000	695.000	745.000	0.000	0.000	0.000	0.000	0.000	0.000
X1	4000.000	8.000	100.000	142.000	500.000	500.000	500.000	0.000	4500.000	0.000
GR	46.500	0.000	46.000	100.000	44.000	110.000	41.000	125.000	41.000	130.000
GR	46.000	136.000	48.000	142.000	48.000	162.000	0.000	0.000	0.000	0.000
EJ	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

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29 JUL 82      9:41:09                                                                    PAGE    4

                                                              THIS RUN EXECUTED 29 JUL 82    9:41:38
**************************************************
  HEC2 RELEASE DATED NOV 76 UPDATED MARC 1982
  ERROR CORR -  01,02,03,04,05
  MODIFICATION -  50,51,52,53,54,55
**************************************************

T1      EXAMPLE 5  FIA FLOOD HAZARD FACTOR ANALYSIS  (J3 = 201 AND 202)
T2      50 YEAR FLOOD
T3      SILLER CANYON CREEK

J1  ICHECK     INQ      NINV      IDIR      STRT    METRIC    HVINS     Q       WSEL       FQ
       0.       3.        0.        0.  0.000000    0.00      0.0       0.  4532.080    0.000

J2  NPROF     IPLOT    PRFVS     XSECV     XSECH      FN     ALLDC     IBW     CHNIM    ITRACE
     2.000    0.000   -1.000     0.000     0.000    0.000    0.000    0.000    0.000    0.000


29 JUL 82      9:41:09                                                                    PAGE    5

                                                              THIS RUN EXECUTED 29 JUL 82    9:41:49
**************************************************
  HEC2 RELEASE DATED NOV 76 UPDATED MARC 1982
  ERROR CORR -  01,02,03,04,05
  MODIFICATION -  50,51,52,53,54,55
**************************************************

T1      EXAMPLE 5  FIA FLOOD HAZARD FACTOR ANALYSIS  (J3 = 201 AND 202)
T2      100 YEAR FLOOD
T3      SILLER CANYON CREEK

J1  ICHECK     INQ      NINV      IDIR      STRT    METRIC    HVINS     Q       WSEL       FQ
       0.       4.        0.        0.  0.000000    0.00      0.0       0.  4532.190    0.000

J2  NPROF     IPLOT    PRFVS     XSECV     XSECH      FN     ALLDC     IBW     CHNIM    ITRACE
     3.000    0.000   -1.000     0.000     0.000    0.000    0.000    0.000    0.000    0.000
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 29 JUL 82     9:41:09                                                                           PAGE    6

                                                                    THIS RUN EXECUTED 29 JUL 82    9:42:02
**************************************************
  HEC2 RELEASE DATED NOV 76 UPDATED MARC 1982
  ERROR CORR -  01,02,03,04,05
  MODIFICATION -  50,51,52,53,54,55
**************************************************

T1       EXAMPLE 5  FIA FLOOD HAZARD FACTOR ANALYSIS  (J3 = 201 AND 202)
T2       500 YEAR FLOOD
T3       SILLER CANYON CREEK

J1   ICHECK     INQ       NINV       IDIR      STRT      METRIC     HVINS      Q        WSEL       FQ

       0.        5.         0.         0.  0.000000     0.00       0.0         0.  4533.260    0.000

J2   NPROF      IPLOT     PRFVS      XSECV     XSECH      FN        ALLDC      IBW      CHNIM      ITRACE

      15.000     0.000    -1.000     0.000     0.000     0.000     0.000     0.000     0.000      0.000


 29 JUL 82     9:41:09                                                                           PAGE    7

                                                                    THIS RUN EXECUTED 29 JUL 82    9:42:19
**************************************************
  HEC2 RELEASE DATED NOV 76 UPDATED MARC 1982
  ERROR CORR -  01,02,03,04,05
  MODIFICATION -  50,51,52,53,54,55
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NOTE- ASTERISK (*) AT LEFT OF CROSS-SECTION NUMBER INDICATES MESSAGE IN SUMMARY OF ERRORS LIST
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SUMMARY OF ERRORS AND SPECIAL NOTES

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CAUTION  SECNO=   0.000  PROFILE= 1  CRITICAL DEPTH ASSUMED
CAUTION  SECNO=   0.000  PROFILE= 1  PROBABLE MINIMUM SPECIFIC ENERGY
CAUTION  SECNO=   0.000  PROFILE= 1  20 TRIALS ATTEMPTED TO BALANCE WSEL
CAUTION  SECNO=   0.000  PROFILE= 2  CRITICAL DEPTH ASSUMED
CAUTION  SECNO=   0.000  PROFILE= 2  PROBABLE MINIMUM SPECIFIC ENERGY
CAUTION  SECNO=   0.000  PROFILE= 2  20 TRIALS ATTEMPTED TO BALANCE WSEL
CAUTION  SECNO=   0.000  PROFILE= 3  CRITICAL DEPTH ASSUMED
CAUTION  SECNO=   0.000  PROFILE= 3  PROBABLE MINIMUM SPECIFIC ENERGY
CAUTION  SECNO=   0.000  PROFILE= 3  20 TRIALS ATTEMPTED TO BALANCE WSEL
CAUTION  SECNO=   0.000  PROFILE= 4  CRITICAL DEPTH ASSUMED
CAUTION  SECNO=   0.000  PROFILE= 4  PROBABLE MINIMUM SPECIFIC ENERGY
CAUTION  SECNO=   0.000  PROFILE= 4  20 TRIALS ATTEMPTED TO BALANCE WSEL

CAUTION  SECNO=   0.000  PROFILE= 1  CRITICAL DEPTH ASSUMED
CAUTION  SECNO=   0.000  PROFILE= 1  PROBABLE MINIMUM SPECIFIC ENERGY
CAUTION  SECNO=   0.000  PROFILE= 1  20 TRIALS ATTEMPTED TO BALANCE WSEL
CAUTION  SECNO=   0.000  PROFILE= 2  CRITICAL DEPTH ASSUMED
CAUTION  SECNO=   0.000  PROFILE= 2  PROBABLE MINIMUM SPECIFIC ENERGY
CAUTION  SECNO=   0.000  PROFILE= 2  20 TRIALS ATTEMPTED TO BALANCE WSEL
CAUTION  SECNO=   0.000  PROFILE= 3  CRITICAL DEPTH ASSUMED
CAUTION  SECNO=   0.000  PROFILE= 3  PROBABLE MINIMUM SPECIFIC ENERGY
CAUTION  SECNO=   0.000  PROFILE= 3  20 TRIALS ATTEMPTED TO BALANCE WSEL
CAUTION  SECNO=   0.000  PROFILE= 4  CRITICAL DEPTH ASSUMED
CAUTION  SECNO=   0.000  PROFILE= 4  PROBABLE MINIMUM SPECIFIC ENERGY
CAUTION  SECNO=   0.000  PROFILE= 4  20 TRIALS ATTEMPTED TO BALANCE WSEL
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29 JUL 82 9:41:09

FLOOD INSURANCE ZONE DATA FOR SILLER CANYON CREEK

FLOOD HAZARD FACTOR FOR ENTIRE REACH USING SECTIONS

SECTION NUMBER	CUMULATIVE DISTANCE	ELEVATION DIFFERENCE BETWEEN BASE FLOOD AND 10	2	0.2
500.000	0.	-1.11	-0.11	1.07
1000.000	500.	-1.08	-0.08	0.98
1500.000	1000.	-1.19	-0.11	1.38
1960.000	1460.	-1.21	-0.12	1.78
2010.000	1510.	-2.08	-0.21	4.24
2040.000	1540.	-1.58	0.55	4.25
2070.000	1570.	-3.04	-0.22	1.85
2100.000	1600.	-2.84	-0.19	0.98
2120.000	1620.	-3.94	-0.33	0.91
2190.000	1690.	-4.29	-0.36	2.05
2260.000	1760.	-3.94	-0.35	2.00
2440.000	1940.	-3.85	-0.39	1.97
2515.000	2015.	-3.82	-0.19	2.08
2595.000	2095.	-3.75	-0.18	2.16
2625.000	2125.	-3.88	-0.21	2.04
2675.000	2175.	-4.17	-0.22	1.95
3000.000	2500.	-2.00	-0.23	1.85
3500.000	3000.	-0.65	-0.12	1.49
4000.000	3500.	-0.80	-0.08	0.64
WEIGHTED AVG FOR REACH		-1.78	-0.15	1.52

FHF FOR THE REACH = 020 WITH 16.6 PERCENT OF THE REACH WITHIN 0.5 FEET
ZONE FOR THE REACH = A 4

CONTINUOUS FLOOD HAZARD FACTORS BY EVEN INCREMENTS

INC NO.	TOTAL LENGTH	AVG ELEVATION DATA 10	1	DIFF.	WTD. AVG.	FHF	PERCENT WITHIN
	0.					SEC.	500.000
1	100.	4531.24	4532.35	-1.11	-1.11	010	100.
2	200.	4531.57	4532.67	-1.10	-1.11	010	100.
3	300.	4531.90	4533.00	-1.10	-1.10	010	100.
4	400.	4532.23	4533.32	-1.09	-1.10	010	100.
	500.					SEC.	1000.000
5	500.	4532.56	4533.64	-1.08	-1.10	010	100.
6	600.	4532.85	4533.95	-1.10	-1.10	010	100.
7	700.	4533.11	4534.23	-1.12	-1.10	010	100.
8	800.	4533.38	4534.52	-1.14	-1.11	010	100.
9	900.	4533.64	4534.80	-1.16	-1.11	010	100.
	1000.					SEC.	1500.000
10	1000.	4533.90	4535.09	-1.19	-1.12	010	100.
11	1100.	4534.15	4535.34	-1.19	-1.13	010	100.
12	1200.	4534.38	4535.58	-1.20	-1.13	010	100.
13	1300.	4534.61	4535.81	-1.20	-1.14	010	100.
14	1400.	4534.84	4536.05	-1.21	-1.14	010	100.
	1460.					SEC.	1960.000
15	1500.	4536.06	4537.62	-1.56	-1.17	010	100.
	1510.					SEC.	2010.000
	1540.					SEC.	2040.000
	1570.					SEC.	2070.000
16	1600.	4538.53	4540.90	-2.37	-1.24	010	94.
	1600.					SEC.	2100.000
	1620.					SEC.	2120.000
	1690.					SEC.	2190.000
17	1700.	4540.04	4543.58	-3.54	-1.38	015	88.
	1760.					SEC.	2260.000
18	1800.	4540.35	4544.43	-4.08	-1.53	015	83.
19	1900.	4540.55	4544.45	-3.90	-1.65	015	37.
	1940.					SEC.	2440.000
20	2000.	4540.68	4544.53	-3.85	-1.76	020	5.
	2015.					SEC.	2515.000
	2095.					SEC.	2595.000
21	2100.	4540.78	4544.58	-3.80	-1.86	020	5.
	2125.					SEC.	2625.000
	2175.					SEC.	2675.000
22	2200.	4540.80	4544.69	-3.89	-1.95	020	9.
23	2300.	4541.18	4544.84	-3.66	-2.03	020	70.
24	2400.	4541.88	4544.88	-3.00	-2.07	020	71.
	2500.					SEC.	3000.000
25	2500.	4542.59	4544.92	-2.33	-2.08	020	72.
26	2600.	4543.13	4544.99	-1.86	-2.07	020	73.
27	2700.	4543.50	4545.10	-1.60	-2.05	020	74.
28	2800.	4543.88	4545.20	-1.32	-2.03	020	75.
29	2900.	4544.25	4545.31	-1.06	-1.99	020	17.
	3000.					SEC.	3500.000
30	3000.	4544.63	4545.41	-0.78	-1.95	020	17.
31	3100.	4544.92	4545.59	-0.67	-1.91	020	16.
32	3200.	4545.14	4545.83	-0.69	-1.87	020	16.
33	3300.	4545.35	4546.08	-0.73	-1.84	020	12.
34	3400.	4545.57	4546.33	-0.76	-1.81	020	12.
	3500.					SEC.	4000.000

THIS REACH CAN BE SUBDIVIDED BY INC NO. TO MEET FIA REQUIREMENTS
INPUT 20N WHERE N IS THE NUMBER OF REACHES AND THEN INPUT THE END
OF EACH REACH BY INC NO. FOR EXAMPLE 202 18 34
A NEGATIVE INC NO. WILL SUPPRESS INTERMEDIATE INC OUTPUT.

```
CONTINUOUS FLOOD HAZARD FACTORS BY EVEN INCREMENTS

INC     TOTAL     WEIGHTED AVG DIFFERENCE
NO.     LENGTH     BETWEEN BASE FLOOD AND
                    10       2         0.2

 18      1800.    -1.53    -0.13      1.43

FHF FOR REACH    1 = 015 WITH   83. PERCENT OF THE REACH WITHIN 0.5 FEET
ZONE FOR THE REACH = A 3
======================================================================

 26      2600.    -3.29    -0.24      1.96

FHF FOR REACH    2 = 035 WITH   88. PERCENT OF THE REACH WITHIN 1.0 FEET
ZONE FOR THE REACH = A 7
======================================================================

 34      3400.    -0.95    -0.14      1.39

FHF FOR REACH    3 = 010 WITH   88. PERCENT OF THE REACH WITHIN 0.5 FEET
ZONE FOR THE REACH = A 2
======================================================================
```

APPENDIX II

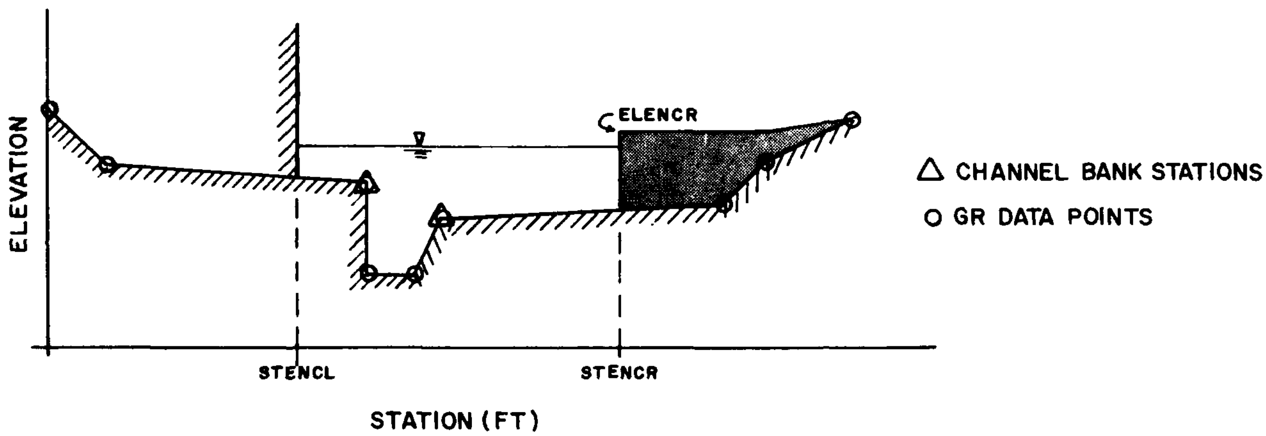
FLOODWAY ENCROACHMENT CALCULATIONS

FLOODWAY ENCROACHMENT CALCULATIONS

1. INTRODUCTION

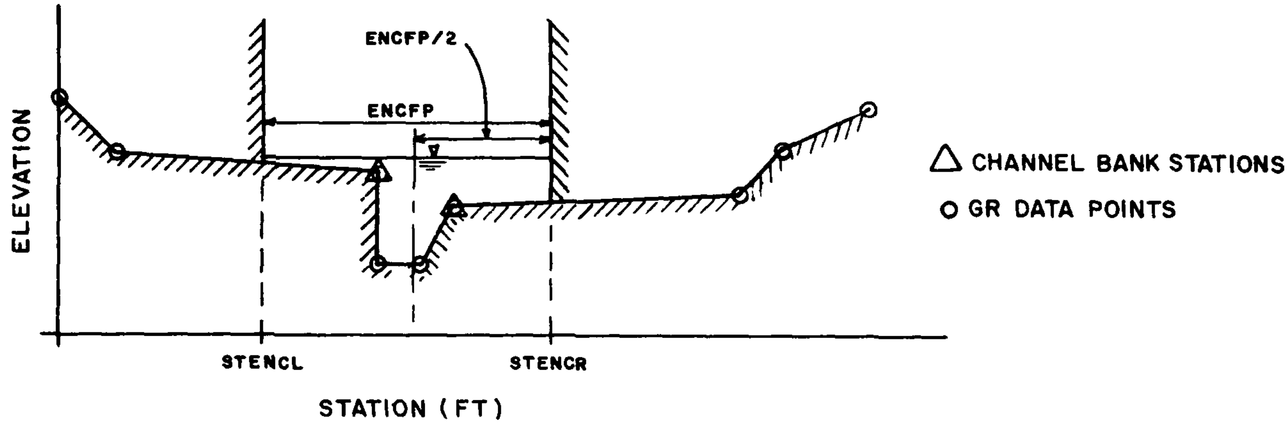
The evaluation of the impact of flood plain encroachments on water surface profiles can be of substantial interest to planners, land developers, and engineers. It is also a significant aspect of flood insurance studies. HEC-2 contains six optional methods for specifying flood plain encroachments. Each method is illustrated in the following paragraphs. Also program options related to encroachment determinations, data organization, and encroachment output will be covered.

2. ENCROACHMENT METHOD 1



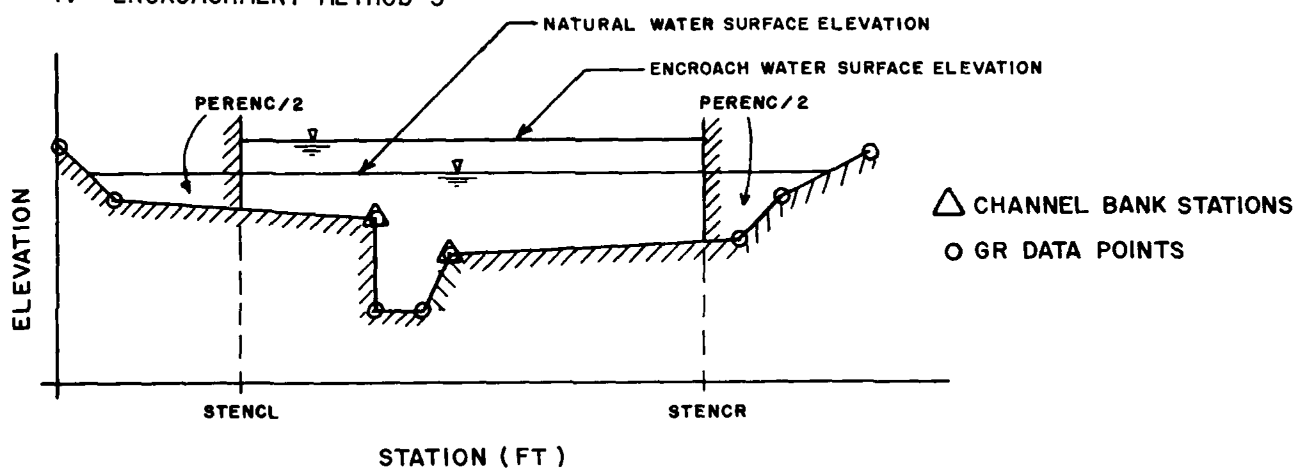
With method 1 the user specifies the exact location of the encroachment for a given cross section. Stations and elevations which apply to all profiles of the left and/or right encroachment, are specified on the X3 card for individual cross sections as desired. Encroachment stations for individual cross sections can also be specified differently for each profile by using the ET card. A 9.1 in the INQ field (J1.2) of the ET card would indicate that method 1 is being used (for current cross section only), and the left and right encroachment stations are specified on fields nine and ten of the ET card.

3. ENCROACHMENT METHOD 2



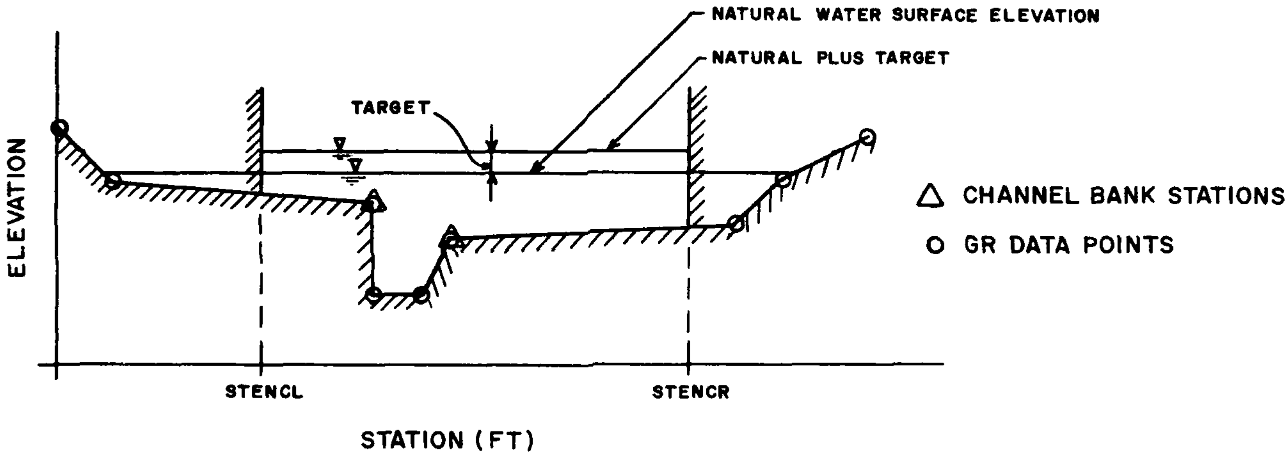
Method 2 utilizes a fixed top width. The top width (ENCFP) can be specified on an ET or X3 card which will be used for the current and all subsequent cross sections until changed by another X3 or ET card. The left and right encroachment stations are made equidistant from the centerline of the channel, which is halfway between the left and right bank stations. A 200.2 in the INQ (J1.2) of the ET card would indicate a two hundred foot width will be used for method 2. No provision is made to insure that all of the channel area is retained as flow area.

4. ENCROACHMENT METHOD 3



Method 3 calculates encroachment stations for a specified percent reduction (PERENC) in the natural conveyance of each cross section. One-half of PERENC is eliminated on each side of the cross section (if possible) as long as the encroachments do not infringe on the main channel. If one-half PERENC exceeds either overbank conveyance, the program will attempt to make up the difference on the other side. If the percent reduction in cross section conveyance cannot be accommodated by both overbank areas combined, the encroachment stations are made equal to the stations of left and right channel banks. This method requires that the first profile (of a multiple profile run) must be a natural (unencroached) profile. Subsequent profiles of multiple profile runs may be utilized for method 3 encroachments. The amount of conveyance reduction is requested by percentages specified on the ET card. The percentage can be changed by inserting another ET card ahead of the appropriate cross section. A 10.3 in the INQ field (J1.2) of the ET card for the second profile would indicate that ten percent of the conveyance based on the natural profile (first profile) will be eliminated - five percent from each overbank. An alternate scheme to equal conveyance reduction is conveyance reduction in proportion to the distribution of natural overbank conveyance. For instance, if the natural cross section had twice as much conveyance in the left overbank as in the right overbank, a 10.3 value would reduce five percent conveyance in each overbank, whereas a -10.3 value would reduce 6.7 percent from the left overbank and 3.3 percent from the right overbank.

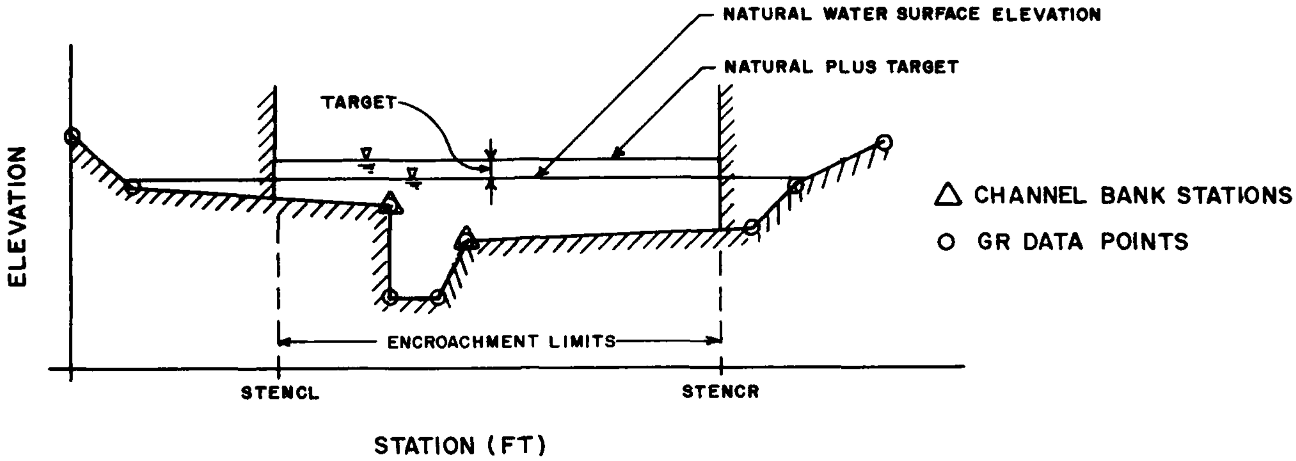
5. ENCROACHMENT METHOD 4



Method 4 computes encroachment stations so that conveyance within the encroached cross section (at some higher elevation) is equal to the conveyance of the natural cross section at the natural water level. This higher elevation is specified as a fixed amount above the natural (e.g., 100 year) profile. The encroachment stations are determined so that an equal loss of conveyance (at the higher elevation) occurs on each overbank, if possible. If half of the loss cannot be obtained in one overbank, the difference will be made up, if possible, in the other overbank, except that encroachments will not be allowed to fall within the main channel.

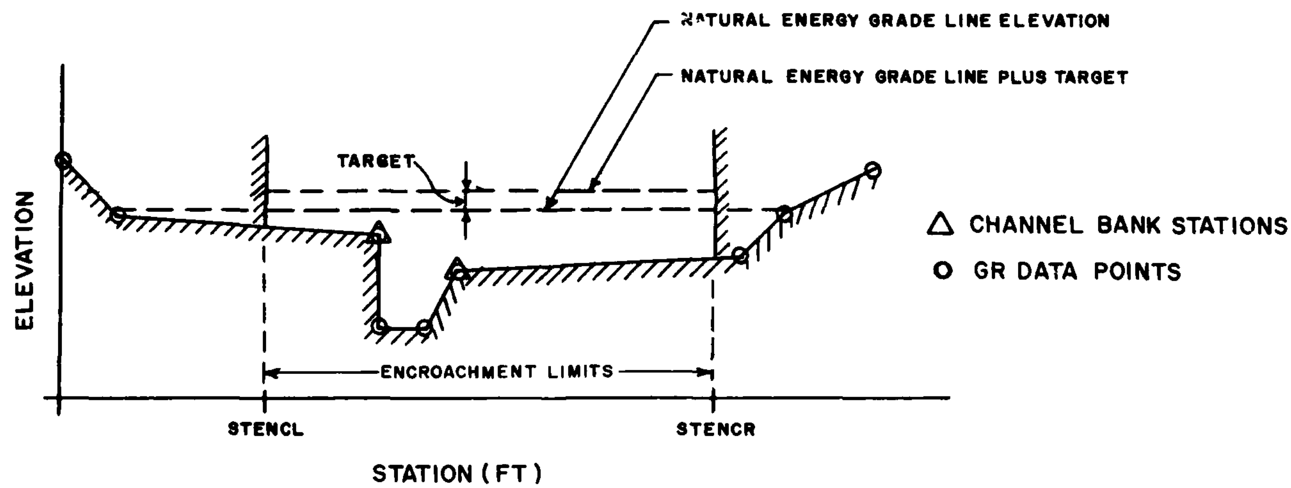
A 10.4 in the INQ field (J1.2) of the ET card indicates that a one foot rise (value is in tenths of a foot on the left side of the decimal point) will be used to determine the encroachments based on equal conveyance. An alternate scheme to equal conveyance reduction is to reduce conveyance in proportion to the distribution of natural overbank conveyance (a value of -10.4). See method 3 for an explanation of this. Also, the first profile must be for natural (unencroached) conditions and subsequent profiles can be computed for different targets.

6. ENCROACHMENT METHOD 5



Method 5 operates much like method 4 except that an optimization scheme is used to obtain the target difference in water surface elevation between natural and encroached conditions. A maximum of twenty-one trials is allowed in attempting a solution. The routine uses the percent reduction in conveyance as the objective function to be optimized to obtain the desired target. Convergence is usually obtained in three of four trials. The number of trials processed is printed under the variable name ICONT. Equal conveyance reduction is attempted in each overbank. Input for method 5 is specified on the ET card in the same fashion as for method 4. A 10.5 value in the INQ field (J1.2) of the ET card would indicate a target of one foot difference in water surface elevations. This method can be changed before any cross section, like methods 1 through 4. Also, as with methods 3 and 4, the first profile must be for natural (unencroached) conditions and subsequent profiles can be computed for different targets.

7. ENCROACHMENT METHOD 6



Method 6 operates in the same manner as method 5 except that the optimization is based on obtaining a target difference in energy grade line elevation between natural and encroached conditions. Input for method 6 is specified on the ET card and can be changed before any cross section, like methods 1 through 5. A 10.6 in the INQ field (J1.2) of the ET card would indicate a floodway with a target of one foot difference in energy elevations. Also, the first profile must be for natural (unencroached) conditions and subsequent profiles can be computed for different targets.

8. BRIDGE ENCROACHMENTS

Each of the six methods can be used to evaluate the effect of encroachments on bridges (BT cards). Bridge encroachments for special bridge analysis must be erquested by adding a .01 to the code on the ET card for the encroachment methods 1 through 6. Thus, 9.11, 100.21, 10.31, 10.41, 10.51, or 10.61 would request the bridge encroachments for method 1 through 6, while 9.1, 100.2, 10.3, 10.4, 10.5, or 10.6 would not encroach BT cards. The followin table describes how each method handles encroachments on special bridges.

METHOD	SPECIAL BRIDGE ENCROACHMENTS
1	Bridge encroachments defined by target values of Method 1.
2	Bridge encroachments defined by target values of Method 2.
3 - 6	Bridge encroachments defined by encroachments determined at the cross section immediately downstream of the bridge.

Without this option, the program will not calculate encroachments on special bridge models. For normal bridge models BT data encroachments are handled in the same manner as GR data encroached.

9. FLOW DISTRIBUTION OPTION

This option is recommended when computing floodway encorachments. With flow distribution the program prints out the lateral distribution of area, velocity, and discharge in the overbank sub-areas (formed by points on the GR card) for each cross section. Because the distribution of discharge is given as a percent, it can also be considered a percentage-distribution of conveyance.

The flow distribution option is called by setting the variable ITRACE (J2.10 or X2.10) equal to fifteen. If the number of sub-areas carrying flow in the overbanks is less than eleven, the distribution using all sub-areas will be printed. Otherwise, the distribution will be based on sub-areas that carry more than three percent of the flow. An example of flow distribution is shown below.

be based on sub-areas that carry more than three percent of the flow. An example of flow distribution is shown below.

```
FLOW DISTRIBUTION FOR SECNO=  37110.00            CWSEL=   706.27

STA=      36.      87.      180.      193.      233.      245.      290.      310.      370.      454.
  PER Q=      3.4      15.7      3.6      51.6      4.0       9.4       3.4       6.2       2.6
  AREA=     216.0     732.6    141.4     697.1    142.5     404.5     157.5     352.6     224.7
   VEL=       1.3       1.7      2.1       5.9      2.2       1.9       1.7       1.4        .9
```

10. ENCROACHMENT DATA ORGANIZATION

The table on the following page illustrates a possible organization of data cards for an encroachment analysis. Only the variables directly associated with encroachment analysis are shown in the table. For this example, three profiles are calculated with the first profile as the natural profile. Both profiles two and three are initiated with encroachment method 4; other methods are then used for subsequent cross sections.

11. COMPUTER OUTPUT FOR FLOODWAY CALCULATIONS

NOTES IN NORMAL OUTPUT

3470 ENCROACHMENT STATIONS = W, X TYPE = Y, TARGET = Z. The values of STENCL and STENCR (left and right encroachment stations) are W and X. The method used in determining these stations is method Y and the specified target (width or percent) for that method is Z. If the target is a percent, a ratio less than one is used instead of percent so that a percent target can be distinguished from a topwidth target.

2800 NATURAL Q1 = A, WSEL = B, ENC Q1 = C, WSEL = D, RATIO = E. This note is printed out for encroachment methods 3 through 6. The index discharge (Q assuming $S^{1/2}$ = .01) is equal to A for the natural profile at the water elevation of B. The index discharge for the encroached cross section is equal to C at elevation D. Elevation D is equal to B for method 3, but is higher for methods 4 through 6. The reduction ratio of 1-(C/A) is shown as E. This ratio for method 3 is normally equal to the target for note 3470 which is based on the input percentage on the ET card. E will be less than the target when the overbanks do not carry the target percentage of flow. The ratio is normally equal to zero for methods 4 through 6 (the target on note 3470 will be the equivalent ratio for method 3), since there is no reduction in the flow carrying capability except for the raise in water elevation from B to D. When the reduction ratio, E, is negative, there is an increase in the index Q using only the channel area.

ENCROACHMENT DATA ORGANIZATION

CARD	VALUES	COMMENTS
T1 - T3		Title information (natural profile)
J1	INQ(J1.2=2) WSEL(J1.9)	Read 2nd field of ET and QT card. Starting water surface elevation is specified here.
J2	ITRACE(J2.10=15)	Request flow distribution for natural profile.
J3	IVAR(J3.1=110), IVAR(J3.2=200)	Summary table 110 and 200 will be requested for summary printout.
NC QT		
ET	ENCFP(ET.2=0) ENCFP(ET.3=8.4) ENCFP(ET.4=10.4)	1st profile is natural profile. 2nd profile is Method 4 with .8 foot rise. 3rd profile is Method 4 with one foot rise.
X1 GR X1 GR		
ET	ENCFP(ET.2=0) ENCFP(ET.3=7.4) ENCFP(ET.4=5.41)	1st profile is natural profile (no change). 2nd profile is changed to 7.4. 3rd profile is changed to 5.41. Bridge encroachment stations (for the BT cards) will be the same as the downstream encroachments.
X1 GR		
SB		
ET	ENCFP(ET.2=0) ENCFP(ET.3=7.11) (ET.7=STENCL) (ET.8=STENCR) ENCFP(ET.4=0)	1st profile is natural profile (no change). 2nd profile is changed to Method 1 for bridge. Bridge encroachments (for both BT and GR cards) are specified in the 7th and 8th fields of the ET card. Continue previous encroachment instructions.
X1 X2 BT		
ET	ENCFP(ET.2=0) ENCFP(ET.3=15.3) ENCFP(ET.4=10.5)	1st profile is natural profile (no change). 2nd profile is changed to Method 3. 3rd profile is changed to Method 5.
X1 GR X1 GR		
EJ		End of data.
T1 - T3		Title information (Method 4 encroachment).
J1	INQ(J1.2=3) STRT(J1.5=0) WSEL(J1.9)	Read 3rd fields of ET and QT card. Slope area method of starting should not be used for encroachment profile. Starting water surface elevation specified here.
J2	NPROF(J2.1=2)	2nd profile.
T1 - T3		Title information (Method 4 encroachment).
J1	INQ(J1.2=4) STRT(J1.5=0) WSEL(J1.9)	Read 4th fields of ET and QT card. Slope area method should not be used. Starting water surface elevation specified area.
J2	NPROF(J2.1=15)	Last profile, request summary printout.
3 blank cards		
ER		End of run.

SUMMARY TABLE 110 (ENCROACHMENT DATA TABLE)

Summary table 110, requested on the J3 card, provides information relating to encroachment analysis. The column headings for Table 110 are described below.

a. SECNO - cross section number

b. CWSEL - computed water surface elevation

c. DIFKWS - the difference between the computed water surface elevations for each profile and the first profile (which should be the natural profile for encroachment options)

d. EG - energy grade line elevation

e. TOPWID - cross section width at the calculated water surface elevation

f. QLOB - amount of flow in the left overbank

g. QCH - amount of flow in the channel

h. QROB - amount of flow in the right overbank

i. PERENC - the target of encroachment requested on ET card

j. STENCL - the station of the left encroachment

k. STCHL - the station of left bank

l. STCHR - the station of right bank

m. STENCR - the station of the right encroachment

SUMMARY TABLE 200 (FIA TABLE 1)

A floodway table similar to FIA Table 1 can also be requested by the J3 card, which summarizes information on floodway widths, mean velocities and water surface elevations as required for flood insurance studies. An example of Table 200 is shown below.

FLOODWAY DATA, LEACH CREEK
PROFILE NO. 2

STATION	------- FLOODWAY ------- WIDTH (FT)	SECTION AREA	MEAN VELOCITY	WATER SURFACE ELEVATION WITH FLOODWAY	WITHOUT FLOODWAY	DIFFERENCE
9500.000	111.	669.	5.1	4574.5	4573.5	1.0
9805.000	50.	289.	11.8	4574.3	4573.9	.4
9855.000	145.	469.	7.3	4577.4	4577.3	.1
9890.000	145.	473.	7.2	4577.5	4577.5	0.0
9940.000	130.	839.	4.1	4578.8	4578.4	.4
10500.000	109.	329.	10.3	4578.8	4578.8	0.0
11000.000	70.	415.	8.2	4581.9	4581.9	0.0
11500.000	36.	235.	14.5	4583.5	4583.8	-.3
12000.000	68.	543.	6.3	4588.0	4587.5	.5
12450.000	62.	474.	7.2	4588.7	4588.2	.5
12500.000	146.	436.	7.8	4592.5	4592.3	.2
12530.000	146.	444.	7.7	4592.8	4592.7	.1
12580.000	109.	1245.	2.7	4594.3	4594.1	.2
13000.000	123.	1014.	3.4	4594.3	4594.1	.2

APPENDIX III

FLOOD HAZARD ZONE DETERMINATION

FLOOD HAZARD ZONE DETERMINATION

1. INTRODUCTION

In order to establish actuarial flood insurance rates, the Federal Insurance Administration (FIA) has developed a process to transform flood frequency information into insurance rates. This process includes the determination of reaches, Flood Hazard Factors and Flood Hazard Zone designations. An option of computer program HEC-2 provides the program user with the capability of directly computing both Flood Hazard Factors and the Flood Hazard Zone designations for riverine flood plains.

2. FLOOD HAZARD FACTORS

The FIA utilizes the average difference in elevation between flood profiles to correlate flood frequency data with flood insurance rates. The elevation difference determined for a stream reach (Flood Hazard Zone) is referred to as the Flood Hazard Factor (FHF). The FHF is expressed as a three digit code that indicates the average difference between the 10- and 100-year profiles in tenths of a foot. The FHF code is rounded to the nearest one-half foot for differences up to ten feet and is rounded to the nearest one foot for differences greater than 10 feet. For instance, if the average difference is 1.2 feet the appropriate FHF is 010; for a difference of 1.4 feet the FHF is 015; and for a difference of 10.4 feet the FHF is 100.

3. REACH DETERMINATION

To determine Flood Hazard Zones, streams are divided into reaches with relatively the same flood frequency characteristics. The hazard within each zone is expressed by a FHF based on the length-weighted elevation difference between the 10- and 100-year profiles. Reaches are determined such that the variation from the length-weighted difference is not greater than the variation indicated in Table 1 for more than twenty percent of the length of the reach.

TABLE 1*

Average Difference Between 10- and 100-Year Floods	Variation Permitted
Less than two feet	0.5 foot
Two to seven feet	1.0 foot
7.1 to twelve feet	2.0 feet
More than twelve feet	3.0 feet

*Flood Insurance Study, Guidelines and Specifications, U.S. Department of Housing and Urban Development, October 1977, Federal Insurance Administration.

For instance, if a stream has an average elevation difference between the 10- and 100-year profiles of 5.2 feet, the permitted elevation difference variation is one foot. If at least 80% of the stream, (by length) had elevation differences of greater than 4.2 feet and/or less than 6.2 feet the stream could be treated as a single reach with a FHF of 050.

4. ZONE DESIGNATIONS

Flood Hazard Zones determined for riverine flood plains are designated A1 through A30. Table 2 shows the relationship of FHF's and zone designations.

TABLE 2

Flood Hazard Factors	Zone Designations
005, 010, 015, ... 095	A1, A2, A3, ... A19
100, 110, 120, ... 200	A20, A21, A22, ... A30

5. APPLICATION OF HEC-2

To determine Flood Hazard Zones with HEC-2 it is necessary to structure the input data set to compute profiles for the 10-, 50-, 100-, and 500-year floods in order (e.g., the 10-year flood profile will be profile 1 and the 500-year flood will be profile 4). FHF computations are provided by the program when summary table 201, the Flood Insurance Zone Data Table, is requested. Table 201 may be requested by coding 201 on the J3 card and by requesting summary printout with the last J2 card (J2.1 = 15).

The Flood Insurance Zone Data Table provides for the computation of Flood Hazard Factors (FHF), Zones, and weighted average differences between the 100-year flood (Base Flood) and the 10, 50, and 500 year flood profiles. The program first computes the FHF for the entire reach of stream and prints a table labeled FLOOD HAZARD FACTOR FOR ENTIRE REACH USING SECTIONS, an example of this table is shown on the following page. For each cross section (SECTION NUMBER) the CUMULATIVE DISTANCE, and the computed ELEVATION DIFFERENCE BETWEEN BASE FLOOD (the 100 year - profile 3) and: 10% (10 year - profile 1), 2% (50 year - profile 2), and 0.2% (500 year - profile 4) FLOODS are shown. At the end of this table the WEIGHTED AVG FOR REACH is shown for the three different categories. Also shown are the FHF, the percentage of the reach that is within the FIA specified range and the ZONE for the reach based on the computed FHF. If the reach has 80% or more of the weighted 10% difference values within the specified range, the computed FHF, ZONE, and weighted average differences satisfy the required FIA criteria for the entire reach.

EXAMPLE OF TABLE 201 (FIRST PART)

FLOOD INSURANCE ZONE DATA FOR LEACH CREEK

FLOOD HAZARD FACTOR FOR ENTIRE REACH USING SECTIONS

SECTION NUMBER	CUMULATIVE DISTANCE	ELEVATION DIFFERENCE BETWEEN BASE FLOOD AND: 10%	2%	0.2%
9500.000	0.	-2.49	-.29	3.91
9805.000	305.	-2.52	-.24	2.31
9855.000	355.	-2.03	-.09	5.90
9890.000	390.	-2.83	-.46	5.17
9940.000	440.	-4.09	-.79	4.80
10500.000	1000.	-3.55	-.74	3.12
11000.000	1500.	-4.43	-1.04	3.46
11500.000	2000.	-4.01	-.93	3.13
12000.000	2500.	-4.67	-1.04	3.42
12450.000	2950.	-4.55	-1.00	3.24
12500.000	3000.	-4.67	-1.10	5.79
12530.000	3030.	-5.01	-1.19	5.31
12580.000	3080.	-5.89	-1.40	4.60
13000.000	3500.	-5.84	-1.39	4.60
13570.000	4070.	-3.66	-.73	3.74
13620.000	4120.	-4.45	-1.03	4.12
13630.000	4130.	-4.45	-1.03	4.24
13680.000	4180.	-3.54	-.78	4.54
14000.000	4500.	-3.26	-.66	2.89
14500.000	5000.	-2.27	-.48	2.16
WEIGHTED AVG FOR REACH		-4.07	-.88	3.62

FHF FOR THE REACH = 040 WITH 72.8% OF THE REACH WITHIN 1.0 FEET
ZONE FOR THE REACH = A 8

If a single reach does not satisfy the 80% criterion the program will automatically divide the reach into even increments and will print a second table showing the FHF computed for each increment. Increment lengths are based on the shortest distance between adjacent cross sections, but must be at least 100 feet long. By using even increments, the FHF can be continuously computed for the reach up to the current increment. The program will automatically subdivide the stream into reaches that meet the 80% criterion. The output information in this table should be sufficient to determine where the reach could be subdivided to meet the FIA requirements for at least 80% of each reach having an elevation variation of less than that shown in Table 1. An example of the CONTINUOUS FLOOD HAZARD FACTORS BY EVEN INCREMENTS table and the automatic subdivision of the reach into acceptable reaches is shown on the following pages. A description of each output column follows.

INC. NO. is the increment number for the even intervals used to subdivide the total reach.

TOTAL LENGTH is the channel length from the first section to the current increment. The length shown for the first increment is the constant interval length used by the program to subdivide the reach.

AVG ELEVATION DATA represent average values within each increment; 10% is the water surface elevation for the 10-year flood (profile 1). 1% is the water surface elevation from the 100-year flood (profile 3). Increment elevations are linearly interpolated from cross section results.

DIFF. is the difference between elevations for profiles 1 and 3.

WTD. AVG. is the length-weighted average elevation difference from the beginning of the reach to the current increment.

FHF is the flood hazard factor based on the weighted average difference; therefore, it represents the FHF from the beginning of the reach up to the current increment.

PERCENT WITHIN represents the portion of the reach (from the beginning to the current increment) that is within the specified range for the current FHF.

Within the printout for even increments the cross section numbers are printed as they are located within the reach. The numbers are printed within the data output on the right side of the table as: SEC. XXX.XXX.

At the end of this table a statement is printed explaining how the reach may be subdivided for subsequent computer runs. For instance, in the example table the statement indicates that the stream could be divided into two reaches; one ending with increment 32 and the second ending with increment 49. The J3 card for a subsequent run should be coded 202 32 49 in fields 1, 2, and 3 to provide FHF computations for these two reaches.

EXAMPLE OF TABLE 201 (SECOND PART)

CONTINUOUS FLOOD HAZARD FACTORS BY EVEN INCREMENTS

INC NO.	TOTAL LENGTH	AVG ELEVATION DATA 10%	1%	DIFF.	WTD. AVG.	FHF	PERCENT WITHIN
	0.					SEC. 9500.000	
1	100.	4568.26	4570.75	-2.49	-2.49	025	100.
2	200.	4568.58	4571.08	-2.50	-2.49	025	100.
3	300.	4568.90	4571.41	-2.51	-2.50	025	100.
	305.					SEC. 9805.000	
	355.					SEC. 4655.000	
	390.					SEC. 9890.000	
4	400.	4569.26	4572.06	-2.80	-2.57	025	100.
	440.					SEC. 9940.000	
5	500.	4569.62	4573.17	-3.55	-2.77	030	100.
6	600.	4570.01	4573.99	-3.98	-2.97	030	83.
7	700.	4570.47	4574.36	-3.89	-3.10	030	100.
8	800.	4570.94	4574.73	-3.79	-3.19	030	100.
9	900.	4571.40	4575.09	-3.69	-3.24	030	100.
	1000.					SEC. 10500.000	
10	1000.	4571.86	4575.46	-3.60	-3.28	035	100.
11	1100.	4572.29	4575.93	-3.64	-3.31	035	100.
12	1200.	4572.67	4576.49	-3.82	-3.35	035	100.
13	1300.	4573.06	4577.05	-3.99	-3.40	035	100.
14	1400.	4573.45	4577.61	-4.16	-3.46	035	100.
	1500.					SEC. 11000.000	
15	1500.	4573.83	4578.17	-4.34	-3.52	035	80.
16	1600.	4574.29	4578.68	-4.39	-3.57	035	81.
17	1700.	4574.82	4579.12	-4.30	-3.61	035	82.
18	1800.	4575.35	4579.57	-4.22	-3.65	035	83.
19	1900.	4575.87	4580.01	-4.14	-3.67	035	84.
	2000.					SEC. 11500.000	
20	2000.	4576.40	4580.46	-4.06	-3.69	035	85.
21	2100.	4576.94	4581.01	-4.07	-3.71	035	86.
22	2200.	4577.47	4581.69	-4.22	-3.73	035	86.
23	2300.	4578.01	4582.36	-4.35	-3.76	040	87.
24	2400.	4578.55	4583.03	-4.48	-3.79	040	88.
	2500.					SEC. 12000.000	
25	2500.	4579.09	4583.70	-4.61	-3.82	040	84.
26	2600.	4579.47	4584.13	-4.66	-3.86	040	85.
27	2700.	4579.70	4584.34	-4.64	-3.88	040	85.
28	2800.	4579.93	4584.54	-4.61	-3.91	040	86.
29	2900.	4580.16	4584.74	-4.58	-3.93	040	86.
	2950.					SEC. 12450.000	
30	3000.	4581.08	4585.69	-4.61	-3.96	040	87.
	3000.					SEC. 12500.000	
	3030.					SEC. 12530.000	
	3080.					SEC. 12580.000	
31	3100.	4582.72	4588.00	-5.28	-4.00	040	84.
32	3200.	4583.58	4589.46	-5.88	-4.06	040	81.
33	3300.	4583.60	4589.48	-5.88	-4.11	040	79.
34	3400.	4583.63	4589.49	-5.86	-4.16	040	76.
	3500.					SEC. 13000.000	
35	3500.	4583.66	4589.51	-5.85	-4.21	040	74.
36	3600.	4583.95	4589.61	-5.66	-4.25	045	72.
37	3700.	4584.52	4589.79	-5.27	-4.28	045	76.
38	3800.	4585.09	4589.98	-4.89	-4.30	045	76.
39	3900.	4585.66	4590.16	-4.50	-4.30	045	77.
40	4000.	4586.23	4590.35	-4.12	-4.30	045	78.
	4070.					SEC. 13570.000	
41	4100.	4587.12	4591.15	-4.03	-4.29	045	78.
	4120.					SEC. 13620.000	
	4130.					SEC. 13630.000	
	4180.					SEC. 13680.000	
42	4200.	4588.23	4592.07	-3.84	-4.28	045	79.
43	4300.	4589.28	4592.77	-3.49	-4.26	045	74.
44	4400.	4590.38	4593.77	-3.39	-4.24	040	75.
	4500.					SEC. 14000.000	
45	4500.	4591.47	4594.77	-3.30	-4.22	040	76.
46	4600.	4592.29	4595.45	-3.16	-4.20	040	74.
47	4700.	4592.84	4595.80	-2.96	-4.17	040	72.
48	4800.	4593.38	4596.15	-2.77	-4.14	040	73.
49	4900.	4593.93	4596.50	-2.57	-4.11	040	71.
	5000.					SEC. 14500.000	

THIS REACH CAN BE SUBDIVIDED BY INC NO. TO MEET FIA REQUIREMENTS
INPUT 20N WHERE N IS THE NUMBER OF REACHES AND THEN INPUT THE END
OF EACH REACH BY INC NO. FOR EXAMPLE: 202 32 49
A NEGATIVE INC NO. WILL SUPPRESS INTERMEDIATE INC OUTPUT.

As coded on the previous page, all of the incremental data will be printed plus the results for the two reaches. If only the results for each reach are desired, the first increment number could be coded with a minus sign. This will suppress all of the intermediate results. For example, 202 -32 49 will give the results shown below.

```
CONTINUOUS FLOOD HAZARD FACTORS BY EVEN INCREMENTS


INC     TOTAL     WEIGHTED AVG DIFFERENCE
NO.     LENGTH     BETWEEN BASE FLOOD AND
                    10%       1%        0.2%

 32      3200.    -3.75     -1.14       .82

FHF FOR REACH    1 = 040 WITH   81.% OF THE REACH WITHIN 1.0 FEET
ZONE FOR THE REACH = A 8
=====================================================================

 49      4900.    -4.23     -.96        .74

FHF FOR REACH    2 = 040 WITH   47.% OF THE REACH WITHIN 1.0 FEET
ZONE FOR THE REACH = A 8
=====================================================================
```

When there is uncertainty as to where to subdivide the reach, the user should code several alternatives on the J3 card and another run should be made. For example, (J3 202 -32 49 203 -32 40 49), would provide for two different subdivisions. The first is the same as the previous example and the second is for three reaches ending with increments 32, 40, and 49, as the example shows below.

```
CONTINUOUS FLOOD HAZARD FACTORS BY EVEN INCREMENTS


INC     TOTAL     WEIGHTED AVG DIFFERENCE
NO.     LENGTH     BETWEEN BASE FLOOD AND
                    10%       1%        0.2%

 32      3200.    -3.75     -1.14       .82

FHF FOR REACH    1 = 040 WITH   81.% OF THE REACH WITHIN 1.0 FEET
ZONE FOR THE REACH = A 8
=====================================================================

 40      4000.    -5.30     -1.27       .52

FHF FOR REACH    2 = 055 WITH   88.% OF THE REACH WITHIN 1.0 FEET
ZONE FOR THE REACH = A11
=====================================================================

 49      4900.    -3.28     -.69        .94

FHF FOR REACH    3 = 035 WITH  100.% OF THE REACH WITHIN 1.0 FEET
ZONE FOR THE REACH = A 7
=====================================================================
```

APPENDIX IV

APPLICATION OF HEC-2 BRIDGE ROUTINES

APPLICATION OF HEC-2 BRIDGE ROUTINES

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BRIDGE LOSS CALCULATIONS

1. INTRODUCTION

HEC-2 computes energy losses caused by structures such as bridges and culverts in two parts. One part consists of the losses that occur in reaches immediately upstream and downstream from the bridge where contraction and expansion of the flow is taking place. The second part consists of losses at the structure itself and is calculated with either the normal bridge method or the special bridge method. As an alternative to having the program compute the losses, it is possible to input a loss (or water surface elevation) determined externally from the program.

2. CONTRACTION AND EXPANSION LOSSES

Losses due to contraction and expansion of flow between cross sections are determined by standard step profile calculations. Manning's equation is used to calculate friction losses, and all other losses are described in terms of a coefficient times the absolute value of the change in velocity head between adjacent cross sections. When the velocity head increases in the downstream direction, a contraction coefficient is used; and when the velocity head decreases, an expansion coefficient is used.

3. NORMAL BRIDGE METHOD

The normal bridge method handles a bridge cross section in the same manner as a natural river cross section, except that the area of the bridge below the water surface is subtracted from the total area, and the wetted perimeter is increased where the water is in contact with the bridge structure. The bridge deck is described either by entering the constant elevations of the top of roadway and low chord as variables ELTRD and ELLC respectively on the X2 card, or by specifying a table of roadway stations and elevations, and corresponding low chord elevations, on the BT cards. When only ELLC and ELTRD are used, these elevations are extended horizontally until they intersect the ground line defined on the GR cards. Pier losses are accounted for by the loss of area and the increased wetted perimeter of the piers as described in terms of cross section coordinates, usually on the GR card.

4. SPECIAL BRIDGE METHOD

The special bridge method computes losses through the structure for either low flow, pressure flow, weir flow, or for a combination of these. The profile through the bridge is calculated using hydraulic formulas to determine the change in energy and water surface elevation through the bridge.

Low Flow. The procedure used for low flow calculations in the special bridge method depends on whether the bridge has piers. Without piers, the low flow solution is accomplished by standard step calculations as in the normal bridge method. The transfer to the normal bridge method is necessary because the equations used in the special bridge method for low flow are based on the obstruction width due to the piers.

Without piers, the special bridge solution would indicate that no losses would occur. For a bridge with piers, the program goes through a momentum balance for cross sections just outside and inside the bridge to determine the class of flow. The momentum calculations are handled by employing the following momentum relations based on the equations proposed by Koch and Carstanjen (references b and c).

$$m_1 - m_{p1} + \frac{Q^2}{g(A_1)^2}\left(A_1 - \frac{C_D}{2} A_{p1}\right) = m_2 + \frac{Q^2}{gA_2} = m_3 - m_{p3} + \frac{Q^2}{gA_3}$$

where:

A_1, A_3 = flow areas at upstream and downstream sections, respectively

A_2 = flow area (gross area - area of piers) at a section within constricted reach

A_{p1}, A_{p3} = obstructed areas at upstream and downstream sections, respectively

$\bar{y}_1$, $\bar{y}_2$, $\bar{y}_3$ = vertical distance from water surface to center of gravity of A_1, A_2, A_3, respectively

m_1, m_2, m_3 = $A_1\bar{y}_1$, $A_2\bar{y}_2$ and $A_3\bar{y}_3$, respectively

m_{p1}, m_{p3} = $A_{p1}\bar{y}_{p1}$ and $A_{p3}\bar{y}_{p3}$, respectively

C_D = drag coefficient equal to 2.0 for square pier ends and 1.33 for piers with semicircular ends

$\bar{y}_{p1}$, $\bar{y}_{p2}$ = vertical distance from water surface to center of gravity of A_{p1} and A_{p3}, respectively

Q = discharge

g = gravitational acceleration

The three parts of the momentum equation represent the total momentum flux in the constriction expressed in terms of the channel properties and flow depths upstream, within and downstream of the constricted section. If each part of this equation is plotted as a function of the water depth, three curves are obtained (Figure 1) representing the total momentum flux in the constriction for various depths at each location. The desired solutions (water depths) are then readily available for any class of flow. The momentum equation is based on a trapezoidal section and therefore requires a trapezoidal approximation of the bridge opening. A logic diagram for the momentum calculation is shown in Figure 2.

Class A low flow occurs when the water surface through the bridge is above critical depth, i.e., subcritical flow. The special bridge method uses the Yarnell equation for this class of flow to determine the change in water surface elevation through the bridge. As in the momentum calculations, a trapezoidal approximation of the bridge opening is used to determine the areas.

$$H_3 = 2K\,(K + 10\omega - 0.6)\,(\alpha + 15\alpha^4)\,V_3^2/2g$$

where:

H_3 = drop in water surface from upstream to downstream sides of the bridge

K = pier shape coefficient

ω = ratio of velocity head to depth downstream from the bridge

$\alpha = \dfrac{\text{obstructed area}}{\text{total unobstructed area}}$

V_3 = velocity downstream from the bridge

The computed upstream water surface elevation is simply the downstream water surface elevation plus H_3. With the upstream water surface elevation known, the program computes the corresponding velocity head and energy elevation for the upstream section.

Class B low flow can exist for either a subcritical or supercritical profile. For either profile, class B low flow occurs when the profile passes through critical depth in the bridge constriction. For a subcritical profile, critical depth is determined in the bridge, a new downstream depth (below critical) and the upstream depth (above critical) are calcuated by finding the depths whose corresponding momentum fluxes equal the momentum flux in the bridge for critical depth. With this solution, Statement 5227 DOWNSTREAM ELEV IS X, NOT Y, HYDRAULIC JUMP OCCURS DOWNSTREAM is printed with the elevation X as the supercritical elevation. The program does not provide the location of the hydraulic jump. A supercritical profile could be computed starting at the downstream section with a water surface elevation X. For a supercritical profile, the bridge is acting as a control and is causing the upstream water surface elevation to be above critical depth. Momentum equations are again used to recompute an upstream water surface elevation (above critical) and a

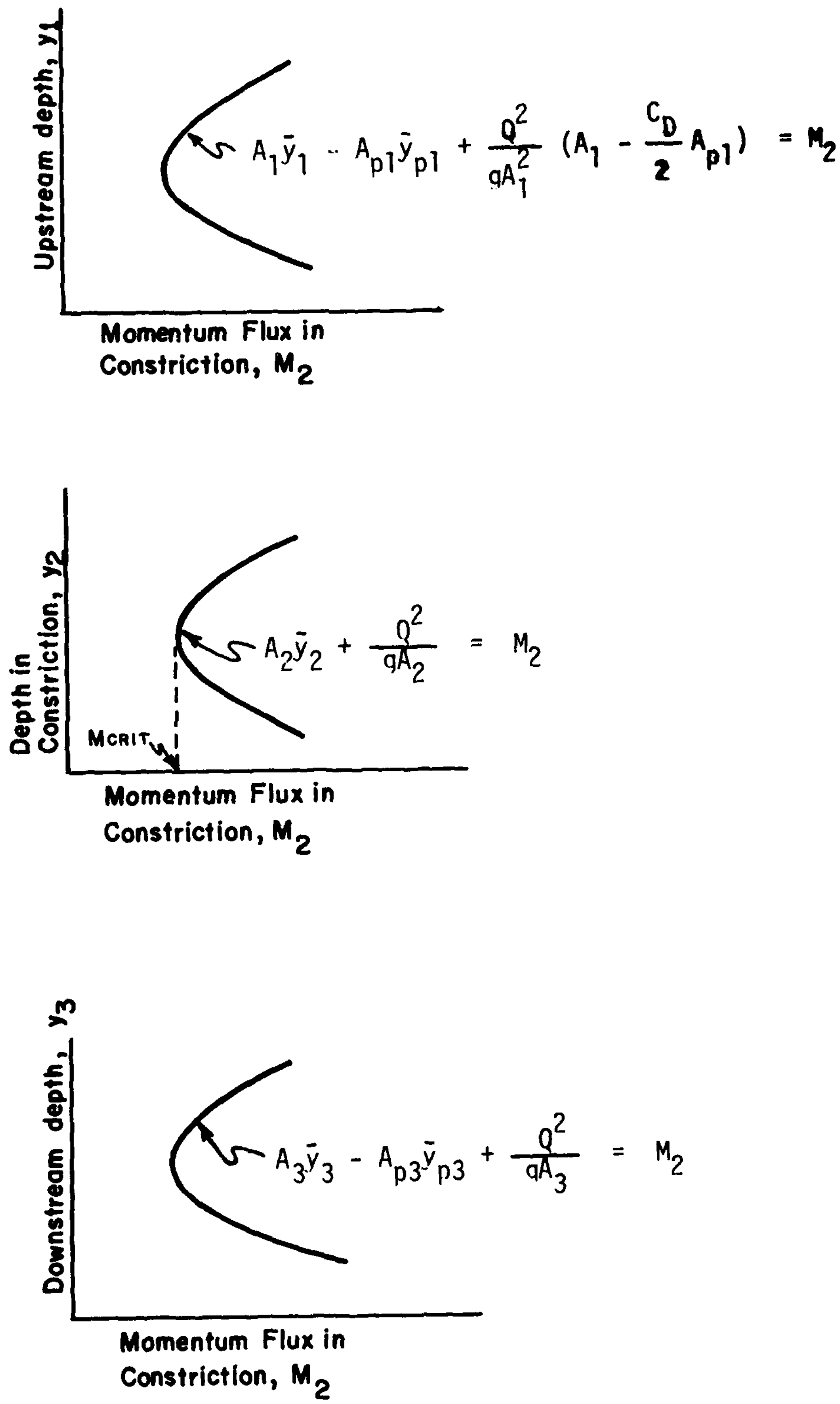


Figure 1. Momentum Curves from Special Bridge Method

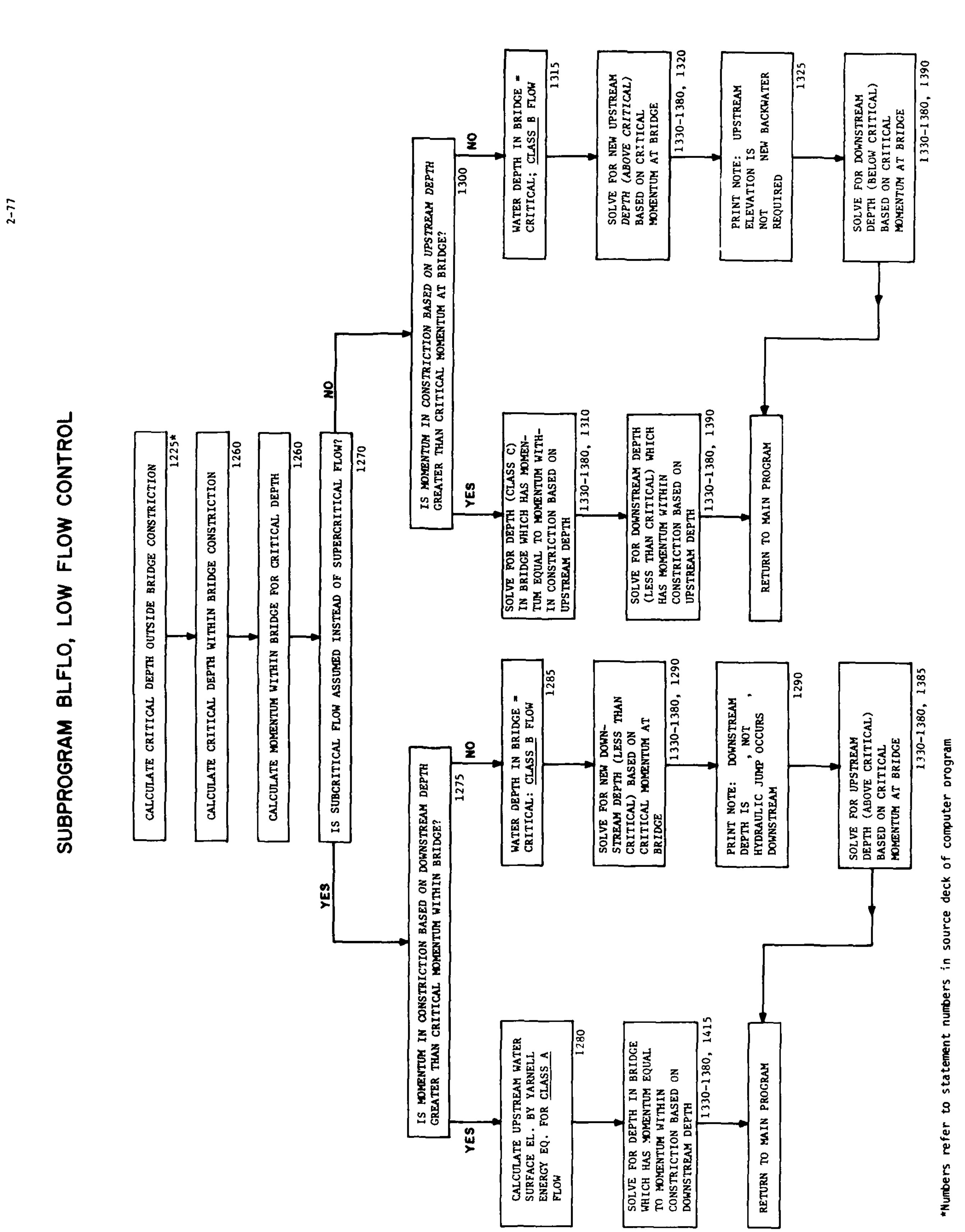


Figure 2. General Program Logic for Low Flow Calculations

downstream elevation below critical depth. For this situation, the Statement 5920 UPSTREAM ELEVATION IS X NOT Y, NEW BACKWATER REQUIRED is printed indicating a subcritical profile should be calculated upstream from the bridge starting at elevation X.

Class C low flow is computed for a supercritical profile where the water surface profile stays supercritical through the bridge constriction. The downstream depth and the depth in the bridge are computed by the momentum equations based on the momentum flux in the constriction and the upstream depth.

Pressure Flow. The pressure flow computations use the orifice flow equation of U.S. Army Engineering Manual 1110-2-1602, "Hydraulic Design of Reservoir Outlet Structures," August 1963 (reference g):

$$Q = A\sqrt{\frac{2gH}{K}}$$

where:

H = difference between the energy gradient elevation upstream and tailwater elevation downstream

K = total loss coefficient

A = net area of the orifice

g = gravitational acceleration

Q = total orifice flow

The total loss coefficient K, for determining losses between the cross sections immediately upstream and downstream from the bridge, is equal to 1.0 plus the sum of loss coefficients for intake, intermediate piers, friction, and other minor losses. The section on Loss Coefficients provides values for the total loss coefficient and shows the derivation of the equation and the definition of the loss coefficient.

Weir Flow. Flow over the bridge and the roadway approaching the bridge is calculated using the standard weir equation:

$$Q = CLH^{3/2}$$

where:

C = coefficient of discharge

L = effective length of weir controlling flow

H = difference between the energy grade line elevation and the roadway crest elevation

Q = total flow over the weir

The approach velocity is included by using the energy grade line elevation in lieu of the upstream water surface elevation for computing the head, H. Values for the coefficient of discharge "C" are presented in the section on Loss Coefficients. Where submergence by tailwater exists, the coefficient "C" is reduced by the program according to the method indicated in reference i. Submergence corrections are based on an ogee spillway shape. As shown in Water Surface Profiles, I.H.D. Vol 6 (reference 1) the correction for submergence based on an ogee section can lead to errors for high submergence on weirs with other shapes. A total weir flow, Q, is computed by subdividing the weir crest into segments, computing L, H, a submergence correction and Q for each segment, and summing the incremental discharges.

Combination Flow. Sometimes combinations of low flow or pressure flow occur with weir flow. In these cases a trial and error procedure is used, with the equations just described, to determine the amount of each type of flow. The procedure consists of assuming energy elevations and computing the total discharge until the computed discharge equals, within one percent, the discharge desired.

Decision Logic. The general flow diagram for the special bridge method is shown in Figure 3. By following the decision logic associated with a bridge solution, the program user can determine what adjustment could be made in the program input to alter the computed solution. A discussion of the logic sequence is provided to assist the user in interpreting the program solutions.

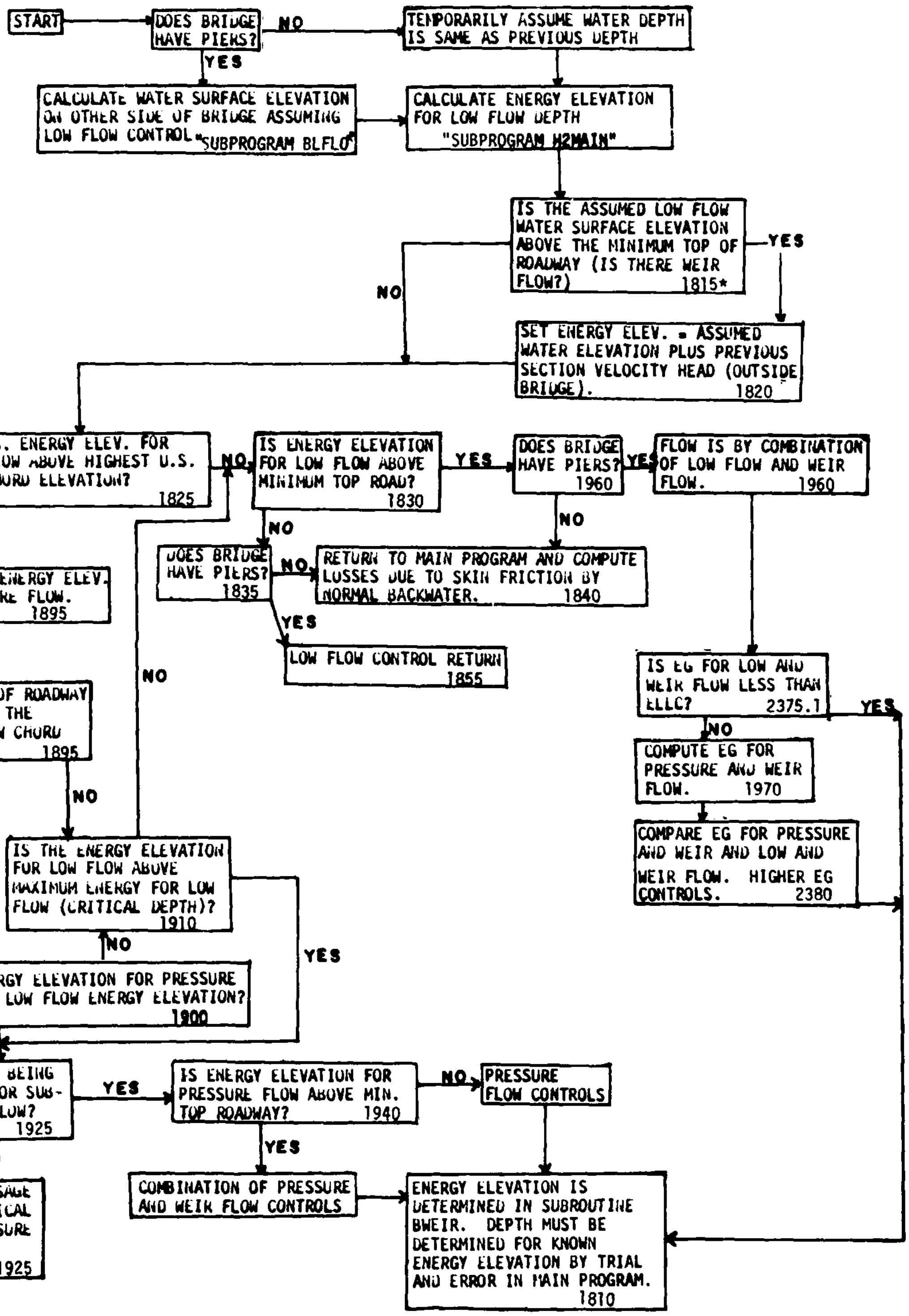
The first step in the special bridge method is to assume low flow conditions and estimate the water surface elevation on the other side of the bridge. How that estimate is made depends on whether the bridge has piers. If there are bridge piers, the program goes through the momentum equations to determine class of flow and water surface elevation. Without piers, the program temporarily assumes the water depth is the same on both sides of the bridges.

The program then checks for weir flow by comparing the estimated water surface elevation to the minimum top of road elevation (ELTRD). If it is possible that weir flow exists, the program estimates an energy elevation based on the velocity head at the previous section.

The program then compares the estimated low flow energy elevation to the maximum elevation of the bridge low chord (ELLC). If the low flow energy elevation (EGLWC) is greater than the low chord elevation (ELLC) the program will calculate an energy elevation assuming pressure flow (EGPRS). If the low flow energy elevation is less than ELLC, the program concludes that low flow controls and checks again to determine if weir flow exists. If there is weir flow, the program will check for piers. With piers, a trial and error solution will be made for low flow (by the Yarnell equation) and weir flow (by the weir equation). Without piers, the normal bridge solution (standard step calculation with adjustments in area and wetted perimeter) wil be used to compute the upstream elevation. If weir flow did not exist, the program would check for piers and then solve for a low flow solution. With piers, the low flow solution would be based on the momentum or the Yarnell equation; and without piers, the solution would be computed using standard step calculations.

GENERAL FLOW DIAGRAM

SPECIAL BRIDGE METHOD



*Numbers refer to statement numbers in subprogram BWEIR.

Figure 3. Special Bridge Method General Logic Diagram

Had the energy elevation required for pressure flow (EGPRS) been calculated, the program would go on to compare the low flow energy elevation EGLWC with EGPRS to see which controls. The higher of the two controls, as illustrated in the Typical Discharge Rating Curve shown in Figure 4.

One exception to the direct comparisons of the two energy elevations is when the minimum elevation of the top of road (ELTRD) is less than the maximum elevation of the low chord (ELLC). For this type of bridge, a combination of weir flow and low flow can occur. The low flow energy elevation (EGLWC) is compared to the estimated maximum energy elevation for low flow control (1.5 times depth plus invert elevation), rather than EGPRS, because the low road elevation would cause weir flow to exist prior to the occurrence of pressure flow. Depth is defined here as the difference between the low chord (ELLC) and the invert elevation (ELMIN).

At critical depth, 1.5 times the depth represents the minimum specific energy that could occur for a rectangular section. If critical depth occurred just at the maximum low chord elevation, it would produce the maximum possible energy elevation for low flow. Therefore, an energy elevation greater than that value would have to be for pressure flow. For the energy range between the low chord and the maximum low flow energy, the program will compute the energy elevations for low and weir flow and pressure and weir flow. The higher of the two energy elevations will control. Energy elevations below the maximum low chord are for low flow or low and weir flow for this type of bridge.

Based on the previous checks, the bridge routine has differentiated between low flow and pressure flow. With either type of flow, the program checks against the minimum top of road elevation (ELTRD) to determine if weir flow also exists. If the energy elevation is greater than ELTRD, a trial and error solution is made to determine the distribution of flow. The computed weir flow is listed under QWEIR and the flow under the bridge is given under QPR regardless of whether it is low flow or pressure flow. The flow diagram for computing the combination flow solution is shown in Figure 5. Up to twenty iterations are made to balance the total discharge to within one percent of the given discharge.

Important parameters in the decision logic of the special bridge method are the two test elevations ELLC and ELTRD. Because they play such an important role in the bridge analysis, <u>it is recommended they always be coded as input on fields four and five of the X2 card.</u>

5. INPUT LOSSES

One other method of computing water surface profiles through bridges is to input the bridge loss. The loss used could be just the "structure" loss, or it could be the total loss between any two adjacent cross sections. Differences in water surface elevations can be read on the X5 card for each discharge profile. The field read on the X5 card is called by variable INQ on the second field of the J1 card.

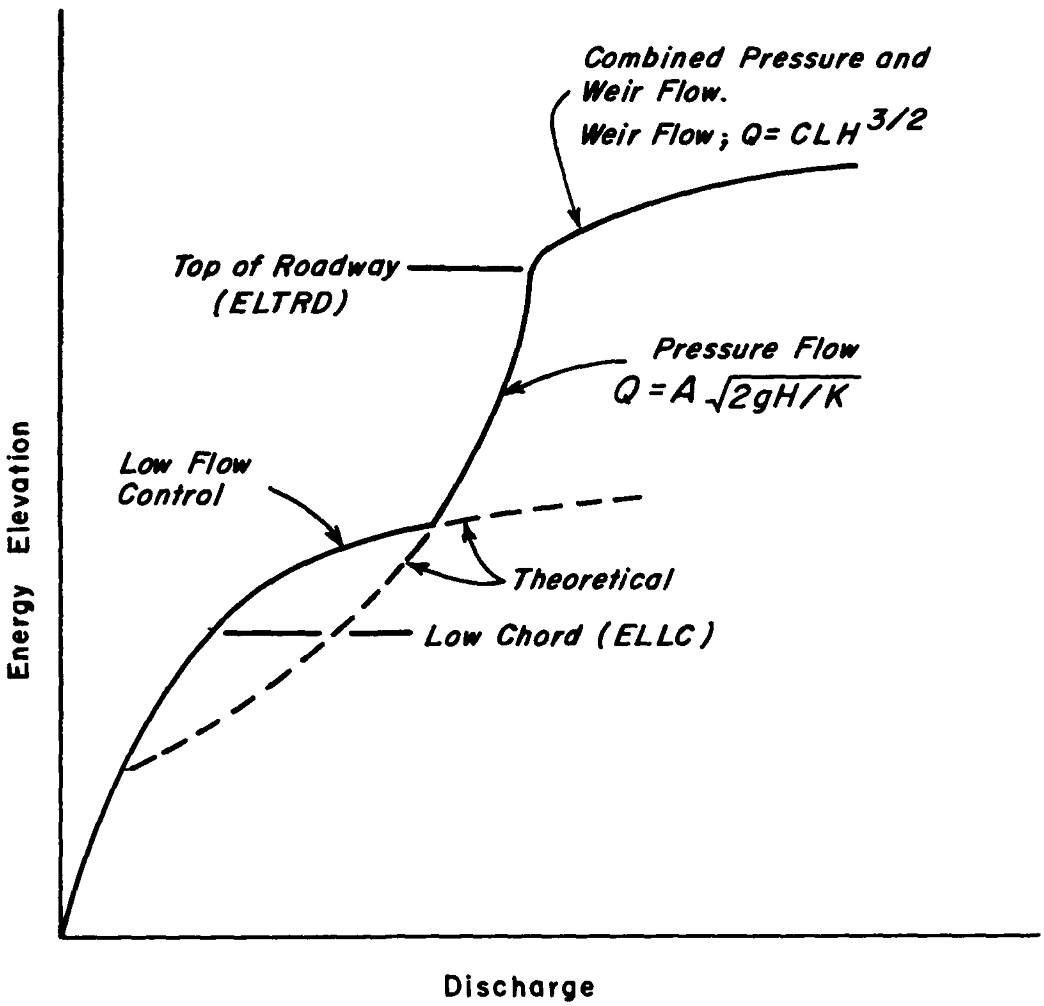


Figure 4. Typical Discharge Rating Curve for Bridge Culvert

SUBPROGRAM BWEIR, COMBINATION OF WEIR FLOW AND ORIFICE (OR LOW) FLOW

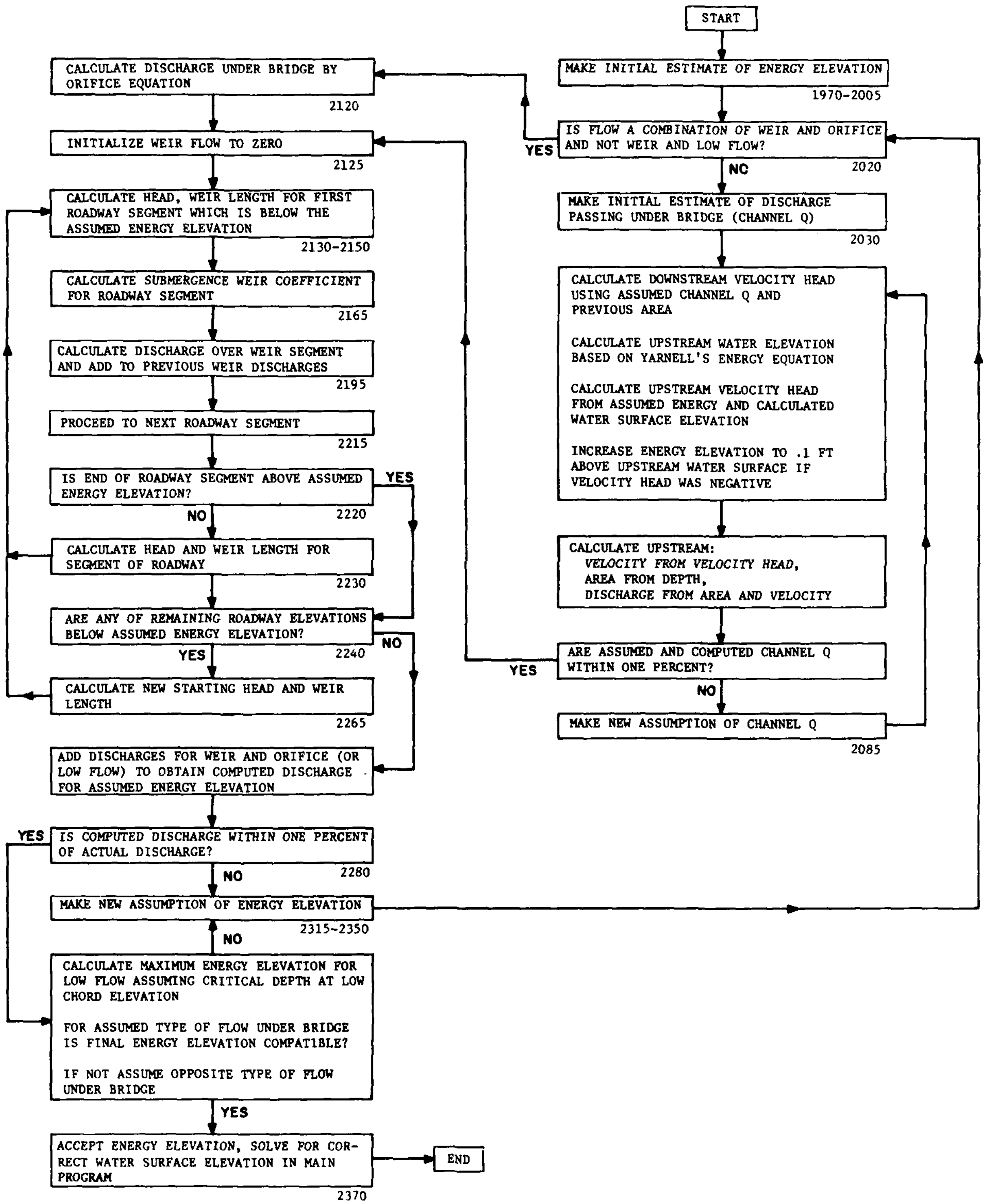


Figure 5. Flow Diagram for Combination Flow

For control structures, the known water surface elevations as provided by a rating curve can be read on an X5 card for multiple profiles or an X2 card for a single profile job. However, for a given X5 card, the data must consist entirely of either known water surface elevations or of differences in water surface elevation. Both types of input cannot be placed on the same card.

6. INTRODUCTION

Considerations in modeling the geometry of a reach of river in the vicinity of a bridge are essentially the same for both the normal bridge method and the special bridge method. Suggested techniques are presented in this section and are applied in subsequent examples on bridge coding.

7. CROSS SECTION LOCATIONS

Figure 6 shows in plan view the basic configuration of cross sections for computing losses through bridges. For ease of discussion, assume a subcritical profile starting downstream from the bridge.

Section 1 is sufficiently downstream from the bridge that flow is not affected by the bridge. The flow has fully expanded, and the basic input problem is to determine how far downstream from the bridge the cross section should be located. A rule of thumb is to locate the downstream section about four times the average length of the side constriction caused by the bridge abutments. Therefore, section 1 would be located downstream from the bridge four times the distance AB or CD shown in Figure 6. Because the constriction of flow may vary with the discharge, the downstream reach length should represent the average condition if a range of discharges are used in the model.

Locating cross section 1 based on a 4:1 expansion of flow downstream from the bridge may provide a reach length to cross section 2 that is too long for a reasonable estimate of friction loss. If intermediate cross sections are required, the 4:1 expansion rate could be used to locate the lateral extent of intermediate sections. The user should carefully review the program output to determine if an adequate number of cross sections are used. A change in conveyance of more than thirty percent between the two sections and a relatively long reach would indicate a need for intermediate sections.

Section 2 is a river cross section immediately (i.e., within a foot or two) downstream from the bridge. The section should represent the effective* flow area just outside the bridge and its location could be considered as the downstream face of the bridge. It is important to work with effective flow area because it is assumed in the application of the energy equation that the mean downstream velocity for each subsection can be determined from Manning's equation. The method used to define the

*Effective flow is that portion of flow where the main velocity is normal to the cross section and in the downstream direction.

effective area at this cross section is discussed under effective flow area. The standard step solution at section 2 would include determination of the expansion loss from section 2 to section 1.

The bridge loss occurring from section 2 to section 3 is determined by either the special bridge method with the SB card or by standard step calculations through one or two sections that define the bridge opening (normal bridge method). The selection of the bridge routine and the input requirements are presented in a subsequent section.

Section 3 represents the effective flow area just upstream from the bridge. The reach lengths from section 2 to section 3 are generally equal to the width of the bridge. The energy elevation computed by the special bridge method is applied to this section or, for the normal bridge method, a standard step solution from a section in the bridge to this section provides the energy elevation. The energy loss computed between sections 2 and 3 represents the loss through the bridge structure itself.

Section 4 is an upstream section where the flow lines are approximately parallel and the full cross section is effective. Because the flow contraction can occur over a shorter distance than the flow expansion, the reach length between sections three and four can be about one times the average bridge opening between the abutments (distance B-C in Figure 6). However, this criterion for locating the upstream section may result in too short a reach length for situations where the ratio of the width of the bridge opening to the width of the flood plain is small. An alternative criterion would be to locate the upstream cross section a distance equal to the bridge contraction (distance AB or CD in Figure 6). The program will compute the contraction portion of the bridge loss over this reach length by the standard step calculations.

8. EFFECTIVE AREA OPTION

A basic problem in setting up the bridge routines is the definition of effective flow area near the bridge structure. Referring to Figure 6, the dashed lines represent the effective flow boundary for low flow and pressure flow conditions. Therefore, for cross sections 2 and 3, ineffective flow areas to either side of the bridge opening (along distance AB and CD) should not be included for low flow or pressure flow. The elimination of the ineffective overbank areas can be accomplished by redefining the geometry at sections 2 and 3 (as shown in part C of Figure 7) or by using the natural ground profile and requesting the program's effective area option to eliminate the use of the overbank area. By redefining the cross section, a fixed boundary is used at the sides of the cross section to contain the flow, when in fact a solid boundary is not physically there. The use of the effective area option does not add wetted perimeter to the flow boundary above the given ground profile.

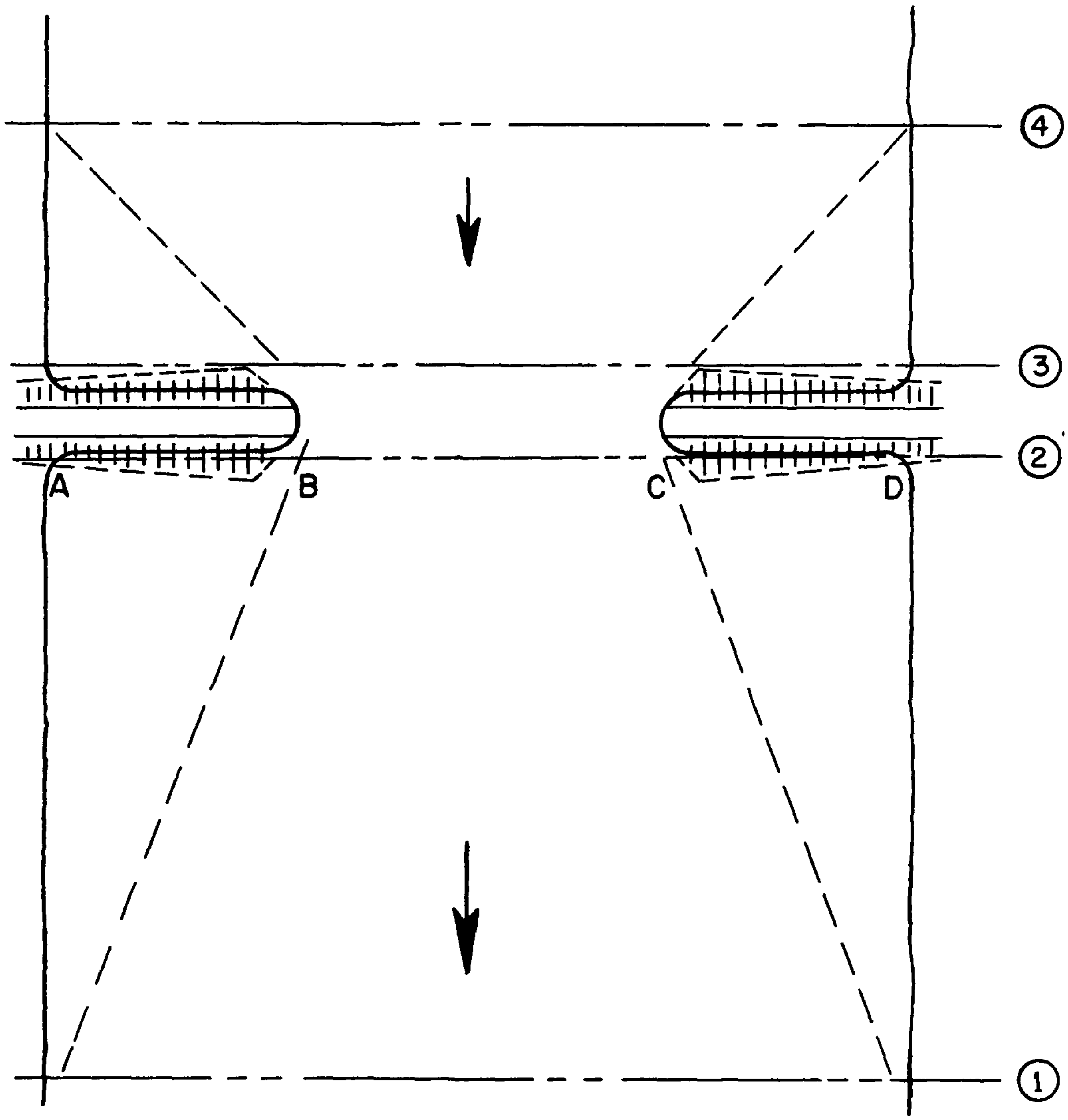


Figure 6. Cross Section Locations in the Vicinity of Bridges

The bridge example shown in Figure 7 is a typical situation where the bridge spans the entire floodway and its abutments obstruct the natural floodway. This is the same situation as was shown in plan view in Figure 6. The section numbers and locations are the same as those discussed in Cross Section Locations. The input problem is to convert the natural ground profile at cross sections 2 and 3 from the section shown in part "B" to that shown in part "C" of Figure 7.

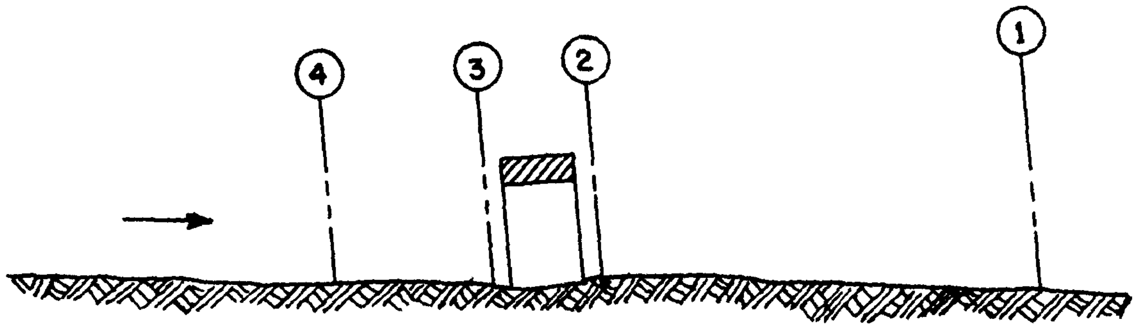
The effective area option of the program (IEARA = 10 field one of the X3 card) is used to keep all the flow in the channel until the elevations associated with the left and/or right bank stations are exceeded by the computed water surface elevation. The program will allow the controlling elevations of the left and right bank stations to be specified by the user. This is done by reading in effective area elevations (ELLA and ELREA) in fields eight and nine of the X3 card. If these elevations are not read in, elevations specified on the GR cards for the left and right bank stations will be used.

The effective area option applies to the left and right bank stations; therefore, those stations should coincide with the abutments of the bridge. For cross sections two and three, the left and right bank stations should line up with the bridge abutments. An X3 card would be used with these sections to call for the effective area option and to designate effective area elevations for the left and right bank stations. The given elevations would correspond to an elevation where weir flow would just start over the bridge. For the downstream section, the threshold water surface elevation for weir flow is not usually known on the initial run, so an estimate must be made. An elevation anywhere between the low chord and top-of-road elevation could be used; so an average of the two elevations might be a reasonable estimate.

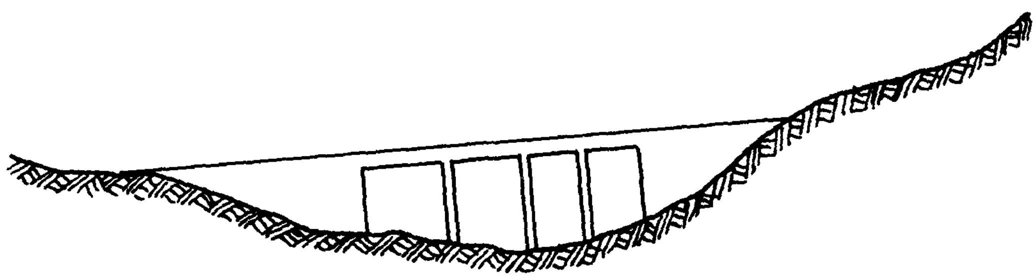
Using the effective area option to define the effective flow area allows the entire overbank to become effective as soon as the effective area elevations are exceeded. The assumption is that under weir flow conditions, the water can generally flow across the whole bridge length and the entire overbank in the vicinity of the bridge would be effectively carrying flow up to and over the bridge. If it is more reasonable to assume only part of the overbank is effective for carrying flow when the bridge is under weir flow, then the cross section should be redefined for sections two and three to eliminate the portion of the overbank area considered ineffective even under weir flow conditions.

Cross section three, just upstream from the bridge, is usually coded in the same manner as section two. In many cases the cross sections are identical. The only difference generally is the elevation to use for the effective area option. For the upstream section, the elevation usually would be the low point of the top-of-road (ELTRD).

Using the effective area option in the manner just described for the two sections on either side of the bridge provides for a constricted section when all of the flow is going under the bridge. When the water surface is higher than the control elevations used, the entire cross section is used. The program user should check the computed solutions on either side of the bridge section to insure they are consistent with



A. Channel Profile and Section Locations



B. Bridge Cross Section on Natural Floodway

C. Portion of Cross Sections 2 & 3 Effective for Low Flow and Pressure Flow

Figure 7. Cross Sections Near Bridges

the type of flow. That is, for low flow or pressure flow solutions, the printout should show the effective area restricted to the main channel. When the bridge data indicates weir flow, the solution should show that the entire cross section is effective.

9. SELECTION OF METHODS

When selecting the method of computing the water surface profile through a bridge, there are three basic choices: (1) determine the change in water surface elevation or the water surface elevation by an "external" technique and input the results into the program, (2) calculate the energy loss based on friction using the standard step method - normal bridge method, or (3) calculate the energy loss by previously discussed formulas of the special bridge method. Each method should be considered and the following discussion provides some basic guidelines.

Input Losses. The following are examples of when a change or known water surface elevation might be read into the program:

1. If a structure acts as a hydraulic control and a rating curve is available, reading in the known water surface elevation is the easiest and surest way to establish proper water surface elevations.

2. The use of observed data to estimate losses through a bridge can also be an expeditious method of establishing the losses.

3. An alternate computation technique can be used such as the Bureau of Public Roads (BPR) procedure (reference i) for determining the loss for low flow conditions. The calculated loss can then be read in. Care must be taken to insure the loss calculated by an alternate method is properly used in the program. For example, the BPR technique provides the increase in water surface elevation above the normal water surface elevation without the bridge. Therefore, it includes the effects of contraction and expansion losses and the loss caused by the structure, but it does not reflect the normal friction loss that would occur without the bridge.

Normal Bridge Method. The use of the standard step method for computing losses is most applicable when friction losses are the predominate consideration. The following examples are some typical cases where the normal bridge method might be used.

1. For long culverts under low flow conditions, the standard step method is the most suitable approach. Several sections can be taken through the culvert to model changes in grade or shape or to model a very long culvert.

2. In cases where the bridge and abutments are a small obstruction to the flow, the normal bridge method can be used.

3. Because the special bridge method requires a trapezoidal approximation of the bridge opening for low flow solutions, the normal bridge method could be used where the flow area cannot be reasonably approximated by a trapezoid. (See paragraph 18).

4. In the special bridge method, the correction for submergence in the weir calculations is not very reliable for high submergence on weirs that are not ogee shaped. The normal bridge method may then be preferable.

Special Bridge Method. The special bridge method is capable of solving a wide range of flow problems. The following are situations where the method is applicable.

1. The special bridge method will determine the class of low flow based on a trapezoidal approximation of a bridge with piers. If a bridge opening can be reasonably modeled by a trapezoid, the program will determine when the profile goes through critical depth and what the corresponding water surface elevation is on either side of the bridge.

2. Pressure flow is computed using the orifice equation. The orifice coefficient can be computed to account for friction; therefore, the special bridge method would be suitable for pressure flow through long culverts.

3. Weir flow is computed in the special bridge method; therefore, dams and weirs can be modeled as well as bridges. When computing pressure flow or weir flow, the program user might consider whether the bridge deck could survive such conditions.

4. Combinations of low or pressure flow and weir flow can be computed using the hydraulic formulas. An iterative procedure solves the combination flow problem for a variety of conditions. For low flow and weir flow solutions the bridge must have piers for the program to handle the low flow part of the combination flow. Otherwise the program will revert to the normal bridge method.

LOSS COEFFICIENTS

10. INTRODUCTION

After the cross sections are located and the method of solution is determined, the program user has to select coefficients associated with the method chosen. For the normal bridge method the Manning's 'n' values are used to determine the friction loss. The contraction and expansion losses caused by the bridge are estimated using contaction and expansion coefficients.

11. CONTRACTION AND EXPANSION COEFFICIENTS

These coefficients are used to compute energy losses associated with changes in the shape of river cross sections (or effective flow areas). The loss due to expansion of flow is usually much larger than the contraction loss, and losses from short abrupt transitions are larger than losses from gradual transitions. The transition loss is computed by multiplying a coefficient times the absolute difference in velocity heads between cross sections. If the values for the coefficients are being redefined to account for contraction and expansion through a bridge, the new values are read on the NC card prior to the section where the change in velocity head is evaluated. Referring back to Figure 6, on a subcritical profile, the new values should be read in just before section two and changed back to the original values after section four. Typical values are shown below.

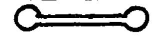
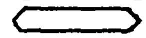
	Coefficients	
	Contraction	Expansion
No transition loss computed	0.0	0.0
Gradual transitions	0.1	0.3
Bridge sections	0.3	0.5
Abrupt transitions	0.6	0.8

The maximum value for the expansion coefficient would be one (1.0).

12. SPECIAL BRIDGE COEFFICIENTS

When using the special bridge method, coefficients must be read in for the Yarnell equation, the orifice equation, and the weir equation. The following discussion provides suggested values and methods for estimating the required coefficients.

Pier Shape Coefficient XK is used in Yarnell's energy equation for computing the change in water surface elevation through a bridge for class A low flow. Because the calculation is based on the presence of piers, both the coefficient and a total width (BWP) must be read on the SB card. If there are no piers, both variables can be left blank and the program will use a standard step solution for low flows. The following table gives values of XK for various pier shapes.

Pier Shape		K
Semicircular nose and tail		0.90
Twin-cylinder piers with connecting diaphragm		0.95
Twin-cylinder piers without diaphragm		1.05
90° triangular nose and tail		1.05
Square nose and tail		1.25

The Yarnell equation is a semi-empirical equation based on hydraulic model data. As such, it probably should not be applied in cases where the flow obstruction is something other than a pier; for example, the fill separating twin circular culverts.

Loss Coefficient XKOR is used in the orifice flow equation,

$Q = A\sqrt{2gH/K}$. This form of the equation can be derived by applying the energy equation from a point just downstream from the bridge (2) to a point just upstream (1).

$$y_1 + Z_1 + \alpha_1 \frac{V_1^2}{2g} = y_2 + Z_2 + \alpha_2 \frac{V_2^2}{2g} + H_L \qquad (1)$$

where:

y = depth of water

Z = invert elevation

$\alpha \frac{V_2^2}{2g}$ = velocity head

H_L = head loss

Defining the head (H) on the orifice as the difference between the upstream energy elevation and the downstream water surface elevation (the definition used in HEC-2) produces:

$$H = \left(y_1 + Z_1 + \frac{\alpha_1 V_1^2}{2g}\right) - (y_2 + Z_2) \qquad (2)$$

Substituting H from equation 2 into equation 1 produces:

$$H = \frac{\alpha_2 V_2^2}{2g} + H_L \qquad (3)$$

Head loss (H_L) through the bridge can be defined in terms of the bridge velocity head and loss coefficient K_b. The example to a point just downstream can be defined by an expansion coefficient K_e and the change in velocity head.

$$H_L = K_b \frac{V_b^2}{2g} + K_e \left(\frac{V_b^2}{2g} - \frac{\alpha_2 V_2^2}{2g} \right) \tag{4}$$

where:

b = subscript designating the bridge

The head loss equation 4 then can be used to define H_L in equation 3:

$$H = \frac{\alpha_2 V_2^2}{2g} + K_b \left(\frac{V_b^2}{2g} \right) + K_e \left(\frac{V_b^2}{2g} - \frac{\alpha_2 V_2^2}{2g} \right) \tag{5}$$

If the expansion coefficient (K_e) is taken as 1.0, the equation can be rewritten into the form of the orifice equation by adding the continuity equation ($Q = VA$).

$$Q = A\sqrt{2gH/K} \tag{6}$$

where:

$K = K_b + 1$

The loss coefficient used in the program's orifice equation can be related to the loss coefficient C from another commonly used orifice flow equation, $Q = CA\sqrt{2gH}$. The conversion ($XKOR = 1/C^2$) can be used for tabulated values of C. However, care must be taken to insure the definition of H used in the various formulations is applicable.

The Bureau of Public Roads (reference 1) shows experimental values for C for fully submerged conditions to vary from 0.7 to 0.9. A value of 0.8 is recommended as being applicable for the average two to four lane concrete girder bridge. The definition of H is consistent with that used in HEC-2. In the absence of calibration data, a value of 1.56 for XKOR (C = 0.8) would be applicable to most bridges and short culverts. For longer culverts, the coefficient can be calculated by the sum of XKOR shown below.

$$XKOR = k_e + k_f + 1$$

where:

k_e = entrance loss coefficient

k_f = friction loss coefficient

The coefficient for friction loss (k_f) can be computed from Manning's equation by equating two equations for friction loss in the culvert.

$$k_f \frac{V_b^2}{2g} = S_f \cdot L \tag{7}$$

where:

S_f = the average friction slope

L = the length of the culvert

Manning's equation for the velocity in the culvert is rearranged to define S_f.

$$V_b = \frac{1.49}{n} R^{2/3} S_f^{1/2}$$

$$S_f = \frac{V_b^2 n^2}{2.22R^{4/3}} \tag{8}$$

By substituting equation 8 for equation 7, the coefficient k_f can be defined based on culvert parameters.

$$k_f = \frac{V_b^2 n^2}{2.22R^{4/3}} \cdot L \cdot \frac{2g}{V_b^2}$$

$$k_f = 29n^2L/R^{4/3} \tag{9}$$

Typical values of the coefficients are shown below:

Description	k
Intake (k_e)	0.1 to 0.9
Intermediate piers	0.05
Friction (Manning's equation)	k_f
	XKOR = $\Sigma k + 1$

where:

English $k_f = 29n^2L/R^{4/3}$

Metric $k_f = 19.6n^2L/R^{4/3}$

King's Handbook (reference e), in its discussion on pipe culverts gives an entrance loss of .1 for a flush inlet, and 0.15 for a projecting inlet for concrete pipes. Inlet loss coefficients as high as 0.9 for a projecting entrance and corregated metal pipes are indicated. All the coefficients were applied to the velocity head for the pipe.

For Multiple Culverts, an equivalent coefficient can be computed to apply in cases where all culverts are flowing full.

$$Q = \sqrt{2gh}\ AT\sqrt{1/K_{equiv}}$$

where:

$$K_{equiv} = \frac{AT^2}{\left[\sum_{i=1}^{n} \sqrt{\frac{A_i^2}{K_i}}\right]^2}$$

AT = total area

A_i = area of individual culvert

K_i = coefficient for individual culvert

n = number of culverts

Coefficient of Discharge, COFQ is used in the standard weir equation: $Q = CLH^{3/2}$. Under free flow conditions (discharge independent of tailwater) the coefficient of discharge "C", ranges from 2.5 to 3.1 (1.39 - 1.72 metric) for broad-crested weirs depending primarily upon the gross head on the crest ("C" increases with head). Increased resistance to flow caused by obstructions such as trash on bridge railings, crubs, and other barriers would decrease the value of C. With submerged flow (discharge affected by tailwater), the coefficient "C" should be reduced. This is done automatically by the program using the Waterways Experiment Station Design Chart 1114. The correction is based on model studies with a low ogee crest weir.

Tables of weir coefficients (C) are given for broad-crested weirs in King's Handbook with the value of C varying with measured head (H) and breadth of weir. For rectangular weirs with a breadth of 15 feet and a H of one foot or more, the given value is 2.63. Trapezoidal shaped weirs generally have a larger coefficient with typical values ranging from 2.7 to 3.08.

Hydraulics of Bridge Waterways (reference i) provides a curve of C versus the head on the roadway. The roadway section is shown as a trapezoid and the coefficient rapidly changes from 2.9 for a very small H to 3.03 for H = 0.6 feet. From there, the curve levels off near a value of 3.05.

With very little prototype data available, it seems the assumption of a rectangular weir for flow over the bridge deck (assuming the bridge can withstand the forces) and a coefficient of 2.6 would be reasonable. If the weir flow is over the roadway approaches to the bridge, a value of 3.0 would be consistent with available data. If weir flow occurs a combination of bridge and roadway, an average coefficient (weighted by weir length) could be used.

EXAMPLE OF INPUT PREPARATION

13. INTRODUCTION

Example problems using the two bridge methods and direct input of bridge loss are provided to illustrate input preparation. The special bridge method is used for a "typical bridge with piers" and the normal bridge method is used for a circular culvert. A simple example illustrates use of the X5 card to read in a change in water surface elevation. A separate section, Bridge Problems and Suggested Approaches, presents the modifications of basic input requirements for some typical bridge problems such as multiple bridge openings, perched bridges, low water bridges and others.

14. SPECIAL BRIDGE EXAMPLE

The example problem shown in Figure 8 is a bridge that spans the entire floodway and has abutments that constrict the natural flow. To simplify input, it will be assumed that the reach has a constant cross sectional shape and has a bed slope of zero. Other pertinent data is shown on the figure. The following discussion describes the input problem and the input is shown in Figure 9. A computer run with the data set is given in Exhibit I.

The problem is set up for a multiple profile run using the QT card. Manning's 'n' values are read on the NC card and contraction and expansion coefficients of 0.3 and 0.5 were selected.

<u>Cross Section 1</u> is the downstream cross section located where the flow has fully expanded back onto the flood plain. The section will be repeated as cross section 2; therefore, the left and right bank stations are selected to be consistent with the bridge opening. The section is located downstream using the 4:1 expansion of the flow as previously presented. The reach lengths for the first section are set to zero as this is the section where the profile is being initiated. The GR cards are used to describe the natural ground section in the usual manner.

<u>Cross Section 2</u> is immediately downstream from the bridge. The reach lengths between sections one and two are set equal to four times the average abutment length (sixty feet ±) for a total reach length of two hundred and forty feet. Because the natural section was considered applicable, the ground profile was repeated.

The effective area option is used at section 2 to confine the flow to the bridge opening when flow through the bridge is low flow or pressure flow. The left and right bank stations have already been set consistent with the abutment locations. All that is required is the X3 card with a ten in the first field and the selection of an elevation above which weir flow can be expected over the bridge. For the initial

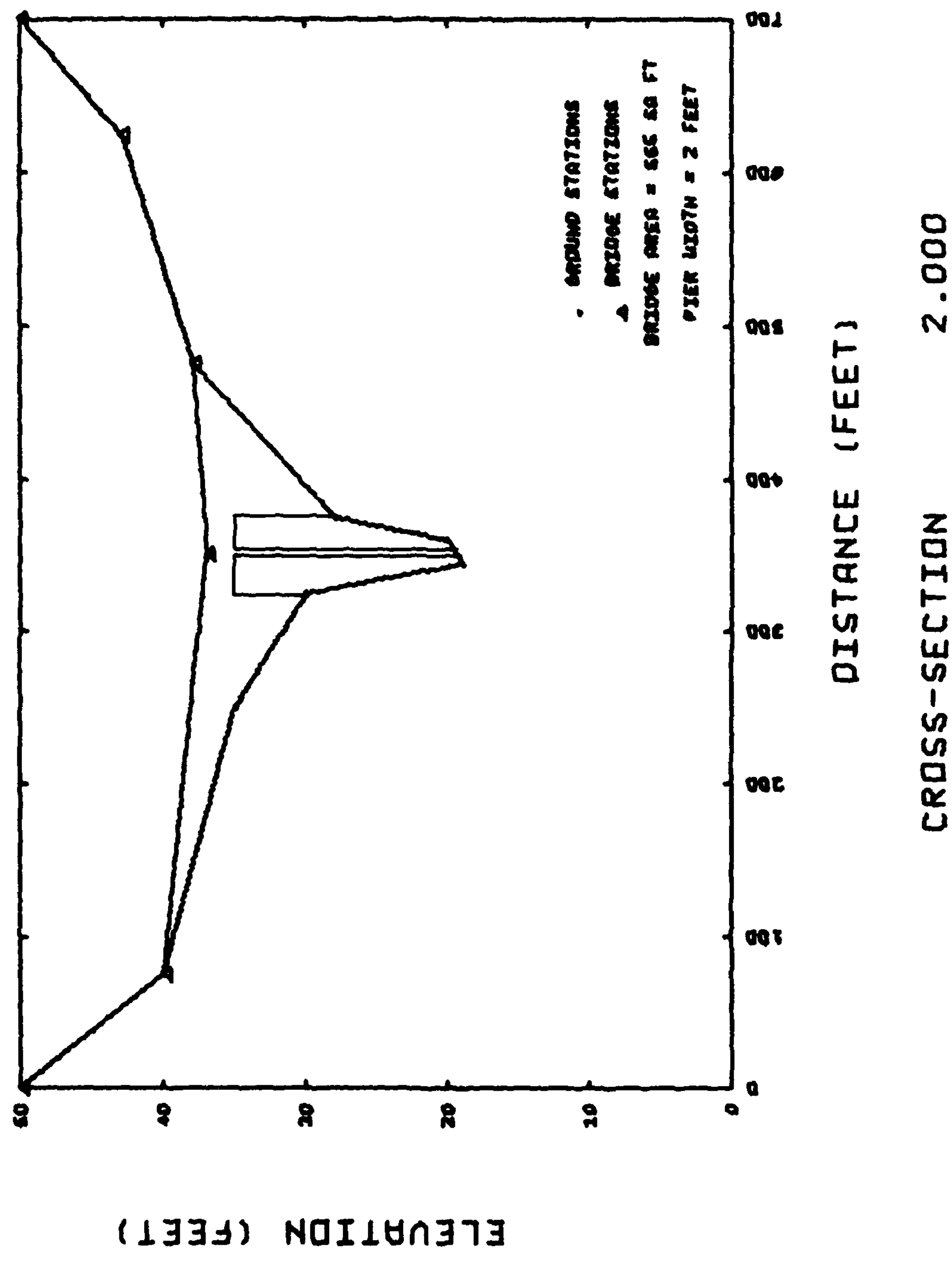


Figure 8. Special Bridge Method Sample Section

PROGRAM HEC-2 | DATE
REQUESTED BY | PREPARED BY | CHECKED BY | PAGE | OF

	1	2	3	4	5	6	7	8	9	10
T1		SPECIAL BRIDGE METHOD EXAMPLE								
T2		LOW FLOW PRØFILE								
T3										
J1		2							30	
NC	.08	.08	.05	.3	.5					
QT	3	2000	4500	6000						
X1	1	10	325	375	0	0	0			
GR	50	0	40	75	35	250	30	325	19	345
GR	20	360	28	375	38	475	43	625	50	700
X1	2				240	240	240			
X3	10							36	36	
SB	1.05	1.6	2.6		15	2	565	1.6	20	20
X1	3				40	40	40			
X2			1	35	37					
X3	10							37	37	
BT	6	0	50		75	40		350	37	
BT	475	38		625	43		700	50		
X1	4				60	60	60			
EJ										
T1		PRESSURE FLOW PRØFILE								
T2										
T3										
J1		3							34	
J2	2									
T1										
T2		PRESSURE AND WEIR FLOW PRØFILE								
T3										
J1		4							36	
J2	15									

Figure 9. Special Bridge Example Input

data input, the elevation at cross section 2 corresponding to weir flow is generally unknown, so an estimate must be made. In the example, water cannot flow around the bridge so weir flow must pass over the bridge. A reasonable estimate for the downstream elevation (i.e., at cross section 2) is an elevation midway between the low chord and top of road elevations, or thrity-six feet in this example. The limiting elevations for the effective area option are entered in fields eight and nine of the X3 card.

Card SB defines bridge characteristics for the special bridge method. The first three variables are the coefficients for computing class A low flow, pressure flow, and weir flow, respectively. The first field contains the pier shape coefficient for the Yarnell equation. The shape of the piers is the basis for selecting the coefficient as shown on page 21. For the example, twin-cylinder piers without diaphragm require a coefficient of 1.05. For a bridge without piers, the first field can be left blank.

For the pressure flow calculations, the value of XKOR is used in the orifice equation. Based on the typical value suggested by the Bureau of Public Roads, a value of 1.6 was selected.

The weir flow coefficient, COFQ, is used to calculate weir flow. In the example, most of the weir flow would occur over the bridge rather than the road, so a value of 2.6 was selected.

The variable RDLEN was not used because it is only applicable for a horizontal weir with a crest length RDLEN. To define the weir profile for the example problem the BT cards are used.

Six variables on the SB card provide the data to model the bridge opening. Five variables define the bridge for low flow calculations with the momentum and Yarnell equations. The bottom width of the trapezoid (BWC) and the side slope (SS) provide the basic trapezoid. Variable BWP gives the total width of piers and ELCHU and ELCHD give the upstream and downstream elevations for the invert of the trapezoid. The sixth variable, BAREA, provides the net area of the bridge opening for calculating pressure flow.

In making a trapezoidal approximation of a bridge opening, dimensions should be chosen so that the corresponding water surface elevation vs. area curve duplicates as closely as possible the elevation vs. area curve for the actual bridge opening. If the area-elevation relation cannot be preserved over the complete range of elevations, emphasis should be placed on the range of elevations to be used in the problem. If low flows are to be run, then the elevation-area curve corresponding to the trapezoid should be appropriate for the lower depths in the bridge section. For high flows, the small depths would not be as important. To check the trapezoidal area for large flows, the user should compare the program computed output variable TRAPEZOID AREA to the net bridge area (BAREA) based on the actual bridge. The two areas should be close, especially if flows near the bridge's low flow capacity are being computed.

The variables ELCHU and ELCHD define the upstream and downstream invert elevations for the trapezoidal area. If the trapezoid invert is the same as the minimum elevation (ELMIN) for the previous cross section (section 2 in this example), then the elevations can be left blank on the SB card. In some cases, the invert elevation must be set higher than ELMIN to give a better bridge model (elevation-area curve) at higher discharges. In those cases, the invert elevations can be read on the SB card.

For the example problem, the invert elevation for the trapezoid was set at twenty feet, slightly higher than the actual elevation. A bottom width of fifteen feet and side slopes of 1.6 give a reasonable trapezoidal approximation. Total net area based on the trapezoidal model is five hundred and fifty-five square feet.

The variable BAREA is the net area under the bridge to be used in the orifice equation. Once the program has determined that flow through the bridge is by pressure flow, the trapezoidal approximation is no longer used, and flow calculations are made using the orifice equation. The total open area under the bridge (BAREA) is used for the pressure flow calculations. Based on the given bridge geometry, an area of five hundred and sixty-five square feet is entered in field seven of the SB card.

Cross section 3, immediately upstream from the bridge, is a repeat of cross section two for this example. The reach lengths for this section are the length of the water course through the bridge.

Following the X1 card for section three is an X2 card. This card is required with the special bridge method to call the special bridge method (IBRID = 1 in field three) and to give test elevations for pressure flow and weir flow (ELLC and ELTRD in fields four and five). The maximum elevation on the low chord of the bridge, ELLC, is used by the program to check if there is a possibility of pressure flow. The low point of the top of road, ELTRD, is used to test if weir flow exists. Even though the program can scan the BT cards to find these elevations, it is good practice to always specify them on the X2 card. Also, the need for low chord elevations on the BT cards is eliminated when coding a bridge with piers for the special bridge method. The effective area option is defined for section three in the same manner as for section two. For the upstream side of the bridge, the elevations for the control of effective area are set to the minimum top of road (ELTRD). As in section two, the X3 cards has a ten in the first field and the control elevations in fields eight and nine.

The BT cards, necessary to define the weir for the special bridge method are placed with input cards for section three. Because the bridge in the example problem has piers, the program will remain with the special bridge method for all solutions. That is, the program cannot revert to the normal bridge method for the given input. This is important to check when coding the BT cards because it can simplify input. If the program remains in the special bridge method, all that is needed on the BT cards is specification of road stations and elevations to define the weir. In defining the weir under these circumstances, road stations do not have to be consistent with the GR card stations.

Without a pier, the special bridge method will use standard step calculations for low flow and for combination weir and low flow solutions (the weir equation would not be used). When standard step calculations are made, the program computes conveyance by segments across the section; therefore, the BT stations under these conditions would have to line up with GR stations and both top of road and low chord elevations would have to be given. The BT cards in the example show the minimum required data for the example problem.

Section three is a repeat section, so there are no GR cards. If GR cards were used with section three, they would follow the BT cards.

Cross section 4 completes the model for the example problem. It is a full flow section located upstream from the bridge beyond the zone of flow contraction. The reach length is estimated by a one to one ratio of the average abutment constriction on the flow. In the example, the distance is sixty feet. Because the same ground geometry is used, no GR cards are read.

If the contraction and expansion coefficients, read on the NC card, were to be changed to lower values for subsequent profile calculations proceeding upstream from cross section four, the new values would be read in after section four and before the next X1 card.

The coded input for this problem was run on HEC-2. The program output is shown in Exhibit I.

15. NORMAL BRIDGE METHOD EXAMPLE

The second example, a circular culvert, will be modeled using the normal bridge method. Again, the problem is fairly simple and intended to illustrate the basic input requirements. The geometric data are shown in Figure 10 and the completed coding form is shown in Figure 11. The computer solution for the problem is shown in Exhibit II. Discussion of the input follows.

A single profile is to be calculated with Manning's 'n' values defined on the NC card. The starting 'n' values define the natural channel and overbanks. Contraction and expansion coefficients of 0.3 and 0.5, respectively, were selected.

The first two cross sections represent the same modeling situtation discussed under the special bridge method example. Cross section 1 is the downstream section located where the flow has fully expanded onto the flood plain. It is located one hundred feet downstream from the bridge based on the 4:1 expansion of the flow as previously presented. Cross section 2 is just downstream from the bridge and represents the contacted effective flow leaving the culvert. The X3 card is used, as before, to call the effective area option and to extend the elevation of channel control for cases where all the flow is going through the culvert.

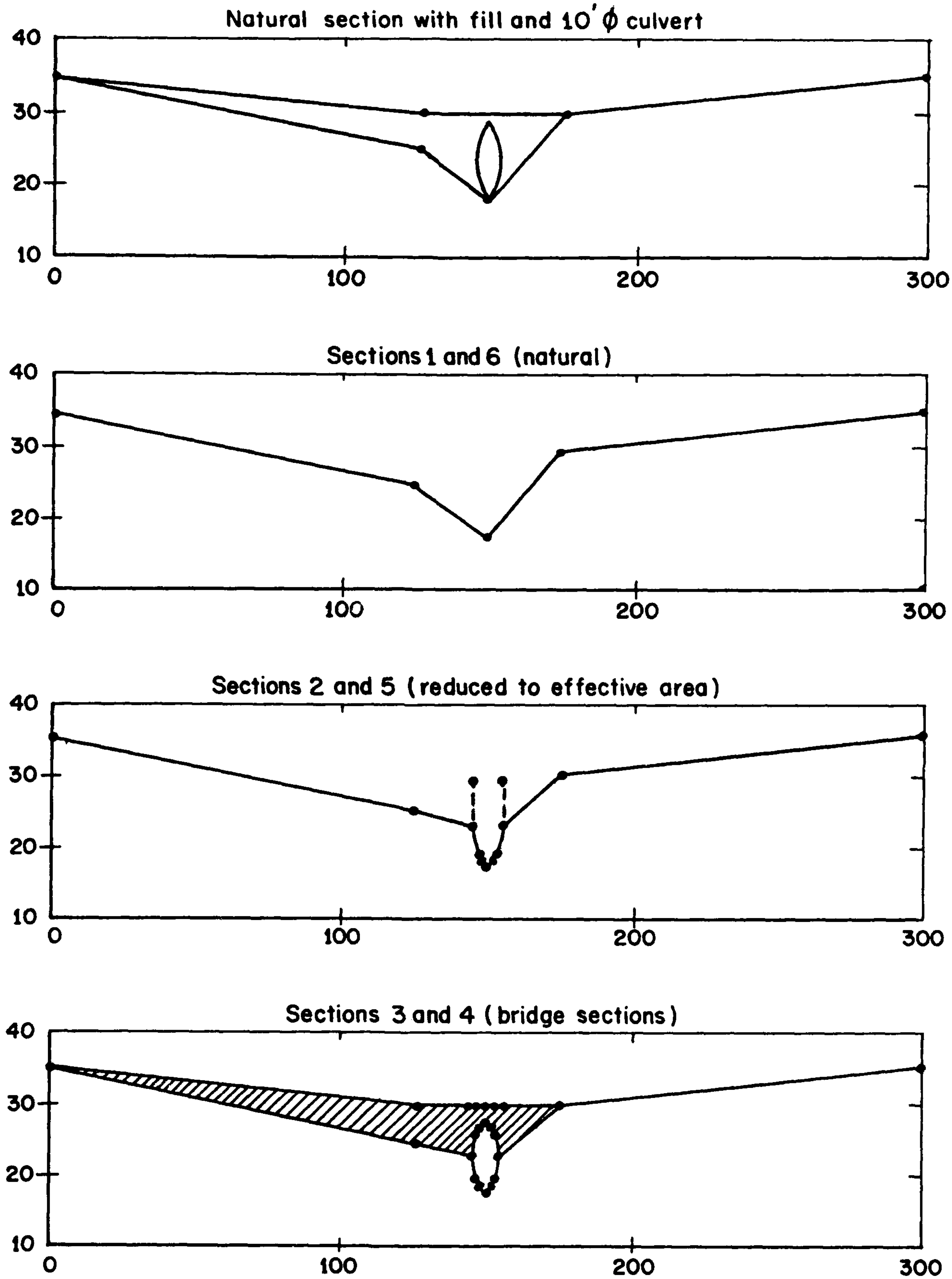


Figure 10. Normal Bridge Method Section

PROGRAM | DATE

REQUESTED BY | PREPARED BY | CHECKED BY | PAGE | OF

Card	1	2	3	4	5	6	7	8	9	10
T1	NORMAL BRIDGE METHOD EXAMPLE									
T2	10 FOOT CIRCULAR CULVERT									
T3										
J1								450	25	
NC	.08	.08	.03	.3	.5					
X1	1	5	125	175	0	0	0			
GR	35	0	25	125	18	150	30	175	35	300
X1	2	11	145	155	100	100	100			
X3	10							29	29	
GR	35	0	25	125	23	145	19.5	145.5	18.5	147.5
GR	18	150	18.5	152.5	19.5	154.5	23	155	30	175
GR	35	300								
NC			.012							
X1	3				10	10	10			
BT	11	0	35	35	125	33	25	145	30	23
BT	145.5	30	25.5	147.5	30	27.5	150	30	28	152.5
BT	30	27.5	154.5	30	25.5	155	30	23	175	30
BT	30	300	35							
X1	4				100	100	100			
X2							1			
NC		.03								
X1	5				10	10	10			
X3	10							30	30	
X1	6	5	125	175	25	25	25			
GR	35	0	25	125	18	150	30	175	35	300
EJ										
ER										

Figure 11. Normal Bridge Example Input

Input for the normal bridge method differs from input for the special bridge at this point, After cross section two, located immediately downstream from the bridge, comes cross section 3 representing a section through the bridge. For the culvert the Manning's 'n' value for the channel should change. Therefore, the NC card is read in prior to cross section three with a channel 'n' value of 0.012 for the culvert.

After changing the 'n' value for the culvert, the culvert is described using the X1 and GR cards to describe the lower half of the culvert and the BT cards to describe the top half. Because the main channel for section two is defined as the lower half of the culvert, section three is read in as a repeat section. To model the culvert, BT cards are added to section three to complete the top half of the culvert.

The BT cards for the normal bridge method should only have stations that are used on the GR cards. Consistent stationing is required because the program computes the conveyance of the cross section incrementally for each GR station. To properly correct the area and wetted perimeter for the presence of the bridge, the given BT stations must coincide with the GR stations. For GR stations between given BT stations, the program will linearly interpolate the road elevation (variable RDEL) and low chord elevation (variable XCEL) to calculate the incremental conveyance.

For bridge stations in the overbank areas, the low chord elevation (XCEL) is usually set equal to the ground point elevation (EL on the GR card). In the channel area, the low chord elevation defines the low chord of the bridge. For the example problem, the low chord elevations define the top half of the culvert. The top of road elevations define the road profile for the cross section.

As cross section three is just inside the culvert on the downstream side, cross section 4 is located inside the culvert at the upstream end. This section is a repeat section of the downstream culvert section. The cross section elevations were not changed; however, the culvert can be modeled with a slope by adding an incremental elevation in field nine of the X1 card. The BT cards for this section are also repeated from section three by using the X2 card with a one in field seven (variable REPBT). If the culvert had been modeled with a slope, the same incremental elevation adjustment used on the X1 card would be applied by the program to the low chord elevations on the BT card. The top of road elevations are not changed by the program. The standard step solution from section three to section four determines friction and expansion or contraction losses through the culvert. If only friction losses should be computed, the values for the contraction and expansion coefficients should be redefined to very small values just before section four. After section four, the values can be reset to calculate shock losses.

Cross section 5 represents the effective flow area just upstream from the bridge. The Manning's 'n' value must first be changed back to represent the channel. An NC card with the channel 'n' value is read in just before cross section five. The section is modeled as a repeat of cross section four, but without the BT cards. The effective area option is again used to maintain the flow in the channel up to the top of road elevation (X3 card with ten in field one and control elevations in fields eight and nine).

The last cross section for the bridge model is a section upstream from the zone of contraction for the bridge. Cross section 6 represents the full flood plain and is located twenty-five feet upstream, determined by using a one on one contaction rate. The ground section is redefined by GR cards. This cross section completes the geometric model for the normal bridge method.

16. INPUT BRIDGE LOSS EXAMPLE

Bridge losses can be read into the program by two different methods. A bridge loss in terms of a change in water surface elevation can be read on the X2 card (variable BLOSS on field six) or on the X5 card. The X5 card will be demonstrated in this example because it can be used for multiple profiles, where as only a single loss can be read on the X2 card.

The example used with the special bridge method will be repeated here. However, instead of modeling the bridge, the calculation will involve only cross sections one through four (see Figure 8 on page 27) and the bridge loss will be input at cross section four. It is assumed for the application that the bridge loss has been determined externally from the program.

The input is a repeat of that for the previous special bridge example (Figures 8 and 9) up through the first cross section. This is followed by input for the far upstream cross section four. An X5 card is added to the usual data at section four.

The X5 card can be used in two ways. Either a water surface elevation or a change in water surface can be defined. The choice is indicated on the card by the sign used (plus or minus) with the variable N on the first field. The variable indicates the number of values to be specified on the X5 card. A positive N indicates water surface elevations and a negative N indicates increments of water surface elevation. The latter is used in this example.

On multiple profile runs, the variable INQ (field two of the J1 card) tells the program which field of the QT card to read. The same procedure is used to read the X5 card. In this example, each field to be read on the QT card has a corresponding bridge loss to be read on the X5 card. The first field of the X5 card shows the number of values to be read. The value in the first field is negative to indicate that changes in water surface elevation are to be read. The changes in the example are the computed results from the special bridge example. The computer run is shown in Exhibit III.

17. INTRODUCTION

The examples presented in the previous section were for relatively simple structures so that fundamental principles of input preparation should be emphasized. However, many bridges are more complex than the one illustrated, and the following discussion is intended to show how HEC-2 can be used to calculate profiles for some of the types of bridges that are frequently encountered. The discussion here will be an extension of the previous examples and will address only those aspects of input preparation that have not been discussed previously.

18. MULTIPLE BRIDGE OPENING

Many bridges have more than one opening for flood flow, especially over very wide flood plains. Multiple culverts, bridges with side relief openings, and separate bridges over a divided channel are all examples of multiple bridge openings. With more than one bridge opening, and possible different control elevations, the problem can be very complicated. Some general consideration follow.

For low flow situations, the normal bridge method is more applicable than the special bridge method. The SB card cannot be used to model more than one trapezoidal bridge opening. Modeling two or more separate bridge openings as one trapezoidal section with wide piers (variable BWP) is generally unsatisfactory because the semi-empirical Yarnell equation has not been calibrated for such flow conditions.

Pressure flow can be modeled with the special bridge method, however, only one controlling elevation (ELLC) can be used. Therefore, if the maximum low chord elevation (variable ELLC) is the same on all bridge openings, or if the flow is high enough to inundate all the openings, the orifice equation can be used. The section on Loss Coefficients provides a method of computing an equivalent coefficient for multiple culverts.

If flow through some of the culverts is low flow while flow through other culverts is pressure flow, the program can not provide a direct solution with the special bridge method. To use the special bridge method, the openings would have to be modeled separately and a "divided flow" approach would be required. (See Chow's "Open Channel Hydraulics," section on Flow Passing Islands, reference j.) A normal bridge solution could be directly obtained if the distribution of flow based on conveyance was reasonable and if one water surface elevation could be assumed for the entire bridge section.

Computer determination of low flow by the normal bridge method and pressure flow by the special bridge method can be obtained in a multiple profile run. By coding the bridge input using the special bridge without a pier, the program will use the normal bridge method for low flow solutions. The BT cards would have to be coded consistent with requirements for the normal bridge method. For the higher discharges where pressure flow occurs, the solution would be obtained from the orifice equation in the special bridge method.

19. DAMS AND WEIRS

Flow over uncontrolled dams and weirs can be modeled with the special bridge method. Weir flow is calculated over weirs defined by either the stations and road elevations on BT cards or by a fixed weir length (RDLEN) and elevation (ELTRD) defined on cards SB and X2, respectively. To use the special bridge method where all flow is weir flow requires the same basic data as for a bridge. Recalling the calculation sequence, the special bridge method assumes low flow and then pressure flow prior to determining that weir flow exists. On the SB card, it is necessary to input some arbitrarily small values for the variables defining the trapezoid and the orifice area (variables BWC, BAREA, and SS). The small areas defined by the trapezoid and BAREA will cause the program to solve for a combination of pressure flow and weir flow. With a very small orifice area, the pressure flow will be negligible and a weir flow solution will have been achieved.

20. PERCHED BRIDGES

A perched bridge is one for which the road approaching the bridge is at the flood plain ground level, and only in the immediate area of the bridge does the road rise above ground level to span the watercourse. A typical flood flow situation with this type of bridge is to have low flow under the bridge and overbank flow around the bridge. Because the road approaching the bridge is usually not much higher than the surrounding ground, the assumption of weir flow is often not justified. A solution based on standard step calculations would be better than a solution based on weir flow with correction for submergence. Therefore, this type of bridge should generally be modeled using the normal bridge method, especially when a large percentage of the total discharge is in the overbank areas.

21. LOW WATER BRIDGES

A low water bridge is designed to carry only low flows under the bridge. Flood flows are carried over the bridge and road. When modeling this bridge for flood flows, the anticipated solution is a combination of pressure and weir flow, which implies using the special bridge method. However, with most of the flow over the top of the bridge, the correction for submergence may introduce considerable error. If the tailwater is going to be high, it may be better to use the normal bridge method. In fact, if almost all the water is over the top, the bridge may be modeled as a cross section over the top of the bridge, ignoring the flow under the bridge.

22. BRIDGES ON A SKEW

Skewed bridge crossings are generally handled by making adjustments to the bridge dimensions to define an equivalent cross section perpendicular to the flow lines. The adjustments can be made in the normal bridge method by multiplying the actual dimensions of the bridge by the cosine of the skew angle. The cosine of the angle is coded on the X1 card (variable PXSECR in field eight) for the cross section coordinates on GR cards and on the X2 card (variable BSQ in field nine) for the data on the BT cards. If the special bridge method is used, the data coded on the SB card must be adjusted prior to input. There is no internal method in the program to adjust the data on the SB card.

In the publication "Hydraulics of Bridge Waterways" (reference i) the effect of skew on low flow is discussed.. In model testing, skewed crossings with angles up to 20° showed no objectionable flow patterns. For increasing angles, flow efficiency decreased. A graph illustrating the impact of skewness indicates that using the projected length is adequate for angles up to 30° for small flow contractions.

23. PARALLEL BRIDGES

With the construction of divided highways, a common modeling problem involved parallel bridges. For new highways, these bridges are often identical structures. The hydraulic losses through the two structures has been shown to be between one and two times the loss for one bridge (reference i). The model results shown in reference i indicate the loss for two bridges ranging from 1.3 to 1.55 times the loss for one bridge crossing, over the range of bridge spacings tested. Presumably if the two bridges were far enough apart, the losses for the two bridges would equal twice the loss for one. For the program user faced with a dual bridge problem, computing a single bridge loss and then adjusting it with criteria from reference i may be the most expedient approach. If both bridges are modeled, care should be exercised in depicting the expansion of flow between the bridges.

REFERENCES

a. "Backwater Curves in River Channels," Engineering Manual 1110-2-1409, U.S. Army Corps of Engineers, 7 December 1959.

b. "Computer Determination of Flow Through Bridges," Eichert, B.S. and Peters, J.C., ASCE, J. Hyd. Div., Vol. 96, No. HY7, July 1970.

c. Koch-Carstanjen, "Von de Bewegung des Wassers und Den Dabei Auftretenden Kraften, Hydrofynamim, Berlin 1962. A partial translation appears in Appendix I, "Report on Engineering Aspects of Flood of March 1938," U.S. Army Engineer Office, Los Angeles, May 1939.

d. "Handbook of Concrete Culvert Pipe Hydraulics," Portland Cement Association, 1964.

e. "Handbook of Hydraulics," Horace W. King and Ernest F. Brater, Fifth Edition, McGraw - Hill Book Company, 1963.

f. "HEC-2, Water Surface Profiles," Programmers Manual, The Hydrologic Engineering Center, September 1982.

g. "Hydraulic Design of Reservoir Outlet Structures," Engineering Manual 1110-2-1602, U.S. Army Engineers, 1 August 1963.

h. "Hydraulic Design of Spillways," Engineering Manual 1110-2-1603, U.S. Army Corps of Engineers, 31 March 1965, Plate 33.

i. "Hydraulics of Bridge Waterways," Hydraulic Design Series No. 1, Joseph Bradley, Federal Highway Administration, U.S. Department of Transportation, revised Second Edition, March 1978.

j. "Open Channel Hydraulics," Ven Te Chow, McGraw - Hill Book Company, 1959.

k. "Water Surface Profiles," IHD Volume 6, The Hydrologic Engineering Center, July 1975.

EXHIBIT I

SPECIAL BRIDGE EXAMPLE

COMPUTER RUN

```
                                                                        THIS RUN EXECUTED 29 JUL 82    9:41:41
**************************************************
  HEC2 RELEASE DATED NOV 76 UPDATED MARC 1982
  ERROR CORR -  01,02,03,04,05
  MODIFICATION -  50,51,52,53,54,55
**************************************************

T1      SPECIAL BRIDGE METHOD EXAMPLE
T2      LOW FLOW PROFILE
T3

J1  ICHECK     INQ       NINV      IDIR      STRT     METRIC     HVINS      Q        WSEL       FQ
       0.        2.        0.        0.  0.000000     0.00       0.0        0.    30.000     0.000

NC      0.080     0.080     0.050     0.300     0.500     0.000     0.000     0.000     0.000     0.000
QT      3.000  2000.000  4500.000  6000.000     0.000     0.000     0.000     0.000     0.000     0.000
X1      1.000    10.000   325.000   375.000     0.000     0.000     0.000     0.000     0.000     0.000
GR     50.000     0.000    40.000    75.000    35.000   250.000    30.000   325.000    19.000   345.000
GR     20.000   360.000    28.000   375.000    38.000   475.000    43.000   625.000    50.000   700.000

X1      2.000     0.000     0.000     0.000   240.000   240.000   240.000     0.000     0.000     0.000
X3     10.000     0.000     0.000     0.000     0.000     0.000     0.000    36.000    36.000     0.000

SB      1.050     1.600     2.600     0.000    15.000     2.000   565.000     1.600    20.000    20.000
X1      3.000     0.000     0.000     0.000    40.000    40.000    40.000     0.000     0.000     0.000
X2      0.000     0.000     1.000    35.000    37.000     0.000     0.000     0.000     0.000     0.000
X3     10.000     0.000     0.000     0.000     0.000     0.000     0.000    37.000    37.000     0.000
BT      6.000     0.000    50.000     0.000    75.000    40.000     0.000   350.000    37.000     0.000
BT    475.000    38.000     0.000   625.000    43.000     0.000   700.000    50.000     0.000     0.000

X1      4.000     0.000     0.000     0.000    60.000    60.000    60.000     0.000     0.000     0.000
EJ      0.000     0.000     0.000     0.000     0.000     0.000     0.000     0.000     0.000     0.000
```

```
 SECNO     DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS   BANK ELEV
 Q         QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA   LEFT/RIGHT
 TIME      VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN      SSTA
 SLOPE     XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID     ENDST

*PROF 1

CCHV=   0.300 CEHV=    0.500
*SECNO 1.000
     1.00     11.00     30.00      0.00     30.00     30.47      0.47      0.00      0.00     30.00
    2000.        0.     1980.       20.        0.      358.       20.        0.        0.     28.00
     0.00      0.00      5.54      0.99     0.080     0.050     0.080     0.000     19.00    325.00
 0.002853        0.        0.        0.         0         0         0      0.00     70.00    395.00

*SECNO 2.000

3495 OVERBANK AREA ASSUMED NON-EFFECTIVE,ELLEA=        36.00 ELREA=        36.00

     2.00     11.68     30.68      0.00      0.00     31.08      0.40      0.59      0.02     30.00
    2000.        0.     2000.        0.        0.      392.        0.        2.        0.     28.00
     0.01      0.00      5.11      0.00     0.080     0.050     0.080     0.000     19.00    325.00
 0.002146      240.      240.      240.         0         0         0      0.00     50.00    375.00


SPECIAL BRIDGE

SB  XK         XKOR       COFQ      RDLEN      BWC        BWP       BAREA       SS        ELCHU      ELCHD
     1.05       1.60       2.60      0.00      15.00       2.00     565.00       1.60     20.00      20.00

*SECNO 3.000
CLASS A LOW FLOW

3420 BRIDGE W.S.=      30.59 BRIDGE VELOCITY=,       6.31      CALCULATED CHANNEL AREA=,       317.

 EGPRS        EGLWC        H3        QWEIR       QLOW       BAREA    TRAPEZOID      ELLC       ELTRD
                                                                       AREA
     0.00      31.12       0.04         0.      2000.        565.      555.       35.00       37.00


3495 OVERBANK AREA ASSUMED NON-EFFECTIVE,ELLEA=        37.00 ELREA=        37.00

     3.00     11.72     30.72      0.00      0.00     31.12      0.40      0.04      0.00     30.00
    2000.        0.     2000.        0.        0.      394.        0.        2.        0.     28.00
     0.02      0.00      5.08      0.00     0.080     0.050     0.080     0.000     19.00    325.00
 0.002112       40.       40.       40.         0         0         0      0.00     50.00    375.00
```

```
 SECNO     DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS    BANK ELEV
 Q         QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA     LEFT/RIGHT
 TIME      VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN       SSTA
 SLOPE     XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID      ENDST

*SECNO 4.000
    4.00     11.90     30.90      0.00      0.00     31.26      0.36      0.12      0.01     30.00
   2000.        3.     1954.       43.        6.      402.       42.        3.        0.      28.00
    0.02      0.47      4.86      1.03     0.080     0.050     0.080     0.000     19.00    311.55
0.001874       60.       60.       60.         2         0         0      0.00     92.42    403.97
```

THIS RUN EXECUTED 29 JUL 82 9:41:51

```
*****************************************************
  HEC2 RELEASE DATED NOV 76 UPDATED MARC 1982
  ERROR CORR -  01,02,03,04,05
  MODIFICATION -  50,51,52,53,54,55
*****************************************************
```

T1 PRESSURE FLOW PROFILE
T2
T3

J1	ICHECK	INQ	NINV	IDIR	STRT	METRIC	HVINS	Q	WSEL	FQ
	0.	3.	0.	0.	0.000000	0.00	0.0	0.	34.000	0.000
J2	NPROF	IPLOT	PRFVS	XSECV	XSECH	FN	ALLDC	IBW	CHNIM	ITRACE
	2.000	0 000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

```
29 JUL 82      9:41:40

   SECNO      DEPTH      CWSEL      CRIWS      WSELK      EG         HV         HL         OLOSS    BANK ELEV
   Q          QLOB       QCH        QROB       ALOB       ACH        AROB       VOL        TWA    LEFT/RIGHT
   TIME       VLOB       VCH        VROB       XNL        XNCH       XNR        WTN        ELMIN       SSTA
   SLOPE      XLOBL      XLCH       XLOBR      ITRIAL     IDC        ICONT      CORAR      TOPWID      ENDST

*PROF 2

CCHV=    0.300 CEHV=    0.500
*SECNO 1.000
      1.00      15.00      34.00       0.00      34.00      34.70       0.70       0.00       0.00      30.00
     4500.       180.      3966.       354.       120.       558.       180.         0.         0.      28.00
      0.00       1.50       7.11       1.96      0.080      0.050      0.080      0.000      19.00     265.00
  0.002603         0.         0.         0.          0          0          0       0.00     170.00     435.00

*SECNO 2.000
3495 OVERBANK AREA ASSUMED NON-EFFECTIVE,ELLEA=       36.00 ELREA=       36.00

      2.00      15.54      34.54       0.00       0.00      35.46       0.92       0.65       0.11      30.00
     4500.         0.      4500.         0.         0.       585.         0.         4.         1.      28.00
      0.01       0.00       7.70       0.00      0.080      0.050      0.080      0.000      19.00     325.00
  0.002859       240.       240.       240.          2          0          0       0.00      50.00     375.00


SPECIAL BRIDGE

SB  XK          XKOR        COFQ        RDLEN       BWC         BWP        BAREA        SS          ELCHU       ELCHD
     1.05        1.60        2.60        0.00       15.00        2.00      565.00        1.60       20.00       20.00

*SECNO 3.000
PRESSURE FLOW

  EGPRS       EGLWC       H3          QWEIR       QPR         BAREA    TRAPEZOID      ELLC        ELTRD
                                                                          AREA
    36.12       35.56       0.11          0.       4500.        565.       555.        35.00       37.00


3495 OVERBANK AREA ASSUMED NON-EFFECTIVE,ELLEA=       37.00 ELREA=       37.00

      3.00      16.31      35.31       0.00       0.00      36.12       0.81       0.66       0.00      30.00
     4500.         0.      4500.         0.         0.       623.         0.         5.         1.      28.00
      0.01       0.00       7.22       0.00      0.080      0.050      0.080      0.000      19.00     325.00
  0.002310        40.        40.        40.          2          0          0       0.00      50.00     375.00
```

```
 SECNO     DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS    BANK ELEV
 Q         QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA    LEFT/RIGHT
 TIME      VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN       SSTA
 SLOPE     XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID     ENDST

*SECNO 4.000
    4.00     16.97     35.97      0.00      0.00     36.35      0.38      0.10      0.13     30.00
   4500.      396.     3583.      520.      277.      656.      318.        6.        1.      28.00
    0.01      1.43      5.46      1.64     0.080     0.050     0.080     0.000     19.00    215.83
0.001233       60.       60.       60.         2         0         0      0.00    238.94    454.76
```

```
                                                          THIS RUN EXECUTED 29 JUL 82    9:41:56
*************************************************
  HEC2 RELEASE DATED NOV 76 UPDATED MARC 1982
  ERROR CORR -  01,02,03,04,05
  MODIFICATION -  50,51,52,53,54,55
*************************************************

T1      PRESSURE AND WEIR FLOW PROFILE
T2
T3

J1  ICHECK    INQ      NINV      IDIR      STRT     METRIC    HVINS     Q        WSEL      FQ
        0.       4.       0.        0.  0.000000    0.00      0.0        0.    36.000    0.000

J2  NPROF     IPLOT    PRFVS     XSECV     XSECH     FN       ALLDC     IBW      CHNIM     ITRACE
     15.000    0.000    0.000     0.000     0.000    0.000     0.000    0.000     0.000     0.000
```

```
  SECNO     DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS    BANK ELEV
  Q         QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA    LEFT/RIGHT
  TIME      VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN       SSTA
  SLOPE     XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID      ENDST

*PROF 3

CCHV=    0.300 CEHV=    0.500
*SECNO 1.000
    1.00     17.00     36.00      0.00     36.00     36.66      0.66      0.00      0.00     30.00
   6000.      533.     4771.      696.      280.      658.      320.        0.        0.     28.00
    0.00      1.90      7.26      2.17     0.080     0.050     0.080     0.000     19.00    215.00
0.002173        0.        0.        0.         0         0         0      0.00    240.00    455.00

*SECNO 2.000
    2.00     17.62     36.62      0.00      0.00     37.16      0.54      0.46      0.04     30.00
   6000.      644.     4599.      758.      355.      688.      371.        7.        1.     28.00
    0.01      1.81      6.68      2.04     0.080     0.050     0.080     0.000     19.00    193.33
0.001732      240.      240.      240.         2         0         0      0.00    267.86    461.19


SPECIAL BRIDGE

S3  XK        XKOR        COFQ        RDLEN       BWC         BWP        BAREA       SS          ELCHU       ELCHD
    1.05      1.60        2.60        0.00        15.00       2.00       565.00      1.60        20.00       20.00

*SECNO 3.000
PRESSURE AND WEIR FLOW

  EGPRS      EGLWC        H3        QWEIR       QPR        BAREA    TRAPEZOID     ELLC      ELTRD
                                                                      AREA
   39.42      37.83      0.04        765.       5182.       565.       555.       35.00     37.00

    3.00     19.40     38.40      0.00      0.00     38.71      0.31      1.55      0.00     30.00
   6000.      973.     4094.      932.      645.      778.      543.        9.        2.     28.00
    0.01      1.51      5.27      1.72     0.080     0.050     0.080     0.000     19.00    130.89
0.000915       40.       40.       40.         2         0         2      0.00    356.21    487.10

*SECNO 4.000
    4.00     19.47     38.47      0.00      0.00     38.77      0.30      0.05      0.00     30.00
   6000.      986.     4073.      941.      659.      781.      551.       12.        2.     28.00
    0.02      1.50      5.21      1.71     0.080     0.050     0.080     0.000     19.00    128.40
0.000891       60.       60.       60.         1         0         0      0.00    360.83    489.23
```

THIS RUN EXECUTED 29 JUL 82 9:42:04

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*****************************************************
 HEC2 RELEASE DATED NOV 76 UPDATED MARC 1982
 ERROR CORR -  01,02,03,04,05
 MODIFICATION -  50,51,52,53,54,55
*****************************************************
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NOTE- ASTERISK (*) AT LEFT OF CROSS-SECTION NUMBER INDICATES MESSAGE IN SUMMARY OF ERRORS LIST

SUMMARY PRINTOUT TABLE 150

SECNO	XLCH	ELTRD	ELLC	ELMIN	Q	CWSEL	CRIWS	EG	10K*S	VCH	AREA	.01K
1.000	0.00	0.00	0.00	19.00	2000.00	30.00	0.00	30.47	28.53	5.54	377.50	374.42
1.000	0.00	0.00	0.00	19.00	4500.00	34.00	0.00	34.70	26.03	7.11	857.50	882.08
1.000	0.00	0.00	0.00	19.00	6000.00	36.00	0.00	36.66	21.73	7.26	1257.50	1287.06
2.000	240.00	0.00	0.00	19.00	2000.00	30.68	0.00	31.08	21.46	5.11	391.74	431.75
2.000	240.00	0.00	0.00	19.00	4500.00	34.54	0.00	35.46	28.59	7.70	584.69	841.64
2.000	240.00	0.00	0.00	19.00	6000.00	36.62	0.00	37.16	17.32	6.68	1414.71	1441.82
3.000	40.00	37.00	35.00	19.00	2000.00	30.72	0.00	31.12	21.12	5.08	393.61	435.20
3.000	40.00	37.00	35.00	19.00	4500.00	35.31	0.00	36.12	23.10	7.22	623.26	936.21
3.000	40.00	37.00	35.00	19.00	6000.00	38.40	0.00	38.71	9.15	5.27	1965.84	1983.93
4.000	60.00	0.00	0.00	19.00	2000.00	30.90	0.00	31.26	18.74	4.86	450.34	462.02
4.000	60.00	0.00	0.00	19.00	4500.00	35.97	0.00	36.35	12.33	5.46	1251.84	1281.44
4.000	60.00	0.00	0.00	19.00	6000.00	38.47	0.00	38.77	8.91	5.21	1991.31	2009.56

29 JUL 82 9:41:40 PAGE 10

SUMMARY PRINTOUT TABLE 150

SECNO	Q	CWSEL	DIFWSP	DIFWSX	DIFKWS	TOPWID	XLCH
1.000	2000.00	30.00	0.00	0.00	0.00	70.00	0.00
1.000	4500.00	34.00	4.00	0.00	0.00	170.00	0.00
1.000	6000.00	36.00	2.00	0.00	0.00	240.00	0.00
2.000	2000.00	30.68	0.00	0.68	0.00	50.00	240.00
2.000	4500.00	34.54	3.87	0.54	0.00	50.00	240.00
2.000	6000.00	36.62	2.08	0.62	0.00	267.86	240.00
3.000	2000.00	30.72	0.00	0.04	0.00	50.00	40.00
3.000	4500.00	35.31	4.59	0.77	0.00	50.00	40.00
3.000	6000.00	38.40	3.09	1.78	0.00	356.21	40.00
4.000	2000.00	30.90	0.00	0.17	0.00	92.42	60.00
4.000	4500.00	35.97	5.08	0.66	0.00	238.94	60.00
4.000	6000.00	38.47	2.49	0.06	0.00	360.83	60.00

29 JUL 82 9:41:40 PAGE 11

SUMMARY OF ERRORS AND SPECIAL NOTES

EXHIBIT II

NORMAL BRIDGE EXAMPLE

COMPUTER RUN

```
                                                          THIS RUN EXECUTED 29 JUL 82    9:42:35
*****************************************************
 HEC2 RELEASE DATED NOV 76 UPDATED MARC 1982
 ERROR CORR -  01,02,03,04,05
 MODIFICATION -  50,51,52,53,54,55
*****************************************************

T1      NORMAL BRIDGE METHOD EXAMPLE
T2      10 FOOT CIRCULAR CULVERT
T3

J1  ICHECK     INQ      NINV      IDIR       STRT     METRIC    HVINS      Q        WSEL      FQ

       0.        0.        0.        0.  0.000000     0.00      0.0     450.    25.000    0.000

NC     0.080     0.080     0.030     0.300     0.500     0.000     0.000     0.000     0.000     0.000
X1     1.000     5.000   125.000   175.000     0.000     0.000     0.000     0.000     0.000     0.000
GR    35.000     0.000    25.000   125.000    18.000   150.000    30.000   175.000    35.000   300.000

X1     2.000    11.000   145.000   155.000   100.000   100.000   100.000     0.000     0.000     0.000
X3    10.000     0.000     0.000     0.000     0.000     0.000     0.000    29.000    29.000     0.000
GR    35.000     0.000    25.000   125.000    23.000   145.000    19.500   145.500    18.500   147.500
GR    18.000   150.000    18.500   152.500    19.500   154.500    23.000   155.000    30.000   175.000
GR    35.000   300.000     0.000     0.000     0.000     0.000     0.000     0.000     0.000     0.000

NC     0.000     0.000     0.012     0.000     0.000     0.000     0.000     0.000     0.000     0.000
X1     3.000     0.000     0.000     0.000    10.000    10.000    10.000     0.000     0.000     0.000
BT    11.000     0.000    35.000    35.000   125.000    30.000    25.000   145.000    30.000    23.000
BT   145.500    30.000    25.500   147.500    30.000    27.500   150.000    30.000    28.000   152.500
BT    30.000    24.500   154.500    30.000    25.500   155.000    30.000    23.000   175.000    30.000
NT    30.000   300.000    35.000     0.000     0.000     0.000     0.000     0.000     0.000     0.000

X1     4.000     0.000     0.000     0.000   100.000   100.000   100.000     0.000     0.000     0.000
X2     0.000     0.000     0.000     0.000     0.000     0.000     1.000     0.000     0.000     0.000

NC     0.000     0.000     0.030     0.000     0.000     0.000     0.000     0.000     0.000     0.000
X1     5.000     0.000     0.000     0.000    10.000    10.000    10.000     0.000     0.000     0.000
X3    10.000     0.000     0.000     0.000     0.000     0.000     0.000    30.000    30.000     0.000

X1     6.000     5.000   125.000   175.000    25.000    25.000    25.000     0.000     0.000     0.000
GR    35.000     0.000    25.000   125.000    18.000   150.000    30.000   175.000    35.000   300.000
EJ     0.000     0.000     0.000     0.000     0.000     0.000     0.000     0.000     0.000     0.000
```

```
   SECNO      DEPTH      CWSEL      CRIWS      WSELK      EG         HV         HL         OLOSS    BANK ELEV
   Q          QLOB       QCH        QROB       ALOB       ACH        AROB       VOL        TWA    LEFT/RIGHT
   TIME       VLOB       VCH        VROB       XNL        XNCH       XNR        WTN        ELMIN       SSTA
   SLOPE      XLOBL      XLCH       XLOBR      ITRIAL     IDC        ICONT      CORAR      TOPWID      ENDST

*PROF 1

CCHV=    0.300 CEHV=    0.500
*SECNO 1.000
      1.00       7.00      25.00       0.00      25.00      25.16       0.16       0.00       0.00      25.00
      450.        0.       450.         0.         0.       139.         0.         0.         0.       30.00
      0.00       0.00       3.25       0.00      0.080      0.030      0.080      0.000      18.00     125.00
  0.000879        0.         0.         0.          0          0          0       0.00      39.58     164.58

*SECNO 2.000

3301 HV CHANGED MORE THAN HVINS

3495 OVERBANK AREA ASSUMED NON-EFFECTIVE,ELLEA=     29.00 ELREA=      29.00

      2.00       6.80      24.80       0.00       0.00      25.69       0.89       0.17       0.36      23.00
      450.        0.       450.         0.         0.        60.         0.         0.         0.       23.00
      0.00       0.00       7.55       0.00      0.080      0.030      0.080      0.000      18.00     145.00
  0.004249       100.       100.       100.          2          0          0       0.00      10.00     155.00

*SECNO 3.000

3370 NORMAL BRIDGE,NRD= 11 MIN ELTRD=    30.00 MAX ELLC=    35.00

      3.00       6.81      24.81      22.81       0.00      25.72       0.91       0.02       0.01      23.00
      450.        0.       450.         0.         0.        59.         0.         0.         0.       23.00
      0.00       0.00       7.64       0.00      0.080      0.012      0.080      0.000      18.00     126.78
  0.000990        10.        10.        10.          2         18          0     -22.16      33.43     160.21

*SECNO 4.000

3370 NORMAL BRIDGE,NRD= 11 MIN ELTRD=    30.00 MAX ELLC=    35.00

      4.00       6.95      24.95      22.81       0.00      25.83       0.87       0.10       0.01      23.00
      450.        0.       450.         0.         0.        60.         0.         0.         0.       23.00
      0.01       0.00       7.50       0.00      0.080      0.012      0.080      0.000      18.00     125.45
  0.000974       100.       100.       100.          4         18          0     -25.60      35.13     160.58
```

```
 SECNO      DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS    BANK ELEV
 Q          QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA    LEFT/RIGHT
 TIME       VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN       SSTA
 SLOPE      XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID     ENDST

*SECNO 5.000

3495 OVERBANK AREA ASSUMED NON-EFFECTIVE,ELLEA=       30.00 ELREA=       30.00

     5.00      7.04     25.04      0.00      0.00     25.86      0.82      0.02      0.02     23.00
     450.        0.      450.        0.        0.       62.        0.        0.        0.      23.00
     0.01      0.00      7.27      0.00     0.080     0.030     0.080     0.000     18.00    145.00
 0.003739       10.       10.       10.         2         0         0      0.00     10.00    155.00

*SECNO 6.000

3301 HV CHANGED MORE THAN HVINS

     6.00      8.00     26.00      0.00      0.00     26.10      0.10      0.02      0.22     25.00
     450.        1.      449.        0.        6.      179.        0.        0.        0.      30.00
     0.01      0.23      2.50      0.00     0.080     0.030     0.080     0.000     18.00    112.47
 0.000397       25.       25.       25.         3         0         0      0.00     54.21    166.67
```

PROFILE FOR STREAM

PLOTTED POINTS (BY PRIORITY)-E-ENERGY,W-WATER SURFACE,I-INVERT,C-CRITICAL W.S.,L-LEFT BANK,R-RIGHT BANK,M-LOWER END STA

```
ELEVATION    18.       20.       22.       24.       26.       28.       30.       32.       34.
    SECNO   CUMDIS

     1.00     0.  I         .         .         .    WE   .         .         R         .         .    M    .         .
              5.  I         .         .         .   LWE   .         .       R .         .         .    M    .         .
             10.  I         .         .         .   LWE   .         .     R   .         .         .    M    .         .
             15.  I         .         .         .  L WE   .         .    R    .         .         .    M    .         .
             20.  I         .         .         .  L WE   .         .  R      .         .         .    M    .         .
             25.  I         .         .         .  L WE   .         .R        .         .         .    M    .         .
             30.  I         .         .         . L  W E  .         R         .         .         .    M    .         .
             35.  I         .         .         .L   W E  .       R .         .         .         .    M    .         .
             40.  I         .         .         .L   W E  .     R   .         .         .         .    M    .         .
             45.  I         .         .         L    W E  .   R     .         .         .         .    M    .         .
             50.  I         .         .         L    W E  .  R      .         .         .         .    M    .         .
             55.  I         .         .        L.   W  E  .R        .         .         .         .    M    .         .
             60.  I         .         .        L.   W  E R.         .         .         .         .    M    .         .
             65.  I         .         .       L .   W  RE .         .         .         .         .    M    .         .
             70.  I         .         .       L .   WR  E .         .         .         .         .    M    .         .
             75.  I         .         .       L .   W   E .         .         .         .         .    M    .         .
             80.  I         .         .      L  . R W   E .         .         .         .         .    M    .         .
             85.  I         .         .     L   R   W   E .         .         .         .         .    M    .         .
             90.  I         .         .     L R .   W   E .         .         .         .         .    M    .         .
             95.  I         .         .    L R  .   W   E .         .         .         .         .    M    .         .
            100.  I         .         .    L    .   W   E .         .         .         .         .    M    .         .
     2.00   105.  I         .         .    L    .   W   E .         .         .         .         .    M    .         .
            110.  I         .         .    L    .   W    E.         .         .         .         .    M    .         .
     3.00   115.  I         .         .   CL    .   W    E.         .         .         .         .    M    .         .
            120.  I         .         .   CL    .   W    E.         .         .         .         .    M    .         .
            125.  I         .         .   CL    .   W    E.         .         .         .         .    M    .         .
            130.  I         .         .   CL    .   W    E.         .         .         .         .    M    .         .
            135.  I         .         .   CL    .   W    E.         .         .         .         .    M    .         .
            140.  I         .         .   CL    .   W    E.         .         .         .         .    M    .         .
            145.  I         .         .   CL    .   W    E.         .         .         .         .    M    .         .
            150.  I         .         .   CL    .   W    E.         .         .         .         .    M    .         .
            155.  I         .         .   CL    .   W    E.         .         .         .         .    M    .         .
            160.  I         .         .   CL    .   W    E.         .         .         .         .    M    .         .
            165.  I         .         .   CL    .   W    E.         .         .         .         .    M    .         .
            170.  I         .         .   CL    .   W    E.         .         .         .         .    M    .         .
            175.  I         .         .   CL    .   W    E.         .         .         .         .    M    .         .
            180.  I         .         .   CL    .    W   E.         .         .         .         .    M    .         .
            185.  I         .         .   CL    .    W   E.         .         .         .         .    M    .         .
            190.  I         .         .   CL    .    W   E.         .         .         .         .    M    .         .
            195.  I         .         .   CL    .    W   E.         .         .         .         .    M    .         .
            200.  I         .         .   CL    .    W   E.         .         .         .         .    M    .         .
            205.  I         .         .   CL    .    W   E.         .         .         .         .    M    .         .
            210.  I         .         .   CL    .    W   E.         .         .         .         .    M    .         .
     4.00   215.  I         .         .   CL    .    W   E.         .         .         .         .    M    .         .
            220.  I         .         .    L    .    W   E.         .         .         .         .    M    .         .
     5.00   225.  I         .         .    L    .    W   E.         .         .         .         .    M    .         .
            230.  I         .         .      L  . R   W   E         .         .         .         .    M    .         .
            235.  I         .         .        L.      W RE         .         .         .         .    M    .         .
            240.  I         .         .         .L      W E     R   .         .         .         .    M    .         .
            245.  I         .         .         .  L     WE         .  R      .         .         .    M    .         .
     6.00   250.  I         .         .         .    L    E         .         R         .         .    M    .         .
```

EXHIBIT III

INPUT LOSS EXAMPLE

COMPUTER RUN

THIS RUN EXECUTED 29 JUL 82 9:42:58

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****************************************************
 HEC2 RELEASE DATED NOV 76 UPDATED MARC 1982
 ERROR CORR -  01,02,03,04,05
 MODIFICATION -  50,51,52,53,54,55
****************************************************
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T1 BRIDGE PROBLEM WITH INPUT LOSS
T2 X5 CARD USED
T3 WSEL CHANGE FROM SPECIAL BRIDGE PROBLEM

J1	ICHECK	INQ	NINV	IDIR	STRT	METRIC	HVINS	Q	WSEL	FQ
	0.	2.	0.	0.	0.000000	0.00	0.0	0.	30.000	0.000

NC	0.080	0.080	0.050	0.300	0.500	0.000	0.000	0.000	0.000	0.000
QT	3.000	2000.000	4500.000	6000.000	0.000	0.000	0.000	0.000	0.000	0.000
X1	1.000	10.000	325.000	375.000	0.000	0.000	0.000	0.000	0.000	0.000
GR	50.000	0.000	40.000	75.000	35.000	250.000	30.000	325.000	19.000	345.000
GR	20.000	360.000	28.000	375.000	38.000	475.000	43.000	625.000	50.000	700.000
X1	4.000	0.000	0.000	0.000	415.000	415.000	415.000	0.000	0.000	0.000
X5	-3.000	1.070	2.200	2.560	0.000	0.000	0.000	0.000	0.000	0.000
EJ	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

```
  SECNO     DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS   BANK ELEV
  Q         QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA    LEFT/RIGHT
  TIME      VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN       SSTA
  SLOPE     XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID     ENDST

*PROF 1

CCHV=    0.300 CEHV=    0.500
*SECNO 1.000
     1.00     11.00     30.00      0.00     30.00     30.47      0.47      0.00      0.00     30.00
    2000.        0.     1980.       20.        0.      358.       20.        0.        0.     28.00
     0.00      0.00      5.54      0.99     0.080     0.050     0.080     0.000     19.00    325.00
 0.002853        0.        0.        0.         0         0         0      0.00     70.00    395.00

*SECNO 4.000
 WATER EL=X5 CARD=     31.070
     4.00     12.07     31.07      0.00      0.00     31.41      0.34      0.91      0.04     30.00
    2000.        4.     1947.       48.        9.      411.       47.        4.        1.     28.00
     0.02      0.51      4.74      1.03     0.080     0.050     0.080     0.000     19.00    308.95
 0.001733      415.      415.      415.         0         0         0      0.00     96.75    405.70
```

THIS RUN EXECUTED 29 JUL 82 9:43:07

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**************************************************
 HEC2 RELEASE DATED NOV 76 UPDATED MARC 1982
 ERROR CORR -  01,02,03,04,05
 MODIFICATION -  50,51,52,53,54,55
**************************************************
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T1 SECOND PROFILE
T2
T3

J1	ICHECK	INQ	NINV	IDIR	STRT	METRIC	HVINS	Q	WSEL	FQ
	0.	3.	0.	0.	0.000000	0.00	0.0	0.	34.000	0.000
J2	NPROF	IPLOT	PRFVS	XSECV	XSECH	FN	ALLDC	IBW	CHNIM	ITRACE
	2.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

```
  SECNO      DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS    BANK ELEV
  Q          QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA     LEFT/RIGHT
  TIME       VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN       SSTA
  SLOPE      XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID      ENDST

*PROF 2

CCHV=    0.300 CEHV=    0.500
*SECNO 1.000
      1.00     15.00     34.00      0.00     34.00     34.70      0.70      0.00      0.00     30.00
     4500.      180.     3966.      354.      120.      558.      180.        0.        0.      28.00
      0.00      1.50      7.11      1.96     0.080     0.050     0.080     0.000     19.00    265.00
  0.002603        0.        0.        0.         0         0         0      0.00    170.00    435.00

*SECNO 4.000
 WATER EL=X5 CARD=     36.200
      4.00     17.20     36.20      0.00      0.00     36.55      0.35      0.68      0.10     30.00
     4500.      426.     3537.      537.      303.      667.      336.       10.        2.      28.00
      0.03      1.41      5.30      1.60     0.080     0.050     0.080     0.000     19.00    208.00
  0.001135      415.      415.      415.         0         0         0      0.00    249.00    457.00
```

THIS RUN EXECUTED 29 JUL 82 9:43:12

```
****************************************************
  HEC2 RELEASE DATED NOV 76 UPDATED MARC 1982
  ERROR CORR -  01,02,03,04,05
  MODIFICATION -  50,51,52,53,54,55
****************************************************
```

```
T1      THIRD PROFILE
T2
T3

J1  ICHECK    INQ      NINV     IDIR      STRT      METRIC    HVINS     Q        WSEL      FQ
        0.       4.       0.       0.  0.000000     0.00      0.0       0.    36.000    0.000

J2  NPROF     IPLOT    PRFVS    XSECV     XSECH     FN        ALLDC     IBW      CHNIM     ITRACE
     15.000    0.000    0.000    0.000     0.000    0.000     0.000    0.000     0.000     0.000
```

```
 SECNO      DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS    BANK ELEV
 Q          QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA    LEFT/RIGHT
 TIME       VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN      SSTA
 SLOPE      XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID     ENDST

*PROF 3

CCHV=    0.300 CEHV=    0.500
*SECNO 1.000
     1.00     17.00     36.00      0.00     36.00     36.66      0.66      0.00      0.00     30.00
    6000.      533.     4771.      696.      280.      658.      320.        0.        0.     28.00
     0.00      1.90      7.26      2.17     0.080     0.050     0.080     0.000     19.00    215.00
 0.002173        0.        0.        0.         0         0         0      0.00    240.00    455.00

*SECNO 4.000
 WATER EL=X5 CARD=     38.560
     4.00     19.56     38.56      0.00      0.00     38.85      0.29      0.54      0.11     30.00
    6000.     1002.     4047.      951.      676.      785.      561.       16.        3.     28.00
     0.03      1.48      5.15      1.70     0.080     0.050     0.080     0.000     19.00    125.40
 0.000864      415.      415.      415.         0         0         0      0.00    366.40    491.80
```

THIS RUN EXECUTED 29 JUL 82 9:43:17

```
**************************************************
  HEC2 RELEASE DATED NOV 76 UPDATED MARC 1982
  ERROR CORR -  01,02,03,04,05
  MODIFICATION -  50,51,52,53,54,55
**************************************************
```

NOTE- ASTERISK (*) AT LEFT OF CROSS-SECTION NUMBER INDICATES MESSAGE IN SUMMARY OF ERRORS LIST

WSEL CHANGE FROM SPECIAL

SUMMARY PRINTOUT TABLE 150

	SECNO	XLCH	ELTRD	ELLC	ELMIN	Q	CWSEL	CRIWS	EG	10K*S	VCH	AREA	.01K
	1.000	0.00	0.00	0.00	19.00	2000.00	30.00	0.00	30.47	28.53	5.54	377.50	374.42
	1.000	0.00	0.00	0.00	13.00	4500.00	34.00	0.00	34.70	26.03	7.11	857.50	882.08
	1.000	0.00	0.00	0.00	19.00	6000.00	36.00	0.00	36.66	21.73	7.26	1257.50	1287.06
*	4.000	415.00	0.00	0.00	19.00	2000.00	31.07	0.00	31.41	17.33	4.74	466.71	480.38
*	4.000	415.00	0.00	0.00	19.00	4500.00	36.20	0.00	36.55	11.35	5.30	1306.40	1335.47
*	4.000	415.00	0.00	0.00	19.00	6000.00	38.56	0.00	38.85	8.64	5.15	2022.49	2040.84

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WSEL CHANGE FROM SPECIAL

SUMMARY PRINTOUT TABLE 150

	SECNO	Q	CWSEL	DIFWSP	DIFWSX	DIFKWS	TOPWID	XLCH
	1.000	2000.00	30.00	0.00	0.00	0.00	70.00	0.00
	1.000	4500.00	34.00	4.00	0.00	0.00	170.00	0.00
	1.000	6000.00	36.00	2.00	0.00	0.00	240.00	0.00
*	4.000	2000.00	31.07	0.00	1.07	0.00	96.75	415.00
*	4.000	4500.00	36.20	5.13	2.20	0.00	249.00	415.00
*	4.000	6000.00	38.56	2.36	2.56	0.00	366.40	415.00

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SUMMARY OF ERRORS AND SPECIAL NOTES

NOTE SECNO= 4.000 PROFILE= 1 WSEL BASED ON X5 CARD
NOTE SECNO= 4.000 PROFILE= 2 WSEL BASED ON X5 CARD
NOTE SECNO= 4.000 PROFILE= 3 WSEL BASED ON X5 CARD

APPENDIX V

SPECIAL NOTE LISTING

SPECIAL NOTES

This appendix explains special notes which commonly appear as part of the normal output. The special notes should be carefully reviewed to assure an accurate profile. If the reason the notes appear are not satisfactorily substantiated, the job may be rerun obtaining trace printout. (A programmers manual or source listing is required to interpret program traces).

Statement Number	Notes and Remarks
1221	NUMBER PROFILES TOO LARGE. The number of profiles calculated exceeds limit of fourteen.
1262	TAILWATER IS BELOW BRIDGE TRAPEZOID BOTTOM PROGRAM ABORTING AT SECTION X. The water surface elevation at the downstream cross section is below the trapezoid bottom specified on the SB card for this section. Remodel the invert of the downstream cross section to raise the water surface elevation or modify the SB trapezoid.
1340	CARD NOT RECOGNIZED. First two columns in input card read did not correspond to any of the standard alphanumber characters used to identify cards.
1362	XKOR INCREASED TO 1.2. The orifice coefficient was zero or minus and was therefore changed to 1.2 since 1.0 is the minimum value. (SB.2)
1365	SB CARD, BWP = 0. On the special bridge method card SB, the pier width omitted. If there are no piers, this is satisfactory. (SB.6)
1366	SB CARD, BAREA = 0. On the special bridge method card SB, the area of the bridge when flowing full is omitted and therefore this job has been terminated. (SB.7)
1400	CCHV = , CEHV - . A change in contraction and expansion losses has been made. (NC.4 & .5)
1415	INQ EXCEEDS NUMQ. The field of the QT cards to be used for the current Q, specified by variable INQ, contained no flow data. (INQ,J1.2)
1445	Q EXCEEDS 19. The number of discharges on the QT card exceed the maximum allowable number of nineteen.
1452	NV CARDS EXCEED 4. The number of items specified on the NV card exceed the allowable.
1455	NV CARD USED. A table of Manning's 'n' values for the channel and corresponding elevations, was used.
1481	EL(N) DON'T INCREASE. The elevations on the NV cards must increase when the channel roughness is varied with elevation and therefore, the job has been terminated.

Statement Number	Notes and Remarks
1490	NH CARD USED. Manning's 'n' value varied horizontally in accordance with values on NH card.
1518	NH CARD STATIONS NOT INCREASING. The stations on the NH card specifying changes in Manning's roughness must increase and therefore, the job has been terminated.
1525	NH VALUES EXCEED 20. Manning's roughness coefficient specified on the NH card exceeded the allowable number.
1535	Q = 0. The discharge was not specified on the QT card.
1537	START TRIB COMP. Since a negative section number was used, the profile is to be computed on a tributary starting with the water surface elevation which was computed for the same (positive) section number on the main stem.
1553	STARTING NC CARD OMITTED. The starting values on the NC card were not given. The roughness values assumed were very small (.00001).
1645	INT SEC ADDED BY RAISING SEC X, Y, FT AND MULTIPLYING BY Z. An intermediate cross section was calculated by the computer and inserted between two cross sections specified by input data.
1707	STCHL OF X, GREATER THAN Y. The station of the left bank is larger than the station of the right bank. The value of STCHL is changed to equal the first station of the cross section. (X1.3)
1740	CHIMP TEMPLATE DOES NOT INTERSECT CROSS SECTION, STMAX SET EQUAL TO X.
1807	BT CARDS EXCEED 100 PTS. Number of points describing the bridge (BT card) exceed allowable.
1857	BT CARD, STA DON'T INCREASE. The roadway stations on the BT card should increase. Data should be corrected.
1860	XLCEL OF X, EXCEEDS RDEL OF Y. The low chord elevation of X exceeds the corresponding value of the top of roadway Y. Data should be corrected. (BT cards)
1912	GR CARDS, STATIONS DON'T INCREASE. The ground profile points do not increse in horizontal station. The data should be corrected.
2020	NUMBER EL, STA, PTS EXCEED 100. The number of points used to describe the ground profile for the current cross section exceed the allowable. Additional GR points may have been generated by encroachment options.

Statement Number	Notes and Remarks
2077	GR CARDS MISSING. The GR cards for a given X1 card with NUMST greater than zero were not given.
2096	WSEL NOT GIVEN, AVG OF MAX, MIN USED. The starting water surface elevation was not given and therefore, has been assumed as halfway between the maximum and minimum elevation in the cross section. (J1.9)
2620	NO IMPROVEMENT MADE TO THIS SECTION. The subroutine CHIMP has been requested by the CI card and the excavation described will not cut the existing cross section.
2725	WSEL EXCEEDS LIMITS OF TABLE FOR MANNING's 'n'. An assumed water surface elevation fell outside the elevation limits which specified Manning's 'n' values on NV card. Table values were extrapolated for 'n' values.
2750	NUMBER OF COMPUTED POINTS EXCEED 100. The number of points added by subroutine CHIMP have caused the total to exceed one hundred. Reduce the number of points on the GR card.
2800	NATURAL Q1 = A, WSEL = b, ENC Q1 = C, WSEL = D, RATIO = E. See explanation on page II-6
3073	NEGATIVE SLOPE, WSEL = , EG = , PCWSE = , XEG = , WLEN = RESTART COMPUTATIONS AT SECNO = , USING 'n' VALUES COMPUTED FOR SECNO = . A negative slope of the energy gradient has been computed while trying to calculate roughness values that will exactly duplicate the observed high water marks. Due to this condition, the computations will start over again using the previous section's roughness values.
3075	SET S = SAVE. The computed slope at this section was negative or zero. The slope was set equal to the computed average slope between this and the previous section.
3170	NO ENCROACHMENT MORE THAN 800 XSEC. The number of cross sections for a given data set exceeded the maximum allowable for encroachment analysis.
3235	SLOPE TOO STEEP, EXCEEDS X. The computed slope of the energy grade line exceeded X, and critical depth has probably been crossed. If this cross section is a bridge, the special bridge method should be used in lieu of the normal bridge.
3265	DIVIDED FLOW. The area below the computed water surface elevation is divided into two or more segments by high ground. If this condition occurs for three or more cross sections consecutively, then separate profiles should be run up each leg of the divided flow as the water surface elevations are not necessarily identical at each cross section.

Statement Number	Notes and Remarks
3280	CROSS SECTION EXTENDED X FEET (METERS). The cross section's ends have been projected vertically fifty feet (meters) in order to calculate the hydraulic properties of the cross section. Exactly X feet (meters) of this extension were used. If this vertical assumption could produce unreasonable results, the input data should be corrected.
3301	HV CHANGED MORE THAN HVINS. The difference between velocity heads computed for the current and previous cross sections exceeded the allowable specified by input as HVINS (or .5 feet if HVINS = 0, J1.7).
3370	NORMAL BRIDGE, NRD = X, MIN ELTRD = Y, MAX ELLC = Z. The normal bridge method was used for this cross section. The number of points used in describing the bridge deck are given.
3377	BLOSS READ IN. The difference in water surface elevation between the previous and current cross section was given by input data. (X2.6)
3420	BRIDGE W.S. = X, BRIDGE VELOCITY = Y. The water surface elevation under the bridge is specified by X and the velocity through the bridge is Y.
3470	ENCROACHMENT STATIONS = W,X TYPE = Y TARGET = Z. The values of STENCL and STENCR (left and right encroachment stations) are W and X. The method used in determining these stations is method Y and the specified target (width or percent) for that method is Z. If the target is a percent, a ratio less than one is used instead of percent so that a percent target can be distinguished from a top width target.
3495	OVERBANK AREA ASSUMED NONEFFECTIVE, XLBEL = X, RBEL = Y. The effective area option (IEARA) was used and the computed water surface elevation was below at least one of the bank elevations specified by X and Y and therefore, this flow area was assumed noneffective. (X3.1)
3649	NUMBER SECTION EXCEED LIMIT. The number of cross sections for the given data set exceeds limit of eight hundred.
3685	20 TRIALS ATTEMPTED WSEL, CWSEL. The number of trials in balancing the assumed and computed water surface elevations for the standard step procedure of backwater has reached twenty. Check the assumed water elevation for reasonableness.

Statement Number	Notes and Remarks
3693	PROBABLE MINIMUM SPECIFIC ENERGY. This note is similar to 7185 except it is not certain (only probable), that critical depth has been crossed. It is known that no depth of flow assumed in any of the trials produced an energy grade line elevation as high as the minimum energy at critical depth.
3700	BRIDGE STENCL = X, STENCR = Y. The bridge profile has been encroached upon, the left and right encroachment stations are X and Y.
3710	WSEL ASSUMED BASED ON MIN DIFF. At the conclusion of twenty trials the assumed water surface elevation will be made equal to the elevation that came the closest to balancing. This condition usually occurs near the top of banks when IEARA = 10. Check results for reasonableness.
3720	ASSUMED CRITICAL DEPTH. Critical depth has been assumed for this cross section. This assumption should be verified by inspection of channel properties. Additional cross sections may need to be inserted in order to preserve the assumption of gradually varying flow.
3790	DATA ERROR. JOB DUMPED. The computer detected an error in input and terminated that particular job (profile), but continued on with the next job of the input data.
3800	PREVIOUS ST GREATER THAN CURRENT. Either an input error caused the stations of the GR card to not increase or a programming error has been found.
3805	Q = 0. The discharge was not specified for this job.
3810	HT IS -. The height (HT), determined by subtracting the ground elevation from the assumed water surface elevation, has been found to be negative. Corrections for bridge deck (ELTRD - ELLC) used in the normal bridge method will have caused this note if any ELLC is greater than the corresponding ELTRD. If this is not the case a program error has been found, and a trace may be required to determine the source of the error.
3820	STA(N) GREATER STMAX. One of the stations of the points on the current ground profile cards (GR) was greater than the maximum station for this profile.
3830	AROB OR ALOB IS -. A negative area in the left or right overbank has been computed. A program error probably has been detected. A trace may be required to determine the program error.
3840	SECTION NOT HIGH ENOUGH. The computed water surface elevation exceeds the maximum specified on input cards, therefore, the cross section ends have been vertically raised fifty feet.

Statement Number	Notes and Remarks
3956	VOL NOT ON J3 CARD. The J4 card has been used. The J4 card requires that variable VOL and TIME be requested on the J3 card.
3965	REACH OF - NOT EQUAL TO SECNO OF -. The J4 card has been used to specify routing reaches which must be equal to the section numbers (SECNO) on the first field of the X1 card. The section numbers must also be in increasing order.
4020	80 TRIALS NOT ENOUGH FOR CRITICAL DEPTH. This note indicates a data error or program error has been detected. If no data error is detected, job may be rerun, with ITRACE equal to one, in order to obtain reason for failure of parabolic optimization process.
4478	FLOATING ICE COVER, ICE THICKNESS LOB = X, CH = Y, ROB = Z. Computations at this cross section include the hydraulic effects of a stationary floating ice cover. Ice cover thickness in left overbank is X feet or meters, channel thickness is Y feet or meters and right overbank thickness is Z feet of meters.
4575	CRITICAL DEPTH ASSUMED BELOW ELLC OF - EGLC = - EGC = - WSEL = -. Critical depth is being computed in a bridge section and the minimum energy below the low chord is less than the minimum energy above the top of the bridge.
4677	BRIDGE DECK DEFINITION ERROR AT STATIONS X Y. The low chord or top of road line, defined on the BT cards for a normal bridge, has intersected the ground line as defined on the GR cards. The program will not account for the bridge deck blockage between GR stations X and Y.
5020	SPECIAL BRIDGE. The input has specified that the bridge routine to be used for this cross section is the special bridge method.
5070	VARIABLE ELCHU OR ELCHD ON CARD SB NOT SPECIFIED. The elevations of the channel upstream and downstream of the bridge are not specified on input fields and have therefore, been assumed equal to the minimum elevation for the previous cross section. (SB.9 & .10)
5227	DOWNSTREAM ELEV IS X, NOT Y, HYDRAULIC JUMP OCCURS DOWNSTREAM (IF LOW FLOW CONTROLS). The upstream momentum is so great that the water downstream of the bridge is supercritical and not subcritical.
5290	UPSTREAM ELEVATION IS X NOT Y, NEW BACKWATER REQUIRED. Since supercritical flow was assumed by input and since the bridge obstruction drowns out the supercritical flow upstream of the bridge, new backwater is required, from the bridge upstream.

Statement Number	Notes and Remarks
5470	ERROR DS DEPTH WRONG SIDE CRITICAL. The calculated depth in the low-flow routine was determined on the wrong side of critical depth. A trace may be required to determine cause.
6070	LOW FLOW BY NORMAL BRIDGE. When the pier width is specified as zero for the special bridge method and when low flow controls, the friction loss is computed using the normal bridge method instead of the special bridge method. (SB.6=0)

V-6

Statement Number	Notes and Remarks
6110	EGLWC OF X LESS THAN XEG OF Y. The energy gradient elevation for the controlling low flow is less than the energy gradient for the previous cross section indicating negative losses. The energy gradient elevation for the current cross section is therefore, assumed equal to that for the previous energy gradient (no loss) and the run has been continued.
6180	SUPERCRITICAL FLOW, PRESSURE FLOW. Based on a comparison of EGPRS and EGLWC (the higher controls) the program concluded pressure flow. The solution of pressure flow in combination with supercritical flow is generally not compatible. The bridge model should be examined for possible input errors.
6400	TRIAL AND ERROR FOR CHANNEL Q FAILED. For the low flow and weir flow combination, the discharge through the channel must be determined. In trying to determine the discharge through the channel by an iterative process, the assumed and computed discharges do not agree in fifty trials. The allowable error of one percent is too severe for the computation or a programming inadequacy has been detected.
6790	POSSIBLE INVALID SOLUTION 20 TRIALS OF EG NOT ENOUGH. In determining the energy grade line elevation for a combination of weir flow and low flow, the discharge computed for an assumed energy grade line elevation could not balance with the actual discharge to be used in the water surface profile determination. When this condition occurs, the job should be rerun using the trace feature and the cause of this failure determined.
6840	FLOW IS BY WEIR AND LOW FLOW. The minimum top of roadway in one or both overbank dips below the low chord over the bridge and the resulting water surface elevation, which is below the low chord over the bridge, was computed using Class A low flow under the bridge and weir flow in the low overbank.

Statement Number	Notes and Remarks
6870	D.S. ENERGY OF X HIGHER THAN COMPUTED ENERGY OF Y. The energy grade line elevation of X for the previous (downstream) cross section is higher than the current cross section's computed energy grade line elevation of Y. The current energy grade line elevation was computed for a combination of weir and pressure flow. The energy grade line elevation for this cross section has been assumed equal to the previous energy elevation in order to eliminate negative losses. The weir coefficients used apparently were too efficient or a very long flat weir section has been encountered.
7185	MIN SPECIFIC ENERGY. The computer determined that it was impossible to procede from the previous cross section to the current cross section without crossing critical depth and therefore, critical depth has been assumed for the current cross section. In other words, maximum losses cannot produce an energy elevation as high as the minimum energy at critical depth. If this note occurs for several consecutive cross sections, it is apparent that the wrong type of flow (IDIR) has been assumed for this segment of the profile. The cross sections should be reversed, IDIR changed and the profile rerun.
7230	SLOPE-AREA TRIALS EXCEED 100. In determining the starting water surface elevation using the slope of the energy grade line from input, one hundred trials were not sufficient to balance the calculated discharge with the actual discharge (Q). If this condition occurs, an error in the input data or a programming error has been encountered. Rerun with trace feature if input data appear satisfactory.
8190	PLOTTED POINTS (BY PRIORITY).. - - - ETC. This note gives the priority for plotting the values for the cross section. If two or more points are close enough together that a single space of the printer cannot distinguish between then then only the last point plotted will be seen on the output. For instance, the energy gradient elevation (E) will hide the water surface elevation (W) for very small velocity heads.
8560	XSEC POINT - , X, EL, ST - Y, Z. The subscript computed for the current point was too low or too high to be plotted and is therefore, not shown on the cross section plot. The X indicates the type of point being plotted (X for ground point). The elevation and station of this point are printed out as Y and Z.

Statement Number	Notes and Remarks
8930	RDST NOT ON GR CARD. The roadway station printed out here does not appear on the ground profile card (GR). For the normal bridge method all stations on the BT card must also appear on the GR card. This note can be ignored for the special bridge method.

APPENDIX VI

OUTPUT DATA DESCRIPTION

OUTPUT DATA DESCRIPTION

This appendix contains a description of all output variables that apply to any cross section. Many of these variables can be selected for summary printout display.

Variable	Description
ACH	Cross section area of the channel.
AEX	Area of channel improvement excavation in square feet at cross section.
ALOB	Cross section area of the left overbank
ALPHA	Velocity head coefficient.
AREA	Cross section area.
AROB	Cross section area of the right overbank.
BANK ELEV LEFT/RIGHT	Left and right bank elevations.
BAREA	Net area of the bridge opening below the low chord. Entered on SB card.
B-S N	Value of composite Manning's n for ice covered stream computed by Belokon-Sabaneev formula.
BW	The bottom width of the trapezoidal excavation.
C	Chezy's roughness coefficient, used in ice stability equation.
CASE	A variable indicating how the water surface elevation was computed. Values of -1, -2, -3, and 0 indicate assumptions of critical depth, minimum difference, a fixed change (X5 card), or a balance between the computed and assumed water surface elevations, respectively.
CCHV	Contraction coefficient.
CEHV	Expansion coefficient.
CHSLOP	Channel slope.
CLASS	Identification number for following types of bridge flow.

CLASS	TYPE OF FLOW
1	Low Flow - Class A
2	Low Flow - Class B
3	Low Flow - Class C
10	Pressure Flow Alone
11, 15	Weir and Low Flow - Class A
12	Weir and Low Flow - Class B
13	Weir and Low Flow - Class C
30	Pressure Flow and Weir Flow
59	Special Bridge Reverts to Normal Bridge Method
67	For Encroachment Methods 3 through 6

Variable	Description
CLSTA	The centerline station of the trapezoidal excavation.
CORAR	Area of the bridge deck subtracted from the total cross sectional area in the normal bridge method.
CRIWS	Critical water surface elevation.
CWSEL	Computed water surface elevation.
DEPTH	Depth of flow.
DIFEG	Difference in energy elevation for each profile.
DIFKWS	Difference in water surface elevation between known and computed.
DIFWSP	Difference in water surface elevation for each profile.
DIFWSX	Difference in water surface elevation between sections.
EG	Energy gradient elevation for a cross section which is equal to the computed water surface elevation CWSEL plus the velocity head HV.
EGLWC	The energy grade line elevation computed assuming low flow.
EGPRS	The energy grade line elevation computed assuming pressure flow.
ELENCL	Elevation of left encroachment.
ELENCR	Elevation of right encroachment.
ELLC	Elevation of the bridge low chord. Equals ELLC entered on the X2 card if used, otherwise it equals maximum low chord in the BT table.
ELMIN	Minimum elevation in the cross section.
ELTRD	Elevation of the top of roadway. Equals ELTRD entered on the X2 card if used, otherwise it equals the minimum top of the road in the BT table.
ENDST	Ending station where the water surface intersects the ground on the right side.
H	Hydraulic radius, used in ice stability equation.
H3	Drop in water surface elevation from upstream to downstream sides of the bridge computed using Yarnell's equation assuming Class A low flow.
HL	Energy loss due to friction.

Variable	Description
HV	Discharge-weighted velocity head for a cross section.
IDC	Number of trials required to determine critical depth.
ICE N	Manning's n value for floating ice entered on IC card.
ICONT	Number of trails to determine the water surface elevation by the slope area method, or the number of trials to balance the energy gradient by the special bridge method, or the number of trials required to calculate encroachment stations by encroachment methods 5 and 6.
IHLEQ	Friction loss equation index.
ITRIAL	Number of trials required to balance the assumed and computed water surface elevations.
KRATIO	Ratio of the upstream to downstream conveyance.
OLOSS	Energy loss due to minor losses such as transition losses.
PERENC	The target of encroachment requested on the ET card.
Q	Total flow in the cross section.
QCH	Amount of flow in channel.
QCHP	Percent of flow in the channel.
QLOB	Amount of flow in theleft overbank.
QLOBP	Percent of flow in the left overbank.
QPR	Total pressure of low flow at the bridge.
QROB	Amount of flow in the right oberbank.
QROBP	Percent of flow in the right overbank.
QWEIR	Total weir flow at the bridge.
RBEL	Right bank elevation.
SECNO	Identifying cross section number. Equal to the number in the first field of the X1 card.
SLOPE	Slope of the energy grade line for the current section.
SPGR	Specific gravity of floating ice. Entered on IC card.
SSTA	Starting station where the water surface intersects the ground.
STENCL	The station of the left encroachment.
STENCR	The station of the right encroachment.

Variable	Description
STCHL	Station of the left bank.
STCHR	Station of the right bank.
TELMX	Elevation of the lower of the end points of the cross section.
T/H	Ratio of channel ice thickness and hydraulic radius, used in ice stability equation.
TIME	Travel time from the first cross section to the current cross section in hours.
TOPWID	Width at the calculated water surface elevation.
TRAPEZOID AREA	Net area of the bridge opening up to the low chord as defined by SS, BWP and BWC on the SB card. Should be close to BAREA on the SB card.
TWA	Cumulative surface area (acres of 1000 square meters) of the stream from the first cross section.
VCH	Mean velocity in the channel.
VEXR	Volume of channel improvement excavation in 1000's of cubic yards in a reach (between two adjacent cross sections).
VEXT	Cummulative volume of channel improvement excavation in 1000's of cubic yards up to the current cross section.
VLOB	Mean velocity in the left overbank
VOL	Cumulative volume (acre-feet or 1000 cubic meters) of water in the stream from the first cross section.
VROB	Mean velocity in the right overbank.
WSELK	Known water surface elevation; for example, a high water mark.
WTN	Length weighted value of Manning's 'n' for the channel. Used when computing Manning's 'n' from high water marks.
X*K	Pariset's ice stability indicator (times 1000).
XLBEL	Left bank elevation.
XLCH	Distance in the channel between the previous cross section and the current cross section.
XLOBL	Distance in the left overbank between the previous cross section and the current cross section.
XLOBR	Distance in the right overbank between the previous cross section and the current cross section.

Variable	Description
XNCH	Manning's 'n' for the channel area.
XNL	Manning's 'n' for the left overbank area.
XNR	Manning's 'n' for the right overbank area.
.01K	The total discharge (index Q) carried with $S^{1/2} = .01$ (equivalent to .01 times conveyance).

APPENDIX VII

INPUT DATA DESCRIPTION

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INPUT DATA DESCRIPTION

This appendix contains a detailed description of the data input requirement for each variable on each input card. It also contains a Functional Use Index which can be used to determine which input variables are required for specific tasks. The Summary of Input Cards shows the sequential arrangment of cards. Many of the cards described can be omitted if the options to which they apply are not required.

The location of the variables for each input card is shown by field number. Each card is divided into ten fields of eight columns each except field one. A variable in field one may only occupy card columns three through eight since card columns one and two (called field zero) are reserved for required identification characters. The values a variable may assume and the conditions for each are described. Some variables simply call for use of program options by using the numbers -1, 0, 1, 10, and 15. Other variables contain numbers which express the magnitude of the variable. For these a plus or minus sign is shown in the description under "value" and the numerical value of the variable is entered as input. Where the value of a variable is to be zero, the variable may be left blank since a blank field is read as zero.

Any number without a decimal point must be right justified in its field. Any number without a sign is considered positive.

The location of variables on cards is often referred to by an abbreviated designation; for example, J1.5 refers to the fifth field of the J1 card.

FUNCTIONAL USE INDEX

	Task	Cards Used
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6.	Traces & Input Data Printout	J1.1, J2.10, X2.10
7.	Storage-Discharge Output	J4
8.	Printer Plots of Cross Sections and Profiles	J2.2 - J2.5, X1.10
9.	Optional Friction Loss Equations	J6.1
10.	Flow Distribution	J2.10, X2.10
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12.	Direct Solution for Manning's 'n'	J1.3, X2.2
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14.	Options for Specifying Discharge	J1.2, J1.8, J1.10, X2.1, QT
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17.	Channel Modification Due to Excavation	J2.8, J2.9, CI
18.	Bridge Losses	X2.3 - X2.6, BT SB, X5
19.	Use of HEC-2 Data Edit Program (EDIT-2)	ED
20.	Use of the Flow Under Ice Option	IC
21.	Water Surface Based on a Rating Curve	J1.5, JR, RC
22.	Basic Applications of Split Flow Option	SF, TW, WS, WC, EE

Optional Card for HEC-2 Data Edit Program (EDIT-2)

Card ED

Controls certain run options for data edit program. Does not need to be removed for HEC-2 runs.

Field	Variable	Value	Description
0	IA	ED	Card identification characters
1	LIST	YES (Blank)	Produce listing of input data before editing it (default)
		NO	Suppress listing
2	CC	YES (Blank)	Produce 81 column output with carriage control in column 1 suitable for line printer output or other wide carriage devices (default)
		NO	Limit output width to 80 columns without carriage control (i.e., for 80 column interactive terminals)
3	GRANGE	0 (Blank)	Use default value (150) for GR card elevation difference test
		+	Value to use for GR card elevation difference test

The HEC-2 data edit program (EDIT-2) is designed to accept as input any HEC-2 data deck exactly as set-up for input to HEC-2. It will handle stacked jobs and all other features which are available in the November 1976 release of HEC-2.

The edit program will function with default run parameters for any HEC-2 data deck. There are 3 parameters which may be entered on an optional ED card. If used, the ED card must be the first card in the data deck and there may be only one. The format of the ED card is similar to HEC-2 data cards; i.e., the letters ED in columns 1 and 2 and the three values in the first three fields right justified to columns 8, 16, and 24.

Suggestion for using the Edit program:

When CARD ØUT ØF ØRDER errors occur, many subsequent fallacious error messages may be triggered. It is suggested that the user correct the CARD ØUT ØF ØRDER errors first and rerun the edit program.

SLIT FLOW TITLE CARD

CARD SF - SPLIT FLOW CARD (REQUIRED IF SPLIT FLOW OPTION IS TO BE USED)

The SF card is used to flag the split flow option. Only one SF card can be used. The SF card has to be the first card in an HEC-2 deck.

Field	Variable	Value	Description
0	IA	SF	Card identification characters.
1-10			Alpha-numeric Title data.

CARD JC - TITLE JOB CARD FOR SPLIT FLOW (OPTIONAL)

The JC card is used to indicate that JP card follows. The JP card must follow the JC card.

Field	Variable	Value	Description
0	IA	JC	Card identification characters.
1-10			Alpha-numeric Title data.

*These cards provide input for the split analysis option which was added to the November 1976 version by modification 55.

JP *

CARD JP - JOB PARAMETER CARD

The JP card is used to set several job parameters dealing with the split flow computations. The JC and JP cards are optional and can be placed anywhere in the split flow data or completely left out. They should be placed normally after the SF cards.

Field	Variable	Value	Description
0	IA	JP	Card identification characters.
1	ISFTR	0	Printout control of split flow computations will be held to a minimum.
		1	Trace each split flow iteration.
		10	Trace both the split flow and backwater iterations.
2	AEROR	0	The program will use a value of 2 percent allowed error for convergence.
		+	The user may specify the allowed percent tolerance for convergence.
3	NAITER	0	The maximum number of iterations for split flow to be executed per profile (20 is the default value).
		+	The user may specify the maximum number of iterations.
4	IUEG	-1,0	The program will use the water surface to determine the overflow.
		1	The program will use the energy grade line to determine the overflow.
5	PERFR	0	One hundred percent of the overflow is to be returned at SNOFR (WS.4, NS.4, and CS.4).
		+	Percent of overflow to be returned at SNOFR (WS.4, NS.4, and CS.4).

*This card provides input for the split analysis option which was added to the November 1976 version by modification 55.

CARD TW - TITLE CARD FOR WEIR LOCATION

The TW card is required for each set of weir outflow data set. The TW card must be followed by a set of WS and WC cards.

Field	Variable	Value	Description
0	IA	TW	Card identification characters.
1-10			Alpha-numeric Title data.

*This card provides input for the split analysis option which was added to the November 1976 version by modification 55.

WS *

CARD WS - WEIR PARAMETER DATA CARD

The WS card is required for each TW card used and must follow it. The WS card contains information dealing with the number of points describing the weir, weir flow coefficient, location of the upstream and downstream limits of the weir in relation to section numbers as used in the X1 cards, and the section number where the flow returns. If the flow does not return, a value of -1 should be used. It is required that the section numbers used to set-up the backwater model increase from downstream to upstream. The same rule applies for supercritical models.

Field	Variable	Value	Description
0	IA	WS	Card identification characters.
1	NWPL	+	Number of coordinate points that describe the weir on the WC card.
2	DSSNO	0,+	Downstream section number where the first weir coordinate applies.
3	USSNO	0,+	Upstream section number where the last weir coordinate applies.
4	SNOFR	0,+	Section number where the lost weir flow returns.
		-1	The weir flow does not return.
5	COEFL	+	Coefficient of discharge for use in weir flow equation.
6-10			Not used.

* This card provides input for the split analysis option which was added to the November 1976 version by modification 55.

CARD WC - THE WEIR COORDINATE CARD

The WC card is used to input the weir coordinates. The weir coordinates must start at the downstream end and proceed upstream. The maximum number of coordinates is 100.

Field	Variable	Value	Description
0	IA	WC	Card identification characters.
1,3,5, 7,9	STA(I)	+	Station Value of weir coordinate.
2,4,6, 8,10	ELO(I)	+	Elevation value of weir coordinate.

*This card provides input for the split analysis option which was added to the November 1976 version by modification 55.

TN*

CARD TN - TITLE CARD FOR NORMAL DEPTH LOCATION

The TN card is required for each set of normal depth outflow data set.
The TN card must be followed by a set of NS and NG cards.

Field	Variable	Value	Description
0	IA	TN	Card identification characters.
1-10			Alpha-numeric Title data.

*This card provides input for the split analysis option which was added to the November 1976 version by modification 55.

CARD NS - NORMAL DEPTH PARAMETER DATA CARD

The NS card is similar to the WS card with the exception that instead of having the weir flow coefficient, it has the energy slope and 'n' value.

Field	Variable	Value	Description
0	IA	NS	Card identification characters.
1	NWPL	+	Number of coordinate points that describe the normal depth flow cross section on the NG card
2	DSSNO	0,+	Downstream section number where the first coordinate point on the NG card applies.
3	USSNO	0,+	Upstream section number where the last coordinate point on the NG card applies.
4	SNOFR	0,+	Section number where the lost flow returns.
		-1	The lost flow does not return.
5	XNVND	+	The 'n' value to be used for normal depth calculation.
6	SLOPND	+	The energy slope to be used for normal depth calculations.
7-10			Not used.

*This card provides input for the split analysis option which was added the November 1976 version by modification 55.

NG *

CARD NG - THE GROUND COORDINATE CARD

The NG card is used to input the normal depth cross section coordinates. The coordinate must start at the downstream end and proceed upstream. The maximum number of coordinates is 100.

Field	Variable	Value	Description
0	IA	NG	Card identification characters.
1,3,5, 7,9	STA(I)	+	Station Value of cross section.
2,4,6, 8,10	ELO(I)	+	Elevation value of cross section.

* This card provides input for the split analysis option which was added to the November 1976 version by modification 55.

CARD TC - TITLE CARD FOR RATING CURVE LOCATION

The TC card is required for each set of rating curve outflow data set. The TN card must be followed by a set of CS and CR cards.

Field	Variable	Value	Description
0	IA	TC	Card identification characters.
1-10			Alpha-numeric Title data.

CARD CS - RATING CURVE PARAMETER DATA CARD

The CS card is similar to the WS card with the exception that the location (upstream and downstream) is a point location and therefore the value entered for USSNO and DSSNO should normally be equal.

Field	Variable	Value	Description
0	IA	CS	Card identification characters.
1	NWPL	+	Number of discharge elevation pairs to be read from the CR cards to follow.
2	DSSNO	0,+	Downstream section number where the rating curve applies.
3	USSNO	0,+	Upstream section number where the rating curve applies.
4	SNOFR	0,+	Section number where the lost flow returns.
		-1	The lost flow does not return.
5-10			Not used.

*These cards provide input for the split analysis option which was added to the November 1976 version by modification 55.

CARD CR - RATING CURVE CARD

The CR card is used to input the rating curve of outflows. The location of the rating curve has to be at a specific location on the river. Therefore the location has to be specified at only one point. The variables DSSNO and USSNO should be set equal. If they are not, the program will use the mean of the two locations. The maximum number of rating curve points is 100.

Field	Variable	Value	Description
0	IA	CR	Card identification characters.
1,3,5, 7,9	STA(I)	+	Discharge values for rating curve.
2,4,6, 8,10	ELO(I)	+	Elevation values for rating curve.

CARD EE - END OF SPLIT FLOW DATA CARD

The EE card is required to terminate the reading of the split flow data. The EE card should be in front of the first regular HEC-2 card, such as the AC, C, or T1 cards.

Field	Variable	Value	Description
0	IA	EE	Card identification characters.
1-10			Not used.

* These cards provide input for the split analysis option which was added to the November 1976 version by modification 55.

ARCHIVAL OPTION

CARD AC - OPTIONAL CARD

To use the Archival Option, one or more AC cards must be inserted at the beginning of a data deck (i.e., before C cards or first T1 card if C cards are not used). Columns three through eighty of each AC card are available for alphanumeric comments to document the Archival tape. As many AC cards as required may be used. It is the users responsibility to provide the required job control statements to insure that the file written to Unit 96 will appear on magnetic tape or otherwise be saved by the system after execution. On an Archival execution cross section plots should not be requested. Also the maximum number of summary tables is reduced by two for an Archival run.

Card Number	Field	Variable	Value	Description
1	0	IA	AC	Card identification characters.
1	1 - 10	--	--	Blank.
2 - as many cards necessary	0	IA	AC	Card identification characters.
	1 - 10			Alphanumeric comments to document the Archival tape.

C_

DATA COMMENT CARDS

CARDS C_ - OPTIONAL CARD

Comment cards for labeling a cross section must be placed immediately ahead of the first T1 card. Comments will be printed in the data input list and in the detailed printout just ahead of the cross section whose number appears in field one of cards 3 - 100. Multiple comment cards may be used to label a single cross section number. (Program versions with modification 55 can use an unlimited number of C cards)

Card Number	Field	Variable	Value	Description
1	0	IA	C_	Card identification characters (C, blank).
1	1 - 10	--	--	Blank.
2	0	IA	C_	Card identification character.
2	1	NUMCT	+	Number of data comment cards to be printed (1 to 98).
2	2 - 10	--	--	Blank.
3 - 100	0	IA	C_	Card identification character.
	1	CNOS		Cross section number (field one of X1 card) where title is to be printed. Cross section numbers (X1.1) referenced by comment cards should be unique.
3 - 100	2 - 10	COCD		Comment to be printed ahead of cross section number CNOS.

TITLE CARDS

CARDS T1, T2, T3 - REQUIRED CARDS

a). CARD T1

Title card for output title. This card is required for each job.

Field	Variable	Value	Description
0	IA	T1	Card identification characters.
1 - 10	none		Numbers and alphabetical characters.

b). CARD T2

Title card for output title. This card is required for each job.

Field	Variable	Value	Description
0	IA	T2	Card identification characters.
1 - 10	none		Numbers and alphabetical characters for title.

c). CARD T3

Title card for output title. The stream name should be entered in fields two through four for output in the title of the summary tables and cross section and profile plots. This card is required for each job.

Field	Variable	Value	Description
0	IA	T3	Card identification characters.
1		0	Not used.
2 - 4	TITLE		Title for summary tables and cross section and profile plots.
5 - 10	none		Numbers and alphabetical characters for title.

J1

JOB CARDS

CARD J1 - REQUIRED CARD

Job card specifying starting conditions and program options. This card is required for each job (profile).

Field	Variable	Value	Description
0	IA	J1	Card identification characters.
1	ICHECK	-10	Do not print data cards NC - EJ.
		0	Print data cards NC - EJ before execution of first profile.
2	INQ	0	Card QT, ET or X5 is not used.
		2 - 20	Field number on QT, ET and X5 cards to be used for job.
3	NINV	0	Option to compute Manning's 'n' from known high water marks will not be used.
		1	Manning's 'n' will be computed from known high water marks. Enter known water surface elevation as variable WSELK on second field of X2 card (X2.2) for each cross section.
4	IDIR	0	Subcritical flow. Cross sectional data (GR cards) are read starting at the downstream end of the stream.
		1	Supercritical flow. Cross sectional data are read starting at the upstream end.
5	STRT	-1	Start computations at critical depth. An approximate value for WSEL may be entered in field nine.
		0	Start with known water surface elevation. Enter WSEL in field nine.

CARD J1 (continued)

Field	Variable	Value	Description
		+ < 1	Start by slope-area method. Enter estimated energy slope here. An approximate value for WSEL may be entered in field nine. This starting option can not be used in conjunction with encroachment methods 3, 4, 5, and 6 at first cross section.
		+ > 1*	Number of rating curve (discharge elevation) pairs to be read on the following JR cards to start the backwater.
6	METRIC	0	Input and output in English units.
		1	Input and output in Metric units.
7	HVINS	0	No interpolated cross sections to be generated by computer.
		+	Enter maximum allowable change in velocity head between cross sections. If this value is exceeded, interpolated cross sections will be inserted by the program.
8	Q	0	Discharge specified by QT card, INQ(J1.2) is two or greater.
		+	Starting river flow.
9	WSEL	+	If STRT(J1.5) is zero enter known starting water surface elevation. If STRT is plus or minus enter approximate water surface elevation.
10	FQ	0	A factor of 1.0 will be used to multiply all discharges (QT, X2.1 and J1.8).
		+	Factor to multiply all flows by (QT, X2.1 and J1.8).

*Modification 55.

CARD JR - STARTING RATING CURVE CARD

The JR cards are used to input a starting rating curve. A set can be placed for each profile being run. They must follow the J1 card and the number of rating curve points must be greater than two. It is required that the number of rating curve points be entered on the J1 card, field five. A maximum of twenty discharge elevation values is allowed. The program linearly interpolates between given rating curve values and extrapolates for values outside the rating curve.

Field	Variable	Value	Description
0	IA	JR	Card identification characters.
1,3,5, 7,9	QJ1(I)	+	Discharge values.
2,4,6, 8,10	XJ1(I)	-,0,+	Water surface elevation values.

JS - CARD STARTING SPLIT FLOW ASSUMPTION CARD

The JS card is used to specify the starting assumed lost discharges for each reach defined in the split flow data set. If the JS card is not entered for a profile, then the program assumes that the first trial assumed lost flow is zero for all the split flow reaches. The JS card should follow the J1 card or the JR card if used. A maximum of 100 values are allowed.

Field	Variable	Value	Description
0	IA	JS	Card identification characters.
1	N	+	Number of assumed lost discharges to read.
2	ARLQ(4,1)	+	Assumed lost discharge for first reach.
3	ARLQ(4,2)	+	Assumed lost discharge for second reach.
.	.	.	.
.	.	.	.
.	.	.	.
	ARLQ(4,N)	+	Assumed lost discharge for last reach.

Continue on in field one of additional JS cards up to ARLQ(4,N).

J2

MULTIPLE PROFILES

CARD J2 - OPTIONAL CARD FOR FIRST PROFILE, REQUIRED CARD FOR ALL SUBSEQUENT PROFILES

Field	Variable	Value	Description
0	IA	J2	Card identification characters.
1	NPROF	0 or 1	Data cards will be read NC - EJ.
		-1	Calls for summary printout for a single profile run.
		2 - 14	Profile number using cross section data from previous job (omit cards NC - EJ). Up to fourteen profiles using cross sections on each can be computed without re-entering cards NC - EJ.
		15 or greater	Same as above except this is the last profile, and therefore, the summary printout will be called.
2	IPLOT	0	No cross sections will be plotted for this job unless individual plots are specified by using IPLOT on X1 card (X1.10).
		1	Line printer plots for all cross sections in this job.
		10	Same as above except, data points will be plotted only up to the water surface elevation.
3	PRFVS	0	Computer selects vertical scale of profile plot for current profile based on an elevation spread not exceeding twelve inches.
		+	Users selects vertical scale to be used for current profile. Enter number of elevation units per inch.
		-	No profile will be plotted.

CARD J2 (continued)

Field	Variable	Value	Description
4	XSECV	0	Computer selects vertical scale of cross section plot for each cross section individually.
		+	User selects vertical scale to be used for all cross sections. Enter number of elevation units per inch.
5	XSECH	0	Computer selects horizontal scale of cross section plot for each cross section individually.
		+	User selects horizontal scale to be used for all cross sections. Enter number of horizontal units per line of output. If the vertical scale of the profile (PRFVS) is given, then the value of XSECH will be used for the horizontal scale of both the cross sections and profiles.
6	FN	0	A factor of 1.0 will be used.
		+	Factor to multiply all Manning's 'n' values by. (NC, NV and NH cards).
		-	Factor to multiply NC channel 'n' values by (NC.3). NC card overbank 'n' values (NC.1 and .2). (All NV and NH 'n' values are modified).
7	ALLDC	-1	Critical depth will be computed for all cross sections using an allowable error of 2.5 percent of the depth.
		-	Same as ALLDC equal -1 except allowable error of ALLDC percent will be used.
		0	Critical depth will not be computed unless the actual depth is close to critical (except when low flow occurs for the special bridge method or when supercritical flow profiles are

CARD J2 (continued)

Field	Variable	Value	Description
			computed). An allowable error of 2.5 percent of the depth will be used.
		+	Same as ALLDC equal zero except, allowable error of ALLDC percent will be used.

CHANNEL MODIFICATION DUE TO EXCAVATION

Through the use of subroutine CHIMP the existing cross section (as described by GR cards) may be modified by a trapezoidal channel excavation as specified by the use of the optional card CI and the eighth and ninth fields of the J2 card. A CI card should be located after the X1 card of the cross section where the improvement is to be initiated. The trapezoidal modification will start on the first cross section that has a CI card and will continue on each cross section until a CI card is read that has .01 for the channel bottom. Any changes in the variables on the CI card must be made by another CI card. Only those variables that change need to be shown on the CI card.

Field	Variable	Value	Description
8	IBW	0	If a CI card is read, the sixth field of the CI card will be used to describe the bottom width of the improvement.
		6 - 10	Field number of field on CI card where channel bottom width is specified.
9	CHNIM	0	Overbank 'n' values are unchanged.
		+	NH card (horizontal 'n' value variation) is to be simulated by the computer so that the channel 'n' value is used for a distance of CHNIM on each side of the left or right bank stations (which may be modified by the channel excavation described by the CI card). NH or NV cards should not be used with this option.
10	ITRACE	0	No trace for this job unless specified by individual cross sections using ITRACE on X2 card (X2.10).

CARD J2 (continued)

Field	Variable	Value	Description
		1	Minor trace for all cross sections.
		10	Major and minor trace for all cross sections. (Large amount of output.)
		15	Flow distribution printout for all cross sections (no major or minor trace for all cross sections).

SUMMARY PRINTOUT OPTIONS

CARD J3 - OPTIONAL CARD

Optional card (up to five cards may be used). Used onthe first profile of a multiple profile run to select variables for the summary printout. If a summary printout is requested (J2.1) and a J3 card is not supplied, a pre-defined table (Table 150) is printed.

Field	Variable	Value	Description
0	IA	J3	Card identification characters.
1 - 10	IVAR(I)		Codes to specify summary tables. Pre-defined tables may be called as shown below (100 and 200 series). User-defined tables may be generated by specifying up to thirteen variable codes per table. Where two or more user-defined tables are specified, a blank field should be used to separate the tables. Tables are printed in order specified. Pre-defined tables are printed in numerical order after any user-defined table. A maximum of five tables may be generated.

CODES FOR PRE-DEFINED TABLES

Code	Table
100	Cross-section output at bridges (special bridge only).
105	Four cross-section output at bridges (special bridge only).
110	Encroachment data.
120	Channel improvement data.
150	Standard summary (two tables produced).
200	Floodway data (FIA Table 1).*
201	Flood insurance zone data (FIA Table 2).*

*Flood Insurance Study, Guidelines and Specifications, Federal emergency Management Agency, June 1983.

CARD J3 (continued)

VARIABLE CODES FOR USER DEFINED TABLES

Cross section and Reach Variables from Input

Variable Name	Code Number
SECNO	38
STCHL	21
STCHR	22
XLBEL	23
RBEL	24
ELMIN	42
XLCH	39
CHSLOP (K*CHSL)	33

Velocity Variables

Variable Name	Code Number
VLOB	55
VRBO	56
VCH	26
HV	10
ALPHA	57
TIME	6

Calculated Geometric Variables

Variable Name	Code Number
DEPTH	8
TOPWID	4
AREA	25
TWA	37
VOL	7
SSTA	53
ENDST	54
TELMX	63

Hydraulic Parameters

Variable Name	Code Number
CASE	20
SLOPE (10K*S)	5
KRATIO	58

Water Surface and Energy Related Variables

Variable Name	Code Number
CWSEL	1
CRIWS	2
WSELK	9
EG	3
HL	11
OLOSS	12
IHLEQ	62

Difference Variables

Variable Name	Code Number
DIFEG	61
DIFWSP	50
DIFWSX	51
DIFKWS	52

Discharge Variables

Variable Name	Code Number
Q	43
QLOB	13
QCH	14
QROB	15
QLOBP	35
QCHP	60
QROBP	59
.01K	34

Manning's 'n' Variable

Variable Name	Code Number
XNL (K*XNL)	16
XNR (K*XNR)	18
XNCH (K*XNCH)	17
WTN (K*WTN)	19

Bridge Variables

Variable Name	Code Number
CLASS	49
QWEIR	46
QPR	47
EGPRS	44
EGLWC	45
H3	48
ELTRD	40
ELLC	41

Encroachment Variables

Variable Name	Code Number
PERENC	36
STENCL	27
STENCR	28
ELENCL	31
ELENCR	32

Channel Improvement (CHIMP) Variables

Variable Name	Code Number
CLSTA	29
BW	30
VEXR	89
VEXT	90

Flow Under Ice Variables

Variable Name	Code Number
TH1	64
XICE1	65
XSTAB1	66
SFCH1	67
TH2	68
XICE2	69
XSTAB2	70
XFCH2	71
TH3	72
XICE3	73
XSTAB3	74
XFCH3	75
TH4	76
XICE4	77
XSTAB4	78
XFCH4	79
ZINCH	80
TVOLI	81
VOLIL	82
VOLIR	83
VOLICH	84
NICE	85
ZITL	86
ZITR	87
ZITCH	88

See following pages for descriptions of variables.

J3

CARD J3 (continued)

SUMMARY PRINTOUT DATA DESCRIPTION

Code Number	Variable Name	Description
1	CWSEL	Computed water surface elevation.
2	CRIWS	Critical water surface elevation.
3	EG	Energy gradient elevation for a cross section which is equal to the computed water surface elevation CWSEL plus the discharge-weighted velocity head HV.
4	TOPWID	Cross section width at the calculated water surface elevation.
5	SLOPE (10K*S)	Slope of the energy grade line for the current section (times 10,000).
6	TIME	Travel time from the first cross section to the present cross section in hours.
7	VOL	Cumulative volume of water in the stream from the first cross section (in acre-feet for English units or 1000 cubic meters in Metric units).
8	DEPTH	Depth of flow.
9	WSELK	Known water surface elevation.
10	HV	Mean velocity head across the entire cross section.
11	HL	Energy loss due to friction.
12	OLOSS	Energy loss due to expansion or contraction.
13	QLOB	Amount of flow in the left overbank.
14	QCH	Amount of flow in the channel.
15	QROB	Amount of flow in the right overbank.

CARD J3 (continued)

SUMMARY PRINTOUT DATA DESCRIPTION (continued)

Code Number	Variable Name	Description
16	XNL (K*XNL)	Manning's 'n' for the left over-bank area (time 1,000).
17	XNCH (K*XNCH)	Manning's 'n' for the channel area (times 1,000).
18	XNR (K*XNR)	Manning's 'n' for the right over-bank area (times 1,000).
19	WTN (K*WTN)	Weighted value of Manning's 'n' for the channel based on the distance between cross sections and channel flow from the first cross section. Used when computing Manning's 'n' from high water marks (times 1,000).
20	CASE	A variable indicating how the water surface elevation was computed. Values of -1, -2, -3, and 0 indicate assumptions of critical depth, minimum difference a fixed change (X5 card) or a balance between the computed and assumed water surface elevations.
21	STCHL	Station of the left bank.
22	STCHR	Station of the right bank.
23	XLBEL	Left bank elevation.
24	RBEL	Right bank elevation.
25	AREA	Cross section area.
26	VCH	Mean velocity in the channel.
27	STENCL	The station of the left encroachment.
28	STENCR	The station of the right encroachment.
29	CLSTA	The centerline station of the trapezoidal excavation.

J3

CARD J3 (continued)

SUMMARY PRINTOUT DATA DESCRIPTION (continued)

Code Number	Variable Name	Description
30	BW	The bottom width of the trapezoidal excavation.
31	ELENCL	Elevation of left encroachment.
32	ELENCR	Elevation of right encroachment.
33	CHSLOP (K*CHSL)	Channel slope (times 1,000).
34	.01K	The total discharge (index Q) carried with $S^{1/2}$ = .01 (equivalent to .01 times conveyance).
35	QLOBP	Percent of flow in the left overbank.
36	PERENC	The target of encroachment requested on ET card.
37	TWA	The cumulative topwidth area (acres or 1000 square meters).
38	SECNO	The cross section identification number.
39	XLCH	Channel reach length.
40	ELTRD	Minimum elevation for top of road profile.
41	ELLC	Maximum low chord elevation.
42	ELMIN	Minimum elevation in cross section.
43	Q	Discharge.
44	EGPRS	Energy elevation assuming pressure flow.
45	EGLWC	Energy elevation assuming low flow.
46	QWEIR	Total weir flow at the bridge.
47	QPR	Total pressure or low flow at the bridge.

CARD J3 (continued)

SUMMARY PRINTOUT DATA DESCRIPTION (continued)

Code Number	Variable Name	Description
48	H3	Change in water surface elevation from Yarnell's equation.
49	CLASS	Controlling flow type for bridge solution.
50	DIFWSP	Difference in water surface elevation for each profile.
51	DIFWSX	Difference in water surface elevation between sections.
52	DIFKWS	Difference between known and computed water surface elevations.
53	SSTA	Starting station where the water surface intersects the ground (on the left side of the cross section).
54	ENDST	Ending station where the water surface intersects the ground on the right side.
55	VLOB	Average velocity in the left overbank area.
56	VROB	Average velocity in the right overbank area.
57	ALPHA	Velocity head coefficient.
58	KRATIO	Ratio of the upstream to downstream conveyance.
59	QROBP	Percent of flow in the right overbank.
60	QCHP	Percent of flow in the channel.
61	DIFEG	Difference in energy elevation for each profile.
62	IHLEQ	Friction loss equation index.
63	TELMX	Elevation of the lower of the two end points of the cross section.

CARD J3 (continued)

SUMMARY PRINTOUT DATA DESCRIPTION (continued)

Code Number	Variable Name	Description
64	TH1	Value for T/H based on an H equal to the maximum depth in the channel.
65	XICE1	Calculated stability fact X based on TH1.
66	XSTAB1	Stability factor based on Pariset Curve based on TH1.
67	XFCH1	Froude Number for the channel based on H equal to the maximum depth in the channel.
68	TH2	Value for T/H based on an H = ACH/BCH (Hydrauic Depth).
69	XICE2	Calculated stability factor X based on TH2.
70	XSTAB2	Stability factor based on Pariset Curve based on TH2.
71	SFCH2	Froude Number for the channel based on H = ACH/BCH.
72	TH3	Value for T/H based on an H = ACH/WPCH (Hydraulic Radius).
73	XICE3	Calculated stability factor X based on TH3.
74	XSTAB3	Stability factor based on Pariset Curve based on TH3.
75	XFCH3	Froude Number for the channel based on H = A/WPCH.
76	TH4	T/H value based on the average of the present and previous values of channel top, width and depth.
77	XICE4	Calculated X value based on the average value between the present and previous values for ZITCH, DEPTH, QCH, C and BCH.
78	XSTAB4	Stability factor based on Pariset Curve for average TH4.

CARD J3 (continued)

SUMMARY PRINTOUT DATA DESCRIPTION (continued)

Code Number	Variable Name	Description
79	XFCH4	Froude Number based on average values of present and previous VCH and H.
80	ZINCH	Channel N value based on Belokon-Sabaneev Formula.
81	TVOLI	Cumulative volume of ice in cubic yards or cubic meters.
82	VOLIL	Cumulative volume of ice on left bank.
83	VOLIR	Cumulative volume of ice on right bank.
84	VOLICH	Cumulative volume of ice in the channel.
85	NICE	ICE N value read in.
86	ZITL	Ice thickness for the left bank.
87	ZITR	Ice thickness for the right bank.
88	ZITCH	Ice thickness for the channel.
89	VEXR	Volume of excavation in reach.
90	VEXT	Volume of excavation, total.

J4

STORAGE-DISCHARGE, PUNCHED CARD OUTPUT

CARD J4 - OPTIONAL CARD

Optional card used only on first profile of a multiple-profile run. This card provides punched cards for routing by the Modified Puls method using program HEC-1. The cards punched are Y, 2, and 3 cards (see program description for HEC-1). This option can be used only if multiple profiles are computed and if variables 6 (TIME) and 7 (VOL) are included in the summary printout. Routing reach cross section numbers (REACH(I)) must be on X1 cards.

Field	Variable	Value	Description
0	IA	J4	Card identification characters.
1	RETLEN	+	Ratio (usually = 1) used to determine the number of subreaches for each routing reach. Equal to the ratio of the travel time (K) to the product of the time interval (ΔT) and the number of routing subreach steps (NSTPS). Use a plus one when K = ΔT for NSTPS = 1, K = 2ΔT for NSTPS = 2, etc. A value of two would provide one step when K = 2ΔT.
2	HYDINT	+	Computation and tabulation interval in minutes for HEC-1.
3	NUMRT	+	Number of values of REACH(I) to be read.
4 - 10	REACH(I)	+	Reach or section numbers where outflow values are needed. Each reach number (X1.1) of the cross section at the downstream end of a routing reach except the last reach. Up to one hundred values may be used.

PRINTOUT CONTROL OPTION

J5

CARD J5 - OPTIONAL CARD

The optional J5 card can be used to suppress detailed (cross section by cross section) and summary printout. The J5 card(s) may be used for single or multiple profile jobs. For multiple profile jobs, the J5 card(s) is inserted with job cards for the first profile. Printout of the data input list, flow distriubtion data, and profile and cross section plots are unaffected by this option; for printout control of these options refer to the J1, J2, X1, and X2 cards. Use of the J5 card for various printout options is illustrated in the following table.

FIELD					
0 (IA)	1 (LPRNT)	2 (NUMSEC)	3 (SECNOS(I))	4 ... N	Desired Printout
J5	-10	-10			Summary printout only for all cross sections.
J5	-10		X		Detailed and summary printout beginning at cross section X.
J5	-10	N	X_1	$X_2 \dots X_n$	Detailed and summary printout for N cross sections (X_1, ... X_n).

Field	Variable	Value	Description
0	IA	J5	Card identification.
1	LPRNT	-10	and NUMSEC = -10, suppress detailed printout for all cross sections. and NUMSEC = 0 or plus, print detailed and summary printout for only those cross sections indicated by NUMSEC and SECNOS(I) (J5.2 and J5.3).
		-1	Same as -10 except a list of cross section numbers is furnished to aid in debugging runs that do not run to completion.

CARD J5 (continued)

Field	Variable	Value	Description
2	NUMSEC	-10	Suppress detailed printout for all cross sections. Requested summary printout is not suppressed.
		0	Suppress all detailed and summary printout from the first cross section to the cross section indicated in J5.3.
		+	Total number of cross sections for which detailed and summary printout are desired. This variable is ignored if J4 card is used.
3 - 10	SECNOS(I)	-,0,+	If NUMSEC is plus, one hundred cross section numbers can be specified. If additional cards are required, all ten fields should be used for SECNOS(I). These variables are ignored if J4 card is used.

FRICTION LOSS EQUATION OPTION

CARD J6 - OPTIONAL CARD

The J6 card is an optional card which can be utilized (a) to select equations for computation of friction losses and (b) to transfer control of output print files to computer system control cards. These options may be used for single or multiple profile jobs. For multiple profiles the J6 card is inserted with job cards for the first profile only.

Field	Variable	Value	Description
0	IA	J6	Card identification.
1	IHLEQ	0	Average conveyance equation used to compute friction losses. This equation has been utilized in the preceding version of HEC-2 and is recommended for general application.
		1	Program selects, on a reach by reach basis; one of the following equations: average friction slope, geometric mean friction slope, or harmonic mean friction slope. Selection is based on flow conditions.*
		2	Average friction slope equation used to compute friction losses.
		3	Geometric mean friction slope equation used to compute friction losses.
		4	Harmonic mean friction slope equation used to compute friction losses.
2	ICOPY	0	The program will internally handle the disk/tape units containing the output print files.
		1	The program will transfer control of disk/tape units for output print files to computer system control cards. See Programmers Manual for details.

*See Table 2, Chapter 4, page 20, for details.

IC

ICE DATA

CARD IC - Optional Card

Used to input or change ice data. Calculations with floating ice cover will start at the first cross section (X1 card) following the IC card and will continue until an IC card is read that has .01 for SPGR (field 5). Insert IC cards with other change cards (NC, NH, ET, etc.) immediately ahead of card X1.

Field	Variable	Value	Description
0	IA	IC	Card identification characters.
1	ZITL	+	Ice thickness for the left overbank.
		0	No change in ice thickness for the left overbank.
		-1	Open water in left overbank.
2	ZITR	+	Ice thickness for the right overbank.
		0	No change in ice thickness for the right overbank.
		-1	Open water in right overbank.
3	ZITCH	+	Ice thickness for the channel.
		0	No change in ice thickness for the channel.
		-1	Open water in the channel.
4	ZIN	+	Manning's 'n' value for ice.
		0	No change in Manning's 'n' value for ice.
5	SPGR	+	Value of ice specific gravity.
		.01	No ice calculations until another IC card is read. (Used to terminate ice calculations).
		0	No change in ice specific gravity if a value was entered on a prior IC card or if none has been previously specified, the default value of 0.916 will be used.

ICE DATA

CARD IC - Optional Card (continued)

Field	Variable	Value	Description
6 - 10**	FZ	+	Factor to multiply ice thickness values (ZITL, ZITR, ZITCH) by.
		0	Ice 'n' values and ice thickness will not be modified.
			Factor to multiply ice 'n' value (ZIN) by.

**Field use (6 - 10) for a profile corresponds to the field specified in field 8 (variable IBW) of the J2 card.

NC

MANNING'S 'n' DESCRIPTION

CARD NC - REQUIRED CARD FOR FIRST CROSS SECTION

Manning's 'n' and the expansion and contraction coefficients for transition (shock) losses are entered for starting each job, or for changing values previously specified.

Field	Variable	Value	Description
0	IA	NC	Card identification characters.
1	XNL	0	No change in Manning's 'n' value for the left overbank.
		+	Manning's 'n' value for the left overbank.
2	XNR	0	No change in Manning's 'n' value for the right overbank.
		+	Manning's 'n' value for the right overbank.
3	XNCH	0	No change in Manning's 'n' value for the channel.
		+	Manning's 'n' value for the channel.
4	CCHV	0	No change in contraction coefficient.
		+	Contraction coefficient used in computing transition losses.
5	CEHV	0	No change in expansion coefficient.
		+	Expansion coefficient used in computing transition losses.
6 - 10			Not used.

HORIZONTAL DESCRIPTION OF MANNING'S 'n'

CARD NH - OPTIONAL CARD

Used to permanently change the roughness coefficients (Manning's 'n') to values which vary with horizontal distances from the left side of the cross section. Roughness coefficients should be redefined for each cross section with new geometry. The NH card should not be used to cross sections employing the NV card or when utilizing the channel improvement (CI) option.

Field	Variable	Value	Description
0	IA	NH	Card identification characters.
1	NUMNH	1-20	Total number of Manning's 'n' values (maximum 20) entered on NH cards. If NUMNH is greater than 4, multiple NH cards are required and, the first field of the second and subsequent NH cards should contain a STN(N) value.
2, 4, 6, 8, 10...etc.	VALN(N)	+	Manning's 'n' coefficient between stations STN(N-1) and STN(N). The first 'n' value applies from the starting left station up to STN(1) (field three).
3, 5, 7, 9, 11...etc.	STN(N)	+	Station corresponding to VALN(N). Each station should equal one of the stations on the next GR cards. Stations must be in increasing order. Station values will not be adjusted by X1.8 PXSECE.

NV

VERTICAL DESCRIPTION MANNING'S 'n'

CARD NV - OPTIONAL CARD

Used to change the channel roughness coefficient 'n' based on water surface elevations. Program interpolates channel 'n' value for each calculated water surface elevation based on 'n' versus elevation data. This option should not be used at cross sections employing the NH card or CHNIM (J2.9) option.

Field	Variable	Value	Description
0	IA	NV	Card identification characters.
1	NUMNV	2-20	Total number of Manning's 'n' values entered on NV cards (maximum 20). If NUMNV is greater than 4, multiple NV cards are required and, the first field of the second and subsequent NV cards should contain an ELN(N) value.
2, 4, 6, 8, 10, 12...etc.	VAL(N)	+	Manning's 'n' coefficient for area below ELN(N). The overbank 'n' values specified on the NC card will be used for the overbank roughness regardless of the values in this table.
3, 5, 7, 9, 11, 13...etc.	ELN(N)	+	Elevation of the water surface corresponding to VALN(N) in increasing order.

DISCHARGE TABLE

CARD QT - OPTIONAL CARD

Specifies a table of flows for use in computing a series of water surface profiles. The field of the flow being used for this job is specified by variable INQ(J1.2).

Field	Variable	Value	Description
0	IA	QT	Card identification characters.
1	NUMQ	1-19	Total number of flows (maximum 19) entered on the QT cards. If NUMQ is greater than 9, two QT cards are required, and the first field of the second QT card should contain a Q(N) value.
2-20	Q(N)	+	Flow values to be used for multiple profiles. Variable INQ(J1.2) indicates which field is used for this job. INQ may range from two to twenty.

ET ENCROACHMENT TABLE

CARD ET - OPTIONAL CARD

This card is used to specify the method (1 - 6) and target of the encroachment. The method and target will be used until changed by another ET card, except for Method 1, which only applies to the next cross section. A zero on the first ET card indicates no encroachment, while a zero on succeeding ET cards indicates no change in encroachment. The field of the ET card that is being used for a particular profile is specified by variable INQ (J1.2). Methods 3 - 6 require a natural profile for the first profile and thus require reading a zero on the ET card of the "INQ" field for the first profile. If Methods 2 - 6 are being used and it is desired to terminate the encroachment option, use Method 1 with the encroachment stations specified near the two ends of the cross section. Each method is capable of evaluating the effects of encroachments on bridges.

Field	Variable	Value	Description
0	IA	ET	Card identification characters.
1	None	None	Blank field.
2 - 10	ENCFP(N)	0	No encroachment or no change in encroachment.
		+ or -	Encorachment method used. The number X.Y is used to specify that method Y is being used and X is the target to be used for that method. Up to nine values may be specified. The encroachment method or target may be changed at any cross section or on different profiles.

Encroachment Methods

Positive values of X.Y for methods 3 through 6 provide an encroachment based on a reduction of conveyance equally in both overbanks. Negative values ov X.Y for methods 3 through 6 provide an encroachment based on a reduction of conveyance in proportion to the distribution of natural overbank conveyance. For instance, if the natural cross section hab twice as much conveyance in the left overbank as in the right overbank, a 10.3 would reduce conveyance by five percent in each overbank, whereas a -10.3 would eliminate 6.7 percent from the left overbank and 3.3 percent from the right overbank.

Card ET (Continued)

Bridge encroachments may be evaluated by adding .01 to the code X.Y for any of the methods. Thus a 9.11, 100.21, 10.31, 10.41, 10.51, or 10.61 would request the bridge encroachments for Methods 1 - 6, while a 9.1, 100.2, 10.3, 10.4, 10.5, or 10.6 would not. The following table describes how each method handles encroachments on bridges.

Method	Description
1	Bridge encroachments set as indicated by target values of Method 1.
2	Bridge encroachments set as indicated by target values of Method 2.
3 - 6	Bridge encroachments defined by encroachments determined at the cross section immediately downstream of the bridge.

Method	ET Card Value	Description
1	X.1 or X.11	The Xth and Xth + 1 fields of the ET card will be used for the encroachment stations STENCL and STENCR. STENCL should not be zero.
2	X.2 or X.21	The top width of X will determine encroachment stations such that the center of the top width will be centered halfway between bank stations.
3	X.3 or X.31	The natural cross section will be encroached so that X percent of the total conveyance will be eliminated <u>equally</u> (X/2 percent) from each overbank.
	-X.3 or -X.31	Same as X.3 except the reduction of conveyance in each overbank will be in <u>proportion</u> to the conveynace in the overbanks.

Card ET (Continued)

Method	Value	Description
4	X.4 or X.41	The natural cross section will be encroached based on a (X/10) foot increase in water surface elevation while maintaining natural conveyance. The reduction of conveyance will be equal in both overbanks. A target of one foot increase in water surface elevation would require a 10.4 and a .5 foot increase would require a 5.4.
	-X.4 or -X.41	Same as X.4 except the reduction of conveyance in each overbank will be in proportion to the conveyance in the overbanks under natural conditions.
5	X.5 or X.51	Operates much like Method 4 except that an optimization scheme is used to obtain the desired difference in water surface elevations as closely as possible to the specified target difference.
	-X.5 or -X.51	Same as X.5 except the reduction of conveyance in each overbank will be in proportion to the conveyance in the overbanks under natural conditions.
6	X.6 or X.61	Uses an optimization scheme to obtain a desired difference in energy grade line elevations as closely as possible to the specified target.
	-X.6 or -X.61	Same as X.6 except the reduction of conveyance in each overbank will be in proportion to the conveyance in the overbanks under natural conditions.

SPECIAL BRIDGE

CARD SB - OPTIONAL CARD

This special bridge card is used to specify data for use in the special bridge method and is only required when using the special bridge method. This card should be entered between cross sections that are upstream and downstream of the bridge. See X2 card fields three through nine for additional input for the special bridge option.

Field	Variable	Value	Description
0	IA	SB	Card identification characters.
1	XK	+	Pier shape coefficient, "K", for use in Yarnell's energy equation for Class A flow.
2	XKOR	+	Total loss coefficient, "K", between cross sections on either side of bridge, for use in orifice flow equation. Should not be less than 1.0.
3	COFQ	+	Coefficient of discharge "C" for use in weir flow equation.
4	RDLEN	0	Flow over roadway is not being considered or a table of roadway elevations and corresponding stations will be read in on the BT card for determining "L" in the weir flow equation.
		+	Average length of roadway "L" in feet for use in the weir flow equation. Use a constant value of "L" only if the length of weir does not change with depth of flow. Otherwise, use the BT card to read in the top of roadway. Weir elevation defined on field five of X2 card.
5	BWC	+	Bottom width of bridge opening including any obstruction.

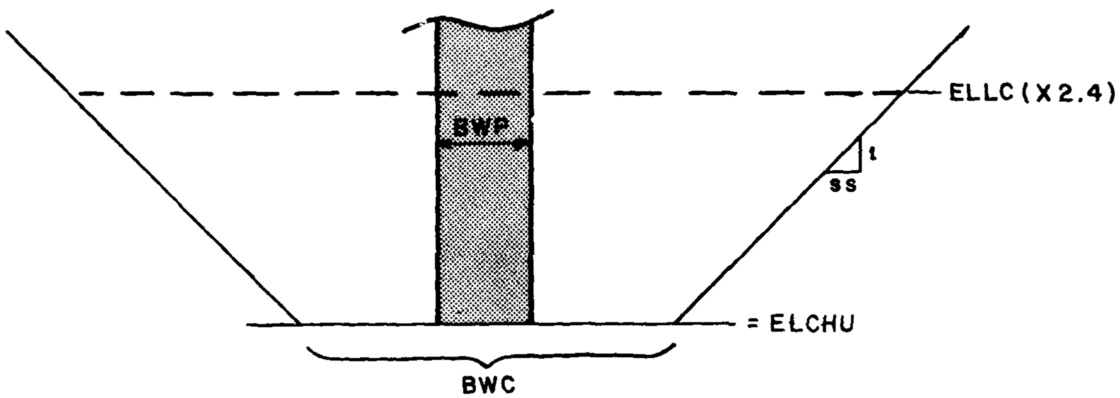
CARD SB (continued)

Field	Variable	Value	Description
6	BWP	0	No obstruction (pier) in the bridge. Normal bridge method will be used in this case if low flow controls.
		+	Total width of obstruction (piers).
7	BAREA	+	Net area of bridge opening below the low chord in square feet or square meters.
8	SS	0	Vertical side slopes.
		+	Number of horizontal units per one vertical unit for the side slopes of the trapezoidal channel under the bridge.
9	ELCHU	0	Channel invert beneath bridge will be equal to the minimum elevation in the previous cross section. This value will not be adjusted by X1.9 PXSECE.
		+ or -	Elevation of the channel invert at the upstream side of the bridge.
10	ELCHD	0	Channel invert will be assumed equal to the minimum elevation in the previous cross section.
		+ or -	Elevation of the channel invert at the downstream side of the bridge. This value will not be adjusted by X1.9 PXSECE.

CARD SB (continued)

The diagram below defines the six variables that model the bridge opening. Variables BWC, BWP, SS, ELCHU, and ELCHD define a trapezoid for low flow calculations. Variable BAREA provides the net area of the bridge opening for pressure flow calculations. For typical applications the net area of the trapezoid (special bridge output variable TRAPEZOID AREA) should be close to the actual net area (BAREA). If BWP is zero, normal bridge calculations will be used for low flow.

TRAPEZOIDAL APPROXIMATION OF BRIDGE OPENING



X1

CROSS SECTION DATA

CARD X1 - REQUIRED CARD

This card is required for each cross section (eight hundred cross sections can be used for each profile) and is used to specify the cross section geometry and program options applicable to that cross section.

Field	Variable	Value	Description
0	IA	X1	Card identification characters.
1	SECNO	+	Cross section identification number.
		-	Start new tributary backwater at this cross section.
2	NUMST	0	Previous cross section is repeated for current section. GR cards are not entered for this cross section.
		+	Total number of stations on the following GR cards.
3	STCHL	0	NUMST(X1.2) is 0.
		+	The station of the left bank of the channel. Must be equal to one of the STA(N) on next GR cards.
4	STCHR	0	NUMST(X1.2) is 0.
		+	The station of the right bank of the channel. Must be equal to one of the STA(N) on GR cards and equal to or greater than STCHL.
5	XLOBL	+	Length of left overbank reach between current cross section and next downstream cross section. Zero for first cross section if IDIR = 0, (J1.4).
6	XLOBR	+	Length of right overbank reach between current cross section and next downstream cross section. Zero for first cross section if IDIR = 0.

CARD X1 (continued)

Field	Variable	Value	Description
7	XLCH	+	Length of channel reach between current cross section and next downstream cross section. Zero for first cross section if IDIR = 0.
8	PXSECR	0	Cross section stations will not be changed by the factor PXSECR.
		+	Factor to modify the horizontal dimensions fo a cross section. The distances between adjacent GR stations (STA) are multiplied by this factor to expand or narrow a cross section. The STA of the first GR point remains the same. The factor can apply to a repeated cross section or a current one. A factor of 1.1 will increase the horizontal distance between the GR stations by ten percent. (See X2.9 for station adjustment to BT data). This factor will adjust data from X3, CI, and ET cards. It will not adjust data from NH, X4, and SB cards.
9	PSXECE	0	Cross section elevations will not be changed.
		+ or -	Constant to be added (+ or -) to GR elevation data (either previous or current). Sediment elevation data (X3.2) input at current cross section is also modified by this factor. (See X2.7 for elevation change to BT data). Will not adjust X4 cards.
10	IPLOT	0	Current cross section will not be plotted, unless all cross sections were requested by J2 card.
		1	Plot current cross section using all points.
		10	Plot current cross section using only those points up to the water surface elevation.

CARD RC - RATING CURVE CARD

The RC card can be entered at any cross section and the program will determine the water surface elevation based on the rating curve and not on backwater computations. The RC card should be placed after the X1 card. A maximum of twenty discharge elevation values are allowed. The program linearly interpolates between given rating curve values and extrapolates for values outside the rating curve.

Field	Variable	Value	Description
0	IA	RC	Card identification characters.
1	NRCP	+	Number of rating curve points being read in.
2	QRC(1)	+	Discharge value.
3	XRC(1)	-,0,+	Water surface elevation value.
4	QRC(2)	+	Discharge value.
5	XRC(2)	-,0,+	Water surface elevation value.
.	.	.	.
.	.	.	.
.	.	.	.
.	.	.	.
	QRC(NRCP)	+	Last discharge value.
	XRC(NRCP)	-,0,+	Last water surface elevation value.

Continue on in field one of additional RC cards up to QRC(NRCP) and XRC(NRCP).

CHANNEL IMPROVEMENT

CARD CI - OPTIONAL CARD

This optional card provides input for the channel improvement (CHIMP) option of the program. This option simulates the modification of cross section data (GR cards) by a trapezoidal excavation. The modification begins at the first cross section with a CI card and continues until a CI card specifying a bottom width equal to 0.01 (variable BW, fields 6-10) is encountered. Up to five bottom widths can be specified for analysis during multiple profile runs. Multiple CI cards may be used to model improved channel sections with pilot channels; up to three CI cards may be used a a single cross section. The channel improvements are performed in the order that the cards are specified. The natural channel may be filled prior to excavation if desired. (see variable BW). Low areas fo the natural cross section may be filled by the sediment option (variable ELSED X3.2). See card J2 fields 8 and 9 for further information.

Note: The CI Card can not be used in conjunction with NH cards.

Field	Variable	Value	Description
0	IA	CI	First two columns of card for card identification.
1	CLSTA	0	Value on previous cross section's CI card is used.
		+	Station of the centerline of trapezoidal channel excavation which is expressed in terms of the stations used in the natural cross section description (GR cards).
		-1	CLSTA is determined by program as halfway between bank stations.
2	CELCH	0	Value on previous cross section's CI card is used.
		+ or -	Elevation of channel invert (but not -1).
		-1	Elevation of channel invert is equal to minimum elevation in cross section. (For pilot channel excavations, second and third CI cards, the channel invert elevation should be specified).
		$.1 \geq CELCH \geq .00001$	Elevation of channel invert is based on CELCH (Slope) X XLCH (Channel Reach Length) + PELMN (D.S. Minimum Elevation). *For HEC-2 Programs updated March 1982 with Modification 55.*

CI

CARD CI (Continued)

Field	Variable	Value	Description
3	XLCH.CNCH	0 or +	Value to the left of decimal point is channel reach length (XLCH), if 0 the channel reach length specified on X1 card will be used. Value to right of decimal point is new channel 'n' value (CNCH), if 0, previously specified 'n' (CI or NC card) will be used.
4	XLSS	0	Value on previous cross section's CI card for left side slope of trapezoidal excavation is to be used or if not previously specified, the left side slope will be vertical.
		+	Left side slope of excavation expressed as number of horizontal units per one vertical unit. (i.e., 2.0 for two horizontal to one vertical).
5	RSS	0 or +	Same as XLSS except for right side of trapezoid.
6-10	BW	0	Value on previous cross section's CI card is used.
		.01	End of channel improvement. If multiple CI cards are being used, then all the CI cards must have .01 to turn off the channel improvement. If not all of the CI cards have a .01, then the cards that do not have a .01 will be used to do the channel improvement.
		+	Bottom width of channel. Field used (6-10) for this profile determined by variable IBW (J2.8).
		-	Same as + but the old channel will be filled up to an elevation equal to the minimum bank elevation.

CROSS SECTION DATA

CARD X2 - OPTIONAL CARD

Field	Variable	Value	Description
0	IA	X2	Card identification characters.
1	QNEW	0	No change inflow.
		+	Value of the new flow in the river. This value will be used for all remaining cross sections unless changed by another X2 card or by a QT card.
2	WSELK	0	High water mark elevations are not being used.
		+	Elevation of known water surface elevation (i.e., high water mark) at this cross section. Required if NINV(J1.3) equals one.
3	IBRID	0	Special bridge method will not be used.
		1	Special bridge method will be used. SB card is required just ahead of the X1 card for the current cross section.
4	ELLC	0	Special or normal bridge methods are not being used.
		+ or -	Elevation of a horizontal low chord for the bridge for use by the normal bridge method <u>or</u> (for the special bridge method) the maximum upstream low chord elevation within the bridge span which is used to help distinguish between pressure flow and low flow.

CARD X2 (continued)

Field	Variable	Value	Description
5	ELTRD	0	Special or normal bridge methods are not being used.
		+ or -	Elevation of a horizontal top of roadway for use by the normal bridge method or (for the special bridge method) the minimum roadway elevation on the BT cards which is used to determine if weir flow exists.
6	BLOSS	0	Change in water surface elevation will not be entered.
		+	Change in water surface elevation to be used between current and previous cross sections.
7	REPBT	0	Do not repeat bridge table (BT cards) used from previous cross section.
		1	Previous bridge table (BT cards) is repeated for use at the current cross section. PXSECE(X1.9) may be utilized to modify the low chord elevations of the repeated BT cards (top of roadways remain the same). This option is used in describing the top of a fixed diameter culvert for several cross sections. Horizontal stations can not be changed when a bridge table is repeated.
8	CMOM	0	Drag coefficient for calculating pier losses with momentum equation is equal to 2.00 (square piers).
		+	Drag coefficient to be used for calculating pier losses with momentum equations (1.33 for piers with semicircular ends).

CARD X2 (continued)

TRACE AND FLOW DISTRIBUTION

Field	Variable	Value	Description
9	BSQ	0	No bridge skew is used. Factor of 1.0 will be used.
		+	This factor is used to modify (skew) the horizontal dimensions of the bridge profile (BT cards). The value of the first RDST on the BT cards to be skewed should be equal to the station (STA) of the first GR data point for the current cross section (see X1.8 to skew GR data).
10	ITRACE	0	No trace for this cross section unless ITRACE on J2(J2.10) card is specified.
		1	Minor trace for current cross section.
		10	Major and minor trace for current cross section.
		15	Flow distribution printout for current cross section.

X3

SPECIFICATION OF INEFFECTIVE FLOW AREAS

CARD X3 - OPTIONAL CARD

Field	Variable	Value	Description
0	IA	X3	Card identification characters.
1	IEARA	0	Total area of cross section described on GR cards below the water surface elevation is used in the computations.
		10	Only the channel area (as defined by STCHL, X1.3 and STCHR, X1.4) is used in the computations, unless the water surface elevation exceeds the elevations of the bank stations. This option can be utilized to contain flow between levees until overtopping occurs, if the bank stations are coded at the top of the levees. Overtopping can occur on either side since the elevations of STCHL and STCHR are tested independently. The elevations can also be extended with ELLEA (X3.8) and ELREA (X3.9) to define artificial levees for bridge applications.
2	ELSED	0	A sediment elevation is not specified.
		+ or -	Elevation of sediment deposition. All elevations below ELSED are set equal to ELSED. This elevation may be modified by PXSECE (X1.9).

Field	Variable	Value	Description
3	ENCFP	0	Width between encroachments is not changed or is not specified.
		+	Width between encroachments is centered in the channel, midway between the left and right overbanks. Flow areas outside this width are not included in the computations. This width will be used for all cross sections unless changed by a positive ENCFP on the X3 card of another cross section or on an ET card or unless overridden by the use of STENCL(X3.4).
4	STENCL	0	Encroachments by specifying station and/or elevation will not be used on the left overbank.
		+	Station of the left encroachment. Flow areas to the left of (less than) this station and below ELENCL are not included in the computations. This option will override the option using ENCFP when both are used.
5	ELENCL	0	An encroachment elevation on the left side is not applicable and is therefore assumed very high or STENCL = 0.
		+ or -	Elevation of the left encroachment. Flow areas below this elevation and less than STENCL are not included in the computations.

CARD X3 (continued)

Field	Variable	Value	Description
6	STENCR	0	An encroachment station on the right is not used.
		+	Station of the right encroachment. Flow areas to the right of (greater than) this station and below ELENCR are not included in the computations.
7	ELENCR	0	An encroachment elevation on the right side is not applicable and is therefore assumed very high or STENCR = 0.
		+ or -	Elevation of the right encroachment. Flow areas below this elevation and greater than STENCR are not included in the computations.
8	ELLEA	0	The elevation (XLBEL) on the GR cards corresponding to STCHL (X1.3) is used to decide if the left flow area is effective or not when using the effective area option (IEARA = 10).
		+ or -	This elevation is used instead of XLBEL. This option, when used with IEARA = 10, defines artificial levees for effective flow applications at bridges.
9	ELREA	0	Same as ELLEA except for right bank flows.
		+ or -	Same as ELLEA except for right bank flows. Left bank value (ELLEA) must be nonzero for program to use the right bank value.
10			Not used.

ADDITIONAL GROUND POINTS

CARD X4 - OPTIONAL CARD

An additional input card X4 may be inserted following cards X1, X2 or X3 in order to add additional points, up to twenty, to describe the ground profile of the cross section. Stations of X4 data points must fall within the range of GR stations. The X4 data point is an added point and cannot be used to replace any GR data point. The sum of GR and X4 data points at a cross section must not exceed 100. This option is useful when modifying data cards for a proposed obstruction as it allows points to be added anywhere in the cross section. The X4 card may not be used to describe the artificial levees required for bridges since the values of STCHL and STCHR must be on the GR cards. (X4 CARDS may be utilized to enter STCHL and STCHR data for HEC-2 programs with modification 54, provided GR cards are present at the current cross section).

Field	Variable	Value	Description
0	IA	X4	Card identification characters.
1	NELT	1-20	Total number of X4 data points (maximum of 20) to be added to the current cross sections GR data set. If NELT is greater than 4, multiple X4 cards are required, and the first field of the second and subsequent X4 cards should contain a STAT(N) value.
2, 4, 6, 8, 10...etc.	ELT(N)	+ or -	Elevation of additional ground point corresponding to STAT(N). Elevations added by X4 cards are not adjusted by X1.9 PXSECE.
3, 5, 7, 9, 11, 13...etc.	STAT(N)	+	Station of additional ground point. All stations must be less than the maximum station on the GR cards. The pairs of elevations and stations do not have to be in any particular order. Station values are not adjusted by X1.8 PXSECR.

X5

WATER SURFACE ELEVATION TABLE

CARD X5 - OPTIONAL CARD

An X5 card is used to input a water surface elevation at a cross section, or to input an increment of elevation to be added to the water surface elevation of the previous cross section to obtain the water surface elevation of the cross section. The X5 card can be inserted for any cross section, including a bridge cross section, and the desired elevation or elevation increment can be specified differently for each profile of a multiple profile job. The field of the X5 card that is used for a particular profile is controlled by variable INQ(J1.2).

Field	Variable	Value	Description
0	IA	X5	Card identification characters.
1	N	1 to 19	Number of fields (maximum of 19) used on X5 card for desired water surface elevations. If the number of fields (N) is greater than 9, a second X5 card is required, and the first field of the second X5 card should have a SBWS(N) value.
		-1 to -19	Number of fields used on X5 card for desired increments of water surface elevation.
2-20	SBWS(N)	±	Water surface elevation (if N is positive) or elevation increment (if N is negative). Variable INQ(J1.2) indicates which field is used for a particular profile.

BRIDGE PROFILES

CARD BT - OPTIONAL CARD

The bridge geometry described by this card may be used by either the normal bridge method or the special bridge method. For the normal bridge method, data from the BT cards are used in conjunction with data from GR cards to define a section through a bridge or culvert. Each station on the BT card should correspond to a station on the GR card. The road elevation (RDEL) defines the top of road, and the low chord elevation (XLCEL) defines the low chord in the bridge span.

For the normal bridge method, the program eliminates the area between the top of road profile and the low chord profile for the full length of the bridge described on the BT cards. The program achieves this by subtracting the height of the obstruction from the water depth for each station on the GR cards. If the ground profile and the top-of-road profile are the same in the overbanks, then the overbank portions of the cross section do not have to be coded on the BT cards because no reduction is required. If the top of road and ground profiles are not identical, it is necessary to set values of XLCEL equal to the ground elevations in the overbanks.

The special bridge method uses the BT card data to define the weir profile for weir flow calculations. If the program cannot revert to the normal bridge method (because SB.6, BWP > 0) and the variable ELLC and ELTRD are defined on the X2 card, only the top-of-road profile need be defined on the BT card and the BT stations do not have to coincide with GR stations. However, if BWP = 0, which causes the program to transfer from the special bridge to the normal bridge method for low flow solutions, the BT cards should be prepared as described for the normal bridge method.

Field	Variable	Value	Description
0	IA	BT	Card identification characters.
1	NRD	+	Number of points describing the bridge roadway and low chord to be read on the BT cards. Entered only on first BT card. The maximum number of points is one hundred.
		-	Same as a positive NRD except an optional data format is utilized for the second and subsequent BT cards. The optional BT format is only available in HEC-2 programs updated in March 1982 with Modification 55.
2	RDST(1)	+	Roadway station corresponding to RDEL(1) and XLCEL(1).
3	RDEL(1)	+	Top of roadway elevation at station RDST(1). Should be greater than the extimated energy elevation for special bridge applications, since weir flow calculations are based on energy elevations.

CARD BT (continued)

Field	Variable	Value	Description
4	XLCEL(1)	+	Low chord elevation at station RDST(1).
5	RDST(2)	+	Roadway station corresponding to RDEL(2) and XLCEL(2).
6	RDEL(2)	+	Top of roadway elevation at station RDST(2).
7	XLCEL(2)	+	Low chord elevation at station RDST(2).
8	RDST(3)	+	Roadway station corresponding to RDEL(3) and XLCEL(3).
9	RDEL(3)	+	Top of roadway elevation at station RDST(3).
10	XLCEL(3)	+	Low chord elevation at station RDST(3).

Format for additional BT cards

STANDARD FORMAT

If NRD is Positive (+) BT data RDST, RDEL, and XLCEL is to be input starting in the second and subsequent BT cards, all ten fields are available for data.

OPTIONAL FORMAT (HEC-2 programs updated March 1982, Modification 55)

If NRD is Negative (-) BT data is to be input in the second through the tenth fields of the second and subsequest BT cards, only nine fields are available for data.

For special bridge method, the last roadway elevation RDEL (NRD) should be greater than the estimated energy elevation.

GROUND PROFILE

CARD GR

This card specifies the elevation and station of each point in a cross section used to describe the ground profile, and is required for each X1 card unless NUMST(X1.2) is zero. The points outside of the channel determine the subdivision of the cross section which influences calculation of a discharge-weighted velocity head for the cross section.

Field	Variable	Value	Description
0	IA	GR	Card identification characters.
1	EL(1)	+ or -	Elevation of cross section point one at station STA(1). May be positive or negative.
2	STA(1)	+	Station of cross section point one.
3	EL(2)	+ or -	Elevation of cross section point two at STA(2).
4	STA(2)	+	Station of cross section point two.

5 - 10 etc.

Continue with additional GR cards using up to one hundred points to describe the cross section. Stations must be in increasing order progressing from left to right across the cross section.

EJ

END OF JOB CARD

CARD EJ - REQUIRED CARD

Required following data for the last cross section. This card is only used for the first profile of multiple profile jobs because the cross section data cards are read for the first profile only. Each group of cards beginning with the T1 card is considered a job.

Field	Variable	Value	Description
0	IA	EJ	Card identification characters.
1 - 10			Not used.

ER

END OF RUN

CARD ER - REQUIRED CARD

Required at the end of a run consisting of one or more jobs in order to end computation on stop command. Three blank cards following the EJ card of a single profile run or following the last J2 card of a multiple profile run are required just ahead of the ER card.

Field	Variable	Value	Description
0	IA	ER	Card identification characters.
1 - 10			Not used.

APPENDIX VIII

HEC-2 FREE-FORMAT OPTION

HEC-2 FREE-FORMAT OPTION

The HEC-2 Program has been modified to allow the use of free-format input. In order to activate the Free-Format option, the first card of input must be an "FR" card. If the first card of input is not an "FR" card, the program will assume that all input is in fixed field format.

Besides the "FR" card requirement, the User must insert "*FREE" cards in front of free-format input data and "*FIX" cards in front of fixed field format input data. The free-format input data must have a blank delimiter following the card identifier and commas or blanks used to delimit the rest of the fields. A blank should be used to delimit a field that is full. If a comma is used to delimit a field that is full, the next field will be blank. Multiple commas are interpreted as blank fields.

The Free-Format Option allows the User to enter more than ten fields per card as long as the input does not exceed 80 characters. The program will reformat the single free-format input card into multiple fixed field input cards having ten fields each. The User also has the option of entering fewer than ten fields per card. The program checks the next card and if it has the same card identifier, the program will combine and reformat the cards into fixed field format of ten fields per card. This last option only applies to HEC-2 cards that belong to a common set of input data such as the "GR" cards that are used to describe cross section coordinates.

The User should be aware that the use of free-format may increase the program's run time by 30% for large runs and up to 100% for small runs. The additional run time is due to the program having to read all the input data, reformat it to fixed field, and then write it to Tape 10. To avoid subsequent added run time, the User should save Tape 10 and in subsequent runs use it as the input file.

The following listings demonstrate the use of the new HEC-2 Free-Format option and the resulting Tape 10 file.

Input listing using Free-Format option

```
FR    FREE FORMAT READER BEING USED
AC
AC THIS IS AN ARCHIVAL TEST RUNB
*FREE
C
C  3,
C  3,  THIS IS SECTION NO 3
C  4,   THIS IS SECTION NO 4
C  7,     THIS IS SECTION NO 7
T1       TEST 1 SUBCRITICAL PROFILE,XSECS 4 AND 5 AND PROFILE PLOTTED
T2       FLOW DISTRIBUTION REQUESTED(X2.1) AT XSECS 4 AND 5
T3       CRITICAL CREEK  TEST 1    DETAILED,SUMMARY OUTPUT SELECTED J2,J3,J5
*FIX
J1                              0.0092                         7800 1756.02
*FREE
J3 38,1,2,3,10,11,12,33,5,58,57,62,20,150,
J5 -1 7 2 4 5 8 10 11 12
NC .1 .1 .04 .1 .3
X1 1.00 61 767 815 0 0 0
GR 1767.0 0,1765.4,23,1763.5,49,1762.0,69,1759.1,87
GR 1758.1 103
GR 1756.9 113
GR 1756.9 122
GR 1753.2 127 1753.1 131
*FIX
GR1757.7      140  1757.7     152  1755.0     160  1755.6     168  1755.6     171
GR1755.6      174  1754.7     177  1755.9     183  1756.0     190  1754.9     208
GR1754.7      220  1753.7     247  1753.3     282  1752.7     321  1750.9     352
GR1748.6      373  1747.2     391  1748.3     404  1752.1     434  1753.6     452
GR1753.7      477  1752.6     499  1753.2     532  1753.4     572  1753.9     613
GR1753.3      644  1754.4     677  1754.7     698  1755.6     728  1756.2     750
GR1755.7      767  1749.9     772  1749.3     775  1748.0     775  1747.4     778
GR1749.3      785  1749.7     789  1752.9     797  1755.5     807  1756.9     815
GR1755.3      827  1756.3     847  1756.2     866  1756.9     871  1759.5     877
GR1760.7      893  1762.0     918  1763.2     936  1764.3     963  1766.2     990
GR1766.7     1006
X1  2.00       61     768     816     500     480     510
GR1774.1        0  1769.5      30  1765.8      59  1762.9      89  1761.4     116

EJ
*FREE
T1    SECOND PROFILE
T2
T3
J1 ,,,,.009,,,20000,1760,
J2 15,

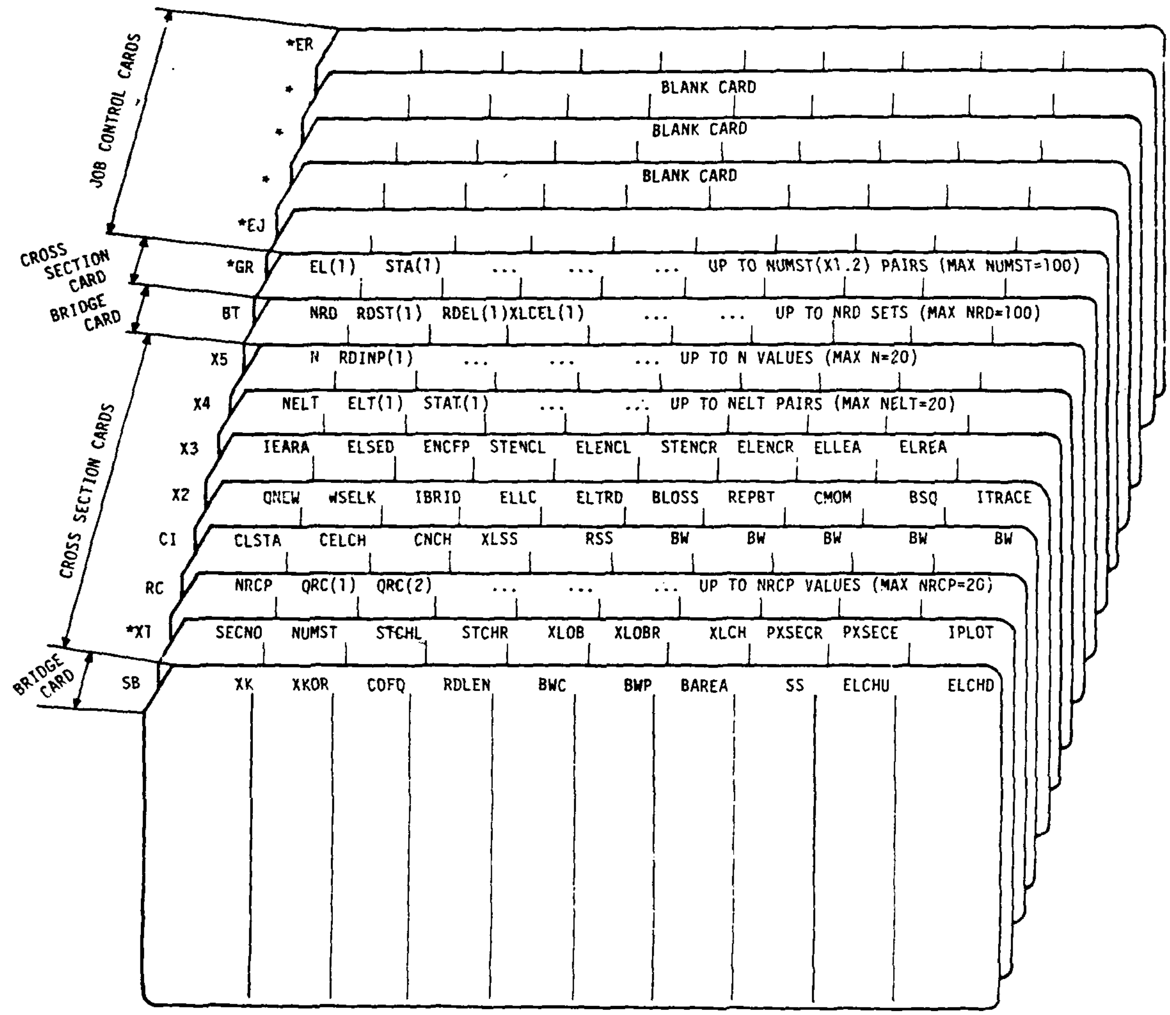

ER
```

Listing of Fixed Field Format Tape 10

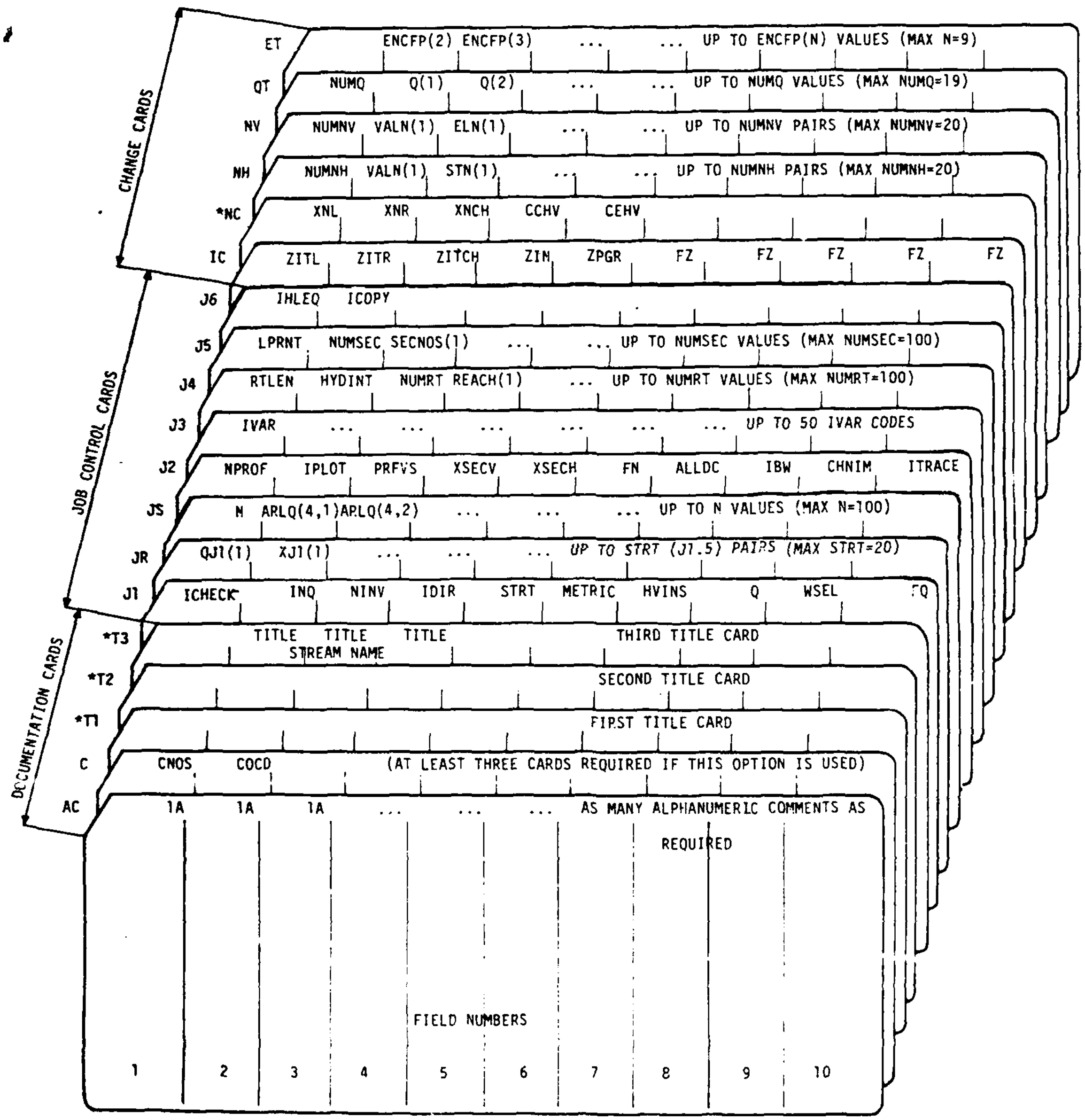
```
AC
AC THIS IS AN ARCHIVAL TEST RUNB
C
C       3
C       3  THIS IS SECTION NO 3
C       4   THIS IS SECTION NO 4
C       7     THIS IS SECTION NO 7
T1       TEST 1 SUBCRITICAL PROFILE,XSECS 4 AND 5 AND PROFILE PLOTTED
T2       FLOW DISTRIBUTION REQUESTED(X2.1) AT XSECS 4 AND 5
T3       CRITICAL CREEK  TEST 1   DETAILED,SUMMARY OUTPUT SELECTED J2,J3,J5
J1                                    0.0092                        7800 1756.02
J3      38       1       2       3      10      11      12      33       5      58
J3      57      62      20     150
J5      -1       7       2       4       5       8      10      11      12
NC      .1      .1     .04      .1      .3
X1    1.00      61     767     815       0       0       0
GR1767.0         0  1765.4      23  1763.5      49  1762.0      69  1759.1      87
GR1758.1       103  1756.9     113  1756.9     122  1753.2     127  1753.1     131
GR1757.7       140  1757.7     152  1755.0     160  1755.6     168  1755.6     171
GR1755.6       174  1754.7     177  1755.9     183  1756.0     190  1754.9     208
GR1754.7       220  1753.7     247  1753.3     282  1752.7     321  1750.9     352
GR1748.6       373  1747.2     391  1748.3     404  1752.1     434  1753.6     452
GR1753.7       477  1752.6     499  1753.2     532  1753.4     572  1753.9     613
GR1753.3       644  1754.4     677  1754.7     698  1755.6     728  1756.2     750
GR1755.7       767  1749.9     772  1749.3     775  1748.0     775  1747.4     778
GR1749.3       785  1749.7     789  1752.9     797  1755.5     807  1756.9     815
GR1755.3       827  1756.3     847  1756.2     866  1756.9     871  1759.5     877
GR1760.7       893  1762.0     918  1763.2     936  1764.3     963  1766.2     990
GR1766.7      1006
X1    2.00      61     768     816     500     480     510
GR1774.1         0  1769.5      30  1765.8      59  1762.9      89  1761.4     116

EJ
T1     SECOND PROFILE
T2
T3
J1                                      .009                       20000    1760
J2      15

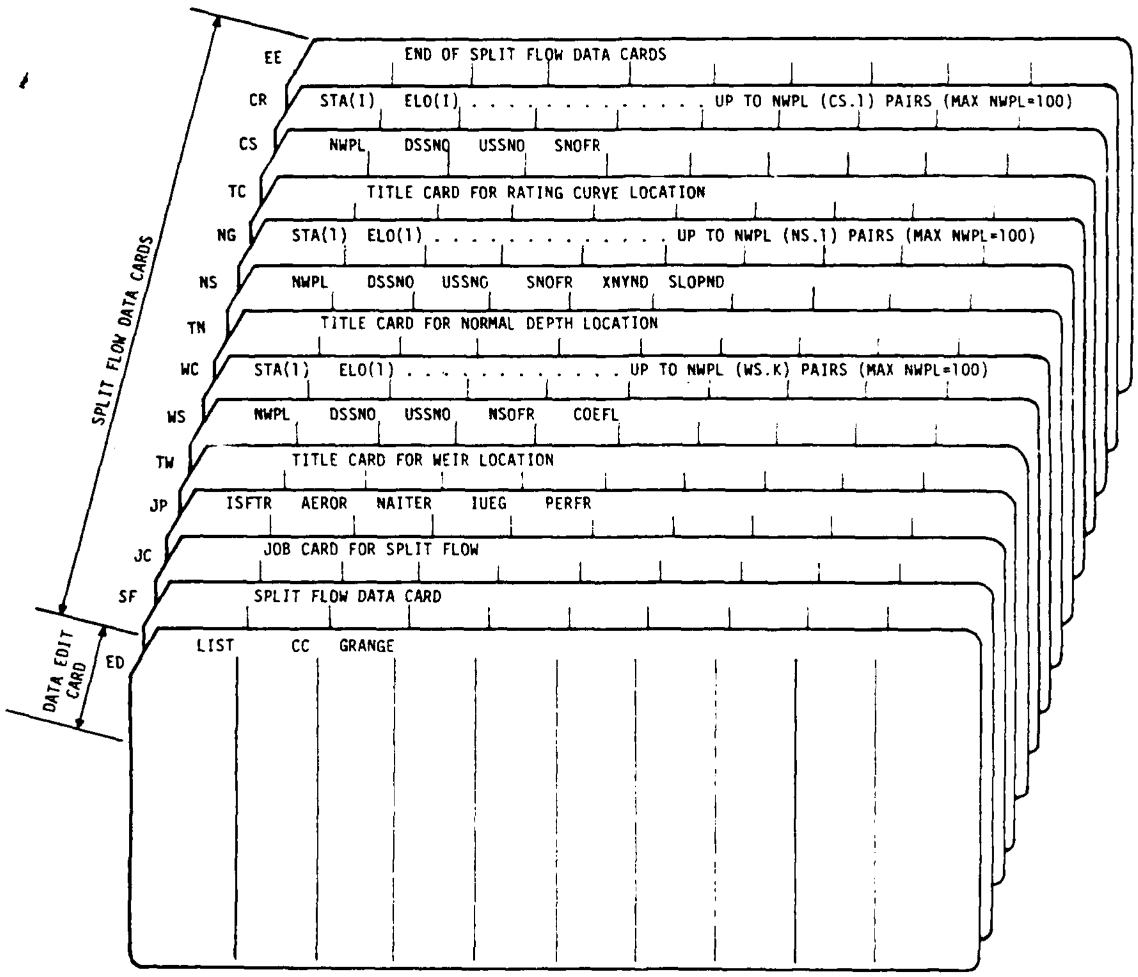

ER
```


JOB CONTROL CARDS
*ER
*
BLANK CARD
*
BLANK CARD
*
BLANK CARD
*EJ
CROSS SECTION CARD
*GR
EL(1) STA(1) ... ... UP TO NUMST(X1.2) PAIRS (MAX NUMST=100)
BRIDGE CARD
BT
NRD RDST(1) RDEL(1)XLCEL(1) ... ... UP TO NRD SETS (MAX NRD=100)
CROSS SECTION CARDS
X5
N RDINP(1) ... ... UP TO N VALUES (MAX N=20)
X4
NELT ELT(1) STAT(1) ... ... UP TO NELT PAIRS (MAX NELT=20)
X3
IEARA ELSED ENCFP STENCL ELENCL STENCR ELENCR ELLEA ELREA
X2
QNEW WSELK IBRID ELLC ELTRD BLOSS REPBT CMOM BSQ ITRACE
CI
CLSTA CELCH CNCH XLSS RSS BW BW BW BW BW
RC
NRCP QRC(1) QRC(2) ... ... UP TO NRCP VALUES (MAX NRCP=20)
*X1
SECNO NUMST STCHL STCHR XLOB XLOBR XLCH PXSECR PXSECE IPLOT
BRIDGE CARD
SB
XK XKOR COFQ RDLEN BWC BWP BAREA SS ELCHU ELCHD

SUMMARY OF INPUT CARDS



*INDICATES CARDS REQUIRED FOR BASIC APPLICATIONS


SPLIT FLOW DATA CARDS
DATA EDIT CARD
EE
END OF SPLIT FLOW DATA CARDS
CR
STA(1) ELO(1) . . . . UP TO NWPL (CS.1) PAIRS (MAX NWPL=100)
CS
NWPL DSSNO USSNO SNOFR
TC
TITLE CARD FOR RATING CURVE LOCATION
NG
STA(1) ELO(1) . . . . UP TO NWPL (NS.1) PAIRS (MAX NWPL=100)
NS
NWPL DSSNO USSNO SNOFR XNYND SLOPND
TN
TITLE CARD FOR NORMAL DEPTH LOCATION
WC
STA(1) ELO(1) . . . . UP TO NWPL (WS.K) PAIRS (MAX NWPL=100)
WS
NWPL DSSNO USSNO NSOFR COEFL
TW
TITLE CARD FOR WEIR LOCATION
JP
ISFTR AEROR NAITER IUEG PERFR
JC
JOB CARD FOR SPLIT FLOW
SF
SPLIT FLOW DATA CARD
ED
LIST CC GRANGE

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SUPPLEMENT TO HEC-2 USERS MANUAL

September 1988

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J6 record - Attachment 4

PREFACE

The purpose of this document is to describe the additional features of the September 1988 version of HEC-2 not covered in the September 1982 Users Manual. The September 1988 version of HEC-2 was created primarily to add a number of hydraulic design applications to the program. These added features of the program include:

1) an equivalent roughness "k" to describe boundary roughness. It is a measure of the roughness height of boundary elements and reflects a change in Manning's "n" with stage.

2) an evaluation of conveyance definition within the channel. The program tests whether conveyance elements are defined properly in the case when two or more "n" values are used within the bank stations. The test checks a bank steepness criterion documented by the USGS in a publication entitled "Computation of Water-surface Profiles in Open Channels", and if either bank does not pass this test, the program composites these "n" values into one "n" value for the entire channel.

3) four new **TAPE95** variables: **CUMDS**, **SHEAR**, **POWER**, and **FRCH**. These variables define the cumulative channel distance, channel boundary shear stress, channel stream power, and channel Froude number respectively.

4) the ability to write a file in HEC-2 input format which contains cross section geometry, roughnesses, reach lengths, etc., after all modifications are performed by the program. This feature is particularly useful when the need arises to combine certain options, such as channel improvement and **NH** records, which ordinarily can not be combined.

5) a revised flow distribution table that shows flow distribution within the channel if conveyance computations subdivide the channel. Average depth in each subsection is also shown.

Other new features of the program are: message records, unlimited title records, revised storage-discharge output, and a new floodway table based on distances from the channel centerline.

INPUT CHANGES

MESSAGES IN INPUT FILE LISTING

Messages, notes, explanation of data, etc., can be inserted anywhere in the input data set by placing the record identifier, "* ", in field zero of the line containing the information. The messages will be printed in the input listing of the output file, but will not be printed at any other location in the output. Blank lines may also be included in the input file and will be shown in the input listing, but will be disregarded by the program during execution.

UNLIMITED TITLE RECORDS

The list of title record identifiers has been expanded to include **T1** through **T9** records. The user can specify these in any order and can specify as many of these record identifiers as they wish. For example, one profile could have five **T1** records and one **T3** record. The last **T3** record of the profile will be used to provide a title for summary printout for that profile.

ELIMINATION OF THREE BLANK LINES PRECEDING THE "ER" RECORD

The three blank lines preceding the **ER** record are no longer required. All blank lines are disregarded during program execution.

EXAMPLE OF NEW INPUT FILE

An example of these new input features is shown in Figure 1.

```
*                    Title records

T1      TEST 2 OPTIONAL START CONDITIONS  MANNINGS N SPECIFIED BY NC,NH,NV CARDS
T2      SLOPE AREA METHOD  (ESTIMATE STARTING ELEVATION)
T3      ROCKY RIVER  TEST 2     USER DEFINED SUMMARY TABLE
T1      REPEATED TITLE RECORD
T9      NEW TITLE RECORD
T6      NEW TITLE RECORD

*                      Job records

J1    -10                            0.0055                         7000    5715

NC                             0.1      0.3
NH      5      .1     415     .05      650     .03     710     .05    1020      .1
NH   1635

*                   Cross section 1

X1      1      11     650     710        0       0       0       0       0       0
GR   5725      20    5718     110     5717     415    5714     650    5701     675
GR   5700     690    5701     710     5713     710    5714    1020    5714    1590
GR   5725    1635

NH      4      .1     415     .05      575     .03     640      .1    1250

*                   Cross section 2

X1      2      10     575     640      450     610     500
GR   5725      30    5720     110     5720     200    5717     415    5710     575
GR   5704     580    5704     615     5718     640    5718    1195    5725    1250

NC     .1      .1     .03
*
*               Description of n varying vertically in channel
*
NV      5    0.06    5710    0.05     5713    0.04    5715    0.03    5719   0.025
NV   5725
X1      3      10     370     600      400     400     400     .95    5000
GR    725      40     722     260    718.7     370     715     420   707.1     500
GR  707.5     530   717.3     560      720     600     722     850     725     875
NC   0.07    0.05   0.036     0.1      0.3
EJ
ER
```

Figure 1. Example of file containing new titling and spacing features.

COMPUTATIONAL CHANGES

EQUIVALENT ROUGHNESS "k"

An equivalent roughness parameter "k", commonly used in the hydraulic design of channels, is provided as an option for describing boundary roughness in HEC-2. Equivalent roughness, sometimes called "roughness height", is a measure of the linear dimension of roughness elements, but is not necessarily equal to the actual, or even the average, height of these elements. In fact, two roughness elements with different linear dimensions may have the same "k" value because of differences in shape and orientation (Reference [1]).

The advantage of using equivalent roughness "k" instead of Manning's "n" is that "k" reflects changes in the friction factor due to stage, whereas Manning's "n" alone does not. This influence can be seen in the definition of Chezy's "C" for a rough channel (equation 6 of Reference [2]):

$$C = 32.6 \log_{10} \left[\frac{12.2R}{k} \right] \qquad (1)$$

where,

C = Chezy roughness coefficient
R = hydraulic radius (feet or meters)
k = equivalent roughness (feet or meters)

Note that as the hydraulic radius increases (which is equivalent to an increase in stage), the friction factor "C" increases. In HEC-2, "k" is converted to a Manning's "n" by using the above equation and equating the Chezy and Manning's equations (equation 4 of Reference [2]) to obtain the following:

$$n = \frac{ZR^{1/6}}{32.6\,[\log_{10}12.2 + \log_{10}(R/k)]} \qquad (2)$$

where,

n = Manning's roughness coefficient
Z = 1.486 (English units) or 1.00 (metric units)

Again, this equation is based on the assumption that all channels (even concrete-lined channels) are "hydraulically rough". A graphical illustration of this conversion can be found in Plates 4 and 5 of Reference [2].

KH records can be used to describe the horizontal variation of "k" in the same manner as **NH** records are used to describe Manning's "n" values. Up to twenty values of "k" can be specified for each cross section with the use of **KH** records. Normally, a set of **KH** records applies to a single cross section, and an **NC** record or another set of **KH** or **NH** records is used to define "k" or "n" values for the next cross section. An input data description for the **KH** record is shown in Attachment 1.

Tables and charts for determining "k" values for concrete-lined channels are provided in EM 1110-2-1601 (Reference [2]). Values for riprap-lined channels may be taken as the theoretical spherical diameter of the median stone size. Approximate "k" values from Chow (Reference [1]) for a variety of bed materials, including those for natural rivers are shown in Table 1.

	k (ft.)
Brass, copper, lead, glass	0.0001 - 0.0030
Wrought iron, steel	0.0002 - 0.0080
Asphalted cast iron	0.0004 - 0.0070
Galvanized iron	0.0005 - 0.0150
Cast iron	0.0008 - 0.0180
Wood stave	0.0006 - 0.0030
Cement	0.0013 - 0.0040
Concrete	0.0015 - 0.0100
Drain tile	0.0020 - 0.0100
Riveted steel	0.0030 - 0.0300
Natural river bed	0.1000 - 3.0000

Table 1. Equivalent roughness values of various bed materials

The values of "k" (0.1 to 3.0 ft.) for natural river channels are normally much larger than the actual diameters of the bed materials to account for boundary irregularities and sand waves.

CHANNEL IMPROVEMENT INVERT SLOPE ELEVATION

When using the channel improvement option of HEC-2, the elevation of the improved channel invert can be determined by specifying the slope of the improved channel invert. This is done by setting **CELCH** in the second field of the **CI** record to between 0.1 and 0.00001. The elevation of the channel invert is then determined as

$$INVERT = CELCH*XLCH + PCELCH \tag{3}$$

where,

INVERT = elevation of channel invert at current cross section (feet or meters)
CELCH = slope of the improved channel invert
XLCH = channel reach length (feet or meters)
PCELCH = previous improved channel invert elevation (feet or meters)

Note that the old method used the previous minimum elevation **PELMN** instead of **PCELCH**.

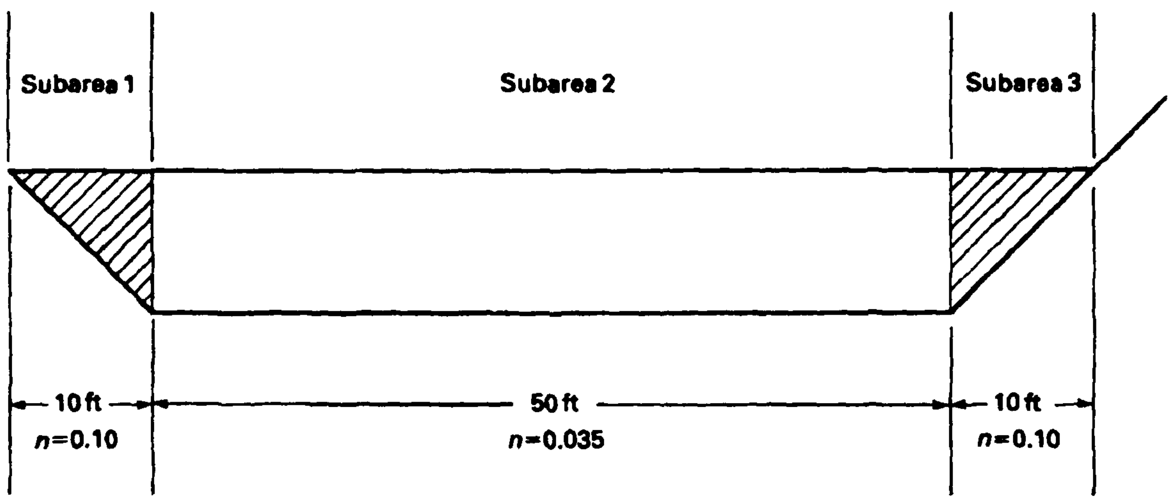
SEDIMENT ELEVATION ELSED

When specifying a sediment elevation by using **ELSED** from the second field of the **X3** record, ground points will be added to the array of ground points in order to create a level sediment fill. Previously, only the elevations of existing ground points were modified by **ELSED** and no ground points were added, in effect creating fill in the areas immediately to the left and right of the intended sediment fill of elevation **ELSED**.

COMPOSITE ROUGHNESS FOR THE CHANNEL

The boundary roughness within the bank stations of a cross section commonly appears to be divided into two distinct regions: one region defining the roughness of the channel banks and the other defining the roughness of the channel bottom. This situation is sometimes modeled by using more than one roughness within the channel, the idea being that this subdivision of roughness will better define the hydraulic properties of the cross section. This assumption, as will be seen in the following example, can often lead to a serious distortion of the computation of conveyance for the cross section.

The cross section of a trapezoidal channel having heavy brush and trees on the side slopes and a relatively smooth bottom is chosen to illustrate the problem. This cross section has been subdivided to obtain a better definition of the variation of roughness (Figure 2). As shown in Reference [3] however, the computation of conveyance based on the wetted perimeters, areas, hydraulic radii and Manning's "n" values of the subsections produces unreasonable results. The total conveyance K_T computed for this cross section would be the equivalent to using a "n" value of 0.034 for the entire cross section, which is less than the "n" values of 0.035 and 0.10 of the subsections. The proper procedure is to use one Manning's "n" value for the entire channel, assigning a value somewhat higher than 0.035 to account for the greater roughness of the banks.



$A_1 = A_3 = 50$
$P_1 = P_3 = 14.14$
$R_1 = R_3 = 3.54$
$K_1 = K_3 = 1730$

$A_2 = 500$
$P_2 = 50$
$R_2 = 10$
$K_2 = 98{,}500$

$K_T = K_1 + K_2 + K_3$
$= 102{,}000$

Composite solution: $A_c = 600$
$P_c = 78.3$
$R_c = 7.66$

$$n_c = \frac{1.486 A_c R_c^{2/3}}{K_T} = 0.034$$

Figure 2. Effects of subdivision on a trapezoidal section (from Reference [3])

HEC-2 has been modified to test the applicability of subdivision of roughness within the channel portion of a cross section, and if it is not applicable, the program will compute a composite "n" value for the entire channel. The program determines if the channel portion of the cross section can be subdivided or if a composite channel "n" value will be utilized based on the following criterion: if a channel side slope is steeper than 5H:1V and the cross section has been subdivided, a composite roughness "n_c" will be computed with equation (2) from Reference [1]. The channel side slope used by HEC-2 is defined as the horizontal distance between adjacent NH stations within the channel over the difference in elevation of these two stations (see S_L and S_R of Figure 3).

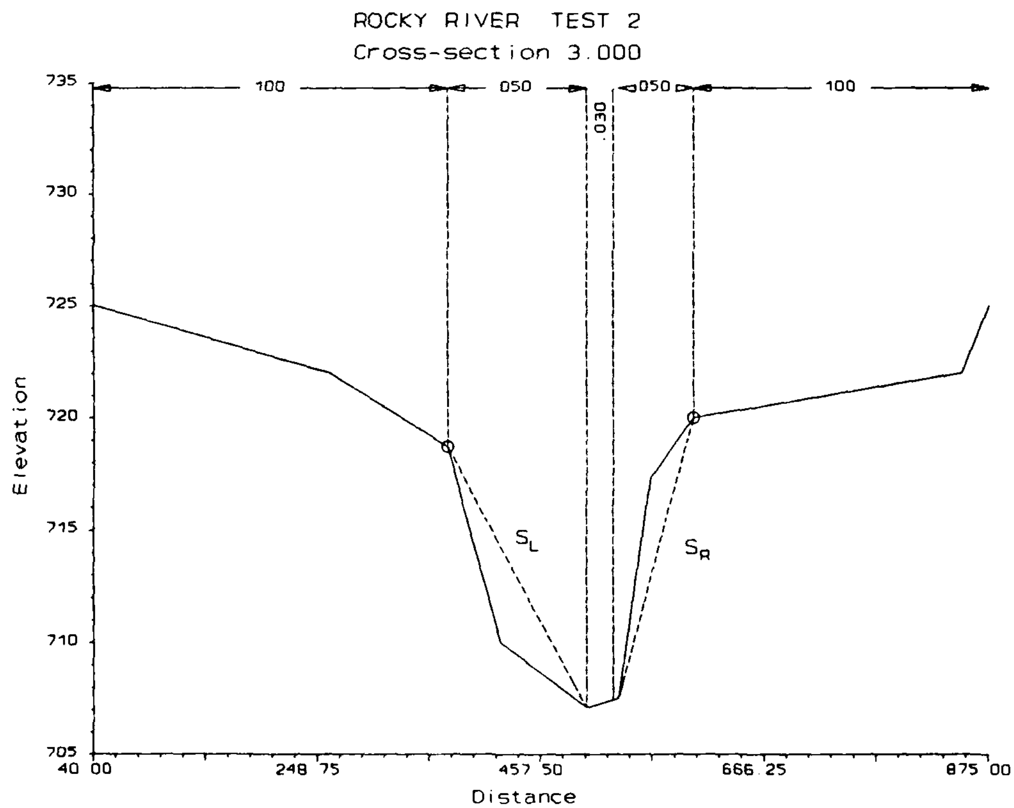


Figure 3. Definition of bank slope when examining conveyance within the channel

For the determination of "n_c", the water area is divided into N imaginary parts, each with a known wetted perimeter P_i and roughness coefficient n_i.

$$n_c = \left[\frac{\sum_{i=1}^{N} (P_i n_c^{1.5})}{P} \right]^{2/3} \tag{4}$$

where,

n_c = composite or equivalent coefficient of roughness
P = wetted perimeter of cross section
P_i = wetted perimeter of imaginary subdivision i
n_i = coefficient of roughness for imaginary subdivision i

The computed composite "n_c" should be checked for reasonableness. The computed value is the channel "n" value (**XNCH**) in the detailed output and summary tables.

Channel subdivision is controlled in HEC-2 by the input variable **SUBDIV** specified in the 3rd field of the **J6** record. Input data for this variable is described under the heading of **J6** record changes.

WEIR SUBMERGENCE COMPUTATIONS

The method of adjustment for weir flow submergence in the Special Bridge routine has been changed. The program will now adjust for weir submergence based on either the curves in U.S. Bureau of Public Roads publication, Hydraulics of Bridge Waterways (Figure 24), Reference [4], or the Waterway Experiment Station's Design Chart 111-4. The Hydraulics of Bridge Waterways method, the new default method of the program, is based on a trapezoidal-shaped roadway embankment, whereas the WES method is based on a ogee-shaped spillway. Use of the WES method is designated by a negative weir coefficient **COFQ** in field 3 of the **SB** record, the Hydraulics of Bridge Waterways method is designated by a positive weir coefficient **COFQ**.

OUTPUT CHANGES

OUTPUT VARIABLE CHANGES

Twelve flow-under-ice output variables, numbered 68 - 79 on the **J3** record, have been eliminated from HEC-2. Variables have been renumbered as follows:

Old Numbers	New Numbers
1 - 63	1 - 63
89 - 90	64 - 65
64 - 67	70 - 73
80 - 88	74 - 82

The following four hydraulic variables have been added:

Number	Name	Definition
66	**CUMDS**	Cumulative channel distance from the cross section at the downstream end of the model. The units of this variable are defined by **METRIC** (**J1.6**) and **STRTDS** (**J6.4**)
67	**SHEAR**	Boundary shear stress within the channel (lb/ft^2 or N/m^2)
68	**FRCH**	Channel Froude number for uniform conditions
69	**POWER**	Channel stream power (lb/(ft*s) or N/(m*s))

Channel boundary shear stress is computed with the equation,

$$\tau_{ch} = \gamma D_{ch} S \tag{5}$$

where,

γ = specific weight of water (lb/ft^3 or N/m^3)
D_{ch} = average depth of water in the channel (feet or meters)
S = slope of the energy grade line (ft/ft or m/m)
τ_{ch} = channel boundary shear stress (lb/ft^2 or N/m^2)

Channel steam power is computed as:

$$\Gamma_{ch} = \tau_{ch} V_{ch} \tag{6}$$

where,

P_{ch} = channel stream power (lb/(ft*s) or N/(m*s))
V_{ch} = average channel velocity (ft/s or m/s)

The channel Froude number equation is:

$$Fr_{ch} = \frac{V_{ch}}{(g*D_{ch})^{1/2}} \tag{7}$$

where,

Fr_{ch} = Froude number for the channel

Note that these computations are based on prismatic flow within the channel, therefore, as the amount of overbank flow increases, their accuracy decreases.

TAPE16 SCRATCH FILE FOR WRITING MODIFIED DATA INPUT

Information reflecting changes to cross-sectional data and reach lengths resulting from channel modification and other program options can be written to an optional scratch file named **TAPE16**. This file can be used as a portion of the input file in subsequent runs, providing additional versatility in the use of program options. With this new file, encroachments can be analyzed and **NH** or **KH** records can be used to define roughness, thus avoiding some of the conflicts that would ordinarily occur between these options and the channel improvement option.

```
T1      Channel improvement option (CHIMP) and creation of TAPE16
T2      bottom width BW = 100
T3      CHIMP CREEK
J1              12                                                 168.1

*    -7 in 8th field will cause TAPE16 file to be created

J2      -1              -1                                      -7
NC    .120    .120    .037     0.1     0.3
QT      11     450     600     900    1200    1500    2300    5000    6700    9400
QT   15000   25000

*   Elevations of all stations will be decreased by 0.85 in TAPE16 for xsec 1

X1    1.05      38   18150   18448                                 1    -.85
GR   200.0   12000   180.0   12200   170.0   13000   170.0   13200   170.0   13500
GR   170.0   14000   170.0   14400   165.0   14500   170.0   14600   170.0   15950
GR   165.0   18149   165.0   18150   165.0   18151   165.0   18168   160.0   18179
GR   149.0   18188   155.0   18201   158.0   18209   159.8   18229   159.9   18234
GR   159.9   18237   160.0   18255   157.5   18259   157.0   18260   145.0   18282
GR   144.8   18308   144.8   18309   145.0   18310   145.0   18324   150.0   18341
GR   155.0   18353   162.0   18364   163.0   18429   164.0   18447   167.0   18448
GR   172.8   18449   180.0   19250   200.0   20600

*   Elevations will be increased by 3.14 compared to sec 1.05 of TAPE16

X1    1.55                            1200    1300    3684            3.14

*  Channel improvement will change sec 1.55 information written to TAPE16

CI   18300  147.09   0.025       3       3      10     100             300     400

*   Elevations will be increased by 1.7 compared to sec 1.55 of TAPE16

X1    1.82                            1400    1250    1450             1.7

*  Channel improvement shut off at sec 1.82

CI                                             .01     .01             .01     .01
EJ
ER
```

Figure 4. Input file used to create **TAPE16** file.

This option is implemented by entering any negative number in Field 8 of the **J2** record. A **TAPE16** file will be written containing information for each cross section of each profile. An example of an input file utilizing this feature and the corresponding **TAPE16** file created by this input file is shown in Figures 4 and 5 respectively.

```
NC .1200   .12000  .03700  .10000  .30000
QT    11.    450.    600.    900.   1200.   1500.   2300.   5000.   6700.   9400.
QT15000.  25000.      0.      0.      0.      0.      0.      0.      0.      0.
X1 1.050       38 18150.0 18448.0      .0      .0      .0
GR 199.1 12000.0  179.15 12200.0  169.15 13000.0  169.15 13200.0  169.15 13500.0
GR 169.1 14000.0  169.15 14400.0  164.15 14500.0  169.15 14600.0  169.15 15950.0
GR 164.1 18149.0  164.15 18150.0  164.15 18151.0  164.15 18168.0  159.15 18179.0
GR 148.1 18188.0  154.15 18201.0  157.15 18209.0  158.95 18229.0  159.05 18234.0
GR 159.0 18237.0  159.15 18255.0  156.65 18259.0  156.15 18260.0  144.15 18282.0
GR 143.9 18308.0  143.95 18309.0  144.15 18310.0  144.15 18324.0  149.15 18341.0
GR 154.1 18353.0  161.15 18364.0  162.15 18429.0  163.15 18447.0  166.15 18448.0
GR 171.9 18449.0  179.15 19250.0  199.15 20600.0
NC .1200   .12000  .02500  .10000  .30000
X1 1.550       43 18150.0 18448.0  1200.0  1300.0  3684.0
GR 202.3 12000.0  182.29 12200.0  172.29 13000.0  172.29 13200.0  172.29 13500.0
GR 172.3 14000.0  172.29 14400.0  167.29 14500.0  172.29 14600.0  172.29 15950.0
GR 167.3 18149.0  167.29 18150.0  167.29 18151.0  167.29 18168.0  162.29 18179.0
GR 151.3 18188.0  157.29 18201.0  160.29 18209.0  160.39 18210.1  154.09 18229.0
GR 152.4 18234.0  151.42 18237.0  147.09 18250.0  147.09 18255.0  147.09 18259.0
GR 147.1 18260.0  147.09 18282.0  147.09 18308.0  147.09 18308.0  147.09 18309.0
GR 147.1 18310.0  147.09 18324.0  147.09 18341.0  147.09 18350.0  148.09 18353.0
GR 151.8 18364.0  164.90 18403.4  165.29 18429.0  166.29 18447.0  169.29 18448.0
GR 175.1 18449.0  182.29 19250.0  202.29 20600.0
NC .1200   .12000  .02500  .10000  .30000
X1 1.820       38 18150.0 18448.0  1400.0  1250.0  1450.0
GR 204.0 12000.0  183.99 12200.0  173.99 13000.0  173.99 13200.0  173.99 13500.0
GR 174.0 14000.0  173.99 14400.0  168.99 14500.0  173.99 14600.0  173.99 15950.0
GR 169.0 18149.0  168.99 18150.0  168.99 18151.0  168.99 18168.0  163.99 18179.0
GR 153.0 18188.0  158.99 18201.0  161.99 18209.0  163.79 18229.0  163.89 18234.0
GR 163.9 18237.0  163.99 18255.0  161.49 18259.0  160.99 18260.0  148.99 18282.0
GR 148.8 18308.0  148.79 18309.0  148.99 18310.0  148.99 18324.0  153.99 18341.0
GR 159.0 18353.0  165.99 18364.0  166.99 18429.0  167.99 18447.0  170.99 18448.0
GR 176.8 18449.0  183.99 19250.0  203.99 20600.0
EJ
```

Figure 5. Example of **TAPE16** file

STORAGE-DISCHARGE OUTPUT

HEC-2 can be used to obtain storage-discharge data in a format required by HEC-1 for modified-Puls routing. **J4** records can be included with the job description for the first profile of the input file to accomplish this task. The storage-discharge information is written to a file, **TAPE7**, which can be incorporated into a HEC-1 data file. A revised **J4** input data description is contained in Attachment 2.

It should be noted that the storage volumes computed by the program do not include any volumes blocked out as ineffective flow. If the reach for which storage-discharge data is being generated has ineffective flow areas, such as those normally located next to bridges, the storage data should be adjusted accordingly. In some cases, it may be convenient to use high roughness coefficients ("n" values) to block out these ineffective flow areas. This approach retains the storage volumes associated with these areas.

FLOW DISTRIBUTION

When the flow distribution option was requested in the previous version of the program, output included lateral distribution of area, velocity, and percent of total discharge for up to thirteen subsections of the cross section. However, this flow distribution output always displayed the channel as one flow element; it did not show subsections within the channel even when conveyance calculations did subdivide the channel. Flow distribution output will now show subsections within the channel if the channel is subdivided.

In addition to the above change, flow distribution tables will now also display an average depth for each subsection of the entire cross section, and, if a **KH** record is used for the cross section, the corresponding Manning's "n" value for each subsection. Figure 6 contains an example of the revised flow distribution table.

FLOW DISTRIBUTION FOR SECNO= 3.00 CWSEL= 723.00

STA=	187.	260.	370.	500.	530.	600.	850.	858.
PER Q=	.1	4.1	41.8	36.2	12.2	5.5	.0	
AREA=	36.7	291.5	1263.5	471.0	492.0	500.0	4.2	
VEL=	.2	1.0	2.3	5.4	1.7	.8	.2	
DEPTH=	.5	2.6	9.7	15.7	7.0	2.0	.5	
"n"=	.1003	.0475	.0485	.0288	.0513	.0508	.1009	

Figure 6. Example of new flow distribution table

WARNING MESSAGE BASED ON CONVEYANCE CHANGE

The message

3302 WARNING: *CONVEYANCE CHANGE* OUTSIDE OF ACCEPTABLE RANGE

is printed with the cross-sectional data output and in the Summary of Errors and Special Notes when the ratio of conveyance between cross sections, **KRATIO**, is computed outside of the following range:

$$0.7 < \textbf{KRATIO} < 1.4$$

A value of **KRATIO** outside of this range usually indicates that a closer spacing of cross sections is required. Cross sections should be spaced at relatively short intervals in reaches where conveyance changes significantly as a result of changes in width, depth and roughness.

Note that this warning message can be expected to occur in the vicinity of bridges as flow contracts upstream and expands downstream from the bridge. Since the conveyance change test is meant to be applied in natural open channel conditions, its significance in the vicinity of bridges is questionable. However, the user should still examine the reach lengths for these steps and if they appear too long, cross sections should be added.

ARCHIVE FILE (TAPE96)

The archive file **TAPE96**, written with the use of the **AC** record, has been changed so that all 82 output variables are written in standard numeric form rather than exponential form. Note that this file contains all of the information found in the **TAPE95** file in a formatted text form rather than a binary form. This feature allows other programs to easily access this information.

WEIR LENGTH IN THE SPECIAL BRIDGE ROUTINE

The variable, **WEIRLN**, the effective length of the weir computed with the special bridge routine, is printed in cross-sectional output of special bridge information. It appears after the variable, **ELTRD**, in the line of special bridge output data, as shown in Figure 7.

PRESSURE FLOW CRITERION

For determining pressure flow, the program has been revised to limit the check for the maximum elevation of the low chord **ELLC** to the area between bank stations.

*SECNO 5.000

PRESSURE AND WEIR FLOW

EGPRS	EGLWC	H3	QWEIR	QPR	BAREA	TRAPEZOID AREA	ELLC	ELTRD	WEIRLN
64.69	61.54	.13	3389.	12541.	1014.	1014.	57.00	60.00	626.

Figure 7. Example of **WEIRLN** in special bridge output.

FLOODWAY WIDTH TABLE 115

An additional table has been added to the list of pre-defined summary printout tables. This table, Table 115, is a printout of information dealing with the location of encroachments relative to the channel centerline as defined by the bank stations. Specifying code 115 on the **J3** record will create an output like the example shown in Figure 8.

Floodway width summary: NORTH BUFFALO CR TEST 14
Profile No. 2

Section Number	Elevation Increase	Top Width	Left Encroach Station	Left Sta Distance From Center	Center Station	Right Sta Distance From Center	Right Encroach Station
29900.000	1.00	250.00	360.00	124.00	484.00	126.00	610.00
33700.000	2.37	240.00	145.00	120.00	265.00	120.00	385.00
35100.000	2.11	230.00	100.00	32.50	132.50	197.50	330.00
36950.000	1.65	240.00	100.00	113.00	213.00	127.00	340.00
37000.000	1.14	240.00	100.00	113,00	213.00	127.00	340.00
37110.000	1.14	240.00	100.00	113.00	213.00	127.00	340.00
40150.000	.94	230.00	10.00	110.00	120.00	120.00	240.00
40800.000	*** Encroachments not set ***						

Figure 8. Example of Floodway Width Table 115.

J5 RECORD CHANGES

There no longer is a conflict when using **J4** records and fields 2 and 3 of the **J5** record for the same run. A revision of the **J5** Input Data Description is contained in Attachment 3.

J6 RECORD ADDITIONS

Three variables have been added to the **J6** record: **SUBDIV**, **STRTDS**, and **RMILE**. Their usage is described in the revision of the **J6** Input Data Description contained in Attachment 4.

REFERENCES

1. Chow, Ven T. Open Channel Hydraulics. McGraw-Hill. 1959.

2. Department of the Army, Corps of Engineers. "Hydraulic Design of Flood Control Channels," Engineer Manual EM 1110-2-1601. Office of the Chief of Engineers. 1970.

3. Department of the Interior, U.S. Geological Survey. "Computation of Water Surface Profiles," Techniques of Water-Resources Investigations of the United States Geological Survey, Book 3, Chapter A15. 1984

4. Federal Highway Administration, "Hydraulics of Bridge Waterways," Hydraulic Design Series No. 1. U.S. Department of Transportation, revised 2nd Edition. 1978

KH

HORIZONTAL DESCRIPTION OF EQUIVALENT ROUGHNESS "k"

RECORD **KH** - OPTIONAL RECORD

Used to specify equivalent roughness coefficients (k values) which vary with horizontal distances from the left side of the cross section. These specifications remain in effect unless changed by new **KH**, **NH**, or **NC** records at subsequent cross sections. Roughness coefficients should be redefined for each cross section with new geometry. The **KH** record should not be used for cross sections employing the **NV** record or channel improvement (**CI**) option.

Field	Variable	Value	Description
0	**IA**	**KH**	Identification characters
1	**NUMKH**	1-20	Total number of equivalent roughness values of "k" (maximum of 20) entered on **KH** records. If **NUMKH** is greater than 4, multiple **KH** records are required, and the first field of the second and subsequent **KH** records should contain a **STK(N)** value.
2, 4, 6, 8, 10, etc.	**VALK(N)**	+	Equivalent roughness "k" coefficient between stations **STK(N-1)** and **STK(N)**. The first "k" value applies from the starting left station up to **STK(1)** (field three).
3, 5, 7, 9, 11, etc.	**STK(N)**	+	Station corresponding to **VALK(N)**. Each station should equal one of the stations on the next **GR** record. Stations must be in increasing order. Station values will not be adjusted by **X1.8 PXSECR**.

J4

STORAGE-DISCHARGE OUTPUT

Record **J4** - OPTIONAL RECORD

Optional record used only on the first profile of a multiple profile run to write storage-discharge data to **TAPE7** in a form that can be used as input to the HEC-1 program for modified-Puls routing. The multiple profile run should cover the range of flows required for routing purposes. A **KK** record is generated by HEC-2 for each routing reach. Storage and corresponding discharge values are written to **SV** and **SQ** records, respectively. **KK** and **KM** records are printed to identify the reach, and an **RS** record is printed without data. The storage-routing variables required on the **RS** record must be added by the HEC-1 user. Routing reach cross section numbers, **REACH(I)**, specified on this record must be defined on an **X1** record.

Field	Variable	Value	Description
0	**IA**	**J4**	Identification characters
1-10	**REACH(I)**	+	Defines routing reaches by pairs of cross section numbers representing upstream and downstream ends of reaches. **REACH(I)**, when **I** is an odd number, indicates a downstream end. An even number for **I** indicates an upstream end. Fifty reaches can be specified. A blank field indicates that no more cross section numbers will follow. Zeros in a field are read as a cross section number, not a blank.

J5

PRINTOUT CONTROL OPTION

RECORD J5 - OPTIONAL RECORD

The optional J5 record can be used to suppress detailed (cross section by cross section) and summary printout. The J5 record(s) may be used for single or multiple profile jobs. For multiple profile jobs, the J5 record(s) is inserted with job records for the first profile only. Printout of the data input list, flow distribution data, and profile and cross section plots are unaffected by this option; for printout control of these options refer to the J1, J2, X1, and X2 records. Use of the J5 record for various printout options is illustrated in the following table.

Field					
0 (IA)	1 (LPRNT)	2 (NUMSEC)	3 (SECNOS(I))	4 .. N	Desired Printout
J5	-10	-10			Summary printout only for all cross sections
J5	-10		X		Detailed and summary printout beginning at cross section X
J5	-10	+	X_1	$X_2..X_n$	Detailed and summary printout for cross sections (X_1, ... X_n)

J5

RECORD **J5** (continued)

Field	Variable	Value	Description
0	**IA**	**J5**	Record identification.
1	**LPRNT**	-10	and **NUMSEC** = -10, suppress detailed printout for all cross sections.
			and **NUMSEC** = 0 or plus, print detailed and summary printout for only those cross sections indicated by **NUMSEC** and **SECNOS(I)** (**J5.2** AND **J5.3**)
		-1	Same as -10 except a list of cross section numbers is furnished to aid in debugging runs that do not run to completion.
2	**NUMSEC**	-10	Suppress detailed printout for all cross sections. Requested summary printout is not suppressed.
		0	Suppress all detailed and summary printout from the first cross section to the cross section indicated in **J5.3**.
		+	Any positive number indicates that the following fields will contain cross section numbers **SECNOS(I)**.

RECORD **J5** (continued)

Field	Variable	Value	Description
3-10	**SECNOS(I)**	-, 0, +	If **NUMSEC** is plus, one hundred cross section numbers can be specified. If additional records are required, all ten fields should be used for **SECNOS(I)**. A blank field indicates that no more cross section numbers will follow. Zeros in a field are read as a cross section number, not a blank.

J6

FRICTION LOSS EQUATION OPTION

RECORD **J6** - OPTIONAL RECORD

The **J6** record is an optional record which can be utilized to select equations for computation of friction losses, transfer control of output print files to computer system control, choose the method of evaluating subdivision of conveyance within the channel, and select the station of the cross section at the downstream end of the model. These options may be used for single or multiple profile jobs. For multiple profiles the **J6** record is inserted with job records for the first profile only.

Field	Variable	Value	Description
0	**IA**	**J6**	Record identification.
1	**IHLEQ**	0	Average conveyance equation used to compute friction losses. This equation has been utilized in the preceding version of HEC-2 and is recommended for general application.
		1	Program selects, on a step by step basis; one of the following equations: average friction slope, geometric mean friction slope, or harmonic mean slope. Selection is based on flow conditions.*
		2	Average friction slope equation used to compute friction losses.
		3	Geometric mean friction slope equation used to compute friction losses.
		4	Harmonic mean friction slope equation used to compute friction losses.

*See Table 2, Chapter 4, page 20, of the Users Manual for details.

RECORD *J6* (continued)

Field	Variable	Value	Description
2	**ICOPY**	0	The program will internally handle the disk/tape units containing the output print files.
		1	The program will transfer control of disk/tape units for output print files to the computer. See Programmers Manual for details.
3	**SUBDIV**	0	Default value. Allow subdivision of the channel if both bank side slopes are flatter than 5H:1V (horizontal to vertical). The slope is computed from the bank station to the point of "n" or "k" value change.
		-1	Allow the program to subdivide if "n" or "k" is changed in the channel cross section for any side slope.
		+	Value defining the side slope criterion for subdividing instead of the default value of five (5).
4	**STRTDS**	(-,0,+)	Station of the first cross section of the downstream end of the model. The units of **STRTDS** can be either in feet or meters or in miles or kilometers as indicated by the variable **RMILE** (J6.5).
5	**RMILE**	0	Units for **STRTDS** are in feet or meters.
		+	Units for **STRTDS** are in miles or kilometers.