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Hydrologic Engineering Center

Application of the HEC-2 Split Flow Option

April 1982

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US Army Corps of Engineers
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14. ABSTRACT
This training document is designed to assist the user of computer program HEC-2 who is using the split flow option and wishes to acquaint themselves with its capabilities and limitations. Provide a detailed description of the HEC-2 spilt flow input requirements, output results, computation method, and example applications.

15. SUBJECT TERMS
digital computer, split flows, HEC-2, backwater, open-channel hydraulics, lateral weir overflows

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US Army Corps of Engineers
Institute for Water Resources
Hydrologic Engineering Center
609 Second Street
Davis, CA 95616

(530) 756-1104
(530) 756-8250 FAX
www.hec.usace.army.mil

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FOREWORD

This training document was written to assist users of Computer Program HEC-2, Water Surface Profiles, in the analysis of split flows. Financial assistance for writing this document was provided by the Flood Plain Management Branch, Office of the Chief of Engineers.

The author wishes to acknowledge contributions by Vernon R. Bonner and Bill S. Eichert to the material contained in this document and for their reviews and comments.

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APPLICATION OF THE HEC-2 SPLIT FLOW OPTION

INTRODUCTION

Purpose and Scope.

The purpose of this training document is to provide information on the capabilities and limitations of the computer program HEC-2 Split Flow option. This document provides a detailed description of the input requirements, output results, computational methods and example applications for the split flow option. It is assumed that the user has a knowledge of the basic HEC-2 input requirements. Information on HEC-2 input requirements is available in the "HEC-2 Water Surface Profiles-Users Manual" (reference 1).

Program Documentation.

The split flow option was added to the HEC-2 Computer Program by Modification 55 which was implemented April 1982. The primary documentation for HEC-2 is the January 1981 Users Manual which describes the program capabilities, input requirements, and output. To use the program, one would need a users manual, as this document does not give details on many program features and input formats. The users manual is available from the Hydrologic Engineering Center.

HEC-2 SPLIT FLOW OPTION

Split flows are flows that leave the main river flow and take completely separate paths from the path taken by the main river flow. The split flows may return further downstream or may be completely lost. The HEC-2 program assumes that none of the split flows return and automatically reduces the discharges downstream from the split flow location unless the user specifies where to return the flow and what percent of it to return.

Capabilities.

The HEC-2 split flow option has the following capabilities:

- Can solve up to 100 separate split flows simultaneously.
- Up to 15 profiles may be solved in one execution.
- Three methods for determining the split flows are available.
  1. Weir flow assumption
  2. Normal depth assumption
  3. Rating curve assumption
- All or a percentage of the split flow can be returned.
- Option of either using the water surface or energy elevation for computing the split flows.
- Allows the use of rating curves for starting the backwater. This capability is now a general HEC-2 capability and may be used without having to use the split flow option.

The split flow option is compatable with multiple profiles and most of the standard HEC-2 options. The only options not available to the user, if the split flow option is used, are encroachment methods 3, 4, 5, and 6.

There are many types of split flows that occur in rivers. The following is a list of the more commonly encountered types of split flows.

- Split flows caused by islands or high ground.
- Split flows caused by levee overtopping.
- Split flows caused by watershed divide overtopping.
- Split flows caused by diversion structures.

The HEC-2 split flow option is capable of analyzing all of the above split flows, with the exception of the island or high ground type of split flows. Appendix III has been provided in this document to assist the user that has a split flow caused by islands or high ground. The solution procedure is the classic divided flow analysis technique.

Computation Procedure.

The computation procedure used to solve the problem of split flows is basically a one dimensional steady state method of trial and error, as follows:

1. The program computes the water surface profile and adjusts the discharges to reflect the assumed overflows. No overflows are assumed to occur for the first iteration unless the user has specified overflow values on JS cards.

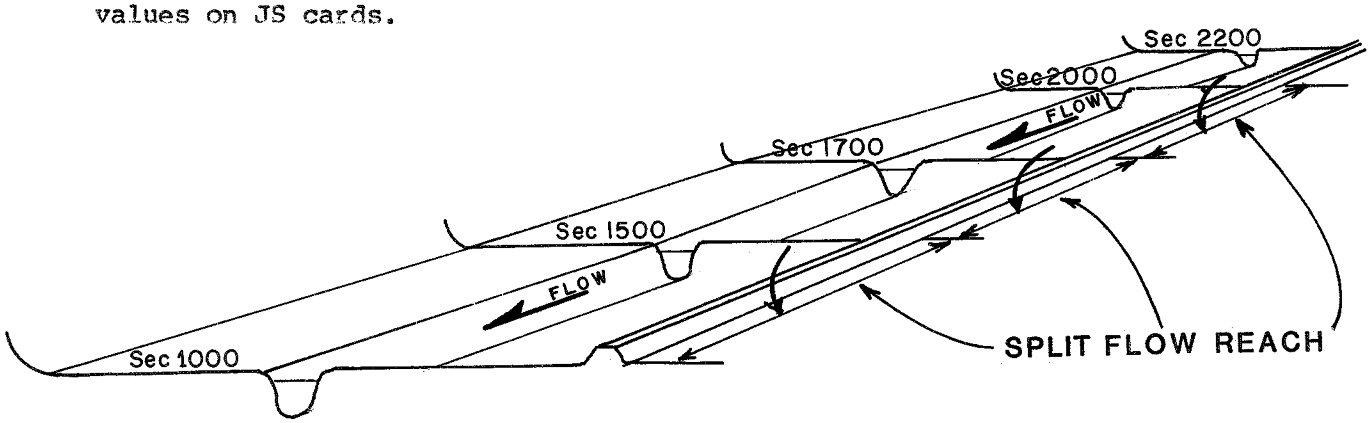


FIGURE 1

2. The location of each split flow reach (Figure 1) is defined in relation to the model by the upstream and downstream cross section numbers. Based on the cross secion numbers, the water surface or energy elevations are determined from the water surface profile performed in step one and are used to calculate the overflow.

3. The computed and assumed overflows for each split flow reach and their cumulative values are compared. If the difference between any of the values for computed and assumed is greater than 2 percent, the program makes a new assumption of overflows and repeats steps 1 through 3 until an acceptable tolerance is met or until the program has performed 20 iterations.

Program Limitations.

The following assumptions are implicit in the analytical expressions used in the HEC-2 program and the split flow option:

1. Flow is steady because time dependent terms are not included.
2. Flow is gradually varied because a hydrostatic pressure distribution is assumed in the energy equation.
3. Flow is one-dimensional because the total energy head is the same for all points at a cross section location.
4. The river has a channel slope of no more than 10 percent.
5. The split flows can be estimated by the standard weir equation, the normal depth equation, or a rating curve of outflow -vs- elevation.
6. Submergence of the overflow weir by tailwater is insignificant.
7. The weir flow is linearly integrated along the length of the weir based on the upstream and downstream water surface or energy elevations.
8. The normal depth conveyance is linearly integrated along the length of the normal depth cross section based on the upstream and downstream water surface elevations.
9. The direction of the main stream flow is at right angle to the split flow.
10. Split flow is controlled by either the water surface elevation or the energy elevation.
11. Flow boundaries are fixed. This is to say that the cross section and weir geometries do not erode or change with time.

12. Split flows that are not returned to the system are removed from the entire model downstream from the split flow location. Because HEC-2 does not take into account the variation of flow with time, the user must be careful in using the HEC-2 split flow option in cases where the split flow at an upstream location does not have a constant effect on the peak discharges further downstream. An explanation of this problem and a solution strategy is given in the section titled Hydrologic Considerations.

HEC-2 SPLIT FLOW INPUT DESCRIPTION

The split flow input data must be entered as the first data of an HEC-2 run, with the exception of the ED card (EDIT2 program). The split flow input data must always start with an SF card and end with an EE card. The EE card must be followed by the regular HEC-2 input data cards.

The split flow input data uses the standard HEC input format, in which the first field contains a two character card identifier, and has six columns for data while the next nine fields contain eight columns each. The above format is for numeric data. The format for title cards is two columns for card identifier and the remaining seventy eight columns for alpha-numeric information.

The split flow data input varies from the standard HEC-2 format in that a set of data cards is always preceded by a title card and the title card is required. The order in which the cards are entered must be followed exactly for each set or group of cards. The sets of cards need not be in any specific order, but it is recommended that split flow reaches be entered in a downstream direction to make the output more readable. A detailed description of the split flow data card input format is given in Appendix I. The following is a description of the general card types.

Split Flow Title Card.

The SF card is a title card used to activate the split flow option. It is a required card and must be the first input data card in the deck.

Job Card Set.

The job card set consists of the JC and JP cards. The job card set is optional and is used to control the processing of the split flow data. A job card set may be placed anywhere in the split flow input data. The JC card is the first card of the set and is used as a title card. The JP card is used to set the level of printout, allowed error tolerance, maximum number of iterations, use of either water surface or energy elevation, and percent of split flow to return.

Weir Reach Card Set.

The weir reach set is composed of three types of cards. The first card of the set is the TW card. The TW card is a title card and must be the first card of the set. The second card is the WS card, which contains information dealing with the number of points describing the weir, weirflow coefficient, location of the downstream and upstream limits of the weir in relation to section numbers and the section number where the flow returns. The third card of the set, the WC card, describes the weir geometry by the use of station and elevation coordinates. The coordinate points must start at the downstream end and proceed in an upstream direction.

Normal Depth Reach Card Set.

The normal depth reach set is composed of three types of cards. The first card of the set is the TN card, which is a title card and must be the first card of the set. The second card, the NS card, is similar to the WS card, with the exception that instead of having the weirflow coefficient, it has the energy slope and 'n' value. The third card, the NG card, is used to describe the normal depth cross section geometry by the use of station and elevation coordinates, with the coordinates starting at the downstream end.

Diversion Reach Card Set.

The diversion reach set is composed of three types of cards. The first card of the set is the TC card, which is a title card and must be the first card of the set. The second card, the CS card, contains information dealing with the number of points describing the diversion rating curve, loaction of the diversion in relation to section numbers, and the section number where the diverted flow returns. The third card, the CR card, is used to describe the rating curve by the use of discharge and elevation coordinates.

End Split Flow.

The EE card is required to terminate the split flow input data.

Additional HEC-2 Cards.

Several additional input data cards have been added to the standard HEC-2 input to facilitate the use of the split flow option. The new cards are the JR, JS, and RC cards.

The JR card is used to input a rating curve that is used to start the backwater. The JR card follows the J1 card and is read when the J1 card variable STRT is greater than one. The STRT value in this case is used to indicate the number of rating curve values that will be read on the JR card.

The RC card is used to input a rating curve at any cross section, which will be used instead of a calculated backwater answer. It operates in the same manner as an X5 card.

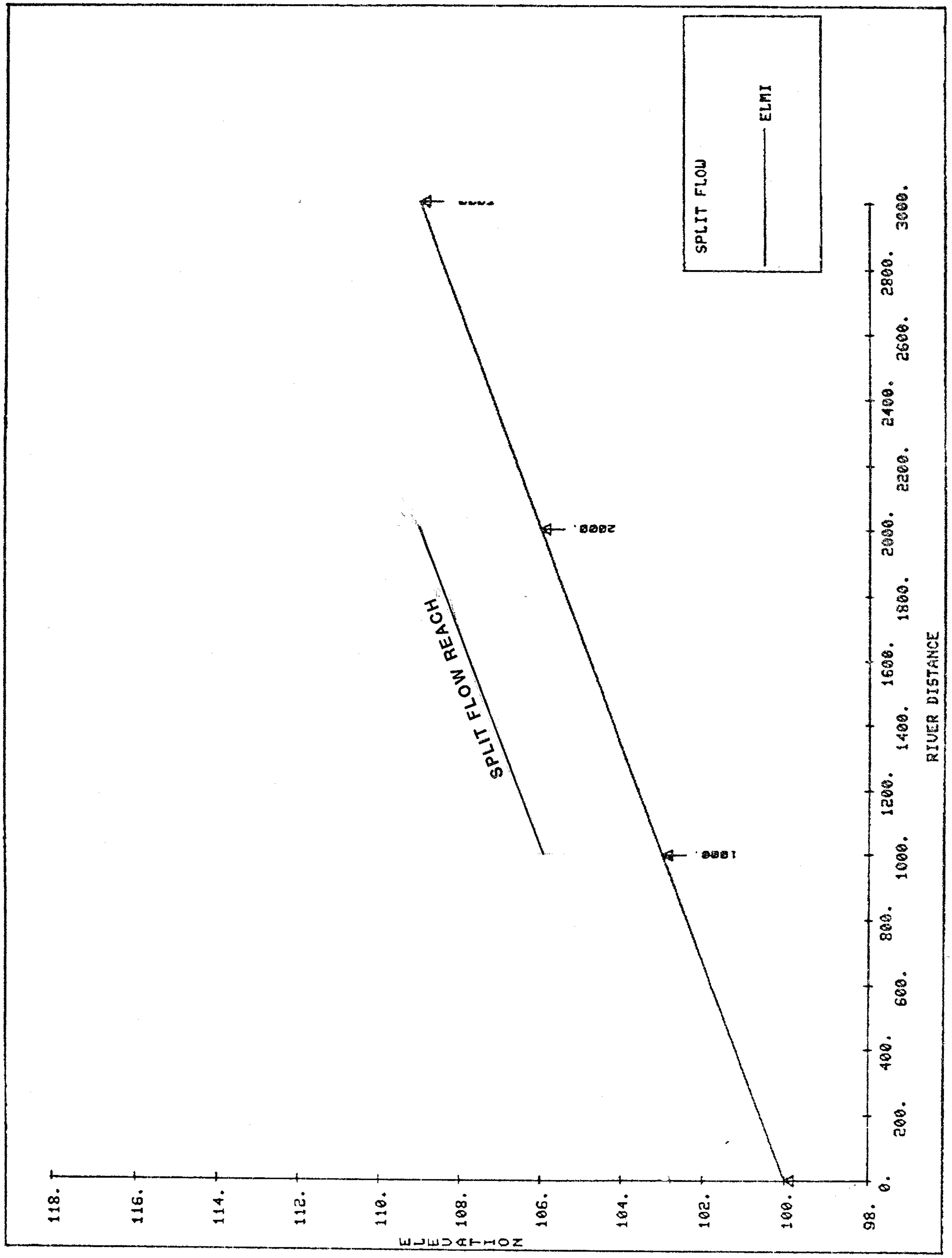
The JS card is used to specify the starting assumed split flow for each reach defined in the split flow data sets. The JS card follows the J1 or JR cards. It is an optional card and if omitted, the program assumes for its first trial that no flow is being lost.

GENERAL MODELING CONSIDERATIONS

The split flow option requires that the cross section numbers (X1 card) continually increase in value from downstream to upstream. It is recommended that station values in feet or miles measured along the main channel be used for cross section numbers. This is important because the HEC-2 program uses the cross section numbers specified on the split flow reaches to determine what water surface or energy grade line elevations to use in determining the amount of flow lost. Each split flow reach is located based on cross section numbers at the downstream and upstream ends of the reach. If the downstream and upstream split flow locations do not match a cross section number, the program will linearly interpolate between cross section numbers to determine the water surfaces or energy grade line elevations. A wise practice would be to start and end the split flow reaches at cross section numbers that appear in the HEC-2 hydraulic model.

Split Flow Reach Length Consideration.

The overflow reaches should be kept as short as possible. The longer the split flow reaches, the less accurate will be the split flows and backwater answers. The split flow problem can be compared to the integration of a curve by the Trapezoidal Rule, which is an approximate method of subdividing the curve into a number of straight line segments and calculating the areas under each straight line segment and then adding up the subareas to calculate the total area under the curve. The smaller the straight line segments and the larger the number of segments, the more accurate will be the calculated area. The same



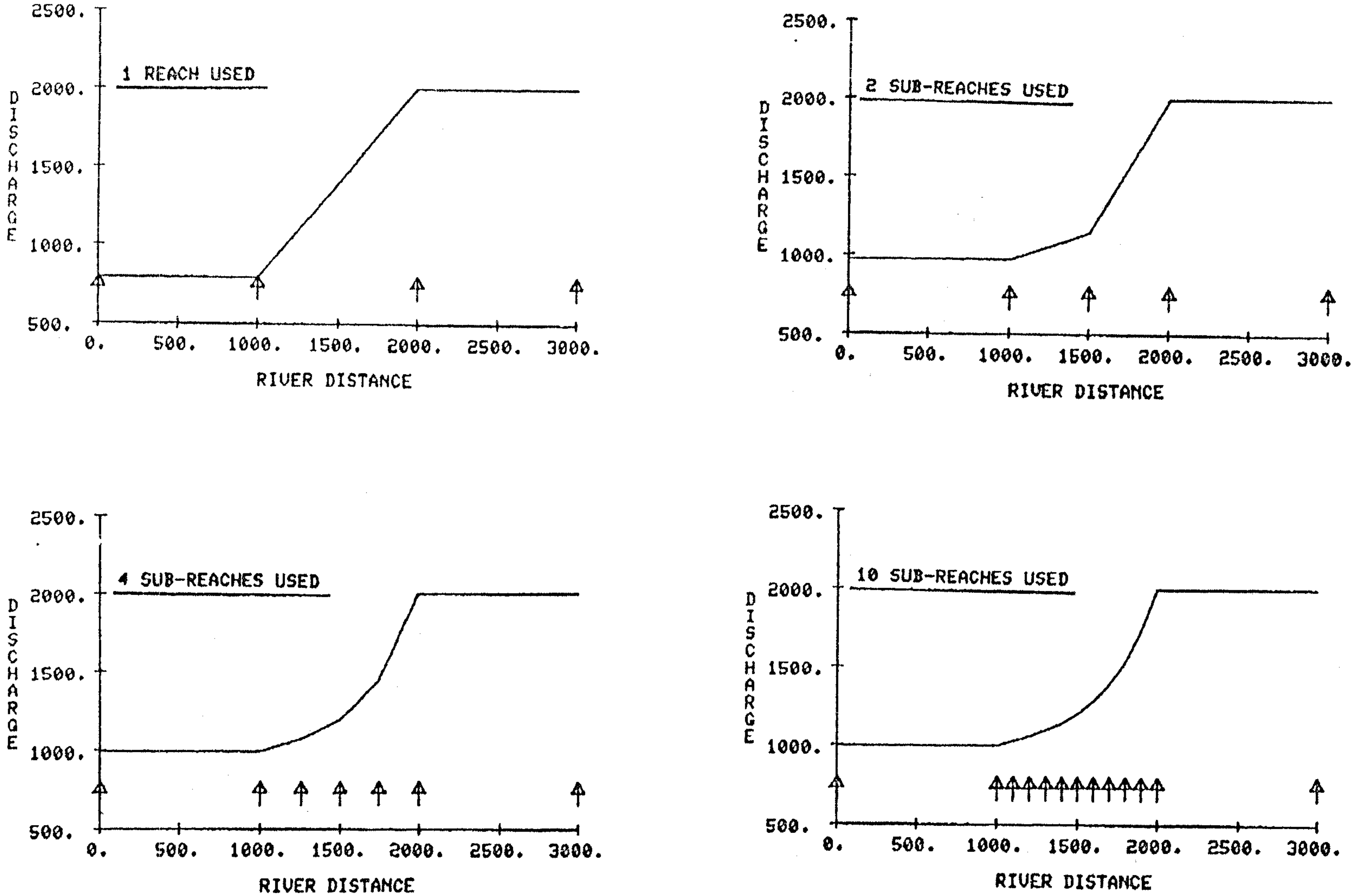
SPLIT FLOW
ELMI
SPLIT FLOW REACH
1000.
2000.
ELEVATION
98.
100.
102.
104.
106.
108.
110.
112.
114.
116.
118.
0.
200.
400.
600.
800.
1000.
1200.
1400.
1600.
1800.
2000.
2200.
2400.
2600.
2800.
3000.
RIVER DISTANCE

FIGURE 2

logic applies to the calculation of the split flows. The shorter the split flow reaches and the additional cross sections defining them, the more accurate will be the calculated outflows and water surface elevations.

The effect of subdividing a split flow reach and addition of cross sections can be seen in the following example. Figure 2 shows a profile plot of a stream and a split flow reach which has a total reach length of 1000 feet. The split flow reach was modeled in four different ways. The first model represented the split flow reach as a single 1000 foot long reach. The second model divided the split flow reach into two 500 foot reaches. The third model divided the split flow reach into four 250 foot reaches and the fourth model divided it into ten 100 foot reaches. Note that each reach has a cross section defining it upstream and downstream. Additional cross sections must be used because the split flow discharges are calculated based on a linear interpolation of the upstream and downstream cross section water surface or energy elevations. The effect of dividing up the split flow reach into shorter and shorter segments, is to produce answers which are more accurate. The results from these four models are presented on Figure 3, which shows plots of the flow in the main river -vs- river distance. The results clearly show that the 1000 foot reach should be divided into shorter reaches. The fourth model produced the most accurate results, but it is also clear from the plotted results, that the second and third models gave acceptable results.

The example also shows that the upstream portion of a uniform split flow reach should be divided into shorter segments than the downstream portion, because a larger proportion of the flow will be lost on the upper portion.



1 REACH USED
2 SUB-REACHES USED
4 SUB-REACHES USED
10 SUB-REACHES USED
DISCHARGE
2500.
2000.
1500.
1000.
500.
0.
500.
1000.
1500.
2000.
2500.
3000.
RIVER DISTANCE

FIGURE 3

Hydrologic Considerations.

A common practice for hydraulic analysis is to use the flood hydrograph peak discharge values for the backwater calculations and ignore the fact that in most cases the peaks of the hydrographs do not occur at the same time. In many cases the effect of this assumption on the calculated water surface profile is well within the accuracy for profile calculations. Most HEC-2 models are assembled in this manner. When it comes to a split flow analysis, the effect of using the peak discharges as steady flow should not be ignored.

The HEC-2 split flow option, as a default, reduces all discharge values downstream from a split flow reach by the calculated split flow values. For example, if 1000 cfs is lost at the headwaters of a stream, the program will reduce all the discharges by 1000 cfs all the way downstream to the start of model or to the section number where the user has specified that it returns. The only way to determine the validity of reducing the discharges in this manner is to look at the entire hydrograph, to see how the loss from the split flow effects the peak discharges downstream. It may be that the peak discharge further downstream will only be partially effected by the split flow loss. The peak discharges downstream may be more dependent on the timing of tributary and local inflows.

To illustrate this problem, the following simple example is presented. As shown on Figure 4, the Upper Main Stem has a split fow reach just upstream from the confluence with Tributary No 1. Figure 5 is a plot of the original hydrographs for the Upper Main Stem, Tributary No 1, and their combined hydrographs on the Lower Main Stem. If flows that exceed 3000 cfs on the Upper Main Stem are lost, then the modified hydrographs plotted on Figure 6 occur.

Comparing the original hydrographs with the modified shows the peak discharge on the Lower Main Stem reduced by 1000 cfs, peak flow on Tributary No 1 unaffected, and the peak discharge on the Lower Main Stem reduced by 500 cfs. The HEC-2 split flow option would have reduced the Lower Main Stem peak discharge by 1000 cfs and not by the correct amount of 500 cfs.

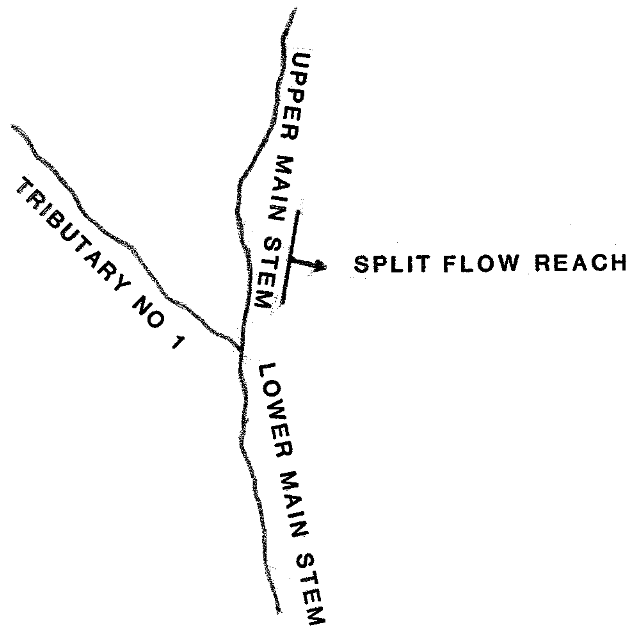


FIGURE 4

Consideration must also be given to the effect of storage routings. The effect of routing a flood wave is to reduce the peak discharge. Therefore a peak discharge further downstream based on routing will not be reduced by the total amount that was lost upstream.

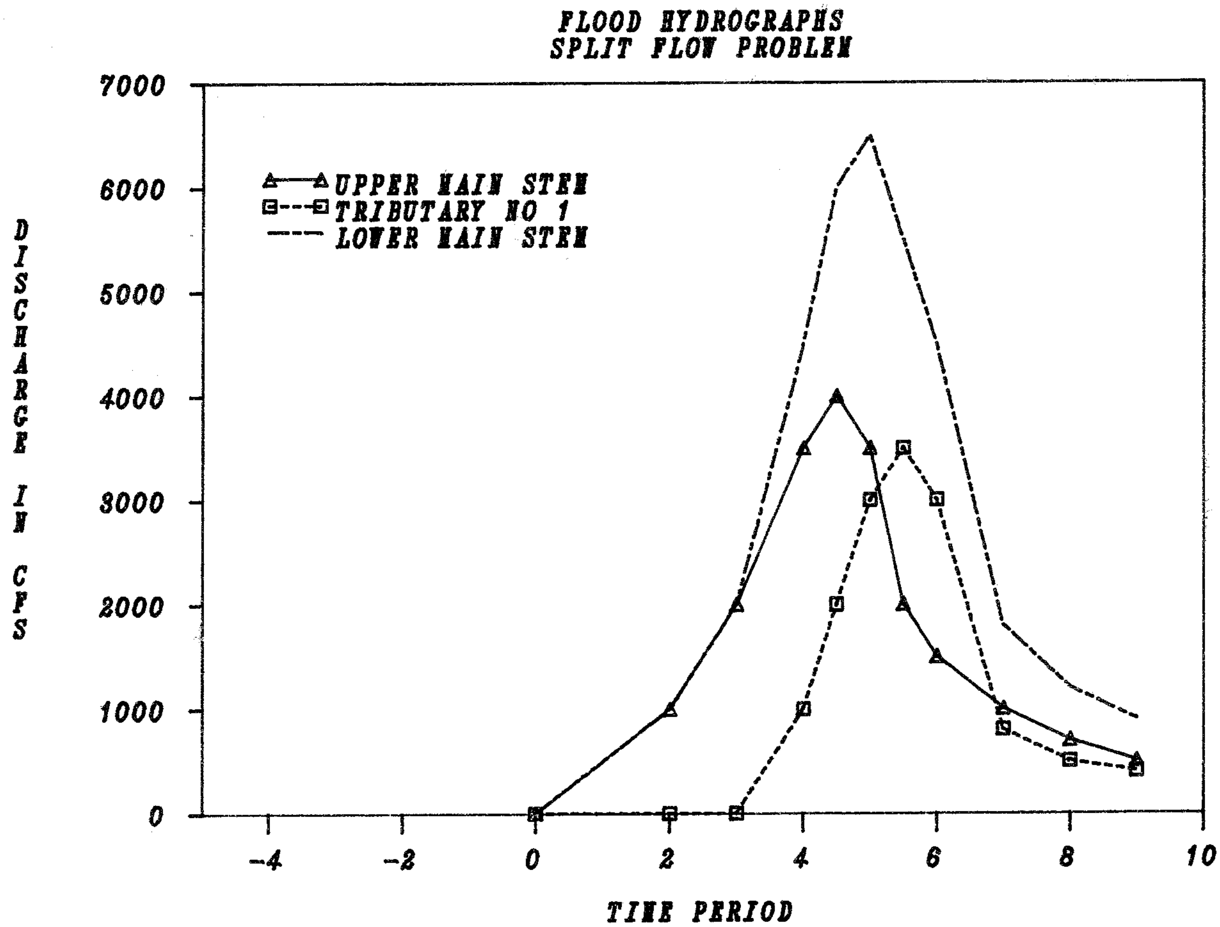


FIGURE 5

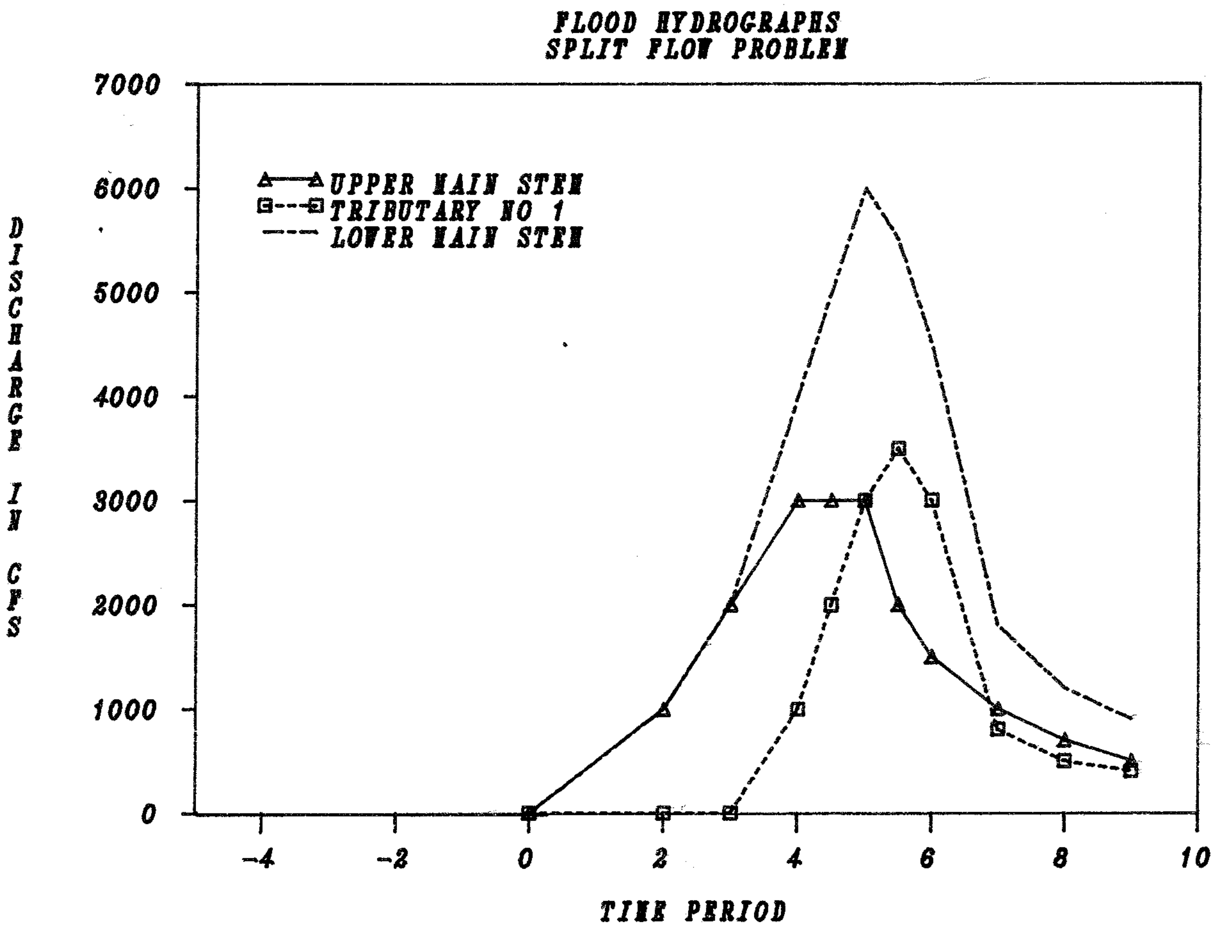


FIGURE 6

The following procedure can be used to account for the hydrologic aspects of a split flow problem.

1. Make an initial HEC-2 run which reduces the split flows all the way downstream.
2. Alter the hydrologic model (HEC-1), at the split flow reach, to reflect the lost flow and execute it again. Analyze the effect that the split flows had on the peak discharges downstream from the split flow reach.
3. If the assumption of reducing the lost flow is valid, then no further analysis are needed. If the lost flow is only partially effective downstream, then the lost flows should be returned further downstream. This can be accomplished by modifying the HEC-2 discharge cards to reflect the expected reductions downstream from the split flow reach and returning the split flows back into the model.
4. An HEC-2 run should be made and steps 2 and 3 repeated until an acceptable solution is achieved.

This procedure is applicable for simple split flow problems which do not have more than three or four separate split flow reaches. For the more complicated split flow problem, an unsteady state program should be used. The DWOPER (Dynamic Wave Operational Model) program developed by the National Weather Service (reference 8) is a one dimension unsteady state program that can be used to solve the split flow problem.

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APPENDIX I

SPLIT FLOW INPUT AND OUTPUT DATA DESCRIPTION

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.

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).

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.

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.

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.

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.

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.

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.

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.

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.

MODIFICATION TO J1 CARD

The J1 card variable STRT (Field 5) has been altered so that the program will accept a rating curve as a starting backwater condition. The option is activated by entering in field five (STRT variable) of the J1 card the number of discharge elevation rating curve points. The rating curve is entered after the J1 card using JR cards.

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).

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).

HEC-2 SPLIT FLOW OPTION OUTPUT VARIABLES

Variable	Description
ASQ	The assumed split flow value used by the program to compute the water surface elevations.
Q COMP	The computed split flow value based on the computed water surface elevation.
ERRAC	The percent error between the assumed discharge and computed discharge.
TASQ	The total assumed split flow for the entire HEC-2 model.
TCQ	The total computed split flow for the entire HEC-2 model.
TABER	Percent of error between the total assumed split flow and total computed split flow.
NITER	The number of iterations that the program has executed in computing the answer.
DSWS	The computed downstream water surface elevation.
USWS	The computed upstream water surface elevation.
DSSNO	The downstream section number where the split flow reach begins.
USSNO	The upstream section number where the split flow reach ends.
TOTAL AREA	The total cross sectional area for a normal depth overflow reach.
AVG VELOCITY	The average velocity of the normal depth overflow reach.
MAX DEPTH	The maximum depth that occurs on the normal depth overflow section.
AV DEPTH	The average depth of flow for the normal depth section based on the total area divided by the water surface topwidth.
TOF WIDTH	The width of the normal depth overflow section.
TOP WIDTH	The width of the overflow section based on the computed water surface.

APPENDIX II

SPLIT FLOW EXAMPLE PROBLEM

EXAMPLE OF INPUT PREPERATION

The following problem is provided to illustrate the input preparation required when using the split flow option. The input is shown on Figure 9 and is described below. A complete HEC-2 computer output listing for this example is also provided.

A plan view of the levee system and floodway of the Red Fox River is shown in Figure 7. A profile view of the stream bed, levees and overflow weir are shown in Figure 8. As can be seen on the profile view, the right bank or south levee is the critical levee for a split flow analysis. This is because it has the overflow weir and is several feet lower than the north levee.

The starting water surface for this example will be based on a normal depth calculation using a slope of .005 ft/ft. The weir coefficient for the levee will be 3.4 and for the overflow weir, 2.7. The weir coefficient for the overflow weir is low to account for the submergence caused by the tailwater in the floodway.

The first card of the split flow input data is the SF card. The split flow reach in this example is divided into three shorter reaches. The first split flow reach to be modeled is the most upstream reach which lies between sections 3 and 4. The TW card follows the SF card and is used to identify the reach. The WS card follows the TW card and is used to specify the number of coordinates that describe the levees geometry, location of the downstream and upstream limits and the section number where the split flow returns. The split flow does not return and a value of -1 is used to so indicate. Station and elevation coordinate data is entered on the WC card to describe the weir geometry. The coordinate data start at section 3 and proceed upstream to section 4.

The same procedure used for the first upstream reach is used for the overflow weir reach, which lies between sections 2 and 3, and for the downstream levee reach which lies between section 1 and 2.

In this example problem it was assumed that the weir equation was the more appropriate to use for calculating the split flows. If a normal depth or diversion assumption had been preferred, then the only difference in input would have been that the normal depth or diversion split flow cards would have been used.

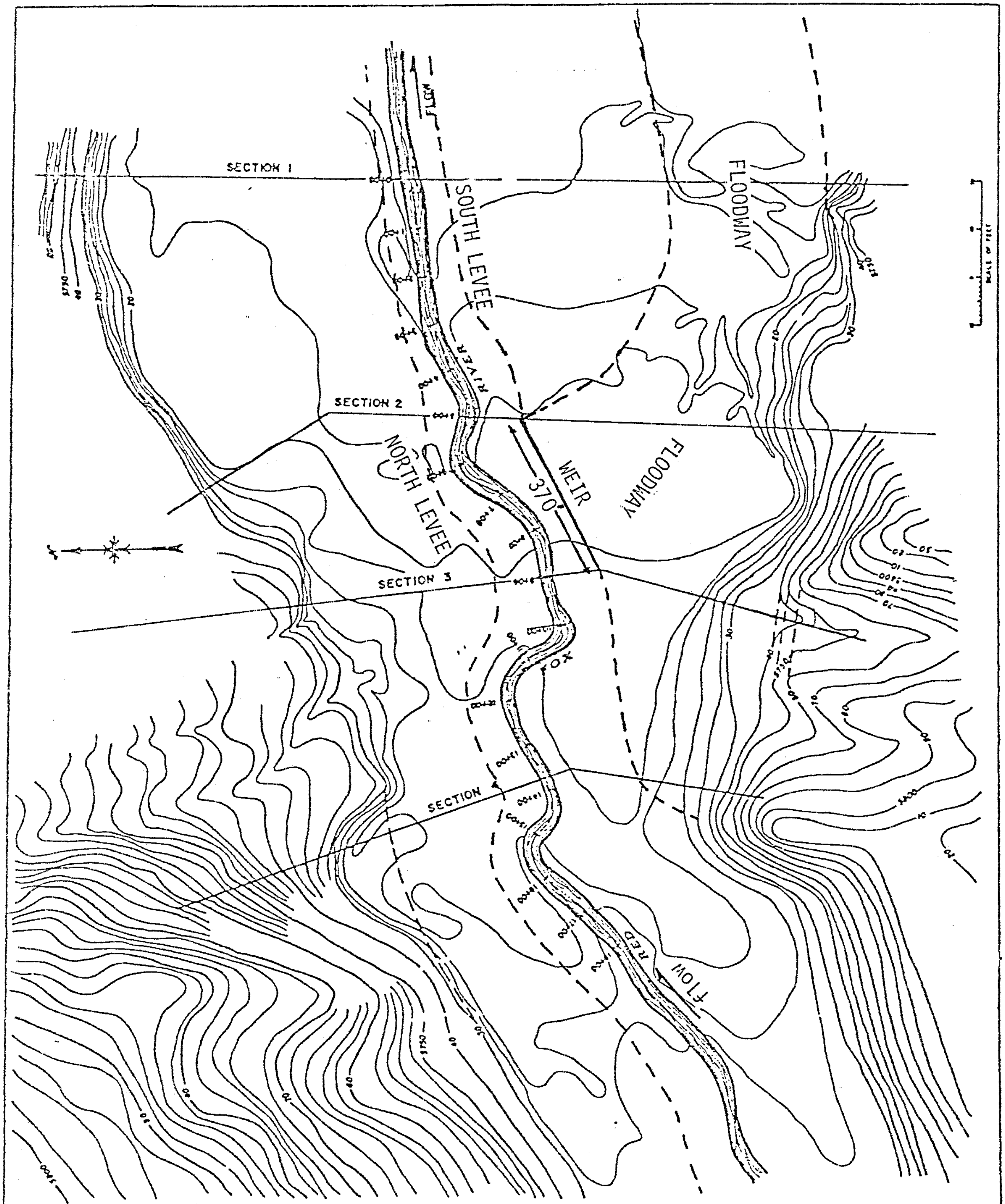

FIGURE 7 Plan view of the Red Fox River, Colorado

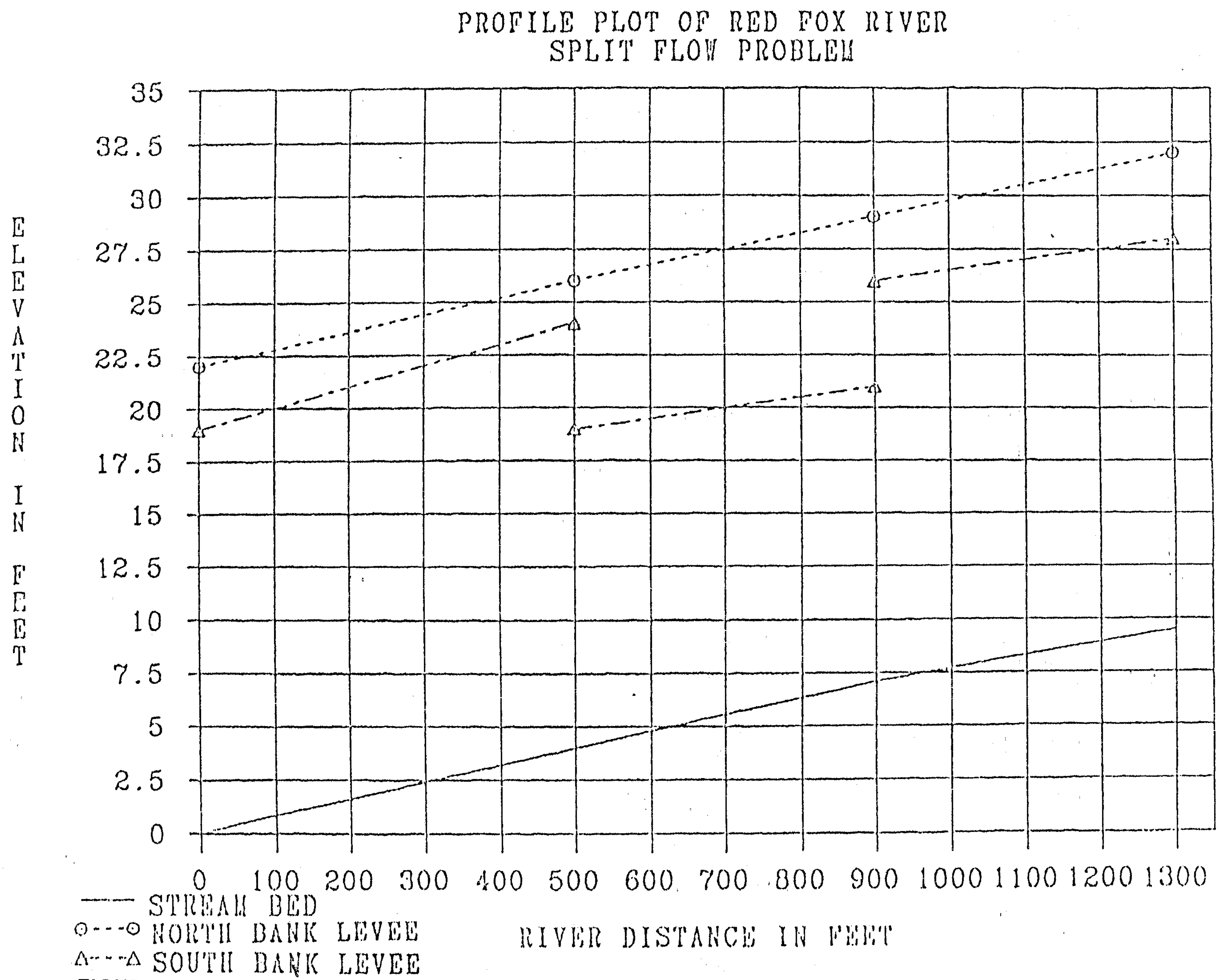
PROFILE PLOT OF RED FOX RIVER
SPLIT FLOW PROBLEM
ELEVATION IN FEET
35
32.5
30
27.5
25
22.5
20
17.5
15
12.5
10
7.5
5
2.5
0
0 100 200 300 400 500 600 700 800 900 1000 1100 1200 1300
RIVER DISTANCE IN FEET
STREAM BED
NORTH BANK LEVEE
SOUTH BANK LEVEE

FIGURE 8

GENERAL PURPOSE DATA FORM

(8 COLUMN FIELDS)

PROGRAM HEC-2 | DATE

REQUESTED BY AL MONTALVO | PREPARED BY | CHECKED BY | PAGE | OF

Card	1	2	3	4	5	6	7	8	9	10
SF		SPLIT FLOW PROBLEM								
TW		RIGHT BANK LEVEE BETWEEN SECTIONS 3 AND 4								
WS	2	3	4	-1	3.4					
WC		26	460	28						
TW		RIGHT BANK FLOODWAY OVER-FLOW WEIR								
WS	2	2	3	-1	2.7					
WC		19	370	21						
TW		RIGHT BANK LEVEE BETWEEN SECTIONS 1 AND 2								
WS	2	2	3	-1	3.4					
WC		19	520	24						
EE										
T1		SPLIT FLOW WORKSHOP SOLUTION								
T2		ADVANCED HEC-2 WORKSHOP								
T3		RED FOX RIVER								
J1		2			.005				3.8	
QT	3	7000	24000	40000						
NC				.1	.3					
NH	5	.1	415	.05	650	.03	710	.05	1020	.1
NH	1635									

SPK FORM 29 JUN 70 321a

FIGURE 9

THIS RUN EXECUTED 28 MAY 81 13.16.47

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

SPLIT FLOW BEING PERFORMED

```
SF      SPLIT FLOW PROBLEM

TW        RIGHT BANK LEVEE BETWEEN SECTIONS 3 AND 4
WS    2         3       4       -1      3.4
WC              26      460     28

TW        RIGHT BANK FLOODWAY OVER-FLOW WEIR
WS    2         2       3       -1      2.7
WC              19      370     21

TW      RIGHT BANK LEVEE BETWEEN SECIONS 1 AND 2
WS    2         1       2       -1      3.4
WC              19      520     24
```

```
T1    SPLIT FLOW WORKSHOP SOLUTION
T2    ADVANCED HEC2 WORKSHOP
T3    RED FOX RIVER

J1  ICHECK     INQ       NINV       IDIR       STRT     METRIC     HVINS     Q         WSEL      FQ

       0.        2.        0.        0.    .005000       0.        0.        0.      3.800      0.

QT     3.000  7000.000 24000.000 40000.000      -0.        -0.       -0.       -0.       -0.       -0.
NC     0.        0.        0.        .100       .300       0.        0.        0.        0.        0.
NH     5.000      .100   415.000     .050    650.000      .030   710.000     .050   1020.000     .100
NH  1635.000     0.        0.        0.         0.         0.        0.        0.        0.        0.

X1     1.000    11.000   650.000   710.000      0.         0.        0.        0.        0.        0.
X3    -0.       -0.       -0.      622.000     -0.      752.000     -0.       -0.       -0.       -0.
GR    25.000    20.000    18.000   110.000    17.000   415.000    14.000   650.000     1.000   675.000
GR     0.      690.000     1.000   710.000    13.000   710.000    14.000  1020.000    14.000  1590.000
GR    25.000  1635.000     0.        0.         0.         0.        0.        0.        0.        0.
NH     4.000      .100   415.000     .050    575.000      .030   640.000     .100   1250.000     0.

X1     2.000    10.000   575.000   640.000   500.000   500.000   500.000     0.        0.        0.
X3    -0.       -0.       -0.      525.000     -0.      735.000     -0.       -0.       -0.       -0.
GR    25.000    30.000    20.000   110.000    20.000   200.000    17.000   415.000    10.000   575.000
GR     4.000   580.000     4.000   615.000    18.000   640.000    18.000  1195.000    25.000  1250.000
NC      .100      .050      .030     0.         0.         0.        0.        0.        0.        0.

X1     3.000    10.000   390.000   600.000   400.000   400.000   400.000     0.        0.        0.
X3    -0.       -0.       -0.      390.000     -0.      600.000     -0.       -0.       -0.       -0.
X4     1.000    17.200   390.000    -0.        -0.       -0.       -0.       -0.       -0.       -0.
GR    25.000    40.000    22.000   260.000    18.700   370.000    15.000   420.000     7.100   500.000
GR     7.500   530.000    17.300   560.000    20.000   600.000    22.000   850.000    25.000   875.000
NH     5.000      .100   130.000     .050    330.000      .036   460.000     .050    610.000     .100
NH   700.000     0.        0.        0.         0.         0.        0.        0.        0.        0.

X1     4.000     8.000   330.000   460.000   400.000   400.000   400.000     0.        0.        0.
X3    -0.       -0.       -0.      300.000     -0.      600.000     -0.       -0.       -0.       -0.
GR    26.000    30.000    24.000   130.000    23.000   330.000     9.500   370.000    10.000   400.000
GR    22.000   460.000    22.000   610.000    26.000   700.000     0.        0.        0.        0.
EJ    -0.       -0.       -0.       -0.        -0.       -0.       -0.       -0.       -0.       -0.
```

```
  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=     .100 CEHV=     .300
1490 NH CARD USED
*SECNO 1.000

3470 ENCROACHMENT STATIONS=      622.0     752.0  TYPE=      1  TARGET=      130.000
     1.00     12.10     12.10    0.         3.80     14.87     2.76      0.        0.       14.00
    7000.        0.     7000.       0.        0.      525.       0.         0.        0.      13.00
      0.        0.      13.34    0.         .050      .030      .050     0.        0.      653.64
   .004965       0.        0.       0.         0         0         6      0.       56.36    710.00

1490 NH CARD USED
*SECNO 2.000

3301 HV CHANGED MORE THAN HVINS

3470 ENCROACHMENT STATIONS=      525.0     735.0  TYPE=      1  TARGET=      210.000
     2.00     11.11     15.11    0.        0.        16.94     1.83      1.97       .09     10.00
    7000.      823.     6177.       0.      201.      540.       0.         7.        1.      18.00
      .01      4.10     11.45    0.         .050      .030      .050      .000      4.00    525.00
   .003213      500.      500.    500.         3         0         0      0.      109.84    634.84

*SECNO 3.000

3301 HV CHANGED MORE THAN HVINS

3470 ENCROACHMENT STATIONS=      390.0     600.0  TYPE=      1  TARGET=      210.000
     3.00     10.16     17.26    0.        0.        18.05      .80      1.02       .10     17.20
    7000.        0.     7000.       0.        0.      978.       0.        15.        2. 100000.00
      .03     0.         7.16    0.         .100      .030      .050      .013      7.10    390.00
   .002060      400.      400.    400.         2         0         0      0.      169.90    559.90

1490 NH CARD USED
*SECNO 4.000

3301 HV CHANGED MORE THAN HVINS
```

```
 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

3685 20 TRIALS ATTEMPTED WSEL,CWSEL
3693 PROBABLE MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED

3470 ENCROACHMENT STATIONS=      300.0      600.0  TYPE=       1  TARGET=      300.000
    4.00       8.59      18.09      18.09       0.      20.87       2.78       1.62        .59      23.00
   7000.        0.       7000.        0.         0.      523.         0.        22.         3.      22.00
     .04       0.        13.38      0.         .100       .036      .050       .018       9.50     344.55
 .011277      400.       400.       400.         20         15          0        0.       95.91     440.45
```



```
TW      RIGHT BANK LEVEE BETWEEN SECTIONS 3 AND 4

    ASQ       QCOMP      ERRAC      TASQ        TCQ       TABER      NITER      DSWS       USWS       DSSNO      USSNO
     0.         0.         0.         0.         0.         0.           2     17.259     18.091      3.000      4.000

TW      RIGHT BANK FLOODWAY OVER-FLOW WEIR

    ASQ       QCOMP      ERRAC      TASQ        TCQ       TABER      NITER      DSWS       USWS       DSSNO      USSNO
     0.         0.         0.         0.         0.         0.           2     15.109     17.259      2.000      3.000

TW    RIGHT BANK LEVEE BETWEEN SECIONS 1 AND 2

    ASQ       QCOMP      ERRAC      TASQ        TCQ       TABER      NITER      DSWS       USWS       DSSNO      USSNO
     0.         0.         0.         0.         0.         0.           2     12.105     15.109      1.000      2.000
```

THIS RUN EXECUTED 28 MAY 81 13.16.48

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

T1 SPLIT FLOW WORKSHOP SOLUTION
T2 ADVANCED HEC2 WORKSHOP
T3 RED FOX RIVER

J1	ICHECK	INQ	NINV	IDIR	STRT	METRIC	HVINS	Q	WSEL	FQ
	0.	3.	0.	0.	.005000	0.	0.	0.	11.000	0.
J2	NPROF	IPLOT	PRFVS	XSECV	XSECH	FN	ALLDC	IBW	CHNIM	ITRACE
	2.000	-0.	-0.	-0.	-0.	-0.	-0.	-0.	-0.	-0.

```
   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=     .100 CEHV=     .300
 1490 NH CARD USED
 *SECNO 1.000

 3470 ENCROACHMENT STATIONS=     622.0     752.0  TYPE=      1  TARGET=     130.000
      1.00     18.30     18.30     17.91     11.00     22.98      4.68       0.         0.       14.00
    18134.      571.    16274.     1289.      115.      893.      220.        0.         0.       13.00
      0.        4.95     18.22      5.86      .050      .030      .050       0.         0.      622.00
   .004996      0.        0.        0.         0        14         0        0.       130.00    752.00

 1490 NH CARD USED
 *SECNO 2.000

 3301 HV CHANGED MORE THAN HVINS

 3470 ENCROACHMENT STATIONS=     525.0     735.0  TYPE=      1  TARGET=     210.000
      2.00     18.50     22.50     0.        0.        24.81      2.31      1.59       .24      10.00
    18134.     3557.    13789.      788.      570.     1012.      427.       19.        2.       18.00
       .01      6.24     13.62      1.84      .050      .030      .100      .000      4.00     525.00
   .002206      500.      500.      500.        2         0         0        0.       210.00    735.00

 *SECNO 3.000

 3301 HV CHANGED MORE THAN HVINS

 3470 ENCROACHMENT STATIONS=     390.0     600.0  TYPE=      1  TARGET=     210.000
      3.00     16.95     24.05     0.        0.        25.67      1.62       .80       .07      17.20
    24000.        0.    24000.        0.        0.     2346.       0.        39.        4.  100000.00
       .02      0.       10.23     0.        .100      .030      .050      .013      7.10     390.00
   .001850      400.      400.      400.        3         0         0        0.       210.00    600.00

 1490 NH CARD USED
 *SECNO 4.000

 3301 HV CHANGED MORE THAN HVINS
```

```
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

3685 20 TRIALS ATTEMPTED WSEL,CWSEL
3693 PROBABLE MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED

3470 ENCROACHMENT STATIONS=    300.0     600.0  TYPE=      1  TARGET=    300.000
    4.00     15.69     25.19     25.19     0.        28.64     3.45      1.25       .55     23.00
  24000.      238.    21492.     2270.       63.     1372.      446.       58.        6.     22.00
     .03      3.76     15.67      5.09      .050      .036      .050      .018      9.50    300.00
 .006443      400.      400.      400.        20        15         0        0.    300.00    600.00
```



```
TW      RIGHT BANK LEVEE BETWEEN SECTIONS 3 AND 4

   ASQ      QCOMP      ERRAC      TASQ       TCQ       TABER      NITER      DSWS      USWS     DSSNO     USSNO
    0.         0.         0.        0.        0.         0.          9    24.048    25.186     3.000     4.000

TW      RIGHT BANK FLOODWAY OVER-FLOW WEIR

   ASQ      QCOMP      ERRAC      TASQ       TCQ       TABER      NITER      DSWS      USWS     DSSNO     USSNO
 5866.49   5916.25       .84   5866.49   5916.25       .84          9    22.496    24.048     2.000     3.000

TW    RIGHT BANK LEVEE BETWEEN SECIONS 1 AND 2

   ASQ      QCOMP      ERRAC      TASQ       TCQ       TABER      NITER      DSWS      USWS     DSSNO     USSNO
    0.         0.         0.   5866.49   5916.25       .84          9    18.302    22.496     1.000     2.000
```

THIS RUN EXECUTED 28 MAY 81 13.16.48

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

T1 SPLIT FLOW WORKSHOP SOLUTION
T2 ADVANCED HEC2 WORKSHOP
T3 RED FOX RIVER

J1	ICHECK	INQ	NINV	IDIR	STRT	METRIC	HVINS	Q	WSEL	FQ
	0.	4.	0.	0.	.005000	0.	0.	0.	20.000	0.
J2	NPROF	IPLOT	PRFVS	XSECV	XSECH	FN	ALLDC	IBW	CHNIM	ITRACE
	15.000	-0.	-0.	-0.	-0.	-0.	-0.	-0.	-0.	-0.

```
  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=     .100 CEHV=     .300
1490 NH CARD USED
*SECNO 1.000

3470 ENCROACHMENT STATIONS=      622.0      752.0  TYPE=       1  TARGET=     130.000
     1.00      20.69      20.69     0.        20.00      26.21      5.52       0.         0.       14.00
   24415.      1168.     20908.     2338.      182.      1036.      320.         0.        0.       13.00
      0.        6.41      20.18      7.31      .050       .030      .050      0.          0.      622.00
   .005024       0.         0.         0.         0          0          3      0.       130.00    752.00

1490 NH CARD USED
*SECNO 2.000

3301 HV CHANGED MORE THAN HVINS

3470 ENCROACHMENT STATIONS=      525.0      735.0  TYPE=       1  TARGET=     210.000
     2.00      20.74      24.74     0.        0.         28.26      3.51       1.84       .20      10.00
   26832.      5355.     19735.     1742.      682.      1158.      640.        23.        2.       18.00
      .01       7.85      17.04      2.72      .050       .030      .100       .000      4.00     525.00
   .002885      500.       500.      500.         2          0          0      0.       210.00    735.00

*SECNO 3.000
3280 CROSS SECTION       3.00 EXTENDED       1.35 FEET

3470 ENCROACHMENT STATIONS=      390.0      600.0  TYPE=       1  TARGET=     210.000
     3.00      19.25      26.35     0.        0.         29.43      3.08       1.14       .04      17.20
   39874.         0.     39874.        0.        0.      2830.      0.          47.        4. 100000.00
      .02     0.          14.09     0.         .100       .030      .050       .013      7.10     390.00
   .002808      400.       400.     400.          3          0          0      0.       210.00    600.00

1490 NH CARD USED
*SECNO 4.000
3280 CROSS SECTION       4.00 EXTENDED       1.98 FEET
```

```
 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

3685 20 TRIALS ATTEMPTED WSEL,CWSEL
3693 PROBABLE MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED

3470 ENCROACHMENT STATIONS=      300.0      600.0  TYPE=      1  TARGET=      300.000
      4.00     18.48     27.98     27.98     0.        32.58     4.60      1.66      .46      23.00
    40000.     939.      32515.    6546.     147.      1735.     837.      73.       6.       22.00
       .02     6.38      18.74     7.82      .050      .036      .050      .018      9.50    300.00
   .006738     400.      400.      400.        20        11         0      0.      300.00    600.00
```



```
TW      RIGHT BANK LEVEE BETWEEN SECTIONS 3 AND 4

   ASQ      QCOMP     ERRAC     TASQ      TCQ       TABER     NITER     DSWS      USWS      DSSNO     USSNO
   125.92   123.90    1.62      125.92    123.90    1.62      20        26.352    27.981    3.000     4.000

TW      RIGHT BANK FLOODWAY OVER-FLOW WEIR

   ASQ      QCOMP     ERRAC     TASQ      TCQ       TABER     NITER     DSWS      USWS      DSSNO     USSNO
 13041.71  13050.42   .07       13167.63  13174.32  .05       20        24.741    26.352    2.000     3.000

TW    RIGHT BANK LEVEE BETWEEN SECIONS 1 AND 2

   ASQ      QCOMP     ERRAC     TASQ      TCQ       TABER     NITER     DSWS      USWS      DSSNO     USSNO
  2417.87   2411.49   .26       15585.50  15585.81  .00       20        20.688    24.741    1.000     2.000
```

THIS RUN EXECUTED 28 MAY 81 13.16.49

```
**************************************************
  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

D FOX RIVER

SUMMARY PRINTOUT TABLE 150

	SECNO	XLCH	ELTRD	ELLC	ELMIN	Q	CWSEL	CRIWS	EG	10K*S	VCH	AREA	.01
	1.000	0.	0.	0.	0.	7000.00	12.10	0.	14.87	49.65	13.34	524.74	993.
	1.000	0.	0.	0.	0.	18133.51	18.30	17.91	22.98	49.96	18.22	1228.42	2565.
	1.000	0.	0.	0.	0.	24414.50	20.69	0.	26.21	50.24	20.18	1538.61	3444.
	2.000	500.00	0.	0.	4.00	7000.00	15.11	0.	16.94	32.13	11.45	740.40	1234.
	2.000	500.00	0.	0.	4.00	18133.51	22.50	0.	24.81	22.06	13.62	2009.61	3860.
	2.000	500.00	0.	0.	4.00	26832.37	24.74	0.	28.26	28.85	17.04	2480.87	4995.
	3.000	400.00	0.	0.	7.10	7000.00	17.26	0.	18.05	20.60	7.16	977.54	1542.
	3.000	400.00	0.	0.	7.10	24000.00	24.05	0.	25.67	18.50	10.23	2346.28	5580.
	3.000	400.00	0.	0.	7.10	39874.08	26.35	0.	29.43	28.08	14.09	2830.30	7524.
*	4.000	400.00	0.	0.	9.50	7000.00	18.09	18.09	20.87	112.77	13.38	523.20	659.
*	4.000	400.00	0.	0.	9.50	24000.00	25.19	25.19	28.64	64.43	15.67	1881.09	2989.
*	4.000	400.00	0.	0.	9.50	40000.00	27.98	27.98	32.58	67.38	18.74	2719.65	4873.

D FOX RIVER

SUMMARY PRINTOUT TABLE 150

	SECNO	Q	CWSEL	DIFWSP	DIFWSX	DIFKWS	TOPWID	XLCH
	1.000	7000.00	12.10	0.	0.	8.30	56.36	0.
	1.000	18133.51	18.30	6.20	0.	7.30	130.00	0.
	1.000	24414.50	20.69	2.39	0.	.69	130.00	0.
	2.000	7000.00	15.11	0.	3.00	0.	109.84	500.00
	2.000	18133.51	22.50	7.39	4.19	0.	210.00	500.00
	2.000	26832.37	24.74	2.24	4.05	0.	210.00	500.00
	3.000	7000.00	17.26	0.	2.15	0.	169.90	400.00
	3.000	24000.00	24.05	6.79	1.55	0.	210.00	400.00
	3.000	39874.08	26.35	2.30	1.61	0.	210.00	400.00
*	4.000	7000.00	18.09	0.	.83	0.	95.91	400.00
*	4.000	24000.00	25.19	7.10	1.14	0.	300.00	400.00
*	4.000	40000.00	27.98	2.80	1.63	0.	300.00	400.00

SUMMARY OF ERRORS

```
CAUTION  SECNO=   4.000  PROFILE= 1  CRITICAL DEPTH ASSUMED
CAUTION  SECNO=   4.000  PROFILE= 1  PROBABLE MINIMUM SPECIFIC ENERGY
CAUTION  SECNO=   4.000  PROFILE= 1  20 TRIALS ATTEMPTED TO BALANCE WSEL
CAUTION  SECNO=   4.000  PROFILE= 2  CRITICAL DEPTH ASSUMED
CAUTION  SECNO=   4.000  PROFILE= 2  PROBABLE MINIMUM SPECIFIC ENERGY
CAUTION  SECNO=   4.000  PROFILE= 2  20 TRIALS ATTEMPTED TO BALANCE WSEL
CAUTION  SECNO=   4.000  PROFILE= 3  CRITICAL DEPTH ASSUMED
CAUTION  SECNO=   4.000  PROFILE= 3  PROBABLE MINIMUM SPECIFIC ENERGY
CAUTION  SECNO=   4.000  PROFILE= 3  20 TRIALS ATTEMPTED TO BALANCE WSEL
```

APPENDIX III

GRAPHICAL METHOD FOR SOLVING ISLAND DIVIDED FLOWS

ISLAND SPLIT FLOW

Where an island or other obstruction in the river separates flow into two or more channels over a substantial length (several cross sections), the quantity of water passing on each side of the island must be determined since total energy loss, past the island, must be the same for both sides.

The example in fig. III.1 illustrates how to solve the divided flow problem graphically. The total discharge is proportioned between the north and south channels, arbitrarily. The water surface elevation for the total flow is determined for river mile 10.0, and a water surface profile is calculated for each assumed discharge through the north channel and through the south channel. The resulting potential water surface elevations at river mile 10.8 are plotted in fig. III.2. A "total" discharge curve is obtained at river mile 10.8 by summing north and south channel discharges for common water surface elevations. This total flow curve intersects the total river discharge, 5000 cfs, at elevation 104.32, thereby defining the upstream water surface elevation. By intersecting the north and south channel curves at elevation 104.32, their respective discharges can be read from the figure.

PROBLEM:

Using the data for the discharge of 5,000 units tabulated below, determine the water-surface elevation at river mile 10.8 when the water-surface elevation at river mile 10.0 is 100.0. What is the discharge in the channel north of the island?

WATER-SURFACE PROFILES FOR VARIOUS BACKWATER PROFILES

CROSS SECTION RIVER MILE	PROFILE 1 NORTH CHANNEL Q = 1000	PROFILE 1 SOUTH CHANNEL Q = 4000	PROFILE 2 NORTH CHANNEL Q = 1500	PROFILE 2 SOUTH CHANNEL Q = 3500	PROFILE 3 NORTH CHANNEL Q = 2000	PROFILE 3 SOUTH CHANNEL Q = 3000	PROFILE 4 NORTH CHANNEL Q = 2500	PROFILE 4 SOUTH CHANNEL Q = 2500
10.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
10.2	100.6	101.4	100.8	101.2	101.0	101.1	101.2	101.0
10.4	101.2	102.8	101.6	102.5	102.0	102.2	102.4	102.0
10.6	101.8	104.2	102.4	103.7	103.0	103.3	103.6	103.0
10.8	102.4	105.5	103.3	105.0	104.1	104.5	104.8	104.0

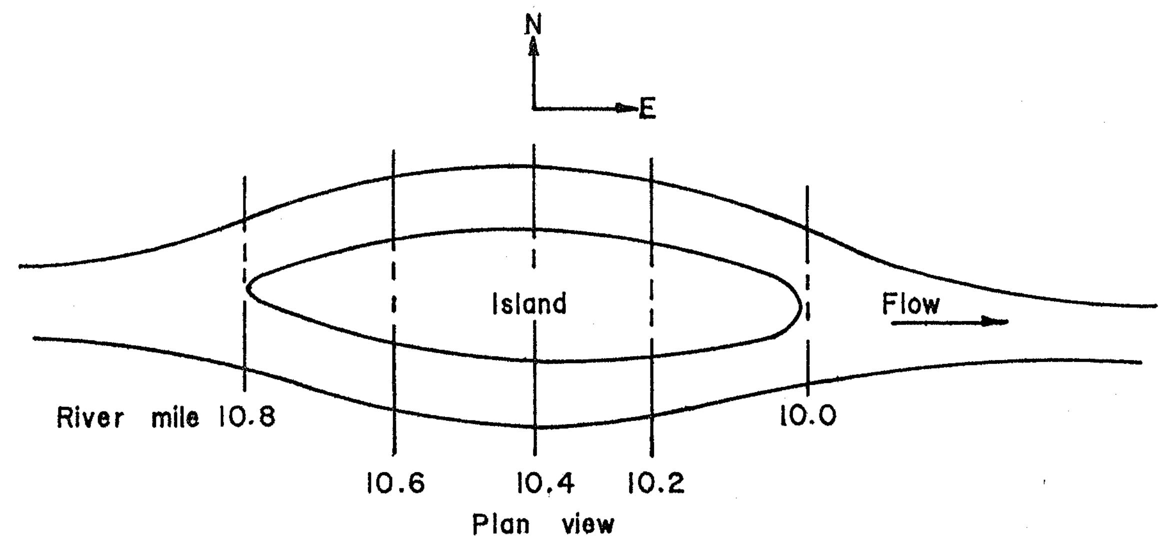

Fig. III-1 Example problem for subcritical island type flow computations

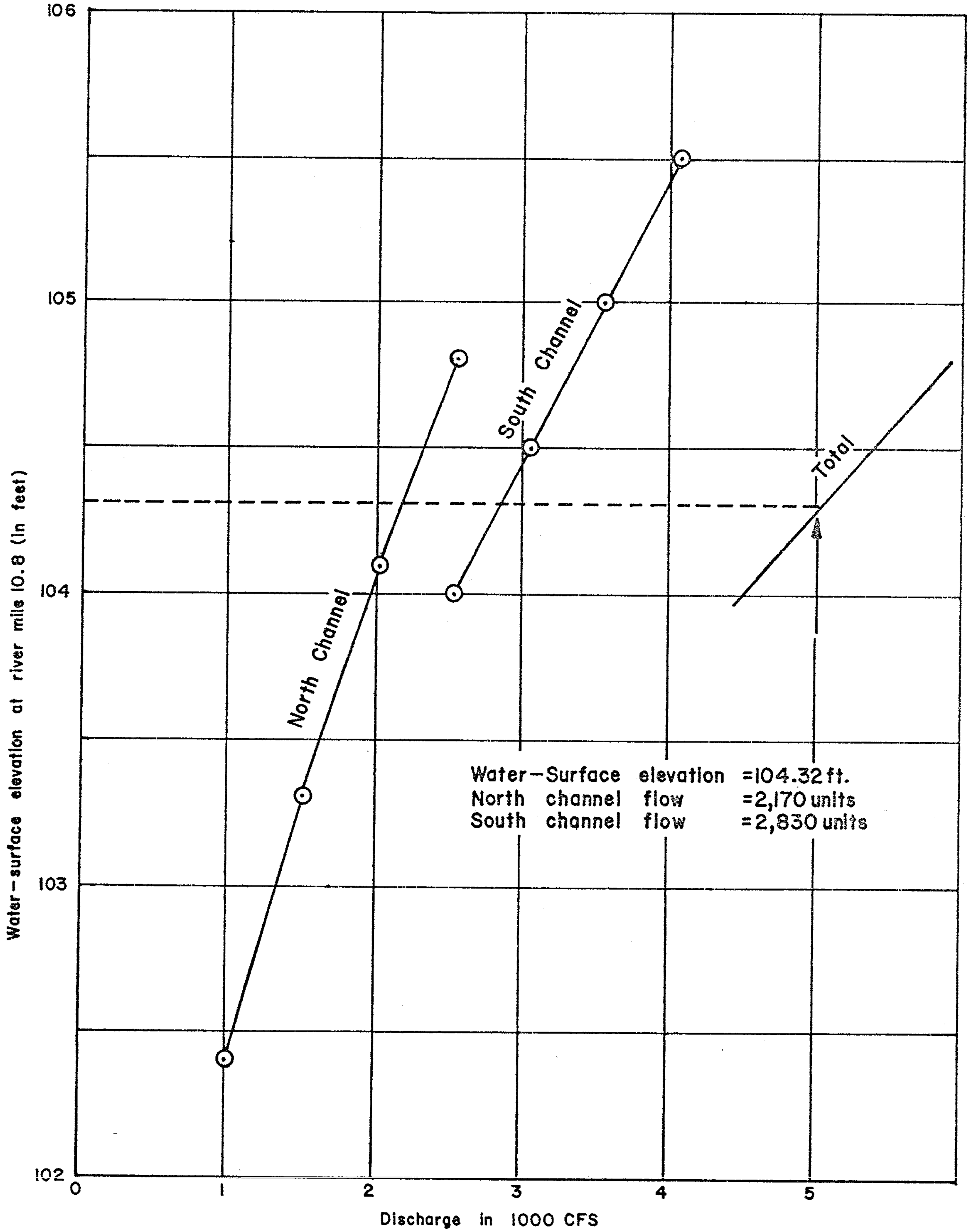

Fig. III-2 Graphical interpolation for divided flow past an island