User Manual For —

TEXAS HYDRAULIC SYSTEM

THYSYS

Texas
State Department of Highways
and
Public Transportation
1977

PREFACE

The THYSYS hydraulic system which was implemented in 1970 has had several modifications and enhancements supported only by revisions and supplements to the original user manual. This 1977 edition of the THYSYS user manual is completely NEW and is designed to REPLACE the original manual and its various revisions and supplements.

The major changes incorporated in this manual include the following:

1. New USGS method of computing design discharge
2. WATERWAY option for solutions to Manning's formula
3. CARRYOVER option for inlet design
4. 100 year flood analysis computations
5. COST analysis option

All of these except the USGS method have previously been made available for use. Utilization of THYSYS for computing design discharge by the USGS method may be implemented with the receipt of this manual. Input data for this method must be coded on the revised HYDRO input form (Form 1306-1,2 Revised 12/76). The forms to be used with the other THYSYS subsystems must have the following numbers and revision dates:

HYDRA	1307-1,2	Revised 8/74
CULBRG	1308-1,2	Revised 8/74
SEWER	1309-1,2	Revised 9/75
PUMP	1310-1,2	

Additional general changes in the user manual have been made in the alphanumeric referencing of error messages, card use check lists for each subsystem, and the preparation of sample problems to illustrate the various system applications. The format for explaining data entry has been changed so that the pertinent portion of the input form accompanies the explanation for each entry.

THYSYS SUBSYSTEM OPTIONS

The THYSYS hydraulic system is designed to enable the user to specify various options to tailor the system to almost any hydraulic problem. However, due to this versatility, it is possible for the user to select an invalid combination of options. All the options given in the user manual for the HYDRO, HYDRA and PUMP subsystems may be selected. For the CULBRG and SEWER subsystems, only the combinations of options listed in the tables below can be used.

VALID CULBRG OPTIONS

DESIGN OR ANALYZE	BRIDGE OR CULVERT	OPENING: SINGLE OR MULTIPLE	PROFILE CONFIGU-RATION	PIPE SHAPE	INLET CONDITION
DESIGN	BRIDGE	SINGLE			
DESIGN	BRIDGE	MULTIPLE			
DESIGN	CULVERT	SINGLE	STRAIGHT	BOX	NORMAL
DESIGN	CULVERT	SINGLE	STRAIGHT	ARCH	NORMAL
DESIGN	CULVERT	SINGLE	STRAIGHT	CIRCULAR	NORMAL
DESIGN	CULVERT	SINGLE	STRAIGHT	CIRCULAR	FLARED
ANALYZE	BRIDGE	SINGLE			
ANALYZE	CULVERT	SINGLE	STRAIGHT	BOX	NORMAL
ANALYZE	CULVERT	SINGLE	STRAIGHT	ARCH	NORMAL
ANALYZE	CULVERT	SINGLE	STRAIGHT	CIRCULAR	NORMAL
ANALYZE	CULVERT	SINGLE	STRAIGHT	CIRCULAR	FLARED
ANALYZE	CULVERT	SINGLE	BROKEN BK.	BOX	NORMAL
ANALYZE	CULVERT	SINGLE	BROKEN BK.	CIRCULAR	NORMAL
ANALYZE	BRIDGE	(100 YEAR FLOOD)			
ANALYZE	CULVERT	(100 YEAR FLOOD)			
COST OPTIONS					

VALID SEWER OPTIONS

DESIGN OR ANALYZE	RUNOFF, INLET OR SEWER		PIPE SHAPE	INLET TYPE
	RUNOFF			
DESIGN	INLET	(CARRYOVER)		
DESIGN	INLET			CURB ON GRADE
DESIGN	INLET			CURB AT SAG
DESIGN	INLET			GRATE ON GRADE
DESIGN	INLET			GRATE AT SAG
DESIGN	SEWER		BOX	
DESIGN	SEWER		CIRCULAR	
ANALYZE	INLET			
ANALYZE	INLET			CURB ON GRADE
ANALYZE	INLET			CURB AT SAG
ANALYZE	INLET			GRATE AT SAG
ANALYZE	SEWER		BOX	
ANALYZE	SEWER		CIRCULAR	
GRAPHS				

PART I - INTRODUCTION

TEXAS HYDRAULIC SYSTEM (THYSYS)

INTRODUCTION

The Texas Hydraulic System (THYSYS) is an integrated system of computer programs for highway hydraulic design and analysis. It is composed of five major programs or subsystems (Figure 1-1). They are as follows:

HYDRO	(abbreviation of hydrology) – which computes peak flow for surface runoff;
HYDRA	(abbreviation of hydraulics) – which computes channel flow characteristics;
CULBRG	(abbreviation of culvert/bridge) – which designs or analyzes hydraulic structures;
SEWER	which designs or analyzes storm sewer networks; and
PUMP	which designs or analyzes pump stations.

THYSYS is designed so that computed data from one subsystem may be automatically passed on to other subsystems and used as input. In addition, it is also designed so that any one of the subsystems can be used independently of the others if the necessary input is given. (Each of the subsystems has its own input form.)

The ability to pass computed data from one subsystem to another provides additional flexibility in hydraulic design. Figure 1-2 is a diagram of the exchange of data within the system. The procedure for designing a pipe culvert using the THYSYS system, for instance, is a good example of this flexibility and Figure 1-3 illustrates three of the methods. In Method A the user enters sufficient data into the HYDRO subsystem to compute the peak flow surface runoff. The surface runoff (peak flow) is then passed on to the HYDRA subsystem which in turn will compute the water surface elevation in the given channel.

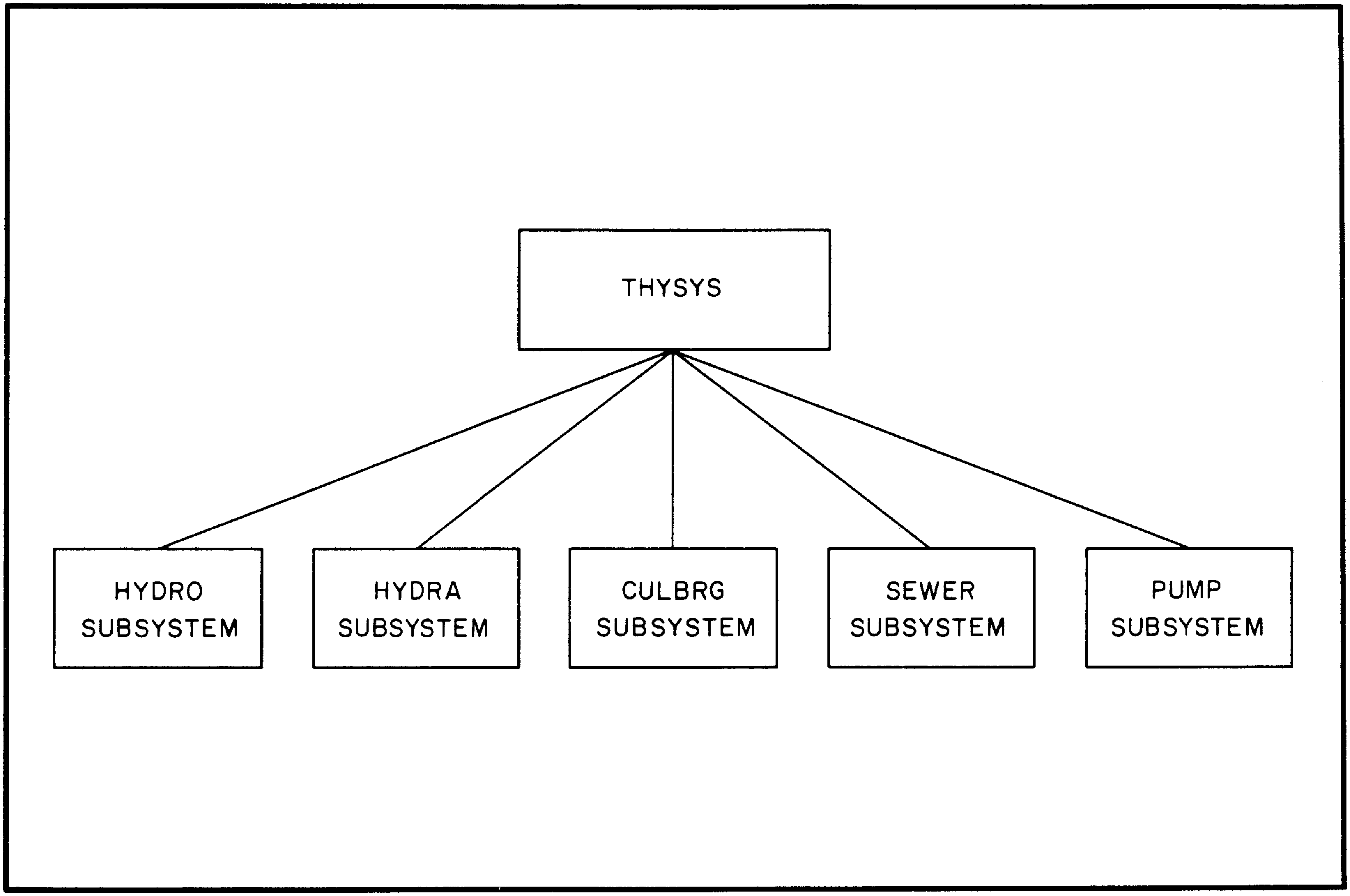


FIGURE 1-1. TEXAS HYDRAULIC SYSTEM (THYSYS)

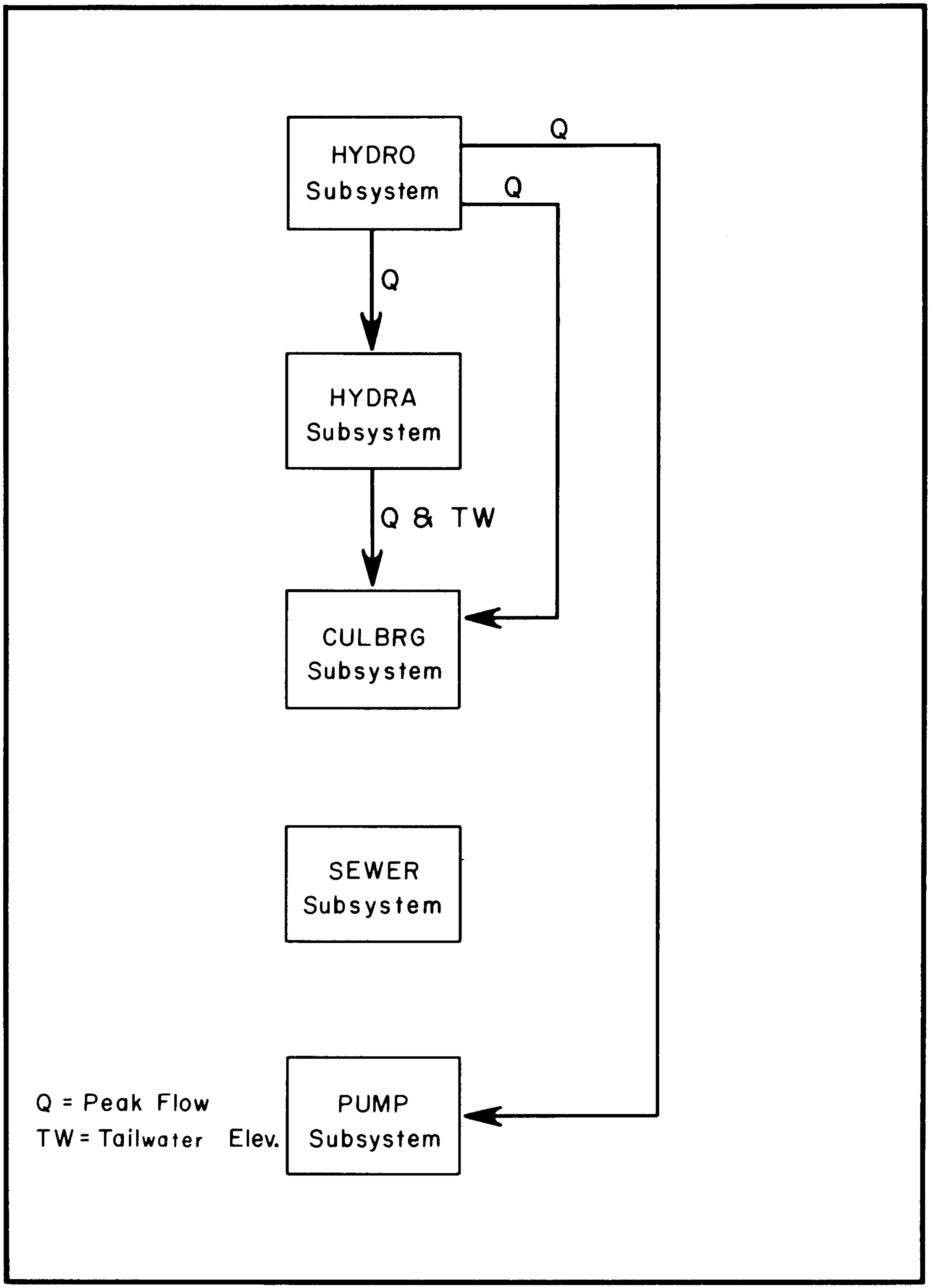


FIGURE 1-2. PATHS OF DATA EXCHANGE WITHIN THYSYS

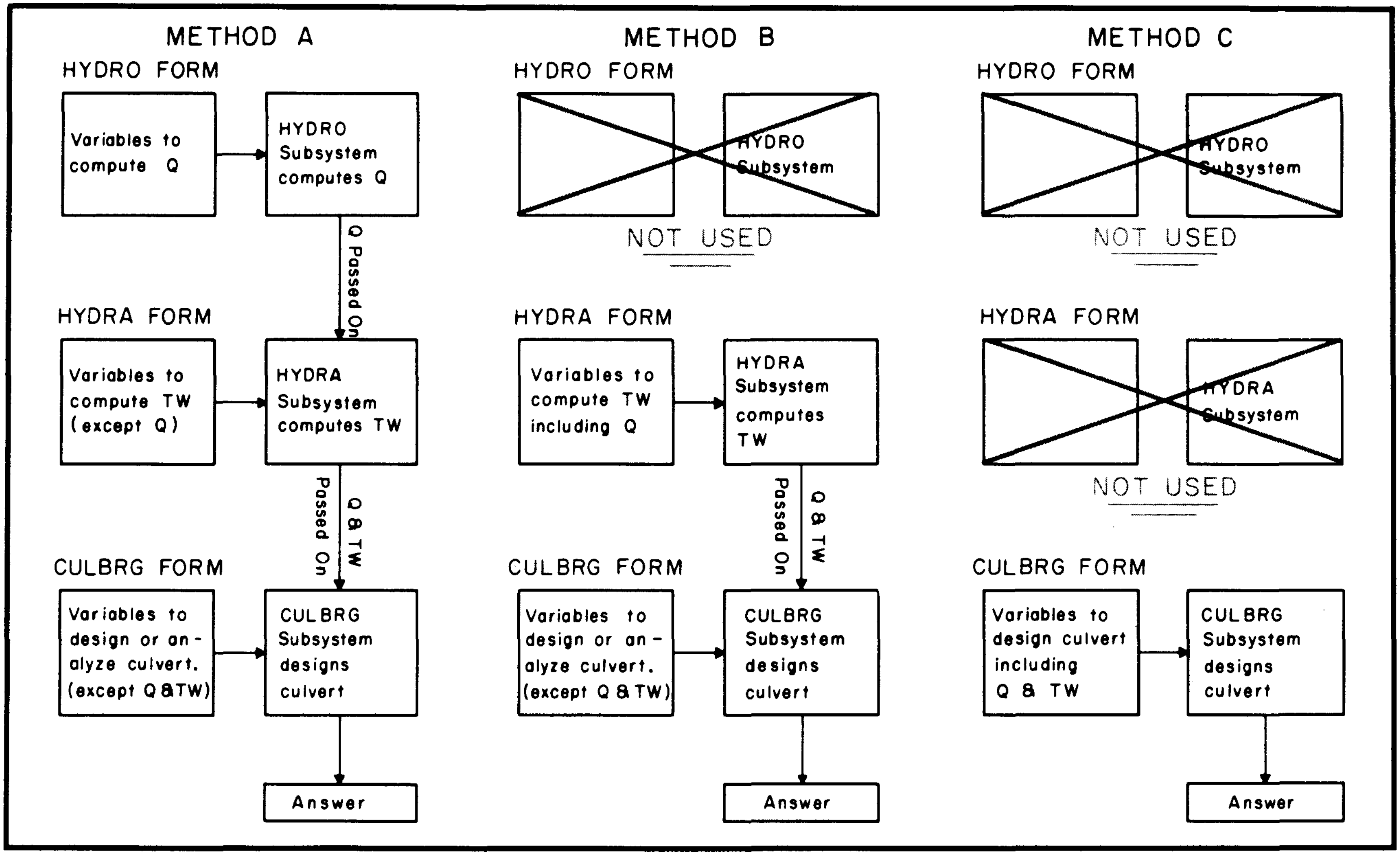


FIGURE 1-3. THREE METHODS FOR DESIGNING A PIPE CULVERT USING THE THYSYS SYSTEM

The tailwater elevation computed in HYDRA and peak flow computed in HYDRO are passed on to the CULBRG subsystem ready for use in designing the actual structure. In Method B, the HYDRO subsystem has been bypassed by entering the surface runoff peak flow directly into the HYDRA subsystem for computation of tailwater elevations. In Method C, both the HYDRO and HYDRA subsystems have been bypassed by entering the peak flow and tailwater elevation directly into CULBRG. Another option available to the user in this problem is to compute a discharge in HYDRO and bypass HYDRA, supplying a tailwater elevation directly in CULBRG. SEWER is the only subsystem that is independent. Data entered into or computed by HYDRO, HYDRA or CULBRG cannot be passed on to SEWER. Options for all subsystems are more fully described later in the manual.

A more complete description of each of the subsystems is given in the following paragraphs in this section.

HYDRO Subsystem

The HYDRO subsystem is used to calculate and/or modify a peak flow for surface runoff. The user may select one of three methods for computing runoff: the rational method which uses features such as area, slope and runoff coefficient to determine peak flow; the gaged analysis method which employs major runoff history on a stream to determine peak flow; and the USGS method, which employs equations derived by regional analysis of the hydrology of the State of Texas. The input for the last method is the drainage area and information concerning the flood region.

Calculated peak flows may be modified by adding a base flow.

HYDRA Subsystem

The HYDRA subsystem is used to compute water surface elevations and cumulative conveyance at stream cross-sections. It offers the user three methods for computing water surface elevations. The one-section method analyzes stream flow based on the characteristics of the channel and an assumed input water surface slope. The two-section method is a variation of the one-section method in which two adjacent cross-sections are analyzed and a water surface slope is determined from the interacting properties of the two sections. The many-section method analyzes the properties of a number of stream cross-sections to compute a water surface profile by the step backwater method. The many-section option is useful in the calculation of reservoir backwater curves.

The HYDRA subsystem provides added capability for translating and rotating existing cross-section data to fit the design location. It also performs the function of storing cross-sections to be used in the design or analysis of bridges.

The output from this subsystem includes water surface (tailwater) elevations and/or cumulative conveyance at the given sections. Graphic output of cross-section and conveyance data may be requested by the user.

The HYDRA subsystem may also be used to calculate solution(s) to Manning's formula covering a specified range of incremental elevations and "n" values for a given cross-section. For each elevation, a table of "n" values and the resulting area, wetted perimeter, hydraulic radius, velocity and K-factor are printed. Total area, discharge and Q/A are also printed. This feature may be requested through the WATERWAY option of the HYDRA subsystem.

CULBRG Subsystem

The CULBRG subsystem, using previously determined or specified peak flow and water surface elevation, performs a complete design or analysis of hydraulic structures under highways. For a given location the user can design a bridge and/or culvert to satisfy certain criteria. The system may also be used to analyze existing structures. The first two subsystems (HYDRO and HYDRA) may be bypassed by inputting the required design data; however, if cross-sections are required, they must be entered and stored in the HYDRA subsystem.

For culverts, three types of barrel sections may be defined. They are circular, arch and rectangular. The user has flexibility in specifying roughness factors for various materials. Two types of profiles are available for culverts: straight and broken-back. Broken-back may be specified only for analysis of circular and box culverts. Two types of inlets are available. These are the normal and flared (improved) inlets. Flared inlets may be specified only for design or analysis of straight, circular, single-opening culverts. Depending on the options selected, the user must then specify the parameters required for computations.

For bridge structures the user must provide bridge header slopes and flow divide information.

The output from the subsystem will be a complete hydraulic design summary for the type of structure specified. Any number of alternate designs can be made for comparison purposes. Two optional outputs are a cost analysis and a summary of culvert designs for the entire project. The latter is designed for direct application to plans. The cost analysis feature computes the cost of the barrel using (1) the latest "Statewide Average Low Bid Price", (2) prices inserted by the user, or (3) a combination of these two. The cost of headwalls, excavation and miscellaneous costs is not computed but can be entered to obtain a total cost. The total cost is printed for each culvert tried in the solution.

SEWER Subsystem

The SEWER subsystem is independent of the other subsystems. It accomplishes complete design of a storm sewer network including runoff calculations, inlet design, and sewer network design. It may also be used for analysis of existing systems.

Analysis of runoff flow to each inlet will be by the rational method with option to specify subareas of the drainage area and to add base flows or other non-runoff contributed flows.

Several types of inlets may be specified and the subsystem will determine the size of inlet required to satisfy the surface runoff. If ponding is allowed, it will analyze gutter flow conditions at the inlet site. If carryover is allowable, excess gutter flow will be computed and directed to a specified inlet.

The storm sewer network may be composed of any combination of circular or box selections. The maximum size network that can be designed or analyzed may have up to 100 junctions, 99 runs and 26 lines. A line is defined as a run or set of runs which make up a complete branch of the network. The input for the system is extensive and flexible. It includes all of the necessary data and option selections to accomplish runoff, inlet and network design.

The output which is called a report covers a network design or analysis. Hydraulic data, configuration data, inlet data, and network stationing are included in the report. Graphic output of pipe flow-lines, hydraulic gradient lines and stationing of junctions is available as an option.

PUMP Subsystem

The PUMP subsystem is used for design or analysis of pump stations used to lift storm drainage.

When used for design, this subsystem makes use of input data describing runoff volumes, storage volume, and allowable pump sizes to determine the most efficient combination of pump sizes to handle the runoff. The output will always list at least two pumps. The program also computes available storage, starting sequence and starting storage for each pump such that the storage is fully utilized without being exceeded. Storage may consist of any combination of one sump (either rectangular or circular), any number of manholes and/or inlets, and submerged barrel lengths.

When used for analysis of an existing pump station, any number up to ten pumps of known size, starting sequence and starting storage volume may be analyzed. The program will compute the storage volume for each minute of a given storm.

Up to five storms may be specified for design or analysis in one pass (computations for one set of data) if storm volume information is supplied by the user. Data for an unlimited number of storms may be transferred from the HYDRO subsystem by returning to that subsystem for each storm.

Output

The printed output for each of the subsystems is designed to present a neat and orderly representation and documentation of the problem and the solution. It is referred to as a report. A more general description of the report is in Part II. Each subsystem has a detailed explanation of its output.

Manual Organization

Part II of this manual provides a more general description of the input forms and the output listings. Parts III through VII describe the operations of each subsystem, the methods used to input data into each of the subsystems, a more detailed explanation of each subsystem's output, and an explanation of messages which may appear in the output. In the Input Section for each subsystem, each line of the input form is shown along with explanations of data entry. In addition, a Card Use Checklist, in tabular form, is included to provide a quick check of the necessary lines of input required for each option. Part VIII contains sample problems for each subsystem. Appendix A contains a glossary of terms used in this manual; Appendix B contains maps for determining USGS region and annual precipitation; and Appendix C contains a discussion on reasons for Two-section Method failures.

PART II - INPUT/OUTPUT

Input/Output

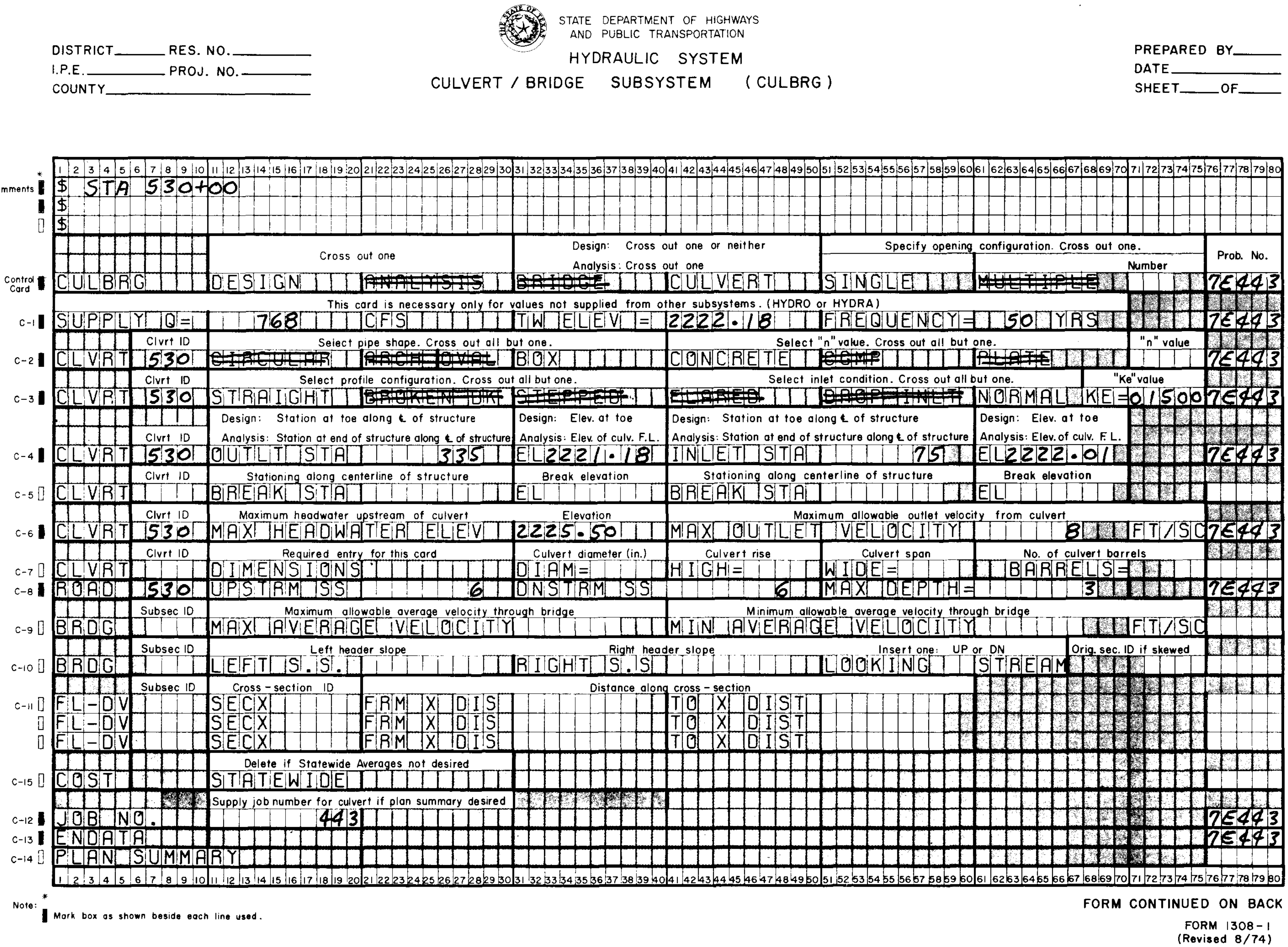
INPUT/OUTPUT

I. INPUT

Input Form

A typical input form for THYSYS is shown in Figure 2-1. The form is for the CULBRG subsystem and it has been completed for a sample problem. Each subsystem has a separate form. The input forms for THYSYS are based on a punched card format with each card containing 80 columns. It is important that the user recognize that each horizontal line on the input form represents one punched card. Within this manual, reference is made to cards as a matter of convenience; however, it should be emphasized that THE USER WORKS ONLY WITH FORMS.

Most of the lines (cards) on the form have preprinted words followed by several blank spaces which require entry of data. Other lines on the form contain preprinted words which reflect options which the user must select. The selection is indicated by crossing out those words that do not apply. The words that have been crossed out will not be keypunched into the card. Each card (or line) on the form is identified by code numbers in the left hand margin of the form. The code numbers are used to identify each type of card. Throughout this manual cards will be referred to by these code numbers. For instance Card C-1 in Figure 2-2 identifies this card as containing the variables of peak flow (Q), tailwater elevation (TW), and flood frequency. On Card C-2 the user must fill in a culvert identification in the field CLVRT ID and must cross out all but one of the words: CIRCULAR, ARCH, BOX. In addition, on that card he may choose to specify the culvert barrel material by crossing out all but one of: CONCRETE, CGMP, PLATE; or he may choose to enter the "n"



DISTRICT_____ RES. NO._____
I.P.E._____ PROJ. NO._____
COUNTY_____

STATE DEPARTMENT OF HIGHWAYS
AND PUBLIC TRANSPORTATION
HYDRAULIC SYSTEM
CULVERT / BRIDGE SUBSYSTEM (CULBRG)

PREPARED BY_____
DATE_____
SHEET_____OF_____

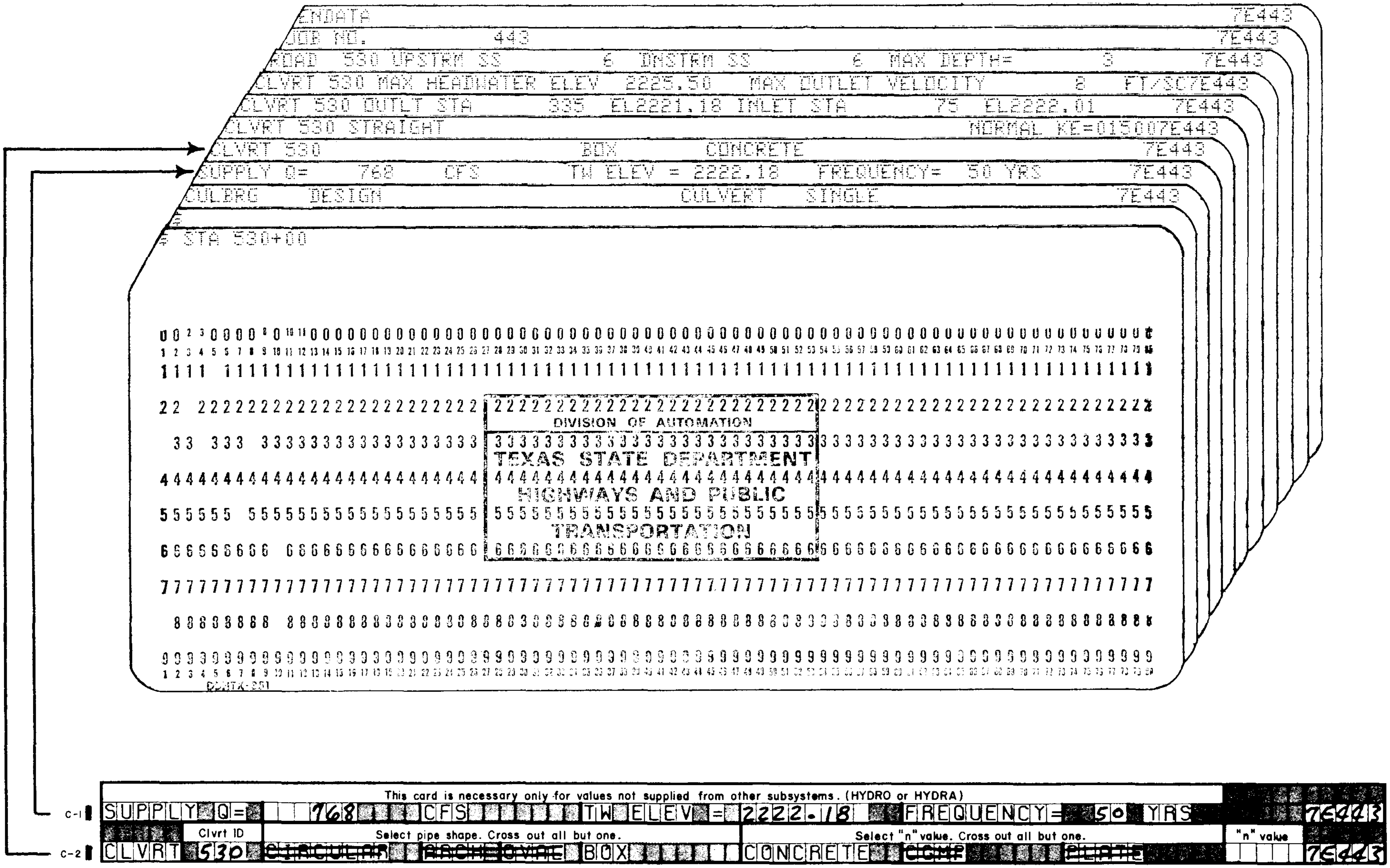
Comments ▮	$ STA 530+00					
▮	$					
☐	$					
		Cross out one		Design: Cross out one or neither Analysis: Cross out one	Specify opening configuration. Cross out one. / Number	Prob. No.
Control Card ▮	CULBRG	DESIGN ~~ANALYSIS~~	~~BRIDGE~~	CULVERT	SINGLE ~~MULTIPLE~~	7E443
		This card is necessary only for values not supplied from other subsystems. (HYDRO or HYDRA)				
C-1 ▮	SUPPLY Q=	768 CFS	TW ELEV =	2222.18	FREQUENCY= 50 YRS	7E443
	Clvrt ID	Select pipe shape. Cross out all but one.		Select "n" value. Cross out all but one.	"n" value	
C-2 ▮	CLVRT 530	~~CIRCULAR~~ ~~ARCH~~ ~~OVAL~~	BOX	CONCRETE ~~CCMP~~	~~PLATE~~	7E443
	Clvrt ID	Select profile configuration. Cross out all but one.		Select inlet condition. Cross out all but one.	"Ke" value	
C-3 ▮	CLVRT 530	STRAIGHT ~~BROKEN BK~~	~~STEPPED~~	~~FLARED~~ ~~DROP INLET~~	NORMAL KE=01500	7E443
	Clvrt ID	Design: Station at toe along ℄ of structure Analysis: Station at end of structure along ℄ of structure	Design: Elev. at toe Analysis: Elev. of culv. F.L.	Design: Station at toe along ℄ of structure Analysis: Station at end of structure along ℄ of structure	Design: Elev. at toe Analysis: Elev. of culv. F.L.	
C-4 ▮	CLVRT 530	OUTLT STA 335	EL2221.18	INLET STA 75	EL2222.01	7E443
	Clvrt ID	Stationing along centerline of structure	Break elevation	Stationing along centerline of structure	Break elevation	
C-5 ☐	CLVRT	BREAK STA	EL	BREAK STA	EL	
	Clvrt ID	Maximum headwater upstream of culvert	Elevation	Maximum allowable outlet velocity from culvert		
C-6 ▮	CLVRT 530	MAX HEADWATER ELEV	2225.50	MAX OUTLET VELOCITY	8 FT/SC	7E443
	Clvrt ID	Required entry for this card	Culvert diameter (in.)	Culvert rise / Culvert span	No. of culvert barrels	
C-7 ☐	CLVRT	DIMENSIONS	DIAM=	HIGH= / WIDE=	BARRELS=	
C-8 ▮	ROAD 530	UPSTRM SS 6	DNSTRM SS	6	MAX DEPTH= 3	7E443
	Subsec ID	Maximum allowable average velocity through bridge		Minimum allowable average velocity through bridge		
C-9 ☐	BRDG	MAX AVERAGE VELOCITY		MIN AVERAGE VELOCITY	FT/SC	
	Subsec ID	Left header slope	Right header slope	Insert one: UP or DN	Orig. sec. ID if skewed	
C-10 ☐	BRDG	LEFT S.S.	RIGHT S.S	LOOKING STREAM		
	Subsec ID	Cross-section ID	Distance along cross-section			
C-11 ☐	FL-DV	SECX	FRM X DIS	TO X DIST		
☐	FL-DV	SECX	FRM X DIS	TO X DIST		
☐	FL-DV	SECX	FRM X DIS	TO X DIST		
		Delete if Statewide Averages not desired				
C-15 ☐	COST	STATEWIDE				
		Supply job number for culvert if plan summary desired				
C-12 ▮	JOB NO.	443				7E443
C-13 ▮	ENDATA					7E443
C-14 ☐	PLAN SUMMARY					

Note: * ▮ Mark box as shown beside each line used.

FORM CONTINUED ON BACK

FORM 1308-1
(Revised 8/74)

FIGURE 2-1. TYPICAL INPUT FORM FOR THYSYS; COMPLETED FOR A SAMPLE PROBLEM



```
ENDATA                                                                          7E443
JOB NO.        443                                                              7E443
ROAD  530 UPSTRM SS          6  DNSTRM SS          6  MAX DEPTH=          3     7E443
CLVRT 530 MAX HEADWATER ELEV  2225.50   MAX OUTLET VELOCITY         8  FT/SC7E443
CLVRT 530 OUTLT STA        335  EL2221.18 INLET STA        75  EL2222.01        7E443
CLVRT 530 STRAIGHT                                              NORMAL KE=015007E443
CLVRT 530                    BOX       CONCRETE                                 7E443
SUPPLY Q=     768     CFS        TW ELEV = 2222.18   FREQUENCY=  50 YRS         7E443
CULBRG    DESIGN                           CULVERT   SINGLE                     7E443
$
$ STA 530+00
```

This card is necessary only for values not supplied from other subsystems. (HYDRO or HYDRA)

C-1 SUPPLY Q= 768 CFS TW ELEV = 2222.18 FREQUENCY= 50 YRS 7E443

Clvrt ID | Select pipe shape. Cross out all but one. | Select "n" value. Cross out all but one. | "n" value

C-2 CLVRT 530 ~~CIRCULAR~~ ~~ARCH~~ ~~OVAL~~ BOX CONCRETE ~~CGMP~~ ~~PLATE~~ 7E443

FIGURE 2-2. RELATIONSHIP OF INPUT TO PUNCHED CARDS value in the field "n" value. The shaded portions of the form are not used; the field Prob. No. should be completed.

In some problems not all the cards (lines) are used. For ready identification the user should indicate which cards he intends to use by marking the box in the left hand margin of the form adjacent to the line. Only those cards preceded by a box which has been marked will be keypunched. The cards necessary to solve each type of problem are listed and explained in the Input sections for each of the five subsystems.

Control Cards

Access to each one of the subsystems in THYSYS requires a special card containing the name of the subsystem. This is called a Control card and it has the name of the subsystem as the first entry beginning in column 1. The Control card is located near the beginning of each input form for the subsystem. Many of the subsequent cards shown on the input forms are optional, depending upon the type of problem the user wishes to solve. The Control card, however, is usually required each time the subsystem is used. The use of this card will be explained later in the discussions of input for each subsystem.

Endata Cards

An Endata card is required at the end of each set of data for each subsystem. This card signals the end of the input for a particular problem and starts the computations. If the Endata card is inadvertently omitted the computation will be skipped and the input data for the next problem will be read in. In general, each Control card must be matched by at least one subsequent Endata card prior to the next Control card. The use of the Endata card is explained in further detail in the discussions of input for each subsystem.

Comments

THYSYS is designed to allow the user to insert comments concerning the problem. The comments will be printed along with the output data in the exact sequence that the user specified on his input form. Comment cards are identified by a dollar sign in column 1. The actual messages are entered in columns 2 through 80 and may be made up of any letter of the alphabet, the numbers 0 through 9 and the symbols / + - . ( ) $ * , = # in the form of a message. There are three Comment cards at the beginning of each input form for each of the subsystems although an unlimited number may be used. It is recommended that the first three Comment cards be used for problem identification. The message or messages in these first three cards on each of the subsystem input forms will be printed out at the beginning of each subsystem output listing.

In the event the user desires to insert comments within the data portions of any form, a supplemental Comment form entitled "Additional Comments" is used and it is shown in Figure 2-3. Each Comment card is numbered in the left margin. There is also a small box in the left margin which must be marked to indicate that the message on that Comment card is to be keypunched. The number of the Comment card must be written in the left margin of the subsystem input form along with a directive arrow indicating where this particular Comment card should be inserted as shown in Figure 2-4. If a blank line is desired, the user marks the box preceding the line and makes the notation in the margin of the subsystem input form where it is to appear. Comment numbers 1 and 4 are blank lines which appear as blank lines in the output (Figure 2-4).

STATE DEPARTMENT OF HIGHWAYS
AND PUBLIC TRANSPORTATION

HYDRAULIC SYSTEM
ADDITIONAL COMMENTS

DISTRICT_____ RES. NO.__________
I.P.E.__________ PROJ. NO.__________
COUNTY______________________

PREPARED BY______
DATE__________
SHEET_____OF_____

* 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80

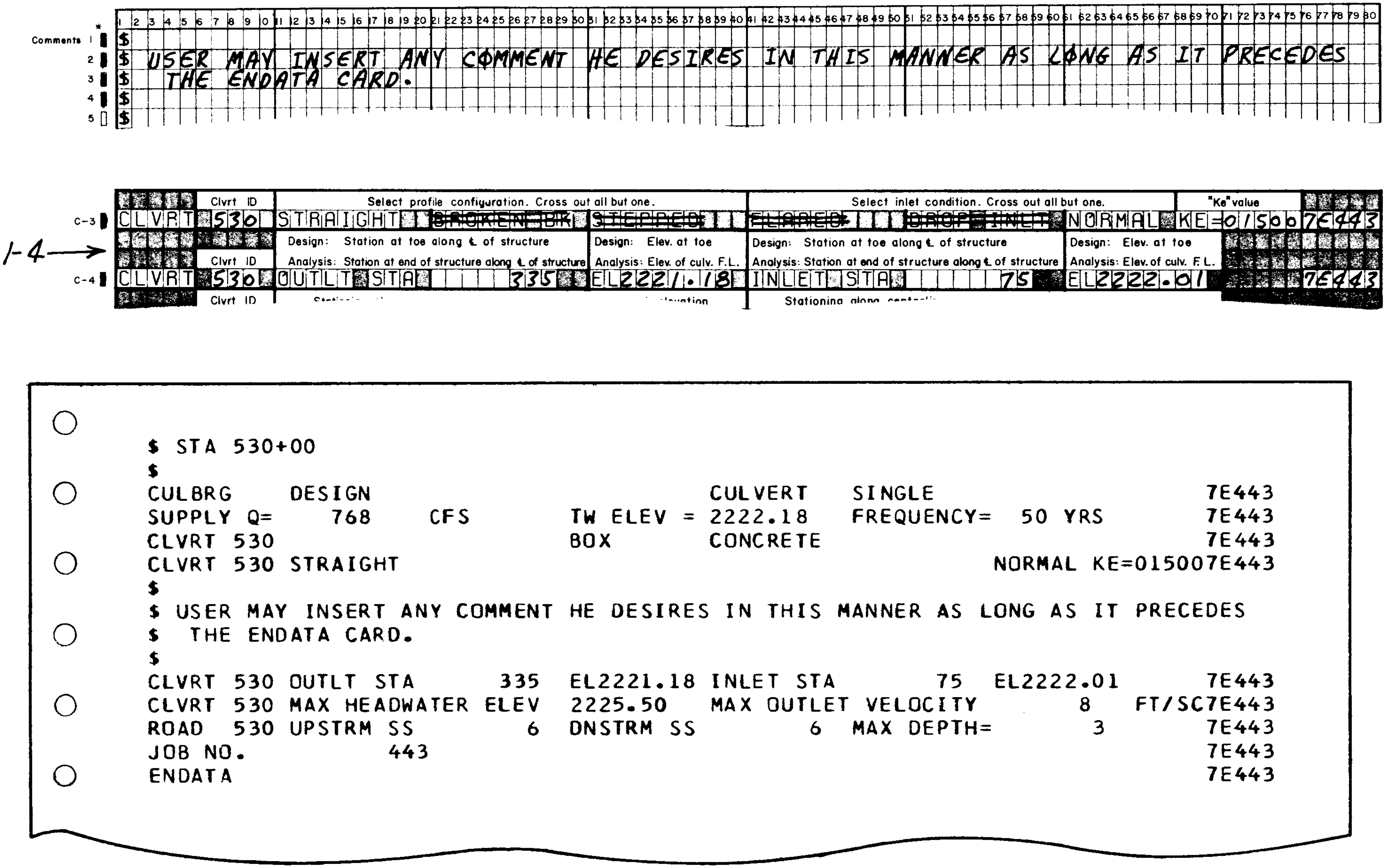
Comments 1 ☐ $
2 ☐ $
3 ☐ $
4 ☐ $
5 ☐ $
6 ☐ $
7 ☐ $
8 ☐ $
9 ☐ $
10 ☐ $
11 ☐ $
12 ☐ $
13 ☐ $
14 ☐ $
15 ☐ $
16 ☐ $
17 ☐ $
18 ☐ $
19 ☐ $
20 ☐ $
21 ☐ $
22 ☐ $
23 ☐ $
24 ☐ $
25 ☐ $
26 ☐ $
27 ☐ $
28 ☐ $
29 ☐ $
30 ☐ $
31 ☐ $
32 ☐ $
33 ☐ $
34 ☐ $
35 ☐ $
36 ☐ $

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80

Note: * ▮ Mark box as shown beside each line used.

1311

FIGURE 2-3. ADDITIONAL COMMENTS FORM



```
$
$ USER MAY INSERT ANY COMMENT HE DESIRES IN THIS MANNER AS LONG AS IT PRECEDES
$  THE ENDATA CARD.
$
$
```

Clvrt ID | Select profile configuration. Cross out all but one. | Select inlet condition. Cross out all but one. | "Ke" value

C-3 CLVRT 530 STRAIGHT ~~BROKEN BK~~ ~~STEPPED~~ ~~FLARED~~ ~~DROP INLET~~ NORMAL KE=01500 7E443

Clvrt ID | Design: Station at toe along ℄ of structure / Analysis: Station at end of structure along ℄ of structure | Design: Elev. at toe / Analysis: Elev. of culv. F.L. | Design: Station at toe along ℄ of structure / Analysis: Station at end of structure along ℄ of structure | Design: Elev. at toe / Analysis: Elev. of culv. F.L.

C-4 CLVRT 530 OUTLT STA 335 EL2221.18 INLET STA 75 EL2222.01 7E443

Clvrt ID

```
$ STA 530+00
$
CULBRG    DESIGN                        CULVERT   SINGLE                    7E443
SUPPLY Q=    768    CFS       TW ELEV = 2222.18   FREQUENCY=  50 YRS        7E443
CLVRT 530                     BOX       CONCRETE                            7E443
CLVRT 530 STRAIGHT                                          NORMAL KE=015007E443
$
$ USER MAY INSERT ANY COMMENT HE DESIRES IN THIS MANNER AS LONG AS IT PRECEDES
$  THE ENDATA CARD.
$
CLVRT 530 OUTLT STA      335  EL2221.18 INLET STA       75  EL2222.01       7E443
CLVRT 530 MAX HEADWATER ELEV  2225.50   MAX OUTLET VELOCITY       8   FT/SC7E443
ROAD  530 UPSTRM SS        6  DNSTRM SS         6  MAX DEPTH=       3       7E443
JOB NO.         443                                                         7E443
ENDATA                                                                      7E443
```

FIGURE 2-4. PROCEDURE FOR INSERTING ADDITIONAL COMMENTS

Problem No.

Columns 76-80 on all cards are assigned by the user for the problem identification number. It is recommended that the first two digits (columns 76-77) represent the District number and the last three columns, 78, 79, 80, be used for sequential problem numbers. Non-duplication of THYSYS problem numbers within a District will aid in properly identifying the problem at a later time. It is suggested that each District issue to each of its offices a series of three-digit sequential problem numbers to use. The problem number may have either alphabetic characters or numbers.

Data Entry

The user should be very careful when completing the form. Those cards on the input forms requiring the entry of a numerical or alphabetic character should be done neatly, boldly, and within the allotted space. In addition, all items that require marking out should be done clearly and boldly. Figure 2-1 is an example of a satisfactorily marked input form.

Blank Spaces

Blank spaces in input data for this program may default to zeros or indicate no entry. It will be noted in the ensuing discussion on each subsystem when entries must be made.

Data Order

Between the Control and Endata cards for each subsystem, the other data cards do not have to be in any specific order. However, the user may find that it is more convenient to maintain everything in its form order. When more than one subsystem is used per problem, the subsystems must be in the order they are discussed in the manual.

Decimal Points, Numeric Entries

In the explanation of input for each subsystem frequent reference is made to decimal number entries. Where a number is called for, the following types of entries may be made when a decimal point is not shown on the form:

1. A decimal number may be entered anywhere within the allotted columns with the decimal point occupying a space.

   For entering 123

   For entering 47.7

2. A whole number may be entered without the decimal point by placing it in the rightmost columns when a decimal point is not indicated on the form. This is termed "right justifying".

   Any numeric entry which is not specified as a decimal must be right justified.

When a decimal point is already printed on the form, the following types of entries may be made:

1. Whole numbers and decimal numbers may be entered by using the preprinted decimal point.

   For entering 123

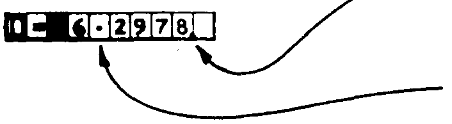
   Note that pre-printed decimals appear between columns.

   For entering 41.7

2. The user may override the preprinted decimal as shown below.

For entering 6.2978



Preprinted decimal

User inserted decimal.

NOTE: When overriding a preprinted decimal point the user must place the new decimal in one of the spaces and not on a line between them. Decimal points which the user enters should be placed in the middle of the allotted space (as shown above) and they should be larger than average size to preclude misinterpretation.

Alphabetic Entries

Alphabetic entries should be capital letters. The alphabetic letter O should be marked Ø to differentiate it from zero. The letter Z should be written Ƶ to differentiate it from the number 2. The letter I should be written with a line at the top and bottom to differentiate it from the number 1.

Justifying (Left or Right)

When "left justifying" is specified, the leftmost columns in the allotted spaces for the field must be used first:

When "right justifying" is specified, the rightmost columns in the allotted spaces for the field must be used first:

Station Numbers

This program is not designed to recognize stationing notation in the form familiar to engineers. It will accept only a decimal number. Therefore, station 22+56.31 must be entered on the form as 2256.31 (the plus sign would not appear and the decimal point occupies a space).

Problem Submission

The user may submit several problems in the same run (entry into the THYSYS system) subject to limitations which are discussed in the sections pertaining to the individual subsystems.

Hydraulic Manual

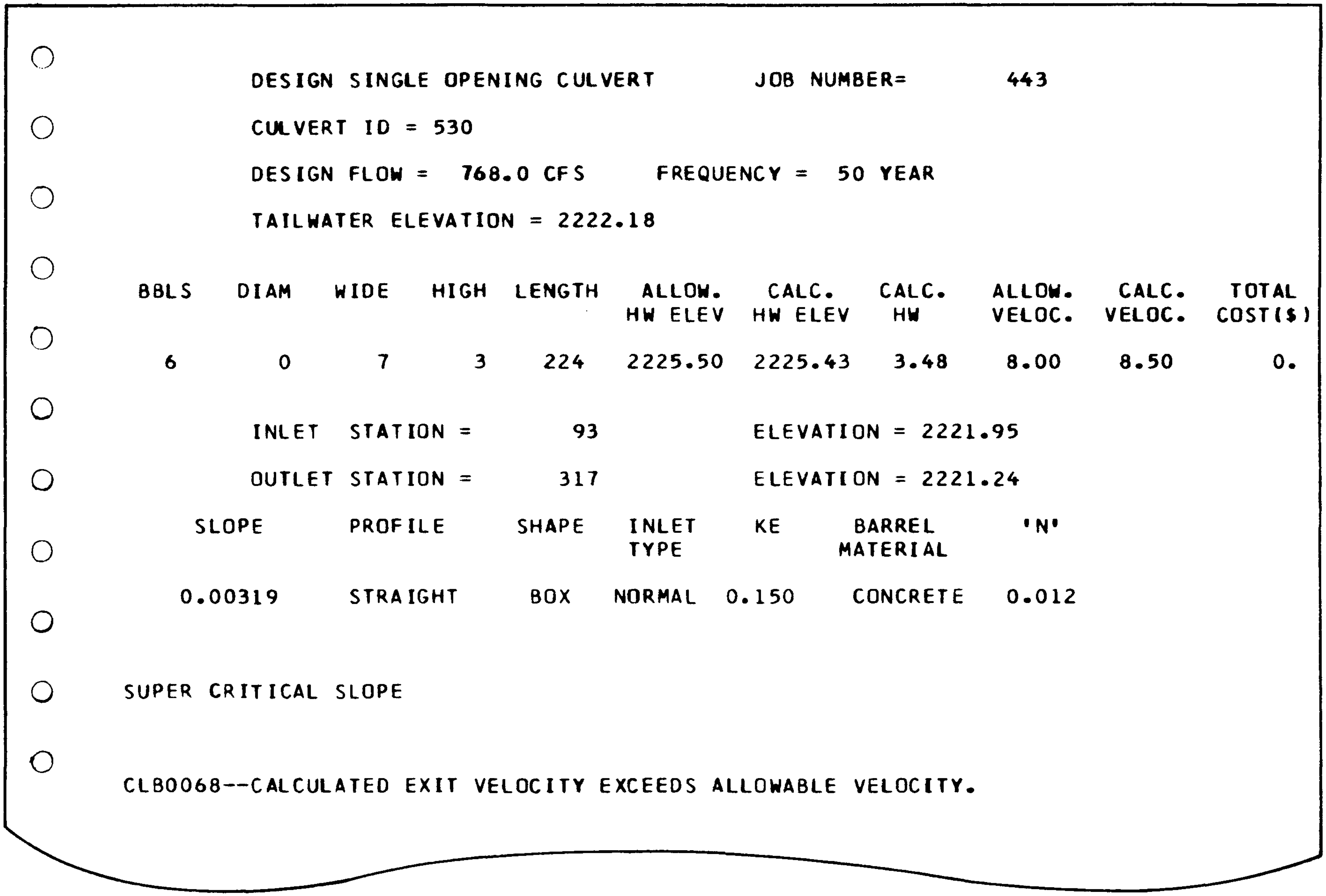
References made to the *Hydraulic Manual* refer to the manual prepared and compiled by the Bridge Division of the State Department of Highways and Public Transportation.

II. OUTPUT

Figure 2-5 is an example of a typical output listing which is also referred to as a report. Additional examples are shown in the Sample Problems (Part VIII). All printout has been positioned so that the pages may be trimmed to 8 1/2" by 11". In addition, one title page is provided for each set of problems. As an optional feature in the CULBRG subsystem, the user may request a plan summary sheet to provide a summary of all culverts that are run under the same Job No. and that meet the design criteria.

The input data is duplicated on the output listings exactly as it is entered in order to facilitate checking and to provide complete documentation. This is called an "echo" print. In each case the echo print precedes the computed output.

Extensive error checking is incorporated into the THYSYS program. Inputs are checked for consistency, completeness, and reasonableness. Error conditions which can be ignored are flagged and the problem solution continues. When errors are encountered that cannot be ignored, checking continues on the remaining data before the problem is terminated. In each case a descriptive message is printed in the echo print of the input which is the first portion of the output listing. The messages which are called Error Messages indicate the errors or describe action taken by the program as a result of errors or omissions in the input data. The possible error messages that may appear on the output listings for each subsystem are listed in an alphanumeric code order. The alphabetic characters denote the subsystem to which the error message applies. Within each subsystem each error message has a sequential number. Section IV of each subsystem contains the Error Messages with additional explanations.



```
          DESIGN SINGLE OPENING CULVERT      JOB NUMBER=      443

          CULVERT ID = 530

          DESIGN FLOW =  768.0 CFS     FREQUENCY =  50 YEAR

          TAILWATER ELEVATION = 2222.18

   BBLS    DIAM    WIDE    HIGH   LENGTH   ALLOW.    CALC.    CALC.    ALLOW.    CALC.    TOTAL
                                          HW ELEV  HW ELEV   HW      VELOC.   VELOC.   COST($)

    6        0       7       3     224    2225.50  2225.43   3.48     8.00      8.50       0.

          INLET  STATION =       93            ELEVATION = 2221.95

          OUTLET STATION =      317            ELEVATION = 2221.24

      SLOPE       PROFILE      SHAPE   INLET     KE      BARREL      'N'
                                       TYPE              MATERIAL

     0.00319      STRAIGHT      BOX    NORMAL  0.150    CONCRETE   0.012


   SUPER CRITICAL SLOPE


   CLB0068--CALCULATED EXIT VELOCITY EXCEEDS ALLOWABLE VELOCITY.
```

FIGURE 2-5. TYPICAL OUTPUT LISTING (REPORT)

PART III - HYDROLOGY SUBSYSTEM (HYDRO)

Hydrology Subsystem (HYDRO)

HYDROLOGY SUBSYSTEM (HYDRO)

I. DESCRIPTION

The primary function of the HYDRO subsystem is to calculate a peak flow of surface water runoff. Three computational procedures are available for determining the peak discharge:

1. U.S. Geological Survey Procedure (USGS)
2. Rational
3. Gaged Analysis

Method 1 is a computational procedure tailored to the hydrology of the State of Texas. Methods 2 and 3 are more general in application. Method 3 (Gaged Analysis) employs the Log-Pearson Type III statistical distribution for computation.

The calculated peak flows or a peak flow supplied by the user can be modified by adding a base flow. Only one peak flow is computed per pass in this subsystem and this peak flow will be reflected in the HYDRO report. In addition, the peak flow may be used as the first discharge to be considered in the HYDRA subsystem or it may be used in the CULBRG subsystem. The PUMP subsystem may also use the peak discharge computed in HYDRO.

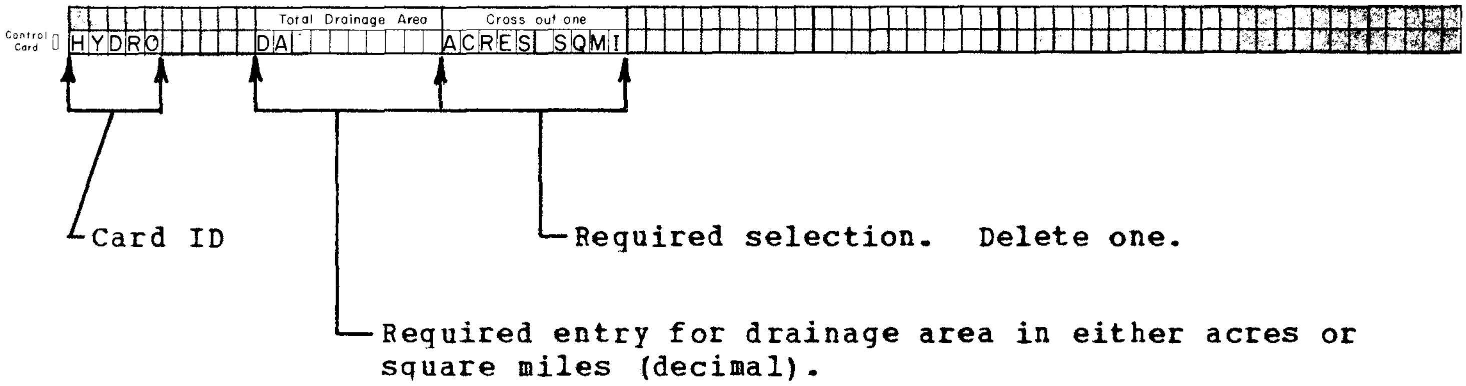
The calculated peak flow for a 100 year flood is automatically computed and output if either the USGS or Gaged Analysis methods are specified. This 100 year discharge is passed on to HYDRA and CULBRG for possible use in 100 year analysis computations.

II. INPUT

The data form for the HYDRO subsystem is printed on the front and back and is shown in Figures 3-1 and 3-2.

HYDRO CONTROL CARD

The HYDRO Control Card is <u>required</u> for entry into the HYDRO subsystem. Drainage area is required entry on this card. The unit of measurement to be used (acres or square miles) must be indicated by marking through the one that is not applicable.



Card ID

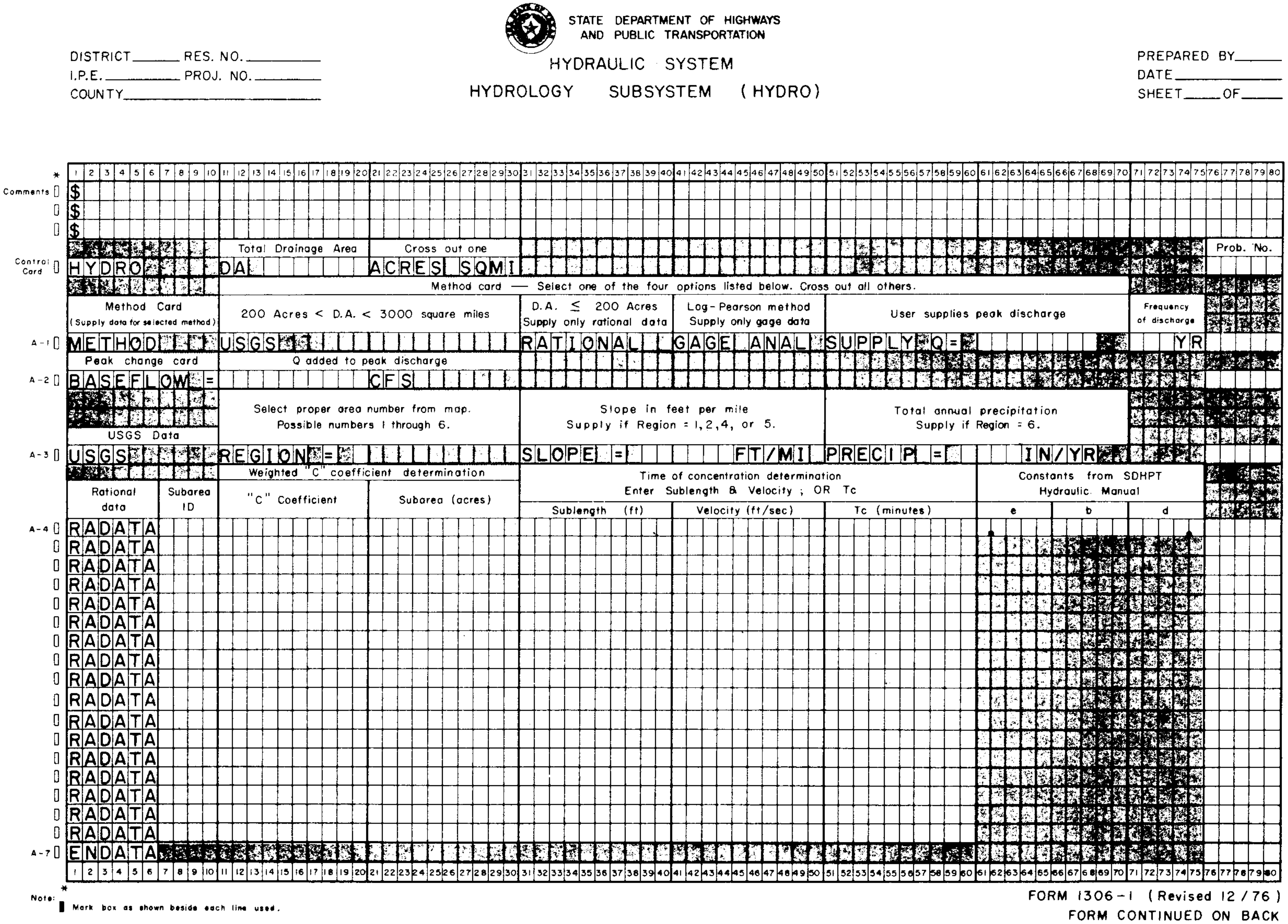
Required selection. Delete one.

Required entry for drainage area in either acres or square miles (decimal).

METHOD CARD (A-1)

The METHOD card (A-1) is a required entry for each HYDRO run and provides the user several options to specify runoff computational methods. The first two methods on this card (USGS and RATIONAL) are best suited to problems involving a limited range of drainage area sizes.

For drainage areas of about 200 acres or less the user should specify the RATIONAL method. For natural, rural areas greater than about 200 acres but less than 3,000 square miles, the USGS method should be used. However, it should be noted that the USGS method is not applicable for urban developed areas. If the USGS method is selected, the user must provide additional information on the USGS card



STATE DEPARTMENT OF HIGHWAYS
AND PUBLIC TRANSPORTATION

DISTRICT______ RES. NO.__________
I.P.E.__________ PROJ. NO.__________
COUNTY__________________________

HYDRAULIC SYSTEM
HYDROLOGY SUBSYSTEM (HYDRO)

PREPARED BY______
DATE____________
SHEET_____OF_____

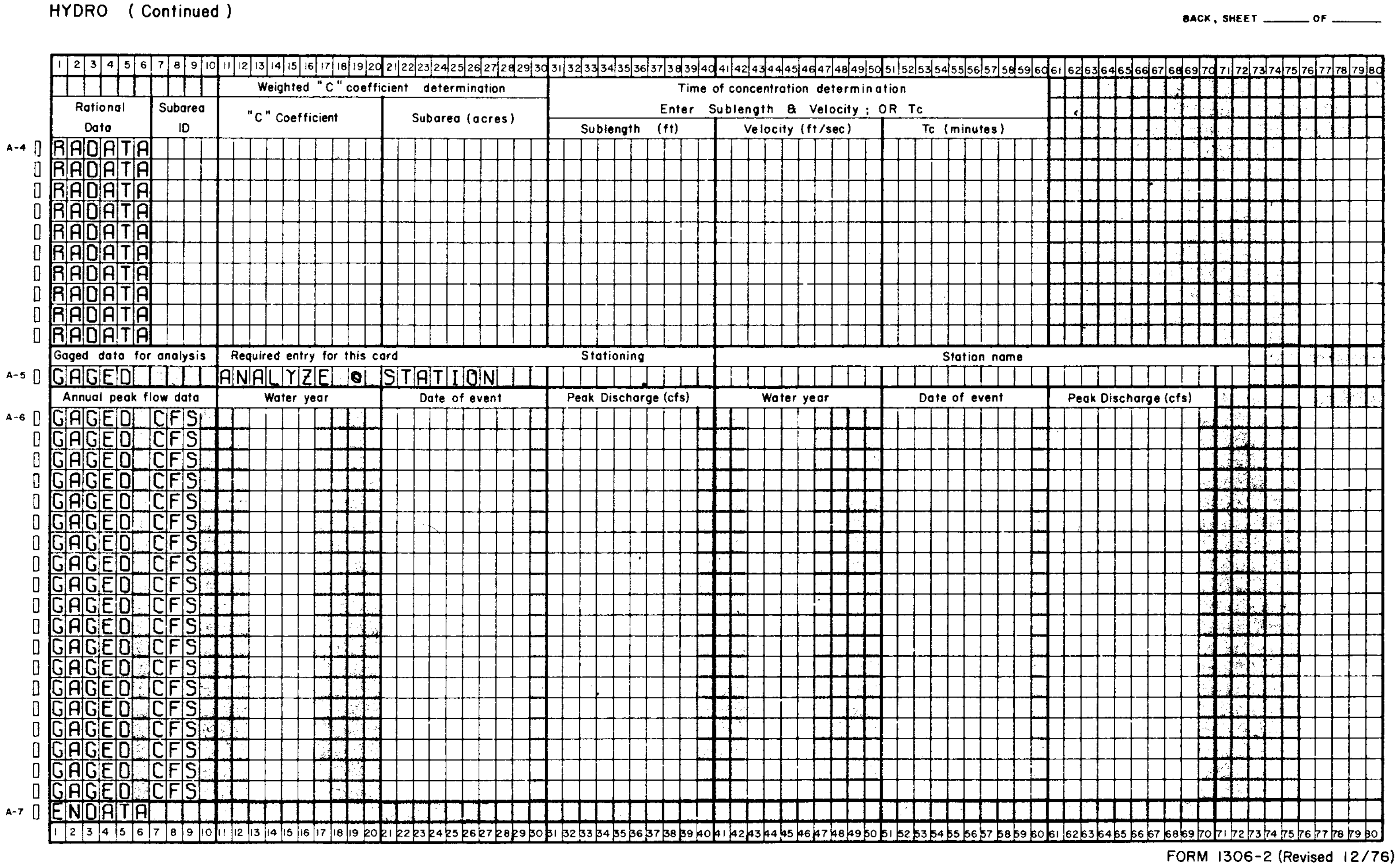
	Columns 1–10	Columns 11–30	Columns 31–50	Columns 51–70	Columns 71–80
Comments	$				
	$				
	$				
		Total Drainage Area / Cross out one			Prob. No.
Control Card	HYDRO	DA / ACRES SQMI			
		Method card — Select one of the four options listed below. Cross out all others.			
	Method Card (Supply data for selected method)	200 Acres < D.A. < 3000 square miles	D.A. ≤ 200 Acres Supply only rational data / Log-Pearson method Supply only gage data	User supplies peak discharge	Frequency of discharge
A-1	METHOD	USGS	RATIONAL / GAGE ANAL	SUPPLY Q=	YR
	Peak change card	Q added to peak discharge			
A-2	BASEFLOW=	CFS			
	USGS Data	Select proper area number from map. Possible numbers 1 through 6.	Slope in feet per mile Supply if Region = 1,2,4, or 5.	Total annual precipitation Supply if Region = 6.	
A-3	USGS	REGION=	SLOPE = FT/MI	PRECIP = IN/YR	

	Rational data	Subarea ID	Weighted "C" coefficient determination: "C" Coefficient	Weighted "C" coefficient determination: Subarea (acres)	Time of concentration determination Enter Sublength & Velocity ; OR Tc: Sublength (ft)	Velocity (ft/sec)	Tc (minutes)	Constants from SDHPT Hydraulic Manual: e	b	d
A-4	RADATA									
	RADATA									
	RADATA									
	RADATA									
	RADATA									
	RADATA									
	RADATA									
	RADATA									
	RADATA									
	RADATA									
	RADATA									
	RADATA									
	RADATA									
	RADATA									
	RADATA									
	RADATA									
	RADATA									
A-7	ENDATA									

Note: * ▌ Mark box as shown beside each line used.

FORM 1306-1 (Revised 12/76)
FORM CONTINUED ON BACK

FIGURE 3-1. FRONT SIDE OF THE HYDROLOGY SUBSYSTEM (HYDRO) INPUT FORM



HYDRO (Continued)

BACK, SHEET ______ OF ______

	1-6	7-10	11-20	21-30	31-40	41-50	51-60	61-80
	Rational Data	Subarea ID	Weighted "C" coefficient determination		Time of concentration determination Enter Sublength & Velocity ; OR Tc			
			"C" Coefficient	Subarea (acres)	Sublength (ft)	Velocity (ft/sec)	Tc (minutes)	
A-4 ☐	RADATA							
☐	RADATA							
☐	RADATA							
☐	RADATA							
☐	RADATA							
☐	RADATA							
☐	RADATA							
☐	RADATA							
☐	RADATA							
☐	RADATA							

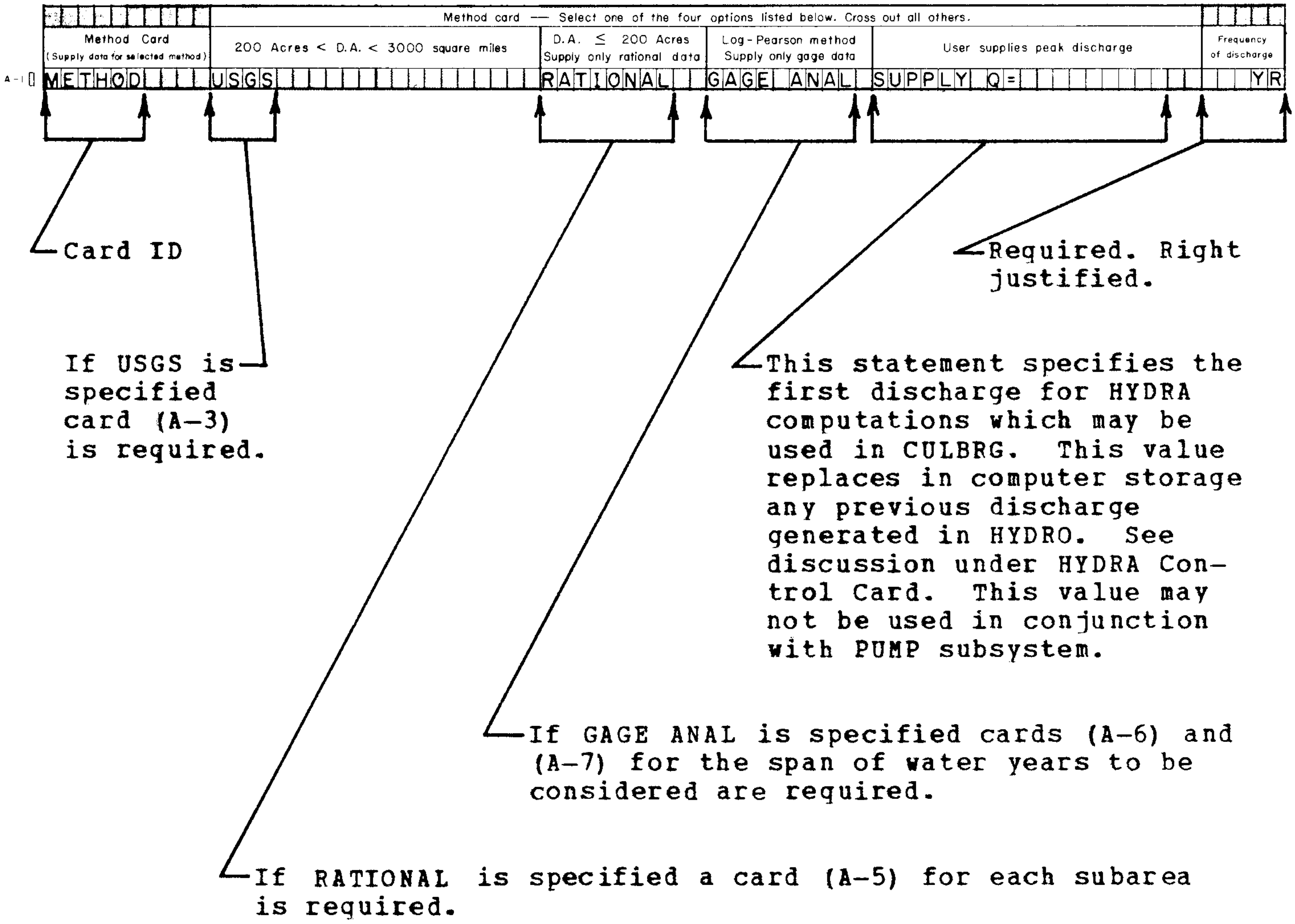
	1-10	11-30	31-40	41-80
	Gaged data for analysis	Required entry for this card	Stationing	Station name
A-5 ☐	GAGED	ANALYZE @ STATION		

	1-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80
	Annual peak flow data	Water year	Date of event	Peak Discharge (cfs)	Water year	Date of event	Peak Discharge (cfs)	
A-6 ☐	GAGED CFS							
☐	GAGED CFS							
☐	GAGED CFS							
☐	GAGED CFS							
☐	GAGED CFS							
☐	GAGED CFS							
☐	GAGED CFS							
☐	GAGED CFS							
☐	GAGED CFS							
☐	GAGED CFS							
☐	GAGED CFS							
☐	GAGED CFS							
☐	GAGED CFS							
☐	GAGED CFS							
☐	GAGED CFS							
☐	GAGED CFS							
☐	GAGED CFS							
☐	GAGED CFS							
☐	GAGED CFS							
A-7 ☐	ENDATA							

FORM 1306-2 (Revised 12/76)

FIGURE 3-2. BACK SIDE OF THE HYDROLOGY SUBSYSTEM (HYDRO) INPUT FORM

(A-3). If the RATIONAL method is selected, RADATA cards (A-4) for all subareas are required.



Card ID

If USGS is specified card (A-3) is required.

Required. Right justified.

This statement specifies the first discharge for HYDRA computations which may be used in CULBRG. This value replaces in computer storage any previous discharge generated in HYDRO. See discussion under HYDRA Control Card. This value may not be used in conjunction with PUMP subsystem.

If GAGE ANAL is specified cards (A-6) and (A-7) for the span of water years to be considered are required.

If RATIONAL is specified a card (A-5) for each subarea is required.

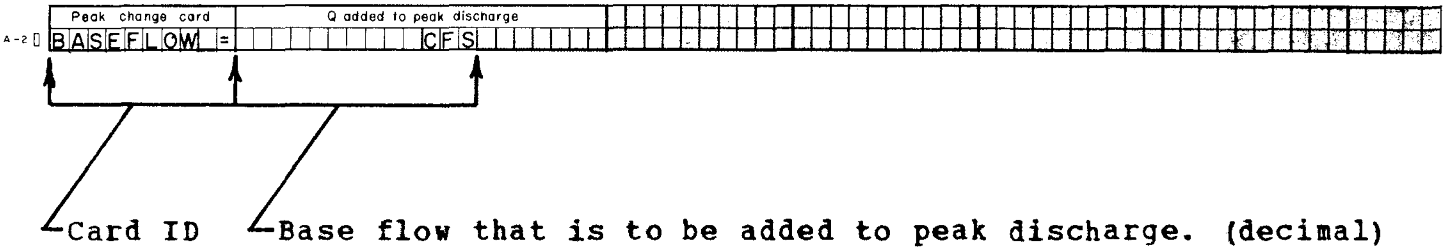
The third procedure which may be specified on the METHOD card (A-1) is GAGED DATA ANALYSIS. If GAGE ANAL is specified it must be accompanied by a GAGED data analysis (station description) card (A-5) and Gaged CFS cards (A-6) for the span of years to be considered in the analysis. This procedure employs the Log-Pearson Type III statistical method of analysis.

Under certain circumstances it may become necessary for a discharge to originate in the HYDRO subsystem for use in other subsystems even though that discharge is already known. In such instances the discharge may be entered with the SUPPLY Q option on the METHOD card. This discharge (Q) can then be passed to other subsystems as having originated in HYDRO. This is necessary only under special conditions which will be discussed more fully in HYDRA. The SUPPLY Q option may not be used in conjunction with the PUMP subsystem. (Refer to METHOD card discussion in the PUMP Input Section.)

Regardless of the option selected, the flood frequency must always be provided on the METHOD card (A-1).

BASEFLOW CARD (A-2)

The BASEFLOW card (A-2) permits the user to make adjustments in the computed flows. With the BASE FLOW option, a flow in addition to the calculated flow may be included in the results of the calculations. Prior to using the BASEFLOW card, the Hydraulic Section of File D-5 should be consulted.



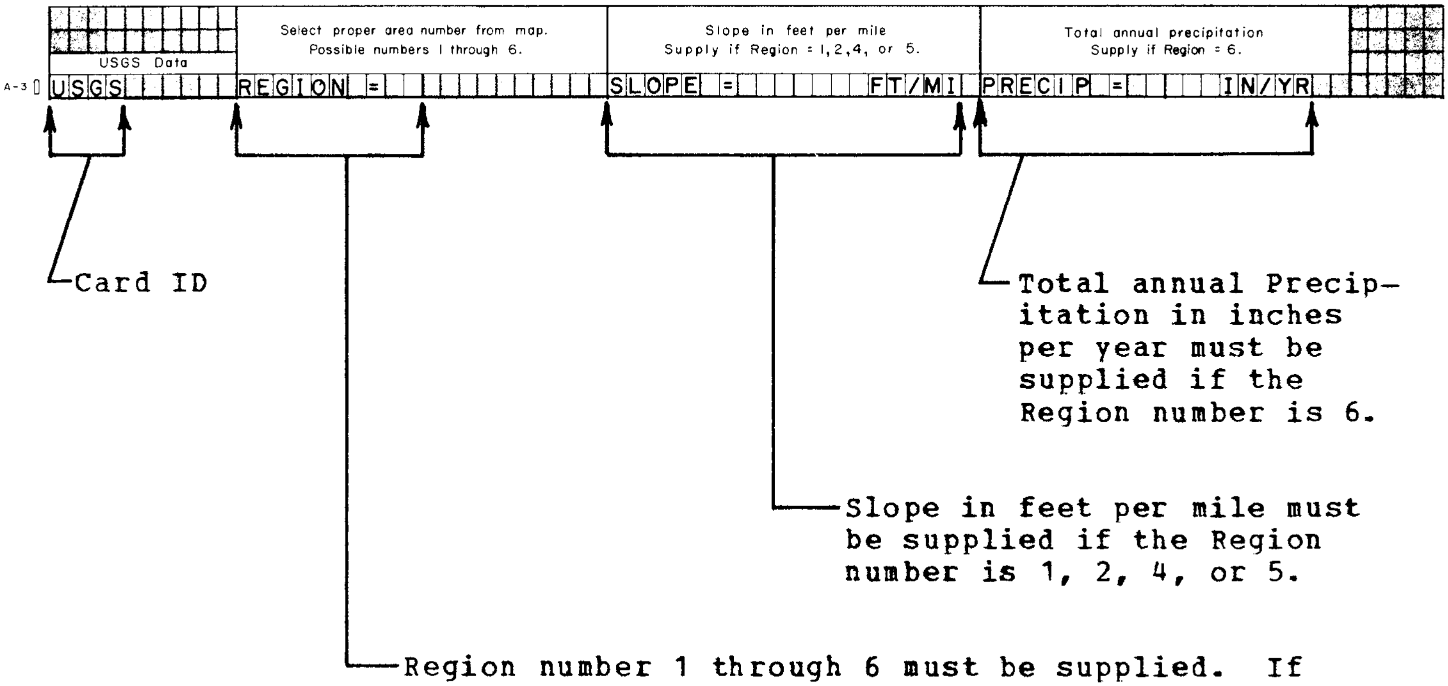
USGS DATA CARD (A-3)

The USGS card (A-3) is used when USGS is specified on the METHOD card (A-1). The following input is required on the USGS card:

1. Region number 1 through 6 which can be obtained from a map in Appendix B.

2. Slope if Region number equals 1, 2, 4, or 5. Slope is defined as the average slope in feet per mile between points 10% and 85% of the drainage area length (the distance from the site to the basin divide).

3. Total Annual precipitation if Region number equals 6. Precipitation can be obtained from a map in Appendix B.



Card ID

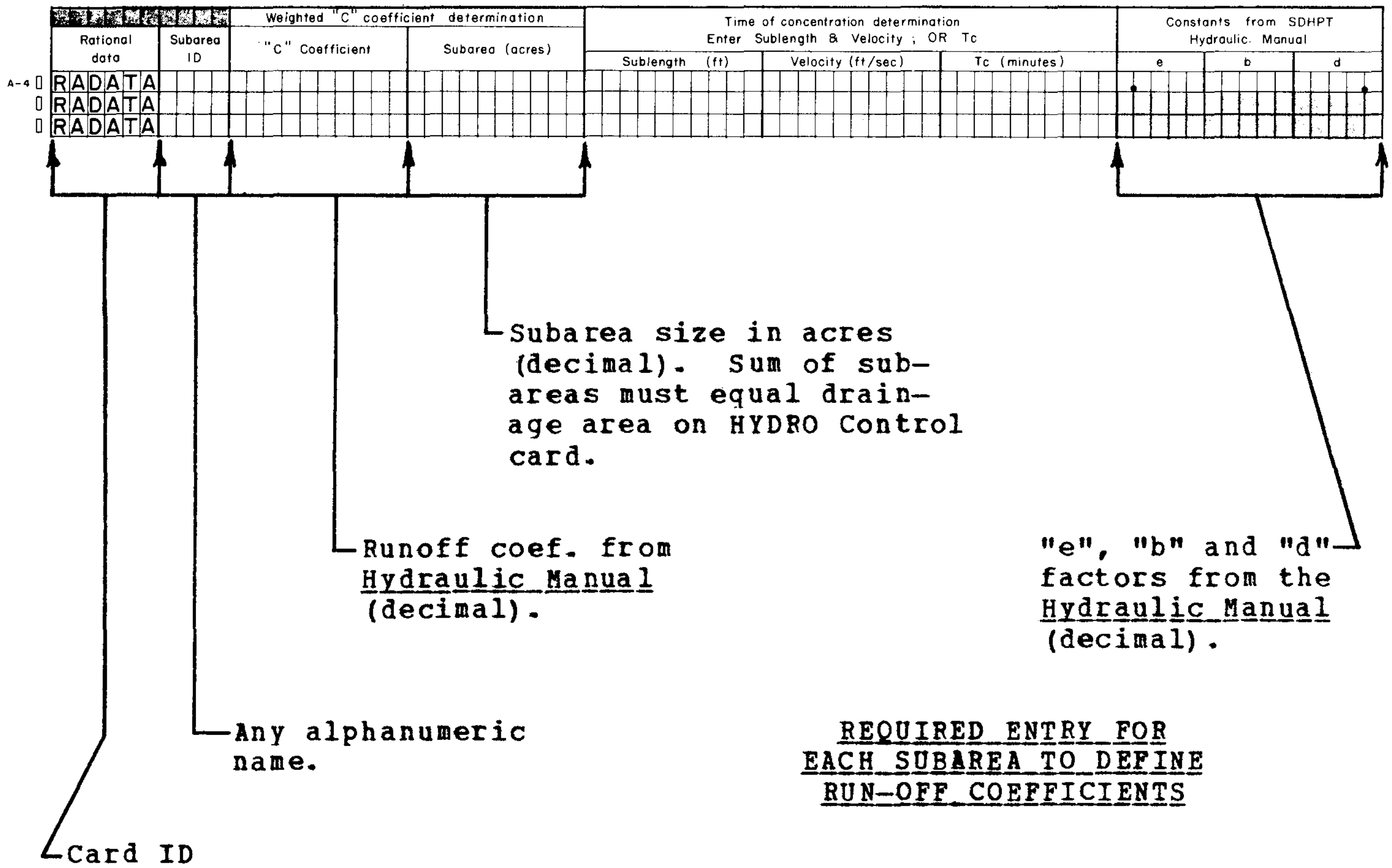
Total annual Precipitation in inches per year must be supplied if the Region number is 6.

Slope in feet per mile must be supplied if the Region number is 1, 2, 4, or 5.

Region number 1 through 6 must be supplied. If Region number is 3 no additional data will be required on this card. Region numbers can be determined from map in Appendix B.

RADATA CARD (A-4)

The RADATA cards (A-4) are used when RATIONAL is specified on the METHOD card (A-1). One RADATA card must be supplied for each subarea considered in the drainage area. The user must assign a unique name to each subarea and enter it in the spaces provided for SUBAREA ID. This identification may consist of any combination of four letters and/or numerals.



Subarea size in acres (decimal). Sum of subareas must equal drainage area on HYDRO Control card.

Runoff coef. from <u>Hydraulic Manual</u> (decimal).

"e", "b" and "d" factors from the <u>Hydraulic Manual</u> (decimal).

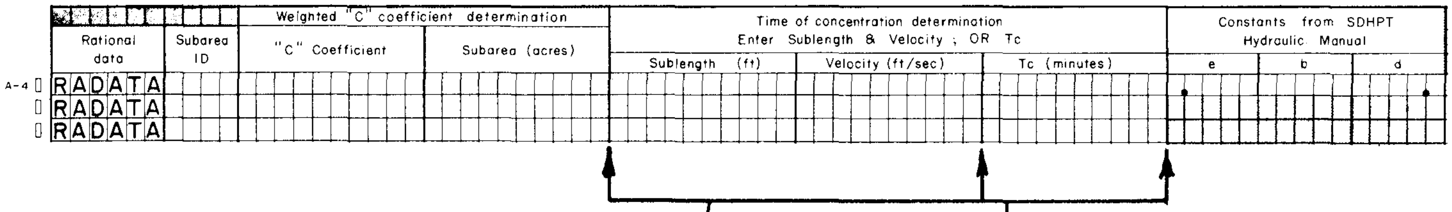
Any alphanumeric name.

<u>REQUIRED ENTRY FOR EACH SUBAREA TO DEFINE RUN-OFF COEFFICIENTS</u>

Card ID

Each RADATA card must also contain entries for the "C" coefficient and size of each subarea. The "C" coefficient is governed by the nature of the terrain within the subarea and may be obtained from the <u>Hydraulic Manual</u>. The subarea total should exactly equal the drainage area entered on the HYDRO Control card. If it does not, the subarea total will be used.

RADATA Card Continued



<u>REQUIRED ENTRIES FOR AREA OR SUBAREAS TO DEFINE TC</u>

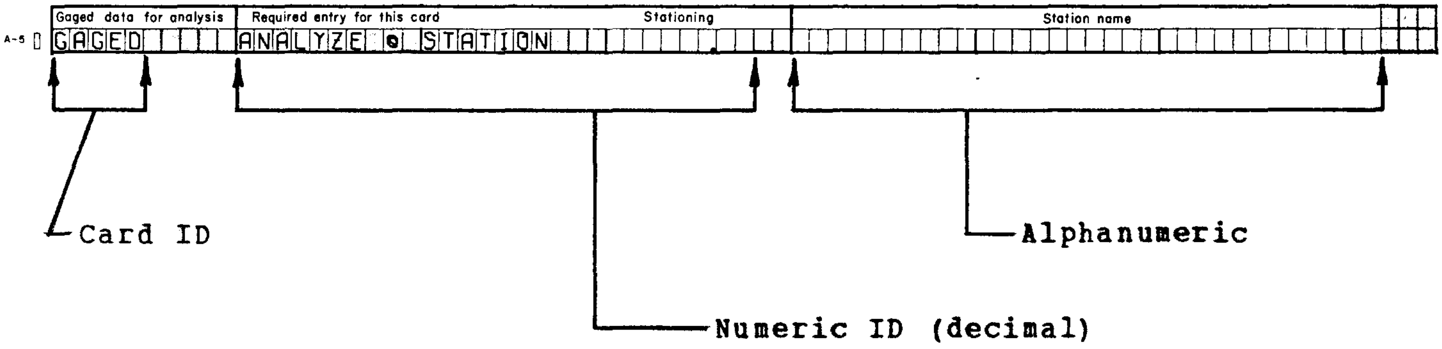
TC in minutes for the sublength. Determined as set forth in the <u>Hydraulic Manual</u> (decimal).

Include sublength and velocity only if TC for the sublength is not known. Sublength in feet and subvelocity in feet/sec determined as set forth in the <u>Hydraulic Manual</u> (decimal).

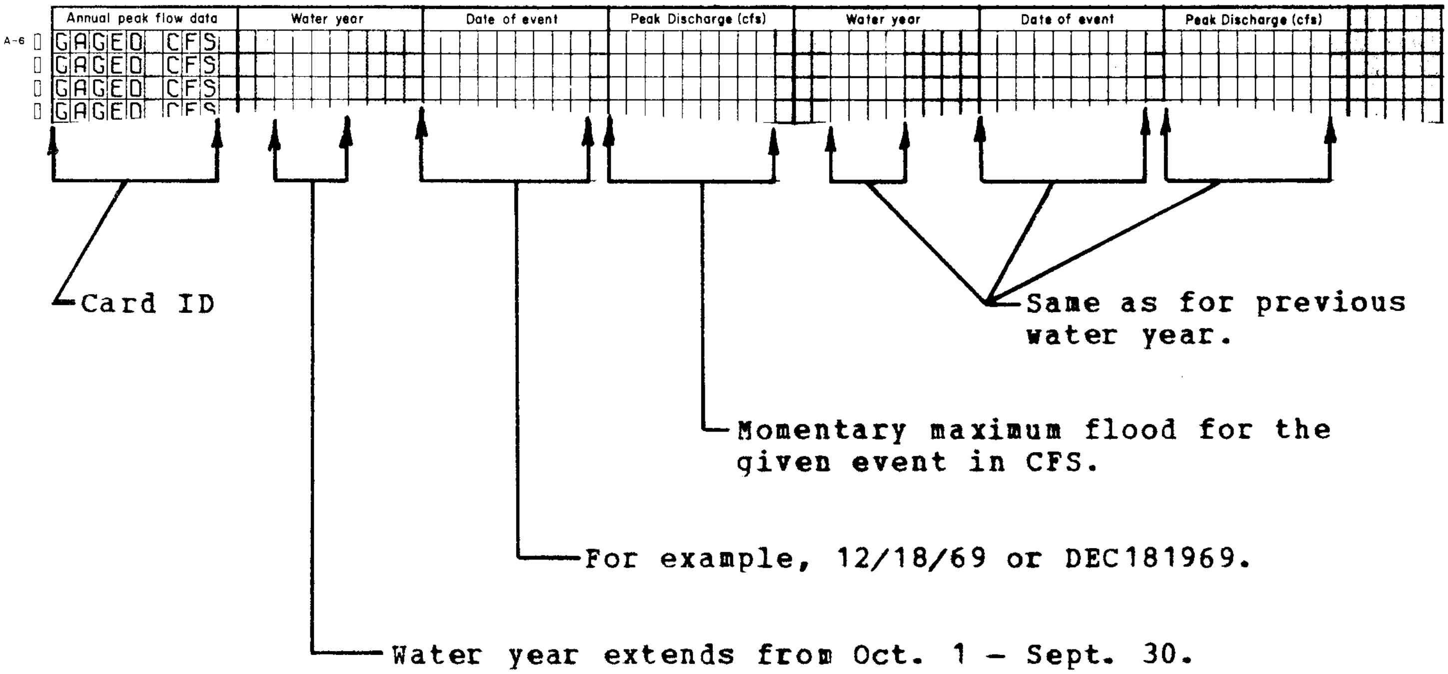
The program does not have the capability of determining the longest route for time of concentration where two or more adjacent subareas contribute to the total discharge of the drainage area. In these instances it will be the responsibility of the user to determine which is the longest route and provide time of concentration data for that path only. In each subarea where time of concentration data is required, the user may enter either the sublength (feet) and the velocity (ft/sec), or the time of concentration, TC (minutes), if it is already known. For each frequency only one set of rainfall intensity factors (e,b,d) found in the <u>Hydraulic Manual</u> is used; and, therefore, it must be entered on only one RADATA card. If conflicting factors are entered on separate cards, the last values entered will be used. The program can accept a total of 20 RADATA cards.

GAGED CARD (A-5) and GAGED CFS CARD (A-6)

The GAGED card (A-5) and the GAGED CFS cards (A-6) are required only when GAGED is specified on the METHOD card (A-1). (The stream gage data for this method is usually obtained from "Water Resources Data for Texas" available from USGS.)



On the GAGED card (A-5) the numeric gaging station description must be entered as a decimal number in the STATIONING field. (Station 08-2515.05 is entered as 82515.05). The user may supply any further description he desires in the field STATION NAME. This description will be reproduced on the output exactly as entered. The user must supply enough GAGED CFS cards to allow entry of data for each water year to be included in the analysis. A maximum of 100 water years may be considered and they must be entered in sequence with two per card, where the first card contains the first and second years, etc. Columns have been provided for both water year and date of event. A water year extends from October 1 through September 30, and the year is that of the month of January. Therefore, a flood (or event) which occurred on November 23, 1940, would be catalogued in water year 1941. The peak discharge to be entered for each year is the momentary maximum for that water year expressed in CFS. The user should ordinarily not enter less than 10 consecutive years of record when using this option.



Card ID

Same as for previous water year.

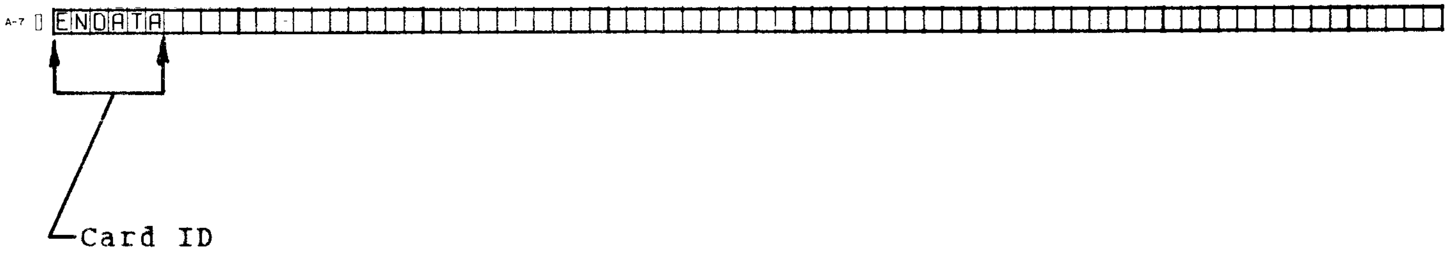
Momentary maximum flood for the given event in CFS.

For example, 12/18/69 or DEC181969.

Water year extends from Oct. 1 - Sept. 30.

ENDATA CARD (A-7)

An ENDATA card is required at the end of the data for each problem. For example, if the flow computed in a HYDRO problem is to be used in another subsystem then the input data for the second subsystem must be placed immediately following the ENDATA card for the HYDRO subsystem.



Card ID

Card Use Checklist

A tabulation of the required and optional cards for each of the HYDRO options is shown in Figure 3-3. This may be used to check the completed input form for possible omissions prior to submission.

HYDRO

CARD IDENT.	CARD TYPE OR REFERENCE	METHOD OR APPLICATION			
		USGS	RATIONAL	GAGED ANALYSIS	SUPPLY Q
CONTROL CARD	HYDRO	YES	YES	YES	YES
A-1	METHOD	YES	YES	YES	YES
A-2	BASEFLOW=	OPTIONAL[1]	OPTIONAL[1]	OPTIONAL[1]	OPTIONAL[1]
A-3	USGS	YES			
A-4	RADATA		YES[2]		
A-5	GAGED			YES	
A-6	GAGED CFS			YES[3]	
A-7	ENDATA	YES	YES	YES	YES

[1] Required if adjustments to computed flow are needed.
[2] A RADATA Card for each sub-area.
[3] Include enough GAGED CFS Cards to enter all water years to be considered, two per card.

FIGURE 3-3. CARD USE CHECKLIST

III. OUTPUT

Output for the HYDRO subsystem may consist of one of four different reports depending upon the procedure used.

U.S. Geological Survey (USGS) Procedure

The report for this procedure consists of the following information:

1. Region (1 through 6) - given
2. Frequency (yrs) - given
3. Drainage Area (sq mi) - given
4. Slope (ft/mi) - given
5. Annual Precipitation (in/yr) - given
6. Baseflow (cfs) - If given, otherwise omitted
7. Peak flow - computed
8. Q_{100} - computed.

Rational Procedure

The report for this procedure prints the following information.

1. Rainfall intensity factors (e, b, d) - given
2. For each subarea:
    a. Subarea identifications - given
    b. "C" coefficient - given
    c. Area (acres) - given
    d. Length (ft) - given
    e. Velocity (fps) - given
    f. Time of concentration (minutes) - given or computed
3. Total CA - computed
4. Total time of concentration (minutes) - computed
5. Rainfall intensity (inches per hour) - computed
6. Frequency - given

7. Total drainage area - given
8. Base flow - If given, otherwise omitted
9. Peak flow - computed.

Gaged Analysis Procedure

This is the only procedure in the THYSYS system that suppresses the direct printing of input cards as a part of the output to the user. Printing of the formal report for this procedure starts when the first GAGED CFS card (A-7) is read. Following the station number and station description the report contains the given water year, date of event and peak discharge for each year as they are read from the cards. Following this list of annual peak flows the report contains:

1. Frequency - given
2. Drainage area (sq mi) - given
3. Base flow (cfs) - If given, otherwise omitted
4. Peak flow - computed
5. Q_{100} - computed.

Supply Q

All values for this report are supplied by the user and include the following:

1. User supplied flow (cfs)
2. Frequency (yrs)
3. Drainage area (in units as given by user, either acres or sq mi)
4. Base flow - If given, otherwise omitted
5. Peak flow (cfs).

**************** ERROR MESSAGES ****************
************** TEXAS HYDRAULIC SYSTEM **************

ERROR MESSAGES ARE GROUPED BY ALPHABETIC PREFIX FOR EACH SUBSYSTEM AND ARE LISTED IN NUMERICAL ORDER WITHIN EACH GROUP. 'EXPL' DENOTES A DETAILED EXPLANATION OF THE ERROR MESSAGE. (FOR ADDITIONAL INFORMATION AND ASSISTANCE CONTACT THE BRIDGE DIVISION HYDRAULIC SECTION OR THE DIVISION OF AUTOMATION FIELD ENGINEER FOR YOUR DISTRICT.)

****

HY00001--NO DRAINAGE AREA DIMENSION GIVEN
EXPL¤ ON THE 'HYDRO' CONTROL CARD NEITHER 'ACRES' NOR 'SQMI' WAS SPECIFIED. FATAL ERROR IF 'USGS' OR 'RATIONAL' WAS SPECIFIED.

HY00002--NO DRAINAGE AREA GIVEN
EXPL¤ ON THE 'HYDRO' CONTROL CARD NO 'DA' IS ENTERED.

HY00003--FREQUENCY GIVEN NOT EQUAL TO 2, 5, 10, 25, 50, OR 100
EXPL¤ THE ROUTINE CAN ACCOMODATE HYDROLOGY COMPUTATIONS FOR ONLY THESE 6 FREQUENCY VALUES.

HY00004--NO FREQUENCY GIVEN
EXPL¤ ON THE 'METHOD' CARD (A-1) NO FREQUENCY WAS INDICATED. FATAL ERROR IF 'USGS OR GAGED ANALYSIS' WAS SPECIFIED.

HY00005--UNIDENTIFIED COMMAND CARD IGNORED
EXPL¤ THE CARD IMMEDIATELY PRECEDING THIS MESSAGE IS NOT RECOGNIZED BY THE PROGRAM AS AN INPUT CARD FOR THE 'HYDRO' SUBSYSTEM. THE PROBLEM WILL BE COMPUTED IF THE OTHER CARDS CONTAIN THE INFORMATION REQUIRED FOR THE SOLUTION. NON-FATAL.

HY00006--PROBABLE BLANK CARD
EXPL¤ THE CARD IMMEDIATELY PRECEDING THIS MESSAGE HAD NO ENTRIES IN POSITIONS SCANNED BY THE PROGRAM. THE CARD WAS ASSUMED TO BE BLANK, AND CONSEQUENTLY WAS IGNORED. THE PROBLEM WILL STILL BE COMPUTED IF NECESSARY INFORMATION IS PROVIDED ON OTHER CARDS. NON-FATAL.

HY00007--INVALID USGS REGION GIVEN
EXPL¤ ON THE 'USGS' CARD (A-3) A HYDROLOGIC REGION OTHER THAN ONE WITH A NUMERAL 1 THROUGH 6 WAS ENTERED. FATAL ERROR IF 'USGS' WAS SPECIFIED.

HY00008--FOR HYDROLOGIC REGION * * A SLOPE VALUE MUST BE PROVIDED
EXPL¤ FOR REGIONS 1,2,4,&5 THE USGS PROCEDURE REQUIRES A GIVEN SLOPE VALUE.

HY00009--TOO MANY RADATA CARDS READ. PROGRAM CAN ACCEPT NO MORE THAN 20.
EXPL¤ IF MORE THAN 20 SUBAREAS ARE TO BE CONSIDERED, THE USER MUST COMBINE SUBAREAS HAVING THE SAME RUNOFF COEFFICIENTS. FATAL ERROR.

HY00010--FOR HYDROLOGIC REGION 6 A PRECIPITATION VALUE MUST BE PROVIDED
EXPL¤ USGS PROCEDURES REQUIRES A PRECIP.VALUE IF REGION 6 IS SPECIFIED.

HY00011--THE (A-1) CARD (METHOD) IS MISSING
EXPL¤ EITHER THE 'METHOD' CARD (A-1) WAS NOT COMPLETED OR THE METHOD SELECTED WAS NOT PROPERLY ENTERED ON THE CARD, CAUSING THE PROGRAM TO BE UNABLE TO RECOGNIZE THE DESIRED PROCEDURE. FATAL ERROR.

HY00012--NO METHOD SPECIFIED ON METHOD CARD A-1

EXPL□ A METHOD CARD WAS PROVIDED BUT METHOD WAS NOT PROPERLY SPECIFIED.

HY00013--USGS PROCEDURE MAY NOT BE USED FOR A DRAINAGE AREA OF * * SQUARE MILES
EXPL□ USGS PROCEDURE MAY BE USED ONLY FOR DRAINAGE AREAS GREATER THAN 200 ACRES AND LESS THAN 3000 SQUARE MILES.

HY00014--USE OF RATIONAL METHOD IS NOT RECOMMENDED FOR DRAINAGE AREAS IN EXCESS OF 200 ACRES.
EXPL□ 'RATIONAL' WAS SPECIFIED BUT 'DA' WAS GREATER THAN 200 ACRES.

HY00015--RATIONAL COEFFICIENT MISSING.
EXPL□ THE PROGRAM ATTEMPTED TO WORK THE PROBLEM USING THE 'RATIONAL' METHOD BUT FOUND AT LEAST ONE SUBAREA WITH NO 'C' COEFFICIENT ENTERED. FATAL ERROR.

HY00016--TOTAL ACRES ON RATIONAL METHOD INPUT CARDS DISAGREES WITH DRAINAGE AREA ON HYDRO CARD.
EXPL□ THE PROGRAM ATTEMPTED TO WORK THE PROBLEM USING THE 'RATIONAL' METHOD AND FOUND A DISCREPANCY BETWEEN THE SUM OF THE SUBAREA SIZES AND THE DRAINAGE AREA SHOWN ON THE 'HYDRO' CONTROL CARD AND IT ASSUMED THE SUM OF THE SUBAREA SIZES WAS CORRECT. NON-FATAL ERROR.

HY00017--COEFFICIENTS E, B, OR D MISSING
EXPL□ THE PROGRAM ATTEMPTED TO WORK THE PROBLEM WITH THE 'RATIONAL' METHOD BUT FOUND AT LEAST ONE OF THE RAINFALL INTENSITY FACTORS (E, B, OR D) MISSING. FATAL ERROR.

HY00018--STATION IDENTIFICATION NOT GIVEN FOR GAGED ANALYSIS
EXPL□ THE PROGRAM ENTERED THE 'GAGED ANALYSIS' PROCEDURE AND FOUND NO GAGING STATION IDENTIFICATION. THE PROGRAM WILL PROCEED IF OTHER GIVEN GAGED DATA IS ADEQUATE. NON-FATAL.

HY00019--NO GAGED DATA GIVEN
EXPL□ THE PROGRAM ATTEMPTED TO WORK THE PROBLEM USING THE 'GAGED ANALYSIS' PROCEDURE BUT FOUND NO GAGED DATA. FATAL ERROR.

HY00020--ONLY * * YEARS OF DATA SUPPLIED. A MINIMUM OF * * CONSECUTIVE YEARS OF RECORD SHOULD BE SUPPLIED FOR A FREQUENCY PERIOD OF * * YEARS. USE OF THIS METHOD IN THIS INSTANCE SHOULD BE COORDINATED WITH D-5 BRIDGE DIVISION.
EXPL□ IN A GAGED ANALYSIS, STATISTICAL REQUIREMENTS ARE THAT THE DISCHARGE DETERMINATION COMPUTATIONS CONFORM TO THE FOLLOWING

FREQ.	MIN. YEARS OF GAGED DATA
5	5
10	10
25	15
50	20
100	25

HY00021--NO Q CFS DATA SUPPLIED
EXPL□ SUPPLY Q WAS SPECIFIED ON THE 'METHOD' CARD (A-1) BUT NO VALUE WAS ENTERED FOR 'Q'. FATAL ERROR IF 'SUPPLY Q' WAS SPECIFIED.

HY00022--RATIONAL SUB-AREA MISSING.
EXPL□ THE PROGRAM ATTEMPTED TO WORK THE PROBLEM USING THE 'RATIONAL' METHOD BUT FOUND AT LEAST ONE SUBAREA SIZE MISSING. FATAL ERROR.

HY00023--ABSOLUTE VALUE OF SKEW COEFFICIENT EXCEEDS 4.1 - M= * *, S= * *, G= * *.
EXPL□ IN THE 'GAGED ANALYSIS' PROCEDURE THE CALCULATED ABSOLUTE VALUE OF THE SKEW COEFFICIENT EXCEEDS THE MAXIMUM ALLOWABLE OF 4.1.

VALUES OF M,S AND G ARE GIVEN TO AID IN LOCATING THE PROBLEM. THE USER SHOULD CONSULT THE D-5 HYDRAULIC SECTION WHEN THE OUTPUT CONTAINS THIS MESSAGE. FATAL ERROR.

PART IV - CHANNEL ANALYSIS SUBSYSTEM (HYDRA)

Channel Analysis Subsystem (HYDRA)

CHANNEL ANALYSIS SUBSYSTEM (HYDRA)

I. DESCRIPTION

The function of the HYDRA subsystem is to calculate water surface elevations and/or the cumulative conveyance across a cross-section and/or store cross-sections for use in the CULBRG subsystem. Three methods of determining water surface elevations are available:

1. One Section Method
2. Two Section Method
3. Many Section Method

In the One Section method calculations are based on a single cross-section. The Two Section method bases its calculations on two cross-sections with the option of interpolating or extrapolating results to a third cross-section. In the Many Section method, calculations are based on as many as 50 cross-sections with 25 starting tailwaters. For each of the three methods as many as four different flows may be considered in one pass.

The user may stack problems for any of the above methods by entering all the data on each card he wishes to change and following each set of revised data with an ENDATA card. The first solution following the last HYDRA card will be retained for use in CULBRG. Several move operations and/or several cumulative conveyances can be processed in one pass using this procedure.

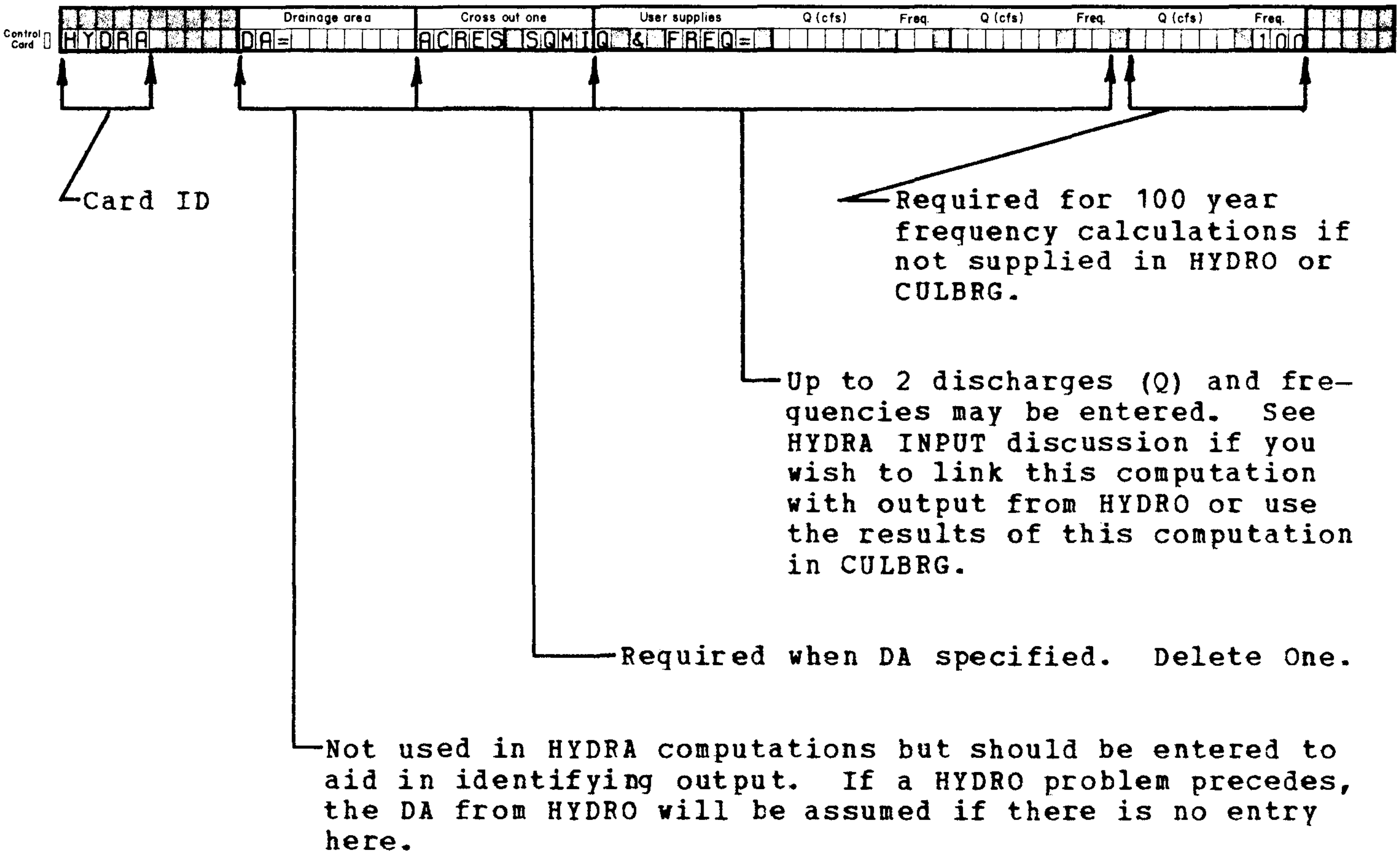
HYDRA also has the capability of translating and/or rotating an existing cross-section to create a new cross-section. The maximum number of points to describe a cross-section is 100. Each cross-section may be divided into a maximum of 10 subsections with different "n" coefficients in each. Additionally, each subsection may be further subdivided at a specified elevation and two different "n" values assigned.

II. INPUT

The data form for the HYDRA subsystem is printed on the front and back and is shown in Figures 4-1 and 4-2.

HYDRA CONTROL CARD

The HYDRA Control Card is required for entry into the HYDRA subsystem. This subsystem is designed to use a peak discharge (computed in HYDRO or entered directly in HYDRA) to compute a tailwater which in turn may be used in the CULBRG subsystem. If the user intends to use a HYDRO supplied peak discharge in HYDRA, he may omit the entry for drainage area on the HYDRA Control Card and it will be assumed to be the same as that used in the preceding HYDRO problem. Otherwise, the drainage area should be entered on this card although it is not necessary for computations in HYDRA.



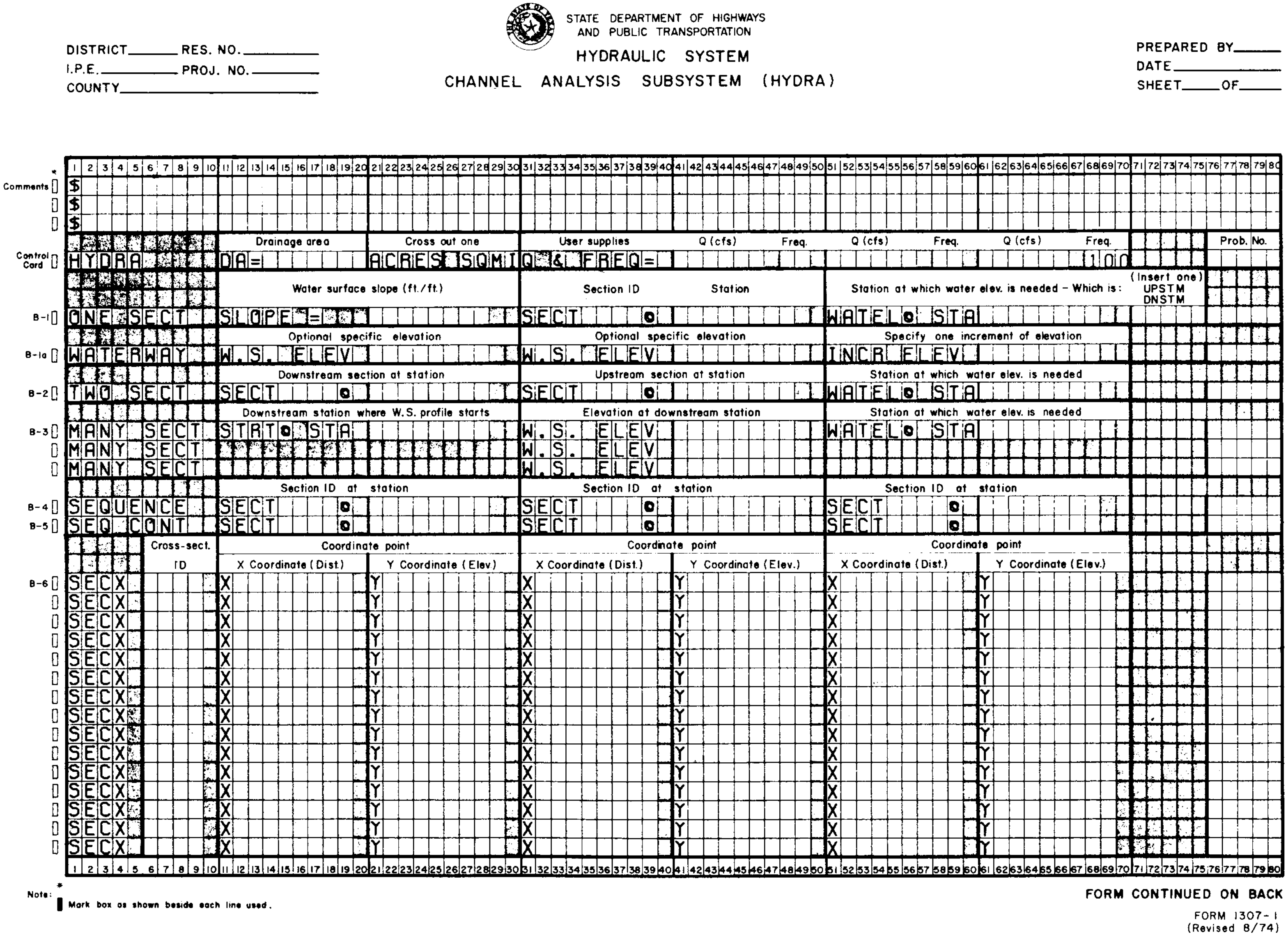
Card ID

Required for 100 year frequency calculations if not supplied in HYDRO or CULBRG.

Up to 2 discharges (Q) and frequencies may be entered. See HYDRA INPUT discussion if you wish to link this computation with output from HYDRO or use the results of this computation in CULBRG.

Required when DA specified. Delete One.

Not used in HYDRA computations but should be entered to aid in identifying output. If a HYDRO problem precedes, the DA from HYDRO will be assumed if there is no entry here.



STATE DEPARTMENT OF HIGHWAYS
AND PUBLIC TRANSPORTATION

HYDRAULIC SYSTEM

CHANNEL ANALYSIS SUBSYSTEM (HYDRA)

DISTRICT______ RES. NO.__________
I.P.E.______ PROJ. NO.__________
COUNTY______________________

PREPARED BY______
DATE______________
SHEET_____OF_____

Comments ▯	$							
▯	$							
▯	$							
		Drainage area	Cross out one	User supplies	Q (cfs) Freq.	Q (cfs) Freq.	Q (cfs) Freq.	Prob. No.
Control Card ▯	HYDRA	DA=	ACRES SQMI	Q & FREQ=			100	
		Water surface slope (ft./ft.)		Section ID	Station	Station at which water elev. is needed – Which is:		(Insert one) UPSTM DNSTM
B-1 ▯	ONE SECT	SLOPE = .		SECT .		WATEL . STA		
		Optional specific elevation		Optional specific elevation		Specify one increment of elevation		
B-1a ▯	WATERWAY	W.S. ELEV		W.S. ELEV		INCR ELEV		
		Downstream section at station		Upstream section at station		Station at which water elev. is needed		
B-2 ▯	TWO SECT	SECT .		SECT .		WATEL . STA		
		Downstream station where W.S. profile starts		Elevation at downstream station		Station at which water elev. is needed		
B-3 ▯	MANY SECT	STRT . STA		W.S. ELEV		WATEL . STA		
▯	MANY SECT			W.S. ELEV				
▯	MANY SECT			W.S. ELEV				
		Section ID at station		Section ID at station		Section ID at station		
B-4 ▯	SEQUENCE	SECT .		SECT .		SECT .		
B-5 ▯	SEQ CONT	SECT .		SECT .		SECT .		
	Cross-sect. ID	Coordinate point X Coordinate (Dist.)	Y Coordinate (Elev)	Coordinate point X Coordinate (Dist.)	Y Coordinate (Elev.)	Coordinate point X Coordinate (Dist.)	Y Coordinate (Elev.)	
B-6 ▯	SECX	X	Y	X	Y	X	Y	
▯	SECX	X	Y	X	Y	X	Y	
▯	SECX	X	Y	X	Y	X	Y	
▯	SECX	X	Y	X	Y	X	Y	
▯	SECX	X	Y	X	Y	X	Y	
▯	SECX	X	Y	X	Y	X	Y	
▯	SECX	X	Y	X	Y	X	Y	
▯	SECX	X	Y	X	Y	X	Y	
▯	SECX	X	Y	X	Y	X	Y	
▯	SECX	X	Y	X	Y	X	Y	
▯	SECX	X	Y	X	Y	X	Y	
▯	SECX	X	Y	X	Y	X	Y	
▯	SECX	X	Y	X	Y	X	Y	
▯	SECX	X	Y	X	Y	X	Y	
▯	SECX	X	Y	X	Y	X	Y	

Note: * ▌ Mark box as shown beside each line used.

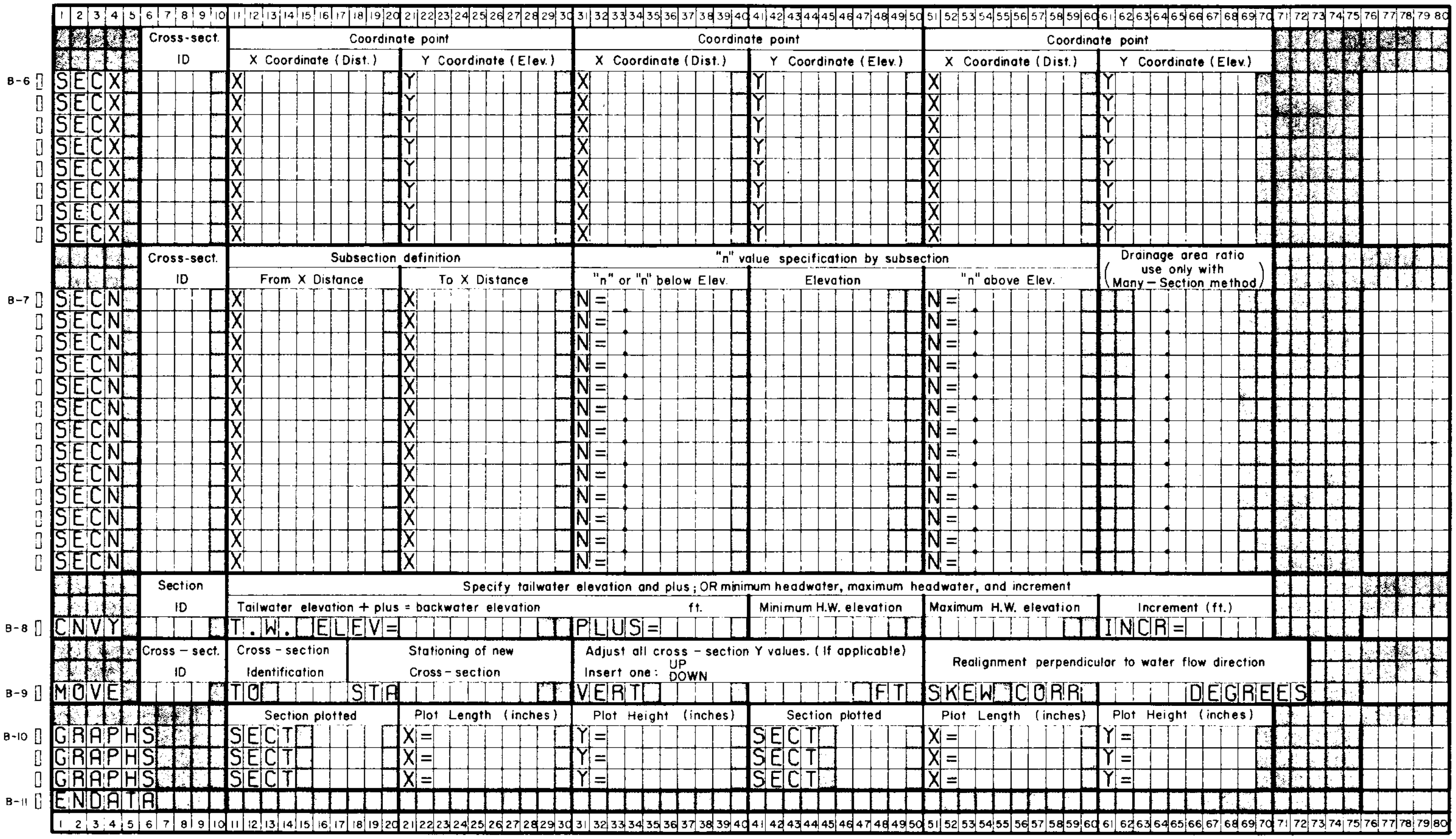
FORM CONTINUED ON BACK

FORM 1307-1
(Revised 8/74)

FIGURE 4-1. FRONT SIDE OF THE CHANNEL ANALYSIS SUBSYSTEM (HYDRA) INPUT FORM

HYDRA (Continued)

BACK , SHEET ______ OF______



		Cross-sect. ID	Coordinate point		Coordinate point		Coordinate point	
			X Coordinate (Dist.)	Y Coordinate (Elev.)	X Coordinate (Dist.)	Y Coordinate (Elev.)	X Coordinate (Dist.)	Y Coordinate (Elev.)
B-6 ☐	SECX		X	Y	X	Y	X	Y
☐	SECX		X	Y	X	Y	X	Y
☐	SECX		X	Y	X	Y	X	Y
☐	SECX		X	Y	X	Y	X	Y
☐	SECX		X	Y	X	Y	X	Y
☐	SECX		X	Y	X	Y	X	Y
☐	SECX		X	Y	X	Y	X	Y
☐	SECX		X	Y	X	Y	X	Y

		Cross-sect. ID	Subsection definition		"n" value specification by subsection			Drainage area ratio (use only with Many – Section method)
			From X Distance	To X Distance	"n" or "n" below Elev.	Elevation	"n" above Elev.	
B-7 ☐	SECN		X	X	N = .		N = .	.
☐	SECN		X	X	N = .		N = .	.
☐	SECN		X	X	N = .		N = .	.
☐	SECN		X	X	N = .		N = .	.
☐	SECN		X	X	N = .		N = .	.
☐	SECN		X	X	N = .		N = .	.
☐	SECN		X	X	N = .		N = .	.
☐	SECN		X	X	N = .		N = .	.
☐	SECN		X	X	N = .		N = .	.
☐	SECN		X	X	N = .		N = .	.
☐	SECN		X	X	N = .		N = .	.
☐	SECN		X	X	N = .		N = .	.
☐	SECN		X	X	N = .		N = .	.

		Section ID	Specify tailwater elevation and plus ; OR minimum headwater, maximum headwater, and increment			
			Tailwater elevation + plus = backwater elevation ft.	Minimum H.W. elevation	Maximum H.W. elevation	Increment (ft.)
B-8 ☐	CNVY		T. W. ELEV= PLUS=			INCR=

		Cross – sect. ID	Cross – section Identification	Stationing of new Cross – section	Adjust all cross – section Y values. (If applicable) Insert one : UP DOWN	Realignment perpendicular to water flow direction
B-9 ☐	MOVE		TO	STA	VERT FT	SKEW CORR DEGREES

		Section plotted	Plot Length (inches)	Plot Height (inches)	Section plotted	Plot Length (inches)	Plot Height (inches)
B-10 ☐	GRAPHS	SECT	X =	Y =	SECT	X =	Y =
☐	GRAPHS	SECT	X =	Y =	SECT	X =	Y =
☐	GRAPHS	SECT	X =	Y =	SECT	X =	Y =
B-11 ☐	ENDATA						

FORM 1307 - 2
(Revised 8/74)

FIGURE 4-2. BACK SIDE OF THE CHANNEL ANALYSIS SUBSYSTEM (HYDRA) INPUT FORM

It is expected that only one discharge will usually be considered per problem; however, the user may wish to compute tailwaters for several discharges at the same site although only one may be passed on for use in CULBRG. Therefore, spaces have been provided on the HYDRA Control Card for entry of three optional sets of discharge and frequency with one set (the rightmost) being reserved for entry of 100 year flood frequency discharge. If a discharge has been computed using HYDRO prior to entry into HYDRA, then this discharge will be considered before those entered on the HYDRA Control Card; and it, along with its computed tailwater, will be passed to the CULBRG subsystem.

Provisions have been made in HYDRA for computing a 100 year flood (basic flood) frequency. The tailwater is calculated in HYDRA and passed on to CULBRG for further basic flood calculations. This feature is entirely separate and is in addition to the normal computations carried out and passed on to the rest of the system. The Q for the 100 year (basic flood) frequency is entered on the HYDRA Control Card. This computed tailwater is only available for use in 100 year flood frequency calculations.

The following is a summary of the options available for entering a peak discharge into HYDRA for computation of tailwater. The summary also shows the values of peak discharge and tailwater which are passed on to CULBRG.

IF HYDRO NOT USED

HYDRA	CULBRG
Q_1, Q_2 (From HYDRA Control Card) TW_1, TW_2 - computed	Q_1 and TW_1 used in CULBRG calculations

IF HYDRO USED

HYDRO	HYDRA	CULBRG
Q_1 – computed	Q_1 (From HYDRO) Q_2, Q_3 (From HYDRA Control Card) TW_1, TW_2, TW_3 – computed	Q_1 and TW_1 used in CULBRG calculations

If several HYDRO problems precede HYDRA, the last HYDRO computed discharge will be used. If a HYDRO problem precedes a HYDRA run and the user wishes to enter HYDRA with a different known input discharge for use in CULBRG, it will be necessary for the known discharge to be entered through the HYDRO subsystem by entering it under SUPPLY Q on the METHOD card (A-1) and as a separate HYDRO problem immediately preceding the entry into HYDRA.

FIRST HYDRO	SECOND HYDRO	HYDRA	CULBRG
Q – computed (Not for use in HYDRA and/or CULBRG)	Q_1 – computed or entered under SUPPLY Q (For use in HYDRA and/or CULBRG)	Q_1 (From HYDRO) Q_2, Q_3 (From HYDRA Control Card) TW_1, TW_2, TW_3 – computed	Q_1 and TW_1 used in CULBRG calculations

If no discharge was previously determined using HYDRO or if a previous HYDRA computation has used the discharge computed in HYDRO, then the first discharge entered on the latest HYDRA Control card and its computed tailwater will be passed to the CULBRG subsystem.

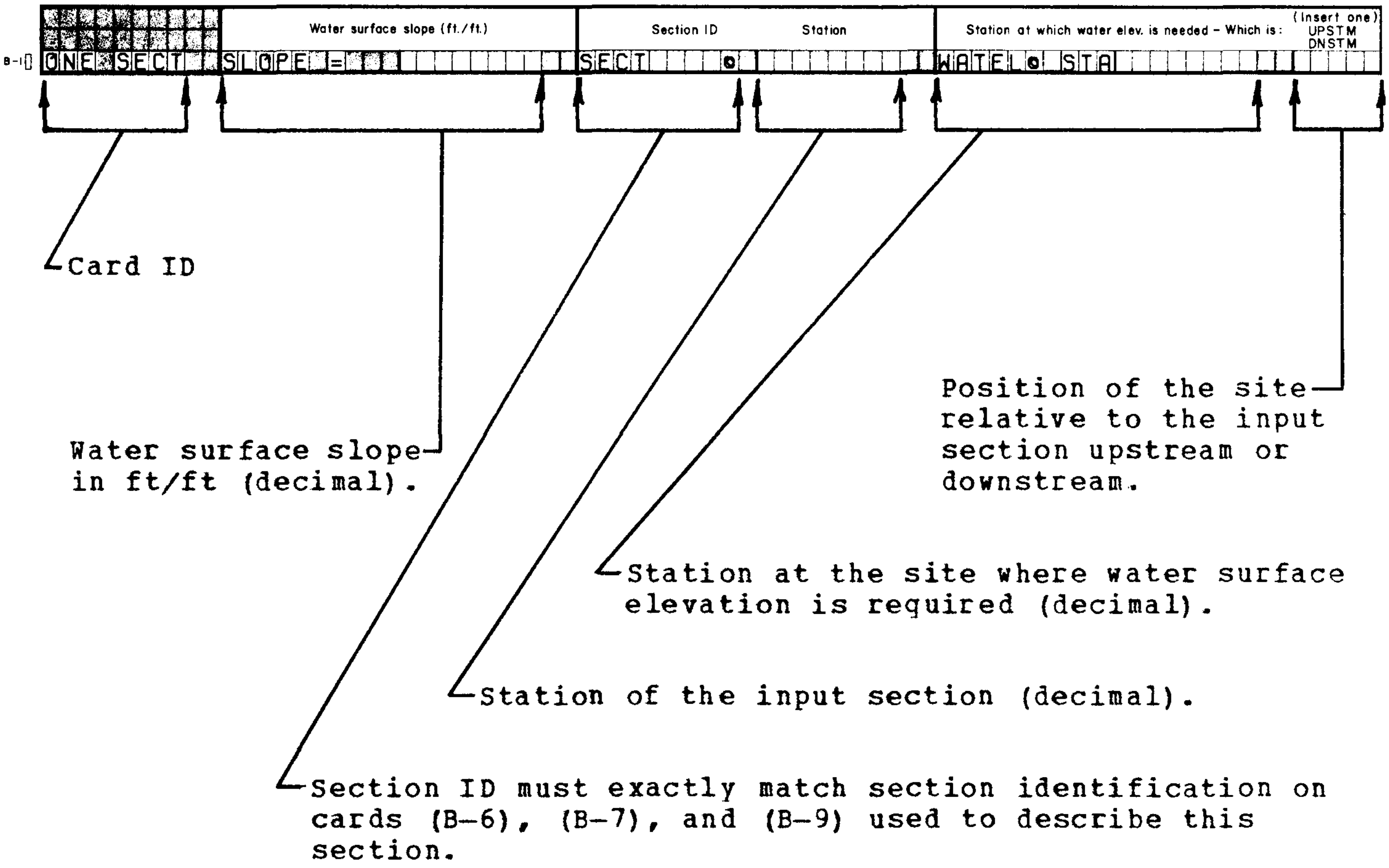
HYDRO	HYDRA	HYDRA	CULBRG
Q_1 – computed	Q_1 (From HYDRO) Q_2, Q_3 (From HYDRA Control Card) TW_1, TW_2, TW_3 – computed	Q_4, Q_5 (From HYDRA Control Card) TW_4, TW_5 – computed	Q_4 and TW_4 used in CULBRG calculations

Methods of Computation

The HYDRA subsystem gives the user the choice of three computational methods for TW elevation determination depending upon the amount of information given. Regardless of the option selected, the user must always supply data describing the referenced cross-sections. This data must contain information concerning the shape of the channel and the Manning's roughness coefficient ("n" value). These values will be entered on SECX cards (B-6) and SECN cards (B-7) which will be discussed later.

ONE SECT CARD (B-1)

The ONE SECT card (B-1) is required when the user wishes to employ the ONE SECTION method (a routine for computing a stage-discharge or rating curve) or to request WATERWAY computations for a specified channel cross-section. With the ONE SECTION method or WATERWAY request, the user must supply the cross-section data for one section (usually a typical cross-section for the stream reach), the slope of the channel and the position of the structure site relative to the given section. This structure position should normally be given at a stream station in the vicinity of the downstream end of the culvert or the centerline of the bridge. The value for slope must be entered in ft/ft. The cross-section identification entered in the field SECTION ID may be any alphanumeric identification which the user wishes to assign to the cross-section being defined. The stream station must be a decimal number. The stream station at the job site must be entered in the field STATION and the position of the site relative to the input section must be given in the field UPSTM, DNSTM (upstream, downstream).



Card ID

Water surface slope in ft/ft (decimal).

Position of the site relative to the input section upstream or downstream.

Station at the site where water surface elevation is required (decimal).

Station of the input section (decimal).

Section ID must exactly match section identification on cards (B-6), (B-7), and (B-9) used to describe this section.

For the problem illustrated in Figure 4-3, the entry for the position of the site should be DNSTM. If the input cross-section is at the site, either UPSTM or DNSTM may be entered. If neither is entered, DNSTM is assumed.

WATERWAY CARD (B-1a)

The WATERWAY card (B-1a) is optional and is used in conjunction with the standard input required for a ONE SECTION method application. WATERWAY provides a solution(s) to Manning's formula covering a specified range of incremented elevations and "n" values for a given cross-section. For each elevation, a table of "n" values and the resulting area, wetted perimeter, hydraulic radius, velocity and K-factor are printed. Total area, discharge and Q/A are also printed. The output produced is described in Section III, Output.

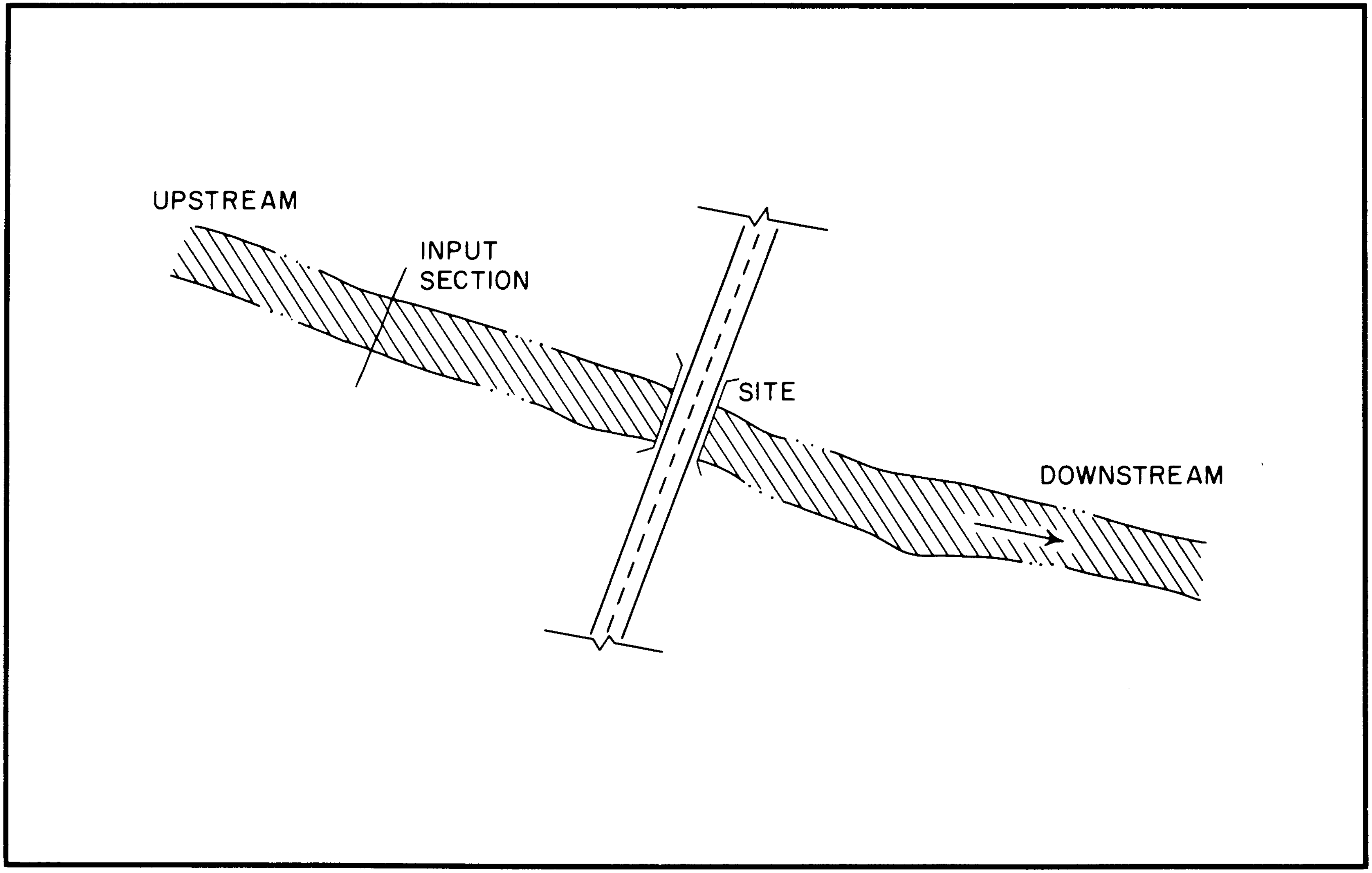
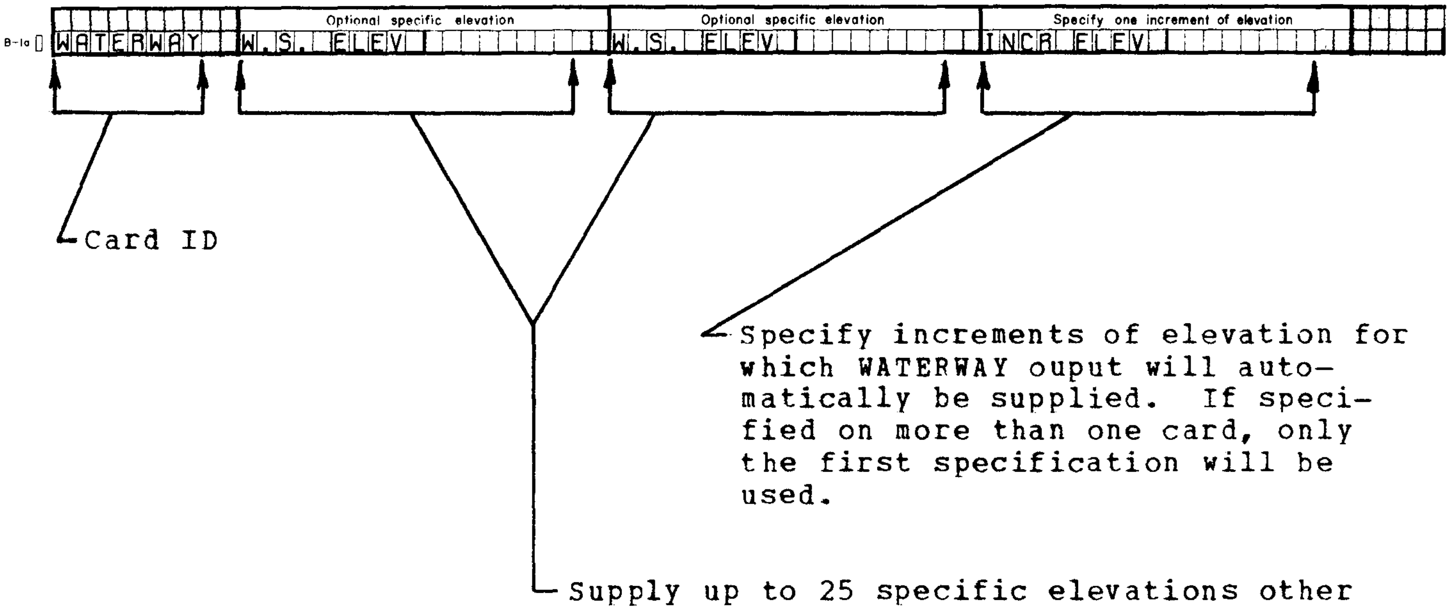


FIGURE 4-3. ILLUSTRATION OF A DOWNSTREAM (DNSTM) SITE RELATIVE TO INPUT SECTION



Card ID

Specify increments of elevation for which WATERWAY ouput will automatically be supplied. If specified on more than one card, only the first specification will be used.

Supply up to 25 specific elevations other than the automatically selected incremental elevations at which WATERWAY output is desired. Use as many of this type of card as required.

Output from the WATERWAY computations will be printed if WATERWAY is punched on card B-1a. If the user does not enter on this card optional specific elevations and elevation increments, then the system will print the data listed above for each one foot of elevation beginning with the lowest even foot in the given cross-section and proceeding in one foot increments to the highest possible water surface elevation in the cross-section. If the highest possible water surface elevation does not occur on an even increment, then an extra output is produced for that elevation.

If increments other than one foot are desired, the user may specify the increment of elevation in the INCR ELEV. field on the WATERWAY card (B-1a). Increments may be specified no smaller than 0.1 foot. (If smaller increments are specified, the program defaults to 1.0 foot increments.) If small increments are specified, care should be exercised to prevent exceeding 250 elevations, the maximum number allowed. Only one increment size may be specified in each run. If more than 250 water surfaces are indicated, the program will accept only the highest 250 elevations.

If the user wishes WATERWAY output at specific elevations that may not occur at even increments, he may indicate up to 25 such elevations on successive WATERWAY cards (B-1a). These additional cards should reflect only the WATERWAY entry and the desired specific elevations in the two W.S. ELEV fields. These given elevations will then be inserted by the program in their proper order within the incremental elevations.

The WATERWAY option permits the user to specify "n" value boundaries at points other than at breaks in the cross-section and also permits a change in "n" value within a subsection at a given elevation as described in SECN cards (B-7). (See Figure 4-6.) When such a change is specified, the program arbitrarily establishes a linear transition from one "n" value to the other covering .5 foot above to .5 foot below the change elevation. This transition will cause the output to contain some "n" values which were not specified.

TWO SECT CARD (B-2)

The TWO SECT card (B-2) is required for the TWO SECTION method. This method employs the interaction of the respective conveyances of each section to determine a hydraulic slope and water elevation. This method requires more information for its use but the results obtained are considered to be more accurate than those from the ONE SECTION method. If the TWO SECTION method is used, the cross-section data and stream station for the downstream section and the upstream section must be provided in addition to the stream station at the structure site. On the B-2 card, fields are provided for entering

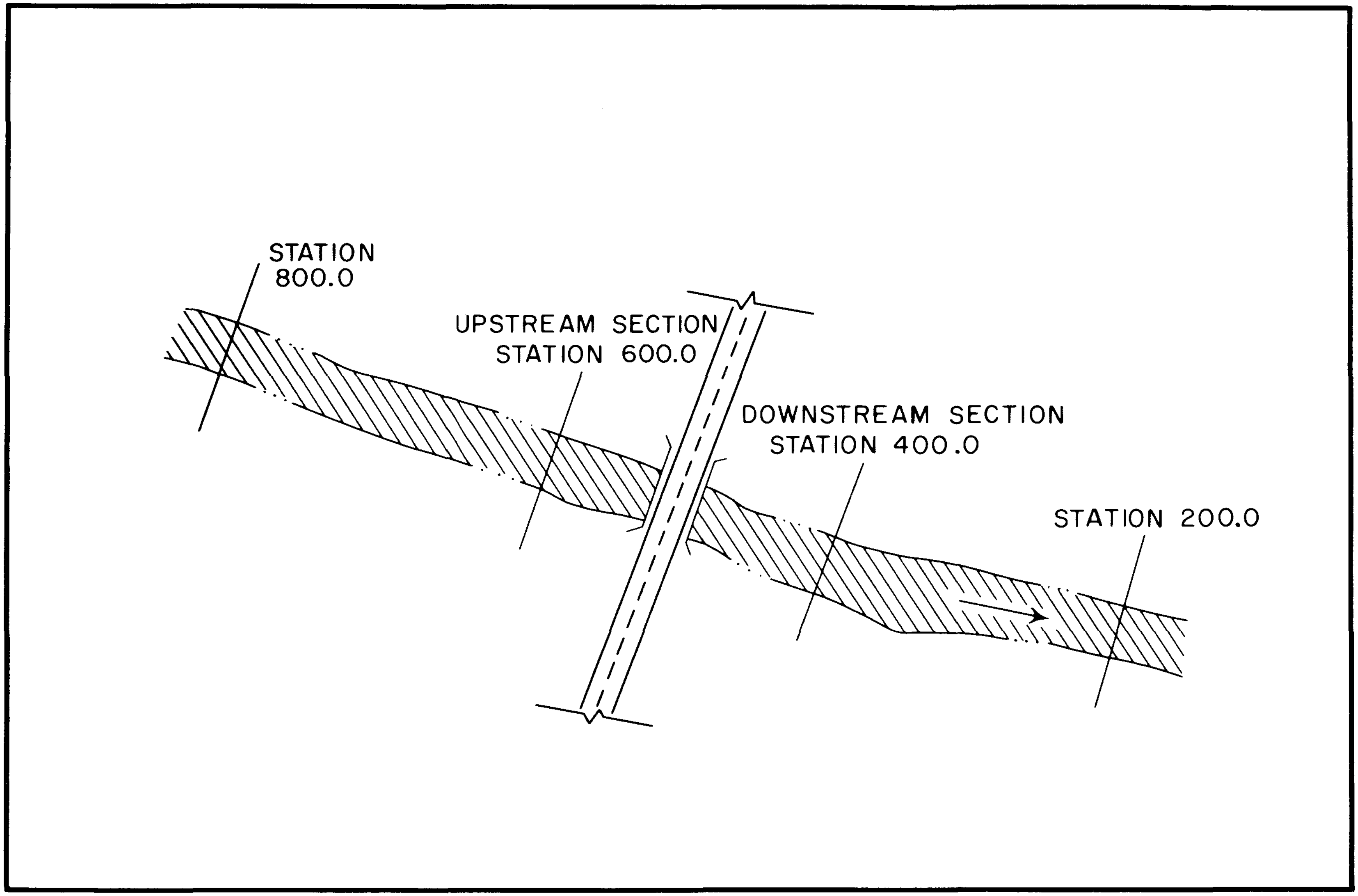
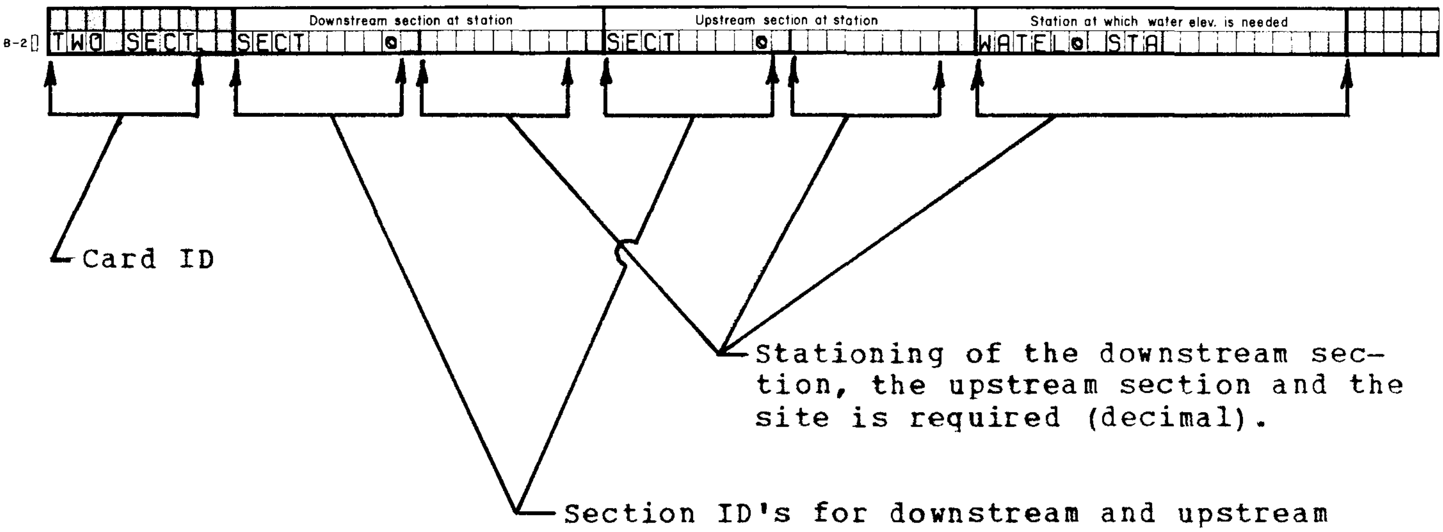


FIGURE 4-4. LIMITS OF ALLOWABLE SITES FOR TWO SECTION METHOD

the cross-section name (ID) and corresponding station for the downstream and upstream sections. The stream station at the structure site must be entered in the WATEL@STA field.



Card ID

Stationing of the downstream section, the upstream section and the site is required (decimal).

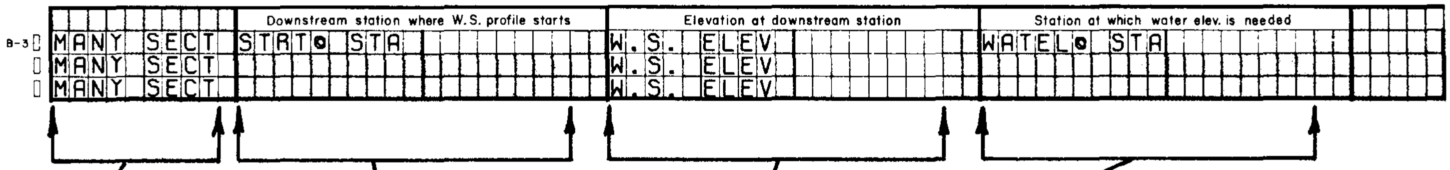
Section ID's for downstream and upstream cross-sections are required and must exactly match the ID's for these cross-sections on SECX and SECN cards used to describe them.

Normally the structure site should be located between the upstream and downstream sections; however, the program will accept a site which lies outside the two sections if the distance from the nearest section does not exceed the distance between the input sections. For example, in Figure 4-4, any site from Station 200.0 to Station 800.0 would be acceptable but, preferably, the design site would lie between Station 400.00 and Station 600.00. It should be noted that if extrapolations from the two input sections are necessary, a certain amount of reliability is lost in the final answer.

Reasons For Two-Section Failures

Computations in this method are based on the premise that discharge is continuous and unchanged and the water surface slope is constant. Therefore, conveyance at the upstream section necessarily equals conveyance at the downstream section since conveyance (K) is equal to the discharge (Q) divided by the square root of the water surface slope. But conveyance is also equal to (1.486 X $AR^{2\ 3}$) "n" which yields conveyances that are a direct function of the cross-sections and "n" values supplied. This can then result in computed water surface slopes that will not physically fit between the two cross-sections with the specified design discharge. (Refer to Appendix C for a more detailed explanation of the TWO SECTION METHOD failures.)

MANY SECT CARD (B-3)



Card ID

Stationing of site (structure location) at which final calculated W.S. ELEV is desired. If no station is given, backwater profiles will be calculated but no tailwater determination will be made.

Water surface elevation at the cross-section farthest downstream. Up to 25 starting W.S. ELEV may be considered. These may be entered on subsequent MANY SECT cards containing only the CARD ID and W.S. ELEV.

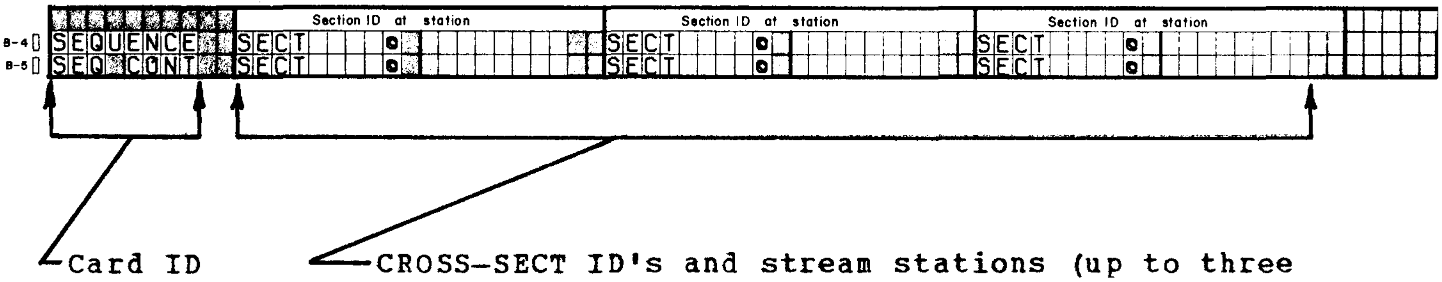
Stationing of the profile of the cross-section farthest downstream.

The MANY SECTION method requires more input data than either the

ONE SECTION or TWO SECTION method, but the results are usually highly reliable. This method employs the step-backwater procedure and may use up to 50 sections downstream of the site. Reference is made to Chapter 3 in the Hydraulic Manual for further discussion of this method. On the first MANY SECT card (B-3) the user must enter (1) the stream station of the cross-section that is farthest downstream in the water surface profile, (2) the first assumed water surface elevation, and (3) the stream station at the structure site. Up to 25 assumed water surface elevations may be entered on subsequent MANY SECT cards (B-3) by entering only MANY SECT and W. S. ELEV. This feature allows the designer to examine the convergence of profiles for the various backwater curves generated if the starting elevation is considered to be unreliable. The starting stream station and site stream station are required on only the first MANY SECT card.

SEQUENCE CARD (B-4) AND SEQ CONT CARD (B-5)

In addition to the MANY SECT card, the MANY SECTION method requires a single SEQUENCE card (B-4) and as many SEQ CONT cards (B-5) as needed to show the stream stations of the cross-sections to be considered for the MANY SECTION procedure. Section ID's and stream stations of all cross-sections considered in the MANY SECTION procedure must be entered on these cards with as many as three entries per card. Up to 50 cross-sections can be stored in the program. It is not necessary to fill all blanks on these cards but the entries must proceed from left to right across the card. The program checks the cards from left to right and goes to the next card when it encounters a blank Section ID. The section identifications must exactly match section identifications for these sections on SECX and SECN cards used to describe them.

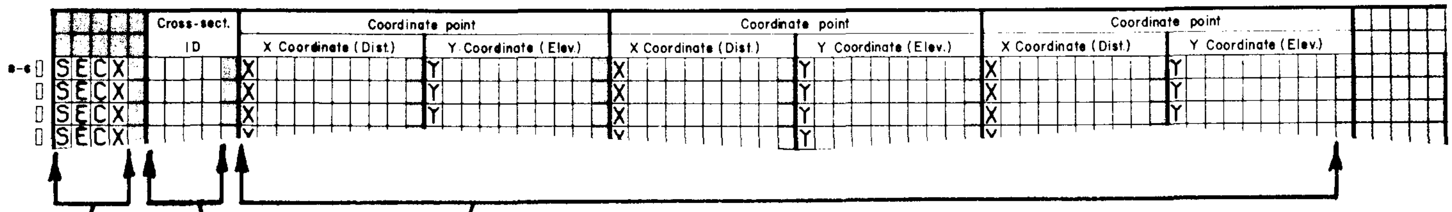


Card ID

CROSS-SECT ID's and stream stations (up to three sections per card). The first two section names and stationing must be entered in the proper sequence to establish the direction of stationing.

SECX CARDS (B-6) AND SECN CARDS (B-7)

The SECX cards (B-6) and SECN cards (B-7) are required in all HYDRA runs to enter data describing each cross-section named in any of the methods being used. The SECX cards (B-6) may also be used to describe the road profile along the crown line of the road which is required for a 100 year flood analysis. When using SECX cards (B-6) for defining the road profile, the identifier HIWY must be entered in the CROSS-SECT ID field. Otherwise the CROSS-SECT ID on each card must exactly correspond to the cross-section names given on the B-1, B-2, B-4 or B-5 cards referring to the cross-section being described. The SECX cards are used to describe the shape of the cross-section by using a coordinate system in which the X COORDINATE represents the point location across the section in feet and the Y COORDINATE represents the elevation in feet. The entry for X must never exceed ± 99999.99. Each card allows space to enter three points. The program will accept a maximum of 100 points per section. Points (X,Y) may be input in any order, except for the provision that the first two X values input must be in the proper order to establish orientation of the cross-section. The other points will then automatically be arranged by the program in their proper order throughout the cross-section, regardless of the order in which they are entered.



Card ID

The X COORDINATE refers to the distance of the point across the section traverse and the Y COORDINATE refers to the elevation of the points. These points may be entered, 3 per card, to a maximum of 100 points per section. All coordinates must be entered in feet as decimal numbers. Stationing of X COORDINATES may be arbitrarily increasing or decreasing, positive or negative. The absolute value of the X COORDINATE must never exceed 99999.99.

CROSS-SECT ID must exactly match the section identification of the referenced section on previous cards for the method used. Enter HIWY if these cards are used to describe the road profile for 100 year flood analysis.

An undercut bank at X_4,Y_4 as illustrated in Figure 4-5 cannot be handled by the program. Therefore, X_4 must be shown as identical to X_3. In this instance the program will accept these two points in the order in which they are given when arranging the point sequence. If the user attempts to describe an undercut, the points will be reversed by the program. Therefore, the closest description approximating an undercut would be a vertical face.

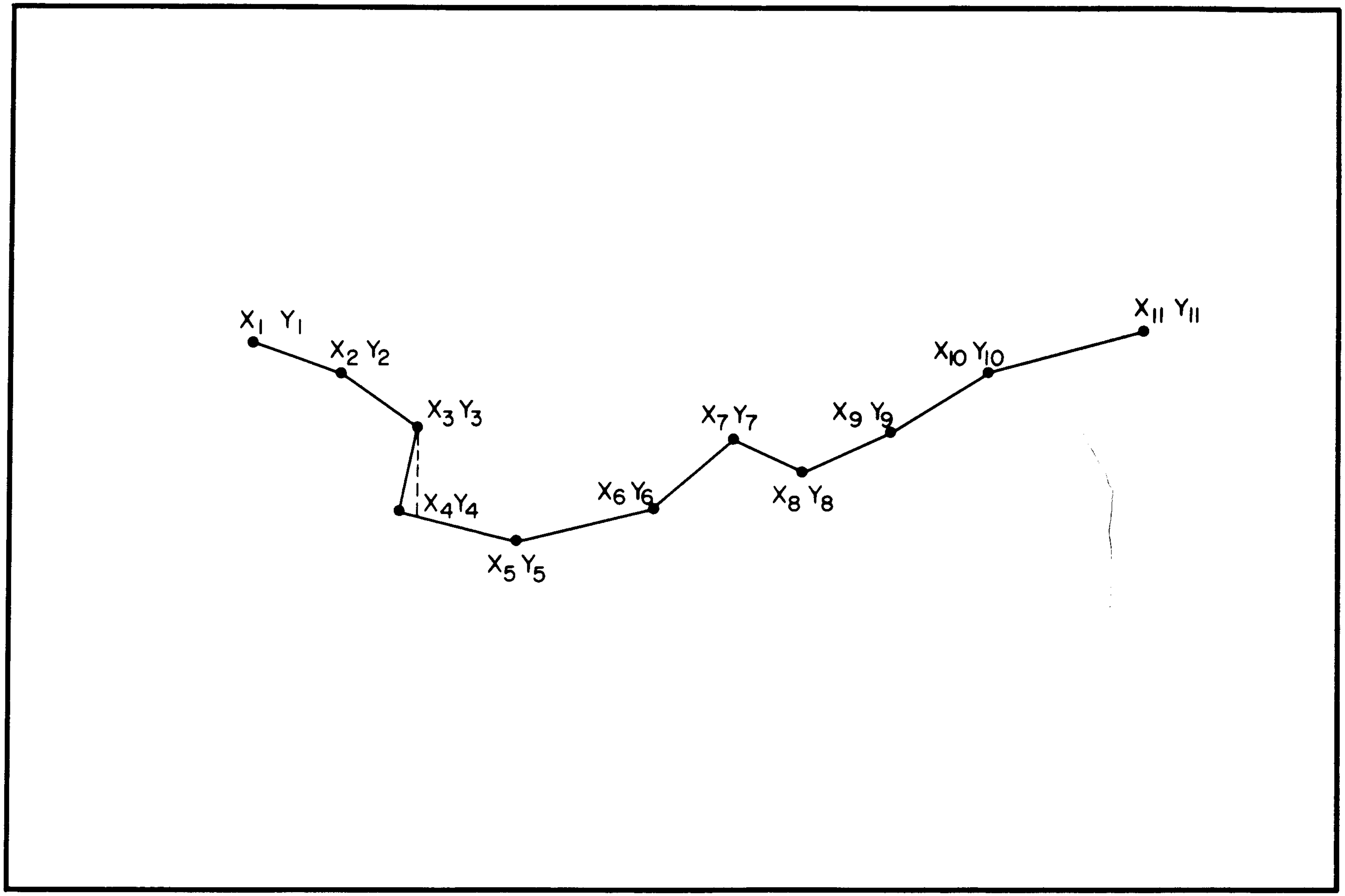
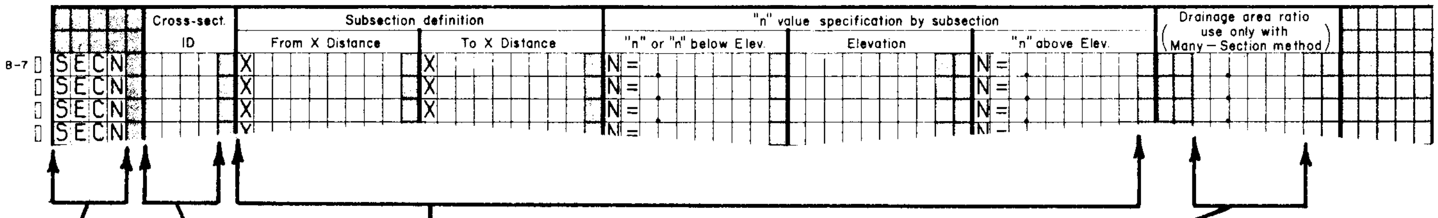


FIGURE 4-5. STREAM CROSS-SECTION SHOWING UNDERCUT BANK



Card ID

Drainage area ratio can be used only when describing a section used in MANY SECTION method. See further discussion of the use of this feature in the SECN cards in HYDRA INPUT.

The values in SUBSECTION DEFINITION and "n" VALUE SPECIFICATION are entered according to the following:

1. If one "n" value applies to the entire section, no X DISTANCE, ELEVATION or "n" ABOVE ELEV is necessary. Only the "n" value in the field "n" or "n" BELOW ELEV is required.
2. If one "n" value applies to a subsection, X DISTANCE information is required but no ELEVATION or "n" ABOVE are necessary.
3. If "n" ABOVE and "n" BELOW values apply to the entire section, no X DISTANCE information is required, but ELEVATION, "n" ABOVE and "n" BELOW are required.
4. If "n" ABOVE and "n" BELOW values apply to a subsection, all information is required.

CROSS-SECT ID must exactly match the section identification of the referenced section on previous cards for the method used.

The SECN cards (B-7) describe the Manning's "n" values across the section. Each cross-section may be divided into a maximum of 10 subsections with different "n" coefficients in each. There are several possibilities concerning these subsections and the options are outlined below:

1. If there is one "n" for the whole section then FROM X DISTANCE, TO X DISTANCE, ELEVATION, and "n" ABOVE ELEV need not be entered on the SECN card. Only the CROSS-SECT ID, "n" or "n" BELOW ELEV. and DRAINAGE AREA RATIO (only for MANY SECTION) need to be entered.

2. If there is more than one subsection in the section and a particular subsection has only one "n", the ELEVATION and "n" ABOVE ELEV may be left blank. In Figure 4-6 the subsection from X_4 to X_5 is of this type. The DA ratio is entered if used in a MANY SECTION problem.

3. In some situations the "n" value may change at a particular elevation within the subsection. This can happen when there are trees, brush, or other similar obstacles in the flood plain. When the water surface elevation attains a height such that is clears the tops of the brush or when it reaches the tree limbs, then the "n" value for the subsection will be affected. Thus, the "n" value for the subsection when the water surface is below a certain elevation will be different from the "n" value for the subsection when the water surface is above that elevation. (See Figure 4-6.) When such a change in "n" value is indicated, the program will automatically make a linear transition from 0.5 ft below the given change elevation to 0.5 ft above. If these conditions are the same all the way across the section, then it is not necessary for the FROM X DISTANCE and TO X DISTANCE to be entered. Only the "n" BELOW ELEV, ELEVATION, and "n" ABOVE ELEV. are required plus DRAINAGE AREA RATIO if using the MANY SECTION method.

4. If there is more than one subsection in the section and a particular subsection is of the type described in (3) above, then all the information on the SECN card must be provided (including the DRAINAGE AREA RATIO if this section is used in a MANY SECTION problem).

The boundaries of the subsections on SECN cards need not necessarily coincide with any X COORDINATE on the SECX cards.

In the use of the MANY SECTION option in HYDRA, provision has been made to vary the discharge along the reach of stream being considered. This is done by means of the DRAINAGE AREA RATIO. The design discharge is applied to a reference section in the reach by assigning the value of 1.000 to the DRAINAGE AREA RATIO of that section. If the designer wishes to vary the discharge along the

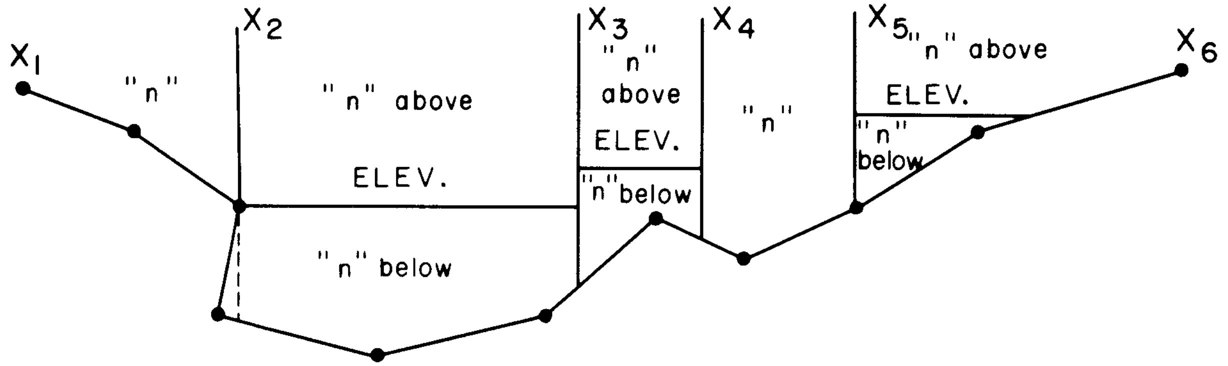


FIGURE 4-6. STREAM CROSS-SECTION SHOWING "N" VALUE SUBSECTIONS

reach length such as at the inflow of a tributary, those sections downstream from the reference section should ordinarily have DRAINAGE AREA RATIO (DAR) values greater than 1.000 and those sections upstream from the reference section should ordinarily have DRAINAGE AREA RATIO values less than 1.000. The user must assure that no upstream value is greater than any downstream value since this constitutes an error condition. The discharge is adjusted by the arbitrary hydrologic method $Q = Q \quad (DAR)^{07}$. If no entry is made the value of 1.0 will be assumed for this section. It is necessary to enter the DRAINAGE AREA RATIO on only one card per section. If conflicting values are entered on separate cards for the same section, the last value read will be used.

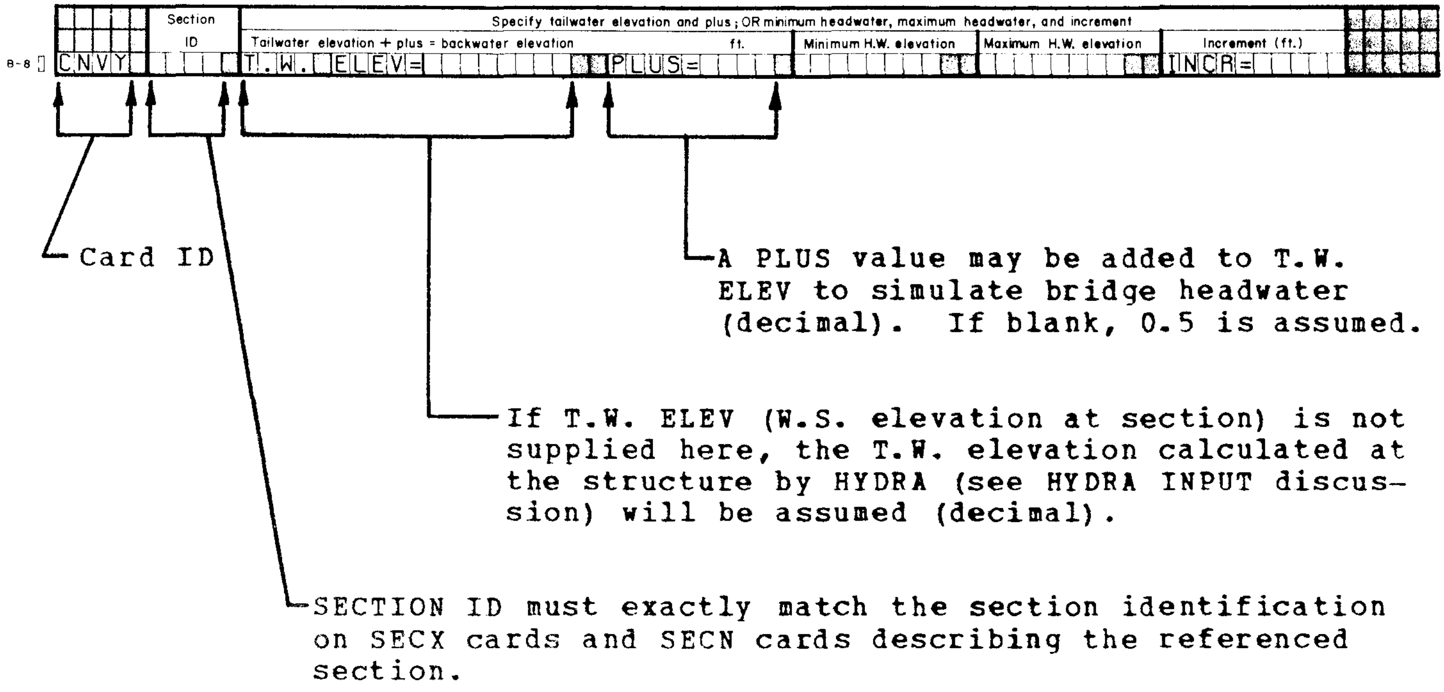
A further function of the HYDRA subsystem is its use as a storage vehicle for cross-section configuration and characteristics for subsequent use in the CULBRG subsystem. No HYDRA option need be specified for this function but SECX and SECN cards should be completed and should follow the HYDRA Control Card. Any section stored in HYDRA, whether or not accompanied by a computations specification (such as ONE SECT, CNVY, etc.), may be subsequently used in CULBRG.

CNVY CARD (B-8)

The cumulative conveyance feature of HYDRA is an option the designer may select if his purpose is to determine flood plain flow divides for use in designing main and relief structures. This is an independent calculation, the results of which are not available for other routines. Analysis of the relative carrying capacity characteristics of a section is possible with this feature. The conveyance is calculated from left bank to right bank of the designated cross-section and an accumulated total conveyance is kept and subsequently plotted with the accumulated total conveyance as the ordinate and the section stationing as the abscissa. Care should be taken by the designer to supply the section which appears to have the most control over the flow divide at flood stages. An automatic plot of accumulated conveyances versus section stationing is included in the output from this option.

Two types of input on the CNVY card are given below: One for bridge type structures and one for multiple culvert type structures requiring flow divides directly upstream.

Input For Bridge Type Structures.



Card ID

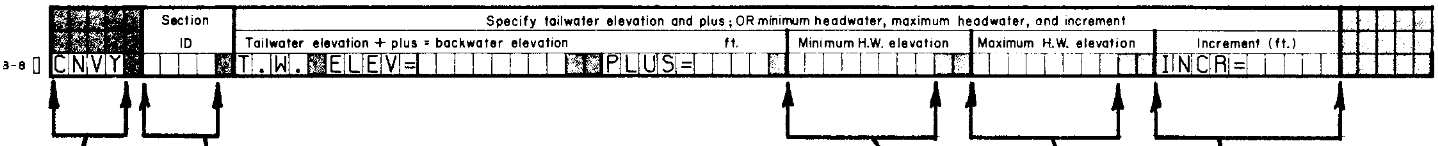
A PLUS value may be added to T.W. ELEV to simulate bridge headwater (decimal). If blank, 0.5 is assumed.

If T.W. ELEV (W.S. elevation at section) is not supplied here, the T.W. elevation calculated at the structure by HYDRA (see HYDRA INPUT discussion) will be assumed (decimal).

SECTION ID must exactly match the section identification on SECX cards and SECN cards describing the referenced section.

The conveyance option is not used in conjunction with any other design or determination procedure contained within the THYSYS system. As in other procedures, the SECTION ID on the CNVY card must exactly agree with the CROSS-SECT ID on the SECX and SECN cards used to describe the section. The T.W. ELEV may be supplied on this card or it may be computed in HYDRA in which case the T.W. ELEV space should be left blank. The T.W. ELEV entered on this card will be used for bridge type structures only. The PLUS value is usually an estimate of possible backwater which is to be added to T.W. to simulate bridge headwater. If T.W. ELEV is given and a value for PLUS is not given, the PLUS is arbitrarily assigned the value of 0.5 ft.

<u>Input For Multiple Culvert Type Structures Requiring Flow Divides Directly Upstream</u>.



Card ID

MINIMUM H.W. to be applied to the section.

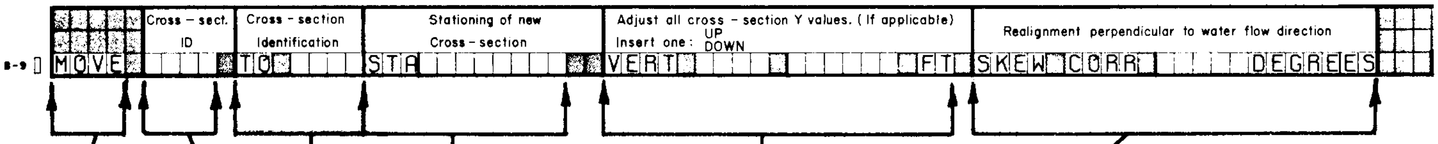
MAXIMUM H.W. to be applied to the section.

INCR designates increments of headwater elevation from minimum to maximum. Each will have a cumulative conveyance curve computed.

SECTION ID must exactly match the section identification on SECX and SECN cards describing the referenced section.

If the structure is to be multiple culverts rather than a bridge, and flow divides are required upstream of the multiple culverts, then MINIMUM H.W. ELEVATION, MAXIMUM H.W. ELEVATION and INCREMENT are required instead of T.W. ELEV and PLUS. When these are given, cumulative conveyance curves will be computed and plotted for each increment from minimum headwater to maximum headwater. Conveyance curves may be plotted for any number of sections by providing a CNVY card (B-8) and an ENDATA card (B-11) for each desired curve plot immediately following the ENDATA card (B-11) of any HYDRA problem.

MOVE CARD (B-9)



Card ID

For realignment of a skewed section, the degree of skew from a line perpendicular to the water flow must be entered here.

For changing datum the direction and amount of change, in feet, must be entered here. The direction must be left justified.

The station of the new cross-section should be relative to the reach stationing.

In addition to supplying the name of the original section, the user must provide a new name for the section that is to be created by the requested move.

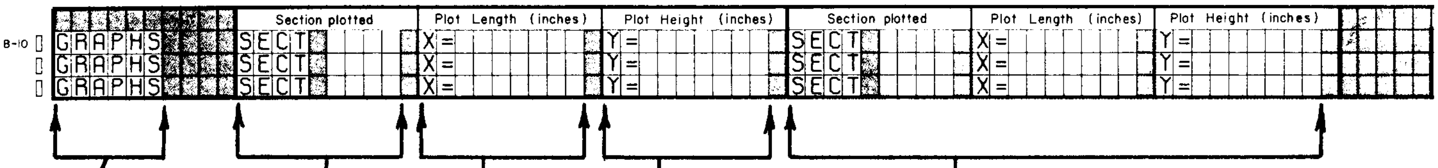
CROSS-SECT ID must exactly match the section identification on the SECX and SECN cards describing the referenced section.

The MOVE card (B-9) is used to normalize a skewed section and/or change a datum and/or change stationing. The CROSS-SECT ID must be the name of the cross-section to be modified. A new name for the modified section must be entered in the field CROSS-SECTION IDENTIFICATION and the corresponding reach stationing of the new section must be entered. This stationing should be relative to the rest of the stationing of the reach. The vertical direction of change in datum is entered in the VERT field if a change is necessary. This entry must be entered as UP or DOWN and it must be left justified. The amount of vertical change, in feet, must be entered as a decimal number. The angle or skew, in degrees, must be entered in the SKEW CORR field.

The MOVE operation may be performed for any number of sections by providing a MOVE card (B-9) and an ENDATA card (B-11) for each desired section immediately following the ENDATA card (B-11) of any HYDRA problem.

GRAPHS CARD (B-10)

The GRAPHS card (B-10) is provided to allow the user to list the cross-sections he wishes plotted. Up to 50 plots may be requested with two given on each card. The user may specify the size in inches of each cross-section to be plotted by entering the section ID in the SECT field and the length (maximum 100 inches) and height (maximum 14 inches) in the X and Y fields. If the X and Y fields are left blank the plots will be 8 1/2 by 11 inches.



Card ID

Same as corresponding fields to left

Desired height of plot along Y-axis. Max. 14.0 inches. If blank 8.5 inches assumed. One and one-half inches of the height are used for labeling.

Desired length of plot along the X-axis. Max. 100.0 inches. If blank 11.0 inches assumed. One inch of this length is used for labeling.

The identification of sections for requested plots must be listed, 2 per card. The section identification must exactly match the section identifications on the SECX and SECN cards describing the referenced sections. Plots may be requested for as many sections as desired up to the maximum of 50.

ENDATA CARD (B-11)

The ENDATA card (B-11) is required at the end of each HYDRA run.

Card ID

Card Use Checklist

A tabulation of the required and optional cards for each of the HYDRA options is shown in Figure 4-7. This may be used to check the completed input form for possible omissions prior to submission.

HYDRA

CARD IDENT.	CARD TYPE OR REFERENCE	ONE SECTION METHOD	WATERWAY CALC. ONLY	TWO SECTION METHOD	MANY SECTION METHOD	CONVEYANCE CALC.	ADD'L. CNVY CALC. AND/OR MOVE	CROSS-SECT STORAGE
CONTROL CARD	HYDRA	YES	YES	YES	YES	YES		YES
B-1	ONE SECT	YES	YES					
B-1a	WATERWAY	OPTIONAL	YES					
B-2	TWO SECT			YES				
B-3	MANY SECT				YES			
B-4	SEQUENCE				YES			
B-5	SEQ CONT				YES[5]			
B-6	SECX	YES[1]	YES[1]	YES[1]	YES[1]	YES[1]		YES[1]
B-7	SECN	YES[2]	YES[2]	YES[2]	YES[2]	YES[2]		YES[2]
B-8	CNVY	OPTIONAL	OPTIONAL	OPTIONAL	OPTIONAL	YES	YES	
B-9	MOVE	OPTIONAL[3]	OPTIONAL[3]	OPTIONAL[3]	OPTIONAL[3]	OPTIONAL[3]	OPTIONAL[3]	OPTIONAL[3]
B-10	GRAPHS	OPTIONAL[4]	OPTIONAL[4]	OPTIONAL[4]	OPTIONAL[4]	OPTIONAL[4]	OPTIONAL[4]	OPTIONAL[4]
B-11	ENDATA	YES	YES	YES	YES	YES	YES	YES

[1] Include enough SECX Cards to enter all points describing the section.
[2] Include one for each subsection.
[3] Required only for normalizing a skewed cross-section and/or changing a datum.
[4] Required if plots of named cross-section is needed.
[5] Include enough DEQ CONT Cards to list all remaining sections.

FIGURE 4-7. CARD USE CHECKLIST

III. OUTPUT

The HYDRA subsystem output consists of two reports. The first report describes the given section of the channel under consideration. It is printed regardless of the method used. A second report contains information which varies with the method used. The output for the first report is given below. The output for the second report is given under the title for the method used.

1. Name of section - given
2. Stationing of section - given
3. Drainage area ratio - significant only in the MANY SECTION method procedure when it is used to relate the flow at each section to the flow at the given reference section. This ratio is described more fully in the HYDRA INPUT section under the SECX and SECN card discussion. - given
4. X and Y coordinates showing respectively the distance across the reach of the stream and the elevation of each point describing the section configuration relative to a fixed datum. - given
5. The "n" value data for each subsection across the reach of the stream. - given

Cumulative Conveyance

When this option is specified by CNVY card (B-8), the program will produce a table of X distances and computed cumulative conveyance and percentages. In addition, a line plot of conveyance versus X distance will automatically be generated along with a plot of the section showing the H.W. elevation.

One Section

The output for the ONE SECTION method consists of:

1. Slope (ft/ft) - given
2. Name of the described section - given
3. Station of the described section - given
4. Station of the section at which answer is needed - given

5. A table beginning with the first even .25 ft. above the lowest point in the section and then for each .25 ft. increment to the highest possible water elevation of the given section. This table will reflect:

    a. Elevation (ft above datum) - computed

    b. Flow at elevation - computed

    c. Average velocity of flow (Q/A) at elevation - computed

6. Tailwater elevation at the described section - computed

7. Tailwater elevation at required site - computed

8. Design flow (cfs) - given or computed in HYDRO

9. Q_{100} - given or computed in HYDRO (if requested)

10. TW_{100} - computed (if requested).

Waterway

The output for the WATERWAY option used in conjunction with the ONE SECTION method consists of:

1. Name and station of the described section - given

2. Station of the section at which the answer is needed - given

3. Slope (ft/ft) - given

4. A table beginning with the first even foot above the lowest point in the section and for each given increment to and including the highest possible water elevation of the given section. This table will reflect for each elevation:

    a. Elevation - given

    b. Table for each subsection indicating:

        (1) Subsection number - computed
        (2) "n" value - given
        (3) Waterway Area - computed
        (4) Wetted Perimeter - computed
        (5) Hydraulic Radius - computed
        (6) Velocity - computed
        (7) K-Factor (conveyance) - computed

    c. Total Discharge - computed

    d. Total Area - computed

    e. Q/A - computed

5. Tailwater elevation at the described section - computed
6. Tailwater elevation at required site - computed
7. Design flow (cfs) - given or computed in HYDRO

Two Section

The output for the TWO SECTION method consists of:

1. Name and station of the described upstream section - given
2. Name and station of the described downstream section - given
3. Station of the site where tailwater is needed - given
4. Design flow (cfs) - given or computed in HYDRO
5. Slope (ft/ft) - computed
6. Downstream velocity (ft/sec) - computed
7. Upstream velocity (ft/sec) - computed
8. Tailwater elevation at the required site - computed
9. Q_{100} - given or computed in HYDRO (if requested)
10. TW_{100} - computed (if requested).

Many Section

For the MANY SECTION method the program lists the following:

1. Discharge (or flow) at the designated base section (cfs) - given or computed in HYDRO
2. A table listing for each section (proceeding upstream) considered in the solution:
   a. Name of the section - given
   b. Stream station - given
   c. Water surface elevation - computed (given for first section)
   d. Contributing drainage area - computed
   e. Drainage area ratio - given
   f. Discharge (or flow) at the section - computed (given for first section)
   g. Q_{100} - given or computed in HYDRO (if requested)

h. TW_{100} – computed (if requested).

This procedure usually requires that several beginning water surface elevations be considered and the table in Item 2 above will be repeated showing the results at each elevation. A graphical plot will then be automatically printed showing the profile of water surface elevations computed in Item 2c above.

***************** ERROR MESSAGES *****************

*************** TEXAS HYDRAULIC SYSTEM ***************

ERROR MESSAGES ARE GROUPED BY ALPHABETIC PREFIX FOR EACH SUBSYSTEM AND ARE LISTED IN NUMERICAL ORDER WITHIN EACH GROUP. 'EXPL' DENOTES A DETAILED EXPLANATION OF THE ERROR MESSAGE. (FOR ADDITIONAL INFORMATION AND ASSISTANCE CONTACT THE BRIDGE DIVISION HYDRAULIC SECTION OR THE DIVISION OF AUTOMATION FIELD ENGINEER FOR YOUR DISTRICT.)

****

HYA0001--TOO MANY SECTIONS. PRESENT LIMIT IS 50.
EXPL□ ON THE CARD IMMEDIATELY PRECEDING THIS MESSAGE A NEW SECTION NAME WAS ENTERED WHICH BROUGHT THE TOTAL OF DIFFERENT SECTIONS NAMED IN THIS RUN TO MORE THAN THE ALLOWABLE MAXIMUM OF 50. FATAL ERROR

HYA0002--STATIONING TOO LARGE FOR VERTICAL BANK.
EXPL□ AN INTERNAL ADJUSTMENT IS MADE WHEN IDENTICAL STATION VALUES ARE ENCOUNTERED. A MINOR DISTANCE OF 0.07 FEET IS ADDED TO THE SECOND VALUE TO APPROXIMATELY DEPICT A VERTICAL BANK. IF THE ORIGINAL VALUE IS LARGER THAN 99999.92, ITS PROPER VALUE IS DESTROYED WHEN THE 0.07 FEET IS ADDED.

HYA0003--SECTION * * IS NOT A VALID SECTION.
EXPL□ IF THERE IS NOT AT LEAST ONE ELEVATION WHICH IS LOWER THAN THE TWO ADJACENT ELEVATIONS, NO USABLE CROSS-SECTION IS DEPICTED. AND IT IS NOT A VALID SECTION FOR THE PURPOSE OF HYDRAULIC CALCULATIONS.

HYA0004--SUPERFLUOUS CROSS-SECTION POINTS HAVE BEEN DELETED FROM SECTION * *.
EXPL□ WHERE THERE ARE POINTS OUTSIDE OF A VALID SECTION WHICH WOULD NOT DEPICT VALID SECTIONS,THEMSELVES,THESE POINTS ARE CONSIDERED SUPERFLUOUS.

HYA0005--SECTION * * DOES NOT HAVE AT LEAST 3 X STATIONS.
EXPL□ WHEN THE ENDATA CARD (B-11) FOR THIS PROBLEM WAS ENCOUNTERED, THE PROGRAM SCANNED THE DATA AND FOUND THAT THE NAMED SECTION DID NOT HAVE THE MINIMUM OF THREE POINTS REQUIRED FOR A VALID SECTION. FATAL ERROR.

HYA0006--X COORDINATES WITH ABSOLUTE VALUES GREATER THAN 99999.99 CANNOT BE ACCEPTED.
EXPL□ X VALUES OF GREATER THAN 99999.99 EXCEED THE SIGNIFICANT DIGIT CAPABILITIES OF THE PROGRAM.

HYA0007--MINIMUM ALLOWABLE W.S. ELEVATION INCREMENT IS 0.10 FOOT. ONE FOOT INCREMENT IS ASSUMED.
EXPL□ ANY INCREMENT LESS THAN 0.1 FOOT WOULD YIELD INSIGNIFICANT DIFFERENTIAL RESULTS.

HYA0008--GIVEN INCREMENT PERMITS MORE THAN THE ALLOWABLE 250 ELEVATIONS. ONLY THE HIGHEST 250 ELEVATIONS WILL BE CONSIDERED.
EXPL□ SELF-EXPLANATORY.

HYA0009--SECTION * * AS GIVEN DOES NOT HAVE ENOUGH DEPTH FOR USE IN THIS WATERWAY SOLUTION.
EXPL□ ANY DEPTH LESS THAN 0.1 FOOT WOULD YIELD RESULTS THAT PROBABLY ARE NOT VERY REALISTIC.

HYA0010--NO SOLUTION POSSIBLE FOR DISCHARGE = * *.
EXPL□ GIVEN DISCHARGE IS GREATER THAN ALL CALCULATED DISCHARGES.

HYA0011--THE WATERWAY AS GIVEN CANNOT ACCOMODATE A DISCHARGE OF * *.

EXPL□ THE GEOMETRIC CHARACTERISTICS AND ROUGHNESS CHARACTERISTICS OF THE CROSS-SECTION AS GIVEN WILL ACCOMODATE LESS THAN THE GIVEN DISCHARGE (Q PEAK) AS A MAXIMUM.

HYA0012--DESIGN FLOW * * IS LESS THAN THE LOWEST CALCULATED FLOW WHICH WILL BE ASSUMED DESIGN FLOW FOR THIS PROBLEM.

EXPL□ IN THE 'ONE SECTION' METHOD COMPUTATIONS,THE PROGRAM FOUND THAT THE GIVEN DESIGN FLOW IS LESS THAN THE FLOW AT THE LOWEST WATER SURFACE ELEVATION CONSIDERED. THE PROGRAM WILL USE THE FLOW AT THE LOWEST POINT CONSIDERED AS THE DESIGN FLOW AND WILL PROCEED ON THAT BASIS. THE NEW ASSUMED FLOW AND THE CORRESPONDING T.W. ELEVATION WILL NOT BE KEPT FOR LATER TRANSFER INTO THE 'CULBRG' SUBSYSTEM. NON-FATAL.

HYA0013--DESIGN FLOW * * IS GREATER THAN THE HIGHEST CALCULATED FLOW WHICH WILL BE ASSUMED DESIGN FLOW FOR THIS PROBLEM.

EXPL□ IN THE 'ONE SECTION' METHOD COMPUTATIONS,THE PROGRAM FOUND THAT THE SECTION AS GIVEN DID NOT HAVE A LARGE ENOUGH WATER-CARRYING CAPACITY TO ACCOMODATE THE GIVEN DESIGN FLOW UNDER THE SPECIFIED CONDITIONS. THE PROGRAM WILL USE THE HIGHEST FLOW WHICH CAN BE CALCULATED FROM THE GIVEN SECTION AS DESIGN FLOW AND WILL PROCEED ON THAT BASIS. THE NEW ASSUMED FLOW AND THE CORRESPONDING T.W. ELEVATION WILL NOT BE KEPT FOR LATER TRANSFER INTO THE 'CULBRG' SUB-SYSTEM. NON-FATAL.

HYA0014--SECTION * * AS GIVEN DOES NOT HAVE ENOUGH DEPTH FOR USE IN THIS PROGRAM.

EXPL□ IN PERFORMING THE TAILWATER COMPUTATIONS THE PROGRAM FOUND THAT THE NAMED SECTION WAS TOO SHALLOW TO ALLOW CALCULATION OF ANY FLOWS. FATAL ERROR.

HYA0015--NUMBER OF COMPUTED WATER SURFACE ELEVATIONS EXCEEDS MAXIMUM OF 250 ALLOWED. NO VALUE GREATER THAN * * WAS CONSIDERED.

EXPL□ IN PERFORMING THE TAILWATER COMPUTATIONS,THE PROGRAM FOUND THAT THE DEPTH OF THE GIVEN SECTION WAS GREATER THAN THE ALLOWABLE MAXIMUM OF APPROXIMATELY 62.5 FEET. THE HIGHEST CALCULATED FLOW WITHIN THE ALLOWABLE DEPTH WILL BE INDICATED AND THE COMPUTATIONS WILL CONTINUE. IF THE DESIGN DISCHARGE HAS NOT BEEN REACHED, THE NEW ASSUMED FLOW AND THE CORRESPONDING T.W. ELEVATION WILL NOT BE KEPT FOR TRANSFER INTO THE 'CULBRG' SUBSYSTEM. NON-FATAL.

HYA0016--IN GIVEN DATA, UPSTREAM BED IS LOWER THAN DOWNSTREAM BED. DIFFERENCE OF AVERAGE ELEVATIONS WILL BE USED AS THE BASE.

EXPL□ IN PERFORMING THE 'TWO SECTION' METHOD CALCULATIONS,THE PROGRAM FOUND THAT THE LOWEST POINT IN THE DOWNSTREAM SECTION WAS HIGHER THAN THE LOWEST POINT IN THE UPSTREAM SECTION. THE PROGRAM MUST USE A REFERENCE SLOPE INDICATIVE OF THE OVERALL CHANNEL SCOPE. SINCE THE BED SLOPE IN THIS CASE DOES NOT PROVIDE AN ACCEPTABLE REFERENCE SLOPE, THE DIFFERENCE OF AVERAGE ELEVATIONS WILL BE USED TO DETERMINE THE REFERENCE SLOPE. THE AVERAGE ELEVATION DETERMINATION IS BASED ON THE WEIGHTED AVERAGE OF ALL THE POINTS USED TO DESCRIBE EACH SECTION. NON-FATAL.

HYA0017--AVERAGE UPSTREAM ELEVATION WAS LOWER THAN AVERAGE DOWNSTREAM ELEVATION. PROGRAM WILL ATTEMPT TO USE HIGHEST POSSIBLE WATER SURFACE ELEVATIONS IN GIVEN SECTIONS AS A BASE.

EXPL□ THIS MESSAGE IS ONLY PRINTED AFTER MESSAGE NUMBER HYA0016 WHEN IT IS FOUND THAT THE AVERAGE ELEVATIONS DO NOT PROVIDE AN ACCEPTABLE BASE SLOPE. A FURTHER ALTERNATIVE FOR BASE SLOPE DETERMINATION WILL BE EMPLOYED. HOWEVER, IF THIS MESSAGE IS RECEIVED, ONE OR BOTH OF THE SECTIONS UNDER CONSIDERATION SHOULD BECOME SUSPECTED AS BEING NOT TYPICAL. A FINAL ANSWER MAY FOLLOW BUT POSSIBLY IT

MAY NOT BE RELIABLE BECAUSE THE SECTIONS MAY NOT HAVE BEEN 'TYPICAL' AS DEFINED IN THE 'HYDRAULIC MANUAL'. IT IS SUGGESTED THAT THE SECTIONS BE RE-EXAMINED TO DETERMINE WHETHER OR NOT THE ANSWER RECEIVED SHOULD BE ACCEPTED. NON-FATAL ERROR.

HYA0018--MAXIMUM WATER SURFACE ELEVATIONS IN GIVEN SECTIONS FAILED TO PROVIDE A USABLE SLOPE. PROBLEM ABANDONED.

EXPL¤ THIS MESSAGE INDICATES THAT ALL AVENUES HAVE BEEN EXHAUSTED IN ATTEMPTING TO USE THE CROSS-SECTION DATA PROVIDED IN A 'HYDRA TWO SECTION' SOLUTION. THE PROGRAM COULD NOT FIND A VALID BASE SLOPE FROM WHICH TO BEGIN CALCULATIONS. FATAL ERROR.

HYA0019--COMPUTED CONVEYANCE CURVES DO NOT OVERLAP. NO SOLUTION POSSIBLE FOR Q= * *.

EXPL¤ IN COMPUTATIONS FOR THE TWO-SECTION METHOD, THE UPSTREAM AND DOWNSTREAM CONVEYANCE CURVES MUST HAVE SOME COMMON CONVEYANCE VALUES, OTHERWISE, FURTHER COMPUTATIONS ARE NOT POSSIBLE.

HYA0020--THE CONVEYANCE CURVES CROSSED CAUSING AN INVALID SOLUTION FOR Q = * *,
LAST U.S. ELEVATION = * *.
LAST D.S. ELEVATION = * *.

EXPL¤ IN CALCULATIONS FOR THE TWO-SECTION METHOD, THE UPSTREAM CONVEYANCE CURVE MUST HAVE HIGHER ELEVATIONS THAN THE DOWNSTREAM CONVEYANCE CURVE FOR ALL VALUES OF CONVEYANCE.

HYA0021--LIMITS OF THE CONVEYANCE CURVES ARE INSUFFICIENT FOR A PROPER SOLUTION WHEN DISCHARGE = * *.

EXPL¤ SELF-EXPLANATORY.

HYA0022--LAST UPSTREAM ELEVATION = * *.
LAST DOWNSTREAM ELEVATION = * *.

EXPL¤ THIS IS SUPPLEMENTAL TO TROUBLE-SHOOT THE SPECIFIC CAUSE OF FAILURE OF THE TWO-SECTION METHOD.

HYA0023--THE ABOVE TABULATION INDICATES A FAILURE IN THE TWO-SECTION METHOD. IF FURTHER INFORMATION IS REQUIRED REFER TO THE SECTION OF THIS MANUAL TITLED 'REASONS FOR TWO-SECTION FAILURES'.

EXPL¤ THIS MESSAGE IS TO SUMMARIZE FAILURE AS SPECIFICALLY DESCRIBED IN ONE OR MORE PRIOR MESSAGES.

HYA0024--SITE IS LOCATED TOO FAR FROM KNOWN SECTIONS TO PERMIT A VALID SOLUTION.

EXPL¤ IN THE 'TWO SECTION' METHOD PROCEDURE, THE STATION AT WHICH THE ANSWER IS NEEDED LIES OUTSIDE OF THE TWO GIVEN STATIONS BY A DISTANCE GREATER THAN THAT SEPARATING THE GIVEN STATIONS. FATAL ERROR.

HYA0025--NO 'N VALUE' INFORMATION IS STORED FOR SECTION * * AND IT WILL NOT BE CONSIDERED IN THIS SOLUTION.

EXPL¤ IN ORDER FOR A CROSS-SECTION TO BE INCLUDED IN CALCULATIONS FOR BACKWATER ELEVATIONS OR PROFILES, IT MUST INCLUDE AN 'N' VALUE SPECIFICATION. HOWEVER IT IS NOT NECESSARY TO SPECIFY 'N' VALUES IF THE CROSS-SECTION IS TO BE USED ONLY FOR BRIDGE DESIGN OR ANALYSIS.

HYA0026--DRAINAGE AREA RATIO FOR UPSTREAM SECTION IS GREATER THAN FOR DOWNSTREAM SECTION. SECTION * * NOT CONSIDERED.

EXPL¤ AN UPSTREAM CROSS-SECTION USUALLY SERVES A SMALLER DRAINAGE AREA THAN A DOWNSTREAM SECTION AND SINCE A DRAINAGE AREA RATIO OF LESS THAN 1. IS USED TO REDUCE THE DRAINAGE SERVED IT IS NOT REALISTIC FOR THE UPSTREAM RATIO TO BE GREATER THAN THE DOWNSTREAM RATIO.

HYA0027--COMPUTED UPSTREAM WATER SURFACE AT SECTION * * IS LOWER THAN DOWNSTREAM WATER SURFACE.

EXPL¤ AN INSTABILITY IN THE COMPUTATIONS IS INDICATED BY THIS MESSAGE. A VARIABLE SET OF CIRCUMSTANCES CAUSES THE ENERGY EQUATION TO BE BALANCED ONLY IF THE UPSTREAM WATER SURFACE ELEVATION IS LOWER THAN THE DOWNSTREAM WATER SURFACE ELEVATION. SINCE THE 'MANY-SECTION' ROUTINE IS NOT DESIGNED TO ACCOMODATE THAT SITUATION, THE QUESTIONABLE SECTION IS IGNORED.

HYA0028--COMPUTED WATER SURFACE EXCEEDS HIGHEST POSSIBLE WATER SURFACE IN SECTION * *.

EXPL¤ THE CROSS-SECTION IN QUESTION IS INADEQUATE IN CAPACITY TO PERFORM ENERGY BALANCE COMPUTATIONS.

HYA0029--FROUDE NUMBER * * NOT ACCEPTABLE. SECTION * * IGNORED.

EXPL¤ THE 'MANY-SECTION' ROUTINE IS DESIGNED TO ACCOMODATE SUB-CRITICAL FLOW ONLY. IF THE FROUDE NUMBER IS GREATER THAN 1.0, THERE IS AN INDICATION OF SUPERCRITICAL FLOW. THE SECTION IN QUESTION IS IGNORED.

HYA0030--ENERGY BALANCE NOT ACHIEVED AT SECTION * * SECTION IGNORED.

EXPL¤ AFTER A REASONABLE NUMBER OF ITERATIONS, THE ROUTINE WAS UNSUCCESSFUL IN BALANCING THE ENERGY EQUATION. THE SECTION IN QUESTION IS IGNORED.

HYA0031--NO SOLUTION FOR BEGINNING WATER SURFACE = * *.

EXPL¤ IF TWO SECTIONS IN SUCCESSION ARE IGNORED FOR REASONS HAVING PRIOR EXPLANATION, NO FURTHER COMPUTATIONS ARE MADE FOR THE CURRENT VALUE OF BEGINNING WATER SURFACE ELEVATION.

HYA0032--MOST UPSTREAM SECTION GIVEN IS BELOW SITE. NO SOLUTION POSSIBLE.

EXPL¤ THE SITE AT WHICH A WATER SURFACE ELEVATION IS DESIRED IS UPSTREAM OF THE LIMIT OF 'MANY-SECTION' CALCULATION. SINCE NO EXTRAPOLATION OF THE WATER SURFACE PROFILE IS POSSIBLE, NO ULTIMATE SOLUTION IS POSSIBLE. HOWEVER, PROFILES ARE VALID.

HYA0033--USER SHOULD EXERCISE DISCRETION IN ACCEPTING ANSWER DUE TO CONDITIONS NOTED.

EXPL¤ WHEN IT IS NECESSARY TO IGNORE ONE OR MORE CROSS-SECTIONS IN THE PROCESS OF THE MANY-SECTION COMPUTATIONS, THE FINAL RESULT MAY BE QUESTIONABLE.

HYA0034--NUMBER OF WATER SURFACES COMPUTED AT STATION * * NOT SUFFICIENT TO AUTOMATICALLY DETERMINE DESIGN WATER SURFACE ELEVATIONS.

EXPL¤ SINCE A STATISTICAL PROCESS IS USED TO CALCULATE THE DESIGN WATER SURFACE ELEVATION, A MINIMUM NUMBER OF PROFILES AND INTERIM WATER SURFACE ELEVATIONS MUST BE AVAILABLE TO THIS ROUTINE.

HYA0035--WATER SURFACES AT STATION * * FAILED TO ACHIEVE AN ACCEPTABLE CONVERGENCE.

EXPL¤ THE VARIOUS PROFILES MUST CONVERGE IN ORDER TO BE CLASSIFIED AS LEGITIMATE. IF ACCEPTABLE CONVERGENCE IS NOT ACHIEVED THE DESIGN WATER SURFACE AT THE DESIRED LOCATION IS NOT COMPUTED.

HYA0036--NO Q CALCULATED IN HYDRO--WILL USE ONLY HYDRA DATA.

EXPL¤ EITHER THE 'HYDRO' ROUTINE WAS NOT USED OR THE LAST Q CALCULATED IN A 'HYDRO' PROBLEM HAS BEEN PREVIOUSLY USED IN A 'HYDRA' ROUTINE AND IS NO LONGER STORED. UP TO TWO T.W. ELEVATIONS WILL BE COMPUTED USING Q AND 'FREQ' DATA FROM THE 'HYDRA' CONTROL CARD AND THE FIRST ONE WILL BE SAVED FOR POSSIBLE USE IN 'CULBRG'. NON-FATAL.

HYA0037--NO Q AVAILABLE.

EXPL¤ NO PEAK DISCHARGE HAS BEEN SUPPLIED TO 'HYDRA' EITHER FROM HYDRO OR FROM THE HYDRA CONTROL CARD. FATAL ERROR.

HYA0038--SLOPE NOT GREATER THAN ZERO.

EXPL¤ ON THE 'ONE SECT' CARD (B-1), NO SLOPE WAS ENTERED OR A NEGATIVE SLOPE WAS ENTERED. FATAL ERROR.

HYA0039--SECTION IDENTIFICATION NOT GIVEN.

EXPL¤ NO SECTION NAME WAS ENTERED ON THE CARD PRECEDING THIS MESSAGE WHICH WAS ONE OF THE FOLLOWING¤

(A) ONE SECT CARD (B-1)
(B) TWO SECT CARD (B-2)
(C) SEQUENCE CARD (B-4)
(D) SECX CARD (B-6)
(E) SECN CARD (B-7)
(F) MOVE CARD (B-9)
FATAL ERROR.

HYA0040--NO CROSS-SECTION STATION GIVEN.

EXPL¤ NO STATION VALUE WAS ENTERED ON THE CARD PRECEDING THIS MESSAGE WHICH WAS ONE OF THE FOLLOWING¤

(A) ONE SECT CARD (B-1)
(B) TWO SECT CARD (B-2)
(C) SEQUENCE CARD (B-4) OR A SEQ CONT CARD (B-5) WHERE A SECTION NAME HAS BEEN SUPPLIED.
FATAL ERROR.

HYA0041--NO STATION GIVEN WHERE ANSWER IS REQUIRED.

EXPL¤ NO STATION VALUE WAS GIVEN IN THE FIELD 'STATION AT WHICH WATER ELEV. IS NEEDED' FATAL ERROR IF OMITTED ON THE 'TWO SECT' CARD. NON-FATAL FOR ONE SECT OR MANY SECT. IF NO ANSWER STATION IS GIVEN FOR ONE SECT THE ANSWER WILL BE COMPUTED AT THE INPUT STATION. IF NO ANSWER STATION IS GIVEN FOR MANY SECT, BACKWATER PROFILES WILL BE CALCULATED BUT NO T.W. DETERMINATION WILL BE MADE.

HYA0042--NO UPSTM/DNSTM GIVEN. ASSUME DNSTM .

EXPL¤ ON THE ONE SECT CARD (B-1) NO INDICATION WAS GIVEN AS TO WHETHER THE STATION AT WHICH THE ANSWER IS NEEDED IS UPSTREAM (UPSTM) OR DOWNSTREAM (DNSTM) FROM THE INPUT STATION. THIS IS A NON-FATAL ERROR SINCE IN THE ABSENCE OF ANY INDICATION 'DNSTM' IS ASSUMED AND THE CALCULATION PROCEEDS ON THAT BASIS.

HYA0043--ONLY 25 GIVEN WATER SURFACE ELEVATIONS ARE ALLOWED FOR WATERWAY.

EXPL¤ DUE TO THE LENGTHY NATURE OF THE WATERWAY OUTPUT FORMAT, THE NUMBER OF GIVEN WATER SURFACE ELEVATIONS IS LIMITED TO 25.

HYA0044--TOO MANY WATER SURFACES SPECIFIED. PRESENT LIMIT IS 25. THIS VALUE IGNORED.

EXPL¤ THE W.S. ELEV. SPECIFIED ON THE PRECEDING 'MANY SECT' CARD (B-3) BROUGHT THE TOTAL NUMBER OF WATER SURFACES TO MORE THAN THE MAXIMUM ALLOWABLE OF 25. THE COMPUTATION WILL PROCEED WITHOUT THIS VALUE. NON-FATAL.

HYA0045--NO STARTING STATION GIVEN.

EXPL¤ ON 'MANY SECT' CARD (B-3) NO STATION WAS GIVEN TO INDICATE THE DOWNSTREAM POINT WHERE THE WATER SURFACE PROFILE IS TO BEGIN. FATAL ERROR.

HYA0046--NO WATER SURFACE ELEVATION GIVEN.

EXPL□ ON 'MANY SECT' CARD (B-3) NO WATER SURFACE ELEVATION AT THE STARTING STATION WAS GIVEN. FATAL ERROR.

HYA0047--NO SECTION IDENTIFICATION. CARD IGNORED.

EXPL□ NO CROSS-SECTION IDENTIFICATION WAS GIVEN ON 'SEQ CONT' CARD (B-5) OR ON 'GRAPHS' CARD (B-10). SECTION NAMES ON THESE CARDS MUST ALWAYS BE ENTERED IN THE FIRST FIELD. ANY ENTRIES TO THE RIGHT OF THE FIRST BLANK SECTION NAME WILL BE IGNORED. THE COMPUTATION WILL PROCEED WITHOUT THE DATA FROM THIS CARD. NON-FATAL.

HYA0048--NO INITIAL COORDINATE. REST OF CARD IGNORED.

EXPL□ ON THE 'SECX' CARD (B-6) IMMEDIATELY PRECEDING THIS MESSAGE, THERE WAS NO ENTRY FOR THE FIRST X COORDINATE. THE PROBLEM WILL BE COMPUTED WITH NO CONSIDERATION OF ANY ENTRIES ON THIS CARD. NON-FATAL.

HYA0049--Y COORDINATE MISSING. THIS SET AND REST OF CARD IGNORED.

EXPL□ ON THE 'SECX' CARD (B-6) IMMEDIATELY PRECEDING THIS MESSAGE, THE PROGRAM ENCOUNTERED AN X COORDINATE THAT HAD NO MATCHING Y COORDINATE. WHEN THIS OCCURS NO VALUE IS STORED FOR THIS SET OF COORDINATES OR ANY SET TO THE RIGHT OF THIS SET ON THE CARD. NON-FATAL.

HYA0050--TOO MANY POINTS DESCRIBING SECTION. PRESENT LIMIT IS 100.

EXPL□ ON THE 'SECX' CARD (B-6) PRECEDING THIS MESSAGE, A SET OF COORDINATES WAS ENTERED WHICH BROUGHT THE TOTAL NUMBER OF COORDINATES FOR THAT SECTION TO MORE THAN THE ALLOWABLE MAXIMUM OF 100. FATAL ERROR.

HYA0051--NO 'N' VALUE SPECIFIED.

EXPL□ ON THE 'SECN' CARD (B-7) PRECEDING THIS MESSAGE NO VALUE WAS ENTERED FOR 'N' OR 'N BELOW ELEV.' NON-FATAL ERROR.

HYA0052--'N' VALUE ABOVE ELEVATION MISSING. ASSUME 'N' VALUE BELOW APPLIES FOR ALL ELEVATIONS.

EXPL□ ON THE 'SECN' CARD (B-7) PRECEDING THIS MESSAGE, AN 'ELEVATION' WAS ENTERED BUT NO 'N ABOVE ELEV.' WAS ENTERED. THE PROBLEM WILL PROCEED ASSUMING THE 'N' OR 'N BELOW ELEV.' TO APPLY AT ALL WATER SURFACE ELEVATIONS IN THE SECTION. NON-FATAL.

HYA0053--'TO X' DISTANCE MISSING.

EXPL□ ON THE 'SECN' CARD (B-7) PRECEDING THIS MESSAGE, A VALUE WAS ENTERED FOR 'FROM X DISTANCE' BUT NO 'TO X DISTANCE' WAS ENTERED. IF THE 'N' VALUE CHARACTERISTICS ARE THE SAME ACROSS THE ENTIRE SECTION, THEN NEITHER 'FROM X DISTANCE' NOR 'TO X DISTANCE' SHOULD BE ENTERED. FATAL ERROR.

HYA0054--TOO MANY SUBSECTIONS. PRESENT LIMIT IS 10.

EXPL□ THE 'SECN' CARD (B-7) PRECEDING THIS MESSAGE BROUGHT THE NUMBER OF 'SECN' CARDS FOR THE CROSS-SECTION NAMED ON THE CARD TO A TOTAL GREATER THAN THE ALLOWED MAXIMUM OF 10 PER SECTION. FATAL ERROR.

HYA0055--CONVEYANCE SECTION IDENTIFICATION MISSING.

EXPL□ ON THE PRECEDING 'CNVY' CARD (B-8), NO SECTION IDENTIFICATION WAS ENTERED. FATAL ERROR.

HYA0056--PLUS MISSING. 000.50 ASSUMED.

EXPL□ ON THE PRECEDING 'CNVY' CARD (B-8), A VALUE WAS STORED FOR 'T.W. ELEVATION' BUT NO 'PLUS' VALUE WAS ENTERED. 'PLUS' IS AN ESTIMATED VALUE, OFTEN LESS THAN 1.0 FT, WHICH IS ADDED TO THE

T.W. ELEVATION TO SIMULATE BRIDGE HEADWATER. IF IT IS OMITTED THE PROGRAM WILL CONTINUE THE COMPUTATION WITH AN ASSUMED 'PLUS' OF 0.5 FT. NON-FATAL.

HYA0057--TAILWATER ELEVATION BLANK. ASSUME COMPUTATION VALUE PRESENT.

EXPL¤ ON THE PRECEDING 'CNVY' CARD (B-8) NEITHER 'T.W. ELEV' NOR 'MINIMUM H.W. ELEVATION' WAS ENTERED. THE PROGRAM WILL ASSUME THE 'T.W. ELEV' STORED FROM THE PREVIOUS 'HYDRA' CALCULATION AND PROCEED WITH THE CONVEYANCE COMPUTATIONS. NON-FATAL.

HYA0058--MAXIMUM HEADWATER MISSING.

EXPL¤ ON THE PRECEDING 'CNVY' CARD (B-8), A VALUE WAS ENTERED FOR 'MINIMUM H.W. ELEVATION' BUT NONE WAS GIVEN FOR 'MAXIMUM H.W. ELEVATION'. FATAL ERROR.

HYA0059--INCREMENT MISSING.

EXPL¤ ON THE PRECEDING 'CNVY' CARD (B-8), VALUES FOR BOTH 'MINIMUM H.W. ELEVATION' AND 'MAXIMUM H.W. ELEVATION' WERE ENTERED, BUT NO VALUE WAS ENTERED TO INDICATE INCREMENTS OF ELEVATION AT WHICH CUMULATIVE CONVEYANCE CURVES ARE DESIRED. FATAL ERROR.

HYA0060--'MOVE TO' STATION MISSING. WILL ASSUME STATION OF ORIGINAL SECTION.

EXPL¤ A POSSIBLE SPECIFICATION ON THE 'MOVE' CARD (B-9) IS BLANK. IT IS ASSUMED THAT THE STATION VALUE WILL REMAIN THE SAME. THIS WOULD BE COMMON WHERE A SECTION IS JUST TO BE NORMALIZED.

HYA0061--VERTICAL DISTANCE SPECIFIED, BUT NO DIRECTION GIVEN. ASSUME UP.

EXPL¤ ON PRECEDING 'MOVE' CARD (B-9), AN ENTRY WAS MADE INDICATING THE DISTANCE OF A VERTICAL MOVE, BUT NO DIRECTION WAS GIVEN FOR THE MOVE. THE PROGRAM WILL ASSUME THE MOVE TO BE UP AND WILL PROCEED. NON-FATAL.

HYA0062--'MOVE TO' SECTION IDENTIFICATION MISSING.

EXPL¤ ON THE PRECEDING 'MOVE' CARD (B-9), NO NEW SECTION NAME WAS PROVIDED TO IDENTIFY THE MOVED SECTION. FATAL ERROR.

HYA0063--NO VERTICAL DISTANCE OR SKEW CORRECTION SPECIFIED.

EXPL¤ ON THE PRECEDING 'MOVE' CARD (B-9) NEITHER VERTICAL DISTANCE NOR SKEW CORRECTION WAS GIVEN. FATAL ERROR.

HYA0064--GRAPH REQUESTED FOR MORE THAN 50 SECTIONS. THIS REQUEST IGNORED.

EXPL¤ ON THE PRECEDING 'GRAPHS' CARD (B-10) ONE OF THE SECTIONS REQUESTED BROUGHT THE TOTAL NUMBER OF GRAPHS TO MORE THAN THE MAXIMUM ALLOWABLE OF 50. ALL GRAPHS UP TO 50 WILL BE PRODUCED. IF THE SECOND GRAPH REQUESTED ON THE 'GRAPHS' CARD WAS THE FIFTY-FIRST, ONLY THE FIRST ONE WILL BE PRODUCED AND THE SECOND REQUEST WILL BE IGNORED. NON-FATAL.

HYA0065--PROBABLE BLANK CARD. CARD IGNORED.

EXPL¤ ON THE CARD PRECEDING THIS MESSAGE, NO ENTRIES WERE FOUND IN POSITIONS NORMALLY OCCUPIED BY CARD IDENTIFIERS. THE CARD IS IGNORED AND THE PROGRAM WILL PROCEED TO THE NEXT CARD.

HYA0066--ERRORS PRECLUDE COMPUTATIONS.

EXPL¤ THIS MESSAGE USUALLY APPEARS AFTER THE INPUT LISTING AND INDICATES THAT ONE OF THE ERRORS NOTED IN THE LISTING HAS CAUSED THE PROBLEM TO BE UNWORKABLE.

HYA0067--NO 'N' VALUE SPECIFIED FOR * *.

EXPL¤ THE USER HAS FAILED TO SUPPLY AN 'N' VALUE FOR THE NAMED SECTION. THEREFORE, NO TAILWATER CAN BE COMPUTED FOR THIS SECTION. FATAL ERROR FOR 'HYDRA' PROBLEMS INVOLVING THIS SECTION EXCEPT IN

'MANY SECTION' PROBLEMS WHERE THIS SECTION WOULD BE DROPPED FROM THE SEQUENCE. HOWEVER, THE GIVEN CROSS-SECTION COORDINATES HAVE BEEN STORED AND ARE AVAILABLE FOR USE IN 'CULBRG'.

HYA0068--PRECEDING - TO X VALUE CHANGED TO AGREE WITH FOLLOWING - FROM X - .

EXPL¤ DUE TO A DISCREPANCY IN SPECIFICATION OF ADJACENT TO X AND FROM X VALUES, THE ROUTINE ARBITRARILY MAKES THE DESCRIBED CORRECTION.

HYA0069--THE 'N' VALUE SPECIFICATIONS FAILED TO MATCH SECTION LIMITS.

EXPL¤ THIS MESSAGE IS A NOTIFICATION THAT THE SPECIFIED 'N' VALUE LIMITS ARE NOT COMPATIBLE WITH THE CROSS-SECTION LIMITS. SUBSEQUENT ACTION TAKEN BY THE ROUTINE DESCRIBED IN MESSAGE NO HYA0070.

HYA0070--THE 'N' VALUE LIMIT OF * * HAS BEEN ADJUSTED TO * *.

EXPL¤ DUE TO A DISCREPANCY IN 'N' VALUE LIMITS, ARBITRARY ADJUSTMENT OF THESE LIMITS IS MADE BY THE ROUTINE.

HYA0071--SECTION * * IMPROPERLY SPECIFIED. NO COORDINATE TABLE WILL BE PRINTED.

EXPL¤ THIS MESSAGE WILL BE PRINTED IN THE SECTION SPECIFICATIONS OUTPUT WHEN THE PROGRAM FINDS THAT THE SECTION BEING DESCRIBED HAS LESS THAN THREE STATIONS. NON-FATAL.

HYA0072--NO METHOD SPECIFIED, NO CONVEYANCE, NO GRAPHS.

EXPL¤ THIS MESSAGE FOLLOWS AN 'ENDATA' CARD (B-11) WHEN NO METHOD (ONE SECTION, TWO SECTION, OR MANY SECTION) HAS BEEN SPECIFIED AND NO 'CNVY' CARD (B-8), 'MOVE' CARD (B-9), OR 'GRAPHS' CARD (B-10) HAS BEEN INSERTED PRIOR TO THE 'ENDATA' CARD. THIS MESSAGE IS FOR THE USER'S INFORMATION AND THE PROGRAM WILL READ THE NEXT CARD, PROCEED TO THE NEXT PROBLEM OR CONTINUE TO READ DATA FOR THIS ONE DEPENDING UPON THE TYPE OF CARD NEXT ENCOUNTERED. THIS MESSAGE WILL BE GENERATED IF THE USER INTENDS ONLY TO USE 'HYDRA' AS A STORAGE VEHICLE FOR A CROSS-SECTION TO BE USED SUBSEQUENTLY IN THE 'CULBRG' SUBSYSTEM. NON-FATAL.

HYA0073--NO COORDINATES SPECIFIED FOR SECTION * * REQUEST FOR GRAPH IGNORED.

EXPL¤ IN PLOTTING THE GRAPHS REQUESTED ON 'GRAPHS' CARDS (B-10), THE PROGRAM ENCOUNTERED A SECTION NAME FOR WHICH NO COORDINATES HAD BEEN STORED. THIS SECTION PLOT WILL NOT BE ATTEMPTED AND THE PROGRAM WILL PROCEED WITH THE NEXT REQUESTED PLOT. NON-FATAL.

HYA0074--CONVEYANCE SECTION IMPROPERLY SPECIFIED. REQUEST FOR CONVEYANCE IGNORED

EXPL¤ THE SECTION FOR WHICH A CONVEYANCE WAS REQUESTED ON THE 'CNVY' CARD (B-8) DID NOT HAVE A MINIMUM OF THREE POINTS STORED. THE PROGRAM WILL IGNORE THE REQUEST FOR CONVEYANCE CURVES AND WILL PROCEED TO CHECK FOR A GRAPHS REQUEST. NON-FATAL.

HYA0075--NO ENDATA CARD PRESENT. HYDRA NOT PROCESSED.

EXPL¤ SELF-EXPLANATORY.

HYA0076--NO Q AVAILABLE

EXPL¤ THE DISCHARGE (Q) FOR USE IN 'CULBRG' COMPUTATIONS MAY BE SUPPLIED FROM EITHER A PREVIOUS 'HYDRO' OR 'HYDRA' COMPUTATION OR IT MAY BE SUPPLIED ON 'SUPPLY' CARD (C-1). THIS MESSAGE INDICATES THAT THE PROGRAM FOUND NO Q VALUE AVAILABLE FROM ANY OF THESE SOURCES. FATAL ERROR.

PART V - CULVERT/BRIDGE SUBSYSTEM (CULBRG)

Culvert/Bridge Subsystem (CULBRG)

CULVERT/BRIDGE SUBSYSTEM (CULBRG)

I. DESCRIPTION

The function of the CULBRG subsystem is to design or analyze culverts and bridges. More specifically, it will:

1. Design
    a. Single opening culverts (one or more barrels) as in Figure 5-1.
    b. Single or multiple opening bridges as shown in Figures 5-2 and 5-3.
    c. A bridge and/or culvert for a given cross-section if either is feasible.
2. Analyze
    a. Single opening culverts (one or more barrels).
    b. Single opening bridges.
    c. Bridges or culverts for the effect of a 100 year flood.

For defining the geometrics and design criteria of culverts the following options are available:

1. Shape: circular, arch, oval, and box
2. Material: concrete, corrugated galvanized metal pipe, and structural plate
3. Profile: straight and broken back
4. Inlet: flared and normal
5. Cost: none, statewide basis and/or local basis.

In using this subsystem, a design flow may be supplied by the user, calculated in HYDRO, or obtained from HYDRA. The design water surface elevation may be supplied by the user or calculated in HYDRA. The maximum allowable headwater is the basis for culvert design calculations. In order to be compatible with the HYDRA subsystem, the values of tailwater and maximum headwater used in CULBRG are in terms of elevation and not in absolute values.

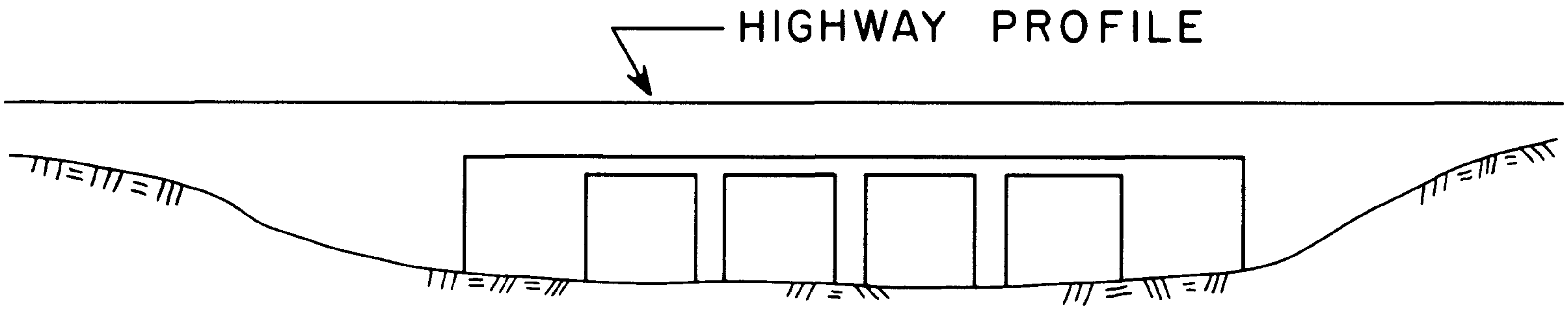


FIGURE 5-1. SINGLE OPENING CULVERT (FOUR BARREL BOX CULVERT)

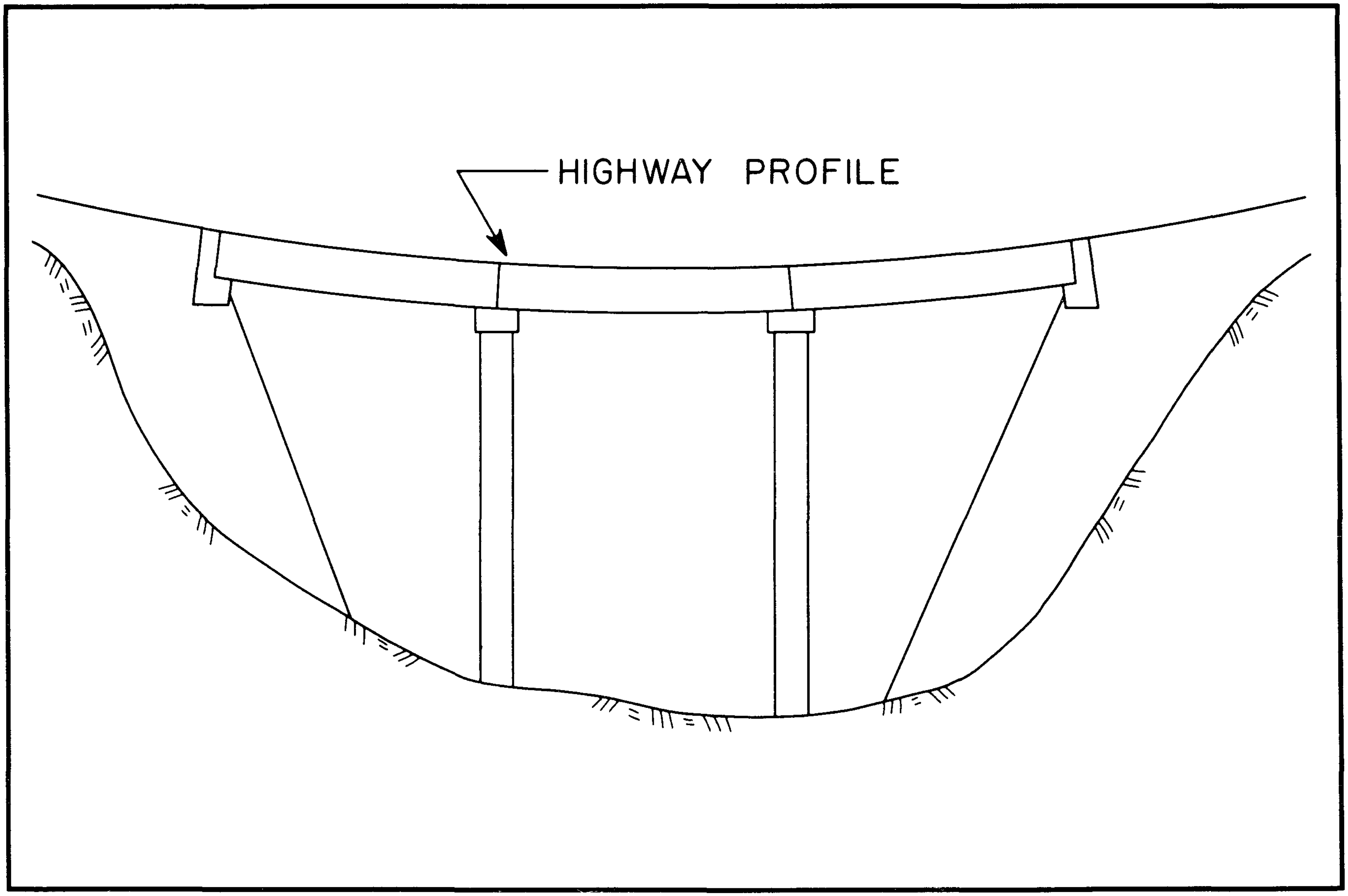


FIGURE 5-2. SINGLE OPENING BRIDGE INSTALLATION (THREE SPAN)

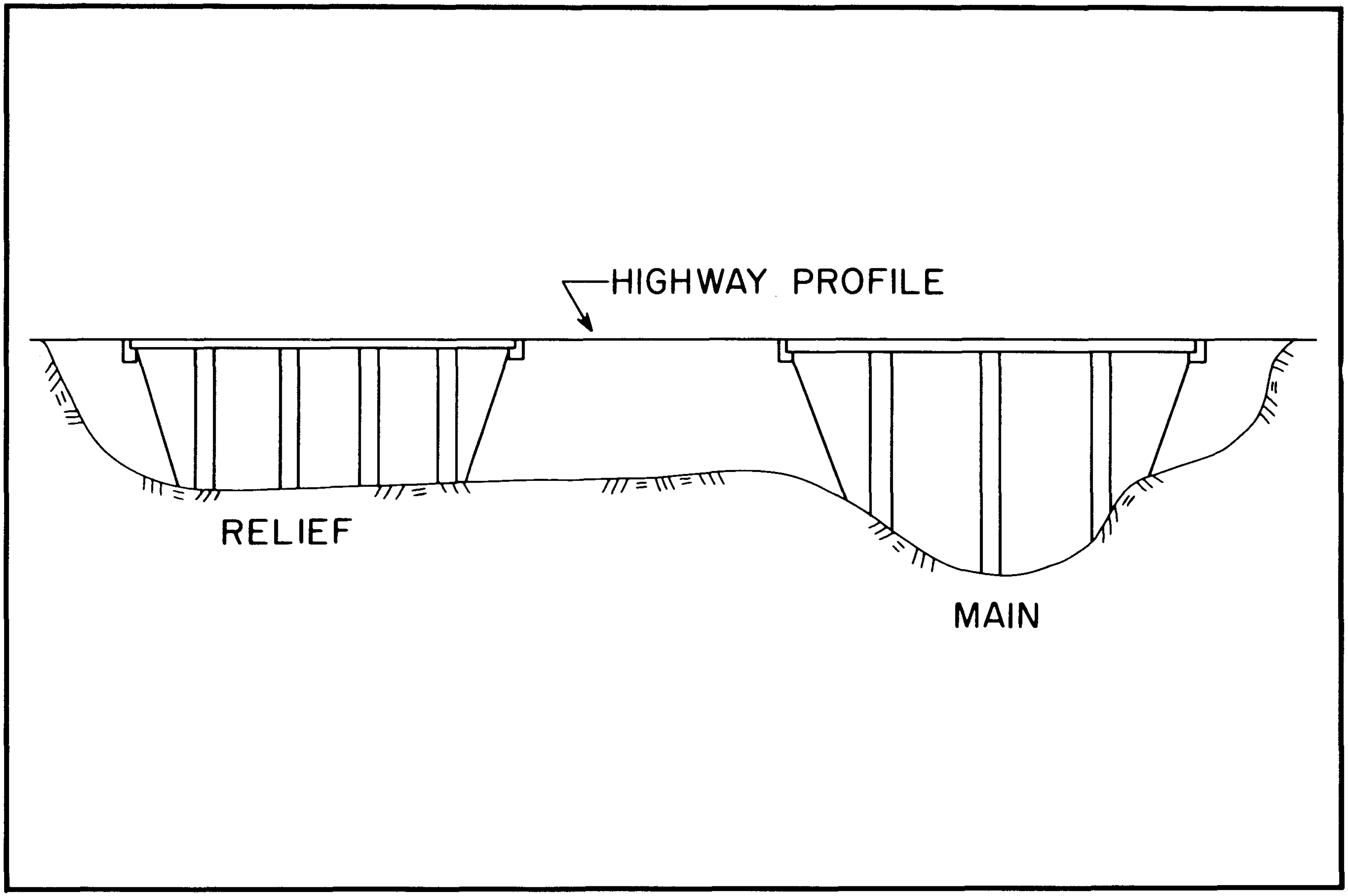


FIGURE 5-3. MULTIPLE OPENING BRIDGE INSTALLATION (TWO OPENINGS)

A 100 year flood analysis can be obtained for a DESIGN or ANALYSIS submission if the required data for the analysis is provided. Specifically HYDRO will compute Q_{100}. HYDRA will compute the Q_{100} tailwater elevation if the 100 year peak discharge is computed in HYDRO or supplied in HYDRA. CULBRG will compute headwater elevation at the structure and depth of flow over the roadway if (1) the 100 year peak discharge is computed in HYDRO or given in HYDRA or CULBRG; (2) the Q_{100} tailwater elevation is computed in HYDRA or given in CULBRG; (3) the Road Profile is given in HYDRA or CULBRG; and (4) the "clear elevation" (in the case of bridges) is given in CULBRG. The user may also request cost comparision information by supplying a request indicating whether to use a statewide or local cost base.

II. INPUT

The data form for the CULBRG subsystem is shown in Figures 5-4 and 5-5. Discharge, tailwater elevation, and frequency used in CULBRG problems will be assumed from previous calculations in HYDRO and/or HYDRA if these values are not specified by the user on the CULBRG input form.

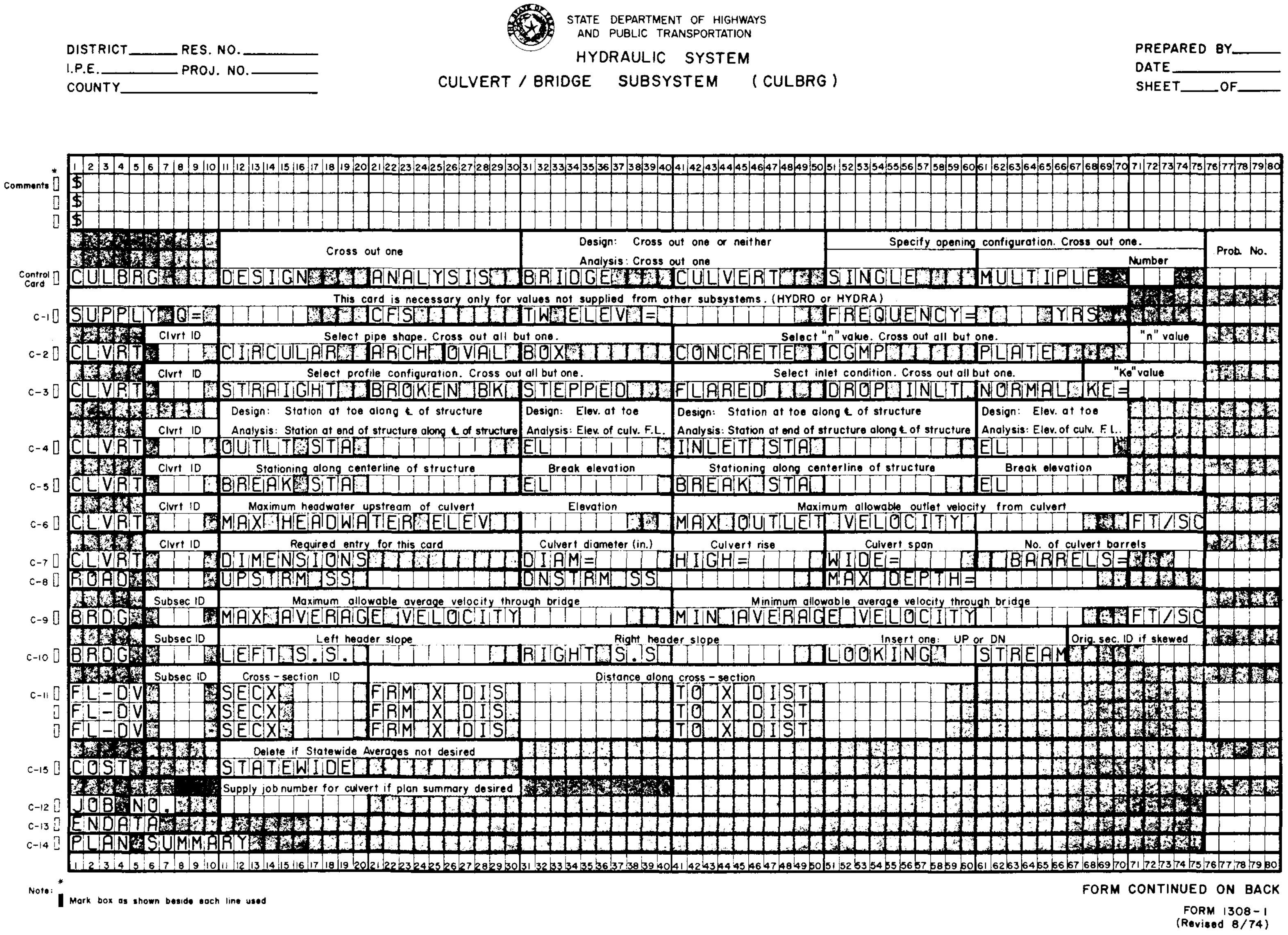
General

The CULBRG subsystem is capable of handling a large variety of problems concerning culverts and bridges. There are, generally, three major categories in which the user must make choices in order to select the proper procedure for his problem. They are DESIGN/ANALYSIS, BRIDGE AND/OR CULVERT, and SINGLE/MULTIPLE (openings).

If both BRIDGE and CULVERT are specified (allowed in DESIGN problems only), the program will first attempt to design a bridge that will satisfy the given conditions and tabulate the results if a feasible design is found. The program will then attempt to design a satisfactory culvert if feasible and tabulate the results. Ordinarily only one of BRIDGE or CULVERT will be specified.

The specification of SINGLE or MULTIPLE openings refers to the number of flow divides rather than the number of culvert barrels or bridge spans. The MULTIPLE option may be used only in conjunction with BRIDGE problems since the program does not handle CULVERT problems with flow divides. (Refer to Figures 5-1, 5-2, and 5-3.)

On all CLVRT, ROAD, BRDG and FL-DV cards, reference is made to CLVRT ID and SUBSEC ID. This is the conveyance subsection identification which in BRIDGE problems identifies the portion of the total section of flood plain that the individual structure is to serve. It



STATE DEPARTMENT OF HIGHWAYS
AND PUBLIC TRANSPORTATION

HYDRAULIC SYSTEM

CULVERT / BRIDGE SUBSYSTEM (CULBRG)

DISTRICT______ RES. NO.__________
I.P.E.__________ PROJ. NO._________
COUNTY_________________________

PREPARED BY______
DATE____________
SHEET_____OF_____

* Comments ☐	$					
☐	$					
☐	$					
		Cross out one	Design: Cross out one or neither Analysis: Cross out one		Specify opening configuration. Cross out one. Number	Prob. No.
Control Card ☐	CULBRG	DESIGN ANALYSIS	BRIDGE	CULVERT	SINGLE MULTIPLE	
	This card is necessary only for values not supplied from other subsystems. (HYDRO or HYDRA)					
C-1 ☐	SUPPLY Q=	CFS	TW ELEV =		FREQUENCY= YRS	
	Clvrt ID	Select pipe shape. Cross out all but one.		Select "n" value. Cross out all but one.	"n" value	
C-2 ☐	CLVRT	CIRCULAR ARCH OVAL	BOX	CONCRETE CGMP	PLATE	
	Clvrt ID	Select profile configuration. Cross out all but one.		Select inlet condition. Cross out all but one.	"Ke" value	
C-3 ☐	CLVRT	STRAIGHT BROKEN BK	STEPPED	FLARED DROP INLT	NORMAL KE=	
	Clvrt ID	Design: Station at toe along ℄ of structure Analysis: Station at end of structure along ℄ of structure	Design: Elev. at toe Analysis: Elev. of culv. F.L.	Design: Station at toe along ℄ of structure Analysis: Station at end of structure along ℄ of structure	Design: Elev. at toe Analysis: Elev. of culv. F.L.	
C-4 ☐	CLVRT	OUTLT STA	EL	INLET STA	EL	
	Clvrt ID	Stationing along centerline of structure	Break elevation	Stationing along centerline of structure	Break elevation	
C-5 ☐	CLVRT	BREAK STA	EL	BREAK STA	EL	
	Clvrt ID	Maximum headwater upstream of culvert	Elevation	Maximum allowable outlet velocity from culvert		
C-6 ☐	CLVRT	MAX HEADWATER ELEV		MAX OUTLET VELOCITY	FT/SC	
	Clvrt ID	Required entry for this card	Culvert diameter (in.)	Culvert rise	Culvert span No. of culvert barrels	
C-7 ☐	CLVRT	DIMENSIONS	DIAM=	HIGH=	WIDE= BARRELS=	
C-8 ☐	ROAD	UPSTRM SS	DNSTRM SS		MAX DEPTH=	
	Subsec ID	Maximum allowable average velocity through bridge		Minimum allowable average velocity through bridge		
C-9 ☐	BRDG	MAX AVERAGE VELOCITY		MIN AVERAGE VELOCITY	FT/SC	
	Subsec ID	Left header slope	Right header slope		Insert one: UP or DN Orig. sec. ID if skewed	
C-10 ☐	BRDG	LEFT S.S.	RIGHT S.S		LOOKING STREAM	
	Subsec ID	Cross - section ID	Distance along cross - section			
C-11 ☐	FL-DV	SECX	FRM X DIS	TO X DIST		
☐	FL-DV	SECX	FRM X DIS	TO X DIST		
☐	FL-DV	SECX	FRM X DIS	TO X DIST		
		Delete if Statewide Averages not desired				
C-15 ☐	COST	STATEWIDE				
		Supply job number for culvert if plan summary desired				
C-12 ☐	JOB NO.					
C-13 ☐	ENDATA					
C-14 ☐	PLAN SUMMARY					

Note: * ▌Mark box as shown beside each line used

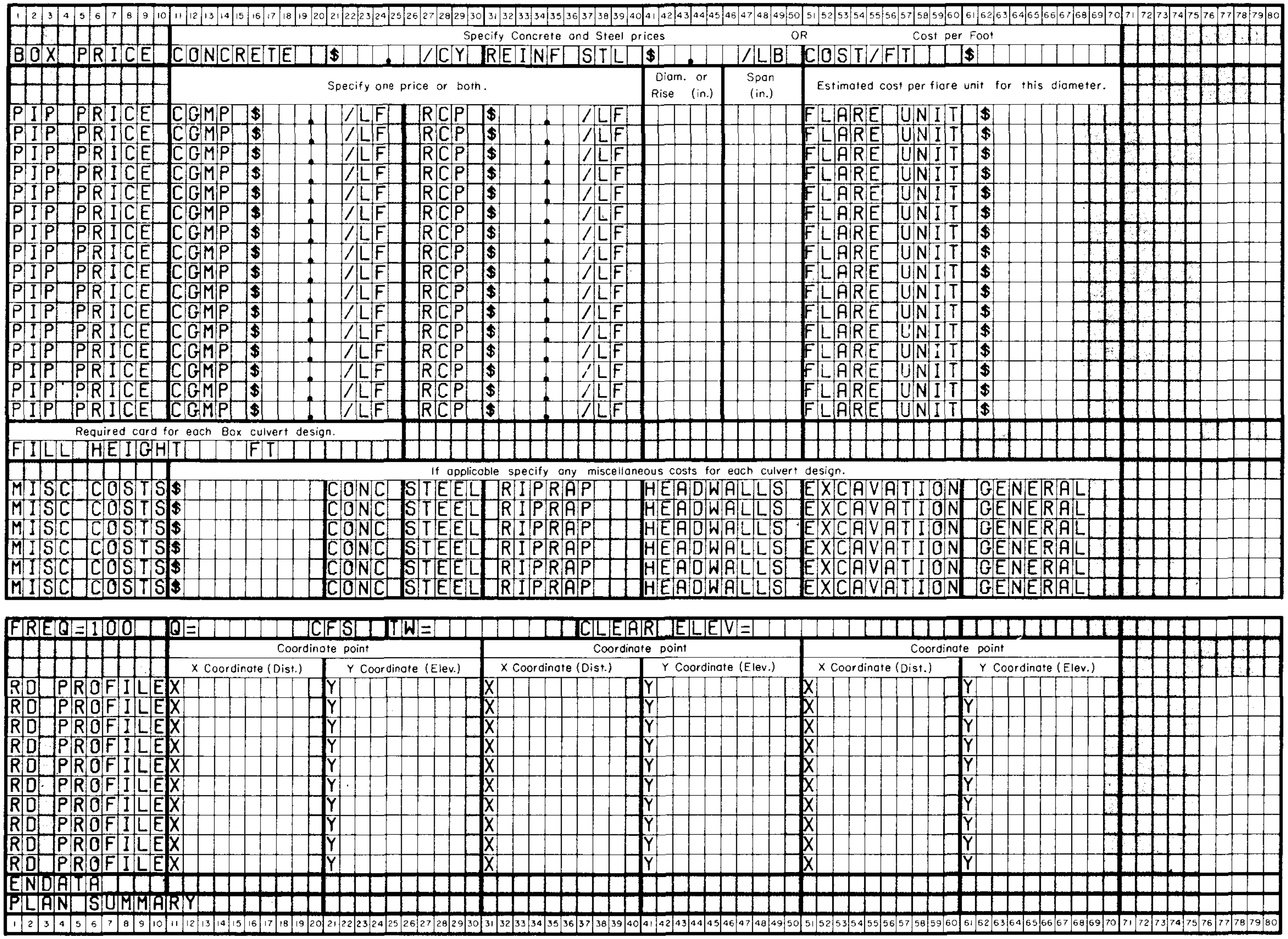
FORM CONTINUED ON BACK

FORM 1308-1
(Revised 8/74)

FIGURE 5-4. FRONT SIDE OF THE CULVERT/BRIDGE SUBSYSTEM (CULBRG) INPUT FORM

CULBRG (Continued)

BACK, SHEET ______ OF ______



1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80

Specify Concrete and Steel prices OR Cost per Foot

C-16 ☐ BOX PRICE CONCRETE $. /CY REINF STL $. /LB COST/FT $

Specify one price or both. Diam. or Rise (in.) Span (in.) Estimated cost per flare unit for this diameter.

C-17 ☐ PIP PRICE CGMP $. /LF RCP $. /LF FLARE UNIT $
☐ PIP PRICE CGMP $. /LF RCP $. /LF FLARE UNIT $
☐ PIP PRICE CGMP $. /LF RCP $. /LF FLARE UNIT $
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☐ PIP PRICE CGMP $. /LF RCP $. /LF FLARE UNIT $
☐ PIP PRICE CGMP $. /LF RCP $. /LF FLARE UNIT $

Required card for each Box culvert design.

C-18 ☐ FILL HEIGHT FT

If applicable specify any miscellaneous costs for each culvert design.

C-19 ☐ MISC COSTS $ CONC STEEL RIPRAP HEADWALLS EXCAVATION GENERAL
☐ MISC COSTS $ CONC STEEL RIPRAP HEADWALLS EXCAVATION GENERAL
☐ MISC COSTS $ CONC STEEL RIPRAP HEADWALLS EXCAVATION GENERAL
☐ MISC COSTS $ CONC STEEL RIPRAP HEADWALLS EXCAVATION GENERAL
☐ MISC COSTS $ CONC STEEL RIPRAP HEADWALLS EXCAVATION GENERAL
☐ MISC COSTS $ CONC STEEL RIPRAP HEADWALLS EXCAVATION GENERAL

C-20 ☐ FREQ=100 Q= CFS TW= CLEAR ELEV=

Coordinate point: X Coordinate (Dist.) Y Coordinate (Elev.) | Coordinate point: X Coordinate (Dist.) Y Coordinate (Elev.) | Coordinate point: X Coordinate (Dist.) Y Coordinate (Elev.)

C-21 ☐ RD PROFILE X Y X Y X Y
☐ RD PROFILE X Y X Y X Y
☐ RD PROFILE X Y X Y X Y
☐ RD PROFILE X Y X Y X Y
☐ RD PROFILE X Y X Y X Y
☐ RD PROFILE X Y X Y X Y
☐ RD PROFILE X Y X Y X Y
☐ RD PROFILE X Y X Y X Y
☐ RD PROFILE X Y X Y X Y
☐ RD PROFILE X Y X Y X Y

C-13 ☐ ENDATA

C-14 ☐ PLAN SUMMARY

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80

FORM 1308-2
(Revised 8/74)

FIGURE 5-5. BACK SIDE OF THE CULVERT/BRIDGE SUBSYSTEM (CULBRG) INPUT FORM presently has no bearing on CULVERT designs and is for the engineer's structure identification in culvert problems. It may be used to relate culvert design criteria to the proper ROAD card.

In BRDG problems the SUBSEC ID is required and has a definite bearing on the problem since, for multiple opening bridge design or analysis, flow divides and their associated conveyances must be matched and, in design, the conveyances for each bridge are balanced to match discharges resulting from indicated flow divides.

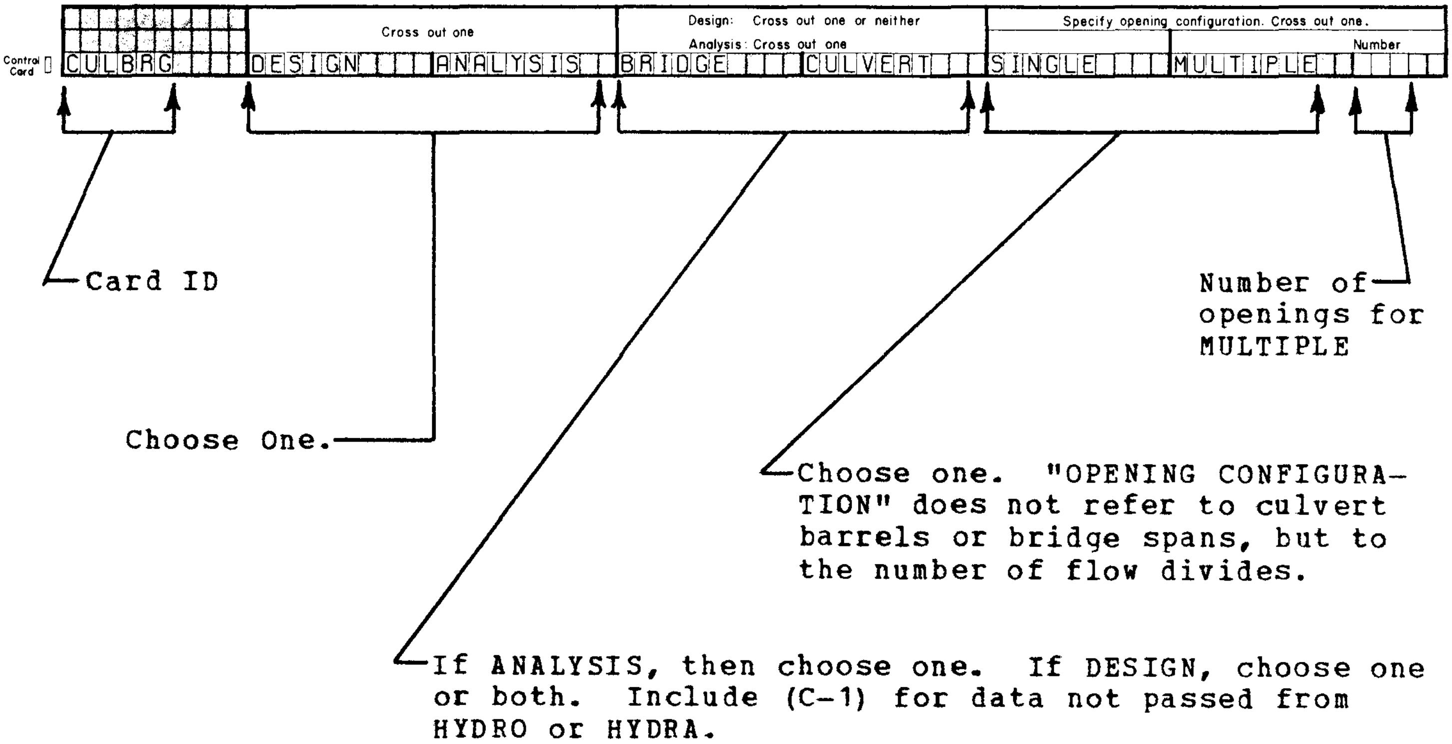
Several solutions to the same basic problem may be secured by using the following procedure:

1. Input all data necessary for the first solution including a CULBRG Control Card and an ENDATA card (C-13).
2. Then the user should input only the cards containing items he wishes to change for the next solution, entering all data for the cards used. As long as a CULBRG Control Card is not included with the subsequent sets of data, only cards with new values need to be entered. After all changes for the second solution have been entered, another ENDATA card must be inserted. This procedure is termed "stacking" and may be repeated for as many solutions as the user desires.

CULBRG CONTROL CARD

The CULBRG Control Card is required for entry into the CULBRG subsystem. A major function of this card is to specify the desired procedure. Either DESIGN or ANALYSIS must be specified by crossing out the one not used. If ANALYSIS is specified it is necessary for either BRIDGE or CULVERT to be designated; but, if DESIGN is specified, it is permissible (but not usual) to designate both BRIDGE and CULVERT when the user wishes to compare the two designs. MULTIPLE

OPENINGS MUST NEVER BE INDICATED when CULVERT has been specified (regardless of whether BRIDGE has also been specified). When a MULTIPLE opening BRIDGE is specified, it is necessary for the number of openings to be indicated in the field NUMBER of this card.



Card ID

Number of openings for MULTIPLE

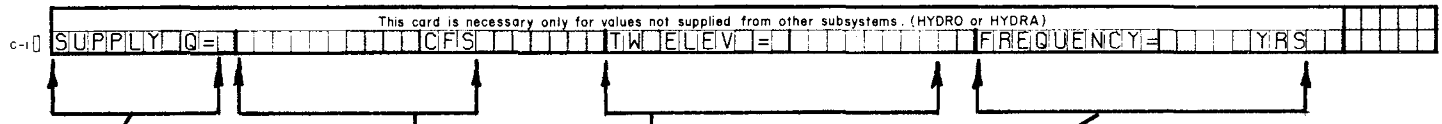
Choose One.

Choose one. "OPENING CONFIGURATION" does not refer to culvert barrels or bridge spans, but to the number of flow divides.

If ANALYSIS, then choose one. If DESIGN, choose one or both. Include (C-1) for data not passed from HYDRO or HYDRA.

<u>SUPPLY CARD (C-1)</u>

This card is used to supply values for DISCHARGE and/or TAILWATER ELEVATION and/or FREQUENCY if these values have not previously been determined for this problem in HYDRO and/or HYDRA. If all of these values have been previously supplied, then this card may be omitted. If some of the values have been supplied previously or if the user wishes to supply values other than those supplied previously, this card may be used to enter the needed values. Only those items with values entered on this card will be altered.



Card ID-Required only if Q is to be supplied.

Frequency value if different from value used in preceding HYDRO, HYDRA or CULBRG problem. Not required, but should be entered if card is used.

Tailwater elevation if different from value used in the preceding HYDRA or CULBRG problem (decimal).

Flow if Q is different from value used in the preceding HYDRO or HYDRA (decimal).

CLVRT CARD (shape and "n" value) (C-2)

This card is required when CULVERT DESIGN or ANALYSIS is specified and is used to supply information relative to the shape and friction factor applicable to the culvert barrels. An entry for pipe shape must be made. If BOX is selected, then no further information is required on this card. The material will automatically be assumed to be CONCRETE with a friction factor of 0.012. If any other shape is indicated, the standard friction factor ("n") for the material used will be automatically selected when the material is designated as concrete, CGMP or Plate by marking out all but one. The standard values which will be assumed are:

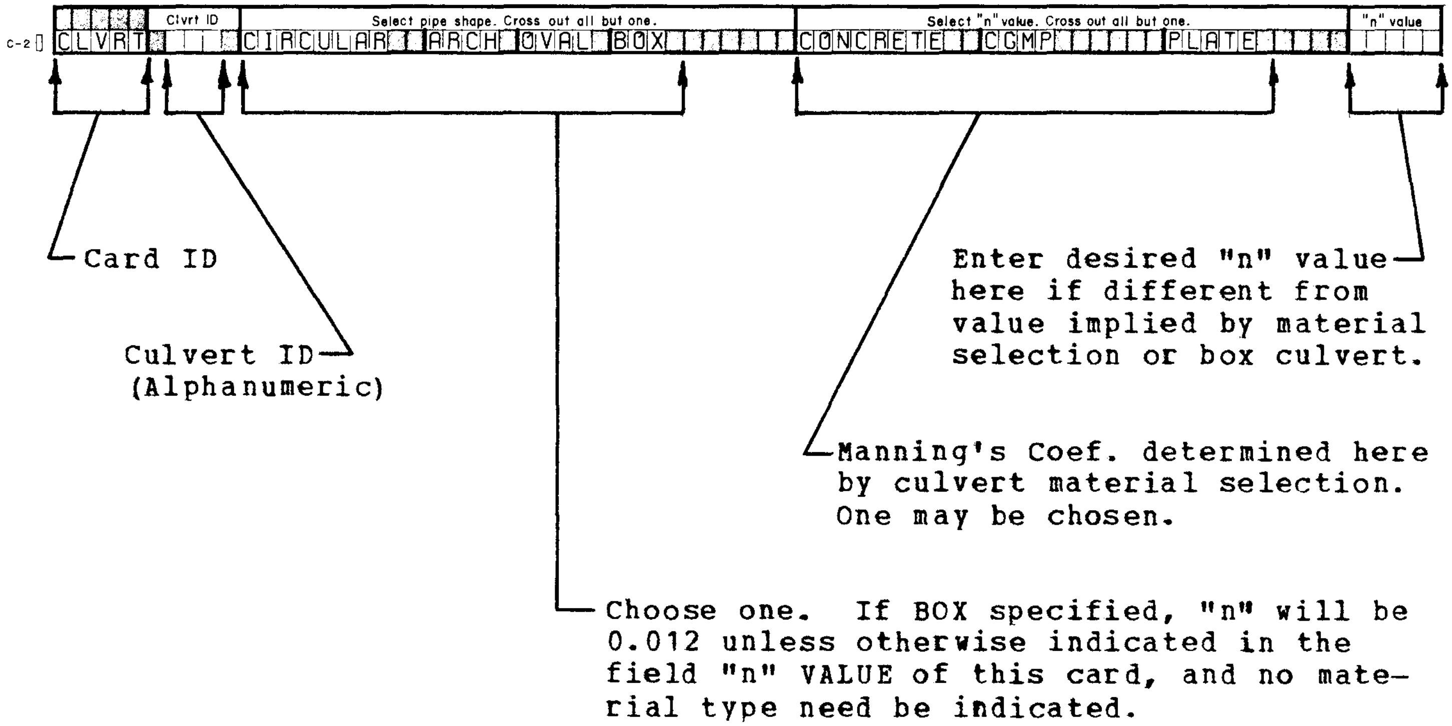
Concrete - 0.012

CGMP - 0.024

Plate, Arch
6'-1" X 4'-7" - 0.0327 (maximum)
20'-7" X 13'-2" - 0.0298 (minimum)

Plate, Circular
5.0' diam. – 0.0328 (maximum)
15.0' diam. – 0.0302 (minimum)

NOTE: The variation of "n" factors for plate diameters between 5' and 15' and arch sizes between 6'-1" X 4'-7" and 20'-7" X 13'-2" is logarithmic. For further information contact the Bridge Division, Hydraulic Section.



Card ID

Culvert ID (Alphanumeric)

Enter desired "n" value here if different from value implied by material selection or box culvert.

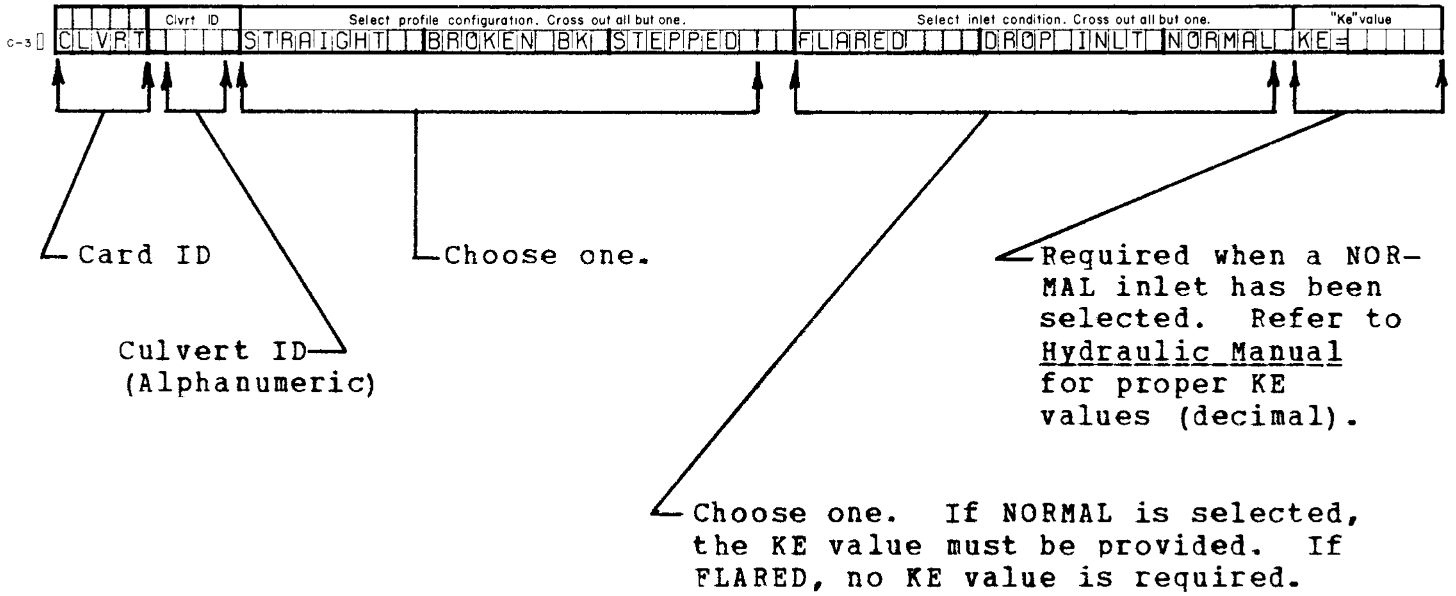
Manning's Coef. determined here by culvert material selection. One may be chosen.

Choose one. If BOX specified, "n" will be 0.012 unless otherwise indicated in the field "n" VALUE of this card, and no material type need be indicated.

If the configuration is specified ARCH and the material is specified PLATE, the standard "n" value may be overridden by specifying the desired "n" value in the field "n" VALUE. For other configurations and materials, a non-standard "n" value may be specified by the user. However, the entry for material must be omitted by marking out CONCRETE, CGMP and PLATE. This should not usually be done if DESIGN has been specified but may be a very useful option if ANALYSIS has been specified. This would be true if an existing culvert (to be analyzed) is old or, for some reason, has an "n" value other than the standard.

CLVRT CARD (profile and inlet) (C-3)

This card is required when CULVERT DESIGN or ANALYSIS is specified. It is used to define the profile along the culvert as well as the inlet conditions. One of three culvert profiles (STRAIGHT, BROKEN BACK, or STEPPED) must be chosen. A STRAIGHT profile is one in which the flow line subtends a straight line from the upstream elevation to the downstream elevation. If BROKEN BK or STEPPED is specified, then break stations and elevations must be provided on CLVRT cards (C-5). As many as two break stations are allowed for BROKEN BK. The user must specify the inlet condition (FLARED, DROP INLET or NORMAL) by marking out all but one. FLARED INLET is a term used to refer to an inlet with a slightly flattened bell shape. This is not a reference to standard flared wing walls. When FLARED or DROP INLET is specified, no KE value need be supplied from the user, since all necessary information will be automatically supplied by the program. The user must always supply a KE value (entrance coefficient) when a NORMAL inlet is specified.



Card ID

Culvert ID (Alphanumeric)

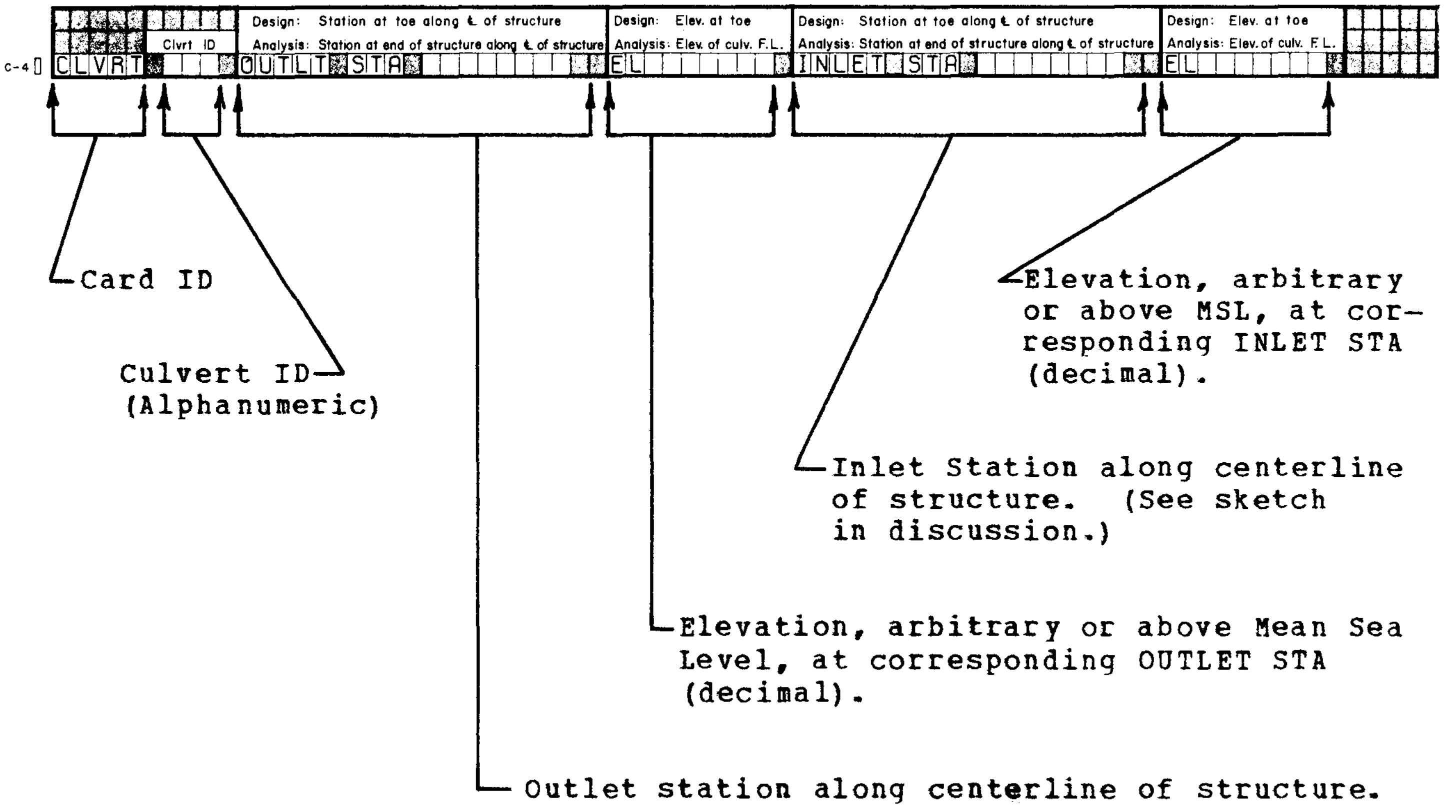
Choose one.

Required when a NORMAL inlet has been selected. Refer to Hydraulic Manual for proper KE values (decimal).

Choose one. If NORMAL is selected, the KE value must be provided. If FLARED, no KE value is required.

The computations for FLARED inlets may be requested directly on this card by specifying FLARED; however, if the user specifies a NORMAL inlet with a circular shape and the design achieved by the program indicates a resulting super critical slope, the program will automatically attempt a FLARED inlet design. In this card the results of both designs will be printed. It should be noted that the NORMAL specification refers to a standard State Department of Highways and Public Transportation headwall (with the appropriate entrance coefficient as outlined in the Hydraulic Manual).

CLVRT CARD (stationing and elevations) (C-4)



Card ID

Culvert ID
(Alphanumeric)

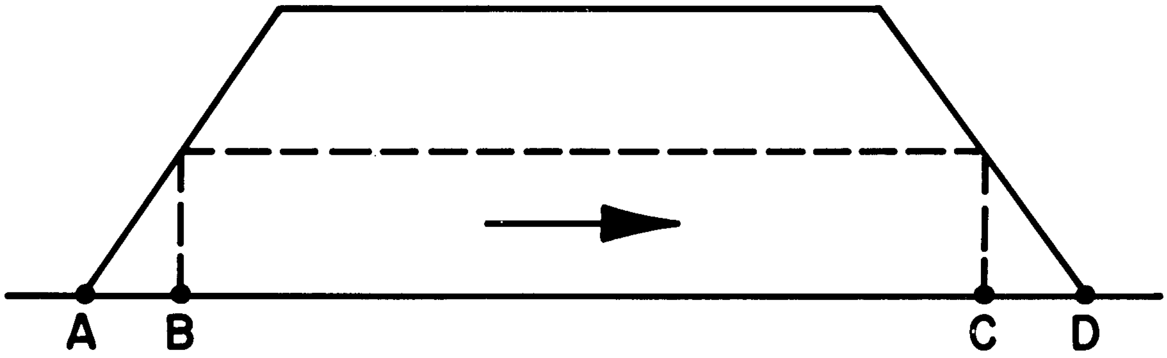
Elevation, arbitrary or above MSL, at corresponding INLET STA (decimal).

Inlet Station along centerline of structure. (See sketch in discussion.)

Elevation, arbitrary or above Mean Sea Level, at corresponding OUTLET STA (decimal).

Outlet station along centerline of structure. (See sketch in discussion.)

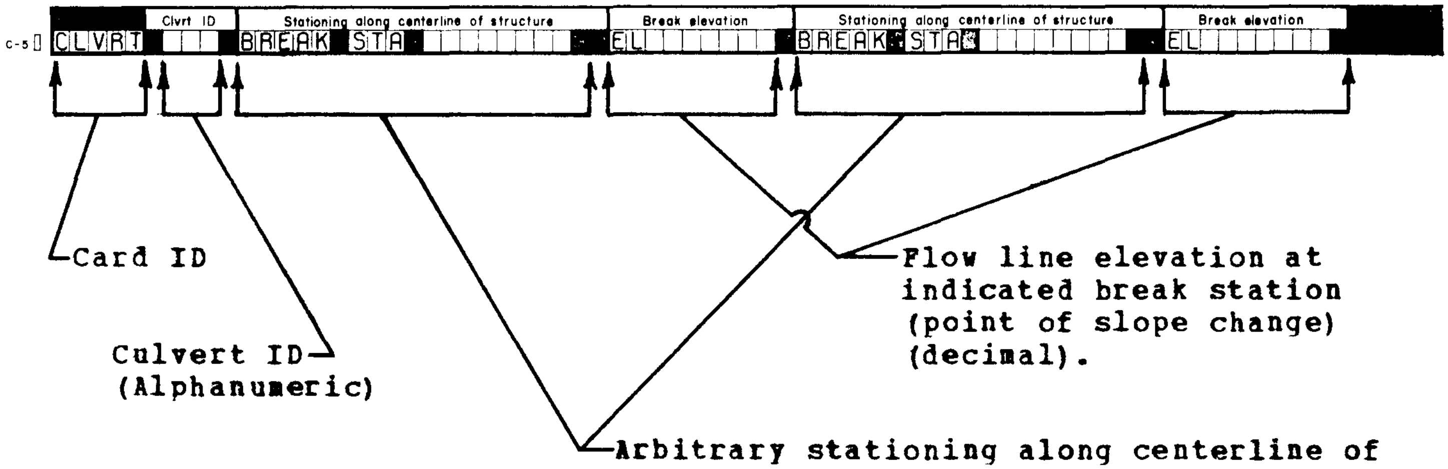
This card provides the culvert length and slope by virtue of inlet and outlet stations and elevations. For design problems the inlet and outlet stations and elevations should usually be given at the toe of the slope of roadway embankment along the centerline of the culvert. The program will then determine the actual barrel length based on the size of barrel and degree of side slope. In analysis problems the inlet and outlet stations and elevations should be given at the flow line (inside bottom) at each end of the barrel.



Computation Type	Inlet Station Is	Outlet Station Is
Design	Point A	Point D
Analysis	Point B	Point C

CLVRT CARD (break stationing and elevations) (C-5)

This card allows entry of positions of breaks when BROKEN BK culverts are specified on the CLVRT Card (C-3). The stationing must be at the point of slope change along the centerline of the structure and the elevation must be the flow line elevation at the point of slope change at the indicated station.



Card ID

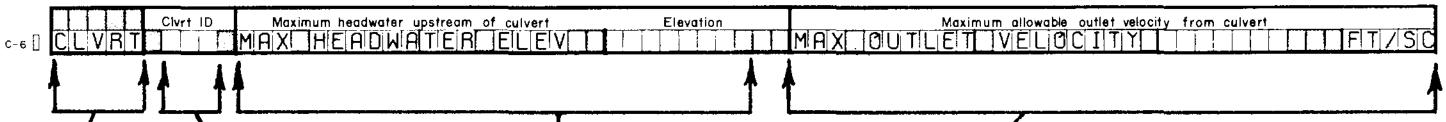
Culvert ID (Alphanumeric)

Flow line elevation at indicated break station (point of slope change) (decimal).

Arbitrary stationing along centerline of structure at points of slope change. Stations must be relative to other break stations, inlet stations and outlet stations (decimal).

CLVRT CARD (maximum allowable headwater and outlet velocity) (C-6)

The maximum allowable headwater elevation provides the basis for culvert design calculations. It is, therefore, mandatory for DESIGN and should be a realistic value. Both maximum allowable headwater elevation and maximum allowable outlet velocity are discretionary values determined by the engineer's judgment based on criteria as outlined in the <u>Hydraulic Manual</u>. If the calculated outlet velocity exceeds the specified maximum, a message to this effect will be supplied in the output, but no further action is taken regarding that velocity.



Card ID

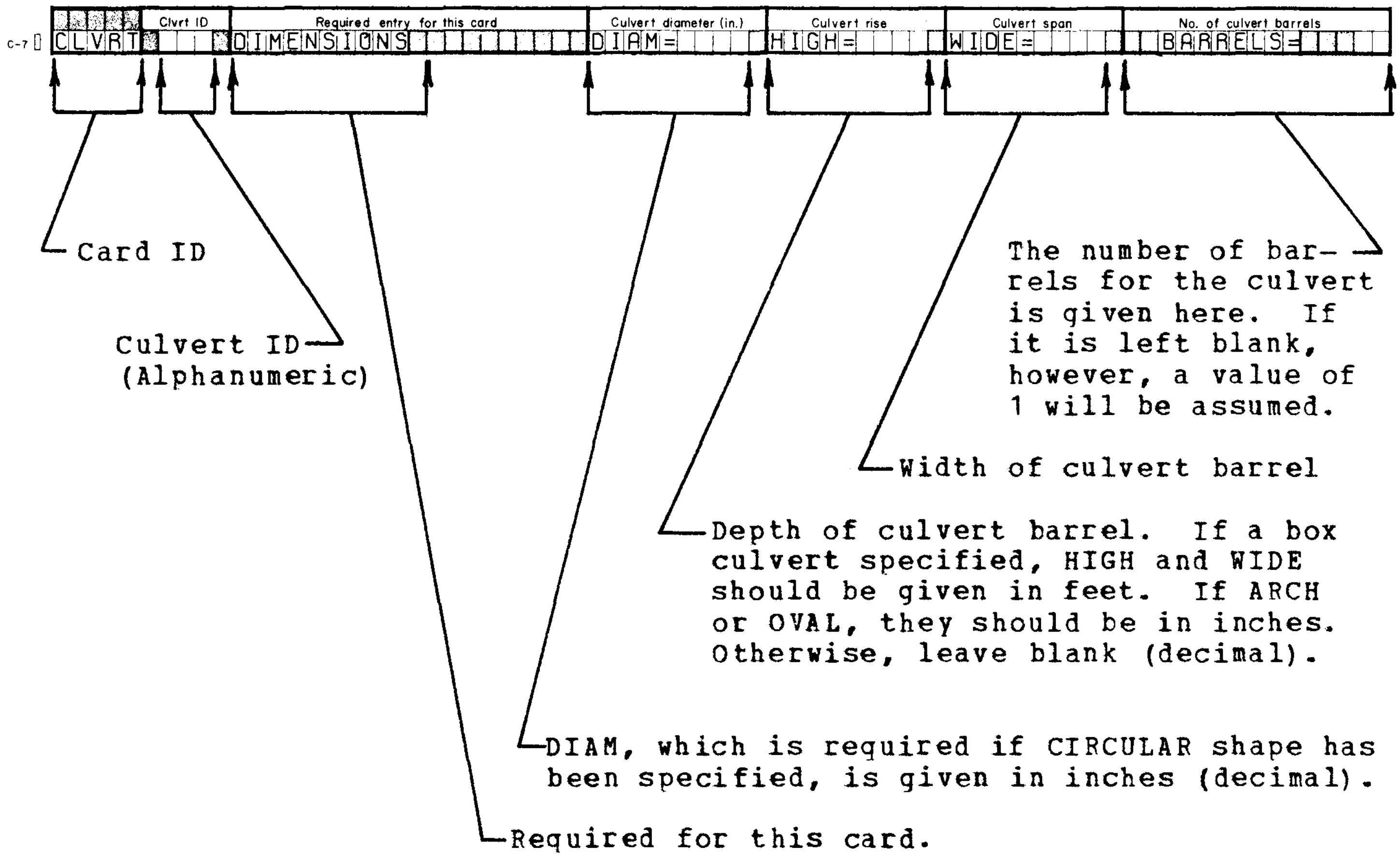
Culvert ID
(Alphanumeric)

This value should be determined as outlined in the Hydraulic Manual. It has no control over the structure design, but is output for the purpose of comparison with the computed velocity.

MAX HEADWATER ELEVATION should be determined as outlined in the Hydraulic Manual. This value required as it controls the design. It must be realistic because the program will search for a beginning culvert size until it finds one which most nearly fits the maximum headwater elevation (decimal).

CLVRT CARD (dimensions) (C-7)

This card provides for entry of culvert dimensions when ANALYSIS has been specified. DIAM must be provided only when the culvert configuration is specified as CIRCULAR on CLVRT card (C-2). The diameter of the circular culvert should be given in inches. HIGH and WIDE are used to describe culverts with a box, arch, or oval configuration. If BOX is specified on CLVRT card (C-2), then these dimensions must be given in feet. If ARCH or OVAL is specified on the CLVRT card (C-2), then these dimensions must be given in inches.



Card ID

Culvert ID (Alphanumeric)

The number of barrels for the culvert is given here. If it is left blank, however, a value of 1 will be assumed.

Width of culvert barrel

Depth of culvert barrel. If a box culvert specified, HIGH and WIDE should be given in feet. If ARCH or OVAL, they should be in inches. Otherwise, leave blank (decimal).

DIAM, which is required if CIRCULAR shape has been specified, is given in inches (decimal).

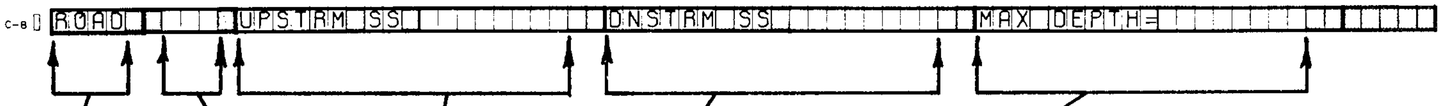
Required for this card.

The value entered in the field NO. OF CULVERT BARRELS refers to the number of barrels composing the culvert. (A culvert is composed of the entire structure which serves the flow in a particular channel.) If no value is entered the program will assume one barrel. This value <u>must</u> be right justified with no decimal.

<u>ROAD CARD (C-8)</u>

This card is required in every culvert design problem. The UPSTRM SS and the DNSTRM SS refer to the numerators of the embankment side slope ratios along the centerline of the structure when the denominators have been reduced to one (e.g., 2:1, SS=2).

The MAXIMUM DEPTH specified by the user will not be exceeded by the program in the culvert design. The program will find the smallest barrel that will fulfill the design criteria, but in no case will it attempt to use a depth that exceeds the maximum depth.



Card ID

Culvert ID
(Alphanumeric)

MAX DEPTH (in feet) should represent the maximum depth of culvert barrel the engineer is prepared to accept in a culvert design. Required entry (decimal).

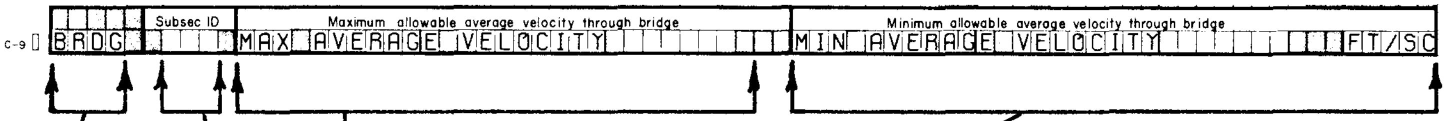
DNSTRM SS is the numerator of the embankment side slope ratio on the downstream side of the roadway section.

UPSTRM SS is the numerator of the embankment side slope ratio <u>along the centerline of the structure</u> on the upstream side of the roadway section (decimal).

Due to the logic in the box culvert design routine (and because of geometry limitations inherent in the box culvert standards), situations may arise where a culvert design has less than optimum efficiency if the maximum depth is too high with respect to the allowable headwater elevation. For this reason, the maximum depth should be no higher than the engineer deems necessary. On the other hand, too low a maximum depth, while yielding an efficient hydraulic design, will often yield an uneconomical structure. Ideally, the user should strive for a realistic balance in his assignment of maximum depth for a box culvert design. However, this balance may be difficult to anticipate until the user gains some experience in the system. Experience in the use of the system and, in particular, the box culvert design option should give the user more insight on how to handle this particular problem.

BRDG CARD (velocities) (C-9)

For bridge design the MAX and MIN AVERAGE VELOCITIES must be supplied. If either or both values are omitted, a maximum of 6 and/or a minimum of 4 ft/sec will be assumed.



Card ID

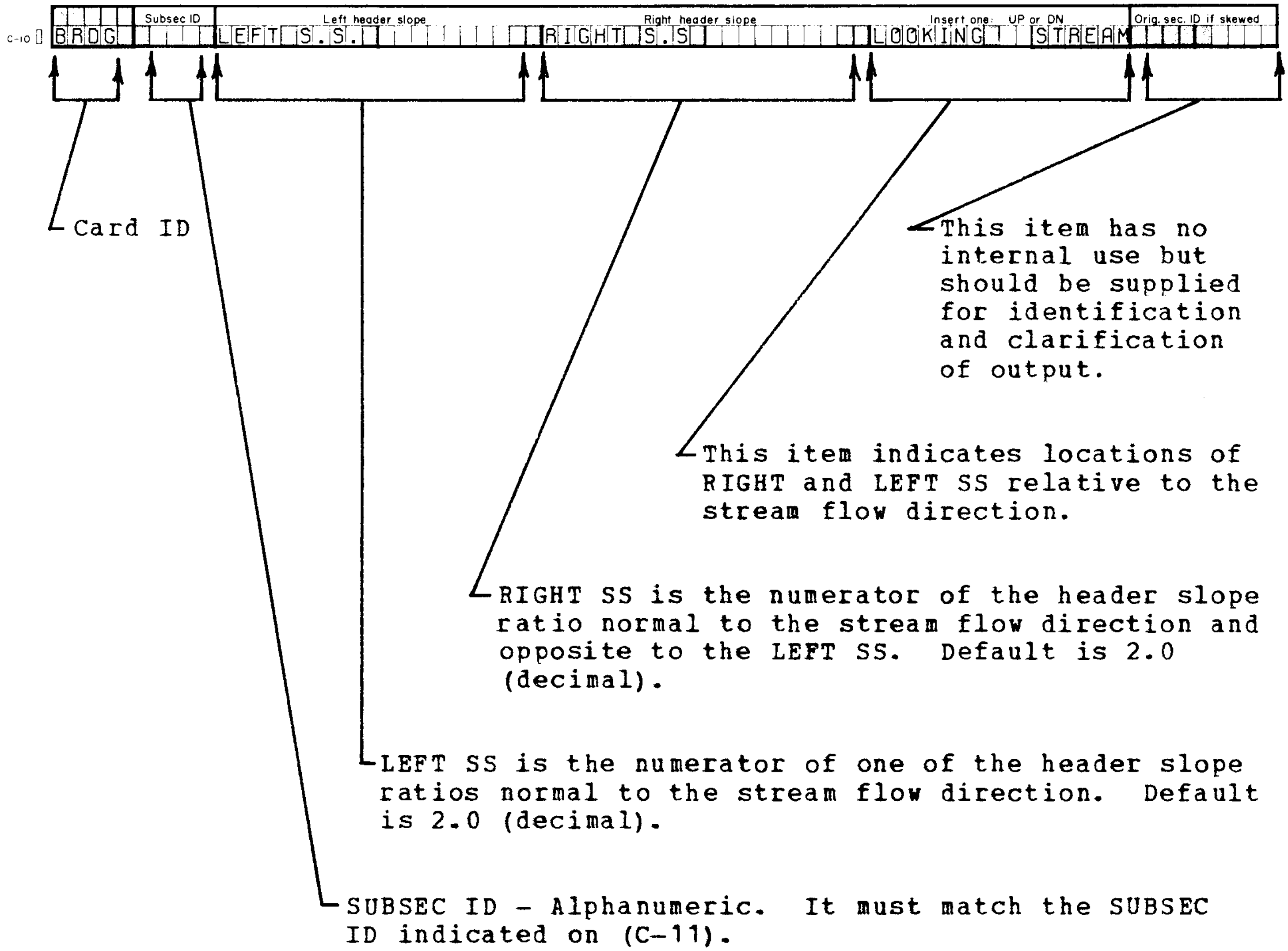
MIN AVERAGE VELOCITY should indicate the minimum through-bridge velocity the engineer is prepared to accept. If not supplied, program will assume 4.0 fps. Although it should be supplied in all cases, it is used primarily in multiple bridge design (decimal).

Maximum through-bridge (or restricted) velocity. If not supplied, program will assume 6.0 fps. MAX AVERAGE VELOCITY should be based on criteria as indicated in the Hydraulic Manual (decimal).

SUBSEC ID - Alphanumeric. It must match the SUBSEC ID indicated on (C-11).

BRDG CARD (side slope) (C-10)

The left and right side slopes on this card must be supplied for all bridge problems. The values entered must be the numerators of the header slope ratios (denominators reduced to one) normal to the stream flow direction.



Card ID

This item has no internal use but should be supplied for identification and clarification of output.

This item indicates locations of RIGHT and LEFT SS relative to the stream flow direction.

RIGHT SS is the numerator of the header slope ratio normal to the stream flow direction and opposite to the LEFT SS. Default is 2.0 (decimal).

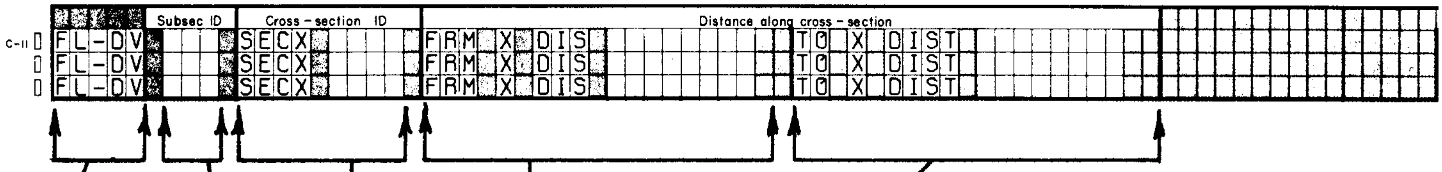
LEFT SS is the numerator of one of the header slope ratios normal to the stream flow direction. Default is 2.0 (decimal).

SUBSEC ID - Alphanumeric. It must match the SUBSEC ID indicated on (C-11).

The user must specify UP (looking upstream) or DN (looking downstream) when making reference to left and right side slopes. The original section name may be entered in the field ORIG SEC ID if the name was changed in order to define the section as a skewed section. This item is not required for computations, but it should be included for clarification of the output.

FL-DV CARD (C-11)

This card is used any time cards C-9 and/or C-10 are used and specifically defines the boundaries of flow divides. It is presently used only in conjunction with BRIDGE problems since the program is not equipped to handle CULVERT problems with divided flow.



Card ID

The other limit of the flow-divide being described (decimal). (Station of toe of other header slope for bridge analysis)

One limit of the flow-divide being described for the section. This would be the same as some stationing of X COORDINATE along the cross-section. (decimal) (Station of toe of one header slope for bridge analysis)

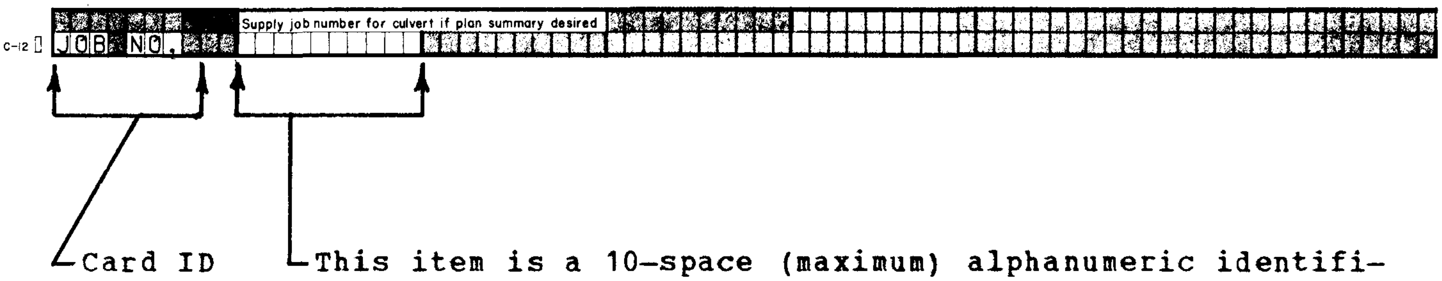
Alphanumeric identification of a section which must first have been stored in the HYDRA subsystem.

SUBSEC ID should be a unique alphanumeric identification.

If BRIDGE is specified, this card must be used. SUBSEC ID must correspond to SUBSEC ID on Cards C-9 and C-10. The section (real or artificial) on which the bridge is based should be indicated under CROSS-SECTION ID. For bridge design, FRM X DIS and TO X DIST should correspond to the first and last X values in the sub-section. For analysis, FRM X DIS and TO X DIST refer to the toes of slope for the existing structure, and the shape of the cross-section should be as it was before the structure was built. The SUBSEC ID describes the name given to the portion of the cross-section which is identified in the field CROSS-SECTION ID and which is defined on this card. This cross-section must have been previously stored in the HYDRA subsystem. For SINGLE BRIDGE ANALYSIS, the SUBSEC ID is arbitrary but must be supplied. For multiple bridge design, the limits of the subsection are defined by entering the beginning and ending stations of the subsection in the FRM X DIS and TO X DIST fields. In SINGLE BRIDGE ANALYSIS, the toe of slope X locations are defined in these fields. The stations must correlate with the stationing of the section as stored in HYDRA. (Note that if a given skewed cross-section has been normalized by use of the MOVE card in HYDRA, the FRM TO X DIST values should correlate with the adjusted X value in the new section.)

JOB NO. CARD (C-12)

If several culvert designs and/or analyses are interrelated (e.g., all pertaining to the same project), the user may wish to have one report in which the results of these computations are summarized. This summary will be in addition to the automatic individual report for each problem. When this is desired the user must assign an identification (possibly the project number) to all problems which are to be included in the summary. This alphanumeric identification must be entered on a JOB NO. card (C-12) at the end of each set of data for which the results are to be included. The same identification must be entered in the same position on each JOB NO. card, and the JOB NO. card must be placed before the ENDATA card for each included problem. When the final problem to be included has been entered, then the PLAN SUMMARY card (C-14) must follow the ENDATA card for that problem. All jobs to be summarized under one job identification must be grouped together and must have the identical job identification. If a job with a different identification is placed within the group, then only the jobs following it will appear in the summary. This summary has been tailored for inclusion in design plans.

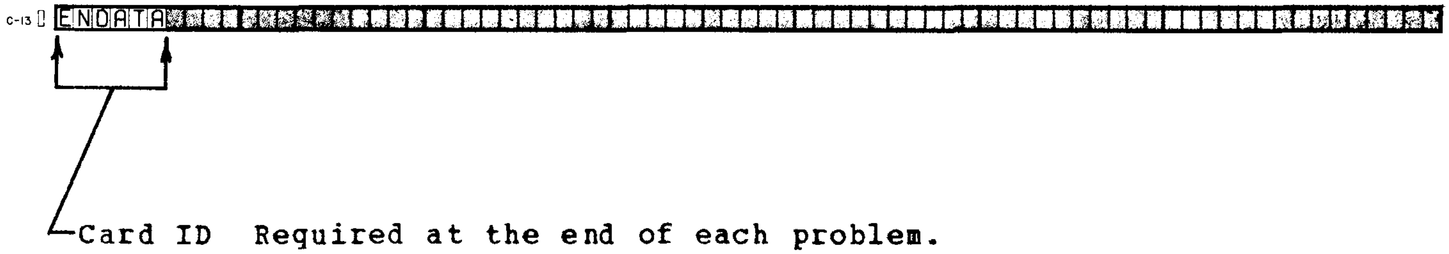


Card ID

This item is a 10-space (maximum) alphanumeric identification for storage of related culvert designs and/or analyses if a plan summary is to be requested.

ENDATA CARD (C-13)

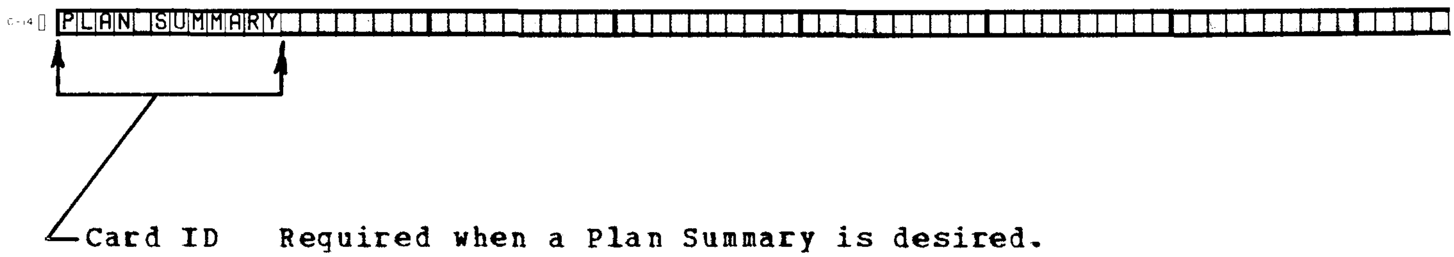
This card marks the end of a set of input data for one problem and signals the program to begin computations.



Card ID Required at the end of each problem.

PLAN SUMMARY CARD (C-14)

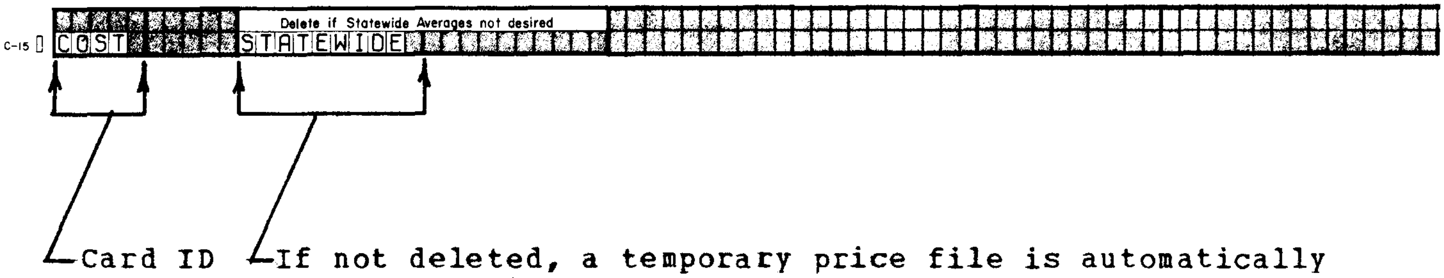
This card is used only when a summary is desired as outlined in the discussion for JOB NO. card (C-12). When all of the problems which are to be included in the summary (i.e., having the same job identification) have been entered, then this card must be placed after the ENDATA card for the last problem in that series. Other problems may follow this plan summary and other summaries may be compiled.



Card ID Required when a Plan Summary is desired.

COST CARD (C-15)

The COST card (C-15) is optional. It specifies that the cost feature for culverts will be used and initiates a temporary price file which uses the Statewide Average Low Bid prices, or the prices inserted by the user, or a combination of both for a series of CULBRG problems in a run. When specifying STATEWIDE on the first COST card in a run or a single problem, a temporary price file is automatically built using prices from the "Statewide Average Low Bid Price" list published by D-19 each month. Not all prices are available on this list and no attempt is made to supply an arbitrary price for any item. The Statewide Average Low Bid Prices available to THYSYS are those for which item and code numbers have been officially issued and an average bid price is available. This list will be expanded as code and item numbers are issued, and the prices will be updated as new statewide average prices are available. The output for the COST option is useful for comparison purposes <u>only</u>.



Card ID

If not deleted, a temporary price file is automatically built using the "Statewide Average Low Bid Prices". STATEWIDE should be indicated only on the first COST card of a run to set these prices for all subsequent problems in the run and deleted on subsequent problems of the run. If marked out on first problem in a run the user must supply prices.

The user may supplement or change this temporary price file by completing the PIP or BOX cards. Data entered on these cards modifies the temporary price file accordingly, and this data is used for subsequent CULBRG problems in the run. Should another COST card specifying STATEWIDE be encountered in the run, the entire temporary price file will be deleted and replaced with only the statewide average prices. The user may again update the file as before. Each subsequent CULBRG problem in the run should contain a COST card with STATEWIDE <u>marked out</u> if the current temporary price file for the run is correct.

If STATEWIDE is marked out on the first COST card in the run, the temporary price file for the run is built entirely from the data supplied by the user on the BOX and PIP cards in the first problem. The file again may be altered in succeeding problems as previously discussed. Should STATEWIDE be specified on a subsequent COST card in the run, the entire temporary price file is deleted and the statewide average prices inserted. Again the COST card must be indicated on each culvert problem in a run.

When the system has no price data for an item that is used by one of the culvert solutions, the cost of that culvert will appear as a series of asterisks in the TOTAL COST column of the CULBRG output listing. The items available to the THYSYS cost feature from the Statewide Average Low Bid Price file are listed in the following Table I. If the COST option is not used the output column labeled TOTAL COST will contain zeros.

TABLE I. ITEMS AVAILABLE TO THYSYS COST ANALYSIS FROM THE STATEWIDE AVERAGE BID PRICE LIST AS OF APRIL, 1972*

ITEM NO.	DESCRIPTION
421 506	CL C CONC (CULV)
440 501	REINF STL
460 503	CGM PIPE (18 in)
460 504	CGM PIPE (21 in)
460 505	CGM PIPE (24 in)
460 506	CGM PIPE (30 in)
460 507	CGM PIPE (36 in)
460 508	CGM PIPE (42 in)
460 509	CGM PIPE (48 in)
460 510	CGM PIPE (54 in)
460 511	CGM PIPE (60 in)
460 512	CGM PIPE (66 in)
460 513	CGM PIPE (72 in)
460 514	CGM PIPE (76 in)
460 515	CGM PIPE (84 in)
460 546	CGM PIPE ARCH (DES 1)
460 547	CGM PIPE ARCH (DES 2)
460 548	CGM PIPE ARCH (DES 3)
460 549	CGM PIPE ARCH (DES 4)
460 550	CGM PIPE ARCH (DES 5)
460 551	CGM PIPE ARCH (DES 6)
460 552	CGM PIPE ARCH (DES 7)
460 553	CGM PIPE ARCH (DES 8)
460 554	CGM PIPE ARCH (DES 9)
460 555	CGM PIPE ARCH (DES 10)
460 557	CGM PIPE ARCH (DES 12)
460 558	CGM PIPE ARCH (DES 13)
460 559	CGM PIPE ARCH (DES 14)
460 560	CGM PIPE ARCH (DES 15)
460 561	CGM PIPE ARCH (DES 16)
460 562	CGM PIPE ARCH (DES 17)
464 503	RC PIPE (CL III) (18 in)
464 504	RC PIPE (CL III) (21 in)
464 505	RC PIPE (CL III) (24 in)
464 506	RC PIPE (CL III) (27 in)
464 507	RC PIPE (CL III) (30 in)
464 508	RC PIPE (CL III) (33 in)

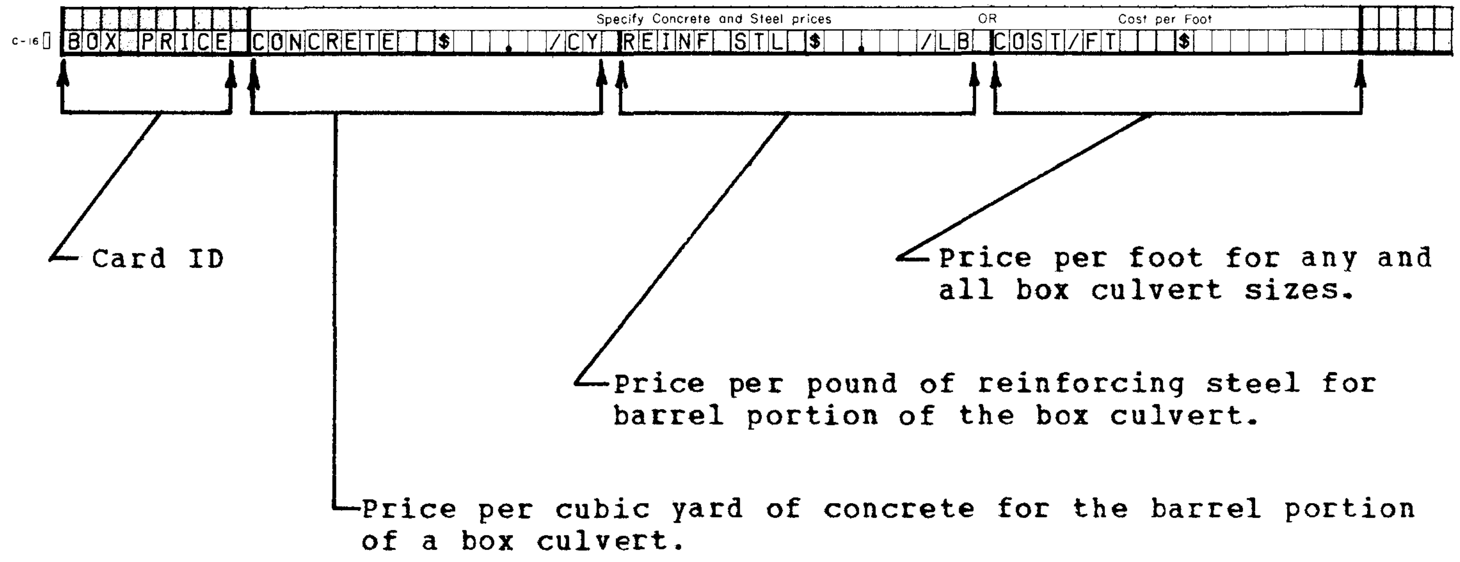
*This list will be expanded as code and item numbers are issued and average bid prices are available.

TABLE I - Continued.

464 509	RC PIPE (CL III) (36 in)
464 510	RC PIPE (CL III) (42 in)
464 511	RC PIPE (CL III) (48 in)
464 512	RC PIPE (CL III) (54 in)
464 513	RC PIPE (CL III) (60 in)
464 514	RC PIPE (CL III) (66 in)
464 515	RC PIPE (CL III) (72 in)
464 516	RC PIPE (CL III) (78 in)
464 517	RC PIPE (CL III) (84 in)
464 545	RC PIPE ARCH (CL III) (DES 1)
464 546	RC PIPE ARCH (CL III) (DES 2)
464 547	RC PIPE ARCH (CL III) (DES 3)
464 548	RC PIPE ARCH (CL III) (DES 4)
464 549	RC PIPE ARCH (CL III) (DES 5)
464 550	RC PIPE ARCH (CL III) (DES 6)
464 551	RC PIPE ARCH (CL III) (DES 7)
464 552	RC PIPE ARCH (CL III) (DES 8)
464 553	RC PIPE ARCH (CL III) (DES 9)
464 554	RC PIPE ARCH (CL III) (DES 10)
464 555	RC PIPE ARCH (CL III) (DES 11)
4005 501	FLARED METAL INLET (36 in)
4005 502	FLARED METAL INLET (48 in)
4005 503	FLARED METAL INLET (66 in)

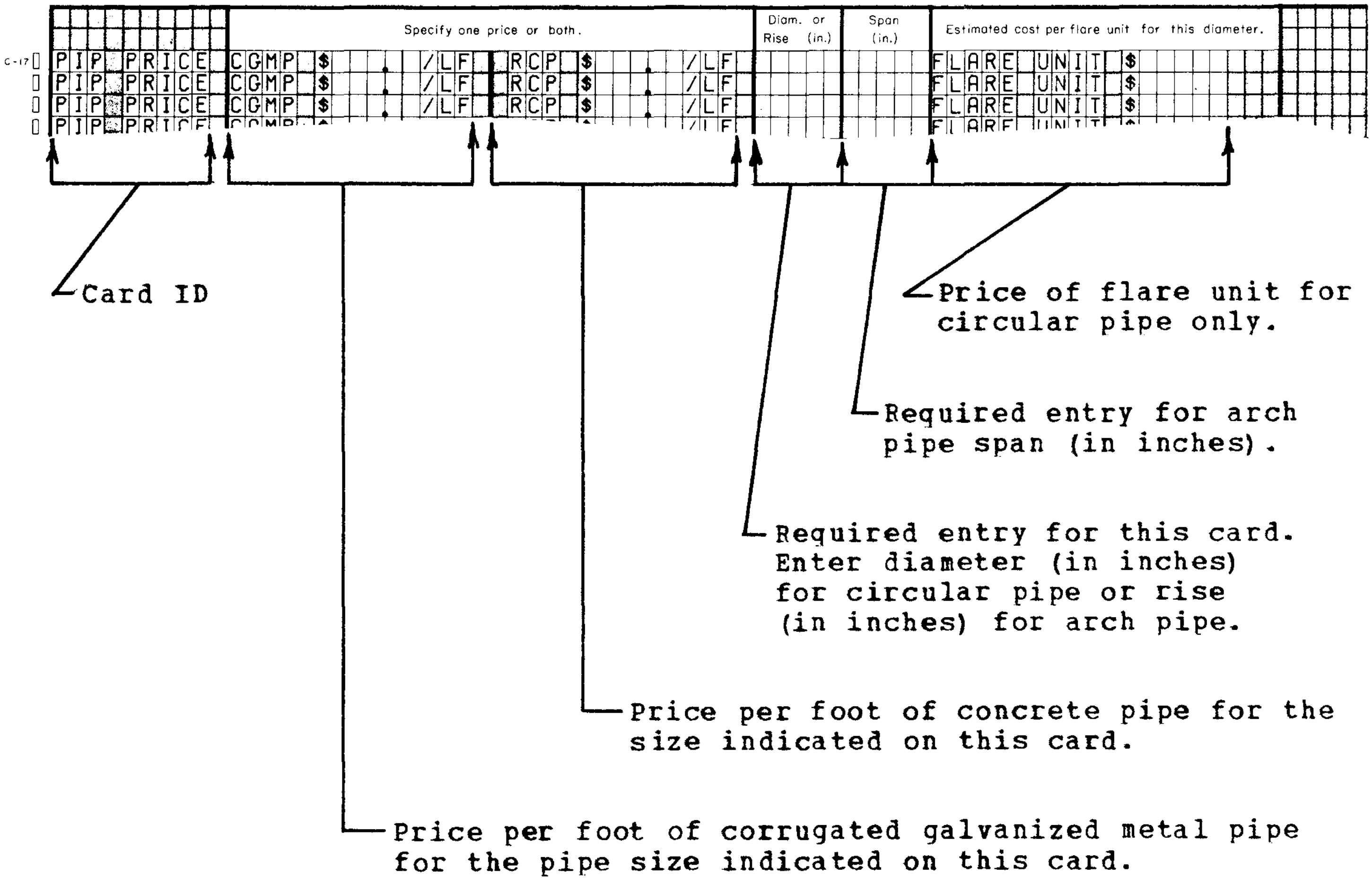
BOX CARD (C-16)

The BOX card is required if STATEWIDE is marked out and BOX is specified in a CULBRG problem. It is used to specify the prices for concrete and steel or the cost per linear foot of a box culvert. The concrete and steel prices refer to the cost of the barrels only. The headwall is not included. If the cost per foot is specified, it applies to any size box culvert calculated, and it supersedes the box price based on concrete and steel quantities. Also, cost per foot applies only to the current problem. If STATEWIDE has been indicated previously, this card may be used to override either concrete or steel prices or both if desired.



PIP CARD (C-17)

This card is required if STATEWIDE was not previously indicated and is used to give the prices for circular or arch pipe and circular flare units. If circular prices are being given, the diameter must be given in inches in the field DIAM. OR RISE of this card. Any or all of the prices that apply to this diameter may be given on one card. If arch prices are given, the rise and span in inches must be given in the appropriate columns. If STATEWIDE has been previously specified, the PIP card may be used to override any price in the statewide averages.



Card ID

Price of flare unit for circular pipe only.

Required entry for arch pipe span (in inches).

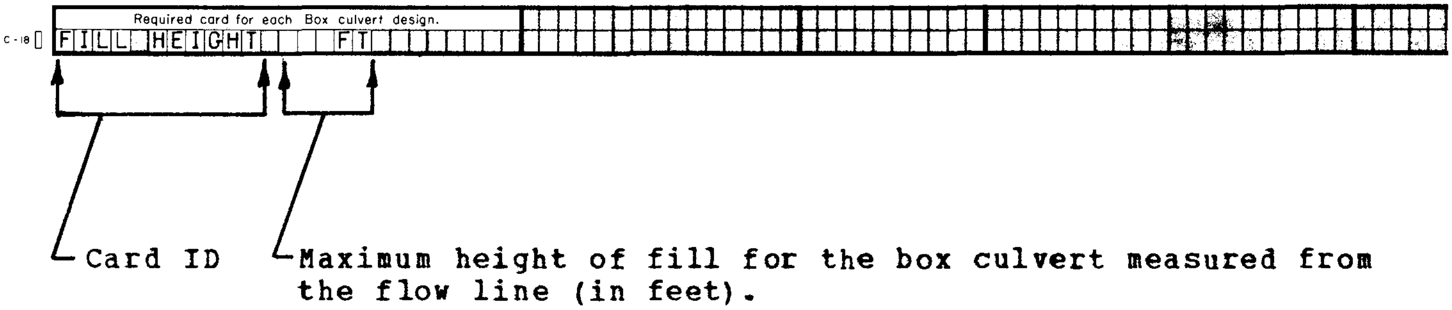
Required entry for this card. Enter diameter (in inches) for circular pipe or rise (in inches) for arch pipe.

Price per foot of concrete pipe for the size indicated on this card.

Price per foot of corrugated galvanized metal pipe for the pipe size indicated on this card.

FILL CARD (C-18)

This card is used to supply the maximum height of roadway fill above the flow line of a box culvert and must be completed when designing or analyzing a box culvert and requesting cost data. It is not required for pipe culverts, or for problems where cost data is not desired. When there is more than one box problem in a run, the data on this card should be entered for each of them; otherwise, the system will use the fill height given for a previous box problem in the run.

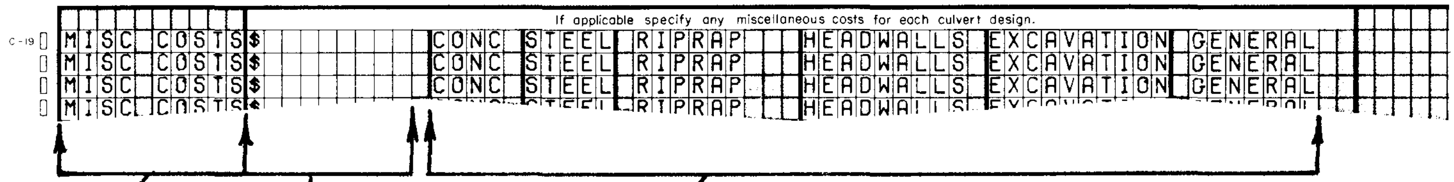


Card ID

Maximum height of fill for the box culvert measured from the flow line (in feet).

MISC COSTS CARD (C-19)

Additional costs for a culvert may be given on this card. The cost specified will be added to the computed barrel cost of each culvert size listed. The preprinted descriptions appearing on the card (CONC, STEEL RIPRAP, etc.) are informational only. Those that are not marked out on the card will appear in the echo print of the input. Miscellaneous costs must be input for each problem in a run.



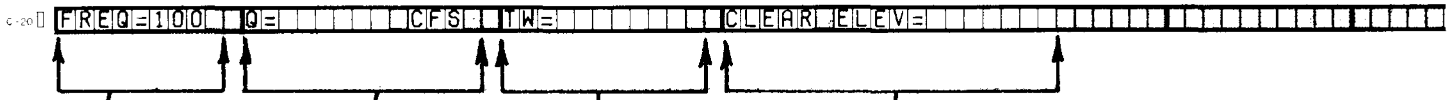
Card ID

Draw a line through those items which do not apply to the price given on this card.

Fill in the miscellaneous cost to be applied to the current culvert.

FREQ=100 CARD (C-20)

This card is used to input the discharge Q_{100} and tailwater TW_{100} for a 100 year flood analysis. Also the CLEAR ELEV (the average maximum elevation at which water can pass under a bridge) is input on this card. Entries for Q_{100} and TW_{100} are not necessary if they were previously entered or computed in HYDRO and/or HYDRA. CLEAR ELEV is used whenever BRIDGE is specified on the CULBRG Control Card and when a 100 year ANALYSIS is desired.



Card ID

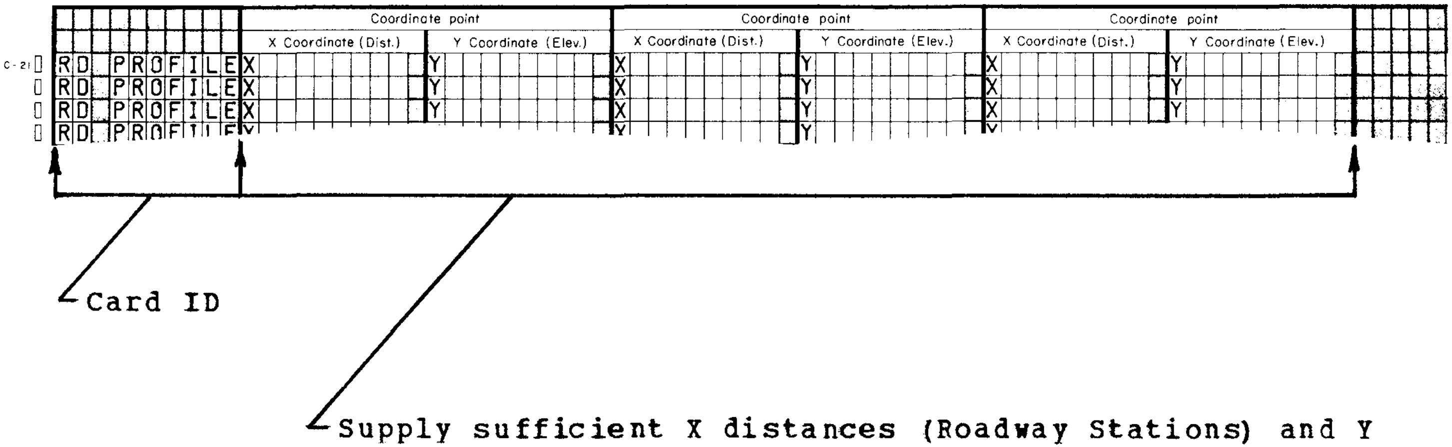
Required entry for bridges.

Tailwater elevation for 100 year flood. Required if not supplied or computed in HYDRA.

Discharge for 100 year flood. Required if not computed in HYDRO or supplied in HYDRA.

RD PROFILE CARD (C-21)

This card is used to input the road profile along the crown line of the road and is required for a 100 year flood analysis. The RD PROFILE cards are not needed if the road profile was defined in HYDRA on the SECX (B-6) cards with a CROSS-SECTION ID of HIWY. This profile must have a minimum of three points in order to define a valid section that can be used to compute a depth of flow over the roadway.



Card ID

Supply sufficient X distances (Roadway Stations) and Y elevations to define the roadway profile (minimum of three sets).

Card Use Checklist

A tabulation of the required and optional cards for each of the CULBRG options is shown in Figure 5-6. This may be used to check the completed input form for possible omissions prior to submission.

CULBRG

CARD IDENT.	CARD TYPE OR REFERENCE	DESIGN			ANALYSIS	
		BRIDGE (SINGLE OR MULTIPLE)	BRIDGE & CULVERT (SINGLE)	CULVERT (SINGLE)	BRIDGE (SINGLE OR MULTIPLE)	CULVERT (SINGLE)
CONTROL CARD	CULBRG	YES	YES	YES	YES	YES
C-1	SUPPLY	YES[1]	YES[1]	YES[1]	YES[1]	YES[1]
C-2	CLVRT		YES	YES		YES
C-3	CLVRT		YES	YES		YES
C-4	CLVRT		YES	YES		YES
C-5	CLVRT					YES[2]
C-6	CLVRT		YES	YES		
C-7	CLVRT					YES
C-8	ROAD		YES	YES		
C-9	BRDG	YES	YES			
C-10	BRDG	YES	YES		YES	
C-11	FL-DV	YES[3]	YES[3]		YES[9]	
C-12	JOB NO.		OPTIONAL[5]	OPTIONAL[5]		OPTIONAL[5]
C-15	COST		OPTIONAL[7]	OPTIONAL		OPTIONAL
C-16	BOX PRICE		OPTIONAL[7]	OPTIONAL		OPTIONAL
C-17	PIP PRICE		OPTIONAL[7]	OPTIONAL		OPTIONAL
C-18	FILL HEIGHT		YES[8]	YES[8]		YES[8]
C-19	MISC COSTS		OPTIONAL[7]	OPTIONAL		OPTIONAL
C-20	FREQ=100		OPTIONAL[4]	OPTIONAL[4]	OPTIONAL[4]	OPTIONAL[4]
C-21	RD PROFILE		OPTIONAL[4]	OPTIONAL[4]	OPTIONAL[4]	OPTIONAL[4]
C-13	ENDATA	YES	YES	YES	YES	YES
C-14	PLAN		OPTIONAL[6]	OPTIONAL[6]		OPTIONAL[6]

[1] Required only for items not previously assigned values in HYDRO and/or HYDRA.

[2] Required only if BROKEN BK specified an CLVRT Card (C-3). Only two Break Stations allowed.

[3] Include enough cards to define flow divides for each opening. Only one FL-DV Card for single bridge DESIGN or ANALYSIS.

[4] Required for 100 yr. flood analysis if not supplied in HYDRA and CLEAR ELEV _must_ be supplied if 100 yr. analysis on single bridge DESIGN/ANALYSIS is specified.

[5] When a PLAN SUMMARY including this culvert is to be requested. NOTE: Bridge design will not be included in PLAN SUMMARY.

[6] After the last problem with the current JOB NO. when a summary is desired.

[7] Required when cost comparison is desired. Enter prices on cards C-16, C-17, and C-19.

[8] Required for cost computations for box culverts.

[9] Designates toe of slopes for structure.

FIGURE 5-6. CARD USE CHECKLIST

III. OUTPUT

The output for the CULBRG routine may be one of the following basic reports plus the additional option of a summary report of results for specified culvert problems.

Multiple Opening Bridge Design

This report reflects the following:

1. Section name and station at the given bridge site - given
2. Total design flow (cfs) - given or computed in HYDRO
3. Water surface elevation (ft) - given or computed in HYDRA
4. Frequency (yrs) - given
5. Backwater head (ft) - This value is the water surface differential at the upstream limit of the bridge due to the constriction of the stream flow by the bridge structure - computed
6. Number of openings - This value refers to the number of flow divides rather than the number of bridge spans - given
7. A table showing for each stream subsection:
    a. Subsection I.D. - given
    b. Left side slope - given
    c. Right side slope - given
    d. Left toe of slope - computed
    e. Right toe of slope - computed
    f. Length at the water surface through the bridge opening (ft) - computed
    g. Flow in the subsection (cfs) - computed
    h. Per cent of the total section flow represented by the flow through this subsection - computed
    i. Conveyance of the bridge opening - computed
    j. Per cent of the total conveyance represented by the conveyance of this bridge opening - computed
    k. Velocity (fps) - computed.

Single Opening Bridge Design

This report reflects the following:

1. Section name and stream station at the given bridge site - given
2. Design flow (cfs) - given or computed in HYDRO
3. Water surface elevation (ft) - given or computed in HYDRA
4. Frequency (yrs) - given
5. Placement of toe of slope of left and right headers in terms of stationing across the stream reach at the cross-section - computed
6. Length between headers at water surface - computed
7. Backwater head (ft) - computed
8. Average through-bridge velocity across the entire bridge section (fps) - computed
9. Maximum allowable velocity (fps) - given.

Single Opening Bridge Analysis

This report reflects the following:

1. Section name and stream station at bridge site - given
2. Design flow (cfs) - given or computed in HYDRO
3. Water surface elevation (ft) - given or computed in HYDRA
4. Frequency (yrs) - given
5. Placement of toe of left and right header slopes - given
6. Length between headers at the water surface - computed
7. Backwater head (ft) - computed
8. Average through-bridge velocity across the entire bridge section (fps) - computed
9. Average channel velocity unrestricted by the bridge (fps) - computed.

Single Opening Culvert Design or Analysis

The reports for single opening culvert design and analysis are similar and will, therefore, be discussed concurrently. Each culvert problem will receive an automatic report reflecting the following:

1. Job Number - In addition to this automatic report for each culvert problem, there is an option of receiving a summary report (plan summary) of the results of related problems. These related problems are grouped according to a job number assigned by the user and printed on each report.
2. Culvert I.D. - given
3. Discharge or flow (cfs) - given or computed in HYDRO
4. Frequency (yrs) - given
5. Tailwater elevation (ft) - given or computed in HYDRA.
6. Culvert description:

   In most culvert DESIGN problems the program will attempt several solutions and will print the results of each solution under the culvert description section. The criteria for these solutions vary with the types of culverts:

   Circular. If a circular culvert design is specified, the output will reflect the program's search for a proper culvert size by listing all trial sizes used (as in the case for box culvert design). The program considers standard circular pipe diameters from 18" minimum to 120" maximum in size increments of 3" for pipe diameters between 18" and 36" and 6" increments for the remainder. (For structural plate, the minimum is 60".) For a circular culvert design, however, the tolerance is very narrow since diameters may be varied independently from the number of barrels. Therefore, the program searches for a circular culvert size so that the calculated headwater elevation is less than or equal to the specified allowable headwater elevation and, at the same time, is no less than the top (soffit) of the pipe. In further steps, the program continues its search until it encounters a culvert size in which the calculated headwater is greater than the specified allowable at which time the program reverts to the last acceptable design. It will be noted that if the program takes the route of increasing successive trial sizes, a trial size may be reworked and relisted. However, in any case, the proper accepted size will be clearly indicated on the output.

Box. After determining a starting box size, the program prints a solution for this box size and each additional box size (if necessary) in standard increments of width and height and number of barrels (never exceeding maximum depth) until the headwater falls within the acceptable range. The acceptable range encompasses calculated headwaters which are less than or equal to the specified allowable headwater elevation and, at the same time, are no more than 0.5 ft lower than the top (soffit) of the box. This tolerance is built in so that a standard sized culvert can be used. Without this tolerance, in certain circumstances, the program would be unable to find a standard structure size.

Arch. If a pipe-arch culvert design is specified, the output will indicate all trial sizes used. The program considers standard pipe-arch sizes as follows:

STANDARD PIPE-ARCH SIZES

RCP	CGM	PLATE (18"r)	PLATE (31"r)
11x18	11x18	55x73	128x190
13x22	13x22	57x76	130x195
18x29	18x29	59x81	132x198
22x36	22x36	61x84	134x204
27x43	27x43	63x87	136x206
31x51	31x51	65x92	138x209
36x58	36x58	67x95	140x215
40x65	40x65	69x98	142x217
45x73	45x73	71x103	144x223
54x88	54x88	73x106	146x225
62x102	62x102	75x112	148x231
	63x87	77x114	150x234
	66x95	79x117	152x236
	71x103	81x123	154x239
	75x112	83x128	156x245
	79x117	85x131	158x247
	83x128	87x137	
		89x139	
		91x142	
		93x148	
		95x150	
		97x152	
		100x154	
		101x161	
		103x167	
		105x169	
		107x171	
		109x178	
		111x184	
		113x186	
		115x188	
		118x190	
		119x197	
		121x199	

The program searches for a pipe-arch size so that the calculated headwater elevation is less than or equal to the specified allowable headwater elevation and also is no lower than the soffit of the pipe. When such a configuration is found, the number of barrels is held constant and the size is reduced in steps until the calculated headwater elevation exceeds the allowable. The process is then stopped and the prior solution is accepted as optimum.

<u>Descriptive Data</u>. Following is the data printed for each culvert solution attempted:

- a. Number of barrels - computed (given for analysis)
- b. Diameter (inches) - circular culverts only - computed (given for analysis)
- c. Width and height (feet for box, inches for arch or oval) - all shapes but circular - computed (given for analysis)
- d. Length of barrels (feet) - computed (given for analysis)
- e. Allowable headwater elevation (ft) - given for design
- f. Calculated headwater elevation (ft) - computed for design only
- g. Headwater elevation (ft) - given for analysis only
- h. Calculated headwater (ft) - computed
- i. Allowable velocity (fps) - given for design
- j. Velocity (fps) - computed
- k. Cost - computed when specified (otherwise 0.0). If COST is specified but no cost data is available for the computed culvert size, this column will contain asterisks (*).

7. Stations and elevations of inlet and outlet - computed in design; given in analysis
8. Stations and elevations of breaks in broken back culverts - given (for analysis only)
9. Additional descriptive values are then printed as they apply to the culvert accepted in design or given in analysis:
    - a. Slope (ft/ft) - computed (directly from given data)
    - b. Profile - given
    - c. Shape - given
    - d. Inlet type - given (although sometimes changed in design)
    - e. KE value - given
    - f. Barrel material - given
    - g. Manning's coefficient for barrel material - supplied by

program (or may be given)

h. "SUPER CRITICAL SLOPE = ____" is output for applicable instances in analysis.

Hundred Year Flood Analysis for Single Opening Bridge

This report reflects the following:

1. Basic flood applied (100 year frequency) - computed in HYDRO or given in HYDRA or CULBRG
2. Hundred year velocity at structure outlet - computed in CULBRG
3. Hundred year tailwater elevation - given or computed in HYDRA
4. Greatest depth of flow over road - computed in CULBRG
5. Elevation of water surface over road - computed in CULBRG
6. Percentage of basic flood over road - computed in CULBRG.

Hundred Year Flood Design or Analysis for Single Opening Culvert

This report reflects the following:

1. Culvert identification and culvert size - given and/or computed in CULBRG
2. Basic flood applied (100 year frequency) - computed in HYDRO or given in HYDRA or CULBRG
3. Hundred year velocity at structure outlet - computed in CULBRG
4. Hundred year tailwater elevation - given or computed in HYDRA
5. Elevation of water surface over road - computed in CULBRG
6. Low elevation of road profile - computed in CULBRG
7. Greatest depth of flow over road - computed in CULBRG
8. Percentage of basic flood over road - computed in CULBRG

Discussion of basic reports for other CULBRG functions will be added to this manual as these capabilities are acquired.

Plan Summary

This is a report reflecting the results of culvert design or analysis problems that have been grouped together under one job number. For each successful run, in this job number grouping, the following information is printed:

1. Job No.
2. Culvert I.D.
3. Barrel shape
4. Number of barrels
5. Width and height (inches for circular, arch and oval; feet for box)
6. Length (feet)
7. Culvert material
8. Type inlet
9. Profile
10. Slope (ft/ft)
11. Flow (cfs)
12. Calculated headwater (ft)
13. Calculated velocity (fps)

Length of culvert for culvert design output is only approximate and the engineer should plot the culvert cross-section for the plans to determine the exact length. The final exact length should ordinarily not vary appreciably from the computer-indicated length.

ERROR MESSAGES ARE GROUPED BY ALPHABETIC PREFIX FOR EACH SUBSYSTEM AND ARE LISTED IN NUMERICAL ORDER WITHIN EACH GROUP. 'EXPL' DENOTES A DETAILED EXPLANATION OF THE ERROR MESSAGE. (FOR ADDITIONAL INFORMATION AND ASSISTANCE CONTACT THE BRIDGE DIVISION HYDRAULIC SECTION OR THE DIVISION OF AUTOMATION FIELD ENGINEER FOR YOUR DISTRICT.)

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CLB0001--NEITHER DESIGN NOR ANALYSIS SPECIFIED.

EXPL□ ON THE 'CULBRG' CONTROL CARD, EITHER 'DESIGN' OR 'ANALYSIS' MUST BE SPECIFIED. IF BOTH ARE SPECIFIED, 'DESIGN' WILL BE ASSUMED. BUT, IF NEITHER IS SPECIFIED, THIS MESSAGE WILL BE PRINTED. FATAL ERROR.

CLB0002--ROUTINE NOT AVAILABLE TO DESIGN OR ANALYZE MULTIPLE OPENING CULVERTS.

EXPL□ THE PROGRAM IS NOT PRESENTLY EQUIPPED TO HANDLE PROBLEMS INVOLVING MULTIPLE OPENING (DIVIDED FLOW) CULVERT PROBLEMS. IF 'BRIDGE' WAS ALSO SPECIFIED, THE PROGRAM WILL HANDLE THE PROBLEM AS IF 'BRIDGE' ALONE HAD BEEN SPECIFIED. NON-FATAL IF 'BRIDGE' ALSO WAS SPECIFIED. FATAL IF 'CULVERT' ALONE WAS SPECIFIED.

CLB0003--NEITHER BRIDGE NOR CULVERT SPECIFIED.

EXPL□ WHEN 'ANALYSIS' IS SPECIFIED ON THE 'CULBRG' CONTROL CARD, IT IS NECESSARY THAT EITHER 'BRIDGE' OR 'CULVERT' BE SPECIFIED. IF 'DESIGN' IS SPECIFIED, THEN EITHER 'BRIDGE' OR 'CULVERT' OR BOTH MAY BE SPECIFIED. IF NEITHER 'BRIDGE' NOR 'CULVERT' IS SPECIFIED, THEN THIS MESSAGE IS PRINTED. FATAL ERROR.

CLB0004--NUMBER OF OPENINGS NOT SPECIFIED.

EXPL□ ON THE 'CULBRG' CONTROL CARD, IF 'SINGLE' IS NOT SPECIFIED, THEN THE NUMBER OF OPENINGS MUST BE SPECIFIED. IF NEITHER SPECIFICATION IS MADE, THIS MESSAGE WILL BE PRINTED. FATAL ERROR.

CLB0005--NO FREQUENCY GIVEN.

EXPL□ ON SOME OF THE REPORTS FROM 'CULBRG', FREQUENCY IS REFLECTED ALTHOUGH THIS VALUE IS NOT USED DIRECTLY IN ANY 'CULBRG' CALCULATIONS. IF A DISCHARGE WAS OBTAINED FROM A PREVIOUS 'HYDRO' OR 'HYDRA' PROBLEM AND NO FREQUENCY WAS GIVEN OR IF A 'SUPPLY' CARD (C-1) WAS READ AND THERE WAS NO VALUE FOR FREQUENCY FROM ANY SOURCE, THEN THIS MESSAGE WILL BE PRINTED. NON-FATAL.

CLB0006--NO Q SUPPLIED OR COMPUTED.

EXPL□ THE DISCHARGE (Q) FOR USE IN 'CULBRG' COMPUTATIONS MAY BE SUPPLIED FROM EITHER A PREVIOUS 'HYDRO' OR 'HYDRA' COMPUTATION OR IT MAY BE SUPPLIED ON 'SUPPLY' CARD (C-1). THIS MESSAGE INDICATES THAT THE PROGRAM FOUND NO Q VALUE AVAILABLE FROM ANY OF THESE SOURCES. FATAL ERROR.

CLB0007--NO SUPPLY Q GIVEN. PREVIOUS VALUE USED.

EXPL□ THIS MESSAGE INDICATES THAT THERE WAS NO ENTRY ON 'SUPPLY' CARD (C-1) FOR DISCHARGE, BUT THE PROGRAM FOUND A PREVIOUSLY STORED VALUE FOR DISCHARGE AND HAS ASSUMED THIS DISCHARGE FOR THE CURRENT PROBLEM. NON-FATAL.

CLB0008--NO TAILWATER ELEVATION GIVEN.

EXPL□ THE TAILWATER ELEVATION FOR USE IN 'CULBRG' COMPUTATIONS MAY BE SUPPLIED FROM EITHER A PREVIOUS 'HYDRA' PROBLEM OR 'SUPPLY' CARD (C-1). FOR CULVERT PROBLEMS, IF A TAILWATER ELEVATION IS NOT SUPPLIED FROM EITHER OF THESE SOURCES, THEN THE TAILWATER ELEVATION WILL BE ASSUMED TO BE THE SAME AS THE OUTLET ELEVATION

PROVIDED ON THE 'CLVRT' CARD (C-4). FATAL ERROR IF 'BRIDGE' SPECIFIED. NON-FATAL FOR 'CULVERT'.

CLB0009--NO TAILWATER ELEVATION GIVEN. PREVIOUS VALUE USED.
EXPL□ THIS MESSAGE INDICATES THAT A 'SUPPLY' CARD (C-1) WAS READ BUT NO TAILWATER ELEVATION WAS ENTERED. HOWEVER, THE PROGRAM FOUND THAT A 'HYDRA' PROBLEM HAD BEEN PREVIOUSLY RUN AND THE FIRST TAILWATER ELEVATION CALCULATED IN THE LAST 'HYDRA' RUN WILL BE USED IN THIS PROBLEM. NON-FATAL.

CLB0010--NO FREQUENCY GIVEN. PREVIOUS VALUE USED.
EXPL□ IF NO FREQUENCY IS ENTERED ON A 'SUPPLY' CARD (C-1) AND A FREQUENCY HAS BEEN PREVIOUSLY DEFINED IN A 'HYDRO' OR 'HYDRA' PROBLEM, THEN THIS MESSAGE WILL BE PRINTED AND THE PREVIOUSLY DEFINED VALUE WILL BE ASSUMED FREQUENCY FOR THIS PROBLEM. NON-FATAL.

CLB0011--NO INITIAL COORDINATE. REST OF CARD IGNORED.
EXPL□ THERE MUST BE AN ENTRY IN THE FIRST COORDINATE SPACES ON THE 'RDPROFILE' CARD (C-21). IF NOT, FURTHER ENTRIES ON THE CARD ARE IGNORED.

CLB0012--Y COORDINATE MISSING. THIS SET AND REST OF CARD IGNORED.
EXPL□ THERE MUST BE AN ELEVATION ENTERED FOR EACH COORDINATE SET. IF NOT, FURTHER ENTRIES ON THE CARD ARE IGNORED.

CLB0013--TOO MANY POINTS DESCRIBING ROAD PROFILE. PRESENT LIMIT IS 100.
EXPL□ DUE TO CAPACITY LIMITATIONS OF THE PROGRAM, SETS OF COORDINATES IN THE ROAD PROFILE SPECIFICATION MUST NOT EXCEED 100 IN NUMBER.

CLB0014--NO 'N' VALUE SPECIFIED OR SUPPLIED.
EXPL□ ON 'CLVRT' CARD (C-2) NO CULVERT MATERIAL WAS SPECIFIED FROM WHICH THE PROGRAM COULD DERIVE A ROUGHNESS COEFFICIENT NOR WAS THE COEFFICIENT SUPPLIED DIRECTLY. FATAL ERROR.

CLB0015--NO 'KE' VALUE SPECIFIED OR SUPPLIED.
EXPL□ WHEN A NORMAL INLET HAS BEEN SPECIFIED ON 'CLVRT' CARD (C-3), A 'KE' VALUE (ENTRANCE COEFFICIENT) MUST BE SUPPLIED. THIS MESSAGE INDICATES THAT THE 'KE' VALUE WAS OMITTED AND A NORMAL INLET WAS SPECIFIED. FATAL ERROR.

CLB0016--TYPE OF INLET CONDITIONS NOT SPECIFIED.
EXPL□ THIS MESSAGE INDICATES THAT NO INLET CONDITION WAS INDICATED ON 'CLVRT' CARD (C-3) OR THAT THIS CARD WAS NOT READ. FATAL ERROR.

CLB0017--CULVERT STATIONING AND ELEVATIONS INCOMPLETE.
EXPL□ ON 'CLVRT' CARD (C-4) EACH BLANK MUST HAVE AN ENTRY (ZERO IS ALLOWED). IF AN ENTRY IS OMITTED OR INCORRECTLY ENTERED OR IF THE CARD IS NOT INCLUDED, THIS MESSAGE WILL BE PRINTED. FATAL ERROR.

CLB0018--CLVRT CARD READ BUT DATA MISSING.
EXPL□ UPON READING A 'CLVRT' CARD THE PROGRAM SCANS THE INFORMATION TO DETERMINE WHICH TYPE OF 'CLVRT' CARD IS BEING READ. IF A PROPER SPECIFICATION OR IDENTIFYING WORD IS NOT FOUND IN THAT SECTION THEN THIS MESSAGE IS PRINTED. FATAL ERROR.

CLB0019--BREAK STATIONING AND ELEVATION DATA INCOMPLETE.
EXPL□ ON 'CLVRT' CARD (C-5), THE DATA MUST BE ENTERED IN PAIRS (I.E., A BREAK STATION AND AN ELEVATION). THIS MESSAGE INDICATES THAT THE PROGRAM DETECTED ONE MEMBER OF A PAIR ENTERED WITHOUT ITS COMPANION MEMBER. FATAL ERROR.

CLB0020--MAXIMUM H.W. ELEV. NOT GIVEN.

EXPL¤ IN ALL CULVERT DESIGN PROBLEMS A MAXIMUM HEADWATER ELEVATION MUST BE PROVIDED ON 'CLVRT' CARD (C-6). IF THERE IS NO ENTRY FOR THIS VALUE ON THIS CARD OR IF THIS CARD IS OMITTED AND CULVERT DESIGN HAS BEEN SPECIFIED, THEN THIS MESSAGE WILL BE PRINTED. FATAL ERROR.

CLB0021--MAX. OUTLET VELOC. NOT GIVEN. VALUE SET AT 8.0.

EXPL¤ IN ALL CULVERT DESIGN PROBLEMS A MAXIMUM OUTLET VELOCITY SHOULD BE PROVIDED ON 'CLVRT' CARD (C-6). IF THERE IS NO ENTRY FOR THIS VALUE AND CULVERT DESIGN HAS BEEN SPECIFIED, THIS MESSAGE WILL BE PRINTED AND THE MAXIMUM OUTLET VELOCITY WILL BE AUTOMATICALLY SET AT 8.0 FPS. NON-FATAL ERROR.

CLB0022--CULVERT DIMENSIONS MISSING.

EXPL¤ ON 'CLVRT' CARD (C-7), EITHER 'DIAM' MUST BE GIVEN (FOR CIRCULAR BARREL) OR BOTH 'HIGH' AND 'WIDE' MUST BE GIVEN (FOR OTHER BARREL CONFIGURATIONS). THIS MESSAGE INDICATES THAT THESE VALUES WERE NOT ENTERED PROPERLY. (IF THE NUMBER OF BARRELS IS NOT ENTERED, 1.0 IS ASSUMED.) FATAL ERROR.

CLB0023--NO ROAD CROSS-SECTION I.D. GIVEN.

EXPL¤ NO 'CLVRT ID' WAS ENTERED ON 'ROAD' CARD (C-8). NON-FATAL.

CLB0024--NO SLOPE GIVEN. VALUE OF 3.0 ASSUMED.

EXPL¤ ON 'ROAD' CARD (C-8) SPACE IS PROVIDED FOR UPSTREAM AND DOWNSTREAM SIDE SLOPES. IF EITHER OF THESE VALUES IS OMITTED, THE PROGRAM WILL ASSUME A SIDE SLOPE RATIO OF 3.0¤1.0 AND PROCEED. IF THE USER WISHES TO ENTER 0.0 SLOPE HE MUST INSERT 0.0 IN THIS SPACE SINCE THE PROGRAM WILL SUPPLY A 3.0 IF THIS SPACE IS BLANK. NON-FATAL.

CLB0025--NO MAX BARREL DEPTH GIVEN FOR CULVERT DESIGN.

EXPL¤ A 'ROAD' CARD (C-8) MUST BE INCLUDED IN EACH CULVERT DESIGN PROBLEM AND EACH 'ROAD' CARD MUST HAVE A VALUE FOR 'MAX DEPTH'. THIS MESSAGE INDICATES THAT EITHER THE CARD WAS OMITTED OR THERE WAS NO VALUE GIVEN ON THE CARD FOR MAXIMUM DEPTH. FATAL ERROR.

CLB0026--BRIDGE SUBSECTION IDENTIFICATION MISSING.

EXPL¤ 'SUBSEC ID' IS A REQUIRED ENTRY ON ALL 'BRDG' AND 'FL-DV' CARDS. IF IT IS OMITTED ON ANY OF THESE CARDS THIS MESSAGE WILL APPEAR. FATAL ERROR.

CLB0027--UNIDENTIFIED BRDG CARD READ.

EXPL¤ THIS MESSAGE INDICATES THAT THE PROGRAM ENCOUNTERED A CARD WITH 'BRDG' PROPERLY PLACED ON THE CARD, BUT OTHER NECESSARY IDENTIFIERS WERE NOT RECOGNIZED. THIS CARD WAS IGNORED. NON-FATAL.

CLB0028--NO MAXIMUM VELOCITY GIVEN. 6.0 ASSUMED.

EXPL¤ IF A 'BRDG' CARD (C-9) IS SUPPLIED BUT THE 'MAX AVERAGE VELOCITY' IS NOT ENTERED, THEN THIS MESSAGE WILL BE PRINTED AND THE 'MAX AVERAGE VELOCITY' WILL BE ARBITRARILY ASSIGNED A VALUE OF 6.0 FPS. NON-FATAL.

CLB0029--NO MINIMUM VELOCITY GIVEN. 4.0 ASSUMED.

EXPL¤ IF A 'BRDG' CARD (C-9) IS SUPPLIED BUT THE 'MIN AVERAGE VELOCITY' IS NOT ENTERED, THEN THIS MESSAGE WILL BE PRINTED AND THE MINIMUM OUTLET VELOCITY WILL BE ARBITRARILY ASSIGNED A VALUE OF 4.0 FPS, NON-FATAL.

CLB0030--BRIDGE HEADER SLOPE DATA MISSING.
EXPL¤ ON 'BRDG' CARD (C-10) BOTH RIGHT AND LEFT SIDE SLOPES MUST BE ENTERED AS WELL AS WHETHER LOOKING UPSTREAM OR DOWNSTREAM. OMISSION OF ANY ONE OF THESE ENTRIES WILL CAUSE THIS MESSAGE TO BE PRINTED. FATAL ERROR.

CLB0031--PROBABLE BLANK CARD.
EXPL¤ THIS MESSAGE INDICATES THAT THE PROGRAM ATTEMPTED TO IDENTIFY THE PREVIOUS CARD BUT FOUND NO ENTRIES IN SPACES USUALLY OCCUPIED BY CARD IDENTIFIERS. THIS CARD WAS IGNORED AND THE NEXT CARD WAS READ. NON-FATAL.

CLB0032--BRIDGE CROSS-SECTION I.D. MISSING.
EXPL¤ ON THE 'FL-DV' CARD (C-11) THE 'SECX' IDENTIFICATION MUST BE PROVIDED IN ORDER FOR THE PROGRAM TO RETRIEVE THE PROPER SECTION FROM STORAGE. IF THIS IDENTIFICATION IS MISSING IT CONSTITUTES A FATAL ERROR.

CLB0033--FLOW DIVIDE X-DISTANCE MISSING.
EXPL¤ ON THE 'FL-DV' CARD (C-11), THE BOUNDARIES OF THE FLOW DIVIDE ARE DEFINED BY GIVING THE 'X' COORDINATES AT EACH OF THE FLOW DIVIDE LIMITS. THIS MESSAGE INDICATES THAT ONE OF THE LIMITS (FRM X DIS OR TO X DIST) IS NOT PROVIDED. FATAL ERROR.

CLB0034--LAST GIVEN FILL HEIGHT ASSUMED.
EXPL¤ NO FILL HEIGHT SPECIFIED FOR CURRENT PROBLEM. A DEFAULT VALUE IS ASSUMED BASED ON THE LAST FILL HEIGHT WHICH WAS SPECIFIED.

CLB0035--DATA MISSING ON BOX PRICE CARD.
EXPL¤ ONE OR MORE ITEMS OF SPECIFICATION HAVE BEEN OMITTED ON THE 'BOX PRICE' CARD (C-16).

CLB0036--PIPE SIZE NOT AVAILABLE.
EXPL¤ SELF-EXPLANATORY.

CLB0037--TAILWATER FROM SUBSYSTEM HYDRA IS NOT REALISTIC FOR Q=* *.
EXPL¤ AN ARBITRARY TAILWATER VALUE WAS ASSUMED IN SUBSYSTEM 'HYDRA' DUE TO SOME DESCRIBED DEFICIENCY IN THE 'HYDRA' COMPUTATION. THAT ARBITRARY VALUE IS NOT AUTOMATICALLY USABLE IN 'CULBRG' CALCULATIONS.

CLB0038--NUMBER OF BREAK STATIONS READ EXCEEDS CAPACITY OF 4.
EXPL¤ AS THE PROGRAM READS 'CLVRT' CARDS (C-5) IT COUNTS THE NUMBER OF BREAK STATIONS STORED. UPON REVIEWING THE STORED DATA, THE PROGRAM WILL PRINT THIS MESSAGE IF IT FINDS MORE THAN THE ALLOWED FOUR BREAK STATIONS HAVE BEEN READ. (NOTE¤ THE PROGRAM WILL READ AND ACCEPT UP TO FOUR BREAK STATIONS, BUT IN THE CALCULATIONS FOR A BROKEN BACK CULVERT NO MORE THAN TWO BREAK STATIONS WILL BE ACCEPTED.) FATAL ERROR.

CLB0039--NUMBER OF BRIDGE SUB-SECTIONS READ EXCEEDS CAPACITY OF 10.
EXPL¤ AS THE PROGRAM READS 'BRDG' CARDS (C-9 AND C-10) AND 'FL-DV' CARDS (C-11), IT COUNTS THE NUMBER OF DIFFERENT 'SUBSEC ID'S' ENCOUNTERED. UPON REVIEWING THE STORED DATA, THE PROGRAM WILL PRINT THIS MESSAGE IF IT FINDS THAT MORE THAN THE ALLOWED TEN BRIDGE 'SUBSEC ID'S' HAVE BEEN USED. FATAL ERROR.

CLB0040--ERRORS PRECLUDE COMPUTATION.
EXPL¤ THIS MESSAGE INDICATES THAT THE PROBLEM HAS BEEN ABANDONED DUE TO FATAL ERRORS WHICH SHOULD HAVE BEEN INDICATED BY PRIOR MESSAGES.

CLB0041--NUMBER OF FLOW DIVIDE CARDS EXCEEDS CAPACITY OF 10.
EXPL¤ AS THE PROGRAM READS 'FL-DV' CARDS (C-11) IT COUNTS THE 'FL-DV' CARDS READ. IF MORE THAN THE ALLOWED TEN ARE READ, THE PROGRAM WILL PRINT THIS MESSAGE. FATAL ERROR.

CLB0042--DATA MISSING ON CULBRG CONTROL CARD.
EXPL¤ THIS MESSAGE INDICATES THAT A FATAL ERROR ON THE 'CULBRG' CONTROL CARD HAS CAUSED THE PROGRAM TO ABANDON THE PROBLEM. A PREVIOUS MESSAGE SHOULD HAVE INDICATED THE NATURE OF THE ERROR.

CLB0043--DATA MISSING ON SUPPLY CARD C-1.
EXPL¤ THIS MESSAGE INDICATES THAT A FATAL ERROR ON CARD C-1 HAS CAUSED THE PROGRAM TO ABANDON THE PROBLEM. A PREVIOUS MESSAGE SHOULD HAVE INDICATED THE NATURE OF THE ERROR

CLB0044--DATA MISSING ON CLVRT CARD C-2.
EXPL¤ THIS MESSAGE INDICATES THAT A FATAL ERROR ON CARD C-2 HAS CAUSED THE PROGRAM TO ABANDON THE PROBLEM. A PREVIOUS MESSAGE SHOULD HAVE INDICATED THE NATURE OF THE ERROR.

CLB0045--DATA MISSING ON CLVRT CARD C-3.
EXPL¤ THIS MESSAGE INDICATES THAT A FATAL ERROR ON CARD C-3 HAS CAUSED THE PROGRAM TO ABANDON THE PROBLEM. A PREVIOUS MESSAGE SHOULD HAVE INDICATED THE NATURE OF THE ERROR

CLB0046--DATA MISSING ON CLVRT CARD C-4.
EXPL¤ THIS MESSAGE INDICATES THAT A FATAL ERROR ON CARD C-4 HAS CAUSED THE PROGRAM TO ABANDON THE PROBLEM. A PREVIOUS MESSAGE SHOULD HAVE INDICATED THE NATURE OF THE PROBLEM.

CLB0047--DATA MISSING ON CLVRT CARD C-5.
EXPL¤ THIS MESSAGE INDICATES THAT A FATAL ERROR ON CARD C-5 HAS CAUSED THE PROGRAM TO ABANDON THE PROBLEM. A PREVIOUS MESSAGE SHOULD HAVE INDICATED THE NATURE OF THE PROBLEM.

CLB0048--DATA MISSING ON CLVRT CARD C-6.
EXPL¤ THIS MESSAGE INDICATES THAT A FATAL ERROR ON CARD C-6 HAS CAUSED THE PROGRAM TO ABANDON THE PROBLEM. A PREVIOUS MESSAGE SHOULD HAVE INDICATED THE NATURE OF THE PROBLEM.

CLB0049--DATA MISSING ON CLVRT CARD C-7.
EXPL¤ THIS MESSAGE INDICATES THAT A FATAL ERROR ON CARD C-7 HAS CAUSED THE PROGRAM TO ABANDON THE PROBLEM. A PREVIOUS MESSAGE SHOULD HAVE INDICATED THE NATURE OF THE PROBLEM.

CLB0050--DATA MISSING ON ROAD CARD C-8.
EXPL¤ THIS MESSAGE INDICATES THAT A FATAL ERROR ON CARD C-8 HAS CAUSED THE PROGRAM TO ABANDON THE PROBLEM. A PREVIOUS MESSAGE SHOULD HAVE INDICATED THE NATURE OF THE PROBLEM.

CLB0051--DATA MISSING ON BRDG CARD C-9 OR C-10.
EXPL¤ THIS MESSAGE INDICATES THAT A FATAL ERROR ON CARD C-9 OR C-10 HAS CAUSED THE PROGRAM TO ABANDON THE PROBLEM. A PREVIOUS MESSAGE SHOULD HAVE INDICATED THE NATURE OF THE PROBLEM.

CLB0052--DATA MISSING ON FL-DV CARD C-11.
EXPL¤ THIS MESSAGE INDICATES THAT A FATAL ERROR ON CARD C-11 HAS CAUSED THE PROGRAM TO ABANDON THE PROBLEM. A PREVIOUS MESSAGE SHOULD HAVE INDICATED THE NATURE OF THE PROBLEM.

CLB0053--NO Q SUPPLIED OR COMPUTED.

EXPL¤ THE DISCHARGE (Q) FOR USE IN CULBRG COMPUTATIONS MAY BE SUPPLIED FROM EITHER A PREVIOUS 'HYDRO' OR 'HYDRA' COMPUTATION OR IT MAY BE SUPPLIED ON A 'SUPPLY' CARD (C-1). THIS MESSAGE INDICATES THAT THE PROGRAM FOUND NO 'Q' VALUE AVAILABLE FROM ANY OF THESE SOURCES. FATAL ERROR.

CLB0054--TAILWATER ELEVATION NOT SUPPLIED. BRIDGE CANNOT BE PROCESSED.

EXPL¤ TAILWATER ELEVATION FOR USE IN BRIDGE PROBLEMS MAY BE PROVIDED FROM EITHER A PREVIOUS 'HYDRA' PROBLEM OR IT MAY BE GIVEN ON A 'SUPPLY' CARD (C-1). THIS MESSAGE INDICATES THAT THE PROGRAM FOUND NO TAILWATER ELEVATION FROM EITHER SOURCE. FATAL ERROR.

CLB0055--NO TAILWATER ELEVATION GIVEN. IT IS ASSUMED TO BE THE SAME AS THE OUTLET ELEVATION.

EXPL¤ IN A CULVERT PROBLEM THE PROGRAM FOUND THAT NO VALUE WAS STORED FOR TAILWATER ELEVATION. WHEN THIS SITUATION OCCURS, THIS MESSAGE WILL BE PRINTED AND THE OUTLET ELEVATION SUPPLIED ON THE 'CLVRT' CARD (C-4) WILL BE THE ASSUMED TAILWATER ELEVATION. NON-FATAL.

CLB0056--NEITHER DESIGN NOR ANALYSIS SPECIFIED.

EXPL¤ ON THE 'CULBRG' CONTROL CARD, EITHER 'DESIGN' OR 'ANALYSIS' MUST BE SPECIFIED. IF BOTH ARE SPECIFIED, 'DESIGN' WILL BE ASSUMED, BUT, IF NEITHER IS SPECIFIED, THIS MESSAGE WILL BE PRINTED. FATAL ERROR.

CLB0057--WHEN PIPE OTHER THAN CONCRETE IS SPECIFIED, KE VALUE MAY NOT EQUAL 0.2. VALUE SET AT 0.5.

EXPL¤ IF MATERIAL OTHER THAN CONCRETE IS SPECIFIED ON 'CLVRT' CARD (C-2), THEN THE USER MAY NOT SPECIFY A 'KE' VALUE OF 0.2 ON 'CLVRT' CARD (C-3). IF THE USER INADVERTENTLY ENTERS THIS COMBINATION, THIS MESSAGE WILL BE PRINTED AND THE 'KE' VALUE WILL BE ARBITRARILY SET AT 0.5. NON-FATAL.

CLB0058--ROUTINE NOT AVAILABLE TO DESIGN OR ANALYZE MULTIPLE OPENING CULVERTS.

EXPL¤ THE PROGRAM IS NOT PRESENTLY EQUIPPED TO HANDLE PROBLEMS INVOLVING MULTIPLE OPENING (DIVIDED FLOW) CULVERT PROBLEMS. IF 'BRIDGE' WAS ALSO SPECIFIED, THE PROGRAM WILL HANDLE THE PROBLEM AS IF 'BRIDGE' ALONE HAD BEEN SPECIFIED. NON-FATAL IF 'BRIDGE' ALSO WAS SPECIFIED. FATAL IF 'CULVERT' ALONE WAS SPECIFIED.

CLB0059--MAXIMUM H.W. ELEV. NOT GIVEN.

EXPL¤ IN ALL CULVERT DESIGN PROBLEMS A MAXIMUM HEADWATER ELEVATION MUST BE PROVIDED ON 'CLVRT' CARD (C-6). IF THERE IS NO ENTRY FOR THIS VALUE ON THIS CARD OR IF THIS CARD IS OMITTED AND CULVERT DESIGN HAS BEEN SPECIFIED, THEN THIS MESSAGE WILL BE PRINTED. FATAL ERROR.

CLB0060--CULVERT STATIONING AND ELEVATIONS INCOMPLETE.

EXPL¤ ON 'CLVRT' CARD (C-4) EACH BLANK MUST HAVE AN ENTRY (ZERO IS NOT ALLOWED). IF ANY ENTRY IS OMITTED OR INCORRECTLY ENTERED OR IF THE CARD IS NOT INCLUDED, THIS MESSAGE WILL BE PRINTED. FATAL ERROR.

CLB0061--TAILWATER ELEVATION IS GREATER THAN OR EQUAL TO MAXIMUM HEADWATER ELEVATION -0.05 FOOT. THIS CONDITION IS IMPOSSIBLE TO SATISFY IN DESIGNING A STRUCTURE.

EXPL¤ THE PROGRAM COMPARES THE 'MAXIMUM HEADWATER ELEVATION' ON 'CLVRT' CARD (C-6) WITH THE TAILWATER ELEVATION FOR THIS PROBLEM AND IF IT FINDS THE TAILWATER ELEVATION TO BE GREATER THAN OR EQUAL TO MAXIMUM HEADWATER ELEVATION -0.05 FOOT, AN ERROR CONDITION EXISTS. FATAL ERROR.

CLB0062--THE DIFFERENCE BETWEEN THE MAXIMUM HEADWATER ELEVATION AND TAILWATER ELEVATION IS LESS THAN 0.1 FOOT. DESIGN WAS ATTEMPTED BUT CULVERT SIZE MAY NOT BE REALISTIC.

EXPL□ DESIGNATION OF MAXIMUM HEADWATER ELEVATION AND CORRESPONDING TAILWATER ELEVATIONS SUCH THAT THE DIFFERENCE IS LOWER THAN 0.1 FOOT CREATES A VERY DIFFICULT ENGINEERING SITUATION DUE TO THE FACT THAT ANY CULVERT MUST NECESSARILY HAVE HEAD LOSSES.

CLB0063--NO MAX BARREL DEPTH GIVEN FOR CULVERT DESIGN.

EXPL□ A 'ROAD' CARD (C-8) MUST BE INCLUDED IN EACH CULVERT DESIGN PROBLEM AND EACH 'ROAD' CARD MUST HAVE A VALUE FOR 'MAX DEPTH'. THIS MESSAGE INDICATES THAT EITHER THE CARD WAS OMITTED OR THERE WAS NO VALUE GIVEN ON THE CARD FOR MAXIMUM DEPTH. FATAL ERROR.

CLB0064--CULVERT PROFILE NOT SPECIFIED.

EXPL□ THE PROGRAM ATTEMPTED TO SELECT THE PROPER PROCEDURE BUT FOUND NO PROFILE SPECIFICATION. THIS PROBABLY RESULTED FROM FAILURE TO INCLUDE A 'CLVRT' CARD (C-3). FATAL ERROR.

CLB0065--CULVERT SHAPE NOT SPECIFIED.

EXPL□ THE PROGRAM ATTEMPTED TO SELECT THE PROPER PROCEDURE BUT FOUND NO SHAPE SPECIFICATION. THIS PROBABLY RESULTED FROM FAILURE TO INCLUDE A 'CLVRT' CARD (C-2). FATAL ERROR.

CLB0066--TYPE OF INLET CONDITIONS NOT SPECIFIED.

EXPL□ THIS MESSAGE INDICATES THAT NO INLET CONDITION WAS INDICATED ON 'CLVRT' CARD (C-3) OR THAT THIS CARD WAS NOT READ. FATAL ERROR.

CLB0067--ANOTHER CULVERT DESIGN WILL BE TRIED USING A FLARED INLET.

EXPL□ IN CULVERT DESIGN PROBLEMS INVOLVING CIRCULAR INLETS, WHEN SUPER CRITICAL SLOPE IS ENCOUNTERED IN THE DESIGN, THE PROGRAM WILL ATTEMPT ANOTHER DESIGN USING A FLARED INLET. NON-FATAL.

CLB0068--CALCULATED EXIT VELOCITY EXCEEDS ALLOWABLE VELOCITY.

EXPL□ THE CALCULATED OUTLET VELOCITY FOR THE CULVERT DESIGN WHICH MOST CLOSELY APPROXIMATES THE DESIGN CRITERA IS GREATER THAN THE 'MAX OUTLET VELOCITY' SPECIFIED ON 'CLVRT' CARD (C-6). THIS MESSAGE IS INTENDED ONLY AS A FLAG TO THE USER TO CALL HIS ATTENTION TO THE SITUATION BUT DOES NOT PRESENTLY AFFECT THE COMPUTATIONS. NON-FATAL.

CLB0069--FLARED INLET MAY NOT BE SPECIFIED FOR THIS CULVERT SHAPE.

EXPL□ FLARED INLETS ARE NOT PERMITTED FOR ARCH OR OVAL CULVERT SHAPES. THIS MESSAGE INDICATES THAT A FLARED INLET WAS SPECIFIED WITH ONE OF THESE NON-ALLOWABLE CONFIGURATIONS. FATAL ERROR.

CLB0070--NEITHER BRIDGE NOR CULVERT SPECIFIED.

EXPL□ WHEN 'ANALYSIS' IS SPECIFIED ON THE 'CULBRG' CONTROL CARD THEN IT IS NECESSARY THAT EITHER 'BRIDGE' OR 'CULVERT' MUST BE SPECIFIED. IF 'DESIGN' IS SPECIFIED, THEN EITHER 'BRIDGE' OR 'CULVERT' OR BOTH MAY BE SPECIFIED. IF NEITHER 'BRIDGE' NOR 'CULVERT' IS SPECIFIED, THEN THIS MESSAGE IS PRINTED. FATAL ERROR.

CLB0071--CULVERT DIMENSIONS CARD NOT SUPPLIED.

EXPL□ IN A CULVERT ANALYSIS PROBLEM A DIMENSION CARD MUST BE SUPPLIED. FATAL ERROR.

CLB0072--* *FILL HEIGHT EXCEEDS STANDARD LIMIT, COST COMPUTED ON THE BASIS OF MAXIMUM FILL HEIGHT STRUCTURE.

EXPL□ 'SDHPT' CULVERT STANDARDS ARE INCORPORATED INTO THE COST

DETERMINATION ROUTINE. WHEN THE FILL HEIGHT EXCEEDS THESE STANDARDS, THE ROUTINE USES THE MAXIMUM STRUCTURE TO ESTIMATE THE COST.

CLB0073--NO STANDARD AVAILABLE FOR **X**X** FILL HEIGHT =**.

EXPL¤ 'SDHPT' CULVERT STANDARDS ARE INCORPORATED INTO THE COST DETERMINATION ROUTINE. ONLY A CULVERT OF STANDARD DIMENSIONS CAN BE ACCOMODATED.

CLB0074--THIS CONDITION EXISTS BECAUSE THE CHANNEL CONFIGURATION AND THE BRIDGE CONFIGURATION ARE THE SAME.

EXPL¤ THIS MESSAGE INDICATES A SITUATION WHERE THE ONLY CROSS-SECTION SPECIFIED WAS THAT IMMEDIATELY UNDER THE BRIDGE. A MORE PROPER SPECIFICATION WOULD BE THE UNRESTRICTED SECTION.

CLB0075--THE MINIMUM SIZE PIPE CONSIDERED FOR DESIGN IS 18 IN. THIS EXCEEDS THE ALLOWABLE DEPTH.

EXPL¤ IN CULVERT DESIGN THE MINIMUM PIPE SIZE CONSIDERED IS 18 INCHES IN DIAMETER. IF THE MAXIMUM ALLOWABLE DEPTH IS LESS THAN 18 INCHES AN IMPOSSIBLE CONTRADICTION EXISTS.

CLB0076--CONDITIONS FOR THIS CULVERT CANNOT BE ECONOMICALLY SATISFIED.

EXPL¤ DUE TO A VARIABLE SET OF CIRCUMSTANCES, THE ROUTINE WAS UNABLE TO SATISFY THE GIVEN DESIGN SPECIFICATIONS WITHIN A REASONABLE NUMBER OF COMPUTATION ITERATIONS.

CLB0078--CURVES ARE ONLY VALID FOR STANDARD REINFORCED CONCRETE PIPE OR CORRUGATED METAL PIPE.

EXPL¤ THE EMPIRICAL CURVES UPON WHICH THE ROUTINE FOR DESIGN OF STRAIGHT, CIRCULAR, FLARED, SINGLE-OPENING CULVERTS IS BASED WERE COMPILED AND DERIVED FOR STANDARD REINFORCED CONCRETE PIPE AND STANDARD 'CGM' PIPE. OTHER MATERIALS WERE NOT USED.

CLB0079--FLARED INLET DESIGN NOT PRACTICAL BECAUSE SLOPE OF CULVERT IS SUBCRITICAL. PROBLEM TERMINATED.

EXPL¤ WHEN A CULVERT SLOPE IS DETERMINED TO BE SUBCRITICAL, THERE IS POSITIVE INDICATION THAT THE HEADWALL GEOMETRY IS NOT SIGNIFICANTLY INFLUENTIAL IN THE CULVERT HYDRAULIC OPERATION. THEREFORE, A FLARED INLET APPLICATION WOULD NOT BE PRACTICAL.

CLB0080--ORIGINAL CONVENTIONAL (NON-FLARED) DESIGN IS ACCEPTABLE. NO FLARED INLET DESIGN IS PRACTICAL.

EXPL¤ IN ATTEMPTING TO DESIGN A STRAIGHT, CIRCULAR, NORMAL, SINGLE-OPENING CULVERT THE PROGRAM FOUND THAT THE SLOPE WAS SUPER CRITICAL AND AUTOMATICALLY ATTEMPTED A FLARED INLET DESIGN. THIS MESSAGE IS PRINTED UNDER THESE CONDITIONS WHEN THE FLARED INLET DESIGN FINDS THE SLOPE IS LESS THAN CRITICAL. NON-FATAL.

CLB0081--FLARED INLET HAS NO EFFECT - HEADWATER BASED ON ENTRANCE CONTROL WITH KE=0.2'.

EXPL¤ THIS MESSAGE INDICATES THAT THE CULVERT CONFIGURATION IS SUCH THAT SUPER CRITICAL FLOW OCCURS BUT THE COMPUTATIONS INDICATE THAT NO ADVANTAGE IS GAINED BY THE APPLICATION OF A FLARED INLET.

CLB0082--OUTLET CONDITIONS NOT CONSIDERED BECAUSE TW INSIGNIFICANT.

EXPL¤ IN DESIGNING A STRAIGHT, CIRCULAR, FLARED, SINGLE-OPENING CULVERT THE PROGRAM FOUND THAT THE BACKWATER EFFECT FROM THE TAILWATER WAS NOT HIGH ENOUGH TO AFFECT THE DESIGN. NON-FATAL.

CLB0083--OUTLET CONDITIONS CONSIDERED BUT FOUND NOT TO CONTROL.

EXPL¤ IN THE DESIGN OF A STRAIGHT, CIRCULAR, FLARED, SINGLE-OPENING CULVERT THE PROGRAM FOUND THAT THE BACKWATER EFFECT FROM THE

TAILWATER WAS NOT HIGH ENOUGH TO HAVE AN EFFECT ON THE CULVERT DESIGN. NON-FATAL.

CLB0084--OUTLET CONDITIONS CONTROL - FLARED INLET HAS NO EFFECT.

EXPL¤ IN DESIGNING A STRAIGHT, CIRCULAR, FLARED, SINGLE-OPENING CULVERT THE PROGRAM FOUND THAT THE BACKWATER EFFECT FROM THE TAILWATER WAS AT A HIGH ENOUGH LEVEL THAT INLET CONDITIONS DID NOT AFFECT THE DESIGN. THE FLARED DESIGN IS PROVIDED, BUT A NORMAL INLET WILL SUFFICE. NON FATAL.

CLB0085--THIS IS THE SMALLEST STRUCTURAL PLATE SIZE AVAILABLE.

EXPL¤ THIS MESSAGE INDICATES THAT THE GIVEN DESIGN SPECIFICATIONS CAUSED THE ROUTINE TO SELECT THE SMALLEST SIZE STRUCTURAL PLATE AVAILABLE. THIS MAY IMPLY THAT A DIFFERENT STRUCTURAL SHAPE/ MATERIAL WOULD BE MORE PRACTICAL OR ECONOMICAL.

CLB0086--THE CONDITIONS FOR THIS BOX DESIGN CANNOT BE REASONABLY SATISFIED.

EXPL¤ THIS MESSAGE INDICATES THAT IN BOX CULVERT DESIGN AND FOR THE GIVEN DESIGN SPECIFICATIONS, AN ACCEPTABLE DESIGN COULD NOT BE FOUND AFTER A REASONABLE NUMBER OF COMPUTATION ITERATIONS AND TRIAL SIZES.

CLB0087--THIS IS THE SMALLEST BOX SIZE AVAILABLE. TRY PIPE.

EXPL¤ IN DESIGNING A SINGLE-OPENING, STRAIGHT, NORMAL BOX CULVERT, THE PROGRAM FOUND THAT THE SMALLEST BOX SIZE AVAILABLE (3'X2') WOULD NOT ESTABLISH A BACKWATER ELEVATION WITHIN 6 IN. OF THE TOP OF THE BOX UNDER DESIGN CONDITIONS. THIS MESSAGE IS FOR USER INFORMATION ONLY. NON-FATAL.

CLB0088--NO CROSS-SECTION IDENTIFICATION GIVEN. (SEE FL-DV CARD).

EXPL¤ IN A BRIDGE DESIGN A CROSS-SECTION AT THE SITE MUST BE PROVIDED. SINCE ALL CROSS-SECTIONS ARE STORED IN 'HYDRA', IT IS NECESSARY THAT THE PROPER CROSS-SECTION IDENTIFICATION BE GIVEN IN 'CULBRG' IN ORDER THAT THE REQUIRED CROSS-SECTION MAY BE RECALLED FROM STORAGE. SPACE HAS BEEN PROVIDED ON THE 'FL-DV' CARD (C-11) FOR ENTRY OF THIS IDENTIFICATION. THIS MESSAGE INDICATES THAT THIS IDENTIFICATION IS NOT PROVIDED. FATAL ERROR.

CLB0089--THERE IS NO CROSS-SECTION ID FROM HYDRA WHICH CORRESPONDS TO FLOW-DIVIDE SECX. PROBLEM ABANDONED.

EXPL¤ IN ORDER TO DESIGN OR ANALYZE A BRIDGE IN 'CULBRG', A CROSS-SECTION MUST BE PROVIDED AT THE DESIRED LOCATION. ALL CROSS-SECTIONS USED IN THE 'THYSYS' SYSTEM MUST BE STORED BY ENTERING THEM IN THE 'HYDRA' SUBSYSTEM. AT THE TIME OF ENTRY EACH CROSS-SECTION IS ASSIGNED A UNIQUE NAME BY THE USER. THIS NAME IS ENTERED ON THE 'SECX' CARDS (B-6) DESCRIBING EACH CROSS-SECTION. IN ORDER FOR THE PROGRAM TO RETRIEVE THE PROPER SECTION FOR USE IN 'CULBRG'. THE CROSS-SECTION MUST BE REFERENCED ON 'FL-DV' CARD CARD (C-11) IN EXACTLY THE SAME MANNER AS PREVIOUSLY ENTERED. THIS MESSAGE INDICATES THAT THE PROGRAM COULD FIND NO CROSS-SECTION STORED BEARING THE IDENTICAL NAME AS THE ONE GIVEN ON THE 'FL-DV' CARD (C-11). THE USER SHOULD CHECK TO BE SURE THAT THE CROSS-SECTION NAMES ARE PLACED IN THE SAME POSITION WITHIN THE ALLOTTED SPACES. FATAL ERROR.

CLB0090--VALUE FOR LEFT AND RIGHT HEADER SLOPES NOT GIVEN. 2.0 ASSUMED FOR BOTH.

EXPL¤ SELF EXPLANATORY

CLB0091--MULTIPLE BRIDGE REQUESTED, BUT NUMBER OF FLOW-DIVIDES NOT EQUAL TO THE NUMBER OF OPENINGS SPECIFIED.

EXPL¤ THE MULTIPLE BRIDGE DESIGN ROUTINE REQUIRES THAT THERE NOT BE ANY DISCREPANCY IN THE NUMBER OF FLOW DIVIDES. IF THE NUMBERS ARE

DIFFERENT, ONE CAN NOT NECESSARILY TAKE PRECEDENCE OVER THE OTHER. FATAL ERROR.

CLB0092--CALCULATED VELOCITY IS LESS THAN MINIMUM VELOCITY. SUGGEST BREAKING DESIGN SECTION INTO MORE X AND Y POINTS.
EXPL¤ SELF-EXPLANATORY.

CLB0093--CALCULATED VELOCITY EXCEEDS INPUT MAXIMUM VELOCITY. SUGGEST THAT THIS MAX VELOCITY IS UNREALISTIC FOR THIS COMBINATION OF Q, WATER ELEVATION, AND DESIGN SECTION.
EXPL¤ IN DESIGNING A SINGLE OPENING BRIDGE, THE PROGRAM CALCULATED A VELOCITY IN EXCESS OF THE MAXIMUM ALLOWABLE VELOCITY ENTERED ON 'BRDG' CARD (C-9). NON-FATAL ERROR.

CLB0094--*** AREA NEEDED TO SATISFY MAX VELOCITY IS GREATER THAN TOTAL AREA OF FLOW-DIVIDE.
EXPL¤ SELF EXPLANATORY.

CLB0095--BROKEN BACK ANALYSIS ROUTINE CAN NOT ACCOMODATE MORE THAN TWO BREAKS.
EXPL¤ THE ROUTINE AS WRITTEN CAN ACCOMODATE NO MORE THAN TWO BREAKS OR A MAXIMUM OF 3 UNITS FOR BROKEN-BACK CULVERT COMPUTATIONS.

CLB0096--BROKEN BACK ANALYSIS ROUTINE CAN NOT ACCOMODATE MORE THAN TWO BREAKS.
EXPL¤ SELF-EXPLANATORY.

CLB0097--THYSYS IS NOT PRESENTLY EQUIPPED TO HANDLE THE BROKEN-BACK SITUATION WHERE CRITICAL DEPTH (* *) IS GREATER THAN BARREL DEPTH.
EXPL¤ SELF-EXPLANATORY.

CLB0098--HEADWATER CALCULATION CURVES ARE ONLY VALID FOR STANDARD REINFORCED CONCRETE PIPE OR STANDARD CORRUGATED METAL PIPE.
EXPL¤ THE EMPIRICAL CURVES UPON WHICH THE ROUTINE FOR DESIGN OF STRAIGHT, CIRCULAR, FLARED, SINGLE-OPENING CULVERTS IS BASED WERE COMPILED AND DERIVED FOR STANDARD 'RC' PIPE AND STANDARD 'CGM' PIPE. OTHER MATERIALS WERE NOT USED.

CLB0099--OUTLET CONDITIONS NOT CONSIDERED BECAUSE TW INSIGNIFICANT.
EXPL¤ IN DESIGNING A STRAIGHT, CIRCULAR, FLARED, SINGLE-OPENING CULVERT THE PROGRAM FOUND THAT THE BACKWATER EFFECT FROM THE TAILWATER WAS NOT HIGH ENOUGH TO AFFECT THE DESIGN. NON-FATAL.

CLB0100--OUTLET CONDITIONS CONSIDERED BUT FOUND NOT TO CONTROL.
EXPL¤ IN THE DESIGN OF A STRAIGHT, CIRCULAR, FLARED, SINGLE-OPENING CULVERT THE PROGRAM FOUND THAT THE BACKWATER EFFECT FROM THE TAILWATER WAS NOT HIGH ENOUGH TO HAVE AN EFFECT ON THE CULVERT DESIGN. NON-FATAL.

CLB0101--OUTLET CONDITIONS CONTROL - FLARED INLET HAS NO EFFECT.
EXPL¤ IN DESIGNING A STRAIGHT, CIRCULAR, FLARED, SINGLE-OPENING CULVERT THE PROGRAM FOUND THAT THE BACKWATER EFFECT FROM THE TAILWATER WAS AT A HIGH ENOUGH LEVEL THAT INLET CONDITIONS DID NOT AFFECT THE DESIGN. THE FLARED DESIGN IS PROVIDED, BUT A NORMAL INLET WILL SUFFICE. NON-FATAL.

CLB0102--CONVENTIONAL CULVERT ANALYSIS USED. FLARED INLET NOT EFFECTIVE.
EXPL¤ FOR VARIABLE REASONS, INCLUDING THAT OF THE CULVERT HAVING SUBCRITICAL FLOW, THE ENTRANCE CONDITIONS HAVE NO SIGNIFICANT INFLUENCE ON THE CULVERT HYDRAULICS. THEREFORE, THE FLARED INLET IS NOT EFFECTIVE.

CLB0103--HEADWATER BASED ON ENTRANCE CONTROL BUT NOT FLARED ENTRANCE.
EXPL¤ IN THE CASE OF A CULVERT OPERATING AT SUPERCRITICAL FLOW, THE

FLARED INLET WAS FOUND NOT TO HAVE SIGNIFICANT INFLUENCE ON THE CULVERT HYDRAULICS BECAUSE OF TAILWATER EFFECTS.

CLB0104--NOMINAL DIMENSIONS GIVEN DO NOT AGREE WITH STANDARD DIMENSIONS.
EXPL¤ THE SPECIFIED DIMENSIONS FOR THE ARCH PIPE GEOMETRY IN QUESTION MUST AGREE WITHIN 2 INCHES OF THE NOMINAL SIZE.

CLB0105--ROAD PROFILE DATA NOT PROVIDED.
EXPL¤ IN ORDER TO PERFORM COMPUTATIONS REGARDING THE 100 YEAR FLOOD, SPECIFICATIONS DESCRIBING THE ROAD PROFILE MUST BE PROVIDED. THIS MAY BE DONE BY MEANS OF 'SECX' CARDS IN 'HYDRA' OR 'RDPROFILE' CARDS IN 'CULBRG'.

CLB0106--HIGHWAY PROFILE DOES NOT FORM A VALID SECTION.
EXPL¤ A VALID SECTION IS FORMED BY AT LEAST 3 POINTS AND THE MIDDLE POINT MUST BE LOWER THAN THE OUTSIDE POINTS. (THE SECTION MUST HOLD WATER).

CLB0107--SUPERFLUOUS POINTS HAVE BEEN DELETED FROM HIGHWAY PROFILE
EXPL¤ WHERE THERE ARE POINTS OUTSIDE OF A VALID SECTION WHICH WOULD NOT DEPICT VALID SECTIONS THEMSELVES, THESE POINTS ARE CONSIDERED SUPERFLUOUS.

CLB0108--HIGHWAY PROFILE DOES NOT HAVE AT LEAST THREE X Y COORDINATES.
EXPL¤ A VALID PROFILE MUST HAVE AT LEAST 3 COORDINATE PAIRS TO FORM A SECTION CAPABLE OF CONTAINING AN OVERFLOW.

CLB0109--CULVERT DIMENSIONS NOT SUPPLIED.
EXPL¤ WHEN A 100 YEAR ANALYSIS ON A CULVERT IS REQUESTED, THE ROUTINE MUST HAVE CERTAIN INFORMATION CONCERNING THAT CULVERT, INCLUDING THE CULVERT DIMENSIONS. NORMAL CULVERT ANALYSIS INPUT IS REQUIRED.

CLB0110--THYSYS DOES NOT PRESENTLY PROCESS 100 YEAR FREQUENCY CALCULATIONS FOR PIPE CULVERTS.
EXPL¤ SELF-EXPLANATORY.

CLB0111--UNABLE TO ACHIEVE BALANCE FOR 100 YEAR FLOOD.
EXPL¤ IF THE 100 YEAR FLOOD OVERFLOWS THE HIGHWAY EMBANKMENT, THE ROUTINE ATTEMPTS TO BALANCE THE DISCHARGE OVER THE ROAD WITH THE REMAINING DISCHARGE THROUGH THE STRUCTURE. THIS MESSAGE INDICATES THAT BALANCE WAS NOT ACHIEVED AFTER A REASONABLE NUMBER OF ITERATIONS.

CLB0112--NO CLEARANCE ELEVATION GIVEN.
EXPL¤ THE ELEVATION OF 'LOW STEEL' FOR A SPAN TYPE BRIDGE MUST BE GIVEN FOR A 100 YEAR ANALYSIS. THIS CLEARANCE ELEVATION INDICATES TO THE ROUTINE AT WHAT POINT ADDITIONAL CROSS-SECTIONAL AREA OF FLOW UNDER THE BRIDGE IS IMPOSSIBLE.

PART VI - SEWER SUBSYSTEM (SEWER)

Sewer Subsystem (SEWER)

SEWER SUBSYSTEM

I. DESCRIPTION

The SEWER subsystem has three functions (options). They are as follows:

1. To compute the flow for each drainage area (RUNOFF)
2. To design or analyze inlets (INLET)
3. To design or analyze a sewer pipe network (SEWER).

In the RUNOFF option, the flow for each drainage area is computed by the Rational Method with the option of adding a base flow to the calculated values.

In the INLET option, inlets are analyzed or designed. Design flows for inlets may be computed in the RUNOFF calculations mentioned above or they may be supplied directly for each inlet. In the Design of Curb on Grade and Grate on Grade inlets there is the choice of specifying CARRYOVER which will allow a portion of the water to flow past an inlet to another designated inlet. However, it should be noted that CARRYOVER is only beneficial in optimizing inlet lengths since the design flow directed at any inlet is neither increased nor decreased by carry over quantities for pipe sizing computations. In analysis, the theoretical ponding depth is computed with no carry over even though the inlet may be inadequate. The following types of inlets are available: (1) CURB on GRADE, (2) CURB at SAG, (3) GRATE on GRADE, and (4) GRATE at SAG.

The SEWER function designs or analyzes a sewer pipe network. If inlet flows have been provided in the other option(s), there is the choice of adding a flow and/or a CA value for each inlet. An added function of the SEWER option is a graphical printout of the pipe flow lines, hydraulic gradient lines, and stationing of the junctions.

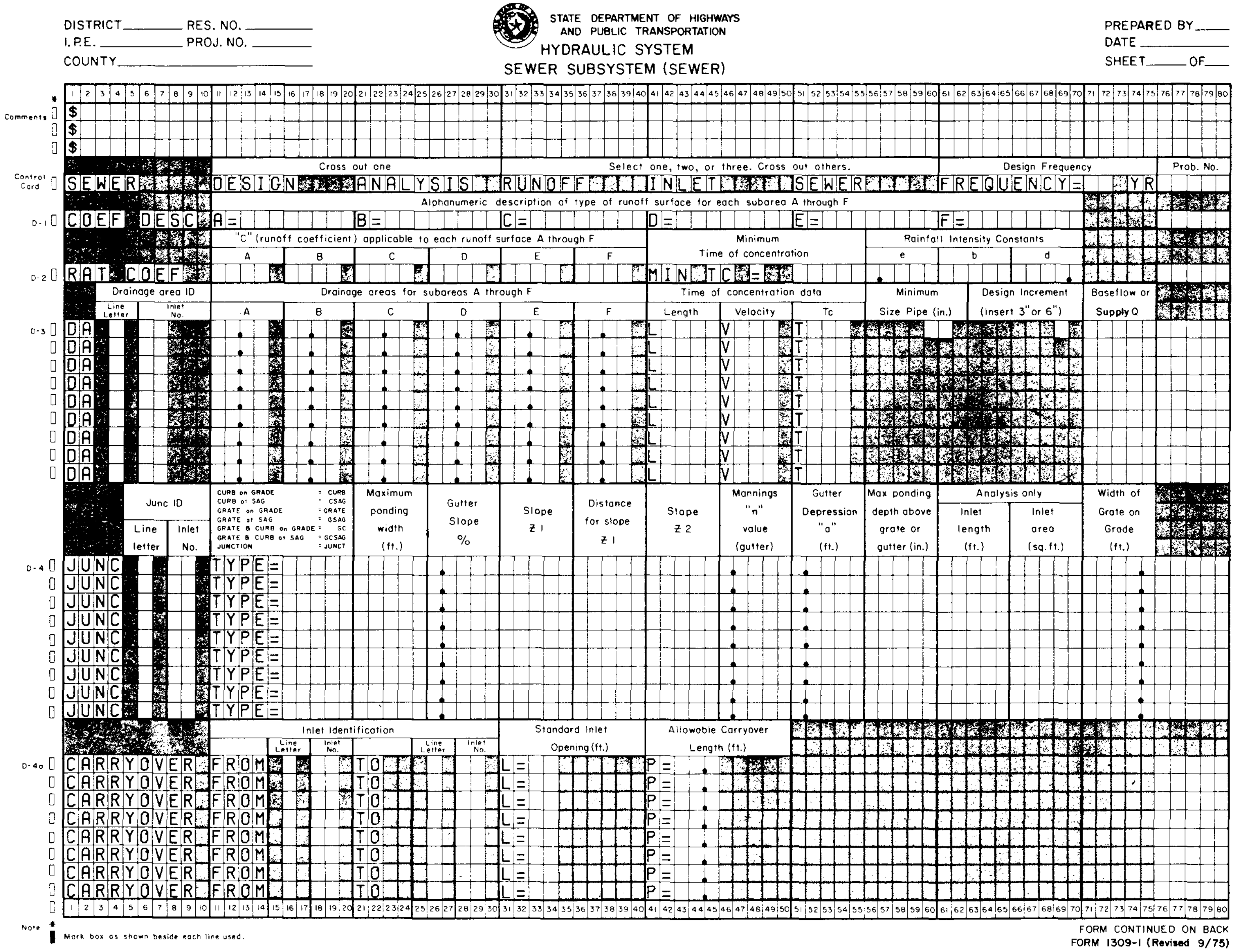
II. INPUT

The data form for the SEWER subsystem is printed on the front and back and is shown in Figures 6-1 and 6-2.

General

The SEWER subsystem does not interact with any of the other subsystems of THYSYS. It receives no information from other subsystems and feeds no information to other subsystems. Therefore, all data to be used in a SEWER problem must be entered in the SEWER input. It is also important that no SEWER problem be placed within a series of CULBRG problems where CULBRG results are to be saved for a PLAN SUMMARY.

The input required for sewer pipe design includes upstream and downstream soffit elevations and "maximum size rise". This input procedure allows the user to bury the pipe as much or as little as he deems necessary. A straight line connecting the upstream and downstream soffit elevations describes the inside top of the pipe run. Then, by specifying "maximum size rise", the user indicates a line defining the greatest depth to which there will be a design. This allows the user to clear any utility lines or other obstacles which may be in the path of the run. Output for sewer pipe design will include the flow line elevations as determined by the program. At first, the above overall technique appears to be a departure from the established technique of storm sewer design; however, it will be seen from using this subsystem that the departure is more apparent than real. The difference is, mainly, that the computer must have on record all information and criteria controlling the design whereas the engineer may not necessarily note or record all data and criteria used in his design.



DISTRICT______ RES. NO. ______
I.P.E. ______ PROJ. NO. ______
COUNTY______

STATE DEPARTMENT OF HIGHWAYS
AND PUBLIC TRANSPORTATION
HYDRAULIC SYSTEM
SEWER SUBSYSTEM (SEWER)

PREPARED BY____
DATE______
SHEET____ OF____

*
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80

Comments ☐ $
☐ $
☐ $

Cross out one | Select one, two, or three. Cross out others. | Design Frequency | Prob. No.

Control Card ☐ SEWER DESIGN ANALYSIS RUNOFF INLET SEWER FREQUENCY= YR

Alphanumeric description of type of runoff surface for each subarea A through F

D-1 ☐ COEF DESC A= B= C= D= E= F=

"C" (runoff coefficient) applicable to each runoff surface A through F: A B C D E F | Minimum Time of concentration | Rainfall Intensity Constants: e b d

D-2 ☐ RAT COEF MIN TC=

Drainage area ID: Line Letter, Inlet No. | Drainage areas for subareas A through F: A B C D E F | Time of concentration data: Length, Velocity, Tc | Minimum Size Pipe (in.) | Design Increment (insert 3" or 6") | Baseflow or Supply Q

D-3 ☐ DA L V T
☐ DA L V T
☐ DA L V T
☐ DA L V T
☐ DA L V T
☐ DA L V T
☐ DA L V T
☐ DA L V T
☐ DA L V T

Junc ID: Line letter, Inlet No.

CURB on GRADE = CURB
CURB at SAG = CSAG
GRATE on GRADE = GRATE
GRATE at SAG = GSAG
GRATE & CURB on GRADE = GC
GRATE & CURB at SAG = GCSAG
JUNCTION = JUNCT

Maximum ponding width (ft.) | Gutter Slope % | Slope Z 1 | Distance for slope Z 1 | Slope Z 2 | Mannings "n" value (gutter) | Gutter Depression "a" (ft.) | Max ponding depth above grate or gutter (in.) | Analysis only: Inlet length (ft.), Inlet area (sq. ft.) | Width of Grate on Grade (ft.)

D-4 ☐ JUNC TYPE=
☐ JUNC TYPE=
☐ JUNC TYPE=
☐ JUNC TYPE=
☐ JUNC TYPE=
☐ JUNC TYPE=
☐ JUNC TYPE=
☐ JUNC TYPE=
☐ JUNC TYPE=

Inlet Identification: Line Letter, Inlet No. ; Line Letter, Inlet No. | Standard Inlet Opening (ft.) | Allowable Carryover Length (ft.)

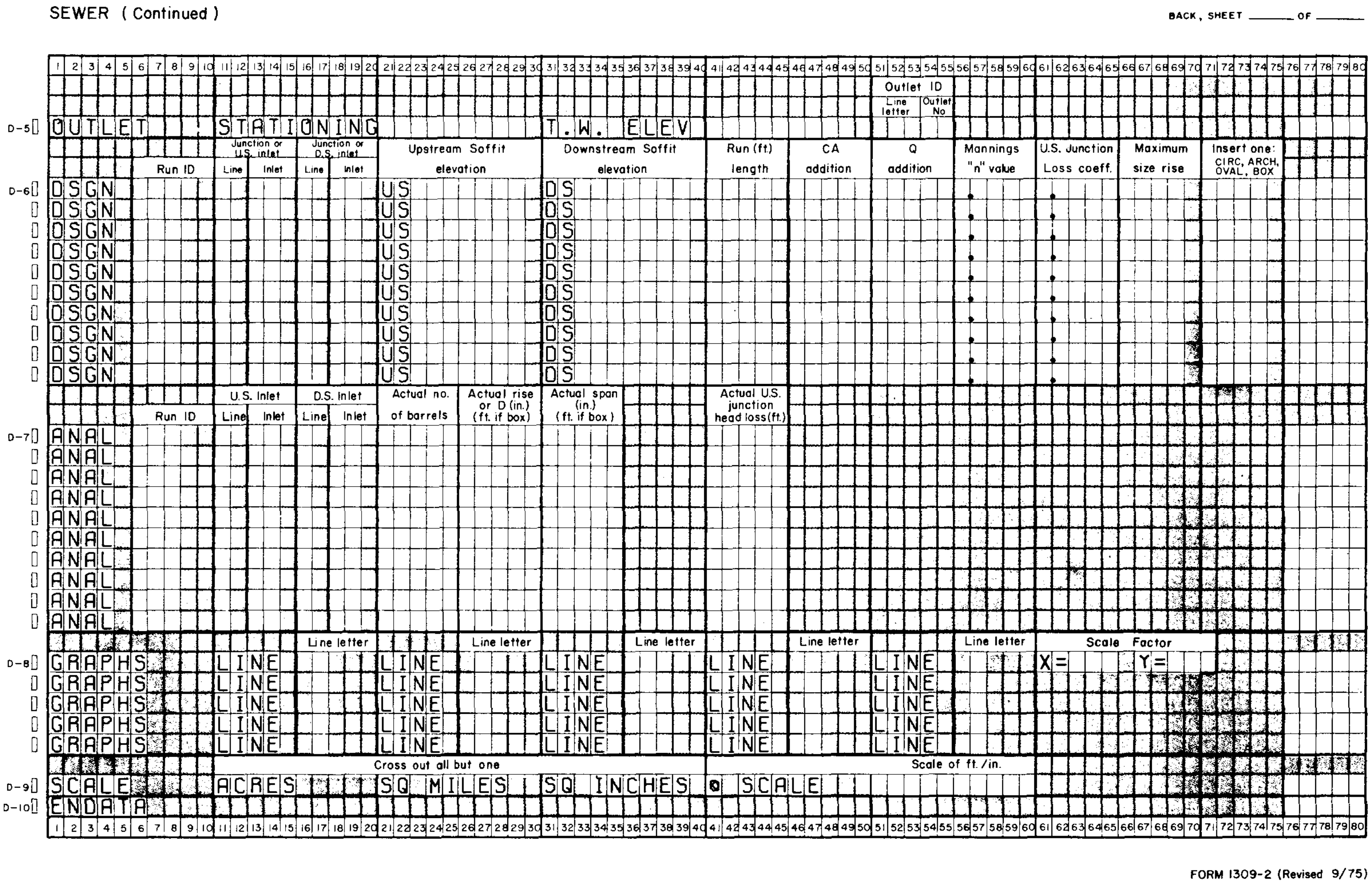
D-4a ☐ CARRYOVER FROM TO L= P=
☐ CARRYOVER FROM TO L= P=
☐ CARRYOVER FROM TO L= P=
☐ CARRYOVER FROM TO L= P=
☐ CARRYOVER FROM TO L= P=
☐ CARRYOVER FROM TO L= P=
☐ CARRYOVER FROM TO L= P=
☐ CARRYOVER FROM TO L= P=

☐ 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80

Note * ▌ Mark box as shown beside each line used.

FORM CONTINUED ON BACK
FORM 1309-1 (Revised 9/75)

FIGURE 6-1. FRONT SIDE OF THE SEWER SUBSYSTEM (SEWER) INPUT FORM



SEWER (Continued)

BACK, SHEET ______ OF ______

	1–6	7–10	11–15	16–20	21–30	31–40	41–50	51–55	56–60	61–65	66–70	71–75
								Outlet ID Line letter / Outlet No				
D-5	OUTLET		STATIONING			T.W. ELEV						

	1–4	6–10	11–15	16–20	21–30	31–40	41–45	46–50	51–55	56–60	61–65	66–70	71–75
		Run ID	Junction or U.S. inlet Line / Inlet	Junction or D.S. inlet Line / Inlet	Upstream Soffit elevation	Downstream Soffit elevation	Run (ft) length	CA addition	Q addition	Mannings "n" value	U.S. Junction Loss coeff.	Maximum size rise	Insert one: CIRC, ARCH, OVAL, BOX
D-6	DSGN				US	DS				.	.		
	DSGN				US	DS				.	.		
	DSGN				US	DS				.	.		
	DSGN				US	DS				.	.		
	DSGN				US	DS				.	.		
	DSGN				US	DS				.	.		
	DSGN				US	DS				.	.		
	DSGN				US	DS				.	.		
	DSGN				US	DS				.	.		
	DSGN				US	DS				.	.		

	1–4	6–10	11–15	16–20	21–25	26–30	31–35	41–45
		Run ID	U.S. Inlet Line / Inlet	D.S. Inlet Line / Inlet	Actual no. of barrels	Actual rise or D (in.) (ft. if box)	Actual span (in.) (ft. if box)	Actual U.S. junction head loss(ft.)
D-7	ANAL							
	ANAL							
	ANAL							
	ANAL							
	ANAL							
	ANAL							
	ANAL							
	ANAL							
	ANAL							
	ANAL							

	1–6	11–14	16–20	21–24	26–30	31–34	36–40	41–44	46–50	51–54	56–60	61–70
			Line letter		Line letter		Line letter		Line letter		Line letter	Scale Factor
D-8	GRAPHS	LINE		LINE		LINE		LINE		LINE		X= Y=
	GRAPHS	LINE		LINE		LINE		LINE		LINE		
	GRAPHS	LINE		LINE		LINE		LINE		LINE		
	GRAPHS	LINE		LINE		LINE		LINE		LINE		
	GRAPHS	LINE		LINE		LINE		LINE		LINE		

	1–6	11–40	41–50	51–60
		Cross out all but one		Scale of ft./in.
D-9	SCALE	ACRES SQ MILES SQ INCHES	⊘ SCALE	
D-10	ENDATA			

FORM 1309-2 (Revised 9/75)

FIGURE 6-2. BACK SIDE OF THE SEWER SUBSYSTEM (SEWER) INPUT FORM

The following is a list of terms and rules that apply to this subsystem. In this discussion the term "points" will be used to refer to inlets, outlets, or junctions. The term "junction" encompasses manholes, pipe junctions, changes in grade and size changes. Figure 6-3 indicates the application of these terms.

1. A line is composed of a series of one or more inlets and junctions; and, generally, terminates at either a junction or an outlet. Each designated line is identified by one of the alphabetic characters A through Z. Each alphabetic character is known as a LINE LETTER on the input form. The maximum number of lines is 26.
2. Each inlet, outlet, and junction is called a point and is identified by a unique combination of alphabetic and numeric characters. The alphabetic character must be the same as that of the line to which the point is assigned. "E16", for instance, indicates that the point is on Line E. The numeric characters may range from 1 through 99. A maximum of 100 points may be used. If the sewer network is larger than the allowed limits, it may be broken into smaller segments which the program can accept and run as separate problems. If this proves necessary, it should be done in consultation with the Bridge Division Hydraulic Section.
3. A run lies between two points. Runs are generally identified by simply numbering them from 1 to 99. Optionally, the identification can be any combination of up to three alphanumeric characters.
4. A maximum of three Runs may enter a Junction and only one Run may leave a Junction.

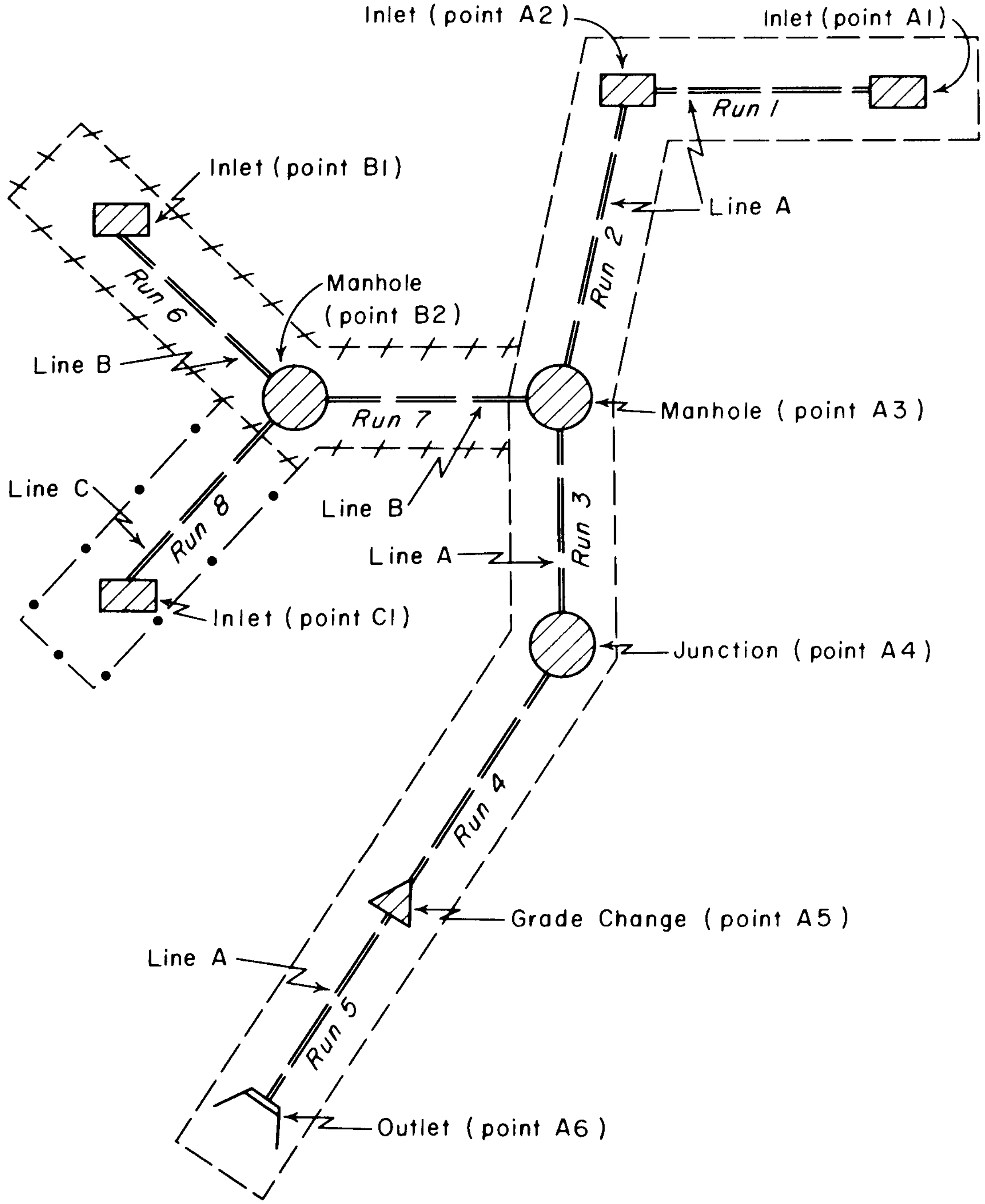
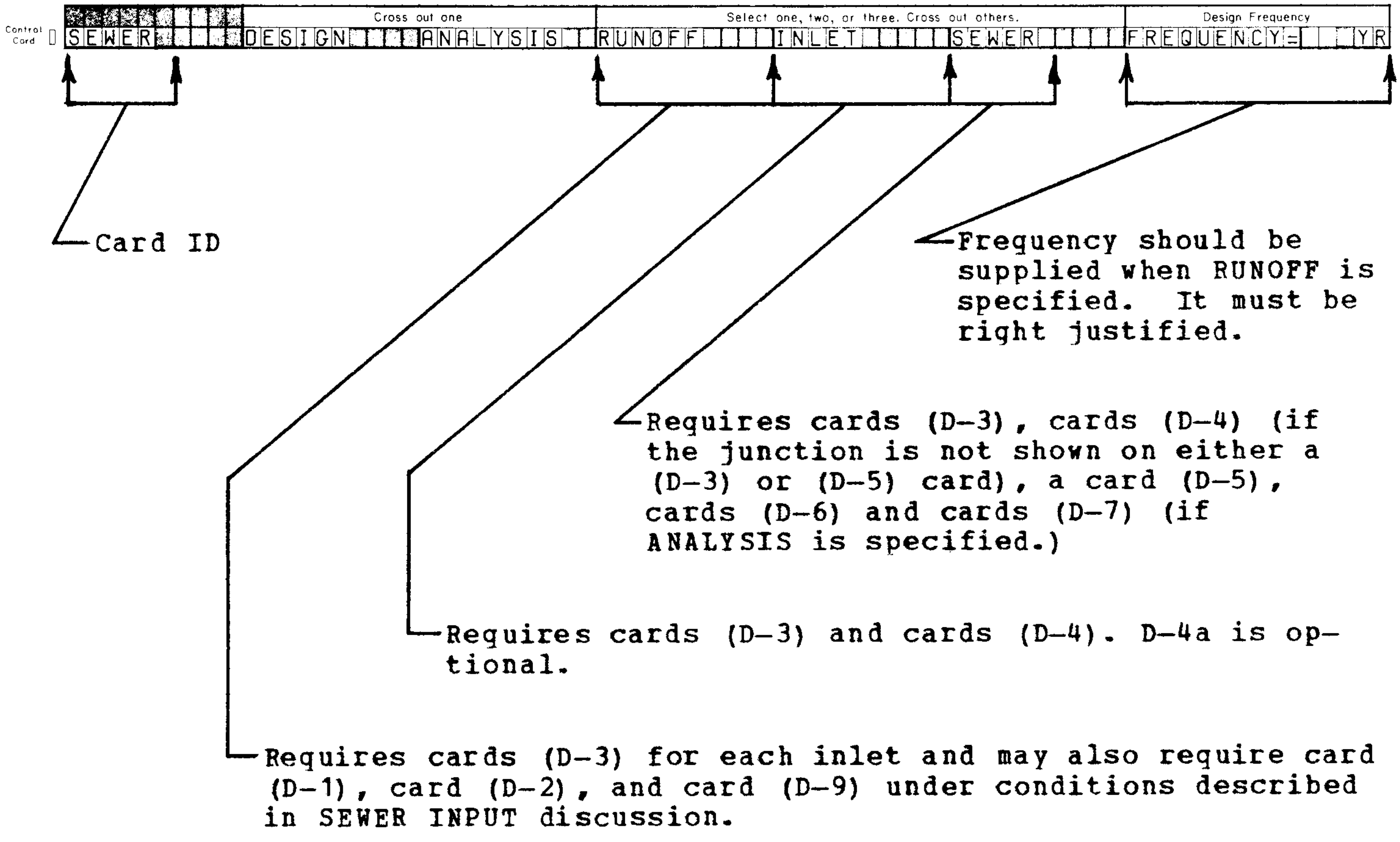


FIGURE 6-3. ILLUSTRATION OF POINTS, RUNS, AND LINES AS USED IN SEWER SUBSYSTEM

SEWER CONTROL CARD

As in the other subsystems of THYSYS, the SEWER subsystem allows the user several options in order to achieve flexibility. On the SEWER Control Card the first option is a choice between DESIGN or ANALYSIS. The user must select one of these. If the DESIGN option is specified the program will use the information provided on subsequent cards to design inlets and/or a sewer network capable of handling a given flow for a given flood frequency. If the ANALYSIS option is specified, the program will analyze existing inlets and/or a sewer network to determine the capability to handle a given flow. The flood frequency is not required for calculations but should be provided since it is included in several reports.



Card ID

Frequency should be supplied when RUNOFF is specified. It must be right justified.

Requires cards (D-3), cards (D-4) (if the junction is not shown on either a (D-3) or (D-5) card), a card (D-5), cards (D-6) and cards (D-7) (if ANALYSIS is specified.)

Requires cards (D-3) and cards (D-4). D-4a is optional.

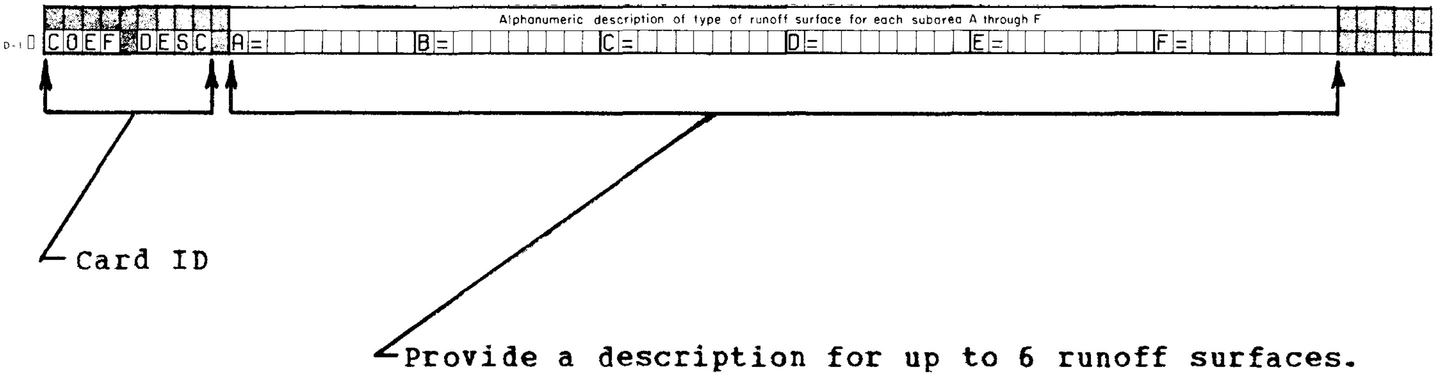
Requires cards (D-3) for each inlet and may also require card (D-1), card (D-2), and card (D-9) under conditions described in SEWER INPUT discussion.

With either DESIGN or ANALYSIS the user may select any combination of three procedures based on the amount of information already known. These procedures are RUNOFF, INLET, and SEWER. A minimum of one of these procedures must be specified and up to three may be specified at one time.

If flows to all inlets are known it is not necessary for the user to specify the RUNOFF option. However, if he wishes a report reflecting the input flows, the RUNOFF option must be specified. If flow to any one inlet is not known, then the RUNOFF option must be specified. The INLET option must be specified if the user wishes to DESIGN or ANALYZE inlets. The SEWER option must be specified in order to DESIGN or ANALYZE a sewer pipe network.

COEF DESC CARD (D-1)

If RUNOFF is specified on the SEWER Control Card and flow to any one inlet is not known, then this card is required. The user may enter up to six eight-letter descriptions of runoff surfaces contributing to the unknown flows. These descriptions are primarily for output identification and may consist of any combination of alphabetic and/or numeric (alphanumeric) characters.

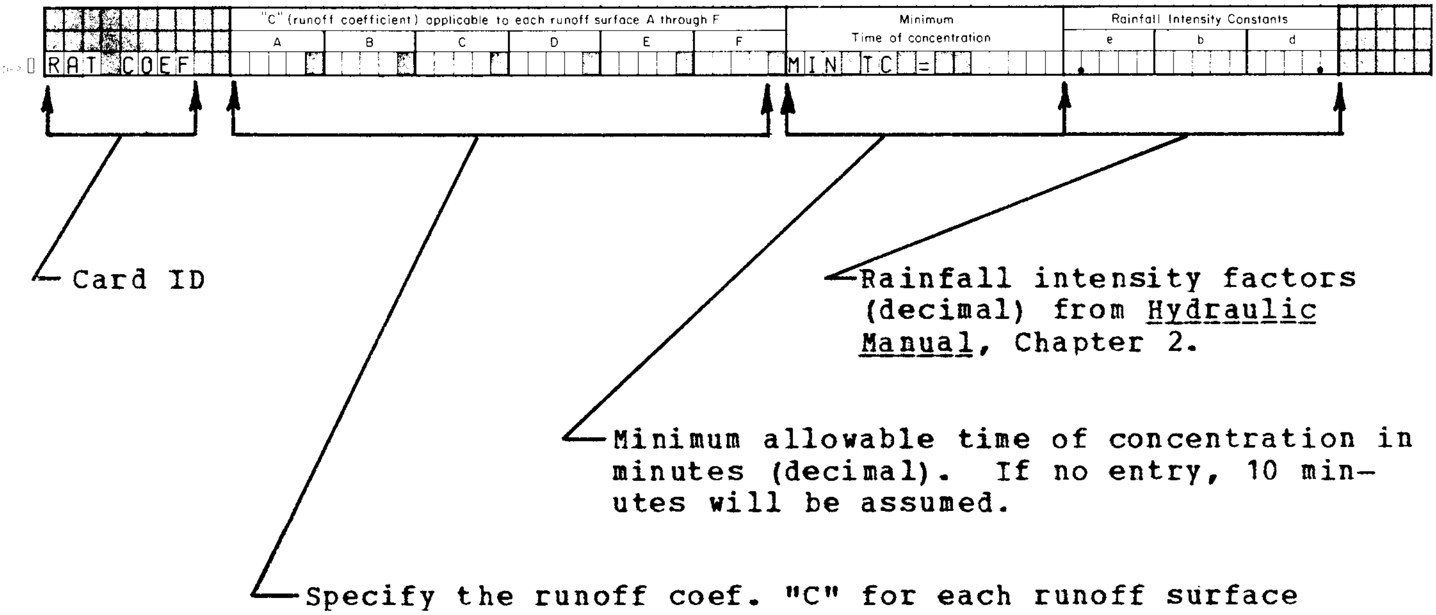


Card ID

Provide a description for up to 6 runoff surfaces.

RAT COEF CARD (D-2)

This card is required when RUNOFF is specified on the SEWER Control Card and flow to any one inlet is not known. The user must enter runoff coefficents relating to the surfaces described on the previous card. Care should be taken to assure that the spaces with the same reference letters are used to refer to each subarea on Cards D-1, D-2 and D-3. Minimum allowable time of concentration is to be entered on this card along with rainfall intensity factors e, b and d from the *Hydraulic Manual*. If MIN TC is not entered, 10 minutes will be assumed.



Card ID

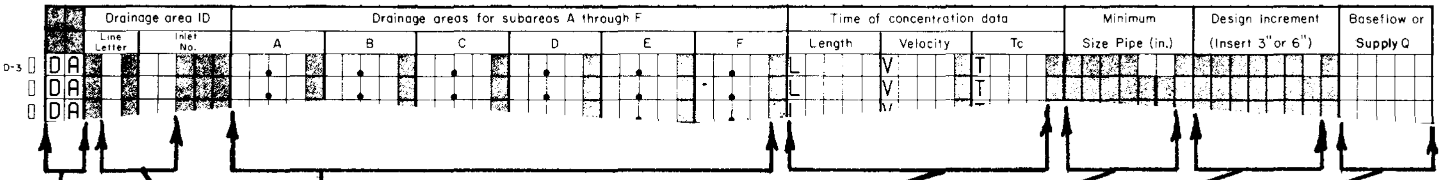
Rainfall intensity factors (decimal) from *Hydraulic Manual*, Chapter 2.

Minimum allowable time of concentration in minutes (decimal). If no entry, 10 minutes will be assumed.

Specify the runoff coef. "C" for each runoff surface (decimal). Refer to *Hydraulic Manual* for coefficient determination.

DA CARD (D-3)

In every problem computed in this subsystem, one of these cards must be included for each inlet regardless of whether the flow to the inlet is known or not known. If the flow to the inlet is known, it may be entered in the field BASEFLOW OR SUPPLY Q of this card and the other information for this inlet need not be supplied.



Card ID

Base flow or discharge (Q), if known, for each inlet in ft³/sec (decimal).

Increments of pipe sizes to be considered in sewer design. If blank, 3" will be assumed.

Minimum Size Pipe (in) to be considered in sewer design.

If TC is known, it must be entered with LENGTH and VELOCITY omitted. TC must be given in minutes (decimal). If TC is not known, LENGTH in feet and VELOCITY in ft/sec as described in the Hydraulic Manual must be provided (decimal).

If the discharge to this inlet is to be computed, necessary data must be supplied in this section. RUNOFF must be specified on the SEWER Control Card and Cards (D-1) and (D-2) must be supplied. Drainage area size for each subarea must be specified (decimal).

Required - LINE LETTER must be an alphabetic character and INLET NO. must be a number. This ID must exactly match this inlet's ID on a (D-4), (D-6) or (D-7) Card. (Maximum total of 100 different ID's can be accepted. These ID's can originate from this card, Card (D-4) or Card (D-5).

For inlets where the flow is not known, it is necessary to provide data to allow the program to compute the flow using the Rational Method. The area of each type of runoff surface contributing to the flow to the inlet must be indicated in the subarea fields A thru F. In most cases the user will know these areas in acres and will use acres as units for these drainage area entries. However, if it is more convenient, the user may enter these areas in units of square miles or square inches measured directly from a map. If square miles or square inches are used, it is necessary that a SCALE card (D-9) be included indicating SQ MILES or SQ INCHES. If SQ INCHES is used the SCALE (ft/in) of the map from which the square inches were measured must also be given.

For inlets where the flow is not known, it is also required that information relative to time of concentration be included. For each of these inlets the user must provide a LENGTH-VELOCITY combination or a known time of concentration (TC). If all three values are left blank or indicated as zero, the time of concentration for the drainage area served by the inlet will be assumed as the minimum TC. (This minimum may be specified on RAT COEF card (D-2); but, if not, the minimum time of concentration is assumed to be 10 minutes.) For RUNOFF calculations and for INLET calculations, the time of concentration used in discharge determination will be no less than the specified minimum (or 10 minutes if not specified). However, in the SEWER calculations, if the input L and V or TC yield a time of concentration of less than the established minimum, the input value will be used as a base for time of concentration accumulation as calculations proceed through the sewer subsystem. No discharge in the sewer subsystem will be based on this accumulated time of concentration unless and until its value has equalled or exceeded the established minimum. Therefore, if the established minimum time of concentration is 10 minutes and the input time of concentration for the most remote drainage area is 5 minutes, the accumulated time of concentration will be based on the 5 minutes. However, discharge will be based on the 10 minute minimum until the accumulated time of concentration equals or exceeds this minimum. The inlet serving this drainage area will be designed or analyzed on the basis of a discharge which has been calculated with no less than the established minimum time of concentration. The user may also specify the MINIMUM SIZE PIPE (IN) and a DESIGN INCREMENT (INSERT 3" OR 6") on the first D-3 card.

If the user provides the data necessary for the Rational solution of flow to an inlet and also wishes to provide a BASEFLOW, he may enter it in the field BASEFLOW OR SUPPLY Q of this card. This value will then be added to the computed flow and the sum will be considered as the flow to the inlet.

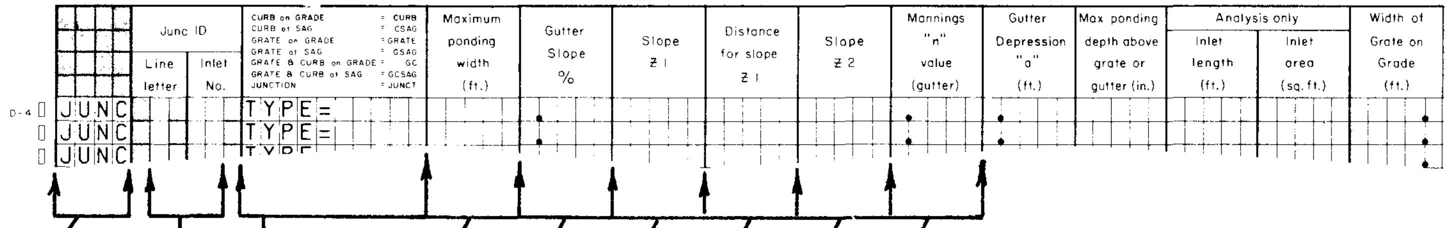
JUNC CARD (D-4)

Table 6-I indicates the required entries for each type of inlet used.

TABLE 6-I. REQUIRED ENTRIES FOR EACH TYPE OF INLET USED FOR CARD D-4

	INLET TYPE		Maximum Ponding Width (ft.)	Gutter Slope %	Slope Z 1	Distance for slope Z 1	Slope Z 2	Mannings "n" value (gutter)	Gutter Depression "a" (ft.)	Max ponding depth above grate or gutter (in.)	Analysis only		Width of Grate on Grade (ft.)
	DESCRIPTION	INPUT CODE									Inlet length (ft.)	Inlet area (sq.ft.)	
DESIGN	Curb on Grade	CURB	X	X	X	X	X	X	X				
	Curb @ Sag	CSAG							X	X			
	Grate on Grade	GRATE	X	X	X	X	X	X	X				X
	Grate @ Sag	GSAG								X			
	Grate & Curb on Grade		NOT AVAILABLE										
	Grate & Curb @ Sag	GCSAG								X			
ANALYSIS	Curb on Grade	CURB		X	X	X	X	X	X		X		
	Curb @ Sag	CSAG							X	X	X		
	Grate on Grade		NOT AVAILABLE										
	Grate @ Sag	GSAG								X		X	
	Grate & Curb on Grade	GC								X	X	X	
	Grate & Curb @ Sag	GCSAG								X	X	X	

A JUNC card (D-4) is required for each inlet when INLET is specified on the SEWER Control card. This permits the user to provide required data describing each inlet and its approaches.



Card ID

Manning's "n" value as defined in <u>Hydraulic Manual</u> (decimal).

Reciprocal of Trans. Slope Z 2 in ft/ft (decimal). If no entry, Slope Z 1 is assumed.

Distance in feet from curb to beginning of Trans. Slope Z 1 if both transverse slopes are given (decimal). If only one slope is given or if they are equal, omit this entry and a value of 1.0 will be assumed.

Reciprocal of Transverse Slope Z 1 (decimal). If blank, Slope Z 2 assumed.

Longitudinal gutter slope in <u>per cent</u> (decimal).

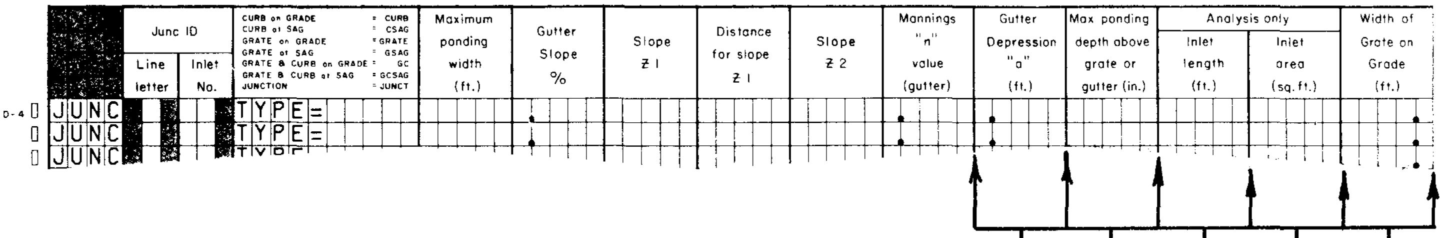
Maximum allowable ponding width in feet (decimal).

Enter the symbol on the right side of the table for the type of inlet desired (<u>left justified</u>). If entry is JUNCT, other entries on the card may be omitted.

Required - LINE LETTER must be an alphabetic character and INLET NO. must be a number. This ID must exactly match the corresponding ID on a Card (D-3), Card (D-6) or Card (D-7). (Maximum total of 100 different ID's can be accepted. These ID's can originate from this card and Card (D-5).

When SEWER is specified on the SEWER Control Card, the JUNC Cards (D-4) are required to provide identification for each junction which is not associated with an inlet or outlet or not otherwise previously identified in the sewer network. This would apply to manholes, changes in grade, changes in size of pipe or junctions where two or more pipes join. In this case only the first twenty columns of Card D-4 need to be completed.

JUNC Card Continued



Gutter depression in feet (decimal).

Maximum allowable ponding depth in inches. Not required when CURB specified (decimal).

Inlet length in feet (decimal).

Inlet area in sq ft (decimal).

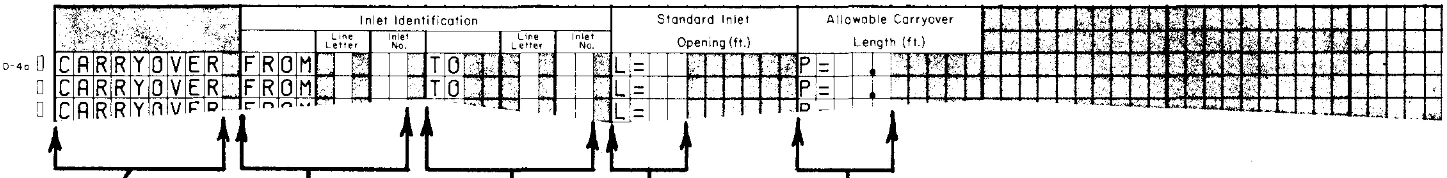
Transverse width in feet (decimal) used in GRATE computations when GRATE ON GRADE is specified. If left blank, 3 feet assumed.

The WIDTH OF GRATE ON GRADE is an optional entry when GRATE ON GRADE is specified and is used to enter the transverse width used in GRATE computations. If left blank the program will default to a standard width of three feet.

CARRYOVER CARD (D-4a)

This card is required when CARRYOVER is desired and can only be used when CURB or GRATE has been entered as the type of inlet on the D-4 card.

Under INLET IDENTIFICATION the inlet ID at which carryover may occur and the inlet ID to which the carryover is assigned must be specified. There are no limitations to this assignment except that such ID must be on the sewer system under consideration by the current computer run.



Card ID

Required entry for allowable carryover in terms of feet of inlet required.

Optional entry for standard inlet length, if blank 5 feet is assumed.

Inlet ID to which carryover is assigned.

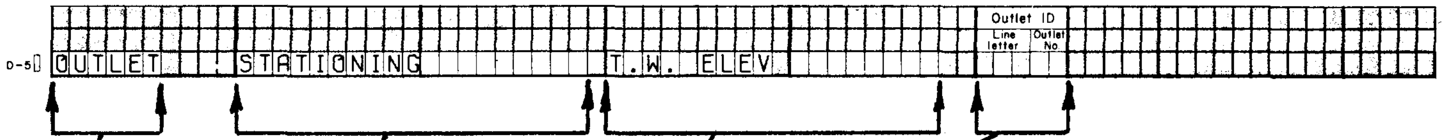
Inlet ID at which carryover may occur.

An entry for STANDARD INLET OPENING is optional. If used, the value represents a standard inlet length measured parallel to the curb line for either curb or grate inlets. If no entry is made, a value of five feet is assumed.

An entry in the ALLOWABLE CARRYOVER field is required and specifies the allowable carryover in terms of feet of inlet required for Grate on Grade and Curb on Grade. If, for example, an inlet opening were computed to be 8.29 feet in length, and the specified allowable carryover is 4.0 feet with a 5 foot standard length, carryover would be allowed and computed. If the specified allowable carryover had been 3.0 feet instead of 4.0, carryover would not be allowed nor computed.

OUTLET CARD (D-5)

An OUTLET card (D-5) is required only when SEWER is specified on the SEWER Control Card. This card supplies the required data describing the location, T.W. elevation, and identification of the outlet of the sewer network. A usual practice is to assign this station the number of 0.0.



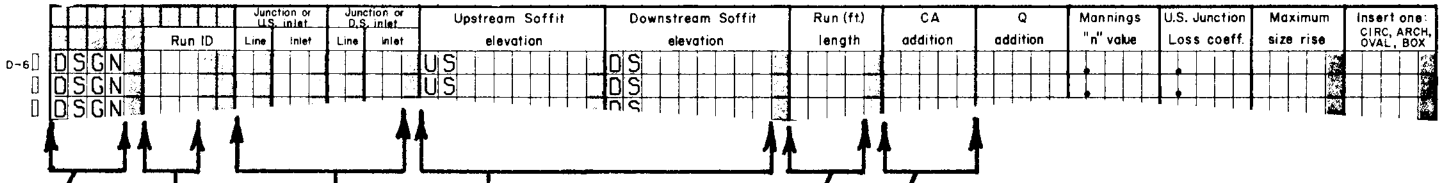
Card ID

Required. LINE LETTER must be an alphabetic character and OUTLET NO. must be a number. This ID must exactly match the corresponding ID on a (D-6) or (D-7) card. The maximum for different ID's on Cards D-3, D-4, and D-5 cannot exceed 100.

Tailwater elevation must be entered (decimal). If not actually known, it is suggested that the user enter soffit elevation of the outlet.

Numeric station description (decimal). For example, a station normally described as 22+56.0 should be entered as 2256.0.

DSGN CARD (D-6)



Card ID

CA as defined in Hydraulic Manual to be added to upstream inlet only if not included in flow determination from cards (D-2) and (D-3) (decimal).

Length of RUN in feet (decimal).

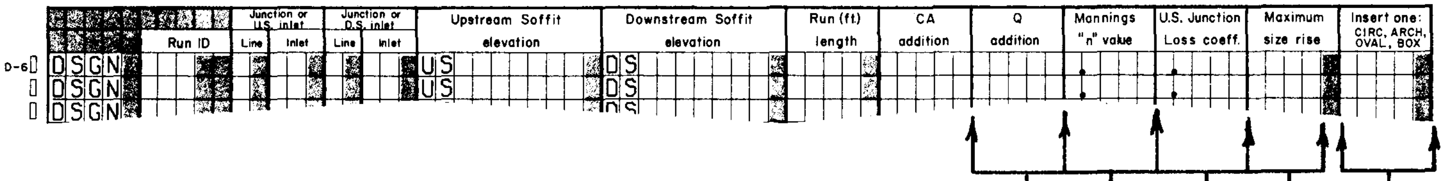
Upstream and downstream elevs. of the top inside surface (soffit) of the RUN (decimal).

ID of the upstream and downstream limits of the RUN.

Run ID may be any combination of alphanumeric characters. (Must not be duplicated.)

These cards are required to describe runs any time SEWER is specified on the SEWER Control Card, regardless of whether the problem is a DESIGN or ANALYSIS. A DSGN card (D-6) must be included to describe each run in the sewer network (maximum of 99). All entries are required except CA ADDITION and Q ADDITION. LINE LETTER and INLET NO. must exactly match the ID's for corresponding inlets on cards (D-3), (D-4), and (D-5).

DSGN Card Continued



Flow to be added to upstream inlet is entered here when INLET is specified and flow addition enters the network by means other than an inlet. (Useful in accommodating previously determined carryover values - may be positive or negative.)

Manning's "n" value for the RUN (decimal). If no entry, .012 will be assumed.

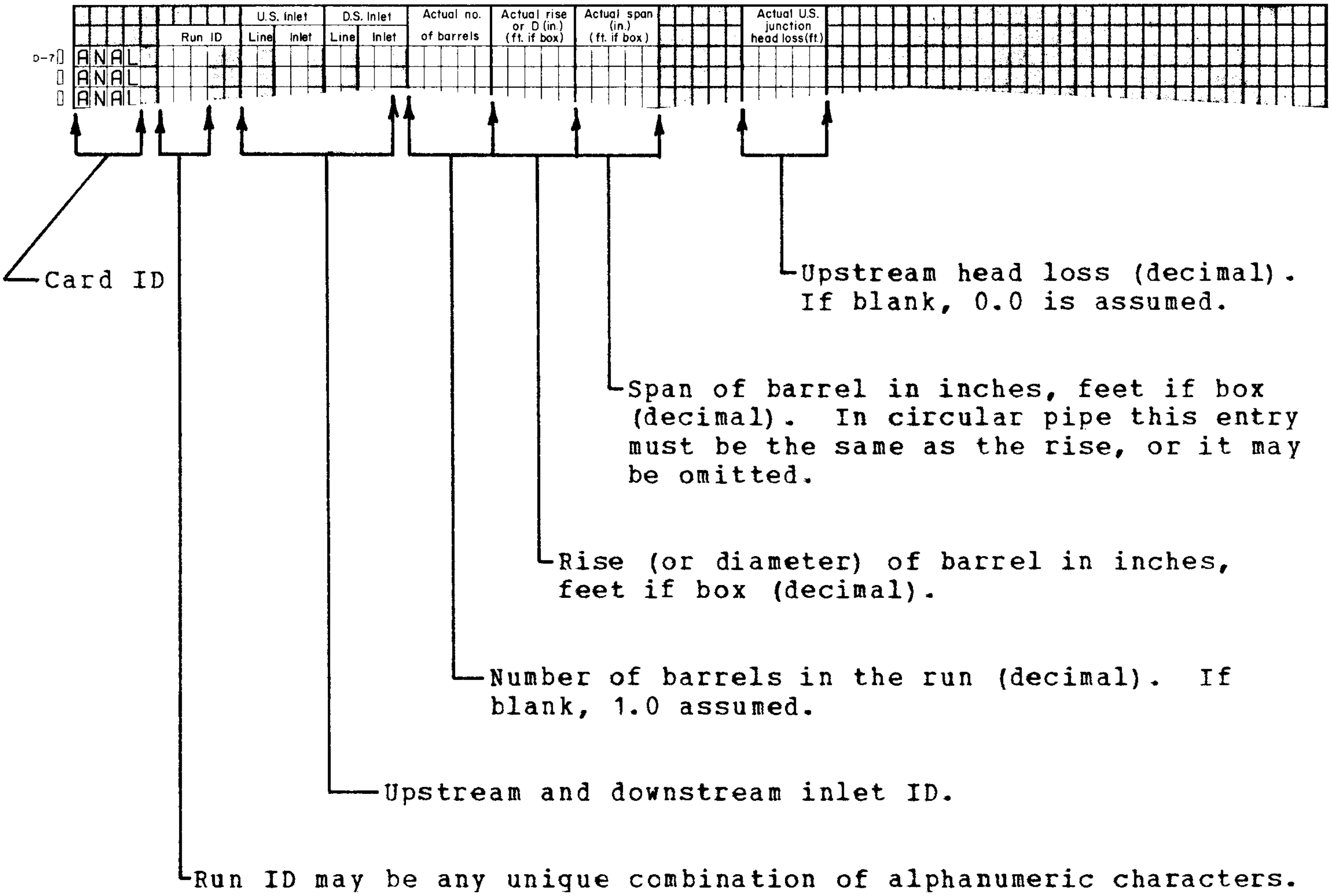
Upstream Junction Loss Coeff (decimal). If no entry, 0.0 will be assumed.

Max. barrel size for design of a RUN (decimal). Units are inches unless BOX specified. Then units are feet.

Barrel shape entered as shown and left justified. If blank, CIRC assumed.

ANAL CARD (D-7)

These cards are used to supply further information when SEWER is specified on the SEWER Control Card and the problem is an ANALYSIS. The identifiers used to describe the points and runs in a sewer network must always be consistent in every respect whenever reference is made on different cards to the same point or run. One card must be used for each run (maximum of 99). All entries required. LINE LETTER and INLET NO. must exactly match the ID's for corresponding inlets on card (D-3), (D-4), and (D-5).



Card ID

Upstream head loss (decimal). If blank, 0.0 is assumed.

Span of barrel in inches, feet if box (decimal). In circular pipe this entry must be the same as the rise, or it may be omitted.

Rise (or diameter) of barrel in inches, feet if box (decimal).

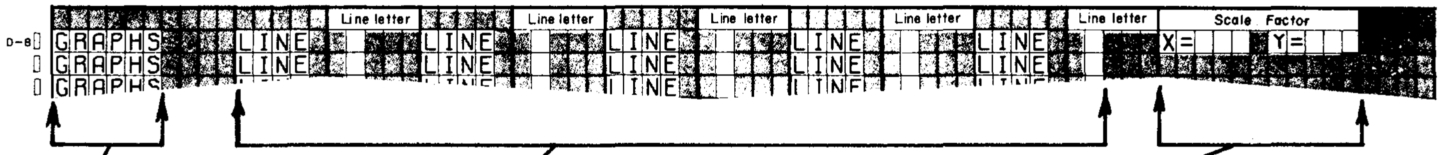
Number of barrels in the run (decimal). If blank, 1.0 assumed.

Upstream and downstream inlet ID.

Run ID may be any unique combination of alphanumeric characters.

GRAPHS CARD (D-8)

The optional GRAPHS cards (D-8) may be used to secure a graphical printout of the data generated for any lines in the problem. Graphs may be requested for any or all of the allowed 26 lines. The graph will include plots of the flow line elevation profile, soffit elevation profile, hydraulic gradient profile, normal depth of flow, and identifiers for each line requested. The LINE LETTER designations of the lines to be graphed must be entered on GRAPHS cards (D-8) with up to five per card.



Card ID

Alphabetical line ID's

Plot scale factors. If left blank 1"=100' for horizontal (X), and 1"=5' for vertical (Y) will be assumed.

SCALE CARD (D-9)

This card is required only when the areas entered on DA cards (D-3) are expressed in units of square miles or in square inches as read directly from a map. In the latter case the SCALE of the map (feet per inch) must be entered in the field scale of ft/in. If the areas on DA cards are expressed in acres, then this card may be omitted or ACRES may be specified on this card.

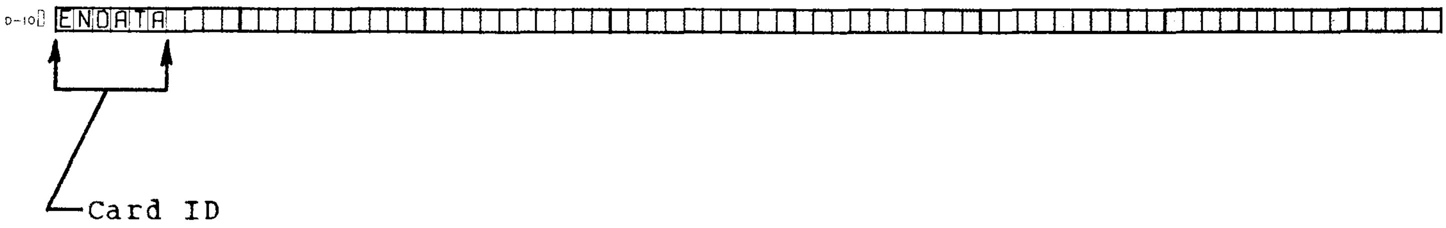
Card ID

If SQ. INCHES @ SCALE is selected, enter scale of map in ft/in. (decimal).

Choose one. If no selection is made, acres is assumed.

ENDATA CARD (D-10)

An ENDATA card (D-10) is required at the end of each set of data associated with one problem.



Card Use Checklist

A tabulation of the required and optional cards for each of the SEWER options is shown in Figure 6-4. This may be used to check the completed input form for possible omissions prior to submission.

SEWER

CARD IDENT.	CARD TYPE OR REFERENCE	DESIGN							ANALYSIS						
		RUNOFF	INLET	SEWER	RUNOFF & INLET	RUNOFF & SEWER	INLET & SEWER	RUNOFF INLET & SEWER	RUNOFF	INLET	SEWER	RUNOFF & INLET	RUNOFF & SEWER	INLET & SEWER	RUNOFF INLET & SEWER
CONTROL CARD	SEWER	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
D-1	COEF DESC	YES			YES	YES		YES	YES			YES	YES		YES
D-2	RAT COEF	YES			YES	YES		YES	YES			YES	YES		YES
D-3	DA	YES[1]	YES[7]	YES[7]	YES[2]	YES[2]	YES[7]	YES[2]	YES[1]	YES[7]	YES[7]	YES[2]	YES[2]	YES[7]	YES[2]
D-4	JUNC		YES[3]	YES[3]	YES[3]	YES[3]	YES[3]	YES[3]		YES[3]	YES[3]	YES[3]	YES[3]	YES[3]	YES[3]
D-4a	CARRY OVER		OPTIONAL		OPTIONAL		OPTIONAL	OPTIONAL							
D-5	OUTLET			YES		YES	YES	YES			YES		YES	YES	YES
D-6	DSGN			YES[4]		YES[4]	YES[4]	YES[4]			YES[4]		YES[4]	YES[4]	YES[4]
D-7	ANAL										YES[8]		YES[8]	YES[8]	YES[8]
D-8	GRAPHS			OPTIONAL[5]		OPTIONAL[5]	OPTIONAL[5]	OPTIONAL[5]			OPTIONAL[5]		OPTIONAL[5]	OPTIONAL[5]	OPTIONAL[5]
D-9	SCALE	OPTIONAL[6]			OPTIONAL[6]	OPTIONAL[6]		OPTIONAL[6]	OPTIONAL[6]		OPTIONAL[6]	OPTIONAL[6]	OPTIONAL[6]	OPTIONAL[6]	OPTIONAL[6]
D-10	ENDATA	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES

[1] Include a DA Card for each Drainage Area.
[2] Include a DA Card for each inlet.
[3] Include a JUNC Card for each inlet and junction not otherwise identified.
[4] Include a DSGN Card for each pipe run.
[5] If graphs of named lines are needed.
[6] If units other than acres are used.
[7] Include a DA Card for each inlet with SUPPLY Q specified.
[8] Include an ANAL Card for each pipe run.

FIGURE 6-4. CARD USE CHECKLIST

III. OUTPUT

Output for the SEWER subsystem may consist of any of five reports based on the procedures requested by the user in the input data.

Runoff Calculations

The report for this procedure is the same for both design and analysis and includes the following:

1. Frequency (yrs) - given
2. Surface descriptions and rational coefficients for up to six runoff surfaces - given
3. Minimum time of concentration (minutes) - given or automatically set to 10.
4. Rainfall intensity factors (e, b and d) - given
5. A table including for each inlet or junction:
    - a. Identification of inlet or junction - given
    - b. CA - computed
    - c. TC (minutes) - computed
    - d. Supply Q (cfs) - base flow or given discharge to be included in the total flow - given
    - e. Rainfall intensity (inches per hour) - computed
    - f. Total flow (cfs) - total discharge (including SUPPLY Q) to this inlet or junction - computed.

    NOTE: Also included are other junctions which have no contributing discharge.

Sewer Design and Analysis

The reports for SEWER DESIGN and ANALYSIS are identical and consist of the following:

1. A table of configuration data including for each run:

   a. Run identification - given
   b. Upstream and downstream junction identifications - given
   c. Upstream and downstream flow line elevations (ft) - computed
   d. Length of run (ft) - given
   e. Slope (ft/ft) - computed from given data
   f. Number of barrels - computed (given for analysis)
   g. Rise (ft if BOX; inches if any other shape) - computed (given for analysis)
   h. Span (ft if BOX; inches if any other shape) - computed (given for analysis)
   i. Shape - given

2. A table of hydraulic data including for each run:
   a. Run identification - given
   b. Upstream and downstream junction identifications - given
   c. "n" value (Manning's friction factor) - given
   d. Junction loss - given
   e. Flow (cfs) - given or computed
   f. Upstream and downstream heads (ft) - computed
   g. Hydraulic gradient slope (ft/ft) - computed
   h. Depth (for most shapes depth will be expressed as a ratio of water depth over rise; for box shapes depth will be expressed in feet and noted as such in the report) - computed
   i. Velocity (fps) - computed
   j. Pipe capacity (cfs) - This is the maximum volume of flow which could be handled by this run - computed
3. A table defining stationing as follows:

a. Run identification - given

b. Upstream junction identification - given

c. Stationing (ft referenced to outlet station) - computed.

Inlet Design

This report consists of a table which reflects for each inlet:

1. Inlet identification - given
2. Inlet type - given
3. Flow (cfs) - given or computed
4. Minimum length required - computed
5. Minimum standard length required - computed
6. Standard inlet opening - given or 5 feet assumed
7. Grate width - given or 3 feet assumed
8. Carryover - CFS computed (where allowed)
9. Carryover assignment inlet ID - given
10. Minimum area of grate required (sq ft) - computed
11. Ponding width - computed

Inlet Analysis

This report consists of a table which reflects for each inlet:

1. Inlet identification - given
2. Inlet type - given
3. Flow (cfs) - given or computed
4. Inlet capacity (cfs) - computed
5. Carryover (cfs) - computed
6. Ponding width (ft) - computed
7. Actual length (ft) - given
8. Required length (ft) - computed length of inlet needed to pass the given flow
9. Actual area (sq ft) - given

10. Required area (sq ft) - computed area of inlet required to pass the given flow

11. Actual head (ft) - computed.

Graphs

This output consists of a computer line plot of: (1) the flow line and soffit line of the inside of the barrel; (2) the calculated uniform (normal) depth of flow in the barrel; (3) the calculated hydraulic gradient line; (4) identifiers such as line letter, run name, run size and length, junction ID's, and tailwater elevation (labeled T.W.); and (5) elevation scale.

Standard scales on the plot are 1"=5' vertically and 1"=100' horizontally. Either or both scales may be varied by the user by inserting the new scale factors in the proper place on the first GRAPHS card (D-8). (X= for horizontal and Y= for vertical scale.) Any and all lines which are part of the storm sewer system may be plotted. The plot can be used for direct application in the plans.

The hydraulic gradient line on the plot is represented by the short-dashed line; the uniform depth of flow in the barrel is represented by the long-dashed line; and the flow line and soffit line are represented by solid lines. In analysis, if the barrel is flowing full, the uniform depth line is coincident with the soffit line.

**************** ERROR MESSAGES ****************
************** TEXAS HYDRAULIC SYSTEM **************

ERROR MESSAGES ARE GROUPED BY ALPHABETIC PREFIX FOR EACH SUBSYSTEM AND ARE LISTED IN NUMERICAL ORDER WITHIN EACH GROUP. 'EXPL' DENOTES A DETAILED EXPLANATION OF THE ERROR MESSAGE. (FOR ADDITIONAL INFORMATION AND ASSISTANCE CONTACT THE BRIDGE DIVISION HYDRAULIC SECTION OR THE DIVISION OF AUTOMATION FIELD ENGINEER FOR YOUR DISTRICT.)

****

SEW0001--SHAPE OF PIPE FOR RUN CANNOT BE IDENTIFIED. ASSUME CIRCULAR.
EXPL¤ SELF EXPLANATORY.

SEW0002--ARCH PIPE ROUTINE IS NOT YET AVAILABLE.
EXPL¤ SELF EXPLANATORY.

SEW0003--OVAL PIPE ROUTINE IS NOT YET AVAILABLE.
EXPL¤ SELF EXPLANATORY.

SEW0004--METHOD FOR ANALYSIS OF ARCH AND OVAL PIPE IS NOT YET AVAILABLE.
EXPL¤ SELF EXPLANATORY.

SEW0005--LINE LETTER FOR GRAPH * * IS NOT IDENTIFIABLE.
EXPL¤ THE SPECIFICATION FOR A LINE TO BE GRAPHICALLY PLOTTED MUST BE AN ALPHABETIC CHARACTER FROM A TO Z. ANY OTHER DESIGNATION IS NOT ACCEPTABLE.

SEW0006--THE SUBROUTINE WHICH COMPUTES THE THEORETICAL AREA AND LENGTH OF A COMBINED GRATE AND CURB INLET TO PASS THE GIVEN FLOW IS NOT YET AVAILABLE.
EXPL¤ SELF EXPLANATORY.

SEW0007--BOX SIZE WAS TOO SMALL. CIRCULAR PIPE SUBSTITUTED ON PREVIOUS RUN.
EXPL¤ IN A 'SEWER DESIGN' PROBLEM THE MINIMUM BOX SIZE WAS LARGER THAN REQUIRED FOR PASSAGE OF THE DESIGN FLOW. A SMALLER CIRCULAR PIPE WAS FOUND TO BE MORE PRACTICAL FOR THIS DESIGN. NON-FATAL.

SEW0008--CAPACITY OF RUN * * IS EXCEED.
EXPL¤ THIS MESSAGE IS PRINTED WHEN THE NAMED RUN IN AN ANALYSIS DOES NOT HAVE ADEQUATE CAPACITY TO HANDLE THE INPUT FLOW. THIS INDICATES PRESSURE FLOW. NON-FATAL.

SEW0009--ERROR IN JUNCTION IDENTIFICATION OF RUN * *.
EXPL¤ AN IDENTIFICATION HAS BEEN GIVEN ON A 'DSGN' CARD (D-6) OR AN 'ANAL' CARD (D-7) WHICH DOES NOT MATCH AN IDENTIFICATION ON ANY 'JUNC' CARD (D-4). FATAL ERROR.

SEW0010--THE SUBROUTINE WHICH COMPUTES THE THEORETICAL CAPACITY OF A COMBINED GRATE AND CURB INLET IS NOT YET AVAILABLE.
EXPL¤ SELF EXPLANATORY.

SEW0011--THE SUBROUTINE WHICH COMPUTES THE REQUIRED HEAD TO PASS THE FLOW FOR AN OVERCHARGED COMBINED GRATE AND CURB INLET IS NOT YET AVAILABLE.
EXPL¤ SELF EXPLANATORY.

SEW0012--THE SUBROUTINE WHICH COMPUTES THE THEORETICAL CAPACITY OF A COMBINED GRATE AND CURB INLET AT A SAG IS NOT YET AVAILABLE.
EXPL¤ SELF EXPLANATORY.

SEW0013--THE SUBROUTINE WHICH COMPUTES THE REQUIRED HEAD TO PASS THE FLOW FOR AN OVERCHARGED COMBINED GRATE AND CURB INLET AT A SAG IS NOT YET AVAILABLE.

```
        EXPL□ SELF EXPLANATORY.

SEW0014--BOTH DESIGN AND ANALYSIS SPECIFIED.
        EXPL□ BOTH 'DESIGN' AND 'ANALYSIS' ARE SPECIFIED ON THE 'SEWER' CARD.
              ONE OF THESE SHOULD BE DELETED. FATAL ERROR.

SEW0015--NEITHER DESIGN NOR ANALYSIS SPECIFIED.
        EXPLL NEITHER 'DESIGN' NOR 'ANALYSIS' WAS SPECIFIED ON THE 'SEWER'
              CONTROL CARD OR THE ONE SPECIFIED WAS MISSPELLED OR IMPROPERLY
              POSITIONED ON THE CARD. FATAL ERROR.

SEW0016--NO SPECIFICATION OF RUNOFF, INLET, OR SEWER.
        EXPL□ AT LEAST ONE OF THESE THREE PROCEDURES MUST BE SPECIFIED ON THE
              'SEWER' CARD. THIS MESSAGE INDICATES THAT NONE OF THESE WAS
              SPECIFIED OR THOSE THAT WERE SPECIFIED WERE EITHER MISSPELLED OR
              IMPROPERLY POSITIONED ON THE CARD. FATAL ERROR.

SEW0017--NO FREQUENCY GIVEN.
        EXPL□ THERE IS NO ENTRY ON THE 'SEWER' CONTROL CARD. NON-FATAL.

SEW0018--NO DESCRIPTION OF TYPE OF RUNOFF SURFACE.
        EXPL□ NO ENTRY WAS MADE FOR ANY RUNOFF SURFACE (A THROUGH F) ON
              'COEF  DESC'  CARD (D-1). NON-FATAL.

SEW0019--NO RUNOFF COEFFICIENTS GIVEN.
        EXPL□ NO ENTRY WAS MADE IN ANY RUNOFF COEFFICIENT SPACE (A THROUGH F)
              ON 'RAT  COEF'  CARD (D-2). FATAL ERROR.

SEW0020--NO MINIMUM TC GIVEN. ASSUME 10 MINUTES.
        EXPL□ MINIMUM ALLOWABLE TIME OF CONCENTRATION (TC) WAS LEFT BLANK ON
              'RAT  COEF'  CARD (D-2). COMPUTATION WILL PROCEED ASSUMING
              MINIMUM TC = 10 MINUTES. NON FATAL.

SEW0021--ONE OR MORE OF ''E'', ''B'', AND ''D'' MISSING.
        EXPL□ ALL OF THE RAINFALL INTENSITY FACTORS (E, B, & D) MUST BE
              PROVIDED ON 'RAT  COEF'  CARD (D-2). FATAL ERROR.

SEW0022--DA IDENTIFICATION MISSING OR INCOMPLETE.
        EXPL□ COMPLETE DA IDENTIFICATION MUST BE PROVIDED ON EACH DA CARD
              (D-3). IF 'LINE  LETTER'  IS NOT AN ALPHABETIC CHARACTER,
              'INLET  NO.'  IS NOT NUMERIC, OR IF EITHER 'LINE  LETTER'  OR
              'INLET  NO.'  IS BLANK, AN ERROR CONDITION EXIST. FATAL ERROR.

SEW0023--NO SUBAREA TC DATA GIVEN. ASSUME MINIMUM.
        EXPL□ THIS MESSAGE INDICATES THAT NEITHER 'LENGTH AND VELOCITY'
              NOR 'TC' WERE PROVIDED ON A 'DA' CARD (D-3). IN THIS CASE THE
              MINIMUM 'TC' PROVIDED ON 'RAT  COEF'  CARD (D-2) IS ASSUMED.
              NON FATAL.

SEW0024--JUNCTION ID MISSING OR INCOMPLETE.
        EXPL□ THIS MESSAGE IS PRINTED WHEN (1) 'LINE  LETTER'  IS NOT ENTERED
              AS AN ALPHABETIC CHARACTER OR (2) 'LINE  LETTER'  OR 'INLET
              NO.'  IS NOT ENTERED ON THE 'JUNC' CARD (D-4), 'DESIGN' CARD
              (D-6) OR 'ANAL' CARD (D-7). FATAL ERROR.

SEW0025--DESIGN RUN LENGTH MISSING.
        EXPL□ 'RUN LENGTH' WAS NOT ENTERED ON 'DSGN' CARD (D-6).  FATAL ERROR.

SEW0026--ERROR IN SPECIFICATION OF INLET OR JUNCTION
        EXPL□ 'TYPE' SYMBOL IS INCORRECT ON 'JUNC' CARD (D-4). THE SYMBOL WAS
              NOT ENTERED, OR WAS MISSPELLED. FATAL ERROR.
```

SEW0027--MAXIMUM PONDING DEPTH NOT GIVEN.

EXPL¤ THIS MESSAGE IS PRINTED WHEN 'PONDING DEPTH' IS NOT ENTERED AS REQUIRED OR IS ZERO ON A 'JUNC' CARD (D-4). THE TABLE IN THE INPUT SECTION UNDER 'JUNC' CARD (D-4) INDICATES WHEN 'PONDING DEPTH' IS REQUIRED. FATAL ERROR FOR THIS INLET.

SEW0028--INLET DATA INCOMPLETE.

EXPL¤ ON 'JUNC' CARD (D-4), (1) 'MAXIMUM PONDING WIDTH', 'GUTTER SLOPE', 'MANNINGS N VALUE' AND/OR 'GUTTER DEPRESSION A' HAVE NOT BEEN ENTERED, (2) 'SLOPE' Z 1 AND/OR 'SLOPE' Z 2 HAVE NOT BEEN GIVEN, OR (3) IF BOTH SLOPES ARE GIVEN AND ARE NOT EQUAL, 'DISTANCE FOR SLOPE' Z 1 HAS NOT BEEN SPECIFIED. FATAL ERROR FOR THIS INLET.

SEW0029--OUTLET STATION NOT GIVEN. ASSUME 0+00.

EXPL¤ ON 'OUTLET' CARD (D-5), THE STATIONING WAS NOT GIVEN. AN OUTLET STATION VALUE OF 0+00 WILL BE ASSUMED AND COMPUTATION CONTINUED. NON-FATAL.

SEW0030--TAILWATER ELEVATION NOT GIVEN.

EXPL¤ 'T.W. ELEV' ON 'OUTLET' CARD (D-5) HAS NOT BEEN SPECIFIED. IF THE PROPER VALUE IS NOT KNOWN, THE SOFFIT ELEVATION AT THE OUTLET SHOULD BE ENTERED AS 'T.W. ELEV'. FATAL ERROR.

SEW0031--OUTLET IDENTIFICATION MISSING OR INCOMPLETE.

EXPL¤ THIS MESSAGE INDICATES THAT ON 'OUTLET' CARD (D-5) (1) AN ALPHABETIC CHARACTER WAS NOT FOUND IN THE 'LINE LETTER' SPACE, (2) 'LINE LETTER' OR 'OUTLET NO.' WAS BLANK, OR (3) 'NO OUTLET' CARD (D-5) WAS READ. FATAL ERROR.

SEW0032--INLET IDENTIFICATION MISSING OR INCORRECT.

EXPL¤ MISSING OR INCORRECT SPECIFICATION(S) ON 'CARRYOVER' CARD (D-4A).

SEW0033--CARRYOVER FROM THIS INLET HAS ALREADY BEEN ASSIGNED TO ANOTHER INLET ON ANOTHER CARRYOVER CARD.

EXPL¤ CARRYOVER DISCHARGE RATES FROM A GIVEN INLET SHOULD BE ASSIGNED TO ONLY ONE LOCATION* HOWEVER, MORE THAN ONE CARRYOVER DISCHARGE RATE MAY BE ASSIGNED TO ANY ONE LOCATION.

SEW0034--ALLOWABLE CARRYOVER LENGTH NOT SPECIFIED.

EXPL¤ CARRYOVER COMPUTATIONS CANNOT PROCEED WITHOUT THE SPECIFICATION OF ALLOWABLE CARRYOVER (IN TERMS OF LENGTH OF INLET).

SEW0035--RUN IDENTIFICATION MISSING.

EXPL¤ 'RUN ID' ON 'DSGN' OR 'ANAL' CARD IS BLANK. FATAL ERROR.

SEW0036--SOFFIT ELEVATION MISSING.

EXPL¤ THIS MESSAGE INDICATES THAT EITHER UPSTREAM OR DOWNSTREAM ELEVATION IS MISSING ON 'DSGN' CARD (D-6). FATAL ERROR.

SEW0037--THE D.S. ELEVATION MUST BE LOWER THAN THE U.S. ELEVATION.

EXPL¤ THE PIPE DESIGN ROUTINE REQUIRES THAT ALL RUNS HAVE A POSITIVE SLOPE. THE ANALYSIS OPTION ALLOWS EITHER POSITIVE, ZERO, OR NEGATIVE SLOPES.

SEW0038--DESIGN RUN LENGTH MISSING.

EXPL¤ 'RUN LENGTH' WAS NOT ENTERED ON 'DSGN' CARD (D-6). FATAL ERROR.

SEW0039--RUN N VALUE MISSING. ASSUME N=0.0120.

EXPL¤ 'MANNINGS N VALUE' WAS MISSING ON 'DSGN' CARD (D-6). AN N VALUE OF 0.0120 HAS BEEN ASSUMED AND COMPUTATIONS CONTINUED. NON-FATAL.

SEW0040--MAXIMUM PIPE SIZE FOR A RUN NOT GIVEN.
EXPL□ ON 'DSGN' CARD (D-6) 'MAXIMUM SIZE RISE' WAS NOT SPECIFIED. FATAL ERROR.

SEW0041--MAXIMUM SIZE RISE NOT PROPER FOR CIRCULAR PIPE. SHOULD BE IN INCHES.
EXPL□ THIS ERROR CONDITION EXISTS WHEN PIPE SHAPE IS CIRCULAR AND MAXIMUM SIZE RISE (ON THE 'DSGN' CARD (D-6)) IS LESS THAN 12. THIS INDICATES THAT (1) USER INTENDED TO SPECIFY 'BOX' AND 'MAXIMUM SIZE RISE' WOULD BE IN FEET, BUT 'BOX' WAS NOT PROPERLY SPECIFIED, OR (2) USER SPECIFIED 'CIRC', BUT GAVE 'MAXIMUM SIZE RISE' IN FEET RATHER THAN INCHES. FATAL ERROR.

SEW0042--SHAPE OF PIPE FOR RUN CANNOT BE IDENTIFIED. ASSUME CIRCULAR.
EXPL□ IF NO ENTRY IS MADE ON 'DSGN' CARD (D-6) OR IF THE ENTRY MADE IS MISSPELLED OR NOT LEFT JUSTIFIED, THE PROGRAM IS UNABLE TO IDENTIFY THE SHAPE. CIRCULAR SHAPE WAS USED AND COMPUTATIONS CONTINUED. NON-FATAL

SEW0043--PIPE SIZE FOR ANALYSIS NOT GIVEN.
EXPL□ 'ACTUAL RISE' OR 'D' (IN) WAS NOT ENTERED ON 'ANAL' CARD (D-7). FATAL ERROR

SEW0044--NO AREA UNITS GIVEN. ASSUME ACRES.
EXPL□ NO UNITS ARE GIVEN ON 'SCALE' CARD (D-9), OR THE TYPE OF UNITS IS MISSPELLED OR MISPLACED ON THE CARD. THE UNITS WERE ASSUMED TO BE ACRES AND COMPUTATIONS CONTINUED. NON-FATAL.

SEW0045--PROBABLE BLANK CARD. CARD IGNORED.
EXPL□ THIS MESSAGE INDICATES THAT THE PROGRAM ATTEMPTED TO IDENTIFY THE PREVIOUS CARD BUT FOUND NO ENTRIES IN SPACES USUALLY OCCUPIED BY CARD IDENTIFIERS. THIS CARD WAS IGNORED AND THE NEXT CARD WAS READ. NON-FATAL.

SEW0046--CARRYOVER SPECIFIED FOR LINE *   * INLET *   * WHICH IS NOT SPECIFIED AS A CURB OR GRATE INLET - CARRYOVER DISREGARDED.
EXPL□ CARRYOVER DISCHARGE CAN ONLY PROCEED FROM A CURB ON GRADE INLET OR A GRATE ON GRADE.

SEW0047--DATA MISSING ON SEWER CONTROL CARD.
EXPL□ WHEN THIS MESSAGE IS PRINTED, A PREVIOUS MESSAGE SHOULD DESCRIBE THE EXACT NATURE OF THE ERROR. AT THIS POINT THE CURRENT PROBLEM WILL BE TERMINATED WITHOUT FURTHER COMPUTATION AND THE NEXT PROBLEM WILL COMMENCE.

SEW0048--DATA MISSING ON RAT COEF CARD D-2.
EXPL□ WHEN THIS MESSAGE IS PRINTED, A PREVIOUS MESSAGE SHOULD DESCRIBE THE EXACT NATURE OF THE ERROR. AT THIS POINT THE CURRENT PROBLEM WILL BE TERMINATED WITHOUT FURTHER COMPUTATION AND THE NEXT PROBLEM WILL COMMENCE.

SEW0049--DATA MISSING ON DA CARD D-3.
EXPL□ WHEN THIS MESSAGE IS PRINTED, A PREVIOUS MESSAGE SHOULD DESCRIBE THE EXACT NATURE OF THE ERROR. AT THIS POINT THE CURRENT PROBLEM WILL BE TERMINATED WITHOUT FURTHER COMPUTATION AND THE NEXT PROBLEM WILL COMMENCE.

SEW0050--DATA MISSING ON JUNC CARD D-4.
EXPL□ WHEN THIS MESSAGE IS PRINTED, A PREVIOUS MESSAGE SHOULD DESCRIBE THE EXACT NATURE OF THE ERROR. AT THIS POINT THE CURRENT PROBLEM WILL BE TERMINATED WITHOUT FURTHER COMPUTATION AND THE NEXT PROBLEM WILL COMMENCE.

```
SEW0051--DATA MISSING ON OUTLET CARD D-5.
         EXPL¤ WHEN THIS MESSAGE IS PRINTED, A PREVIOUS MESSAGE SHOULD DESCRIBE
               THE EXACT NATURE OF THE ERROR. AT THIS POINT THE CURRENT PROBLEM
               WILL BE TERMINATED WITHOUT FURTHER COMPUTATION AND THE NEXT
               PROBLEM WILL COMMENCE.

SEW0052--ERROR ON DESIGN CARD D-6.
         EXPL¤ WHEN THIS MESSAGE IS PRINTED, A PREVIOUS MESSAGE SHOULD DESCRIBE
               THE EXACT NATURE OF THE ERROR. AT THIS POINT THE CURRENT PROBLEM
               WILL BE TERMINATED WITHOUT FURTHER COMPUTATION AND THE NEXT
               PROBLEM WILL COMMENCE.

SEW0053--DATA MISSING ON ANAL CARD D-7.
         EXPL¤ WHEN THIS MESSAGE IS PRINTED, A PREVIOUS MESSAGE SHOULD DESCRIBE
               THE EXACT NATURE OF THE ERROR. AT THIS POINT THE CURRENT PROBLEM
               WILL BE TERMINATED WITHOUT FURTHER COMPUTATION AND THE NEXT
               PROBLEM WILL COMMENCE.

SEW0054--DATA MISSING ON CARRYOVER CARD D-4A.
         EXPL¤ WHEN THIS MESSAGE IS PRINTED, A PREVIOUS MESSAGE SHOULD DESCRIBE
               THE EXACT NATURE OF THE ERROR. AT THIS POINT THE CURRENT PROBLEM
               WILL BE TERMINATED WITHOUT FURTHER COMPUTATION AND THE NEXT
               PROBLEM WILL COMMENCE.

SEW0055--NUMBER OF POINTS STORED EXCEEDS CAPACITY OF 100.
         EXPL¤ EACH UNIQUE IDENTIFICATION GIVEN BY THE LINE LETTER AND NUMBER
               WHETHER ON A 'DA', 'JUNC', 'OUTLET', 'DESIGN', OR 'ANAL' CARD
               INDICATES A POINT. THESE POINTS MUST NOT EXCEED 100 IN NUMBER.
               FATAL ERROR.

SEW0056--NUMBER OF DESIGN RUNS STORED EXCEEDS CAPACITY OF 99.
         EXPL¤ THE NUMBER OF 'DSGN' CARDS (D-6) MUST NOT EXCEED 99. FATAL ERROR.

SEW0057--NUMBER OF ANALYSIS RUNS STORED EXCEEDS CAPACITY OF 99.
         EXPL¤ THE NUMBER OF 'ANAL' CARDS (D-7) MUST NOT EXCEED 99. FATAL ERROR.

SEW0058--SUM OF CA'S FOR LINE *   * INLET *   * IS ZERO.
         EXPL¤ THIS ERROR CONDITION COULD EXIST IF THE SCALE OF FT/IN. ON THE
               'SCALE' CARD (D-9) WAS ENTERED AS ZERO OR IF ALL THE 'DRAINAGE
               AREAS' (A-F) ON 'DA' CARD (D-3) WERE BLANK OR ZERO. FATAL ERROR
               FOR THIS INLET.

SEW0059--RUNOFF TO LINE *   * INLET *   * IS ZERO.
         EXPL¤ THIS MESSAGE IS PRINTED WHEN NO SPECIFIED OR COMPUTED RUNOFF
               VALUE (Q) WAS GIVEN THAT CAN BE CORRELATED WITH THE INLET
               SPECIFIED BY  LINE  AND  INLET . THE RUNOFF FOR EACH INLET MUST
               BE PROVIDED ON THE 'DA' CARD (D-3) BY GIVING 'SUPPLY Q' OR THE
               RUNOFF DATA. IF THE RUNOFF DATA IS USED ON ANY ONE 'DA' CARD THEN
               'RUNOFF' MUST BE SPECIFIED ON THE SEWER CARD. IF THE 'SUPPLY Q'
               ITEM IS ALL THAT IS EVER USED, THEN 'RUNOFF' NEED NOT BE
               SPECIFIED UNLESS THE USER DESIRES A 'RUNOFF' REPORT IN THE
               OUTPUT. IF RUNOFF CALCULATIONS APPEAR TO BE IN ORDER, THE USER
               SHOULD CHECK TO BE SURE THAT EACH INLET IDENTIFICATION ON 'JUNC'
               CARDS (D-4), 'DSGN' CARDS (D-6) AND 'ANAL' CARDS (D-7)
               CORRESPONDS EXACTLY TO A 'DA' IDENTIFICATION ON A 'DA' CARD
               (D-3). FATAL ERROR FOR THIS INLET.

SEW0060--INLET DATA MISSING FOR LINE *   * INLET *   *.
         EXPL¤ THE 'JUNC' CARD (D-4) RELATING TO THE INLET SPECIFIED IS IN
               ERROR. FATAL ERROR FOR THIS INLET.
```

SEW0061-- * CALCULATED PONDED WIDTH EXCEEDS ALLOWABLE PONDED WIDTH, CALCULATIONS CONTINUE WITH NO SPECIFIC ACTION TAKEN.

EXPL¤ THIS MESSAGE IS PRINTED AS A FOOTNOTE TO ASTERISKS THAT MAY OCCUR IN INDIVIDUAL DATA LINES. NON-FATAL.

SEW0062--MAXIMUM PONDING DEPTH NOT GIVEN.

EXPL¤ THIS MESSAGE IS PRINTED WHEN 'PONDING DEPTH' IS NOT ENTERED AS REQUIRED OR IS ZERO ON A 'JUNC' CARD (D-4). THE TABLE IN THE INPUT SECTION UNDER 'JUNC' CARD (D-4) INDICATES WHEN 'PONDING DEPTH' IS REQUIRED. FATAL ERROR FOR THIS INLET.

SEW0063--OUTLET IDENTIFICATION MISSING OR INCOMPLETE.

EXPL¤ THIS MESSAGE INDICATES THAT ON AN 'OUTLET' CARD (D-5), (1) AN ALPHABETIC CHARACTER WAS NOT FOUND IN THE 'LINE LETTER' SPACE, (2) 'LINE LETTER' OR 'OUTLET NO.' WAS BLANK, OR (3) NO 'OUTLET' CARD (D-5) WAS READ. FATAL ERROR.

SEW0064--FLOW TO RUN NUMBER *   * IS ZERO. PROBLEM ABANDONED.

EXPL¤ IN A 'SEWER DESIGN' PROBLEM THE PROGRAM FOUND THE FLOW TO THE NAMED RUN TO BE ZERO. FATAL ERROR.

PART VII - PUMP SUBSYSTEM (PUMP)

Pump Subsystem (PUMP)

PUMP SUBSYSTEM

I. DESCRIPTION

The PUMP subsystem has two functions. They are as follows:

1. To design a system of pumps (sizes, starting sequences and starting times) using a specified flow and storage capacity such that the storage is fully utilized without being exceeded.
2. To compute the hydraulic characteristics including storage volume for a specified pump station operation for each minute of storm with a given discharge by using a specified number of pumps of known size, their starting sequence and the starting storage volume.

Up to five storms may be specified for pump design or analysis for each use of the PUMP subsystem. The computed flow from the most recent HYDRO problem may be specified as one of the five flows to be considered each time the PUMP subsystem is used. However, ordinarily only one storm is considered by the user.

The design function always seeks to use at least two pumps, whether they are of the same size or not. This is a safety factor which is in the form of a back-up pump should one fail. The design itself, however, will be based on no pump failure.

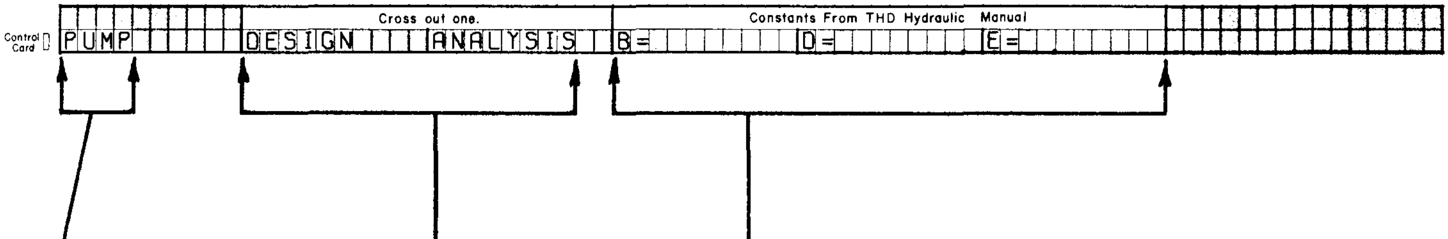
The storage allowed in the system in which the pumps are employed may consist of one sump (either rectangular or circular), any number of manholes and/or inlets, and submerged pipe lengths.

II. INPUT

The data form is printed on the front and back and is shown in Figures 7-1 and 7-2.

PUMP CONTROL CARD

The PUMP Control card is required for entry into this subsystem. The user must specify whether this is a DESIGN or ANALYSIS problem by drawing a line through the option that does not apply. The rainfall intensity factors (b, d and e) must be entered on this card. These factors may be determined by reference to the Hydraulic Manual.



Card ID

b, d, and e factors (from Hydraulic Manual) must be provided.

Either DESIGN or ANALYSIS must be specified. Cards (E-1) and (E-8) must accompany each problem. If DESIGN is specified, the total storage capacity must be supplied by giving the known capacity on card (E-2) and/or the storage dimensions for unknown capacities on cards (E-2), (E-3), and (E-4) (where applicable). Card (E-5) must be provided. If ANALYSIS is specified, cards (E-6) must be provided. (In addition, a card (E-7) may be provided if plots are desired for either DESIGN or ANALYSIS.)

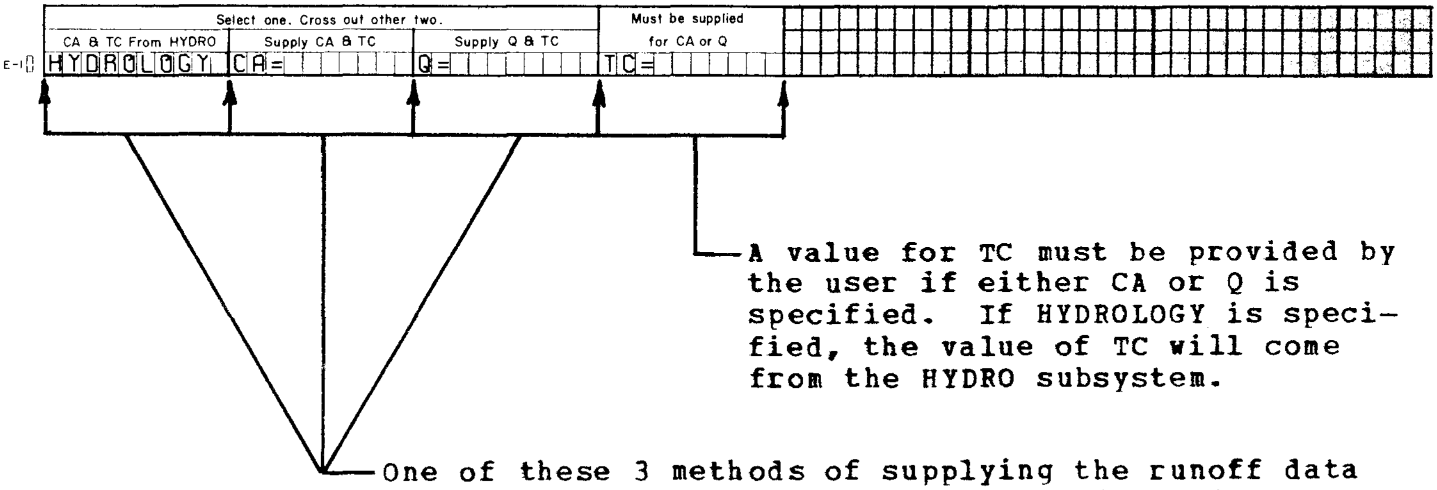
METHOD CARD (E-1)

The METHOD Card (E-1) is required for each problem so that run-off data can be obtained.

There are three methods by which discharge data describing up to five storms may be supplied for use in one entry into the PUMP subsystem. These methods are:

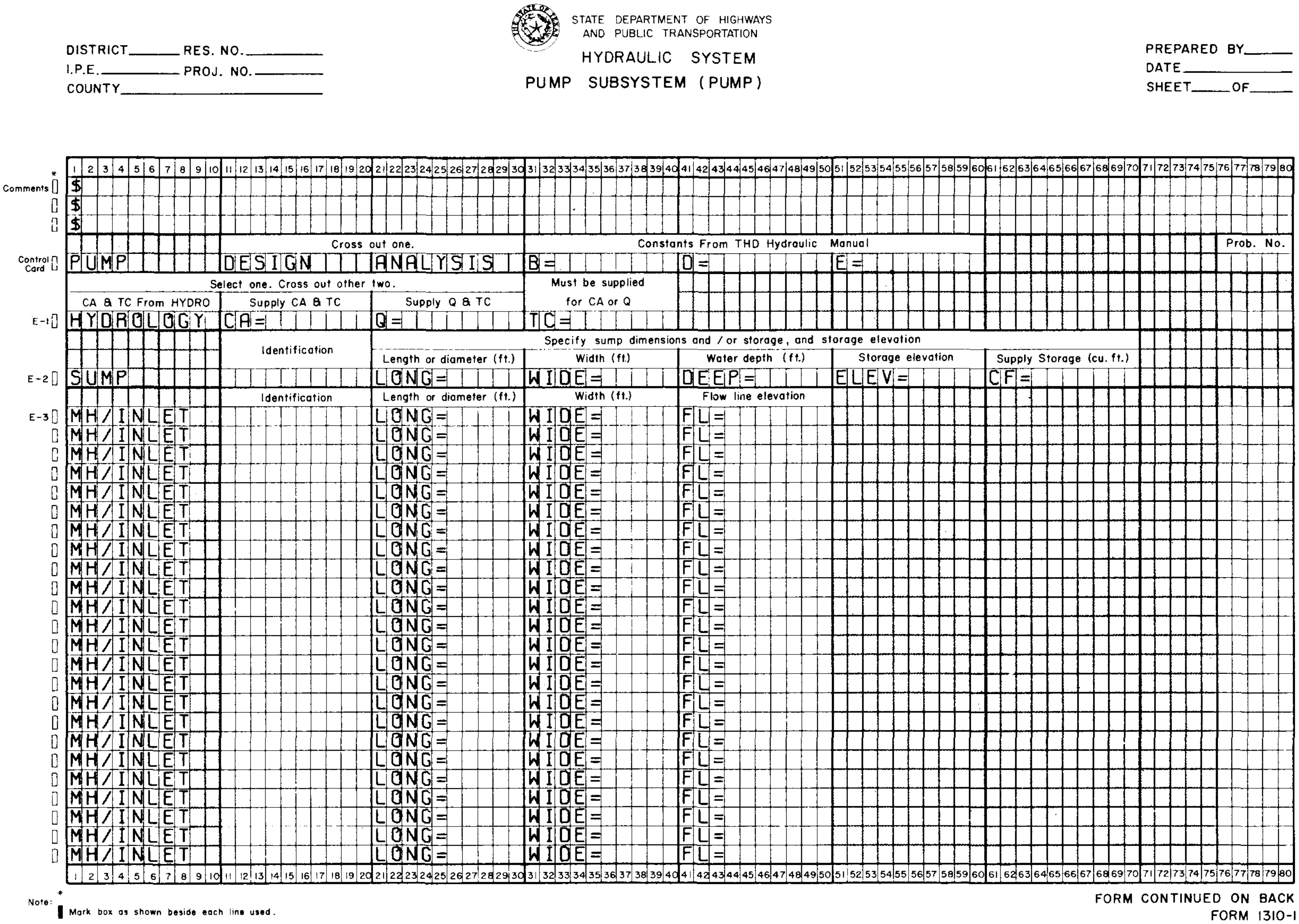
1. HYDROLOGY - Using values of CA and TC determined in the most recent HYDRO problem
2. CA and TC - User supplies these values
3. Q and TC - User supplies these values.

Up to five of these cards for specifying different discharges may be used in one pump problem; however, if the user wishes to specify HYDROLOGY, the HYDROLOGY specification should be made on the first METHOD card and the values from HYDRO will automatically be used for the first solution. On all other METHOD cards (E-1) the user must supply a time of concentration (TC) (in minutes) along with either a CA or Q (cfs) value. If HYDROLOGY is not specified on this card and TC along with either CA or Q is not provided, then the program will not consider this card and will solve for only those storms having proper input.



A value for TC must be provided by the user if either CA or Q is specified. If HYDROLOGY is specified, the value of TC will come from the HYDRO subsystem.

One of these 3 methods of supplying the runoff data must be selected by deleting the remaining 2. If HYDROLOGY is selected, a HYDRO problem in which the desired values for CA and TC were calculated must precede this problem and card (E-1) specifying HYDROLOGY must precede any other (E-1) cards. If CA is selected, then that value and the value for TC must be provided by the user. If Q is selected, then that value and the value for TC must be provided by the user.



STATE DEPARTMENT OF HIGHWAYS
AND PUBLIC TRANSPORTATION

HYDRAULIC SYSTEM

PUMP SUBSYSTEM (PUMP)

DISTRICT______ RES. NO.__________
I.P.E.__________ PROJ. NO.__________
COUNTY____________________

PREPARED BY______
DATE______________
SHEET_____OF_____

*	1 2 3 4 5 6 7 8 9 10	11 12 13 14 15 16 17 18 19 20	21 22 23 24 25 26 27 28 29 30	31 32 33 34 35 36 37 38 39 40	41 42 43 44 45 46 47 48 49 50	51 52 53 54 55 56 57 58 59 60	61 62 63 64 65 66 67 68 69 70	71 72 73 74 75 76 77 78 79 80
Comments ☐	$							
☐	$							
☐	$							
		Cross out one.		Constants From THD Hydraulic Manual				Prob. No.
Control Card ☐	PUMP	DESIGN	ANALYSIS	B=	D=	E=		
	Select one. Cross out other two.			Must be supplied				
	CA & TC From HYDRO	Supply CA & TC	Supply Q & TC	for CA or Q				
E-1 ☐	HYDROLOGY	CA=	Q=	TC=				
		Identification	Specify sump dimensions and / or storage, and storage elevation					
			Length or diameter (ft.)	Width (ft.)	Water depth (ft.)	Storage elevation	Supply Storage (cu. ft.)	
E-2 ☐	SUMP		LONG=	WIDE=	DEEP=	ELEV=	CF=	
		Identification	Length or diameter (ft.)	Width (ft.)	Flow line elevation			
E-3 ☐	MH/INLET		LONG=	WIDE=	FL=			
☐	MH/INLET		LONG=	WIDE=	FL=			
☐	MH/INLET		LONG=	WIDE=	FL=			
☐	MH/INLET		LONG=	WIDE=	FL=			
☐	MH/INLET		LONG=	WIDE=	FL=			
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	1 2 3 4 5 6 7 8 9 10	11 12 13 14 15 16 17 18 19 20	21 22 23 24 25 26 27 28 29 30	31 32 33 34 35 36 37 38 39 40	41 42 43 44 45 46 47 48 49 50	51 52 53 54 55 56 57 58 59 60	61 62 63 64 65 66 67 68 69 70	71 72 73 74 75 76 77 78 79 80

Note: *▌ Mark box as shown beside each line used.

FORM CONTINUED ON BACK
FORM 1310-1

FIGURE 7-1. FRONT SIDE OF THE PUMP SUBSYSTEM (PUMP) INPUT FORM

PUMP. (Continued)

BACK, SHEET ______ OF ______

	1–10	11–15	16–20	21–30	31–40	41–50	51–60	61–70	71–80
		From	To	Height or diameter (ft.)	Width (ft.)	Length (ft.)			
E-4 ☐	PIPE			HIGH= .	WIDE=	LONG=			
☐	PIPE			HIGH= .	WIDE=	LONG=			
☐	PIPE			HIGH= .	WIDE=	LONG=			
☐	PIPE			HIGH= .	WIDE=	LONG=			
☐	PIPE			HIGH= .	WIDE=	LONG=			
☐	PIPE			HIGH= .	WIDE=	LONG=			
☐	PIPE			HIGH= .	WIDE=	LONG=			
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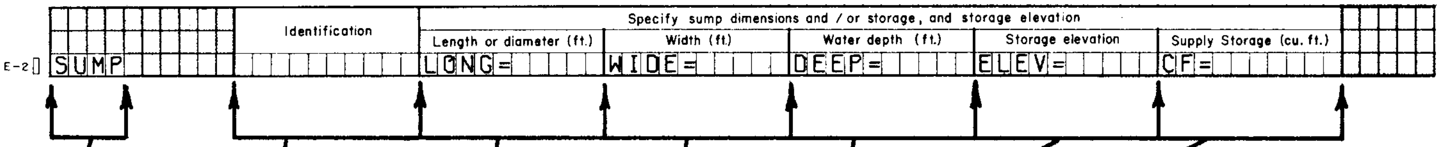
☐	PIPE			HIGH= .	WIDE=	LONG=			
☐	PIPE			HIGH= .	WIDE=	LONG=			
		Specify range of pump capacities and increment in gpm for design.							
E-5 ☐	APC DATA	MIN=		MAX=	INC=				
		Specify known pump capacity & storage volume at which pump starts.							
E-6 ☐	ANALYSIS	GPM=		CF=	GPM=	CF=	GPM=	CF=	
☐	ANALYSIS	GPM=		CF=	GPM=	CF=	GPM=	CF=	
E-7 ☐	GRAPHS								
E-8 ☐	ENDATA								

FORM 1310-2

FIGURE 7-2. BACK SIDE OF PUMP SUBSYSTEM (PUMP) INPUT FORM

SUMP CARD (E-2)



Card ID

Total available storage space in cu. ft. for water storage, or additional storage not indicated by dimensions on (E-2), (E-3) and/or (E-4).

The maximum elevation to which water may be stored is a required entry for all pump design problems in which storage volumes are to be calculated in the program.

Distance in feet between maximum allowable water level and bottom of sump.

If the sump is rectangular, the short horizontal (inside) dimension must be specified here. If circular, these columns may be left blank. If the sump is square, enter identical LONG and WIDE values.

If the sump is of rectangular shape, the long horizontal (inside) dimension must be specified here. If circular, the inside diameter is used.

Pump station ID (any name or number the user wishes to associate with this data on the reprint of input). It is not used in any computations or reports but should be useful as identification.

The SUMP card (E-2), MH/INLET card (E-3) and PIPE card (E-4) are related in that they are used to define the storage capacity for a pump design problem. Total storage may be entered in three ways.

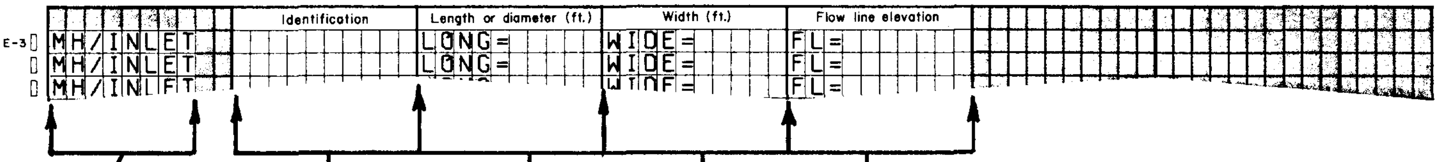
(1) The total storage for the entire system may be given on SUMP card (E-2) in the field SUPPLY STORAGE (cu. ft.) and no dimensions may be entered on SUMP, MH/INLET, or PIPE cards. (2) The SUPPLY STORAGE (cu. ft.) field on card (E-2) may be used to enter a portion of total storage for which the capacity is known and dimensions for any unknown portion(s) may be entered on SUMP, MH/INLET, and/or PIPE cards. In the latter case, the program will compute the volume represented by the dimensions and add it to the known volume to secure the total storage capacity for use in the problem. (3) If none of the storage capacity is known, the dimensions of all portions of the system must be entered on SUMP, MH/INLET, and/or PIPE cards and SUPPLY STORAGE on the SUMP card must be left blank. In any case care should be taken so that a volume is not entered twice by including it in the SUPPLY STORAGE and also giving dimensions.

SUMP card (E-2) is required for all pump design problems as noted above. In addition, ELEV must be entered on this card to indicate the maximum allowable water surface elevation any time dimensions are used to describe a portion of a system for which the total capacity is not known.

The IDENTIFICATION field is not presently used in any report but will appear in the reprint of the input data and should be useful for identification.

MH/INLET CARD (E-3)

The MH/INLET card (E-3) is required for pump DESIGN problems when this volume has not been included in SUPPLY STORAGE on SUMP card (E-2). When this card is used, the dimensions and flow line elevation must be entered.



Card ID

Bottom elevation of manhole or inlet.

Short dimension of manhole or inlet (horizontal inside). Leave blank if circular.

Long dimension of manhole or inlet (horizontal inside). Diameter if circular.

ID of manhole or inlet under consideration (any name or number the user wishes to associate with this data on the reprint of input). It is not used in any computations or reports but should be useful as an identification.

PIPE CARD (E-4)

This card is also required for pump DESIGN problems when the storage capacity of the pipes has not been included in SUPPLY STORAGE on SUMP card (E-2). All dimensions on this card must be entered in feet. In some installations a pipe which is placed in other than a horizontal position may not be full of water over the entire length when the maximum storage elevation is reached. In this case, the user should enter the estimated length of the pipe which will be full of water (Figure 7-3). If the entire pipe is only part full, the user should estimate a length of pipe in proportion to the depth/diameter (d/D).

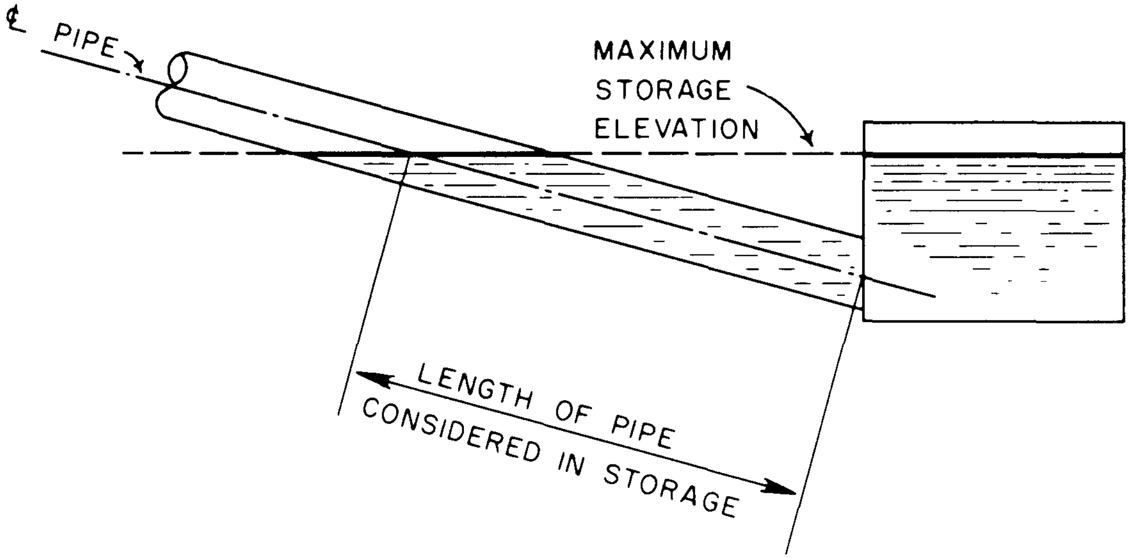
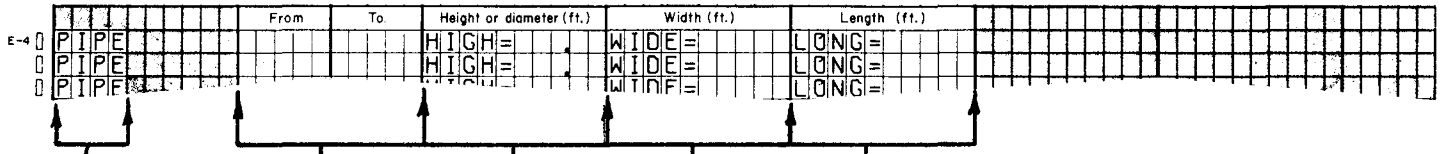


FIGURE 7-3. PIPE LENGTH FOR STORAGE DETERMINATION



Card ID

Length (in feet) of pipe or box under consideration. If water does not fill the entire length of pipe, this dimension should be estimated by the engineer.

If box, arch, or oval, this is the inside width dimension in feet. If circular pipe, this may be left blank.

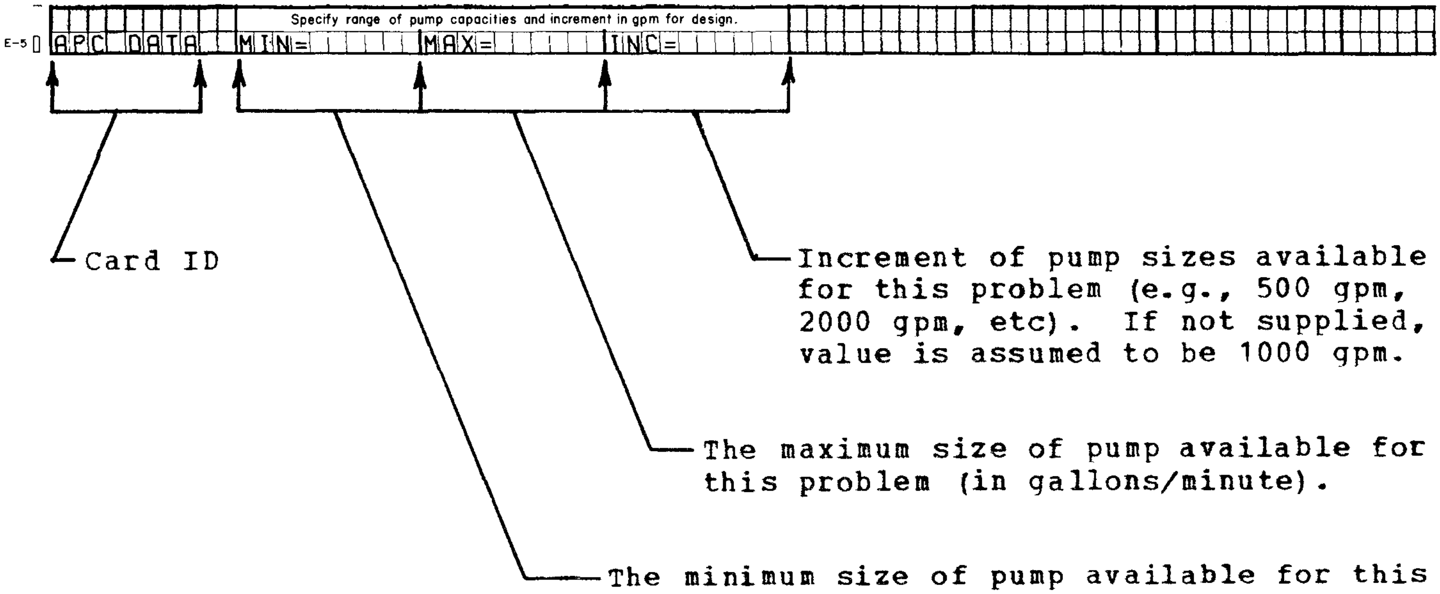
If box, arch, or oval, this is the inside depth dimension in feet. If circular, this is the inside diameter in inches.

Engineer's designation of pipe run limits. These may be any values the user wishes as aids in identification on the reprint of input data. They are not used for any computations or reports but should be useful as identifications.

The FROM and TO designations on this card are arbitrary identifications for the user's convenience and will appear only on the reprint of the input data. They are not used in any computations and will not appear in any reports but should be useful for identification.

APC DATA CARD (E-5)

This card is required for all pump DESIGN problems. The user must specify the pump sizes available by indicating both the minimum and maximum capacities and the increment at which intermediate sizes are available. Thus, if MIN = 6000, MAX = 12000 and INC = 2000, then pumps with capacities of 6000, 8000, 10000 and 12000 gpm will be considered in the design problem. Values for MIN and MAX must be entered; however, if INC is left blank, then increments of 1000 between the MIN and MAX will be considered. INC should never be specified as 0.0 but may be left blank. If only one pump size is available, then this size must be entered in both MIN and MAX, and INC must be left blank.



Card ID

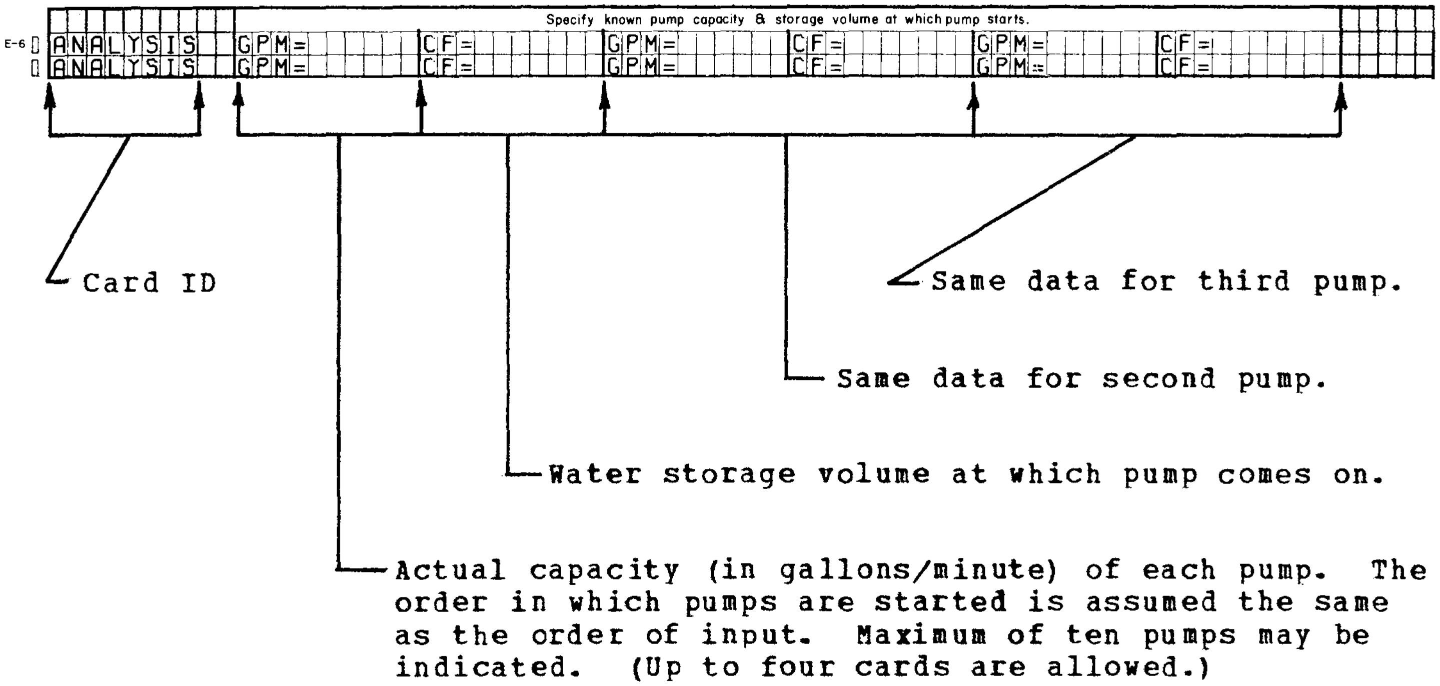
Increment of pump sizes available for this problem (e.g., 500 gpm, 2000 gpm, etc). If not supplied, value is assumed to be 1000 gpm.

The maximum size of pump available for this problem (in gallons/minute).

The minimum size of pump available for this problem (in gallons/minute).

ANALYSIS CARD (E-6)

This card is required for analyzing an existing pump station. The pump sizes and the storage volumes at which the pumps begin pumping must be given. It will be assumed that the pumps begin pumping in the sequence in which they are entered on the input forms. Three pumps may be entered per line, and a maximum of 10 pumps may be entered per problem.



Card ID

Same data for third pump.

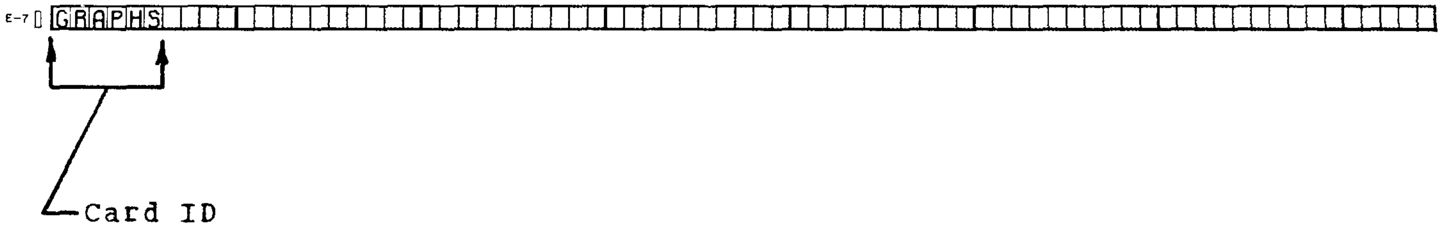
Same data for second pump.

Water storage volume at which pump comes on.

Actual capacity (in gallons/minute) of each pump. The order in which pumps are started is assumed the same as the order of input. Maximum of ten pumps may be indicated. (Up to four cards are allowed.)

GRAPHS CARD (E-7)

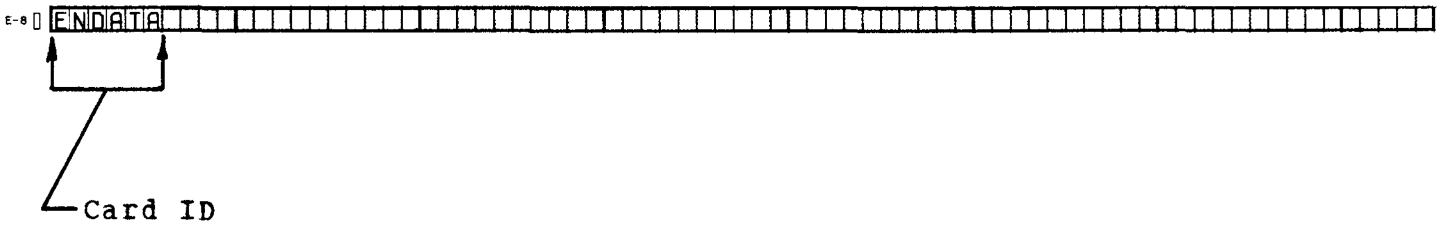
This card must be used if graphical output in addition to printed output is desired for either DESIGN or ANALYSIS. The graphs produced by this option will be generated on the plotter in a space 8 1/2" by 11" in size. They will reflect the accumulated volume of inflow with no pumps on, the maximum allowable storage and the accumulated remaining volume using pumps as indicated in the printed output for either the accepted DESIGN or the given ANALYSIS.



Card ID

ENDATA CARD (E-8)

An ENDATA card is required following the input data for each problem.



Card Use Checklist

A tabulation of the required and optional cards for each of the PUMP options is shown in Figure 7-4. This may be used to check the completed input form for possible omissions prior to submission.

PUMP

CARD IDENT.	CARD TYPE OR REFERENCE	PUMP DESIGN	PUMP ANALYSIS
CONTROL CARD	PUMP	YES	YES
E-1	HYDROLOGY	YES[1]	YES[1]
E-2	SUMP	YES	
E-3	MH/INLET	OPTIONAL[2]	
E-4	PIPE	OPTIONAL[3]	
E-5	APC DATA	YES	
E-6	ANALYSIS		YES[5]
E-7	GRAPHS	OPTIONAL[4]	OPTIONAL[4]
E-8	ENDATA	YES	YES

[1] Include a HYDROLOGY Card for each discharge considered.
[2] Include one for each MH/INLET not included in given storage.
[3] Include one for each PIPE not included in given storage.
[4] Include if graphs are needed.
[5] Include enough cards to enter all pumps in the installation.

FIGURE 7-4. CARD USE CHECKLIST

III. OUTPUT

The output for the PUMP subsystem may consist of one report for each analysis problem or one or more reports for each design problem. Design problems will usually have several solutions based on using different pump sizes and starting sequences and a report will be generated for each solution. The report for each pump analysis or design solution consists of:

1. Available storage capacity (cf) - given or computed
2. For each pump used in the solution the following will be printed:
    a. Pump output capacity (gpm) - given for ANALYSIS; computed from within the given range for DESIGN
    b. Storage volume at which the pump is started (cf) - given for ANALYSIS; computed for DESIGN
3. A table reflecting for each minute of a given storm:
    a. Minute
    b. Accumulated inflow at that minute if no pumps are used (cf) - computed
    c. Volume remaining when pumps are used according to the starting sequence shown above (cf) - computed.

If graphs are requested a line plot will be produced showing the above information as volume versus time curves.

```
MAR 14, 1977
   ****************          E R R O R   M E S S A G E S          *****************
   **************   T E X A S   H Y D R A U L I C   S Y S T E M   ***************
           ERROR MESSAGES ARE GROUPED BY ALPHABETIC PREFIX FOR EACH
        SUBSYSTEM AND ARE LISTED IN NUMERICAL ORDER WITHIN EACH GROUP.
        'EXPL' DENOTES A DETAILED EXPLANATION OF THE ERROR MESSAGE.
        (FOR ADDITIONAL INFORMATION AND ASSISTANCE CONTACT THE BRIDGE
        DIVISION HYDRAULIC SECTION OR THE DIVISION OF AUTOMATION FIELD
        ENGINEER FOR YOUR DISTRICT.)
   *******************************************************************************

PMP0001--NEITHER DESIGN NOR ANALYSIS SPECIFIED.
        EXPL□ NEITHER 'DESIGN' NOR 'ANALYSIS' WAS SPECIFIED ON THE 'PUMP'
              CONTROL CARD. FATAL ERROR.

PMP0002--RUNOFF COEFFICIENT MISSING.
        EXPL□ THE B, D, AND E FACTORS MUST BE GIVEN ON THE 'PUMP' CONTROL CARD.
              THIS MESSAGE INDICATES THAT AT LEAST ONE OF THESE FACTORS IS
              MISSING OR IS BLANK OR ZERO. FATAL ERROR.

PMP0003--PROBABLE BLANK CARD.
        EXPL□ THE CARD PRECEDING THIS MESSAGE WAS NOT RECOGNIZABLE AS A VALID
              'PUMP' DATA CARD OR 'CONTROL' CARD FOR ANOTHER SUBSYSTEM.  THE
              CARD IS IGNORED AND PROCESSING CONTINUES.  NON-FATAL.

PMP0004--SUPPLY CA SPECIFIED BUT NOT GIVEN.
        EXPL□ 'CA' WAS INDICATED ON 'HYDROLOGY' CARD (E-1) BUT ITS VALUE WAS
              ZERO OR BLANK.  IF THE 'SUPPLY CA & TC' OPTION IS NOT BEING USED,
              'CA' MUST BE CROSSED OUT.  CARD IGNORED.

PMP0005-- TC NOT GIVEN.
        EXPL□ WHEN A VALUE FOR 'CA' OR 'Q' IS GIVEN ON 'HYDROLOGY' CARD (E-1),
              THE VALUE FOR 'TC' MUST BE GIVEN ALSO.  CARD IGNORED.  NON-FATAL.

PMP0006--SUPPLY Q SPECIFIED BUT NOT GIVEN.
        EXPL□ 'Q' WAS INDICATED ON HYDROLOGY' CARD (E-1), BUT ITS VALUE WAS
              ZERO OR BLANK.  IF THE 'SUPPLY Q & TC' OPTION IS NOT BEING USED,
              'Q' MUST BE CROSSED OUT.  CARD IGNORED.  NON-FATAL.

PMP0007--NO SUMP WATER DEPTH GIVEN.
        EXPL□ IF 'LENGTH' AND 'WIDTH' ARE GIVEN ON 'SUMP' CARD (E-2), DEPTH
              BELOW STORAGE ELEVATION MUST BE GIVEN ALSO.  FATAL ERROR.

PMP0008--NO STORAGE DATA GIVEN.
        EXPL□ THIS ERROR RESULTS WHEN NEITHER 'LENGTH' OR 'DIAMETER' NOR
              'SUPPLY STORAGE' ARE GIVEN ON 'SUMP' CARD (E-2). ONE OR THE
              OTHER MUST BE GIVEN WHEN 'SUMP' CARD (E-2) IS USED. 'SUMP'
              CARD (E-2) MUST BE USED IF 'DESIGN' IS SPECIFIED. FATAL ERROR.

PMP0009--NO STORAGE ELEVATION GIVEN.
        EXPL□ THIS ERROR RESULTS FROM FAILING TO GIVE THE MAXIMUM ALLOWABLE
              STORAGE ELEVATION IN THE FIELD 'STORAGE ELEVATION' ON THE 'SUMP'
              CARD (E-2). THIS VALUE IS NECESSARY FOR USE IN PUMP DESIGN WHEN
              'MH/INLET' STORAGE IS USED. NON-FATAL ERROR.

PMP0010--INSUFFICIENT MH/INLET DIMENSIONS.
        EXPL□ THIS ERROR RESULTS FROM FAILURE TO GIVE A VALUE FOR 'LENGTH' OR
              'DIAMETER' ON 'MH/INLET' CARD (E-3). FATAL ERROR.

PMP0011--MH/INLET FLOW LINE ELEVATION NOT GIVEN.
        EXPL□ THE FLOW LINE ELEVATION MUST ALWAYS BE GIVEN WHEN 'MH/INLET' CARD
              (E-3) IS USED. FATAL ERROR.
```

PMP0012--INSUFFICIENT PIPE DIMENSIONS.

EXPL□ THIS ERROR RESULTS FROM FAILURE TO SUPPLY 'HEIGHT' OR 'DIAMETER', 'WIDTH', AND 'LENGTH' ON 'PIPE' CARD (E-4). FATAL ERROR.

PMP0013--AVAILABLE PUMP SIZE DATA MISSING.

EXPL□ THIS ERROR RESULTS FROM FAILURE TO GIVE MINIMUM OR MAXIMUM PUMP CAPACITY ON 'APC DATA' CARD (E-5). IF ONLY ONE CAPACITY IS AVAILABLE, IT MUST BE PUT IN BOTH COLUMNS.

PMP0014--MAXIMUM PUMP SIZE IS GREATER THAN MINIMUM PUMP SIZE, BUT THE GIVEN INCREMENT IS ZERO. MAXIMUM IS ASSUMED AS THE ONLY PUMP SIZE.

EXPL□ THIS ERROR OCCURS WHEN THE INCREMENT IS GIVEN AS ZERO, BUT THE MINIMUM AND MAXIMUM PUMP SIZES (CAPACITIES) ARE NOT EQUAL (ALL ON 'APC DATA' CARD (E-5)). UNDER THESE CONDITIONS, THE MAXIMUM PUMP SIZE IS THE ONLY ONE USED IN DESIGN. THIS ERROR WILL NOT OCCUR IF THE INCREMENT IS BLANK, SINCE AN INCREMENT OF 1000 GPM WILL THEN BE ASSUMED. NON-FATAL.

PMP0015--STARTING VOLUME FOR PUMP MISSING.

EXPL□ THIS ERROR RESULTS WHEN A PUMP SIZE IS GIVEN ON 'ANALYSIS' CARD (E-6) AND ITS STARTING VOLUME (CF) IS NOT. THE STARTING VOLUME IS ALWAYS GIVEN IN THE COLUMN TO THE RIGHT OF THE CORRESPONDING PUMP SIZE. FATAL ERROR.

PMP0016--DATA MISSING ON PUMP CONTROL CARD.

EXPL□ THIS MESSAGE IS PRINTED AFTER ALL CARDS HAVE BEEN DECODED FOR ONE PROBLEM AND AN 'ENDATA' CARD (E-8) HAS BEEN ENCOUNTERED. IT INDICATES THAT A FATAL ERROR WAS DETECTED AND NOTED WHEN THE 'PUMP' CONTROL CARD WAS READ.

PMP0017--DATA MISSING ON SUMP CARD E-2.

EXPL□ THIS INDICATES A FATAL ERROR WAS DETECTED WHEN 'SUMP' CARD (E-2) WAS READ. A PREVIOUS MESSAGE WILL HAVE INDICATED THE NATURE OF THE PROBLEM.

PMP0018--DATA MISSING ON APC DATA CARD E-5.

EXPL□ THIS INDICATES A FATAL ERROR WAS DETECTED WHEN 'APC DATA' CARD (E-5) WAS READ. A PREVIOUS MESSAGE WILL HAVE INDICATED THE NATURE OF THE ERROR.

PMP0019--DATA MISSING ON ANALYSIS CARD E-6.

EXPL□ THIS INDICATES A FATAL ERROR WAS DETECTED WHEN 'ANALYSIS' CARD (E-6) WAS READ. A PREVIOUS MESSAGE WILL HAVE INDICATED THE NATURE OF THE ERROR.

PMP0020--NUMBER OF CA'S STORED EXCEEDS CAPACITY OF 5.

EXPL□ ONLY FIVE STORMS (INDICATED BY 'HYDROLOGY' CARDS (E-1)) MAY BE SPECIFIED FOR EACH PROBLEM. THIS MESSAGE INDICATES THAT MORE THAN FIVE WERE SUPPLIED.

PMP0021--NUMBER OF MH/INLETS STORED EXCEEDS CAPACITY OF 100.

EXPL□ SELF-EXPLANATORY.

PMP0022--NUMBER OF PUMPS STORED FOR ANALYSIS EXCEEDS CAPACITY OF 10.

EXPL□ THE MAXIMUM NUMBER OF PUMPS THAT MAY BE USED IN AN ANALYSIS IS TEN. THE DATA DESCRIBING THESE PUMPS MUST BE ENTERED ON 'ANALYSIS' CARDS (E-6), WITH A MAXIMUM OF THREE PUMPS PER CARD. FATAL ERROR.

PMP0023--ERRORS PRECLUDE COMPUTATION.

EXPL□ THIS MESSAGE INDICATES THAT A FATAL ERROR HAS BEEN DETECTED AND

NOTED EARLIER. THE PROBLEM IS TERMINATED AND THE NEXT ONE ATTEMPTED.

PMP0024--STORAGE ELEVATION =0.0.

EXPL¤ THIS MESSAGE IS PRINTED WHEN THE 'MH/INLET' VOLUME IS BEING ADDED TO THE TOTAL STORAGE VOLUME. IT INDICATES THAT THE STORAGE ELEVATION ON 'SUMP' CARD (E-2) WAS EITHER BLANK OR ZERO. THIS COULD INDICATE AN ERROR, AND THE 'MH/INLET' FLOW LINE ELEVATION SHOULD BE EXAMINED TO DETERMINE IF THE TWO ELEVATIONS ARE RELATIVELY CORRECT TO EACH OTHER. IF NOT, AN ERRONEOUS STORAGE VOLUME WILL BE USED IN THE PUMP DESIGN. NON-FATAL.

PMP0025--MH/INLET FLOW LINE ELEVATION IS ABOVE STORAGE ELEVATION.

EXPL¤ THIS MESSAGE RESULTS WHEN THE FLOW LINE ELEVATION GIVEN ON 'MH/INLET' CARD (E-3) IS GREATER THAN THE MAXIMUM ALLOWABLE STORAGE ELEVATION IN THE FIELD 'STORAGE ELEVATION' ON THE 'SUMP' CARD (E-2). THE INPUT STORAGE ELEVATION IS ASSUMED TO BE CORRECT AND PROCESSING CONTINUES, BUT THE 'MH/INLET' UNDER CONSIDERATION WILL NOT BE INCLUDED IN THE TOTAL STORAGE. NON-FATAL.

PMP0026--NO HYDROLOGIC DATA GIVEN.

EXPL¤ THIS MESSAGE IS PRINTED WHEN THE 'TC' FOR THE FIRST STORM (ENTERED ON 'HYDROLOGY' CARD (E-1)) IS FOUND TO BE ZERO. FATAL ERROR.

PMP0027--PUMP DATA FOR ANALYSIS NOT GIVEN.

EXPL¤ THIS MESSAGE INDICATES THAT NO 'ANALYSIS' CARDS (E-6) WHICH PROVIDE THE PUMP INFORMATION FOR ALL PUMP ANALYSIS PROBLEMS HAVE BEEN SUPPLIED. FATAL ERROR.

PMP0028--THE RANGE AND INCREMENT OF AVAILABLE PUMP SIZES GIVEN ON APC DATA CARD E-5 PERMIT MORE THAN 10 ALLOWABLE PUMP SIZES. THE MINIMUM PUMP SIZE CONSIDERED IN THIS SOLUTION IS * *.

EXPL¤ THE PROGRAM ALLOWS FOR STORAGE OF NO MORE THAN 10 DIFFERENT PUMP SIZES. (NOTE¤ A MAXIMUM OF 10 DIFFERENT PUMPS PER INSTALLATION IS ALLOWED.) NON-FATAL.

PMP0029--CA VALUE =0.0.

EXPL¤ THIS ERROR OCCURS DURING THE PUMP DESIGN CALCULATIONS. THE 'CA' VALUE FOR ONE OF THE STORMS IS ZERO. THEREFORE, THIS STORM IS IGNORED AND CALCULATIONS CONTINUE. THIS ERROR COULD OCCUR IF A 'CA' VALUE IS GIVEN AS ZERO ON 'HYDROLOGY' CARD (E-1), OR A VALUE OF ZERO IS PASSED FROM 'HYDRO' WHEN 'HYDROLOGY' OPTION IS USED ON THAT CARD, OR IF 'CA' IS CALCULATED AS ZERO BECAUSE 'Q' HAS A VALUE OF ZERO ON 'HYDROLOGY' CARD (E-1). NON-FATAL.

PMP0030--DURATION OF STORM EXCEEDS CAPACITY OF THIS PROGRAM.

EXPL¤ THIS COMPUTATION ROUTINE CAN ACCOMODATE A STORM UP TO A MAXIMUM OF 500 MINUTES.

PMP0031--AVAILABLE STORAGE CAPACITY IS ADEQUATE FOR THIS DISCHARGE WITHOUT USING PUMPS.

EXPL¤ THIS MESSAGE INDICATES A SITUATION WHERE THE ENTIRE FLOOD CAN BE ACCOMODATED BY THE GIVEN STORAGE CAPACITY. THEORETICALLY, NO PUMP WOULD BE NECESSARY. (REALISTICALLY A WATER REMOVAL PUMP WOULD BE NECESSARY).

PMP0032--THE MINIMUM AVAILABLE PUMP SIZE IS TOO LARGE TO PROVIDE FOR MORE THAN ONE PUMP IN THIS SOLUTION.

EXPL¤ THIS MESSAGE IS PROVIDED FOR USER INFORMATION AND IS A STATEMENT OF FACT RATHER THAN AN ERROR MESSAGE. HOWEVER THE PUMP DESIGN

WILL BE WITHOUT A SAFETY FACTOR IN THE FORM OF A BACK-UP PUMP. STEPS SHOULD BE TAKEN TO REMEDY THIS SITUATION AS IT IS NOT CONSIDERED GOOD DESIGN PRACTICE TO HAVE ONLY ONE PUMP AVAILABLE IN AN INSTALLATION. NON-FATAL.

PART VIII - SAMPLE PROBLEMS

Sample Problems

SAMPLE PROBLEMS

I. SAMPLE OUTPUT

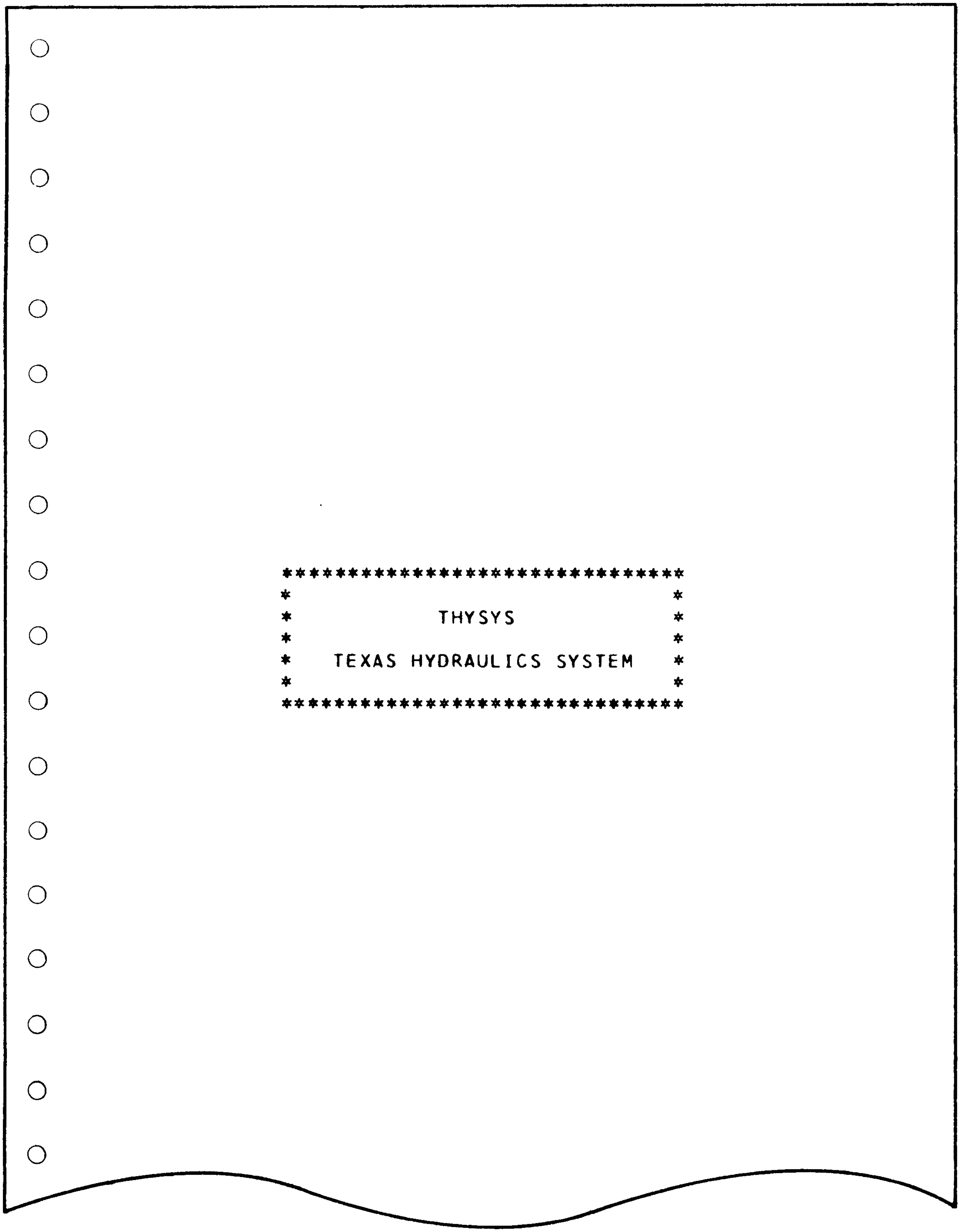
The following problems are provided as examples of the results obtained from each subsystem. Not all of the options in each subsystem have been used but the selected examples should give the user an understanding of the output from each subsystem.

The first three problems also show how data may be passed from one subsystem to another. For example, the discharge is calculated in HYDRO, and used in HYDRA where the tailwater is calculated, and then both these values are used in CULBRG for the design of a box culvert and a circular corrugated galvanized metal pipe (CGMP) culvert.

The fourth problem uses the HYDRO, HYDRA and CULBRG subsystems for the 100 year flood analysis. A SEWER problem is next in the set of example problems and involves the Inlet Carryover option.

The sixth problem uses the SEWER subsystem and includes runoff calculation and sewer design. A PUMP problem is next in the set of example problems and involves the pump design option. Last is a CULBRG problem which is included as an example of what one may expect when fatal errors are encountered in the input data.

All printout has been positioned so the pages may be trimmed to 8 1/2" by 11". Because of the number of items printed on the PLAN SUMMARY sheet in CULBRG, the INLET DESIGN in SEWER, the WATERWAY OPTION in HYDRA, and the HYDRAULIC DATA sheet in SEWER, these pages must be turned on their side to fit the 8 1/2" by 11" criteria. One title page is provided for each set of problems.



```
*******************************
*                             *
*           THYSYS            *
*                             *
*   TEXAS HYDRAULICS SYSTEM   *
*                             *
*******************************
```

FIGURE 8-1. TITLE PAGE FOR THYSYS REPORT

II. HYDRO SAMPLE PROBLEM

Figure 8-3 on the following page shows the input for the HYDRO problem. In this problem, data is given for the RATIONAL METHOD since the size of the drainage area is less than 200 acres. An illustration of the problem is shown in Figure 8-2.

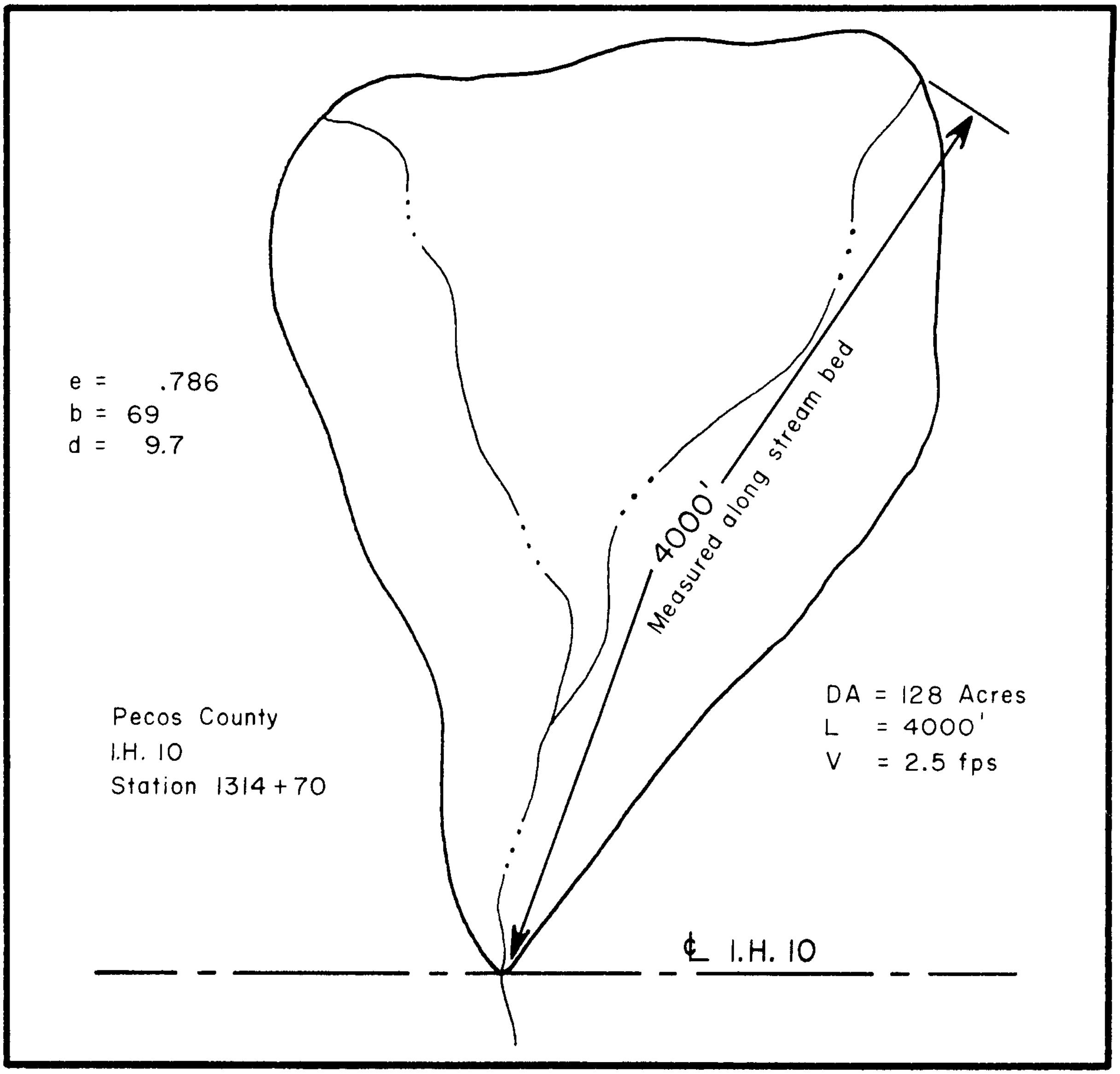
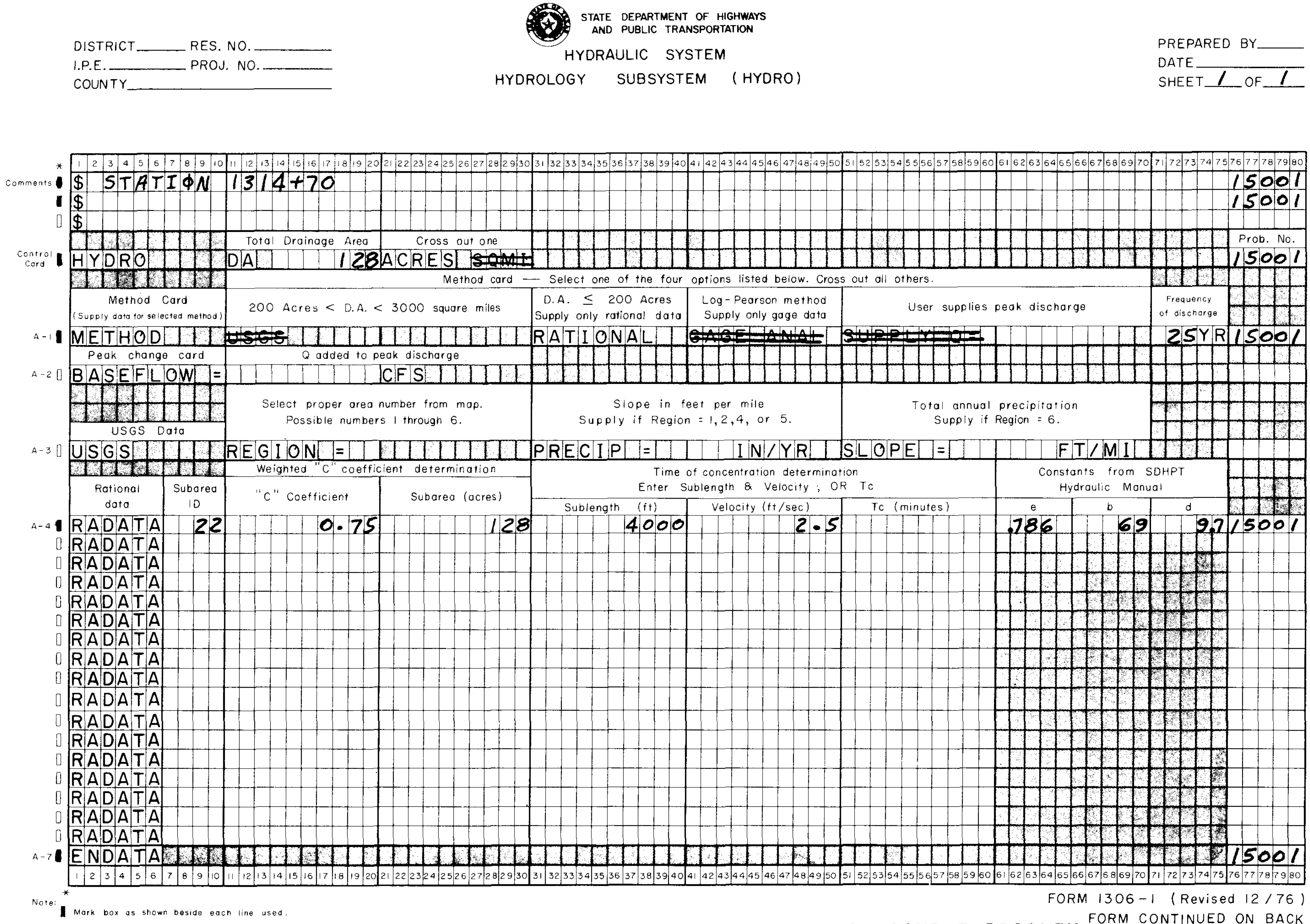


FIGURE 8-2. DRAWING FOR THE HYDRO EXAMPLE PROBLEM



STATE DEPARTMENT OF HIGHWAYS
AND PUBLIC TRANSPORTATION

HYDRAULIC SYSTEM

HYDROLOGY SUBSYSTEM (HYDRO)

DISTRICT______ RES. NO.______
I.P.E.______ PROJ. NO.______
COUNTY______

PREPARED BY______
DATE______
SHEET 1 OF 1

* 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80

Comments ▮ $ STATION 1314+70 15001
▮ $ 15001
▯ $

Total Drainage Area — Cross out one — Prob. No.

Control Card ▮ HYDRO DA 128 ACRES ~~SQMI~~ 15001

Method card — Select one of the four options listed below. Cross out all others.

Method Card (Supply data for selected method)	200 Acres < D.A. < 3000 square miles	D.A. ≤ 200 Acres Supply only rational data	Log-Pearson method Supply only gage data	User supplies peak discharge	Frequency of discharge	
A-1 ▮ METHOD	~~USGS~~	RATIONAL	~~GAGE ANAL~~	~~SUPPLY Q=~~	25YR	15001

Peak change card — Q added to peak discharge

A-2 ▯ BASEFLOW = CFS

USGS Data	Select proper area number from map. Possible numbers 1 through 6.	Slope in feet per mile Supply if Region = 1,2,4, or 5.	Total annual precipitation Supply if Region = 6.
A-3 ▯ USGS	REGION =	PRECIP = IN/YR	SLOPE = FT/MI

		Weighted "C" coefficient determination		Time of concentration determination Enter Sublength & Velocity ; OR Tc			Constants from SDHPT Hydraulic Manual			
Rational data	Subarea ID	"C" Coefficient	Subarea (acres)	Sublength (ft)	Velocity (ft/sec)	Tc (minutes)	e	b	d	
A-4 ▮ RADATA	22	0.75	128	4000	2.5		.786	69	9.7	15001
▯ RADATA										
▯ RADATA										
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▯ RADATA										
▯ RADATA										
▯ RADATA										
A-7 ▮ ENDATA										15001

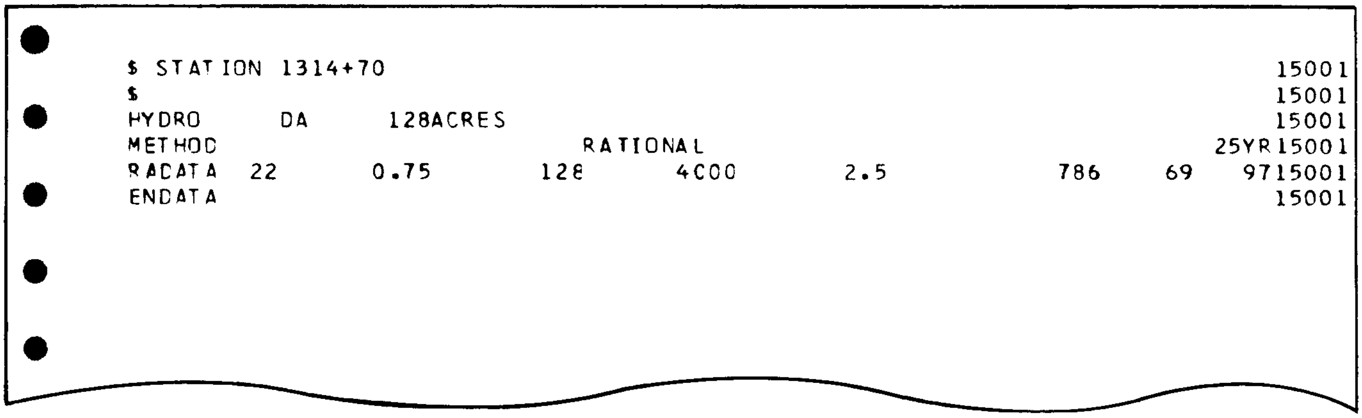
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80

Note: * ▮ Mark box as shown beside each line used.

FORM 1306-1 (Revised 12/76)
FORM CONTINUED ON BACK

FIGURE 8-3. HYDRO INPUT FORM COMPLETED FOR SAMPLE PROBLEM

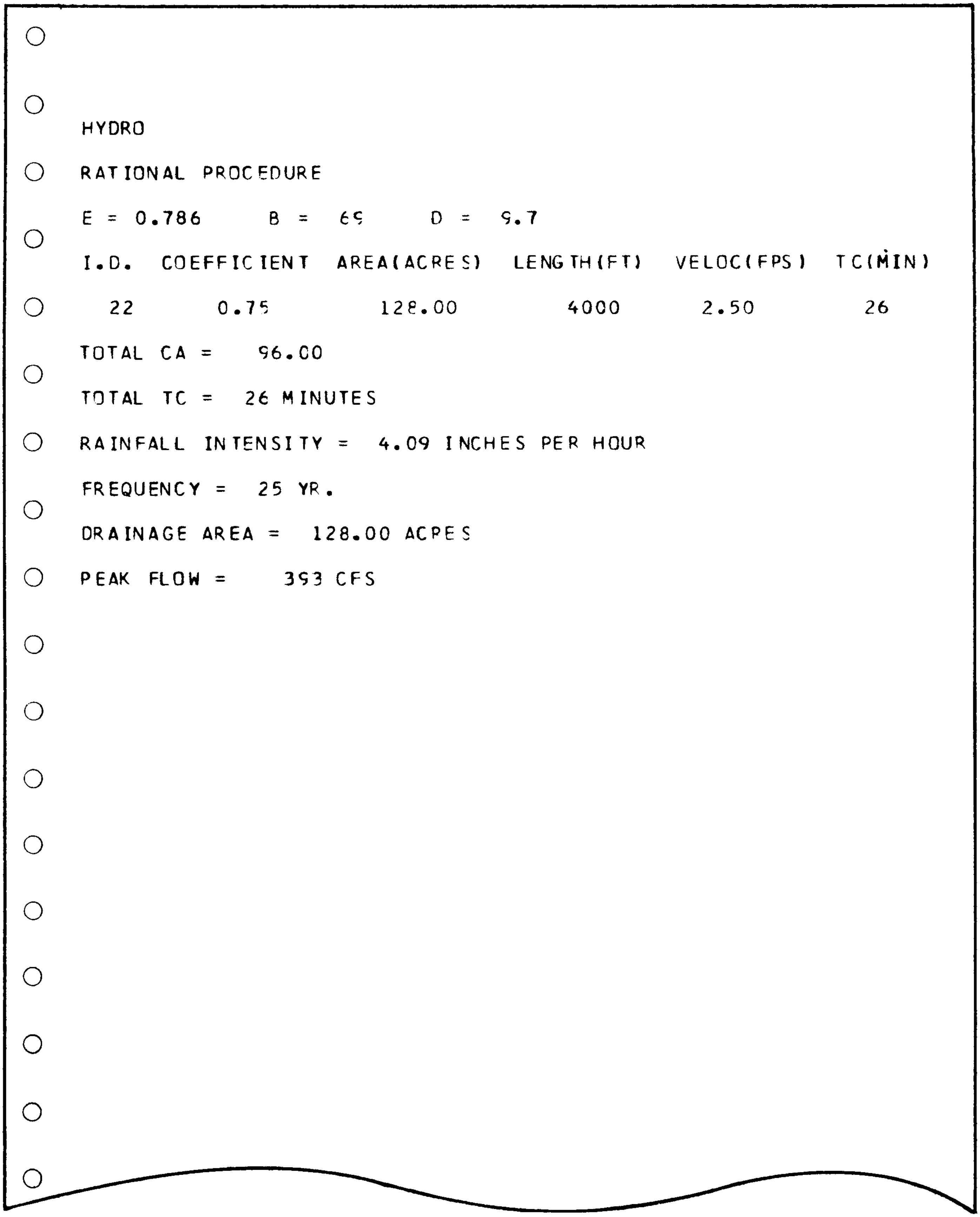
The input data is printed out exactly as it is read into the computer. (See Figure 8-4.) The data editing portion of the subsystem checks the data for input errors; and, if any are found, a message explaining the nature of the error will be printed immediately after the line containing that error. After the ENDATA card is printed, checks are made to determine whether necessary data items have been supplied. If there are any errors, a message will be printed. If any of the errors noted were fatal errors, the message "ERRORS PRECLUDE COMPUTATIONS" will be printed, and the program will go to the next problem. In this example, no errors were encountered.



```
$ STATION 1314+70                                                          15001
$                                                                          15001
HYDRO     DA     128ACRES                                                  15001
METHOD                        RATIONAL                                 25YR15001
RADATA  22      0.75       128      4000       2.5           786    69   9715001
ENDATA                                                                     15001
```

FIGURE 8-4. COMPUTER PRINTED INPUT DATA

The results of the rational procedure are shown in Figure 8-5. The values used in the computations are again printed out so that the user may verify that the values were input properly. The computed values are printed out also, with the discharge (PEAK FLOW) printed as the last item on the report.



```
HYDRO
RATIONAL PROCEDURE
E = 0.786     B =  69     D =  9.7
I.D.  COEFFICIENT  AREA(ACRES)  LENGTH(FT)  VELOC(FPS)  TC(MIN)
  22      0.75         128.00        4000       2.50        26
TOTAL CA =   96.00
TOTAL TC =  26 MINUTES
RAINFALL INTENSITY =  4.09 INCHES PER HOUR
FREQUENCY =  25 YR.
DRAINAGE AREA =  128.00 ACRES
PEAK FLOW =    393 CFS
```

FIGURE 8-5. TYPICAL HYDRO OUTPUT LISTING

III. HYDRA SAMPLE PROBLEM

Using the discharge computed in HYDRO, the HYDRA subsystem is now utilized to find the tailwater value for later use in a culvert design (CULBRG). On the data input sheets shown in Figures 8-7 and 8-8, the ONE SECTION method is specified, and the following data is supplied: the slope of the channel, the section identification, stations at the section and at the culvert location, and whether the culvert is upstream or downstream from the section. In this problem, the approximate downstream end of the culvert is 200' upstream from the cross-section site. The WATERWAY option is used with an optional specific elevation and an increment elevation given. The cross-section data and the Mannings ("n") value for the section are also given. The GRAPHS option is used which requires section identification, plot length and plot height. A graphical representation of this problem is shown in Figure 8-6 and the edited input data is shown in Figure 8-9.

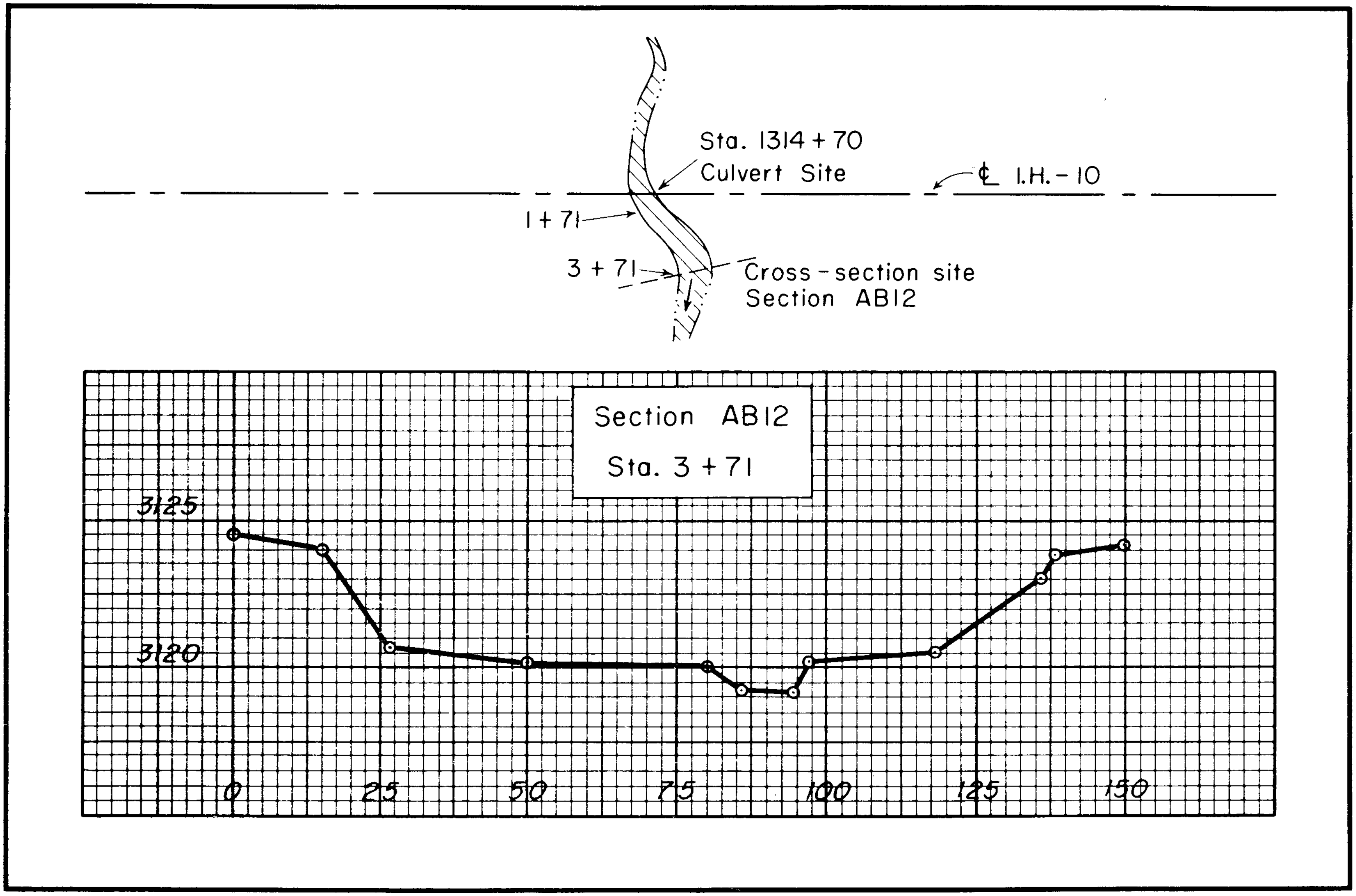
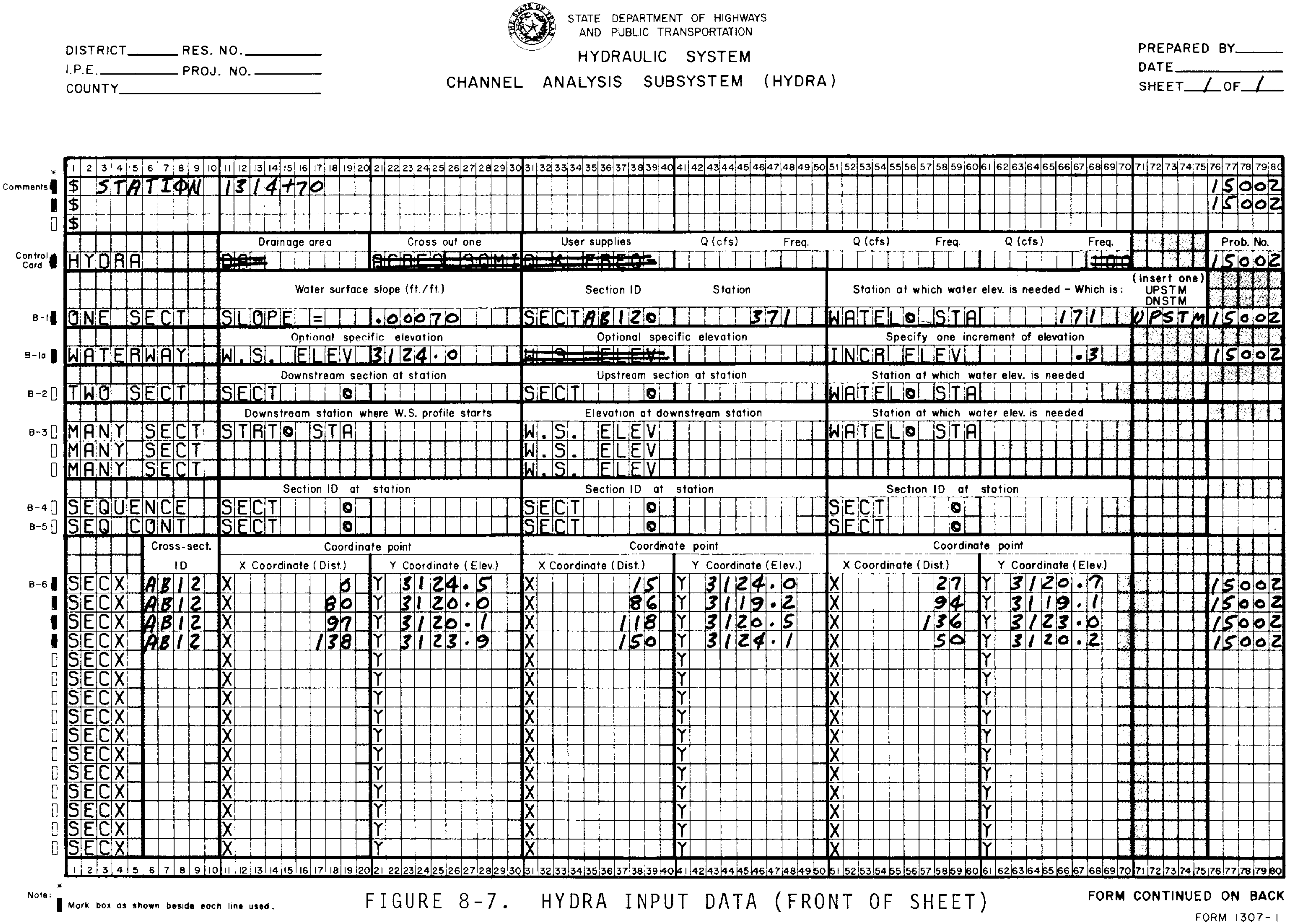


FIGURE 8-6. CULVERT LOCATION AND CROSS-SECTION DATA



DISTRICT______ RES. NO.__________
I.P.E.__________ PROJ. NO.________
COUNTY______________________________

STATE DEPARTMENT OF HIGHWAYS
AND PUBLIC TRANSPORTATION

HYDRAULIC SYSTEM

CHANNEL ANALYSIS SUBSYSTEM (HYDRA)

PREPARED BY______
DATE____________
SHEET 1 OF 1

*	1 2 3 4 5 6 7 8 9 10	11 12 13 14 15 16 17 18 19 20	21 22 23 24 25 26 27 28 29 30	31 32 33 34 35 36 37 38 39 40	41 42 43 44 45 46 47 48 49 50	51 52 53 54 55 56 57 58 59 60	61 62 63 64 65 66 67 68 69 70	71 72 73 74 75	76 77 78 79 80
Comments ▮	$ STATION	1314+70							15002
▮	$								15002
☐	$								
		Drainage area	Cross out one	User supplies	Q (cfs) Freq.	Q (cfs) Freq.	Q (cfs) Freq.		Prob. No.
Control Card ▮	HYDRA	~~DA=~~	~~ACRES SQMI~~	~~Q & FREQ~~			~~100~~		15002
		Water surface slope (ft./ft.)		Section ID	Station	Station at which water elev. is needed – Which is:		(insert one) UPSTM DNSTM	
B-1 ▮	ONE SECT	SLOPE =	.00070	SECTAB12●	371	WATEL● STA	171	UPSTM	15002
		Optional specific elevation		Optional specific elevation		Specify one increment of elevation			
B-1a ▮	WATERWAY	W.S. ELEV	3124.0	~~W.S. ELEV~~		INCR ELEV	.3		15002
		Downstream section at station		Upstream section at station		Station at which water elev. is needed			
B-2 ☐	TWO SECT	SECT ●		SECT ●		WATEL● STA			
		Downstream station where W.S. profile starts		Elevation at downstream station		Station at which water elev. is needed			
B-3 ☐	MANY SECT	STRT● STA		W.S. ELEV		WATEL● STA			
☐	MANY SECT			W.S. ELEV					
☐	MANY SECT			W.S. ELEV					
		Section ID at station		Section ID at station		Section ID at station			
B-4 ☐	SEQUENCE	SECT ●		SECT ●		SECT ●			
B-5 ☐	SEQ CONT	SECT ●		SECT ●		SECT ●			
	Cross-sect. ID	Coordinate point X Coordinate (Dist.)	Y Coordinate (Elev.)	Coordinate point X Coordinate (Dist.)	Y Coordinate (Elev.)	Coordinate point X Coordinate (Dist.)	Y Coordinate (Elev.)		
B-6 ▮	SECX AB12	X 0	Y 3124.5	X 15	Y 3124.0	X 27	Y 3120.7		15002
▮	SECX AB12	X 80	Y 3120.0	X 86	Y 3119.2	X 94	Y 3119.1		15002
▮	SECX AB12	X 97	Y 3120.1	X 118	Y 3120.5	X 136	Y 3123.0		15002
▮	SECX AB12	X 138	Y 3123.9	X 150	Y 3124.1	X 50	Y 3120.2		15002
☐	SECX	X	Y	X	Y	X	Y		
☐	SECX	X	Y	X	Y	X	Y		
☐	SECX	X	Y	X	Y	X	Y		
☐	SECX	X	Y	X	Y	X	Y		
☐	SECX	X	Y	X	Y	X	Y		
☐	SECX	X	Y	X	Y	X	Y		
☐	SECX	X	Y	X	Y	X	Y		
☐	SECX	X	Y	X	Y	X	Y		
☐	SECX	X	Y	X	Y	X	Y		
☐	SECX	X	Y	X	Y	X	Y		
☐	SECX	X	Y	X	Y	X	Y		
	1 2 3 4 5 6 7 8 9 10	11 12 13 14 15 16 17 18 19 20	21 22 23 24 25 26 27 28 29 30	31 32 33 34 35 36 37 38 39 40	41 42 43 44 45 46 47 48 49 50	51 52 53 54 55 56 57 58 59 60	61 62 63 64 65 66 67 68 69 70	71 72 73 74 75	76 77 78 79 80

Note: * ▮ Mark box as shown beside each line used.

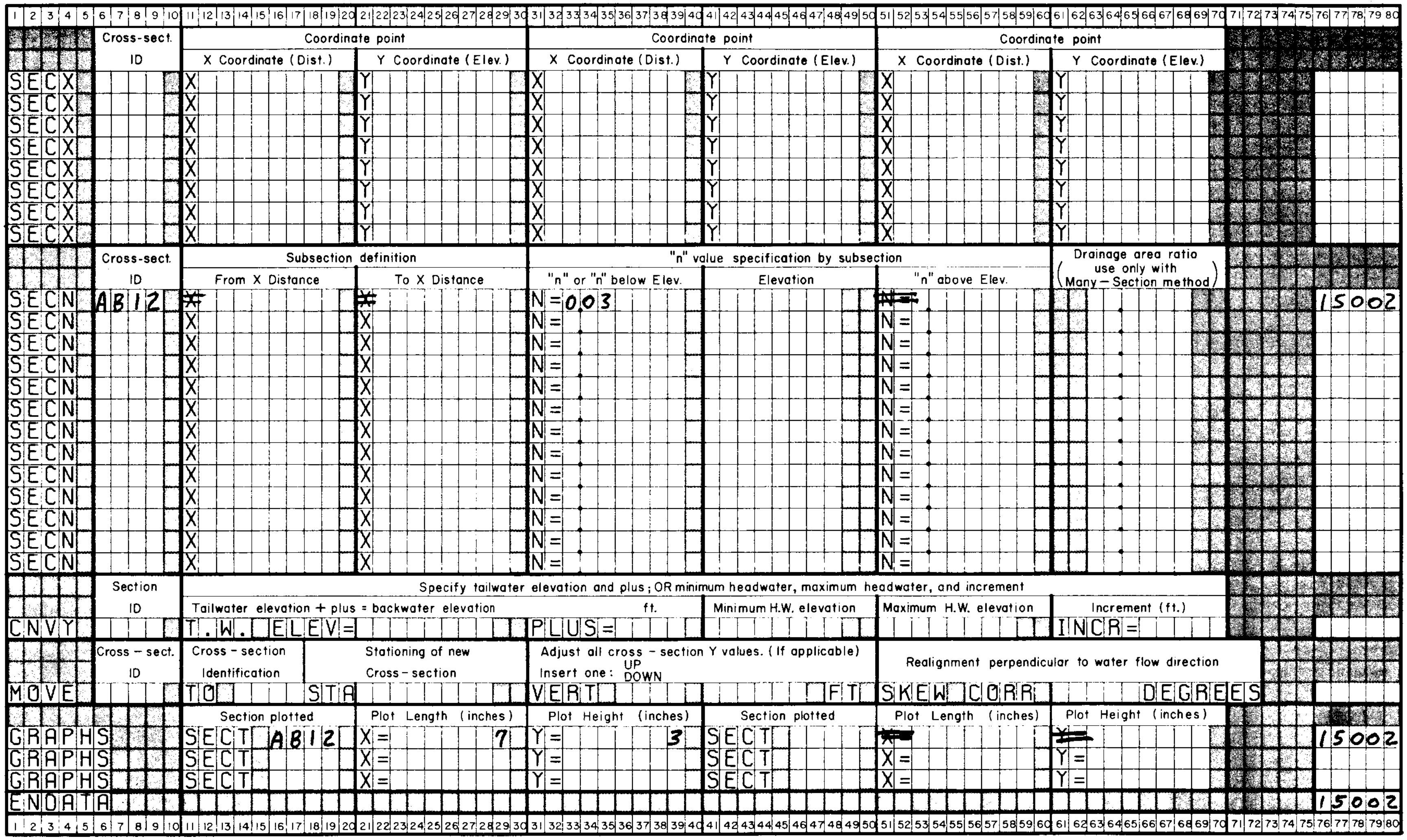
FORM CONTINUED ON BACK

FORM 1307-1
(Revised 8/74)

FIGURE 8-7. HYDRA INPUT DATA (FRONT OF SHEET)

HYDRA (Continued)

BACK, SHEET 1 OF 1



		Cross-sect. ID	Coordinate point X Coordinate (Dist.)	Coordinate point Y Coordinate (Elev.)	Coordinate point X Coordinate (Dist.)	Coordinate point Y Coordinate (Elev.)	Coordinate point X Coordinate (Dist.)	Coordinate point Y Coordinate (Elev.)	
B-6	SECX		X	Y	X	Y	X	Y	
	SECX		X	Y	X	Y	X	Y	
	SECX		X	Y	X	Y	X	Y	
	SECX		X	Y	X	Y	X	Y	
	SECX		X	Y	X	Y	X	Y	
	SECX		X	Y	X	Y	X	Y	
	SECX		X	Y	X	Y	X	Y	
	SECX		X	Y	X	Y	X	Y	

		Cross-sect. ID	Subsection definition: From X Distance	Subsection definition: To X Distance	"n" value specification by subsection: "n" or "n" below Elev.	"n" value specification by subsection: Elevation	"n" value specification by subsection: "n" above Elev.	Drainage area ratio (use only with Many – Section method)	
B-7	SECN	AB12	~~X~~	~~X~~	N=0.03		~~N=~~		15002
	SECN		X	X	N= .		N= .	.	
	SECN		X	X	N= .		N= .	.	
	SECN		X	X	N= .		N= .	.	
	SECN		X	X	N= .		N= .	.	
	SECN		X	X	N= .		N= .	.	
	SECN		X	X	N= .		N= .	.	
	SECN		X	X	N= .		N= .	.	
	SECN		X	X	N= .		N= .	.	
	SECN		X	X	N= .		N= .	.	
	SECN		X	X	N= .		N= .	.	
	SECN		X	X	N= .		N= .	.	
	SECN		X	X	N= .		N= .	.	

Specify tailwater elevation and plus; OR minimum headwater, maximum headwater, and increment

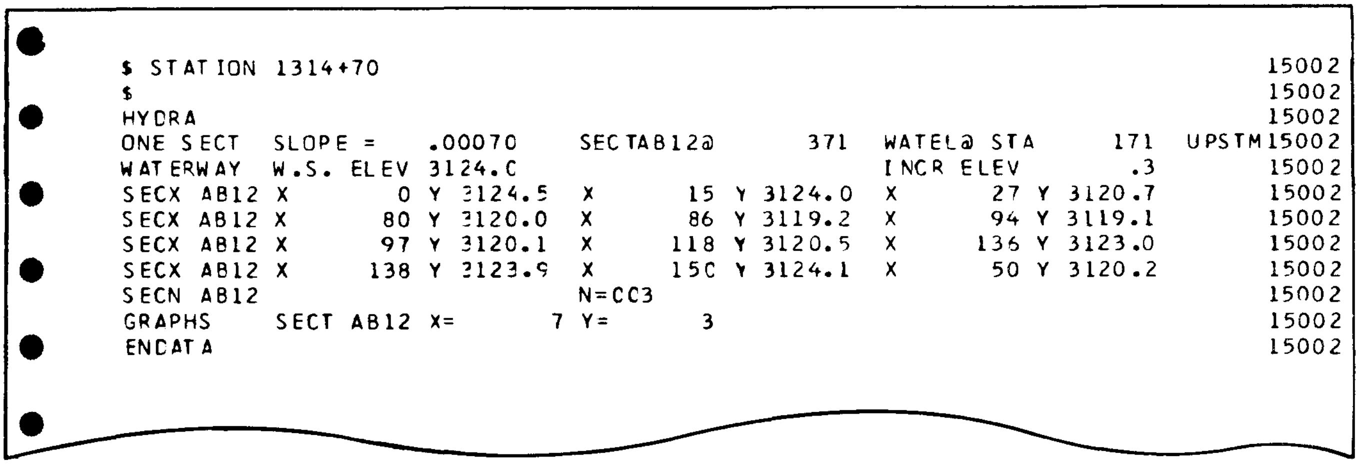
		Section ID	Tailwater elevation + plus = backwater elevation ft.	Minimum H.W. elevation	Maximum H.W. elevation	Increment (ft.)
B-8	CNVY		T.W. ELEV= PLUS=			INCR=

		Cross – sect. ID	Cross – section Identification	Stationing of new Cross – section	Adjust all cross – section Y values. (If applicable) Insert one: UP DOWN	Realignment perpendicular to water flow direction
B-9	MOVE		TO	STA	VERT FT	SKEW CORR DEGREES

		Section plotted	Plot Length (inches)	Plot Height (inches)	Section plotted	Plot Length (inches)	Plot Height (inches)	
B-10	GRAPHS	SECT AB12	X= 7	Y= 3	SECT	~~X=~~	~~Y=~~	15002
	GRAPHS	SECT	X=	Y=	SECT	X=	Y=	
	GRAPHS	SECT	X=	Y=	SECT	X=	Y=	
B-11	ENDATA							15002

FIGURE 8-8. HYDRA INPUT DATA (BACK OF SHEET)

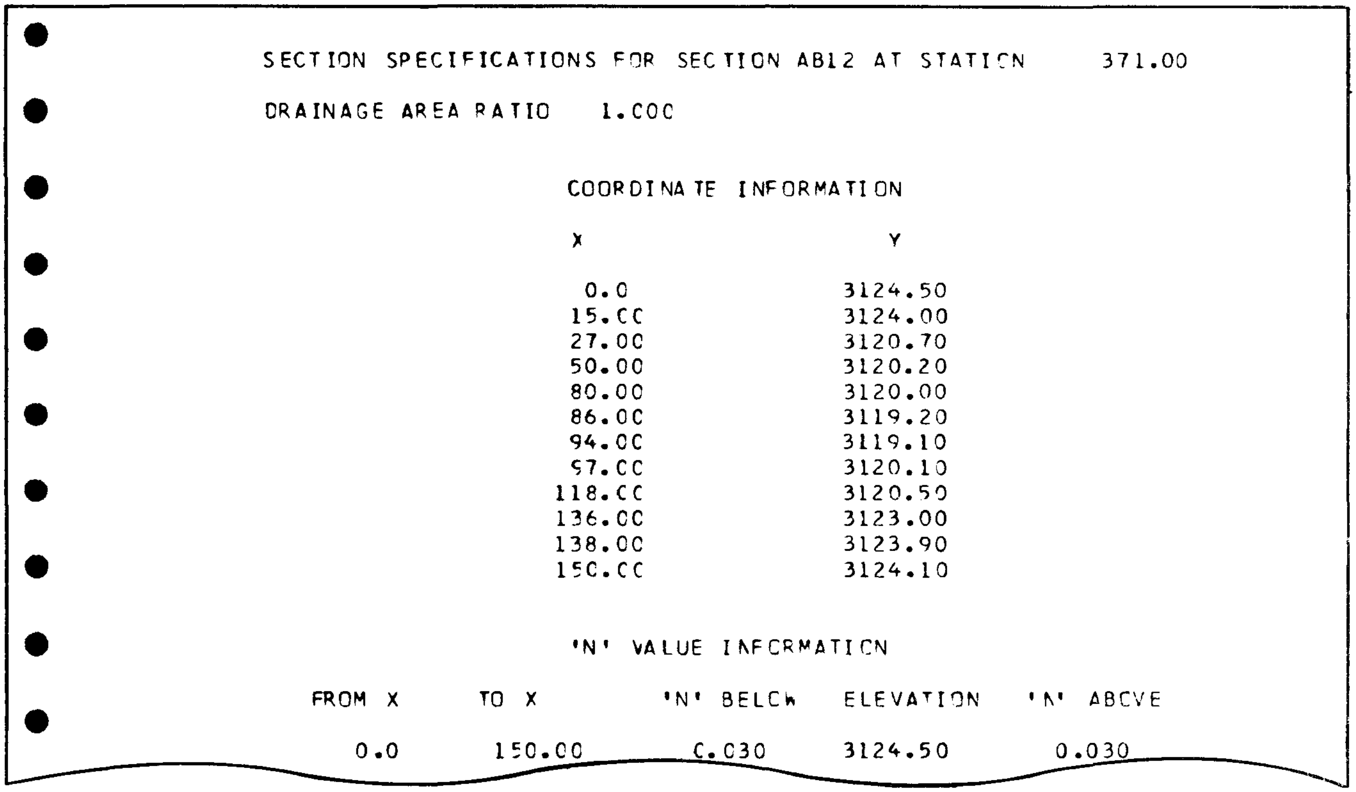
FORM 1307-2
(Revised 8/74)



```
$ STATION 1314+70                                                                     15002
$                                                                                     15002
HYDRA                                                                                 15002
ONE SECT  SLOPE =    .00070    SECTAB12@       371  WATEL@ STA       171  UPSTM15002
WATERWAY  W.S. ELEV 3124.C                           INCR ELEV         .3             15002
SECX AB12 X        0 Y 3124.5  X        15 Y 3124.0  X        27 Y 3120.7             15002
SECX AB12 X       80 Y 3120.0  X        86 Y 3119.2  X        94 Y 3119.1             15002
SECX AB12 X       97 Y 3120.1  X       118 Y 3120.5  X       136 Y 3123.0             15002
SECX AB12 X      138 Y 3123.9  X       15C Y 3124.1  X        50 Y 3120.2             15002
SECN AB12                      N=CC3                                                  15002
GRAPHS    SECT AB12 X=        7 Y=       3                                            15002
ENDATA                                                                                15002
```

FIGURE 8-9. COMPUTER PRINTED INPUT DATA

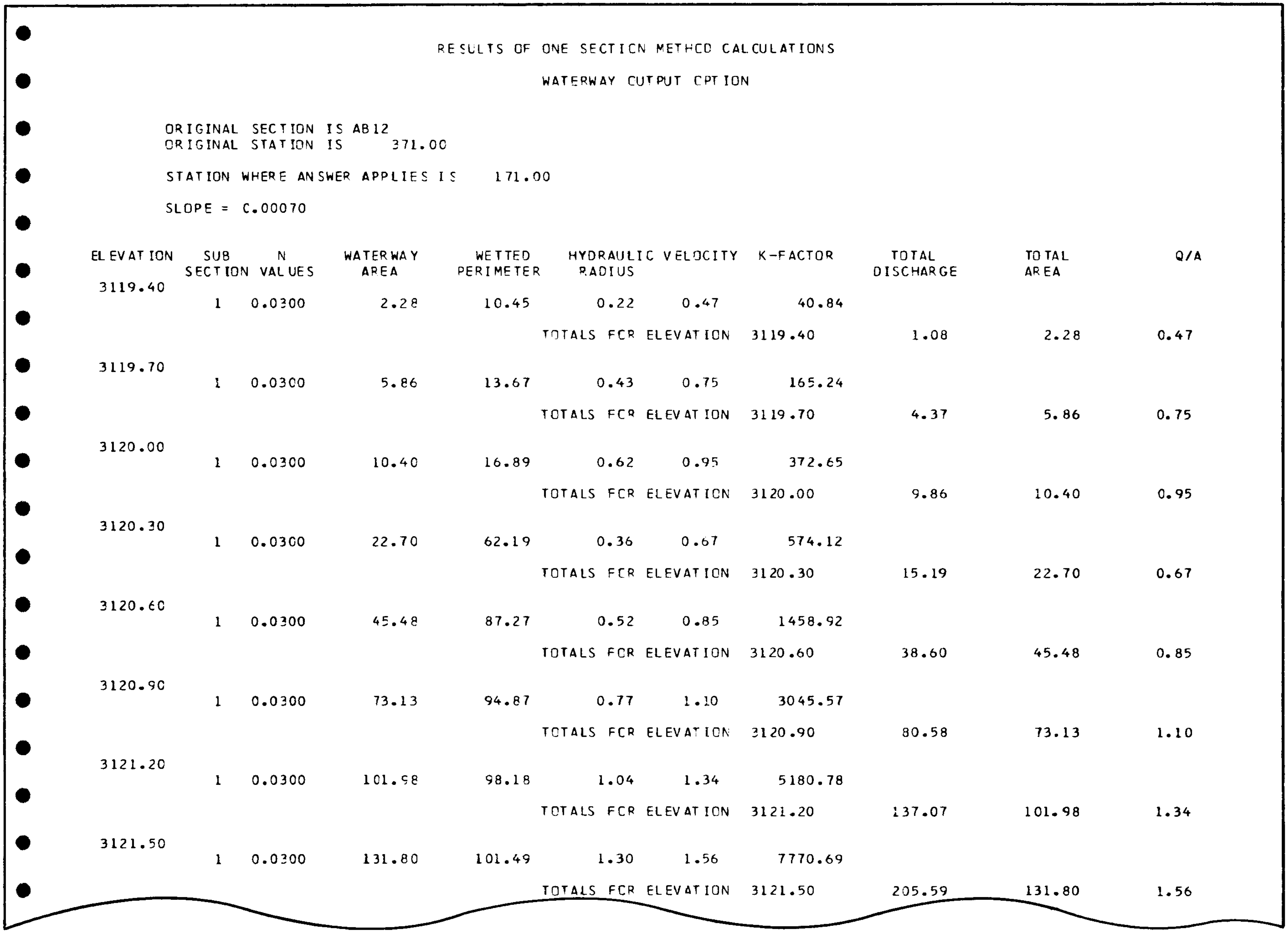
As shown in Figure 8-10, the program then arranges the cross-section data in order, if necessary, and lists the point coordinates and the "n" value information so that they may be checked by the user. In Figures 8-7 and 8-9, it may be noted that the last cross-section point is out of order, but in Figure 8-10, it has been placed in the proper sequence. This information is tabulated for each section and is identified by the heading on the page.



```
SECTION SPECIFICATIONS FOR SECTION AB12 AT STATION     371.00

DRAINAGE AREA RATIO    1.COC


                         COORDINATE INFORMATION

                          X                  Y

                          0.0              3124.50
                         15.CC             3124.00
                         27.0C             3120.70
                         50.00             3120.20
                         80.00             3120.00
                         86.0C             3119.20
                         94.0C             3119.10
                         97.CC             3120.10
                        118.CC             3120.50
                        136.0C             3123.00
                        138.0C             3123.90
                        15C.CC             3124.10


                         'N' VALUE INFORMATION

    FROM X      TO X        'N' BELOW    ELEVATION    'N' ABOVE

      0.0      150.00       C.030       3124.50        0.030
```

FIGURE 8-10. HYDRA CROSS-SECTION DATA

The next report (Figure 8-11 and 8-12) gives the results of the tailwater calculations. The identification is given at the top of the page (after the heading). The WATERWAY option, as used in the sample problem, produces more printed output data than the normal printed calculations which only show the water surface elevation, Q and velocity. Following this, the tailwater elevation for the design discharge is printed both at the culvert site and at the cross-section. The design Q in this case was computed in the HYDRO subsystem, but it could have been supplied directly in HYDRA by entering it on the control card in its proper place. Figure 8-13 is a plot of the cross-section.

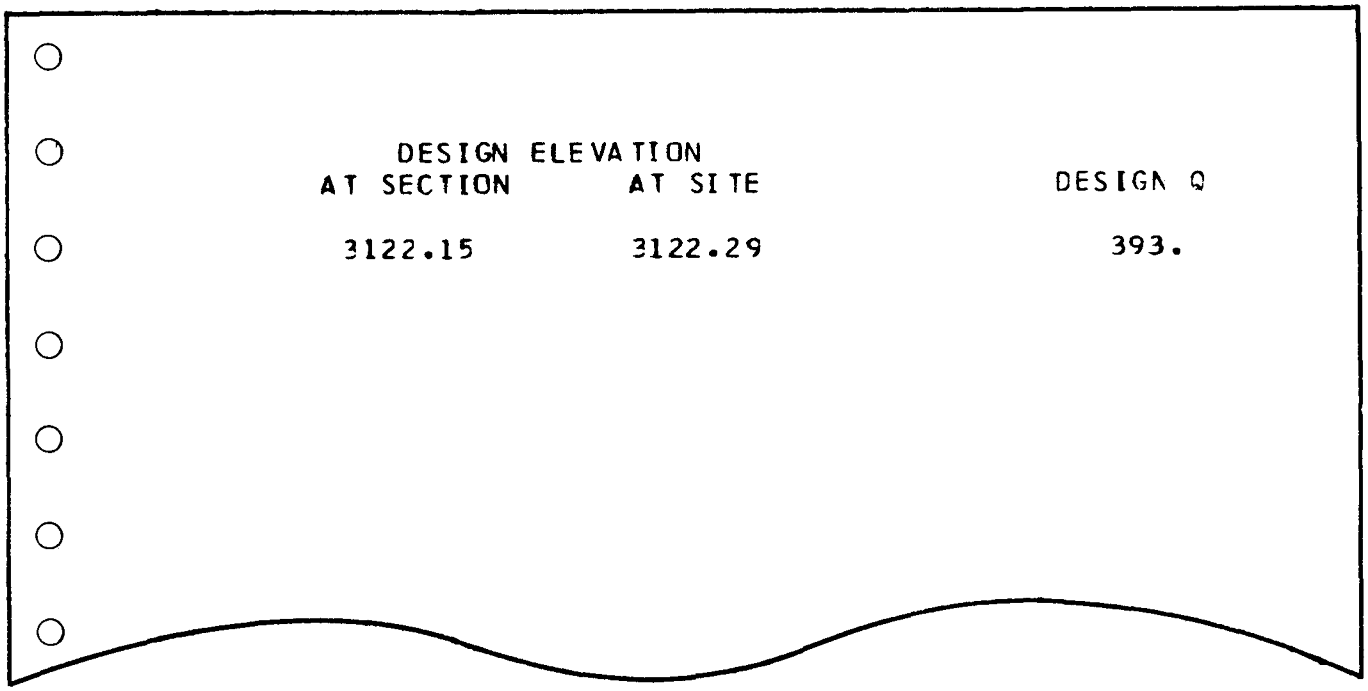


```
                                   RESULTS OF ONE SECTICN METHCD CALCULATIONS

                                               WATERWAY CUTPUT CPTION

          ORIGINAL SECTION IS AB12
          ORIGINAL STATION IS      371.00

          STATION WHERE ANSWER APPLIES IS     171.00

          SLOPE = C.00070

ELEVATION  SUB      N      WATERWAY     WETTED    HYDRAULIC VELOCITY  K-FACTOR     TOTAL        TOTAL          Q/A
         SECTION VALUES      AREA      PERIMETER    RADIUS                        DISCHARGE     AREA
 3119.40
            1    0.0300       2.28       10.45       0.22      0.47      40.84
                                                 TOTALS FCR ELEVATION  3119.40       1.08         2.28        0.47

 3119.70
            1    0.0300       5.86       13.67       0.43      0.75     165.24
                                                 TOTALS FCR ELEVATION  3119.70       4.37         5.86        0.75

 3120.00
            1    0.0300      10.40       16.89       0.62      0.95     372.65
                                                 TOTALS FCR ELEVATION  3120.00       9.86        10.40        0.95

 3120.30
            1    0.0300      22.70       62.19       0.36      0.67     574.12
                                                 TOTALS FCR ELEVATION  3120.30      15.19        22.70        0.67

 3120.60
            1    0.0300      45.48       87.27       0.52      0.85    1458.92
                                                 TOTALS FCR ELEVATION  3120.60      38.60        45.48        0.85

 3120.90
            1    0.0300      73.13       94.87       0.77      1.10    3045.57
                                                 TOTALS FCR ELEVATION  3120.90      80.58        73.13        1.10

 3121.20
            1    0.0300     101.98       98.18       1.04      1.34    5180.78
                                                 TOTALS FCR ELEVATION  3121.20     137.07       101.98        1.34

 3121.50
            1    0.0300     131.80      101.49       1.30      1.56    7770.69
                                                 TOTALS FCR ELEVATION  3121.50     205.59       131.80        1.56
```

FIGURE 8-11. WATERWAY OPTION TAILWATER CALCULATIONS

```
ELEVATION   SUB      N        WATERWAY     WETTED     HYDRAULIC VELOCITY  K-FACTOR       TOTAL          TOTAL         Q/A
          SECTION  VALUES      AREA      PERIMETER     RADIUS                          DISCHARGE       AREA
  3121.80
              1    0.0300     162.59      104.80        1.55      1.76     10793.15

                                                    TOTALS FOR ELEVATION  3121.80       285.56        162.59       1.76

  3122.10
              1    0.0300     194.36      108.11        1.80      1.94     14233.85

                                                    TOTALS FOR ELEVATION  3122.10       376.59        194.36       1.94

  3122.40
              1    0.0300     227.10      111.42        2.04      2.11     18083.38

                                                    TOTALS FOR ELEVATION  3122.40       478.44        227.10       2.11

  3122.70
              1    0.0300     260.81      114.73        2.27      2.27     22335.55

                                                    TOTALS FOR ELEVATION  3122.70       590.94        260.81       2.27

  3123.00
              1    0.0300     295.50      118.04        2.50      2.42     26986.54

                                                    TOTALS FOR ELEVATION  3123.00       714.00        295.50       2.42

  3123.30
              1    0.0300     330.94      119.91        2.76      2.58     32253.30

                                                    TOTALS FOR ELEVATION  3123.30       853.34        330.94       2.58

  3123.60
              1    0.0300     366.91      121.78        3.01      2.73     37913.91

                                                    TOTALS FOR ELEVATION  3123.60      1003.11        366.91       2.73

  3123.90
              1    0.0300     403.41      123.64        3.26      2.88     43958.83

                                                    TOTALS FOR ELEVATION  3123.90      1163.04        403.41       2.88

  3124.00
              1    0.0300     416.46      130.05        3.20      2.85     44817.55

                                                    TOTALS FOR ELEVATION  3124.00      1185.76        416.46       2.85

  3124.10
              1    0.0300     429.79      139.04        3.09      2.78     45175.09

                                                    TOTALS FOR ELEVATION  3124.10      1195.22        429.79       2.78
```

FIGURE 8-11. (CONTINUED) WATERWAY OPTION TAILWATER CALCULATIONS



```
              DESIGN ELEVATION
         AT SECTION        AT SITE                  DESIGN Q

          3122.15          3122.29                    393.
```

FIGURE 8-12. TAILWATER CALCULATIONS FOR DESIGN ELEVATIONS

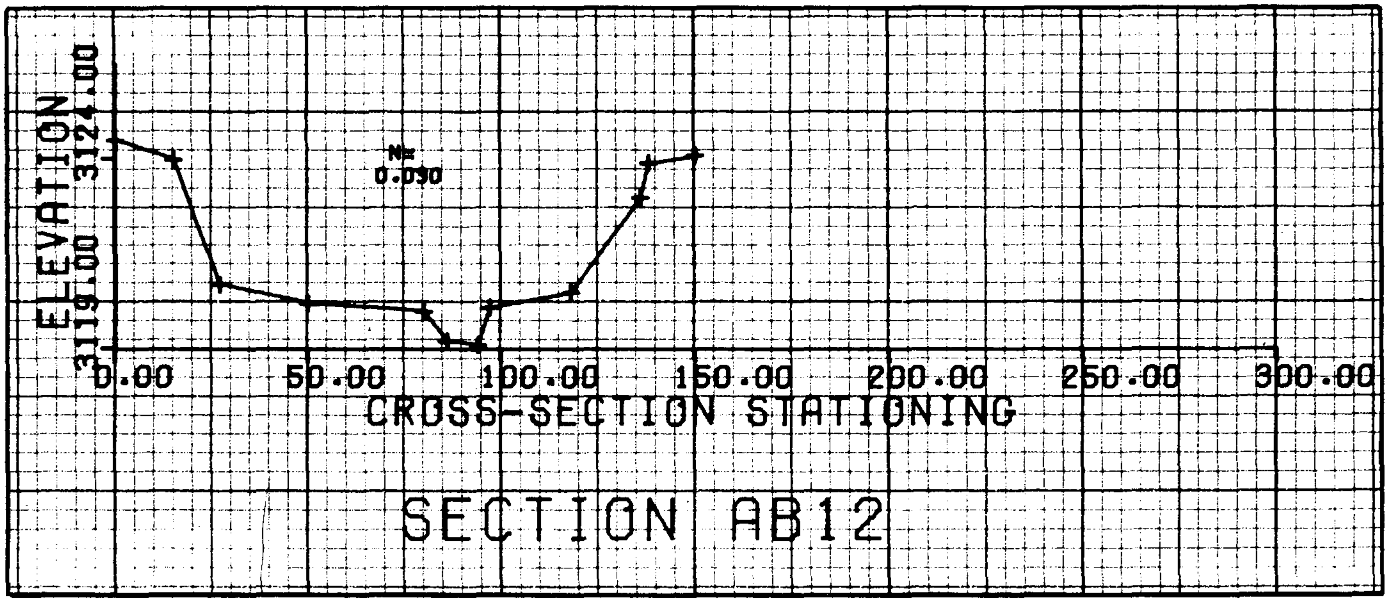
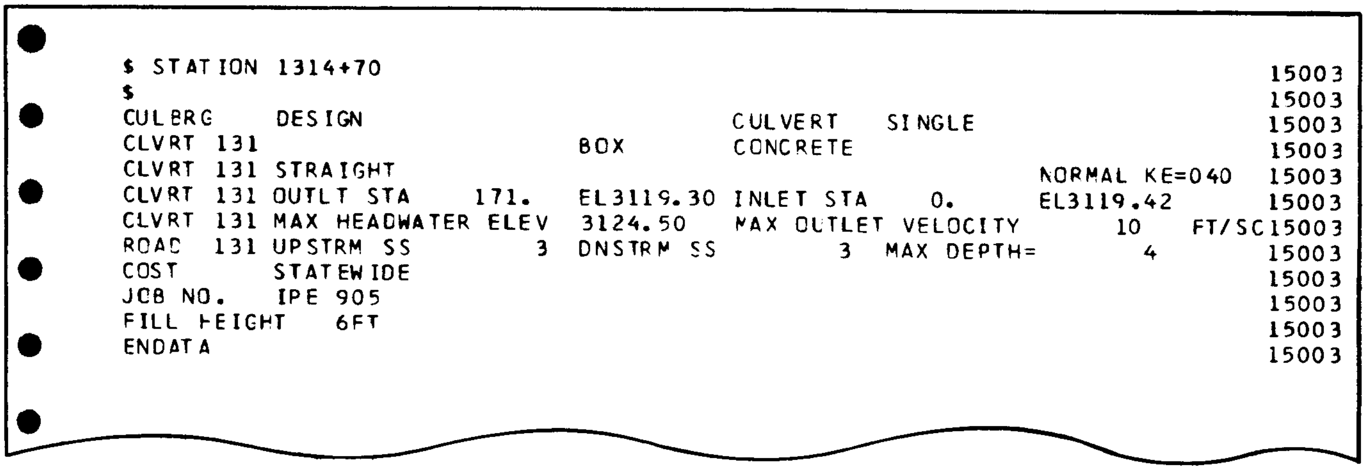


FIGURE 8-13. PLOT OF CROSS-SECTION

IV. CULBRG SAMPLE PROBLEM

An illustration of a culvert design (CULBRG) problem is shown in Figure 8-15 and the input is shown in Figure 8-16. A concrete box culvert with straight profile and normal inlet is given. All other pertinent information is also supplied such as inlet and outlet stations with their elevations, maximum headwater elevation, maximum velocity, road side slopes along the centerline of the culvert, maximum culvert depth, statewide cost and, since a plan summary will be requested later, a job number.

The data is printed as it is read and edited (Figure 8-14).



```
$ STATION 1314+70                                                                  15003
$                                                                                  15003
CULBRG    DESIGN                               CULVERT   SINGLE                    15003
CLVRT 131                        BOX           CONCRETE                            15003
CLVRT 131 STRAIGHT                                                 NORMAL KE=040   15003
CLVRT 131 OUTLT STA     171.     EL3119.30 INLET STA     0.        EL3119.42       15003
CLVRT 131 MAX HEADWATER ELEV     3124.50   MAX OUTLET VELOCITY          10   FT/SC15003
ROAD  131 UPSTRM SS          3   DNSTRM SS          3  MAX DEPTH=       4          15003
COST      STATEWIDE                                                                15003
JOB NO.   IPE 905                                                                  15003
FILL HEIGHT   6FT                                                                  15003
ENDATA                                                                             15003
```

FIGURE 8-14. COMPUTER PRINTED INPUT DATA (FIRST CULVERT)

The culvert calculations are performed, and the results tabulated (Figure 8-18). The culvert identification is printed along with factors supplied by the user. For box culvert design, the trial sizes and their related values are tabulated. One or more lines of size may be listed, with the last line being the acceptable size. Then the adjusted stations, their elevations, and other factors used in the design (slope, profile, etc.) are printed.

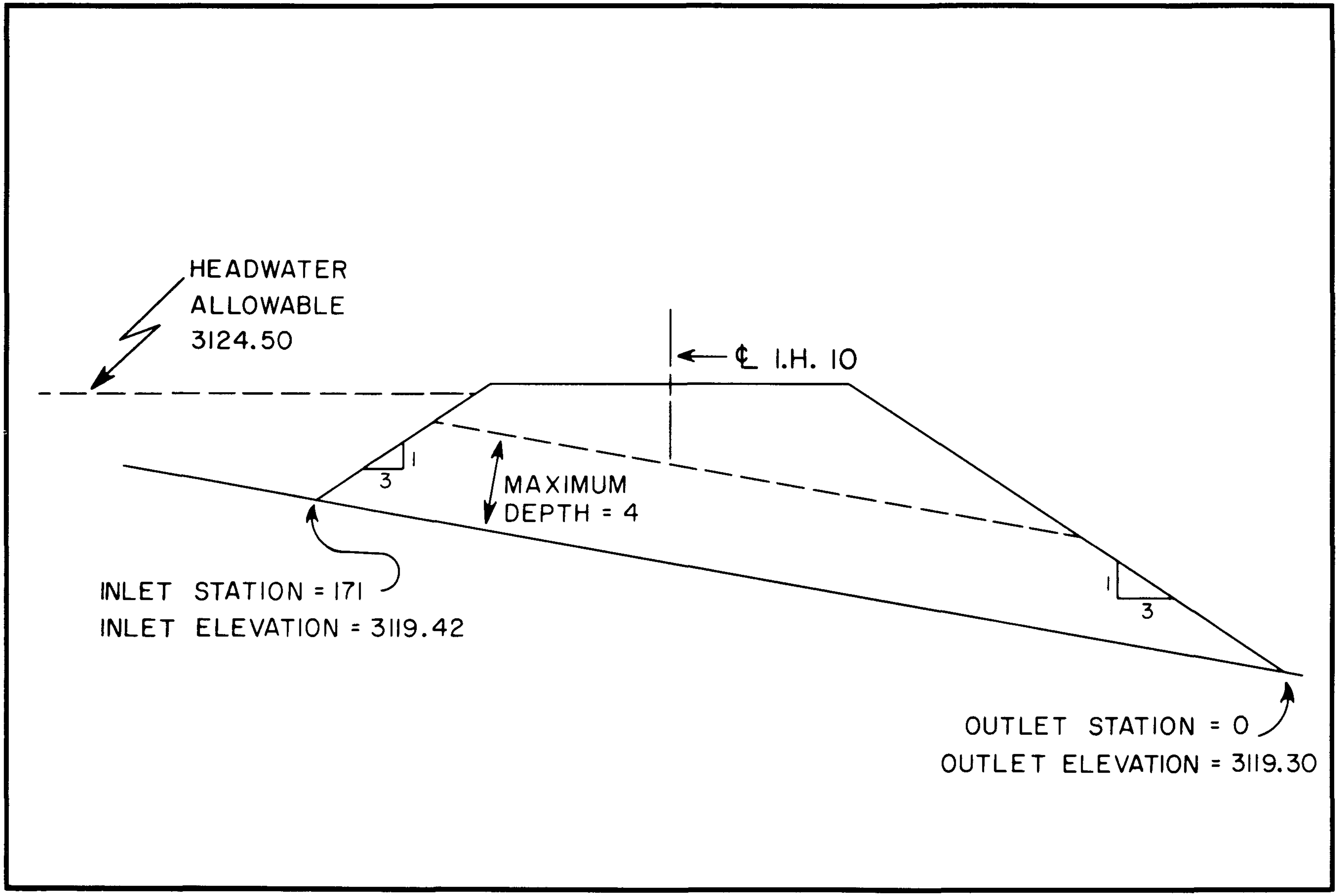


FIGURE 8-15. ILLUSTRATION OF CULVERT DESIGN PROBLEM

STATE DEPARTMENT OF HIGHWAYS
AND PUBLIC TRANSPORTATION

HYDRAULIC SYSTEM

CULVERT / BRIDGE SUBSYSTEM (CULBRG)

DISTRICT______ RES. NO.__________
I.P.E.________ PROJ. NO.__________
COUNTY______________________

PREPARED BY______
DATE__________
SHEET 1 OF 1

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80

Comments ☐	$ STATION		1314+70					15003
☐	$							15003
☐	$							
			Cross out one	Design: Cross out one or neither Analysis: Cross out one		Specify opening configuration. Cross out one.	Number	Prob. No.
Control Card ▮	CULBRG		DESIGN ~~ANALYSIS~~	~~BRIDGE~~	CULVERT	SINGLE	~~MULTIPLE~~	15003
			This card is necessary only for values not supplied from other subsystems. (HYDRO or HYDRA)					
C-1 ☐	SUPPLY	Q=	CFS	TW ELEV =		FREQUENCY=	YRS	
		Clvrt ID	Select pipe shape. Cross out all but one.		Select "n" value. Cross out all but one.		"n" value	
C-2 ▮	CLVRT	131	~~CIRCULAR~~ ~~ARCH~~ ~~OVAL~~	BOX	CONCRETE	~~CGMP~~	~~PLATE~~	15003
		Clvrt ID	Select profile configuration. Cross out all but one.		Select inlet condition. Cross out all but one.		"Ke" value	
C-3 ▮	CLVRT	131	STRAIGHT ~~BROKEN BK~~	~~STEPPED~~	~~FLARED~~	~~DROP INLET~~	NORMAL KE=040	15003
		Clvrt ID	Design: Station at toe along ℄ of structure Analysis: Station at end of structure along ℄ of structure	Design: Elev. at toe Analysis: Elev. of culv. F.L.	Design: Station at toe along ℄ of structure Analysis: Station at end of structure along ℄ of structure		Design: Elev. at toe Analysis: Elev. of culv. F.L.	
C-4 ▮	CLVRT	131	OUTLT STA 171.	EL3119.30	INLET STA	0.	EL3119.42	15003
		Clvrt ID	Stationing along centerline of structure	Break elevation	Stationing along centerline of structure		Break elevation	
C-5 ☐	CLVRT		BREAK STA	EL	BREAK STA		EL	
		Clvrt ID	Maximum headwater upstream of culvert	Elevation	Maximum allowable outlet velocity from culvert			
C-6 ▮	CLVRT	131	MAX HEADWATER ELEV	3124.50	MAX OUTLET	VELOCITY	10 FT/SC	15003
		Clvrt ID	Required entry for this card	Culvert diameter (in.)	Culvert rise	Culvert span	No. of culvert barrels	
C-7 ☐	CLVRT		DIMENSIONS	DIAM=	HIGH=	WIDE=	BARRELS=	
C-8 ▮	ROAD	131	UPSTRM SS 3	DNSTRM SS	3	MAX DEPTH=	4	15003
		Subsec ID	Maximum allowable average velocity through bridge		Minimum allowable average velocity through bridge			
C-9 ☐	BRDG		MAX AVERAGE VELOCITY		MIN AVERAGE	VELOCITY	FT/SC	
		Subsec ID	Left header slope	Right header slope		Insert one: UP or DN	Orig. sec. ID if skewed	
C-10 ☐	BRDG		LEFT S.S.	RIGHT S.S		LOOKING	STREAM	
		Subsec ID	Cross – section ID Distance along cross – section					
C-11 ☐	FL-DV		SECX FRM X DIS		TO X DIST			
☐	FL-DV		SECX FRM X DIS		TO X DIST			
☐	FL-DV		SECX FRM X DIS		TO X DIST			
			Delete if Statewide Averages not desired					
C-15 ▮	COST		STATEWIDE					15003
			Supply job number for culvert if plan summary desired					
C-12 ▮	JOB NO.		IPE 905					15603
C-13 ☐	ENDATA							
C-14 ☐	PLAN SUMMARY							

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80

Note: *
▮ Mark box as shown beside each line used.

FORM CONTINUED ON BACK

FORM 1308-1
(Revised 8/74)

FIGURE 8-16. CULBRG INPUT DATA (FIRST CULVERT DESIGN)

BACK, SHEET 1 OF 1

		Specify Concrete and Steel prices		OR Cost per Foot
C-16	BOX PRICE	CONCRETE $. /CY	REINF STL $. /LB	COST/FT $

		Specify one price or both.		Diam. or Rise (in.)	Span (in.)	Estimated cost per flare unit for this diameter.
C-17	PIP PRICE	CGMP $. /LF	RCP $. /LF			FLARE UNIT $
	PIP PRICE	CGMP $. /LF	RCP $. /LF			FLARE UNIT $
	PIP PRICE	CGMP $. /LF	RCP $. /LF			FLARE UNIT $
	PIP PRICE	CGMP $. /LF	RCP $. /LF			FLARE UNIT $
	PIP PRICE	CGMP $. /LF	RCP $. /LF			FLARE UNIT $
	PIP PRICE	CGMP $. /LF	RCP $. /LF			FLARE UNIT $
	PIP PRICE	CGMP $. /LF	RCP $. /LF			FLARE UNIT $
	PIP PRICE	CGMP $. /LF	RCP $. /LF			FLARE UNIT $
	PIP PRICE	CGMP $. /LF	RCP $. /LF			FLARE UNIT $
	PIP PRICE	CGMP $. /LF	RCP $. /LF			FLARE UNIT $
	PIP PRICE	CGMP $. /LF	RCP $. /LF			FLARE UNIT $
	PIP PRICE	CGMP $. /LF	RCP $. /LF			FLARE UNIT $
	PIP PRICE	CGMP $. /LF	RCP $. /LF			FLARE UNIT $
	PIP PRICE	CGMP $. /LF	RCP $. /LF			FLARE UNIT $
	PIP PRICE	CGMP $. /LF	RCP $. /LF			FLARE UNIT $
	PIP PRICE	CGMP $. /LF	RCP $. /LF			FLARE UNIT $

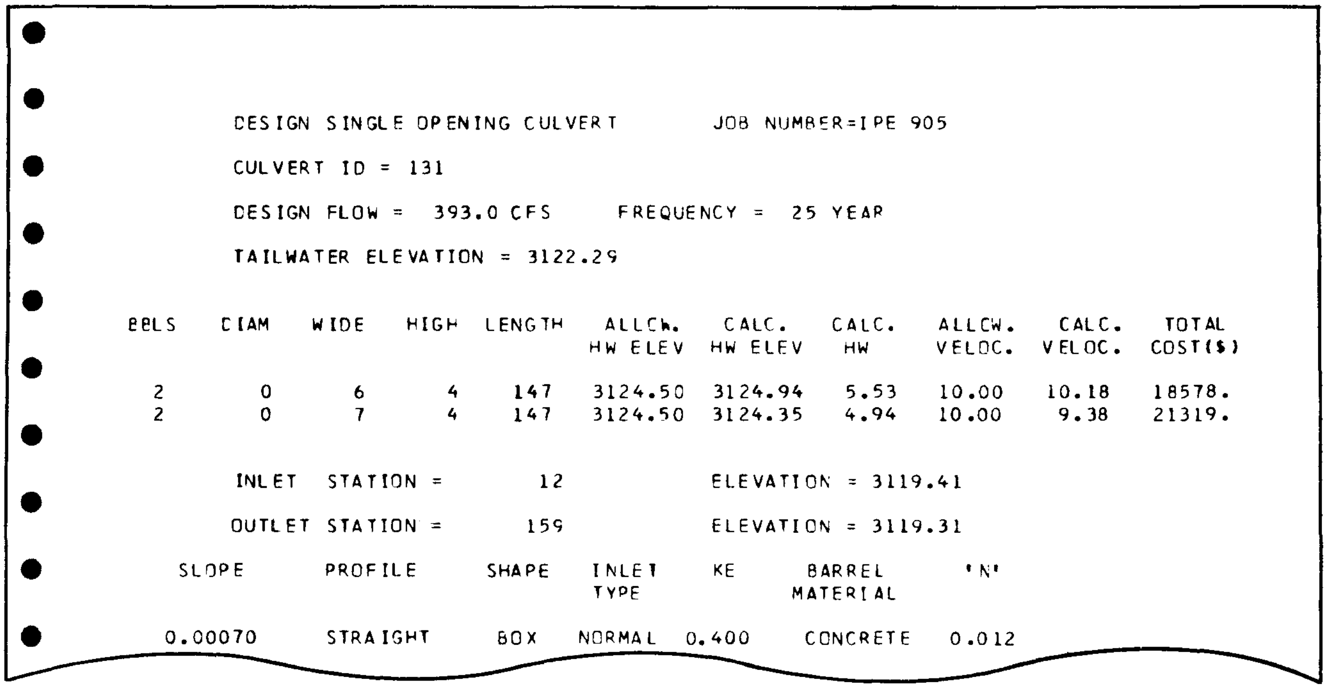
	Required card for each Box culvert design.	
C-18	FILL HEIGHT 6FT	15003

		If applicable specify any miscellaneous costs for each culvert design.					
C-19	MISC COSTS $	CONC	STEEL	RIPRAP	HEADWALLS	EXCAVATION	GENERAL
	MISC COSTS $	CONC	STEEL	RIPRAP	HEADWALLS	EXCAVATION	GENERAL
	MISC COSTS $	CONC	STEEL	RIPRAP	HEADWALLS	EXCAVATION	GENERAL
	MISC COSTS $	CONC	STEEL	RIPRAP	HEADWALLS	EXCAVATION	GENERAL
	MISC COSTS $	CONC	STEEL	RIPRAP	HEADWALLS	EXCAVATION	GENERAL
	MISC COSTS $	CONC	STEEL	RIPRAP	HEADWALLS	EXCAVATION	GENERAL

C-20 FREQ=100 Q= CFS TW= CLEAR ELEV=

		Coordinate point		Coordinate point		Coordinate point	
		X Coordinate (Dist.)	Y Coordinate (Elev.)	X Coordinate (Dist.)	Y Coordinate (Elev.)	X Coordinate (Dist.)	Y Coordinate (Elev.)
C-21	RD PROFILE	X	Y	X	Y	X	Y
	RD PROFILE	X	Y	X	Y	X	Y
	RD PROFILE	X	Y	X	Y	X	Y
	RD PROFILE	X	Y	X	Y	X	Y
	RD PROFILE	X	Y	X	Y	X	Y
	RD PROFILE	X	Y	X	Y	X	Y
	RD PROFILE	X	Y	X	Y	X	Y
	RD PROFILE	X	Y	X	Y	X	Y
	RD PROFILE	X	Y	X	Y	X	Y
	RD PROFILE	X	Y	X	Y	X	Y
C-13	ENDATA						
C-14	PLAN SUMMARY						

FIGURE 8-17. CULBRG INPUT DATA (FIRST CULVERT DESIGN)

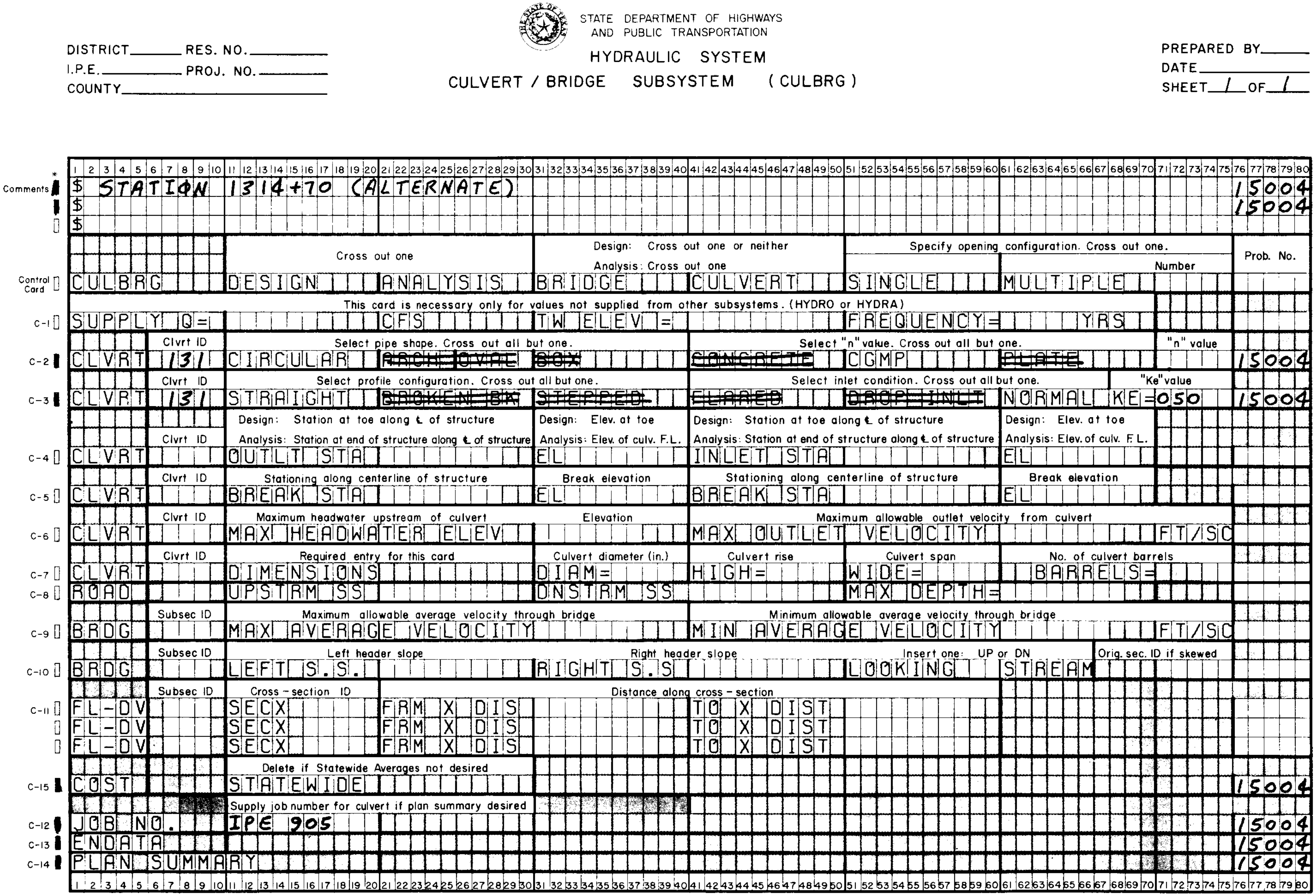


```
          CESIGN SINGLE OPENING CULVERT        JOB NUMBER=IPE 905

          CULVERT ID = 131

          CESIGN FLOW =  393.0 CFS      FREQUENCY =  25 YEAR

          TAILWATER ELEVATION = 3122.29

  BBLS    CIAM    WIDE    HIGH  LENGTH   ALLCW.    CALC.    CALC.   ALLCW.   CALC.   TOTAL
                                         HW ELEV  HW ELEV    HW     VELOC.  VELOC.  COST($)

   2       0       6       4     147    3124.50  3124.94   5.53    10.00    10.18   18578.
   2       0       7       4     147    3124.50  3124.35   4.94    10.00     9.38   21319.

          INLET  STATION =        12            ELEVATION = 3119.41

          OUTLET STATION =       159            ELEVATION = 3119.31

     SLOPE       PROFILE     SHAPE   INLET    KE      BARREL      'N'
                                     TYPE             MATERIAL

    0.00070      STRAIGHT     BOX   NORMAL  0.400    CONCRETE   0.012
```

FIGURE 8-18. CULVERT CALCULATIONS FOR THE FIRST CULVERT DESIGN

Several culvert designs for the same site may be attempted by entering all the data for one CULBRG problem (including the CULBRG Control card and ENDATA card) followed by consecutive problems where only the cards containing changes and an ENDATA card are used for each additional design. When changes are to be made in this manner, it is necessary to reenter all data for only the cards containing the changes and to include an ENDATA card following each new design. As shown in Figure 8-19, the user wishes to try a circular CGMP culvert with a different KE factor; therefore, only those data lines are completed. The Job card is included so that this data may be printed in the plan summary. The ENDATA line signals the end of the data, and then the PLAN SUMMARY line is indicated so that a list of the previous design sizes will be printed.

The edited input data for the second culvert is shown in Figure 8-20. The output in Figure 8-21 is identical to the output for the box culvert, except that the acceptable design size is printed again after all the trial sizes have been tabulated.



STATE DEPARTMENT OF HIGHWAYS
AND PUBLIC TRANSPORTATION

HYDRAULIC SYSTEM

CULVERT / BRIDGE SUBSYSTEM (CULBRG)

DISTRICT______ RES. NO.________

I.P.E.________ PROJ. NO.________

COUNTY________________

PREPARED BY______

DATE________

SHEET 1 OF 1

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80

* Comments ▮	$ STATION	1314+70	(ALTERNATE)							15004
▮	$									15004
☐	$									
			Cross out one		Design: Cross out one or neither Analysis: Cross out one		Specify opening configuration. Cross out one.		Number	Prob. No.
Control Card ☐	CULBRG		DESIGN	ANALYSIS	BRIDGE	CULVERT	SINGLE	MULTIPLE		
	This card is necessary only for values not supplied from other subsystems. (HYDRO or HYDRA)									
C-1 ☐	SUPPLY Q=			CFS	TW ELEV =		FREQUENCY=	YRS		
		Clvrt ID	Select pipe shape. Cross out all but one.			Select "n" value. Cross out all but one.			"n" value	
C-2 ▮	CLVRT	131	CIRCULAR	~~ARCH~~ ~~OVAL~~	~~BOX~~	~~CONCRETE~~	CGMP	~~PLATE~~		15004
		Clvrt ID	Select profile configuration. Cross out all but one.			Select inlet condition. Cross out all but one.			"Ke" value	
C-3 ▮	CLVRT	131	STRAIGHT	~~BROKEN BK~~	~~STEPPED~~	~~FLARED~~	~~DROP INLT~~	NORMAL KE=	050	15004
		Clvrt ID	Design: Station at toe along ℄ of structure Analysis: Station at end of structure along ℄ of structure		Design: Elev. at toe Analysis: Elev. of culv. F.L.	Design: Station at toe along ℄ of structure Analysis: Station at end of structure along ℄ of structure		Design: Elev. at toe Analysis: Elev. of culv. F.L.		
C-4 ☐	CLVRT		OUTLT STA		EL	INLET STA		EL		
		Clvrt ID	Stationing along centerline of structure		Break elevation	Stationing along centerline of structure		Break elevation		
C-5 ☐	CLVRT		BREAK STA		EL	BREAK STA		EL		
		Clvrt ID	Maximum headwater upstream of culvert		Elevation	Maximum allowable outlet velocity from culvert				
C-6 ☐	CLVRT		MAX HEADWATER	ELEV		MAX OUTLET	VELOCITY		FT/SC	
		Clvrt ID	Required entry for this card		Culvert diameter (in.)	Culvert rise	Culvert span	No. of culvert barrels		
C-7 ☐	CLVRT		DIMENSIONS		DIAM=	HIGH=	WIDE=	BARRELS=		
C-8 ☐	ROAD		UPSTRM SS		DNSTRM SS		MAX DEPTH=			
		Subsec ID	Maximum allowable average velocity through bridge			Minimum allowable average velocity through bridge				
C-9 ☐	BRDG		MAX AVERAGE	VELOCITY		MIN AVERAGE	VELOCITY		FT/SC	
		Subsec ID	Left header slope		Right header slope		Insert one: UP or DN		Orig. sec. ID if skewed	
C-10 ☐	BRDG		LEFT S.S.		RIGHT S.S		LOOKING	STREAM		
		Subsec ID	Cross - section ID	Distance along cross - section						
C-11 ☐	FL-DV		SECX	FRM X DIS		TO X DIST				
☐	FL-DV		SECX	FRM X DIS		TO X DIST				
☐	FL-DV		SECX	FRM X DIS		TO X DIST				
			Delete if Statewide Averages not desired							
C-15 ▮	COST		STATEWIDE							15004
			Supply job number for culvert if plan summary desired							
C-12 ▮	JOB NO.		IPE 905							15004
C-13 ▮	ENDATA									15004
C-14 ▮	PLAN SUMMARY									15004

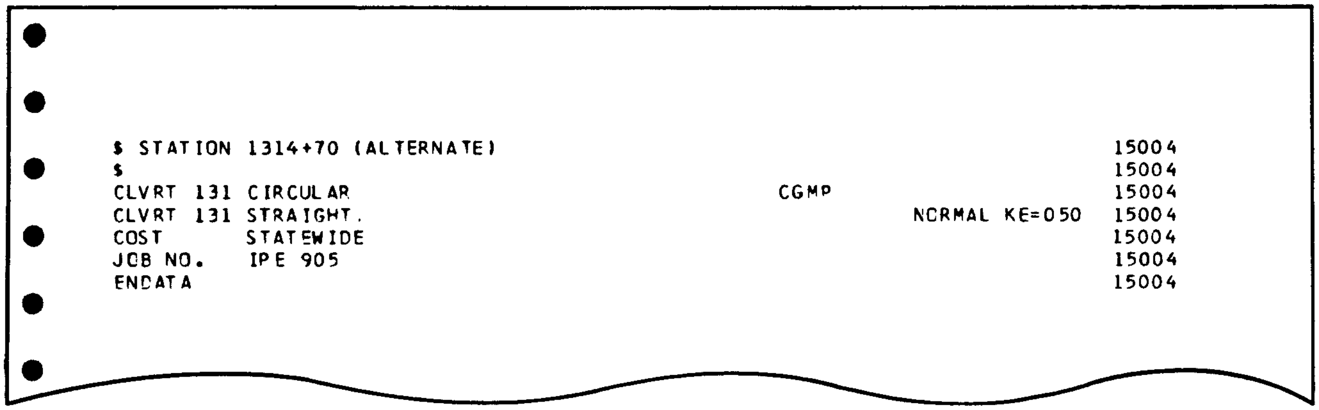
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80

Note: * ▮ Mark box as shown beside each line used.

FORM CONTINUED ON BACK

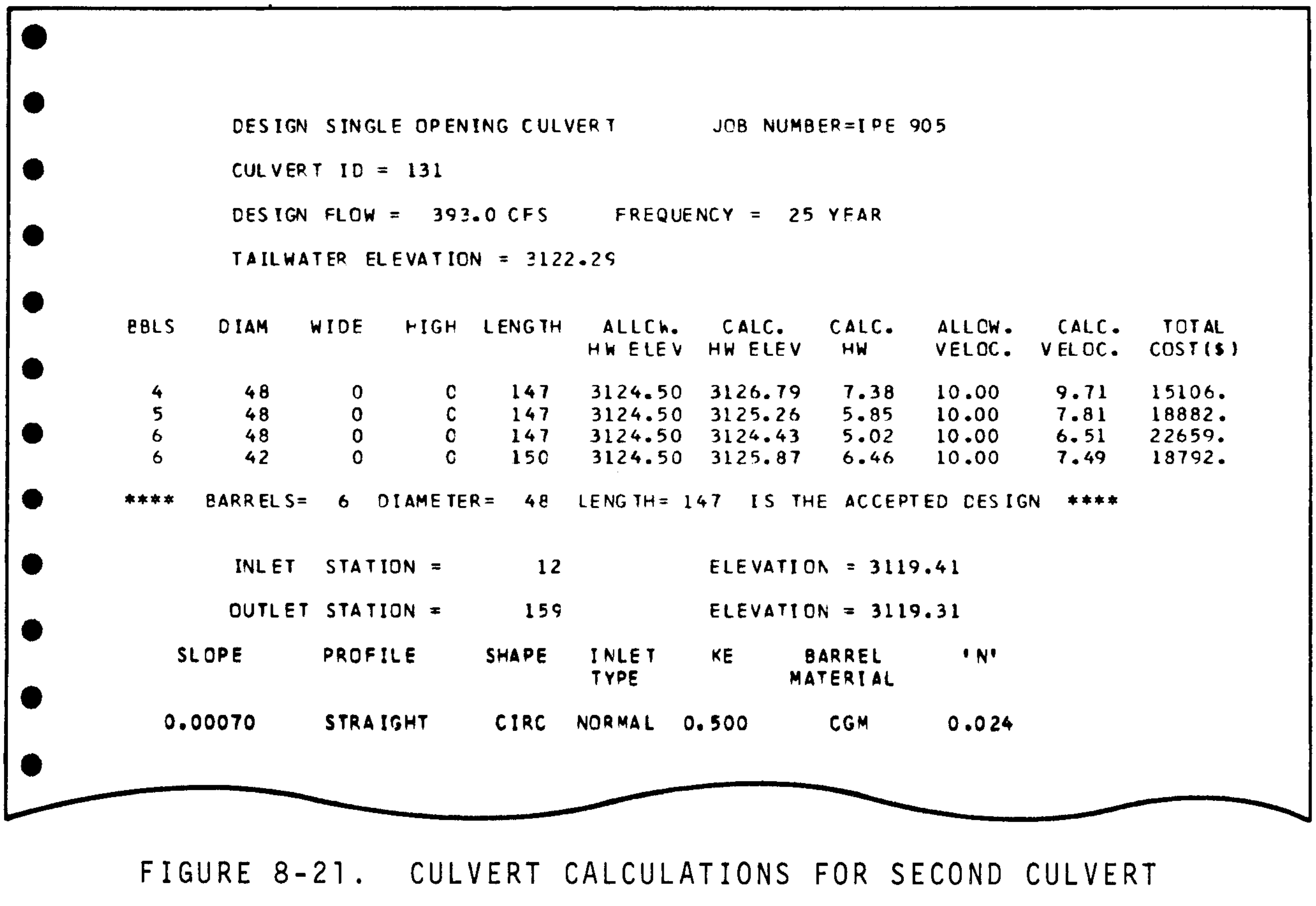
FORM 1308-1
(Revised 8/74)

FIGURE 8-19. CULBRG INPUT FORM (SECOND CULVERT DESIGN)



```
$ STATION 1314+70 (ALTERNATE)                                                        15004
$                                                                                    15004
CLVRT  131 CIRCULAR                                   CGMP                           15004
CLVRT  131 STRAIGHT.                                            NORMAL KE=050        15004
COST        STATEWIDE                                                                15004
JOB NO.     IPE 905                                                                  15004
ENDATA                                                                               15004
```

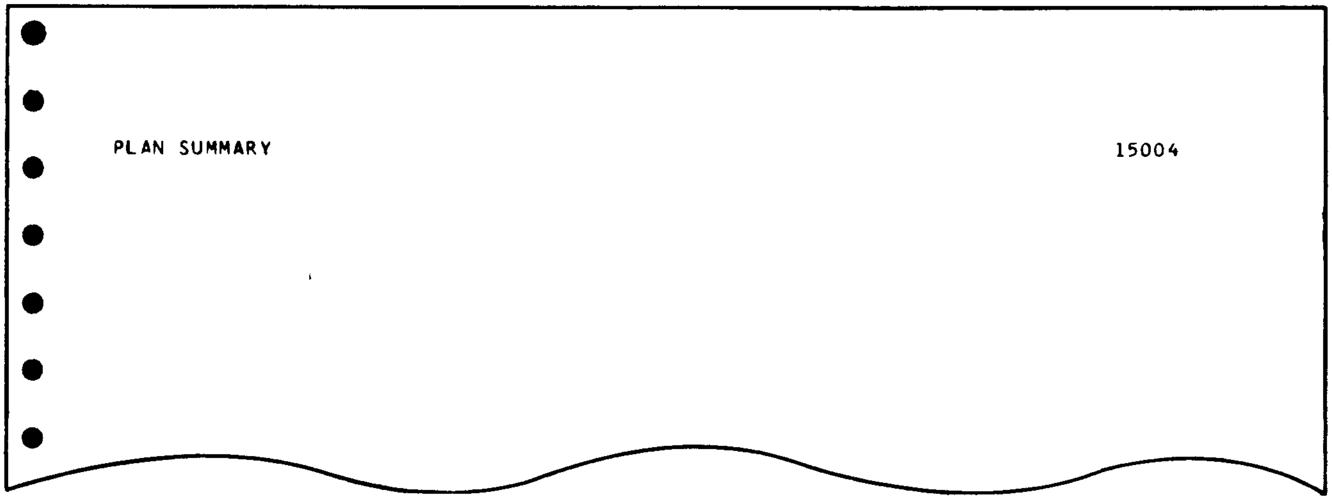
FIGURE 8-20. COMPUTER PRINTED INPUT DATA (SECOND CULVERT)



```
         DESIGN SINGLE OPENING CULVERT        JOB NUMBER=IPE 905

         CULVERT ID = 131

         DESIGN FLOW =   393.0 CFS     FREQUENCY =  25 YEAR

         TAILWATER ELEVATION = 3122.29

 BBLS    DIAM    WIDE    HIGH  LENGTH    ALLOW.    CALC.    CALC.    ALLOW.    CALC.    TOTAL
                                        HW ELEV   HW ELEV   HW       VELOC.   VELOC.   COST($)

  4       48      0       0     147    3124.50   3126.79   7.38     10.00     9.71    15106.
  5       48      0       0     147    3124.50   3125.26   5.85     10.00     7.81    18882.
  6       48      0       0     147    3124.50   3124.43   5.02     10.00     6.51    22659.
  6       42      0       0     150    3124.50   3125.87   6.46     10.00     7.49    18792.

 ****  BARRELS=  6  DIAMETER=  48  LENGTH= 147  IS THE ACCEPTED DESIGN  ****

         INLET  STATION =       12            ELEVATION = 3119.41

        OUTLET  STATION =      159            ELEVATION = 3119.31

     SLOPE       PROFILE      SHAPE    INLET     KE      BARREL      'N'
                                       TYPE              MATERIAL

   0.00070      STRAIGHT      CIRC    NORMAL   0.500      CGM       0.024
```

FIGURE 8-21. CULVERT CALCULATIONS FOR SECOND CULVERT

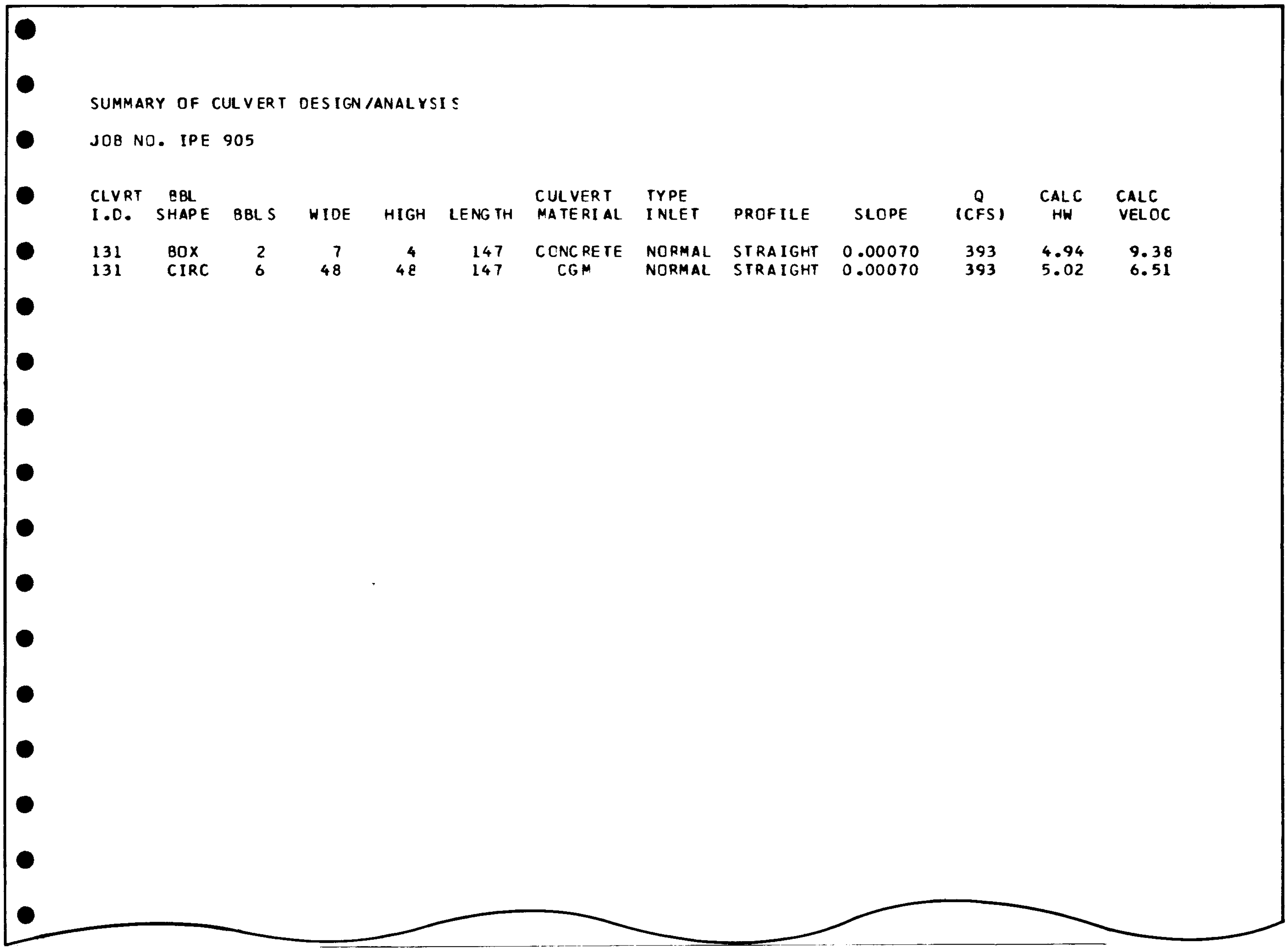
When a plan summary is specified, that instruction will be printed (Figure 8-22) and the plan summary will appear on the following computer output page as shown in Figure 8-23. Due to the number of items printed on each line, this report must be turned on its side before trimming to fit an 8 1/2" by 11" binder.



```
PLAN SUMMARY                                                      15004
```

FIGURE 8-22. PLAN SUMMARY INSTRUCTIONS

Only culvert data will be printed on the plan summary, but it may include both analysis and design problems. Up to 100 culverts may be listed per job. Each line represents a preceding report for either culvert design or analysis; and, in the case of design, only the accepted design size is printed.



```
SUMMARY OF CULVERT DESIGN/ANALYSIS

JOB NO. IPE 905

CLVRT  BBL                                    CULVERT   TYPE                                 Q      CALC     CALC
I.D.   SHAPE   BBLS    WIDE    HIGH  LENGTH   MATERIAL  INLET   PROFILE     SLOPE          (CFS)    HW      VELOC

131     BOX     2        7       4     147    CONCRETE  NORMAL  STRAIGHT  0.00070          393     4.94      9.38
131     CIRC    6       48      48     147      CGM     NORMAL  STRAIGHT  0.00070          393     5.02      6.51
```

FIGURE 8-23. COMPUTER PRINTED PLAN SUMMARY SHEET

V. 100 YEAR FLOOD ANALYSIS SAMPLE PROBLEM

An illustration of an existing bridge is shown in Figure 8-24. Following is the input and output required to perform a 100 year flood analysis for this structure. Note that the Q for a 100 year flood was computed in HYDRO and passed to HYDRA and CULBRG.

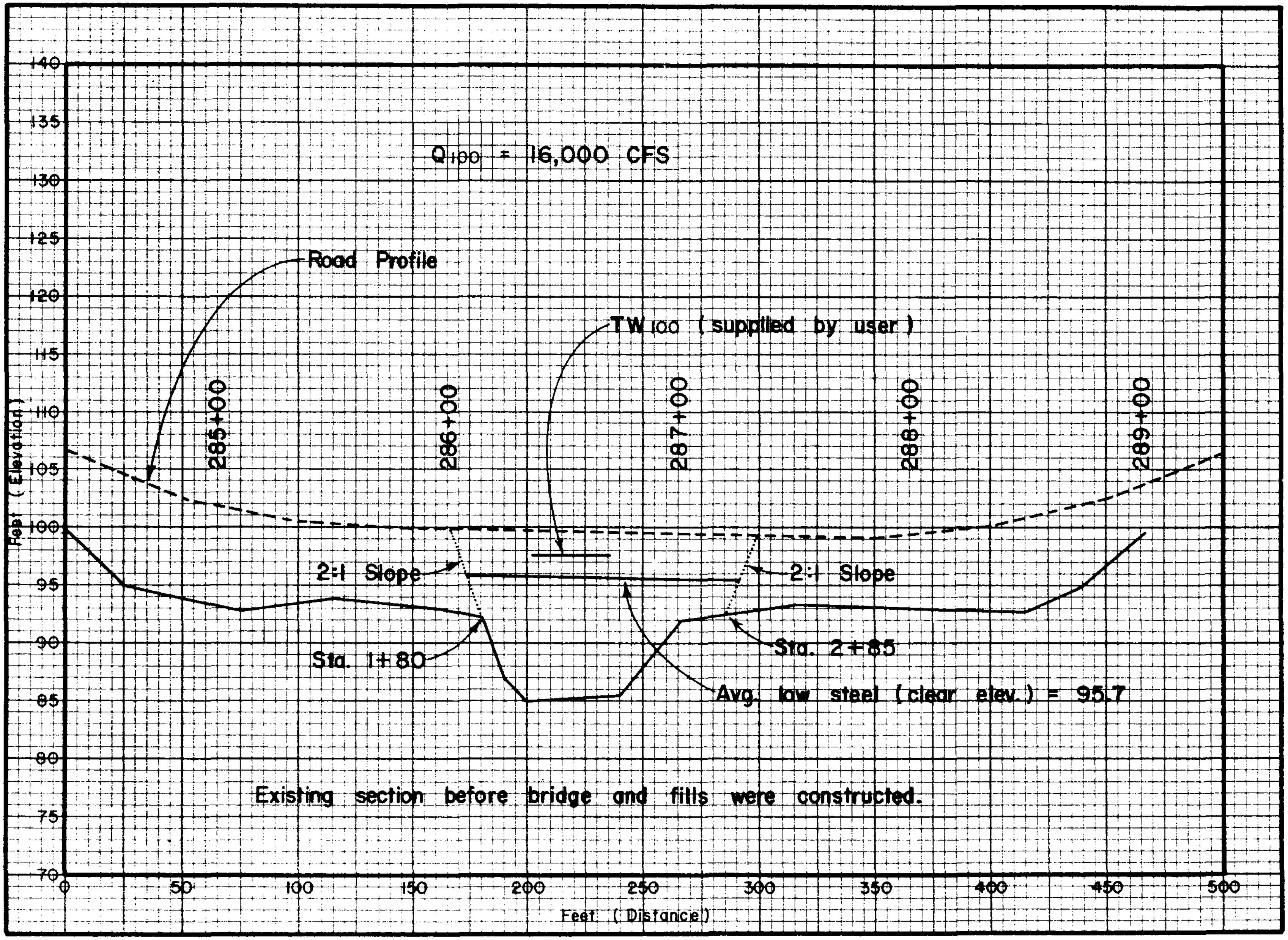


FIGURE 8-24. CROSS-SECTION AT BRIDGE SITE

STATE DEPARTMENT OF HIGHWAYS
AND PUBLIC TRANSPORTATION

HYDRAULIC SYSTEM

HYDROLOGY SUBSYSTEM (HYDRO)

DISTRICT_____ RES. NO.______
I.P.E.______ PROJ. NO.______
COUNTY____________

PREPARED BY_____
DATE______
SHEET 1 OF 3

*	1 2 3 4 5 6	7 8 9 10	11–20	21–30	31–40	41–50	51–60	61–65	66–70	71–75	76 77 78 79 80
Comments ▮	$ SAMPLE PROBLEM--100 YEAR FLOOD ANALYSIS										15008
▮	$										15008
☐	$										
			Total Drainage Area	Cross out one							Prob. No.
Control Card ▮	HYDRO		DA 9.222	~~ACRES~~ SQMI							15008
			Method card — Select one of the four options listed below. Cross out all others.								
	Method Card (Supply data for selected method)		200 Acres < D.A. < 3000 square miles		D.A. ≤ 200 Acres Supply only rational data	Log-Pearson method Supply only gage data	User supplies peak discharge			Frequency of discharge	
A-1 ▮	METHOD		USGS		~~RATIONAL~~	~~GAGE ANAL~~	~~SUPPLY Q=~~			100YR	15008
	Peak change card		Q added to peak discharge								
A-2 ☐	BASEFLOW =			CFS							
			Select proper area number from map. Possible numbers 1 through 6.		Slope in feet per mile Supply if Region = 1,2,4, or 5.		Total annual precipitation Supply if Region = 6.				
	USGS Data										
A-3 ▮	USGS		REGION = 5		SLOPE =	51.0FT/MI	~~PRECIP =~~	~~IN/YR~~			15008
			Weighted "C" coefficient determination		Time of concentration determination Enter Sublength & Velocity ; OR Tc			Constants from SDHPT Hydraulic Manual			
	Rational data	Subarea ID	"C" Coefficient	Subarea (acres)	Sublength (ft)	Velocity (ft/sec)	Tc (minutes)	e	b	d	
A-4 ☐	RADATA										
☐	RADATA										
☐	RADATA										
☐	RADATA										
☐	RADATA										
☐	RADATA										
☐	RADATA										
☐	RADATA										
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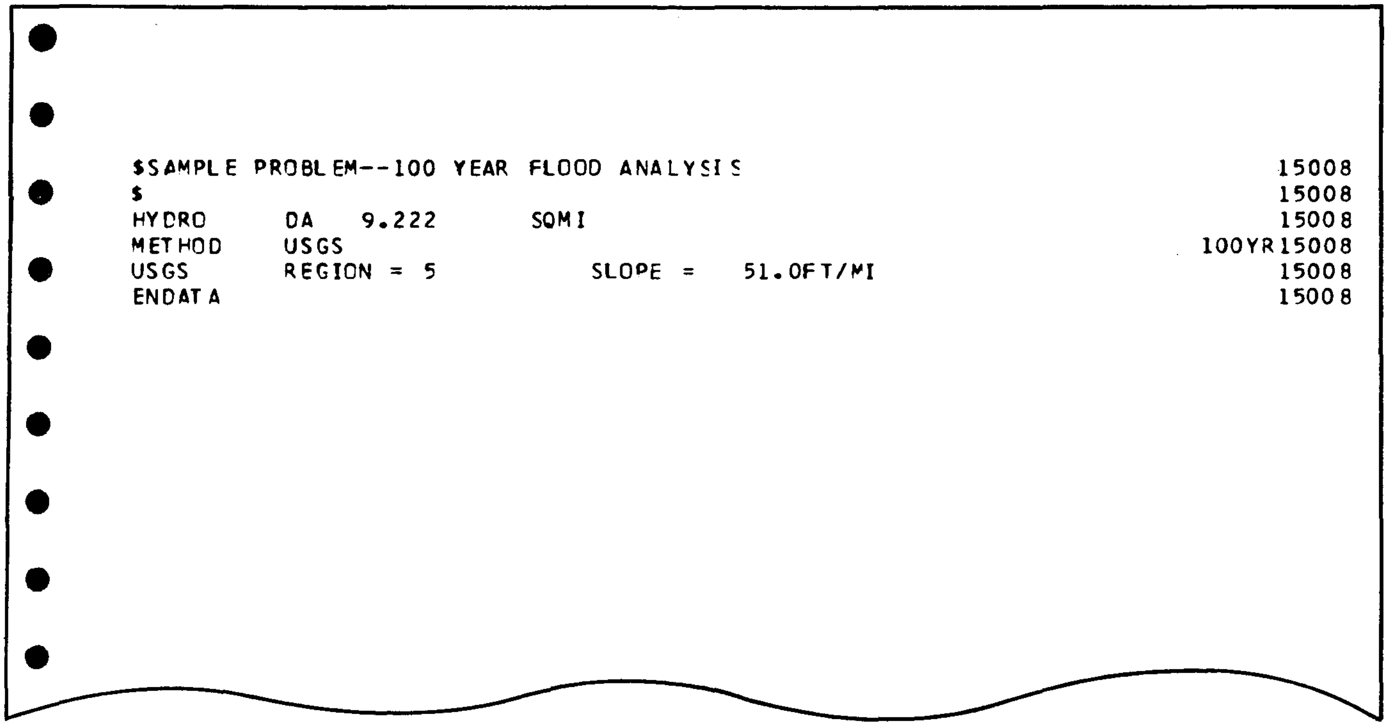
☐	RADATA										
☐	RADATA										
☐	RADATA										
☐	RADATA										
☐	RADATA										
☐	RADATA										
☐	RADATA										
☐	RADATA										
A-7 ▮	ENDATA										15008
	1 2 3 4 5 6	7 8 9 10	11–20	21–30	31–40	41–50	51–60	61–65	66–70	71–75	76 77 78 79 80

*Note: ▮ Mark box as shown beside each line used.

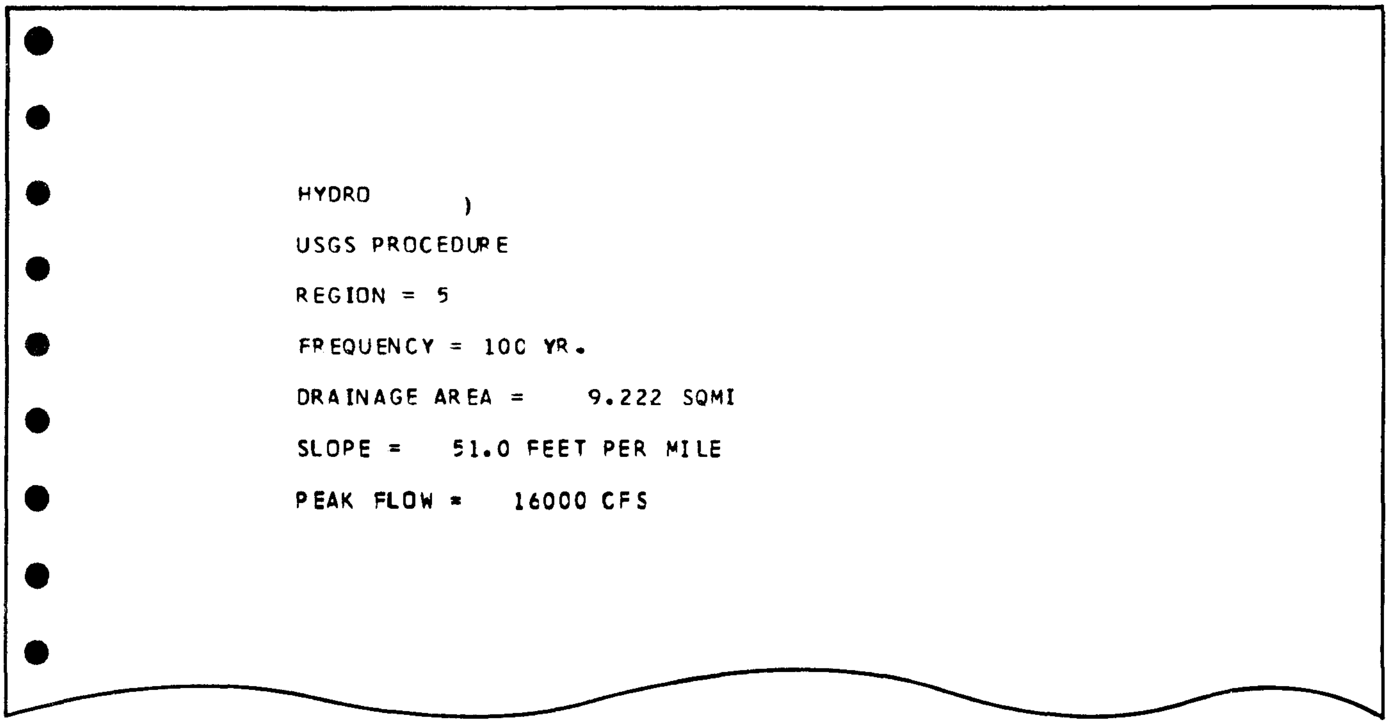
FIGURE 8-25. HYDRO INPUT DATA

FORM 1306-1 (Revised 12/76)
FORM CONTINUED ON BACK



```
$SAMPLE PROBLEM--100 YEAR FLOOD ANALYSIS                                          15008
$                                                                                 15008
HYDRO     DA   9.222      SQMI                                                    15008
METHOD    USGS                                                               100YR15008
USGS      REGION = 5          SLOPE =    51.0FT/MI                                15008
ENDATA                                                                            15008
```

FIGURE 8-26. COMPUTER PRINTED HYDRO INPUT DATA



```
HYDRO        )

USGS PROCEDURE

REGION = 5

FREQUENCY = 100 YR.

DRAINAGE AREA =     9.222 SQMI

SLOPE =    51.0 FEET PER MILE

PEAK FLOW =    16000 CFS
```

FIGURE 8-27. HYDRO CALCULATIONS FOR PEAK FLOW

DISTRICT______ RES. NO.__________
I.P.E.__________ PROJ. NO.__________
COUNTY______________________

STATE DEPARTMENT OF HIGHWAYS
AND PUBLIC TRANSPORTATION

HYDRAULIC SYSTEM
CHANNEL ANALYSIS SUBSYSTEM (HYDRA)

PREPARED BY______
DATE__________
SHEET 2 OF 3

	1–10	11–20	21–30	31–40	41–50	51–60	61–70	71–75	76–80
Comments ▮	$ SAMPLE P	ROBLEM--10	0 YEAR FLO	OD ANALYSIS					15008
▮	$								15008
▯	$								
		Drainage area	Cross out one	User supplies	Q (cfs) Freq.	Q (cfs) Freq.	Q (cfs) Freq.		Prob. No.
Control Card ▮	HYDRA	DA= 9.222	~~ACRES~~ SQMI	~~Q & FREQ=~~			~~100~~		15008
		Water surface slope (ft./ft.)		Section ID	Station	Station at which water elev. is needed – Which is:		(Insert one) UPSTM DNSTM	
B-1 ▯	ONE SECT	SLOPE =		SECT ⊙		WATEL⊙ STA			
		Optional specific elevation		Optional specific elevation		Specify one increment of elevation			
B-1a ▯	WATERWAY	W.S. ELEV		W.S. ELEV		INCR ELEV			
		Downstream section at station		Upstream section at station		Station at which water elev. is needed			
B-2 ▯	TWO SECT	SECT ⊙		SECT ⊙		WATEL⊙ STA			
		Downstream station where W.S. profile starts		Elevation at downstream station		Station at which water elev. is needed			
B-3 ▯	MANY SECT	STRT⊙ STA		W.S. ELEV		WATEL⊙ STA			
▯	MANY SECT			W.S. ELEV					
▯	MANY SECT			W.S. ELEV					
		Section ID at station		Section ID at station		Section ID at station			
B-4 ▯	SEQUENCE	SECT ⊙		SECT ⊙		SECT ⊙			
B-5 ▯	SEQ CONT	SECT ⊙		SECT ⊙		SECT ⊙			

		Cross-sect. ID	Coordinate point		Coordinate point		Coordinate point			
			X Coordinate (Dist.)	Y Coordinate (Elev.)	X Coordinate (Dist.)	Y Coordinate (Elev.)	X Coordinate (Dist.)	Y Coordinate (Elev.)		
B-6 ▮	SECX	A	X 0	Y 100.0	X 25	Y 95.0	X 75	Y 93.0		15008
▮	SECX	A	X 116	Y 94.0	X 180	Y 92.4	X 190	Y 87.0		↓
▮	SECX	A	X 200	Y 85.0	X 240	Y 85.5	X 266	Y 91.8		↓
▮	SECX	A	X 316	Y 93.3	X 417	Y 92.6	X 440	Y 94.9		15008
▮	SECX	A	X 472	Y 100.0	≠	≠	≠	≠		15008
▯	SECX		X	Y	X	Y	X	Y		
▯	SECX		X	Y	X	Y	X	Y		
▯	SECX		X	Y	X	Y	X	Y		
▯	SECX		X	Y	X	Y	X	Y		
▯	SECX		X	Y	X	Y	X	Y		
▯	SECX		X	Y	X	Y	X	Y		
▯	SECX		X	Y	X	Y	X	Y		
▯	SECX		X	Y	X	Y	X	Y		
▯	SECX		X	Y	X	Y	X	Y		
▯	SECX		X	Y	X	Y	X	Y		

Note: * ▮ Mark box as shown beside each line used.

FIGURE 8-28. HYDRA INPUT DATA

FORM CONTINUED ON BACK

FORM 1307-1
(Revised 8/74)

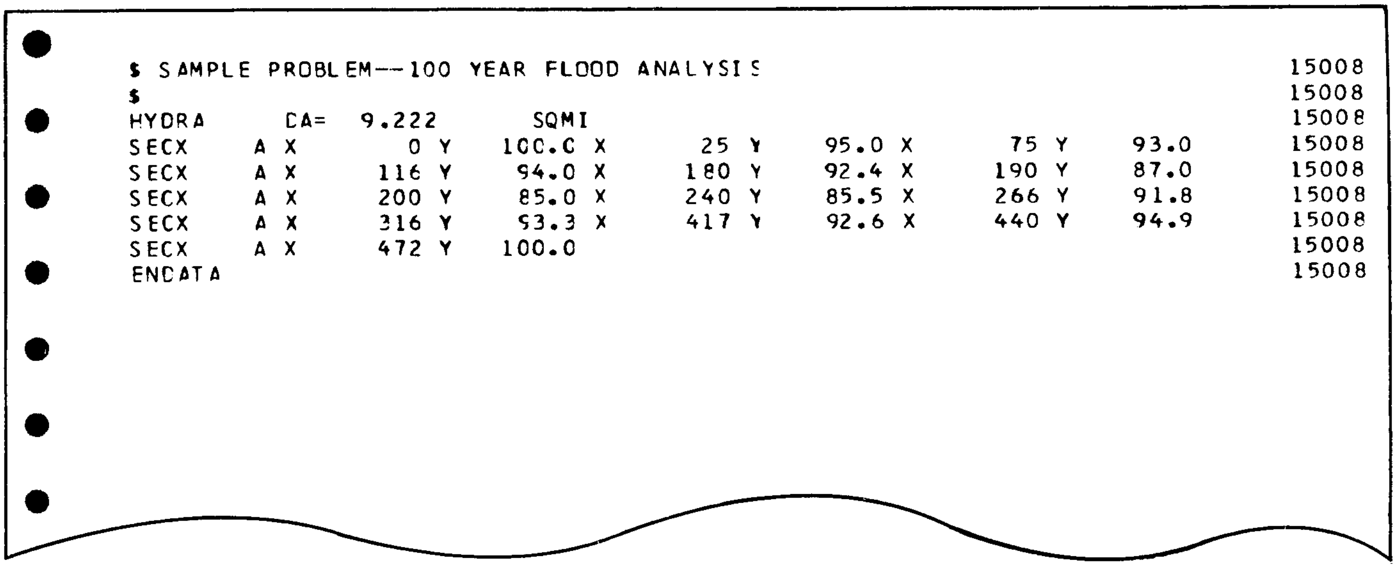
HYDRA (Continued)

BACK, SHEET 2 OF 3

		Cross-sect. ID	Coordinate point X Coordinate (Dist.)	Y Coordinate (Elev.)	Coordinate point X Coordinate (Dist.)	Y Coordinate (Elev.)	Coordinate point X Coordinate (Dist.)	Y Coordinate (Elev.)	
B-6 ☐	SECX		X	Y	X	Y	X	Y	
☐	SECX		X	Y	X	Y	X	Y	
☐	SECX		X	Y	X	Y	X	Y	
☐	SECX		X	Y	X	Y	X	Y	
☐	SECX		X	Y	X	Y	X	Y	
☐	SECX		X	Y	X	Y	X	Y	
☐	SECX		X	Y	X	Y	X	Y	
☐	SECX		X	Y	X	Y	X	Y	
		Cross-sect. ID	Subsection definition From X Distance	To X Distance	"n" value specification by subsection "n" or "n" below Elev.	Elevation	"n" above Elev.	Drainage area ratio (use only with Many – Section method)	
B-7 ☐	SECN		X	X	N = .		N = .	.	
☐	SECN		X	X	N = .		N = .	.	
☐	SECN		X	X	N = .		N = .	.	
☐	SECN		X	X	N = .		N = .	.	
☐	SECN		X	X	N = .		N = .	.	
☐	SECN		X	X	N = .		N = .	.	
☐	SECN		X	X	N = .		N = .	.	
☐	SECN		X	X	N = .		N = .	.	
☐	SECN		X	X	N = .		N = .	.	
☐	SECN		X	X	N = .		N = .	.	
☐	SECN		X	X	N = .		N = .	.	
☐	SECN		X	X	N = .		N = .	.	
☐	SECN		X	X	N = .		N = .	.	
		Section ID	Specify tailwater elevation and plus ; OR minimum headwater, maximum headwater, and increment Tailwater elevation + plus = backwater elevation		ft.	Minimum H.W. elevation	Maximum H.W. elevation	Increment (ft.)	
B-8 ☐	CNVY		T.W. ELEV=		PLUS=			INCR=	
		Cross – sect. ID	Cross – section Identification	Stationing of new Cross – section	Adjust all cross – section Y values. (If applicable) Insert one: UP DOWN		Realignment perpendicular to water flow direction		
B-9 ☐	MOVE		TO	STA	VERT	FT	SKEW CORR	DEGREES	
			Section plotted	Plot Length (inches)	Plot Height (inches)	Section plotted	Plot Length (inches)	Plot Height (inches)	
B-10 ☐	GRAPHS		SECT	X=	Y=	SECT	X=	Y=	
☐	GRAPHS		SECT	X=	Y=	SECT	X=	Y=	
☐	GRAPHS		SECT	X=	Y=	SECT	X=	Y=	
B-11 ■	ENDATA								15008

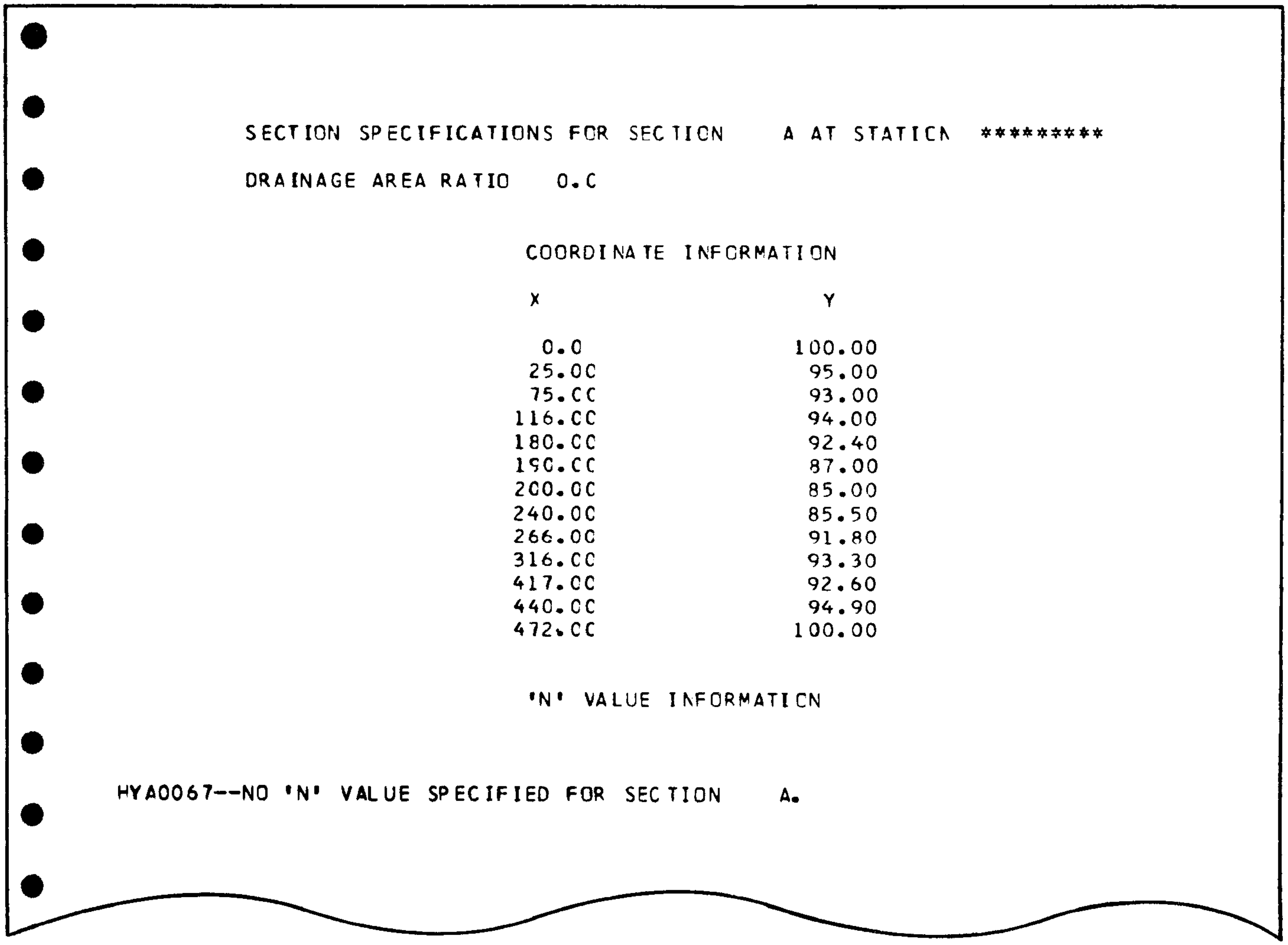
FIGURE 8-29. HYDRA INPUT DATA

FORM 1307-2
(Revised 8/74)



```
$ SAMPLE PROBLEM--100 YEAR FLOOD ANALYSIS                                                    15008
$                                                                                            15008
HYDRA     CA=  9.222       SQMI                                                              15008
SECX    A X        0 Y   100.0 X       25 Y    95.0 X       75 Y     93.0                    15008
SECX    A X      116 Y    94.0 X      180 Y    92.4 X      190 Y     87.0                    15008
SECX    A X      200 Y    85.0 X      240 Y    85.5 X      266 Y     91.8                    15008
SECX    A X      316 Y    93.3 X      417 Y    92.6 X      440 Y     94.9                    15008
SECX    A X      472 Y   100.0                                                               15008
ENDATA                                                                                       15008
```

FIGURE 8-30. COMPUTER PRINTED HYDRA INPUT DATA



```
         SECTION SPECIFICATIONS FOR SECTION    A AT STATION  *********

         DRAINAGE AREA RATIO    0.0


                              COORDINATE INFORMATION

                              X                  Y

                             0.0              100.00
                            25.00              95.00
                            75.00              93.00
                           116.00              94.00
                           180.00              92.40
                           190.00              87.00
                           200.00              85.00
                           240.00              85.50
                           266.00              91.80
                           316.00              93.30
                           417.00              92.60
                           440.00              94.90
                           472.00             100.00


                              'N' VALUE INFORMATION


HYA0067--NO 'N' VALUE SPECIFIED FOR SECTION    A.
```

FIGURE 8-31. COORDINATE INFORMATION FOR CROSS-SECTION

DISTRICT______ RES. NO.________
I.P.E.________ PROJ. NO.________
COUNTY________________

STATE DEPARTMENT OF HIGHWAYS
AND PUBLIC TRANSPORTATION

HYDRAULIC SYSTEM

CULVERT / BRIDGE SUBSYSTEM (CULBRG)

PREPARED BY______
DATE______
SHEET 3 OF 3

Comments *	▮	$ SAMPLE PROBLEM--100 YEAR FLOOD ANALYSIS — 15008
	▮	$ — 15008
	▯	$
		Cross out one | Design: Cross out one or neither / Analysis: Cross out one | Specify opening configuration. Cross out one. | Number | Prob. No.
Control Card	▮	CULBRG ~~DESIGN~~ ANALYSIS BRIDGE ~~CULVERT~~ SINGLE ~~MULTIPLE~~ 15008
		This card is necessary only for values not supplied from other subsystems. (HYDRO or HYDRA)
C-1	▯	SUPPLY Q= CFS TW ELEV = FREQUENCY= YRS
		Clvrt ID | Select pipe shape. Cross out all but one. | Select "n" value. Cross out all but one. | "n" value
C-2	▯	CLVRT CIRCULAR ARCH OVAL BOX CONCRETE CGMP PLATE
		Clvrt ID | Select profile configuration. Cross out all but one. | Select inlet condition. Cross out all but one. | "Ke" value
C-3	▯	CLVRT STRAIGHT BROKEN BK STEPPED FLARED DROP INLT NORMAL KE=
		Clvrt ID | Design: Station at toe along ℄ of structure / Analysis: Station at end of structure along ℄ of structure | Design: Elev. at toe / Analysis: Elev. of culv. F.L. | Design: Station at toe along ℄ of structure / Analysis: Station at end of structure along ℄ of structure | Design: Elev. at toe / Analysis: Elev. of culv. F.L.
C-4	▯	CLVRT OUTLT STA EL INLET STA EL
		Clvrt ID | Stationing along centerline of structure | Break elevation | Stationing along centerline of structure | Break elevation
C-5	▯	CLVRT BREAK STA EL BREAK STA EL
		Clvrt ID | Maximum headwater upstream of culvert | Elevation | Maximum allowable outlet velocity from culvert
C-6	▯	CLVRT MAX HEADWATER ELEV MAX OUTLET VELOCITY FT/SC
		Clvrt ID | Required entry for this card | Culvert diameter (in.) | Culvert rise | Culvert span | No. of culvert barrels
C-7	▯	CLVRT DIMENSIONS DIAM= HIGH= WIDE= BARRELS=
C-8	▯	ROAD UPSTRM SS DNSTRM SS MAX DEPTH=
		Subsec ID | Maximum allowable average velocity through bridge | Minimum allowable average velocity through bridge
C-9	▯	BRDG MAX AVERAGE VELOCITY MIN AVERAGE VELOCITY FT/SC
		Subsec ID | Left header slope | Right header slope | Insert one: UP or DN | Orig. sec. ID if skewed
C-10	▮	BRDG B LEFT S.S. 2 RIGHT S.S 2 LOOKING DN STREAM 15008
		Subsec ID | Cross-section ID | Distance along cross-section
C-11	▮	FL-DV B SECX A FRM X DIS 180 TO X DIST 285 15008
	▯	FL-DV SECX FRM X DIS TO X DIST
	▯	FL-DV SECX FRM X DIS TO X DIST
		Delete if Statewide Averages not desired
C-15	▯	COST STATEWIDE
		Supply job number for culvert if plan summary desired
C-12	▯	JOB NO.
C-13	▯	ENDATA
C-14	▯	PLAN SUMMARY

Note: * ▮ Mark box as shown beside each line used.

FIGURE 8-32. CULBRG INPUT DATA

FORM CONTINUED ON BACK

FORM 1308-1
(Revised 8/74)

BACK, SHEET 3 OF 3

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80

		Specify Concrete and Steel prices		OR	Cost per Foot
C-16 ☐	BOX PRICE	CONCRETE $. /CY	REINF STL $. /LB		COST/FT $

		Specify one price or both.		Diam. or Rise (in.)	Span (in.)	Estimated cost per flare unit for this diameter.
C-17 ☐	PIP PRICE	CGMP $. /LF	RCP $. /LF			FLARE UNIT $
☐	PIP PRICE	CGMP $. /LF	RCP $. /LF			FLARE UNIT $
☐	PIP PRICE	CGMP $. /LF	RCP $. /LF			FLARE UNIT $
☐	PIP PRICE	CGMP $. /LF	RCP $. /LF			FLARE UNIT $
☐	PIP PRICE	CGMP $. /LF	RCP $. /LF			FLARE UNIT $
☐	PIP PRICE	CGMP $. /LF	RCP $. /LF			FLARE UNIT $
☐	PIP PRICE	CGMP $. /LF	RCP $. /LF			FLARE UNIT $
☐	PIP PRICE	CGMP $. /LF	RCP $. /LF			FLARE UNIT $
☐	PIP PRICE	CGMP $. /LF	RCP $. /LF			FLARE UNIT $
☐	PIP PRICE	CGMP $. /LF	RCP $. /LF			FLARE UNIT $
☐	PIP PRICE	CGMP $. /LF	RCP $. /LF			FLARE UNIT $
☐	PIP PRICE	CGMP $. /LF	RCP $. /LF			FLARE UNIT $
☐	PIP PRICE	CGMP $. /LF	RCP $. /LF			FLARE UNIT $
☐	PIP PRICE	CGMP $. /LF	RCP $. /LF			FLARE UNIT $
☐	PIP PRICE	CGMP $. /LF	RCP $. /LF			FLARE UNIT $
☐	PIP PRICE	CGMP $. /LF	RCP $. /LF			FLARE UNIT $

	Required card for each Box culvert design.
C-18 ☐	FILL HEIGHT FT

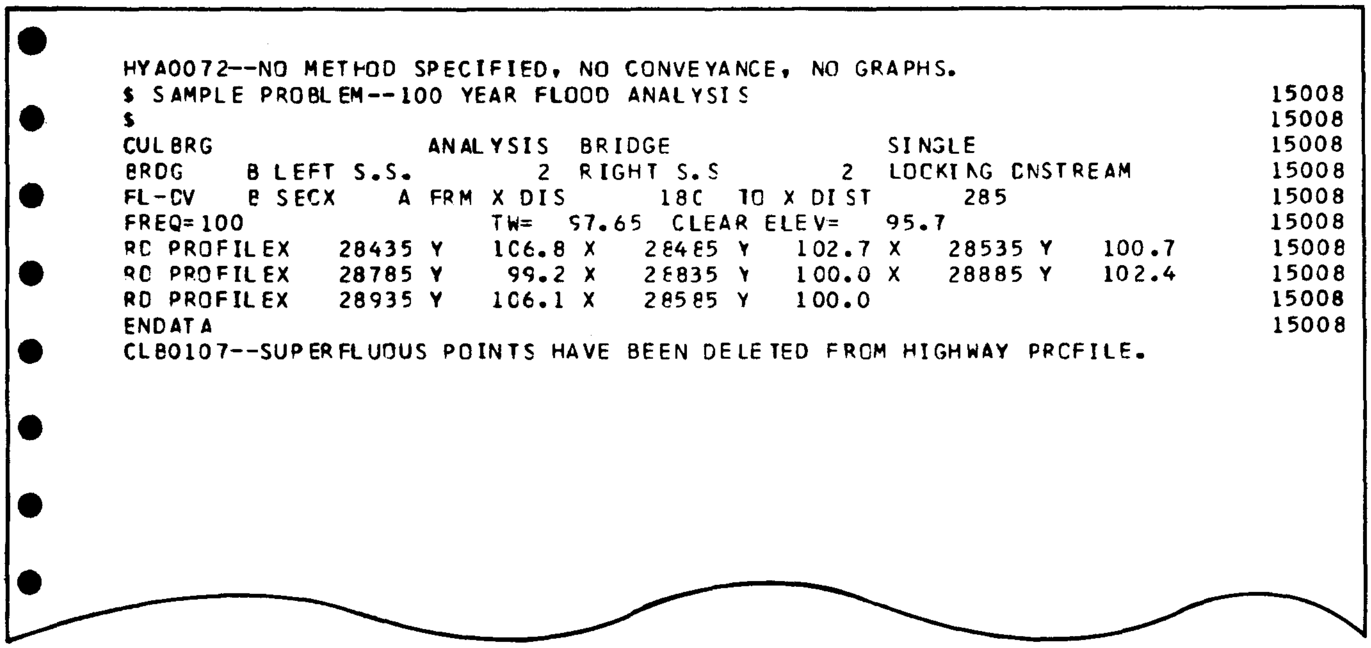
		If applicable specify any miscellaneous costs for each culvert design.						
C-19 ☐	MISC COSTS	$	CONC	STEEL	RIPRAP	HEADWALLS	EXCAVATION	GENERAL
☐	MISC COSTS	$	CONC	STEEL	RIPRAP	HEADWALLS	EXCAVATION	GENERAL
☐	MISC COSTS	$	CONC	STEEL	RIPRAP	HEADWALLS	EXCAVATION	GENERAL
☐	MISC COSTS	$	CONC	STEEL	RIPRAP	HEADWALLS	EXCAVATION	GENERAL
☐	MISC COSTS	$	CONC	STEEL	RIPRAP	HEADWALLS	EXCAVATION	GENERAL
☐	MISC COSTS	$	CONC	STEEL	RIPRAP	HEADWALLS	EXCAVATION	GENERAL

C-20 ■	FREQ=100	~~Q=~~ ~~CFS~~	TW= 97.65	CLEAR ELEV=	95.7			15008
		Coordinate point		Coordinate point		Coordinate point		
		X Coordinate (Dist.)	Y Coordinate (Elev.)	X Coordinate (Dist.)	Y Coordinate (Elev.)	X Coordinate (Dist.)	Y Coordinate (Elev.)	
C-21 ■	RD PROFILE	X 28435	Y 106.8	X 28485	Y 102.7	X 28535	Y 100.7	15008
■	RD PROFILE	X 28785	Y 99.2	X 28835	Y 100.0	X 28885	Y 102.4	15008
■	RD PROFILE	X 28935	Y 106.1	X 28585	Y 100.0	~~X~~	~~Y~~	15008
☐	RD PROFILE	X	Y	X	Y	X	Y	
☐	RD PROFILE	X	Y	X	Y	X	Y	
☐	RD PROFILE	X	Y	X	Y	X	Y	
☐	RD PROFILE	X	Y	X	Y	X	Y	
☐	RD PROFILE	X	Y	X	Y	X	Y	
☐	RD PROFILE	X	Y	X	Y	X	Y	
☐	RD PROFILE	X	Y	X	Y	X	Y	
C-13 ■	ENDATA							15008
C-14 ☐	PLAN SUMMARY							

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80

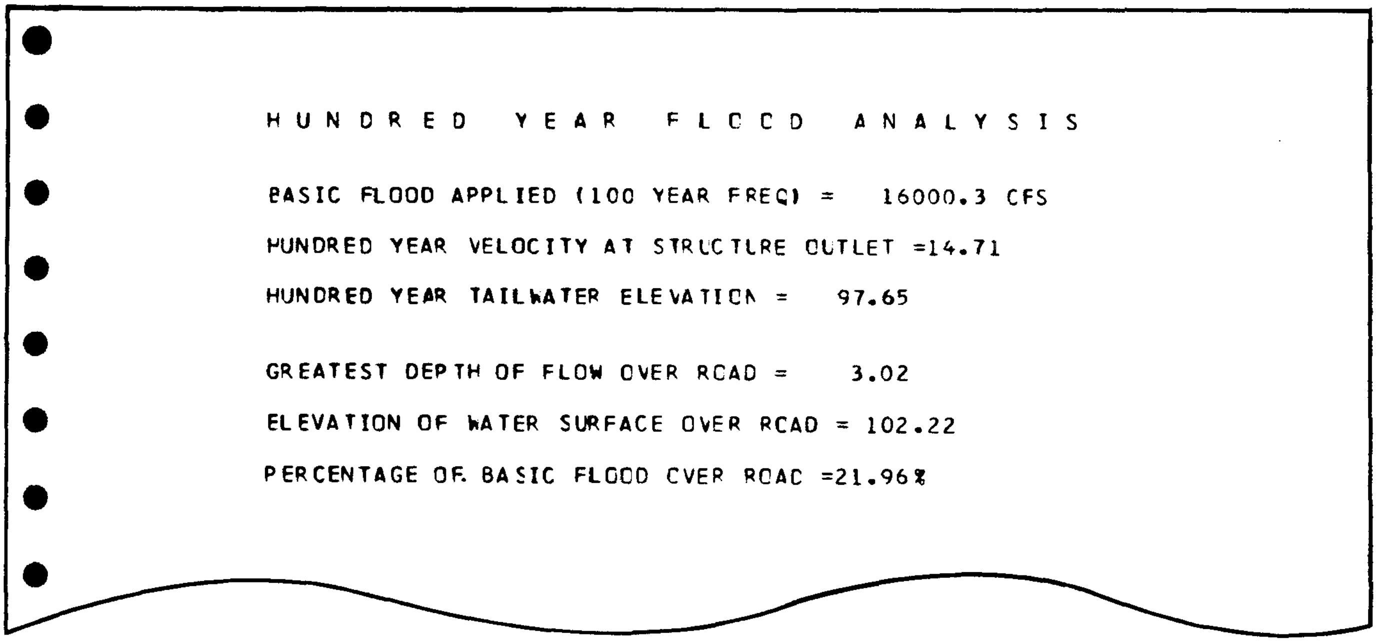
FIGURE 8-33. CULBRG INPUT DATA

FORM 1308-2
(Revised 8/74)



```
HYA0072--NO METHOD SPECIFIED, NO CONVEYANCE, NO GRAPHS.
$ SAMPLE PROBLEM--100 YEAR FLOOD ANALYSIS                                             15008
$                                                                                     15008
CULBRG              ANALYSIS  BRIDGE              SINGLE                              15008
BRDG    B LEFT S.S.        2  RIGHT S.S        2  LOCKING CNSTREAM                    15008
FL-DV   B SECX     A  FRM X DIS       180   TO X DIST      285                        15008
FREQ=100                TW=  97.65  CLEAR ELEV=   95.7                                15008
RC PROFILEX   28435 Y   106.8 X   28485 Y   102.7 X   28535 Y   100.7                 15008
RC PROFILEX   28785 Y    99.2 X   28835 Y   100.0 X   28885 Y   102.4                 15008
RD PROFILEX   28935 Y   106.1 X   28585 Y   100.0                                     15008
ENDATA                                                                                15008
CLB0107--SUPERFLUOUS POINTS HAVE BEEN DELETED FROM HIGHWAY PRCFILE.
```

FIGURE 8-34. COMPUTER PRINTED CULBRG INPUT DATA



```
H U N D R E D   Y E A R   F L C C D   A N A L Y S I S

BASIC FLOOD APPLIED (100 YEAR FREQ) =   16000.3 CFS

HUNDRED YEAR VELOCITY AT STRLCTLRE OUTLET =14.71

HUNDRED YEAR TAILWATER ELEVATICN =   97.65


GREATEST DEPTH OF FLOW OVER RCAD =    3.02

ELEVATION OF WATER SURFACE OVER RCAD = 102.22

PERCENTAGE OF BASIC FLOOD CVER ROAC =21.96%
```

FIGURE 8-35. CALCULATIONS FOR 100 YEAR FLOOD ANALYSIS

VI. INLET CARRYOVER SAMPLE PROBLEM

An illustration of a storm sewer system is shown in Figure 8-36. Following is the input and output required to perform the inlet carryover calculations for the design of the system.

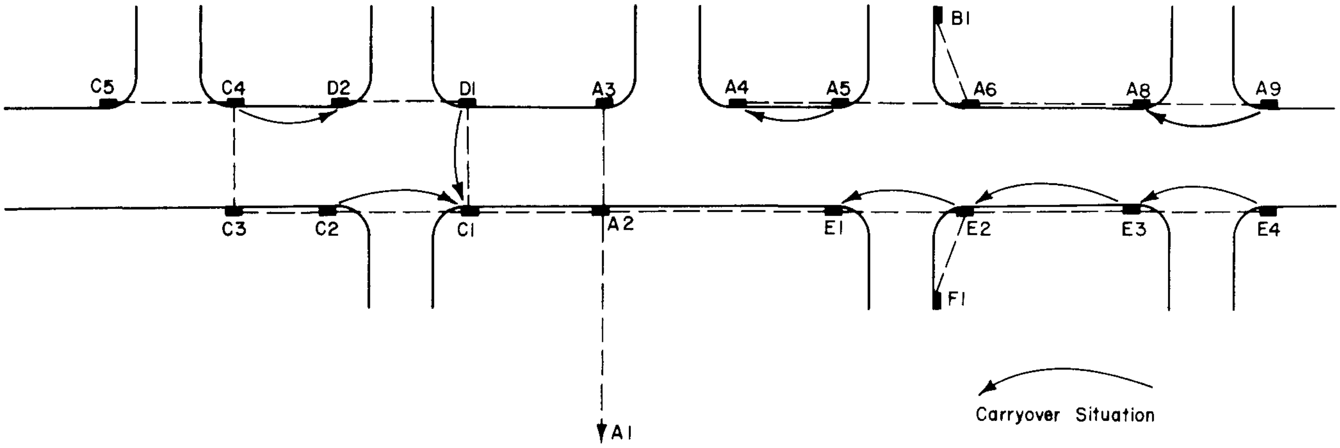


FIGURE 8-36. INLET LAYOUT TO SHOW CARRYOVER

DISTRICT ________ RES. NO. ________
I.P.E. ________ PROJ. NO. ________
COUNTY ________

STATE DEPARTMENT OF HIGHWAYS
AND PUBLIC TRANSPORTATION
HYDRAULIC SYSTEM
SEWER SUBSYSTEM (SEWER)

PREPARED BY ________
DATE ________
SHEET 1 OF 3

Comments	$	SAMPLE PRØBLEM ILLUSTRATING CARRYØVER ØPTIØN	15007
	$		15007
	$		

		Cross out one		Select one, two, or three. Cross out others.			Design Frequency	Prob. No.
Control Card	SEWER	DESIGN	~~ANALYSIS~~	RUNOFF	INLET	~~SEWER~~	FREQUENCY=25 YR	15007

Alphanumeric description of type of runoff surface for each subarea A through F

D-1	COEF DESC	A=PARK	B=RES. A	C=RES. B	D=CØMM.	E=PAVEMENT ~~F=~~	15007

		"C" (runoff coefficient) applicable to each runoff surface A through F						Minimum Time of concentration	Rainfall Intensity Constants			
		A	B	C	D	E	F		e	b	d	
D-2	RAT COEF	0.45	0.60	0.65	0.70	0.80		MIN TC = 10	0.800	75	10.0	15007

		Drainage area ID		Drainage areas for subareas A through F						Time of concentration data			Minimum Size Pipe (in.)	Design Increment (Insert 3" or 6")	Baseflow or Supply Q	
		Line Letter	Inlet No.	A	B	C	D	E	F	Length	Velocity	Tc				
D-3	DA	C	5	.	.	.	.55	.	.	L 220	V 2.0	~~T~~				15007
	DA	C	4	.	.	.	.60	.	.	L 240	V 2.5	~~T~~				↓
	DA	C	3	.	1.35	.	.	.	.	L 540	V 1.5	~~T~~				↓
	DA	C	2	.	1.20	.	.	.	.	L 480	V 2.0	~~T~~				↓
	DA	C	1	.	.90	.	.	.	.	L 360	V 2.5	~~T~~				↓
	DA	D	2	.	.55	.	.	.	.	L 220	V 2.0	~~T~~				↓
	DA	D	1	.	.	.	.60	.	.	L 240	V 2.5	~~T~~				↓
	DA	A	3	.	.	.	1.30	.	.	L 490	V 2.5	~~T~~				↓
	DA	A	2	.	.	.	.25	.	.	L 150	V 1.5	~~T~~				15007

		Junc ID		CURB on GRADE = CURB CURB at SAG = CSAG GRATE on GRADE = GRATE GRATE at SAG = GSAG GRATE & CURB on GRADE = GC GRATE & CURB at SAG = GCSAG JUNCTION = JUNCT	Maximum ponding width (ft.)	Gutter Slope %	Slope Z 1	Distance for slope Z 1	Slope Z 2	Mannings "n" value (gutter)	Gutter Depression "a" (ft.)	Max ponding depth above grate or gutter (in.)	Analysis only		Width of Grate on Grade (ft.)	
		Line letter	Inlet No.										Inlet length (ft.)	Inlet area (sq. ft.)		
D-4	JUNC	C	5	TYPE= CURB	20	.50	50			.015	.25				.	15007
	JUNC	C	4	TYPE= ↓	↓	.55	↓			↓	↓				.	↓
	JUNC	C	3	TYPE= ↓	↓	.40	↓			↓	↓				.	↓
	JUNC	C	2	TYPE= ↓	↓	.50	↓			↓	↓				.	↓
	JUNC	C	1	TYPE= ↓	↓	.60	↓			↓	↓				.	↓
	JUNC	D	2	TYPE= ↓	↓	.55	↓			↓	↓				.	↓
	JUNC	D	1	TYPE= ↓	↓	.45	↓			↓	↓				.	↓
	JUNC	A	3	TYPE= ↓	↓	.50	↓			↓	↓				.	↓
	JUNC	A	2	TYPE= CURB	20	.40	50			.015	.25				.	15007

		Inlet Identification						Standard Inlet Opening (ft.)	Allowable Carryover Length (ft.)	
			Line Letter	Inlet No.		Line Letter	Inlet No.			
D-4a	CARRYOVER	FROM	C	4	TO	D	2	L= 5	P= 2.5	15007
	CARRYOVER	FROM	A	5	TO	A	4	L= ↓	P= 5.0	↓
	CARRYOVER	FROM	C	2	TO	C	1	L= ↓	P= 5.0	↓
	CARRYOVER	FROM	D	1	TO	C	1	L= ↓	P= 2.5	↓
	CARRYOVER	FROM	E	2	TO	E	1	L= ↓	P= 1.0	↓
	CARRYOVER	FROM	E	3	TO	E	2	L= ↓	P= 1.0	↓
	CARRYOVER	FROM	A	9	TO	A	8	L= ↓	P= 3.0	↓
	CARRYOVER	FROM	E	4	TO	E	3	L= 5	P= 3.0	15007

Note * Mark box as shown beside each line used.

FIGURE 8-37. CARRYOVER INPUT DATA

FORM CONTINUED ON BACK
FORM 1309-1 (Revised 9/75)

DISTRICT________ RES. NO.__________
I.P.E.__________ PROJ. NO.__________
COUNTY______________________________

STATE DEPARTMENT OF HIGHWAYS
AND PUBLIC TRANSPORTATION
HYDRAULIC SYSTEM
SEWER SUBSYSTEM (SEWER)

PREPARED BY_____
DATE__________
SHEET 2 OF 3

Comments
$
$
$

	Cross out one		Select one, two, or three. Cross out others.		Design Frequency	Prob. No.
Control Card	SEWER	DESIGN ANALYSIS	RUNOFF INLET SEWER	FREQUENCY= YR	

Alphanumeric description of type of runoff surface for each subarea A through F

D-1 COEF DESC A= B= C= D= E= F=

	"C" (runoff coefficient) applicable to each runoff surface A through F						Minimum Time of concentration	Rainfall Intensity Constants		
	A	B	C	D	E	F		e	b	d
D-2 RAT COEF							MIN TC =	.		.

	Drainage area ID		Drainage areas for subareas A through F						Time of concentration data			Minimum	Design Increment	Baseflow or	
	Line Letter	Inlet No.	A	B	C	D	E	F	Length	Velocity	Tc	Size Pipe (in.)	(Insert 3" or 6")	Supply Q	
D-3 DA	A	4	.	1.05	.	.	.	.	L 420	V 2.5	T=				15007
DA	A	5	.	1.05	.	.	.	.	L 420	V 2.0	T=				
DA	E	1	.	.	.	.	1.90	.	L 480	V 1.5	T=				
DA	B	1	.	.	.	0.75	.	.	L 300	V 2.0	T=				
DA	E	2	.	.	.	0.45	.	.	L 180	V 2.5	T=				
DA	F	1	.	.	1.00	.	.	.	L 380	V 1.5	T=				
DA	A	8	1.25	.	.	.	.	.	L 440	V 2.0	T=				
DA	E	3	.	.	.	1.30	.	.	L 460	V 2.5	T=				
DA	A	9	.	.	.	1.25	.	.	L 440	V 2.5	T=				15007

CURB on GRADE = CURB
CURB at SAG = CSAG
GRATE on GRADE = GRATE
GRATE at SAG = GSAG
GRATE & CURB on GRADE = GC
GRATE & CURB at SAG = GCSAG
JUNCTION = JUNCT

	Junc ID			Maximum ponding width (ft.)	Gutter Slope %	Slope Z 1	Distance for slope Z 1	Slope Z 2	Mannings "n" value (gutter)	Gutter Depression "a" (ft.)	Max ponding depth above grate or gutter (in.)	Analysis only		Width of Grate on Grade (ft.)	
	Line letter	Inlet No.										Inlet length (ft.)	Inlet area (sq. ft.)		
D-4 JUNC	A	4	TYPE= CURB	20	.55	50			.015	.25				.	15007
JUNC	A	5	TYPE=		.50				.	.				.	
JUNC	E	1	TYPE=		.55				.	.				.	
JUNC	B	1	TYPE=		.40				.	.				.	
JUNC	E	2	TYPE=		.50				.	.				.	
JUNC	F	1	TYPE=		.45				.	.				.	
JUNC	A	8	TYPE=		.55				.	.				.	
JUNC	E	3	TYPE=		.60				.	.				.	
JUNC	A	9	TYPE= CURB	20	.50	50			.015	.25				.	15007

	Inlet Identification						Standard Inlet Opening (ft.)	Allowable Carryover Length (ft.)
		Line Letter	Inlet No.		Line Letter	Inlet No.		
D-4a CARRYOVER	FROM			TO			L=	P= .
CARRYOVER	FROM			TO			L=	P= .
CARRYOVER	FROM			TO			L=	P= .
CARRYOVER	FROM			TO			L=	P= .
CARRYOVER	FROM			TO			L=	P= .
CARRYOVER	FROM			TO			L=	P= .
CARRYOVER	FROM			TO			L=	P= .
CARRYOVER	FROM			TO			L=	P= .

Note: * ▌ Mark box as shown beside each line used.

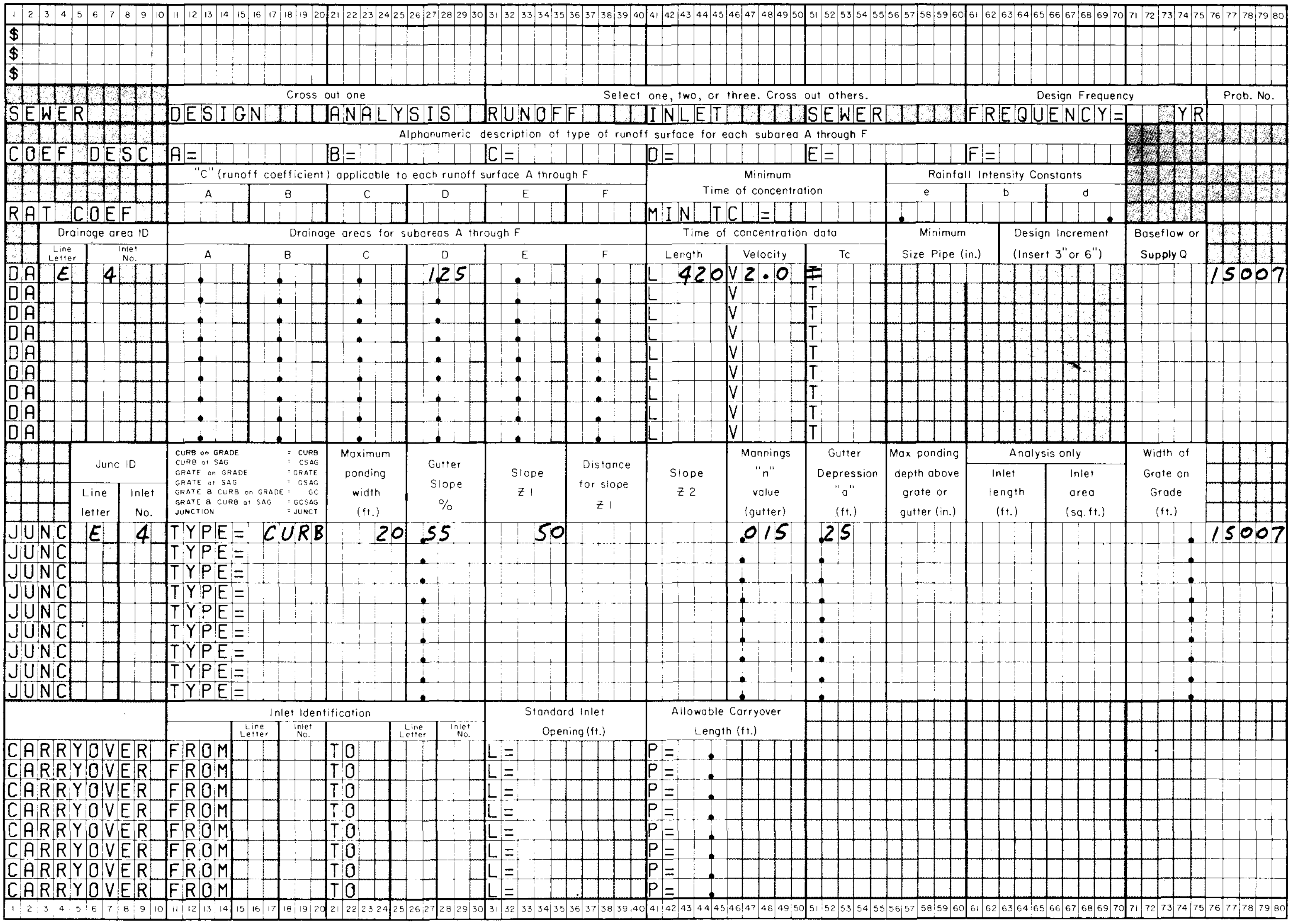
FIGURE 8-38. CARRYOVER INPUT DATA

FORM CONTINUED ON BACK
FORM 1309-1 (Revised 9/75)

DISTRICT______ RES. NO. ______
I.P.E. ______ PROJ. NO. ______
COUNTY______

STATE DEPARTMENT OF HIGHWAYS
AND PUBLIC TRANSPORTATION
HYDRAULIC SYSTEM
SEWER SUBSYSTEM (SEWER)

PREPARED BY______
DATE ______
SHEET 3 OF 3



Comments	$						
	$						
	$						

	Cross out one		Select one, two, or three. Cross out others.			Design Frequency	Prob. No.
Control Card: SEWER	DESIGN	ANALYSIS	RUNOFF	INLET	SEWER	FREQUENCY= YR	

	Alphanumeric description of type of runoff surface for each subarea A through F					
D-1 COEF DESC	A=	B=	C=	D=	E=	F=

	"C" (runoff coefficient) applicable to each runoff surface A through F						Minimum Time of concentration	Rainfall Intensity Constants		
	A	B	C	D	E	F		e	b	d
D-2 RAT COEF							MIN TC =			

	Drainage area ID		Drainage areas for subareas A through F						Time of concentration data			Minimum	Design Increment	Baseflow or	
	Line Letter	Inlet No.	A	B	C	D	E	F	Length	Velocity	Tc	Size Pipe (in.)	(Insert 3" or 6")	Supply Q	
D-3 DA	E	4	.	.	.	125	.	.	L 420	V 2.0	~~T~~				15007
DA			.	.	.	.	.	.	L	V	T				
DA			.	.	.	.	.	.	L	V	T				
DA			.	.	.	.	.	.	L	V	T				
DA			.	.	.	.	.	.	L	V	T				
DA			.	.	.	.	.	.	L	V	T				
DA			.	.	.	.	.	.	L	V	T				
DA			.	.	.	.	.	.	L	V	T				
DA			.	.	.	.	.	.	L	V	T				

	Junc ID		CURB on GRADE = CURB CURB at SAG = CSAG GRATE on GRADE = GRATE GRATE at SAG = GSAG GRATE & CURB on GRADE = GC GRATE & CURB at SAG = GCSAG JUNCTION = JUNCT	Maximum ponding width (ft.)	Gutter Slope %	Slope Z 1	Distance for slope Z 1	Slope Z 2	Mannings "n" value (gutter)	Gutter Depression "a" (ft.)	Max ponding depth above grate or gutter (in.)	Analysis only		Width of Grate on Grade (ft.)	
	Line letter	Inlet No.										Inlet length (ft.)	Inlet area (sq. ft.)		
D-4 JUNC	E	4	TYPE= CURB	20	.55	50			.015	.25				.	15007
JUNC			TYPE=		.				.	.				.	
JUNC			TYPE=		.				.	.				.	
JUNC			TYPE=		.				.	.				.	
JUNC			TYPE=		.				.	.				.	
JUNC			TYPE=		.				.	.				.	
JUNC			TYPE=		.				.	.				.	
JUNC			TYPE=		.				.	.				.	
JUNC			TYPE=		.				.	.				.	

	Inlet Identification						Standard Inlet Opening (ft.)	Allowable Carryover Length (ft.)
		Line Letter	Inlet No.		Line Letter	Inlet No.		
D-4a CARRYOVER	FROM			TO			L=	P= .
CARRYOVER	FROM			TO			L=	P= .
CARRYOVER	FROM			TO			L=	P= .
CARRYOVER	FROM			TO			L=	P= .
CARRYOVER	FROM			TO			L=	P= .
CARRYOVER	FROM			TO			L=	P= .
CARRYOVER	FROM			TO			L=	P= .
CARRYOVER	FROM			TO			L=	P= .

Note: * Mark box as shown beside each line used.

FIGURE 8-39. CARRYOVER INPUT DATA (FRONT OF SHEET)

FORM CONTINUED ON BACK
FORM 1309-1 (Revised 9/75)

SEWER (Continued)

BACK, SHEET 3 OF 3

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80

D-5	OUTLET	STATIONING	T.W. ELEV	Outlet ID: Line letter	Outlet No.

	Card	Run ID	Junction or U.S. inlet Line	Junction or U.S. inlet Inlet	Junction or D.S. inlet Line	Junction or D.S. inlet Inlet	Upstream Soffit elevation	Downstream Soffit elevation	Run (ft.) length	CA addition	Q addition	Mannings "n" value	U.S. Junction Loss coeff.	Maximum size rise	Insert one: CIRC, ARCH, OVAL, BOX
D-6	DSGN						US	DS				.	.		
	DSGN						US	DS				.	.		
	DSGN						US	DS				.	.		
	DSGN						US	DS				.	.		
	DSGN						US	DS				.	.		
	DSGN						US	DS				.	.		
	DSGN						US	DS				.	.		
	DSGN						US	DS				.	.		
	DSGN						US	DS				.	.		
	DSGN						US	DS				.	.		

	Card	Run ID	U.S. Inlet Line	U.S. Inlet Inlet	D.S. Inlet Line	D.S. Inlet Inlet	Actual no. of barrels	Actual rise or D (in.) (ft. if box)	Actual span (in.) (ft. if box)		Actual U.S. junction head loss(ft.)
D-7	ANAL										
	ANAL										
	ANAL										
	ANAL										
	ANAL										
	ANAL										
	ANAL										
	ANAL										
	ANAL										
	ANAL										

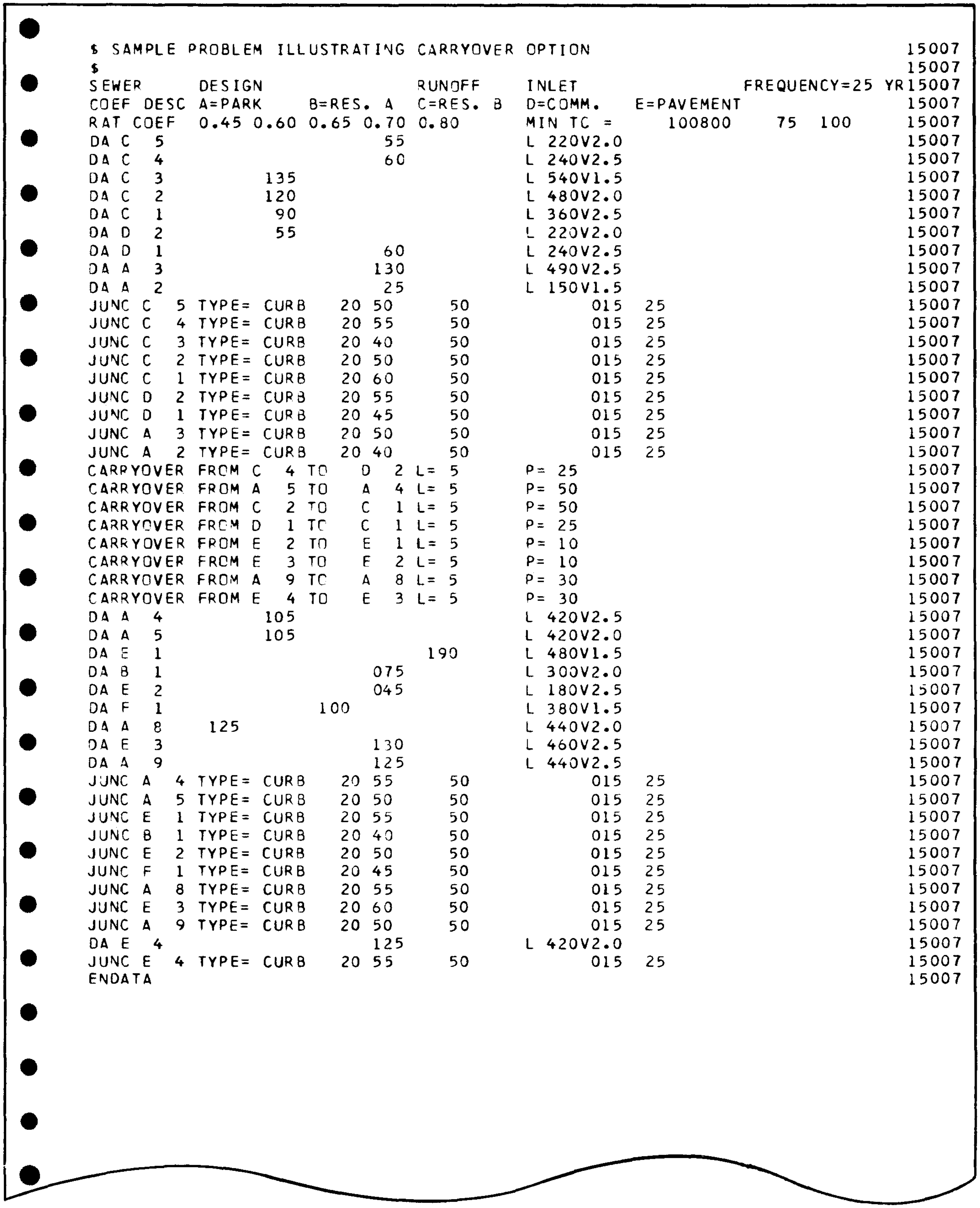
	Card		Line letter		Line letter		Line letter		Line letter		Line letter	Scale Factor
D-8	GRAPHS	LINE		LINE		LINE		LINE		LINE		X= Y=
	GRAPHS	LINE		LINE		LINE		LINE		LINE		
	GRAPHS	LINE		LINE		LINE		LINE		LINE		
	GRAPHS	LINE		LINE		LINE		LINE		LINE		
	GRAPHS	LINE		LINE		LINE		LINE		LINE		

	Card	Cross out all but one				Scale of ft./in.
D-9	SCALE	ACRES	SQ MILES	SQ INCHES	⊘ SCALE	
D-10	ENDATA					15007

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80

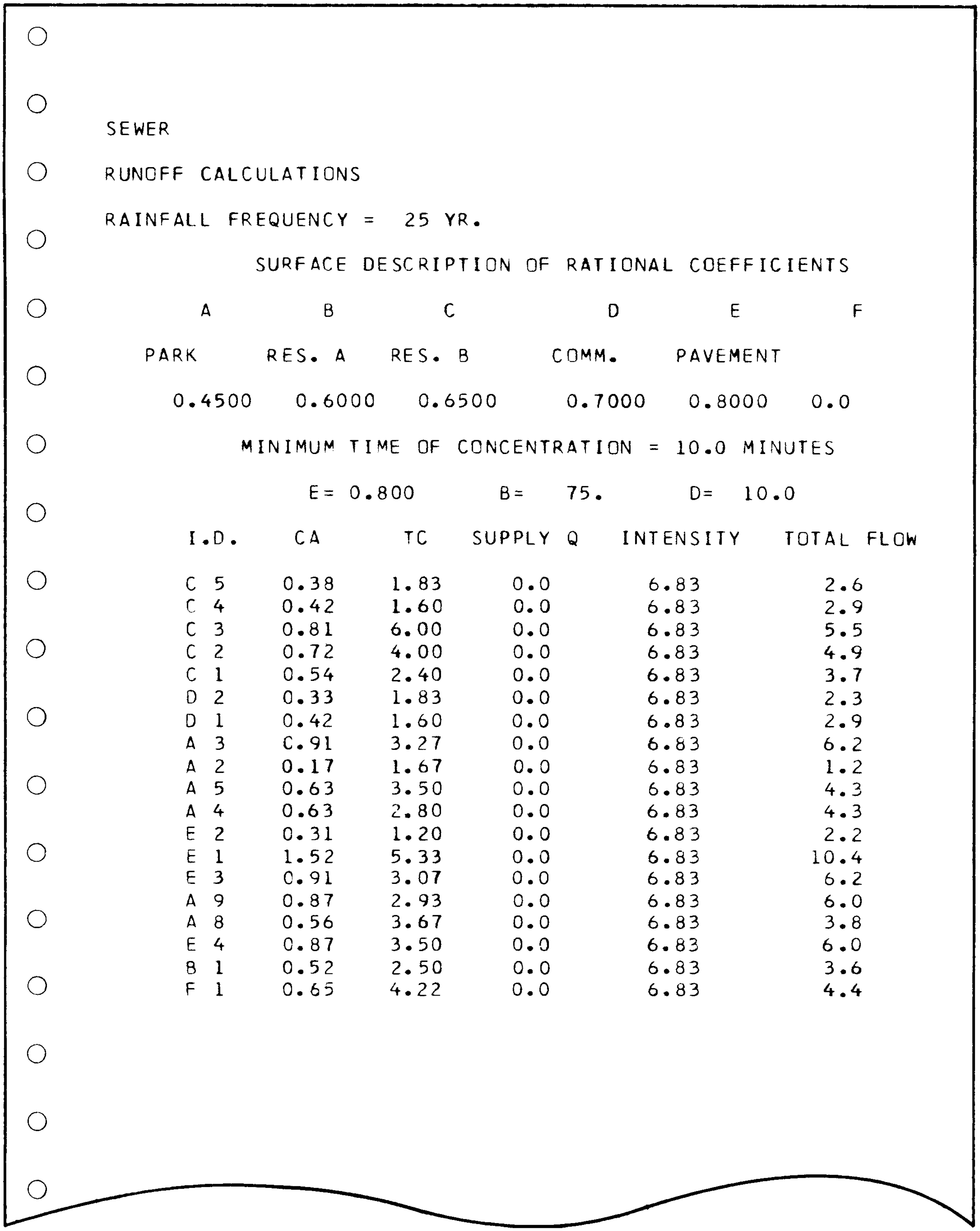
FIGURE 8-40. CARRYOVER INPUT DATA (BACK OF SHEET)

FORM 1309-2 (Revised 9/75)



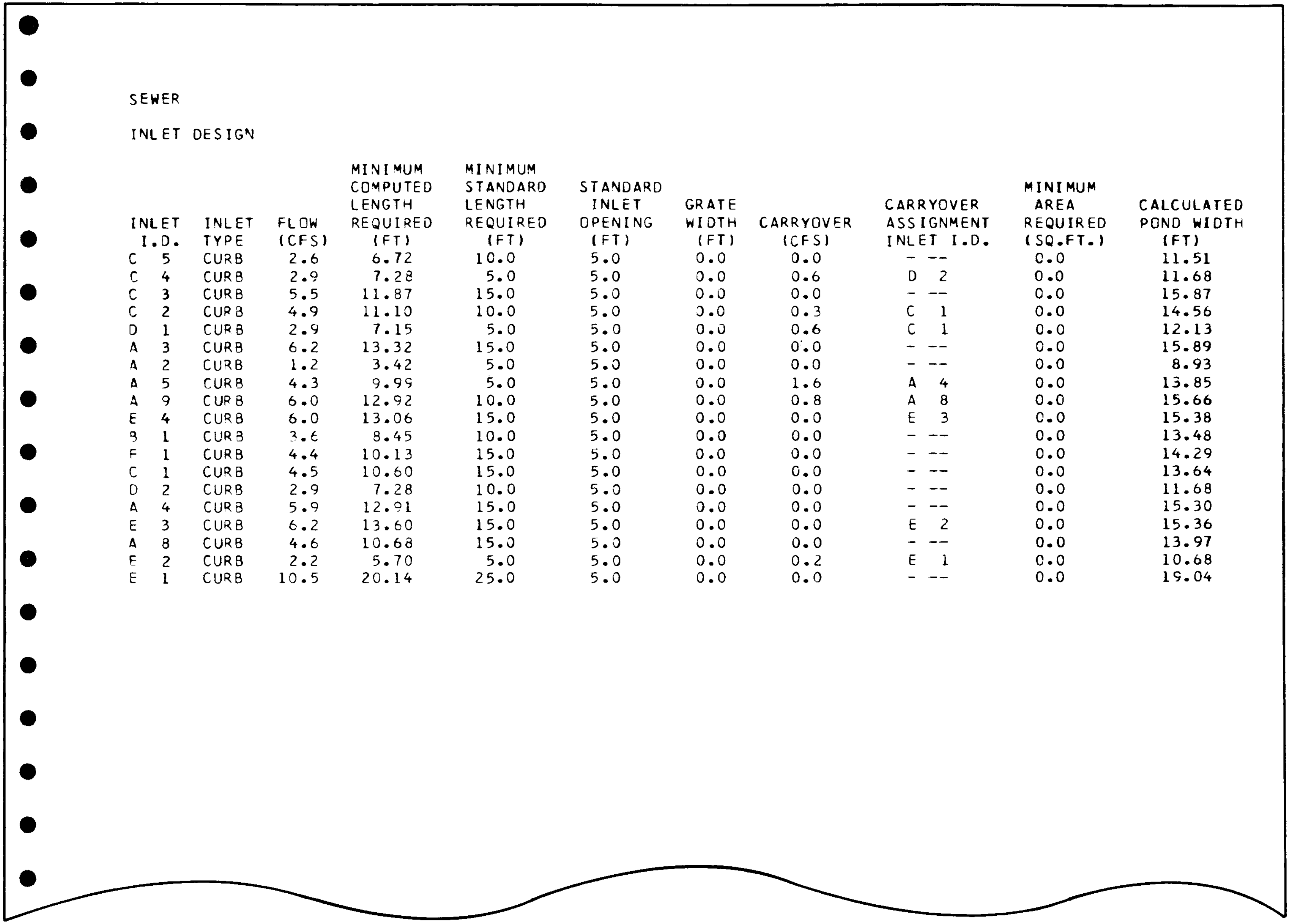
```
$ SAMPLE PROBLEM ILLUSTRATING CARRYOVER OPTION                             15007
$                                                                          15007
SEWER     DESIGN              RUNOFF    INLET                FREQUENCY=25 YR15007
COEF DESC A=PARK    B=RES. A  C=RES. B  D=COMM.   E=PAVEMENT               15007
RAT COEF  0.45 0.60 0.65 0.70 0.80      MIN TC =     100800    75  100     15007
DA C  5                    55           L 220V2.0                          15007
DA C  4                    60           L 240V2.5                          15007
DA C  3         135                     L 540V1.5                          15007
DA C  2         120                     L 480V2.0                          15007
DA C  1          90                     L 360V2.5                          15007
DA D  2          55                     L 220V2.0                          15007
DA D  1                    60           L 240V2.5                          15007
DA A  3                   130           L 490V2.5                          15007
DA A  2                    25           L 150V1.5                          15007
JUNC C  5 TYPE= CURB   20 50     50           015  25                      15007
JUNC C  4 TYPE= CURB   20 55     50           015  25                      15007
JUNC C  3 TYPE= CURB   20 40     50           015  25                      15007
JUNC C  2 TYPE= CURB   20 50     50           015  25                      15007
JUNC C  1 TYPE= CURB   20 60     50           015  25                      15007
JUNC D  2 TYPE= CURB   20 55     50           015  25                      15007
JUNC D  1 TYPE= CURB   20 45     50           015  25                      15007
JUNC A  3 TYPE= CURB   20 50     50           015  25                      15007
JUNC A  2 TYPE= CURB   20 40     50           015  25                      15007
CARRYOVER FROM C  4 TO   D  2 L= 5      P= 25                              15007
CARRYOVER FROM A  5 TO   A  4 L= 5      P= 50                              15007
CARRYOVER FROM C  2 TO   C  1 L= 5      P= 50                              15007
CARRYOVER FROM D  1 TO   C  1 L= 5      P= 25                              15007
CARRYOVER FROM E  2 TO   E  1 L= 5      P= 10                              15007
CARRYOVER FROM E  3 TO   E  2 L= 5      P= 10                              15007
CARRYOVER FROM A  9 TO   A  8 L= 5      P= 30                              15007
CARRYOVER FROM E  4 TO   E  3 L= 5      P= 30                              15007
DA A  4         105                     L 420V2.5                          15007
DA A  5         105                     L 420V2.0                          15007
DA E  1                        190      L 480V1.5                          15007
DA B  1                   075           L 300V2.0                          15007
DA E  2                   045           L 180V2.5                          15007
DA F  1              100                L 380V1.5                          15007
DA A  8    125                          L 440V2.0                          15007
DA E  3                   130           L 460V2.5                          15007
DA A  9                   125           L 440V2.5                          15007
JUNC A  4 TYPE= CURB   20 55     50           015  25                      15007
JUNC A  5 TYPE= CURB   20 50     50           015  25                      15007
JUNC E  1 TYPE= CURB   20 55     50           015  25                      15007
JUNC B  1 TYPE= CURB   20 40     50           015  25                      15007
JUNC E  2 TYPE= CURB   20 50     50           015  25                      15007
JUNC F  1 TYPE= CURB   20 45     50           015  25                      15007
JUNC A  8 TYPE= CURB   20 55     50           015  25                      15007
JUNC E  3 TYPE= CURB   20 60     50           015  25                      15007
JUNC A  9 TYPE= CURB   20 50     50           015  25                      15007
DA E  4                   125           L 420V2.0                          15007
JUNC E  4 TYPE= CURB   20 55     50           015  25                      15007
ENDATA                                                                     15007
```

FIGURE 8-41. COMPUTER PRINTED INPUT DATA



```
SEWER

RUNOFF CALCULATIONS

RAINFALL FREQUENCY =  25 YR.

             SURFACE DESCRIPTION OF RATIONAL COEFFICIENTS

        A          B          C            D          E          F

   PARK      RES. A    RES. B       COMM.     PAVEMENT

      0.4500    0.6000    0.6500      0.7000    0.8000    0.0

            MINIMUM TIME OF CONCENTRATION = 10.0 MINUTES

                  E= 0.800       B=   75.        D=  10.0

       I.D.     CA        TC    SUPPLY Q   INTENSITY   TOTAL FLOW

       C 5     0.38      1.83      0.0        6.83          2.6
       C 4     0.42      1.60      0.0        6.83          2.9
       C 3     0.81      6.00      0.0        6.83          5.5
       C 2     0.72      4.00      0.0        6.83          4.9
       C 1     0.54      2.40      0.0        6.83          3.7
       D 2     0.33      1.83      0.0        6.83          2.3
       D 1     0.42      1.60      0.0        6.83          2.9
       A 3     0.91      3.27      0.0        6.83          6.2
       A 2     0.17      1.67      0.0        6.83          1.2
       A 5     0.63      3.50      0.0        6.83          4.3
       A 4     0.63      2.80      0.0        6.83          4.3
       E 2     0.31      1.20      0.0        6.83          2.2
       E 1     1.52      5.33      0.0        6.83         10.4
       E 3     0.91      3.07      0.0        6.83          6.2
       A 9     0.87      2.93      0.0        6.83          6.0
       A 8     0.56      3.67      0.0        6.83          3.8
       E 4     0.87      3.50      0.0        6.83          6.0
       B 1     0.52      2.50      0.0        6.83          3.6
       F 1     0.65      4.22      0.0        6.83          4.4
```

FIGURE 8-42. RUNOFF CALCULATIONS



```
SEWER

INLET DESIGN

                        MINIMUM    MINIMUM
                        COMPUTED   STANDARD   STANDARD                               MINIMUM
                        LENGTH     LENGTH     INLET      GRATE              CARRYOVER    AREA      CALCULATED
INLET   INLET   FLOW    REQUIRED   REQUIRED   OPENING    WIDTH   CARRYOVER  ASSIGNMENT  REQUIRED   POND WIDTH
 I.D.   TYPE    (CFS)    (FT)       (FT)       (FT)      (FT)     (CFS)     INLET I.D.  (SQ.FT.)     (FT)
C  5    CURB     2.6      6.72      10.0       5.0       0.0       0.0        - --        0.0        11.51
C  4    CURB     2.9      7.28       5.0       5.0       0.0       0.6        D  2        0.0        11.68
C  3    CURB     5.5     11.87      15.0       5.0       0.0       0.0        - --        0.0        15.87
C  2    CURB     4.9     11.10      10.0       5.0       0.0       0.3        C  1        0.0        14.56
D  1    CURB     2.9      7.15       5.0       5.0       0.0       0.6        C  1        0.0        12.13
A  3    CURB     6.2     13.32      15.0       5.0       0.0       0.0        - --        0.0        15.89
A  2    CURB     1.2      3.42       5.0       5.0       0.0       0.0        - --        0.0         8.93
A  5    CURB     4.3      9.99       5.0       5.0       0.0       1.6        A  4        0.0        13.85
A  9    CURB     6.0     12.92      10.0       5.0       0.0       0.8        A  8        0.0        15.66
E  4    CURB     6.0     13.06      15.0       5.0       0.0       0.0        E  3        0.0        15.38
B  1    CURB     3.6      8.45      10.0       5.0       0.0       0.0        - --        0.0        13.48
F  1    CURB     4.4     10.13      15.0       5.0       0.0       0.0        - --        0.0        14.29
C  1    CURB     4.5     10.60      15.0       5.0       0.0       0.0        - --        0.0        13.64
D  2    CURB     2.9      7.28      10.0       5.0       0.0       0.0        - --        0.0        11.68
A  4    CURB     5.9     12.91      15.0       5.0       0.0       0.0        - --        0.0        15.30
E  3    CURB     6.2     13.60      15.0       5.0       0.0       0.0        E  2        0.0        15.36
A  8    CURB     4.6     10.68      15.0       5.0       0.0       0.0        - --        0.0        13.97
E  2    CURB     2.2      5.70       5.0       5.0       0.0       0.2        E  1        0.0        10.68
E  1    CURB    10.5     20.14      25.0       5.0       0.0       0.0        - --        0.0        19.04
```

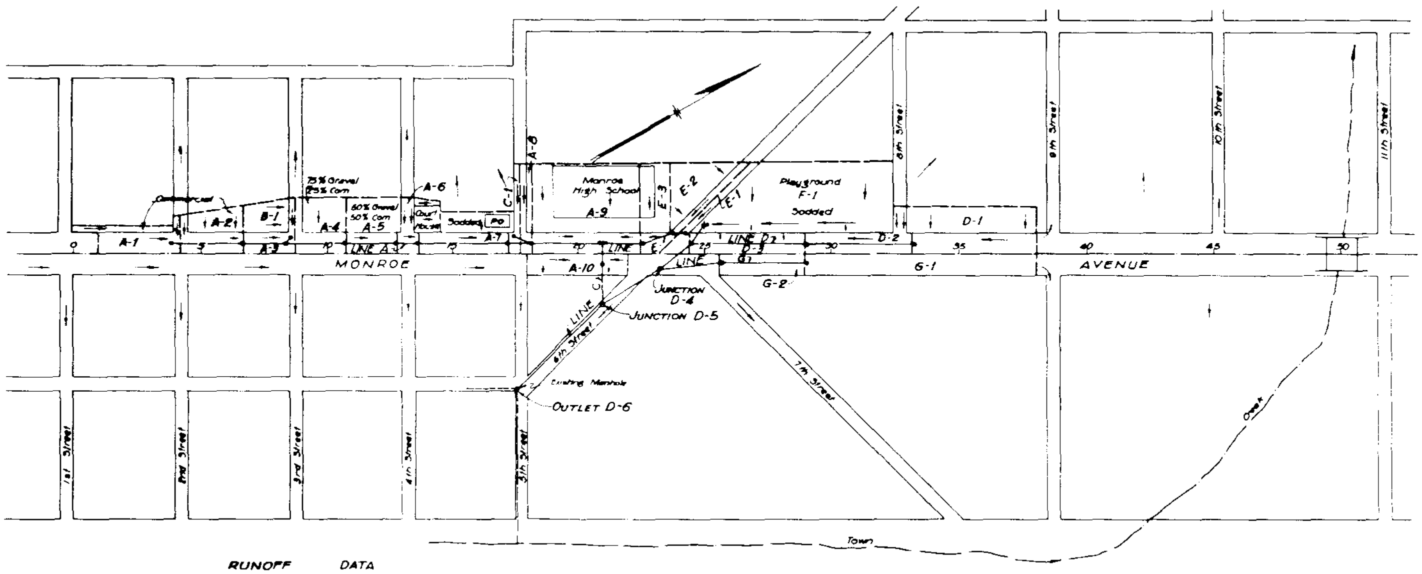
FIGURE 8-43. INLET DATA DESIGN CALCULATIONS

VII. SEWER SAMPLE PROBLEM

In this SEWER sample problem, the runoff to the inlets is to be calculated, and the sewer network is to be designed. An illustration of the problem is provided in Figures 8-44 and 8-45.

The data input forms, shown in Figures 8-46 through 8-51, are then completed giving all information necessary to the solution of the problem. The control card specifies the type of calculations to be performed. The data pertaining to the runoff calculations is given on the COEF DESC, RAT COEF, and DA cards. The results of these calculations plus data given on the JUNC, OUTLET, and DSGN cards are used in the sewer design. The input data as it has been read and edited by the program is shown in Figure 8-52.

The output resulting from the runoff calculations is shown in Figure 8-53. The user supplied factors are printed at the top of the page in this figure, and the runoff (TOTAL FLOW) for each junction is listed as well as other calculated factors which have been used in determining the TOTAL FLOW. The CONFIGURATION DATA is the next output page and is shown in Figure 8-54. This report gives all the physical characteristics of the pipe for each run specified on the DSGN card. The HYDRAULIC DATA (shown in Figure 8-55) follows the configuration data. This report presents the hydraulic characteristics of the pipe for each run specified on the DSGN card. The last SEWER report is STATIONING and is shown in Figure 8-56. This report lists the stationing for all junctions referenced from the outlet.



RUNOFF DATA

Drainage Area		Acres - Drained						Time of Concentration minutes	Length	Velocity
ID	Ac.	Res'l C=0.9	Comm. C=0.7	Resid C=0.35	Gravel C=0.4	Imperv Sodded C=0.3			ft	fps
A-1	0.6	0.12	0.21		0.27				396	2.0
A-2	0.9	0.24	0.43		0.23				370	1.6
B-1	0.5	0.03	0.47						326	1.6
A-3	0.4	0.19			0.21				180	2.0
A-4	1.0	0.24	0.16		0.60				380	1.5
A-5	1.0	0.18	0.33		0.49				380	1.5
A-6	0.54	0.20	0.23		0.06	0.05			290	2.5
A-7	1.1	0.30	0.11		0.30	0.39			370	2.0
C-1	0.24	0.12			0.12				290	2.6
A-8	0.39	0.15			0.08	0.16			316	2.5
A-9	3.4	0.37	1.61		0.40	1.02			596	1.6
E-3	0.92	0.11	0.23		0.11	0.47			360	1.6
E-2	1.93	0.14			0.09	1.70			486	1.6
E-1	0.35	0.20				0.15			416	2.0
F-1	4.2					4.20			1000	1.5
D-1	2.0	0.44		1.12		0.44			650	2.0
D-2	1.0	0.40				0.60			550	2.5
D-3	0.7	0.36				0.34			470	2.6
A-10	0.31	0.31							306	2.6
G-2	0.29	0.29							346	1.6
G-1	0.76	0.76							920	1.5

Design Frequency: 5 Years
Time of Concentration: Minimum 10 minutes

MAP OF
DRAINAGE AREAS

FED ROAD DIV NO	STATE	FEDERAL AID PROJECT NO			SHEET NO
6	TEXAS				
STATE DIST NO	COUNTY	CONT NO	SEC NO	JOB NO	HIGHWAY NO

FIGURE 8-44. MAP OF DRAINAGE AREAS AND RUNOFF DATA FOR SEWER SAMPLE PROBLEM

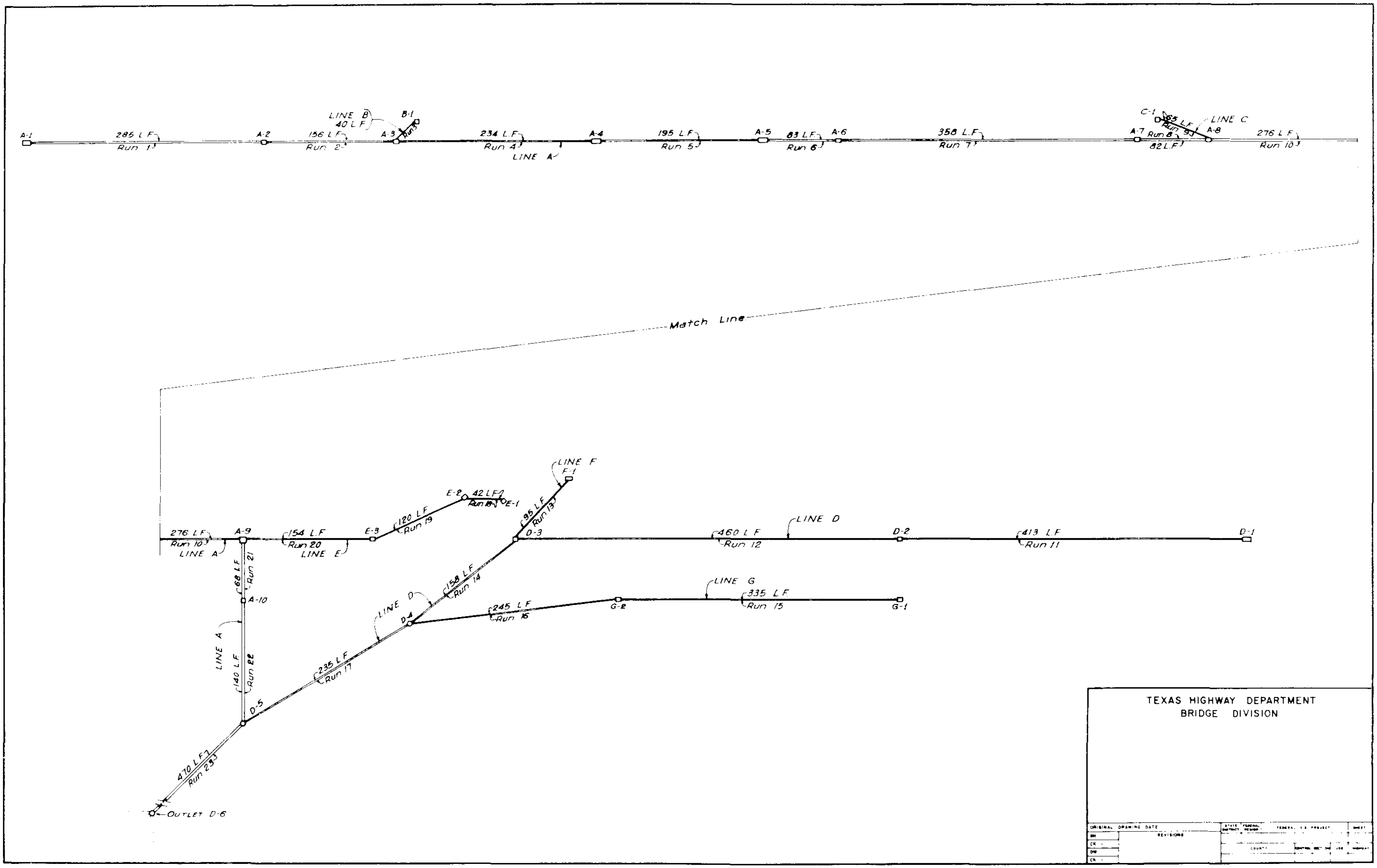


FIGURE 8-45. MAP OF SEWER NETWORK FOR SEWER SAMPLE PROBLEM

DISTRICT________ RES. NO. ________
I.P.E. ________ PROJ. NO. ________
COUNTY________

STATE DEPARTMENT OF HIGHWAYS
AND PUBLIC TRANSPORTATION
HYDRAULIC SYSTEM
SEWER SUBSYSTEM (SEWER)

PREPARED BY____
DATE____
SHEET 1 OF 3

Comments	$	THIS IS A SAMPLE PRΦBLEM FΦR INCLUSIΦN IN THE THYSYS USER MANUAL		12345
	$			12345
	$			

		Cross out one		Select one, two, or three. Cross out others.			Design Frequency	Prob. No.
Control Card	SEWER	DESIGN	~~ANALYSIS~~	RUNOFF	~~INLET~~	SEWER	FREQUENCY= 5 YR	12345

		Alphanumeric description of type of runoff surface for each subarea A through F						
D-1	COEF DESC	A=PAVEMENT	B=CΦMM.	C=RES.	D=GRVL.	E=SΦD	~~F=~~	12345

		"C" (runoff coefficient) applicable to each runoff surface A through F						Minimum Time of concentration	Rainfall Intensity Constants			
		A	B	C	D	E	F		e	b	d	
D-2	RAT COEF	0.90	0.70	0.50	0.40	0.30		MIN TC = 10.	0.749	70	7.7	12345

		Drainage area ID		Drainage areas for subareas A through F						Time of concentration data			Minimum	Design Increment	Baseflow or	
		Line Letter	Inlet No.	A	B	C	D	E	F	Length	Velocity	Tc	Size Pipe (in.)	(Insert 3" or 6")	Supply Q	
D-3	DA	A	1	.32	.21	.	.27	.	.	L 395	V 2.0	≠	12	3		12345
	DA	A	2	.24	.43	.	.23	.	.	L 370	V 1.5	≠				
	DA	B	1	.03	.47	.	.	.	.	L 325	V 1.5	≠				
	DA	A	3	.19	.	.	.21	.	.	L 180	V 2.0	≠				
	DA	A	4	.24	.16	.	.60	.	.	L 380	V 1.5	≠				
	DA	A	5	.18	.33	.	.49	.	.	L 380	V 1.5	≠				
	DA	A	6	.20	.23	.	.06	.05	.	L 290	V 2.5	≠				
	DA	A	7	.30	.11	.	.30	.39	.	L 370	V 2.0	≠				
	DA	C	1	.12	.	.	.12	.	.	L 290	V 2.5	≠				12345

CURB on GRADE = CURB
CURB at SAG = CSAG
GRATE on GRADE = GRATE
GRATE at SAG = GSAG
GRATE & CURB on GRADE = GC
GRATE & CURB at SAG = GCSAG
JUNCTION = JUNCT

		Junc ID			Maximum ponding width (ft.)	Gutter Slope %	Slope Z 1	Distance for slope Z 1	Slope Z 2	Mannings "n" value (gutter)	Gutter Depression "a" (ft.)	Max ponding depth above grate or gutter (in.)	Analysis only		Width of Grate on Grade (ft.)	
		Line letter	Inlet No.										Inlet length (ft.)	Inlet area (sq. ft.)		
D-4	JUNC	D	4	TYPE=JUNCT		.				.	.				.	12345
	JUNC	D	5	TYPE=JUNCT		.				.	.				.	12345
	JUNC			TYPE=		.				.	.				.	
	JUNC			TYPE=		.				.	.				.	
	JUNC			TYPE=		.				.	.				.	
	JUNC			TYPE=		.				.	.				.	
	JUNC			TYPE=		.				.	.				.	
	JUNC			TYPE=		.				.	.				.	
	JUNC			TYPE=		.				.	.				.	

		Inlet Identification						Standard Inlet Opening (ft.)	Allowable Carryover Length (ft.)
			Line Letter	Inlet No.		Line Letter	Inlet No.		
D-4a	CARRYOVER	FROM			TO			L=	P= .
	CARRYOVER	FROM			TO			L=	P= .
	CARRYOVER	FROM			TO			L=	P= .
	CARRYOVER	FROM			TO			L=	P= .
	CARRYOVER	FROM			TO			L=	P= .
	CARRYOVER	FROM			TO			L=	P= .
	CARRYOVER	FROM			TO			L=	P= .
	CARRYOVER	FROM			TO			L=	P= .

Note: * ▮ Mark box as shown beside each line used.

FIGURE 8-46. SEWER INPUT DATA (SHEET 1 - FRONT)

FORM CONTINUED ON BACK
FORM 1309-1 (Revised 9/75)

SEWER (Continued)

BACK, SHEET 1 OF 3

						Outlet ID Line letter	Outlet ID Outlet No.	
D-5	OUTLET	STATIONING	0.0	T.W. ELEV	84.66	D	06	12345

		Run ID	Junction or U.S. inlet Line	Junction or U.S. inlet Inlet	Junction or D.S. inlet Line	Junction or D.S. inlet Inlet	Upstream Soffit elevation	Downstream Soffit elevation	Run (ft) length	CA addition	Q addition	Mannings "n" value	U.S. Junction Loss coeff.	Maximum size rise	Insert one: CIRC, ARCH, OVAL, BOX	
D-6	DSGN	1	A	1	A	2	US 108.47	DS 104.90	265			0.012	.	24	CIRC	12345
	DSGN	2	A	2	A	3	US 104.84	DS 102.89	156			.	.	24		
	DSGN	3	B	1	A	3	US 102.97	DS 102.83	40			.	.	18		
	DSGN	4	A	3	A	4	US 102.83	DS 99.84	234			.	.	24		
	DSGN	5	A	4	A	5	US 99.78	DS 97.28	195			.	.	24		
	DSGN	6	A	5	A	6	US 97.22	DS 96.18	83			.	.	24		
	DSGN	7	A	6	A	7	US 96.12	DS 91.64	358			.	.	30		
	DSGN	8	A	7	A	8	US 91.58	DS 90.65	82			.	.	30		
	DSGN	9	C	1	A	8	US 91.79	DS 91.66	65			.	.	18		
	DSGN	10	A	8	A	9	US 90.60	DS 87.55	276			0.012	.	30	CIRC	12345

		Run ID	U.S. Inlet Line	U.S. Inlet Inlet	D.S. Inlet Line	D.S. Inlet Inlet	Actual no. of barrels	Actual rise or D (in.) (ft. if box)	Actual span (in.) (ft. if box)		Actual U.S. junction head loss (ft.)
D-7	ANAL										
	ANAL										
	ANAL										
	ANAL										
	ANAL										
	ANAL										
	ANAL										
	ANAL										
	ANAL										
	ANAL										

			Line letter		Line letter		Line letter		Line letter		Line letter	Scale Factor
D-8	GRAPHS	LINE		LINE		LINE		LINE		LINE		X= Y=
	GRAPHS	LINE		LINE		LINE		LINE		LINE		
	GRAPHS	LINE		LINE		LINE		LINE		LINE		
	GRAPHS	LINE		LINE		LINE		LINE		LINE		
	GRAPHS	LINE		LINE		LINE		LINE		LINE		

		Cross out all but one			Scale of ft./in.
D-9	SCALE	ACRES	SQ MILES	SQ INCHES	● SCALE
D-10	ENDATA				

FIGURE 8-47. SEWER INPUT DATA (SHEET 1 - BACK)

FORM 1309-2 (Revised 9/75)

DISTRICT________ RES. NO. __________
I.P.E. ___________ PROJ. NO. _________
COUNTY_______________________________

STATE DEPARTMENT OF HIGHWAYS
AND PUBLIC TRANSPORTATION
HYDRAULIC SYSTEM
SEWER SUBSYSTEM (SEWER)

PREPARED BY_____
DATE ___________
SHEET 2 OF 3

Comments
$
$
$

Control Card: SEWER | Cross out one: DESIGN ANALYSIS | Select one, two, or three. Cross out others.: RUNOFF INLET SEWER | Design Frequency: FREQUENCY= YR | Prob. No.

D-1: COEF DESC | Alphanumeric description of type of runoff surface for each subarea A through F: A= B= C= D= E= F=

D-2: RAT COEF | "C" (runoff coefficient) applicable to each runoff surface A through F: A B C D E F | Minimum Time of concentration: MIN TC = | Rainfall Intensity Constants: e b d

D-3:

	Drainage area ID		Drainage areas for subareas A through F						Time of concentration data			Minimum Size Pipe (in.)	Design Increment (Insert 3" or 6")	Baseflow or Supply Q	Prob. No.
	Line Letter	Inlet No.	A	B	C	D	E	F	Length	Velocity	Tc				
DA	A	8	.15	.	.	.08	.16	.	L 315	V 2.5	Ŧ				12345
DA	A	9	.37	1.61	.	.40	1.02	.	L 595	V 1.5	Ŧ				
DA	E	3	.11	.23	.	.11	.47	.	L 360	V 1.5	Ŧ				
DA	E	2	.14	.	.	.09	1.70	.	L 435	V 1.5	Ŧ				
DA	E	1	.20	.	.	.	.15	.	L 415	V 2.0	Ŧ				
DA	F	1	.	.	.	.	4.20	.	L 1000	V 1.5	Ŧ				
DA	D	1	.44	.	1.12	.	.44	.	L 650	V 2.0	Ŧ				
DA	D	2	.40	.	.	.	.60	.	L 550	V 2.5	Ŧ				
DA	D	3	.36	.	.	.	.34	.	L 470	V 2.5	Ŧ				12345

D-4:

CURB on GRADE = CURB
CURB at SAG = CSAG
GRATE on GRADE = GRATE
GRATE at SAG = GSAG
GRATE & CURB on GRADE = GC
GRATE & CURB at SAG = GCSAG
JUNCTION = JUNCT

	Junc ID Line letter	Junc ID Inlet No.		Maximum ponding width (ft.)	Gutter Slope %	Slope Ƶ 1	Distance for slope Ƶ 1	Slope Ƶ 2	Mannings "n" value (gutter)	Gutter Depression "a" (ft.)	Max ponding depth above grate or gutter (in.)	Analysis only Inlet length (ft.)	Analysis only Inlet area (sq. ft.)	Width of Grate on Grade (ft.)
JUNC			TYPE=		.				.	.				.
JUNC			TYPE=		.				.	.				.
JUNC			TYPE=		.				.	.				.
JUNC			TYPE=		.				.	.				.
JUNC			TYPE=		.				.	.				.
JUNC			TYPE=		.				.	.				.
JUNC			TYPE=		.				.	.				.
JUNC			TYPE=		.				.	.				.
JUNC			TYPE=		.				.	.				.

D-4a:

	Inlet Identification	Line Letter	Inlet No.		Line Letter	Inlet No.	Standard Inlet Opening (ft.)	Allowable Carryover Length (ft.)
CARRYOVER	FROM			TO			L=	P= .
CARRYOVER	FROM			TO			L=	P= .
CARRYOVER	FROM			TO			L=	P= .
CARRYOVER	FROM			TO			L=	P= .
CARRYOVER	FROM			TO			L=	P= .
CARRYOVER	FROM			TO			L=	P= .
CARRYOVER	FROM			TO			L=	P= .
CARRYOVER	FROM			TO			L=	P= .

Note: * ▌ Mark box as shown beside each line used.

FIGURE 8-48. SEWER INPUT DATA (SHEET 2 - FRONT)

FORM CONTINUED ON BACK
FORM 1309-I (Revised 9/75)

SEWER (Continued)

BACK, SHEET 2 OF 3

					Outlet ID Line letter	Outlet ID Outlet No.
D-5	OUTLET	STATIONING		T.W. ELEV		

		Run ID	Junction or U.S. inlet Line	Junction or U.S. inlet Inlet	Junction or D.S. inlet Line	Junction or D.S. inlet Inlet	Upstream Soffit elevation	Downstream Soffit elevation	Run (ft.) length	CA addition	Q addition	Mannings "n" value	U.S. Junction Loss coeff.	Maximum size rise	Insert one: CIRC, ARCH, OVAL, BOX	
D-6	DSGN	11	D	1	D	2	US 93.00	DS 91.92	413			0.012	.	24	CIRC	12345
	DSGN	12	D	2	D	3	US 91.92	DS 89.29	460			.	.			
	DSGN	13	F	1	D	3	US 89.68	DS 89.48	95			.	.			
	DSGN	14	D	3	D	4	US 89.24	DS 88.20	158			.	.			
	DSGN	15	G	1	G	2	US 91.99	DS 90.07	335			.	.			
	DSGN	16	G	2	D	4	US 90.04	DS 88.64	245			.	.			
	DSGN	17	D	4	D	5	US 88.15	DS 85.50	235			.	.			
	DSGN	18	E	1	E	2	US 89.79	DS 89.70	42			.	.	18		
	DSGN	19	E	2	E	3	US 89.69	DS 89.38	120			.	.	24		
	DSGN	20	E	3	A	9	US 89.37	DS 88.52	154			0.012	.	24	CIRC	12345

		Run ID	U.S. Inlet Line	U.S. Inlet Inlet	D.S. Inlet Line	D.S. Inlet Inlet	Actual no. of barrels	Actual rise or D (in.) (ft. if box)	Actual span (in.) (ft. if box)		Actual U.S. junction head loss (ft.)
D-7	ANAL										
	ANAL										
	ANAL										
	ANAL										
	ANAL										
	ANAL										
	ANAL										
	ANAL										
	ANAL										
	ANAL										

			Line letter		Line letter		Line letter		Line letter		Line letter	Scale Factor
D-8	GRAPHS	LINE		LINE		LINE		LINE		LINE		X= Y=
	GRAPHS	LINE		LINE		LINE		LINE		LINE		
	GRAPHS	LINE		LINE		LINE		LINE		LINE		
	GRAPHS	LINE		LINE		LINE		LINE		LINE		
	GRAPHS	LINE		LINE		LINE		LINE		LINE		

		Cross out all but one				Scale of ft./in.
D-9	SCALE	ACRES	SQ MILES	SQ INCHES	0 SCALE	
D-10	ENDATA					

FIGURE 8-49. SEWER INPUT DATA (SHEET 2 - BACK)

FORM 1309-2 (Revised 9/75)

DISTRICT________ RES. NO. __________
I.P.E. __________ PROJ. NO. __________
COUNTY__________________________

STATE DEPARTMENT OF HIGHWAYS
AND PUBLIC TRANSPORTATION
HYDRAULIC SYSTEM
SEWER SUBSYSTEM (SEWER)

PREPARED BY_____
DATE __________
SHEET 3 OF 3

* 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80

Comments ☐ $
☐ $
☐ $

		Cross out one		Select one, two, or three. Cross out others.			Design Frequency	Prob. No.
Control Card ☐	SEWER	DESIGN	ANALYSIS	RUNOFF	INLET	SEWER	FREQUENCY= YR	

		Alphanumeric description of type of runoff surface for each subarea A through F					
D-1 ☐	COEF DESC	A=	B=	C=	D=	E=	F=

		"C" (runoff coefficient) applicable to each runoff surface A through F						Minimum Time of concentration	Rainfall Intensity Constants		
		A	B	C	D	E	F		e	b	d
D-2 ☐	RAT COEF							MIN TC =	.		.

		Drainage area ID		Drainage areas for subareas A through F						Time of concentration data			Minimum Size Pipe (in.)	Design Increment (Insert 3" or 6")	Baseflow or Supply Q	
		Line Letter	Inlet No.	A	B	C	D	E	F	Length	Velocity	Tc				
D-3 ▮	DA	A	10	.31	.	.	.	.	.	L 305	V 2.5	~~T~~				12345
▮	DA	6	2	.29	.	.	.	.	.	L 345	V 1.5	~~T~~				12345
▮	DA	G	1	.74	.	.	.	.	.	L 920	V 1.5	~~T~~				12345
☐	DA			.	.	.	.	.	.	L	V	T				
☐	DA			.	.	.	.	.	.	L	V	T				
☐	DA			.	.	.	.	.	.	L	V	T				
☐	DA			.	.	.	.	.	.	L	V	T				
☐	DA			.	.	.	.	.	.	L	V	T				
☐	DA			.	.	.	.	.	.	L	V	T				

		Junc ID		CURB on GRADE = CURB CURB at SAG = CSAG GRATE on GRADE = GRATE GRATE at SAG = GSAG GRATE & CURB on GRADE = GC GRATE & CURB at SAG = GCSAG JUNCTION = JUNCT	Maximum ponding width (ft.)	Gutter Slope %	Slope Z 1	Distance for slope Z 1	Slope Z 2	Mannings "n" value (gutter)	Gutter Depression "a" (ft.)	Max ponding depth above grate or gutter (in.)	Analysis only		Width of Grate on Grade (ft.)
		Line letter	Inlet No.										Inlet length (ft.)	Inlet area (sq. ft.)	
D-4 ☐	JUNC			TYPE=		.				.	.				.
☐	JUNC			TYPE=		.				.	.				.
☐	JUNC			TYPE=		.				.	.				.
☐	JUNC			TYPE=		.				.	.				.
☐	JUNC			TYPE=		.				.	.				.
☐	JUNC			TYPE=		.				.	.				.
☐	JUNC			TYPE=		.				.	.				.
☐	JUNC			TYPE=		.				.	.				.
☐	JUNC			TYPE=		.				.	.				.

		Inlet Identification						Standard Inlet Opening (ft.)	Allowable Carryover Length (ft.)
			Line Letter	Inlet No.		Line Letter	Inlet No.		
D-4a ☐	CARRYOVER	FROM			TO			L=	P= .
☐	CARRYOVER	FROM			TO			L=	P= .
☐	CARRYOVER	FROM			TO			L=	P= .
☐	CARRYOVER	FROM			TO			L=	P= .
☐	CARRYOVER	FROM			TO			L=	P= .
☐	CARRYOVER	FROM			TO			L=	P= .
☐	CARRYOVER	FROM			TO			L=	P= .
☐	CARRYOVER	FROM			TO			L=	P= .

☐ 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80

Note. *
▮ Mark box as shown beside each line used.

FIGURE 8-50. SEWER INPUT DATA (SHEET 3 - FRONT)

FORM CONTINUED ON BACK
FORM 1309-1 (Revised 9/75)

SEWER (Continued)

BACK, SHEET 3 OF 3

				Outlet ID Line letter	Outlet ID Outlet No.
D-5 ☐	OUTLET	STATIONING	T.W. ELEV		

		Run ID	Junction or U.S. inlet Line	Junction or U.S. inlet Inlet	Junction or D.S. inlet Line	Junction or D.S. inlet Inlet	Upstream Soffit elevation	Downstream Soffit elevation	Run (ft.) length	CA addition	Q addition	Mannings "n" value	U.S. Junction Loss coeff.	Maximum size rise	Insert one: CIRC, ARCH, OVAL, BOX	
D-6 ▮	DSGN	21	A	9	A	10	US 87.50	DS 86.75	68			0.012	.	36	CIRC	12345
▮	DSGN	22	A	10	D	5	US 86.71	DS 85.08	140			0.012	.	36	CIRC	12345
▮	DSGN	23	D	5	D	6	US 85.00	DS 83.12	470			0.012	.	42	CIRC	12345
☐	DSGN						US	DS				.	.			
☐	DSGN						US	DS				.	.			
☐	DSGN						US	DS				.	.			
☐	DSGN						US	DS				.	.			
☐	DSGN						US	DS				.	.			
☐	DSGN						US	DS				.	.			
☐	DSGN						US	DS				.	.			

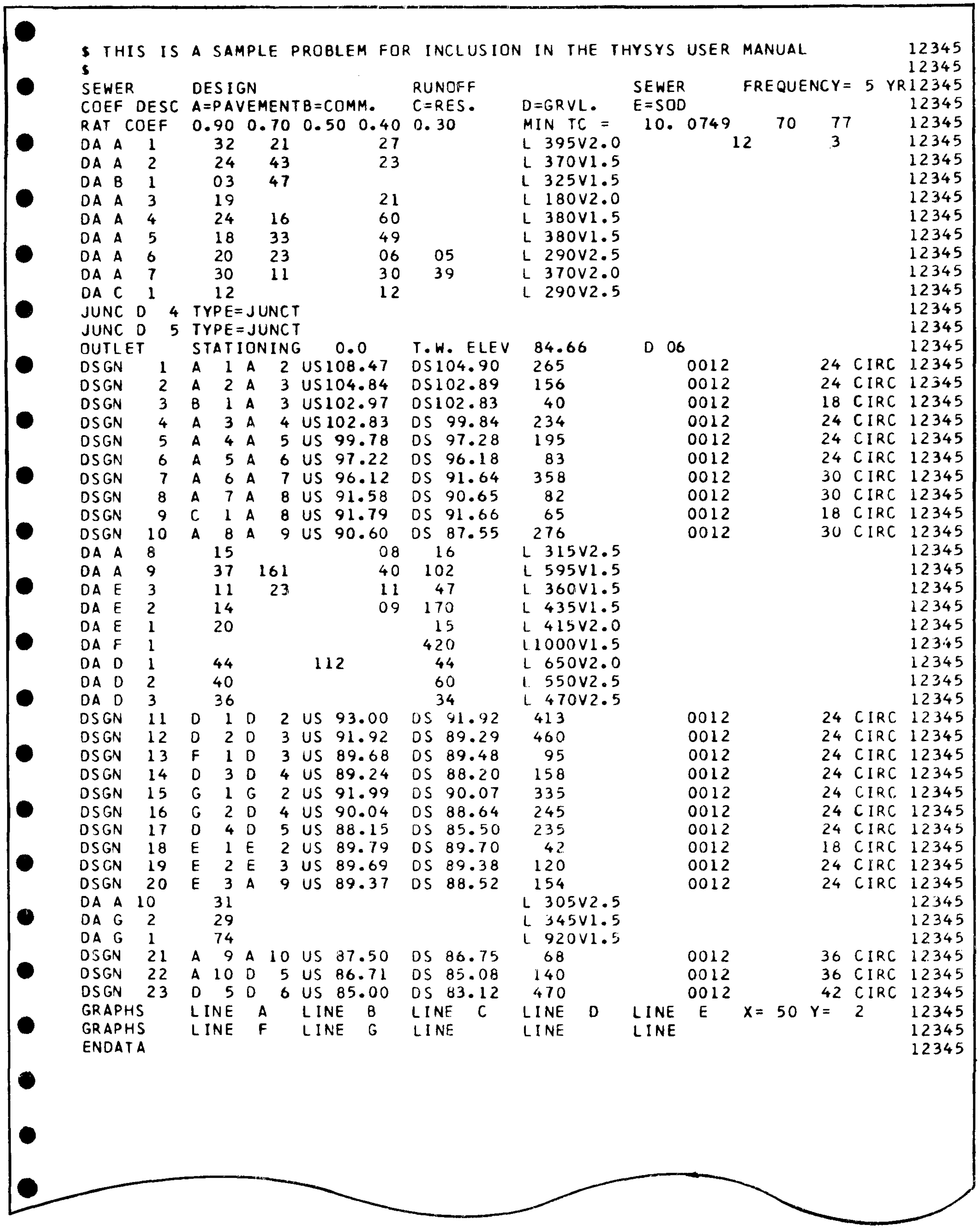
		Run ID	U.S. Inlet Line	U.S. Inlet Inlet	D.S. Inlet Line	D.S. Inlet Inlet	Actual no. of barrels	Actual rise or D (in.) (ft. if box)	Actual span (in.) (ft. if box)		Actual U.S. junction head loss(ft.)
D-7 ☐	ANAL										
☐	ANAL										
☐	ANAL										
☐	ANAL										
☐	ANAL										
☐	ANAL										
☐	ANAL										
☐	ANAL										
☐	ANAL										
☐	ANAL										

			Line letter		Line letter		Line letter		Line letter		Line letter	Scale Factor	
D-8 ▮	GRAPHS	LINE	A	LINE	B	LINE	C	LINE	D	LINE	E	X= 50 Y= 2	12345
▮	GRAPHS	LINE	F	LINE	G	LINE		LINE		LINE			12345
☐	GRAPHS	LINE		LINE		LINE		LINE		LINE			
☐	GRAPHS	LINE		LINE		LINE		LINE		LINE			
☐	GRAPHS	LINE		LINE		LINE		LINE		LINE			

		Cross out all but one			Scale of ft./in.	
D-9 ☐	SCALE	ACRES	SQ MILES	SQ INCHES	● SCALE	
D-10 ▮	ENDATA					12345

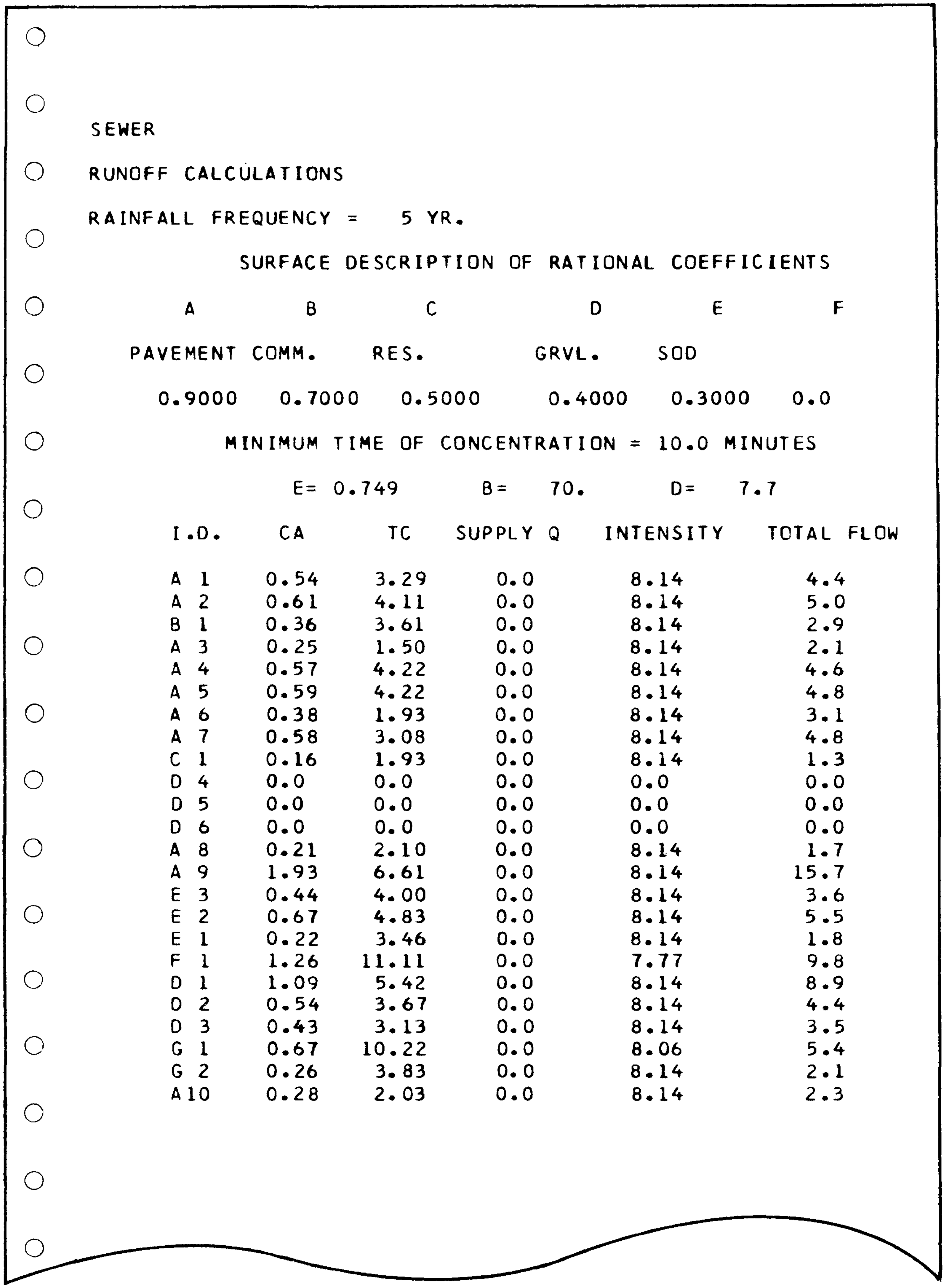
FIGURE 8-51. SEWER INPUT DATA (SHEET 3 - BACK)

FORM 1309-2 (Revised 9/75)



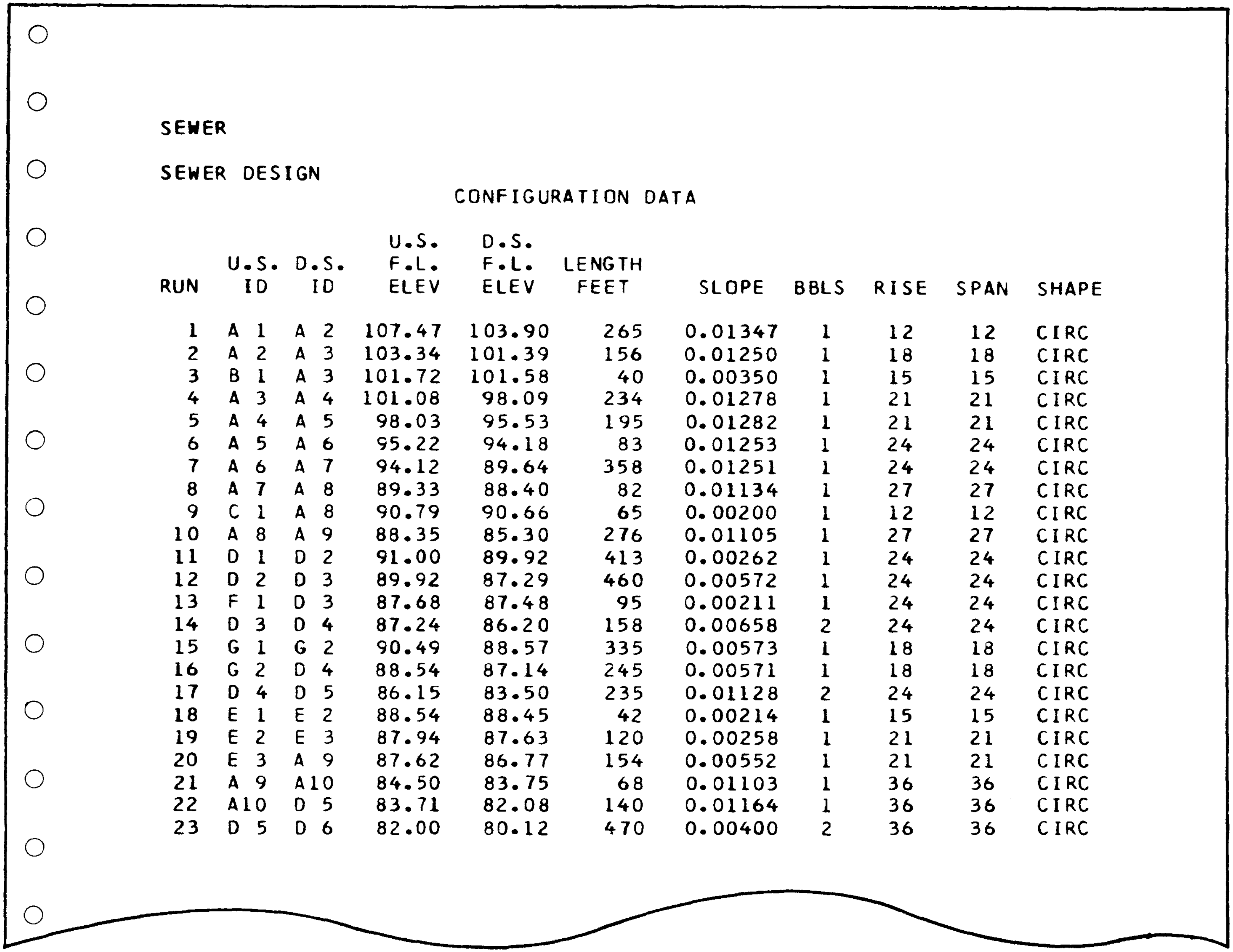
```
$ THIS IS A SAMPLE PROBLEM FOR INCLUSION IN THE THYSYS USER MANUAL         12345
$                                                                          12345
SEWER     DESIGN              RUNOFF              SEWER     FREQUENCY= 5 YR12345
COEF DESC A=PAVEMENTB=COMM.   C=RES.    D=GRVL.   E=SOD                    12345
RAT COEF  0.90 0.70 0.50 0.40 0.30      MIN TC =   10. 0749    70   77     12345
DA A  1     32   21        27           L 395V2.0          12        3     12345
DA A  2     24   43        23           L 370V1.5                          12345
DA B  1     03   47                     L 325V1.5                          12345
DA A  3     19             21           L 180V2.0                          12345
DA A  4     24   16        60           L 380V1.5                          12345
DA A  5     18   33        49           L 380V1.5                          12345
DA A  6     20   23        06   05      L 290V2.5                          12345
DA A  7     30   11        30   39      L 370V2.0                          12345
DA C  1     12             12           L 290V2.5                          12345
JUNC D  4 TYPE=JUNCT                                                       12345
JUNC D  5 TYPE=JUNCT                                                       12345
OUTLET    STATIONING   0.0    T.W. ELEV  84.66     D 06                    12345
DSGN   1  A  1 A  2 US108.47  DS104.90   265           0012        24 CIRC 12345
DSGN   2  A  2 A  3 US104.84  DS102.89   156           0012        24 CIRC 12345
DSGN   3  B  1 A  3 US102.97  DS102.83    40           0012        18 CIRC 12345
DSGN   4  A  3 A  4 US102.83  DS 99.84   234           0012        24 CIRC 12345
DSGN   5  A  4 A  5 US 99.78  DS 97.28   195           0012        24 CIRC 12345
DSGN   6  A  5 A  6 US 97.22  DS 96.18    83           0012        24 CIRC 12345
DSGN   7  A  6 A  7 US 96.12  DS 91.64   358           0012        30 CIRC 12345
DSGN   8  A  7 A  8 US 91.58  DS 90.65    82           0012        30 CIRC 12345
DSGN   9  C  1 A  8 US 91.79  DS 91.66    65           0012        18 CIRC 12345
DSGN  10  A  8 A  9 US 90.60  DS 87.55   276           0012        30 CIRC 12345
DA A  8     15             08   16      L 315V2.5                          12345
DA A  9     37  161        40  102      L 595V1.5                          12345
DA E  3     11   23        11   47      L 360V1.5                          12345
DA E  2     14             09  170      L 435V1.5                          12345
DA E  1     20                  15      L 415V2.0                          12345
DA F  1                        420      L1000V1.5                          12345
DA D  1     44       112        44      L 650V2.0                          12345
DA D  2     40                  60      L 550V2.5                          12345
DA D  3     36                  34      L 470V2.5                          12345
DSGN  11  D  1 D  2 US 93.00  DS 91.92   413           0012        24 CIRC 12345
DSGN  12  D  2 D  3 US 91.92  DS 89.29   460           0012        24 CIRC 12345
DSGN  13  F  1 D  3 US 89.68  DS 89.48    95           0012        24 CIRC 12345
DSGN  14  D  3 D  4 US 89.24  DS 88.20   158           0012        24 CIRC 12345
DSGN  15  G  1 G  2 US 91.99  DS 90.07   335           0012        24 CIRC 12345
DSGN  16  G  2 D  4 US 90.04  DS 88.64   245           0012        24 CIRC 12345
DSGN  17  D  4 D  5 US 88.15  DS 85.50   235           0012        24 CIRC 12345
DSGN  18  E  1 E  2 US 89.79  DS 89.70    42           0012        18 CIRC 12345
DSGN  19  E  2 E  3 US 89.69  DS 89.38   120           0012        24 CIRC 12345
DSGN  20  E  3 A  9 US 89.37  DS 88.52   154           0012        24 CIRC 12345
DA A 10     31                          L 305V2.5                          12345
DA G  2     29                          L 345V1.5                          12345
DA G  1     74                          L 920V1.5                          12345
DSGN  21  A  9 A 10 US 87.50  DS 86.75    68           0012        36 CIRC 12345
DSGN  22  A 10 D  5 US 86.71  DS 85.08   140           0012        36 CIRC 12345
DSGN  23  D  5 D  6 US 85.00  DS 83.12   470           0012        42 CIRC 12345
GRAPHS    LINE  A   LINE  B   LINE  C   LINE  D   LINE  E   X= 50 Y=  2    12345
GRAPHS    LINE  F   LINE  G   LINE      LINE      LINE                     12345
ENDATA                                                                     12345
```

FIGURE 8-52. COMPUTER PRINTED INPUT DATA



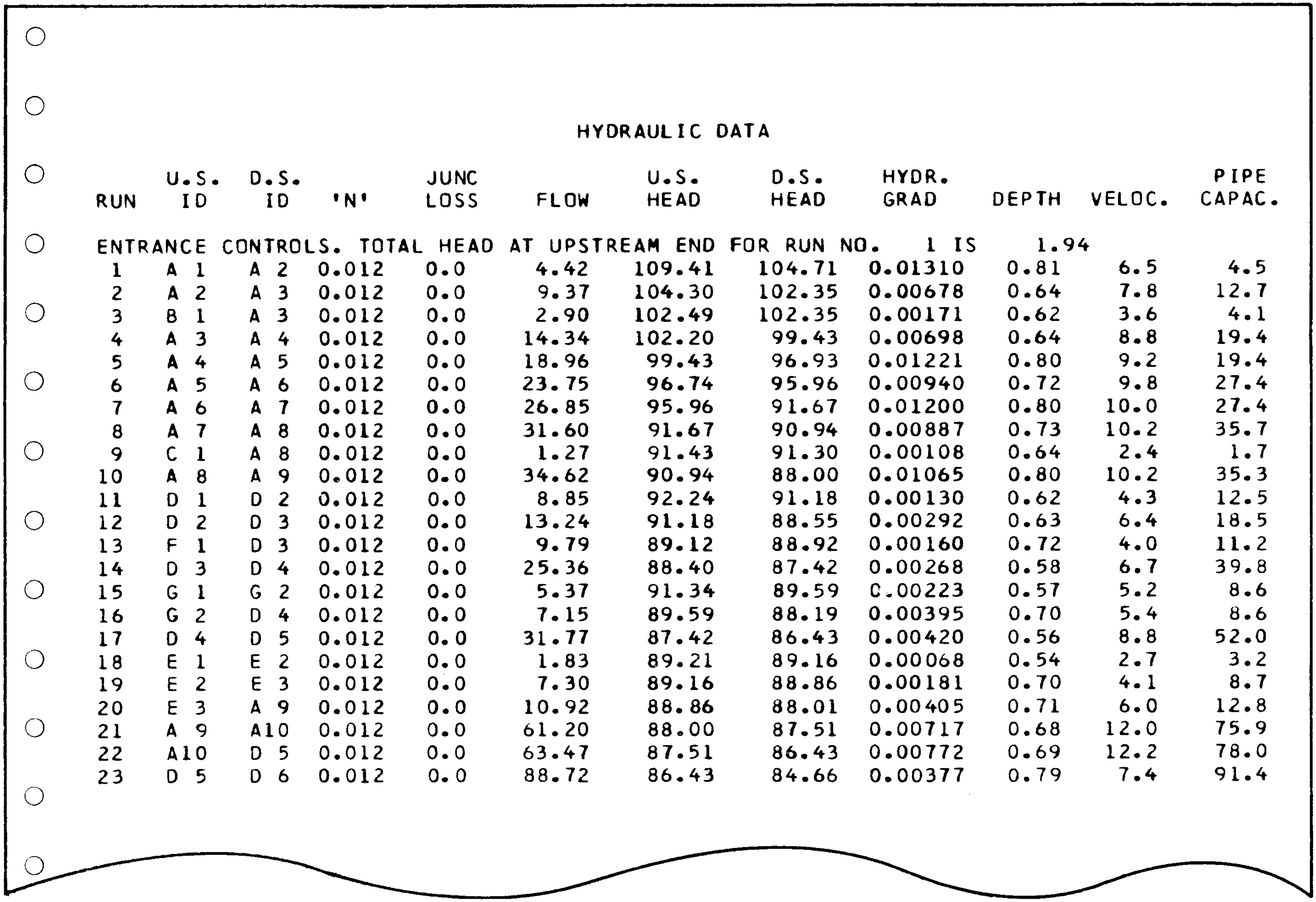
```
SEWER

RUNOFF CALCULATIONS

RAINFALL FREQUENCY =   5 YR.

                SURFACE DESCRIPTION OF RATIONAL COEFFICIENTS

          A          B          C            D          E          F

    PAVEMENT COMM.    RES.          GRVL.     SOD

      0.9000    0.7000    0.5000      0.4000    0.3000    0.0

              MINIMUM TIME OF CONCENTRATION = 10.0 MINUTES

                   E= 0.749       B=    70.        D=    7.7

         I.D.     CA        TC     SUPPLY Q     INTENSITY     TOTAL FLOW

         A  1    0.54      3.29      0.0           8.14           4.4
         A  2    0.61      4.11      0.0           8.14           5.0
         B  1    0.36      3.61      0.0           8.14           2.9
         A  3    0.25      1.50      0.0           8.14           2.1
         A  4    0.57      4.22      0.0           8.14           4.6
         A  5    0.59      4.22      0.0           8.14           4.8
         A  6    0.38      1.93      0.0           8.14           3.1
         A  7    0.58      3.08      0.0           8.14           4.8
         C  1    0.16      1.93      0.0           8.14           1.3
         D  4    0.0       0.0       0.0           0.0            0.0
         D  5    0.0       0.0       0.0           0.0            0.0
         D  6    0.0       0.0       0.0           0.0            0.0
         A  8    0.21      2.10      0.0           8.14           1.7
         A  9    1.93      6.61      0.0           8.14          15.7
         E  3    0.44      4.00      0.0           8.14           3.6
         E  2    0.67      4.83      0.0           8.14           5.5
         E  1    0.22      3.46      0.0           8.14           1.8
         F  1    1.26     11.11      0.0           7.77           9.8
         D  1    1.09      5.42      0.0           8.14           8.9
         D  2    0.54      3.67      0.0           8.14           4.4
         D  3    0.43      3.13      0.0           8.14           3.5
         G  1    0.67     10.22      0.0           8.06           5.4
         G  2    0.26      3.83      0.0           8.14           2.1
         A10     0.28      2.03      0.0           8.14           2.3
```

FIGURE 8-53. RUNOFF CALCULATIONS



```
SEWER

SEWER DESIGN
                         CONFIGURATION DATA

                      U.S.    D.S.
     U.S.  D.S.       F.L.    F.L.   LENGTH
RUN   ID    ID        ELEV    ELEV    FEET       SLOPE   BBLS   RISE   SPAN   SHAPE

  1  A 1   A 2     107.47  103.90     265    0.01347     1     12     12    CIRC
  2  A 2   A 3     103.34  101.39     156    0.01250     1     18     18    CIRC
  3  B 1   A 3     101.72  101.58      40    0.00350     1     15     15    CIRC
  4  A 3   A 4     101.08   98.09     234    0.01278     1     21     21    CIRC
  5  A 4   A 5      98.03   95.53     195    0.01282     1     21     21    CIRC
  6  A 5   A 6      95.22   94.18      83    0.01253     1     24     24    CIRC
  7  A 6   A 7      94.12   89.64     358    0.01251     1     24     24    CIRC
  8  A 7   A 8      89.33   88.40      82    0.01134     1     27     27    CIRC
  9  C 1   A 8      90.79   90.66      65    0.00200     1     12     12    CIRC
 10  A 8   A 9      88.35   85.30     276    0.01105     1     27     27    CIRC
 11  D 1   D 2      91.00   89.92     413    0.00262     1     24     24    CIRC
 12  D 2   D 3      89.92   87.29     460    0.00572     1     24     24    CIRC
 13  F 1   D 3      87.68   87.48      95    0.00211     1     24     24    CIRC
 14  D 3   D 4      87.24   86.20     158    0.00658     2     24     24    CIRC
 15  G 1   G 2      90.49   88.57     335    0.00573     1     18     18    CIRC
 16  G 2   D 4      88.54   87.14     245    0.00571     1     18     18    CIRC
 17  D 4   D 5      86.15   83.50     235    0.01128     2     24     24    CIRC
 18  E 1   E 2      88.54   88.45      42    0.00214     1     15     15    CIRC
 19  E 2   E 3      87.94   87.63     120    0.00258     1     21     21    CIRC
 20  E 3   A 9      87.62   86.77     154    0.00552     1     21     21    CIRC
 21  A 9   A10      84.50   83.75      68    0.01103     1     36     36    CIRC
 22  A10   D 5      83.71   82.08     140    0.01164     1     36     36    CIRC
 23  D 5   D 6      82.00   80.12     470    0.00400     2     36     36    CIRC
```

FIGURE 8-54. CONFIGURATION DATA



```
                                        HYDRAULIC DATA

      U.S.   D.S.          JUNC                U.S.      D.S.     HYDR.                      PIPE
RUN    ID     ID    'N'    LOSS      FLOW      HEAD      HEAD     GRAD      DEPTH   VELOC.  CAPAC.

ENTRANCE CONTROLS. TOTAL HEAD AT UPSTREAM END FOR RUN NO.   1 IS     1.94
  1   A 1    A 2  0.012    0.0       4.42    109.41    104.71   0.01310    0.81     6.5      4.5
  2   A 2    A 3  0.012    0.0       9.37    104.30    102.35   0.00678    0.64     7.8     12.7
  3   B 1    A 3  0.012    0.0       2.90    102.49    102.35   0.00171    0.62     3.6      4.1
  4   A 3    A 4  0.012    0.0      14.34    102.20     99.43   0.00698    0.64     8.8     19.4
  5   A 4    A 5  0.012    0.0      18.96     99.43     96.93   0.01221    0.80     9.2     19.4
  6   A 5    A 6  0.012    0.0      23.75     96.74     95.96   0.00940    0.72     9.8     27.4
  7   A 6    A 7  0.012    0.0      26.85     95.96     91.67   0.01200    0.80    10.0     27.4
  8   A 7    A 8  0.012    0.0      31.60     91.67     90.94   0.00887    0.73    10.2     35.7
  9   C 1    A 8  0.012    0.0       1.27     91.43     91.30   0.00108    0.64     2.4      1.7
 10   A 8    A 9  0.012    0.0      34.62     90.94     88.00   0.01065    0.80    10.2     35.3
 11   D 1    D 2  0.012    0.0       8.85     92.24     91.18   0.00130    0.62     4.3     12.5
 12   D 2    D 3  0.012    0.0      13.24     91.18     88.55   0.00292    0.63     6.4     18.5
 13   F 1    D 3  0.012    0.0       9.79     89.12     88.92   0.00160    0.72     4.0     11.2
 14   D 3    D 4  0.012    0.0      25.36     88.40     87.42   0.00268    0.58     6.7     39.8
 15   G 1    G 2  0.012    0.0       5.37     91.34     89.59   0.00223    0.57     5.2      8.6
 16   G 2    D 4  0.012    0.0       7.15     89.59     88.19   0.00395    0.70     5.4      8.6
 17   D 4    D 5  0.012    0.0      31.77     87.42     86.43   0.00420    0.56     8.8     52.0
 18   E 1    E 2  0.012    0.0       1.83     89.21     89.16   0.00068    0.54     2.7      3.2
 19   E 2    E 3  0.012    0.0       7.30     89.16     88.86   0.00181    0.70     4.1      8.7
 20   E 3    A 9  0.012    0.0      10.92     88.86     88.01   0.00405    0.71     6.0     12.8
 21   A 9    A10  0.012    0.0      61.20     88.00     87.51   0.00717    0.68    12.0     75.9
 22   A10    D 5  0.012    0.0      63.47     87.51     86.43   0.00772    0.69    12.2     78.0
 23   D 5    D 6  0.012    0.0      88.72     86.43     84.66   0.00377    0.79     7.4     91.4
```

FIGURE 8-55. HYDRAULIC DATA

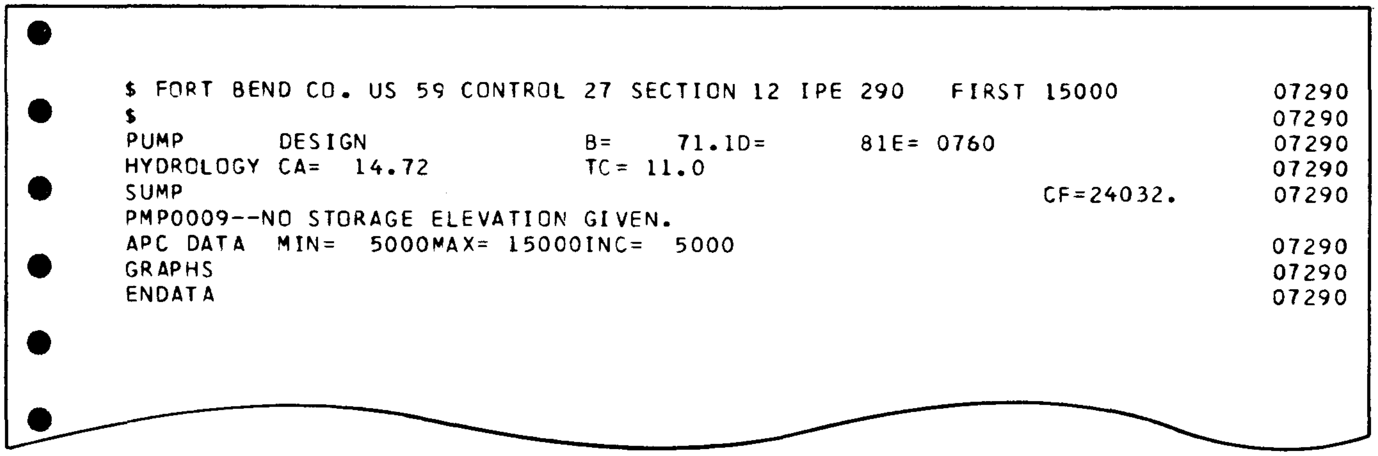
```
                          STATIONING

                           UPSTREAM
          RUN            JUNCTION ID               STATIONING

           1                 A 1                      2327
           2                 A 2                      2062
           3                 B 1                      1946
           4                 A 3                      1906
           5                 A 4                      1672
           6                 A 5                      1477
           7                 A 6                      1394
           8                 A 7                      1036
           9                 C 1                      1019
          10                 A 8                       954
          11                 D 1                      1736
          12                 D 2                      1323
          13                 F 1                       958
          14                 D 3                       863
          15                 G 1                      1285
          16                 G 2                       950
          17                 D 4                       705
          18                 E 1                       994
          19                 E 2                       952
          20                 E 3                       832
          21                 A 9                       678
          22                 A10                       610
          23                 D 5                       470
```

FIGURE 8-56. JUNCTION STATIONING REFERENCE FROM OUTLET

VIII. PUMP SAMPLE PROBLEM

In this example, a pump design will be calculated from the data supplied by the user. The input data sheets for this problem are shown in Figures 8-58 and 8-59 on the following pages. The input includes the rainfall intensity factors, values for CA and TC, sump storage capacity, and available pump sizes that may be used in the design. A graph is also called for; this is followed by the ENDATA line.

The input data is printed out as it is read and edited by the program (Figure 8-57).



```
$ FORT BEND CO. US 59 CONTROL 27 SECTION 12 IPE 290   FIRST 15000                07290
$                                                                                07290
PUMP       DESIGN                 B=    71.1D=      81E= 0760                     07290
HYDROLOGY CA=  14.72              TC= 11.0                                       07290
SUMP                                                            CF=24032.        07290
PMP0009--NO STORAGE ELEVATION GIVEN.
APC DATA  MIN=  5000MAX= 15000INC=  5000                                         07290
GRAPHS                                                                           07290
ENDATA                                                                           07290
```

FIGURE 8-57. EDITED PUMP DATA

If the data contains any errors which are discernible by the program, they will be noted. In this example, the message "NO STORAGE ELEVATION GIVEN" is printed immediately after the SUMP card is read. This does not constitute a fatal error in this case because this value is not used in any calculations; but, if MH/INLET data were given it would be fatal because this elevation is used to calculate storage capacity. No fatal errors are present and calculations continue.

DISTRICT______ RES. NO.__________
I.P.E.__________ PROJ. NO.__________
COUNTY____________________

STATE DEPARTMENT OF HIGHWAYS
AND PUBLIC TRANSPORTATION

HYDRAULIC SYSTEM

PUMP SUBSYSTEM (PUMP)

PREPARED BY______
DATE__________
SHEET 1 OF 1

	Cols 1–10	Cols 11–20	Cols 21–30	Cols 31–40	Cols 41–50	Cols 51–60	Cols 61–70	Cols 71–75	Cols 76–80
Comments ▮	$ FORT BEN	D CO. US 5	9 CONTROL	27 SECTION	12 IPE 29	0 FIRST	15000		07290
▮	$								07290
☐	$								
		Cross out one.		Constants From THD Hydraulic Manual					Prob. No.
Control Card ▮	PUMP	DESIGN	~~ANALYSIS~~	B= 71.1	D= 81	E= 0760			07290
	Select one. Cross out other two.			Must be supplied for CA or Q					
	CA & TC From HYDRO	Supply CA & TC	Supply Q & TC						
E-1 ▮	HYDROLOGY	CA= 14.72	~~Q=~~	TC= 11.0					07290
		Identification	Specify sump dimensions and / or storage, and storage elevation						
			Length or diameter (ft.)	Width (ft.)	Water depth (ft.)	Storage elevation	Supply Storage (cu. ft.)		
E-2 ▮	SUMP		~~LONG=~~	~~WIDE=~~	~~DEEP=~~	~~ELEV=~~	CF=24032.		07290
		Identification	Length or diameter (ft.)	Width (ft.)	Flow line elevation				
E-3 ☐	MH/INLET		LONG=	WIDE=	FL=				
☐	MH/INLET		LONG=	WIDE=	FL=				
☐	MH/INLET		LONG=	WIDE=	FL=				
☐	MH/INLET		LONG=	WIDE=	FL=				
☐	MH/INLET		LONG=	WIDE=	FL=				
☐	MH/INLET		LONG=	WIDE=	FL=				
☐	MH/INLET		LONG=	WIDE=	FL=				
☐	MH/INLET		LONG=	WIDE=	FL=				
☐	MH/INLET		LONG=	WIDE=	FL=				
☐	MH/INLET		LONG=	WIDE=	FL=				
☐	MH/INLET		LONG=	WIDE=	FL=				
☐	MH/INLET		LONG=	WIDE=	FL=				
☐	MH/INLET		LONG=	WIDE=	FL=				
☐	MH/INLET		LONG=	WIDE=	FL=				
☐	MH/INLET		LONG=	WIDE=	FL=				
☐	MH/INLET		LONG=	WIDE=	FL=				
☐	MH/INLET		LONG=	WIDE=	FL=				
☐	MH/INLET		LONG=	WIDE=	FL=				
☐	MH/INLET		LONG=	WIDE=	FL=				
☐	MH/INLET		LONG=	WIDE=	FL=				
☐	MH/INLET		LONG=	WIDE=	FL=				
☐	MH/INLET		LONG=	WIDE=	FL=				
☐	MH/INLET		LONG=	WIDE=	FL=				
☐	MH/INLET		LONG=	WIDE=	FL=				

Note: * ▮ Mark box as shown beside each line used.

FIGURE 8-58. PUMP DATA SHEET (FRONT OF SHEET)

FORM CONTINUED ON BACK
FORM 1310-1

PUMP (Continued)

BACK, SHEET 1 OF 1

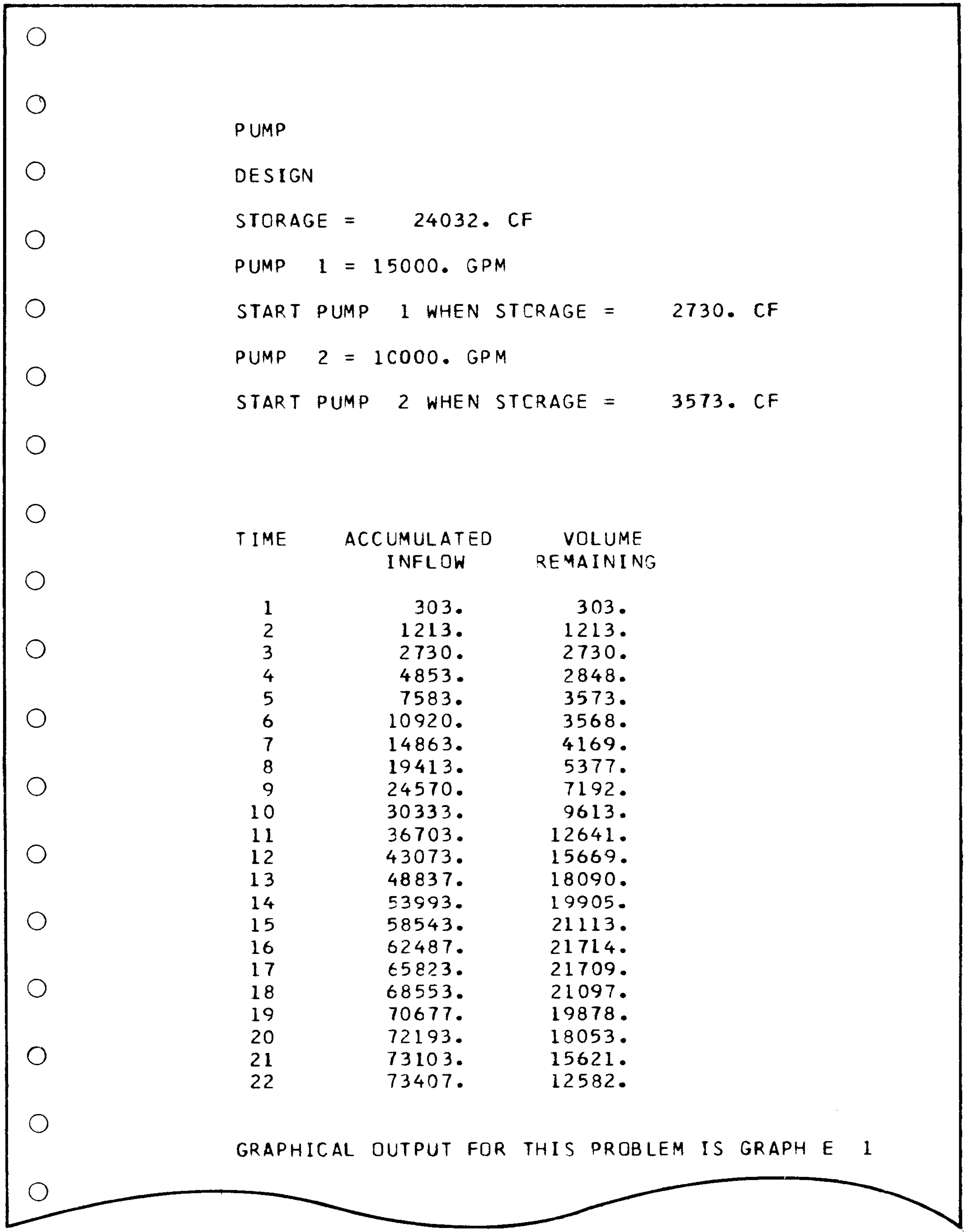
	1–10	11–15	16–20	21–30	31–40	41–50	51–60	61–70	71–75	76–80
		From	To	Height or diameter (ft.)	Width (ft.)	Length (ft.)				
E-4 ☐	PIPE			HIGH= .	WIDE=	LONG=				
☐	PIPE			HIGH= .	WIDE=	LONG=				
☐	PIPE			HIGH= .	WIDE=	LONG=				
☐	PIPE			HIGH= .	WIDE=	LONG=				
☐	PIPE			HIGH= .	WIDE=	LONG=				
☐	PIPE			HIGH= .	WIDE=	LONG=				
☐	PIPE			HIGH= .	WIDE=	LONG=				
☐	PIPE			HIGH= .	WIDE=	LONG=				
☐	PIPE			HIGH= .	WIDE=	LONG=				
☐	PIPE			HIGH= .	WIDE=	LONG=				
☐	PIPE			HIGH= .	WIDE=	LONG=				
☐	PIPE			HIGH= .	WIDE=	LONG=				
☐	PIPE			HIGH= .	WIDE=	LONG=				
☐	PIPE			HIGH= .	WIDE=	LONG=				
☐	PIPE			HIGH= .	WIDE=	LONG=				
☐	PIPE			HIGH= .	WIDE=	LONG=				
☐	PIPE			HIGH= .	WIDE=	LONG=				
☐	PIPE			HIGH= .	WIDE=	LONG=				
☐	PIPE			HIGH= .	WIDE=	LONG=				
☐	PIPE			HIGH= .	WIDE=	LONG=				
☐	PIPE			HIGH= .	WIDE=	LONG=				
☐	PIPE			HIGH= .	WIDE=	LONG=				
☐	PIPE			HIGH= .	WIDE=	LONG=				
☐	PIPE			HIGH= .	WIDE=	LONG=				
☐	PIPE			HIGH= .	WIDE=	LONG=				
☐	PIPE			HIGH= .	WIDE=	LONG=				
☐	PIPE			HIGH= .	WIDE=	LONG=				
☐	PIPE			HIGH= .	WIDE=	LONG=				
		Specify range of pump capacities and increment in gpm for design.								
E-5 ▮	APC DATA	MIN= 5000		MAX= 15000	INC= 5000					07290
		Specify known pump capacity & storage volume at which pump starts.								
E-6 ☐	ANALYSIS	GPM=		CF=	GPM=	CF=	GPM=	CF=		
☐	ANALYSIS	GPM=		CF=	GPM=	CF=	GPM=	CF=		
E-7 ▮	GRAPHS									07290
E-8 ▮	ENDATA									07290

FIGURE 8-59. PUMP DATA SHEET (BACK OF SHEET)

FORM 1310-2

The printed output for the first pump design solution is shown in Figure 8-60 on the following page. The output contains: (1) storage capacity; (2) the pump sizes, their starting sequence and storage capacity at which they start; and (3) a table for each minute of runoff until the accumulated volume reaches a peak. The table lists, for each minute of storm, the accumulated volume, and the volume remaining after the indicated pumps have been started. If a graph has been requested, the graph number associated with that problem is printed at the bottom of the page. The graph for this problem is graph E-1 (shown in Figure 8-61) and it has accumulated volume as its ordinate and time (minutes) as its abscissa. The long, smooth curve represents the accumulated volume with no pumps on. The other curve which branches out from the first curve represents the remaining volume as the pumps are started, and the straight horizontal line represents maximum storage (as it is labeled).

If the pump sizes are not the same, another solution is provided reversing the starting order of the pumps. The condition exists in this example, and the printed output is shown in Figure 8-62. Graph E-2 (Figure 8-63) for this output is also shown.



```
PUMP

DESIGN

STORAGE =     24032. CF

PUMP  1 = 15000. GPM

START PUMP  1 WHEN STCRAGE =     2730. CF

PUMP  2 = 1C000. GPM

START PUMP  2 WHEN STCRAGE =     3573. CF




TIME    ACCUMULATED     VOLUME
          INFLOW      REMAINING

  1          303.         303.
  2         1213.        1213.
  3         2730.        2730.
  4         4853.        2848.
  5         7583.        3573.
  6        10920.        3568.
  7        14863.        4169.
  8        19413.        5377.
  9        24570.        7192.
 10        30333.        9613.
 11        36703.       12641.
 12        43073.       15669.
 13        48837.       18090.
 14        53993.       19905.
 15        58543.       21113.
 16        62487.       21714.
 17        65823.       21709.
 18        68553.       21097.
 19        70677.       19878.
 20        72193.       18053.
 21        73103.       15621.
 22        73407.       12582.

GRAPHICAL OUTPUT FOR THIS PROBLEM IS GRAPH E  1
```

FIGURE 8-60. PUMP DESIGN FOR FIRST SOLUTION

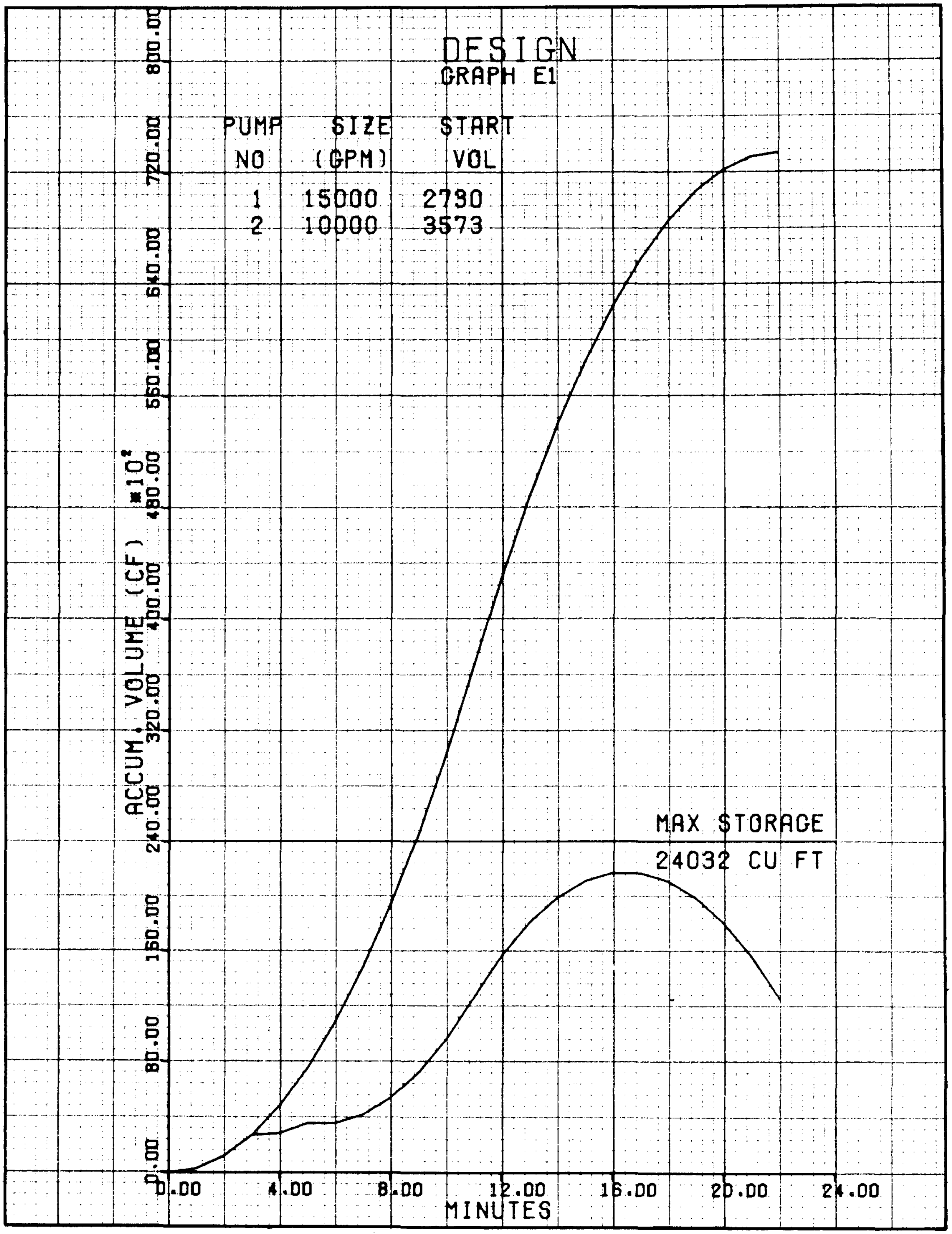
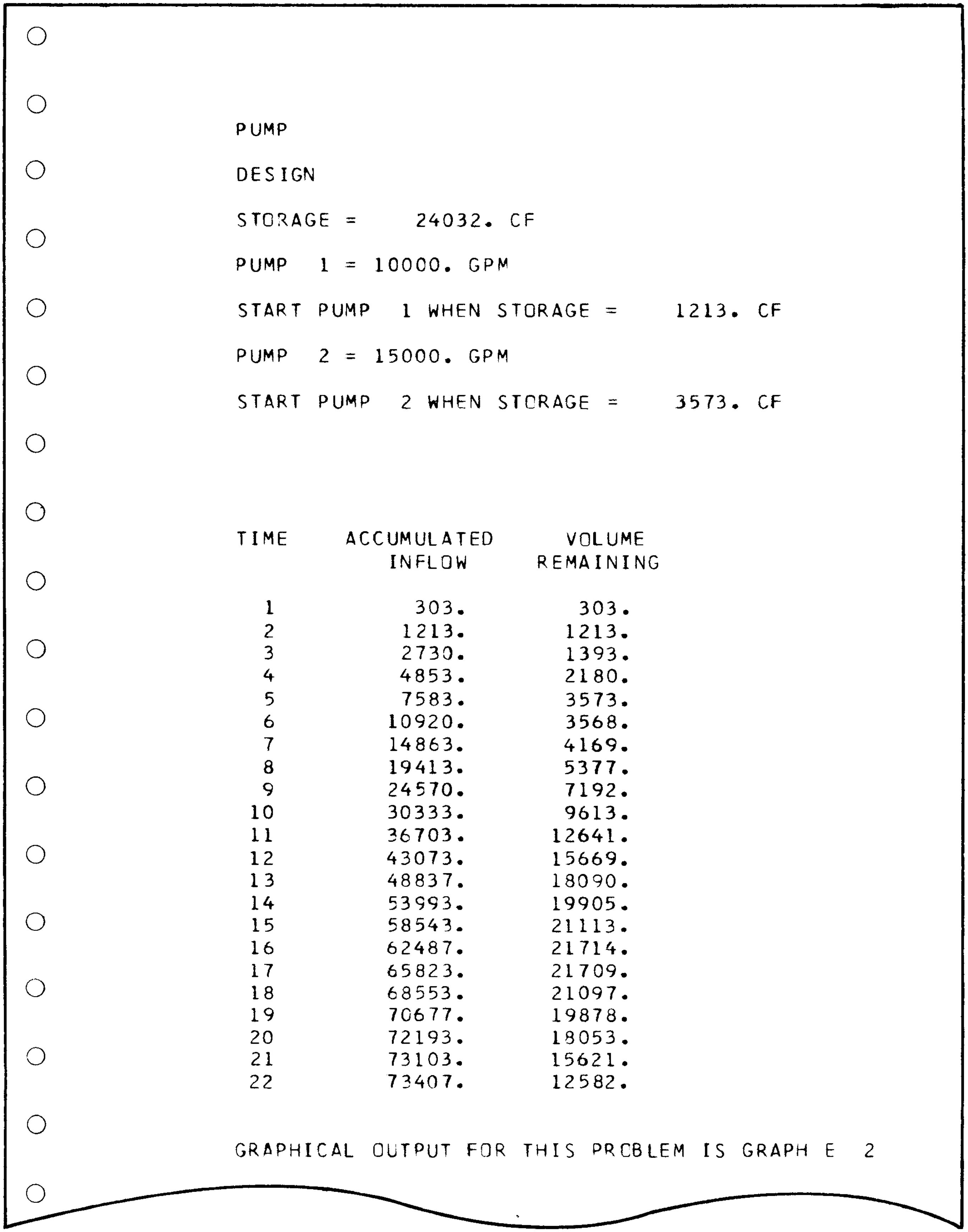


FIGURE 8-61. GRAPHICAL OUTPUT FOR FIRST PUMP DESIGN



```
PUMP

DESIGN

STORAGE =     24032. CF

PUMP  1 = 10000. GPM

START PUMP  1 WHEN STORAGE =    1213. CF

PUMP  2 = 15000. GPM

START PUMP  2 WHEN STORAGE =    3573. CF




TIME    ACCUMULATED     VOLUME
           INFLOW     REMAINING

  1          303.        303.
  2         1213.       1213.
  3         2730.       1393.
  4         4853.       2180.
  5         7583.       3573.
  6        10920.       3568.
  7        14863.       4169.
  8        19413.       5377.
  9        24570.       7192.
 10        30333.       9613.
 11        36703.      12641.
 12        43073.      15669.
 13        48837.      18090.
 14        53993.      19905.
 15        58543.      21113.
 16        62487.      21714.
 17        65823.      21709.
 18        68553.      21097.
 19        70677.      19878.
 20        72193.      18053.
 21        73103.      15621.
 22        73407.      12582.

GRAPHICAL OUTPUT FOR THIS PRCBLEM IS GRAPH E  2
```

FIGURE 8-62. PUMP DESIGN FOR SECOND SOLUTION

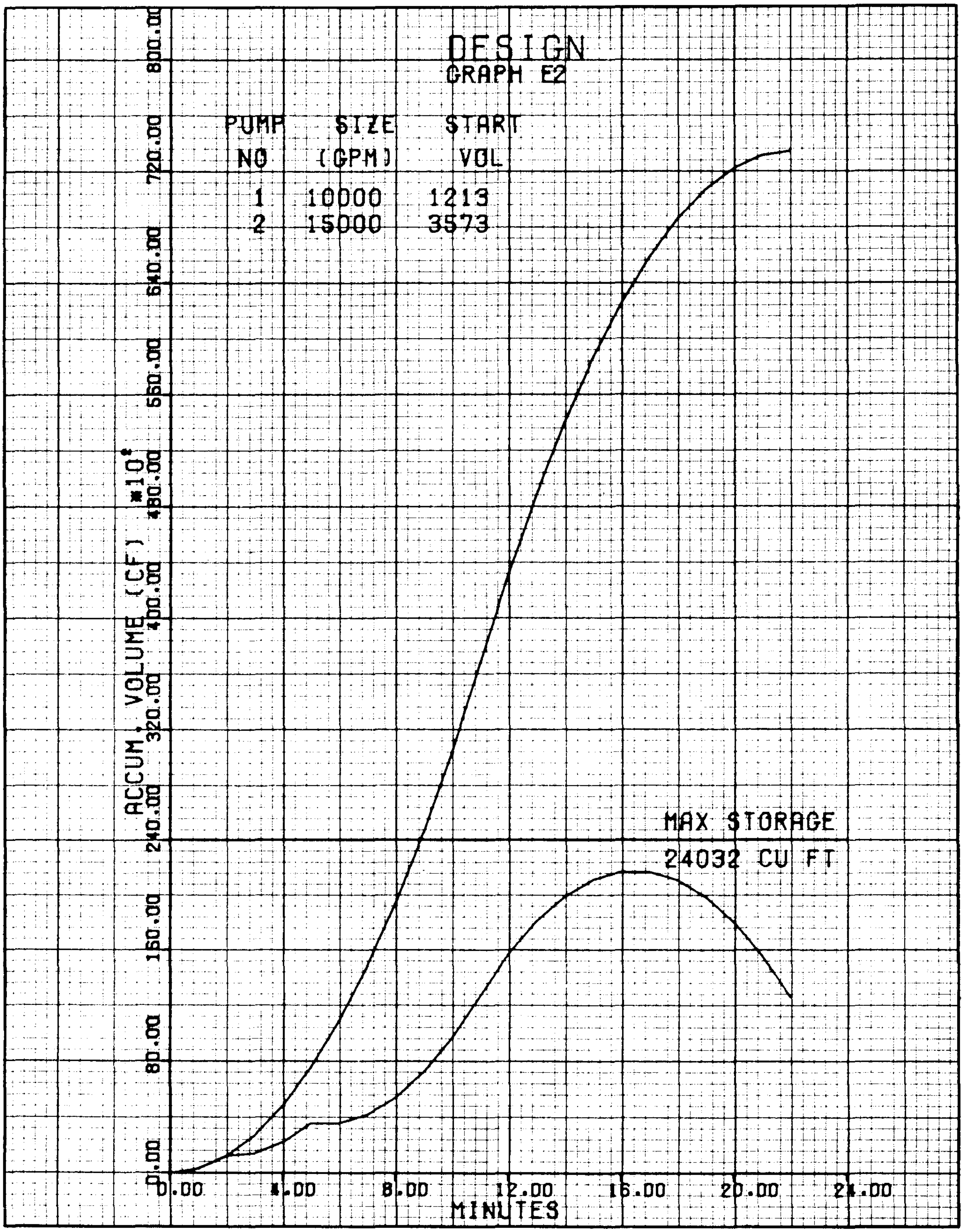
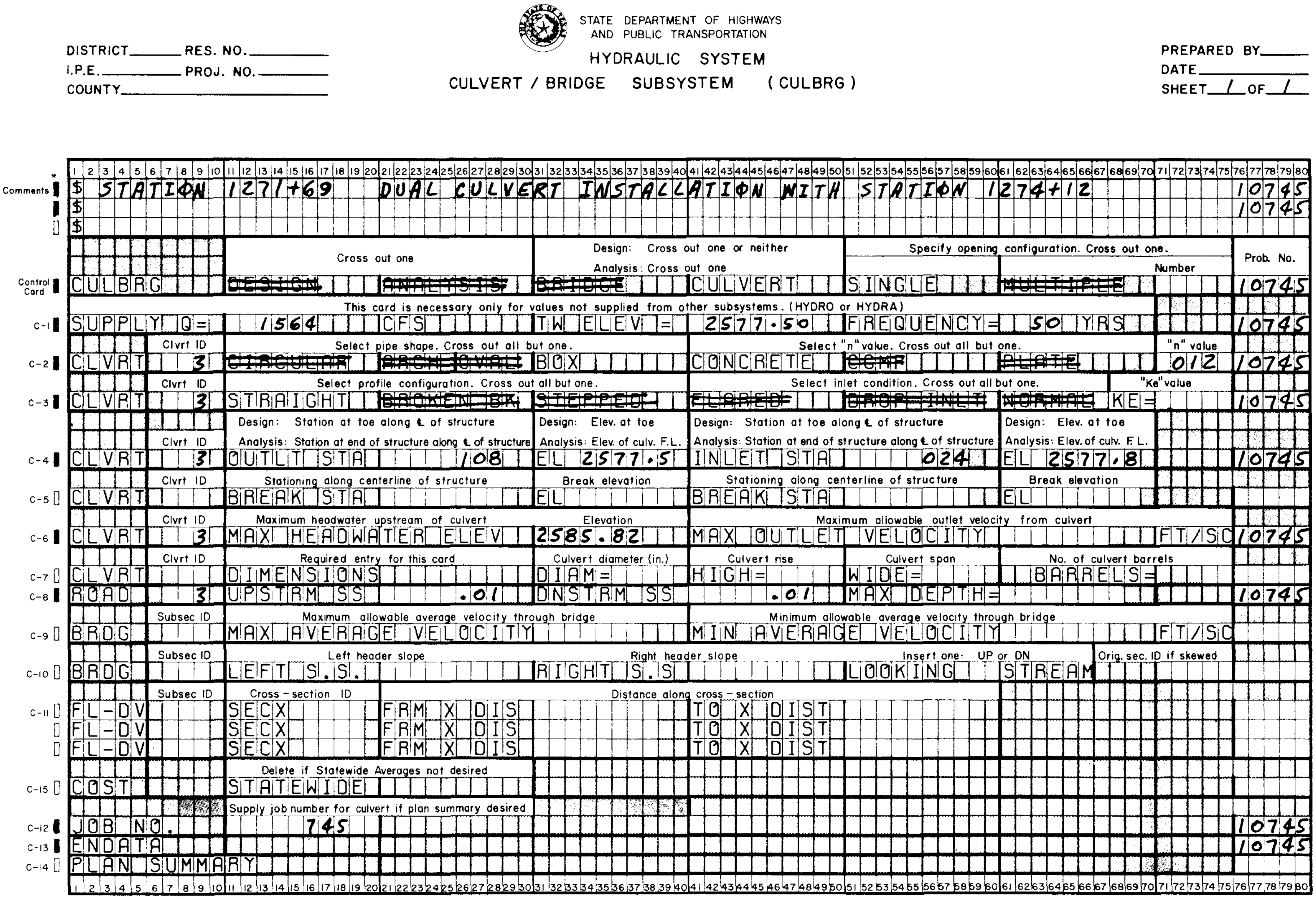


FIGURE 8-63. GRAPHICAL OUTPUT FOR SECOND PUMP DESIGN

IX. CULBRG SAMPLE PROBLEM SHOWING FATAL ERRORS

This CULBRG sample problem has been included to acquaint the user with the action taken when a fatal error is encountered in the input data. Even though a CULBRG problem is used in this example, all subsystems (HYDRO, HYDRA, etc.) work the same in this respect. The input data sheet is shown in Figure 8-64.

The following errors have been incorporated in the input data. On the Control card, both DESIGN and ANALYSIS were deleted. On Card C-3, all types of inlet conditions were deleted. On Card D-6, the maximum outlet velocity was not given, but a value of 8.0 was supplied by the program which would have allowed the problem to be completed, assuming there were no fatal errors present. On Card C-8 the maximum barrel depth was left blank. The edited input data is shown in Figure 8-65 with each of these errors noted following the card on which it appeared. After the ENDATA card was read, the program checked to see if any of the errors noted were fatal. When a fatal error is detected, as it was in this case, the program indicates the last card having a fatal error and proceeds to the next problem. Thus, although fatal errors occurred on several cards in the sample problem input, only the error on C-8 was noted after ENDATA was printed. The final message, "ERRORS PRECLUDE COMPUTATION", is printed under any conditions that prevent completion of the problem. Following this message the program proceeded to the next problem.



STATE DEPARTMENT OF HIGHWAYS
AND PUBLIC TRANSPORTATION

HYDRAULIC SYSTEM

CULVERT / BRIDGE SUBSYSTEM (CULBRG)

DISTRICT______ RES. NO.________

I.P.E.________ PROJ. NO.________

COUNTY________

PREPARED BY______

DATE______

SHEET 1 OF 1

Columns 1–80

Comments* ■ $ STATION 1271+69 DUAL CULVERT INSTALLATION WITH STATION 1274+12 — Prob. No. 10745

■ $ — 10745

☐ $

Control Card ■ CULBRG — Cross out one: ~~DESIGN~~ ~~ANALYSIS~~ — Design: Cross out one or neither / Analysis: Cross out one: ~~BRIDGE~~ CULVERT — Specify opening configuration. Cross out one.: SINGLE ~~MULTIPLE~~ — Number — Prob. No. 10745

This card is necessary only for values not supplied from other subsystems. (HYDRO or HYDRA)

C-1 ■ SUPPLY Q= 1564 CFS TW ELEV = 2577.50 FREQUENCY= 50 YRS — 10745

C-2 ■ CLVRT — Clvrt ID 3 — Select pipe shape. Cross out all but one.: ~~CIRCULAR~~ ~~ARCH~~ ~~OVAL~~ BOX — Select "n" value. Cross out all but one.: CONCRETE ~~CCMP~~ ~~PLATE~~ — "n" value .012 — 10745

C-3 ■ CLVRT — Clvrt ID 3 — Select profile configuration. Cross out all but one.: STRAIGHT ~~BROKEN BK~~ ~~STEPPED~~ — Select inlet condition. Cross out all but one.: ~~FLARED~~ ~~DROP INLET~~ ~~NORMAL~~ — "Ke" value KE= — 10745

C-4 ■ CLVRT — Clvrt ID 3 — Design: Station at toe along ℄ of structure / Analysis: Station at end of structure along ℄ of structure: OUTLT STA 108 — Design: Elev. at toe / Analysis: Elev. of culv. F.L.: EL 2577.5 — Design: Station at toe along ℄ of structure / Analysis: Station at end of structure along ℄ of structure: INLET STA 024 — Design: Elev. at toe / Analysis: Elev. of culv. F.L.: EL 2577.8 — 10745

C-5 ☐ CLVRT — Clvrt ID — Stationing along centerline of structure: BREAK STA — Break elevation: EL — Stationing along centerline of structure: BREAK STA — Break elevation: EL

C-6 ■ CLVRT — Clvrt ID 3 — Maximum headwater upstream of culvert: MAX HEADWATER ELEV — Elevation: 2585.82 — Maximum allowable outlet velocity from culvert: MAX OUTLET VELOCITY FT/SC — 10745

C-7 ☐ CLVRT — Clvrt ID — Required entry for this card: DIMENSIONS — Culvert diameter (in.): DIAM= — Culvert rise: HIGH= — Culvert span: WIDE= — No. of culvert barrels: BARRELS=

C-8 ■ ROAD 3 UPSTRM SS .01 DNSTRM SS .01 MAX DEPTH= — 10745

C-9 ☐ BRDG — Subsec ID — Maximum allowable average velocity through bridge: MAX AVERAGE VELOCITY — Minimum allowable average velocity through bridge: MIN AVERAGE VELOCITY FT/SC

C-10 ☐ BRDG — Subsec ID — Left header slope: LEFT S.S. — Right header slope: RIGHT S.S — Insert one: UP or DN: LOOKING STREAM — Orig. sec. ID if skewed

C-11 ☐ FL-DV — Subsec ID — Cross-section ID: SECX — Distance along cross-section: FRM X DIS TO X DIST

☐ FL-DV SECX FRM X DIS TO X DIST

☐ FL-DV SECX FRM X DIS TO X DIST

C-15 ☐ COST — Delete if Statewide Averages not desired: STATEWIDE

C-12 ■ JOB NO. — Supply job number for culvert if plan summary desired: 745 — 10745

C-13 ■ ENDATA — 10745

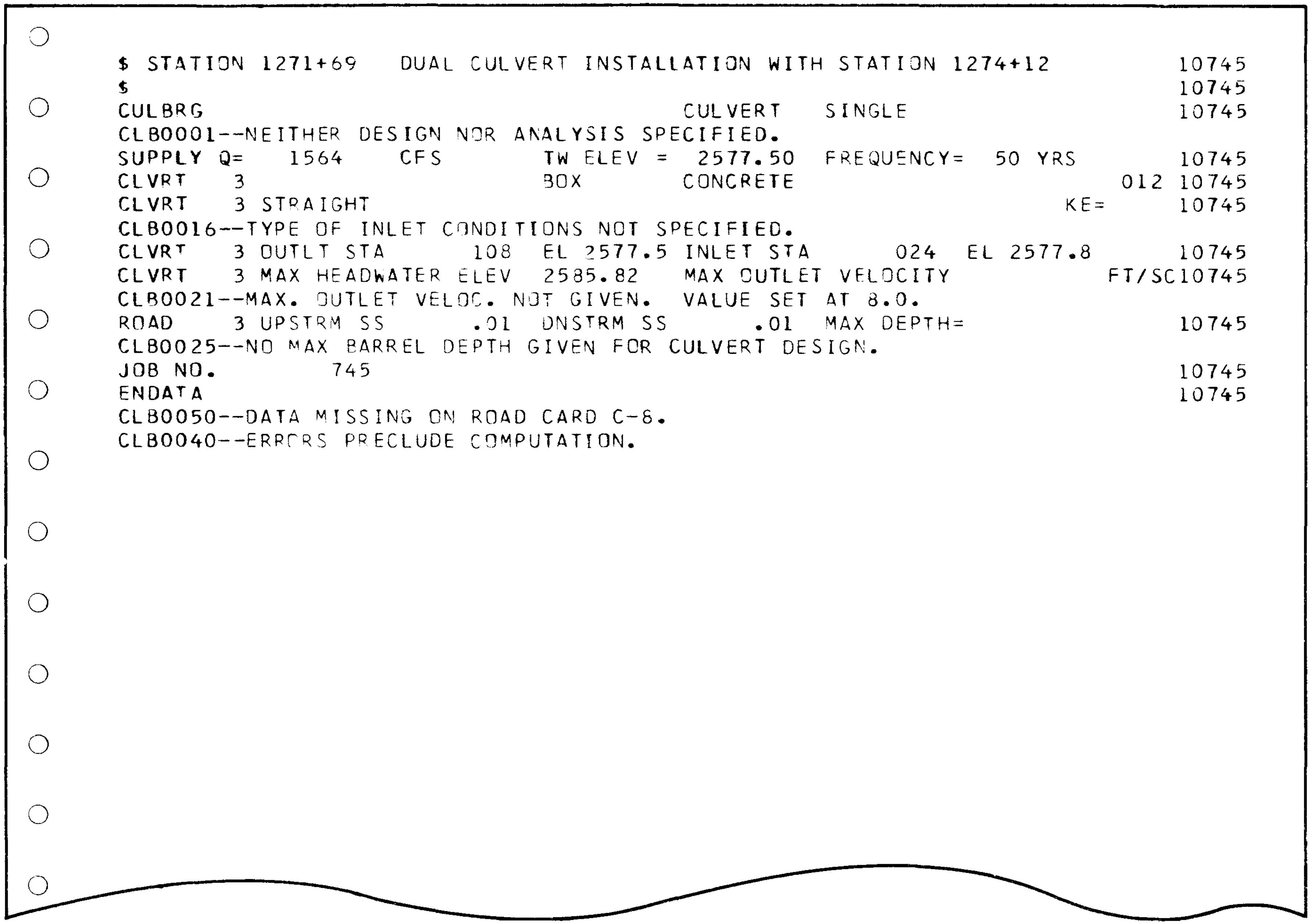
C-14 ☐ PLAN SUMMARY

Note: * ■ Mark box as shown beside each line used.

FORM CONTINUED ON BACK

FORM 1308-1
(Revised 8/74)

FIGURE 8-64. INPUT DATA SHEET WITH ERRORS

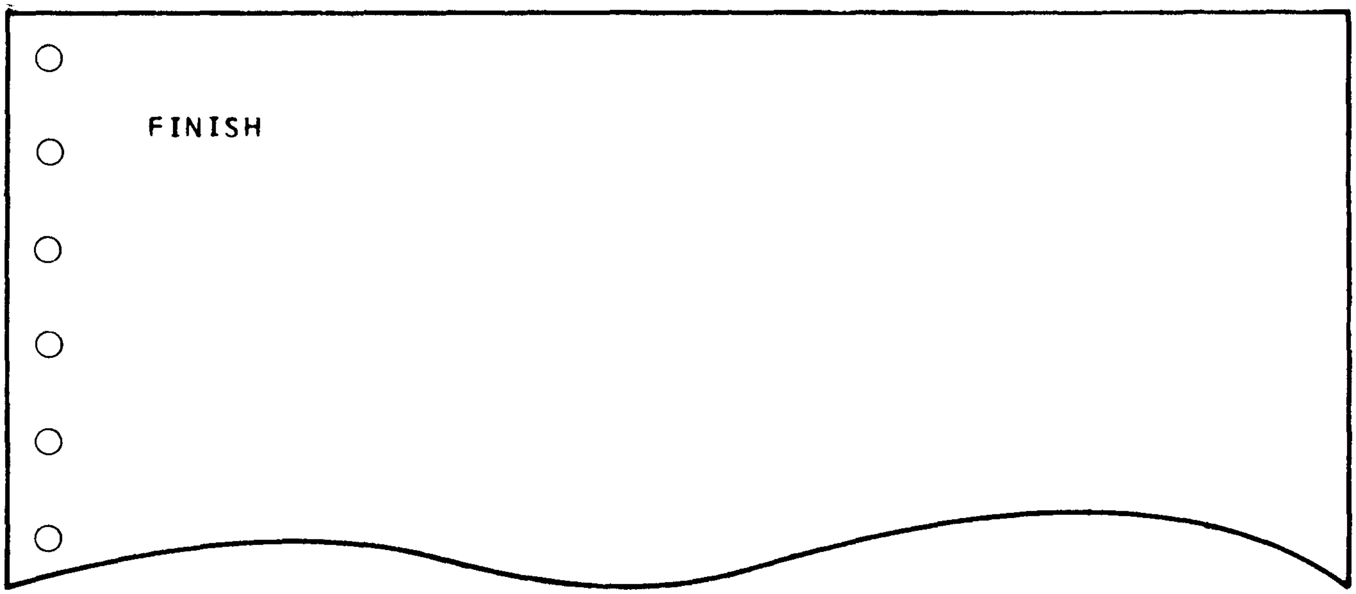


```
$ STATION 1271+69   DUAL CULVERT INSTALLATION WITH STATION 1274+12          10745
$                                                                           10745
CULBRG                                     CULVERT   SINGLE                 10745
CLB0001--NEITHER DESIGN NOR ANALYSIS SPECIFIED.
SUPPLY Q=   1564    CFS        TW ELEV =  2577.50  FREQUENCY=  50 YRS       10745
CLVRT   3                      BOX         CONCRETE                     012 10745
CLVRT   3 STRAIGHT                                                KE=       10745
CLB0016--TYPE OF INLET CONDITIONS NOT SPECIFIED.
CLVRT   3 OUTLT STA      108  EL 2577.5 INLET STA      024  EL 2577.8       10745
CLVRT   3 MAX HEADWATER ELEV  2585.82   MAX OUTLET VELOCITY             FT/SC10745
CLB0021--MAX. OUTLET VELOC. NOT GIVEN.  VALUE SET AT 8.0.
ROAD    3 UPSTRM SS      .01  DNSTRM SS      .01  MAX DEPTH=                10745
CLB0025--NO MAX BARREL DEPTH GIVEN FOR CULVERT DESIGN.
JOB NO.       745                                                           10745
ENDATA                                                                      10745
CLB0050--DATA MISSING ON ROAD CARD C-8.
CLB0040--ERRORS PRECLUDE COMPUTATION.
```

FIGURE 8-65. COMPUTER PRINTED INPUT WITH ERRORS

X. FINISH

The Finish page shown in Figure 8-66 is the last page for any THYSYS run. It indicates that the job terminated properly after all data was processed.



```
FINISH
```

FIGURE 8-66. FINISH PAGE PRINTED BY THE COMPUTER

APPENDICES

Appendices

APPENDIX A. GLOSSARY

GLOSSARY

Alphanumeric - Refers to alphabetic letters or numbers or any combination of the two.

Echo Print - A printed copy of information exactly as it was coded on input form.

Fatal Error - Following explanations of some error messages. This term is used to indicate that the condition causing the message to be printed is such that the program cannot continue in the problem solution. Data editing will continue, however.

Non-fatal - Used to indicate that, although an apparent error was detected, the computations continued under the conditions stated in the error message.

Pass - Each use of one of the major subsystems in THYSYS is termed a pass through that subsystem. Usually each problem will require one pass through a subsystem.

Problem - One set of input data for one subsystem solution. Each problem must be followed by an ENDATA card and conversely each ENDATA card signifies the end of a problem.

Program - The THYSYS system including all of its subsystems.

Report - Refers to the printed output from the computer reflecting the results of a pass through a subsystem.

Routine - A procedure which performs a specific function within the framework of a subsystem.

Run - 1. Generally, a run (computer run) refers to a complete set of input data submitted at one time for entry into THYSYS. A run may consist of one or several problems.

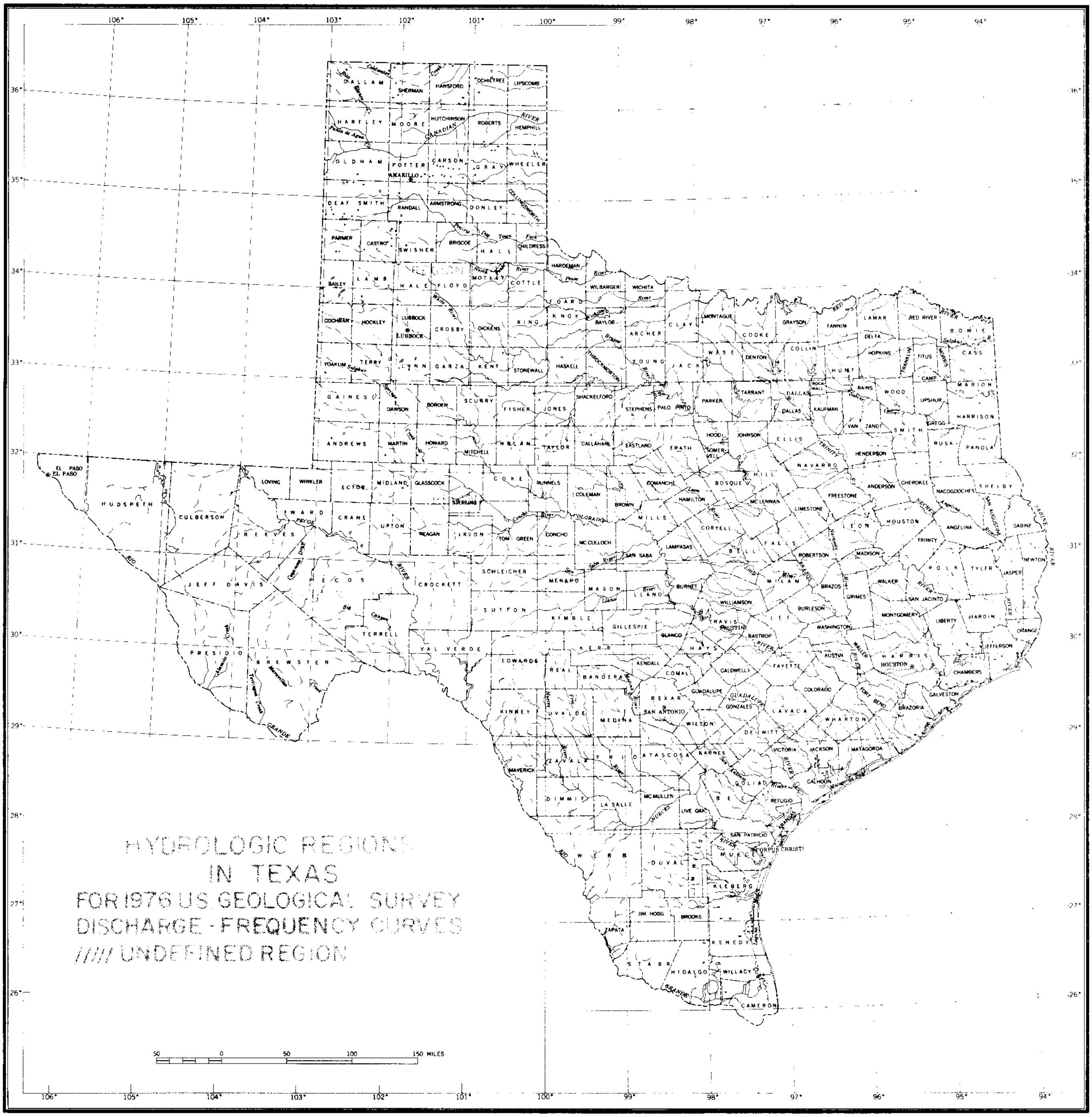
2. Sewer runs are defined in the SEWER subsystem on page 6-5.

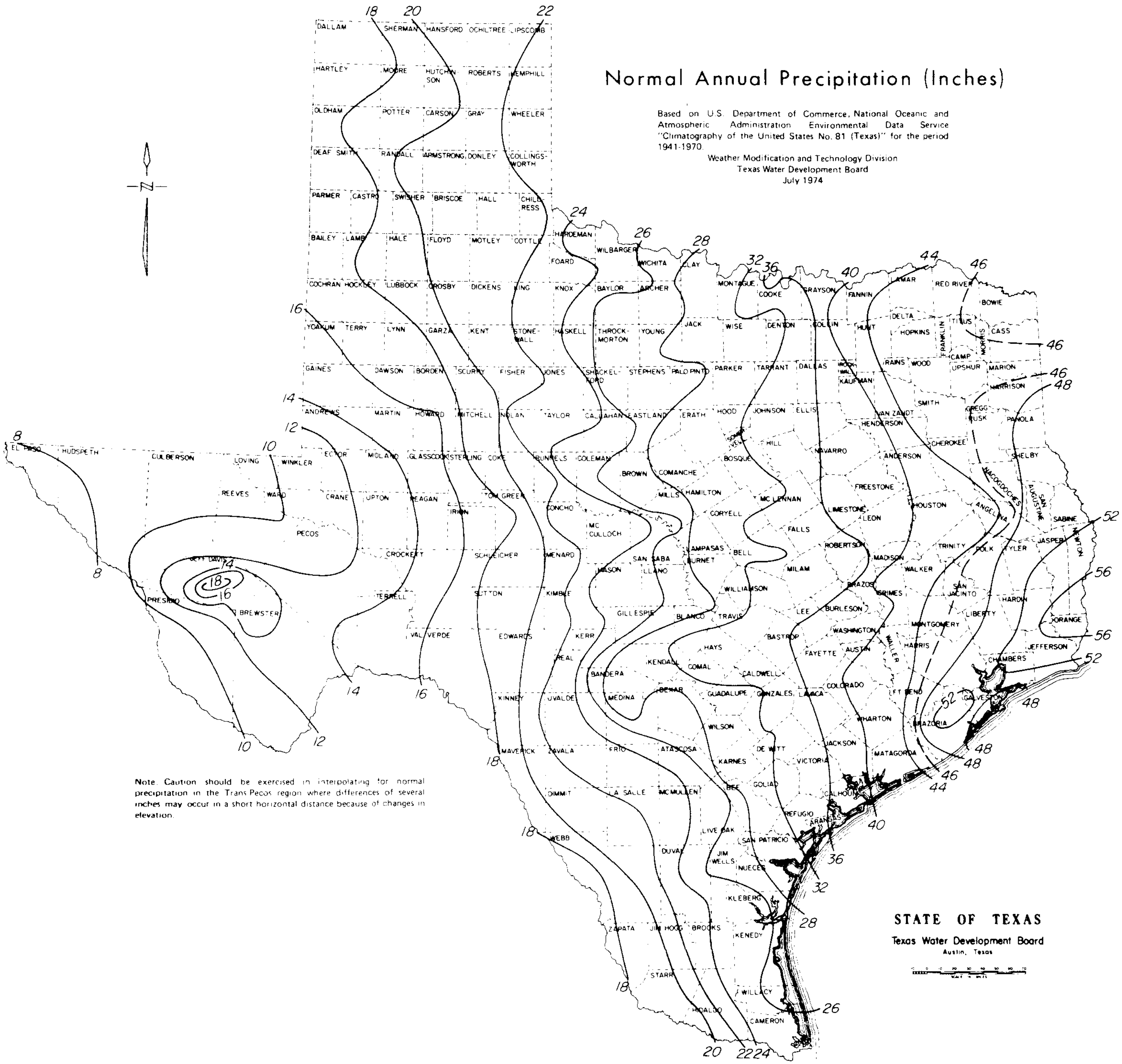
Subsystem - A term used in reference to any of the five major divisions of THYSYS.

System - A network of related computer procedures which are available to one another for solution of a problem.

Unique - Term normally used in reference to names used for identification. It indicates that each name or number used for identification must be different in some respect from any other identifier used in the same problem.

APPENDIX B. HYDROLOGY INFORMATION


HYDROLOGIC REGIONS
IN TEXAS
FOR 1976 U.S. GEOLOGICAL SURVEY
DISCHARGE - FREQUENCY CURVES
///// UNDEFINED REGION
50 0 50 100 150 MILES
106° 105° 104° 103° 102° 101° 100° 99° 98° 97° 96° 95° 94°
36° 35° 34° 33° 32° 31° 30° 29° 28° 27° 26°
DALLAM
SHERMAN
HANSFORD
OCHILTREE
LIPSCOMB
HARTLEY
MOORE
HUTCHINSON
ROBERTS
HEMPHILL
OLDHAM
POTTER
CARSON
GRAY
WHEELER
AMARILLO
DEAF SMITH
RANDALL
ARMSTRONG
DONLEY
COLLINGSWORTH
PARMER
CASTRO
SWISHER
BRISCOE
HALL
CHILDRESS
HARDEMAN
BAILEY
LAMB
HALE
FLOYD
MOTLEY
COTTLE
WILBARGER
WICHITA
COCHRAN
HOCKLEY
LUBBOCK
CROSBY
DICKENS
KING
KNOX
BAYLOR
ARCHER
CLAY
MONTAGUE
COOKE
GRAYSON
FANNIN
LAMAR
RED RIVER
BOWIE
DELTA
HOPKINS
TITUS
CASS
YOAKUM
TERRY
LYNN
GARZA
KENT
STONEWALL
HASKELL
THROCKMORTON
YOUNG
JACK
WISE
DENTON
COLLIN
HUNT
FRANKLIN
MORRIS
CAMP
MARION
GAINES
DAWSON
BORDEN
SCURRY
FISHER
JONES
SHACKELFORD
STEPHENS
PALO PINTO
PARKER
TARRANT
DALLAS
ROCKWALL
KAUFMAN
RAINS
WOOD
UPSHUR
HARRISON
GREGG
VAN ZANDT
SMITH
ANDREWS
MARTIN
HOWARD
MITCHELL
NOLAN
TAYLOR
CALLAHAN
EASTLAND
ERATH
HOOD
SOMERVELL
JOHNSON
ELLIS
HENDERSON
RUSK
PANOLA
EL PASO
HUDSPETH
LOVING
WINKLER
ECTOR
MIDLAND
GLASSCOCK
STERLING
COKE
RUNNELS
COLEMAN
BROWN
COMANCHE
HAMILTON
BOSQUE
HILL
NAVARRO
FREESTONE
ANDERSON
CHEROKEE
NACOGDOCHES
SHELBY
CULBERSON
WARD
CRANE
UPTON
REAGAN
IRION
TOM GREEN
CONCHO
McCULLOCH
MILLS
CORYELL
McLENNAN
LIMESTONE
LEON
HOUSTON
ANGELINA
SAN AUGUSTINE
SABINE
REEVES
JEFF DAVIS
PECOS
CROCKETT
SCHLEICHER
MENARD
MASON
LLANO
SAN SABA
LAMPASAS
BELL
FALLS
ROBERTSON
MADISON
TRINITY
POLK
TYLER
JASPER
NEWTON
BURNET
WILLIAMSON
MILAM
BRAZOS
GRIMES
WALKER
SAN JACINTO
SUTTON
KIMBLE
GILLESPIE
BLANCO
TRAVIS
AUSTIN
BASTROP
LEE
BURLESON
WASHINGTON
MONTGOMERY
LIBERTY
HARDIN
ORANGE
JEFFERSON
PRESIDIO
BREWSTER
TERRELL
VAL VERDE
EDWARDS
REAL
KERR
BANDERA
KENDALL
COMAL
HAYS
CALDWELL
FAYETTE
WALLER
HARRIS
HOUSTON
CHAMBERS
GALVESTON
BEXAR
SAN ANTONIO
GUADALUPE
GONZALES
LAVACA
COLORADO
FORT BEND
BRAZORIA
WHARTON
KINNEY
UVALDE
MEDINA
WILSON
DE WITT
JACKSON
MATAGORDA
VICTORIA
CALHOUN
MAVERICK
ZAVALA
FRIO
ATASCOSA
KARNES
GOLIAD
REFUGIO
DIMMIT
LA SALLE
McMULLEN
LIVE OAK
BEE
SAN PATRICIO
ARANSAS
WEBB
DUVAL
JIM WELLS
NUECES
CORPUS CHRISTI
KLEBERG
ZAPATA
JIM HOGG
BROOKS
KENEDY
STARR
HIDALGO
WILLACY
CAMERON
CANADIAN RIVER
RED RIVER
PECOS RIVER
COLORADO RIVER
BRAZOS RIVER
TRINITY RIVER
NECHES RIVER
SABINE RIVER
GUADALUPE RIVER
NUECES RIVER
RIO GRANDE



Normal Annual Precipitation (Inches)

Based on U.S. Department of Commerce, National Oceanic and Atmospheric Administration Environmental Data Service "Climatography of the United States No. 81 (Texas)" for the period 1941-1970.

Weather Modification and Technology Division
Texas Water Development Board
July 1974

Note: Caution should be exercised in interpolating for normal precipitation in the Trans Pecos region where differences of several inches may occur in a short horizontal distance because of changes in elevation.

STATE OF TEXAS
Texas Water Development Board
Austin, Texas

APPENDIX C. TWO-SECTION METHOD ERROR ANALYSIS

TWO-SECTION METHOD ERROR ANALYSIS

The HYDRA Subsystem of the Texas Hydraulic System (THYSYS) contains several optional methods for computing water surface elevations in open channels. The use of one of these options, the Two-Section Method, has led to numerous inquiries regarding the reasons for failure of the computer program to produce a solution, as evidenced by the following error message:

```
"LIMITS OF THE CONVEYANCE CURVES ARE INSUFFICIENT FOR A PROPER SOLUTION WHEN
DISCHARGE EQUALS nnnnn.
LAST UPSTREAM ELEVATION = nnnn.nn
LAST DOWNSTREAM ELEVATION = nnnn.nn
                        UPSTREAM SECTION aaaa
                      Elevation       Conveyance
                       nnnn.nn          nnnnn
                       nnnn.nn          nnnnn
                          .               .
                          .               .
                          .               .
                      DOWNSTREAM SECTION bbbb
                      Elevation       Conveyance
                       nnnn.nn          nnnnn
                       nnnn.nn          nnnnn
                          .               .
                          .               .
                          .               .
THE ABOVE TABULATION INDICATES A FAILURE IN THE TWO SECTION METHOD.  IF
FURTHER INFORMATION IS REQUIRED CONTACT YOUR D-19 FIELD REPRESENTATIVE OR
BRIDGE DIVISION HYDRAULIC SECTION."
```

This is a generalized error message indicating a fatal problem in the processing for solution by the Two-Section Method. The failure of the method can occur in one of several possible ways as explained on the following pages. The error message contains enough information for the user to determine which of these failings has occurred. Actual use of the information and data contained in the error message is also discussed.

A comprehensive discussion of the Two-Section Method and its use is given in Chapter III of the Hydraulic Manual and the user should refer to that manual for particular details. Briefly, the method is based on the premise that the discharge is continuous and unchanged and the water surface slope is constant between two adjacent cross-sections in a reach of stream. Elevation versus conveyance curves are calculated for each of the two-sections (upstream and downstream). Since conveyance (K) is equal to discharge (Q) divided by the square root of the <u>water surface slope</u> for any trial slope and given design discharge, a corresponding conveyance may be calculated. The application of a vertical line at this conveyance on the plots of the two conveyance curves describes an elevation difference for that particular conveyance-discharge combination. A slope is then calculated by dividing this described elevation difference by the stream reach distance between the two sections. This process is repeated until the calculated slope approximately equals the original trial slope.

In Figure 1 the 45° line represents the locus of points at which the calculated slope (S_c) equals the trial slope (S_t). Ideally, the curved line would represent the locus of trial points in a successful solution to the Two-Section Method; the point of intersection of the two lines is the point where S_c equals S_t. Unfortunately, the Two-Section process does not always follow the ideal. The failures are as follows:

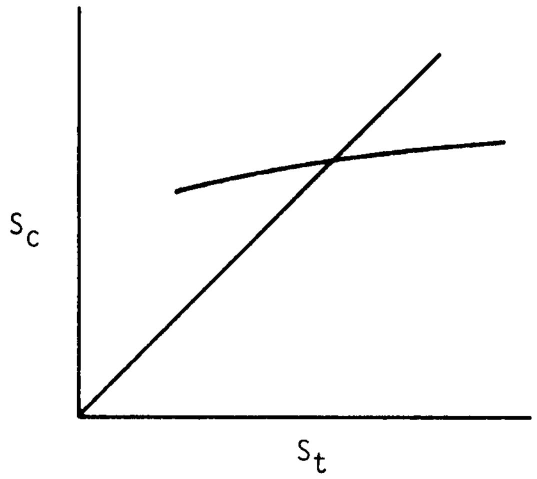


Figure 1

A. In Figure 2, the locus of points of S_c versus S_t falls short to the left of the $S_c = S_t$ line. As indicated in Figure 3, one or both of the conveyance curves do not extend to a low enough value of K. The last possible trial yielded a calculated slope greater than the corresponding trial slope.

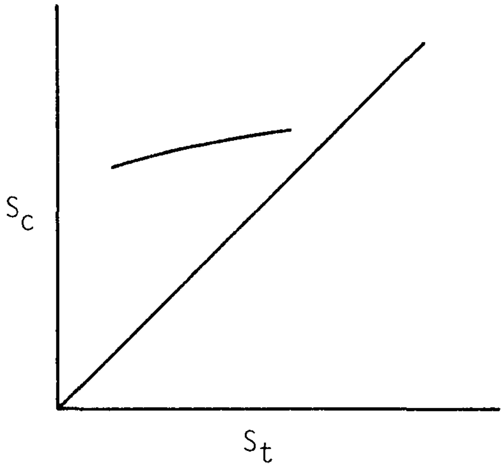


Figure 2

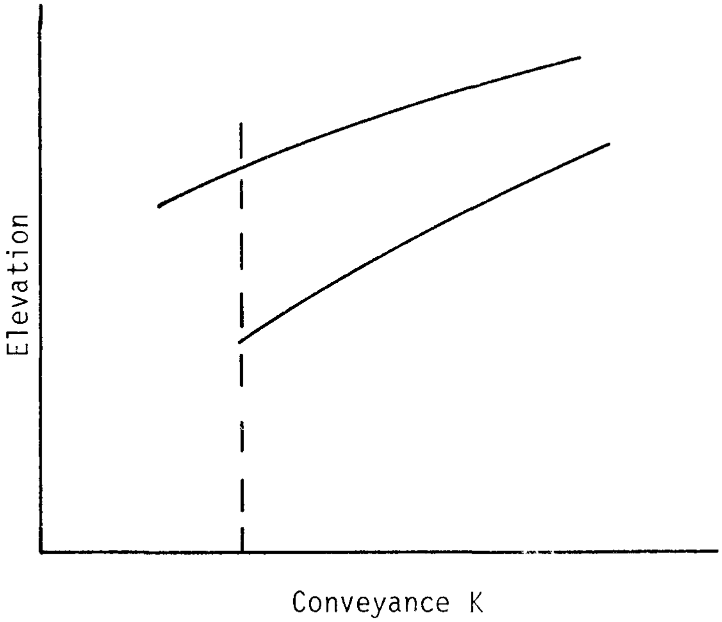


Figure 3

B. In Figure 4, the locus of points of S_c versus S_t falls short to the right of the $S_c = S_t$ line. As indicated in Figure 5, one or both of the conveyance curves do not extend to a high enough value of K. The last possible trial yielded a calculated slope less than the corresponding trial slope.

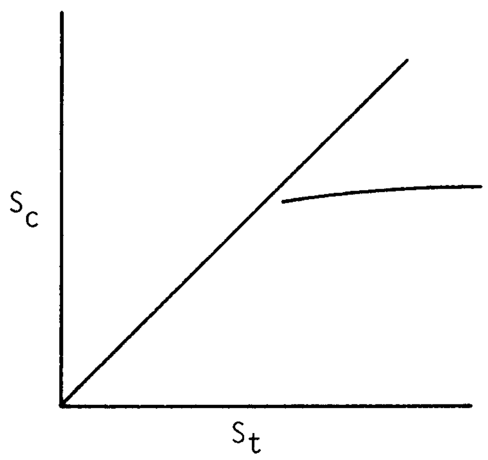


Figure 4

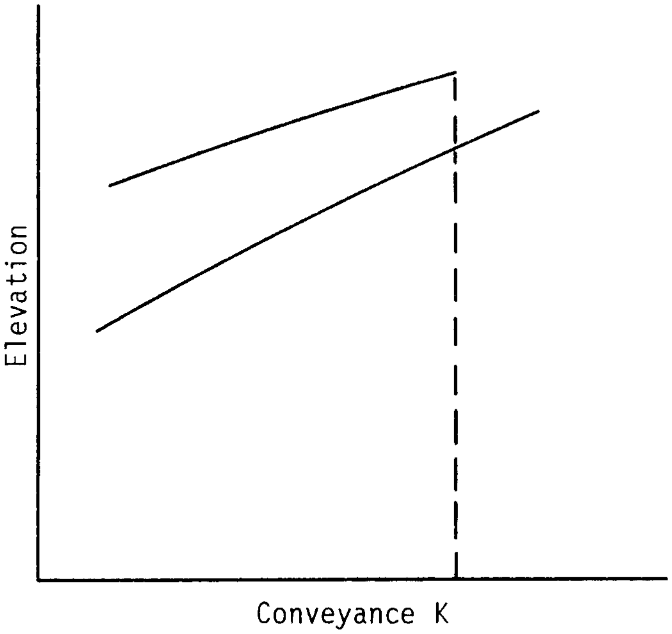


Figure 5

It is probable that most failures will be resultant from either A or B. However, other possibilities are as follows:

C. In Figure 6, the locus of points of S_c versus S_t approaches then veers away from the $S_c = S_t$ line on the left side. This is the result of a condition as indicated in Figure 7 where the ends (both left and right) of the conveyance curves are mutually divergent with a relatively close approach in the middle area.

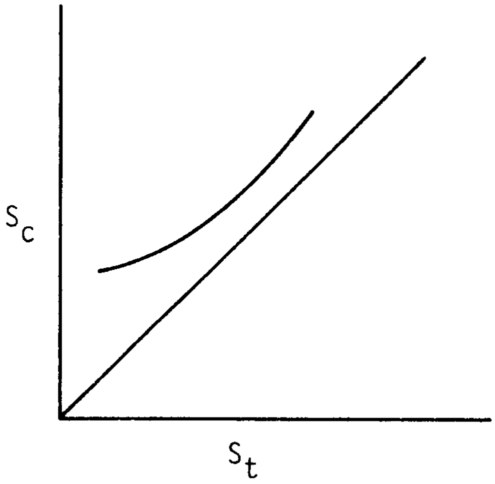


Figure 6

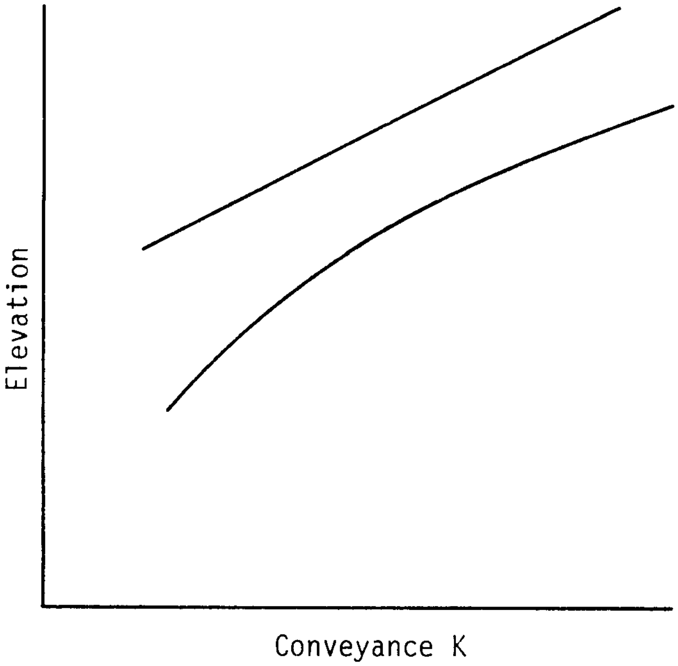


Figure 7

D. In Figure 8, the locus of points of S_c versus S_t approaches then veers away from the $S_c = S_t$ line on the right side. This is the result of a condition as indicated in Figure 9 where the ends (both left and right) of the conveyance curves are mutually convergent with a divergence in the middle area.

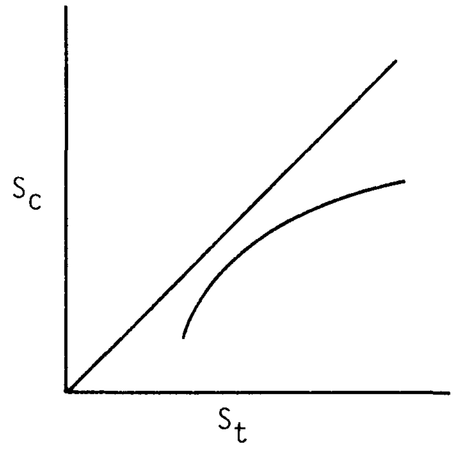


Figure 8

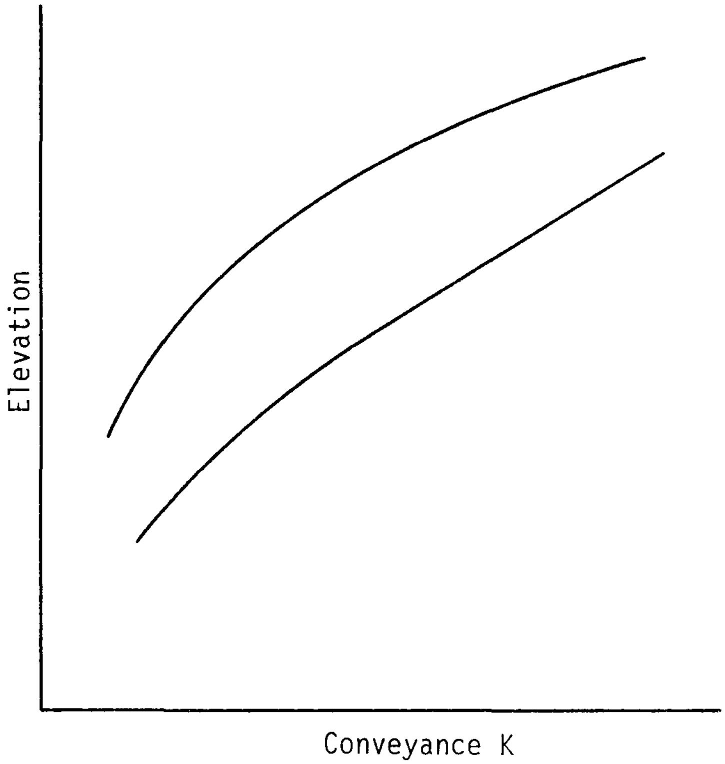


Figure 9

E. Figure 10 depicts a situation which is rare but possible. The two conveyance curves may be in such a relationship to each other as to yield more than one $S_c = S_t$ intersection. The logic in the computer routine forces the answer to be that nearest the stream bed slope.

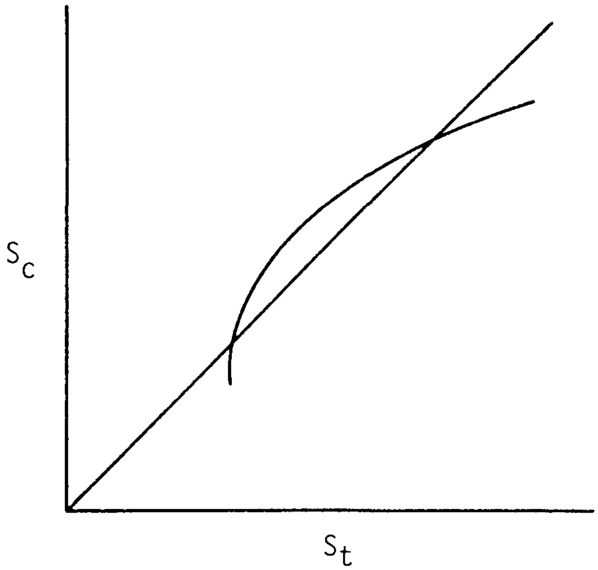


Figure 10

F. In Figure 11, the locus of points of S_c versus S_t is a straight horizontal line ending to the left of the $S_c = S_t$ line. This is the result of a situation as indicated in Figure 12 where the two conveyance curves are exactly parallel with only a constant difference in elevation. The conveyance curves either do not extend far enough to the left or (and less likely) they are too far apart in elevation.

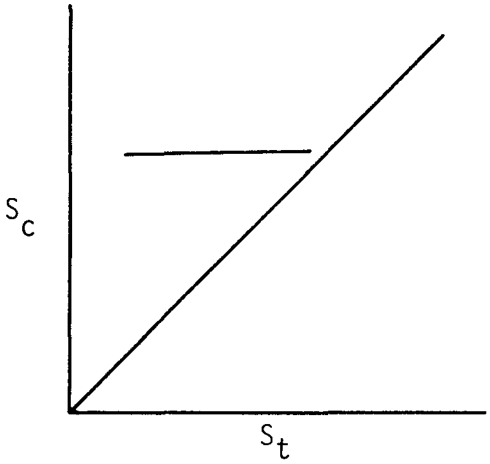


Figure 11

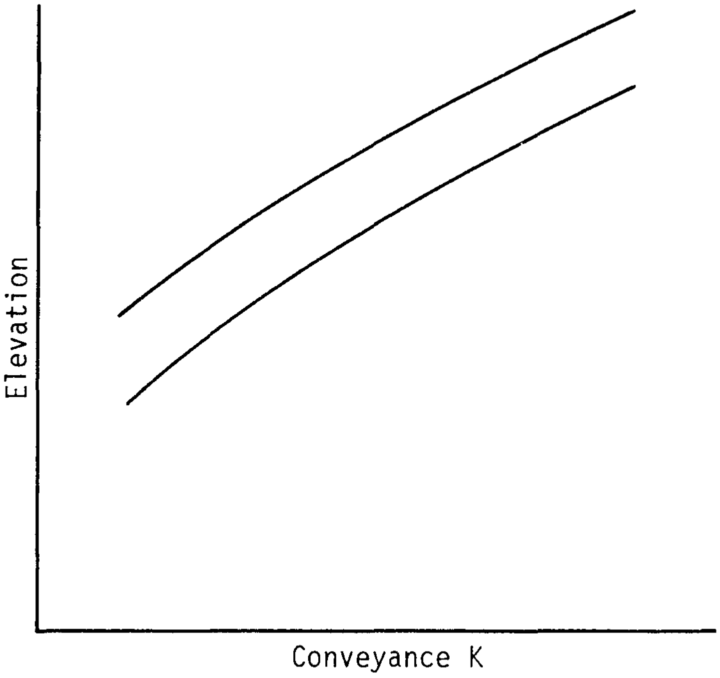


Figure 12

G. In Figure 13, the locus of the points of S_c versus S_t is a straight horizontal line ending to the right of the $S_c = S_t$ line. As indicated in Figure 12, this is the result of a similar situation as in Item F except that the conveyance curves either do not extend far enough to the right or (and less likely) they are too close together in elevation.

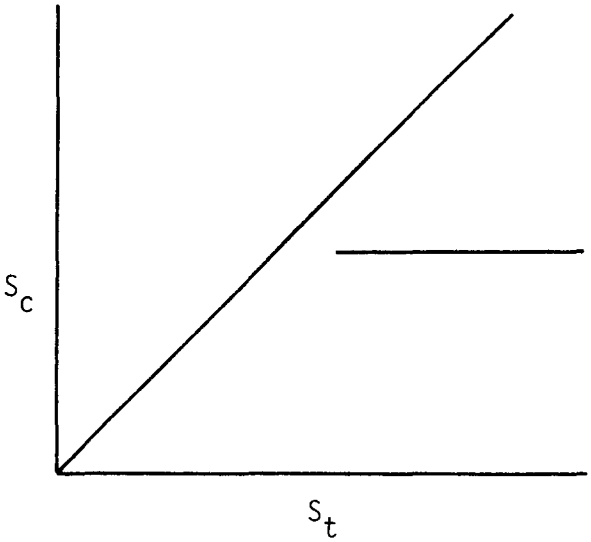


Figure 13

H. Two other conditions may cause an abnormal termination of the Two-Section Method in the computer process. These are indicated in Figures 14 and 15. In Figure 14, the upstream and downstream conveyance curves do not overlap; that is, they have no common conveyance values from which a solution may be derived. An appropriate message to this effect is output. In Figure 15, the upstream and downstream conveyance curves cross. Obviously, any computation to the right of the intersection would be incorrect. Therefore, for this situation, a solution is possible and is sought only until it is determined that the curves do cross. Again, an appropriate, self-explanatory error message is output.

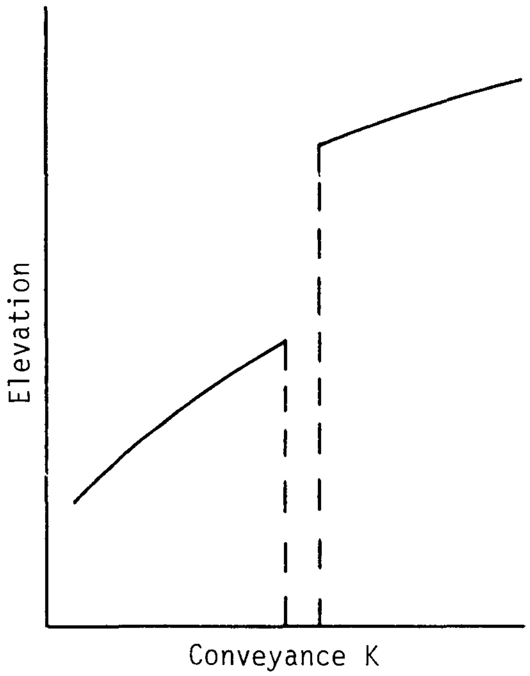


Figure 14

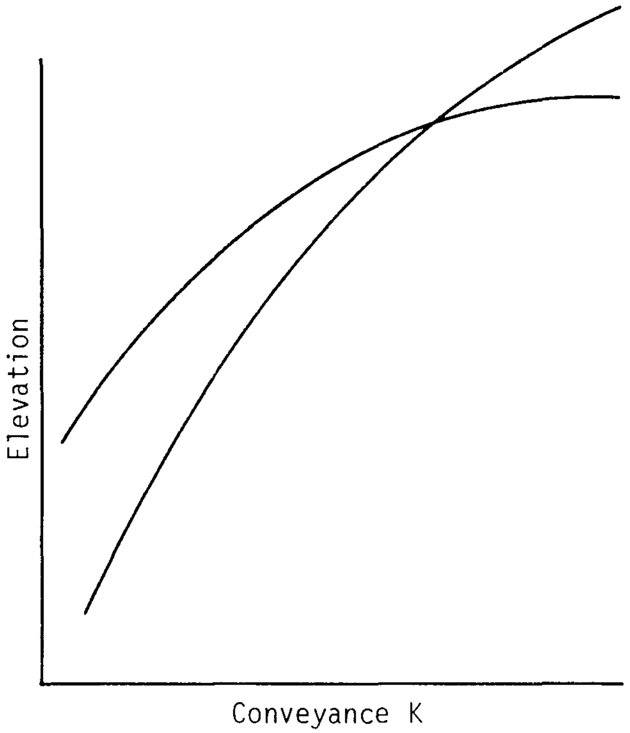


Figure 15

The physical reasons for the above failures and shortcomings are many and varied. A comprehensive, but probably not complete, list of these reasons is given below. Any one or a combination of these physical errors may cause a failure in the Two-Section Method process. The errors are listed along with a possible remedy.

1. The upstream or downstream or both section elevations and distances have not been extended far enough. The remedy is a more extensive survey.
2. The upstream or downstream or both sections are not truly representative of the channel configuration under design discharge conditions. (See the discussion of "typical" sections in Chapter III of the Hydraulic Manual.) The remedy is to relocate and survey section(s) as necessary.
3. Upstream or downstream or both section "n" values and/or subsection locations are invalid. The remedy is to reinvestigate roughness and subdivision characteristics of appropriate section(s).
4. Input QPEAK (design discharge) may be too large or some way in error. The remedy is to reinvestigate hydrology for the design site.
5. Input sections are too far apart to be represented realistically by a constant slope and/or discharge. The remedy is to try to locate calculation sections closer together but no closer than the width of the flood plain.
6. Upstream or downstream or both sections were input on a skewed basis and not normalized. Normal sections (90° to flood flow direction) are required for this method. The remedy is to normalize section(s) either by manual means or by computer. (See MOVE CARD discussions in THYSYS User's Manual.)

The type of failure as given in Items A through H may be determined by using the data supplied in the error message. The error message given on the first page includes a tabulation of conveyance curves for each of the sections (upstream and downstream). In using the tabulations, the conveyance value is plotted as the abscissa (x-direction) and the elevation value as the ordinate (y-direction). Both the upstream and downstream curves are plotted on the same graph. By means of the "LAST UPSTREAM ELEVATION" and the "LAST DOWNSTREAM ELEVATION", the user can determine the location on these curves at which the program recognized a failure situation. Only when the calculated slope is within 2% of the assumed slope is the Two-Section Method successful. The calculated slope is the difference in upstream and downstream water elevation divided by the distance between the sections. The last assumed slope may be determined by locating that conveyance on the two conveyance curves at which the "LAST UPSTREAM ELEVATION" and the "LAST DOWNSTREAM ELEVATION" are subtended. Since $Q = KS^{1/2}$ and $S = (Q/K)^2$, the design discharge should be divided by that conveyance and the result squared for the assumed slope last used by the program. This determination, along with the original conveyance plots, should give some indication of which of the failure situations exists for the current two-section problem. A comparison of the conveyance curves and the S_t versus S_c situation to those given in this write-up should give that indication.

It is very likely that the particular problem for a given failure lies in one or more of the reasons listed. However, the Two-Section Method is relatively new and virtually unresearched so that it may be fallible for certain problem situations. If one or both of the cross-sections involved is of a relatively complex nature (e.g., a large number of subsections, highly varied topography or extreme flood plain width), it is suggested that the user consult with the Bridge Division Hydraulic Section before attempting to process the problem under the Two-Section specification.