PHABSIM TECHNICAL NOTE NO. 1

Selection of Number of Cells in a Cross Section

The purpose of this note is to illustrate that the selection of the number of cells in a cross section can have an impact on the total area and the habitat areas. Also, it is illustrated that the impact is largest when binary criteria are used for the species of aquatic animal of interest.

The hydraulic simulation used here are for a cross section measured for a canal near the Instream Flow Group's office. The species of aquatic animal is one vector for Shistosomiasis (Biomphalaria glabrata). Two life stages are considered here - passage which uses a binary criteria (PASSAGE) and habitat which can support the snails already there (HABITAT) which has some aspects of binary criteria. No substrate/cover index was used.

The hydraulic simulation was made using the WSP program with 5, 15, and 75 cells in a total width of 29.6 feet. The impact on the total area is shown in Attachment A. This impact results from the energy loss between two cross sections being calculated differently because the the program uses the equation.

$$HV = \sum_{i=1}^{nw} \frac{v(i)^2}{2g} \frac{q(i)}{Q}$$

to approximate the integral

$$HV = \frac{1}{Q} \int_A \left(\frac{v^2}{2g} \right) v \; d \; A$$

where: HV = velocity head

v(i) = cell velocity

q(i) = cell discharge

Q = stream discharge

nw = number of wet cells

A = area of the cross section

The number of cells will determine how well the simulation of HV will approximate the desired results (the integral).

The user should be aware that the selection of the number of cells will influence the simulated total area of the stream but it will be uncommon for this impact to be of much significance.

The impact of number of cells on the physical habitat calculated for the usual criteria (not binary) is shown in Attachment B. The percent of total width in each cell is:

5 cells	20.0 percent
15 cells	6.7 percent
75 cells	1.3 percent

The usual recommendation is that **not more than 10% of the flow be through any one cell**. For this case that would be about 15 cells.

The results in Attachment B suggests that for typical criteria the goal of not more than 10% of the flow in anyone cell is reasonable, but if one misses the the goal slightly the impact on the end results will probably not be major.

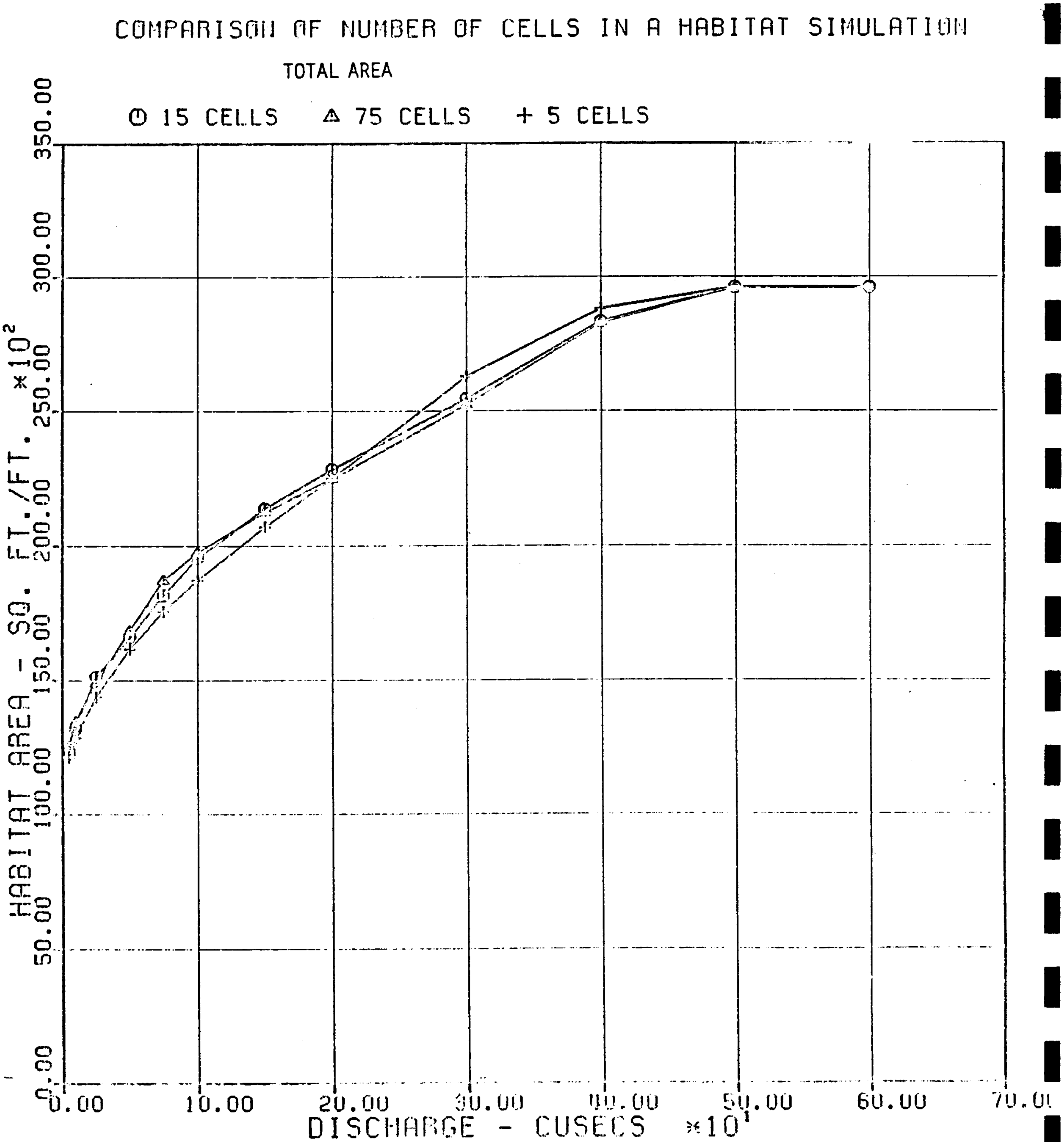
The use of binary criteria is shown in Attachment C. The wild fluctuation of the 5 cell line results from the simulation habitat parameters just missing or landing on the critical curves (i.e., missing by falling off the edge and droping from a value of 1 to 0 because the parameter changes a rather small amount). The impact of a small number of cells is large because there is much area in each cell and the average depth and/or velocity changes in "jumps" from cell to cell. These results suggest more cells are needed for binary criteria than for more typical criteria.

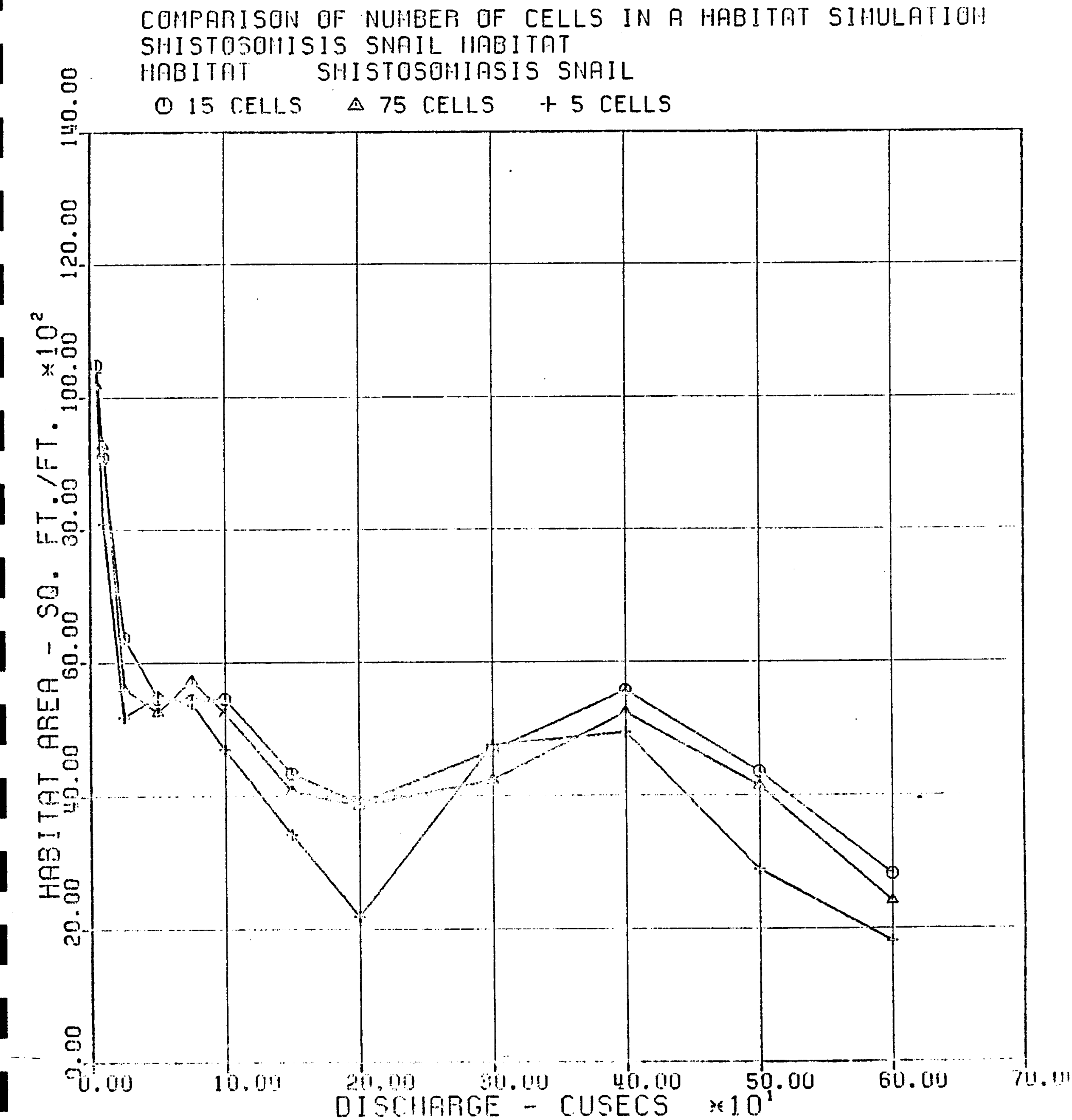
Recommendations:

1. When using binary criteria, increase the number of cells. When WSP is used, this can be done in the office as well as the field.

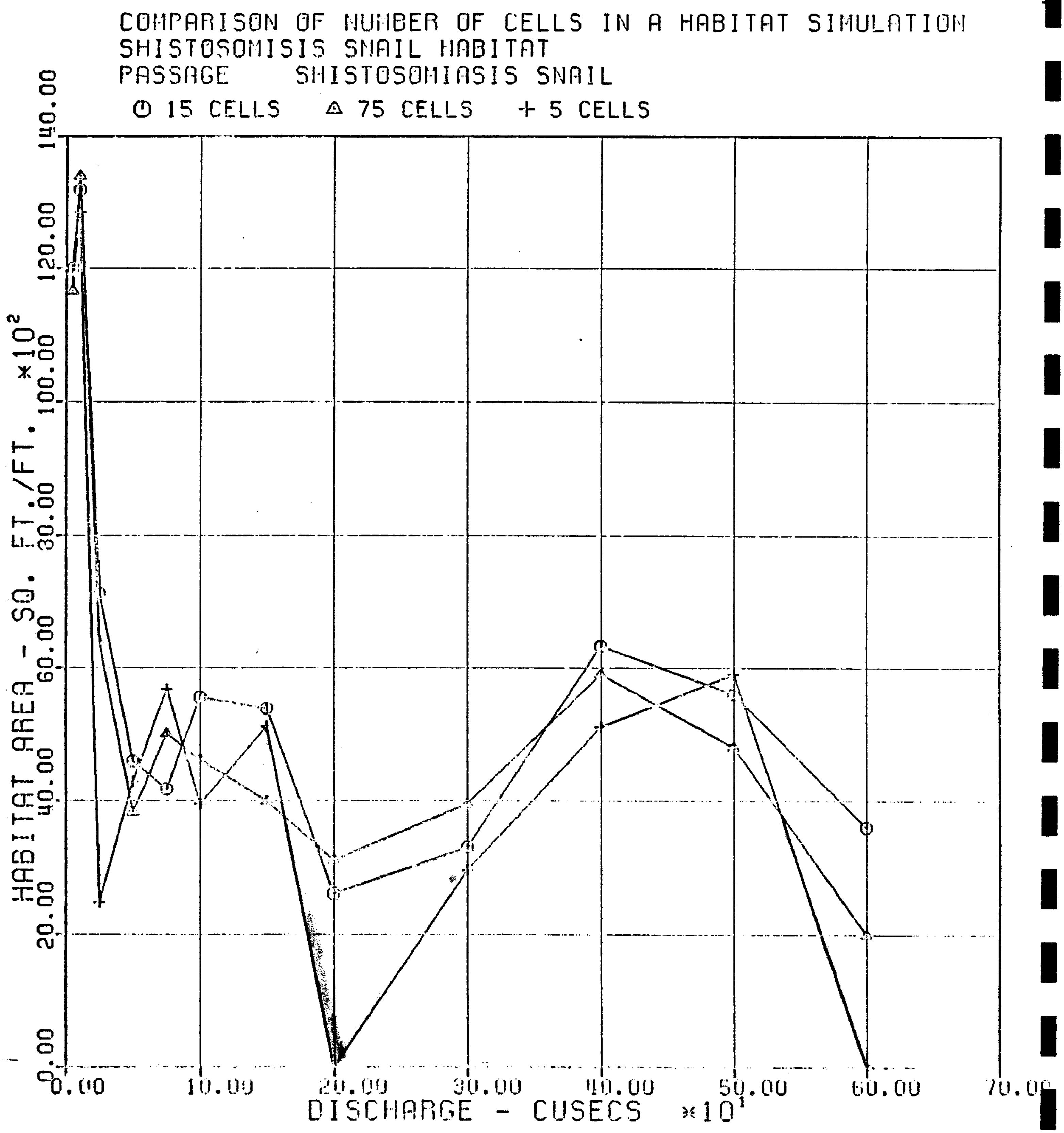
2. Continue to use a 10% rule for measuring velocities.

3. Recognize the choice of the number of cells to use in an analysis will have an impact on the total area of stream calculated when WSP is used.


COMPARISON OF NUMBER OF CELLS IN A HABITAT SIMULATION
TOTAL AREA
15 CELLS
75 CELLS
+ 5 CELLS
HABITAT AREA - SQ. FT./FT. *10²
0.00
50.00
100.00
150.00
200.00
250.00
300.00
350.00
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
DISCHARGE - CUSECS *10¹



COMPARISON OF NUMBER OF CELLS IN A HABITAT SIMULATION
SHISTOSOMISIS SNAIL HABITAT
HABITAT SHISTOSOMIASIS SNAIL
15 CELLS
75 CELLS
5 CELLS
HABITAT AREA - SQ. FT./FT. ×10²
0.00
20.00
40.00
60.00
80.00
100.00
120.00
140.00
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
DISCHARGE - CUSECS ×10¹


COMPARISON OF NUMBER OF CELLS IN A HABITAT SIMULATION
SHISTOSOMISIS SNAIL HABITAT
PASSAGE SHISTOSOMIASIS SNAIL
15 CELLS
75 CELLS
+ 5 CELLS
HABITAT AREA - SQ. FT./FT. *10²
0.00
20.00
40.00
60.00
80.00
100.00
120.00
140.00
DISCHARGE - CUSECS *10¹
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00

TSLIB TECHNICAL NOTE NO. 2

THE USE OF THE COMBHA PROGRAM TO COMBINE MONTHLY TIME SERIES

by

Robert T. Milhous

Hydraulic Engineer

May 1985

INTRODUCTION

Often during the course of an instream flow study it is desirable to combine two time series of either stream discharge or physical habitat. If the series is in terms of monthly values, the COMBHA program can be used.

The equation used in the COMBHA program is:

$$HAC(I,J) = A * HA1(I,J) + B * HA2(2,J)$$

where J is the month index,

I is the year index,

HAC(I,J) is the combined value for month J and year I

HA1(I,J) is the monthly value for month J and year I from the first time series,

HA2(I,J) is the month value for month J and year I from the second time series,

A is a multiplier for the first series supplied by the user, and

B is a multiplier for the second series supplied by the user.

The coefficients A and B are any value the user elects to use.

The monthly time series must be in USGS format. If not, use the RCHGFMT procedure to change from NWDC to USGS format.

THE USE OF THE COMBHA PROGRAM

The procedure file used to execute the program is RCOMBHA. The approach is:

RCOMBHA,TFIL1,TFIL2,TFILC

where TFIL1 is the first monthly time series

TFIL2 is the second monthly time series

TFILC is the combined series.

The program is interactive with the user supplying responses to questions from the program. If the user has a file with the answer the approach is:

RCOMBHA,TFIL1,TFIL2,TFILC,INFL

where INFL is the file with the answers.

The program will list the two titles line from each of the two monthly time series and then ask for the two multipliers A and B. The next question will be for two lines of title for the combined file followed by a question asking for a new eight character station identification for the new series. A file with all of the answers would look like the following:

```
A, B
TITL1
TITL2
STATID00
```

The results will be on a file in USGS format.

CONVERSION FROM NWDL TO USGS OR VICE VERSA

The procedure to use for conversion from either USGS to NWDC, or from NWDC to USGS is:

```
RCHGFMT,FILO,FILN
```

where FILO is a file in either USGS or NWDC format and FICN is in the opposite format. The program requires no additional information.

PHABSIM TECHNICAL NOTE NO. 2

CALCULATION OF PASSAGE HABITAT

by

Robert T. Milhous
Hydraulic Engineer

The Physical Habitat Simulation System (PHABSIM) is generally used to calculate the physical habitat in a reach of river. The system can also be used to calculate passage habitat through a river. The purpose of this paper is to outline a procedure which can be used to make the calculations.

The typical use of PHABSIM calculates the physical habitat wherever it occurs within the stream; in contrast, for passage we would like the minimum passage habitat at a given flow no matter where it occurs in a study reach. In other words, we would like to look at a cross section, determine the passage habitat for that cross section and then look at the next cross section the same way. The passage habitat for the two cross sections is the minimum of the two. We then proceed to following cross sections using the same logic.

At this point it is best to illustrate using an example. The example is passage in the Tweed River in Northwestern New South Wales, Australia for Australian Bass. The Australian Bass spends most of its life in freshwater but migrates into estuaries during the winter to breed (June to August). Both the adults and young migrate upstream. Because of this migration to estuaries, passage can be rather important. Staff of the Instream Flow Group have assisted Ms. Barbara Richardson of New South Wales Fisheries in applying PHABSIM to the Tweed River. As part of this cooperative effort passage criteria has been developed. Two possible adult passage criteria were developed, the one used in this example had the following properties: for velocities less than 6.07 feet per second (fps) the suitability is 1.0, for a velocity greater than 6.08 fps the suitability is 0.0 with a linear decrease from 1.0 to 0.0 between 6.07 and 6.08 fps; for depth, the usability is 1.0 for all depth ≥ 0.66 ft and 0.0 for all depths ≤ 0.62 with a linear change between 0.62 and 0.66 ft.

The study reach on the Tweed River critical for passage had five cross sections. The passage criteria given above was used with the hydraulic simulation results to give a passage habitat versus stream flow relationship for each cross section. The results are given in Figure 1. The passage habitat for the whole reach is the minimum for all cross sections as also shown in Figure 1.

The steps to follow in developing the passage habitat versus streamflow function are:

Step 1 - Calibrate the hydrautic simulation model and develop the two files (TAPE3 and TAPE4) used to transfer the results of the hydraulic simulation programs.

Step 2 - Develop the passage criteria.

Step 3 - Use the EXT3T4 program to extract the data for an individual cross section and develop new hydraulic data files containing data just for a single cross section.

Step 4 - Use the HABTAT program and the hydraulic files containing data for a single cross section to develop a passage habitat versus streamflow relationship for the individual cross section.

Step 5 - Repeat steps 3 and 4 for all the cross sections in the study reach.

Step 6 - Select the minimum cross section passage habitat for a specific flow to develop a reach passage habitat vs. streamflow relationship (as shown in Figure 1).

The EXT3T4 program is not part of the usual PHABSIM library but can be made available to anyone wishing to use PHABSIM to develop a passage habitat vs. streamflow relationship.

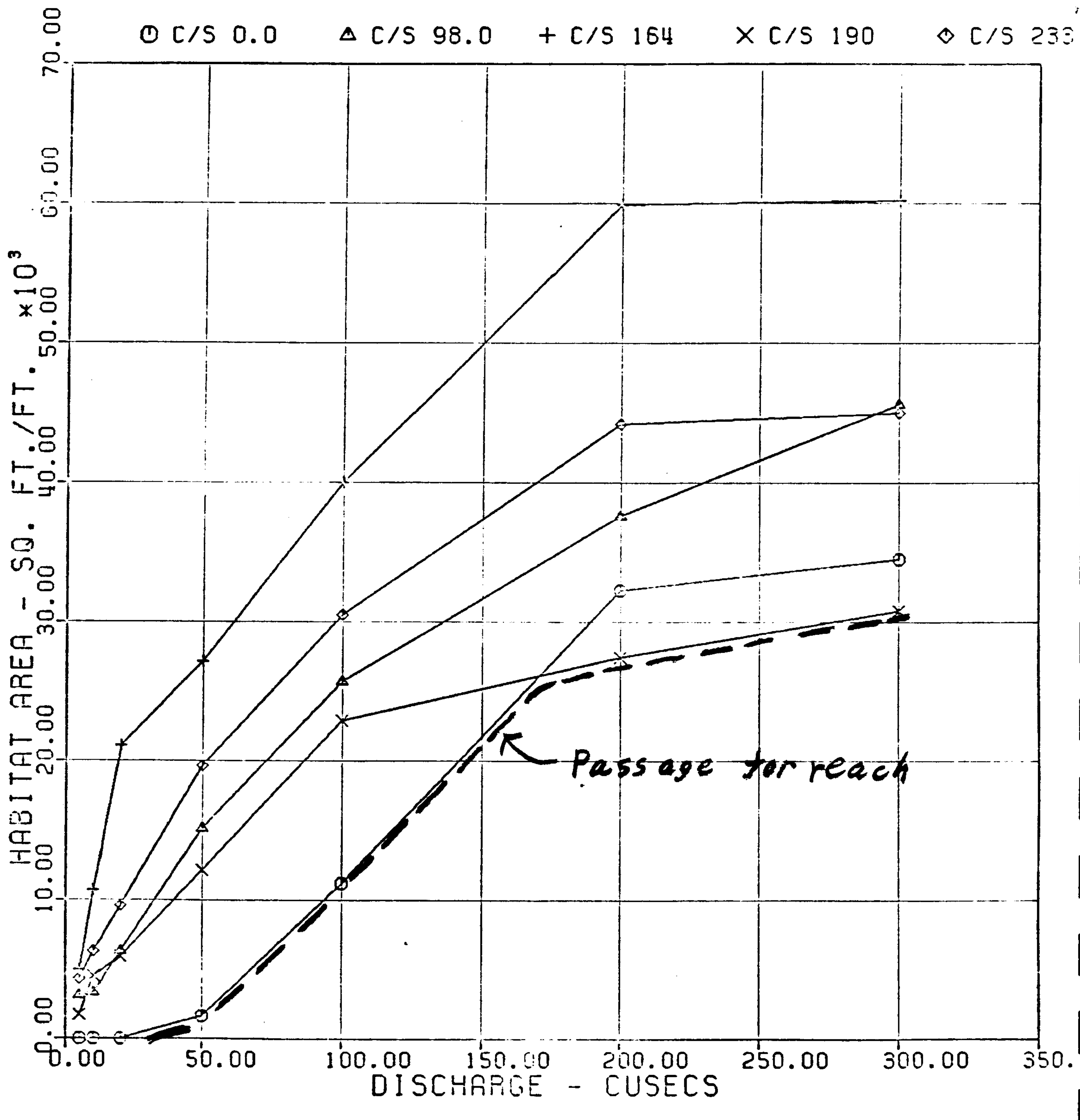


Figure 1. The development of an adult Australian Bass passage versus streamflow relationship for the Tweed River in New South Wales.

TSLIB TECHNICAL NOTE NO. 3

Determining the Time Series of Effective Spawning

By Keith D. Garlinghouse

I. Introduction

Effective spawning is achieved when eggs laid by the fish survive critical events that occur during the incubation period and hatch into fry. Thus, the effective spawning program determines the amount of weighted usable area (WUA) that meets both the spawning and incubation criteria. The output from the program represents the maximum amount of usable area available given the two critical time periods that affect the fish; in this case the spawning and incubation seasons.

II. Use of the Output from the Effective Spawning Program

The program SPWTABL takes output from the effective spawning program (EFFSPWN) and writes an output file containing the weighted usable area available, in a tabular format, for the combination of spawning and incubation flows that were modeled. This table allows the relationship between the variables to be determined easily. To run the SPWTABL program successfully one needs only the results from the EFFSPWN program.

III. Additional Effective Spawning Analysis

Often during a particular spawning-incubation season a critical peak flow is encountered that is of short duration but may have a dramatic impact on egg survival. This flow could be either a maximum or a minimum type of event that would cause the loss of incubation area by scouring the river bed (removing the eggs) or dewatering the spawning area causing irreparable harm to the eggs.

The program SPWITRP performs a combined peak and normal effective spawning analysis for a set of historical streamflow data. It determines the minimum amount of weighted usable area available in a stream reach during a given spawning-incubation period. The WUA available to the study species is determined by comparing two possible combinations of three critical events that occur during a yearly cycle, calculating the minimum WUA.

The important combinations considered are the monthly average spawning flow combined with the minimum monthly incubation flow and the instantaneous incubation peak flow. The critical amount of weighted usable area available during a yearly cycle for that species of fish would be the minimum between the two combinations.

Several pieces of information are needed to perform the analysis. First, the theoretical relationship between WUA and spawning-incubation flows in the study site needs to be determined. Secondly, the average monthly spawning, minimum monthly incubation, and critical instantaneous incubation flows need to be determined.

The average spawning and minimum monthly incubation flows are determined by the program QINCSP. One must have a data file containing monthly flows for the years of interest in either USGS or NWDC format ready as input to QINCSP. The program will prompt the user for the beginning month of the data set and the months defining the spawning and incubation periods.

Output from QINCSP comes in the form of three files. One data file contains the critical spawning and incubation flows for the years of data entered into the program. Two output files are written by QINCSP to allow the user to review results from the program. One file is a summary of the monthly flows entered into the program. This file may be reviewed to determine if the beginning month was correctly identified. The other file is a summary of the critical flows determined for the spawning and incubation periods of each year.

The program MAKQAF is used to build the peak flow file. The critical instantaneous flow occurring during the incubation season should be determined from available historical flow records and entered into this program. The critical flows may be either a minimum or maximum event as described previously.

Once the programs MAKQAF and QINCSP have been run, the two output files must be merged to create a file that is used to determine the critical habitat available during the spawning and incubation season for each year. The program ADQPK merges the two files in preparation for the analysis program SPWITRP.

Now that the three flows of interest have been combined into one file, the analysis is performed using the program SPWITRP. The only other needed input for SPWITRP is the output file from the effective spawning program that contains thw WUA versus spawning-incubation flow relationship.

To further analyze the effective spawning information developed by the EFFSPWN program, the following steps should be taken.

IV. Running the Extended Effective Spawning Analysis Programs

A) Program:SPWTABL

Commands:

GET,TSPROC

BEGIN,RSPWTAB,TSPROC,INPUTF,OUTPUTF

INPUTF - data file containing the WUA vs. spawning and incubation flows (output from program EFFSPWN).

OUTPUTF - line printer file with the EFFSPWN data arranged in tabular format.

B) Program: SPWITRP

1) Create a file containing the spawning and incubation flows for each year in the historical period of study.

Commands:

GET,TSPROC

BEGIN,RQINSCP,TSPROC,INPUTF,TAPE2,TAPE3,TAPE4

INPUTF - the monthly flow file (USGS or NWDC format).

TAPE2 - output data file containing the spawning and incubation flows for that period of record.

TAPE3 - line printer file containing the flows from the input file.

TAPE4 - line printer file containing the spawning and incubation flows.

2) Creating the peak flow file.

Commands:

GET,TSPROC

BEGIN,RMAKQAF,TSPROC,OUT1

OUT1 - data file that contains the peak flows entered from the terminal.

3) Merging the two flow files.

Commands:

GET,TSPROC

BEGIN,RADQPK,TSPROC,INPUTF1,INPUTF2,OUT1,OUT2

INPUTF1 - file from QINCSP which containing the spawning and incubation flows.

INPUTF2 - peak flow file.

OUT1 - data file containing the three flows, ready for use by the SPWITRP program.

OUT2 - a line printer file containing the three flows.

4) Running the SOWITRP program.

Commands:

GET,TSPROC

BEGIN,RSPWITP,TSPROC,IN1,IN2,OUT1,OUT2

IN1 - the spawning/incubation flow versus WUA relationship (output from the EFFSPWN program).

IN2 - the three flow file (output from ADQAF).

OUT1 - a line printer file containing the spawning and incubation table from the effective spawning program and the WUA determined from the three flows entered into the program.

OUT2 - contains the minimum weighted usable areas determined by the SPWITRP program in a data file format.

RIVRLIB TECHNICAL NOTE NO. 3

ROUTING OF FLOWS

by

Robert T. Milhous

INTRODUCTION

In the analysis instream flows for those situations with rapid changes in streamflows (for example hydropeaking) **it is adviseable to route the streamflows to different locations along the stream being studied**. The purpose of this note is to present three computer programs available to do the routing. The three programs are RMUSK, ROUTS, and DROUT. The RMUSK programs uses the MUSKINGUM method of routing streamflow. The ROUTS program is similar to the RMUSK program except that a stage versus channel storage function is used. In contrast, the DROUT program uses a linear diffusion analogy to route streamflows. In addition, the HEC1 program of the Hydrologic Engineering Center can be used to route streamflows.

For most situations the ROUTS program should be used for the case of little lateral inflow to the stream between the initial point and the point of interest and the HEC1 program when there is a significant laterial inflow.

All four programs route the streamflows in discrete "jumps" along the stream. A different, and expensive, approach would have to be used to determine the hydrograph at every part along the stream.

HEC1 is well documented by HEC and will not be covered any further in this note.

BASIC THEORY

The two basic equations describing flow in an open channel are:

The equation of motion -

$$\frac{\partial y}{\partial x} + \frac{\nu}{a}\frac{\partial \nu}{\partial x} + \frac{1}{a}\frac{\partial \nu}{\partial t} = S_o - S_f$$

and the equation of continuity -

$$y\frac{\partial \nu}{\partial x} + \nu\frac{My}{\partial x} + \frac{\partial y}{\partial t} = 0$$

where y = depth of flow in the channel

ν = average velocity in the channel

x = the distance along the channel

τ = time

S_o = channel slope

S_f = friction slope

These equations are often referred to as the "St. Venant" differential equations.

The friction slope can be calculated using any number of equations, one of the most common is the manning equation which is

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

which can be rearranged to:

$$S_f = \frac{\nu^2 \nu|\nu|}{2.22 R^{4/3}}$$

where n is the Manning roughness factor, and R the hydraulic roughness.

The Equation of motion can be rearranged to the form

$$S_f = S_o - \frac{\partial y}{\partial x} - \frac{\nu}{g}\frac{\partial \nu}{\partial x} - \frac{1}{\partial}\frac{\partial \nu}{\partial t}$$

For steady uniform flow we assume the rate flow does not change with time and the depth does not change with location along the channel. In this case

$$S_f = S_o$$

If the flow does change with location along a channel but not with time we have

$$S_f = S_o - \frac{\partial y}{\partial x} - \frac{v}{g}\frac{\partial v}{\partial x}$$

Simplified methods, make simplifying assumptions which make them less accurate than the more complicated methods which make less simplifying assumptions.

For more information on the basic theory of unsteady flow the reader should see Hendersen - Open Channel Flow and Chow - Open-Channel Hydraulics.

Two additional concepts are useful, these are first the speed (c) of a long low wave in water at depth y is

$$C = \sqrt{gy}$$

and if oten referred to as the "celerity".

The other concept, is that if the water the wave occurs in is moving, the velocity of the wave (ν_w) will be

$$\nu_w = \nu + C$$

when ν is the velocity of the flowing water. If the wave travels upstream then this is the equation we solve for gradually varied flows.

When we have the flows as a function of time, then we have all the terms in the equation of motion. The problem at hand in this paper is to present simpler methods of routing unsteady flows in a channel.

DATA NEEDS

For all of the routing programs it is adviseable to have the hydrographs for both the initial point and the point of interest. It is possible to estimate the needed parameters without the hydrographs but it is much better to use measured hydrographs to determine the needed parameters by calibration of the model being used.

It is also adviseable to develop a stage versus channel storage function using a WSP data set with the AVDEPTH Program (see IFIP 11 for use of the program.)

THE RMUSK PROGRAM

The basic equation used in the Muskingum method is the channel storage equation.

$$S = K\,(x\,I + (1-x)\,O)$$

where S is the storage in a reach,

I is the inflow to a reach,

O is the outflow from a reach,

K is the storage per unit of streamflow, and

x is a factor defining the relative weight given the inflow and outflow

The values of K and x depend on the channel characteristics of the reach of stream. The value of K may be established using the AVEDEPTH program and the value of x estimated using Figure 1.

The data input is free format in the following order:

1. Reach length in miles,
2. Unit storage function in sq. ft. per cubic foot/second,
3. the x factor,
4. time step in hours, and,
5. number of cascades used.

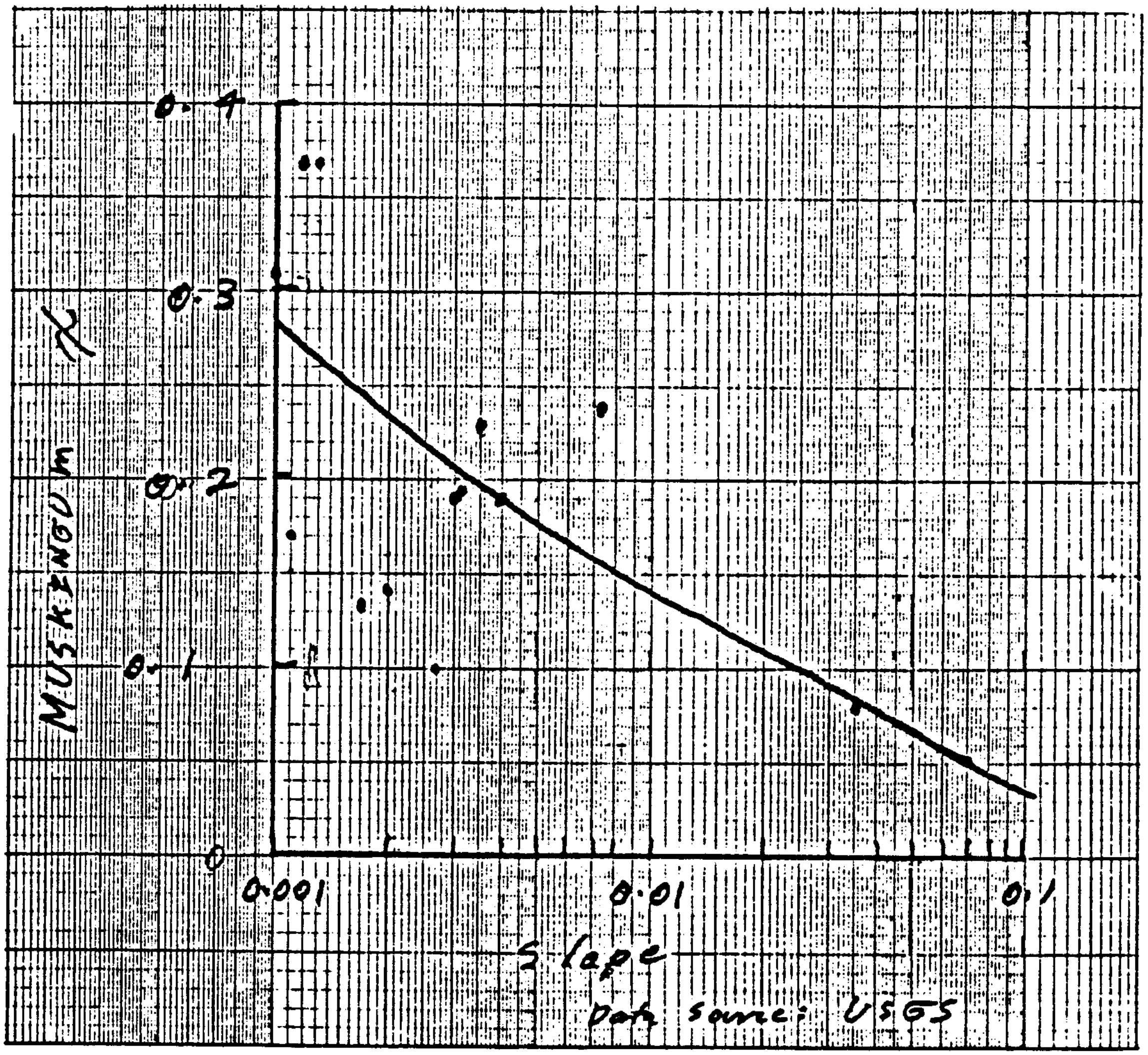


Figure 1. The Muskingum x as a function of stream slope.

These five items of data are followed by the inflow hydrograph.

The output is the hydrograph at the end of the reach.

THE ROUTS PROGRAM

The ROUTS program is similar to the RMUSK program except storage versus discharge function is used instead of a constant rate of storage change assumed with the use of K in RMUSK.

The input data are in free format in the following order:

1. reach length in miles,
2. the number of points on the storage version discharge function,
3. the x factor,
4. the time step
5. the number of cascades,
6. the discharge - storage table with the discharge first for each point and,
7. the inflow hydrograph.

The results are the outflow hydrograph.

THE DROUT PROGRAM

The DROUT program is based on a linear differsion analogy. The input is in free format in the following factors:

1. time step,
2. reach length,
3. the number of points in the celerity and dispersion coefficient version discharge functions,
4. the number of steps to use in routing,
5. the data for the celerity versus discharge function, and the dispersion coefficient version discharge function entered in the of celerity, despersion, coefficient, and discharge.
6. the inflow hydrograph.

The results of the analysis is the hydrograph at the end of the reach.

SUMMARY

The three programs presented here can be used for the analysis of most instream problems associated with hydropeaking projects.

PHABSIM TECHNICAL NOTE NO. 3

THE SIMULATION OF PHYSICAL HABITAT IN A REACH WITH ISLANDS - THE DIVIDED FLOW APPROACH USING IFG4

by

Robert T. Milhous
Hydraulic Engineer

Instream flow studies are often made where islands--some large and some small--divide the flow. The purpose of this technical note is to outline one approach which can be taken to develop a physical habitat version streamflow relationship when the study reach contains divided simulation cross sections and the IFG4 program is being used for hydraulic simulation. The number of cross sections can be as few as one, or as many as the user wants.

The general nature of the problem is shown in Figure 1, followed by an outline of an approach which can be used.

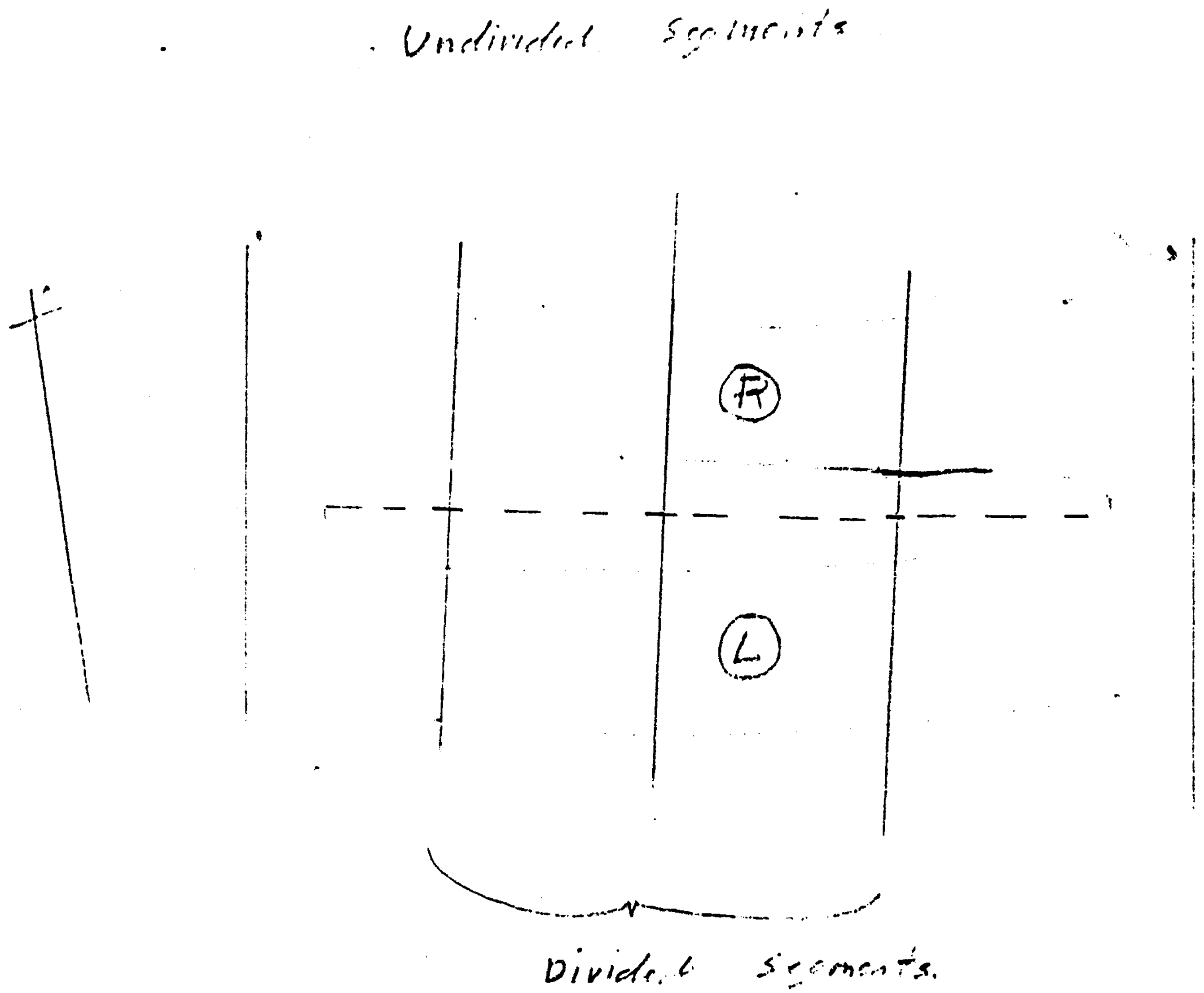


Figure 1. The divided stream problem.

OUTLINE OF APPROACH

1. Select cross section locations using the appropriate logic for the study at hand.

2. For the partial segment with divided channels, treat each channel as a separate stream.

3. Collect data such that the relationship

$$Q_L = f(Q_T)$$

can be developed where Q_L is the discharge in the left channel and Q_T is the total discharge. Remember that:

$$Q_T = Q_L + Q_R$$

where Q_R is the discharge in the right channel.

4. Develop a seperate stage-discharge relationship for each channel.

5. Calibrate and run IFG4 and HABTAT models for (a) the left channel, (b) the right channel, and (c) the stream segments segments without the divided channels. This will result in a TAPE8 for each of these. For the following steps we will define these as TP8L for the TAPE8 from the run on the left channel, TP8R for the richt channel, and TP8UD or part of the study reach not divided.

6. The total habitat for the part of the reach with divided flow is

$$TP8D = TP8R + TP8L$$

where TP8D is the habitat for the length of stream with divided flow.

7. Develop weights for the divided segment and undivided segments. Note that

$$W_{UD} + W_D = 1.0$$

where W_{UD} is the weight for the undivided segments and W_D is the weight for the divided segment.

8. Use the equation

$$TP8T = (TP8UD * W_{UD}) + (TP8D * W_D)$$

where TP8T is the final TAPE8 and is for the total study segement.

Note that when TAPE8's are being multiplied and summed it means that the habitat areas for the appropriate life stages and species and the streamflow are being multiplied and summed.

TSLIB TECHNICAL NOTE NO. 4

USING A DAILY STREAMFLOW DURATION TABLE TO DETERMINE A DAILY HABITAT DURATION TABLE

by

Keith D. Garlinghouse

INTRODUCTION

When addressing problems associated with the effect of rapid streamflow fluctuations on aquatic life, an important variable to consider is the change in habitat associated with the change in flow. A change in flow often dictates a change in the velocity distribution for a study transect, and in turn, the amount of quality habitat area [weighted usable area (WUA)] available to the study species. Thus, good habitat area and whether it fluctuates over time is the important variable to the species.

To determine the degree of flow fluctuation at a river site, a duration analysis is preformed on flow values measured at regular intervals of time. A flow duration analysis is the determiniation of the probability of exceeding a certain flow during the frequency period. The probability of exceedance is determined by comparing the relative position of an individual flow value to the values recorded over a historical period of time. Thus, it becomes necessary to distinguish between two time periods used in performing the duration analysis; the frequency of measurement period and historical flow period.

The frequency of measurement period is the frequency at which the flow values are measured and when the probability of exceeding a flow value is expected to occur. Thus, curves having different frequency of measurement periods can't be compared. For example, the monthly and daily flow curves can't be compared because the daily curve represents flow fluctuations that might occur at a study site during a particular day in a given month, while the monthly curve represents the probable average monthly flow fluctuation.

The historical flow period is the period of time that the data was collected over, and should be carefully specified. A dramatic change occurring on a river (e.g., a dam was built) would necessitate separate duration analyses for the periods before and after the event took place to determine whether a change in the probability of exceedance curves occurred at the study site.

The USGS's WATSTORE database contains flow values recorded at a variety of frequencies. Programs exist within the database system that will determine probability of exceedance curves for flow values recorded at a variety of frequencies. The probability of exceedance concepts has been applied to the amount of weighted usable habitat area available in the study reach because habitat area is the important variable to any study species.

PROGRAMS INVOLVED IN THE ANALYSIS

The daily habitat exceedance program (HABEXCD) uses information gained from a daily flow duration analysis and the habitat versus flow relationship obtained from the habitat program to define a daily habitat probability exceedance curve. Each exceedance curve is applicable only for a particular life stage of species at a given study site. Several programs are utilized to manipulate the data into the form required by HABEXCD. The first step in obtaining the daily habitat exceedance is to run the flow duration analysis program associated with the USGS's database. The USGS has documentation on details needed to run the analysis.

After running the duration analysis, one would obtain a file that contains a ranking and the probability of exceedance for flows occurring during a given day of a particular month. This extremely large file is read by the SELDUR program and condensed into a more manageable file that contains just the important flow duration table. Two programs, DURPCNT and CLASDST, operate on the condensed flow duration information to create files that are used in the rapid fluctuation analysis.

The program DURPCNT takes the output file from SELDUR and writes a line printer file containing the flow exceedance curve information determined in the duration analysis.

Program CLASDST also uses the output from SELDUR but builds a datafile that contains the classes, flow values, and probability of exceedance for each flow. This file created by the habitat exceedance curve. When performing a normal PHABSIM analysis, the habitat program is run to determine the amount of weighted usable habitat area available to the life stage of a species at a particular flow. A file called TAPE8 is created and contains the flow versus WUA function for the species and life stage of interest. This file is used in the habitat exceedance program along with the data file created in the CLASDST program to develop the daily habitat exceedance function for the study site of interest.

The program HABEXCD takes the probability of low exceedance curve and determines the flows correspondig to all exceedance percentages occurring at one percent intervals for the entire range defined on a curve. It then interpolates either linearly or by polynomial representations for the WUA values from the flows. Polynomial interpolation is applicable when the data can be fit easily by a third order equation, otherwise linear interpolation should be used. The WUA values are then ranked in ascending order and the probabily of exceedance is determined for a given habitat value from its ranking relative to the total range of habitat values. Thus, the habitat probability of the exceedance curve is determined based on the probability of exceedance for flows occurring on a daily basis during a particular month. This curve, however, is only indirectly related to the flow exceedance curve. Therefore, there is not a one to one correspondence between the two curves.

The output from the HABEXCD program comes in two forms. One output file is a datafile containing the WUA values and their probability of exceedances for each month of the year. A line printer file is also created that contains the WUA versus percentage exceedance relationship presented in the form of plots for each month of the year.

RUNNING THE HABITAT EXCEEDANCE PROGRAM

The following steps must be taken to obtain the percentage exceedance habitat function.

(1) Run the Watstore duration analysis on the daily flow values for the period of historical time at the stream site of interest.

(2) Run the SELDUR program to condense the duration analysis information into the information needed for the habitat analysis.

Commands:

```
GET,TSPROC

BEGIN,RSLDR,TSPROC,INPUTF,OUT1,OUT2
```

INPUTF - file obtained from WATSTORE duration analysis program

OUT1 - condensed duration analysis information

OUT2 - intermediate dummy file (must be checked to see if WATSTORE file contained unusual errors)

(3) Run the DURPCNT program to obtain a line printer file of the percentage flow exceedance function.

Commands:

```
GET,TSPROC

BEGIN,RDRPRUN, TSPROC,INPUTF1,OUT1,OUT2
```

INPUTF1 - condensed duration analysis information (output from SELDUR)

OUT1 - line printer file containing percentage exceedance tables

OUT2 - dummy file (checked to see if errors occurred during run)

(4) Run the CLASDST program to create a datafile for use in determining the habitat exceedance function.

Commands:

```
GET,TSPROC

BEGIN,RCLSRUN,TSPROC,INPUTF1,OUT1,OUT2
```

INPUTF1 - condensed duration analysis information (output from SELDUR)

OUT1 - datafile of duration information (from SELDUR)

OUT2 - dummy file (checked to see if errors occurred during run)

(5) Run HABEXCD program to determine the percentage habitat exceedance for that study site based on daily flow values.

Commands:

```
GET,TSPROC

BEGIN,RHBEXCD,TSPROC,INPUTF1,INPUTF2,OUT1,OUT2
```

INPUTF1 - flow percentage exceedance file from CLASDST

INPUTF2 - habitat/flow relationship from habitat program

OUT1 - line printer file containing the habitat percentage plots

OUT2 - datafile containing habitat percentage function

PHABSIM TECHNICAL NOTE NO. 4

THE USE OF ONE VELOCITY CALIBRATION DATA SET WITH IFG4

by

Robert T. Milhous
Hydraulic Engineer

The IFG4 program can be used with only one set of velocity data to calibrate the model. This is done by placing water surface elevation on the WSL cards for each streamflow for which simulation results are desired. The single set of velocities are used to determine the Manning's roughness (n) values. These Manning's n's are effectively velocity distributuion terms and not roughness in the usual energy loss sense. The water surface elevations must be deterined external to the IFG4 program. This can be done by using the WSP program, by use of a stage-discharge relationship for each cross section, or by use of the Manning equation calibrate to a single data set. If the stage-discharge relationship is used it is recommended that at least three reasonably spread-out points will be used (i.e., the three points must not be for essentially the same streamflow).

The use of a single velocity calibration data set has proven to be more reliable that the use of three velocity calibration data sets in many cases--provided the water surface elevetions are determined using stage-discharge relationships based on three or more points or using the WSP model calibrated to water surface elevations with a stage-discharge relationship for the starting water surface elevations.

The use of the water surface profile program (WSP) requires the condition be such that the use of WSP program is appropriate. The use of WSP is adequately discussed in Instream Flow Information Paper No. 11.

When using the stage-discharge relationship the same approach is used as with the stage data in IFG4 - see Instream Flow Information Paper No. 11 for details.

The use of the Manning equation requires one set of water surface elevations and the assumption is made that the Manning equation is valid at each cross section and there is no backwater effect at any cross section.

The use of each approach is outlined on the following pages.

OUTLINE OF APPROACH FOR USING THE WSP PROGRAM WITH A SINGLE VELOCITY IFG4.

1. Collect one set of velocity measurements.

2. Collect water surface elevations at each cross section for at least one streamflow.

3. Prepare and check an IFG4 data file with the single velociy data set.

4. Place the single water surface elevation for the calibration velocity set on the WSL card for each cross section and the corresponding streamflow on a single QARD card and run the IFG4 program. Review the results and select options for the production runs.

5. Transform the IFG4 input file to a WSP input file also retaining the IFG4 input file.

6. Calibrate the WSP model to water surface elevations with constant roughness for all cells and cross sections.

7. Calibrate the WSP model to constant roughness in each cross section but varying from cross section to cross section if there is a physical reason to do so.

8. Select the streamflows needed to develop the physical habitat versus streamflow relationship.

9. Select roughness multipliers; if appropriate.

10. Run the calibrated WSP model with the streamflows from step 8.

11. Use the WSEI4 program to read the TAPE4 from step 10 and place the calculated water surface elevations on the appropriate WSL cards. The streamflow from step 8 are also written as the streamflow on the QARD cards in the IFG4 input file.

12. Make the production runs with the IFG4 input file.

OUTLINE OF APPROACH FOR USING THE STAGE-DISCHARGE RELATIONSHIP WITH A SINGLE VELOCITY IFG4.

1. Collect one set of velocity measurements.

2. Collect water surface elevations at each cross section for three or more streamflows.

3. Prepare and check an IFG4 data file with the single velociy data set.

4. Place the single water surface elevation for the calibration velocity set on the WSL card for each cross section and the corresponding streamflow on a single QARD card and run the IFG4 program. Review the results and select options for the production runs.

5. Select the streamflows needed to develop the physical habitat versus streamflow relationship.

6. Use the stage-discharge data with the WSEI4S program to create the WSL cards in the IFG4 data file for the production run.

7. Make the production runs.

OUTLINE OF APPROACH USING THE MANNING EQUATION TO DETERMINE WATER SURFACE ELEVATION FOR A SINGLE VELOCITY IFG4.

1. Collect one set of velocity measurements and one set of water surface elevation for cross sections.

2. Prepare an IFG4 data file with the single velociy data set.

3. Place the single water surface elevation for the calibration velocity set on the WSL cards for each cross section and the corresponding streamflow on a single QARD card and run the IFG4 program. Review the results and select options for the production runs.

4. Select the streamflow needed to develop the physical habitat versus streamflow relationship.

5. Use the single set of water surface elvation-discharge data with the MANSQ program to create a TAPE4 with the water surface elevation and average channel velocities for the flows of interest.

6. Use the WSEI4 program to add the WSL cards (lines) to an IFG4 data set.

7. Make the production runs.

PHABSIM TECHNICAL NOTE NO. 5

IMPACT OF A CHANNEL INDEX ON THE PHYSICAL HABITAT VERSUS STREAMFLOW RELATIONSHIP

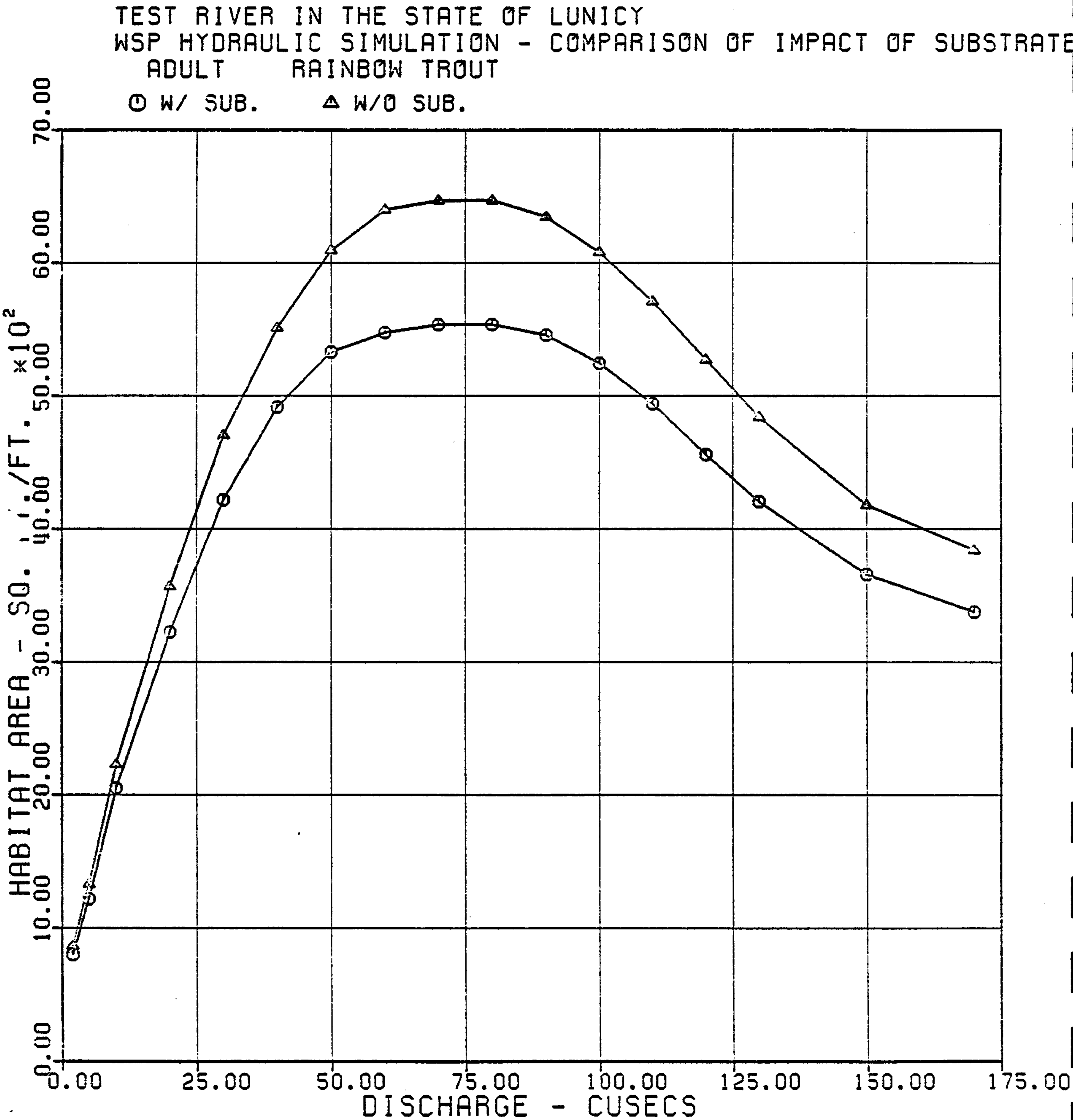
by

Robert T. Milhous
Hydraulic Engineer

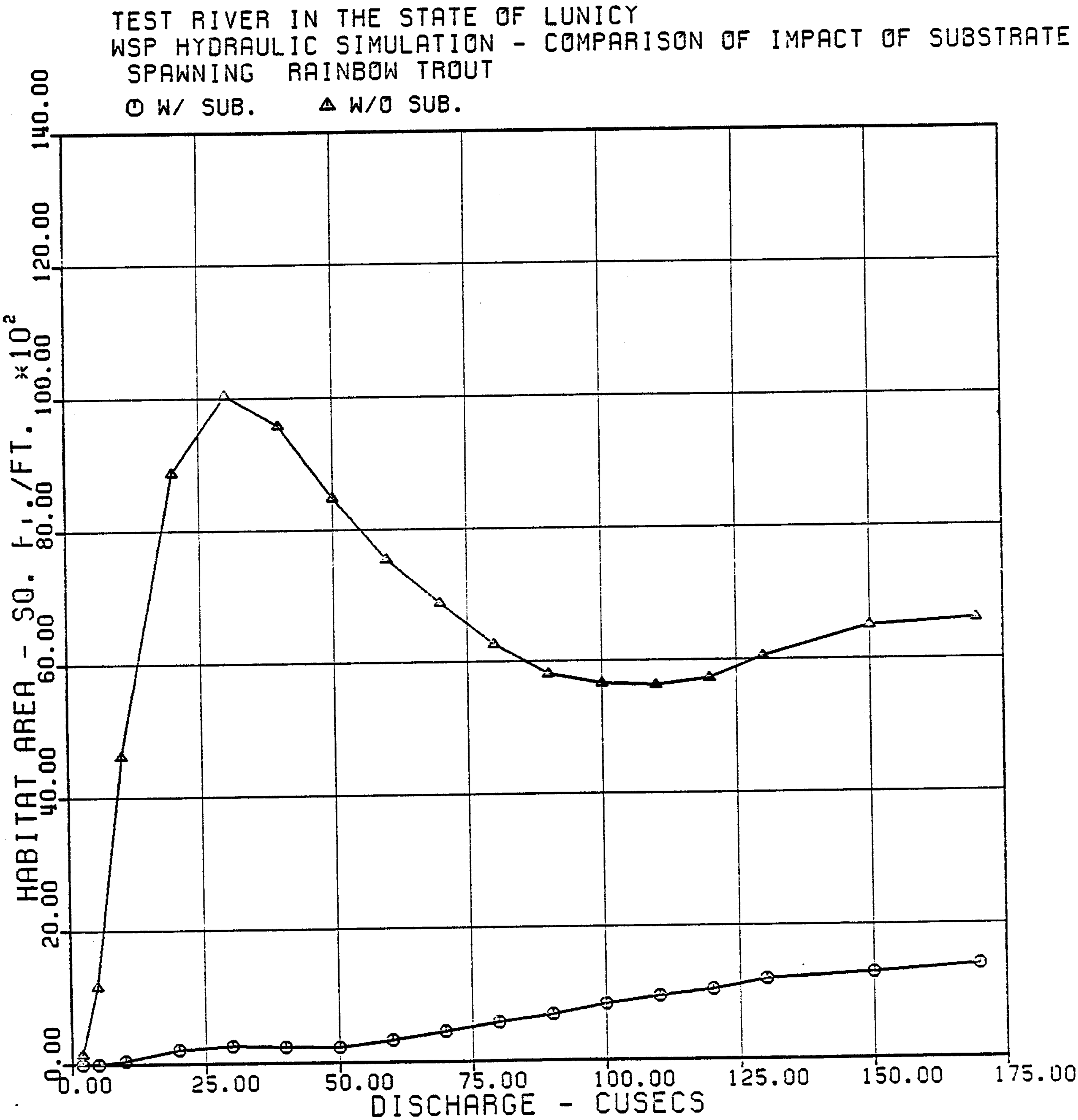
If different channel indexes were used with different habitat simulations, the results of habitat simulation will be different but to what degree depends on the importance of the channel index on the life stage being simulated. The experted range is illustrated in this appendix by comparing the case of where no channel index was used in the habitat simulation to the case where substrate was used. The channel notes used for comparison is the index based on bed material size, "substrate", as presented in Instream Flow Information Paper No. 3.

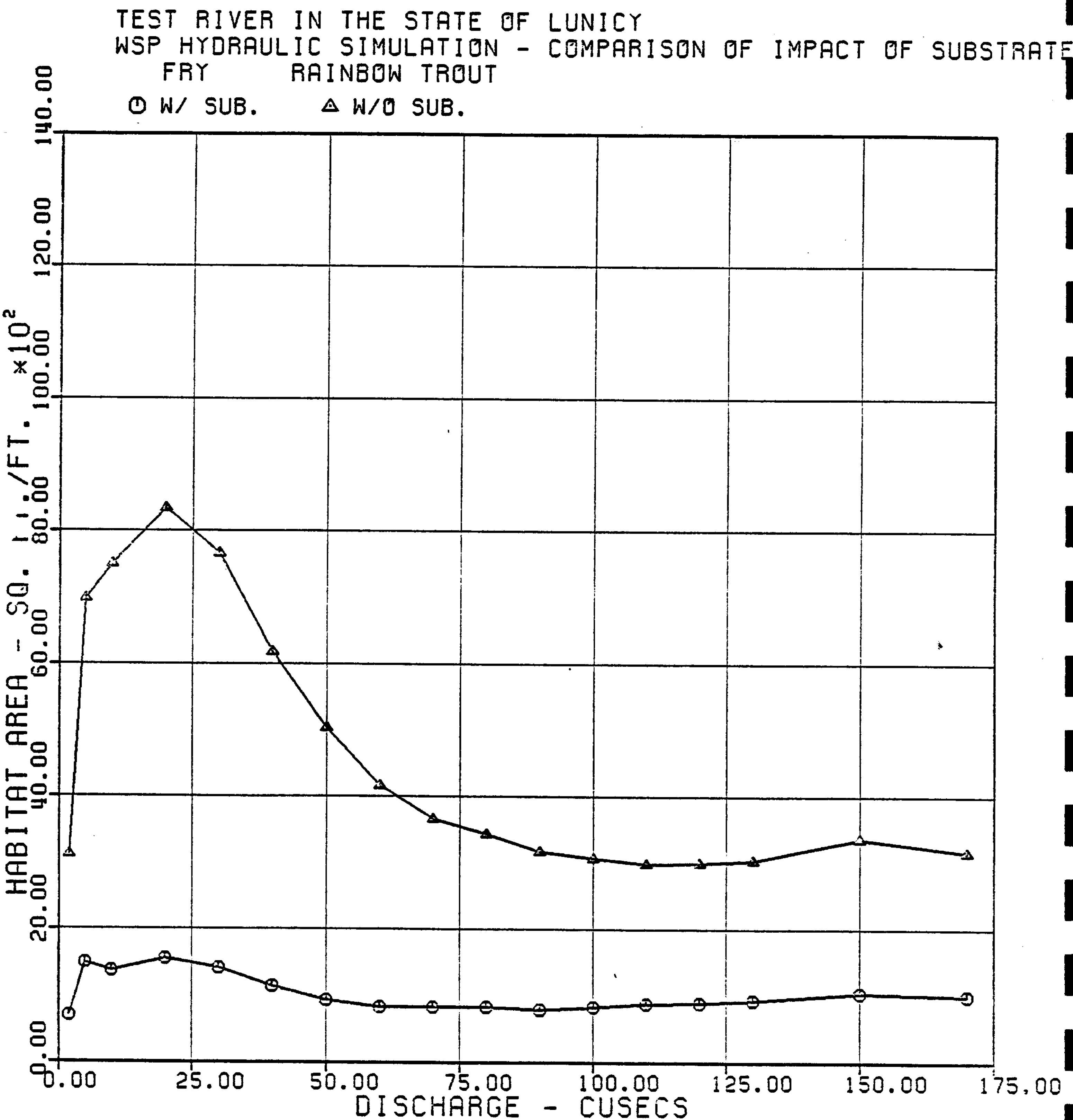
The writer's experience has been that the channel index is often of not much importance for adults but of major importance for spawning. The results given here substanuate this observation.

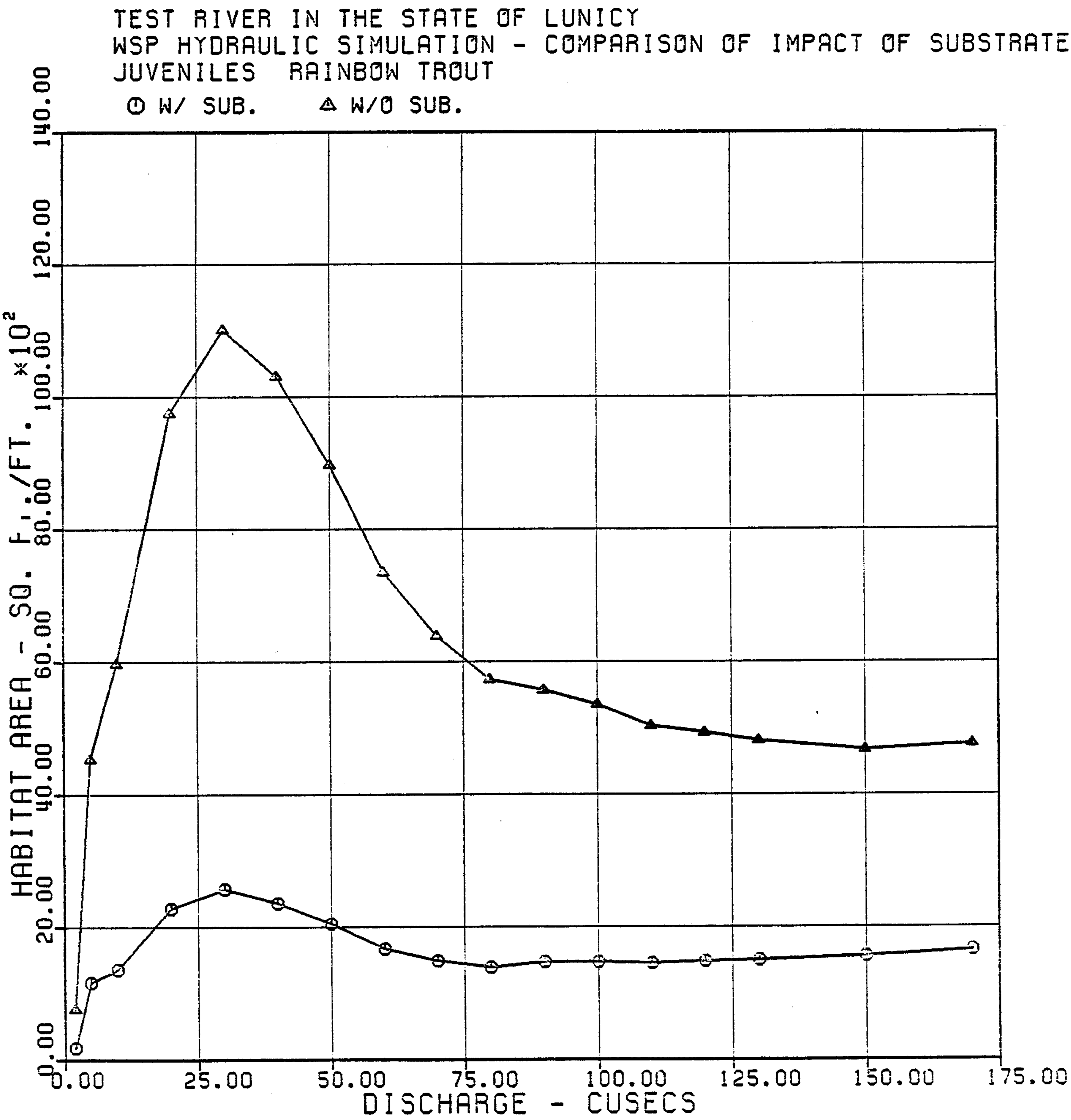
The results indicate the channel index is of major importance. Consequently, when comparing habitat simulation models, care must be taken to see that the same channel index is used in each simulation. The channel index must be designed with care considering the task at hand and the resources available to complete the task.



TEST RIVER IN THE STATE OF LUNICY
WSP HYDRAULIC SIMULATION - COMPARISON OF IMPACT OF SUBSTRATE
ADULT RAINBOW TROUT
W/ SUB.
W/O SUB.
HABITAT AREA - SQ. FT./FT. ×10²
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
0.00
25.00
50.00
75.00
100.00
125.00
150.00
175.00
DISCHARGE - CUSECS


TEST RIVER IN THE STATE OF LUNICY
WSP HYDRAULIC SIMULATION - COMPARISON OF IMPACT OF SUBSTRATE
SPAWNING RAINBOW TROUT
W/ SUB.
W/O SUB.
HABITAT AREA - SQ. FT./FT. ×10²
0.00
20.00
40.00
60.00
80.00
100.00
120.00
140.00
0.00
25.00
50.00
75.00
100.00
125.00
150.00
175.00
DISCHARGE - CUSECS


TEST RIVER IN THE STATE OF LUNICY
WSP HYDRAULIC SIMULATION - COMPARISON OF IMPACT OF SUBSTRATE
FRY RAINBOW TROUT
W/ SUB.
W/O SUB.
HABITAT AREA - SQ. FT./FT. *10²
0.00
20.00
40.00
60.00
80.00
100.00
120.00
140.00
0.00
25.00
50.00
75.00
100.00
125.00
150.00
175.00
DISCHARGE - CUSECS



TEST RIVER IN THE STATE OF LUNICY
WSP HYDRAULIC SIMULATION - COMPARISON OF IMPACT OF SUBSTRATE
JUVENILES RAINBOW TROUT
W/ SUB.
W/O SUB.
HABITAT AREA - SQ. FT./FT. *10²
0.00
20.00
40.00
60.00
80.00
100.00
120.00
140.00
0.00
25.00
50.00
75.00
100.00
125.00
150.00
175.00
DISCHARGE - CUSECS

PHABSIM TECHNICAL NOTE NO. 6

VARIABLE ROUGNESS IN THE HYDRAULIC SIMULATION PROGRAM IFG4

by

Robert T. Milhous
Hydraulic Engineer

A new option is available in the October 1984 version of the IFG4 hydraulic simulation model that allows the user to adjust the roughness in a cell as a function of the depth in a cell.

This should help in reducing the negative impacts often resulting from too high roughness at the edges in the calibration data set.

More expense must be obtained in the actual application of the option before a high degree of confidence in its use is appropriate. Consequently, any user of the option must be proceeded with considerable care. Do not be a WALA! User. This option can byte.

THEORY

Rougness in a stream channel varies with discharges. In a sand bed stream the variation can be rather complex as a result of the formation and distruction of ripples and dunes. In a non-sand bed river the problem can be approached on the basis of the equation

$$n = f(R/DI)$$

where n is the Manning roughness, R is the hydraulic radius, and DI is an index to the size of the bed material.

For many cases the function can be expressed as

$$n = \alpha(R/DI)^{\omega}$$

where α and ω are coefficients. If we then define n_o as the roughness when the hydraulic radius is 1.0 and

$$n_o = \alpha \left(\frac{1}{DI}\right)^{\omega}$$

and the function then becomes

$$n = n_o R^{\omega}$$

If the coefficient ω is known and one set of data available, the value of n_o can be determined using the equation

$$n_o = n_c/(R_c^{\omega})$$

where the subscript c refers to the calibration data set. If enough data is available, the value of n_o and ω can be determined from regression analysis.

Anohter approach, which is applicable to all rivers is based on the stream morphology relationships

$$n = r\ Q^y$$

$$d = c\ Q^f$$

where Q is the stream flow, d is the average depth, and r, y, c, and f are coefficients. Combining the equations in order to eliminate the discharge, Q, yeilds

$$n = r\ (\frac{d}{c})^{y/f}$$

and define n_o' as the roughness at a depth of 1.0; the value of n_o' is

$$n_o' = r \left(\frac{1}{c}\right)^{y/f}$$

and also using

$$\beta = y/f$$

results in

$$n = n_o' \, d^{\beta}$$

For most national river channels the hydraulic radius is approximately the same as the average depth, consequently, it is safe to assume

$$\omega = \beta$$

$$n_o = n_o'$$

and then writing the equation to use with a data set to calibrate the equation is

$$n = n_c \left(\frac{d}{d_c}\right)^{\beta}$$

where n is the roughness at the flow of interest, n_c is the calibration roughness, d the depth at the flow of interest, d_c is the depth at the calibration flow.

IMPLEMENTATION IN IFG4

THe IFG4 program is strongest when used for the determination of the distribution of velocities across a channel. The theory described in the previous section will change the velocity distribution by reducing velocities in shallow areas and increasing them in the deeper areas.

The program first calculates the calibration roughness, n_c, using the equation

$$n_c = \frac{1.49}{v} d_c^{2/3} S^{1/2}$$

The calculation of n_c is made for each vertical (coordinate point). The program then calculates the unit roughness, n_o, using the equation

$$n_o = n_c/(d_c)^{\beta}$$

The user supplies the β coefficient and the same value for β is used for all verticals and for all cross sections.

For the streamflows given on the QARD CARDS ("the flows of interest"), the program uses either the given water surface elevation or the water surface elevations determined from a stage-discharge relationship to calculate the depth at a vertical. The roughness (n) for the flow of interest is then calculated using the equation

$$n = n_o (d)^{\beta}$$

which is then used for the calculation of the velocities.

If a vertical has more than one calibration velocity, a log or semi-log function is used to calculate velocities and the adjustment of n is not done for that particular vertical.

The values of roughness written on output is n_o on the calibration details table and n on the computational details table.

One additional point is that the mass balance option <u>must</u> be left on, otherwise irrational results may be obtained from the simulation runs.

To use the option, the user supplies a 1 in column 27 of the IOC cards (IOC(16) = 1) and the β coefficient on an "NSLP" card. The "NSLP" card has the format

Col. 1-4	NSLP
Col. 5-10	blank
Col. 11-20	the β coefficient with decimal point

The order of the line procedure of the first QARD line is

Title	line 1
Title	line 2
IOC	line 3
BMAX	line 4
NMAX	line 5
NSLP	line 6

The BMAX and NMAX lines are used only when appropriate.

DETERMINATION OF THE β COEFFICIENT

The value of the β coefficient can be determined from the literature on hydraulic geometry of river channels. The range of values for all but humid tropical channels is from 0.0 to -2.04 with a typical value being more in the range of -0.3 to -0.8. The main point here is that the β coefficient is negative and has an unknown value.

The best approach available at this time is to assume a negative β term and run the IFG4 model to determine what happens to the roughness values. For flows on the high side, the values of n_o should approach the handbook roughness for many of the verticals.

Obviously, judgement is required is selecting the value of β.

EXAMPLE APPLICATION

An example of the input of selecting the β coefficient (the NSLP value) on two life stages of trout in the Williams Fork River, Colorado, is given in Figures 1 and 2. The input can be rather significant.

The value of simulated velocity and the roughness value used are given in Tables 1 and 2 for one cross section and a discharge of 1,500 cfs.

The calibration data set was for a discharge of 111 cfs; hence, the discharge of 1,500 cfs is well outside the usual range of extrapolation (about 300 cfs). Nevertheless, the high discharge illustrates the input of the selection of NSLP values (i.e., β coefficients). The best value for this data set is probably -0.10.

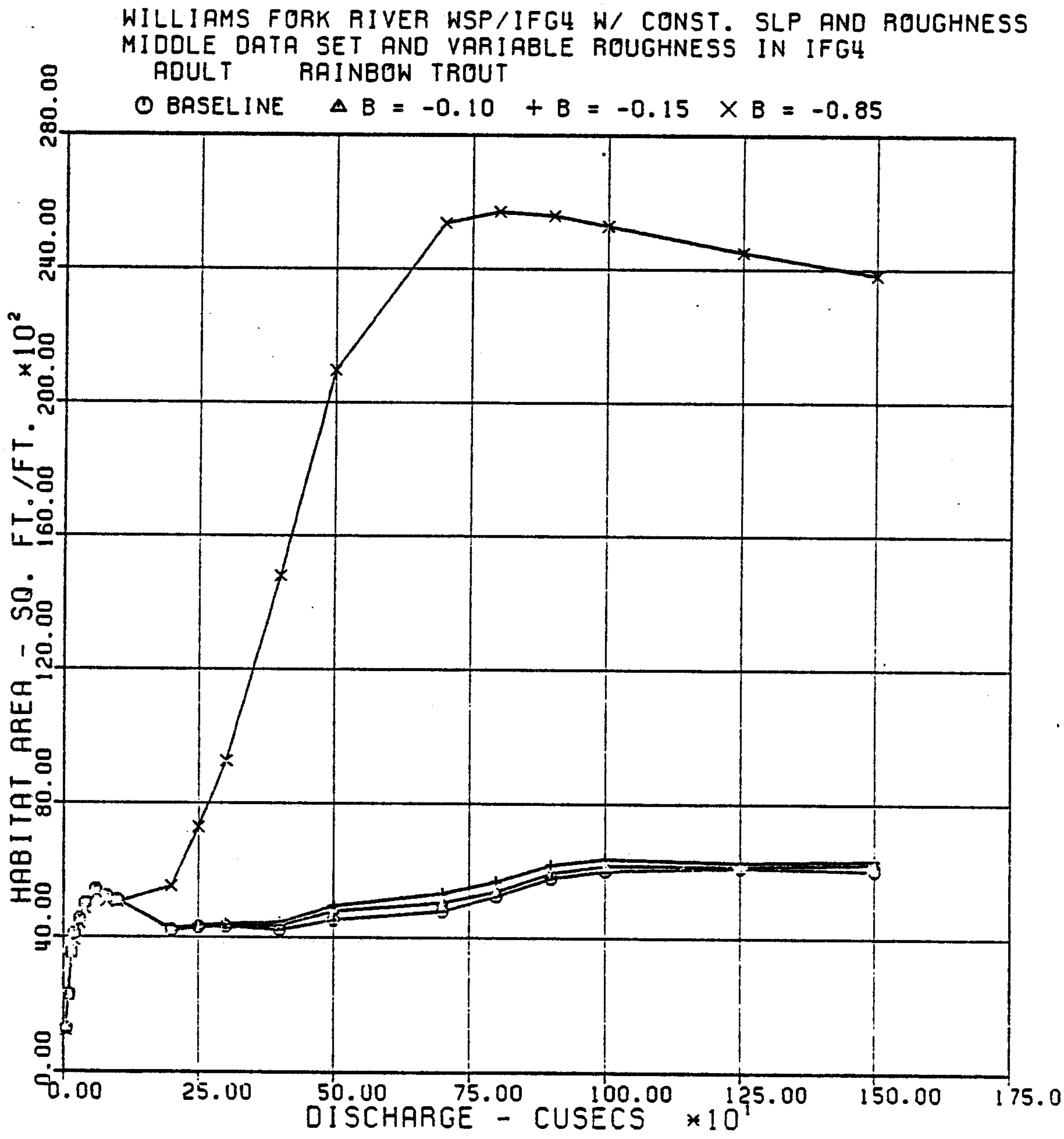


Figure 1. The physical habitat versus streamflow relationship for adult rainbow trout in the Williams Fork River as influenced by the coefficient in $n = n_o d^{\beta}$.

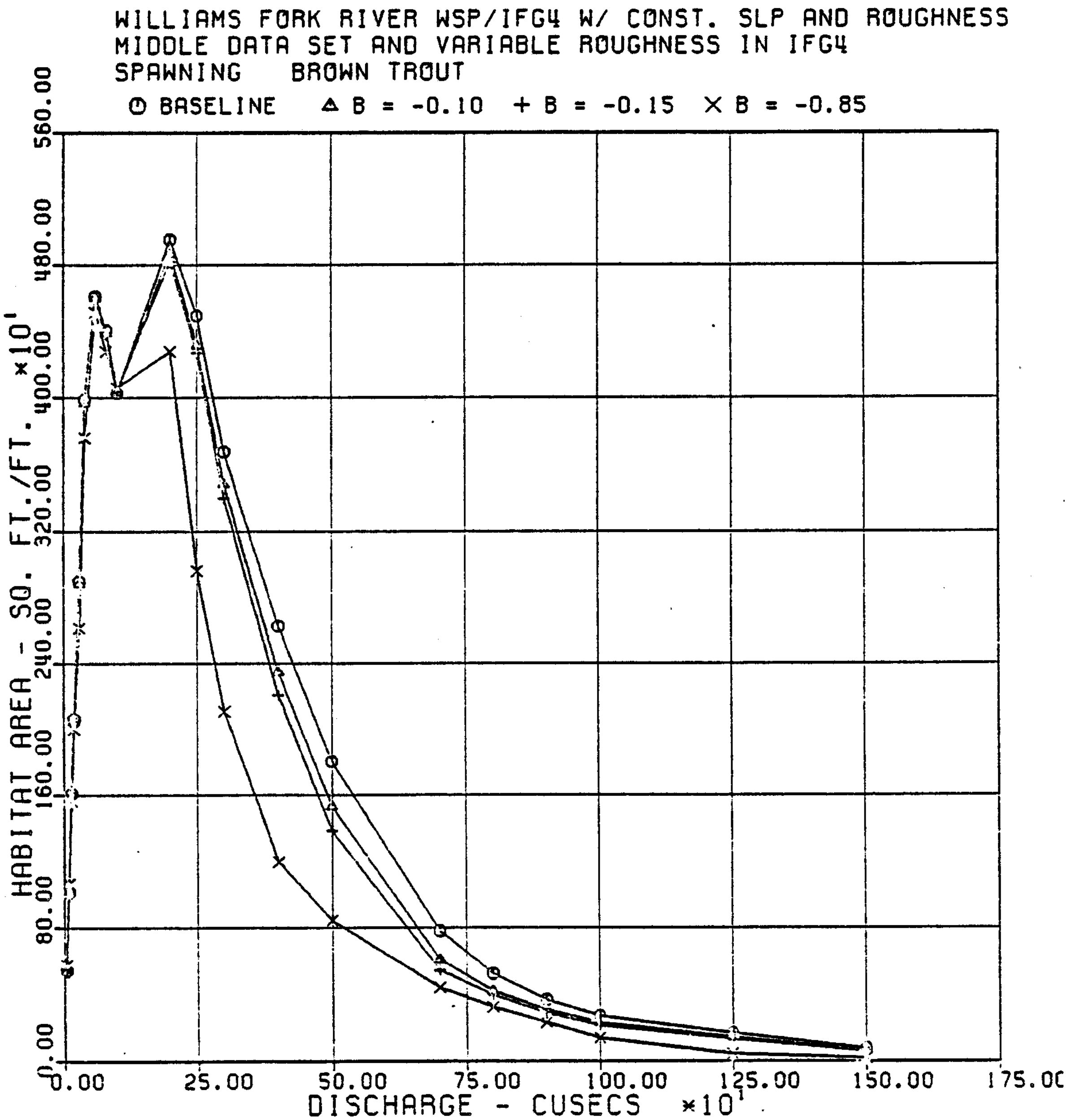


Figure 2. The physical habitat versus streamflow relationship for spawning brown trout in the Williams Fork River as influenced by the coefficient in $n = n_o d^{\beta}$.

Table 1. Simulated velocity at one cross section of the Williams Fork River with various NSLP values and discharge of 1,500 cfs.

	NSLP			
Cell	0	-0.15	-0.10	-0.85
1	1.38	0.97	1.10	0.07
2	2.47	1.98	2.15	0.27
3	2.65	2.16	2.33	0.32
4	3.15	2.67	2.84	0.47
5	3.10	2.61	2.78	0.45
6	5.10	4.33	4.60	0.78
7	5.79	4.88	5.19	0.85
8	5.84	4.89	5.22	0.83
9	5.70	4.75	5.08	0.79
10	6.20	5.22	5.56	0.91
11	5.31	4.43	4.73	0.73
12	5.31	4.43	4.73	0.73
13	5.04	4.22	4.50	0.71
14	5.58	4.70	5.01	0.82
15	5.04	4.31	4.57	0.80
16	4.96	4.30	4.54	0.86
17	6.61	5.74	6.05	1.15
18	6.16	5.40	5.68	1.13
19	6.16	5.40	5.68	1.13
20	6.99	6.20	6.49	1.37
21	7.13	6.40	6.67	1.50
22	5.57	5.07	5.27	1.27
23	7.04	6.41	6.65	1.61
24	7.62	7.06	7.29	1.93
25	7.69	7.29	7.47	2.20
26	7.11	6.93	7.03	2.37
27	8.82	9.39	9.25	4.88
28	8.23	8.77	8.64	4.55
29	7.06	8.24	7.87	6.54
30	7.06	8.24	7.87	6.54
31	6.18	7.21	6.89	5.72
32	12.84	21.33	18.12	88.10
33	8.56	14.22	12.08	58.73
34	12.84	21.33	18.12	88.10
35	5.30	6.18	5.90	4.91
36	5.29	5.64	5.55	2.93
37	3.56	3.46	3.51	1.19
38	3.81	3.53	3.64	0.96
39	3.22	2.94	3.05	0.74
40	4.39	3.94	4.11	0.92
41	3.11	2.75	2.88	0.61
42	2.96	2.59	2.73	0.54
43	4.14	3.67	3.85	0.81
44	4.06	3.58	3.75	0.77
45	3.71	3.20	3.38	0.63
46	3.40	2.91	3.09	0.53
VAF	1.10	0.81	0.90	0.07

Table 2. Roughness values at one cross section of the William Fork River with various NSLP values and discharge of 1,500 cfs.

	NSLP			
Cell	0	-0.15	-0.10	-0.85
1	0.065	0.068	0.067	0.083
2	0.065	0.060	0.062	0.039
3	0.065	0.059	0.061	0.036
4	0.065	0.057	0.059	0.029
5	0.065	0.057	0.060	0.030
6	0.039	0.034	0.035	0.017
7	0.035	0.030	0.032	0.016
8	0.035	0.031	0.032	0.016
9	0.037	0.032	0.034	0.018
10	0.033	0.028	0.030	0.015
11	0.040	0.035	0.036	0.019
12	0.040	0.035	0.036	0.019
13	0.041	0.036	0.037	0.019
14	0.036	0.032	0.033	0.016
15	0.039	0.033	0.035	0.016
16	0.038	0.032	0.034	0.015
17	0.029	0.024	0.025	0.011
18	0.030	0.025	0.027	0.011
19	0.030	0.025	0.027	0.011
20	0.026	0.021	0.023	0.009
21	0.025	0.020	0.022	0.008
22	0.031	0.025	0.027	0.009
23	0.025	0.020	0.021	0.007
24	0.022	0.018	0.019	0.006
25	0.022	0.017	0.018	0.005
26	0.023	0.017	0.019	0.005
27	0.017	0.012	0.014	0.002
28	0.019	0.013	0.015	0.002
29	0.021	0.013	0.016	0.002
30	0.021	0.013	0.016	0.002
31	0.024	0.015	0.018	0.002
32	0.011	0.005	0.007	<0.001
33	0.017	0.008	0.010	<0.001
34	0.011	0.005	0.007	<0.001
35	0.028	0.018	0.021	0.002
36	0.029	0.020	0.023	0.003
37	0.046	0.034	0.038	0.009
38	0.045	0.035	0.038	0.012
39	0.054	0.043	0.047	0.016
40	0.040	0.033	0.035	0.013
41	0.058	0.048	0.051	0.020
42	0.062	0.052	0.055	0.023
43	0.044	0.036	0.038	0.015
44	0.044	0.036	0.039	0.015
45	0.044	0.037	0.039	0.017
46	0.044	0.038	0.040	0.019
VAF	1.10	0.81	0.90	0.07

PHABSIM TECHNICAL NOTE NO. 7

THE USE OF MULTIPLE WSP MODELS FOR HYDRAULIC SIMULATION

by

Robert T. Milhous
Hydraulic Engineer

In some cases, the use of a single WSP model for hydraulic simulation is not appropriate **because the assumption of gradually varied flow is violated somewhere in a study reach**. In such cases, the reach can be modeled using two, and sometimes three, hydraulic simulation models with the results combined prior to the calculation of physical habitat using the HABTAT program.

An example of the problem at hand is the instream flow study of the Cossatat River in Arkansas. The field notes indicate a "water fall" or "weir" section at a distance of 547 feet from the starting point followed by a deep pool and a run upstream. For some streamflows the assumption of gradually varied flow was violated at the weir section.

To analyze the problem, the downstream sectors were modeled using the WSP program and a dummy section located just downstream (3 feet) of the weir. The water surface elevation at this dummy section is compared to the water surface elevation at the weir section in Figure 1. The stage-discharge relationship, in this case, was determined using measured data. If only one set of measurements is available, other techniques will have to be used.

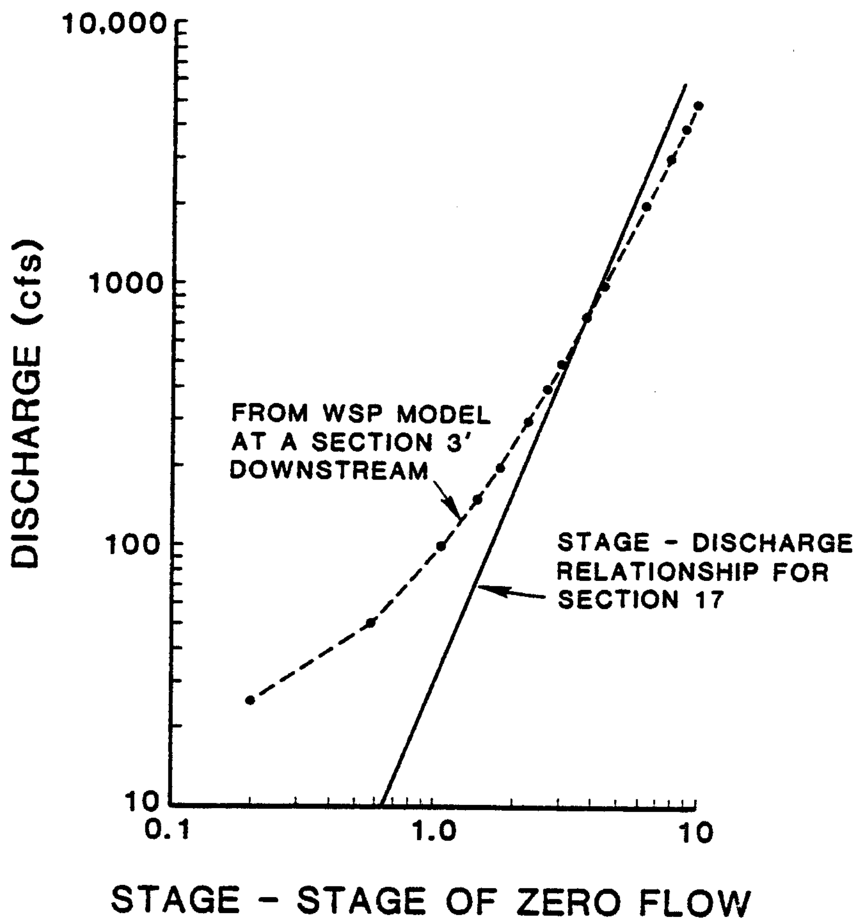


Figure 1. Comparison of water surface elevations from a WSP model to a stage-discharge relationship for a natural "weir section in the Cossatat River, Arkansas.

The information in Figure 1 indicates three WSP models should be used to simulate the hydraulic information needed for the simulation of physical habitat. The weir at cross sector 17 is drowned out at a flow of 750 cfs. For flows above 750 cfs, the control at the weir section is downstream of the section. For flows below 750 cfs, the control for the reach are at the weir section and the initial downstream section. Consequently, the three models are:

Model 1: The first 547 feet of the reach, and for streamflows less than 750 cfs.

Model 2: The second 1845 feet of the reach, and for streamflows less than 750 cfs.

Model 3: The whole 2392 feet of the reach and for flows 750 cfs and greater. These are shown schematically in Figure 2.

The combining of the TAPE3's and TAPE4's from the three models into a single TAPE3 and a single TAPE4 requires the following programs:

- MTAPE4: adds the TAPE4 from Model 1 to the TAPE4 from Model 2.

- ITAPE4: adds the TAPE4 from Model 3 to the TAPE4 resulting from the combining of the TAPE4's Model 1 and Model 2 which was obtained by using MTAPE4.

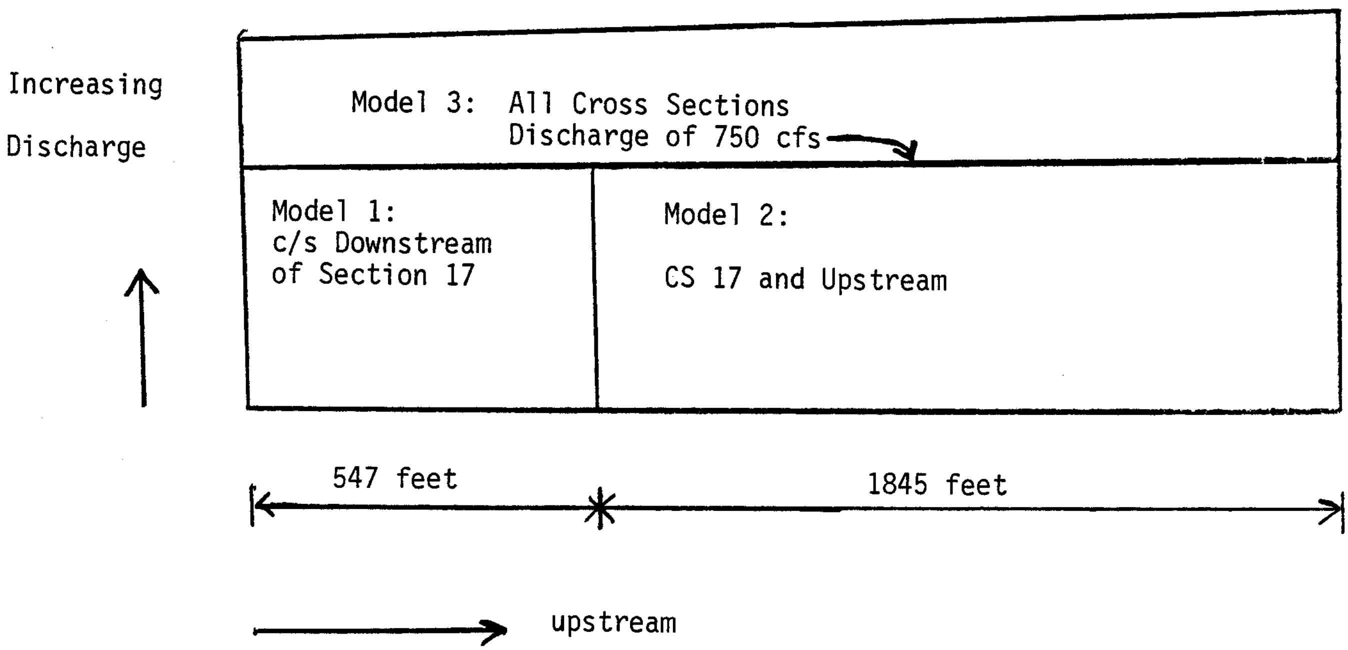


Figure 2. The three WSP models for the Cossatat River, Arkansas.

- MRGTP3 adds the cross section data from Model 2 to the data from Model 1.

- ADDRL allows the setting of a reach length for the cross section of the upper end of Model 1 so that the model continues.

In the case of the Cossatat River, ADDRL and MRSTP3 were not needed because the TAPE3 from Model 3 could be used for the HABTAT simulation. The TAPE4 from ITAPE4 must be transformed to a TP4 type file using the PHABARR program.

PHABSIM TECHNICAL NOTE NO. 7

THE USE OF MULTIPLE WSP MODELS FOR HYDRAULIC SIMULATION

by

Robert T. Milhous
Hydraulic Engineer

In some cases, the use of a single WSP model for hydraulic simulation is not appropriate because the assumption of gradually varied flow is violated somewhere in a study reach. In such cases, the reach can be modeled using two, and sometimes three, hydraulic simulation models with the results combined prior to the calculation of physical habitat using the HABTAT program.

An example of the problem at hand is the instream flow study of the Cossatat River in Arkansas. The field notes indicate a "water fall" or "weir" section at a distance of 547 feet from the starting point followed by a deep pool and a run upstream. For some streamflows the assumption of gradually varied flow was violated at the weir section.

To analyze the problem, the downstream sectors were modeled using the WSP program and a dummy section located just downstream (3 feet) of the weir. The water surface elevation at this dummy section is compared to the water surface elevation at the weir section in Figure 1. The stage-discharge relationship, in this case, was determined using measured data. If only one set of measurements is available, other techniques will have to be used.

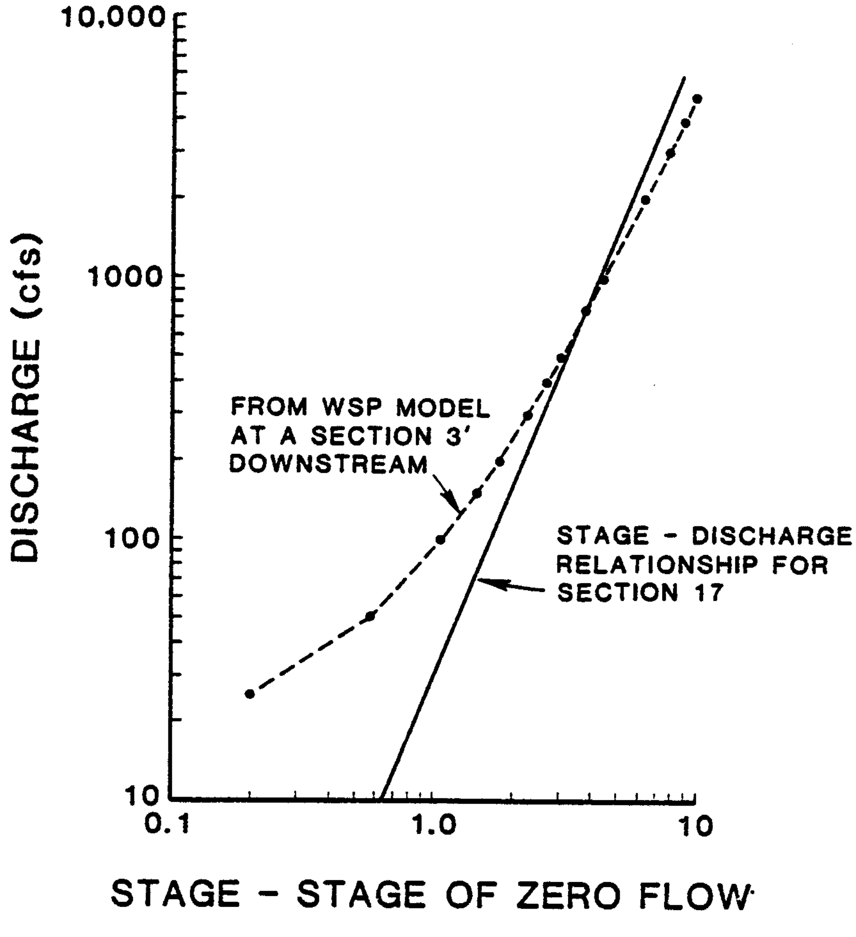


Figure 1. Comparison of water surface elevations from a WSP model to a stage-discharge relationship for a natural "weir section in the Cossatat River, Arkansas.

The information in Figure 1 indicates three WSP models should be used to simulate the hydraulic information needed for the simulation of physical habitat. The weir at cross sector 17 is drowned out at a flow of 750 cfs. For flows above 750 cfs, the control at the weir section is downstream of the section. For flows below 750 cfs, the control for the reach are at the weir section and the initial downstream section. Consequently, the three models are:

Model 1: The first 547 feet of the reach, and for streamflows less than 750 cfs.

Model 2: The second 1845 feet of the reach, and for streamflows less than 750 cfs.

Model 3: The whole 2392 feet of the reach and for flows 750 cfs and greater. These are shown schematically in Figure 2.

The combining of the TAPE3's and TAPE4's from the three models into a single TAPE3 and a single TAPE4 requires the following programs:

- MTAPE4: adds the TAPE4 from Model 1 to the TAPE4 from Model 2.

- ITAPE4: adds the TAPE4 from Model 3 to the TAPE4 resulting from the combining of the TAPE4's Model 1 and Model 2 which was obtained by using MTAPE4.

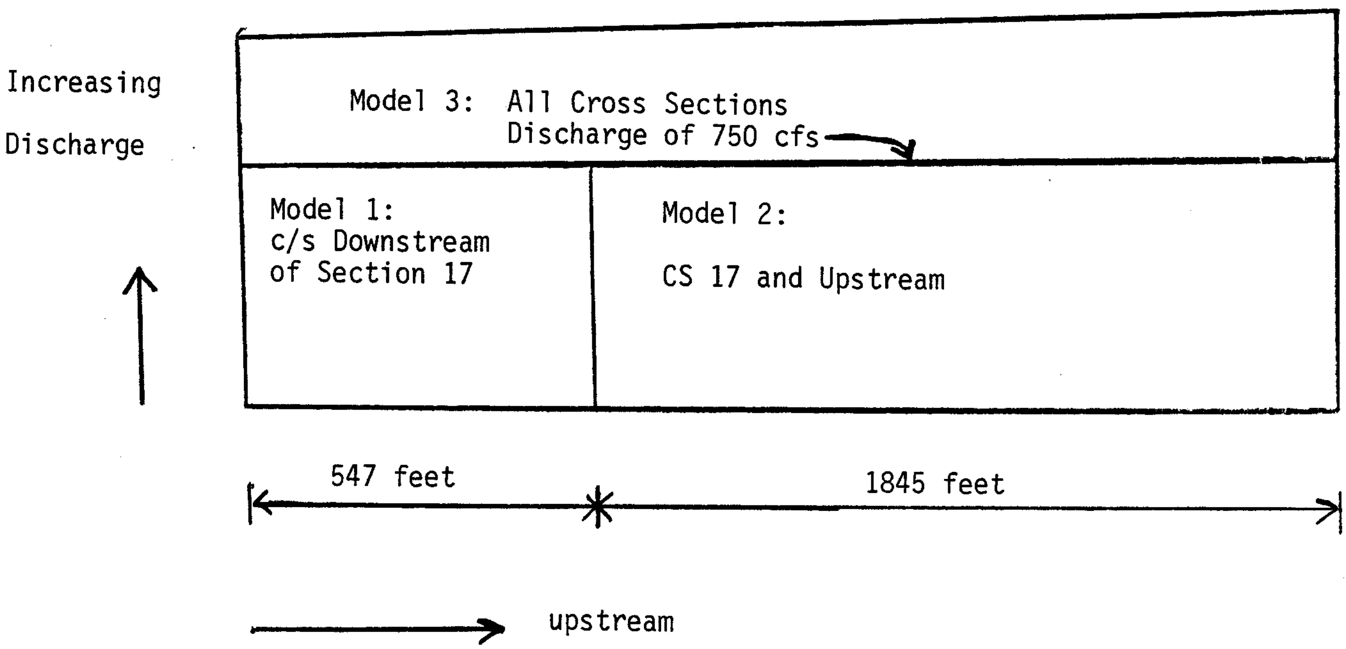


Figure 2. The three WSP models for the Cossatat River, Arkansas.

- MRGTP3 adds the cross section data from Model 2 to the data from Model 1.

- ADDRL allows the setting of a reach length for the cross section of the upper end of Model 1 so that the model continues.

In the case of the Cossatat River, ADDRL and MRSTP3 were not needed because the TAPE3 from Model 3 could be used for the HABTAT simulation. The TAPE4 from ITAPE4 must be transformed to a TP4 type file using the PHABARR program.

PHABSIM TECHNICAL NOTE 8

THE USE OF THE MANSQ PROGRAM TO DETERMINE WATER SURFACE ELEVATIONS

by

Robert T. Milhous
Hydraulic Engineer

The MANSQ program can be used to simulate the water surface elevation using the Manning equation calibrated to one set of water surface elevations. The input file is similar to the IFG4 input file and is discussed in Attachment A. The line printer results are discussed in Attachment B.

A TAPE3 and TAPE4 are written by MANSQ. The TAPE3 is the standard TAPE3 used in PHABSIM. The TAPE4 is also standard <u>except</u> only one velocity is written for each cross section. The velocity is the average velocity for the cross sections.

The Manning equation is:

$$Q = \frac{1.49}{n} R^{2/3} A S^{1/2}$$

where Q is the streamflow,

R is the hydraulic radius,

A is the cross-sectional area, and

S is the energy slope.

Using the term

$$CFAC = \frac{1.49}{n} S^{1/2}$$

the Manning equation becomes

$$Q = CFAC\ (R^{2/3}\ A)$$

The term CFAC can be determined using one set of measurements. If the assumption can be made that the energy slope and the roughness are constant, the water surface elevation for various streamflows can be calculated. In general, it is reasonable to assume the slope is constant but not to assume the roughness is constant. The variations in roughness can be expressed in two forms -

$$n = \alpha\ Q^{\beta}$$

$$n = a\left(\frac{R}{D84}\right)^{B}$$

where α, β, a, and B are coefficients,

n is the Manning roughness,

R is the hydraulic radius,

D84 is bed surface partial, size at which 84 percent is fines, and

Q is the streamflow.

For a given set of calibrated data we can write

$$n = n_c \left(\frac{Q}{Q_c}\right)^{\beta} \quad \text{and}$$

$$n = n_c \left(\frac{R}{R_c}\right)^{B}$$

where the subscript c refers to the calibrated data set. Using these equations with the CFAC term we have

$$CFACQ = CFAC\left(\frac{Q}{Q_c}\right)^{-\beta} \quad \text{and}$$

$$CFACQ = CFAC\left(\frac{R}{R_c}\right)^{-B}$$

The user of MANSQ has the option of using either equation or in using a constant CFAC. The B term has the range of at least 0.0 to -2.5 in gravel, cobble, and boulder streams. The range of β is from 0.0 to -0.60. The median value for β is -0.22. A set of data with more than one set of discharge-water surface elevation pairs for each cross section can be calibrated by adjusting β or B term. The use of β is preferred over the use of B. The selection of a β or B coefficient is the responsibility of the user.

The basic assumption made when using the MANSQ program to simulate water surface elevation is that each cross section is at normal depth and no back-water effect occurs between the various cross sections.

In some cases, this assumption is not correct as illustrated in Figure 1. The overall slope of the Tweed River in the study reach is 0.026 and it is reasonable to assume normal depth for all sections except for C/S 188, which clearly has a backwater effect from C/S 164. For the hydraulic simulation of the Tweed River, the MANSQ program was used for the four sections exclusive of C/S 188. For the water surface elevation at section 188, a two-section WSP model was used with C/S 164 and 188. The starting water surface elevations at section 164 were from the MANSQ program.

The use of the MANSQ program requires judgment and should be used only by individuals with a thorough understanding of river hydraulics.

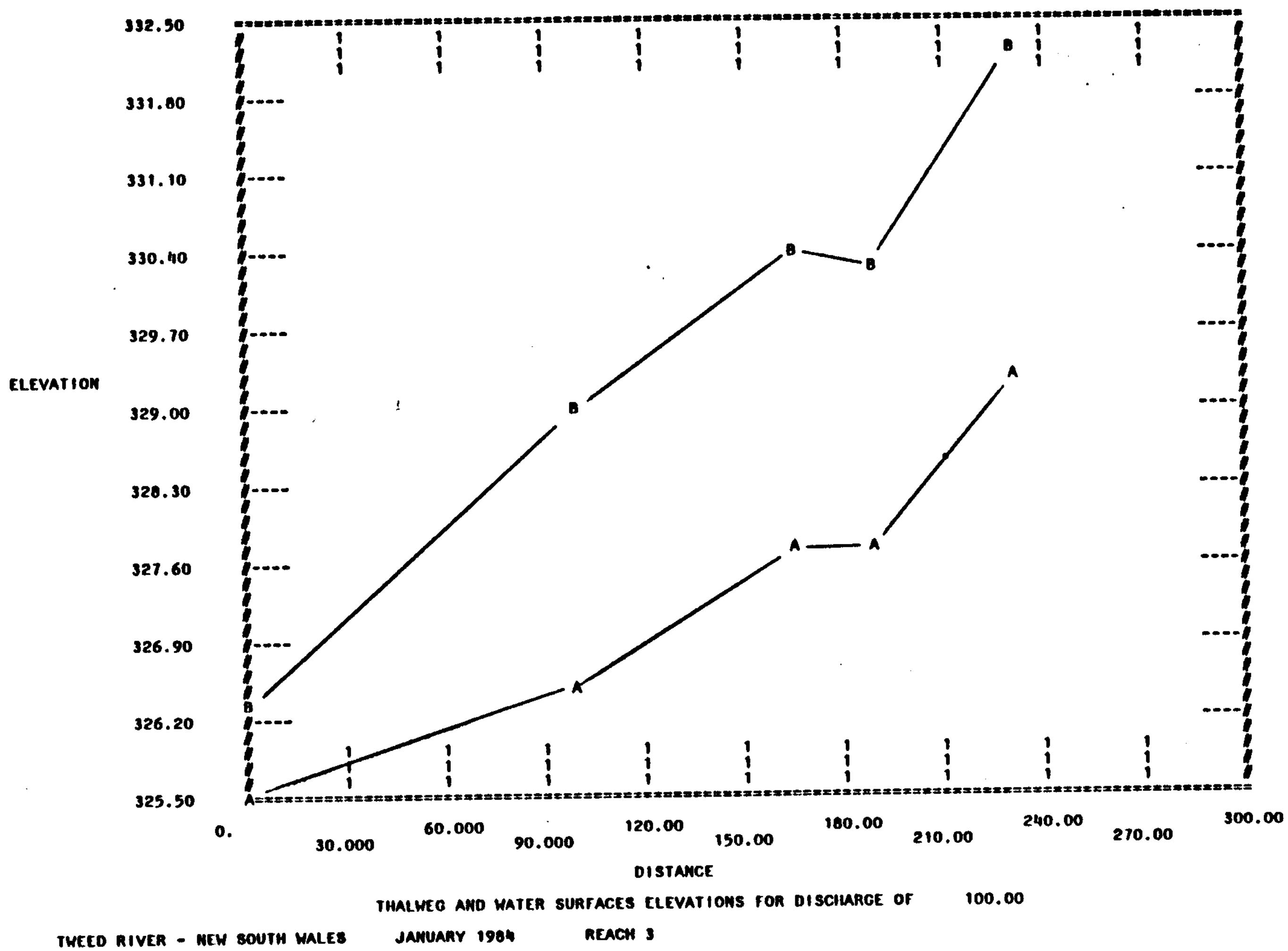


Figure 1. The results of using MANSQ for the Tweer River, New South Wales and for a streamflow of 100 cfs.

ATTACHMENT A

INPUT FOR MANSQ

The input for the MANSQ program is the same as for the IFG4 program except that the VEL and CAL cards are not used. The first CAL card is replaced by a CALQ card.

The options available are

IOC(1) = 0 do not print details of water surface elevation calculations

= 1 do print details of water surface elevation calculations

IOC(2) = 0 use (Q/Q_c) * *B to adjust roughness

= 1 use (RH/RH_c) * *B to adjust roughness

If B is not supplied, no adjustment in roughness is made.

IOC(3) = 0 do not print initial stage-discharge table

= 1 do print table

The format of the CALQ card is:

Columns	Information
1-4	CALQ
5-10	Station ID (Real)
11-20	Calibration Stage
21-30	Calibration Streamflow
31-40	B Coefficient

The general data set is

```
Title line 1
Title line 2
IOC
----------------------------------------
QARD    } up to 30
----------------------------------------
XSEC
coordinate cards
NS                        repeat as needed
CALQ
----------------------------------------
ENDJ
```

An example of a MANSQ input file follows.

```
          TWEED RIVER - NEW SOUTH WALES     JANUARY 1984
                REACH 3
IOC          000000000000000000000
QARD  5.0
QARD 10.0
QARD 20.0
QARD 50.0
QARD100.0
QARD200.0
QARD300.0
XSEC     0.       0.00 .50    325.50
         0.  0.0329.4  6.6326.8 13.1328.6 19.7328.0 26.2327.1 32.8326.3
         0. 39.4326.4 41.2325.9 41.3325.9 44.3325.7 47.6325.8 50.9326.0
         0. 52.5325.7 54.1325.8 55.8325.8 57.4325.9 59.1325.8 60.7325.9
         0. 62.3326.0 64.0326.0 65.0326.0 65.1326.0 67.3325.8 73.6326.1
         0. 73.7326.1 75.5325.9 77.1325.8 78.7325.8 80.4325.6 82.0325.5
         0. 83.7325.8 85.3326.1 86.5326.0 86.6326.0 88.6326.3 91.9327.4
         0. 95.1327.5 96.5327.3 97.8326.8 98.4327.6101.7328.3105.0328.5
         0.107.3328.7108.6328.5110.9329.2114.8329.2118.1330.1121.4330.8
         0.124.7331.1
NS       0. .060 20.0 .060 20.0 .060 20.0 .060 20.0 .060 20.0 .060 20.0
NS       0. .060 20.0 .060 20.0 .060 20.0 .060 20.0 .060 20.0 .060 20.0
NS       0. .060 20.0 .060 20.0 .060 20.0 .060 20.0 .060 20.0 .060 20.0
NS       0. .060 20.0 .060 20.0 .060 20.0 .060 20.0 .060 20.0 .060 20.0
NS       0. .060 20.0 .060 20.0 .060 20.0 .060 20.0 .060 20.0 .060 20.0
NS       0. .060 20.0 .060 20.0 .060 20.0 .060 20.0 .060 20.0 .060 20.0
NS       0. .060 20.0 .060 20.0 .060 20.0 .060 20.0 .060 20.0 .060 20.0
NS       0. .060 20.0 .060 20.0 .060 20.0 .060 20.0 .060 20.0 .060 20.0
NS       0. .060 20.0
CALQ     0.     326.11      24.0  -0.225
XSEC    98.      98.00 .50    326.50
        98.  0.0331.0  4.9330.9  9.8330.6 14.8329.8 19.7329.4 24.6328.8
        98. 26.5328.5 26.6328.3 27.9328.0 29.5328.5 31.2328.5 32.8328.6
        98. 34.4328.5 36.1328.3 37.7327.6 38.6328.7 38.7327.3 40.0329.2
        98. 40.9328.3 41.0327.7 42.3327.8 43.5328.3 43.6327.7 44.6329.0
        98. 45.8328.6 45.9328.5 47.2327.9 48.2326.5 50.5328.1 52.2328.5
        98. 52.3328.6 55.1329.8 59.4327.8 59.5328.9 61.4327.9 62.3327.8
        98. 64.0327.5 65.6328.4 68.9328.8 70.5328.5 70.6328.6 72.2329.1
        98. 78.7329.8 85.3330.4 89.2330.9
NS      98. .060 20.0 .060 20.0 .060 20.0 .060 20.0 .060 20.0 .060 20.0
NS      98. .060 20.0 .060 20.0 .060 20.0 .060 20.0 .060 20.0 .060 20.0
NS      98. .060 20.0 .060 20.0 .060 20.0 .060 20.0 .060 20.0 .060 20.0
NS      98. .060 20.0 .060 20.0 .060 20.0 .060 20.0 .060 20.0 .060 20.0
NS      98. .060 20.0 .060 20.0 .060 20.0 .060 20.0 .060 20.0 .060 20.0
NS      98. .060 20.0 .060 20.0 .060 20.0 .060 20.0 .060 20.0 .060 20.0
NS      98. .060 20.0 .060 20.0 .060 20.0 .060 20.0 .060 20.0 .060 20.0
NS      98. .060 20.0 .060 20.0 .060 20.0
CALQ    98.     328.54      24.0   -0.225
XSEC   164.      66.00 .50    327.70
       164.  0.0332.2  1.3329.4  2.3329.7  3.3329.8  4.6330.3  8.2329.8
       164.  9.8330.6 13.1330.2 14.8330.9 16.4330.0 18.0331.0 20.7330.7
       164. 23.0330.6 26.2330.7 26.8329.4 26.9329.3 27.4328.9 27.8329.4
       164. 27.9329.4 28.5329.4 28.8329.4 28.9329.4 29.5328.3 31.2328.7
       164. 32.8328.9 33.1328.3 34.4328.7 36.1328.3 37.7328.2 39.4328.0
       164. 41.0328.6 42.7328.5 44.3328.1 46.3327.9 47.6328.1 49.2327.8
```

```
             164. 50.9327.7 52.5328.5 55.1329.3 55.2329.3 57.1329.8 60.2330.5
      NS     164. .060 20.0 .060 20.0 .060 20.0 .060 20.0 .060 20.0 .060 20.0
      NS     164. .060 20.0 .060 20.0 .060 20.0 .060 20.0 .060 20.0 .060 20.0
      NS     164. .060 20.0 .060 20.0 .060 20.0 .060 20.0 .060 20.0 .060 20.0
      NS     164. .060 20.0 .060 20.0 .060 20.0 .060 20.0 .060 20.0 .060 20.0
      NS     164. .060 20.0 .060 20.0 .060 20.0 .060 20.0 .060 20.0 .060 20.0
      NS     164. .060 20.0 .060 20.0 .060 20.0 .060 20.0 .060 20.0 .060 30.0
      NS     164. .060 40.0 .060 40.0 .060 40.0 .060 40.0 .060 40.0 .060 40.0
      CALQ   164.     329.33     24.0  -0.225
      XSEC   190.      24.00 .50     327.80
             190.  0.0332.3  3.3331.3  6.6330.6  8.8329.4  8.9329.4  9.8328.4
             190. 11.5327.8 12.3328.8 13.0327.9 14.4329.4 14.5329.4 16.1330.1
             190. 16.7329.4 16.8329.4 17.1329.1 18.0329.4 19.7328.4 21.0328.4
             190. 21.7329.5 21.8329.5 23.0329.8 24.6329.2 24.7329.4 24.9329.3
             190. 26.2329.4 26.3329.5 27.9330.8 29.5330.8 32.8331.7 34.4331.4
             190. 36.1330.8 37.7329.9 39.4329.9 42.7331.4
      NS     190. .060 20.0 .060 20.0 .060 20.0 .060 20.0 .060 20.0 .060 20.0
      NS     190. .060 20.0 .060 20.0 .060 20.0 .060 20.0 .060 20.0 .060 20.0
      NS     190. .060 20.0 .060 20.0 .060 20.0 .060 20.0 .060 20.0 .060 20.0
      NS     190. .060 20.0 .060 20.0 .060 20.0 .060 20.0 .060 20.0 .060 40.0
      NS     190. .060 30.0 .060 30.0 .060 30.0 .060 30.0 .060 30.0 .060 30.0
      NS     190. .060 30.0 .060 30.0 .060 30.0 .060 30.0
      CALQ   190.     329.51     24.0  -0.225
      XSEC   233.      43.00 .50     329.30
             233.  0.0334.4  2.0333.5  2.5330.8  2.6330.2  3.3329.7  4.9329.3
             233.  6.6330.1  8.2330.8  8.9330.1 10.2329.6 11.2329.8 12.1330.7
             233. 14.1331.3 14.2331.3 16.4332.0 19.7332.0 23.0331.7 25.3331.5
             233. 26.2331.9 29.5332.0 32.8332.4 36.1332.6 37.1330.9 39.4330.9
             233. 42.7330.8 45.9331.8 50.2333.5
      NS     233. .060 20.0 .060 20.0 .060 20.0 .060 20.0 .060 20.0 .060 20.0
      NS     233. .060 20.0 .060 20.0 .060 20.0 .060 20.0 .060 20.0 .060 20.0
      NS     233. .060 20.0 .060 20.0 .060 20.0 .060 20.0 .060 20.0 .060 20.0
      NS     233. .060 20.0 .060 20.0 .060 20.0 .060 20.0 .060 20.0 .060 20.0
      NS     233. .060 20.0 .060 20.0 .060 40.0
      CALQ   233.     331.33     24.0  -0.225
      ENDJ
```

ATTACHMENT B

OUTPUT FROM MANSQ

The appropriation used on the output for one cross section presented on the following pages is listed below.

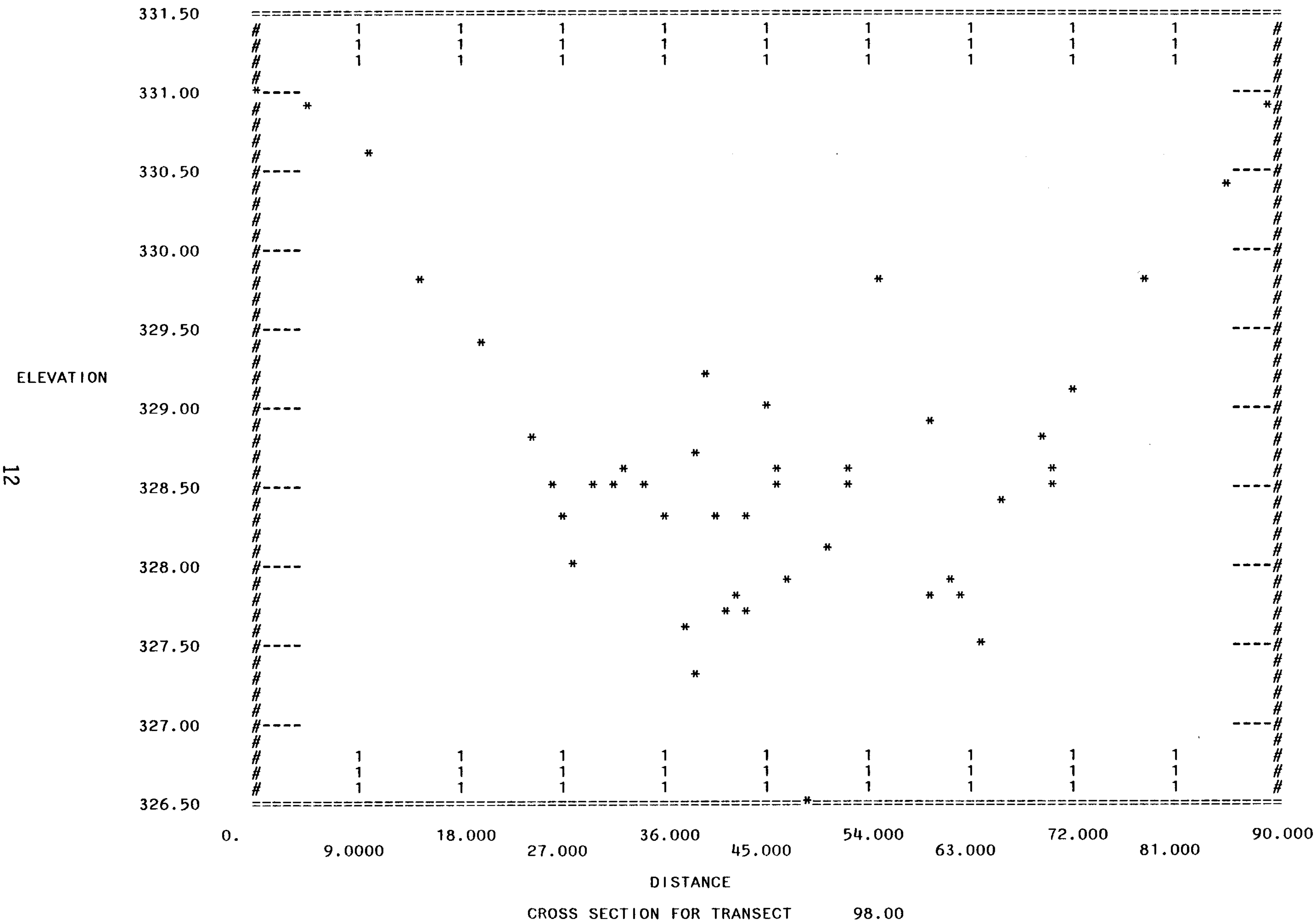
x	Distance to coordinate point
y	Ground elevation of coordinate point
n	roughness of vertical
Q	Streamflow (Discharge)
WSL	Water Surface Elevation
VEL	Velocity
RH	Hydraulic Radius
DAVE	Average Depth
DMAX	Maximum Depth
WP	Wetted Perimeter

TWEED RIVER - NEW SOUTH WALES   JANUARY 1984
REACH 3

STATION ID IS 98.
WEIGHT ON SECTION WORKING UPSTREAM IS .5
REACH LENGTH TO DOWNSTREAM SECTION IS 98.
STAGE OF ZERO FLOW IS 326.5
GIVEN SLOPE IS 0.
BETA COEFFICIENT IS -.225
USING (Q/QC)**B
NUMBER OF COORIDINETE POINTS IS 45
COORIDINATE DATA FOLLOWS (X,Y,N,CHANNEL INDEX)

0.0	331.0	.060	20.00
4.9	330.9	.060	20.00
9.8	330.6	.060	20.00
14.8	329.8	.060	20.00
19.7	329.4	.060	20.00
24.6	328.8	.060	20.00
26.5	328.5	.060	20.00
26.6	328.3	.060	20.00
27.9	328.0	.060	20.00
29.5	328.5	.060	20.00
31.2	328.5	.060	20.00
32.8	328.6	.060	20.00
34.4	328.5	.060	20.00
36.1	328.3	.060	20.00
37.7	327.6	.060	20.00
38.6	328.7	.060	20.00
38.7	327.3	.060	20.00
40.0	329.2	.060	20.00
40.9	328.3	.060	20.00
41.0	327.7	.060	20.00
42.3	327.8	.060	20.00
43.5	328.3	.060	20.00
43.6	327.7	.060	20.00
44.6	329.0	.060	20.00
45.8	328.6	.060	20.00
45.9	328.5	.060	20.00
47.2	327.9	.060	20.00
48.2	326.5	.060	20.00
50.5	328.1	.060	20.00
52.2	328.5	.060	20.00
52.3	328.6	.060	20.00
55.1	329.8	.060	20.00
59.4	327.8	.060	20.00
59.5	328.9	.060	20.00
61.4	327.9	.060	20.00
62.3	327.8	.060	20.00
64.0	327.5	.060	20.00
65.6	328.4	.060	20.00
68.9	328.8	.060	20.00
70.5	328.5	.060	20.00
70.6	328.6	.060	20.00
72.2	329.1	.060	20.00
78.7	329.8	.060	20.00
85.3	330.4	.060	20.00
89.2	330.9	.060	20.00

GRAPH 11


ELEVATION
331.50
331.00
330.50
330.00
329.50
329.00
328.50
328.00
327.50
327.00
326.50
0.
9.0000
18.000
27.000
36.000
45.000
54.000
63.000
72.000
81.000
90.000
DISTANCE
CROSS SECTION FOR TRANSECT 98.00

84/12/01. 10.50.06.

TWEED RIVER - NEW SOUTH WALES JANUARY 1984
REACH 3

CALIBRATION STAGE = 328.540

CALIBRATION DISCHARGE = 24.00

CROSS-SECTIONAL AREA = 14.44

HYDRAULIC RADIUS = .39

AVERAGE DEPTH = .49

MAXIMUM DEPTH = 2.04

LOW POINT ON CROSS SECTION IS 326.50

STREAM WIDTH IS 29.69

WETTED PERIMETER IS 36.70

WATER TRANSPORT PARAMETER (1.49*(S**.5)/N) IS 3.09

84/12/01.   10.50.06.

TWEED RIVER - NEW SOUTH WALES   JANUARY 1984
REACH 3

SPECIFIC DATA Q,WSL,VEL,AREA,RH,DAVE,DMAX,WIDTH,WTP

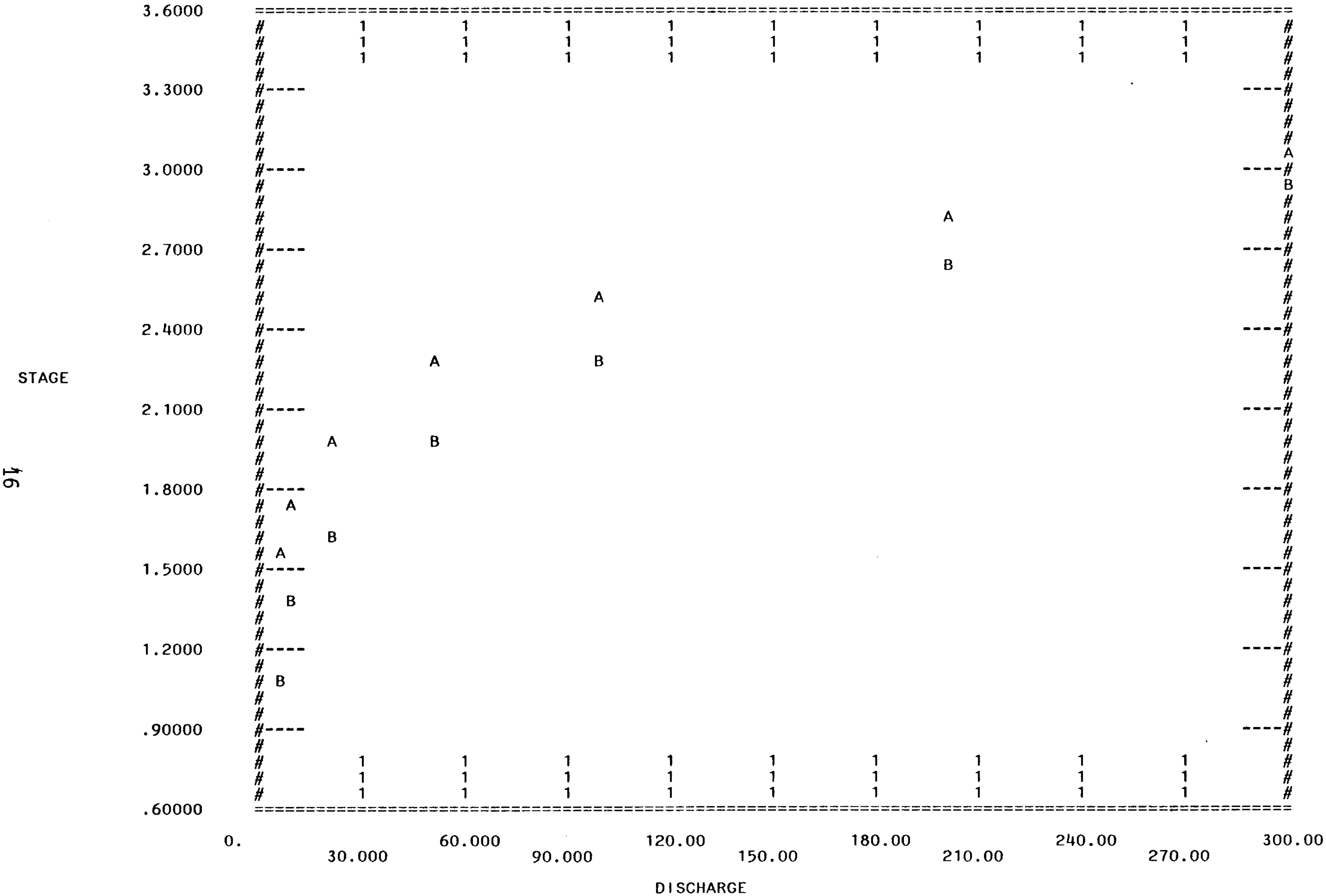
Q	WSL	VEL	AREA	RH	DAVE	DMAX	WIDTH	WTP
5.00	328.07	.97	5.14	.30	.39	1.57	13.08	17.18	2.17
10.00	328.26	1.24	8.04	.34	.44	1.76	18.08	23.45	2.54
20.00	328.46	1.62	12.36	.40	.51	1.96	24.19	30.77	2.97
50.00	328.77	2.21	22.59	.47	.57	2.27	39.52	47.63	3.65
100.00	329.01	3.05	32.75	.61	.73	2.51	45.16	53.96	4.27
200.00	329.31	4.22	47.39	.78	.92	2.81	51.60	60.74	4.99
300.00	329.53	5.07	59.23	.89	1.04	3.03	56.93	66.19	5.47

84/12/01.   10.50.06.

TWEED RIVER - NEW SOUTH WALES   JANUARY 1984
REACH 3

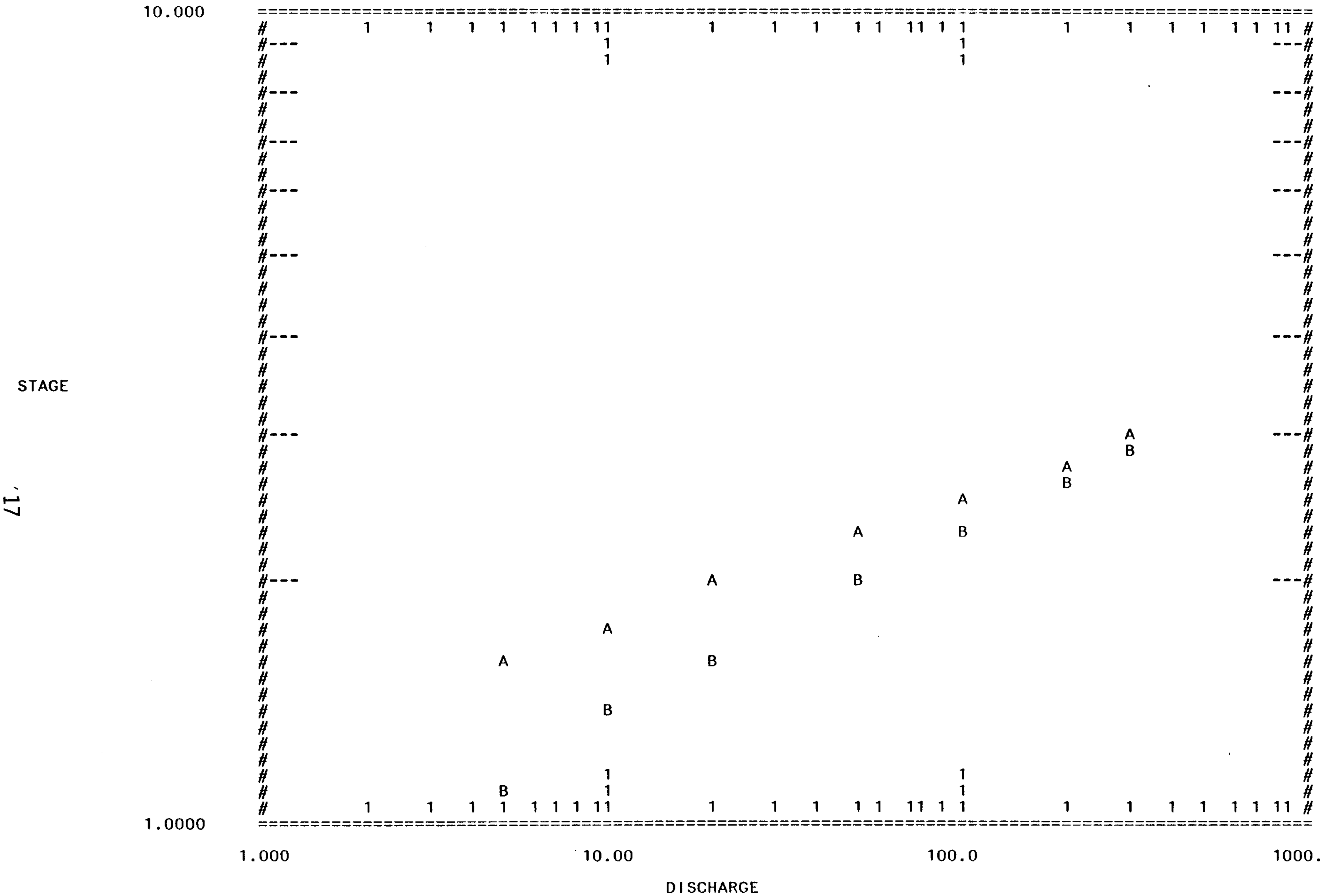
DISCHARGE	MANNING	CRITICAL
5.00	328.07	327.60
10.00	328.26	327.88
20.00	328.46	328.10
50.00	328.77	328.46
100.00	329.01	328.79
200.00	329.31	329.15
300.00	329.53	329.43

GRAPH 12



STAGE - Q RELATIONSHIP (A=MANNING, B=CRITICAL) TRANSECT - 98.00

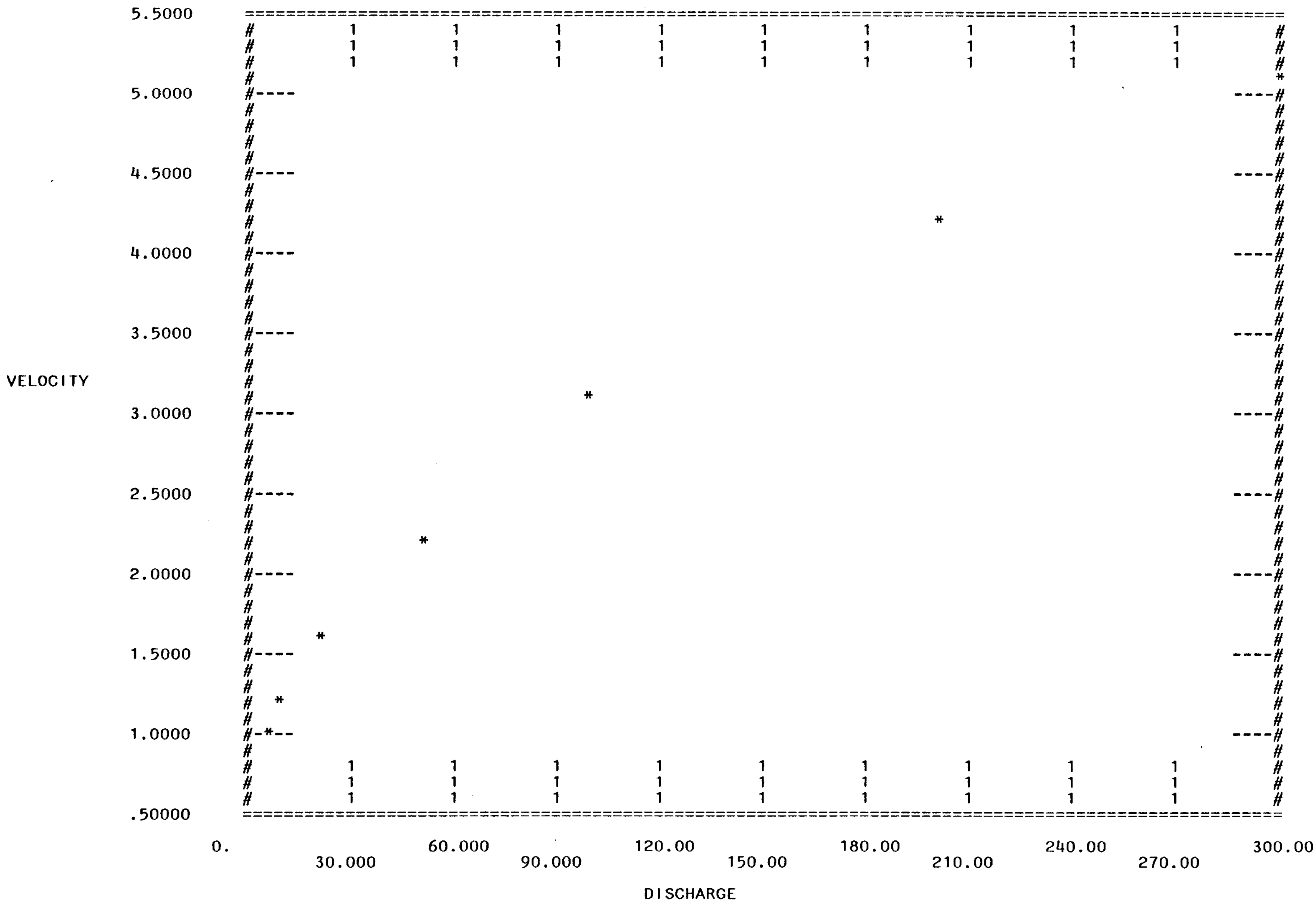
GRAPH 13



STAGE - Q RELATIONSHIP (A=MANNING, B=CRITICAL) TRANSECT - 98.00

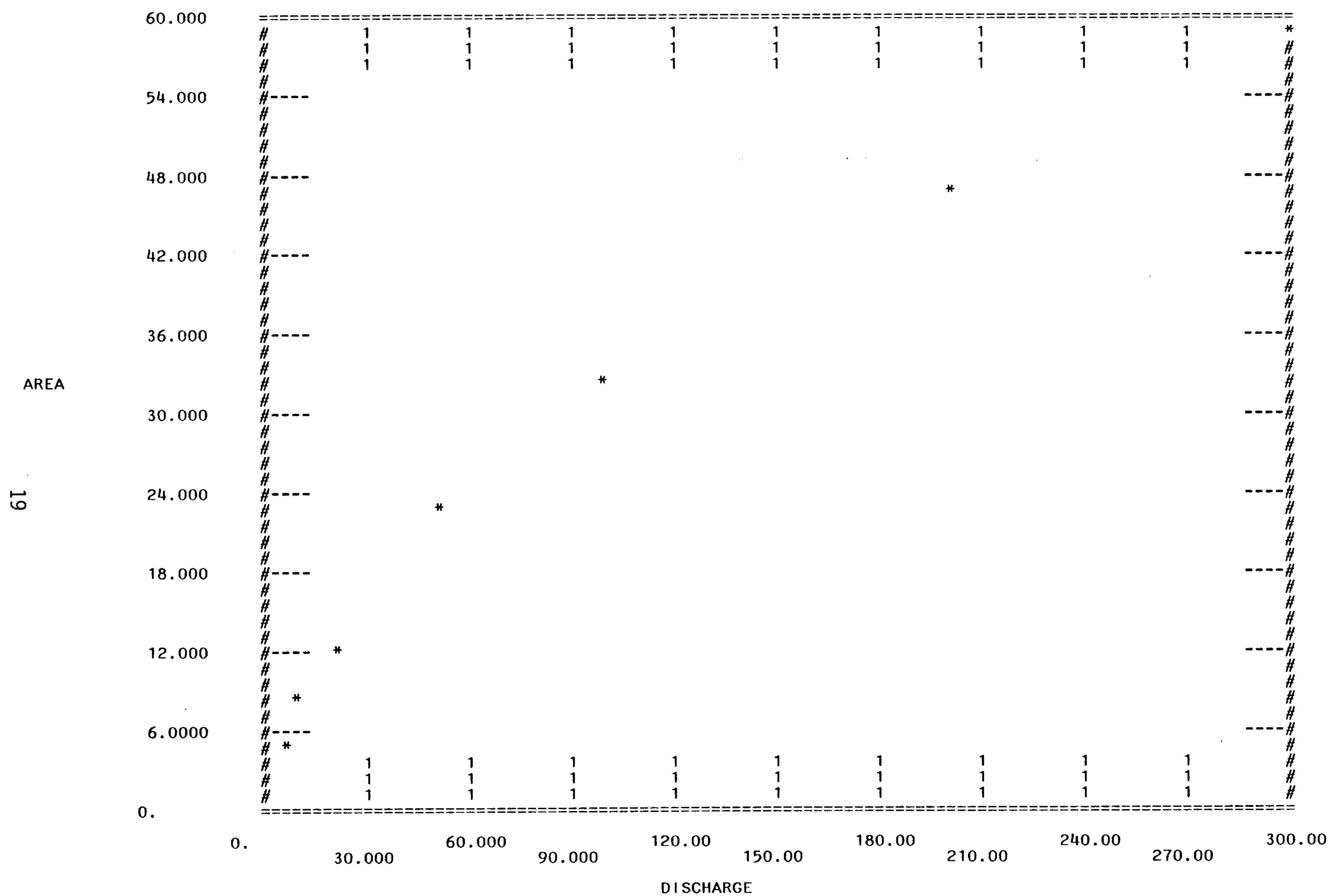
'17

GRAPH 14



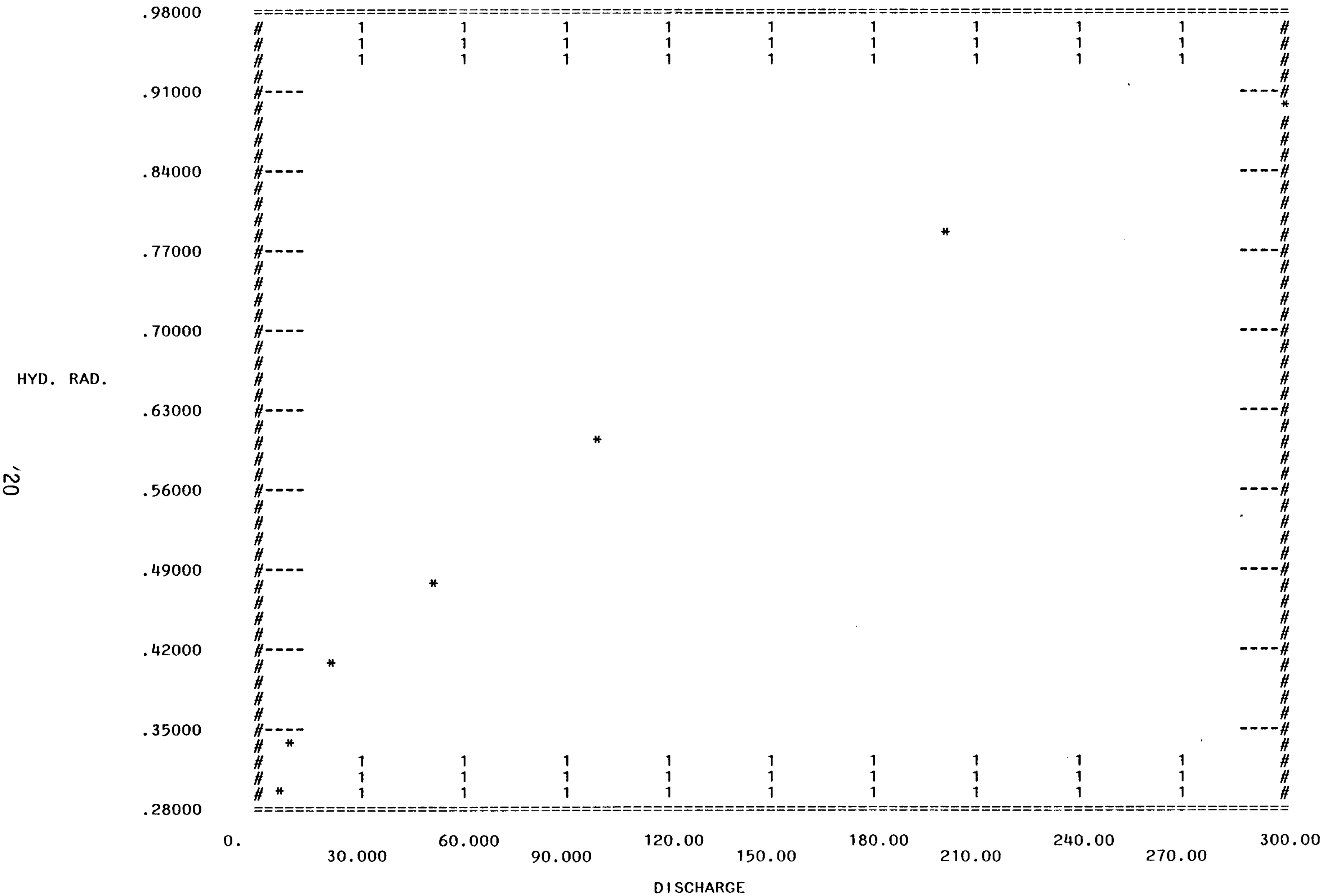
CROSS SECTION PARAMETERS FOR TRANSECT 98.00 - MANNING EQUATION

GRAPH 15



CROSS SECTION PARAMETERS FOR TRANSECT 98.00 - MANNING EQUATION

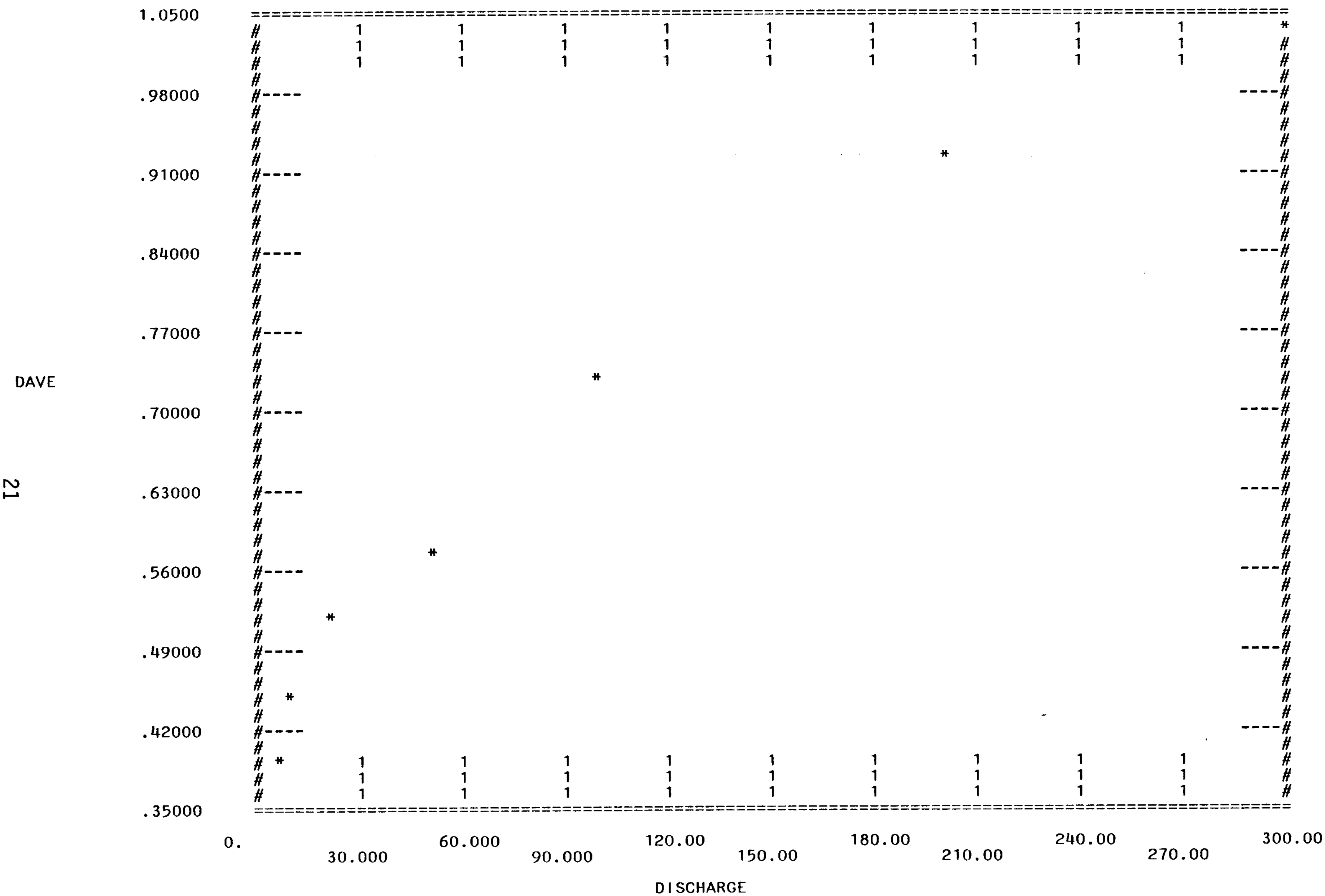
GRAPH 16



CROSS SECTION PARAMETERS FOR TRANSECT 98.00 - MANNING EQUATION

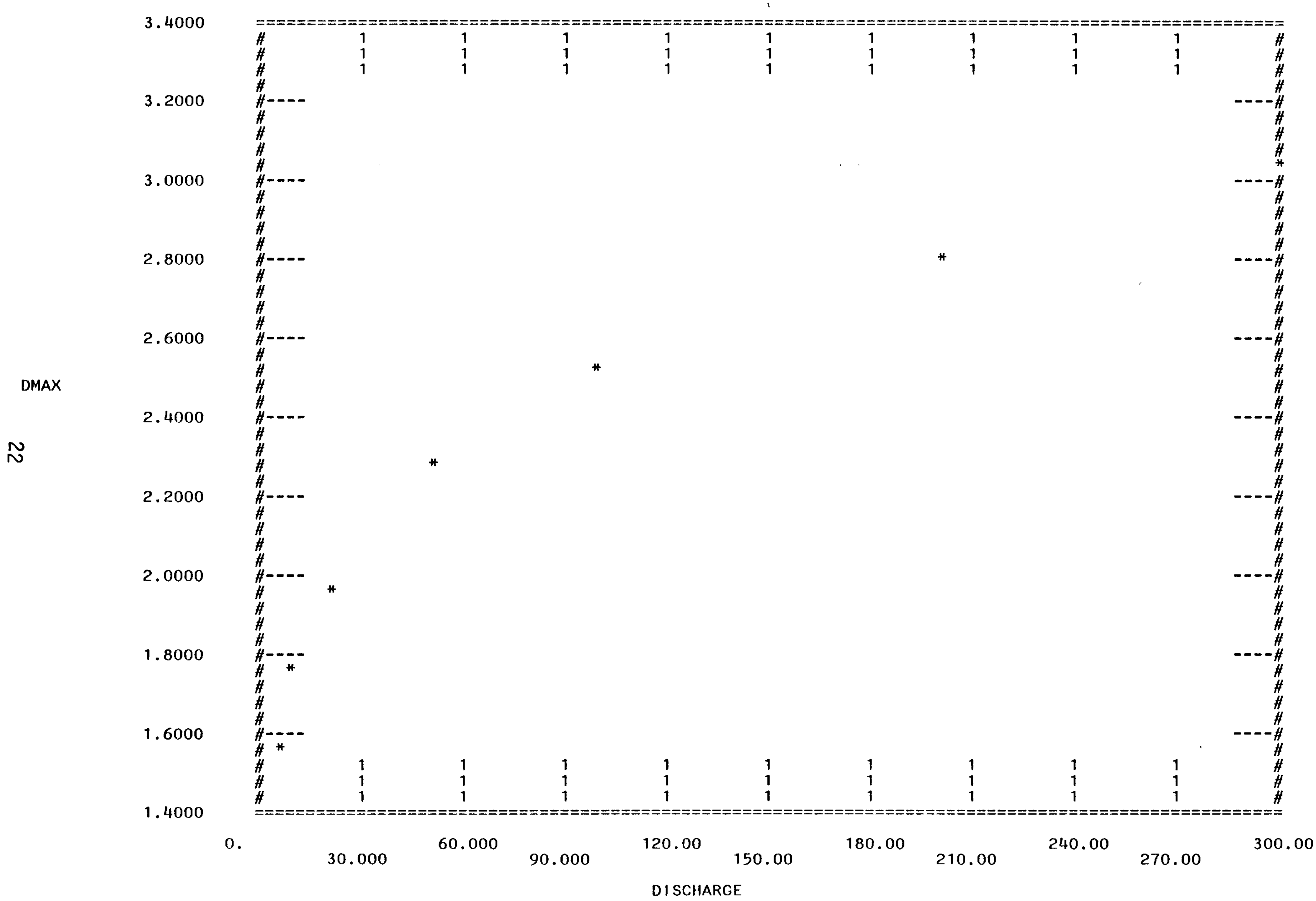
'20

GRAPH 17



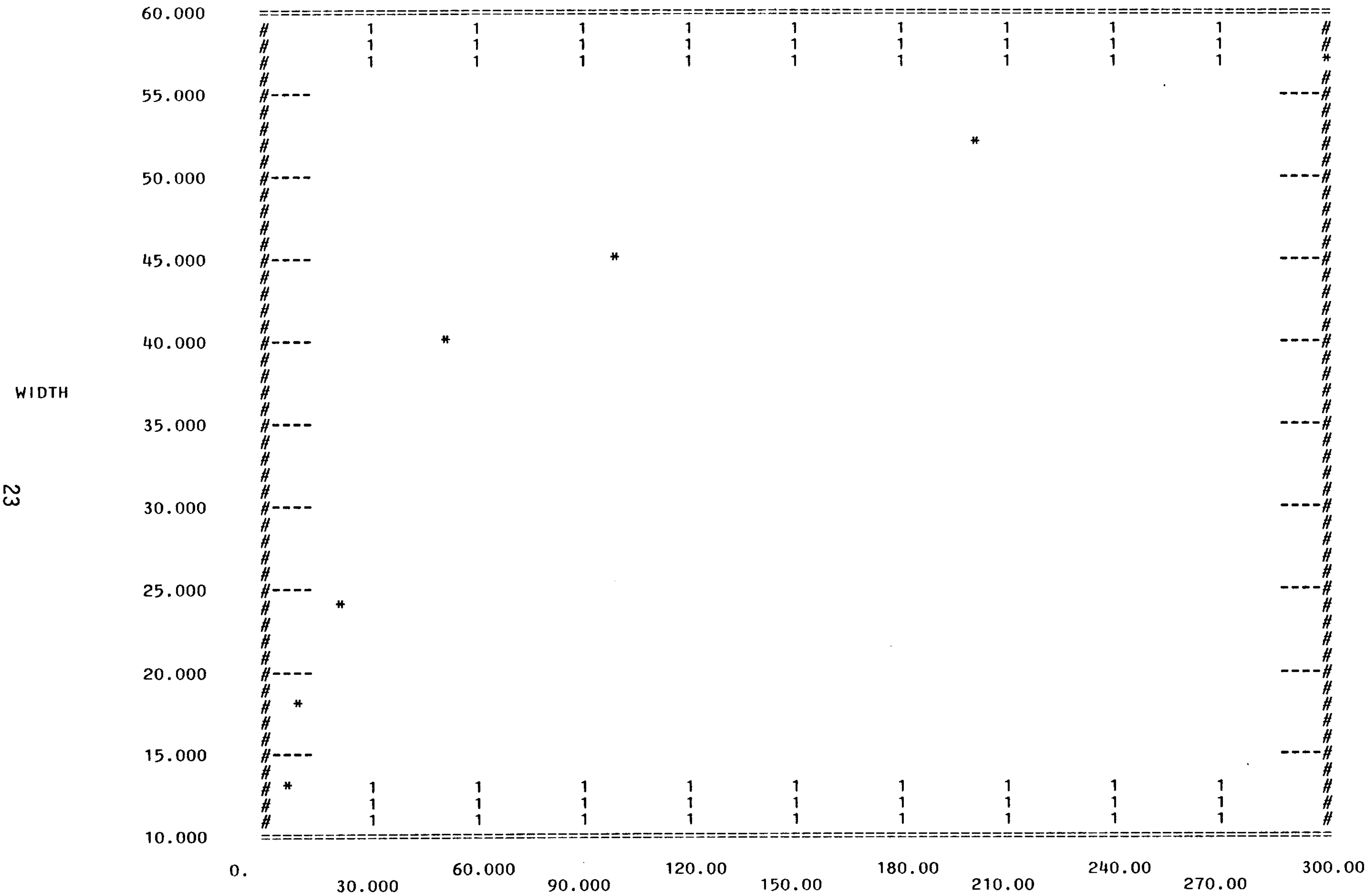
CROSS SECTION PARAMETERS FOR TRANSECT 98.00 - MANNING EQUATION

GRAPH 18



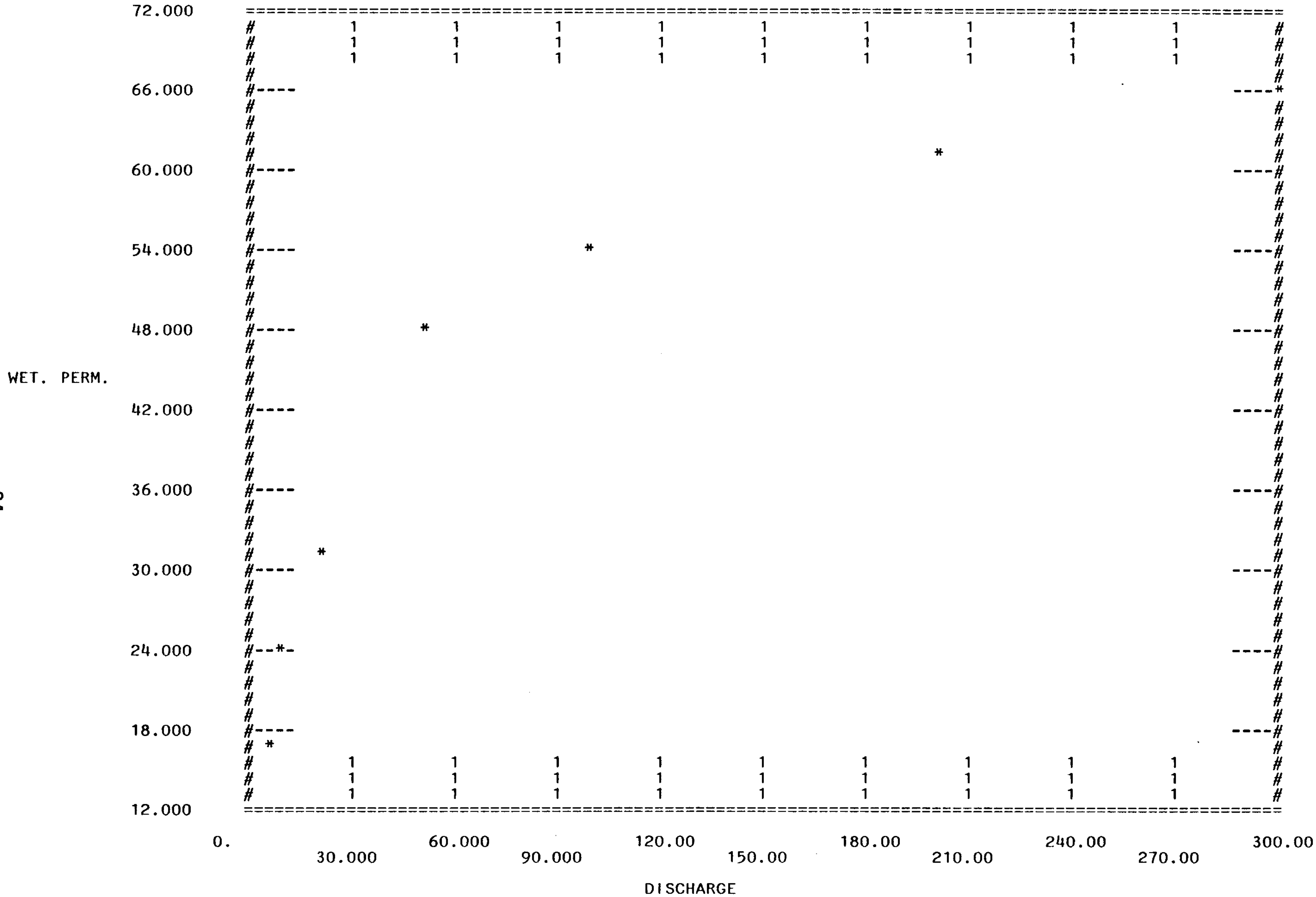
CROSS SECTION PARAMETERS FOR TRANSECT 98.00 - MANNING EQUATION

GRAPH 19



CROSS SECTION PARAMETERS FOR TRANSECT 98.00 - MANNING EQUATION

GRAPH 20



CROSS SECTION PARAMETERS FOR TRANSECT 98.00 - MANNING EQUATION

PHABSIM TECHNICAL NOTE NO. 9
THE HABVD PROGRAM FOR CALCULATING PHYSICAL HABITAT

By

Robert T. Milhous
Hydraulic Engineer

This note presents a program using a "short cut" method that uses data readily available from the U.S. Geological Survey with the logic and concept of the HABTAT Program. The resulting physical habitat versus stream flow relationship is not as valuable as the standard HABTAT output but the results cost a lot less as well ($100.00 versus up to $5,000.00).

The purpose of this note is to present the program and how to use the program. The proper use of the program within the Instream Flow Incremental Method (IFIM) is being left to other papers and reports.

PROGRAM LOGIC

The logic of the program is basically the same as the HABTAT program except only one velocity and depth is used to represent the habitat in the stream. Specifically, the weighted measurable area for a streamflow Q is:

$$WUA(Q) = A * f(v) * g(d) * h(s)$$

Where Q is the streamflow,

WUA the weighted useable area at the discharge Q,

A the surface area per unit length (same as stream width) at streamflow Q,

v the velocity at stream flow Q,

d the depth at streamflow Q,

s the channel substitute/cover index, and the therms

f ( ), g ( ), h ( ) are functions dependent on the species and life stage of interest (or receational activity if reaction is of concern).

The summary of discharge measurements available for numerous gauging stations can be used to determine the velocity, average depth, and surface width. Not all USGS data are useful for this purpose because some of the data is collected at man-made controls such as weirs and bridges. Only data for reasonably natural measurement points should be used with the HABVD program.

In some cases, stream morphology relationships have been developed for a specific location - these can be used directly. Substrate/cover information is not available as part of the discharge measurement summaries and will have to be obtained from some other source. Only one substrate/ cover index for the stream may be used.

The stream morphology relationships are of the form:

$$v = k\ Q^m$$

$$d = c\ Q^f$$

$$w = a\ Q^b$$

v, d, and Q are as defined above, w is the stream width and k, m, c, f, a, and b are coefficients.

Depending on the options selected, the program is supplied the coefficients or the program calculates the coefficients from the data supplied.

PROGRAM INPUT AND OUTPUT

The input file and flow file used by the program is described in Appendix B with the options presented in Appendix A. An example output is given in Appendix C. The procedure file used in running the program is given in Appendix D.

PROGRAM RESULTS

The results from the HABVD program are different from the results from the HABTAT program. Examples of the results from HABVD are given in Figures 1 and 2 and from the HABTAT program in Figures 3 and 4. The writer's experience indicates the differences shown are typical.

The HABVD program was written in 1982 to solve some missing data problems and has been used to determine if one set of HABTAT results could be transferred downstream. Both cases were an appropriate use of the program.

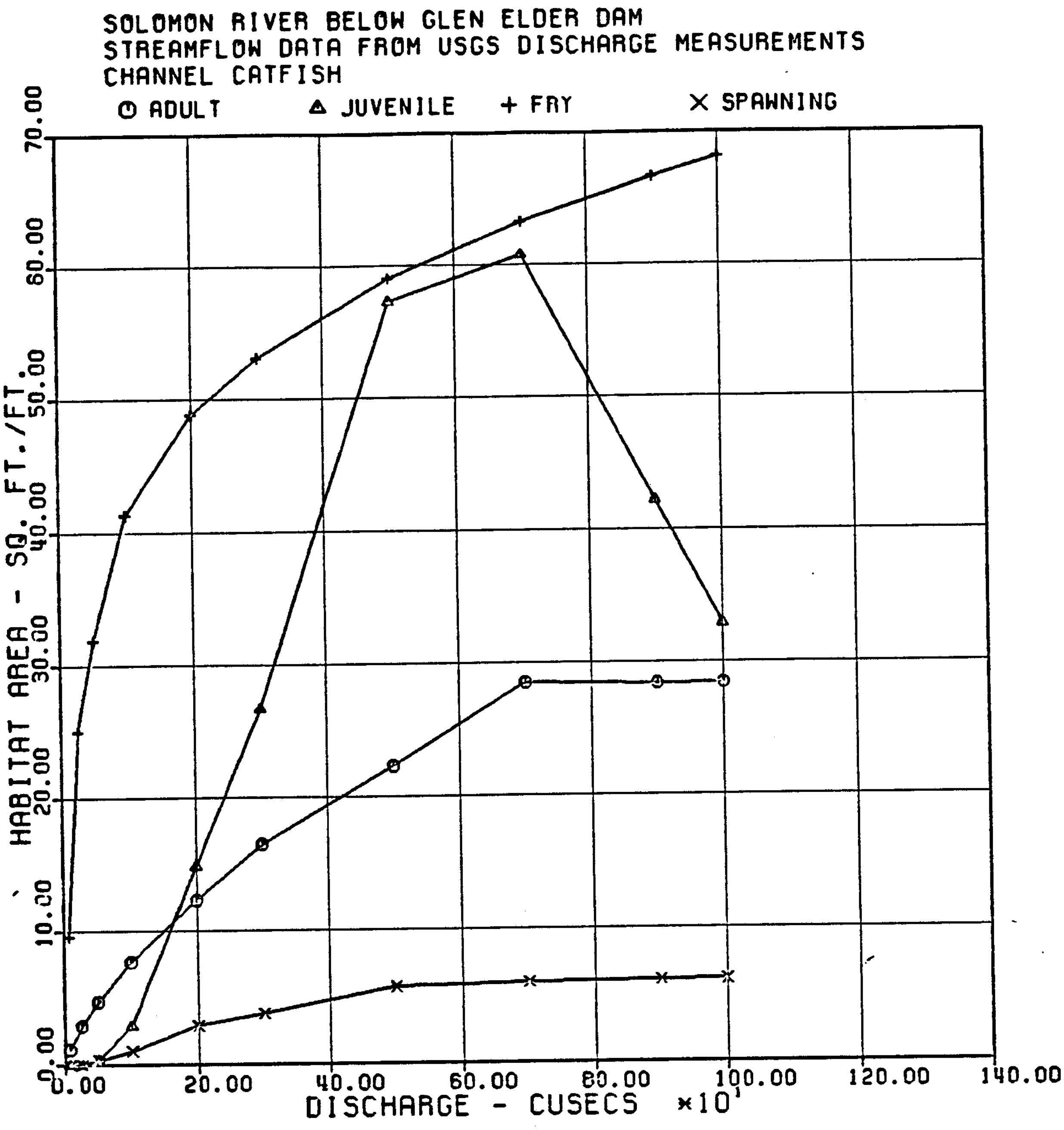


Figure 1. Physical habitat versus streamflow relationship for channel catfish - HABVD program results.

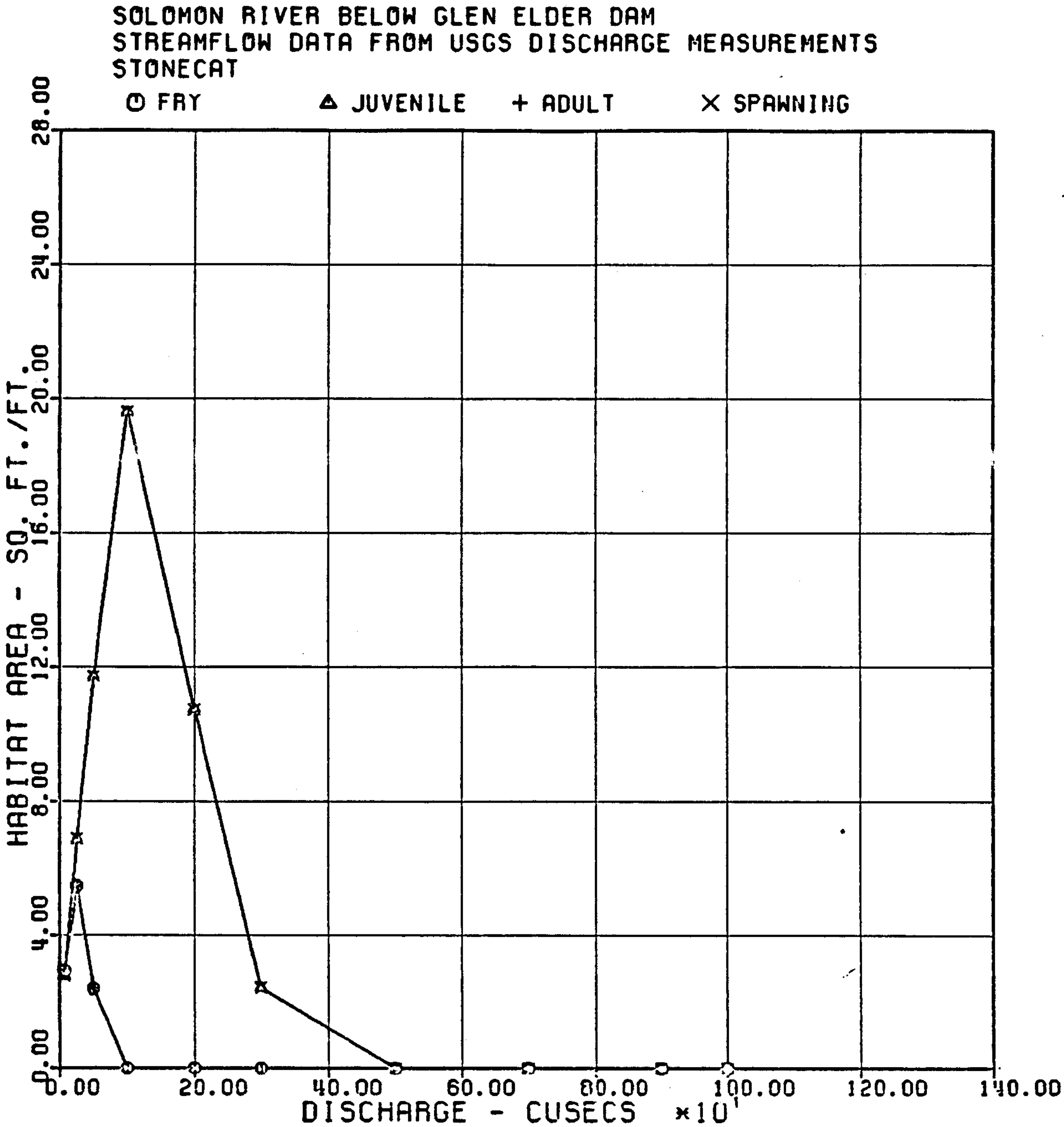


Figure 2. Physical habitat versus streamflow relationship for stonecat - HABVD program results.

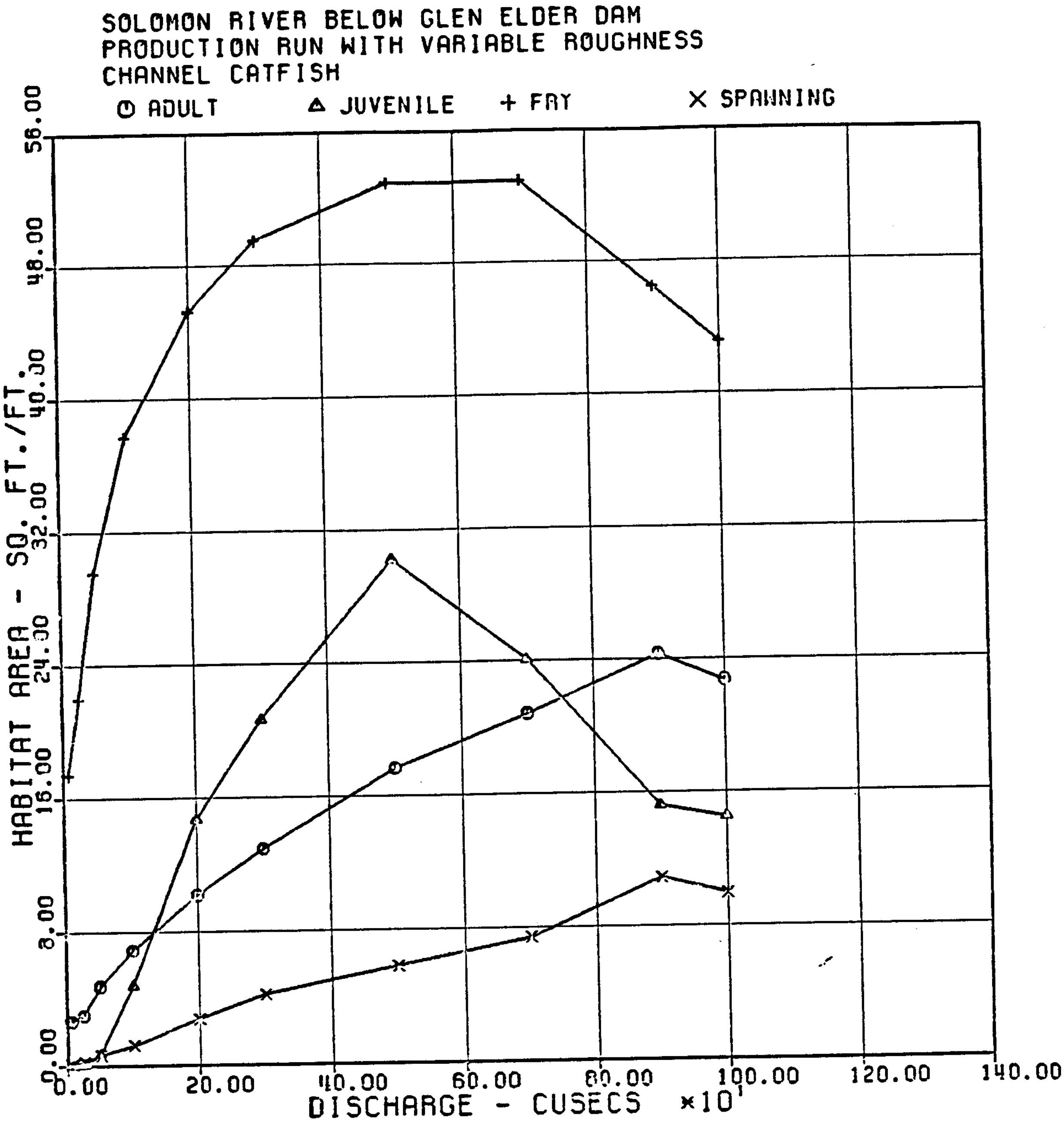


Figure 3. Physical habitat versus streamflow relationship for channel catfish - HABTAT program results.

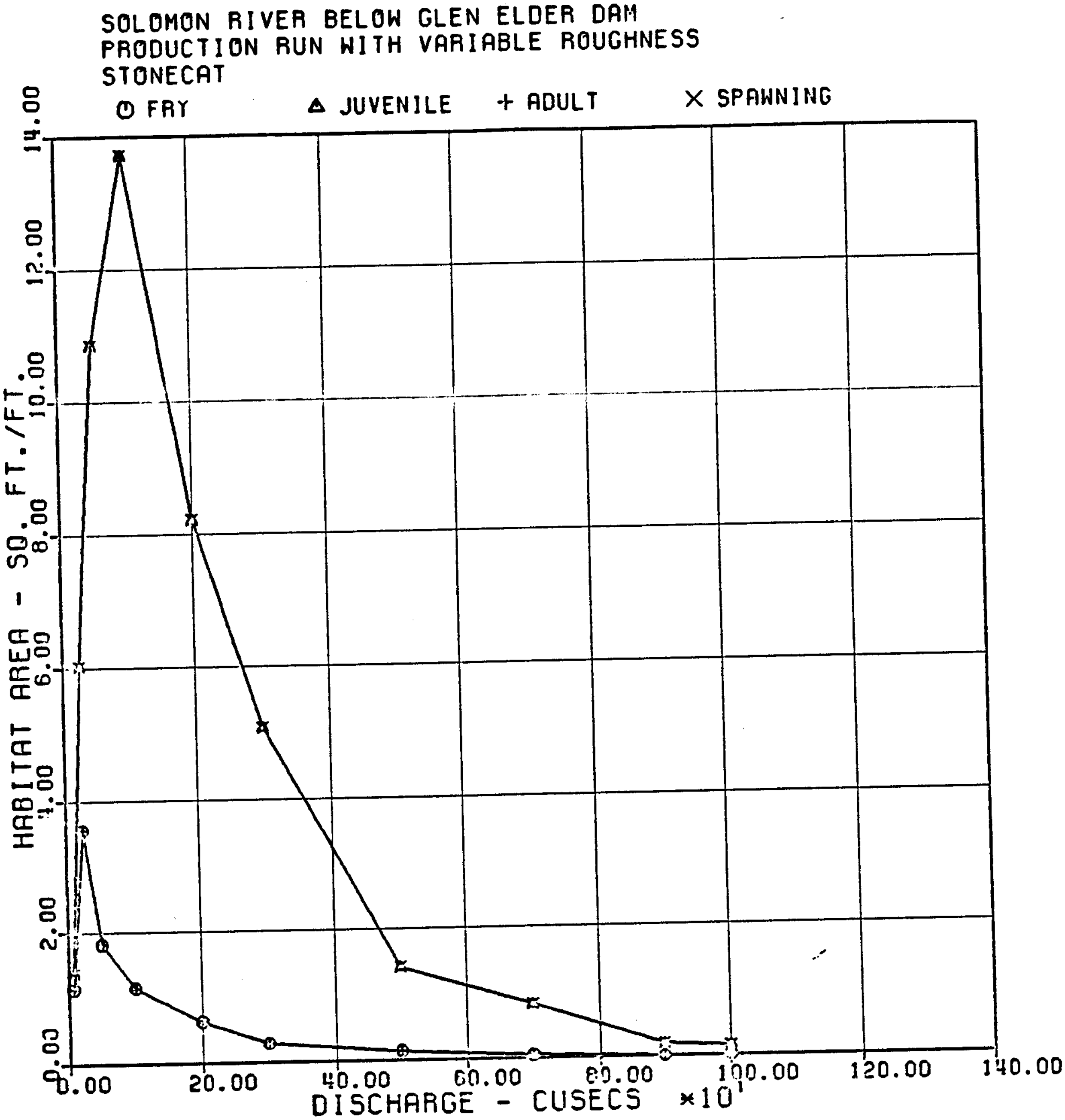


Figure 4. Physical habitat versus streamflow relationship for stonecat - HABTAT program results.

The HABVD program cannot be considered a replacement for HABTAT but as a supplemental program. As with all programs, the user should proceed with due care.

APPENDIX A

PROGRAM OPTIONS

The options are selected on the IOC card (third card in input file). The options available are:

IOC	Column	Value	Description
1	11	0	Not used.
2	12	0	Do not print the new velocity, depths, and discharges resulting from IOC (5)=0 or 1.
		1	Prints a new velocity depths, and discharges.
3	13	0	Do not print stream morphology relationships.
		1	Prints stream morphology relationships.
4	14	0	Do not print details of habitat calculations.
		1	Print details of habitat calcuations.
5	15	0	Read discharges of interest from the input file.
		1	Derive streamflows of interest from the ranges of discharges on flow file.
		2	Use streamflow from data points.
6	16	0	Do not print species criteria.
		1	Print species criteria.
7	17	0	Do not write habitat versus streamflow data on TAPE7.
		1	Write habitat versus streamflow data on TAPE7.

IOC	Column	Value	Description
8	18	0	Read discharge, width and cross section area from flow file.
		1	Read stream morphology parameters from flow file.
9	19	0	Standard weighting factor calculations.
		1	Geometric mean used for weighting factor.
		2	Lowest parameter used as weighting factor.
		3	Weighting factor calculation method supplied by user in subroutine WFTEST (as per HABITAT) 10.
10	20	0	Do not print weighted useable area as percent of total area.
		1	Print weighted useable area as percent of total area.

See the PHABSIM Users Guide (IFIP 11) for additional information on options 7, 9, and 10. These options are the same as for the HABTAT program.

APPENDIX B

INPUT FOR PROGRAM

There are two or three data files which must be created in order to use the HABVD program. One file contains the job title; job control cards; and, at the option of the user, the species criteria. The second file contains the streamflow data in free format form or the stream morphology parameters. The third file is optional and is a "FISHFIL" type file as described in the PHABSIM manual.

The stacking order for the HABVD input file is given in Table B-1. The lines following the CURVES cards may contain species criteria at the option of the user. Use a negative number on the "CURVES" card to designate species criteria to be read from the input file 8+ QARD card(s). Except for the "Substrate" card and the QARD cards, the formats from B-1 of various cards are as described for the HABTAT program in the PHABSIM manual. The format for the substrate card is:

Col.	1-9	Substrate
Col.	10	Blank
Col.	11-20	Substrate Index

The format of the QARD card lists QARD in columns 1 through 4 and the discharge in Column 11 through 20. An example input file is in Table B-2.

The flow data file is of two possible forms depending on the options selected by the user.

TABLE B-1

STACKING ORDER FOR HABVD INPUT FILE

Line Number	
1	Title Line 1
2	Title Line 2
3	"IOC" Card
4	"Substrate" Card
5	"Header" Card
6+	"Curves" Card(s)
7+	"Species" Criteria
8+	"QARD" card(s)

Table B-2. Example HABVD input file.

```
FILE NAME - HKANSQ2                    84/12/12.   23.45.39.                    PAGE    1

          SOLOMON RIVER BELOW GLEN ELDER DAM
          STREAMFLOW DATA FROM USGS DISCHARGE MEASUREMENTS
          1OC         00000000010
          HEADER      28
          CURVES       20000   20010   20020   20030   70000   70010   80001   80002   30000
          CURVES       30001   30002   30003   20300   20301   20302   20303   20801   20802
          CURVES       20803   20800   50000   50001   50002   50003  100200  100201  100202
          CURVES      100203
          QARD            7.
          QARD           25.
          QARD           50.
          QARD          100.
          QARD          200.
          QARD          300.
          QARD          500.
          QARD          700.
          QARD          900.
          QARD         1000.
```

In both cases, the first two lines are title lines. If the user selects an IOC (8) of 0 the data are free format with each two having the stream width, the cross sectional area, and the discharge in that order. If the user selects to supply the stream morphology parameters directly, the format is:

Col. 1-10	11-20	21-31
Velocity	k	m
Depth	c	f
Width	a	b

See text for definition of terms; they are the same as standard in most stream morphology reports.

An example of the flow data file is given in Table B-3.

For information of "FISHFIL" type file, see the PHABSIM Users Guide (IFIP 11).

Table B-3. Example flow data file for HABVD.

```
FILE NAME - KNSOLO                          84/12/12.   23.45.12.                PAGE    1

    1          SOLOMON RIVER NEAR GLEN ELDER,KANSAS
    2          DATA FROM USGS DISCHARGE SUMMARY SHEETS (WY79-81)
    3          44 34.3 31
    4          33.5 76.8 122
    5          65 257 515
    6          27.5 16 17.4
    7          36.5 13.9 17.8
    8          22 23.2 13.7
```

APPENDIX C

OUTPUT FROM PROGRAM

```
        TITLE OF INPUT DATA SET IS -

        SOLOMON RIVER BELOW GLEN ELDER DAM
        STREAMFLOW DATA FROM USGS DISCHARGE MEASUREMENTS

        TITLE OF STREAM DATA SET IS -

        SOLOMON RIVER NEAR GLEN ELDER,KANSAS
        DATA FROM USGS DISCHARGE SUMMARY SHEETS (WY79-81)

        IOC = 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0

        CURVES TO BE USED ARE-
    20000     20010     20020     20030     70000
    70010     80001     80002     30000     30001
    30002     30003     20300     20301     20302
    20303     20801     20802     20803     20800
    50000     50001     50002     50003    100200
   100201    100202    100203
CURVE SET DEFINITION DATA WAS OBTAINED FROM THE FILE -

      KANSAS LIBRARY OF FISH SPECIES CRITERIA

        LAST UPDATED ON  82/10/12.  08.15.26.
```

SOLOMON RIVER NEAR GLEN ELDER, KANSAS
DATA FROM USGS DISCHARGE SUMMARY SHEETS (WY79-81)

DATA FOR STREAM MORPHOLOGY ANALYSIS

DISCHARGE	VELOCITY	DEPTH	WIDTH
31.00	.90	.78	44.00
122.00	1.59	2.29	33.50
515.00	2.00	3.95	65.00
17.40	1.09	.58	27.50
17.80	1.28	.38	36.50
13.70	.59	1.05	22.00

RELATIONSHIP BETWEEN VELOCITY AND DISCHARGE

VELOCITY = .454 * DISCHARGE ** .245

RELATIONSHIP BETWEEN DEPTH AND DISCHARGE

DEPTH = .135 * DISCHARGE ** .548

RELATIONSHIP BETWEEN WIDTH AND DISCHARGE

WIDTH = 16.295 * DISCHARGE ** .207

RELATIONSHIP BETWEEN DISCHARGE AND DEPTH

DISCHARGE = 39.772 * DEPTH ** 1.468

SOLOMON RIVER BELOW GLEN ELDER DAM
STREAMFLOW DATA FROM USGS DISCHARGE MEASUREMENTS

Q VS. AVAILABLE HABITAT AREA PER 1000 FEET OF STREAM FOR CHANNEL CATFISH

MONTH	Q	ADULT	JUVENILE	FRY	SPAWNING
1	7.00	1143.02	0.00	9564.25	0.00
2	25.00	2904.37	0.00	25006.79	0.00
3	50.00	4707.72	357.63	31881.07	343.09
4	100.00	7691.92	2914.08	41302.18	1026.63
5	200.00	12305.28	14800.22	48800.64	2912.02
6	300.00	16449.41	26706.35	53073.78	3818.63
7	500.00	22288.64	57263.78	58993.91	5726.28
8	700.00	28478.41	60746.50	63249.73	5994.11
9	900.00	28381.90	42209.22	66627.54	6122.86
10	1000.00	28436.76	32912.29	68096.77	6172.22

Q VS. AVAILABLE HABITAT AREA AS A PERCENTAGE OF THE GROSS AREA FOR CHANNEL CATFISH

MONTH	Q	GROSS	ADULT	JUVENILE	FRY	SPAWNING
1	7.	24379.	4.69	0.00	39.23	0.00
2	25.	31730.	9.15	0.00	78.81	0.00
3	50.	36626.	12.85	.98	87.05	.94
4	100.	42277.	18.19	6.89	97.69	2.43
5	200.	48801.	25.22	30.33	100.00	5.97
6	300.	53074.	30.99	50.32	100.00	7.19
7	500.	58994.	37.78	97.07	100.00	9.71
8	700.	63250.	45.03	96.04	100.00	9.48
9	900.	66628.	42.60	63.35	100.00	9.19
10	1000.	68097.	41.76	48.33	100.00	9.06

SOLOMON RIVER BELOW GLEN ELDER DAM
STREAMFLOW DATA FROM USGS DISCHARGE MEASUREMENTS

Q VS. AVAILABLE HABITAT AREA PER 1000 FEET OF STREAM FOR WHITE BASS

MONTH	Q	SPAWNING	FRY
1	7.00	0.00	0.00
2	25.00	5940.49	0.00
3	50.00	16444.93	2090.25
4	100.00	33219.40	9825.47
5	200.00	48800.64	13069.12
6	300.00	53073.78	10495.57
7	500.00	58172.34	7284.19
8	700.00	51945.05	3715.90
9	900.00	47143.40	1224.49
10	1000.00	44773.26	367.15

Q VS. AVAILABLE HABITAT AREA AS A PERCENTAGE OF THE GROSS AREA FOR WHITE BASS

MONTH	Q	GROSS	SPAWNING	FRY
1	7.	24379.	0.00	0.00
2	25.	31730.	18.72	0.00
3	50.	36626.	44.90	5.71
4	100.	42277.	78.58	23.24
5	200.	48801.	100.00	26.78
6	300.	53074.	100.00	19.78
7	500.	58994.	98.61	12.35
8	700.	63250.	82.13	5.87
9	900.	66628.	70.76	1.84
10	1000.	68097.	65.75	.54

SOLOMON RIVER BELOW GLEN ELDER DAM
STREAMFLOW DATA FROM USGS DISCHARGE MEASUREMENTS

Q VS. AVAILABLE HABITAT AREA PER 1000 FEET OF STREAM FOR WHITE BASS

MONTH	Q	JUVENILE	ADULTS
1	7.00	0.00	0.00
2	25.00	0.00	0.00
3	50.00	0.00	0.00
4	100.00	5777.19	0.00
5	200.00	28765.62	0.00
6	300.00	43137.87	2879.97
7	500.00	57373.61	29668.51
8	700.00	57657.79	47292.55
9	900.00	56917.11	55165.04
10	1000.00	56173.72	56969.55

Q VS. AVAILABLE HABITAT AREA AS A PERCENTAGE OF THE GROSS AREA FOR WHITE BASS

MONTH	Q	GROSS	JUVENILE	ADULTS
1	7.	24379.	0.00	0.00
2	25.	31730.	0.00	0.00
3	50.	36626.	0.00	0.00
4	100.	42277.	13.67	0.00
5	200.	48801.	58.95	0.00
6	300.	53074.	81.28	5.43
7	500.	58994.	97.25	50.29
8	700.	63250.	91.16	74.77
9	900.	66628.	85.43	82.80
10	1000.	68097.	82.49	83.66

SOLOMON RIVER BELOW GLEN ELDER DAM
STREAMFLOW DATA FROM USGS DISCHARGE MEASUREMENTS

Q VS. AVAILABLE HABITAT AREA PER 1000 FEET OF STREAM FOR STONECAT

MONTH	Q	FRY	JUVENILE	ADULT	SPAWNING
1	7.00	2940.49	2774.88	2940.49	2774.88
2	25.00	5463.68	6878.95	5463.68	6878.95
3	50.00	2394.14	11725.41	2394.14	11725.41
4	100.00	0.00	19626.95	0.00	19626.95
5	200.00	0.00	10746.72	0.00	10746.72
6	300.00	0.00	2429.05	0.00	2429.05
7	500.00	0.00	0.00	0.00	0.00
8	700.00	0.00	0.00	0.00	0.00
9	900.00	0.00	0.00	0.00	0.00
10	1000.00	0.00	0.00	0.00	0.00

Q VS. AVAILABLE HABITAT AREA AS A PERCENTAGE OF THE GROSS AREA FOR STONECAT

MONTH	Q	GROSS	FRY	JUVENILE	ADULT	SPAWNING
1	7.	24379.	12.06	11.38	12.06	11.38
2	25.	31730.	17.22	21.68	17.22	21.68
3	50.	36626.	6.54	32.01	6.54	32.01
4	100.	42277.	0.00	46.42	0.00	46.42
5	200.	48801.	0.00	22.02	0.00	22.02
6	300.	53074.	0.00	4.58	0.00	4.58
7	500.	58994.	0.00	0.00	0.00	0.00
8	700.	63250.	0.00	0.00	0.00	0.00
9	900.	66628.	0.00	0.00	0.00	0.00
10	1000.	68097.	0.00	0.00	0.00	0.00

SOLOMON RIVER BELOW GLEN ELDER DAM
STREAMFLOW DATA FROM USGS DISCHARGE MEASUREMENTS

Q VS. AVAILABLE HABITAT AREA PER 1000 FEET OF STREAM FOR LARGEMOUTH BASS NORTHERN STOCK

MONTH	Q	FRY	JUVENILES	ADULT	SPAWNING
1	7.00	75.32	704.85	0.00	0.00
2	25.00	100.81	1979.49	0.00	0.00
3	50.00	0.00	4850.22	104.97	0.00
4	100.00	0.00	3762.42	435.97	0.00
5	200.00	0.00	1401.95	1152.14	0.00
6	300.00	0.00	374.67	1910.75	0.00
7	500.00	0.00	0.00	2836.89	0.00
8	700.00	0.00	0.00	3203.05	0.00
9	900.00	0.00	0.00	2252.18	0.00
10	1000.00	0.00	0.00	1428.63	0.00

Q VS. AVAILABLE HABITAT AREA AS A PERCENTAGE OF THE GROSS AREA FOR LARGEMOUTH BASS NORTHERN STOCK

MONTH	Q	GROSS	FRY	JUVENILES	ADULT	SPAWNING
1	7.	24379.	.31	2.89	0.00	0.00
2	25.	31730.	.32	6.24	0.00	0.00
3	50.	36626.	0.00	13.24	.29	0.00
4	100.	42277.	0.00	8.90	1.03	0.00
5	200.	48801.	0.00	2.87	2.36	0.00
6	300.	53074.	0.00	.71	3.60	0.00
7	500.	58994.	0.00	0.00	4.81	0.00
8	700.	63250.	0.00	0.00	5.06	0.00
9	900.	66628.	0.00	0.00	3.38	0.00
10	1000.	68097.	0.00	0.00	2.10	0.00

SOLOMON RIVER BELOW GLEN ELDER DAM
STREAMFLOW DATA FROM USGS DISCHARGE MEASUREMENTS

Q VS. AVAILABLE HABITAT AREA PER 1000 FEET OF STREAM FOR WHITE CRAPPIE

MONTH	Q	JUVENILES	ADULTS	SPAWNING	FRY
1	7.00	0.00	0.00	0.00	0.00
2	25.00	3168.34	0.00	8061.22	1.01
3	50.00	17782.22	0.00	14038.48	0.00
4	100.00	23728.68	0.00	21434.45	0.00
5	200.00	21838.96	623.83	21939.27	0.00
6	300.00	19856.05	3162.40	14840.86	0.00
7	500.00	16274.49	4138.67	10683.03	0.00
8	700.00	10293.00	3707.05	7991.45	0.00
9	900.00	6403.47	3287.70	4248.39	0.00
10	1000.00	5042.26	3083.91	1698.64	0.00

Q VS. AVAILABLE HABITAT AREA AS A PERCENTAGE OF THE GROSS AREA FOR WHITE CRAPPIE

MONTH	Q	GROSS	JUVENILES	ADULTS	SPAWNING	FRY
1	7.	24379.	0.00	0.00	0.00	0.00
2	25.	31730.	9.99	0.00	25.41	.00
3	50.	36626.	48.55	0.00	38.33	0.00
4	100.	42277.	56.13	0.00	50.70	0.00
5	200.	48801.	44.75	1.28	44.96	0.00
6	300.	53074.	37.41	5.96	27.96	0.00
7	500.	58994.	27.59	7.02	18.11	0.00
8	700.	63250.	16.27	5.86	12.63	0.00
9	900.	66628.	9.61	4.93	6.38	0.00
10	1000.	68097.	7.40	4.53	2.49	0.00

SOLOMON RIVER BELOW GLEN ELDER DAM
STREAMFLOW DATA FROM USGS DISCHARGE MEASUREMENTS

Q VS. AVAILABLE HABITAT AREA PER 1000 FEET OF STREAM FOR WALLEYE

MONTH	Q	FRY	JUVENILES	ADULTS	SPAWNING
1	7.00	0.00	0.00	0.00	0.00
2	25.00	0.00	0.00	0.00	0.00
3	50.00	0.00	0.00	0.00	452.68
4	100.00	0.00	0.00	0.00	3639.88
5	200.00	0.00	1479.45	0.00	16050.40
6	300.00	0.00	1904.99	0.00	21456.00
7	500.00	0.00	1316.67	2359.76	32600.56
8	700.00	0.00	0.00	2529.99	49562.85
9	900.00	0.00	0.00	2665.10	43545.78
10	1000.00	0.00	0.00	2723.87	34661.37

Q VS. AVAILABLE HABITAT AREA AS A PERCENTAGE OF THE GROSS AREA FOR WALLEYE

MONTH	Q	GROSS	FRY	JUVENILES	ADULTS	SPAWNING
1	7.	24379.	0.00	0.00	0.00	0.00
2	25.	31730.	0.00	0.00	0.00	0.00
3	50.	36626.	0.00	0.00	0.00	1.24
4	100.	42277.	0.00	0.00	0.00	8.61
5	200.	48801.	0.00	3.03	0.00	32.89
6	300.	53074.	0.00	3.59	0.00	40.43
7	500.	58994.	0.00	2.23	4.00	55.26
8	700.	63250.	0.00	0.00	4.00	78.36
9	900.	66628.	0.00	0.00	4.00	65.36
10	1000.	68097.	0.00	0.00	4.00	50.90

SOLOMON RIVER BELOW GLEN ELDER DAM
STREAMFLOW DATA FROM USGS DISCHARGE MEASUREMENTS

Q VS. AVAILABLE HABITAT AREA PER 1000 FEET OF STREAM FOR WHITE SUCKER

MONTH	Q	FRY	JUVENILE	ADULTS	SPAWNING
1	7.00	0.00	18715.88	0.00	0.00
2	25.00	.53	29680.31	27582.89	10033.20
3	50.00	0.00	22136.39	36625.78	36481.49
4	100.00	0.00	13138.71	42277.20	42277.20
5	200.00	0.00	5543.58	47199.86	7869.22
6	300.00	0.00	2350.18	47284.72	0.00
7	500.00	0.00	0.00	42906.52	0.00
8	700.00	0.00	0.00	35837.46	0.00
9	900.00	0.00	0.00	26651.86	0.00
10	1000.00	0.00	0.00	22271.89	0.00

Q VS. AVAILABLE HABITAT AREA AS A PERCENTAGE OF THE GROSS AREA FOR WHITE SUCKER

MONTH	Q	GROSS	FRY	JUVENILE	ADULTS	SPAWNING
1	7.	24379.	0.00	76.77	0.00	0.00
2	25.	31730.	.00	93.54	86.93	31.62
3	50.	36626.	0.00	60.44	100.00	99.61
4	100.	42277.	0.00	31.08	100.00	100.00
5	200.	48801.	0.00	11.36	96.72	16.13
6	300.	53074.	0.00	4.43	89.09	0.00
7	500.	58994.	0.00	0.00	72.73	0.00
8	700.	63250.	0.00	0.00	56.66	0.00
9	900.	66628.	0.00	0.00	40.00	0.00
10	1000.	68097.	0.00	0.00	32.71	0.00

WSP

APPENDIX D

PROCEDURE FILE FOR USING HABVD

The procedure file used to execute the HABVD is named RHABVD and is located on the file PROCFIL at all locations supported by the Instream Flow Group. The procedure file is given in Table D-1.

To use the program after PROCFIL is a local file enter the command

```
-RHABVD,,FHIN,FQS,FISH,OUT,TAPE8
```

where FHIN is the input file,

FQ is the streamflow properties file,

FISH is the FISHFIL type file,

OUT is the results file, and

TAPE8 is a file containing the physical habitat versus streamflow relationships.

If the input file is not available, the user will be questioned interactively as to what the input file should be. The resulting file will have the name FHIN or whatever the user has used as a substitute name.

If the FISHFIL type file is not found, it is assumed the criteria is on the input file. Species criterion are assumed to come from a "FISHFIL" file if the user does not supply FHIN and the species criterion are not on input.

Table D-1. The RHABVD procedure file.

```
FILE NAME - RHABVD                          85/01/12.   22.23.14.                    PAGE   1

.PROC,RHABVD,FHIN,FQS,FISH,OUT,TAPE8.
*
*  RUNS THE HABVD PROGRAM TO CALCULATE
*  WEIGHTED USEABLE AREAS USING FLOW RELATED
*  FROM USGS DISCHARGE SUMMARY SHEET
*
IFE,.NOT.FILE(PHABSIM,MS),RHVD4.
ATTACH,PHABSIM/UN=SAS6SWT,PW=HOTDAY.
ENDIF,RHVD4.
IFE,.NOT.FILE(FHIN,MS),RHVD1.
GET,FHIN/NA.
IFE,.NOT.FILE(FHIN,MS),RHVD1.
LDSET,LIB=PHABSIM.
HBVDIN,FHIN.
ENDIF,RHVD1.
IFE,.NOT.FILE(FQS,MS),RHVD2.
GET,FQS.
ENDIF,RHVD2.
IFE,.NOT.FILE(FISH,MS),RHVD3.
GET,FISH/NA.
ENDIF,RHVD3.
REWIND,FHIN,FQS,FISH,ZMAP.
LDSET,LIB=PHABSIM,MAP=SB/ZMAP.
HABVD,FHIN,OUT,FQS,FISH,TAPE8.
REVERT. OUTPUT IS ON OUT.
```

PHABSIM TECHNICAL NOTE NO. 10
SELECTION OF PARTIAL DATA FROM THE INTERMEDIATE
FILES TAPE3 AND TAPE4

By
Robert T. Milhous
Hydraulic Engineer

During work on many instream flow studies, it is desirable to look at the physical habitat versus streamflow relationship for an individual cross section or for a series of cross sections less than the total series for a study reach. Also, detailed analysis sometimes needs to be done for one streamflow but not for all of the flows simulated in the hydraulic simulation program.

An example of the situation where only one section is used is for the simulation of passage habitat. The problem with using a single cross section is that a minimum of two cross sections are needed in the HABTAT program. In order to use a single cross section, the section of interest is duplicated with a reach length of 100 feet. An example of the use of EXT3T4 is when it is desirable to compare one type of habitat to another within a total study reach when the types are grouped, say, in one type in the upper part and another type in the lower part.

The program used to extract the cross section properties for one section from TAPE3 and the flow related data from TAPE4 with the single cross section written on a new TAPE3 and TAPE4 is EXCS34. The program is used with the following series of commands after the file PHABSIM is local.

```
LDSET,LIB=PHABSIM
EXCS34,OTP3,OTP4,NTP3,NTP4
where OTP3 is the original TAPE3,
      OTP4 is the original TAPE4,
      NTP3 is the new TAPE3 with data for one cross section, and
      NTP4 is the new TAPE4 data for all flows of interest for the subset
        of cross sections
```

The program will ask for the series number, (i.e. first, second, etc.) of the cross section of interest.

The case of a partial series of cross sections out of a large total is handled using the program EXT3T4. The partial series must be continuous. The program is used with the following commands:

```
LDSET,LIB=PHABSIM
EXT3T4,OTP3,OTP4,NTP3,NTP4
```

where OTP3, OTP4, NTP3 and NTP4 are as described above except information for a group of consecutive cross sections.

The third case is where it is desirable to look at the stream flow properties of one flow out of a much larger total such as the use of the more detailed graphics programs. The program is the EXQT4 program and is used with the following commands:

```
LDSET,LIB=PHABSIM
EXQT4,OTP4,NTP4
```

The same TAPE3 is used with both TAPE4's.

Sometime in the future, procedure files to use these three programs will be written and this note revised at that time.

PHABSIM TECHNICAL NOTE NO. 11
THE USE OF THE REVI4 PROGRAM

by
Robert T. Milhous
Hydraulic Engineer

The purpose of the REVI4 program is to assist in determining the best approach to hydraulic simulation for a given site using an IFG4 data set. The purpose of this technical note is to present the program and how to get results from the program. A later note, or a revision of this note, will have to discuss how to interpret the results from a view point of developing the best approach to hydraulic simulation for a given data set.

INPUT FILE

The input file for the REVI4 program is a standard IFG4 input file. It is recommended the user approach hydraulic simulation using the following steps:

1. Review and check the original data.

2. Build the IFG4 data set.

3. Use the CKI4 program to check the data file and correct then any errors.

4. Run the REVI4 program.

5. If not already done so, visit the study reach.

6. Based on 4 and 5, select the most appropriate approach to hydraulic simulation.

7. Do the hydraulic simulations.

The REVI4 program is executed using the procedure file RREVI4. The command is:

```
-RREVI4,,FI4,OUT
```

where FI4 is the IFG4 data file and OUT is the results which are to be used in selecting the most appropriate approach to hydraulic simulation.

An example of the results from the REVI4 program is given in the appendix.

APPENDIX. RESULTS FROM THE REV14 PROGRAM

```
        85/01/12.           22.17.12.

WILLIAMS FORK RIVER   SECTION 1   **   COLORADO/NEHRING   **
ONE MILE BELOW KINNEY CREEK CONFLUENCE    IFG4 DATA

  IOC'S ARE   1  1  0  0  0  0  0  2  0  1  0  0  1  0  0  0  0  0  0  0

 METRIC INDEX IS.................. 0

 NUMBER OF STREAMFLOWS SIMULATED IS 20
 THE SIMULATED FLOWS ARE -

  5. 10. 15. 20. 30. 40.

  60. 80. 100. 200. 250. 300.

  400. 500. 700. 800. 900. 1000.

  1250. 1500.
```

85/01/12.   22.17.12.

WILLIAMS FORK RIVER   SECTION 1   **   COLORADO/NEHRING   **
ONE MILE BELOW KINNEY CREEK CONFLUENCE   IFG4 DATA

STATION ID IS 0.00

WEIGHT ON SECTION WORKING UPSTREAM IS .50

REACH LENGTH TO DOWNSTREAM SECTION IS 0.00

STAGE OF ZERO FLOW IS............... 95.50

GIVEN SLOPE IS...................... .00000000

NUMBER OF COORDINATE POINTS IS...... 42

COORIDINATE DATA FOLLOWS
========================

DISTANCE	1.0	2.0	4.0	6.0	8.0	10.0	12.0	14.0	16.0	18.0
ELEVATION	96.6	96.5	96.3	96.2	96.1	96.1	95.9	96.0	95.8	95.8
CHANNEL INDEX	4.0	4.0	4.0	5.5	5.5	5.5	5.5	5.5	5.5	5.5
DISTANCE	20.0	22.0	24.0	26.0	28.0	30.0	32.0	34.0	36.0	38.0
ELEVATION	95.8	95.8	95.7	95.7	95.7	95.8	95.7	95.5	95.9	96.0
CHANNEL INDEX	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5
DISTANCE	40.0	42.0	44.0	46.0	48.0	50.0	52.0	54.0	56.0	58.0
ELEVATION	96.1	96.2	96.4	96.5	96.5	96.5	96.4	96.1	96.3	96.5
CHANNEL INDEX	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5
DISTANCE	60.0	62.0	64.0	66.0	68.0	70.0	72.0	74.0	76.0	78.0
ELEVATION	96.6	96.6	96.6	96.7	96.5	96.4	96.1	96.0	96.1	96.6
CHANNEL INDEX	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5
DISTANCE	80.0	82.0								
ELEVATION	97.5	98.8								
CHANNEL INDEX	4.0	4.0								

85/01/12. 22.17.12.

WILLIAMS FORK RIVER SECTION 1 ** COLORADO/NEHRING **
ONE MILE BELOW KINNEY CREEK CONFLUENCE IFG4 DATA

STATION ID. IS 0.

FLOW	263.00	111.00	40.90
STAGE	97.25	96.77	96.50

VELOCITY CALIBRATION DATA

LOCATION	VELOCITIES		
1.0	0.00	0.00	0.00
2.0	.40	0.00	0.00
4.0	.20	1.00	.60
6.0	1.00	1.60	.50
8.0	3.00	2.30	1.00
10.0	3.50	2.20	1.00
12.0	3.00	2.60	1.30
14.0	3.50	2.00	1.60
16.0	3.20	2.40	1.70
18.0	3.50	2.40	1.70
20.0	3.80	2.70	1.70
22.0	3.80	2.30	2.00
24.0	3.50	3.20	1.90
26.0	4.20	2.80	1.90
28.0	4.40	2.70	1.80
30.0	3.80	3.30	1.80
32.0	4.10	2.20	1.90
34.0	3.70	2.70	1.90
36.0	3.20	2.40	1.30
38.0	4.20	2.70	1.40
40.0	3.80	2.40	1.10
42.0	3.50	2.40	.90
44.0	3.00	1.60	.70
46.0	3.40	.90	0.00
48.0	2.40	1.30	0.00
50.0	3.50	1.50	0.00
52.0	2.70	1.90	0.00
54.0	3.00	2.10	0.00
56.0	3.10	1.30	0.00
58.0	3.30	.40	0.00
60.0	2.60	.50	0.00
62.0	2.40	.40	0.00
64.0	2.40	.40	0.00
66.0	3.20	.30	0.00
68.0	3.00	.20	.30
70.0	3.00	1.10	0.00
72.0	2.20	.90	0.00
74.0	2.20	1.90	0.00
76.0	1.90	.60	0.00
78.0	.40	0.00	0.00
80.0	0.00	0.00	0.00
82.0	0.00	0.00	0.00

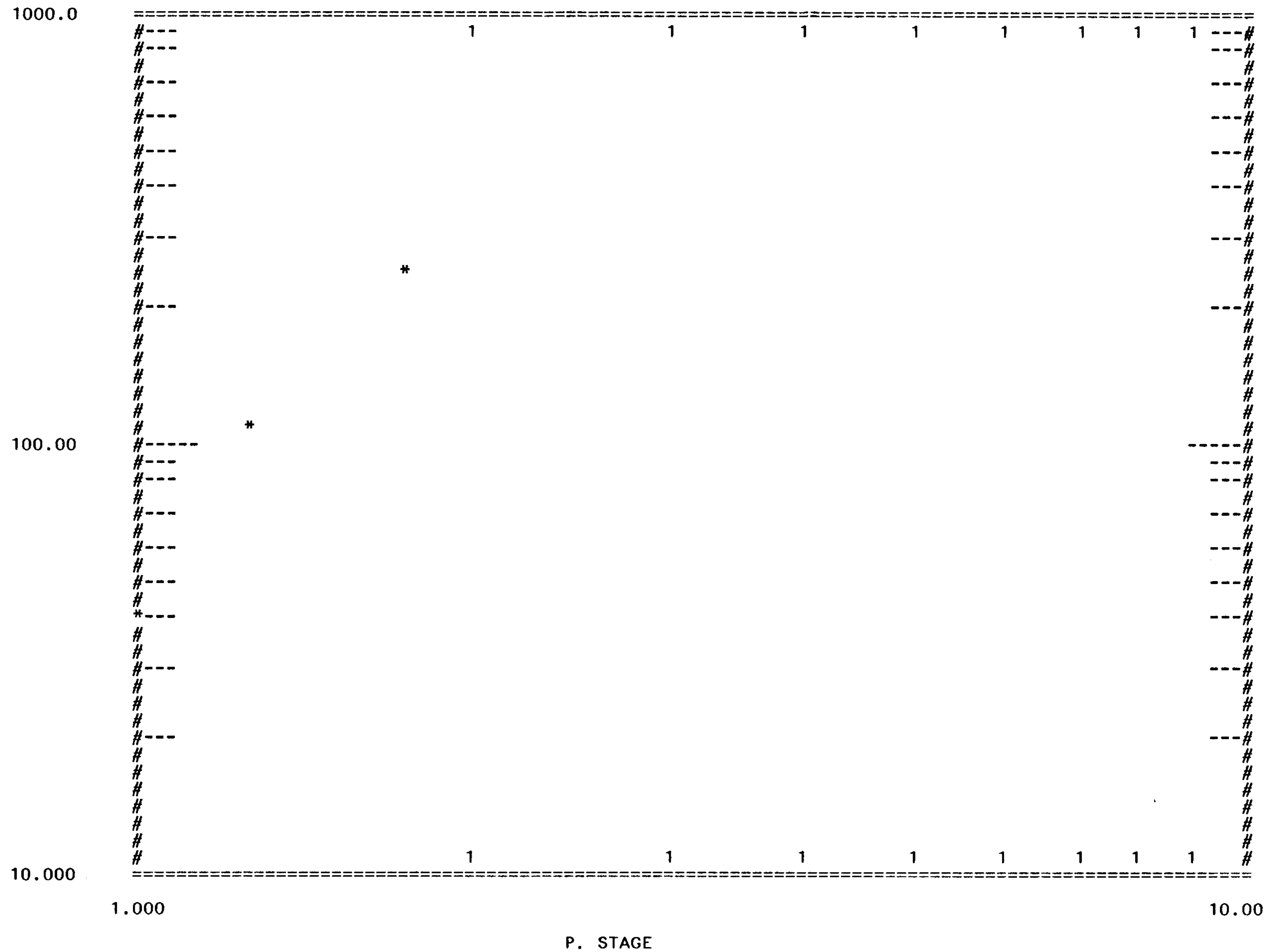
85/01/12. 22.17.12.

WILLIAMS FORK RIVER SECTION 1 ** COLORADO/NEHRING **
ONE MILE BELOW KINNEY CREEK CONFLUENCE IFG4 DATA

AVERAGE CHANNEL PARAMETERS FOR SECTION

STREAM FLOW	WATER SURFACE ELEVATION	WIDTH	CROSS SEC. AREA	WETTED PERIMETER	AVERAGE DEPTH	MAX DEPTH	PLOTTING STAGE	HYDRAULIC RADIUS	CONVAYENCE FACTOR
263.0	97.25	78.4	85.3	78.9	1.09	1.75	1.75	1.081	2.93
111.0	96.77	77.4	47.9	77.7	.62	1.27	1.27	.616	3.20
40.9	96.50	61.6	28.1	61.8	.46	1.00	1.00	.455	2.46

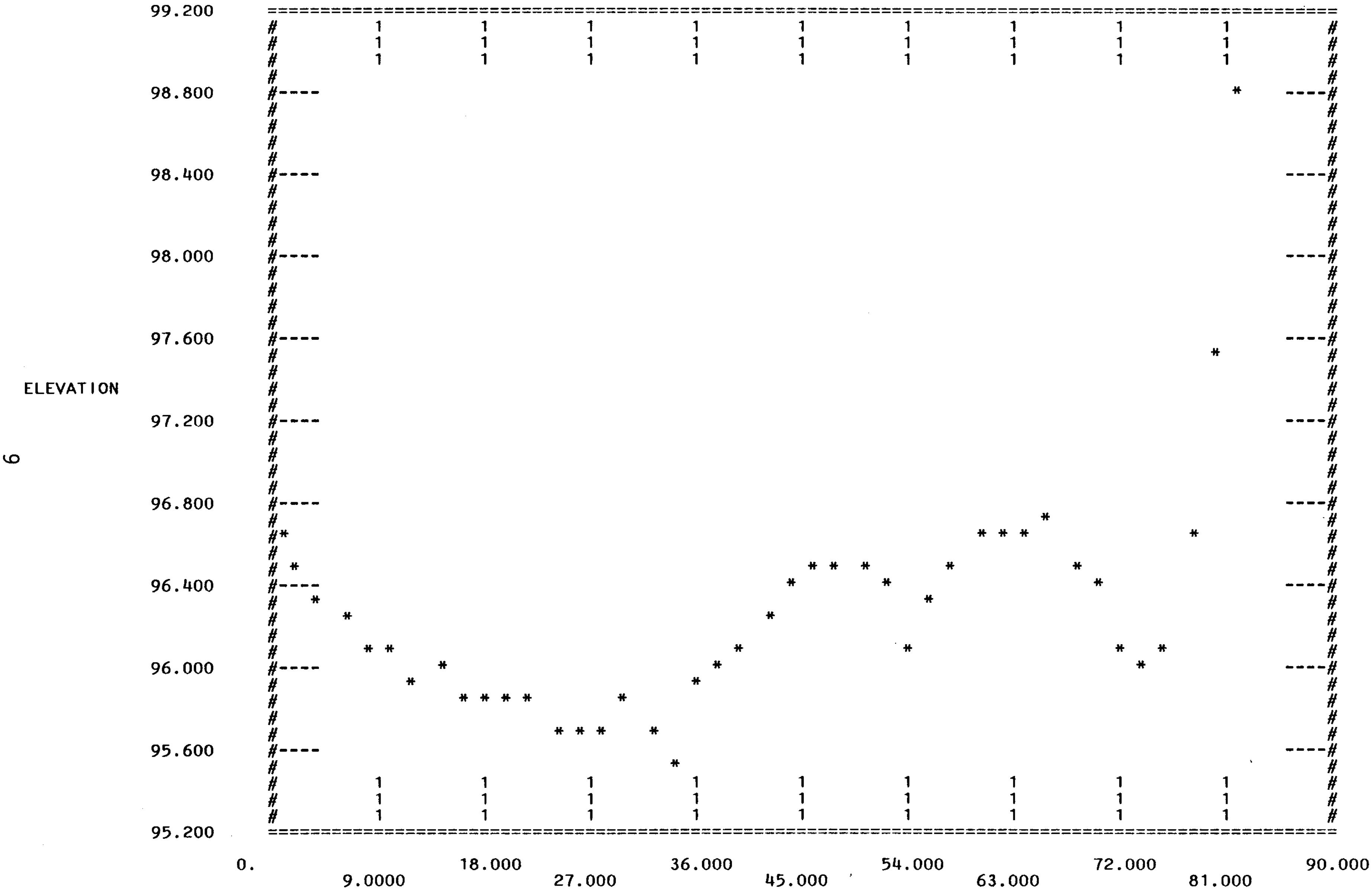
GRAPH 1



STAGE - DISCHARGE DATA FOR SECTION 0.00 STZ = 95.50

WILLIAMS FORK RIVER SECTION 1 ** COLORADO/NEHRING **ONE MILE BELOW KINNEY CREEK CONFLUENCEIFG4 DATA

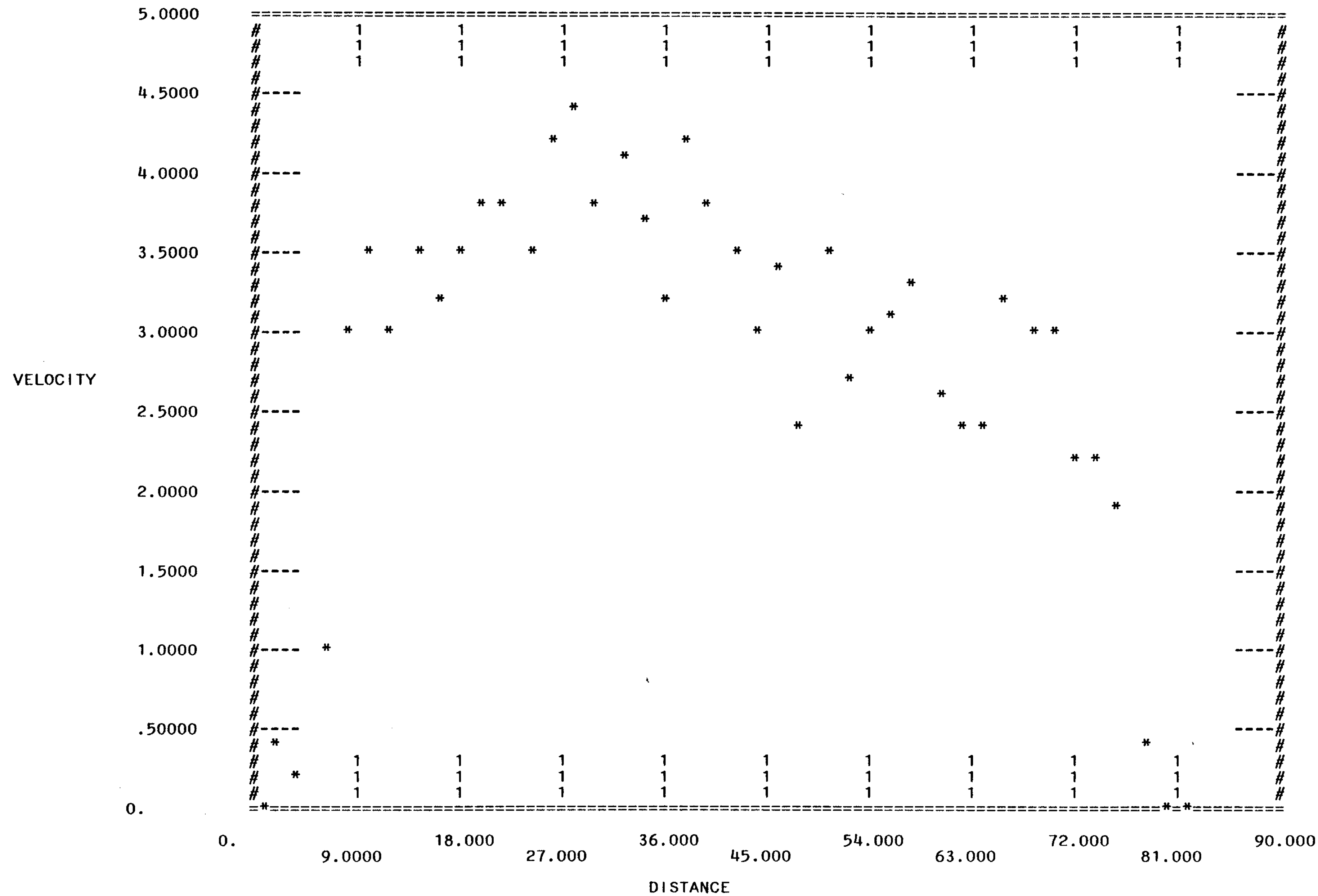
GRAPH 2



CROSS SECTION FOR TRANSECT 0.00

WILLIAMS FORK RIVER SECTION 1 ** COLORADO/NEHRING **ONE MILE BELOW KINNEY CREEK CONFLUENCEIFG4 DATA

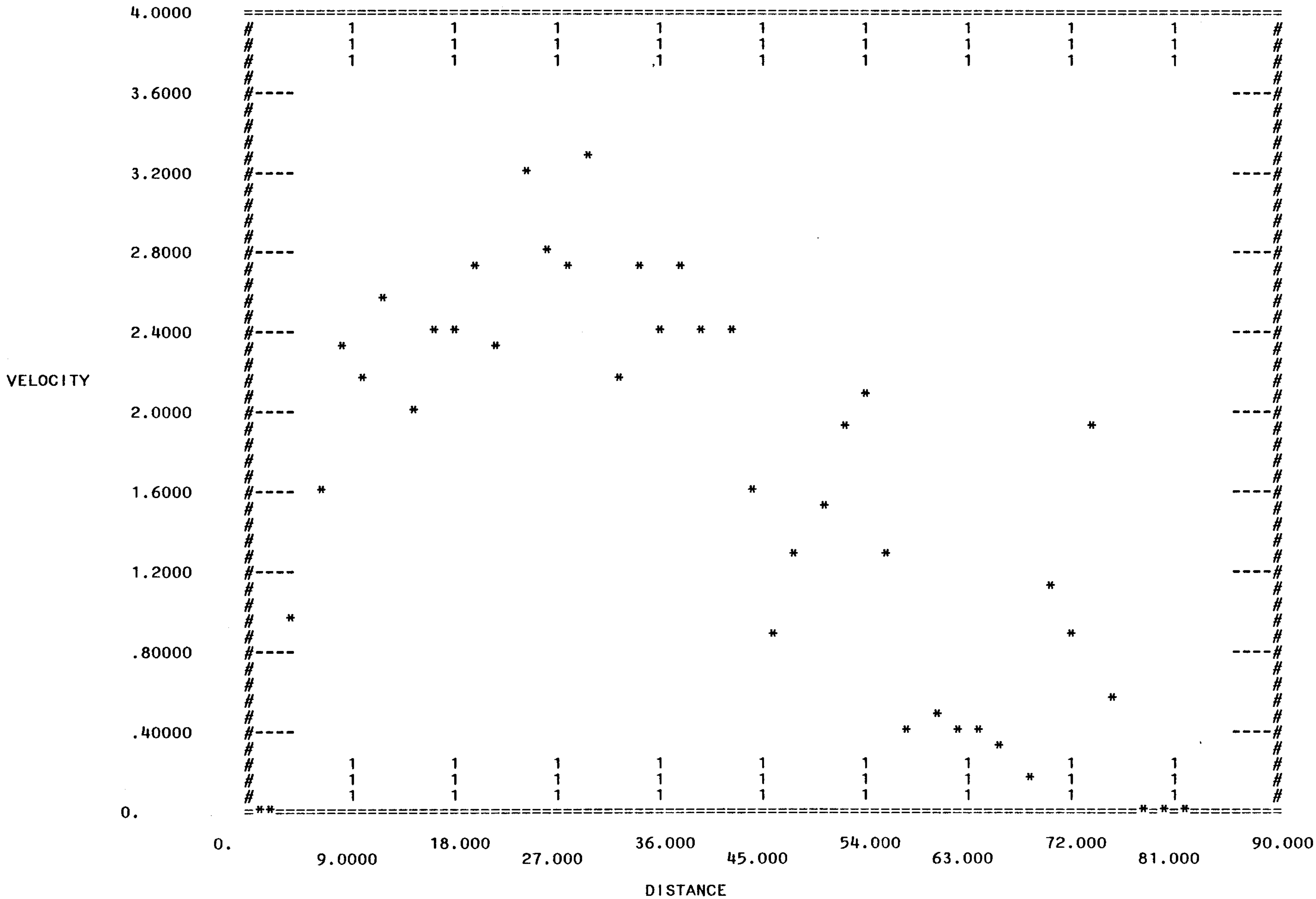
GRAPH 3



VELOCITY ACROSS CHANNEL FOR TRANSECT 0.00 Q = 263.00

WILLIAMS FORK RIVER SECTION 1 ** COLORADO/NEHRING **ONE MILE BELOW KINNEY CREEK CONFLUENCEIFG4 DATA

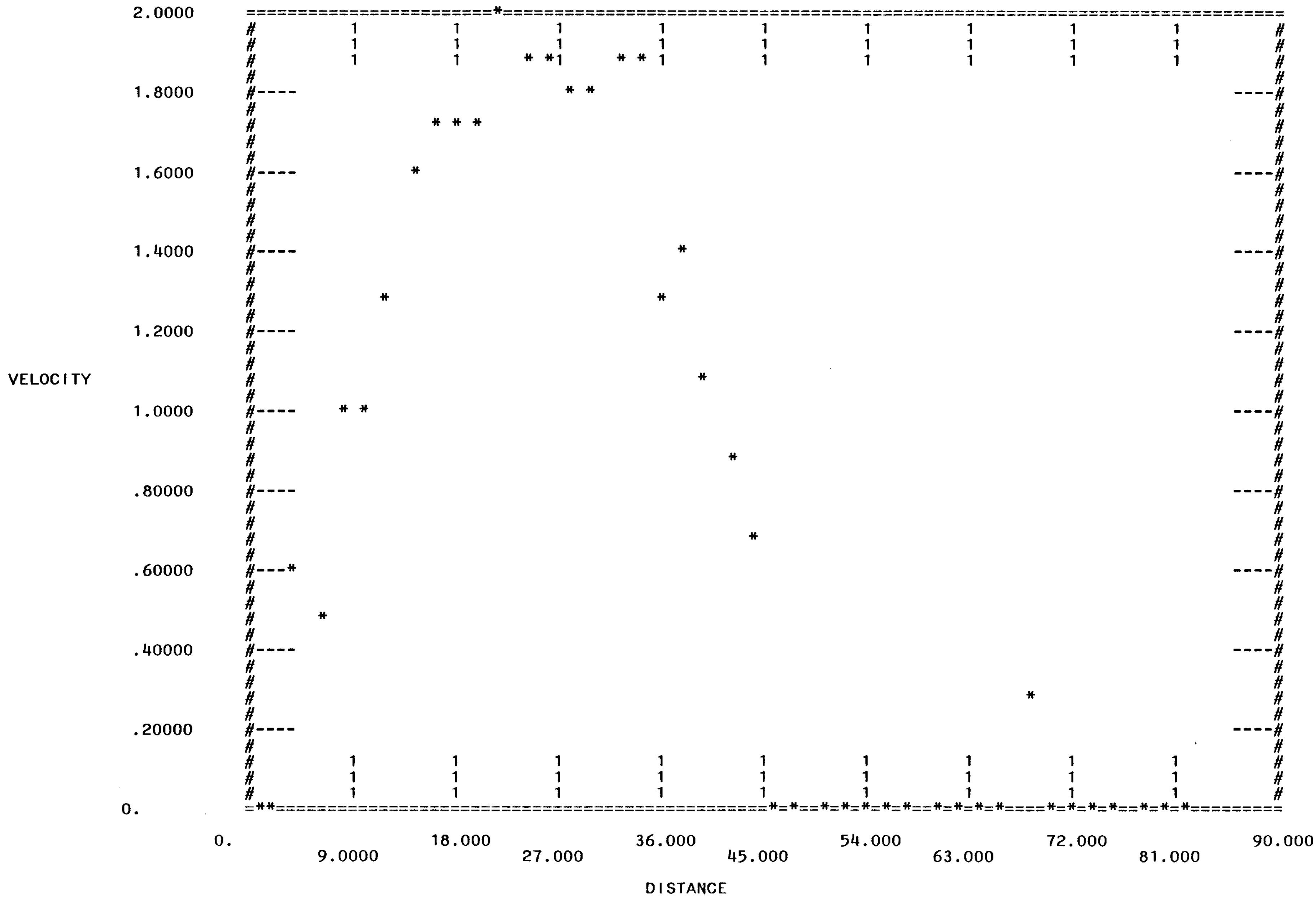
GRAPH 4



VELOCITY ACROSS CHANNEL FOR TRANSECT 0.00 Q = 111.00

WILLIAMS FORK RIVER SECTION 1 ** COLORADO/NEHRING **ONE MILE BELOW KINNEY CREEK CONFLUENCEIFG4 DATA

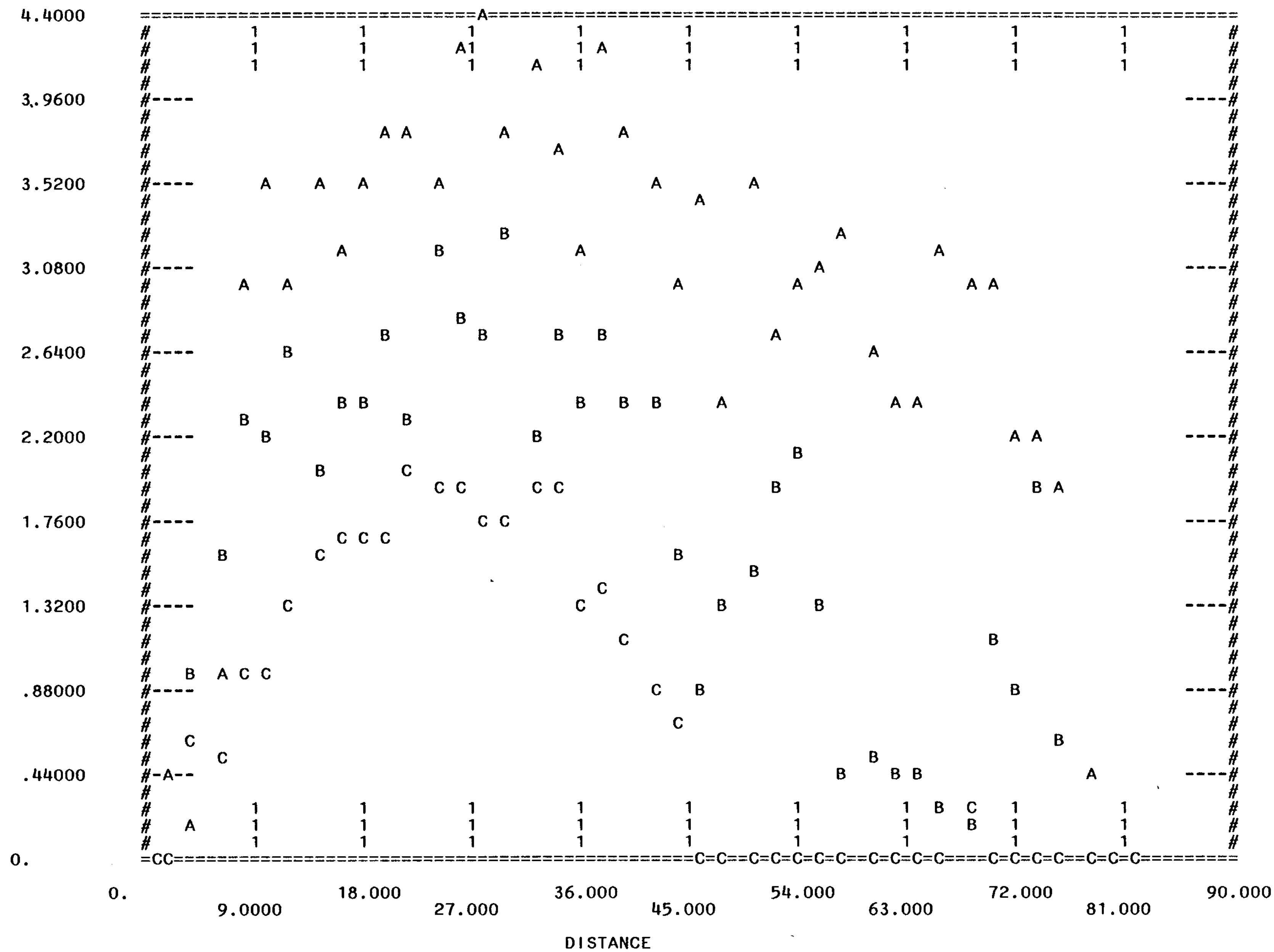
GRAPH 5



VELOCITY ACROSS CHANNEL FOR TRANSECT 0.00 Q = 40.90

WILLIAMS FORK RIVER SECTION 1 ** COLORADO/NEHRING **ONE MILE BELOW KINNEY CREEK CONFLUENCEIFG4 DATA

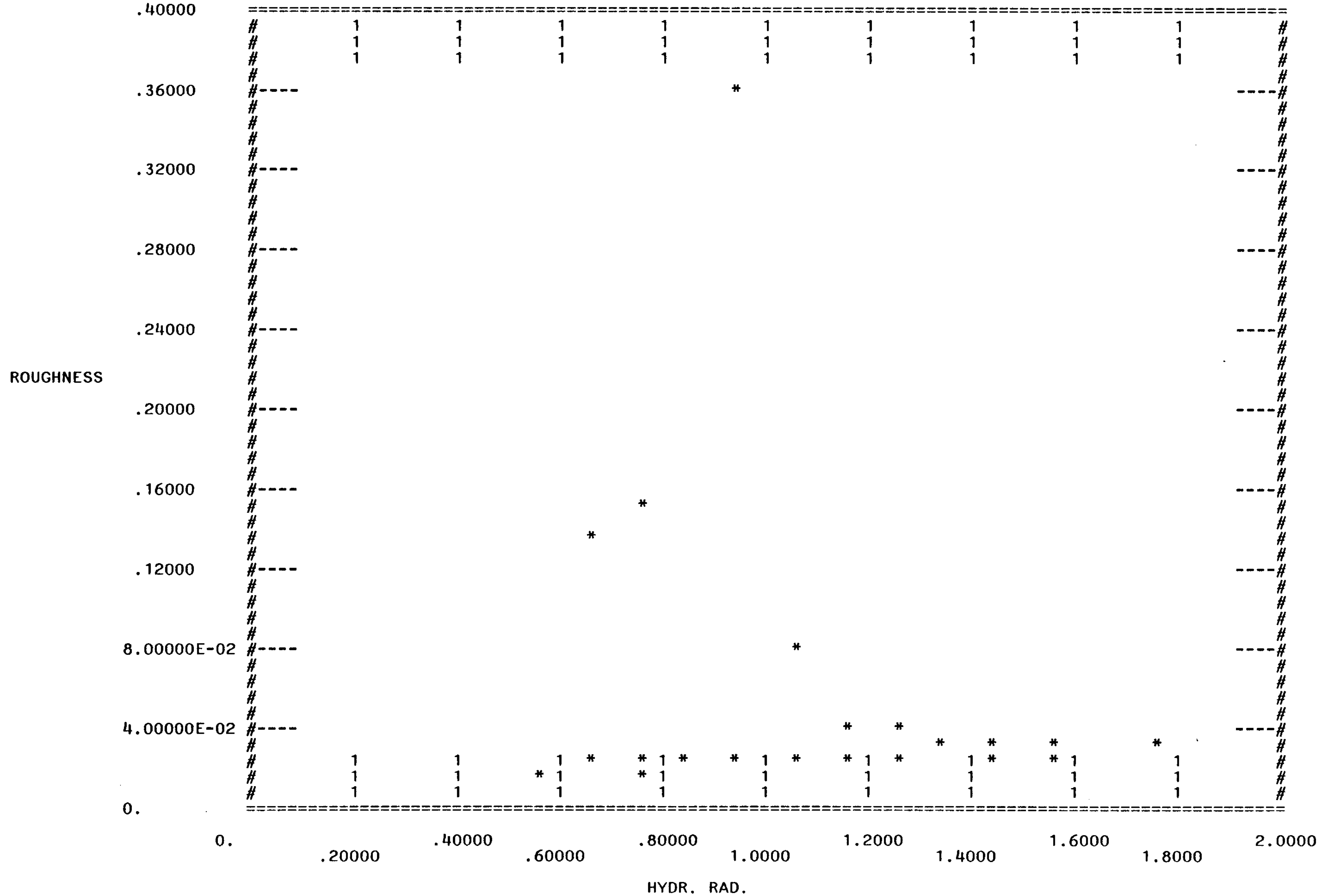
GRAPH 6



VELOCITY ACROSS CHANNEL FOR TRANSECT 0.00

WILLIAMS FORK RIVER SECTION 1 ** COLORADO/NEHRING **ONE MILE BELOW KINNEY CREEK CONFLUENCEIFG4 DATA

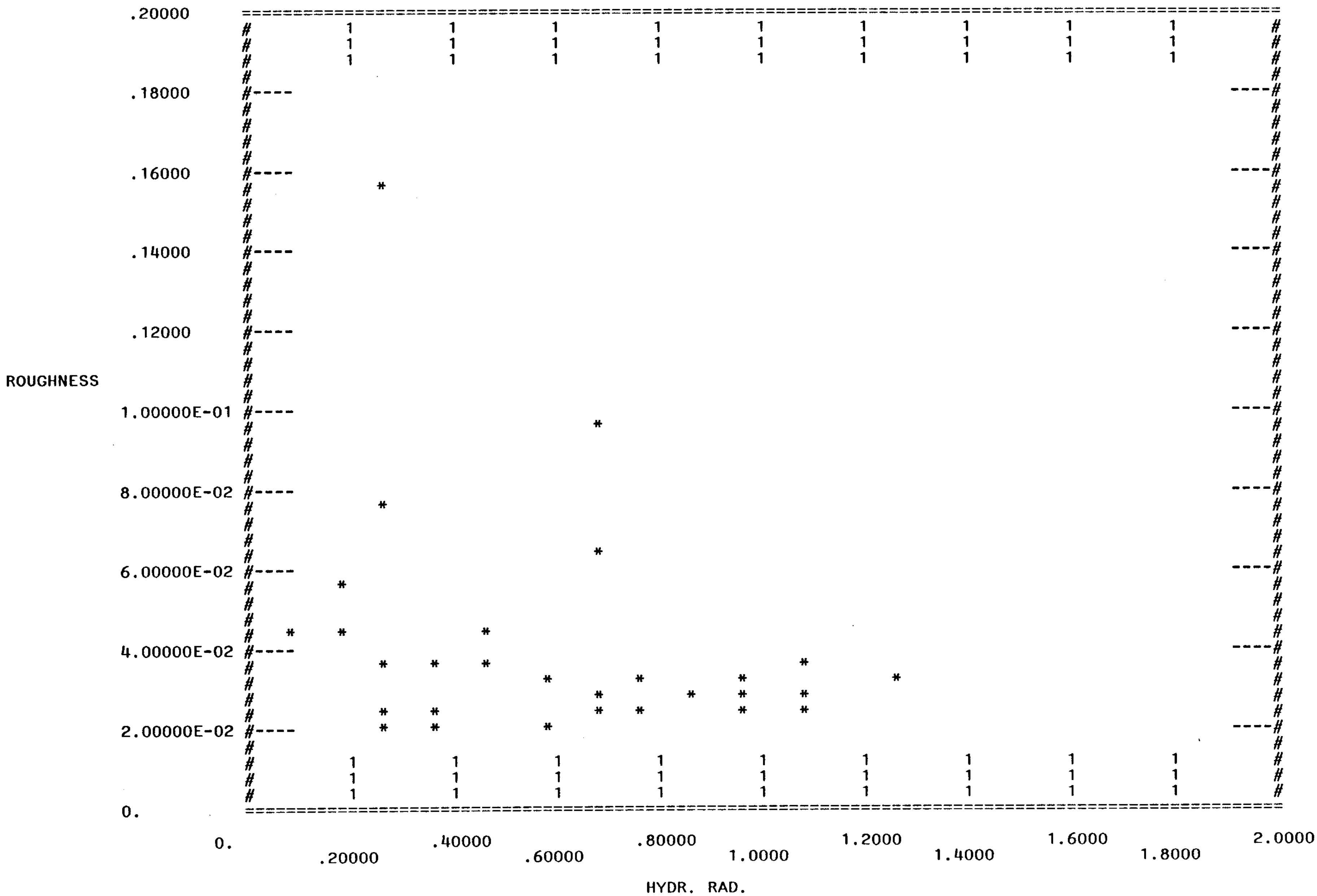
GRAPH 7



R-N PLOT FOR TRANSECT 0.00 Q = 263.00

WILLIAMS FORK RIVER SECTION 1 ** COLORADO/NEHRING **ONE MILE BELOW KINNEY CREEK CONFLUENCEIFG4 DATA

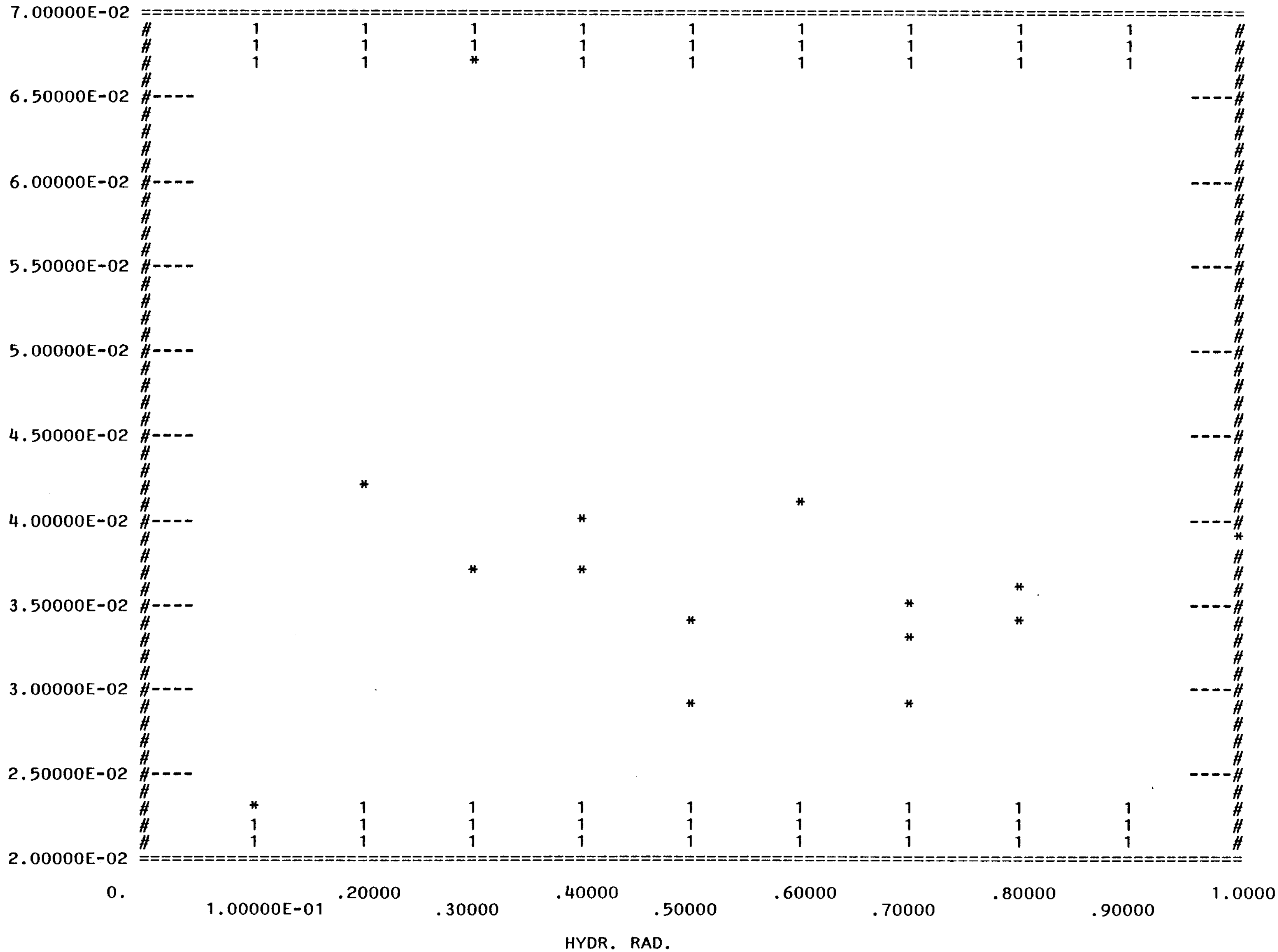
GRAPH 8



R-N PLOT FOR TRANSECT 0.00 Q = 111.00

WILLIAMS FORK RIVER SECTION 1 ** COLORADO/NEHRING **ONE MILE BELOW KINNEY CREEK CONFLUENCEIFG4 DATA

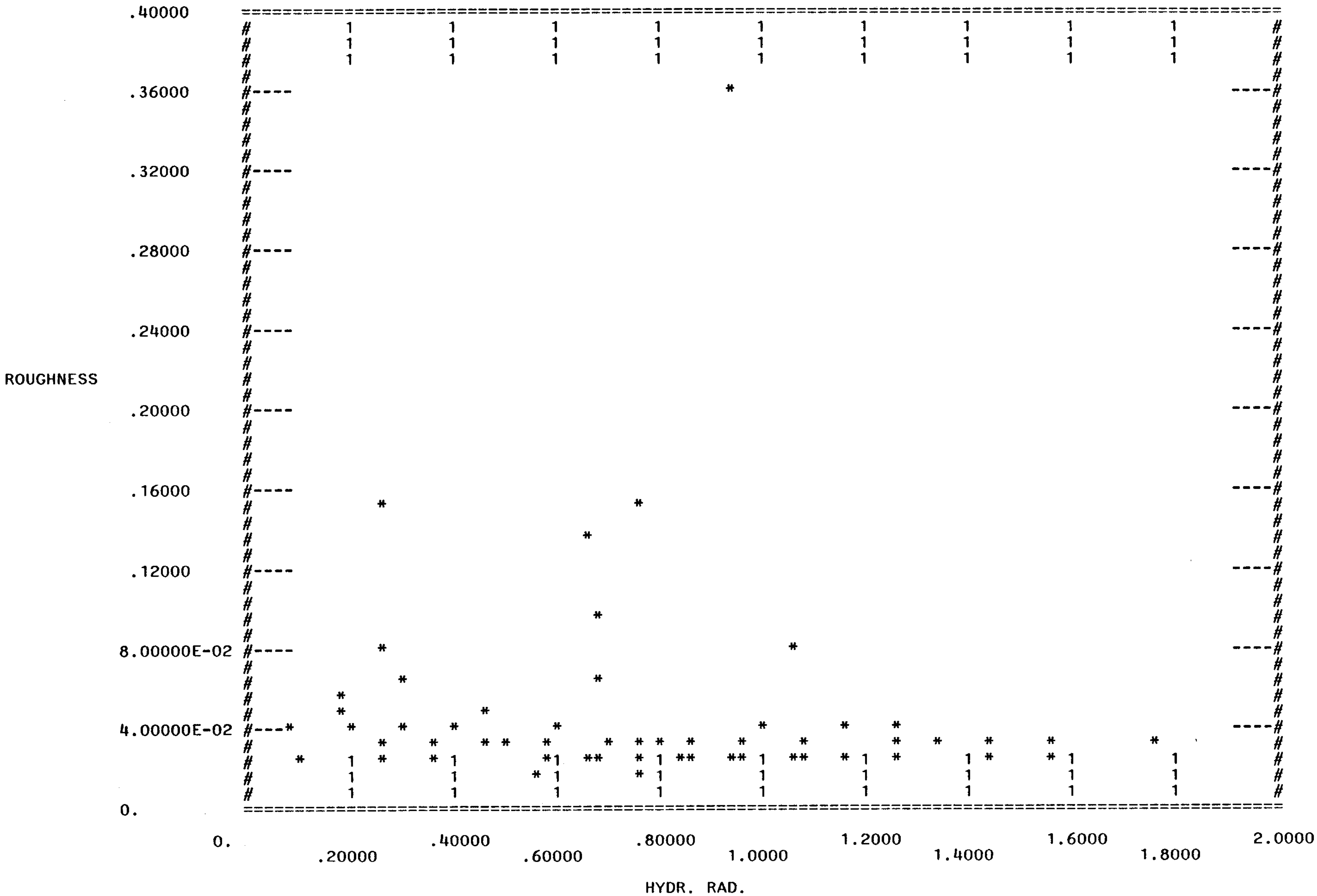
GRAPH 9



R-N PLOT FOR TRANSECT 0.00 Q = 40.90

WILLIAMS FORK RIVER SECTION 1 ** COLORADO/NEHRING **ONE MILE BELOW KINNEY CREEK CONFLUENCEIFG4 DATA

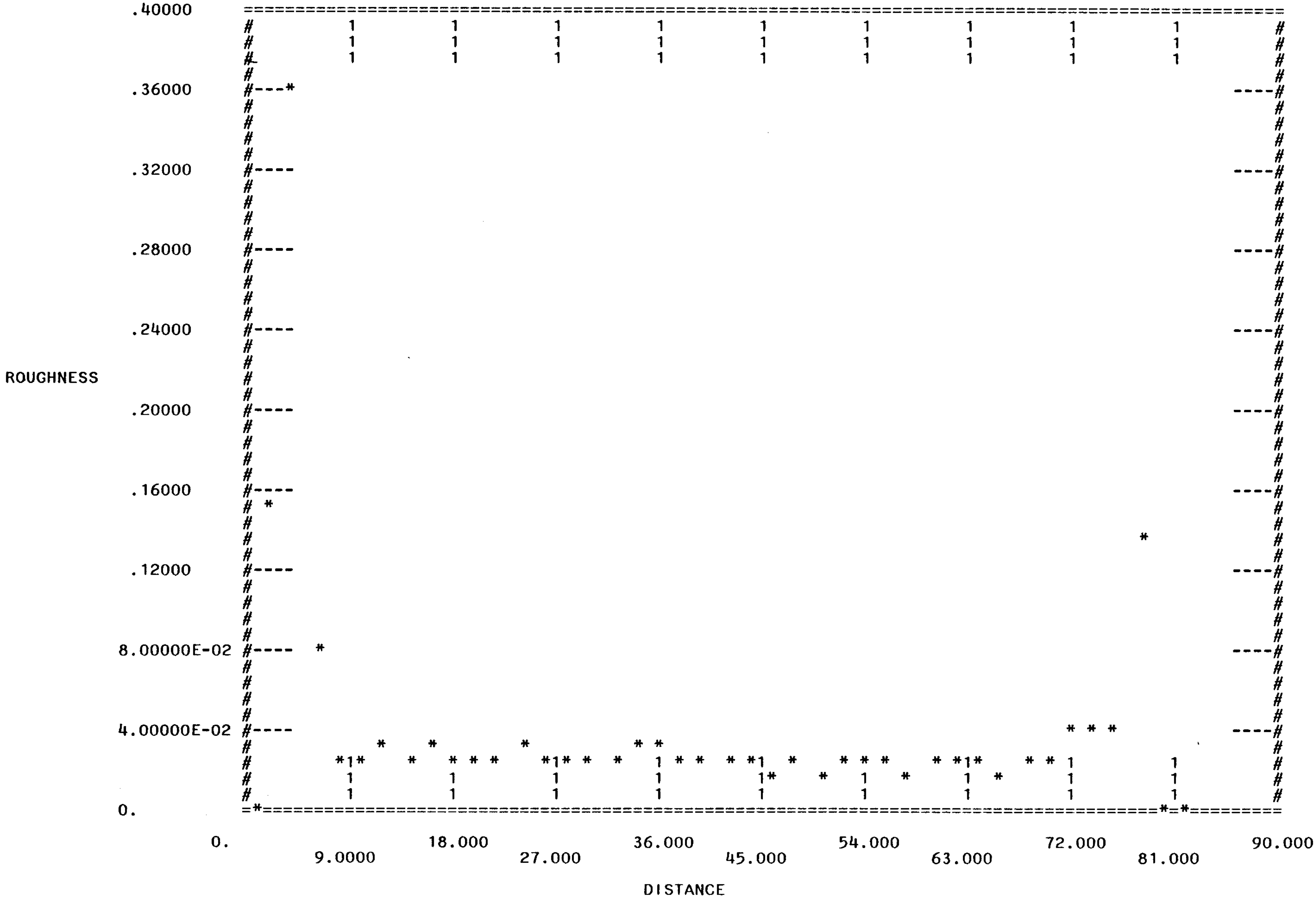
GRAPH 10



R-N RELATIONSHIP FOR TRANSECT 0.00 (ALL SETS)

WILLIAMS FORK RIVER SECTION 1 ** COLORADO/NEHRING **ONE MILE BELOW KINNEY CREEK CONFLUENCEIFG4 DATA

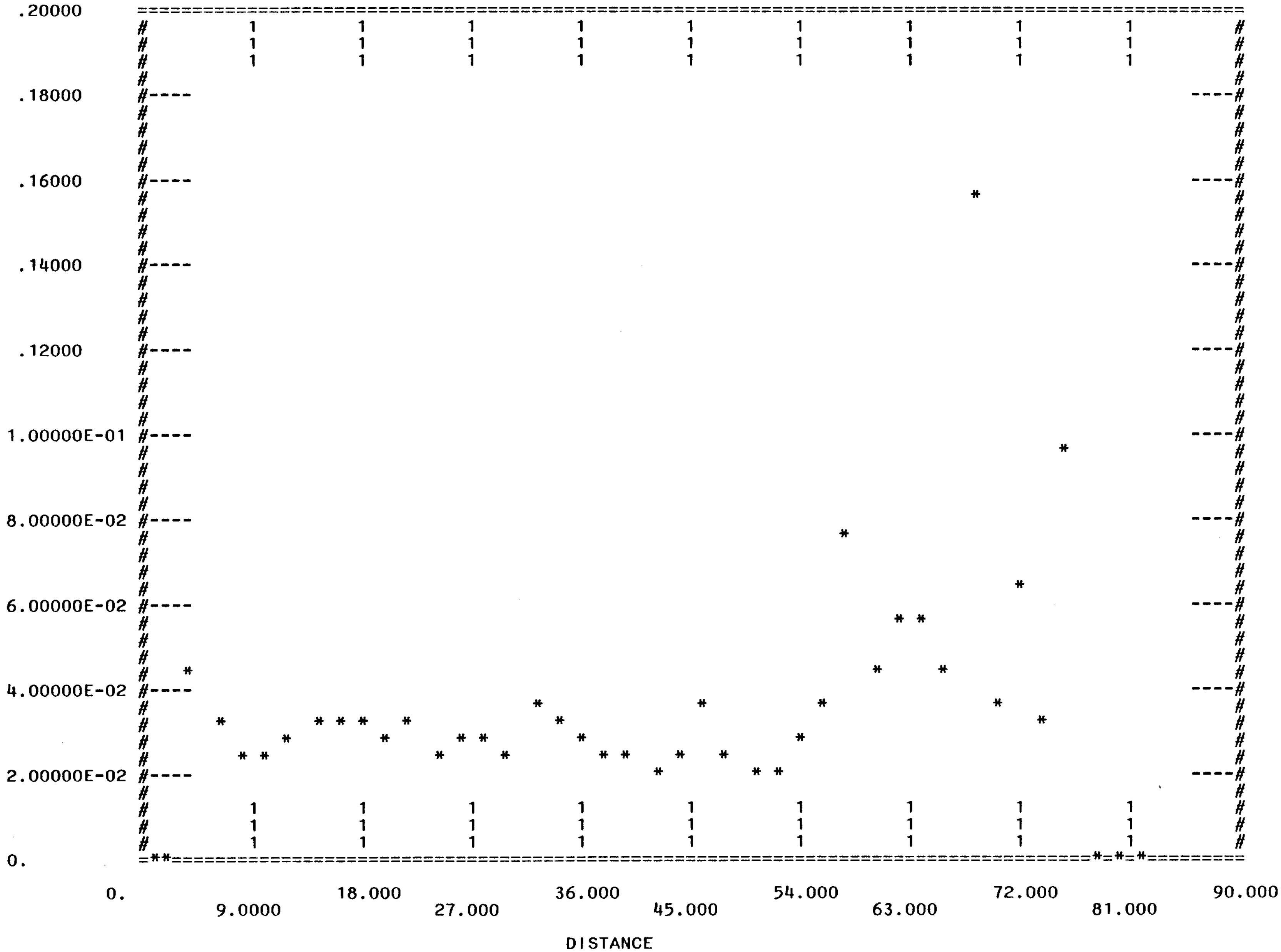
GRAPH 11



ROUGHNESS IN CHANNEL FOR TRANSECT 0.00 Q = 263.00

WILLIAMS FORK RIVER SECTION 1 ** COLORADO/NEHRING **ONE MILE BELOW KINNEY CREEK CONFLUENCEIFG4 DATA

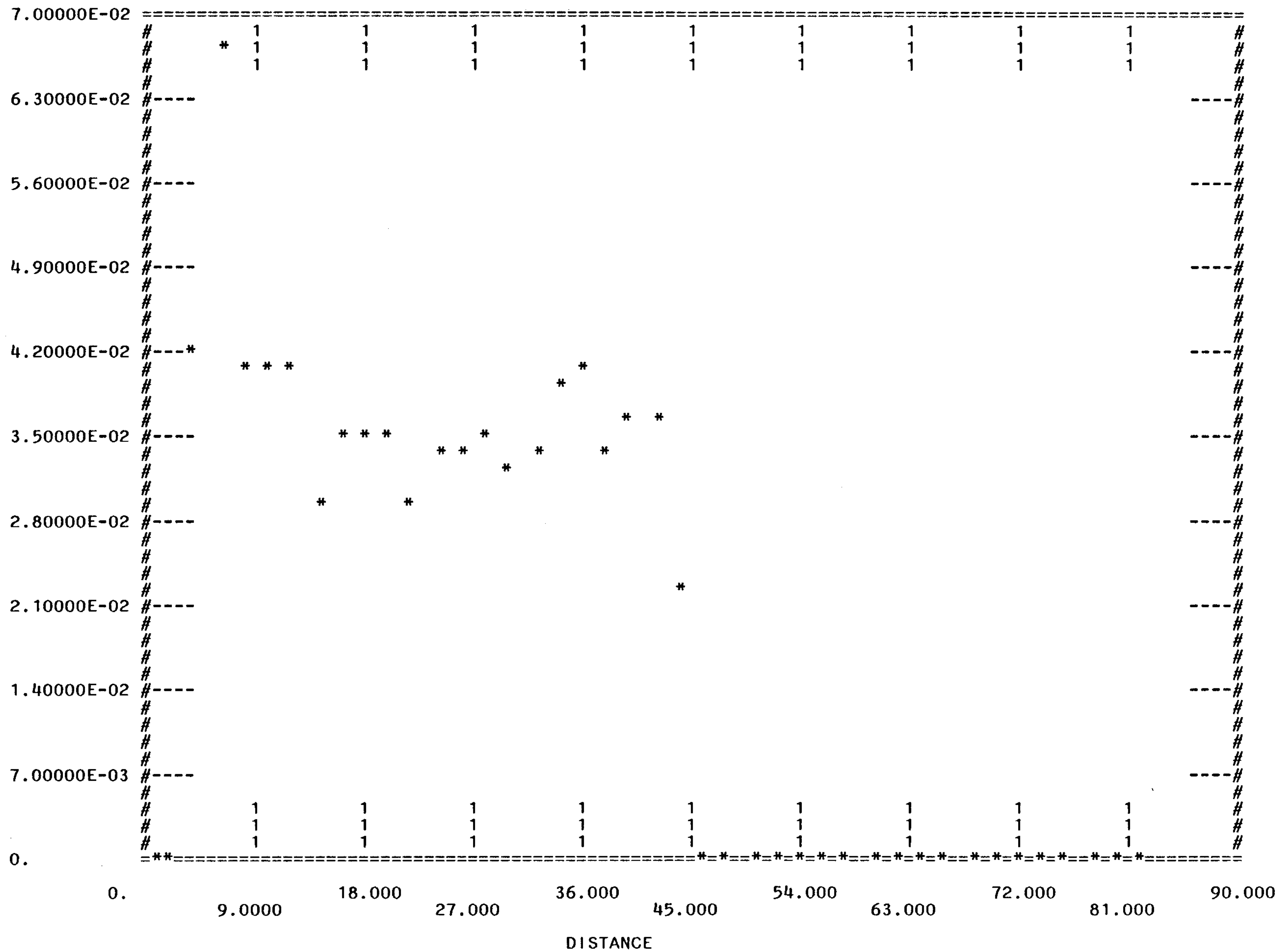
GRAPH 12



ROUGHNESS IN CHANNEL FOR TRANSECT 0.00 Q = 111.00

WILLIAMS FORK RIVER SECTION 1 ** COLORADO/NEHRING **ONE MILE BELOW KINNEY CREEK CONFLUENCEIFG4 DATA

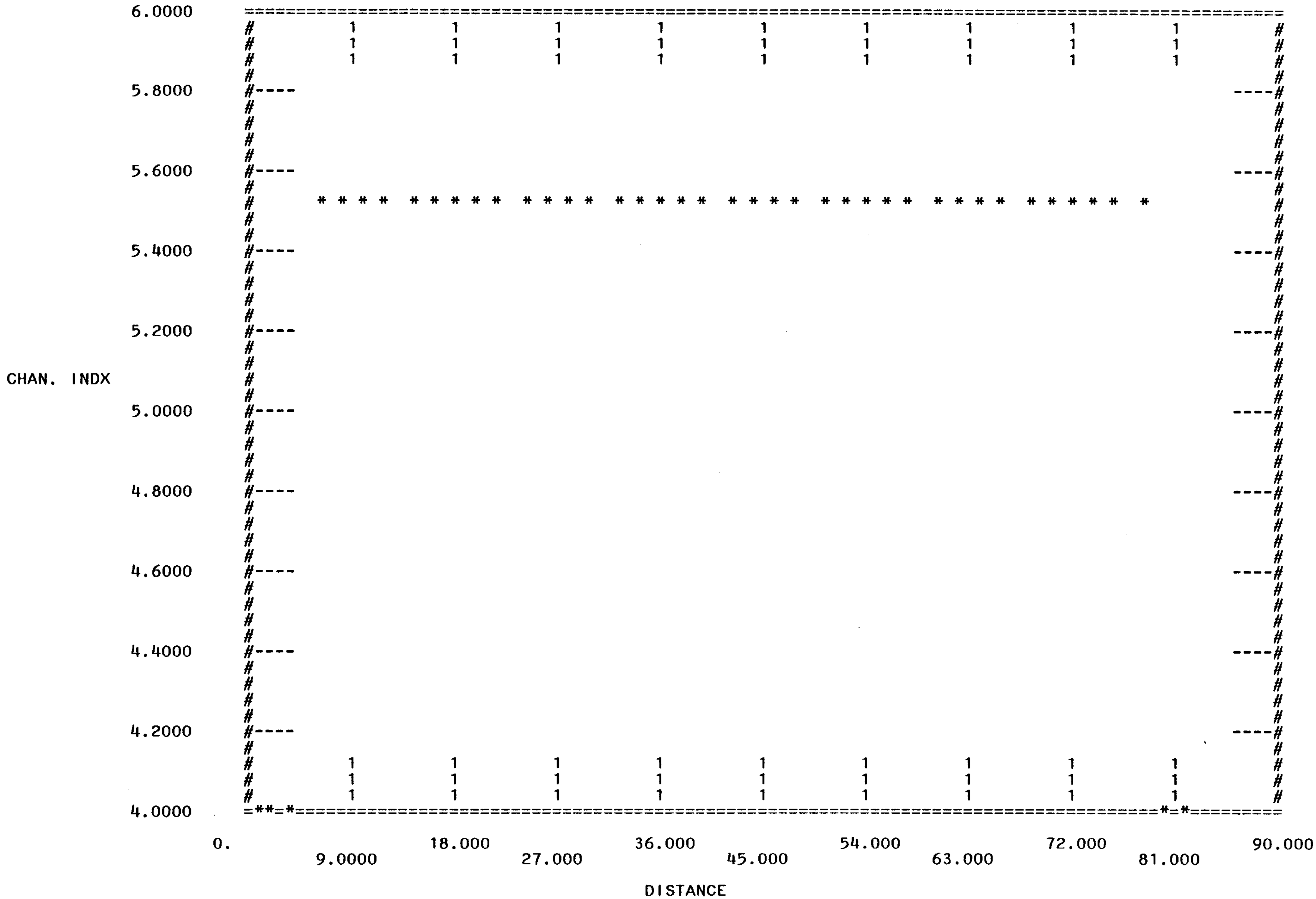
GRAPH 13



ROUGHNESS IN CHANNEL FOR TRANSECT 0.00 Q = 40.90

WILLIAMS FORK RIVER SECTION 1 ** COLORADO/NEHRING **ONE MILE BELOW KINNEY CREEK CONFLUENCEIFG4 DATA

GRAPH 14



CHANNEL INDEX FOR TRANSECT 0.00

WILLIAMS FORK RIVER SECTION 1 ** COLORADO/NEHRING **ONE MILE BELOW KINNEY CREEK CONFLUENCEIFG4 DATA

PHABSIM TECHNICAL NOTE NO. 15
THE HABSP PROGRAM FOR HABITAT SIMULATION

by
Robert T. Milhous
Hydraulic Engineer

The purpose of this HABSP program is to allow the calculation of physical habitat considering the conditions at two streamflows and/or for two life stages (or species) of fish. The program uses two TAPE13's created by the HABTAT program.

The options available are:

1. Union of life stage 1 with life stage 2.

2. Minimum habitat given two streamflows.

3. Competition analysis for two life stages or species.

4. Maximum habitat given two streamflows.

5. Minimum of life stage 1 and life stage 2.

6. Maximum of life stage 1 and life stage 2.

Option 5 is similar to option 2 and option 6 is similar to option 4 except only one streamflow is considered.

The union of two life stages is useful when one is interested in the total habitat for a combination of, say, brown and rainbow trout. In contrast, the competition analysis would show where brown and rainbow trout compete for space.

An example of where minimum habitat analysis is useful for two streamflows is where there is a "base" flow assessment with a project subject to rapid changes in streamflows. The question is: Given the base flow - how much habitat remains for the peak flow?

An example of where maximum habitat analysis is, for example, the case of a desire of knowing the total spawning habitat given a range of streamflows.

An example of a minimum habitat analysis is given in Figure 1 and of a maximum habitat analysis in Figure 2. The information in Table 1 illustrates the types of information available from a minimum habitat analysis.

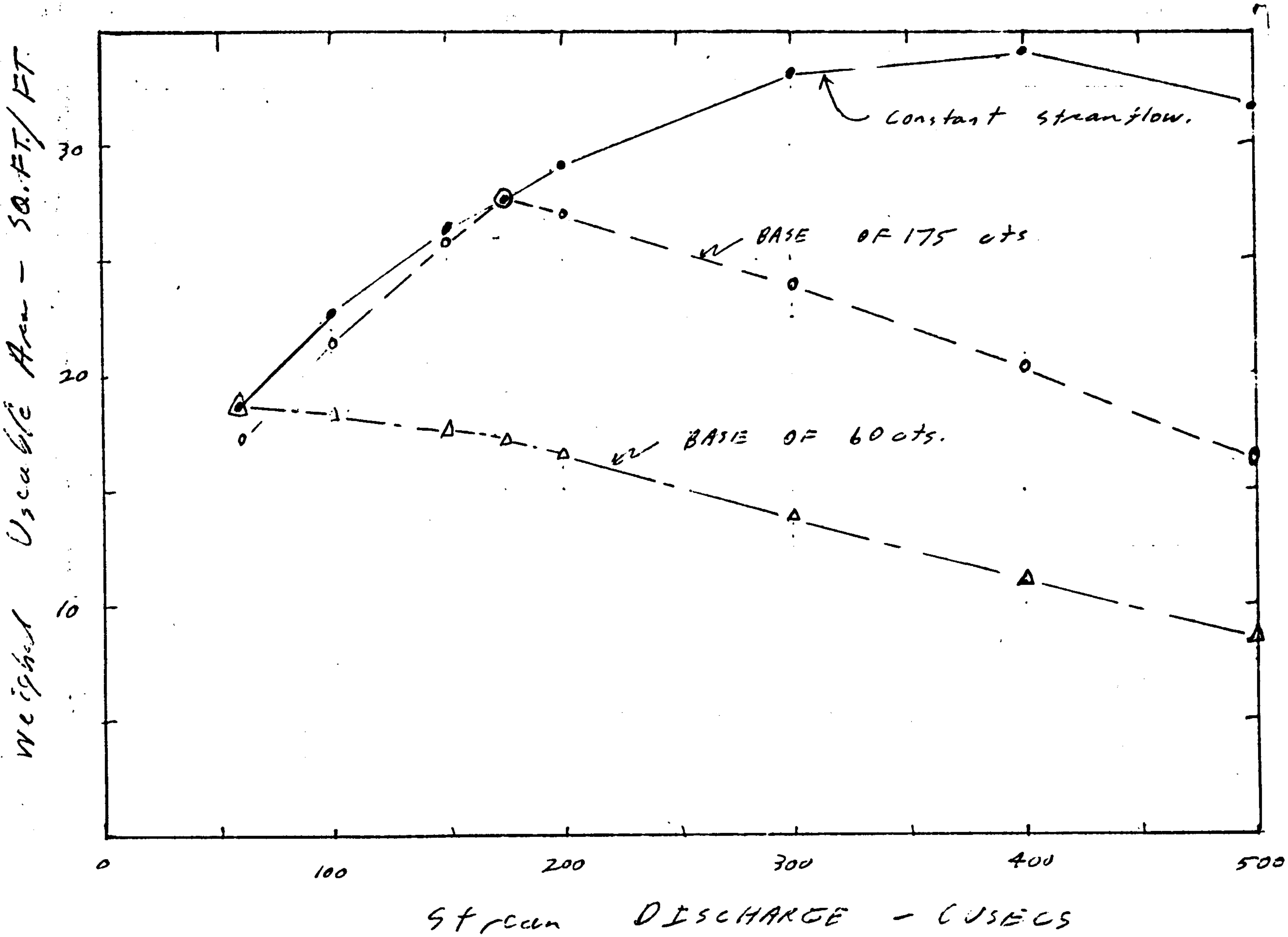


Figure 1. Impact of short term variations in streamflow on spawning habitat of pink salmon in Terror River, Alaska.

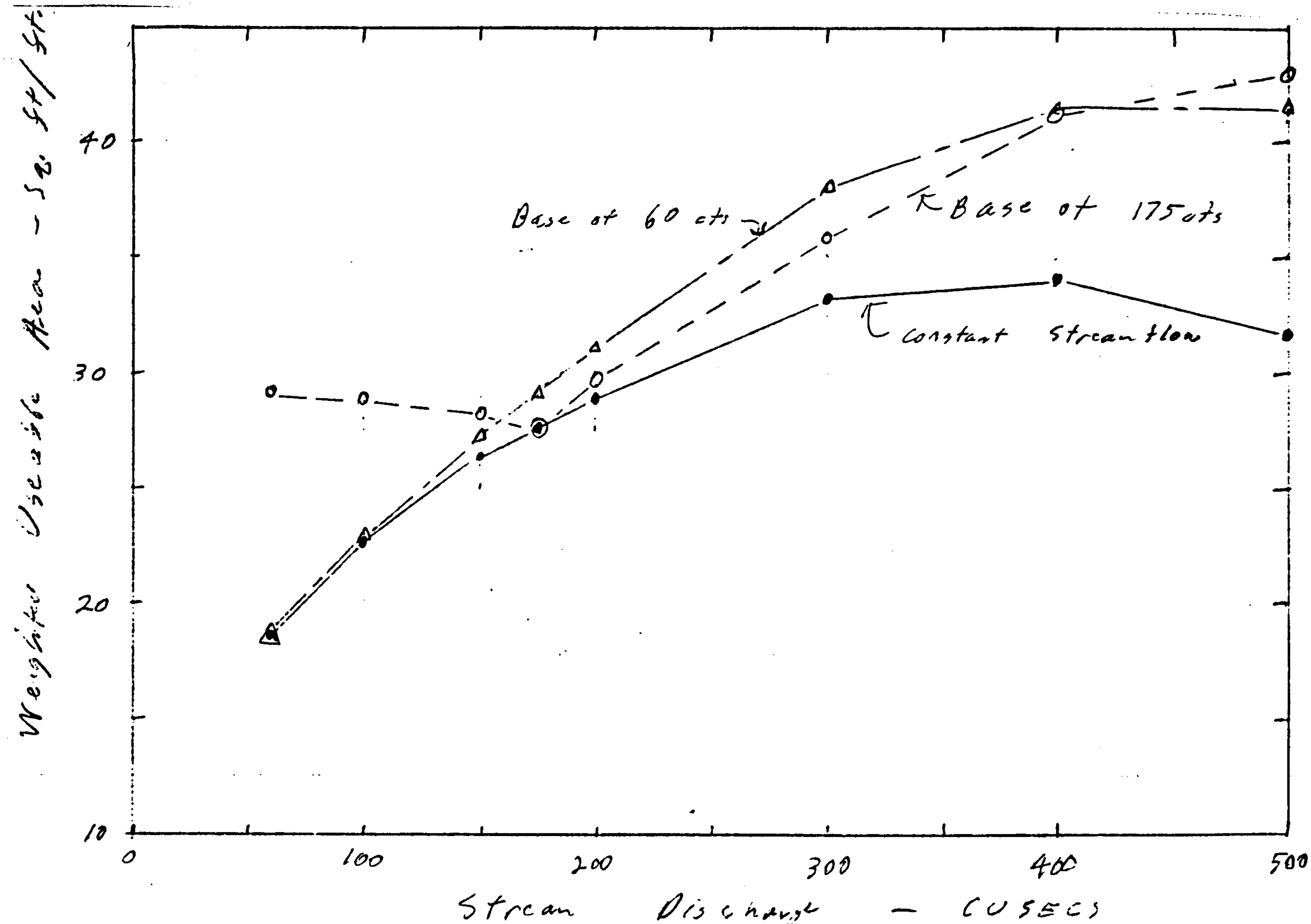


Figure 2. Impact of long term variations in streamflow on spawning habitat of pink salmon in Terror River, Alaska.

Table 1. Physical habitat in the Williams Fork River for an adult brown trout and a base flow of 15 cfs.

Discharge (cfs)	Steady state (sq/feet x 100) Weighted usable area	Usable area	Total area	Composite weighed usable area for baseflow of 15 cfs
10	1098	2586	8767	1071
15	1332	2848	8814	1332
20	1499	3256	9747	1325
30	1590	1438	10720	1190
40	1632	4979	11834	1100
60	1745	6538	14054	987
80	1778	7339	15593	847
100	1758	7899	16294	756
200	1749	11419	18848	555
250	1778	12836	19334	506
300	1844	14240	19377	472
400	1828	16005	19449	413
500	1833	15616	19511	360
700	1903	12804	19711	309
800	1867	11309	19783	292
900	1800	10221	19799	278
1000	1738	9275	19809	266
1250	1596	7932	19820	250
1500	1577	7204	19828	240

The program may be used with the following commands after PHABSIM is a local file:

```
LDSET,LIB= PHABSIM
HABSP,T13A,T13B,OUT
```

T13A is the TAPE13 from HABTAT for one life stage, and T13B is the TAPE13 for the second life stage. For a minimum or maximum habitat analysis T13 may be a copy of T13A.

PHABSIM TECHNICAL NOTE NO. 16

USE OF THE HABTAV PROGRAM FOR PHYSICAL HABITAT SIMULATION

by

Laure A. Pawenska
Applications Programmer

26 August 1985

INTRODUCTION

A new microhabitat simulation program, HABTAV, is available as an alternative to the current PHABSIM HABTAT model. HABTAV was developed to simulate situations where fish habitat is determined by hydraulic parameters at the fish's location, as well as by velocities near the fish.

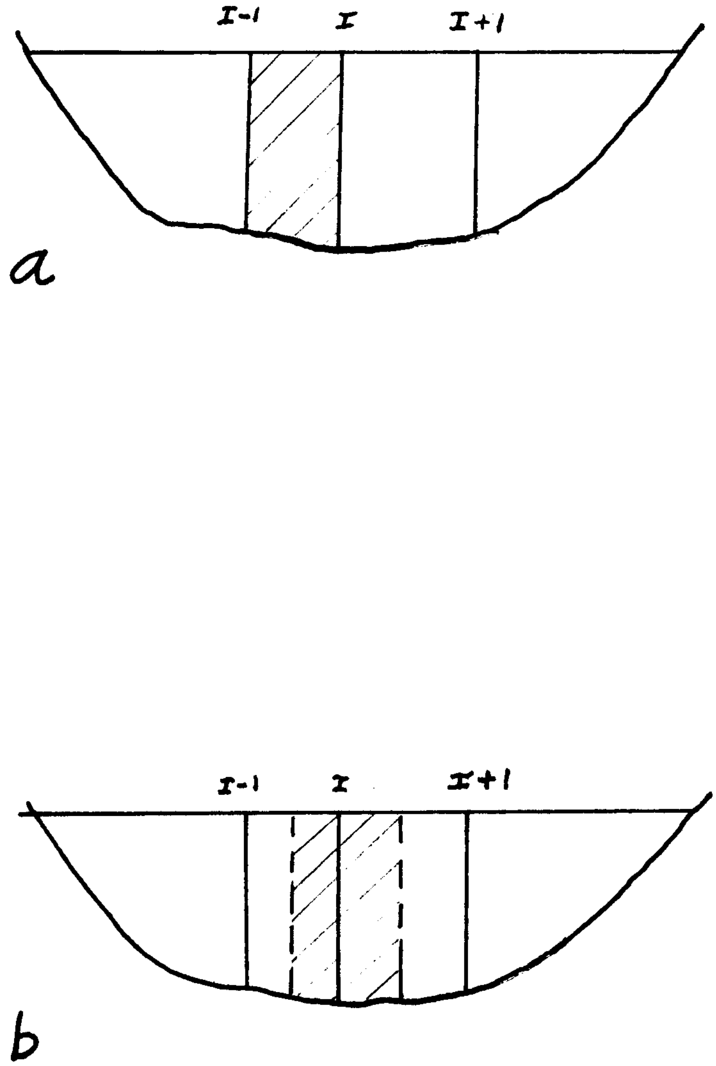
This note presents the HABTAV program, and its use in conjunction with other new and existing PHABSIM programs including DIRI4A, LSTVDA, and IFG4.

PROGRAM DESCRIPTION

The logic of the HABTAV program is similar to that of HABTAT (see Instream Flow Information Paper 11) with 2 major exceptions, the first being cell definition. The HABTAT Program calculates weighted useable area (WUA) by summing area of cells whose boundaries are defined by 2 measured verticals. In the new HABTAV program, cells are defined by 1 measured vertical located at the center of the cell. Figure 1 illustrates the difference in cell definition between HABTAT and HABTAV.

The values of stream characteristics (depth, velocity, and channel index) for each program are determined by this cell definition. The HABTAT program assumes the value of the depth and velocity for a cell is the average of the values measured at boundaries of the cell; the Channel Index is determined by the value of the vertical defining the right side of the cell. On the other hand, the new HABTAV program assumes that the value of the velocity, depth, and channel index, at the measured vertical (center of the cell) is the value for the entire cell.

The second major difference between HABTAT and HABTAV is the different new options available in HABTAV. As in the current HABTAT, the new program calculates WUA using functions of velocity, depth, and channel index. HABTAV then scans (with option 1 on) the cross section a distance, DIST (specified by user), out from cell of interest for a velocity, VLIM (specified by user), in adjacent cells. If the velocity, VLIM, is found within distance, DIST, the WUA calculated for the cell is multiplied by 1. If VLIM is not found, HABTAV can scan (with option 5 on) the cross section a second time for an initial



Area of cell (I) is shaded.

Figure 1. The way a cell as viewed by (a) The HABTAT program and (b) the HABTAV program

velocity, VO. This initial velocity is the first velocity where fish habitat is worth more than 0. HABTAV searches for a velocity between VO and VLIM, closets to VLIM and then interpolates a worth for this velocity between 0 and 1. This worth is multiplied by WUA, for a new value. If option 5 is off, and VLIM is not found, WUA is multiplied by 0.

USE OF HABTAV WITH OTHER PROGRAMS

The HABTAV program can be used with input from DIRI4A or IFG4. Unlike HABTAT, HABTAV does not run with a direct input file. DIRI4A is also a new PHABSIM program. DIRI4A works with HABTAV as DIR14 works with HABTAT. DIRI4A takes an IFG4 input deck and creates a TAPE3 and TP4 in the format needed by HABTAV.

A new option, IOC(17), has been added to the existing IFG4 program. When option 17 is on, IFG4 creates TAPE3 and TP4 in HABTAV format rather than HABTAT.

These are the only 2 ways currently available to create TAPE3 and TP4 as input to HABTAV. As for running the HABTAT program, an input file and FISHFIL are needed to run HABTAV. Refer to the next section for information about the input file.

LSTVDA is another new PHABSIM program available for use with the HABTAV program. Like LSTVD, it lists velocities, depths, and cross section data on

TAPE3 and TAPE4. LSTVDA uses TAPE3 and TAPE4 created by DIRI4A or IFG4 (IOC(17)=1).

INPUT/OUTPUT FILES

Input file for the HABTAV program is similar to that for HABTAT except for cards needed for the new options.

Input Card Format/Stacking Order

Short Form:

No. of Cards	Description
1	Input/Output Control Card (IOC)
1	HEADER Card
Varies	NOSE velocity card (IOC(6)on or (IOC(14)on)
Varies	CURVES cards
Varies	DIST cards (IOC(1)on)
Varies	VLIM cards (IOC(1)on)
Varies	VO cards (IOC(5)on)

Long Form is the same as the short form with curve definition input added to the bottom of the file. Refer to section 5 in IFG Information Paper 11 about curve definition input.

Input/Output Control Card (IOC)

The IOC Card is used to control various input/output options by the data entered in Columns 11-24 on this card. Each column is allocated to a specific control. The setting for control 1 is in Column 11, for control 2 in Column 12, and so on. Typical settings are 0 for off and 1 for on. The options controlled on this care are discuccsed in the HABTAT options section.

COLUMNS	DESCRIPTION	IMPLIED DECIMAL PT. TO RT. OF COLUMN
1-3	Always punched as "IOC"	
4-10	Not used	-
11-24	Control settings punched on per column. The setting for control 1 is punched in column 11 (integer)	-
24-80	Not used	-

HEADER Card

The HEADER card is used to indicate how many life stages are to be processed per run (up to 40 may be processed).

Columns	Description
1-6	Always punched as "HEADER"
4-10	Not used
11-12	Number of life stages to be processed (Integer)
13-80	Not used

NOSE card (Point Velocity Used with IOC(14) or IOC(6)

Nose Cards are used to determine if mean velocity or point velocity (a specific distance form the stream bed) of the cell is used for the hydraulic simulation. The user can chose from one of four values for IOC 14. Value 0 is the mean velocity, and Values 1, 2, and 3 allow different equations to be used for determining the point velocity.

Value 0 uses the mean velocity of the cell.

Value 1 uses the following equation to determine the point velocity:

$$N = A\bar{V}\left(\frac{DN}{D}\right)^{B} \qquad V(2)$$

where:

N	=	nose velocity of the cell
A and B	=	user defined calibration parameter
V	=	mean velocity of the cell
DN	=	nose depth for species in question
D	=	stream depth of the cell

The user has to supply the nose depth for which a velocit is to be calculated, and the calibration parameters A and B.

Value 2 uses the 1/7th power law equation, and only the nose depth needs to be supplied.

Value 3 uses the logarithmic velocity distribution equation. The nose depth and the D65 of the bed material must be provided to the program by the user.

The A, B, DN, and D65 values are all real, with a decimal point included.

COLUMNS	DESCRIPTION	IMPLIED DECIMAL PT. TO RT. OF COLUMN
1-4	"NOSE"	
11-20	Nose depth DN	18
21-30	"A" parameter for IOC 14 = 1, blank for IOC 14 = 2. D65 of bed material for IOC 14 = 3	28
31-40	"B" parameter for IOC 14 = 1 blank for IOC 14 = 2 or 3	38
41-80	Not used	-

DIST Cards

The DIST card is used to indicate the distance out from the cell that will be searched for maximum or minimum velocity in adjacent cells. The number of DIST cards should correspond to the number of CURVES Cards.

Columns	Description
1-4	Always punched as "DIST"
5-10	Not used
11-17	Distance in feet (real, 2 decimals)
18-24	Distance in feet (real, 2 decimals)
25-31	Distance in feet (real, 2 decimals)
32-38	Distance in feet (real, 2 decimals)
39-45	Distance in feet (real, 2 decimals)
46-52	Distance in feet (real, 2 decimals)
53-59	Distance in feet (real, 2 decimals)
60-66	Distance in feet (real, 2 decimals)
67-73	Distance in feet (real, 2 decimals)
74-80	Not Used

VLIM Cards

The VLIM Cards indicate what maximum or minimum velocity should be searched for. The number of VLIM cards should correspond to the number of CURVES cards.

Column	Description
1-4	Always punched as "VLIM"
5-10	Not used
18-17	Mean Column Velocity (real, 2 decimals)
25-31	Mean Column Velocity (real, 2 decimals)
32-38	Mean Column Velocity (real, 2 decimals)
39-45	Mean Column Velocity (real, 2 decimals)
46-52	Mean Column Velocity (real, 2 decimals)
53-59	Mean Column Velocity (real, 2 decimals)
60-66	Mean Column Velocity (real, 2 decimals)
67-73	Mean Column Velocity (real, 2 decimals)
74-80	Not used

VO Cards

VO Cards are used to enter the first velocity where fish habitat becomes worthless (0). Again, the number of VO Cards should match the number of CURVES cards.

Column	Description
1-2	Always punched as "NO"
3-10	Not used
11-17	Mean Column Velocity (real, 2 decimals)
18-24	Mean Column Velocity (real, 2 decimals)
25-31	Mean Column Velocity (real, 2 decimals)
32-38	Mean Column Velocity (real, 2 decimals)
39-45	Mean Column Velocity (real, 2 decimals)
46-52	Mean Column Velocity (real, 2 decimals)
53-59	Mean Column Velocity (real, 2 decimals)
60-66	Mean Column Velocity (real, 2 decimals)
67-73	Mean Column Velocity (real, 2 decimals)
74-80	Not used

Please refer to Appendix A for examples of two sample input files (WILHAB1 and WILHAB2). WILHAB2 is an example with scanning (IOC(1))off. WILHAB1 has IOC(1) and IOC(5) on.

Output file for HABTAV is also set up similar to output from HABTAT. Changes were made for adding new options and where changes were made for ease of reading. See Appendix B for two example output files (HBTV 1 and HBTV5) which correspond to the two input files in Appendix A. When option 4 is turned on to print out computational details, the format is different in HABTAV than was for HABTAT.

HABTAV OPTIONS

Table 1 describes the options available in the HABTAV program. Compare it to Table V.1 in IFG Info Paper 11 for differences between HABTAT and HABTAV.

Table 1. options in the HABTAV Program.

Column	Control	Value	Action
11	1	0	Does not scan a distance (DIST) for velocity (VLIM) in adjacent cells
		1	Scans a distance (DIST) for velocity ≥ VLIM in adjacent cells
		2	Scans a distance (DIST) for velocity ≤ VLIM in adjacent cells
12	2	0	Do not print cross section information
		1	Print cross section and channel index information.
13	3	0	Do not print flow related data.
		1	Print flow related data.
14	4	0	Do not print computation details
		1	Print computation details
15	5	0	If VLIM is not found in adjacent cells, multiply WUA * 0
		1	If VLIM is not found in adjacent cells, scan for velocity closest to VLIM, between VO and VLIM.
16	*6	0	Scan adjacent cells for mean column velocity.
		1	Scan adjacent cells for nose velocity. User defined equation based on 1/7th power law.
		2	Scan adjacent cells for nose velocity. Uses 1/7th power law equation.
		3	Scan adjacent cells for nose velocity. Uses logarithmic velocity distribution equation.

Table 1 continued.

Column	Control	Value	Action
17	7	0	
		1	
18	8		Not used
19	9	0	Standard calculation of habitat area
		1	Geometric mean
		2	Lowest limiting parameter
		3	User defined calculation
20	10	0	No print of habitat area as a % of total area.
		1	Print habitat area as a % of total area (Habitat Suitability Index)
21	11		Not used
22	12	0	Use reach as rectangels in plan view
		1	Use reach as trapezoids - used to describe bends
23	13	0	Interface file not written on Tape 13
		1	Write interface file on TAPE 13, which may be used in subsequent programs (not functioning at this time).
24	*14	0	Use mean velocity for cell
		1	Use no velocity for cell. User defined equation based on 1/7th power law
		2	Use nose velocity for cell. Uses 1/7th power law equation
		3	Use nose velocity for cell. Uses logarithmic velocity distribution equation.

*If both IOC14 and IOC6 are not equal to 0 , they must be the same value.

APPENDIX A

EXAMPLE INPUT FILES

```
FILE NAME - WILHAB1                        85/09/11.   13.31.08.                PAGE    1

  1        IOC         11101000010000000000
  2        HEADER        3
  3        CURVES      -11100    11102    11302
  4        DIST           -1.00    10.00    12.00
  5        VLIM            0.00    -2.20     3.00
  6        VO              0.00     2.20     1.00
  7        H  11100 22 20 25 22  RAINBOW TROUT                                      FRY      82/08/06
  8        V  11100  0.00   .06   .10   .18   .15   .24   .20   .39   .25   .88   .30   .96
  9        V  11100   .40  1.00   .60  1.00   .70   .95   .75   .86   .80   .81   .90   .75
 10        V  11100  1.05   .70  1.25   .63  1.50   .56  1.65   .49  1.80   .38  2.00   .26
 11        V  11100  2.20   .14  2.40   .06  2.65  0.00100.00  0.00
 12        D  11100  0.00  0.00   .20  0.00   .40   .15   .50   .30   .60  1.00   .90  1.00
 13        D  11100  1.00   .98  1.10   .88  1.30   .60  1.50   .40  1.60   .33  1.70   .27
 14        D  11100  1.90   .19  2.10   .13  2.40   .08  2.70   .03  3.00   .02  5.00   .02
 15        D  11100  6.00   .02100.00   .02
 16        S  11100  0.00  0.00  1.00  0.00  4.00   .02  4.20   .03  4.30   .04  4.50   .08
 17        S  11100  4.60   .12  4.70   .22  4.90   .98  5.00  1.00  5.10   .96  5.20   .76
 18        S  11100  5.30   .64  5.40   .58  5.60   .46  5.80   .37  6.00   .30  6.30   .22
 19        S  11100  6.80   .11  7.00   .07  7.20   .05  7.50   .03  8.50   .01  9.00  0.00
 20        S  11100100.00  0.00
 21        T  11100  0.00  0.00 32.00  0.00 34.00   .12 35.00   .20 36.00   .28 37.00   .36
 22        T  11100 38.00   .50 40.00   .64 41.00   .70 44.00   .82 47.00   .90 49.00   .94
 23        T  11100 55.00  1.00 66.00  1.00 69.00   .96 70.00   .86 71.00   .50 72.00   .28
 24        T  11100 73.00   .14 74.00   .06 75.00  0.00100.00  0.00
```

```
 1          IOC         011000000010000000000
 2          HEADER        3
 3          CURVES      -11100    11102    11302
 4          H  11100 22 20 25 22 RAINBOW TROUT                                     FRY      82/08/06
 5          V  11100  0.00   .06   .10   .18   .15    .24   .20   .39   .25   .88   .30   .96
 6          V  11100   .40  1.00   .60  1.00   .70    .95   .75   .86   .80   .81   .90   .75
 7          V  11100  1.05   .70  1.25   .63  1.50    .56  1.65   .49  1.80   .38  2.00   .26
 8          V  11100  2.20   .14  2.40   .06  2.65   0.00100.00  0.00
 9          D  11100  0.00  0.00   .20  0.00   .40    .15   .50   .30   .60  1.00   .90  1.00
10          D  11100  1.00   .98  1.10   .88  1.30    .60  1.50   .40  1.60   .33  1.70   .27
11          D  11100  1.90   .19  2.10   .13  2.40    .08  2.70   .03  3.00   .02  5.00   .02
12          D  11100  6.00   .02100.00   .02
13          S  11100  0.00  0.00  1.00  0.00  4.00    .02  4.20   .03  4.30   .04  4.50   .08
14          S  11100  4.60   .12  4.70   .22  4.90    .98  5.00  1.00  5.10   .96  5.20   .76
15          S  11100  5.30   .64  5.40   .58  5.60    .46  5.80   .37  6.00   .30  6.30   .22
16          S  11100  6.80   .11  7.00   .07  7.20    .05  7.50   .03  8.50   .01  9.00  0.00
17          S  11100100.00  0.00
18          T  11100  0.00  0.00 32.00  0.00 34.00    .12 35.00   .20 36.00   .28 37.00   .36
19          T  11100 38.00   .50 40.00   .64 41.00    .70 44.00   .82 47.00   .90 49.00   .94
20          T  11100 55.00  1.00 66.00  1.00 69.00    .96 70.00   .86 71.00   .50 72.00   .28
21          T  11100 73.00   .14 74.00   .06 75.00   0.00100.00  0.00
```

APPENDIX B

EXAMPLE RESULTS

HABTAV PROGRAM VERSION NUMBER 1.0
LAST UPDATE ON 2 AUGUST 1985

IOC　1 1 1 0 1 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0

HEADER　3

CURVE ID	DIST	VLIM	VO	CURVE ID	DIST	VLIM	VO	CURVE ID	DIST	VLIM	VO
-11100	-1.00	.00	.00	11102	10.00	-2.20	2.20	11302	12.00	3.00	1.00

CROSS-SECTION COORDINATES FOR .00 NP= 42 RL= .00 W= .50

1.00	96.60	4.00	2.00	96.50	4.00	4.00	96.30	4.00	6.00	96.20	5.50
8.00	96.10	5.50	10.00	96.10	5.50	12.00	95.90	5.50	14.00	96.00	5.50
16.00	95.80	5.50	18.00	95.80	5.50	20.00	95.80	5.50	22.00	95.80	5.50
24.00	95.70	5.50	26.00	95.70	5.50	28.00	95.70	5.50	30.00	95.80	5.50
32.00	95.70	5.50	34.00	95.50	5.50	36.00	95.90	5.50	38.00	96.00	5.50
40.00	96.10	5.50	42.00	96.20	5.50	44.00	96.40	5.50	46.00	96.50	5.50
48.00	96.50	5.50	50.00	96.50	5.50	52.00	96.40	5.50	54.00	96.10	5.50
56.00	96.30	5.50	58.00	96.50	5.50	60.00	96.60	5.50	62.00	96.60	5.50
64.00	96.60	5.50	66.00	96.70	5.50	68.00	96.50	5.50	70.00	96.40	5.50
72.00	96.10	5.50	74.00	96.00	5.50	76.00	96.10	5.50	78.00	96.60	5.50
80.00	97.50	4.00	82.00	98.80	4.00						

CROSS-SECTION COORDINATES FOR 40.00 NP= 41 RL= 40.00 W= .50

4.00	98.30	4.00	4.40	97.20	4.00	4.50	96.70	4.00	4.60	96.10	4.00
6.00	96.00	5.50	8.00	95.90	5.50	10.00	95.90	5.50	12.00	95.80	5.50
14.00	95.80	5.50	16.00	95.70	5.50	18.00	95.60	5.50	20.00	95.50	5.50
22.00	95.50	5.50	24.00	95.50	5.50	26.00	95.40	5.50	28.00	95.40	5.50
30.00	95.70	5.50	32.00	95.60	5.50	34.00	95.90	5.50	36.00	96.20	5.50
38.00	96.50	5.50	40.00	96.60	5.50	42.00	96.70	5.50	44.00	96.80	5.50
46.00	96.80	5.50	48.00	96.80	5.50	50.00	96.90	5.50	52.00	96.90	5.50
54.00	96.90	5.50	56.00	97.00	5.50	58.00	96.70	5.50	60.00	96.70	5.50
62.00	96.40	5.50	64.00	96.20	5.50	66.00	96.00	5.50	68.00	95.90	5.50
70.00	96.10	5.50	72.00	96.40	5.50	74.00	96.70	6.00	76.00	97.10	7.00
78.00	97.40	7.00									

HABTV1

CROSS-SECTION COORDINATES FOR 91.00 NP= 41 RL= 51.00 W= .50

4.00	98.50	4.00	6.00	98.10	4.00	6.10	96.90	4.00	6.20	96.70	4.00
7.00	95.40	4.00	8.00	95.30	4.00	10.00	94.90	4.00	12.00	94.70	4.00
14.00	94.70	4.00	16.00	94.70	5.50	18.00	94.60	5.50	20.00	94.80	5.50
22.00	94.90	5.50	24.00	95.30	5.50	26.00	95.40	5.50	28.00	95.40	5.50
30.00	95.50	5.50	32.00	95.80	5.50	34.00	96.10	5.50	36.00	96.30	5.50
38.00	96.40	5.50	40.00	96.60	5.50	42.00	96.80	5.50	44.00	97.00	5.50
46.00	97.20	5.50	48.00	97.30	5.50	50.00	97.30	5.50	52.00	97.50	5.50
54.00	97.40	5.50	56.00	97.30	5.50	58.00	97.00	5.50	60.00	96.80	5.50
62.00	96.80	5.50	64.00	96.60	5.50	66.00	96.70	5.50	68.00	96.70	5.50
70.00	96.80	5.50	72.00	97.00	5.50	74.00	97.10	5.50	78.00	97.30	5.50
80.00	98.40	5.50									

CROSS-SECTION COORDINATES FOR 192.00 NP= 46 RL= 101.00 W= .50

2.00	99.20	4.00	3.00	97.60	4.00	3.10	97.30	4.00	3.20	96.40	6.00
4.00	96.50	6.00	6.00	96.60	6.00	8.00	96.50	6.00	10.00	96.40	6.00
12.00	96.30	6.00	14.00	96.50	6.00	16.00	96.30	6.00	18.00	96.30	6.00
20.00	96.40	6.00	22.00	96.50	6.00	24.00	96.70	6.00	26.00	96.90	6.00
28.00	96.90	6.00	30.00	97.00	6.00	32.00	97.00	6.00	34.00	97.10	6.00
36.00	97.20	6.00	38.00	97.30	6.00	40.00	97.30	6.00	42.00	97.40	6.00
44.00	97.50	6.00	46.00	97.60	6.00	48.00	97.80	6.00	50.00	97.80	6.00
52.00	97.90	6.00	54.00	97.90	6.00	56.00	97.90	6.00	58.00	98.00	6.00
60.00	98.00	6.00	62.00	98.00	6.00	64.00	97.90	6.00	66.00	97.80	6.00
68.00	97.60	6.00	70.00	97.40	6.00	72.00	97.30	6.00	74.00	97.20	6.00
76.00	97.10	6.00	78.00	97.00	6.00	80.00	97.10	6.00	80.50	97.20	7.00
82.00	97.60	7.00	84.00	97.90	7.00						

CROSS-SECTION COORDINATES FOR 226.00 NP= 45 RL= 34.00 W= .50

6.00	99.30	4.00	7.00	97.90	4.00	7.10	97.50	4.00	8.00	96.60	4.00
10.00	96.40	4.00	12.00	96.40	4.00	14.00	96.10	4.00	16.00	96.10	5.50
18.00	96.10	5.50	20.00	96.60	5.50	22.00	96.80	5.50	24.00	96.90	5.50
26.00	96.90	5.50	28.00	96.80	5.50	30.00	96.80	5.50	32.00	96.90	5.50
34.00	96.90	5.50	36.00	96.80	5.50	38.00	96.90	5.50	40.00	97.10	5.50
42.00	97.20	5.50	44.00	97.20	5.50	46.00	97.20	5.50	48.00	97.40	5.50
50.00	97.50	5.50	52.00	97.50	5.50	54.00	97.70	5.50	56.00	97.60	5.50
58.00	97.60	5.50	60.00	97.70	5.50	62.00	97.90	5.50	64.00	97.70	5.50
66.00	97.70	5.50	68.00	97.70	5.50	70.00	97.80	5.50	72.00	97.50	5.50
74.00	97.60	5.50	76.00	97.40	5.50	78.00	97.30	5.50	80.00	97.20	5.50
82.00	97.20	5.50	84.00	97.10	5.50	85.00	97.40	5.50	86.00	98.40	5.50
88.00	99.20	7.00									

CROSS-SECTION COORDINATES FOR 255.00 NP= 36 RL= 29.00 W= .50

2.00	99.90	4.00	3.90	98.10	4.00	4.00	97.60	4.00	4.10	96.70	4.00
6.00	96.40	5.50	8.00	96.20	5.50	10.00	96.40	5.50	12.00	96.50	5.50
14.00	96.80	5.50	16.00	97.00	5.50	18.00	97.20	5.50	20.00	97.20	5.50
22.00	97.00	5.50	24.00	97.10	5.50	26.00	97.00	5.50	28.00	97.00	5.50
30.00	96.90	5.50	32.00	97.00	5.50	34.00	97.00	5.50	36.00	97.00	5.50
38.00	97.00	5.50	40.00	97.10	5.50	42.00	97.10	5.50	44.00	97.20	5.50
46.00	97.20	5.50	48.00	97.20	5.50	50.00	97.40	5.50	52.00	97.70	5.50
54.00	97.70	5.50	56.00	97.80	5.50	58.00	97.60	5.50	60.00	97.70	5.50
62.00	97.60	5.50	64.00	97.70	5.50	66.00	97.70	5.50	68.00	99.60	7.00

```
Q RELATED DATA FOR THE CROSS SECTION        .00
     DISCHARGE =     100.00 IVS =    40 WSEL =      96.78

VELOCITIES         .15      .21      .51      .90     1.82     1.88     2.09     2.16     2.29     2.35
                  2.50     2.52     2.69     2.72     2.67     2.73     2.49     2.59     2.07     2.40
                  2.05     1.86     1.42      .82     1.24     1.40     1.84     2.03     1.21      .34
                   .44      .35      .35      .25      .52     1.02      .84     1.86      .55      .17

Q RELATED DATA FOR THE CROSS SECTION      40.00
     DISCHARGE =     100.00 IVS =    36 WSEL =      96.99

VELOCITIES         .25      .53     1.38     1.66     1.83     2.04     1.92     1.95     2.05     2.31
                  2.28     2.28     2.37     2.13     2.09     1.77     1.61     1.66      .99      .83
                   .65      .55      .46      .67      .27      .18      .30      .47      .77     1.18
                  1.11      .75      .75      .64      .73      .36

Q RELATED DATA FOR THE CROSS SECTION      91.00
     DISCHARGE =     100.00 IVS =    30 WSEL =      97.06

VELOCITIES         .05      .08      .23      .37      .39      .82     1.82     1.38     2.16     2.67
                  2.44     2.61     2.95     2.51     2.15     2.02     1.46     1.36      .83      .27
                   .49      .25      .59     1.32      .86      .92      .75     1.26     1.59     1.07

Q RELATED DATA FOR THE CROSS SECTION     192.00
     DISCHARGE =     100.00 IVS =    34 WSEL =      97.72

VELOCITIES         .78     1.84     3.98     2.29     3.12     3.19     3.78     3.46     3.18     3.33
                  3.38     3.08     3.16     2.78     2.21     1.89     2.02     1.78     2.49     2.42
                  1.52     2.21     2.27     2.15     1.54      .64      .88      .78     1.37      .85
                   .68     3.11     1.14      .42

Q RELATED DATA FOR THE CROSS SECTION     226.00
     DISCHARGE =     100.00 IVS =    40 WSEL =      97.86

VELOCITIES         .14      .31      .47      .95     1.16     1.50     2.39     2.19     2.33     2.39
                  2.09     2.23     2.26     2.52     2.59     2.29     2.08     1.49     1.44     1.72
                  1.45     2.18     2.09     1.80     1.52     1.52     1.33     1.23      .76      .77
                   .58      .95      .86      .29      .08     2.29     1.87     1.87     2.06     1.47

Q RELATED DATA FOR THE CROSS SECTION     255.00
     DISCHARGE =     100.00 IVS =    33 WSEL =      97.99

VELOCITIES        1.32     1.40     1.60     1.43     1.48     1.40     1.30     1.52     1.73     1.94
                  2.19     1.80     2.24     2.39     2.67     2.55     2.73     2.67     2.53     2.55
                  2.31     2.18     1.90     1.82     1.60     1.79     1.21     1.31     1.21     1.20
                  1.21      .86      .72
```

Q RELATED DATA FOR THE CROSS SECTION .00
DISCHARGE = 200.00 IVS = 40 WSEL = 97.08

VELOCITIES	.30	.34	.35	1.20	2.82	3.09	2.93	2.98	2.98	3.16
	3.48	3.29	3.48	3.76	3.83	3.72	3.41	3.41	2.98	3.72
	3.35	3.18	2.51	2.27	2.01	2.73	2.46	2.73	2.40	1.72
	1.57	1.39	1.39	1.54	1.26	2.22	1.69	2.14	1.34	.33

Q RELATED DATA FOR THE CROSS SECTION 40.00
DISCHARGE = 200.00 IVS = 39 WSEL = 97.30

VELOCITIES	.12	.41	.65	2.02	2.72	2.68	2.76	2.71	2.76	3.29
	3.36	3.40	3.31	3.35	3.27	2.97	2.60	2.40	2.49	2.26
	1.86	1.48	1.46	1.15	1.31	.98	.76	.87	.64	.86
	1.11	1.27	2.39	1.49	1.39	1.58	.98	.59	.28	

Q RELATED DATA FOR THE CROSS SECTION 91.00
DISCHARGE = 200.00 IVS = 37 WSEL = 97.41

VELOCITIES	.10	.13	.25	.64	.65	1.19	2.75	2.28	3.85	4.11
	3.61	3.37	4.02	3.23	3.06	3.07	2.16	2.39	1.86	.91
	.84	.86	.32	.45	.30	.08	.45	.92	1.52	1.68
	1.97	1.86	2.28	2.26	1.79	1.84	1.51			

Q RELATED DATA FOR THE CROSS SECTION 192.00
DISCHARGE = 200.00 IVS = 45 WSEL = 98.16

VELOCITIES	2.03	2.70	4.35	1.94	2.36	2.77	3.28	3.43	3.29	3.23
	3.33	3.15	3.25	3.08	3.00	3.79	3.23	3.04	3.19	3.03
	2.97	2.84	2.71	2.33	2.46	1.92	2.13	1.53	1.42	1.32
	.79	.84	1.06	1.57	1.80	1.80	2.21	2.22	2.20	2.38
	1.00	.43	1.55	1.08	.65					

Q RELATED DATA FOR THE CROSS SECTION 226.00
DISCHARGE = 200.00 IVS = 42 WSEL = 98.23

VELOCITIES	.12	.21	.35	.75	1.28	1.04	1.47	2.59	2.52	2.79
	2.89	2.40	2.93	2.50	2.96	2.96	2.89	2.24	2.08	2.71
	3.00	2.61	2.91	3.11	2.92	2.71	2.31	2.21	1.84	1.51
	1.44	1.69	1.43	1.60	1.79	.64	.12	3.05	2.39	2.39
	2.54	2.07								

Q RELATED DATA FOR THE CROSS SECTION 255.00
DISCHARGE = 200.00 IVS = 34 WSEL = 98.35

VELOCITIES	.88	1.48	1.61	2.02	1.73	1.81	1.88	1.77	1.79	2.11
	2.35	2.68	2.34	2.68	3.20	3.15	3.14	3.14	3.41	3.33
	3.58	3.25	3.14	3.11	2.93	2.63	2.53	2.33	2.35	2.29
	2.19	2.38	1.47	1.22						

Q RELATED DATA FOR THE CROSS SECTION .00
DISCHARGE = 400.00 IVS = 40 WSEL = 97.45

VELOCITIES	.42	.45	.22	1.46	3.99	4.62	3.76	3.74	3.53	3.88
	4.40	3.92	4.10	4.74	5.02	4.61	4.26	4.10	3.92	5.26
	5.00	4.95	4.05	5.78	2.99	4.83	3.00	3.34	4.32	7.89
	5.08	4.99	4.99	8.55	2.79	4.43	3.10	2.24	2.99	.46

Q RELATED DATA FOR THE CROSS SECTION 40.00
DISCHARGE = 400.00 IVS = 40 WSEL = 97.68

VELOCITIES	.34	.55	.76	2.84	4.29	3.79	3.60	3.68	3.78	5.07
	4.68	4.88	4.62	4.56	4.84	4.06	3.66	3.43	3.60	4.98
	3.98	3.27	3.73	2.79	1.86	3.48	3.13	1.32	1.05	1.50
	1.55	1.30	4.94	2.88	2.47	3.72	1.20	.80	.56	.35

Q RELATED DATA FOR THE CROSS SECTION 91.00
DISCHARGE = 400.00 IVS = 38 WSEL = 97.83

VELOCITIES	.14	.16	.27	1.05	1.02	1.64	3.98	3.59	6.54	6.05
	5.12	4.15	5.23	3.97	4.16	4.44	3.06	3.99	3.96	2.92
	1.12	1.30	.64	1.25	.83	1.47	1.26	1.25	1.37	1.67
	3.12	4.02	4.42	3.94	3.07	2.85	2.74	2.22		

Q RELATED DATA FOR THE CROSS SECTION 192.00
DISCHARGE = 400.00 IVS = 45 WSEL = 98.75

VELOCITIES	2.31	2.70	3.73	1.30	1.40	1.89	2.24	2.68	2.68	2.47
	2.59	2.54	2.63	2.69	3.22	5.99	4.05	4.08	3.20	2.98
	4.56	2.86	2.55	1.98	3.07	2.19	3.14	3.18	2.64	2.68
	2.61	5.61	5.56	5.23	3.98	3.98	4.36	4.99	2.80	5.20
	1.14	.05	1.51	1.24	1.01					

Q RELATED DATA FOR THE CROSS SECTION 226.00
DISCHARGE = 400.00 IVS = 43 WSEL = 98.70

VELOCITIES	.20	.26	.39	1.16	1.68	.92	1.42	2.74	2.83	3.28
	3.41	2.71	3.76	2.70	3.39	3.31	3.57	2.35	2.84	5.01
	5.12	4.61	3.80	4.53	4.61	4.73	3.43	3.59	2.68	2.34
	2.67	3.63	3.46	2.62	3.66	1.38	.15	3.69	2.84	2.84
	2.96	2.58	.96							

Q RELATED DATA FOR THE CROSS SECTION 255.00
DISCHARGE = 400.00 IVS = 34 WSEL = 98.78

VELOCITIES	1.71	1.66	1.86	2.55	2.09	2.23	2.52	2.42	2.12	2.56
	2.85	3.28	3.03	3.22	4.27	3.71	3.88	3.62	4.37	4.40
	5.03	4.57	4.54	5.09	4.72	4.31	3.57	4.50	4.24	4.34
	4.01	4.67	2.50	1.70						

Q RELATED DATA FOR THE CROSS SECTION .00
DISCHARGE = 500.00 IVS = 41 WSEL = 97.59

VELOCITIES

.43	.46	.18	1.49	4.29	5.06	3.92	3.87	3.59	3.99
4.57	3.99	4.16	4.92	5.27	4.75	4.41	4.19	4.11	5.66
5.47	5.50	4.55	7.52	3.27	5.59	3.08	3.44	5.02	12.38
7.14	7.26	7.26	14.29	3.46	5.32	3.62	2.19	3.73	.48
.10									

Q RELATED DATA FOR THE CROSS SECTION 40.00
DISCHARGE = 500.00 IVS = 40 WSEL = 97.82

VELOCITIES

.40	.59	.79	3.12	4.91	4.18	3.87	4.01	4.12	5.76
5.14	5.42	5.08	4.97	5.42	4.43	4.04	3.79	4.00	6.34
5.02	4.16	4.98	3.66	2.01	5.16	4.89	1.44	1.21	1.77
1.71	1.30	6.16	3.50	2.94	4.84	1.26	.85	.63	.44

Q RELATED DATA FOR THE CROSS SECTION 91.00
DISCHARGE = 500.00 IVS = 38 WSEL = 97.98

VELOCITIES

.15	.17	.27	1.22	1.18	1.80	4.45	4.12	7.71	6.80
5.69	4.41	5.65	4.22	4.56	4.97	3.39	4.67	5.01	4.22
1.20	1.41	.72	1.44	.96	1.85	1.51	1.44	1.55	1.71
3.78	5.03	5.79	4.67	3.36	3.29	3.09	2.50		

Q RELATED DATA FOR THE CROSS SECTION 192.00
DISCHARGE = 500.00 IVS = 45 WSEL = 98.98

VELOCITIES

2.18	2.48	3.31	1.06	1.10	1.56	1.85	2.31	2.34	2.11
2.23	2.21	2.30	2.40	3.07	6.48	4.07	4.19	2.99	2.77
4.88	2.68	2.33	1.76	3.08	2.13	3.32	3.76	3.01	3.14
3.59	9.67	8.84	7.18	4.79	4.79	5.06	6.05	2.82	6.25
1.12	.02	1.38	1.16	.99					

Q RELATED DATA FOR THE CROSS SECTION 226.00
DISCHARGE = 500.00 IVS = 43 WSEL = 98.87

VELOCITIES

.22	.28	.39	1.33	1.82	.87	1.39	2.77	2.92	3.42
3.57	2.79	4.05	2.75	3.52	3.41	3.80	2.38	3.12	6.05
6.03	5.50	4.12	5.08	5.31	5.62	3.87	4.16	3.00	2.67
3.23	4.62	4.57	3.06	4.57	1.76	.15	3.86	2.95	2.95
3.07	2.71	1.26							

Q RELATED DATA FOR THE CROSS SECTION 255.00
DISCHARGE = 500.00 IVS = 34 WSEL = 98.94

VELOCITIES

1.96	1.72	1.94	2.75	2.22	2.37	2.76	2.67	2.23	2.73
3.02	3.49	3.29	3.40	4.68	3.91	4.14	3.78	4.72	4.80
5.60	5.09	5.11	5.95	5.49	5.05	3.99	5.55	5.11	5.32
4.86	5.79	2.97	1.86						

CURVE SET DEFINITION DATA WAS OBTAINED FROM THE FILE -

RTMFSH FILE OF SUITABILITY OF USE CURVES DATE - 82/08/06

LAST UPDATED ON 85/06/13. 09.04.18.

RAINBOW TROUT FRY 11100

VELOCITY DATA

VELOCITY	.00	.10	.15	.20	.25	.30	.40	.60	.70	.75
INDEX	.06	.18	.24	.39	.88	.96	1.00	1.00	.95	.86
VELOCITY	.80	.90	1.05	1.25	1.50	1.65	1.80	2.00	2.20	2.40
INDEX	.81	.75	.70	.63	.56	.49	.38	.26	.14	.06
VELOCITY	2.65	100.00								
INDEX	.00	.00								

DEPTH DATA

DEPTH	.00	.20	.40	.50	.60	.90	1.00	1.10	1.30	1.50
INDEX	.00	.00	.15	.30	1.00	1.00	.98	.88	.60	.40
DEPTH	1.60	1.70	1.90	2.10	2.40	2.70	3.00	5.00	6.00	100.00
INDEX	.33	.27	.19	.13	.08	.03	.02	.02	.02	.02

CHAN.INDEX DATA

CHAN.INDEX	.00	1.00	4.00	4.20	4.30	4.50	4.60	4.70	4.90	5.00
INDEX	.00	.00	.02	.03	.04	.08	.12	.22	.98	1.00
CHAN.INDEX	5.10	5.20	5.30	5.40	5.60	5.80	6.00	6.30	6.80	7.00
INDEX	.96	.76	.64	.58	.46	.37	.30	.22	.11	.07
CHAN.INDEX	7.20	7.50	8.50	9.00	100.00					
INDEX	.05	.03	.01	.00	.00					

THE WATER SURFACE ELEVATION (96.8) IS (.2) FEET ABOVE THE LEFT END OF XSEC 0. Q= 100.
HOWEVER, SINCE THERE IS LESS THAN 10.0 FEET INVOLVED, THE RUN IS ALLOWED TO CONTINUE.

THE WATER SURFACE ELEVATION (97.1) IS (.5) FEET ABOVE THE LEFT END OF XSEC 0. Q= 200.
HOWEVER, SINCE THERE IS LESS THAN 10.0 FEET INVOLVED, THE RUN IS ALLOWED TO CONTINUE.

THE WATER SURFACE ELEVATION (98.2) IS (.3) FEET ABOVE THE RIGHT END OF XSEC 192. Q= 200.
HOWEVER, SINCE THERE IS LESS THAN 10.0 FEET INVOLVED, THE RUN IS ALLOWED TO CONTINUE.

THE WATER SURFACE ELEVATION (97.5) IS (.9) FEET ABOVE THE LEFT END OF XSEC 0. Q= 400.
HOWEVER, SINCE THERE IS LESS THAN 10.0 FEET INVOLVED, THE RUN IS ALLOWED TO CONTINUE.

THE WATER SURFACE ELEVATION (97.7) IS (.3) FEET ABOVE THE RIGHT END OF XSEC 40. Q= 400.
HOWEVER, SINCE THERE IS LESS THAN 10.0 FEET INVOLVED, THE RUN IS ALLOWED TO CONTINUE.

THE WATER SURFACE ELEVATION (98.8) IS (.9) FEET ABOVE THE RIGHT END OF XSEC 192. Q= 400.
HOWEVER, SINCE THERE IS LESS THAN 10.0 FEET INVOLVED, THE RUN IS ALLOWED TO CONTINUE.

THE WATER SURFACE ELEVATION (97.6) IS (1.0) FEET ABOVE THE LEFT END OF XSEC 0. Q= 500.
HOWEVER, SINCE THERE IS LESS THAN 10.0 FEET INVOLVED, THE RUN IS ALLOWED TO CONTINUE.

THE WATER SURFACE ELEVATION (97.8) IS (.4) FEET ABOVE THE RIGHT END OF XSEC 40. Q= 500.
HOWEVER, SINCE THERE IS LESS THAN 10.0 FEET INVOLVED, THE RUN IS ALLOWED TO CONTINUE.

THE WATER SURFACE ELEVATION (99.0) IS (1.1) FEET ABOVE THE RIGHT END OF XSEC 192. Q= 500.
HOWEVER, SINCE THERE IS LESS THAN 10.0 FEET INVOLVED, THE RUN IS ALLOWED TO CONTINUE.

RAINBOW TROUT ADULT 11102

VELOCITY DATA

VELOCITY	.00	.10	.25	.50	.75	.95	1.00	1.05	1.15	1.20
INDEX	.04	.18	.32	.48	.63	.81	.88	.95	.98	1.00
VELOCITY	1.30	1.35	1.45	1.65	1.95	2.10	2.25	2.40	2.90	100.00
INDEX	1.00	.98	.93	.79	.66	.56	.42	.30	.00	.00

DEPTH DATA

DEPTH	.00	.15	.30	.50	.80	.85	1.00	1.10	1.20	1.30
INDEX	.00	.06	.11	.14	.18	.19	.22	.26	.30	.36
DEPTH	1.40	1.45	1.50	1.55	1.60	1.65	1.75	4.00	100.00	
INDEX	.46	.54	.73	.91	.95	.98	1.00	1.00	1.00	

CHAN.INDEX DATA

CHAN.INDEX	.00	4.00	4.30	4.40	4.70	4.80	4.90	5.00	5.40	6.50
INDEX	.00	.00	.12	.18	.42	.54	.70	.92	1.00	1.00
CHAN.INDEX	6.80	7.00	7.10	7.20	7.30	7.50	8.00	8.50	9.00	100.00
INDEX	.98	.90	.78	.64	.56	.44	.26	.16	.00	.00

Q .VS. AVAILABLE HABITAT AREA PER 1000 FEET OF STREAM FOR RAINBOW TROUT

Q	FRY	ADULT
100.00	4480.73	7226.20
200.00	3916.99	5777.41
400.00	2578.30	5559.46
500.00	2596.56	7346.09

AND FOR VELOCITES BETWEEN -1 AND -1

NOTE: AVAILABLE HABITAT AREA FOR ADULT WAS CALCULATED BY SCANNING THE
XSEC 10.00 FT. FOR VELOCITIES LESS THAN 2.20
AND FOR VELOCITES BETWEEN 2.20 AND 2.20

Q .VS. AVAILABLE HABITAT AREA AS A PERCENTAGE OF THE GROSS AREA FOR RAINBOW TROUT

Q	GROSS	FRY	ADULT
100.00	63188.	7.09	11.44
200.00	74414.	5.26	7.76
400.00	75884.	3.40	7.33
500.00	76032.	3.42	9.66

BROWN TROUT ADULTS 11302

VELOCITY DATA

VELOCITY	.00	.80	.90	.95	1.00	1.05	1.10	1.15	1.20	1.25
INDEX	1.00	1.00	.98	.95	.91	.81	.74	.68	.65	.62
VELOCITY	1.30	1.35	1.45	1.65	1.75	1.85	1.95	2.05	2.15	2.30
INDEX	.59	.57	.55	.50	.47	.44	.38	.33	.28	.23
VELOCITY	2.45	2.65	2.75	3.00	3.25	3.50	3.75	4.00	5.00	6.00
INDEX	.19	.15	.14	.11	.09	.07	.06	.05	.03	.00
VELOCITY	100.00									
INDEX	.00									

DEPTH DATA

DEPTH	.00	.75	.80	.85	.90	.95	1.00	1.05	1.10	1.35
INDEX	.00	.00	.06	.15	.27	.51	.58	.60	.61	.63
DEPTH	1.60	1.70	1.80	1.90	2.00	2.05	2.15	2.20	2.25	2.35
INDEX	.65	.67	.68	.70	.72	.74	.78	.81	.86	.94
DEPTH	2.40	2.45	2.50	100.00						
INDEX	.97	.99	1.00	1.00						

CHAN.INDEX DATA

CHAN.INDEX	.00	1.00	2.00	2.20	2.40	2.70	2.90	3.10	3.30	3.50
INDEX	.00	.31	.31	.32	.34	.37	.40	.44	.49	.55
CHAN.INDEX	3.60	3.80	4.00	4.10	4.20	4.30	5.60	5.80	5.90	6.00
INDEX	.59	.70	.91	.96	.99	1.00	1.00	.99	.96	.91
CHAN.INDEX	6.10	6.20	6.30	6.50	6.60	6.70	6.80	6.90	7.10	7.20
INDEX	.72	.58	.48	.34	.29	.25	.22	.18	.13	.11
CHAN.INDEX	7.40	7.60	7.80	8.00	100.00					
INDEX	.08	.04	.02	.00	.00					

Q .VS. AVAILABLE HABITAT AREA PER 1000 FEET OF STREAM FOR BROWN TROUT

Q	ADULTS
100.00	4871.19
200.00	5986.59
400.00	7933.29
500.00	8894.16

NOTE: AVAILABLE HABITAT AREA FOR ADULTS WAS CALCULATED BY SCANNING THE
XSEC 12.00 FT. FOR VELOCITIES GREATER THAN 3.00
AND FOR VELOCITES BETWEEN 1.00 AND 3.00

Q .VS. AVAILABLE HABITAT AREA AS A PERCENTAGE OF THE GROSS AREA FOR BROWN TROUT

Q	GROSS	ADULTS
100.00	63188.	7.71
200.00	74414.	8.04
400.00	75884.	10.45
500.00	76032.	11.70

$$$ NORMAL COMPLETION OF HABTAV $$$

HABTAV PROGRAM VERSION NUMBER 1.0
LAST UPDATE ON 2 AUGUST 1985

IOC 0 1 1 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0

HEADER 3

CURVE ID NUMBERS -11100 11102 11302

CROSS-SECTION COORDINATES FOR .00 NP= 42 RL= .00 W= .50

1.00	96.60	4.00	2.00	96.50	4.00	4.00	96.30	4.00	6.00	96.20	5.50
8.00	96.10	5.50	10.00	96.10	5.50	12.00	95.90	5.50	14.00	96.00	5.50
16.00	95.80	5.50	18.00	95.80	5.50	20.00	95.80	5.50	22.00	95.80	5.50
24.00	95.70	5.50	26.00	95.70	5.50	28.00	95.70	5.50	30.00	95.80	5.50
32.00	95.70	5.50	34.00	95.50	5.50	36.00	95.90	5.50	38.00	96.00	5.50
40.00	96.10	5.50	42.00	96.20	5.50	44.00	96.40	5.50	46.00	96.50	5.50
48.00	96.50	5.50	50.00	96.50	5.50	52.00	96.40	5.50	54.00	96.10	5.50
56.00	96.30	5.50	58.00	96.50	5.50	60.00	96.60	5.50	62.00	96.60	5.50
64.00	96.60	5.50	66.00	96.70	5.50	68.00	96.50	5.50	70.00	96.40	5.50
72.00	96.10	5.50	74.00	96.00	5.50	76.00	96.10	5.50	78.00	96.60	5.50
80.00	97.50	4.00	82.00	98.80	4.00						

CROSS-SECTION COORDINATES FOR 40.00 NP= 41 RL= 40.00 W= .50

4.00	98.30	4.00	4.40	97.20	4.00	4.50	96.70	4.00	4.60	96.10	4.00
6.00	96.00	5.50	8.00	95.90	5.50	10.00	95.90	5.50	12.00	95.80	5.50
14.00	95.80	5.50	16.00	95.70	5.50	18.00	95.60	5.50	20.00	95.50	5.50
22.00	95.50	5.50	24.00	95.50	5.50	26.00	95.40	5.50	28.00	95.40	5.50
30.00	95.70	5.50	32.00	95.60	5.50	34.00	95.90	5.50	36.00	96.20	5.50
38.00	96.50	5.50	40.00	96.60	5.50	42.00	96.70	5.50	44.00	96.80	5.50
46.00	96.80	5.50	48.00	96.80	5.50	50.00	96.90	5.50	52.00	96.90	5.50
54.00	96.90	5.50	56.00	97.00	5.50	58.00	96.70	5.50	60.00	96.70	5.50
62.00	96.40	5.50	64.00	96.20	5.50	66.00	96.00	5.50	68.00	95.90	5.50
70.00	96.10	5.50	72.00	96.40	5.50	74.00	96.70	6.00	76.00	97.10	7.00
78.00	97.40	7.00									

HABTV5

CROSS-SECTION COORDINATES FOR 91.00 NP= 41 RL= 51.00 W= .50

4.00	98.50	4.00	6.00	98.10	4.00	6.10	96.90	4.00	6.20	96.70	4.00
7.00	95.40	4.00	8.00	95.30	4.00	10.00	94.90	4.00	12.00	94.70	4.00
14.00	94.70	4.00	16.00	94.70	5.50	18.00	94.60	5.50	20.00	94.80	5.50
22.00	94.90	5.50	24.00	95.30	5.50	26.00	95.40	5.50	28.00	95.40	5.50
30.00	95.50	5.50	32.00	95.80	5.50	34.00	96.10	5.50	36.00	96.30	5.50
38.00	96.40	5.50	40.00	96.60	5.50	42.00	96.80	5.50	44.00	97.00	5.50
46.00	97.20	5.50	48.00	97.30	5.50	50.00	97.30	5.50	52.00	97.50	5.50
54.00	97.40	5.50	56.00	97.30	5.50	58.00	97.00	5.50	60.00	96.80	5.50
62.00	96.80	5.50	64.00	96.60	5.50	66.00	96.70	5.50	68.00	96.70	5.50
70.00	96.80	5.50	72.00	97.00	5.50	74.00	97.10	5.50	78.00	97.30	5.50
80.00	98.40	5.50									

CROSS-SECTION COORDINATES FOR 192.00 NP= 46 RL= 101.00 W= .50

2.00	99.20	4.00	3.00	97.60	4.00	3.10	97.30	4.00	3.20	96.40	6.00
4.00	96.50	6.00	6.00	96.60	6.00	8.00	96.50	6.00	10.00	96.40	6.00
12.00	96.30	6.00	14.00	96.50	6.00	16.00	96.30	6.00	18.00	96.30	6.00
20.00	96.40	6.00	22.00	96.50	6.00	24.00	96.70	6.00	26.00	96.90	6.00
28.00	96.90	6.00	30.00	97.00	6.00	32.00	97.00	6.00	34.00	97.10	6.00
36.00	97.20	6.00	38.00	97.30	6.00	40.00	97.30	6.00	42.00	97.40	6.00
44.00	97.50	6.00	46.00	97.60	6.00	48.00	97.80	6.00	50.00	97.80	6.00
52.00	97.90	6.00	54.00	97.90	6.00	56.00	97.90	6.00	58.00	98.00	6.00
60.00	98.00	6.00	62.00	98.00	6.00	64.00	97.90	6.00	66.00	97.80	6.00
68.00	97.60	6.00	70.00	97.40	6.00	72.00	97.30	6.00	74.00	97.20	6.00
76.00	97.10	6.00	78.00	97.00	6.00	80.00	97.10	6.00	80.50	97.20	7.00
82.00	97.60	7.00	84.00	97.90	7.00						

CROSS-SECTION COORDINATES FOR 226.00 NP= 45 RL= 34.00 W= .50

6.00	99.30	4.00	7.00	97.90	4.00	7.10	97.50	4.00	8.00	96.60	4.00
10.00	96.40	4.00	12.00	96.40	4.00	14.00	96.10	4.00	16.00	96.10	5.50
18.00	96.10	5.50	20.00	96.60	5.50	22.00	96.80	5.50	24.00	96.90	5.50
26.00	96.90	5.50	28.00	96.80	5.50	30.00	96.80	5.50	32.00	96.90	5.50
34.00	96.90	5.50	36.00	96.80	5.50	38.00	96.90	5.50	40.00	97.10	5.50
42.00	97.20	5.50	44.00	97.20	5.50	46.00	97.20	5.50	48.00	97.40	5.50
50.00	97.50	5.50	52.00	97.50	5.50	54.00	97.70	5.50	56.00	97.60	5.50
58.00	97.60	5.50	60.00	97.70	5.50	62.00	97.90	5.50	64.00	97.70	5.50
66.00	97.70	5.50	68.00	97.70	5.50	70.00	97.80	5.50	72.00	97.50	5.50
74.00	97.60	5.50	76.00	97.40	5.50	78.00	97.30	5.50	80.00	97.20	5.50
82.00	97.20	5.50	84.00	97.10	5.50	85.00	97.40	5.50	86.00	98.40	5.50
88.00	99.20	7.00									

CROSS-SECTION COORDINATES FOR 255.00 NP= 36 RL= 29.00 W= .50

2.00	99.90	4.00	3.90	98.10	4.00	4.00	97.60	4.00	4.10	96.70	4.00
6.00	96.40	5.50	8.00	96.20	5.50	10.00	96.40	5.50	12.00	96.50	5.50
14.00	96.80	5.50	16.00	97.00	5.50	18.00	97.20	5.50	20.00	97.20	5.50
22.00	97.00	5.50	24.00	97.10	5.50	26.00	97.00	5.50	28.00	97.00	5.50
30.00	96.90	5.50	32.00	97.00	5.50	34.00	97.00	5.50	36.00	97.00	5.50
38.00	97.00	5.50	40.00	97.10	5.50	42.00	97.10	5.50	44.00	97.20	5.50
46.00	97.20	5.50	48.00	97.20	5.50	50.00	97.40	5.50	52.00	97.70	5.50
54.00	97.70	5.50	56.00	97.80	5.50	58.00	97.60	5.50	60.00	97.70	5.50
62.00	97.60	5.50	64.00	97.70	5.50	66.00	97.70	5.50	68.00	99.60	7.00

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Q RELATED DATA FOR THE CROSS SECTION        .00
     DISCHARGE =      100.00 IVS =    40 WSEL =      96.78

VELOCITIES        .15       .21       .51       .90      1.82      1.88      2.09      2.16      2.29      2.35
                 2.50      2.52      2.69      2.72      2.67      2.73      2.49      2.59      2.07      2.40
                 2.05      1.86      1.42       .82      1.24      1.40      1.84      2.03      1.21       .34
                  .44       .35       .35       .25       .52      1.02       .84      1.86       .55       .17

Q RELATED DATA FOR THE CROSS SECTION      40.00
     DISCHARGE =      100.00 IVS =    36 WSEL =      96.99

VELOCITIES        .25       .53      1.38      1.66      1.83      2.04      1.92      1.95      2.05      2.31
                 2.28      2.28      2.37      2.13      2.09      1.77      1.61      1.66       .99       .83
                  .65       .55       .46       .67       .27       .18       .30       .47       .77      1.18
                 1.11       .75       .75       .64       .73       .36

Q RELATED DATA FOR THE CROSS SECTION      91.00
     DISCHARGE =      100.00 IVS =    30 WSEL =      97.06

VELOCITIES        .05       .08       .23       .37       .39       .82      1.82      1.38      2.16      2.67
                 2.44      2.61      2.95      2.51      2.15      2.02      1.46      1.36       .83       .27
                  .49       .25       .59      1.32       .86       .92       .75      1.26      1.59      1.07

Q RELATED DATA FOR THE CROSS SECTION     192.00
     DISCHARGE =      100.00 IVS =    34 WSEL =      97.72

VELOCITIES        .78      1.84      3.98      2.29      3.12      3.19      3.78      3.46      3.18      3.33
                 3.38      3.08      3.16      2.78      2.21      1.89      2.02      1.78      2.49      2.42
                 1.52      2.21      2.27      2.15      1.54       .64       .88       .78      1.37       .85
                  .68      3.11      1.14       .42

Q RELATED DATA FOR THE CROSS SECTION     226.00
     DISCHARGE =      100.00 IVS =    40 WSEL =      97.86

VELOCITIES        .14       .31       .47       .95      1.16      1.50      2.39      2.19      2.33      2.39
                 2.09      2.23      2.26      2.52      2.59      2.29      2.08      1.49      1.44      1.72
                 1.45      2.18      2.09      1.80      1.52      1.52      1.33      1.23       .76       .77
                  .58       .95       .86       .29       .08      2.29      1.87      1.87      2.06      1.47

Q RELATED DATA FOR THE CROSS SECTION     255.00
     DISCHARGE =      100.00 IVS =    33 WSEL =      97.99

VELOCITIES       1.32      1.40      1.60      1.43      1.48      1.40      1.30      1.52      1.73      1.94
                 2.19      1.80      2.24      2.39      2.67      2.55      2.73      2.67      2.53      2.55
                 2.31      2.18      1.90      1.82      1.60      1.79      1.21      1.31      1.21      1.20
                 1.21       .86       .72
```

Q RELATED DATA FOR THE CROSS SECTION .00
DISCHARGE = 200.00 IVS = 40 WSEL = 97.08

VELOCITIES	.30	.34	.35	1.20	2.82	3.09	2.93	2.98	2.98	3.16
	3.48	3.29	3.48	3.76	3.83	3.72	3.41	3.41	2.98	3.72
	3.35	3.18	2.51	2.27	2.01	2.73	2.46	2.73	2.40	1.72
	1.57	1.39	1.39	1.54	1.26	2.22	1.69	2.14	1.34	.33

Q RELATED DATA FOR THE CROSS SECTION 40.00
DISCHARGE = 200.00 IVS = 39 WSEL = 97.30

VELOCITIES	.12	.41	.65	2.02	2.72	2.68	2.76	2.71	2.76	3.29
	3.36	3.40	3.31	3.35	3.27	2.97	2.60	2.40	2.49	2.26
	1.86	1.48	1.46	1.15	1.31	.98	.76	.87	.64	.86
	1.11	1.27	2.39	1.49	1.39	1.58	.98	.59	.28	

Q RELATED DATA FOR THE CROSS SECTION 91.00
DISCHARGE = 200.00 IVS = 37 WSEL = 97.41

VELOCITIES	.10	.13	.25	.64	.65	1.19	2.75	2.28	3.85	4.11
	3.61	3.37	4.02	3.23	3.06	3.07	2.16	2.39	1.86	.91
	.84	.86	.32	.45	.30	.08	.45	.92	1.52	1.68
	1.97	1.86	2.28	2.26	1.79	1.84	1.51			

Q RELATED DATA FOR THE CROSS SECTION 192.00
DISCHARGE = 200.00 IVS = 45 WSEL = 98.16

VELOCITIES	2.03	2.70	4.35	1.94	2.36	2.77	3.28	3.43	3.29	3.23
	3.33	3.15	3.25	3.08	3.00	3.79	3.23	3.04	3.19	3.03
	2.97	2.84	2.71	2.33	2.46	1.92	2.13	1.53	1.42	1.32
	.79	.84	1.06	1.57	1.80	1.80	2.21	2.22	2.20	2.38
	1.00	.43	1.55	1.08	.65					

Q RELATED DATA FOR THE CROSS SECTION 226.00
DISCHARGE = 200.00 IVS = 42 WSEL = 98.23

VELOCITIES	.12	.21	.35	.75	1.28	1.04	1.47	2.59	2.52	2.79
	2.89	2.40	2.93	2.50	2.96	2.96	2.89	2.24	2.08	2.71
	3.00	2.61	2.91	3.11	2.92	2.71	2.31	2.21	1.84	1.51
	1.44	1.69	1.43	1.60	1.79	.64	.12	3.05	2.39	2.39
	2.54	2.07								

Q RELATED DATA FOR THE CROSS SECTION 255.00
DISCHARGE = 200.00 IVS = 34 WSEL = 98.35

VELOCITIES	.88	1.48	1.61	2.02	1.73	1.81	1.88	1.77	1.79	2.11
	2.35	2.68	2.34	2.68	3.20	3.15	3.14	3.14	3.41	3.33
	3.58	3.25	3.14	3.11	2.93	2.63	2.53	2.33	2.35	2.29
	2.19	2.38	1.47	1.22						

Q RELATED DATA FOR THE CROSS SECTION .00
DISCHARGE = 400.00 IVS = 40 WSEL = 97.45

VELOCITIES	.42	.45	.22	1.46	3.99	4.62	3.76	3.74	3.53	3.88
	4.40	3.92	4.10	4.74	5.02	4.61	4.26	4.10	3.92	5.26
	5.00	4.95	4.05	5.78	2.99	4.83	3.00	3.34	4.32	7.89
	5.08	4.99	4.99	8.55	2.79	4.43	3.10	2.24	2.99	.46

Q RELATED DATA FOR THE CROSS SECTION 40.00
DISCHARGE = 400.00 IVS = 40 WSEL = 97.68

VELOCITIES	.34	.55	.76	2.84	4.29	3.79	3.60	3.68	3.78	5.07
	4.68	4.88	4.62	4.56	4.84	4.06	3.66	3.43	3.60	4.98
	3.98	3.27	3.73	2.79	1.86	3.48	3.13	1.32	1.05	1.50
	1.55	1.30	4.94	2.88	2.47	3.72	1.20	.80	.56	.35

Q RELATED DATA FOR THE CROSS SECTION 91.00
DISCHARGE = 400.00 IVS = 38 WSEL = 97.83

VELOCITIES	.14	.16	.27	1.05	1.02	1.64	3.98	3.59	6.54	6.05
	5.12	4.15	5.23	3.97	4.16	4.44	3.06	3.99	3.96	2.92
	1.12	1.30	.64	1.25	.83	1.47	1.26	1.25	1.37	1.67
	3.12	4.02	4.42	3.94	3.07	2.85	2.74	2.22		

Q RELATED DATA FOR THE CROSS SECTION 192.00
DISCHARGE = 400.00 IVS = 45 WSEL = 98.75

VELOCITIES	2.31	2.70	3.73	1.30	1.40	1.89	2.24	2.68	2.68	2.47
	2.59	2.54	2.63	2.69	3.22	5.99	4.05	4.08	3.20	2.98
	4.56	2.86	2.55	1.98	3.07	2.19	3.14	3.18	2.64	2.68
	2.61	5.61	5.56	5.23	3.98	3.98	4.36	4.99	2.80	5.20
	1.14	.05	1.51	1.24	1.01					

Q RELATED DATA FOR THE CROSS SECTION 226.00
DISCHARGE = 400.00 IVS = 43 WSEL = 98.70

VELOCITIES	.20	.26	.39	1.16	1.68	.92	1.42	2.74	2.83	3.28
	3.41	2.71	3.76	2.70	3.39	3.31	3.57	2.35	2.84	5.01
	5.12	4.61	3.80	4.53	4.61	4.73	3.43	3.59	2.68	2.34
	2.67	3.63	3.46	2.62	3.66	1.38	.15	3.69	2.84	2.84
	2.96	2.58	.96							

Q RELATED DATA FOR THE CROSS SECTION 255.00
DISCHARGE = 400.00 IVS = 34 WSEL = 98.78

VELOCITIES	1.71	1.66	1.86	2.55	2.09	2.23	2.52	2.42	2.12	2.56
	2.85	3.28	3.03	3.22	4.27	3.71	3.88	3.62	4.37	4.40
	5.03	4.57	4.54	5.09	4.72	4.31	3.57	4.50	4.24	4.34
	4.01	4.67	2.50	1.70						

Q RELATED DATA FOR THE CROSS SECTION .00
DISCHARGE = 500.00 IVS = 41 WSEL = 97.59

VELOCITIES	.43	.46	.18	1.49	4.29	5.06	3.92	3.87	3.59	3.99
	4.57	3.99	4.16	4.92	5.27	4.75	4.41	4.19	4.11	5.66
	5.47	5.50	4.55	7.52	3.27	5.59	3.08	3.44	5.02	12.38
	7.14	7.26	7.26	14.29	3.46	5.32	3.62	2.19	3.73	.48
	.10									

Q RELATED DATA FOR THE CROSS SECTION 40.00
DISCHARGE = 500.00 IVS = 40 WSEL = 97.82

VELOCITIES	.40	.59	.79	3.12	4.91	4.18	3.87	4.01	4.12	5.76
	5.14	5.42	5.08	4.97	5.42	4.43	4.04	3.79	4.00	6.34
	5.02	4.16	4.98	3.66	2.01	5.16	4.89	1.44	1.21	1.77
	1.71	1.30	6.16	3.50	2.94	4.84	1.26	.85	.63	.44

Q RELATED DATA FOR THE CROSS SECTION 91.00
DISCHARGE = 500.00 IVS = 38 WSEL = 97.98

VELOCITIES	.15	.17	.27	1.22	1.18	1.80	4.45	4.12	7.71	6.80
	5.69	4.41	5.65	4.22	4.56	4.97	3.39	4.67	5.01	4.22
	1.20	1.41	.72	1.44	.96	1.85	1.51	1.44	1.55	1.71
	3.78	5.03	5.79	4.67	3.36	3.29	3.09	2.50		

Q RELATED DATA FOR THE CROSS SECTION 192.00
DISCHARGE = 500.00 IVS = 45 WSEL = 98.98

VELOCITIES	2.18	2.48	3.31	1.06	1.10	1.56	1.85	2.31	2.34	2.11
	2.23	2.21	2.30	2.40	3.07	6.48	4.07	4.19	2.99	2.77
	4.88	2.68	2.33	1.76	3.08	2.13	3.32	3.76	3.01	3.14
	3.59	9.67	8.84	7.18	4.79	4.79	5.06	6.05	2.82	6.25
	1.12	.02	1.38	1.16	.99					

Q RELATED DATA FOR THE CROSS SECTION 226.00
DISCHARGE = 500.00 IVS = 43 WSEL = 98.87

VELOCITIES	.22	.28	.39	1.33	1.82	.87	1.39	2.77	2.92	3.42
	3.57	2.79	4.05	2.75	3.52	3.41	3.80	2.38	3.12	6.05
	6.03	5.50	4.12	5.08	5.31	5.62	3.87	4.16	3.00	2.67
	3.23	4.62	4.57	3.06	4.57	1.76	.15	3.86	2.95	2.95
	3.07	2.71	1.26							

Q RELATED DATA FOR THE CROSS SECTION 255.00
DISCHARGE = 500.00 IVS = 34 WSEL = 98.94

VELOCITIES	1.96	1.72	1.94	2.75	2.22	2.37	2.76	2.67	2.23	2.73
	3.02	3.49	3.29	3.40	4.68	3.91	4.14	3.78	4.72	4.80
	5.60	5.09	5.11	5.95	5.49	5.05	3.99	5.55	5.11	5.32
	4.86	5.79	2.97	1.86						

CURVE SET DEFINITION DATA WAS OBTAINED FROM THE FILE -

RTMFSH FILE OF SUITABILITY OF USE CURVES DATE - 82/08/06

LAST UPDATED ON 85/06/13. 09.04.18.

RAINBOW TROUT FRY 11100

VELOCITY DATA

VELOCITY	.00	.10	.15	.20	.25	.30	.40	.60	.70	.75
INDEX	.06	.18	.24	.39	.88	.96	1.00	1.00	.95	.86
VELOCITY	.80	.90	1.05	1.25	1.50	1.65	1.80	2.00	2.20	2.40
INDEX	.81	.75	.70	.63	.56	.49	.38	.26	.14	.06
VELOCITY	2.65	100.00								
INDEX	.00	.00								

DEPTH DATA

DEPTH	.00	.20	.40	.50	.60	.90	1.00	1.10	1.30	1.50
INDEX	.00	.00	.15	.30	1.00	1.00	.98	.88	.60	.40
DEPTH	1.60	1.70	1.90	2.10	2.40	2.70	3.00	5.00	6.00	100.00
INDEX	.33	.27	.19	.13	.08	.03	.02	.02	.02	.02

CHAN.INDEX DATA

CHAN.INDEX	.00	1.00	4.00	4.20	4.30	4.50	4.60	4.70	4.90	5.00
INDEX	.00	.00	.02	.03	.04	.08	.12	.22	.98	1.00
CHAN.INDEX	5.10	5.20	5.30	5.40	5.60	5.80	6.00	6.30	6.80	7.00
INDEX	.96	.76	.64	.58	.46	.37	.30	.22	.11	.07
CHAN.INDEX	7.20	7.50	8.50	9.00	100.00					
INDEX	.05	.03	.01	.00	.00					

```
THE WATER SURFACE ELEVATION (   96.8) IS (    .2) FEET ABOVE THE LEFT END OF XSEC      0. Q=   100.
HOWEVER, SINCE THERE IS LESS THAN 10.0 FEET INVOLVED,  THE RUN IS ALLOWED TO CONTINUE.

THE WATER SURFACE ELEVATION (   97.1) IS (    .5) FEET ABOVE THE LEFT END OF XSEC      0. Q=   200.
HOWEVER, SINCE THERE IS LESS THAN 10.0 FEET INVOLVED,  THE RUN IS ALLOWED TO CONTINUE.

THE WATER SURFACE ELEVATION (   98.2) IS (    .3) FEET ABOVE THE RIGHT END OF XSEC    192. Q=   200.
HOWEVER, SINCE THERE IS LESS THAN 10.0 FEET INVOLVED,  THE RUN IS ALLOWED TO CONTINUE.

THE WATER SURFACE ELEVATION (   97.5) IS (    .9) FEET ABOVE THE LEFT END OF XSEC      0. Q=   400.
HOWEVER, SINCE THERE IS LESS THAN 10.0 FEET INVOLVED,  THE RUN IS ALLOWED TO CONTINUE.

THE WATER SURFACE ELEVATION (   97.7) IS (    .3) FEET ABOVE THE RIGHT END OF XSEC     40. Q=   400.
HOWEVER, SINCE THERE IS LESS THAN 10.0 FEET INVOLVED,  THE RUN IS ALLOWED TO CONTINUE.

THE WATER SURFACE ELEVATION (   98.8) IS (    .9) FEET ABOVE THE RIGHT END OF XSEC    192. Q=   400.
HOWEVER, SINCE THERE IS LESS THAN 10.0 FEET INVOLVED,  THE RUN IS ALLOWED TO CONTINUE.

THE WATER SURFACE ELEVATION (   97.6) IS (   1.0) FEET ABOVE THE LEFT END OF XSEC      0. Q=   500.
HOWEVER, SINCE THERE IS LESS THAN 10.0 FEET INVOLVED,  THE RUN IS ALLOWED TO CONTINUE.

THE WATER SURFACE ELEVATION (   97.8) IS (    .4) FEET ABOVE THE RIGHT END OF XSEC     40. Q=   500.
HOWEVER, SINCE THERE IS LESS THAN 10.0 FEET INVOLVED,  THE RUN IS ALLOWED TO CONTINUE.

THE WATER SURFACE ELEVATION (   99.0) IS (   1.1) FEET ABOVE THE RIGHT END OF XSEC    192. Q=   500.
HOWEVER, SINCE THERE IS LESS THAN 10.0 FEET INVOLVED,  THE RUN IS ALLOWED TO CONTINUE.
```

RAINBOW TROUT ADULT 11102

VELOCITY DATA

VELOCITY	.00	.10	.25	.50	.75	.95	1.00	1.05	1.15	1.20
INDEX	.04	.18	.32	.48	.63	.81	.88	.95	.98	1.00
VELOCITY	1.30	1.35	1.45	1.65	1.95	2.10	2.25	2.40	2.90	100.00
INDEX	1.00	.98	.93	.79	.66	.56	.42	.30	.00	.00

DEPTH DATA

DEPTH	.00	.15	.30	.50	.80	.85	1.00	1.10	1.20	1.30
INDEX	.00	.06	.11	.14	.18	.19	.22	.26	.30	.36
DEPTH	1.40	1.45	1.50	1.55	1.60	1.65	1.75	4.00	100.00	
INDEX	.46	.54	.73	.91	.95	.98	1.00	1.00	1.00	

CHAN. INDEX DATA

CHAN. INDEX	.00	4.00	4.30	4.40	4.70	4.80	4.90	5.00	5.40	6.50
INDEX	.00	.00	.12	.18	.42	.54	.70	.92	1.00	1.00
CHAN. INDEX	6.80	7.00	7.10	7.20	7.30	7.50	8.00	8.50	9.00	100.00
INDEX	.98	.90	.78	.64	.56	.44	.26	.16	.00	.00

Q .VS. AVAILABLE HABITAT AREA PER 1000 FEET OF STREAM FOR RAINBOW TROUT

Q	FRY	ADULT
100.00	4480.73	7226.20
200.00	3916.99	5777.41
400.00	2578.30	5970.86
500.00	2596.56	7515.79

Q .VS. AVAILABLE HABITAT AREA AS A PERCENTAGE OF THE GROSS AREA FOR RAINBOW TROUT

Q	GROSS	FRY	ADULT
100.00	63188.	7.09	11.44
200.00	74414.	5.26	7.76
400.00	75884.	3.40	7.87
500.00	76032.	3.42	9.89

BROWN TROUT ADULTS 11302

VELOCITY DATA

VELOCITY	.00	.80	.90	.95	1.00	1.05	1.10	1.15	1.20	1.25
INDEX	1.00	1.00	.98	.95	.91	.81	.74	.68	.65	.62
VELOCITY	1.30	1.35	1.45	1.65	1.75	1.85	1.95	2.05	2.15	2.30
INDEX	.59	.57	.55	.50	.47	.44	.38	.33	.28	.23
VELOCITY	2.45	2.65	2.75	3.00	3.25	3.50	3.75	4.00	5.00	6.00
INDEX	.19	.15	.14	.11	.09	.07	.06	.05	.03	.00
VELOCITY	100.00									
INDEX	.00									

DEPTH DATA

DEPTH	.00	.75	.80	.85	.90	.95	1.00	1.05	1.10	1.35
INDEX	.00	.00	.06	.15	.27	.51	.58	.60	.61	.63
DEPTH	1.60	1.70	1.80	1.90	2.00	2.05	2.15	2.20	2.25	2.35
INDEX	.65	.67	.68	.70	.72	.74	.78	.81	.86	.94
DEPTH	2.40	2.45	2.50	100.00						
INDEX	.97	.99	1.00	1.00						

CHAN.INDEX DATA

CHAN.INDEX	.00	1.00	2.00	2.20	2.40	2.70	2.90	3.10	3.30	3.50
INDEX	.00	.31	.31	.32	.34	.37	.40	.44	.49	.55
CHAN.INDEX	3.60	3.80	4.00	4.10	4.20	4.30	5.60	5.80	5.90	6.00
INDEX	.59	.70	.91	.96	.99	1.00	1.00	.99	.96	.91
CHAN.INDEX	6.10	6.20	6.30	6.50	6.60	6.70	6.80	6.90	7.10	7.20
INDEX	.72	.58	.48	.34	.29	.25	.22	.18	.13	.11
CHAN.INDEX	7.40	7.60	7.80	8.00	100.00					
INDEX	.08	.04	.02	.00	.00					

Q .VS. AVAILABLE HABITAT AREA PER 1000 FEET OF STREAM FOR BROWN TROUT

Q	ADULTS
100.00	6447.95
200.00	6441.54
400.00	7933.29
500.00	8894.16

Q .VS. AVAILABLE HABITAT AREA AS A PERCENTAGE OF THE GROSS AREA FOR BROWN TROUT

Q	GROSS	ADULTS
100.00	63188.	10.20
200.00	74414.	8.66
400.00	75884.	10.45
500.00	76032.	11.70

$$$ NORMAL COMPLETION OF HABTAV $$$

PHABSIM TECHNICAL NOTE NO. 17

THE SELECTION OF THE CONSTANT SLOPE IN A WSP DATA SET

by

Robert T. Milhous
Hydraulic Engineer

INTRODUCTION

One approach to making calculations of water surface elevatons using the WSP hydraulic simulation program is to use a constant slope at the first cross section and allow the program to calculate the water surface for this most downstream cross section using Manning's equation. The assumption made is that the downstream cross section is a normal depth control. This means the water surface elevation at the section is not subject to backwater effects from downstream sections over the range of flows of interest nor is the section a critical depth control.

THE PROCEDURE

The steps to follow in using the WSP program assuming constant slope are:

1. Enter data and <u>check</u> data, looking for both data entry errors and problems with the field data;

2. Calibrate the model to one set of water surface elevations;

3. Select flows of interest;

4. Select the constant slope;

5. Test the constant slope;

6. Select roughness multipliers, for the flows of interest; and

7. Run the WSP model for the flows of interest.

The results from the calibration phase (step 2) will include a page with the slope at the first cross section. An example is given in Figure 1.

The constant slope to use is 0.00006. The result should then be tested by entering on the QARD card inplace of the water surface elevation used in the calibration phase. The program should give exactly the same results as resulted from step 2. If not, an adjustment must be made. For example, the initial water surface elevation for the data set in Figure 1 was 91.27, but when the slope of 0.00006 is used the calculated water surface elevation is 91.31 - an error of 0.04 fcet.

85/07/24.
11.54.51.

YAKIMA RIVER BELOW PROSSER
CALIBRATION RUN

PROGRAM-WSP(IFG2)
PAGE 6

STATION 0 + 0 ENGLISH SYSTEM ASSUMED ELEV. 0.00 THALWEG ELEV. 83.4 THALWEG SLOPE 0.0000

THIS IS A CONTROL SECTION -COMPUTATION LINE NOT REQD

LENGTH OF CENTROID	CONVEYANCE AREAS	TOP WIDTHS	HYDRALIC, RADII	ROUGHNESS COEFFICIENTS	CONVEYANCE FACTORS	VELOCITIES	DISCHARGES
0.	5.	4.	1.0	.02200	319.	.54	3
0.	44.	13.	3.4	.02200	6772.	1.20	53
0.	78.	15.	5.2	.02200	15856.	1.59	124
0.	139.	20.	6.9	-.02200	34287.	1.93	269
0.	156.	20.	7.8	.02200	41648.	2.09	325
0.	145.	20.	7.3	.02200	36850.	1.99	289
0.	101.	15.	6.7	.02200	24261.	1.89	190
0.	100.	15.	6.7	.02200	23961.	1.88	188
0.	99.	15.	6.6	.02200	23662.	1.87	186
0.	98.	15.	6.5	.02200	23069.	1.85	181
0.	96.	15.	6.4	.02200	22190.	1.82	174
0.	92.	15.	6.1	.02200	20756.	1.77	163
0.	87.	15.	5.8	.02200	19088.	1.72	150
0.	81.	15.	5.4	.02200	16947.	1.64	133
0.	69.	15.	4.6	.02200	12730.	1.46	100
0.	58.	15.	3.9	.02200	9669.	1.31	76
0.	56.	15.	3.7	.02200	9053.	1.27	71
0.	39.	10.	3.9	.02200	6443.	1.31	51
0.	62.	15.	4.1	.02200	10733.	1.36	84
0.	62.	15.	4.1	.02200	10733.	1.36	84
0.	78.	20.	3.9	.02200	13170.	1.32	103
0.	26.	8.	3.1	.02200	3706.	1.12	29
0.	12.	6.	1.9	.02200	1244.	.83	10
0.	6.	7.	.9	.02200	371.	.48	3
0.	0.	1.	.1	.02200	3.	.14	0
SUM OR AVG	1790.	339.			387522.	1.77	3039

THIS SECTION HAS 30 ROUGHNESS SEGMENT(S). 25 SEGMENT(S) WERE USED FOR THIS DISCHARGE.
THIS SECTION IS AN INITIAL CONTROL - FLOW IS SUB-CRITICAL - COMPUTED SLOPE = .00006 W.S. ELEV. = 91.27

Figure 1. Example of page with the calculated slope at the most downstream section in a WSP data set.

ADJUSTMENT OF SLOPE

The slope may have to be adjusted if the number of significant numbers is less than 2, as occurred in the example above. The steps to follow as shown in the example follows.

The first step is to run the model using a slope one-half a unit above and one-half a unit above the initial slope where one unit has the same significant figure as the given slope - in this case, 0.00001. Hence, the two slopes used are 0.000055 and 0.000065. The resulting water surface elevation are thus

Slope	Water Surface Elevation
0.000055	91.46
0.000060	91.31
0.000065	91.18

These are then plotted as shown in Figure 2 and slope corresponded to the water surface elevation of 91.27 selecters; this is a slope of 0.0000615. A test of this slope results in the same simulated water surface elevation as the calibration data set.

ACKNOWLEDEMENTS

The problem of using single digit constant slopes was pointed out by Dell Simons of Fisheries Association in Vancouver, Washington, and the example data used was supplied by him also.

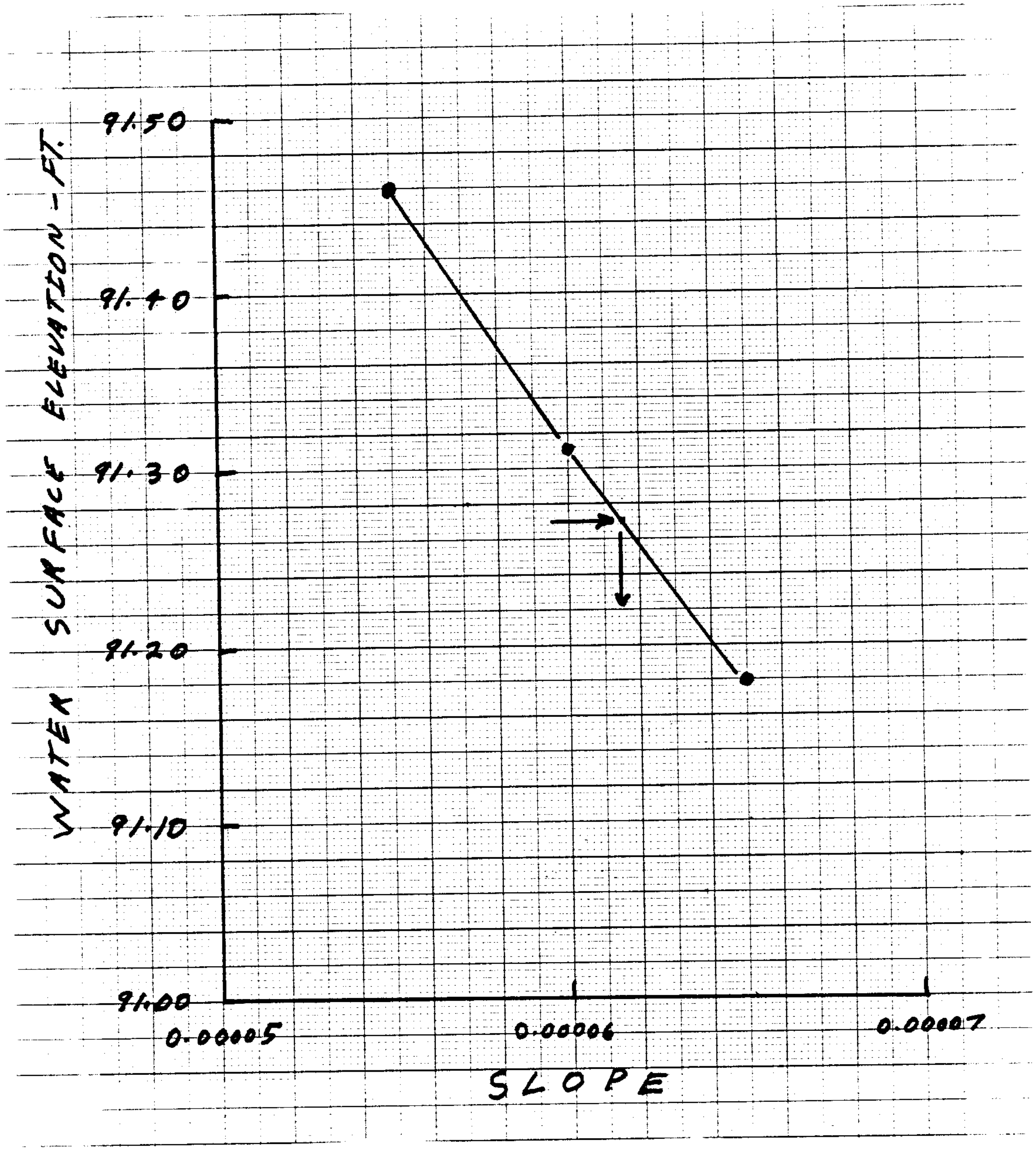


Figure 2. Graph of assumed slope versus calculated water surface elevations.

PHABSIM TECHNICAL NOTE NO.19

IMPACT OF ALTERNATIVE ASSUMPTIONS ON RESULTS OBTAINED FROM THE PHYSICAL HABITAT SIMULATION SYSTEM

by

Robert T. Milhous
Hydraulic Engineer

INTRODUCTION

The purpose of this note is to explore the impact on the physical habitat versus streamflow relationship of certain alternatives in the hydraulic simulations. The work was done in 1983 and the approachs developed in the subsequent two years are not included. Nevertheless, the discussion will be helpful in understanding the use of the various hydraulic simulation programs.

The impact of the alternatives investigated using rainbow trout suitability criteria and a data set for a stream in the Rocky Mountain region. The data set is not of high quality and was chosen because alternatives in the hydraulic simulations, acting with the random errors in the velocity and water surface elevation measurements, will result in the maximum variation in the habitat versus streamflow relationships. The use of species criteria with relatively narrow optimum depths and velocities will also maximize the impact of the various hydraulic simulation alternatives.

THE RESULTS

The "best" set of the physical habitat versus streamflow relationship is given in Figure 1. This hydraulic simulation was made using a calibrated WSP model to simulate the water surface elevations and a three data set IFG4 model to calculate the velocities given the water surface elevations.

There are situations in which the data available is limited. Examples of typical data which may be available are:

1. Cross-section coordinates plus at least one set of water surface elevations;

2. Cross-section coordinates, water surface elevations, and one set of velocity measurements; and,

3. Cross-section coordinates, water surface elevations, and at least three sets of velocity measurements.

For the first case, only the WSP program with the model calibrated to water surface elevation may be used.

For the second case, the WSP model can be calibrated to water surface elevations and to velocities; also, the WSP/IFG4 combination may be used with the one set of velocity measurements. In the latter case, the WSP program is used to simulate the water surface elevations and the IFG4 program used to

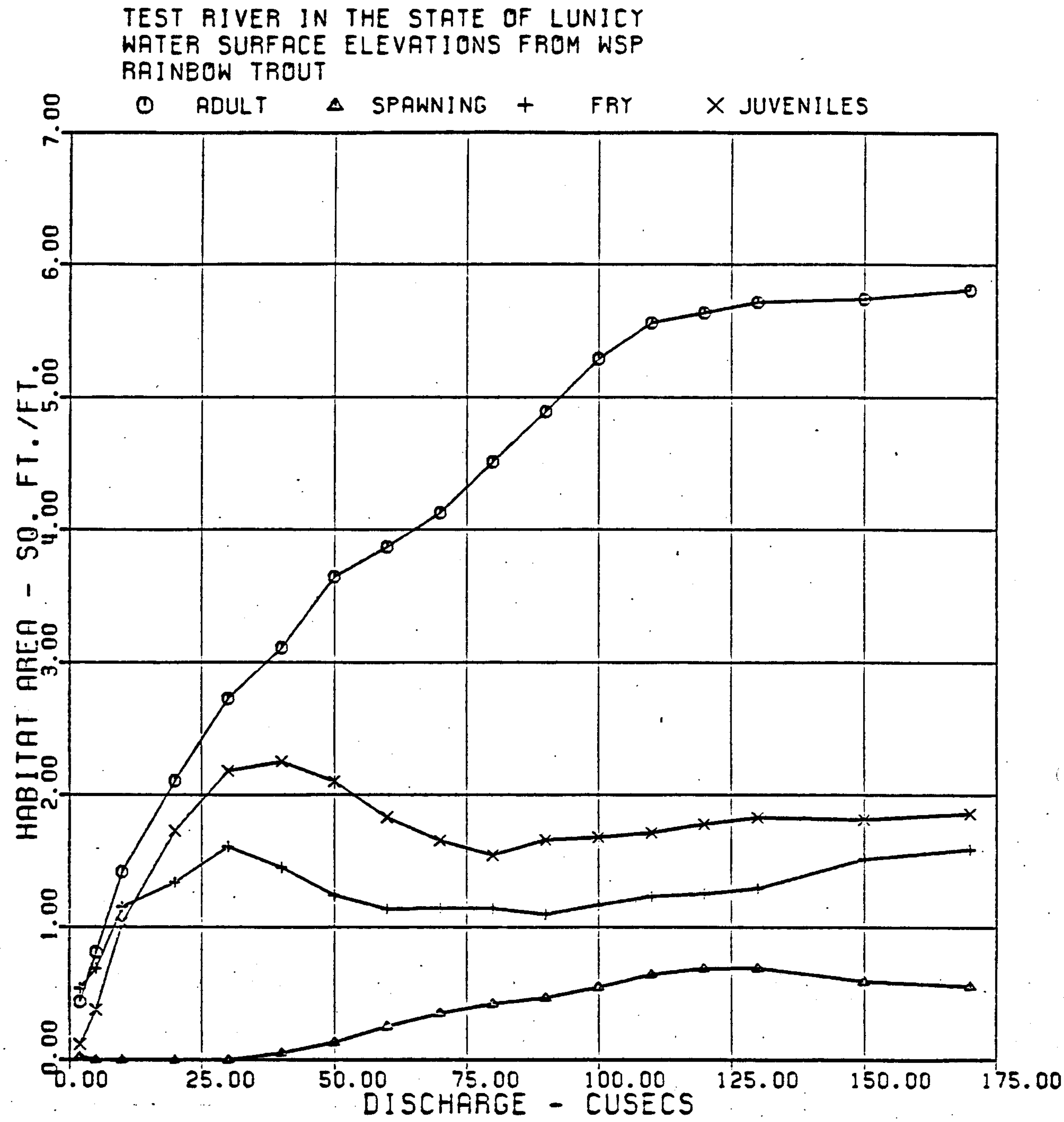


Figure 1. The "best" physical habitat versus streamflow relationship for rainbow trout in the State of Lunicy.

simulate the velocities. The latter approach is the most effective, but should only be done if the size of the roughness coefficient is limited (IOC(15) = 1).

The third data set contains the most data and can be used with the IFG4 program alone or with the WSP program simulating the water surface elevations and the IFG4 program simulating the velocities with a limit on the slope, B, of the regression equation, v = A*Q**B; and a on the limited roughness.

A comparison of the results using the three hydraulic simulation models is given in Figure 2. There is a difference in each life stage.

The selection of the "best" model for a given problem must be based on judgement. The opinion of the writer, based on the analysis presented in the various appendicies is that the "best" results for the data set at hand is the use of the IFG4 program with the water surface elevation being simulated using a WSP model calibration to water surface elevations only. There should also be a limit on the roughness and on the slope B in the equation v = A*Q**B.

If only one set of velocity measurements are available, then the WSP model for water surface elevation plus the IFG4 model for velocity simulation should be used. There must be a limit on the roughness.

If only cross-section data is available, then only the WSP model is available.

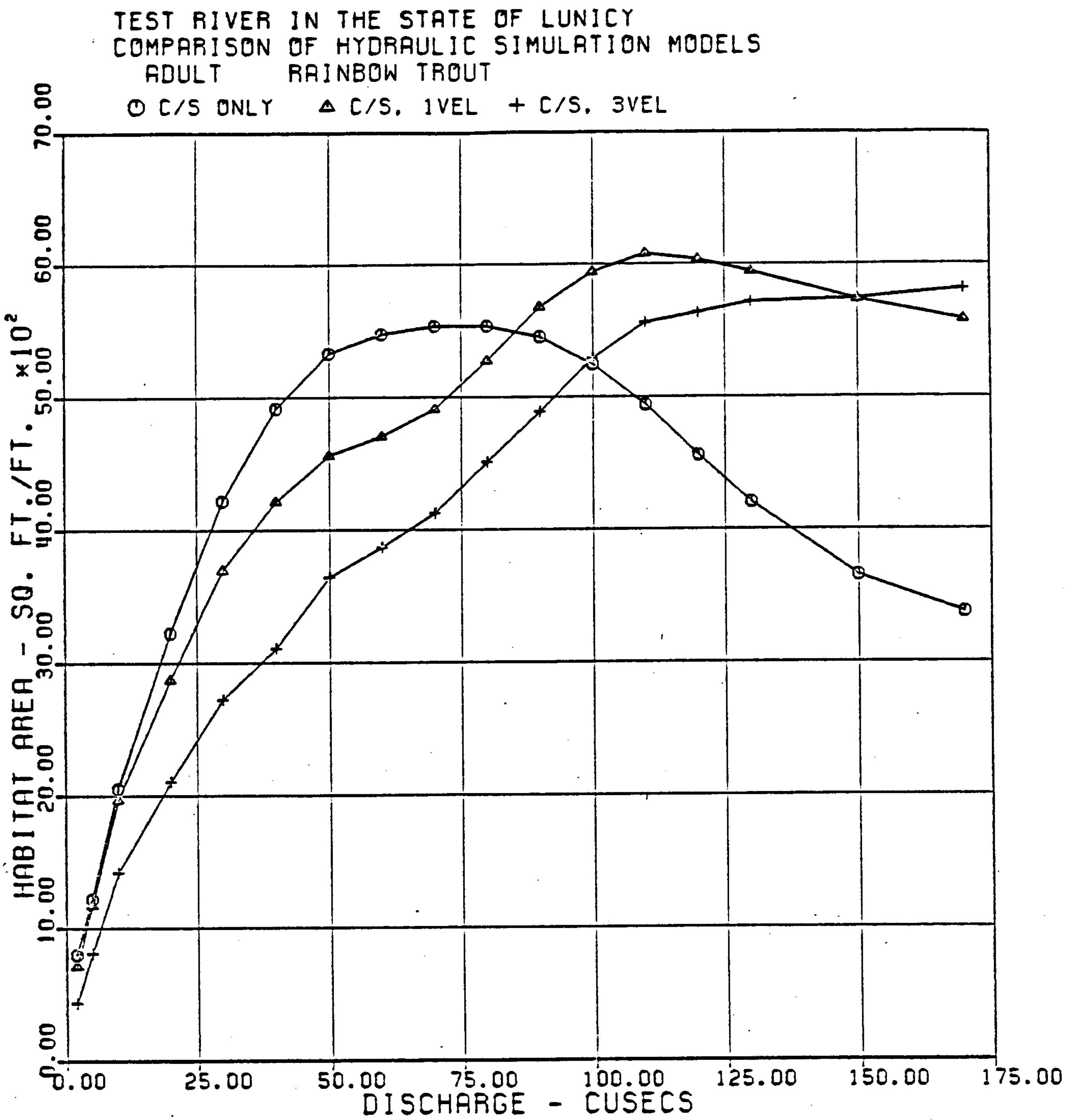


Figure 2. Comparison of the impact of three hydraulic simulations on the physical habitat versus streamflow relationship.

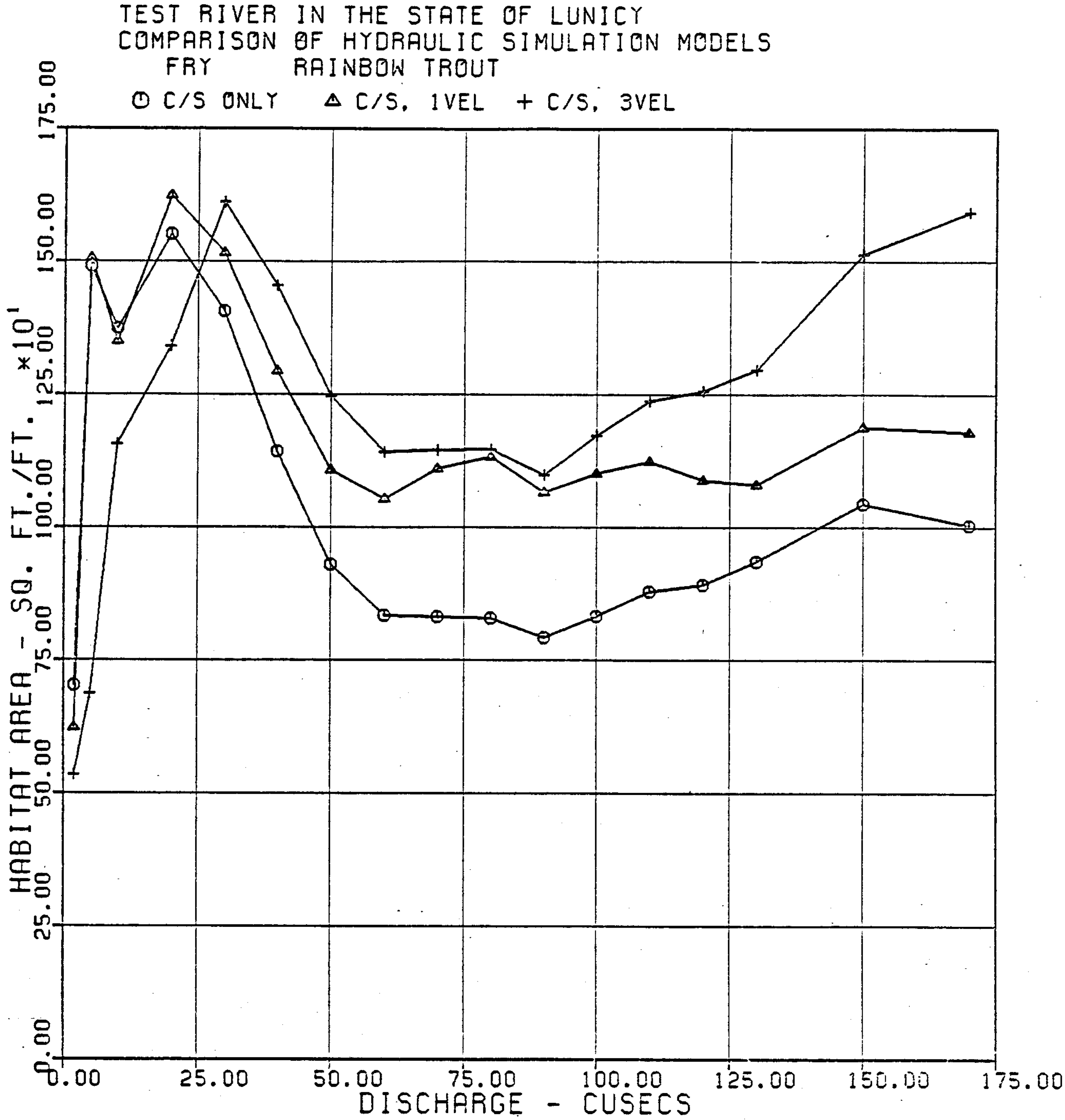


Figure 2. Continued

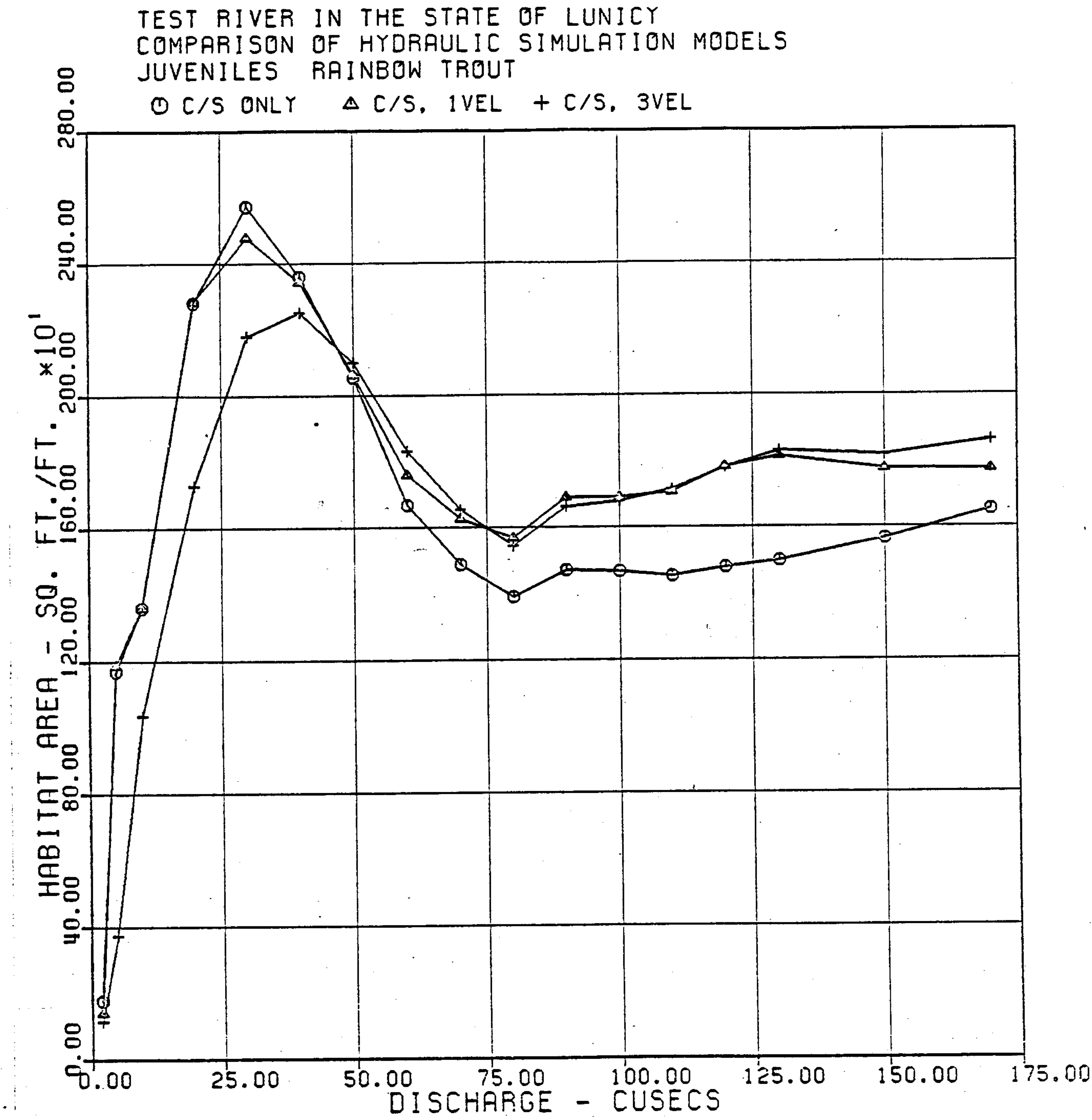


Figure 2. Continued

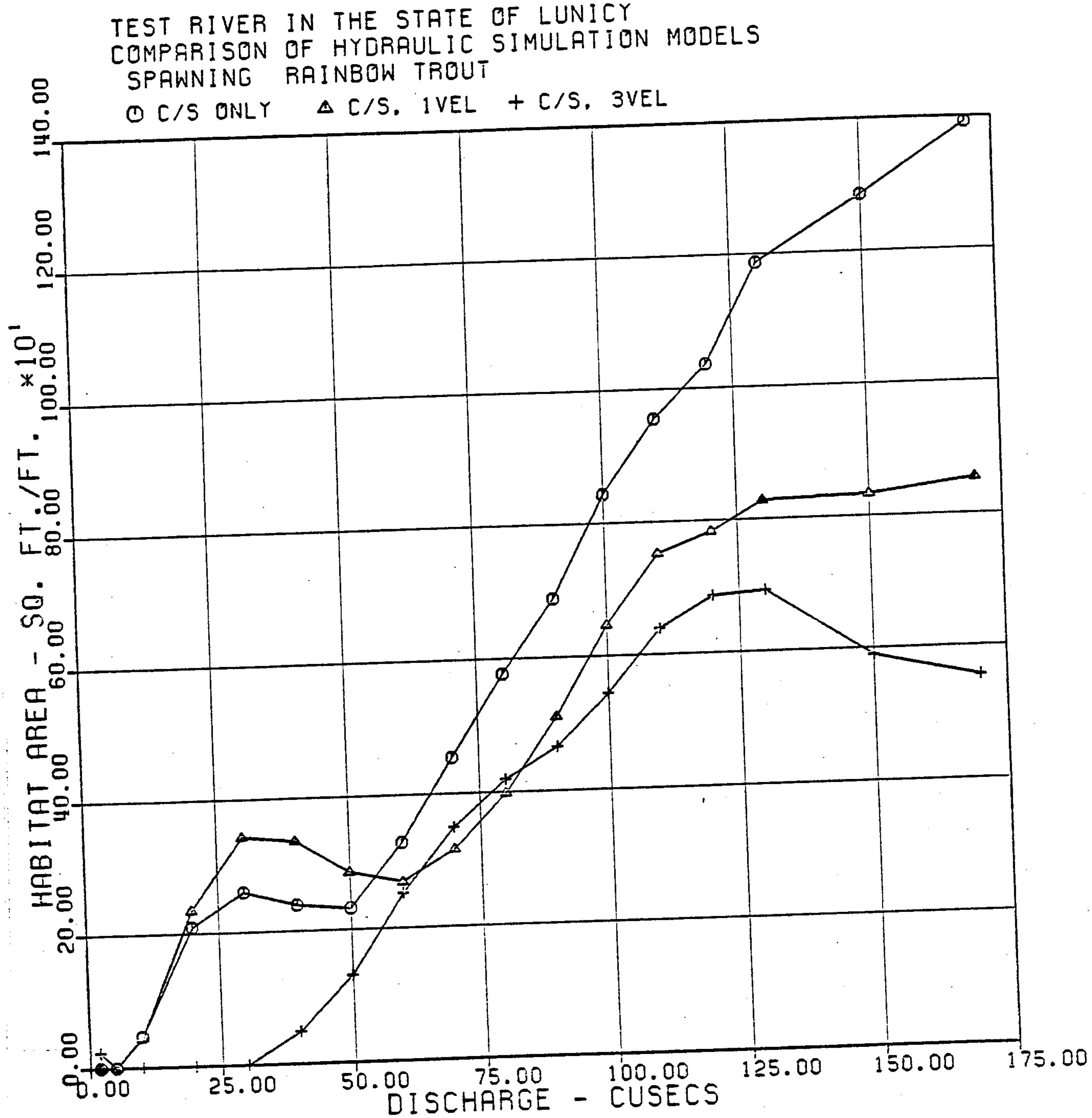


Figure 2. Continued

The determination of a good stage-discharge relationship for the downstream cross section in a WSP model is likely to be as valuable as the measurement of velocities. In other words, the results are improved if a stage-discharge is used to obtain a starting water surface elevation instead of assuming constant slope.

APPENDIX A

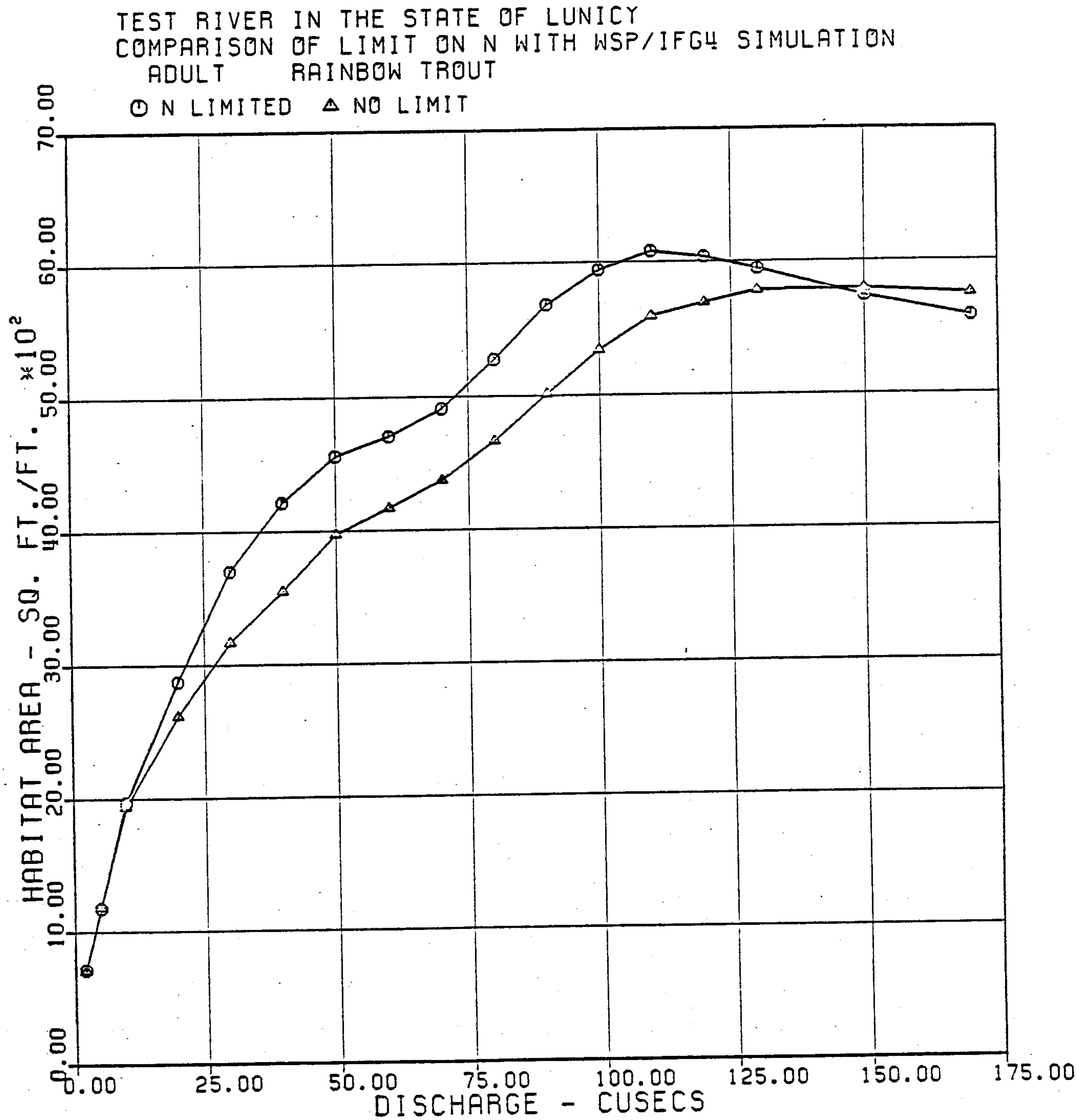
RESULTS OF A LIMIT ON ROUGHNESS

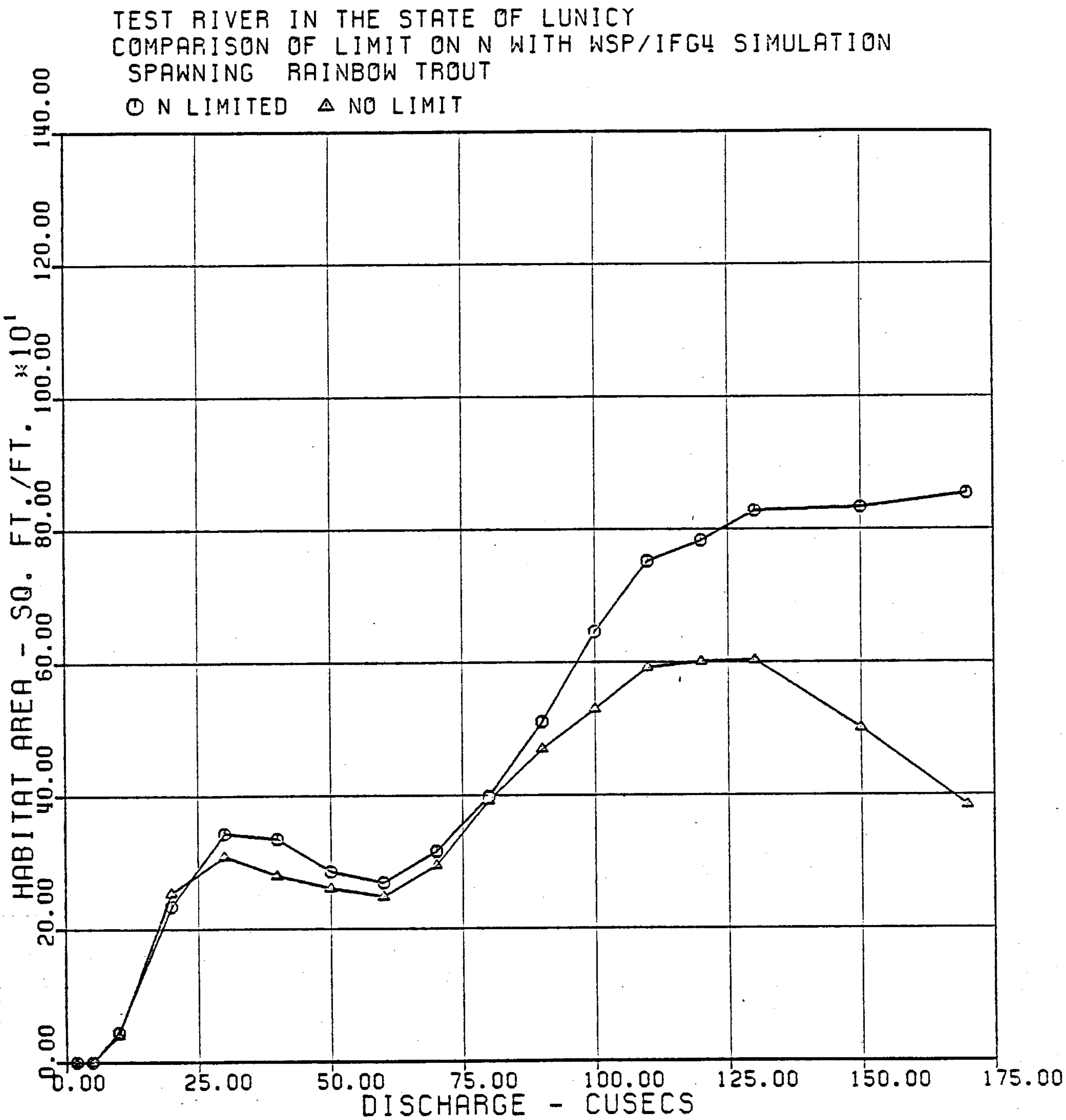
Some IFG4 or WSP datasets can result in very large values of the Manning roughness coefficient n on the edge of the stream. These large values of roughness are unrealistic and can result in hydraulic simulations that have water too slow at the edges and too fast in the center. This hydraulic simulation can be improved by limiting the value of the roughness coefficient. Because the water surface elevations are determined independently of the roughness values, there will be no change in the depths, substrates, or cover used in the habitat analysis as a result of limiting the roughness coefficient. The impact is soley on the velocity.

Using the test river dataset, the imput on physical habitat for rainbow trout of limiting the value of the roughness coefficient is shown in this appendix. The water surface elevation were determined using a WSP dataset calibrated to water surface elevations only and then using an IFG4 data file with one set of calibration velocities.

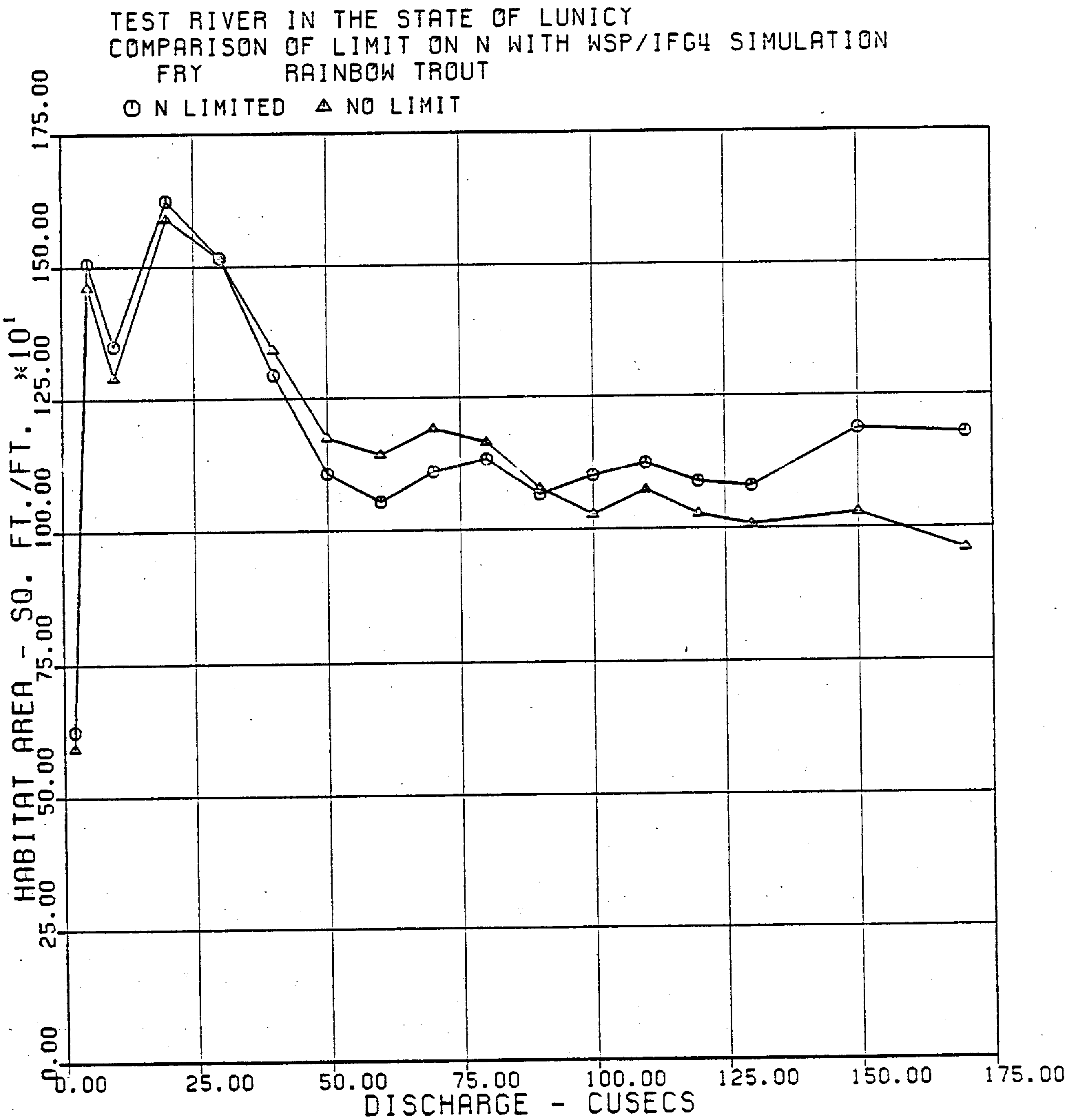
The results of the comparison show differences in the physical habitat versus streamflow relationship.

The calibration flow for both the WSP and the IFG4 datasets was 100 cfs. As a result, streamflow greater than 100 cfs have cells not wet at the calibration flow and will tend to have too slow water and the center cells will have water that is too fast. Unlimited cases will have more habitat at flows greater than 100 cfs for those life stages which like slow and shallow water and those that like deep or fast water than probably exists. As the diagrams show, the major input was on the habitat curves for flows greater than 100 cfs. Except for the spawning flow versus physical habitat for streamflows greater than 100 cfs, the maximum change from limiting the roughness is about 12%.

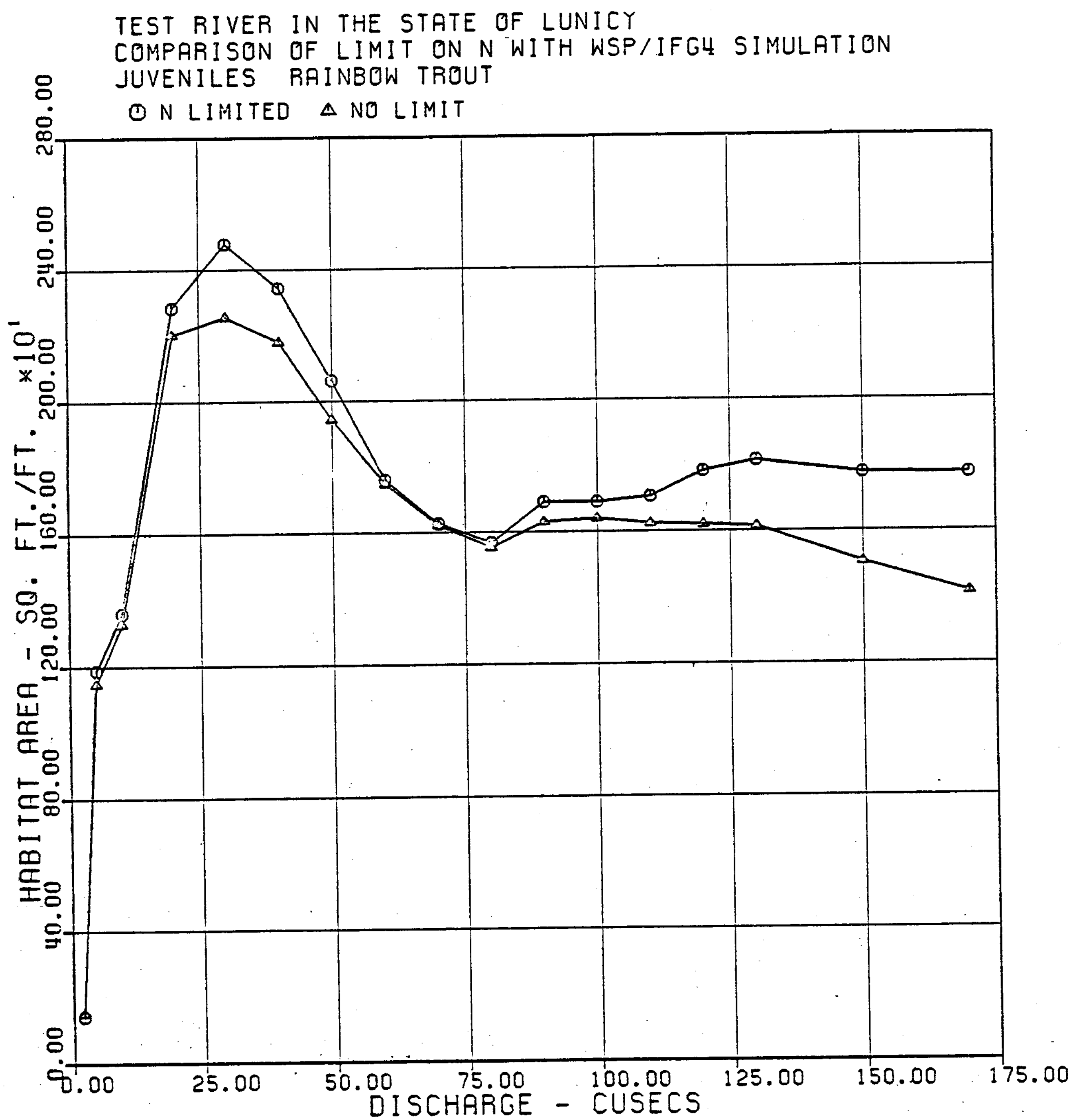

TEST RIVER IN THE STATE OF LUNICY
COMPARISON OF LIMIT ON N WITH WSP/IFG4 SIMULATION
ADULT RAINBOW TROUT
N LIMITED
NO LIMIT
HABITAT AREA - SQ. FT./FT. *10²
DISCHARGE - CUSECS
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
25.00
50.00
75.00
100.00
125.00
150.00
175.00



TEST RIVER IN THE STATE OF LUNICY
COMPARISON OF LIMIT ON N WITH WSP/IFG4 SIMULATION
SPAWNING RAINBOW TROUT
N LIMITED
NO LIMIT
HABITAT AREA - SQ. FT./FT. ×10[1]
0.00
20.00
40.00
60.00
80.00
100.00
120.00
140.00
0.00
25.00
50.00
75.00
100.00
125.00
150.00
175.00
DISCHARGE - CUSECS



TEST RIVER IN THE STATE OF LUNICY
COMPARISON OF LIMIT ON N WITH WSP/IFG4 SIMULATION
FRY RAINBOW TROUT
N LIMITED
NO LIMIT
HABITAT AREA - SQ. FT./FT. ×10[1]
DISCHARGE - CUSECS
0.00
25.00
50.00
75.00
100.00
125.00
150.00
175.00


TEST RIVER IN THE STATE OF LUNICY
COMPARISON OF LIMIT ON N WITH WSP/IFG4 SIMULATION
JUVENILES RAINBOW TROUT
N LIMITED
NO LIMIT
HABITAT AREA - SQ. FT./FT. *10[1]
0.00
40.00
80.00
120.00
160.00
200.00
240.00
280.00
0.00
25.00
50.00
75.00
100.00
125.00
150.00
175.00
DISCHARGE - CUSECS

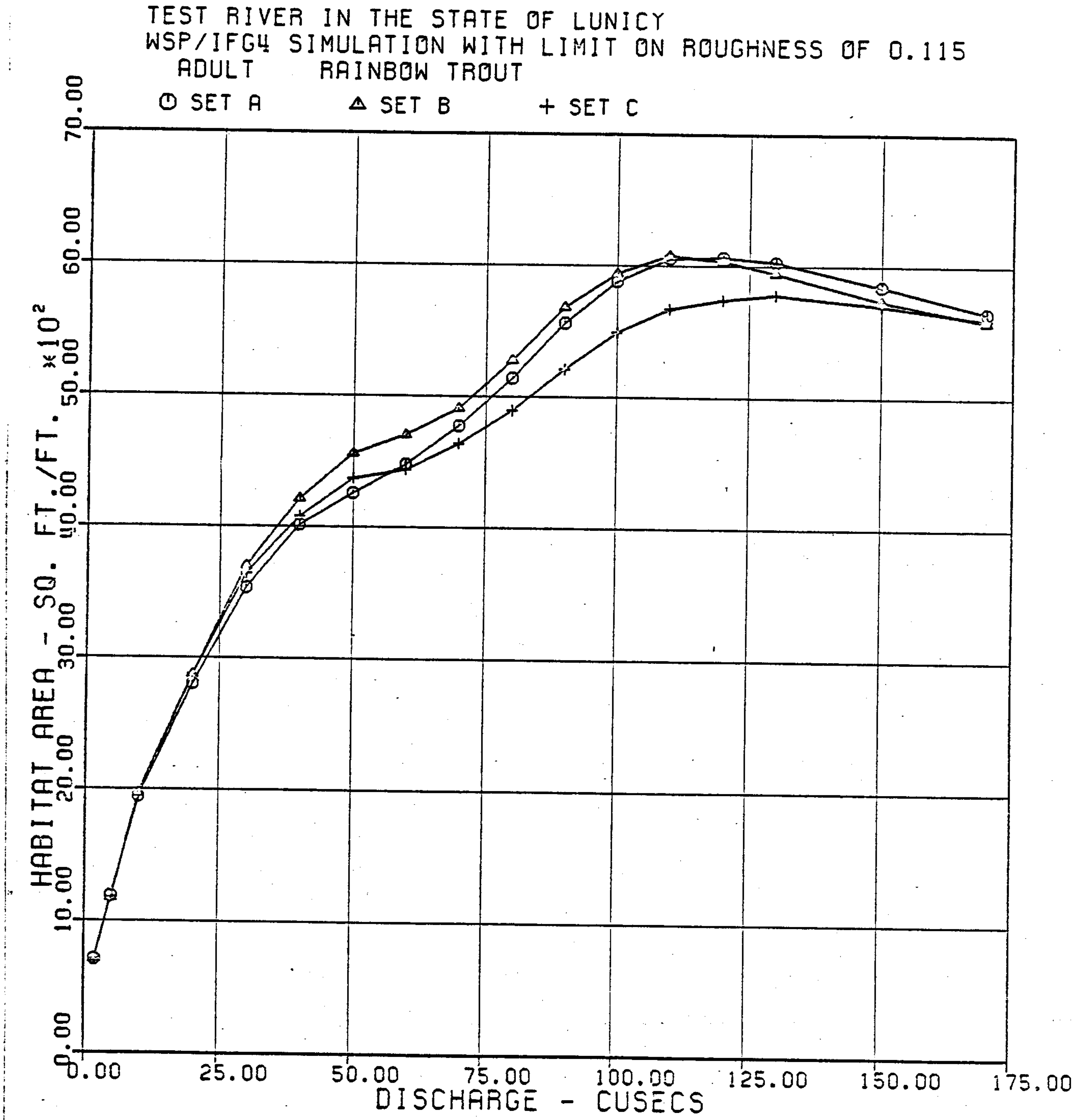
APPENDIX B

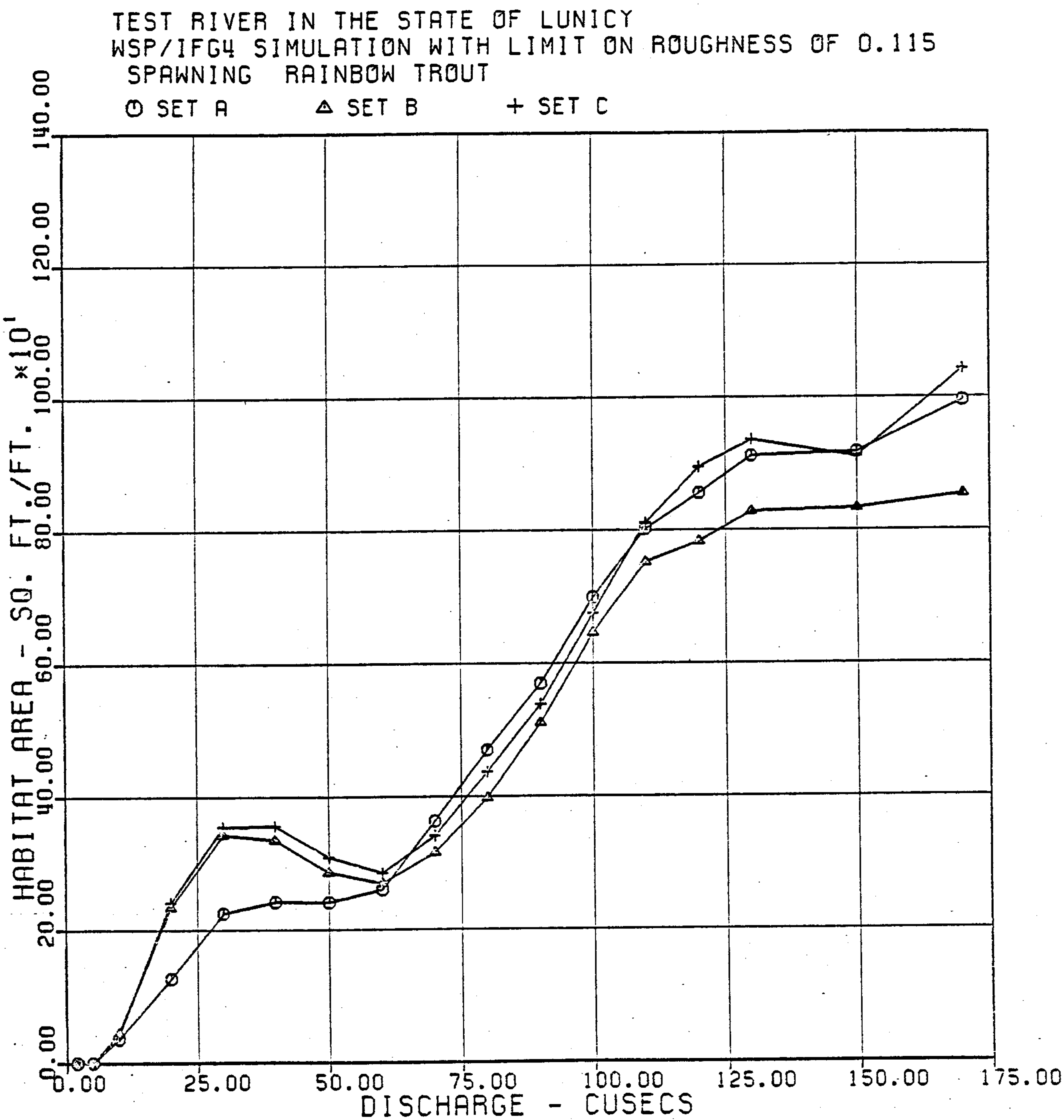
COMPARISON OF CALIBRATION DATASETS

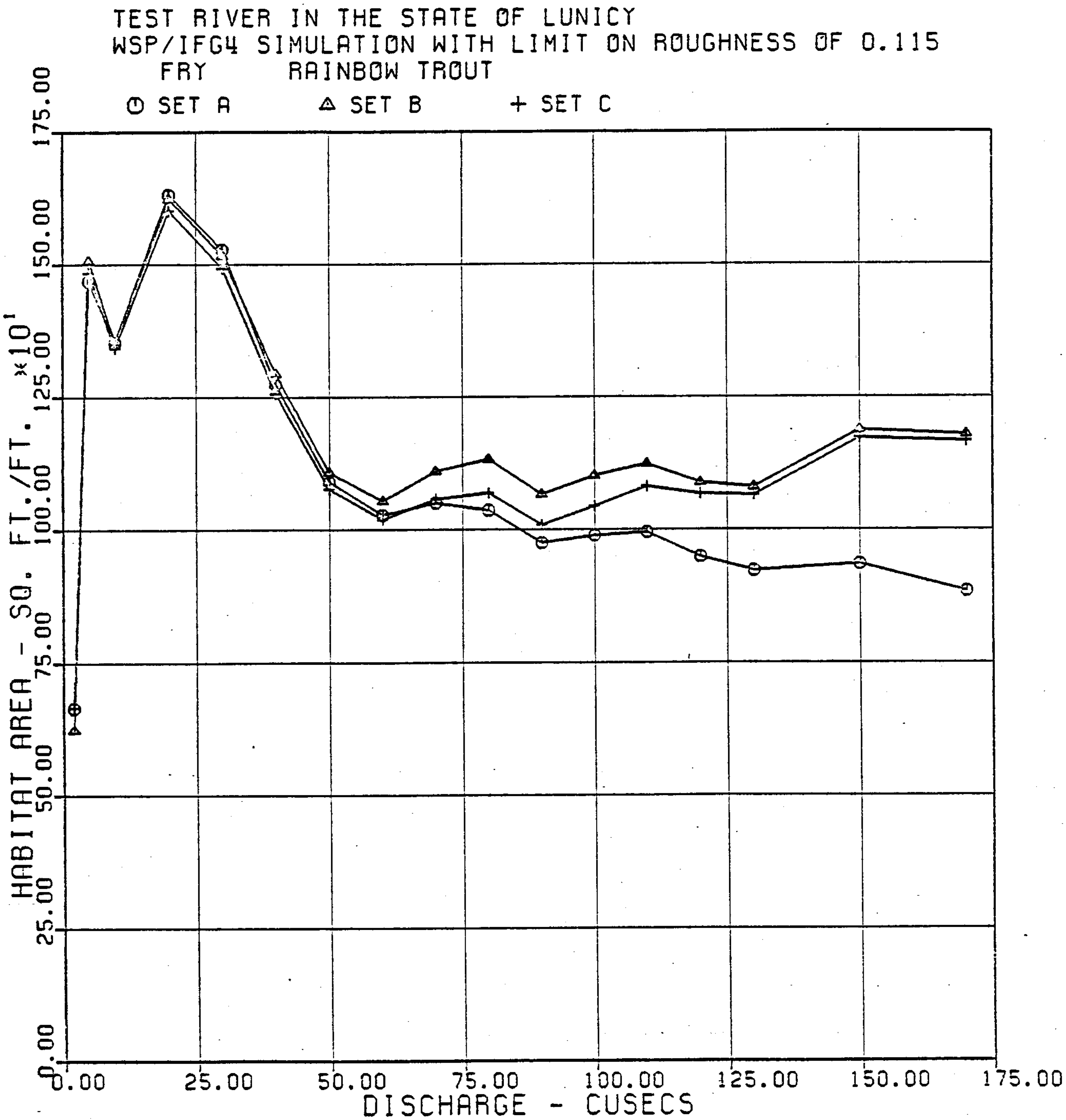
The WSP/IFG4 approach to hydraulic simulation can be used with one set of calibration velocity measurements. The purpose of this appendix is to illustrate the impact of alternative calibration datasets or the physical habitat versus streamflow relationship. Three datasets were used with the following calibration flows:

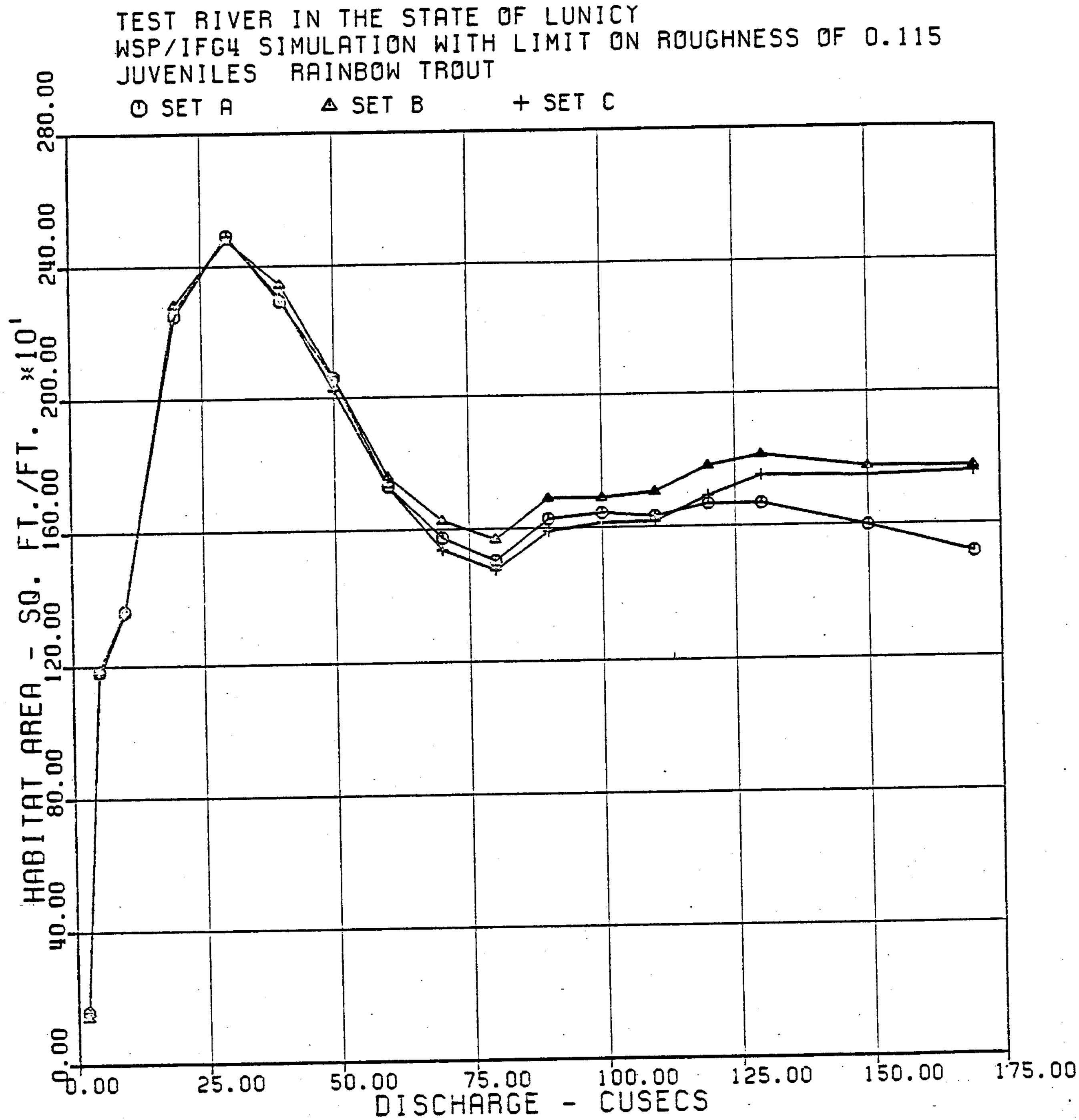
Set	Calibration Flow
A	68 cfs
B	100 cfs
C	124 cfs

In general, the calibration sets result in similar physical habitat for rainbow trout in the test river.


TEST RIVER IN THE STATE OF LUNICY
WSP/IFG4 SIMULATION WITH LIMIT ON ROUGHNESS OF 0.115
ADULT RAINBOW TROUT
SET A
SET B
SET C
HABITAT AREA - SQ. FT./FT. ×10²
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
0.00
25.00
50.00
75.00
100.00
125.00
150.00
175.00
DISCHARGE - CUSECS


TEST RIVER IN THE STATE OF LUNICY
WSP/IFG4 SIMULATION WITH LIMIT ON ROUGHNESS OF 0.115
SPAWNING RAINBOW TROUT
SET A
SET B
SET C
HABITAT AREA - SQ. FT./FT. *10¹
DISCHARGE - CUSECS
0.00
20.00
40.00
60.00
80.00
100.00
120.00
140.00
25.00
50.00
75.00
100.00
125.00
150.00
175.00


TEST RIVER IN THE STATE OF LUNICY
WSP/IFG4 SIMULATION WITH LIMIT ON ROUGHNESS OF 0.115
FRY RAINBOW TROUT
SET A
SET B
SET C
HABITAT AREA - SQ. FT./FT. ×10¹
DISCHARGE - CUSECS
0.00
25.00
50.00
75.00
100.00
125.00
150.00
175.00


TEST RIVER IN THE STATE OF LUNICY
WSP/IFG4 SIMULATION WITH LIMIT ON ROUGHNESS OF 0.115
JUVENILES RAINBOW TROUT
SET A
SET B
+ SET C
HABITAT AREA - SQ. FT./FT. ×10¹
DISCHARGE - CUSECS
0.00
40.00
80.00
120.00
160.00
200.00
240.00
280.00
25.00
50.00
75.00
100.00
125.00
150.00
175.00

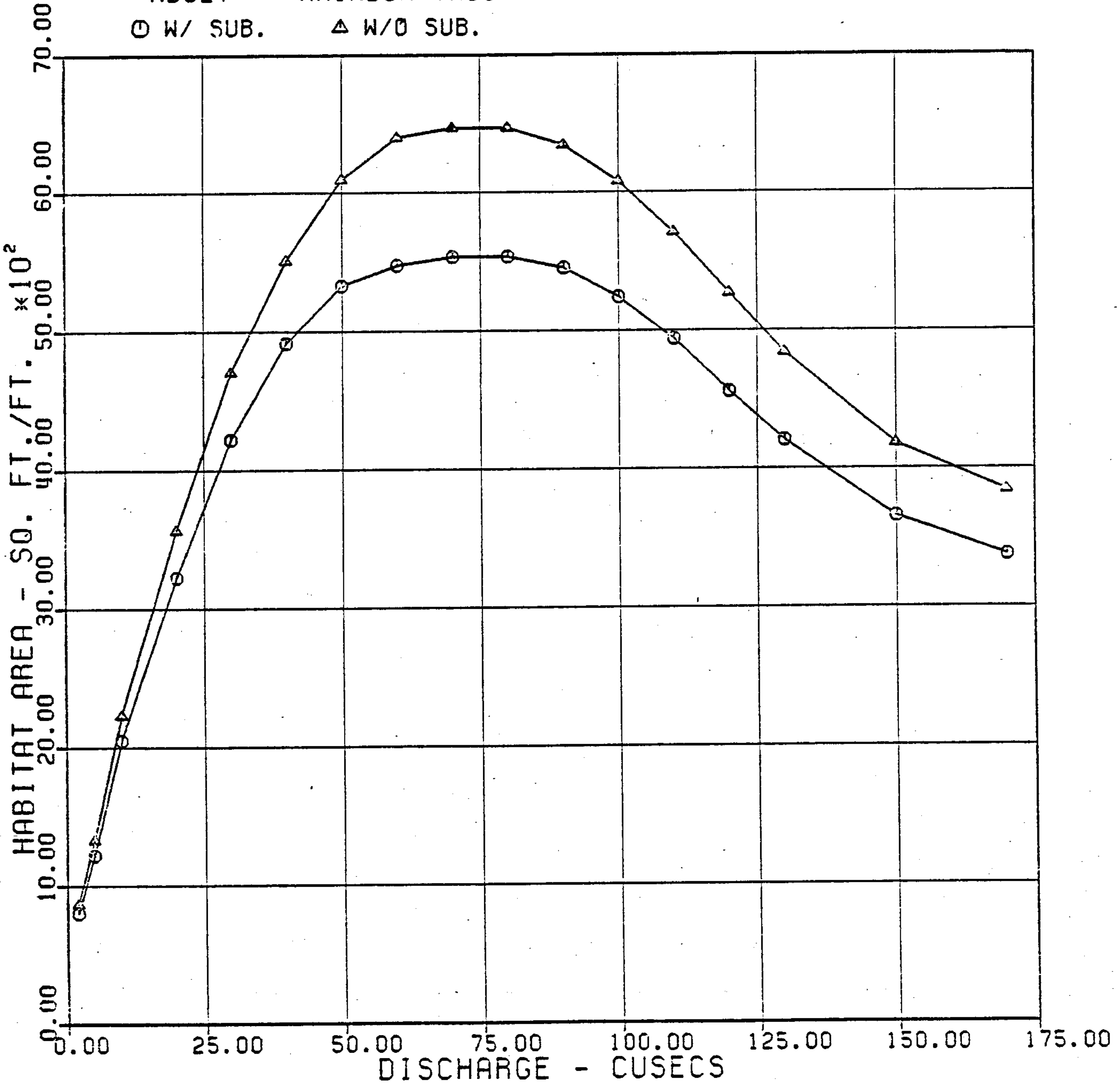
APPENDIX C

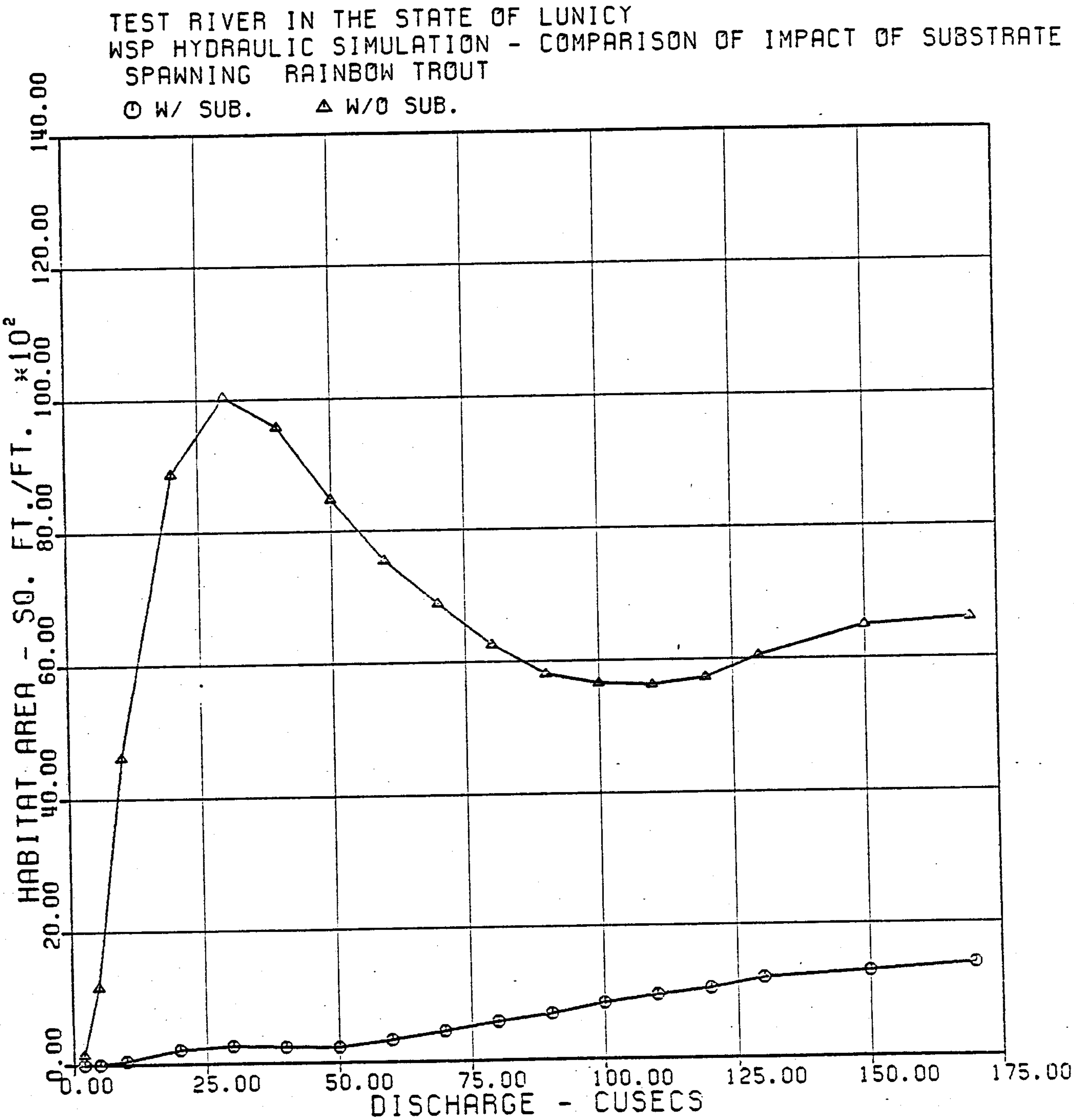
IMPACT OF SUBSTRATE ON PHYSICAL HABITAT VERSUS STREAMFLOW RELATIONSHIP

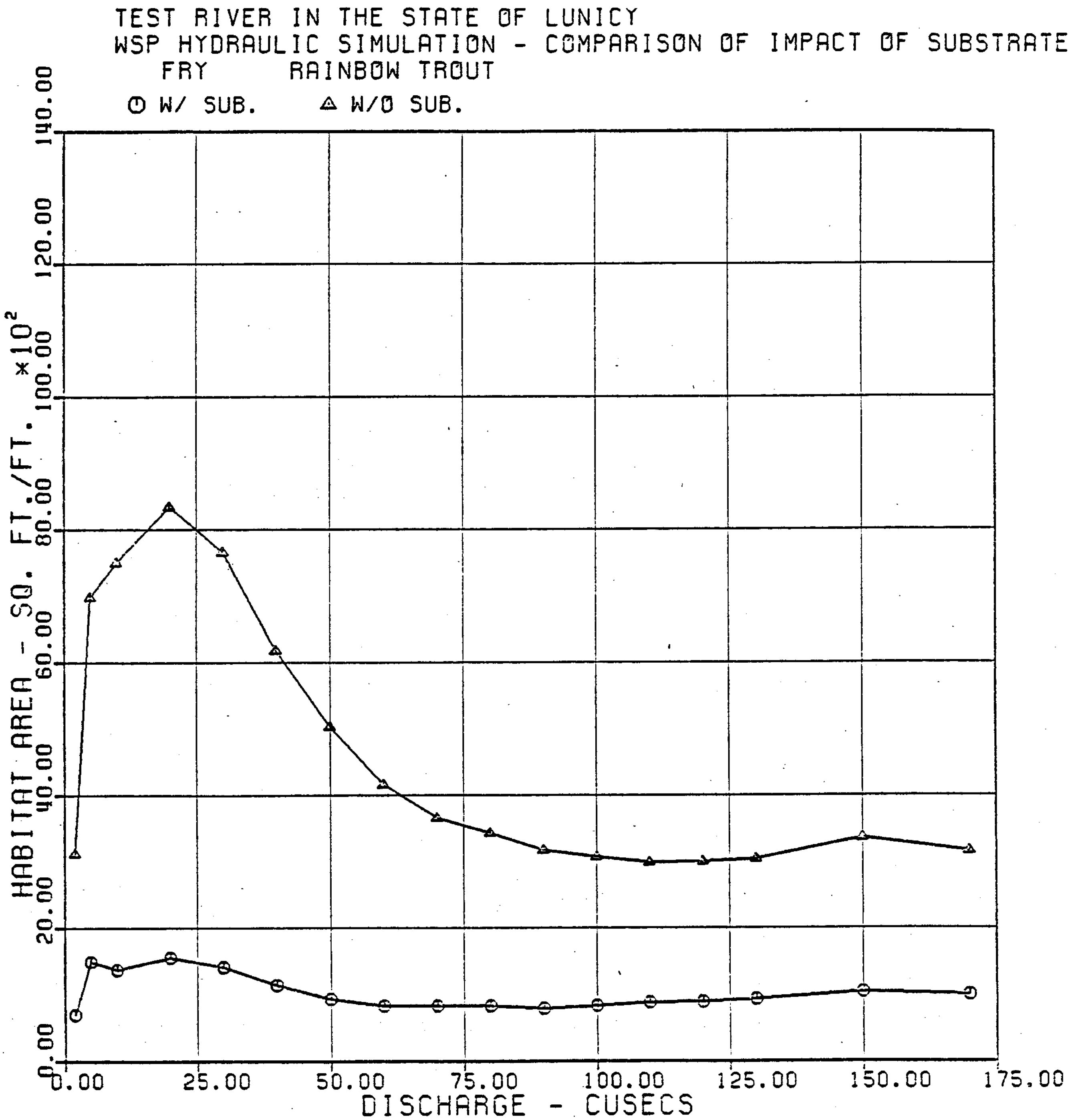
If different substrate and/or cover indexes were used with different habitat simulations, the results of habitat simulation will be different but to what degree depends on the importance of the substrate on the life stage being simulated. The maximum range is illustrated in this appendix by comparing the case of where no substrate was used in the habitat simultation to the case where substrate was used.

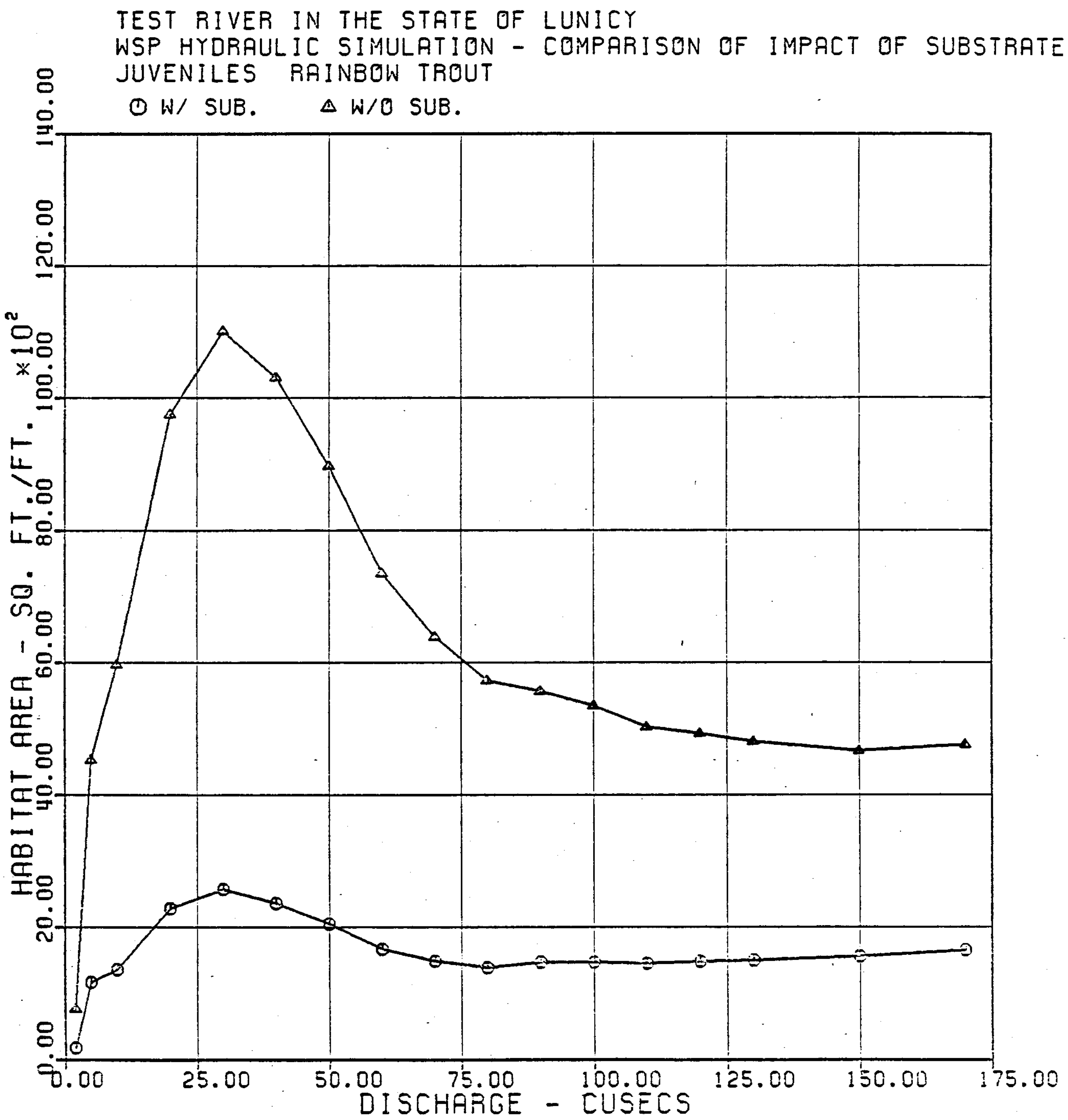
The results indicate substrate is of major importance. Consequently, when comparing habitat simulation models, care must be taken to see that the same substrate index is used in each simulation.

TEST RIVER IN THE STATE OF LUNICY
WSP HYDRAULIC SIMULATION - COMPARISON OF IMPACT OF SUBSTRATE
ADULT RAINBOW TROUT




TEST RIVER IN THE STATE OF LUNICY
WSP HYDRAULIC SIMULATION - COMPARISON OF IMPACT OF SUBSTRATE
SPAWNING RAINBOW TROUT
W/ SUB.
W/O SUB.
HABITAT AREA - SQ. FT./FT. *10²
0.00
20.00
40.00
60.00
80.00
100.00
120.00
140.00
0.00
25.00
50.00
75.00
100.00
125.00
150.00
175.00
DISCHARGE - CUSECS


TEST RIVER IN THE STATE OF LUNICY
WSP HYDRAULIC SIMULATION - COMPARISON OF IMPACT OF SUBSTRATE
FRY RAINBOW TROUT
⊙ W/ SUB. △ W/O SUB.
HABITAT AREA - SQ. FT./FT. *10²
0.00
20.00
40.00
60.00
80.00
100.00
120.00
140.00
0.00
25.00
50.00
75.00
100.00
125.00
150.00
175.00
DISCHARGE - CUSECS



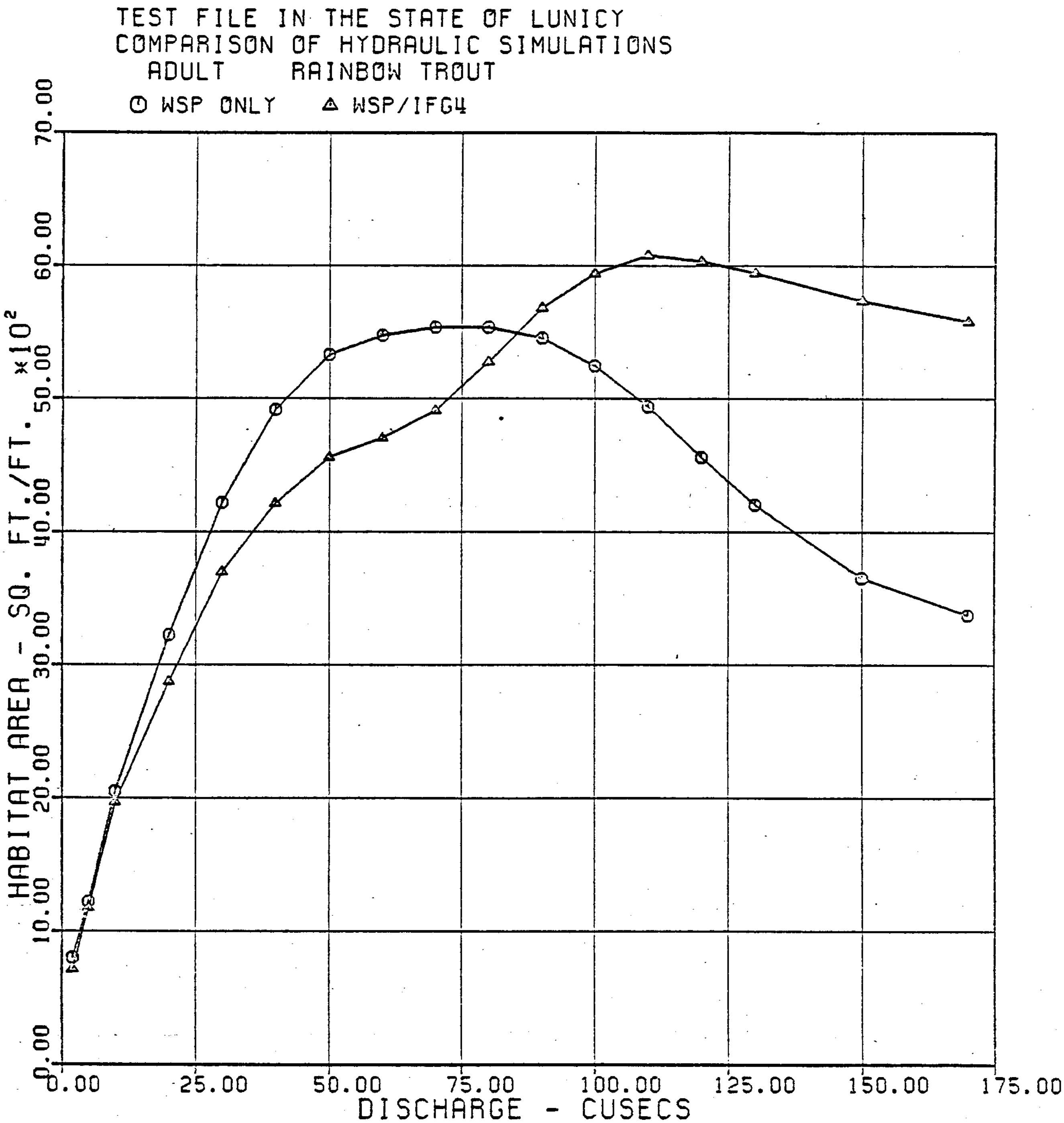
TEST RIVER IN THE STATE OF LUNICY
WSP HYDRAULIC SIMULATION - COMPARISON OF IMPACT OF SUBSTRATE
JUVENILES RAINBOW TROUT
W/ SUB.
W/O SUB.
HABITAT AREA - SQ. FT./FT. *10²
DISCHARGE - CUSECS
0.00
20.00
40.00
60.00
80.00
100.00
120.00
140.00
25.00
50.00
75.00
100.00
125.00
150.00
175.00

APPENDIX D

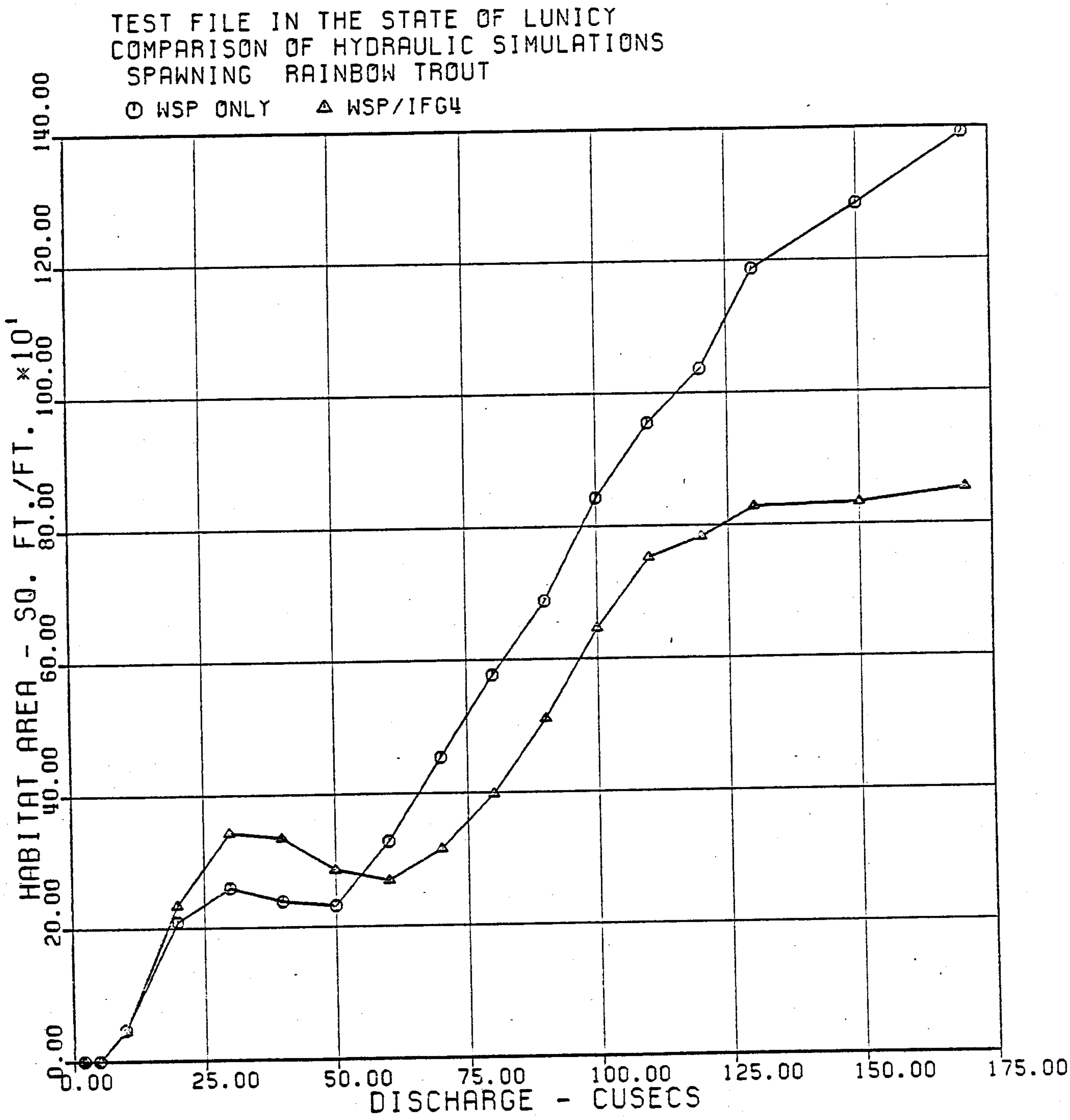
IMPACT OF VELOCITY CALIBRATION

The importance of velocity calibration can be illustrated by using a WSP dataset calibrated to water surface elevations only and the WSP program with a single set of velocity measurement using the WSP/IFG4 combination. The results of the WSP/IFG4 simulation can be considered to result in the "best" estimate of physical habitat relationships for a single set of velocity measurements. The WSP hydraulic simulation alone illustrate the case of poor simulation of velocities, because the model was not calibrated to velocities.

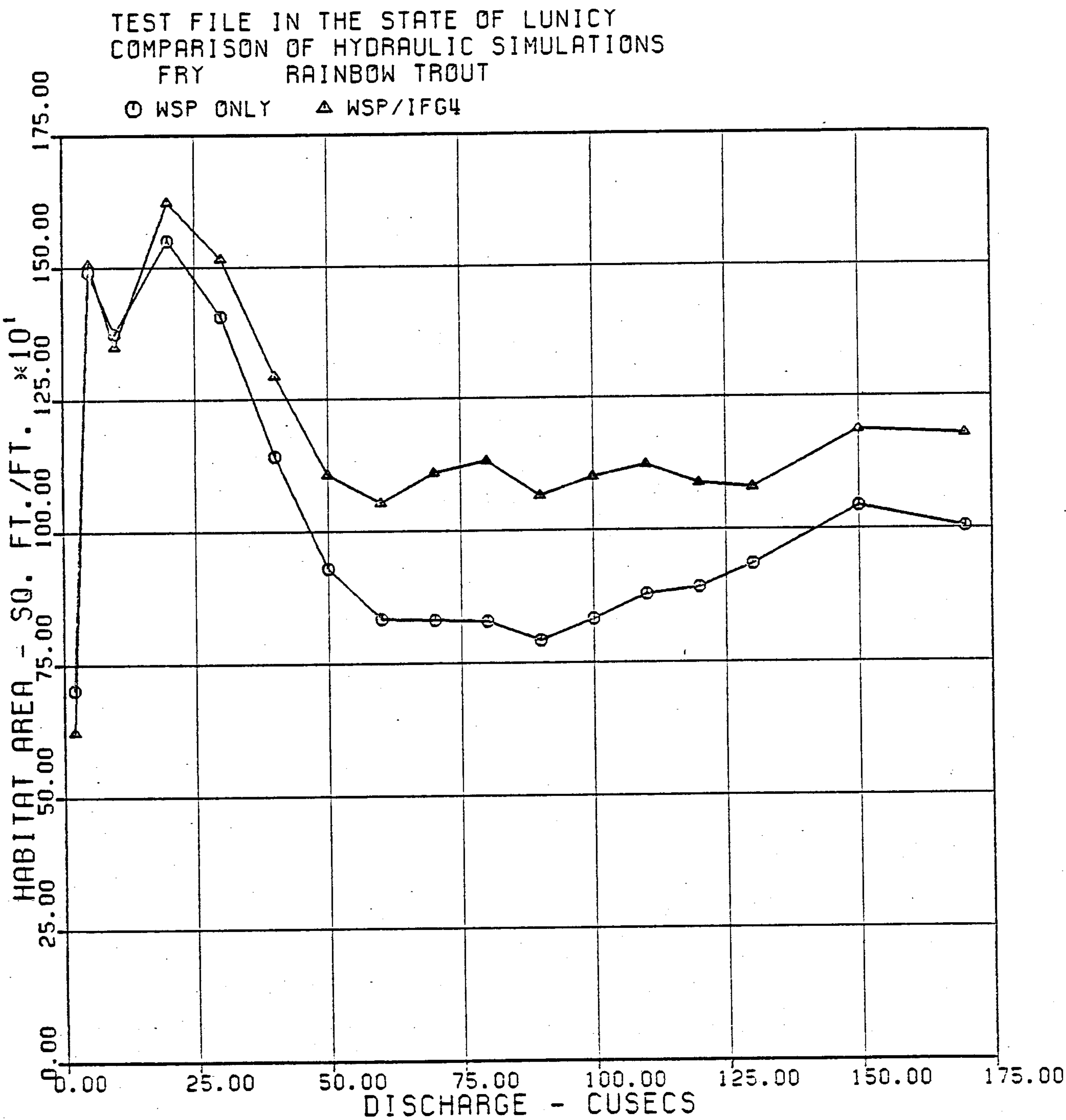
The results given in this appendix suggest velocity calibration is important but note that the shape of the curves for each life stage are similar.



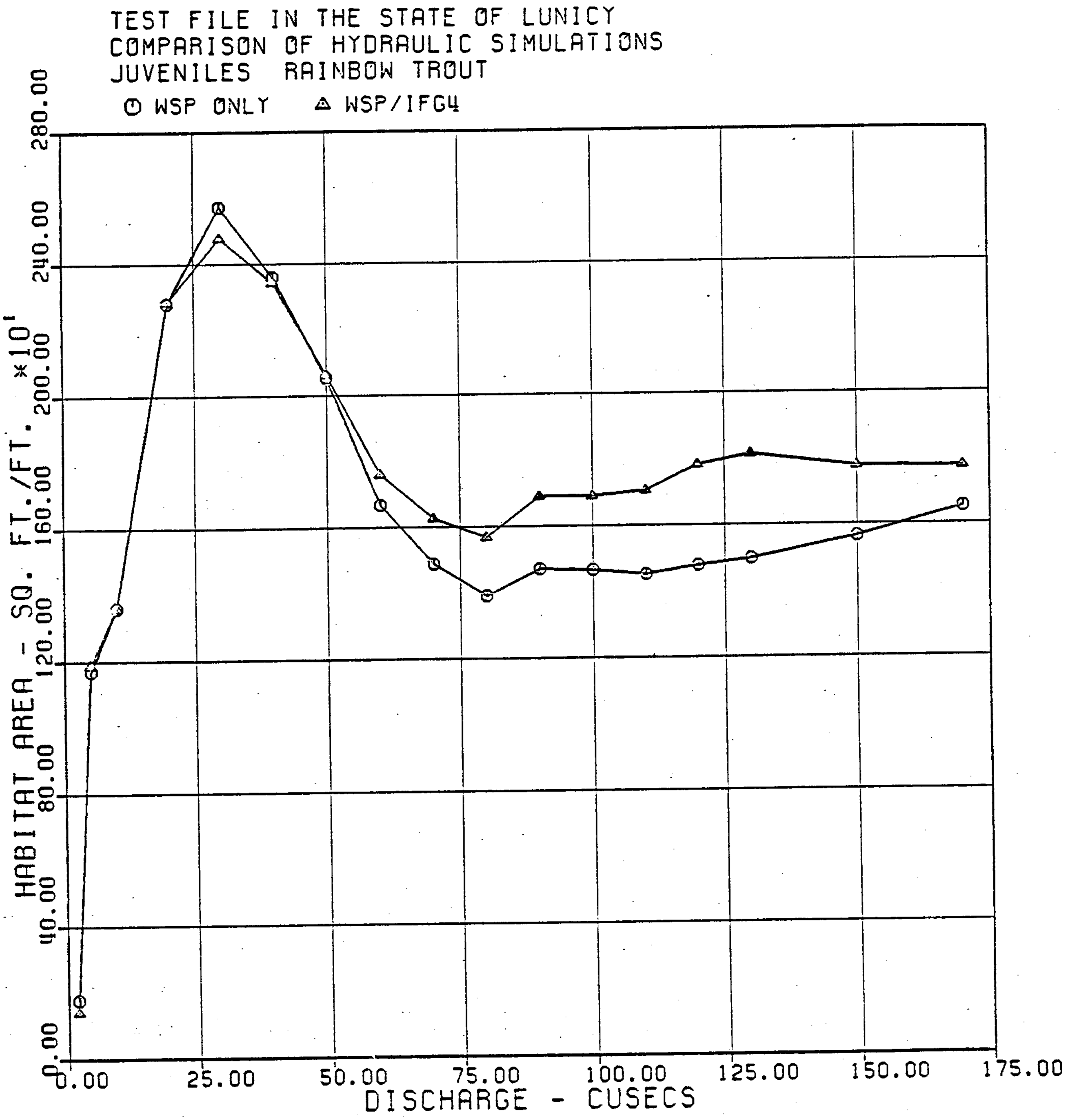
TEST FILE IN THE STATE OF LUNICY
COMPARISON OF HYDRAULIC SIMULATIONS
ADULT RAINBOW TROUT
WSP ONLY
WSP/IFG4
HABITAT AREA - SQ. FT./FT. x10²
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
0.00
25.00
50.00
75.00
100.00
125.00
150.00
175.00
DISCHARGE - CUSECS



TEST FILE IN THE STATE OF LUNICY
COMPARISON OF HYDRAULIC SIMULATIONS
SPAWNING RAINBOW TROUT
WSP ONLY
WSP/IFG4
HABITAT AREA - SQ. FT./FT. *10[1]
0.00
20.00
40.00
60.00
80.00
100.00
120.00
140.00
0.00
25.00
50.00
75.00
100.00
125.00
150.00
175.00
DISCHARGE - CUSECS



TEST FILE IN THE STATE OF LUNICY
COMPARISON OF HYDRAULIC SIMULATIONS
FRY RAINBOW TROUT
WSP ONLY
WSP/IFG4
HABITAT AREA - SQ. FT./FT. *10¹
DISCHARGE - CUSECS
0.00
25.00
50.00
75.00
100.00
125.00
150.00
175.00



TEST FILE IN THE STATE OF LUNICY
COMPARISON OF HYDRAULIC SIMULATIONS
JUVENILES RAINBOW TROUT
WSP ONLY
WSP/IFG4
HABITAT AREA - SQ. FT./FT. *10¹
0.00
40.00
80.00
120.00
160.00
200.00
240.00
280.00
0.00
25.00
50.00
75.00
100.00
125.00
150.00
175.00
DISCHARGE - CUSECS

APPENDIX E

THE IMPACT OF ALTERNATIVE APPROACHES TO DETERMINING WATER SURFACE ELEVATION

Two approaches to the simulation of water surface elevations in a study reach are available. One of these is to determine the stage-discharge relationship at the downstream cross-section and then use a calibrated WSP model to calculate the water surface elevation at each upstream cross section. The second approach is to develop a stage-discharge for each cross section and then use this to determine the water surface elevation.

The dataset for the Test River was used in both modes with the WSP model being calibrated to water surface elevation and the IFG4 mode containing one calibration set of flows. In the stage-discharge case, three streamflow stage and data points were used for each cross section. The water surface elevation for the first cross-section was determined using the same stage-discharge relationship. The water surface elevation for each cross section is given in Table E-1.

Table E-1. Water Surface Elevations Simulated by IFG4 and WSP

		Water Surface Elevation					
		Q = 5 cfs		Q = 40 cfs		Q = 170 cfs	
Section	Elevation	WSP	S-Q	WSP	S-Q	WSP	S-Q
1	95.55	97.55	97.44	98.10	98.10	98.90	98.90
2	96.64	97.64	97.63	98.16	98.29	99.10	99.02
3	97.25	97.88	97.36	98.64	98.22	99.70	99.97
4	96.23	97.96	97.71	98.86	98.79	100.04	100.47
5	97.47	98.02	98.69	99.03	99.44	100.36	100.14
6	98.15	99.18	99.70	99.62	100.40	101.12	101.16
7	98.68	99.47	99.53	100.18	100.33	101.65	101.33

The impact of a difference in the water surface elevation is to increase the velocities if the water surface elevation is decreased and to decrease the velocities if the water surface elevation is increased. As an example of the relative change in depth as a function of discharge, the change in maximum depth for cross section 5 of the WSP elevation compared to a stage-discharge elevation as a percent of WSP elevation is as follows:

Percent Error with Difference of 0.5 feet	Discharge	Error	Difference in Maximum Depth
110%	5 cfs	122%	0.67
32%	40 cfs	26%	0.41
17%	170 cfs	8%	0.22

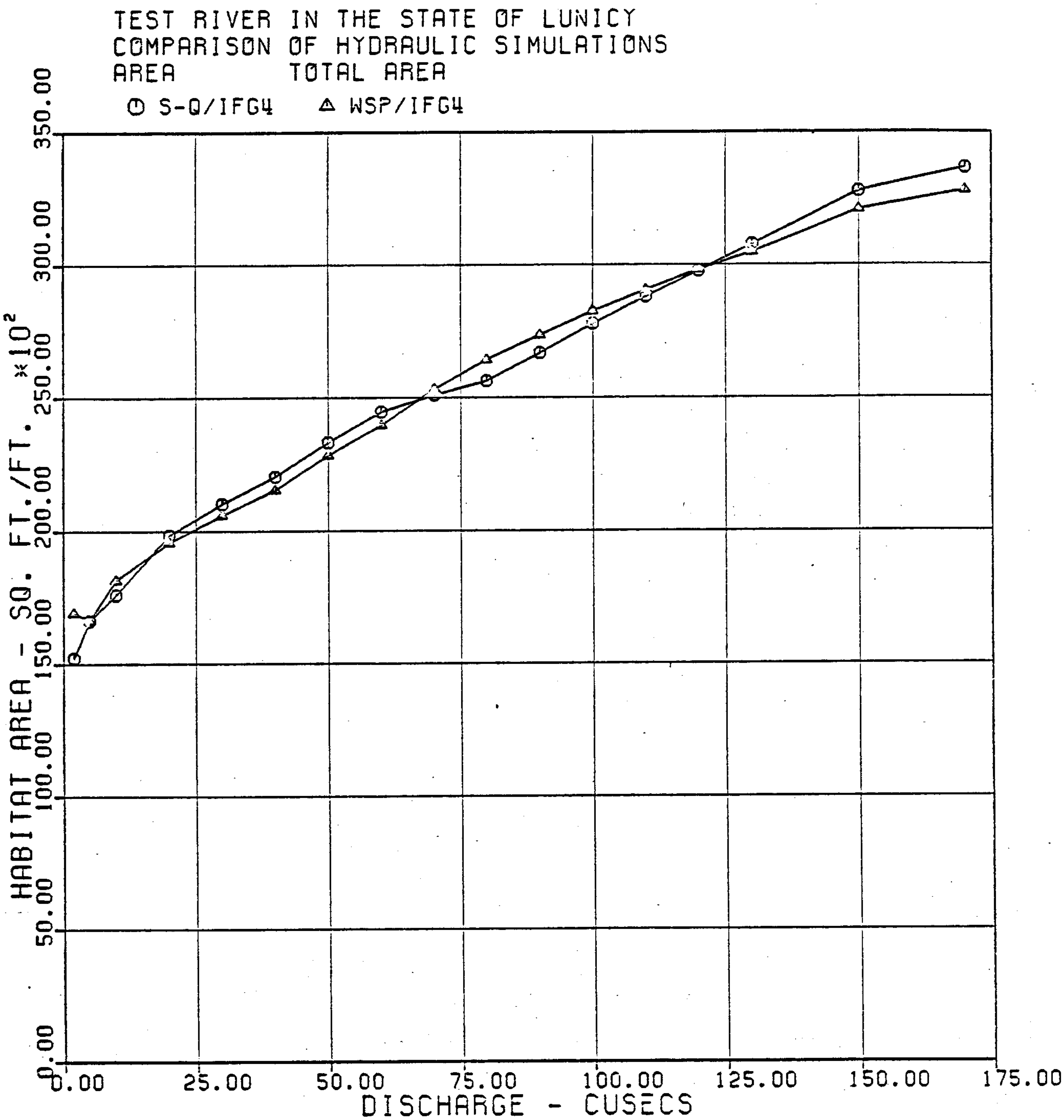
An important consideration is that the same difference in water surface elevations will result in larger impacts at low flows than at high flows. This impact will be on both the depths and velocities.

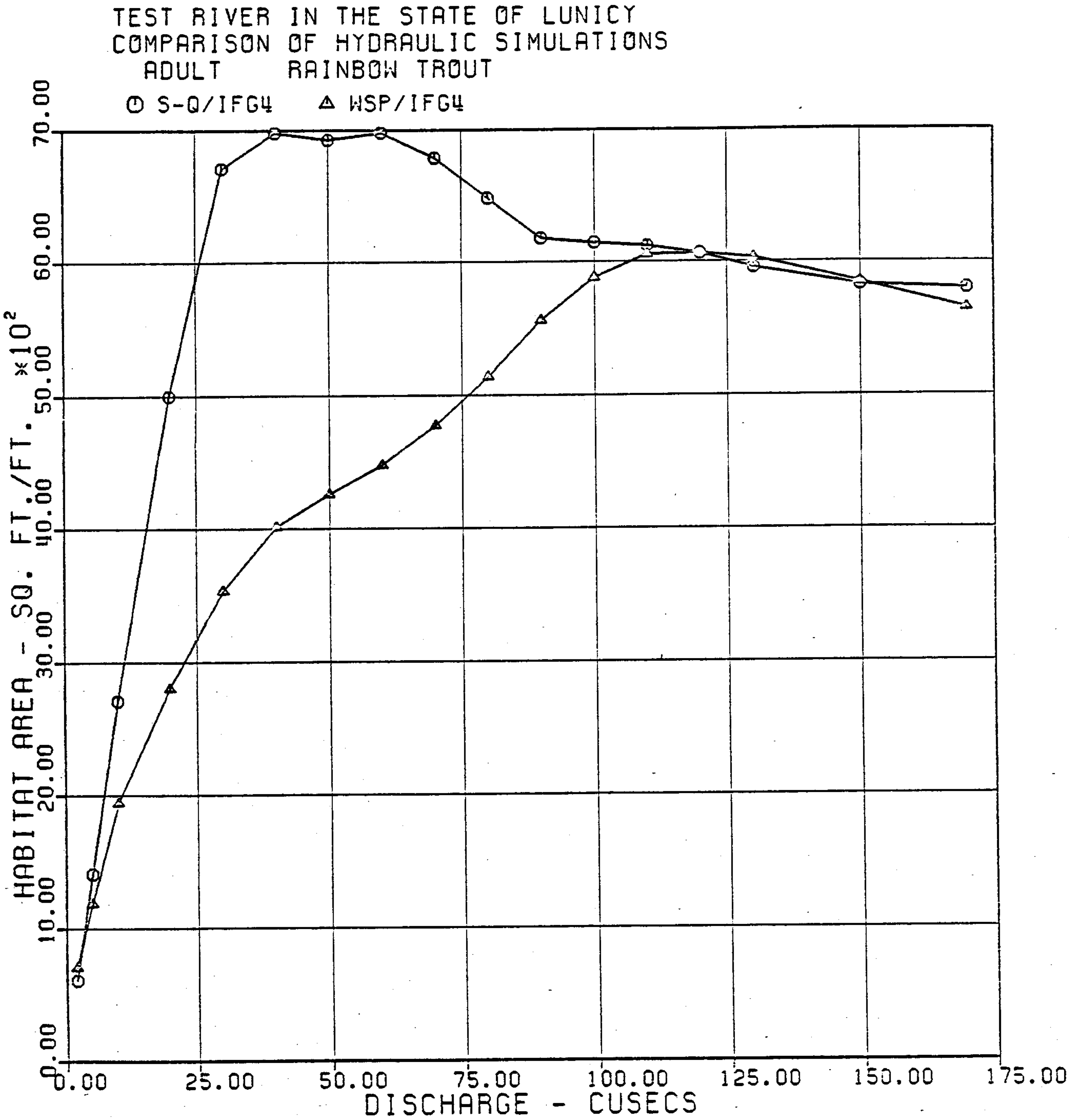
The results indicate the total surface area of the stream is the same but the physical habitat is definitely changed by the difference in water surface elevation.

The error in the three point regression for each cross section was:

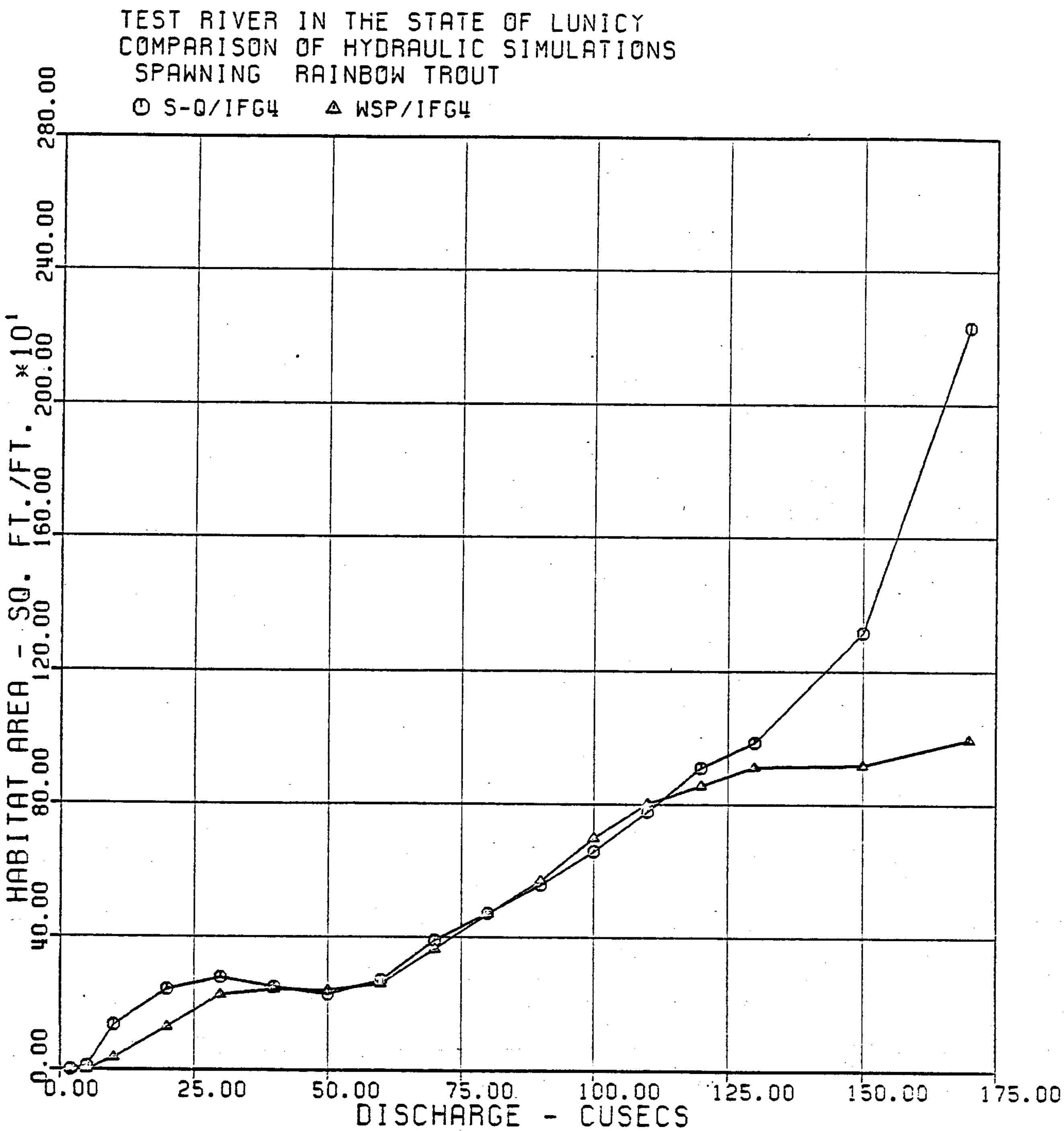
Section	Percent Error
1	1.9
2	1.1
3	5.4
4	4.2
6	12.1
7	2.2

Only two points were used for Section 5. In this case, the water surface elevation determined using the WSP model are the most reliable.

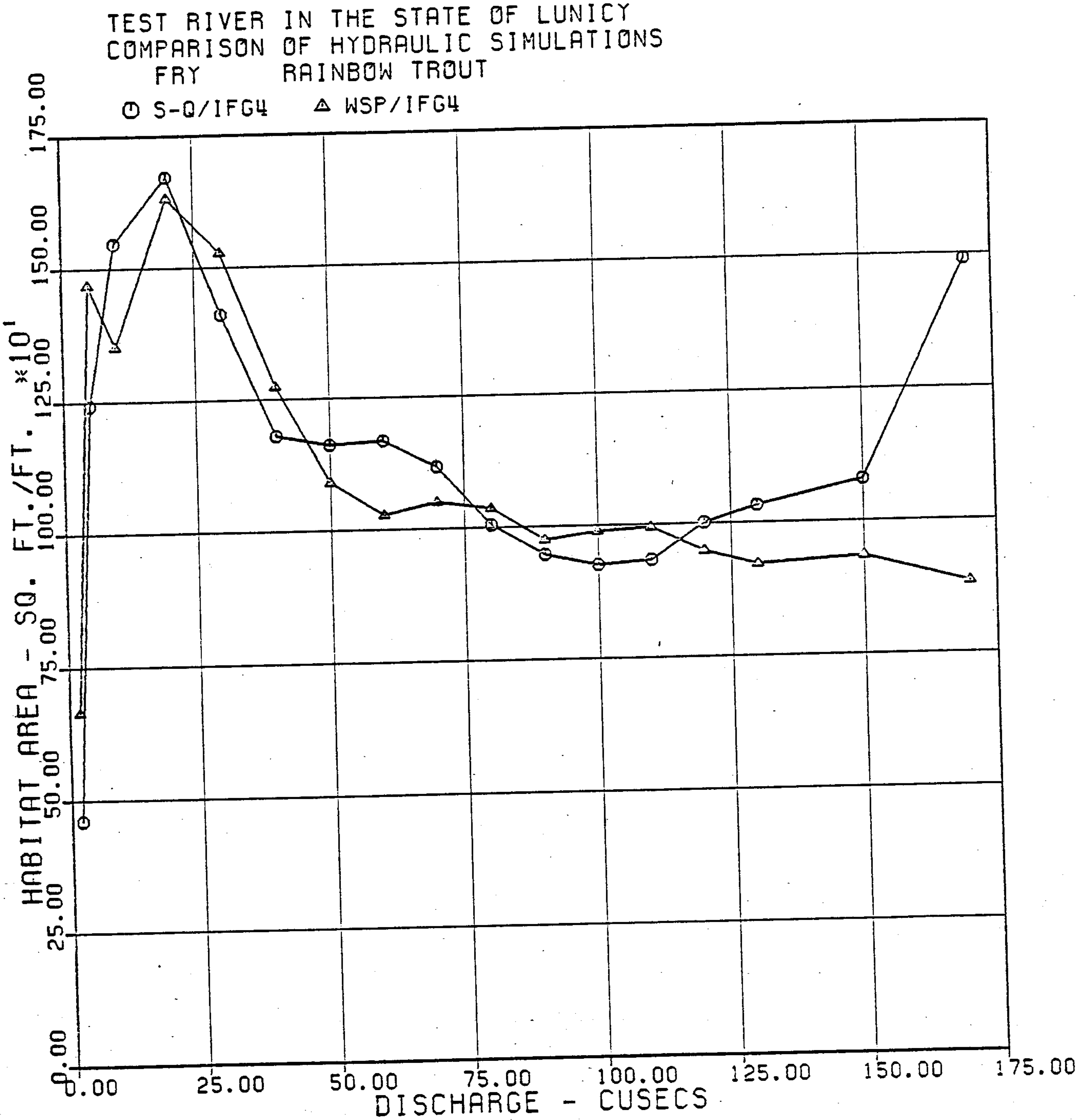

TEST RIVER IN THE STATE OF LUNICY
COMPARISON OF HYDRAULIC SIMULATIONS
AREA TOTAL AREA
S-Q/IFG4
WSP/IFG4
HABITAT AREA - SQ. FT./FT. $\times 10^2$
0.00
50.00
100.00
150.00
200.00
250.00
300.00
350.00
0.00
25.00
50.00
75.00
100.00
125.00
150.00
175.00
DISCHARGE - CUSECS

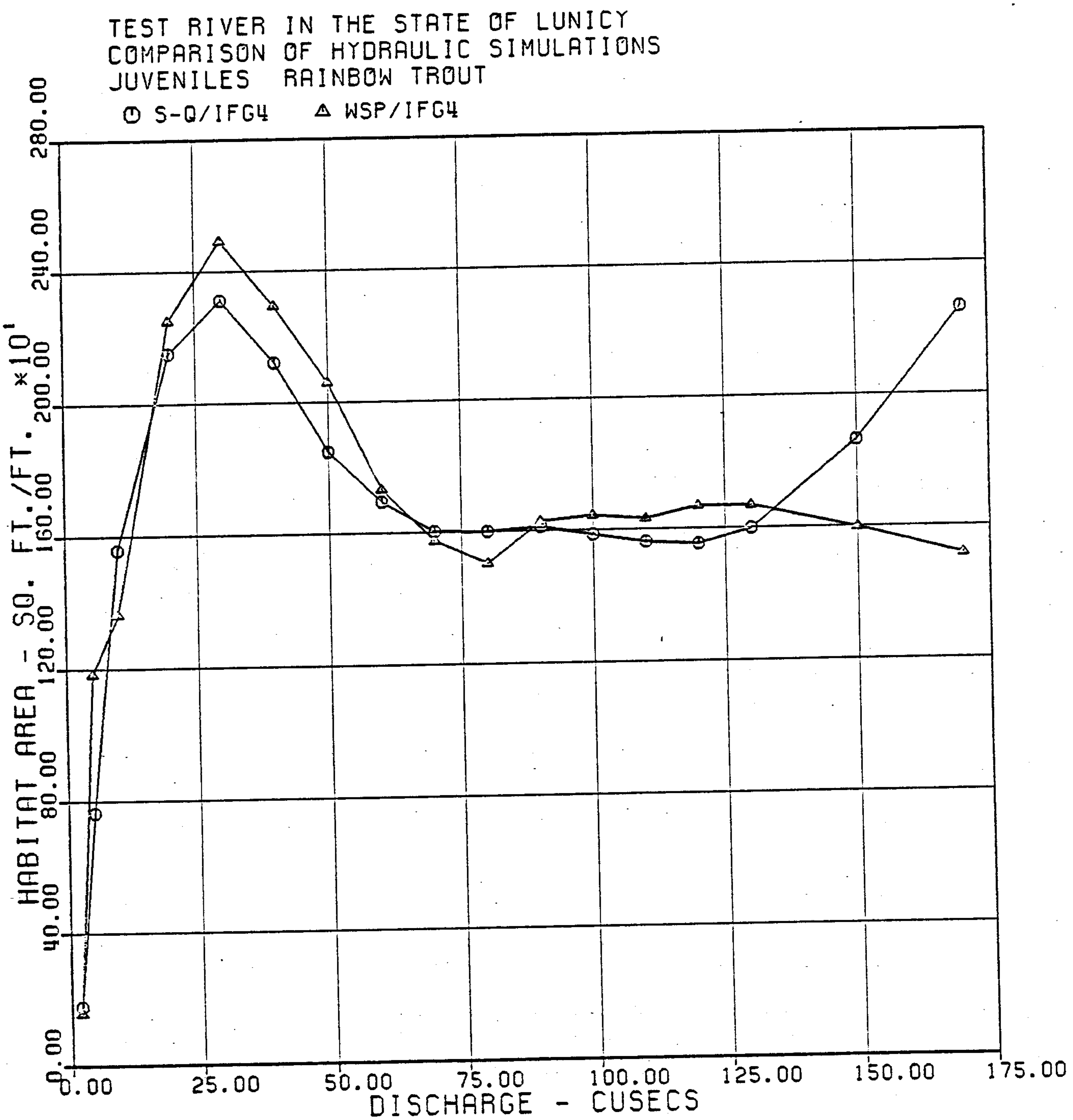


TEST RIVER IN THE STATE OF LUNICY
COMPARISON OF HYDRAULIC SIMULATIONS
ADULT RAINBOW TROUT
S-Q/IFG4
WSP/IFG4
HABITAT AREA - SQ. FT./FT. ×10²
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
0.00
25.00
50.00
75.00
100.00
125.00
150.00
175.00
DISCHARGE - CUSECS



TEST RIVER IN THE STATE OF LUNICY
COMPARISON OF HYDRAULIC SIMULATIONS
SPAWNING RAINBOW TROUT
S-Q/IFG4
WSP/IFG4
HABITAT AREA - SQ. FT./FT. *10¹
0.00
40.00
80.00
120.00
160.00
200.00
240.00
280.00
0.00
25.00
50.00
75.00
100.00
125.00
150.00
175.00
DISCHARGE - CUSECS


TEST RIVER IN THE STATE OF LUNICY
COMPARISON OF HYDRAULIC SIMULATIONS
FRY RAINBOW TROUT
S-Q/IFG4
WSP/IFG4
HABITAT AREA - SQ. FT./FT. *10[1]
0.00
25.00
50.00
75.00
100.00
125.00
150.00
175.00
DISCHARGE - CUSECS

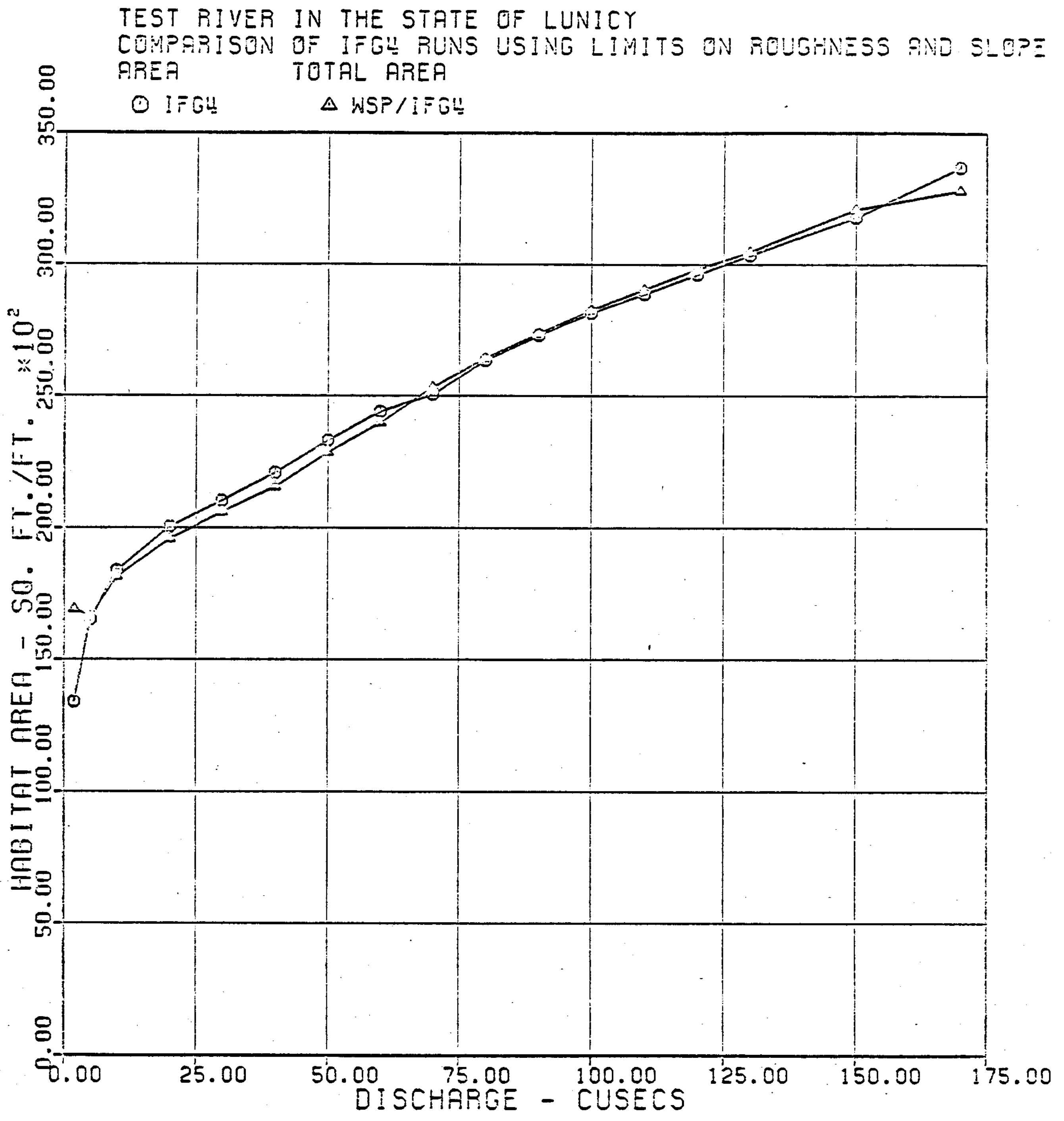

TEST RIVER IN THE STATE OF LUNICY
COMPARISON OF HYDRAULIC SIMULATIONS
JUVENILES RAINBOW TROUT
S-Q/IFG4
WSP/IFG4
HABITAT AREA - SQ. FT./FT. *10¹
0.00
40.00
80.00
120.00
160.00
200.00
240.00
280.00
0.00
25.00
50.00
75.00
100.00
125.00
150.00
175.00
DISCHARGE - CUSECS

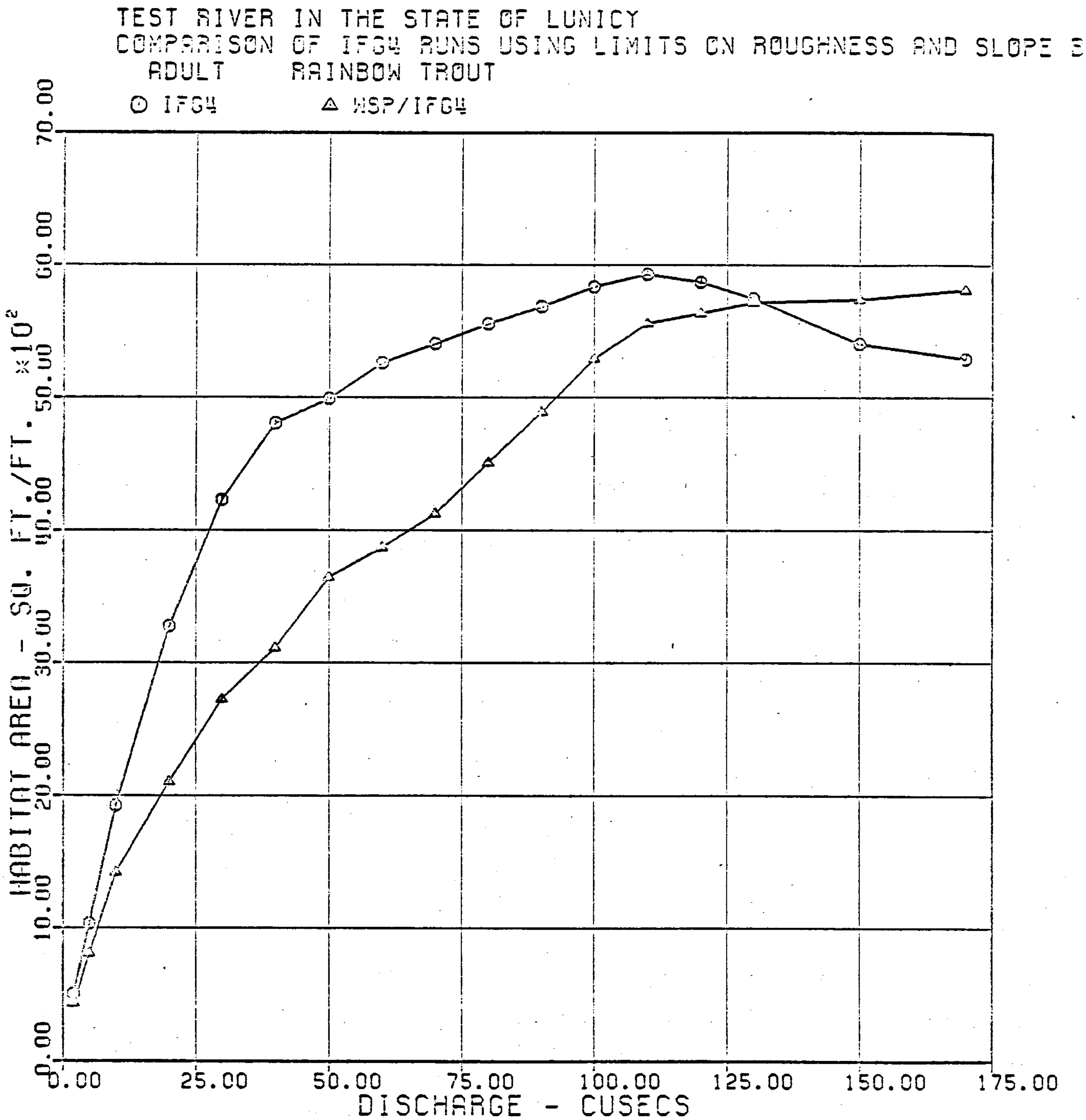
APPENDIX F

THE VALUE OF USING WSP AND IFG4 TOGETHER

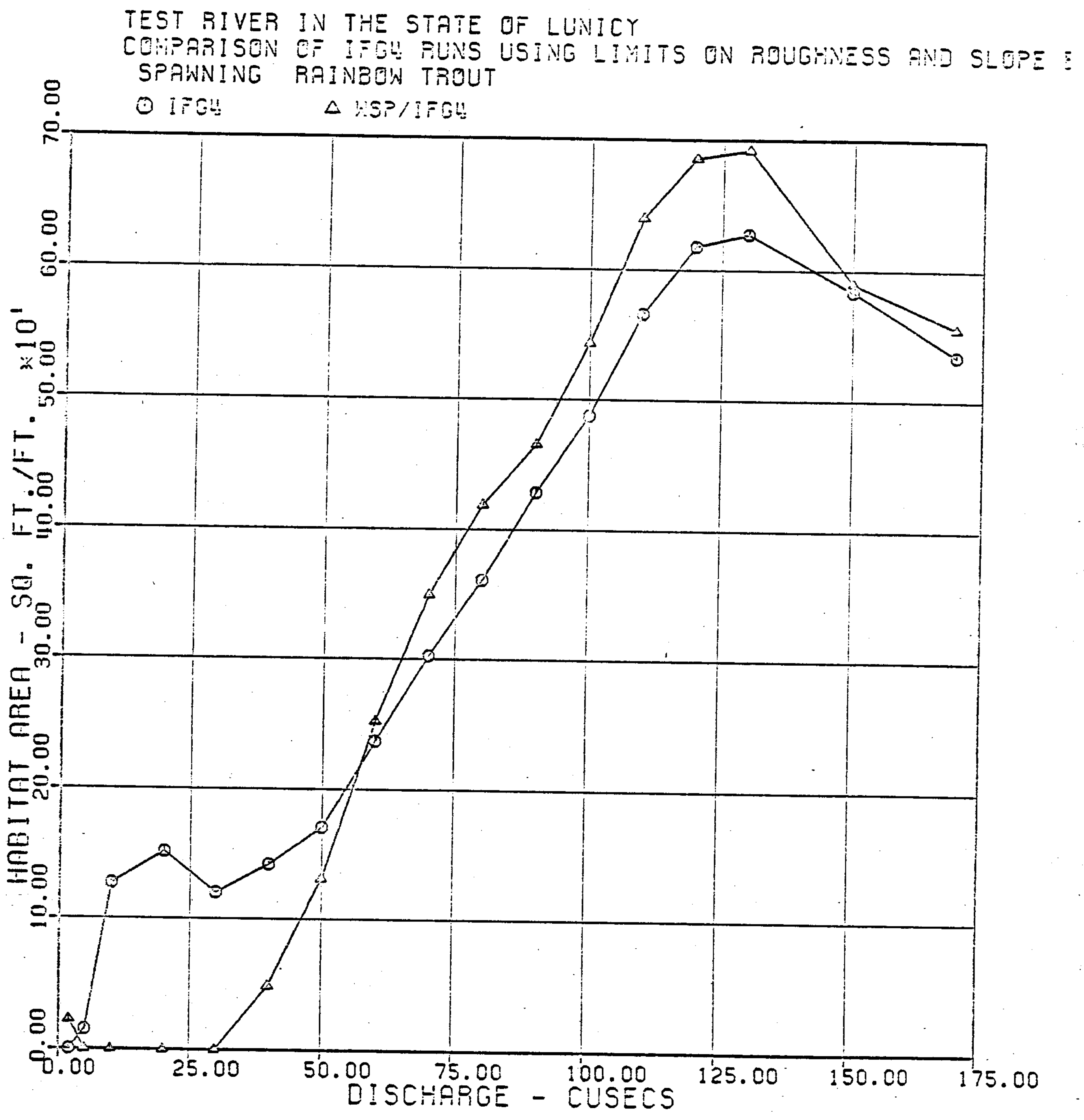
The standard application of the IFG4 with at least three datasets uses a stage-discharge relationship to calculate the water surface elevations for each cross section independent of the other cross sections. Another approach is to determine the water surface elevation using a WSP model calibrated to water surface elevation and use the water surface elevation calculated for each streamflow of interest in the IFG4 program to simulate the velocities in the stream channel. The five figures of the appendix illustrate the impact of the two approaches towards simulating water surface elevations.

The comparison of total stream surface area indicates both approaches yield essentially the same results. This is not the case for the adult life stage of rainbow trout. The habitat versus discharge relationship are similar for the other three life stages.

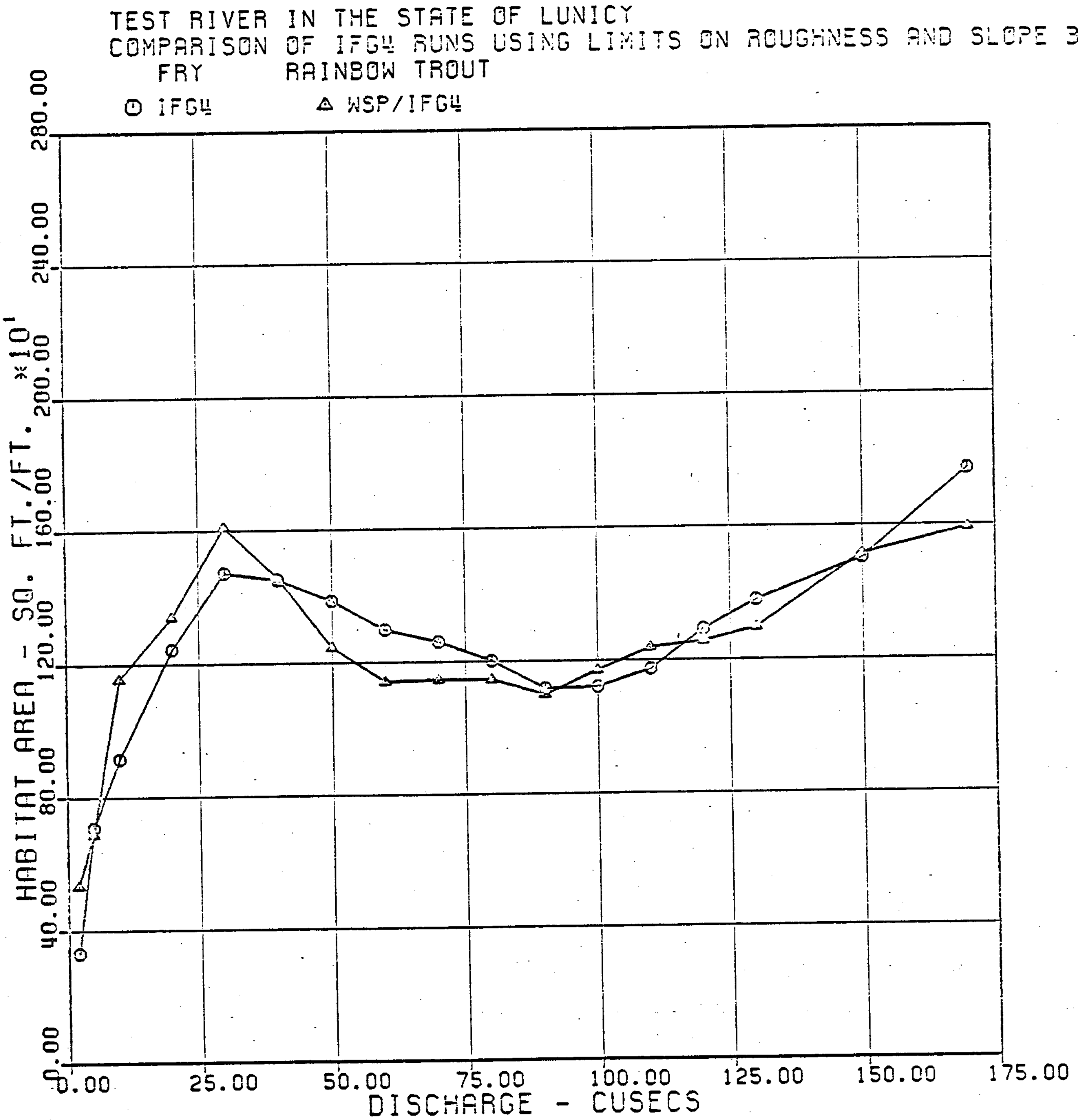

TEST RIVER IN THE STATE OF LUNICY
COMPARISON OF IFG4 RUNS USING LIMITS ON ROUGHNESS AND SLOPE
AREA TOTAL AREA
IFG4
WSP/IFG4
HABITAT AREA - SQ. FT./FT. ×10²
0.00
50.00
100.00
150.00
200.00
250.00
300.00
350.00
0.00
25.00
50.00
75.00
100.00
125.00
150.00
175.00
DISCHARGE - CUSECS

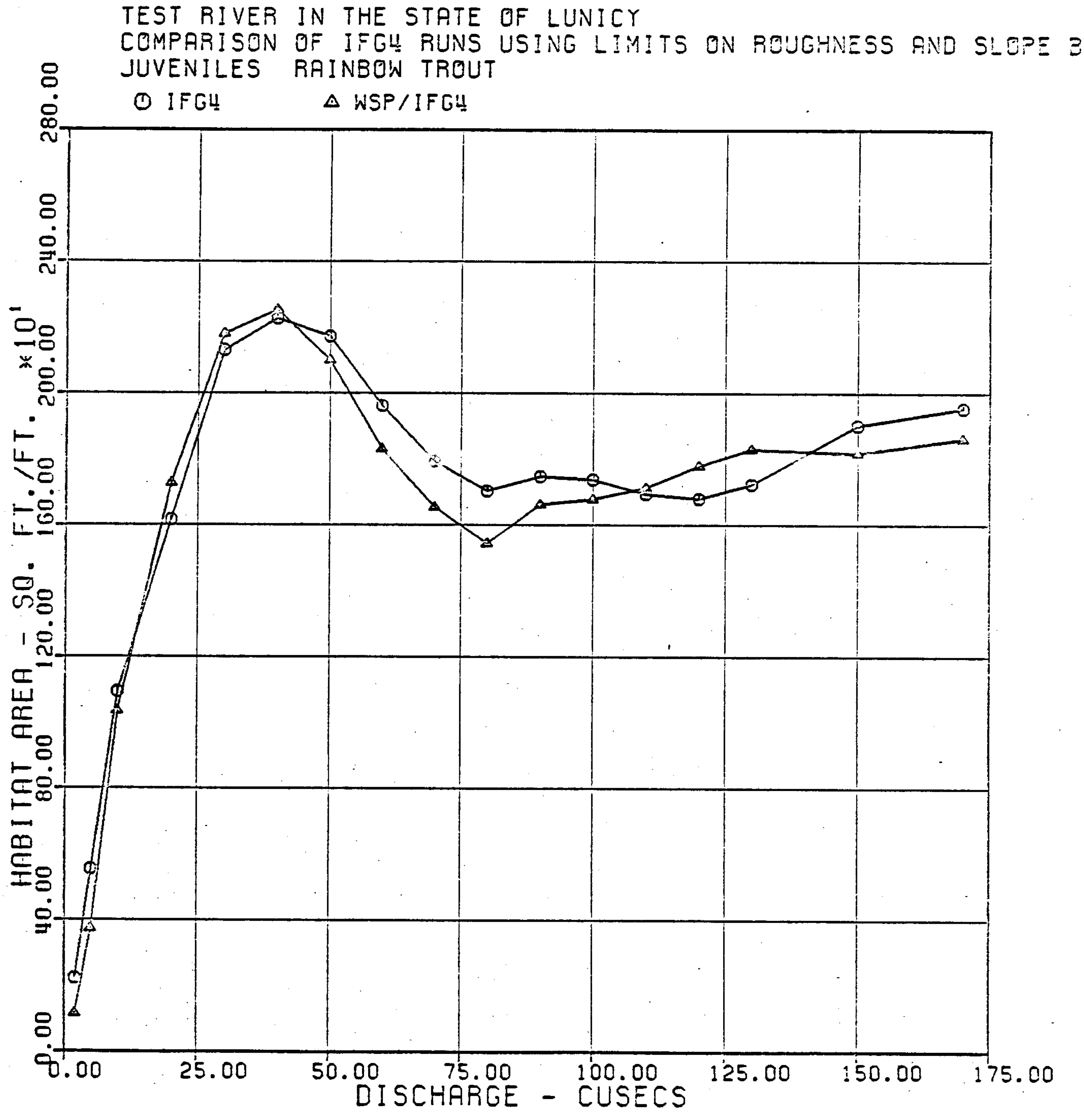


TEST RIVER IN THE STATE OF LUNICY
COMPARISON OF IFG4 RUNS USING LIMITS ON ROUGHNESS AND SLOPE 3
ADULT RAINBOW TROUT
IFG4
WSP/IFG4
HABITAT AREA - SQ. FT./FT. ×10²
DISCHARGE - CUSECS
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
25.00
50.00
75.00
100.00
125.00
150.00
175.00



TEST RIVER IN THE STATE OF LUNICY
COMPARISON OF IFG4 RUNS USING LIMITS ON ROUGHNESS AND SLOPE
SPAWNING RAINBOW TROUT
IFG4
WSP/IFG4
HABITAT AREA - SQ. FT./FT. x10'
DISCHARGE - CUSECS
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
25.00
50.00
75.00
100.00
125.00
150.00
175.00


TEST RIVER IN THE STATE OF LUNICY
COMPARISON OF IFG4 RUNS USING LIMITS ON ROUGHNESS AND SLOPE 3
FRY RAINBOW TROUT
IFG4
WSP/IFG4
HABITAT AREA - SQ. FT./FT. *10¹
0.00
40.00
80.00
120.00
160.00
200.00
240.00
280.00
0.00
25.00
50.00
75.00
100.00
125.00
150.00
175.00
DISCHARGE - CUSECS

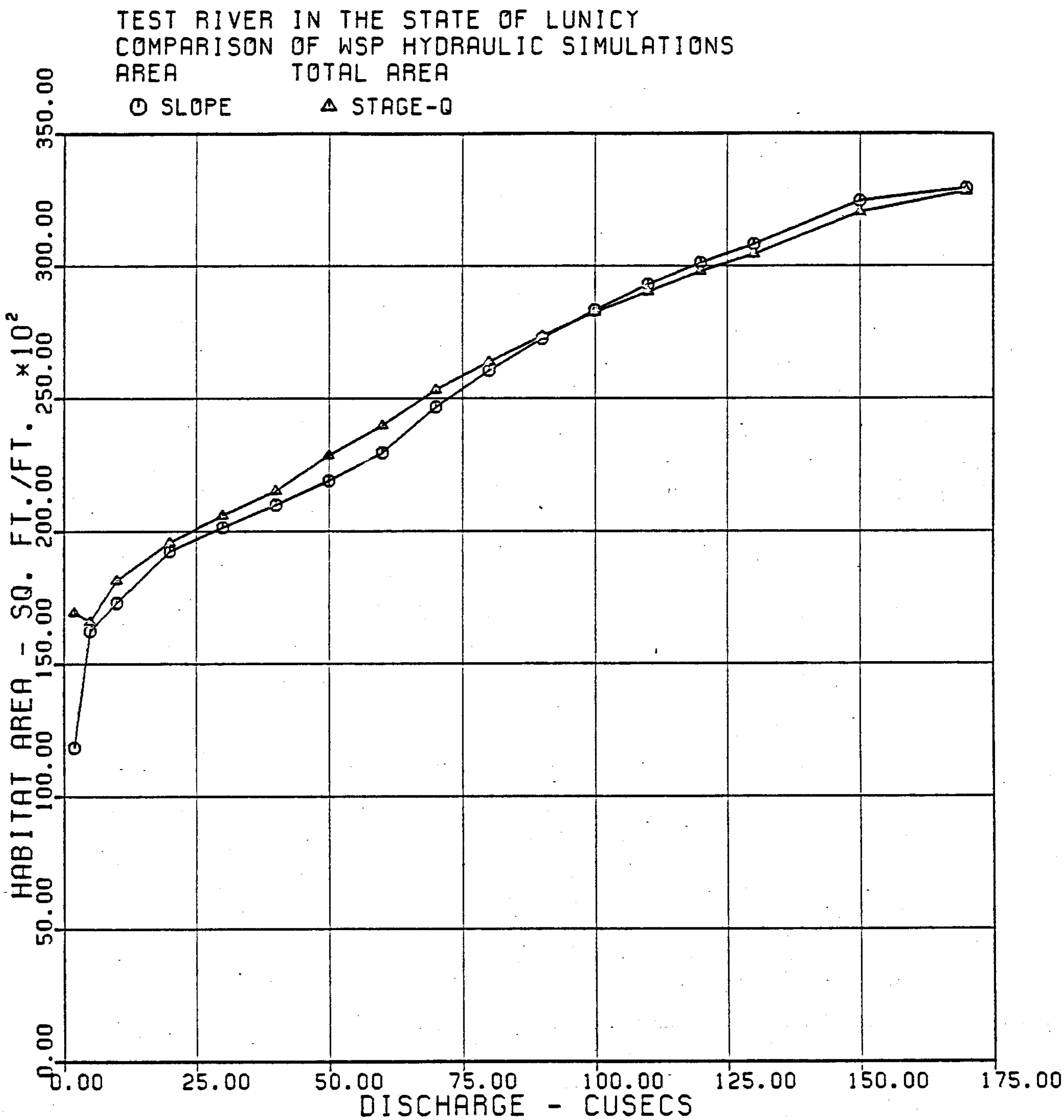

TEST RIVER IN THE STATE OF LUNICY
COMPARISON OF IFG4 RUNS USING LIMITS ON ROUGHNESS AND SLOPE 3
JUVENILES RAINBOW TROUT
⊙ IFG4
△ WSP/IFG4
HABITAT AREA - SQ. FT./FT. *10¹
0.00
40.00
80.00
120.00
160.00
200.00
240.00
280.00
0.00
25.00
50.00
75.00
100.00
125.00
150.00
175.00
DISCHARGE - CUSECS

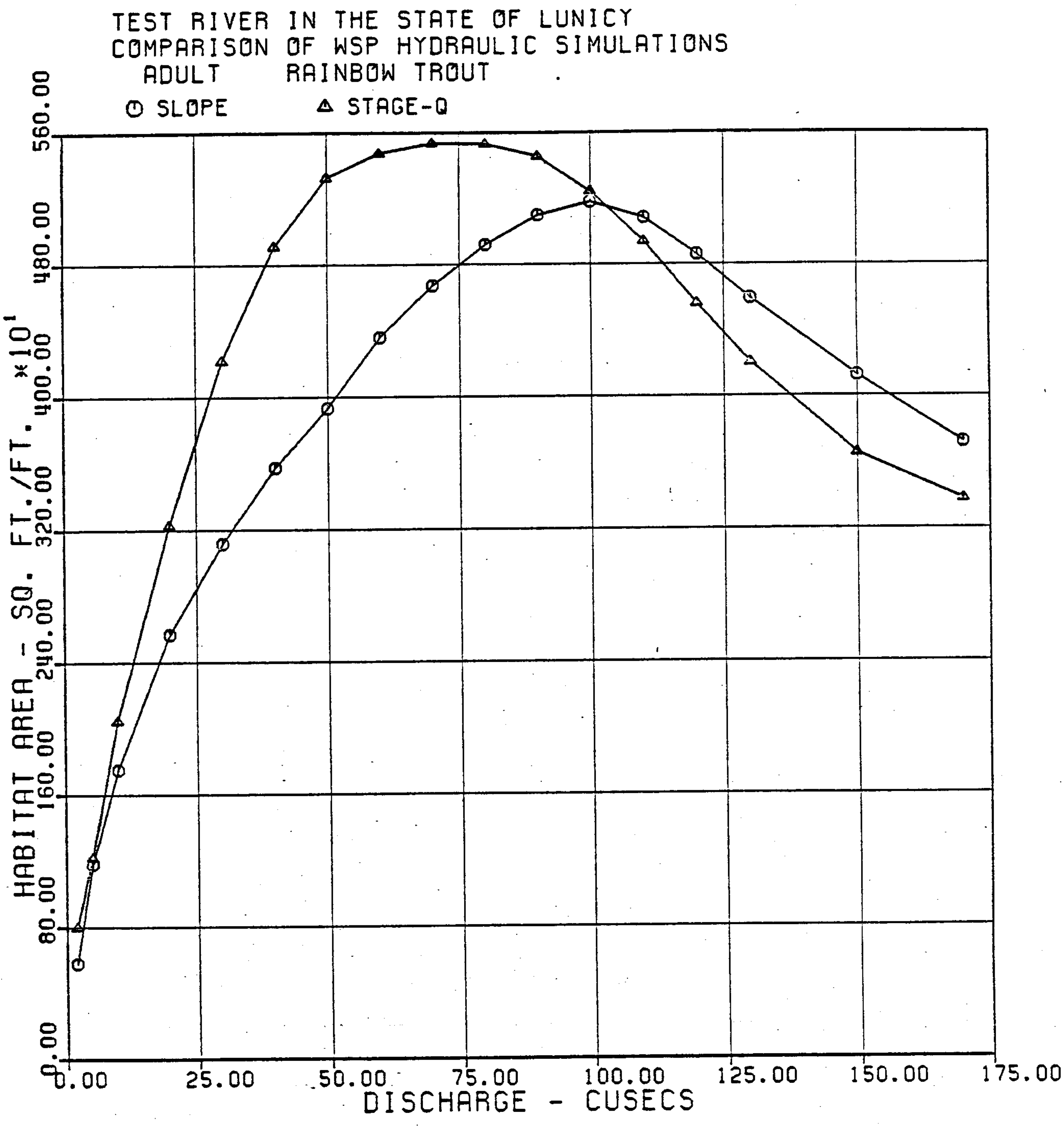
APPENDIX G

THE IMPACT OF THE METHOD OF DETERMINING THE INITIAL WATER SURFACE ELEVATIONS ON WSP

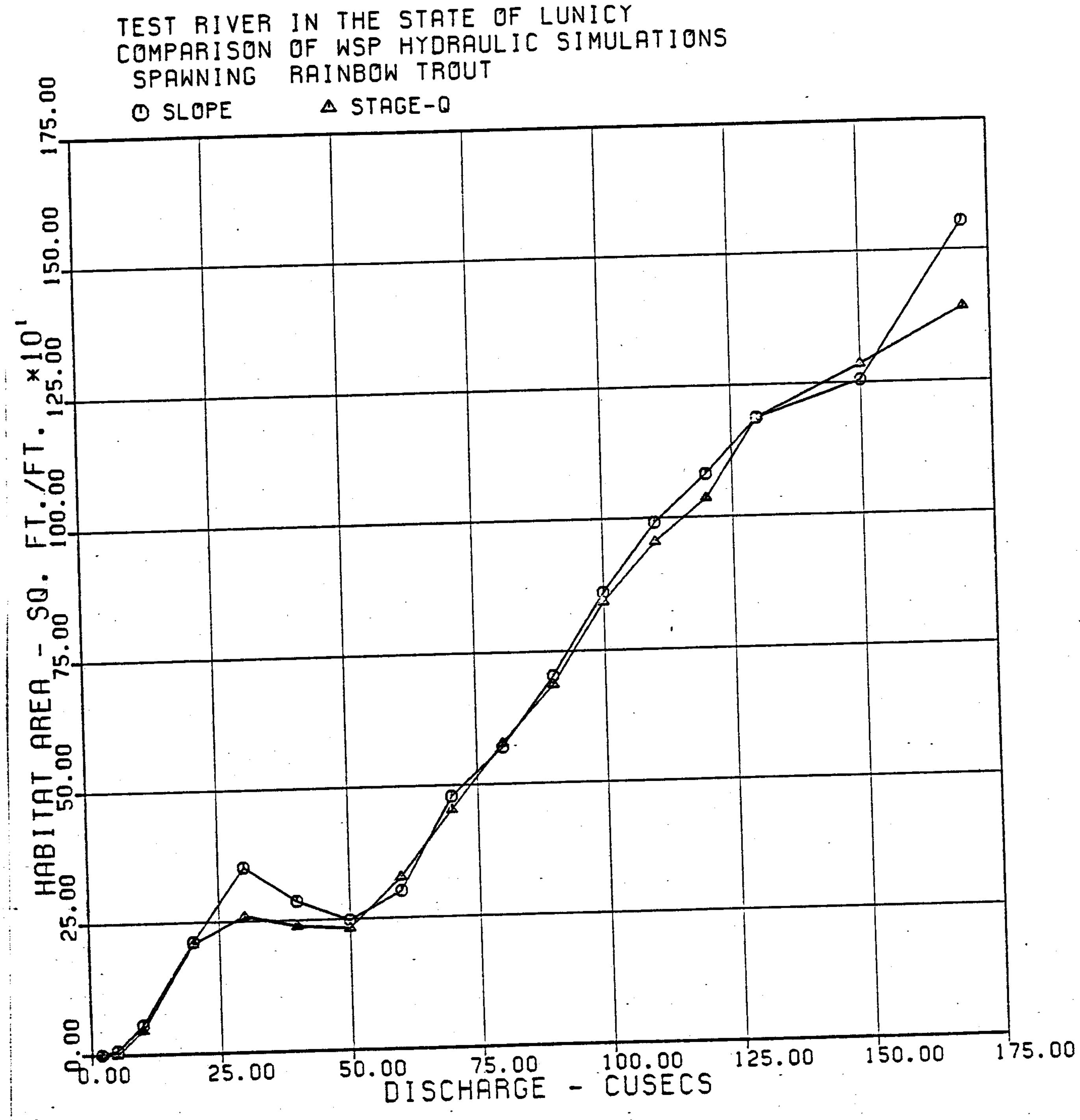
Two methods of determining the water surface elevations at the downstream section for the flows of interest are available when applying the WSP program. One method is to use a stage-discharge relationship based on three or more points. The second is to use the Manning equation with a constant slope for all the simulated flows.

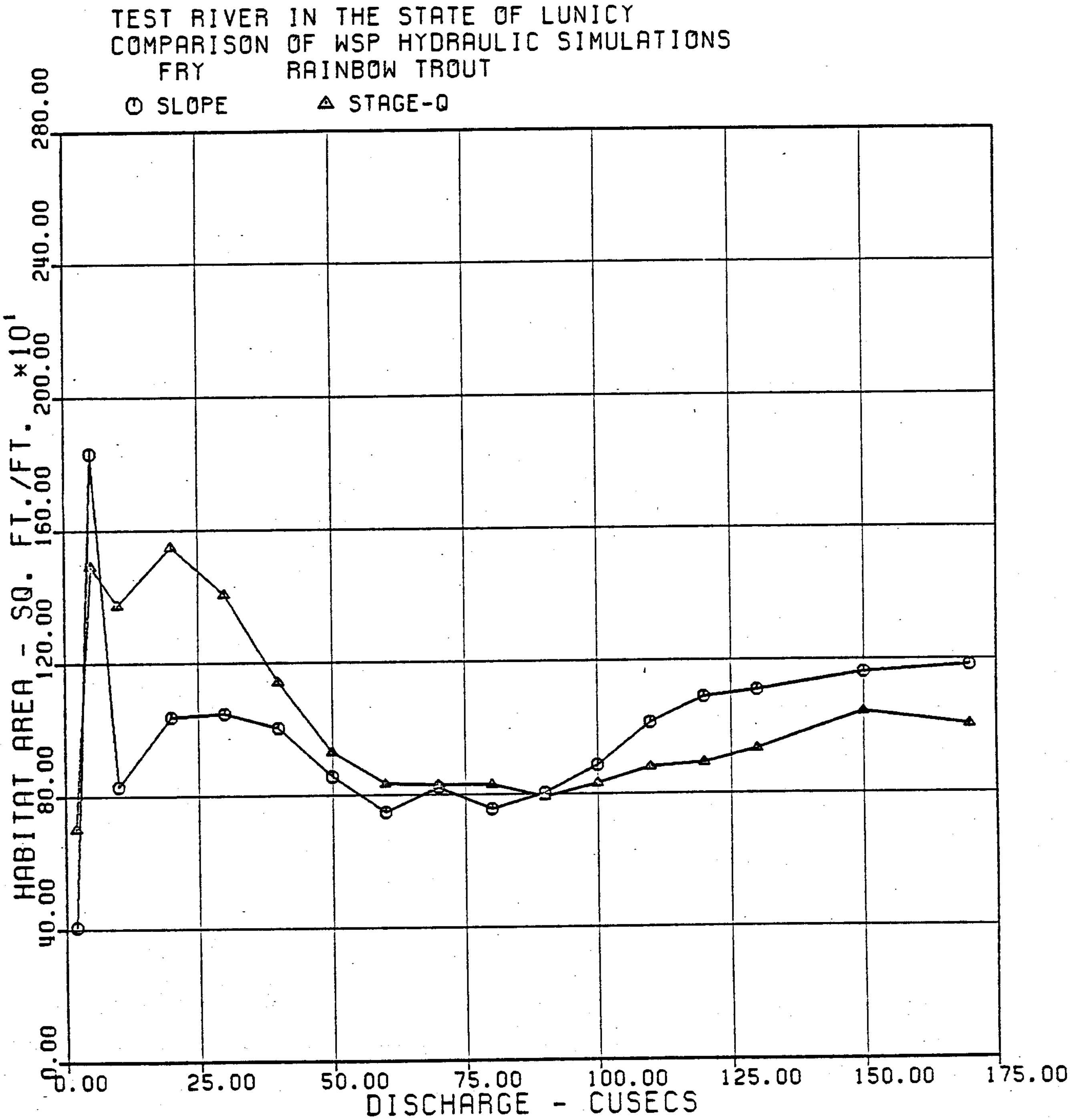
The results presented in this appendix indicate the impact on the surface area is small but that the impact on the life stages of rainbow trout can be important. In all cases, the general shape and the relative magnitude of the physical habitat remains the same.

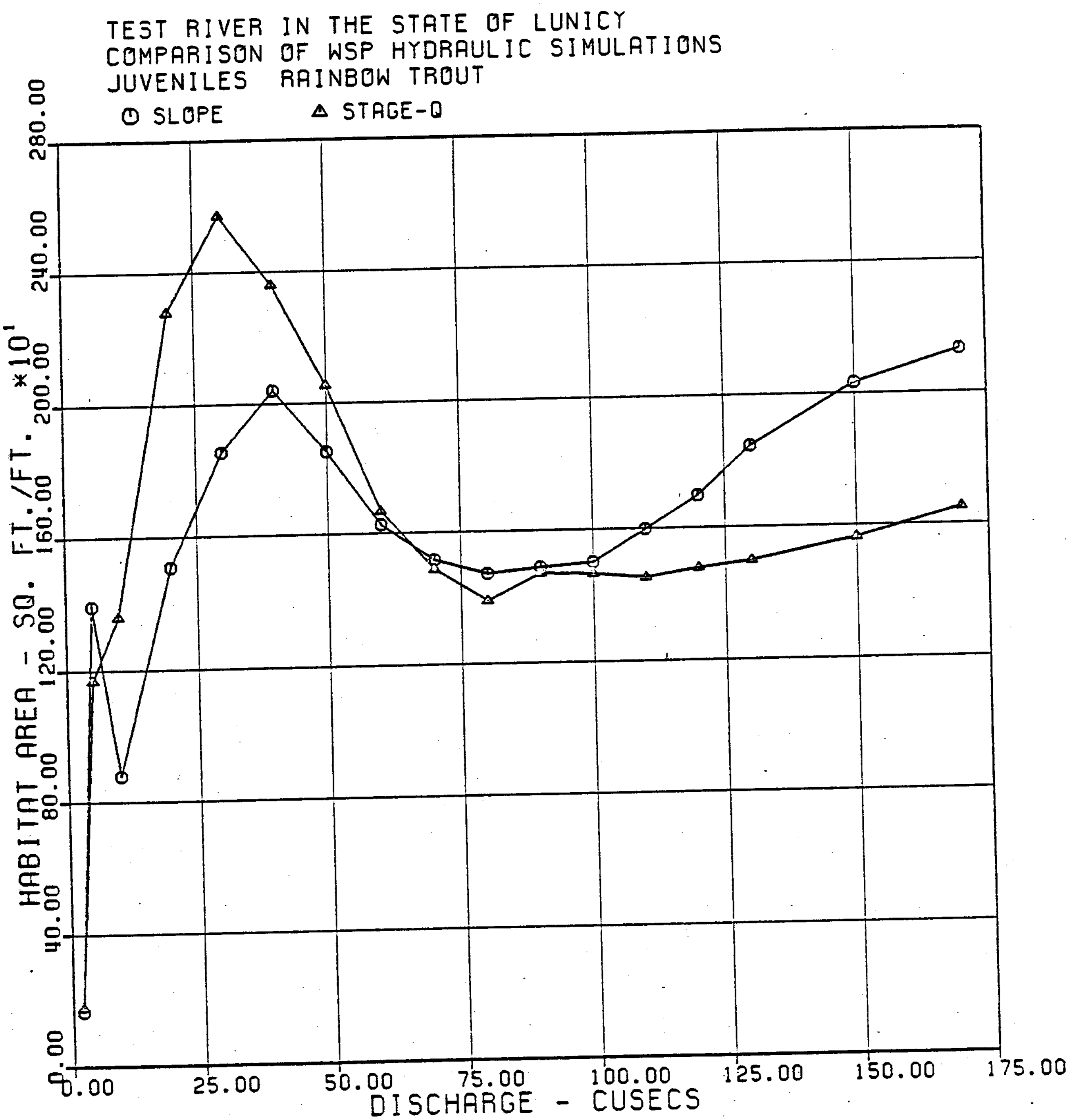

TEST RIVER IN THE STATE OF LUNICY
COMPARISON OF WSP HYDRAULIC SIMULATIONS
AREA TOTAL AREA
SLOPE
STAGE-Q
HABITAT AREA - SQ. FT./FT. *10²
0.00
50.00
100.00
150.00
200.00
250.00
300.00
350.00
0.00
25.00
50.00
75.00
100.00
125.00
150.00
175.00
DISCHARGE - CUSECS



TEST RIVER IN THE STATE OF LUNICY
COMPARISON OF WSP HYDRAULIC SIMULATIONS
ADULT RAINBOW TROUT
SLOPE
STAGE-Q
HABITAT AREA - SQ. FT./FT. *10
0.00
80.00
160.00
240.00
320.00
400.00
480.00
560.00
0.00
25.00
50.00
75.00
100.00
125.00
150.00
175.00
DISCHARGE - CUSECS


TEST RIVER IN THE STATE OF LUNICY
COMPARISON OF WSP HYDRAULIC SIMULATIONS
SPAWNING RAINBOW TROUT
SLOPE
STAGE-Q
HABITAT AREA - SQ. FT./FT. *10¹
DISCHARGE - CUSECS
0.00
25.00
50.00
75.00
100.00
125.00
150.00
175.00


TEST RIVER IN THE STATE OF LUNICY
COMPARISON OF WSP HYDRAULIC SIMULATIONS
FRY RAINBOW TROUT
SLOPE
STAGE-Q
HABITAT AREA - SQ. FT./FT. *10¹
DISCHARGE - CUSECS
0.00
40.00
80.00
120.00
160.00
200.00
240.00
280.00
0.00
25.00
50.00
75.00
100.00
125.00
150.00
175.00



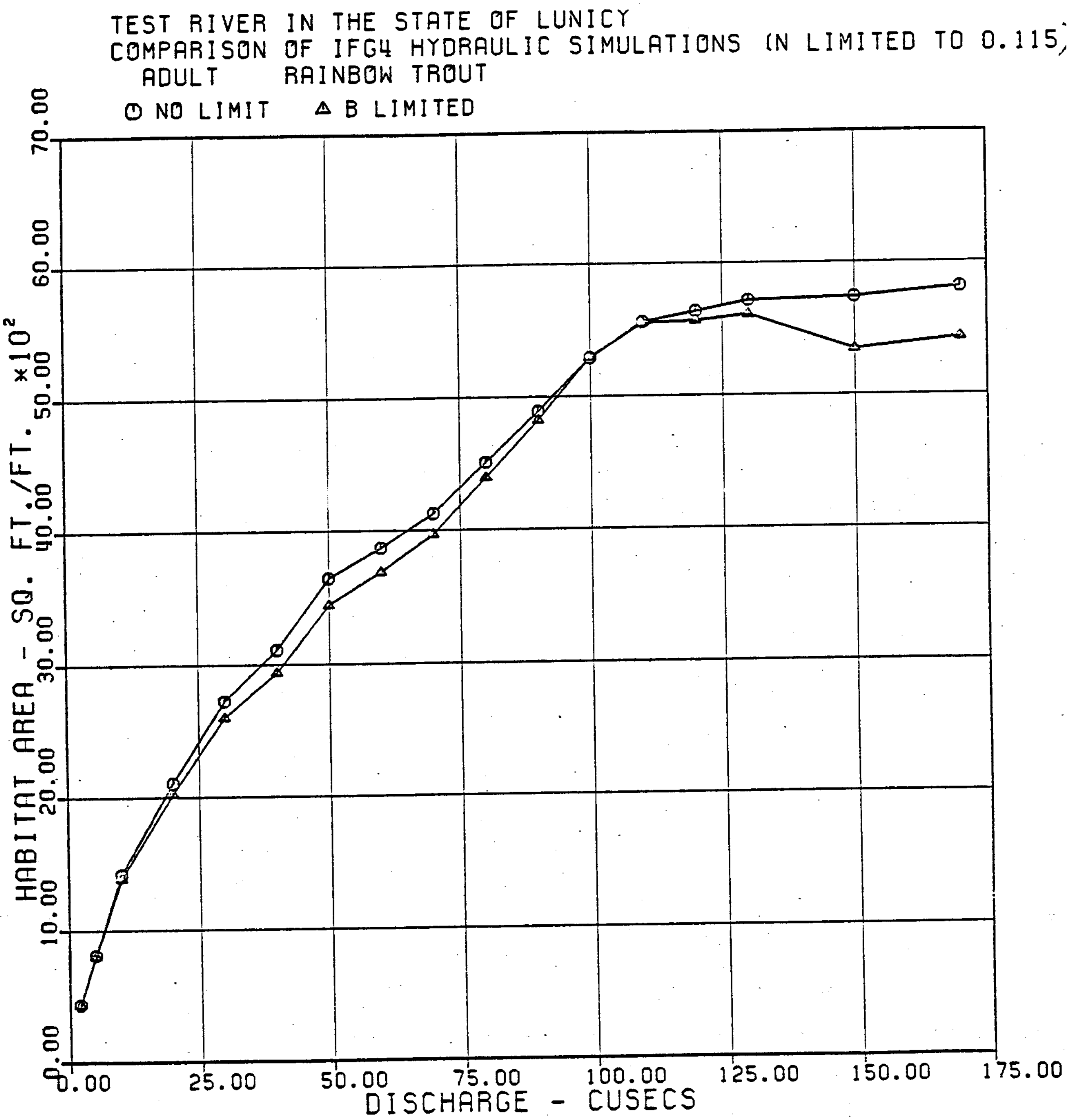
TEST RIVER IN THE STATE OF LUNICY
COMPARISON OF WSP HYDRAULIC SIMULATIONS
JUVENILES RAINBOW TROUT
SLOPE
STAGE-Q
HABITAT AREA - SQ. FT./FT. *10[1]
0.00
40.00
80.00
120.00
160.00
200.00
240.00
280.00
0.00
25.00
50.00
75.00
100.00
125.00
150.00
175.00
DISCHARGE - CUSECS

APPENDIX H

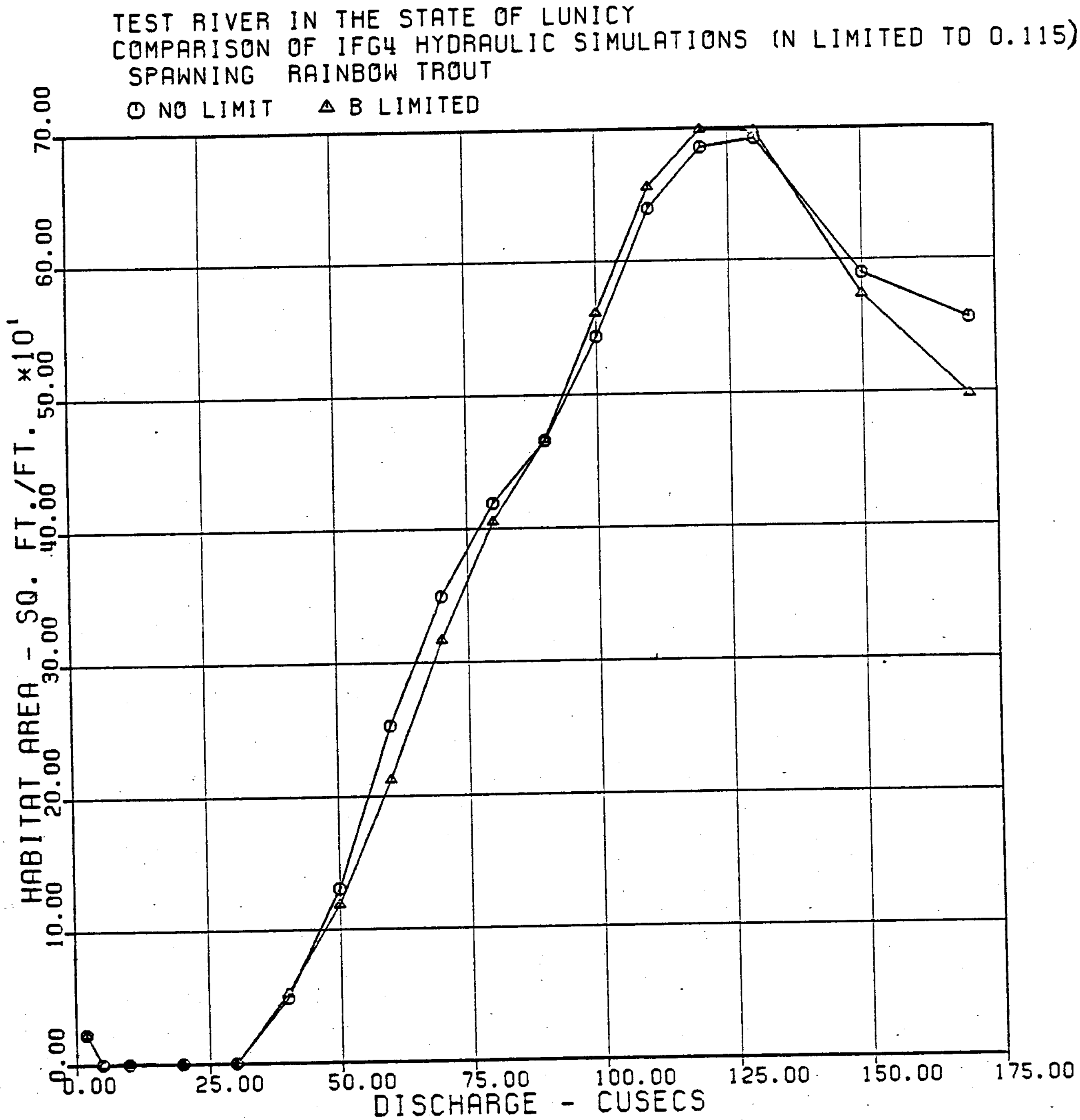
THE IMPACT OF LIMITING THE SLOPE, B, IN AN IFG4 SIMULATION

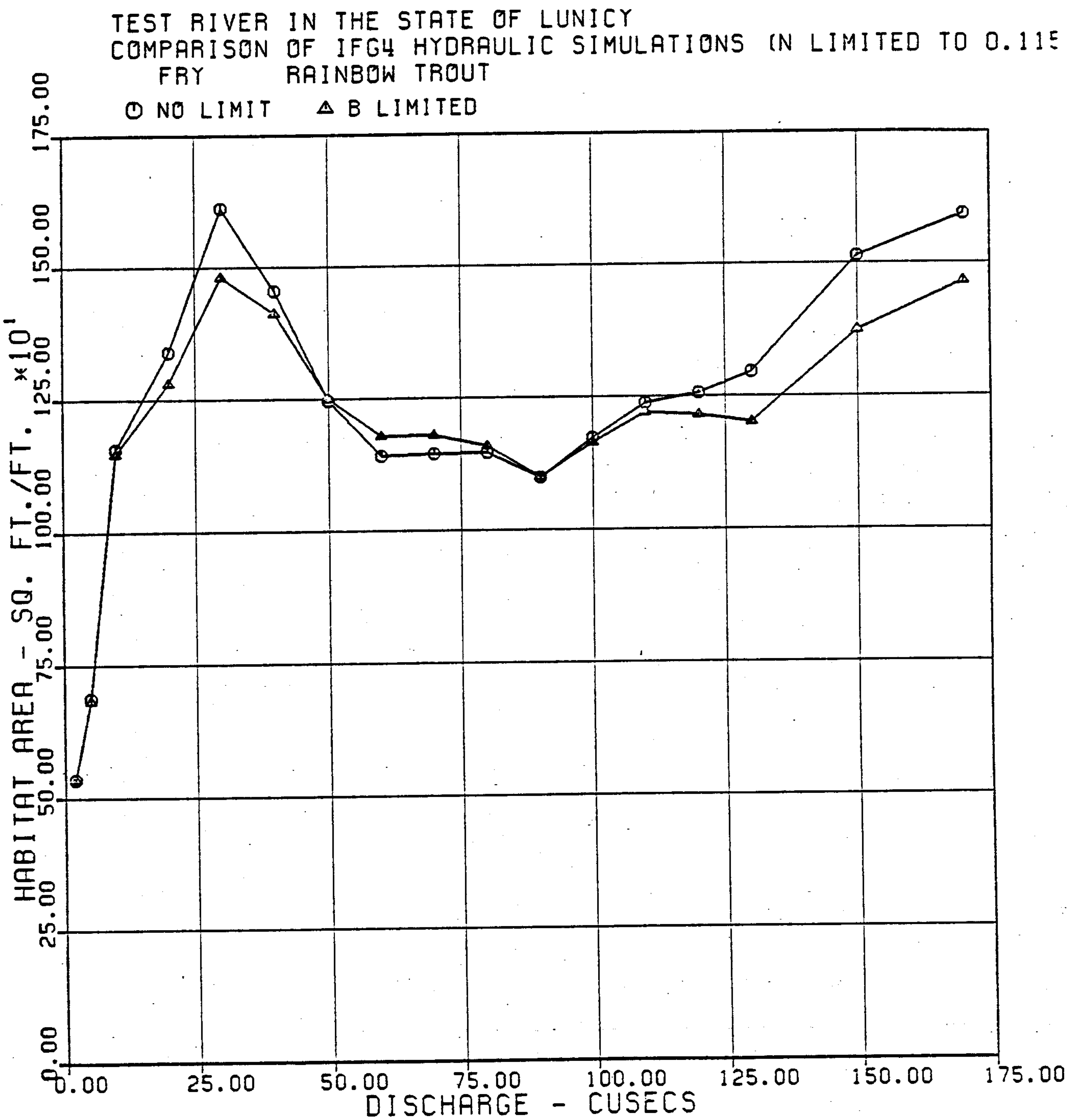
In some datasets, such as that for the Test River, the quality is such that the slope, B, in the equation v = A*Q**B may be very large. The large slopes may result in unreasonable results by simulating very high velocities in some cells and low velocities in others.

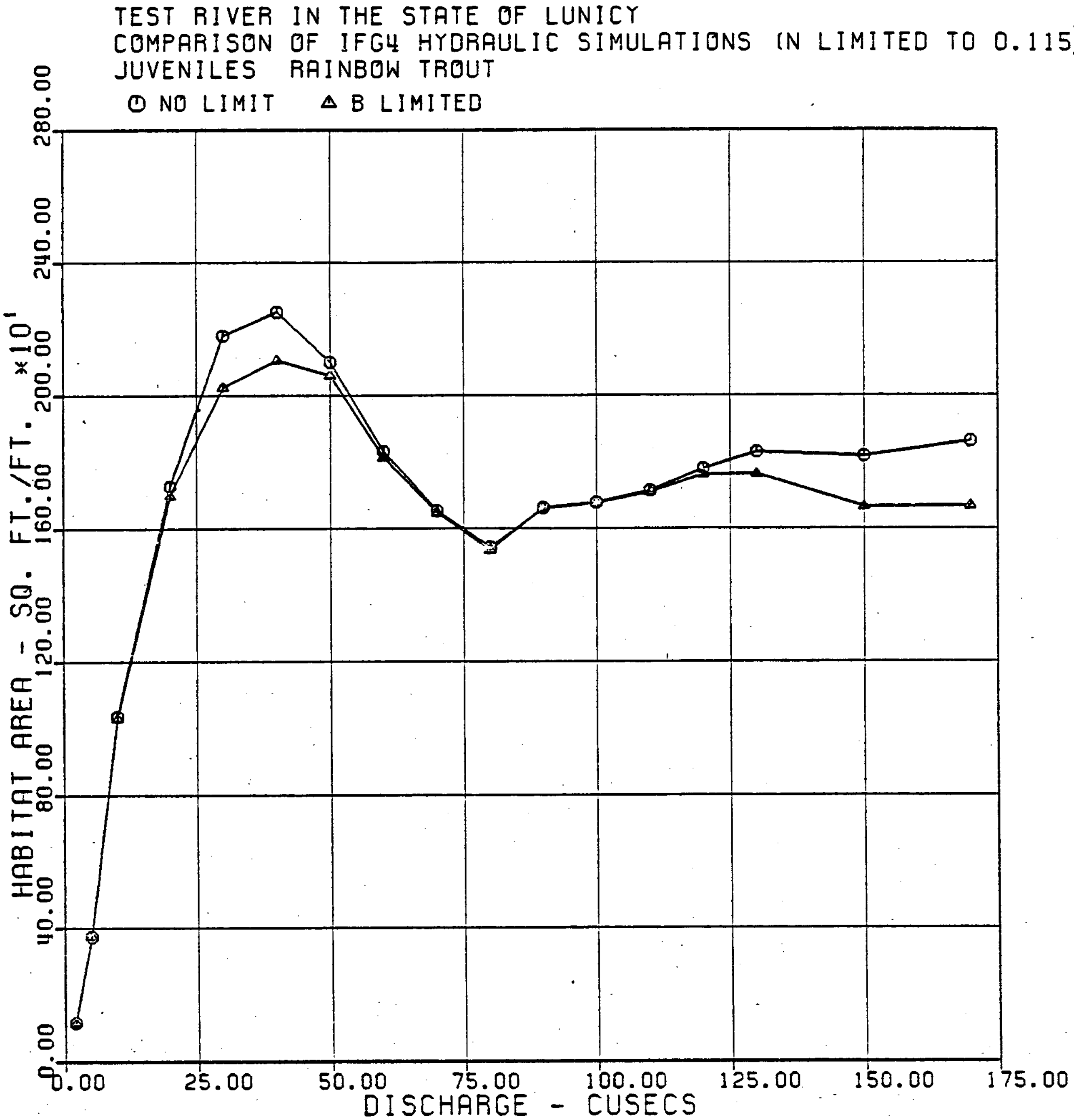
The results of limiting the slope, B, for the Test River is given in this appendix.



TEST RIVER IN THE STATE OF LUNICY
COMPARISON OF IFG4 HYDRAULIC SIMULATIONS (N LIMITED TO 0.115)
ADULT RAINBOW TROUT
NO LIMIT
B LIMITED
HABITAT AREA - SQ. FT./FT. ×10²
DISCHARGE - CUSECS
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
25.00
50.00
75.00
100.00
125.00
150.00
175.00


TEST RIVER IN THE STATE OF LUNICY
COMPARISON OF IFG4 HYDRAULIC SIMULATIONS (N LIMITED TO 0.115)
SPAWNING RAINBOW TROUT
NO LIMIT
B LIMITED
HABITAT AREA - SQ. FT./FT. *10[1]
DISCHARGE - CUSECS
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
25.00
50.00
75.00
100.00
125.00
150.00
175.00


TEST RIVER IN THE STATE OF LUNICY
COMPARISON OF IFG4 HYDRAULIC SIMULATIONS (N LIMITED TO 0.115
FRY RAINBOW TROUT
NO LIMIT
B LIMITED
HABITAT AREA - SQ. FT./FT. *10'
DISCHARGE - CUSECS
0.00
25.00
50.00
75.00
100.00
125.00
150.00
175.00


TEST RIVER IN THE STATE OF LUNICY
COMPARISON OF IFG4 HYDRAULIC SIMULATIONS (N LIMITED TO 0.115)
JUVENILES RAINBOW TROUT
NO LIMIT
B LIMITED
HABITAT AREA - SQ. FT./FT. *10[1]
0.00
40.00
80.00
120.00
160.00
200.00
240.00
280.00
0.00
25.00
50.00
75.00
100.00
125.00
150.00
175.00
DISCHARGE - CUSECS

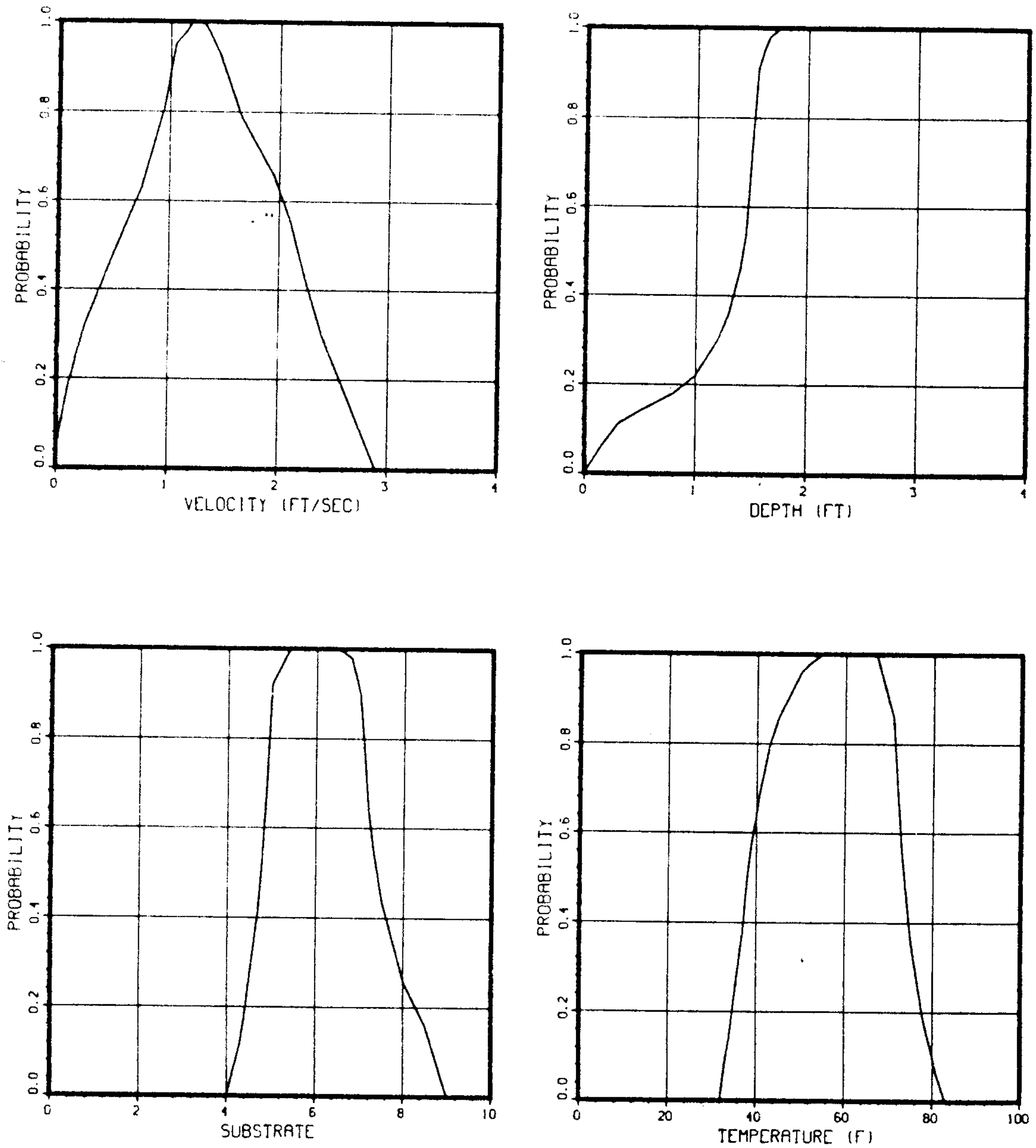
APPENDIX I

SUITABILITY CRITERIA FOR RAINBOW TROUT

The suitability criteria for rainbow trout used in all of the physical habitat simulation present in this paper were the same and are presented in the following four diagrams.

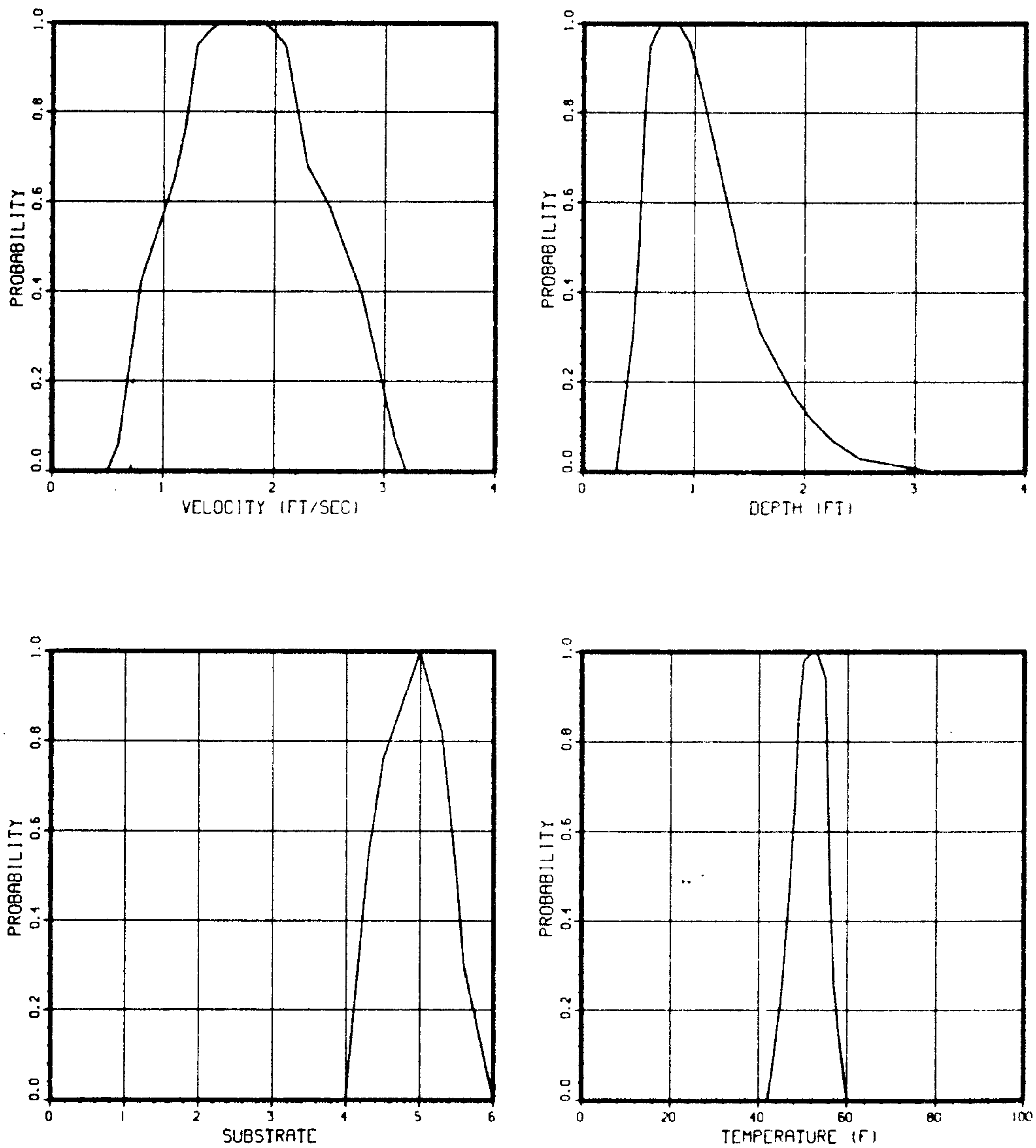
RAINBOW TROUT

11102 ADULT 78/01/24.



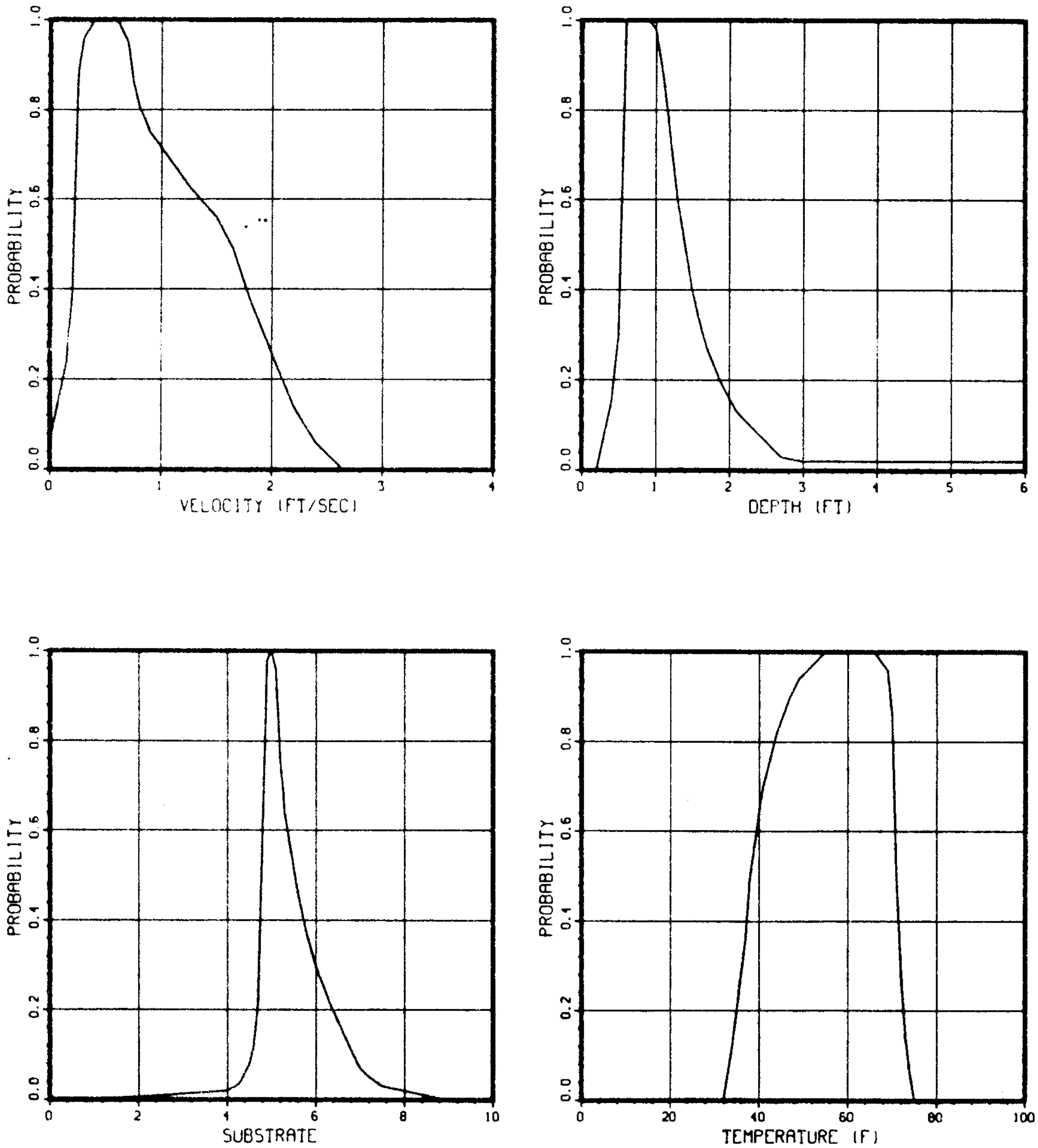
RAINBOW TROUT

11110 SPAWNING 78/01/24.



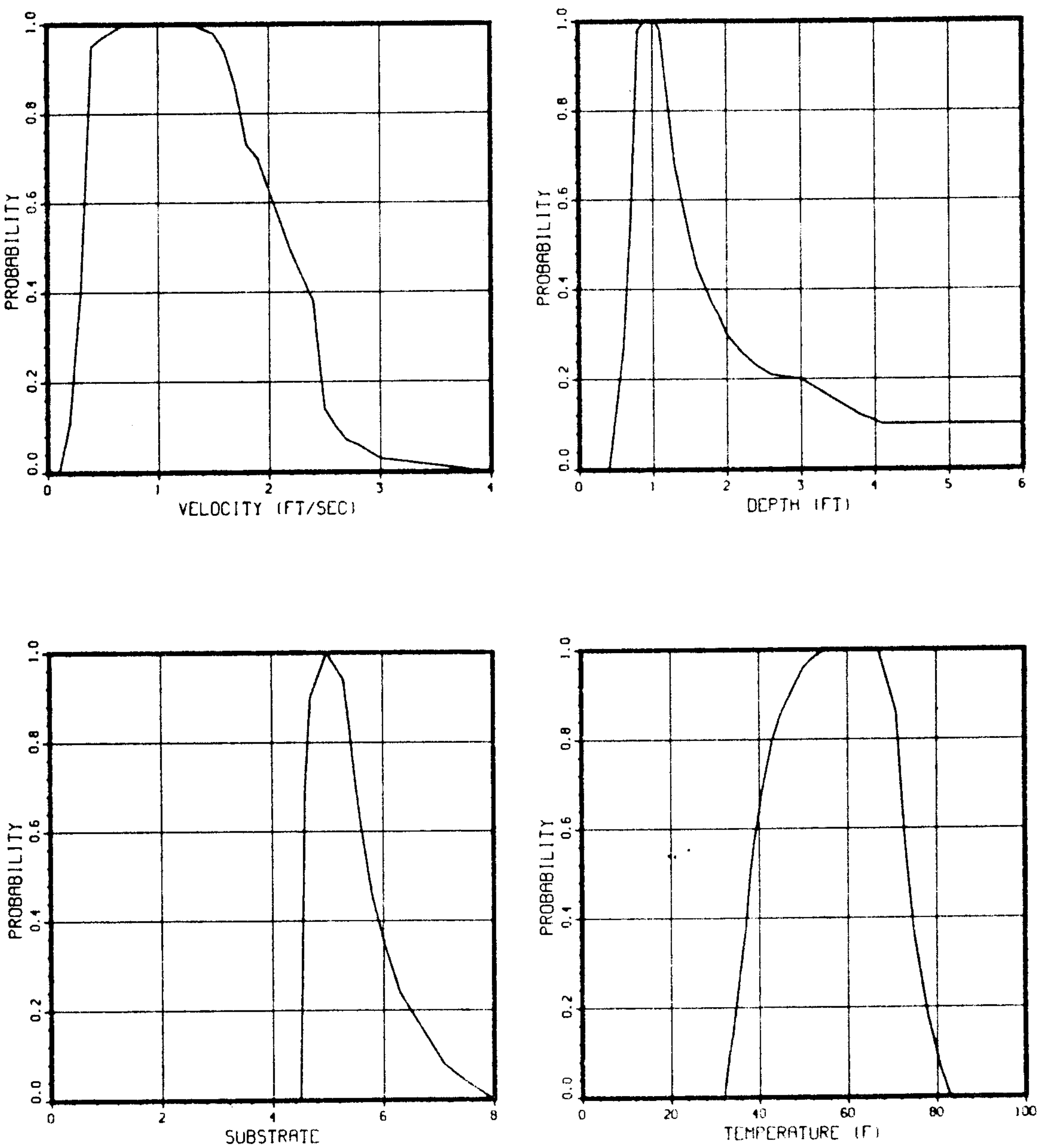
RAINBOW TROUT

11100 FRY 78/01/24.



RAINBOW TROUT

11101 JUVENILES 78/01/24.



PHABSIM TECHNICAL NOTE NO. 22
NEW OPTIONS IN THE IFG4
HYDRAULIC SIMULATION PROGRAM

by

Robert T. Milhous
Hydraulic Engineer

INTRODUCTION

New options have been added to the IFG4 Hydraulic Simulation Program. The purpose of this technical note is to present these. This note is limited to giving the options. The user will have to look elsewhere for specifics on how to use the options effectively in hydraulic simulation. In addition, IOC(8) and IOC(15) has been enhanced, see the latter sections for details.

THE NEW OPTIONS

The new options and their IOC values are:

(16) uses variables roughness if IOC(16) = 1

(17) writes velocities to TAPE4 using three criteria

IOC(17) = 0: writes normal

cell velocites as used in HABTAT

IOC(17) = 1: writes velocities at <u>wet verticals</u>

IOC(17) = 2: writes velocities at <u>all verticals</u>

(18) the stage-discharge may be different on right and left sides if IOC(18) = 1

(19) if IOC(19) = 1 print a QCAL table

(20) multiply the cross section distance by a constant

(21) read water surface elevations and discharges from another file

(22) overrides limits on the equation v = A * Q ** B

Option 21 is not available on 2 February 1986, it will appear shortly. Each of the options is discussed below.

<u>Option 16</u>

Option 16 has been discussed in PHABSIM Technical Note No. 6; use the note for details.

Option 17

In the HABTAT program, cell velocities are used. The usual approach is to average the velocity at the verticals defining the right and left side of a cell to determine the cell velocity - if IOC(17) = 0 this is still done.

In future programs it is desirable to have the actual velocities determined by IFG4, if IOC(17) = 1 these will be written to TAPE4.

In some other applications, it is desirable to have a velocity on TAPE4 for every vertical, either wet or dry, on TAPE3 - use IOC(17) = 2 to obtain these results.

Option 18

Do not use 18 until it is implemented in HABTAT - at that time this note will be revised.

Option 19

Print a summary table of the calculated flows if IOC(19) = 1

Option 20

Five values of IOC(20) are possible, these are IOC(20) = 0 no action IOC(20) = 1,2 multiply the coordinate distance (XC) by $10.^{IOC(20)}$, if IOC(20) = 3 or 4 multiply the coordinate distance by $10.^{(2.0-IOC(20))}$.

This option is useful for rivers of over 1000.0 feet width if IOC(20) = 1, 2; and for using centimeters in stead of meters for metric data (in this case IOC(20) = 3)

Option 21

This is an option for unsteady flow situation - see future RIVRLIB Technical Notes for details.

Option 22

The IFG4 program has been modified to abort if on slopes (B) in the equation V = A*Q**B exceeds 3.0. To override the abort, set IOC(22) = 1. IT IS RECOMMENDED YOU NOT USE STANDARD IFG4 - ESPECIALLY IN THIS CASE.

Option 15

Option 15 has been modified to allow a lower limit as well as an upper limit on the value of the roughness coefficient (n). The upper limit on roughness is placed in columns 11-20 on the "NMAX" line and the lower limit is placed in columns 21-30. The decimal points must be included in the number entered.

The use of a lower limit is appropriate when using variable roughness (IOC(16)).

Option 8

IOC(8) = 2 can be used with one set of velocities if the calculated discharge is entered in the CAL lines for the calibration sets without velocities. The calculated discharge must be the same as IFG4 would calculate if the measured velocities were present.

The calculated discharge is entered in columns 31-40 with a decimal point.

If only one set of velocities were measured and it is known the hydraulic at the section should be simulated using IOC(8) = 2, the velocity adjustment factor for the single set could be used to estimate discharge to be used on the CAL units. In this case, use:

QCAL = VAF*QBEST

and enter QCAL on the CAL line for these data sets with no measured velocities.

CONCLUSION

As with all the other options, the use is totally responsible for the selection of appropriate options. Consequently, proceed with care.