Q U I C K - 2
Computer Program

*COMPUTATION OF WATER SURFACE
ELEVATIONS IN OPEN
CHANNELS*

VERSION 1.0

JANUARY 1995

QUICK-2

Computation of Water Surface Elevations in Open Channels

User's Guide

Federal Emergency Management Agency

1995

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Chapter 1: Introduction

QUICK-2 is a user friendly program that assists in the computation of flood Water Surface Elevations (WSEs) in open channels of all types. It is much easier to use than the United States Army Corps of Engineers (USACE) HEC-2 program. However, a QUICK-2 step-backwater file can also be used, as is, with the HEC-2 program, which is also included in the QUICK-2 package of programs. Therefore a HEC-2 output file can be generated with a QUICK-2 input data file, without ever leaving the QUICK-2 environment; and, without having to know how to set-up and run the HEC-2 program. This version of QUICK-2 (Version 1.0) however, does not perform hydraulic calculations through bridges or culverts.

QUICK-2 was primarily developed to accompany the FEMA technical guidance manual titled, "MANAGING FLOODPLAIN DEVELOPMENT IN ZONE A AREAS - A GUIDE FOR OBTAINING AND DEVELOPING BASE FLOOD ELEVATIONS." That manual is intended to assist local community officials who are responsible for administering and enforcing the floodplain management requirements of the National Flood Insurance Program (NFIP). The purpose of that manual is to provide guidance for obtaining and developing base flood (100-year) elevations (BFEs) where Special Flood Hazard Areas (SFHAs) on a community's Flood Hazard Boundary Map (FHBM) or Flood Insurance Rate Map (FIRM) have been identified and designated as Zone A.

QUICK-2 will also be useful to community engineers, architect/engineer firms, developers, builders and others at the local level who may be required to develop BFEs for use in Special Flood Hazard Areas.

This manual includes four other chapters: **Overview**, **Getting Started**, **Tutorials** and **Formulas**. The Formulas section describes the "complex" equations and methodologies used in the development of the program. An Appendix is also included that contains a list of Definitions of the variables shown on the screen and on the printouts.

> *To get started as quickly as possible in using QUICK-2 we recommend that the user read the <u>Overview</u> and <u>Getting Started</u> chapters; and then work through the <u>Tutorials</u>.*

MINIMUM SYSTEM REQUIREMENTS

Random Access Memory (RAM)	–	512K
Hard disk storage	–	800K
Monitor	–	Color or Monotone
Printer (prints to LPT1)	–	Dot-matrix to LaserJet
Disk Operating System (DOS)	–	Version 3.0 or higher

Chapter 2: Overview

√ FOUR OPTIONS

This user friendly program computes:

- *Critical Depth*,

- *Cross Section Capacity* (Rating Curves),

- *Normal Depth*, and

- *Step-Backwater Analysis* (similar to the USACE HEC-2 program)

CRITICAL DEPTH: This option should be used to determine a Base Flood Elevation (BFE) if a previous calculation using the Normal Depth option computed a depth that was determined to be SUPERCRITICAL. Super Critical depths are generally not accepted for use as BFEs.

CHANNEL CAPACITY: This option is used to determine a rating curve for a cross section. The program computes a discharge based on the entered depth. Repeating with other depths produces a rating curve. A BFE may be determined by interpolation with the correct discharge.

NORMAL DEPTH: This is the usual option to use in determining BFEs. The user should watch the "Flow Type" message to make sure that the calculation is CRITICAL or SUBCRITICAL. Use Option 1 if SUPERCRITICAL.

STEP-BACKWATER: This option should be used to calculate BFEs if more than one cross-section is warranted to cover the extent of the property. Generally if the property parallels more than 500 feet of a flooding source this option should be used.

√ HANDLES "REGULAR" *AND* "IRREGULAR" SHAPED CROSS SECTIONS

The REGULAR shape cross-sections include:

- *V-shape*,

- *Trapezoidal*,

- *Rectangular*, and

- *Circular*

For IRREGULAR cross-sections:

- up to 40 points can be input to describe the ground points

- Ground points are easily modified using the Insert or Delete Keys

- Encroachments or other changes in the floodplain are easily modeled

- An unlimited number of cross sections may be modeled

In addition, ground points and other input variables for the irregular shape cross-sections can be saved to a file, for later use.

√ SINGLE SCREEN DATA INPUT, COMPUTATION AND OUTPUT

One of the most user-friendly aspects of this program that sets it apart from many other computational programs is that all of the data input, the computation, and the printing or plotting, is performed from the same screen. You will not get lost in a maze of menus.

√ GRAPHICS

- *Cross-Section Plots*,

- *Water Surface Elevation Profiles*, and

- *Rating Curve Plots*

Cross section plots and water surface elevation profiles from QUICK-2's step-backwater analysis can be viewed on the screen using the USACE PLOT-2 program that comes with the QUICK-2 package of programs. The channel capacity option of QUICK-2 can be used to generate rating curve plots of individual cross sections that can be viewed on screen and printed.

√ AUTOMATIC ERROR CHECKING

This software is designed to virtually eliminate the need for user's manuals. The program incorporates error-checking routines and warning messages to alert the user to incorrect input data or potentially incorrect output data. The program prompts the user for the required input data so that there is no need to worry about which columns to put data in; whether or not it needs to be left-justified, or right- justified, etc.

SPECIAL FEATURES OF QUICK-2

»» Critical Depth, Channel Capacity, and Normal Depth Options ««

EASY VIEW: All of the input data is viewed on the same screen (and changes can be made) before starting the computations

EASY CHANGE: After an initial calculation, the following parameters can be changed, and the above options can be re-calculated in seconds:

Discharge	Channel Slope	Manning's N
Base width or Diameter	Channel Side Slope	Ground Points
Channel Stations		

AUTO-SAVE: For irregular channels the program automatically stores all the input variables to a file designated as "TEMP.XSC", which is stored in the C:\QUICK2\DATA Directory.

RATING CURVES: A special feature of the Channel Capacity Option for irregular channels is the Rating Curve Print Option. A rating curve plot can be automatically generated with 20 computations of water surface elevation versus discharge. The maximum elevation of the rating curve will be just lower than the channel depth specified by the user. The rating curve can be viewed on the screen and/or printed.

»» Step-Backwater Option ««

EASY VIEW: All of the input data is viewed on the same screen (and changes can be made) before starting the computations

PRECISE: Balances the energy equation to within .01 foot.

COMPUTES CRITICAL DEPTH AUTOMATICALLY: After up to 40 energy balance trials (without a balance) the program automatically computes critical depth.

OUTPUT OPTIONS: Detailed and Summary printouts are available

AUTO-SAVE: The program automatically saves the first cross-section into a file designated as T0.XSC, and subsequent cross-sections are saved adding the Channel distance (XLCH) to the previous cross-section's file name. Therefore, if we run 3 cross-sections that are 200 feet apart their filenames will be: T0.XSC, T200.XSC, and T400.XSC. These files are automatically stored in a directory named C:\QUICK2\DATA.

HEC-2 RUNS WITH QUICK-2 FILES: *The backwater option also automatically saves all of the cross-sections into a HEC-2 compatible file called HEC2.DAT, which is stored in the C:\QUICK2 Directory. The QUICK-2 program is linked with the USACE HEC-2 program such that any backwater computation that is run using QUICK-2 can also be run using the HEC-2 program within the QUICK-2 environment. The user does not need to have any previous experience in running the HEC-2 model.*

AUTOMATIC ERROR CHECKS AND WARNING MESSAGES

ERROR CHECKS

Error checks prevent the user from continuing by re-prompting the user for correct input data. The following are error checks performed automatically by the program:

- Ground Point (GR) stations should be increasing

- Stations of the left and right bank should match a GR point

WARNING MESSAGES

Warning messages instruct the user that the program has had to modify the input data in order to complete a calculation, or that the completed calculation may not be valid. The following are warning messages performed by the program:

Extended Cross Section
The computed water surface elevation is higher than one or both ends of the cross-section, and the program automatically extended the end(s) of the cross-section vertically to complete the computation.

Divided Flow
There is a ground point(s) within the cross-section which is higher than the computed water surface elevation which is dividing the flow within the cross-section.

No Energy Balance ... Computing Critical Depth
The program attempted up to 40 trial computations and could not arrive at an energy balance; and therefore, critical depth is assumed to occur at this cross-section.

Computing Critical Depth ... Critical Depth Assumed
Either the initial Starting Water Surface Elevation or an energy balance between two cross sections occurred at an elevation for which the froude number or the index froude number was equal to or greater than 1. Thus, the computed water surface elevation is suspected of being below the critical depth. Therefore the critical depth is computed and compared to the previous calculated water surface elevation. In this case the critical depth elevation was higher, and thus Critical Depth is Assumed.

Computing Critical Depth ... Critical Depth Not Assumed
Same as above except, the critical depth is computed and compared to the previous calculated water surface elevation; and, in this case the critical depth elevation was lower, and thus Critical Depth is **Not** Assumed.

Chapter 3: Getting Started

This   section   provides   you   with
convenient   installation   and   run
procedures   that   will   enable   you
to run the program from the hard
disk drive or the floppy disk drive.
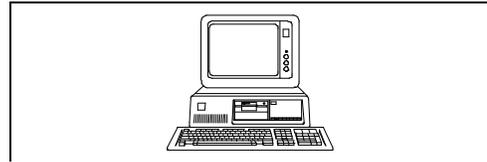
HARD DISK INSTALLATION AND RUN PROCEDURE

To install and run QUICK-2 simply place the floppy disk in either your "A"
disk drive or your "B" disk drive.

For "A" Drive users: Type   **A:\AQ2**   and Press <Enter>

For "B" Drive users: Type   **B:\BQ2**   and Press <Enter>

Follow the screen message to start the program. That's it!

The program resides in a C:\QUICK2 directory. To run the program in the
future, just change to that directory and type Q2 and press <Enter>.

FLOPPY DISK INSTALLATION AND RUN PROCEDURE

To install and run QUICK-2 from the floppy disk drive simply place the floppy
disk in either your "A" disk drive or your "B" disk drive.

For "A" Drive users: Type   **A:\FAQ2**   and Press <Enter>
For "B" Drive users: Type   **B:\FBQ2**   and Press <Enter>

Follow the screen message to start the program. That's it!

To run the program in the future, just place the disk in your floppy drive,
change to that directory and type Q2 and press <Enter>. *Although the
program will run from the floppy disk drive it will run much faster if
installed and run on the hard disk drive.*

REMINDER:

Entering and editing data, as well as moving around within the input screens
is performed using the Function keys, the Backspace Key and the Enter Key. *DO
NOT USE THE CURSOR CONTROL KEYS (ARROW KEYS) FOR ENTERING, DELETING, OR
EDITING DATA.*

Chapter 4: TUTORIALS

Normal Depth

Step-Backwater

Channel Capacity

PLOT - 2
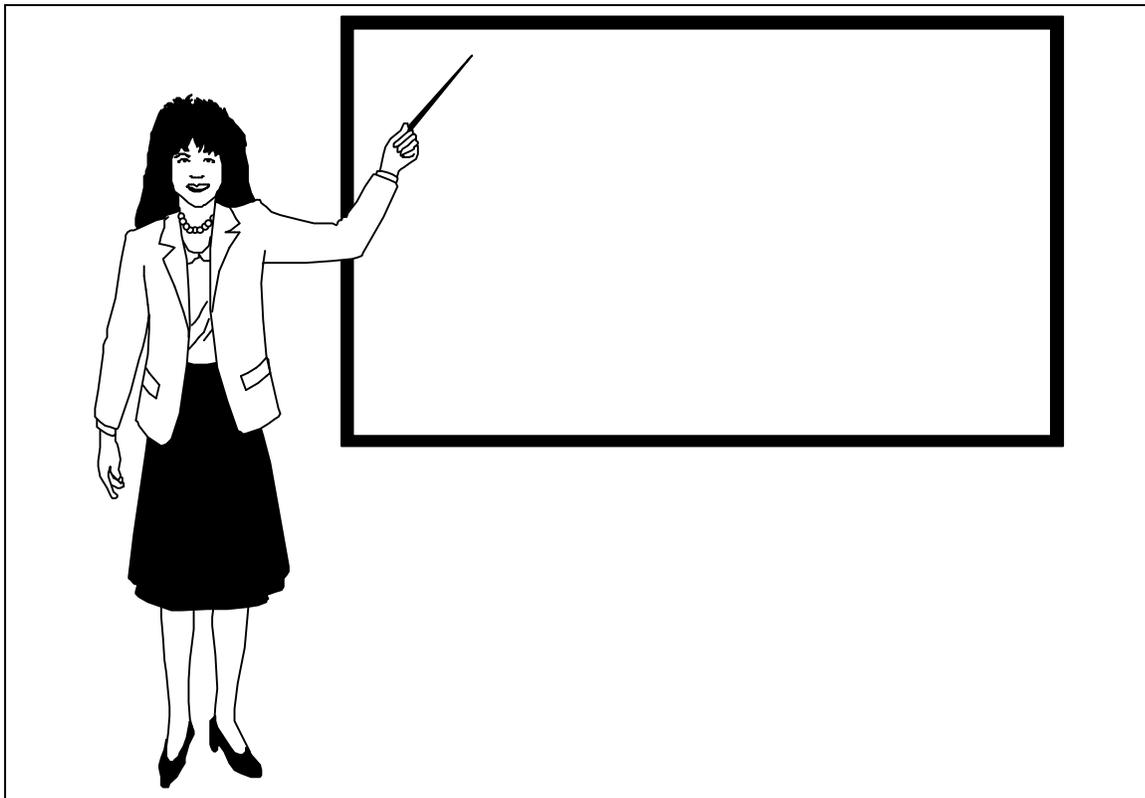
NORMAL DEPTH {Tutorial Time: 5 to 10 minutes}

After pressing **Q2** and **<Enter>** to start the program you will come to   the
Main Menu screen of QUICK-2 as shown below.

```
┌─────────────────────────────────────┐ ▐█
║              QUICK - 2              ║ ▐█
║        MAIN       MENU             ║ ▐█
║                          Press     ║ ▐█
║                          -----     ║ ▐█
║ Critical Depth             1       ║ ▐█
║ Channel Capacity           2       ║ ▐█
║ Normal Depth               3       ║ ▐█
║ Step-Backwater             4       ║ ▐█
║                                  ▐█
║──────────────────────────────────▐█
║ QUIT                   <F10>     ▐█
└─────────────────────────────────────┘ ▐█
 ███████████████████████████████████████
```

```
┌──────────────────┐
│<F1> - Help      │▐█
└──────────────────┘
 ███████████████
```
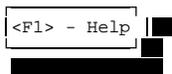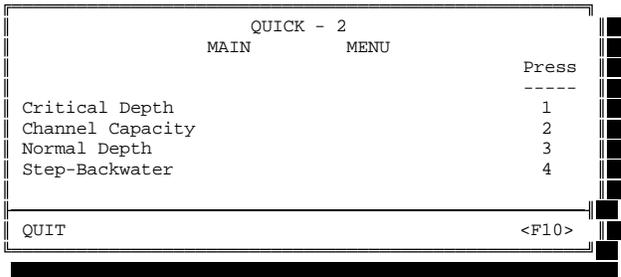
1. Press **3** and then press **<Enter>** to start the Normal Depth Option.

Next you will see the Shape of Cross Section screen:

```
┌─────────────────────────────────────┐▐█
║      SHAPE OF CROSS SECTION        ║▐█
║                          Press     ║▐█
║                          -----   ▐█
║ V - Ditch                  V       ║▐█
║ Rectangular Channel        R       ║▐█
║ Trapezoidal Channel        T       ║▐█
║ Circular    Channel        C       ║▐█
║                                  ║▐█
║ Irregular   Channel        I       ║▐█
└─────────────────────────────────────┘▐█
 ███████████████████████████████████████
```

```
┌──────────────────────┐
│<F7> - Main Menu    │▐█
└──────────────────────┘
 ████████████████████
```
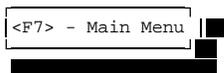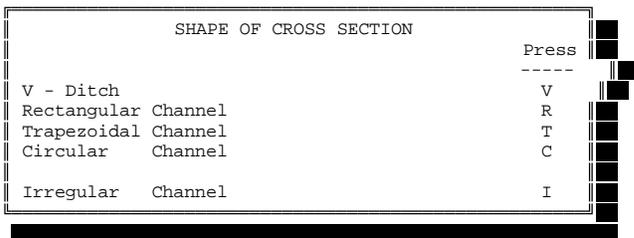
Let's try the Trapezoidal Channel option.

2. Press **T** and then press **<Enter>** to perform a Normal Depth calculation
for a trapezoidal channel.

4-2

The next screen you will see is the Input / Output screen:

```
╔════════════════════════════════════╗ ▌■
║           NORMAL  DEPTH             ║ ▌■
║        TRAPEZOIDAL CHANNEL          ║ ▌■
║                                    ║ ▌■
║           INPUT VARIABLES          ║ ▌■
║                                    ║ ▌■
║ L Side Slope (H:V)    :1  R Side Slope (H:V)    :1 ║ ▌■
║ Bottom Width (ft)         Manning's n  ║ ▌■
║ Discharge (cfs)           Depth (ft)   ║ ▌■
║ Slope (ft/ft)                          ║ ▌■
╟────────────────────────────────────╢ ▌■
║           OUTPUT VARIABLES          ║ ▌■
║                                    ║ ▌■
║ Area (sq ft)          Wet Perimeter (ft) ║ ▌■
║ Velocity (ft/s)       Hyd Radius      ║ ▌■
║ Top Width (ft)        Froude #        ║ ▌■
║                       Flow Type       ║ ▌■
╟────────────────────────────────────╢ ▌■
║ **Enter Left Side Slope  and Press  <Enter>**    :1║ ▌■
║                                    ║ ▌■
║ <- Back Tab  <F2>         Main Menu  <F7> ║ ▌■
╚════════════════════════════════════╝ ▌■
```

The program is currently prompting you to enter the Left Side Slope (in terms of the Number of Horizontal feet (H) to every 1 foot Vertical (H : 1). **Let's say our left side slope is 3 to 1 (3:1).**

3. Enter **3** and then Press **<Enter>.**

The next screen you will see is the Input / Output screen with a new prompt:

```
╔════════════════════════════════════╗ ▌■
║           NORMAL  DEPTH             ║ ▌■
║                                    ║ ▌■
║        TRAPEZOIDAL CHANNEL          ║ ▌■
║                                    ║ ▌■
║           INPUT VARIABLES          ║ ▌■
║                                    ║ ▌■
║ L Side Slope (H:V) **3.0**:1  R Side Slope (H:V)    :1 ║ ▌■
║ Bottom Width (ft)         Manning's n  ║ ▌■
║ Discharge (cfs)           Depth (ft)   ║ ▌■
║ Slope (ft/ft)                          ║ ▌■
╟────────────────────────────────────╢ ▌■
║           OUTPUT VARIABLES          ║ ▌■
║                                    ║ ▌■
║ Area (sq ft)          Wet Perimeter (ft) ║ ▌■
║ Velocity (ft/s)       Hyd Radius      ║ ▌■
║ Top Width (ft)        Froude #        ║ ▌■
║                       Flow Type       ║ ▌■
╟────────────────────────────────────╢ ▌■
║ **Enter Right Side Slope  and Press  <Enter>**   :1║ ▌■
║                                    ║ ▌■
║ <- Back Tab  <F2>         Main Menu  <F7> ║ ▌■
╚════════════════════════════════════╝ ▌■
```

Notice that the
3 has been entered
to the right of
"L Side Slope (H:V)"

The program is currently prompting you to enter the Right Side Slope (in terms of the Number of Horizontal feet (H) to every 1 foot Vertical (H : 1). **Let's say our right side slope is 2 to 1 (2:1).**

4. Enter **2** and then Press **<Enter>.**

```
╔══════════════════════════════════════╗ ▐█
║            NORMAL  DEPTH              ║ ▐█
║          TRAPEZOIDAL CHANNEL          ║ ▐█
║                                       ║ ▐█
║            INPUT VARIABLES            ║ ▐█
║                                       ║ ▐█
║ L Side Slope (H:V) 3.0:1  R Side Slope (H:V) 2.0:1 ║ ▐█
║ Bottom Width (ft)         Manning's n  ║ ▐█
║ Discharge (cfs)           Depth (ft)   ║ ▐█
║ Slope (ft/ft)                          ║ ▐█
║ ───────────────────────────────────── ║ ▐█
║            OUTPUT VARIABLES           ║ ▐█
║                                       ║ ▐█
║ Area (sq ft)         Wet Perimeter (ft)║ ▐█
║ Velocity (ft/s)      Hyd Radius         ║ ▐█
║ Top Width (ft)       Froude #           ║ ▐█
║                      Flow Type          ║ ▐█
║ ───────────────────────────────────── ║ ▐█
║ Enter "............."  and Press  <Enter> ║ ▐█
║                                       ║ ▐█
║ <- Back Tab  <F2>        Main Menu  <F7> ║ ▐█
╚══════════════════════════════════════╝ ▐█
```

The program will continue to prompt you for input data.

Let's say our channel is **10** feet wide, with a Manning's n value of **0.035**, the discharge is **300** cfs, and the channel slope is **.005** ft/ft.

SCREEN PROMPT - "Enter Bottom Width and Press <Enter>"
5. Enter **10** and then Press **<Enter>.**

SCREEN PROMPT - "Enter Manning's n and Press <Enter>"
6. Enter **.035** and then Press **<Enter>.**

SCREEN PROMPT - "Enter Discharge and Press <Enter>"
7. Enter **300** and then Press **<Enter>.**

SCREEN PROMPT - "Enter Slope and Press <Enter>"
8. Enter **.005** and then Press **<Enter>.**

```
╔══════════════════════════════════════╗ ▐█
║            NORMAL  DEPTH              ║ ▐█
║          TRAPEZOIDAL CHANNEL          ║ ▐█
║                                       ║ ▐█
║            INPUT VARIABLES            ║ ▐█
║                                       ║ ▐█
║ L Side Slope (H:V) 3.0:1  R Side Slope (H:V) 2.0:1 ║ ▐█
║ Bottom Width (ft)  10.0   Manning's n      0.0350 ║ ▐█
║ Discharge (cfs)     300   Depth (ft)         0.00 ║ ▐█
║ Slope (ft/ft)    0.0050                     ║ ▐█
║ ───────────────────────────────────── ║ ▐█
║            OUTPUT VARIABLES           ║ ▐█
║                                       ║ ▐█
║ Area (sq ft)         Wet Perimeter (ft)║ ▐█
║ Velocity (ft/s)      Hyd Radius         ║ ▐█
║ Top Width (ft)       Froude #           ║ ▐█
║                      Flow Type          ║ ▐█
║ ───────────────────────────────────── ║ ▐█
║ Begin Calculations  <Enter>            ║ ▐█
║                                       ║ ▐█
║ <- Back Tab  <F2>        Main Menu  <F7> ║ ▐█
╚══════════════════════════════════════╝ ▐█
```

After all the data
is input your screen
should look like this

To begin the calculation simply ...

9. Press **<Enter>**.

After a split second the screen should look like this:

```
╔═══════════════════════════════════════════╗█
║            NORMAL  DEPTH                   ║█■
║          TRAPEZOIDAL CHANNEL               ║█■
║                                           ║█■
║            INPUT VARIABLES                 ║█■
║                                           ║█■
║                                           ║█■
║ L Side Slope (H:V) 3.0:1  R Side Slope (H:V) 2.0:1 ║█■
║ Bottom Width (ft)  10.0   Manning's n       0.0350 ║█■
║ Discharge (cfs)     300   Depth (ft)          3.27 ║█■
║ Slope (ft/ft)     0.0050                    ║█■
╟───────────────────────────────────────────╢█■
║            OUTPUT VARIABLES                ║█■
║                                           ║█■
║ Area (sq ft)       59.6   Wet Perimeter (ft) 27.7 ║█■
║ Velocity (ft/s)     5.0   Hyd Radius          2.2 ║█■
║ Top Width (ft)     26.4   Froude #           0.6 ║█■
║                           Flow Type  SUBCRITICAL  ║█■
╟───────────────────────────────────────────╢█■
║ Begin Calculations  <Enter>                ║█■
║ Print               <F5>                   ║█■
║ <- Back Tab         <F2>        Main Menu <F7> ║█■
╚═══════════════════════════════════════════╝█
 ███████████████████████████████████████████
```

Notice that the Depth is no longer 0.00, but equals **3.27** feet, which is the Normal Depth for this particular Trapezoidal cross-section. **If 300 cfs represents the 100-year discharge, then the 100-year flood depth would equal 3.27 feet.** All of the output variables have also been computed and listed.

10. To print the output simply **Press** the **<F5>** Function key.

The printed output is shown below.

QUICK - 2
NORMAL DEPTH
Trapezoidal Channel

```
                    INPUT  VARIABLES              OUTPUT VARIABLES
 ___
  ^           \                    /          Depth (ft)         3.27
  |      1|    \     n = 0.035    /    |1     Discharge (cfs)   300.0
Depth    |____  \              /  ____|       Velocity (ft/s)    5.04
  |        3.0   \            /    2.0         Top Width (ft)    26.4
 _v_             _____/                 Froude No.         0.59
          Base Width =   10.0                 Flow Type:  SUBCRITICAL
          Slope      = 0.0050
```

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CHANGING THE VARIABLES

```
╔══════════════════════════════════════════════╗ ██
║              NORMAL  DEPTH                    ║ ██
║            TRAPEZOIDAL CHANNEL                ║ ██
║                                              ║ ██
║             INPUT VARIABLES                  ║ ██
║                                              ║ ██
║ L Side Slope (H:V) 3.0:1   R Side Slope (H:V) 2.0:1 ║██
║ Bottom Width (ft)  10.0    Manning's n      0.0350 ║██
║ Discharge (cfs)     300    Depth (ft)         3.27 ║██
║ Slope (ft/ft)    0.0050                       ║ ██
║                                              ║ ██
║             OUTPUT VARIABLES                 ║ ██
║                                              ║ ██
║ Area (sq ft)        59.6   Wet Perimeter (ft) 27.7 ║██
║ Velocity (ft/s)      5.0   Hyd Radius          2.2 ║██
║ Top Width (ft)      26.4   Froude #           0.6 ║██
║                            Flow Type  SUBCRITICAL  ║██
║                                              ║ ██
║ Begin Calculations  <Enter>                  ║ ██
║ Print               <F5>                      ║ ██
║ <- Back Tab         <F2>        Main Menu <F7>║ ██
╚══════════════════════════════════════════════╝ ██
     ████████████████████████████████████████████
```

Let's say we want to run this calculation again but with a discharge of **500** cfs instead of 300 cfs.

1. **Press** the Function Key **<F2>**

```
╔══════════════════════════════════════════════╗ ██
║              NORMAL  DEPTH                    ║ ██
║            TRAPEZOIDAL CHANNEL                ║ ██
║                                              ║ ██
║             INPUT VARIABLES                  ║ ██
║                                              ║ ██
║ L Side Slope (H:V) 3.0:1   R Side Slope (H:V) 2.0:1 ║██
║ Bottom Width (ft)  10.0    Manning's n      0.0350 ║██
║ Discharge (cfs)     300    Depth (ft)         3.27 ║██
║ Slope (ft/ft)    0.0050                       ║ ██
║             OUTPUT VARIABLES                 ║ ██
║                                              ║ ██
║ Area (sq ft)        59.6   Wet Perimeter (ft) 27.7 ║██
║ Velocity (ft/s)      5.0   Hyd Radius          2.2 ║██
║ Top Width (ft)      26.4   Froude #           0.6 ║██
║                            Flow Type  SUBCRITICAL  ║██
║ Enter Slope  and Press  <Enter>              ║ ██
║                                              ║ ██
║ <- Back Tab  <F2>              Main Menu  <F7>║ ██
╚══════════════════════════════════════════════╝ ██
     ████████████████████████████████████████████
```

The above screen is what you should be looking at. The **<F2>** key will move the prompt backwards through all the variables. Note that since we want to change the Discharge (from **300** to **500**), we will need to Press <F2> again to come to the Enter Discharge prompt. **Follow the steps as shown on the following page to rerun this calculation with a new discharge.**

SCREEN PROMPT - "Enter Slope and Press <Enter>"

2. Press **<F2>.**

SCREEN PROMPT - "Enter Discharge and Press <Enter>"

3. Enter **500** and then Press **<Enter>.**

SCREEN PROMPT - "Enter Slope and Press <Enter>"

4. Press **<Enter>.**

After all of the data is input your screen should look like this:

```
┌─────────────────────────────────────────┐██
║            NORMAL  DEPTH                 ║██
║          TRAPEZOIDAL CHANNEL             ║██
║                                          ║██
║            INPUT VARIABLES               ║██
║                                          ║██
║ L Side Slope (H:V) 3.0:1  R Side Slope (H:V) 2.0:1 ║██
║ Bottom Width (ft)  10.0  Manning's n      0.0350 ║██
║ Discharge (cfs)     500  Depth (ft)         3.27 ║██
║ Slope (ft/ft)    0.0050                   ║██
╟──────────────────────────────────────────╢██
║            OUTPUT VARIABLES              ║██
║                                          ║██
║ Area (sq ft)      59.6  Wet Perimeter (ft) 27.7 ║██
║ Velocity (ft/s)    5.0  Hyd Radius           2.2 ║██
║ Top Width (ft)    26.4  Froude #             0.6 ║██
║                         Flow Type  SUBCRITICAL ║██
╟──────────────────────────────────────────╢██
║ Begin Calculations  <Enter>              ║██
║                                          ║██
║ <- Back Tab      <F2>      Main Menu  <F7> ║██
└─────────────────────────────────────────┘██
   ████████████████████████████████████████
```

5. Press **<Enter>** to begin the calculation.

After a split second the screen should look like this:

```
╔═══════════════════════════════════════════════╗ ■
║               NORMAL  DEPTH                     ║ ■
║             TRAPEZOIDAL CHANNEL                 ║ ■
║                                                 ║ ■
║               INPUT VARIABLES                   ║ ■
║                                                 ║ ■
║ L Side Slope (H:V) 3.0:1   R Side Slope (H:V) 2.0:1 ║ ■
║ Bottom Width (ft)   10.0   Manning's n       0.0350 ║ ■
║ Discharge (cfs)      500   Depth (ft)          4.22 ║ ■
║ Slope (ft/ft)     0.0050                        ║ ■
║─────────────────────────────────────────────── ║ ■
║               OUTPUT VARIABLES                  ║ ■
║                                                 ║ ■
║ Area (sq ft)        86.7   Wet Perimeter (ft)  32.8 ║ ■
║ Velocity (ft/s)      5.8   Hyd Radius          2.6 ║ ■
║ Top Width (ft)      31.1   Froude #            0.6 ║ ■
║                            Flow Type   SUBCRITICAL ║ ■
║─────────────────────────────────────────────── ║
║ Begin Calculations  <Enter>                     ║ ■
║ Print               <F5>                         ║ ■
║ <- Back Tab         <F2>        Main Menu <F7>   ║ ■
╚═══════════════════════════════════════════════╝ ■
   ███████████████████████████████████████████   ■
```

Let's return to the Main Menu... Just **Press** the **<F7>** Function Key

```
╔═══════════════════════════════════════════════╗ ■
║                   QUICK - 2                      ║ ■
║           MAIN         MENU                      ║ ■
║                                    Press         ║ ■
║                                    -----         ║ ■
║ Critical Depth                       1           ║ ■
║ Channel Capacity                     2           ║ ■
║ Normal Depth                         3           ║ ■
║ Step-Backwater                       4           ║ ■
║─────────────────────────────────────────────── ║ ■
║ QUIT                              <F10>          ║ ■
╚═══════════════════════════════════════════════╝ ■
   ███████████████████████████████████████████   ■
```

```
┌────────────┐
│<F1> - Help │ ■
└────────────┘  ■
   ███████
```

➢ If you want to continue and to perform the Step-Backwater
Tutorial, then *turn to the next page.* ══════════════════════➤➤➤➤

➢ If you want to exit out of the program for now, **Press <F10>.** ◄

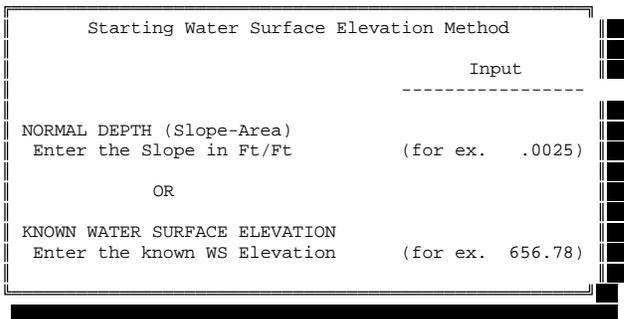**STEP-BACKWATER** {Tutorial Time: 20 to 25 minutes}

Let's say that we have a piece of property located in an unnumbered Zone A, and we need to determine if our property is really in or out of the floodplain. We will be referring to Figure 1 on the next page which represents a plan view of our proposed floodplain study (step-backwater analysis). We have field surveyed 3 cross-sections to use in the step-backwater analysis. The next page lists all of the data from the field surveyed cross-sections.

If you have continued from the previous Normal Depth Tutorial you should see the screen below. If you are just starting the program, you will see the screen below after pressing **Q2** and **<Enter>**.

```
                    QUICK - 2
               MAIN        MENU
                                       Press
                                       -----
     Critical Depth                      1
     Channel Capacity                    2
     Normal Depth                        3
     Step-Backwater                      4


     QUIT                              <F10>
```

```
<F1> - Help
```
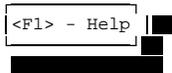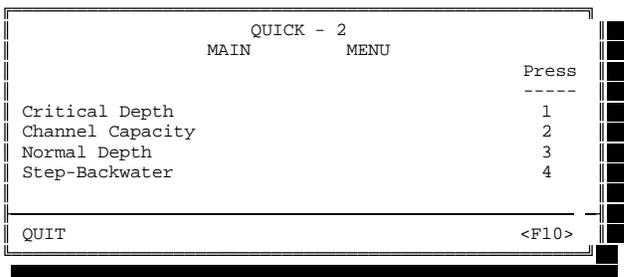
1. Press **4** and then press **<Enter>** to start the Step-Backwater Option.

Next you will see the Starting Water Surface Elevation Method screen:

```
      Starting Water Surface Elevation Method

                                     Input
                                -----------------


     NORMAL DEPTH (Slope-Area)
      Enter the Slope in Ft/Ft        (for ex.   .0025)

               OR

     KNOWN WATER SURFACE ELEVATION
      Enter the known WS Elevation    (for ex.  656.78)
```
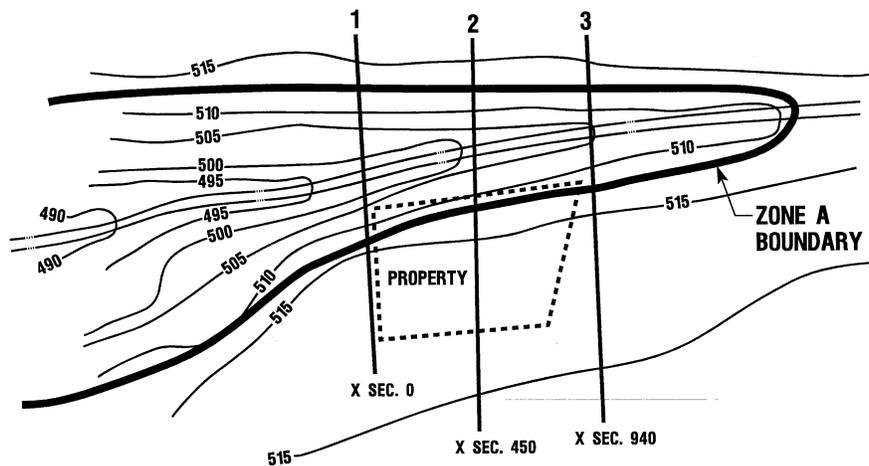
Enter a Slope or an Elevation:

Let's say that we do not have any previous information about flood elevations for our sample stream. Thus we need to start the step-backwater analysis assuming that the flow in our first cross-section is at Normal Depth. (This assumes that the channel slope downstream of our first cross-section will approximate the slope of the energy grade at the first cross-section of our study.) Let's assume that our calculated downstream channel slope is .0029 ft/ft.

2. Type **.0029** and then press **<Enter>**.

CROSS SECTION INFORMATION

Cross-Section 1		Cross-Section 2		Cross-Section 3	

GROUND POINTS

Station	Elevation	Station	Elevation	Station	Elevation
362	505.0	0	510.0	0	515.0
425	499.1	150	504.8	433	510.1
509	498.0	233	502.2	600	506.3
512	496.9	236	500.9	614	504.9
602	496.9	331	500.9	701	504.8
605	498.2	334	501.8	725	506.5
732	500.1	402	505.5	866	511.1
1020	504.7	591	510.1	1240	514.6

CHANNEL BANK STATIONS

Left 509 Right 605	Left 233 Right 334	Left 600 Right 725

MANNING'S N VALUES

Left .065	Left .055	Left .065
Channel .040	Channel .040	Channel .040
Right .060	Right .060	Right .060

CHANNEL REACH LENGTHS

Left ---	Left 450	Left 490
Channel ---	Channel 450	Channel 490
Right ---	Right 450	Right 490

LOSS COEFFICIENTS

Cont --- Expan ---	Cont 0.1 Expan 0.3	Cont 0.1 Expan 0.3

100-YEAR DISCHARGE

3000	3000	3000

FIGURE 1

The next screen you will see is the Input / Output screen as shown:

```
XSEC ID:      0            >> STEP - BACKWATER <<           GROUND  POINTS
STAT      ELEV      STAT      ELEV      STAT      ELEV      STAT      ELEV




│
│
│
│
│
│
│
│
││ CHANNEL BANK STATIONS:      Left                        Right          ║
║ MANNING'S  N   VALUES:      Left        Channel          Right          ║
║ CHANNEL REACH LENGTHS:      Left        Channel          Right          ║
║ LOSS      COEFFICIENTS: Contractn       Expansn         :Dschrg         ║
║ WS ELEV                     Depth       Top Wid          Kratio         ║
║ EG ELEV             Flow Regime         ChanVel          Froud#         ║
║
║F2}<-Back Tab F5}List Files F6}Retrieve File F7}Main Menu F10}Ed/Ex GrPt║
║ F3}Insert GrPt F4}Delete GrPt                           F1 }HELP        ║
```

Before we go on let's read about how data is to be input for this screen.

3. Press **<F1>** to access the Help screen.

4. When you are finished reading the Help screen just **Press <Enter>.**

If you refer to the previous page, you will see a tabulation of the Ground Points for the first field surveyed cross-section listed by Station and Elevation. You will also see the Channel Bank Stations, Manning's N values, and Discharge.

5. Following the method explained in the Help Screen, enter the Ground Points one at a time, by their respective Station and Elevation. Be sure to Press <Enter> after you have typed in each correct number.

Once you have entered all of the Ground Points correctly ...

6. Press **<F10>** to Exit from entering Ground Point data

NOTE: The **<F10> Key** will <u>EXIT</u> you from the top of the screen, or it will <u>RETURN</u> you to the top of the screen if you need to go back to <u>EDIT</u> the Ground Points.

Your screen should now look like this:

```
┌─────────────────────────────────────────────────────────────────────┐
│XSEC ID:      0          >> STEP - BACKWATER <<          GROUND  POINTS│
│STAT      ELEV      STAT      ELEV      STAT      ELEV      STAT    ELEV│
│362       505.0     425      499.1      509      498.0     512    496.9│
│602       496.9     605      498.2      732      500.1     1020   504.7│
│                                                                       │
│                                                                       │
│                                                                       │
│                                                                       │
│                                                                       │
│  ╔═══════════════════════════════════════════════════════════════╗   │
│  ║ CHANNEL BANK STATIONS:      Left                     Right      ║   │
│  ║ MANNING'S  N   VALUES:      Left         Channel     Right      ║   │
│  ║ CHANNEL REACH LENGTHS:      Left         Channel     Right      ║   │
│  ║ LOSS     COEFFICIENTS: Contractn       Expansn      :Dschrg     ║   │
│  ║ WS ELEV                   Depth        Top Wid      Kratio      ║   │
│  ║ EG ELEV              Flow Regime       ChanVel      Froud#      ║   │
│  ╠═══════════════════════════════════════════════════════════════╣   │
│  ║ F2}<- Back Tab F5}PRINT F6}SAVE F7}Main Menu F8}New XSEC F10}Ed/Ex GrPt║│
│  ║ Enter  LEFT  Channel Bank Station  and Press  <Enter>          ║   │
│  ╚═══════════════════════════════════════════════════════════════╝   │
└─────────────────────────────────────────────────────────────────────┘
```

The program is currently prompting you to **enter the Left Channel Bank Station**. Using the information contained on the previous page, we know that our Left Channel Bank Station is **509**. Therefore ...

7. Enter **509** and then Press **<Enter>.** (Notice that the **509** has been entered to the right of "CHANNEL BANK STATIONS: Left".)

Next you will see the Input / Output screen with a new prompt:
SCREEN PROMPT - "Enter RIGHT Channel Bank Station and Press <Enter>"

Using the information for Cross-section 1, simply follow the screen prompts to input the required data, as follows:

SCREEN PROMPT - "Enter RIGHT Channel Bank Station and Press <Enter>"
8. Type **605** and then Press **<Enter>.**

SCREEN PROMPT - "Enter LEFT Manning's n Value and Press <Enter>"
9. Type **.065** and then Press **<Enter>.**

SCREEN PROMPT - "Enter CHANNEL Manning's n Value and Press <Enter>"
10. Type **.040** and then Press **<Enter>.**

SCREEN PROMPT - "Enter RIGHT Manning's n Value and Press <Enter>"
11. Type **.060** and then Press **<Enter>.**

SCREEN PROMPT - "Enter Discharge and Press <Enter>"
12. Type **3000** and then Press **<Enter>.**

Your screen should now look like this:

```
┌─────────────────────────────────────────────────────────────────────┐
│XSEC ID:     0          >> STEP - BACKWATER <<       GROUND  POINTS    │
│STAT      ELEV      STAT      ELEV      STAT      ELEV      STAT      ELEV │
│362      505.0     425      499.1     509      498.0     512      496.9│
│602      496.9     605      498.2     732      500.1    1020      504.7│
│                                                                      │
│                                                                      │
│                                                                      │
│                                                                      │
│                                                                      │
│                                                                      │
│  ╔═════════════════════════════════════════════════════════════════╗ │
│  ║ CHANNEL BANK STATIONS:      Left 509.0            Right  605.0   ║ │
│  ║ MANNING'S N   VALUES:       Left 0.0650  Channel 0.0400 Right 0.0600 ║ │
│  ║ CHANNEL REACH LENGTHS:      Left        Channel        Right     ║ │
│  ║ LOSS     COEFFICIENTS: Contractn       Expansn       :Dschrg  3000 ║ │
│  ║ WS ELEV              Depth      Top Wid      Kratio             ║ │
│  ║ EG ELEV          Flow Regime      ChanVel      Froud#           ║ │
│  ╠═════════════════════════════════════════════════════════════════╣ │
│  ║ F2}<- Back Tab F5}PRINT F6}SAVE F7}Main Menu F8}New XSEC F10}Ed/Ex GrPt║ │
│  ║ TO BEGIN CALCULATIONS    Press  <Enter>                          ║ │
└─────────────────────────────────────────────────────────────────────┘
```

The program is now ready to begin the calculations since all of the required data has been entered for the 1st cross-section of our step-backwater analysis. Note that even at this point, if any of the data on the screen has been typed in incorrectly, the user can simply press the <F2> key to toggle backwards through all of the input data, even back to the Ground Points. Remember that you can instantly go back to the Ground Points by pressing <F10>, also.

13. Press **<Enter>** to Begin the Calculations.

Your screen should now look like this:

```
┌─────────────────────────────────────────────────────────────────────┐
│XSEC ID:     0          >> STEP - BACKWATER <<       GROUND  POINTS    │
│STAT      ELEV      STAT      ELEV      STAT      ELEV      STAT      ELEV │
│362      505.0     425      499.1     509      498.0     512      496.9│
│602      496.9     605      498.2     732      500.1    1020      504.7│
│                                                                      │
│                                                                      │
│                                                                      │
│                                                                      │
│                                                                      │
│  ╔═════════════════════════════════════════════════════════════════╗ │
│  ║ CHANNEL BANK STATIONS:      Left 509.0            Right  605.0   ║ │
│  ║ MANNING'S N   VALUES:       Left 0.0650  Channel 0.0400 Right 0.0600 ║ │
│  ║ CHANNEL REACH LENGTHS:      Left        Channel        Right     ║ │
│  ║ LOSS     COEFFICIENTS: Contractn       Expansn       :Dschrg  3000 ║ │
│  ║ WS ELEV   501.03           Depth  4.13 Top Wid   385 Kratio 1.00 ║ │
│  ║ EG ELEV   501.32   Flow Regime  M-1  ChanVel  5.10 Froud# 0.50  ║ │
│  ╠═════════════════════════════════════════════════════════════════╣ │
│  ║ F2}<- Back Tab F5}PRINT F6}SAVE F7}Main Menu F8}New XSEC F10}Ed/Ex GrPt║ │
└─────────────────────────────────────────────────────────────────────┘
```

As you can see from the screen, the (100-year) Water Surface Elevation (WS ELEV) has been computed (*501.03*), with other variables.

4-13

Before we move on to enter the data for the next cross-section let's obtain a printout of this first calculation.
_ Press **<F5>**.

The screen prompt will be ...
PRINT: Summary or Detailed?   Press S or D   and <Enter>

Let's obtain a Detailed Printout ... Therefore ...
_ Press **D** and then Press **<Enter>**.

Assuming your printer is turned on, the detailed printout will look like this:

Cross Section: 0

XLOB: 0 XLCH: 0 XROB: 0 CC: 0 CE: 0

NLOB: .065 STCHL: 509 NCHL: .04 STCHR: 605 NROB: .06

STAT	ELEV	STAT	ELEV	STAT	ELEV	STAT	ELEV
362.00	505.00	425.00	499.10	509.00	498.00	512.00	496.90
602.00	496.90	605.00	498.20	732.00	500.10	1020.00	504.70

CWSEL	EG	ELMIN	QLOB	QCH	QROB
Chan Vel	HV	KRATIO	ALOB	ACH	AROB
Depth	HL	Top Width	STAT-L	ST-MIDCH	STAT-R
Discharge	OL	Froude #	CH-Slope	EG-Slope	FlowRegim
501.03	501.317	496.90	493	2003	505
5.10	0.29	1.00	228	392	265
4.13	0.00	385	404.4	557.0	789.9
3000	0.00	0.50	0.0000	0.0029	---

If any of the above variables are unfamiliar, a description of each is provided in Appendix 1.

*If you want to save the cross-section data to a different name and/or directory, **before pressing** <F8>, you can Press <F6>, (**F6}**SAVE)   , to perform this.*

Now we need to enter the data for the 2nd cross-section. Since we are entering a new cross-section (**New XSEC**), we need to ...
_ Press **<F8>**.

Before the Screen changes you will notice that at the bottom of the screen a message will briefly appear ...

SAVING TEMPORARY FILE   C:\QUICK2\DATA\T0.XSC
This alerts you that your cross-section data has been saved to a file called T0.XSC, which is located in your C:\QUICK2\DATA directory.

Your screen should be blank again as shown below:

```
┌──────────────────────────────────────────────────────────────────────────┐
│XSEC ID:     0            >> STEP - BACKWATER <<          GROUND  POINTS    │
│STAT      ELEV      STAT      ELEV      STAT      ELEV     STAT      ELEV    │
│                                                                            │
│                                                                            │
│                                                                            │
│                                                                            │
│                                                                            │
│                                                                            │
│                                                                            │
│                                                                            │
│                                                                            │
│                                                                            │
│                                                                            │
│  ╔══════════════════════════════════════════════════════════════════╗    │
│  ║ CHANNEL BANK STATIONS:       Left                     Right        ║    │
│  ║ MANNING'S  N   VALUES:       Left        Channel      Right        ║    │
│  ║ CHANNEL REACH LENGTHS:       Left        Channel      Right        ║    │
│  ║ LOSS     COEFFICIENTS: Contractn        Expansn       :Dschrg      ║    │
│  ║ WS ELEV               Depth          Top Wid         Kratio        ║    │
│  ║ EG ELEV              Flow Regime      ChanVel        Froud#        ║    │
│  ╠══════════════════════════════════════════════════════════════════╣    │
│  ║**F2**}<-Back Tab **F5**}List Files **F6**}Retrieve File **F7**}Main Menu **F10**}Ed/Ex GrPt║  │
│  ║ **F3**}Insert GrPt **F4**}Delete GrPt                  **F1** }**HELP**      ║    │
│  ╚══════════════════════════════════════════════════════════════════╝    │
└──────────────────────────────────────────────────────────────────────────┘
```

_ Following the method used before, for the 1st cross-section, enter the Ground Points one at a time, by their respective Station and Elevation for the 2nd cross-section using the data provided. Be sure to Press <Enter> after you have typed in each correct number.

_ Once you have entered all of the Ground Points correctly, remember to Press **<F10>** to Exit from entering Ground Point data .

_ Follow the on screen prompts to enter all of the other data.

Remember that if any of the data on the screen has been typed in incorrectly, the user can simply press the <F2> key to toggle backwards through all of the input data, even back to the Ground Points. (You can also Press <F10> to go back to the Ground Points immediately for editing).

After entering all the data your screen should now look like this:

```
┌──────────────────────────────────────────────────────────────────────────┐
│XSEC ID:    450           >> STEP - BACKWATER <<         GROUND  POINTS     │
│STAT      ELEV      STAT      ELEV      STAT      ELEV     STAT      ELEV    │
│  0      510.0      150      504.8      233      502.2     236      500.9   │
│331      500.9      334      501.8      402      505.5     591      510.1   │
│                                                                            │
│                                                                            │
│                                                                            │
│                                                                            │
│                                                                            │
│                                                                            │
│                                                                            │
│  ╔══════════════════════════════════════════════════════════════════╗    │
│  ║ CHANNEL BANK STATIONS:       Left **233.0**                Right **334.0** ║  │
│  ║ MANNING'S  N   VALUES:       Left **0.0550**  Channel **0.0400** Right **0.0600**║  │
│  ║ CHANNEL REACH LENGTHS:       Left   **450**   Channel   **450** Right   **450** ║  │
│  ║ LOSS     COEFFICIENTS: Contractn   **0.1** Expansn    **0.3** :Dschrg **3000** ║  │
│  ║ WS ELEV               Depth          Top Wid         Kratio        ║    │
│  ║ EG ELEV              Flow Regime      ChanVel        Froud#        ║    │
│  ╠══════════════════════════════════════════════════════════════════╣    │
│  ║ **F2**}<- Back Tab **F5**}PRINT **F6**}SAVE **F7**}Main Menu **F8**}New XSEC **F10**}Ed/Ex GrPt║ │
│  ║ **TO BEGIN CALCULATIONS      Press  <Enter>**                      ║    │
│  ╚══════════════════════════════════════════════════════════════════╝    │
└──────────────────────────────────────────────────────────────────────────┘
```

The program is now ready to begin the calculations since all of the required data has been entered for the 2nd cross-section of our step-backwater analysis.

_ Press **<Enter>** to Begin the Calculations.

Once the calculation is finished you may ...

_ Press **<F5>** to obtain a printout

_ Press **<F6>** to save the data to another name and/or directory

_____

Finally, to finish our analysis we need to enter in the data for the 3rd cross-section.

_ Press **<F8>**

Before the Screen changes you will notice that at the bottom of the screen a message will briefly appear ...

SAVING TEMPORARY FILE   C:QUICK2\DATA\T450.XSC

This alerts you that your 2nd cross-section data has been saved to a file called T450.XSC, which is located in your C:\QUICK2\DATA directory. Notice that the **450**, represents the channel distance between the 1st and 2nd cross-sections.

_ Following the method used before for the other cross-sections, enter the Ground Points one at a time, by their respective Station and Elevation for the 3rd cross-section using the data provided. Be sure to Press <Enter> after you have typed in each correct number.

_ Once you have entered all of the Ground Points correctly, remember to Press **<F10>** to Exit from entering Ground Point data .

_ Follow the on screen prompts to enter all of the other data.

After entering all the data for the 3rd cross-section ...

_ Press **<Enter>** to Begin the Calculations.

Once the calculation is finished you may ...

_ Press **<F5>** to obtain a printout

_ Press **<F6>** to save the data to another name and/or directory

_____

TO EXIT OUT OF THIS SCREEN NOW THAT OUR ANALYSIS IS COMPLETED ...

_ Press **<F7>**

You will see a screen prompt at the bottom ...

SUMMARY PRINTOUT: Press <F5>,   otherwise Press <Enter>

To print a summary of the output for all 3 cross-sections then ...

_ Press **<F5>**,   otherwise just Press **<Enter>**

The on screen Summary or the printed summary will look like this:

SECNO	Q	XLCH	CWSEL	FR#	ELMIN	AVG.VEL.	AREA	TOPWID
0	3000.0	0	501.03	0.50	496.90	3.39	885.0	385.5
450	3000.0	450	503.96	1.06	500.90	7.54	398.1	196.9
940	3000.0	490	508.54	0.71	504.80	4.95	606.5	286.2

---

*If we carefully compare the Computed Water Surface Elevations
(CWSELs) at each cross-section, to the topographic contours on
Figure 1, we will see that the property is clearly higher than
the CWSEL at every cross-section. Therefore this analysis with
more detailed cross-section data has proven that the property
has been inadvertently included in an unnumbered Zone A Special
Flood Hazard Area.*

RUNNING HEC-2 USING QUICK-2 FILES {Tutorial Time: 5 minutes}

_ You will be prompted one more time to Press <Enter>. The next prompt will ask you a question concerning running the HEC-2 or PLOT-2 programs.

Press Y and <Enter> to rerun w/HEC-2 or PLOT-2: If NO Press <Enter>

_ For purposes of this tutorial let's answer "**Y**" , (and Press **<Enter>**) to run the HEC-2 program. The next screen that will appear will include the following:

To Run	Type
QUICK-2	Q2
HEC-2	H2
AUTOHEC-2	AH2
PLOT-2	P2
VIEW/PRINT	LIST

_ Type **AH2** and Press **<Enter>**.

Once the HEC-2 run is complete it will return you to the above-mentioned screen.

NOTE: Typing **AH2** runs the HEC-2 program automatically using the QUICK-2 generated HEC2.DAT, HEC-2 data file.

*If you are using a HEC-2 data file other than HEC2.DAT, then Type **H2** and Press **<Enter>**. Follow the directions on the screen for naming the Input, Output and Tape95 files; pressing <Enter> after each filename is typed in.*

_ Type **LIST** and Press **<Enter>**, and then enter your output filename, (Default is HEC2.OUT), to view the results. *Note that you move up, down and across the screen using the <Page UP>,<Page Down>, the cursor keys, etc.*

_ To **Print** the data that appears on the screen simply **Press P.**

_ To **Exit** from the screen simply **Press X** or the **Escape** key.

If you would like to complete the next tutorial example, then

Type Q2 and **Press <Enter>**; and, *turn to the next page.*═══════➢➢➢➢

RERUNNING USING SAVED CROSS-SECTION FILES
{Tutorial Time: 5 minutes}

Let's say that in the analysis that was performed in the previous tutorial, we want to change the discharge from 3000 to 5000, and run the step-backwater option again with the same cross-sections. This is quite easily done. Just follow the steps as shown below.

1. At the Main Menu Screen **Type 4 and Press <Enter>**

2. At the Starting Water Surface Elevation Method Screen
  Type .0029 and Press <Enter>

3. At the Input/Output Screen **Press <F6>** to retrieve a saved cross-section file

  Assuming your 1st cross-section file is stored as
C:\QUICK2\DATA\T0.XSC

  Type C and Press <Enter>   when prompted for the directory
  Type QUICK2\DATA & Press <Enter> when prompted for the subdirectory
  Type T0 and Press <Enter>   when prompted for the filename

4. Press <F2> to toggle back to the "Enter Discharge" prompt

5. Type 5000 and Press <Enter> to enter the new discharge

6. Press <Enter> to Begin the Calculations

7. Press <F8> to input another cross-section
  Press <F6> to retrieve a saved cross-section file

  Assuming your 2nd cross-section file is stored as
C:\QUICK2\DATA\T450.XSC

  Type C and Press <Enter>   when prompted for the directory
  Type QUICK2\DATA & Press <Enter> when prompted for the subdirectory
  Type T450 and Press <Enter>   when prompted for the filename

8. Press <F2> to toggle back to the "Enter Discharge" prompt

9. Type 5000 and Press <Enter> to enter the new discharge

10. Press <Enter> to Begin the Calculations

11. **Press <F8>** to input another cross-section

   Press <F6> to retrieve a saved cross-section file

  Assuming your 3rd cross-section file is stored as
  C:\QUICK2\DATA\T940.XSC
  Type C and Press <Enter>   when prompted for the directory
  Type QUICK2\DATA & Press <Enter> when prompted for the subdirectory
  Type T940 and Press <Enter>   when prompted for the filename

12. **Press <F2>** to toggle back to the "Enter Discharge" prompt

13. **Type 5000 and Press <Enter>** to enter the new discharge

14. **Press <Enter>** to Begin the Calculations

_ **Press <F7>** to Exit out of the screen

_ **Press <F5>** to obtain a summary printout

_ **Press <Enter>** <u>twice</u> to get back to the main menu

_ **Press <F10>** to leave the program

Q.E.D.

CHANNEL CAPACITY OPTION WITH THE RATING CURVE PLOT
{Tutorial Time: 5 to 10 minutes}

Let's say that we need to determine a Base Flood Elevation (BFE) for the property shown in Figure 1. We do not want to exempt the entire property from the flood plain, only a structure which is located in the middle of the property. Therefore, we can use one cross-section (the 2nd cross-section (T450.XSC) from our previous tutorial and shown on Figure 1), to compute a BFE.

Let's assume that we know the discharge is between 3000 cfs and 4000 cfs based on our best estimates.

Let's assume our structure does not have a basement; the lowest adjacent grade (LAG) to the house is at elevation 510 NGVD; and the first floor elevation (FFE) is 510.5 NGVD.

Let's determine the maximum carrying capacity of the floodplain using a depth equal to the lowest adjacent grade (510.0) minus the minimum stream elevation (500.9). For purposes of this example we'll use a depth of 9 feet (510-501).

To perform a channel capacity calculation we also need to know the downstream slope, which in this case is easy to compute from the information on page 15. Slope = 500.9 - 496.9 / 450 = .0089.

The graphic below sums up our situation so far:

```
                                              =========
                                              |■   ■|
                                              |■   ■|
                                              |■ ┌┐ ■|
  |                                         ┌──┴─┴┴─┴──┐←────── FFE = 510.5
  |_____                          _____ %─┘ ←── LAG = 510.0
       \                         |         ↑
        \_____        \/ WSE = ?     /     |
              \    ░░░░░░░░░░░░░░░░░░/      9.1'
               \  ░Q=3000 - 4000░░░/       |
                \░░░░░░░░░░░░░░░░░/         |
                 \░░░░░░░░░░░░░░░/_____  ↓_____Stream Invert = 500.9
                   Slope = .0089
```
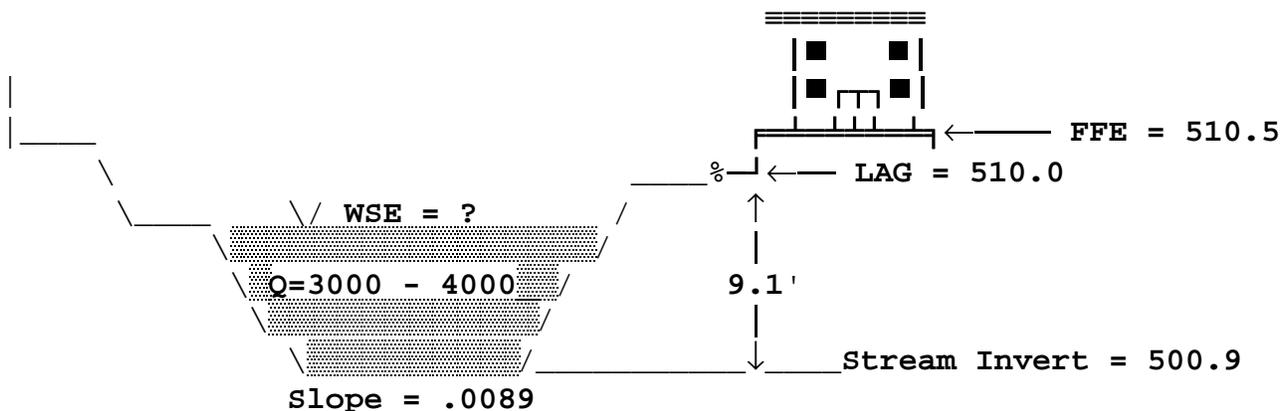

Follow the steps as shown on the next page to compute the rating curve
...===➤➤➤

1. At the Main Menu Screen **Type 2 and Press <Enter>**

2. At the Shape of Cross Section Screen
   Type I and Press <Enter>

3. At the Input/Output Screen **Press <F6>**

  We are using the 2nd cross-section file stored as
C:\QUICK2\DATA\T450.XSC

   Type C and Press <Enter>   when prompted for the directory
   Type QUICK2\DATA & Press <Enter> when prompted for the subdirectory
   Type T450 and Press <Enter>   when prompted for the filename

4. Type .0089 and Press <Enter> to enter the slope

5. Type 9 and Press <Enter> to enter the depth

6. Press <Enter> to Begin the Calculations

7. Press <F4> to Plot to screen .... **Press <F5>** to Print

Looking at the rating curve plot we can see that for a discharge range of between 3000cfs - 4000cfs the BFE ranges from about 504.3 to 504.8. Since our lowest adjacent grade and first floor elevation are at or above 510, it is clear that this structure is above the BFE.

```
                                        =========
                                       |■    ■|
                                       |■  ┌┐  ■|
  |                                     |__|  |__|
  |____                                |        |←————— FFE = 510.5
     \                            ____%┘ ←——— LAG = 510.0
      \____    WSE = 504.3-504.8  /      ↑
          \                      /       |
           \  Q=3000 - 4000    /        9.1'
            \                 /          |
             _____/_____↓____Stream Invert = 500.9
              Slope = .0089
```
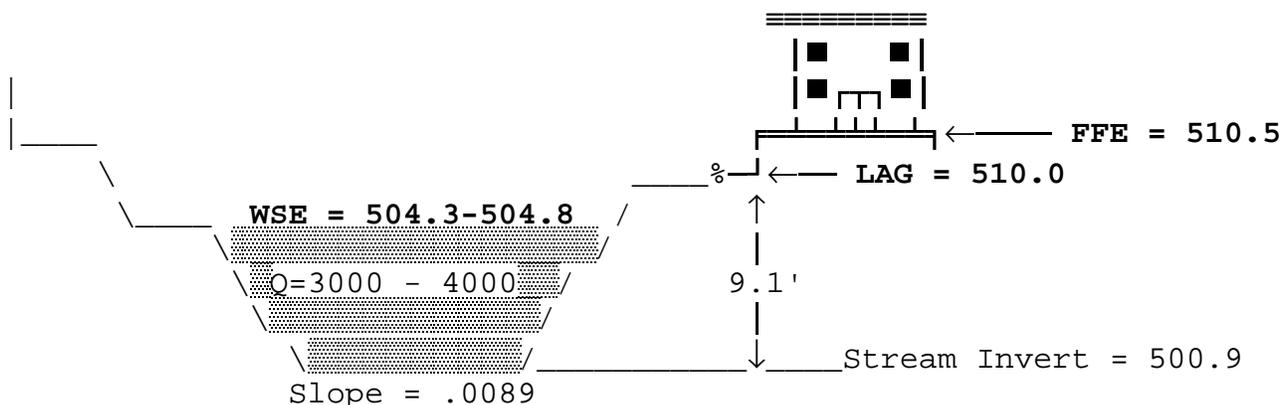
8. Press <Enter> to continue

9. Press <F7> to go back to the Main Menu

10. Press <F10> to Exit the program

PLOT-2

In general PLOT-2 will only work on QUICK-2 files that have been converted into HEC-2 format using QUICK-2's Step-Backwater option.

Profile plots from PLOT-2 will work only if the QUICK-2 generated data file (HEC2.DAT) is also run using the HEC-2 program (see Running HEC-2 Using QUICK-2 Files, page 4-18), since a HEC2.T95 file needs to be generated by the HEC-2 program for use by PLOT-2.

PLOT-2 Cross-section plots can be generated using the QUICK-2 generated data file (HEC2.DAT) even if it is not run with HEC-2. However, the Cross-section plot will not show the computed water surface elevation (CWSEL) unless the QUICK-2 HEC2.DAT file is run with HEC-2, since the CWSEL is found on the HEC2.T95 file.

Note that the user can compute a normal depth elevation for only one cross-section and have that cross-section plotted by choosing the Step-Backwater option and the Normal Depth starting water surface elevation method. Once the computation is finished, the user simply exits (Presses <F7>), and the QUICK-2 program automatically creates the HEC2.DAT file for that one cross-section, which can be used by the PLOT-2 program.

Let's say that we want to view the water surface elevation profile and the cross-section plots from our previous tutorial on the Step-Backwater option.

_ From the QUICK-2 Title screen **Press P2**

_ You are now into the PLOT-2 program, **Press <Enter> to continue**

PROFILE PLOT {Tutorial Time: 5 to 10 minutes}

1. Let's view the profile first. **Press 1** from the PLOT-2 main menu selection

2. Cursor to the <u>HEC2 Tape95 file name</u> entry and **Type ?**

This will list all of the data files in the QUICK-2 directory. T95 files are designated with the 3 letter extension .T95 . Therefore cursor over to highlight that file (HEC2.T95) and **Press <Enter>.**

3. Move up to highlight the <u>Plot profiles</u> entry and **Press <Enter>.**

4. Your profile is now plotted. **Pressing <Enter>** moves you back to the Profile plots main menu screen. You can explore the different Profile and Plotting options and replot the profile if you wish.

5. When you are finished plotting, highlight the <u>Return to main menu</u> message and **Press <Enter>**

CROSS-SECTION PLOT   {Tutorial Time: 5 to 10 minutes}

1. From the PLOT-2 main menu **Press 2** from the menu selection.

2. Cursor down to the <u>HEC2 input file name</u> entry and **Type ?**

This will list all of the data files in the QUICK-2 directory. Input files
are designated with the 3 letter extension .DAT . Therefore cursor over to
highlight that file (HEC2.DAT) and **Press <Enter>**. If we want to view a
different data file than that of the profile we previously viewed, we would
have to specify a different file here before proceeding.

  3. Cursor down to the <u>HEC2 Tape95 file name</u> entry

Note that we do not have to re-enter this file since we have already
entered it previously. If we want to view a different Tape95 file than that
of the profile we previously viewed, we would have to **Type ?**, and then
specify a different file here before proceeding.

4. Move up to highlight the <u>Plot cross sections</u> entry and **Press <Enter>.**

5. You now have the option of printing all or selected cross sections from
your data file. Press Y for plotting all, or N for plotting selected cross
sections.

Your first cross-section is now plotted. Pressing <Enter> moves you back to
the Cross-section plots main menu screen or plots additional cross-sections
depending on how many cross-section plots you have. You can explore the
different Cross-section and Plotting options if you wish.

6. Highlight the <u>Return to main menu</u> message and **Press <Enter>**

Pressing 4 at the PLOT-2 main menu exits you from PLOT-2 and back to the
QUICK-2 title screen.

*Note: To use PLOT-2 and to access data files that are in another directory
(i.e., they are not in the C:\QUICK2 directory), just change to that data
directory (i.e., CD\dirname) and access PLOT-2 by typing C:\QUICK2\PLOT2
(or A:\PLOT2 if using the program from the floppy drive) from that data
directory.*

Chapter 5: FORMULAS

Critical Depth

Channel Capacity

Normal Depth

Step-Backwater
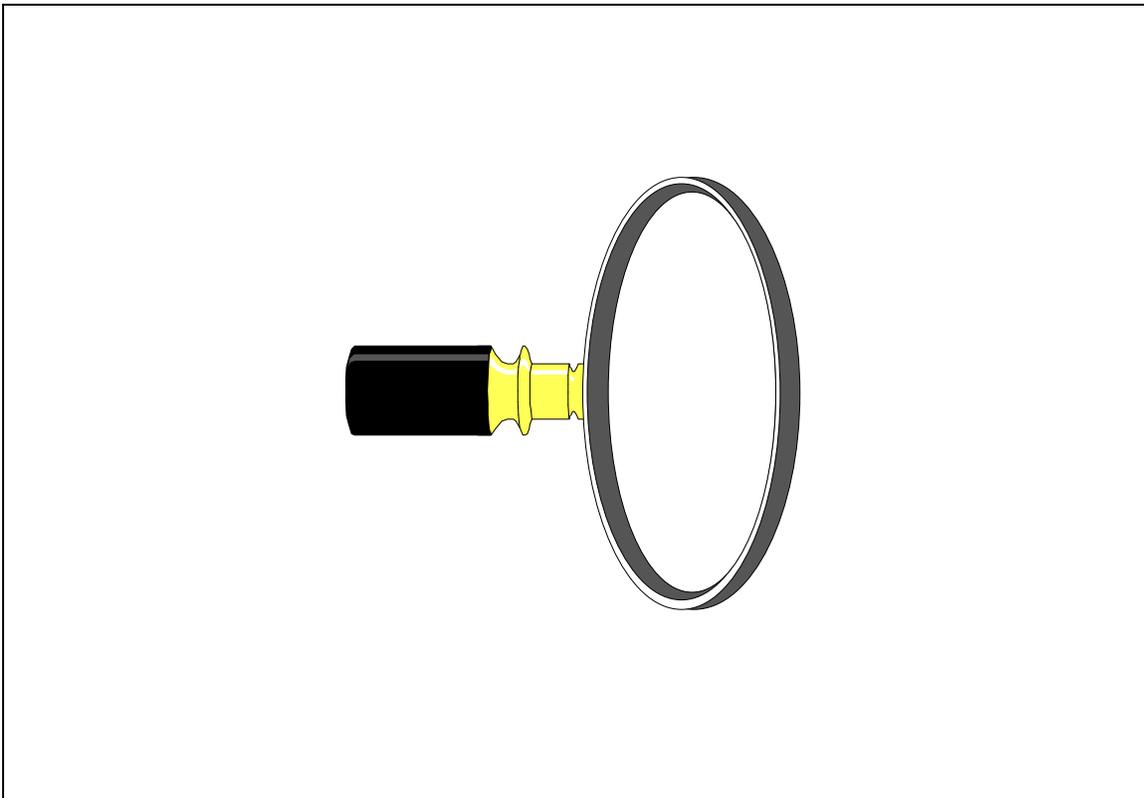
1. *CRITICAL DEPTH*

In every cross-section for a given discharge there exists a critical depth, where the energy grade (depth of water plus velocity head - $V^2/2G$) is at a minimum. Increasing the discharge above this given discharge will force the flow into the super-critical regime. Discharges below the given discharge will remain in the sub-critical regime. Super-critical depths will be lower than the critical depth, and sub-critical depths will be above the critical depth. Super-critical flow is characterized by small water depths with large velocity heads; while, sub-critical flow is characterized by large water depths with small velocity heads. A rule of thumb used to determine critical depth is that when the Velocity Head equals 1/2 the hydraulic depth (Area/Topwidth) critical flow is probable.

A formula which can be used to approximate critical depth (D_c) is given below.

$$Qc^2 \ / \ g \ = \ A^3 \ / \ T$$

Where Qc is the discharge (in cfs) based on critical depth, g is the gravitational constant (32.15 feet/second squared), A is the cross-section area (in square feet), and T is the top width of the water surface (in feet). Note: for rectangular channels the above equation can be reduced so that

$$D_c \ = \ (Qc/5.67 \ T)^{.667}.$$

The more exact way to compute critical depth (minimum specific energy) is to find a specific depth of water within a cross-section for a given discharge which produces the lowest energy grade. The following represents the process that the Critical Depth option of QUICK-2 goes through to calculate critical depth.

After the cross-section information (ground points, channel stations, etc.) has been input the program starts computing the water surface elevation (WSE) and corresponding energy grade elevation (EG) at a depth of 0.1 foot above the lowest elevation in the cross-section. It continues to calculate WSE and EG at intervals of 0.5 foot. As the depth of water in the cross-section increases the EG will decrease. At one point the EG will begin to increase. This means that between the last 0.5 foot interval there exists a minimum energy grade. Once this has occurred the program decreases the WSE in intervals of .02 foot. As the depth of water decreases in the cross-section the EG will also decrease as it approaches the minimum specific energy. At one point the EG will begin to increase again.

This means that between the last .02 foot interval critical depth exists. At this point the screen will display the actual critical water surface elevation (along with other variables) by assuming that the next to the last iteration was the critical depth.

The calculations performed by the program for a given cross-section are listed on the next page. The calculations include the iterations that the program goes through to arrive at critical depth.

```
ELMIN = 92.5
WSE   = 92.6       Qc=  6.026845E-02  Q=  260    EG=466080.8      EG Decreasing

WSE=  93.1        Qc=  5.314738      Q=  260    EG=452.6406    -        |
WSE=  93.6        Qc=  24.18726      Q=  260    EG=125.4259    -        |
WSE=  94.1        Qc=  61.71717      Q=  260    EG=101.21      -        |
WSE=  94.6        Qc=  121.451       Q=  260    EG=96.99928    -        |
WSE=  95.1        Qc=  204.4488      Q=  260    EG=96.14474    -        v
WSE=  95.6        Qc=  311.15        Q=  260    EG=96.14897    + EG Increasing
```

Therefore Minimum Specific Energy is between WSE's of 95.1 and 95.6. Note also that the Discharge (Q = 260) is also within the computed Critical Discharge (Qc) range of 204 - 311.

```
WSE=  95.58       Qc=  306.5006      Q=  260    EG=96.14179    - EG Decreasing
WSE=  95.56       Qc=  301.8821      Q=  260    EG=96.13499    -        |
WSE=  95.54       Qc=  297.2962      Q=  260    EG=96.12863    -        |
WSE=  95.52       Qc=  292.7447      Q=  260    EG=96.12271    -        |
WSE=  95.50       Qc=  288.2256      Q=  260    EG=96.11724    -        |
WSE=  95.48       Qc=  283.737       Q=  260    EG=96.11225    -        |
WSE=  95.46       Qc=  279.2825      Q=  260    EG=96.10776    -        |
WSE=  95.44       Qc=  274.8583      Q=  260    EG=96.1038     -        v
WSE=  95.42       Qc=  270.4678      Q=  260    EG=96.10038    -        |
WSE=  95.40       Qc=  266.1075      Q=  260    EG=96.09752    -        |
WSE=  95.38       Qc=  261.7806      Q=  260    EG=96.09525    -        |
WSE=  95.36       Qc=  257.4854      Q=  260    EG=96.09361    -        |
WSE=  95.34       Qc=  253.22        Q=  260    EG=96.09262    -        |
```

WSE= 95.32   Qc= 248.986   Q= 260   EG=96.09199 minimum v

```
WSE=  95.30       Qc=  244.76        Q=  260    EG=96.09271    + EG Increasing
```

We assume that ... Critical Depth = 95.32', Minimum Specific Energy = 96.09199'

The Froude number would be, Q / Qc, or 260 / 248.986 = 1.04.

It is not unusual for the Froude number to not equal exactly 1.0, since the calculation of critical discharge using the formula Qc^2 / g = A^3 / T, does not always yield a WSE that is exactly at the True minimum specific energy.

You should notice from the above tabulation, that as you approach critical depth (minimum specific energy), for very small changes in EG there are large jumps in the water surface elevation. The EG is only changing by .001' to .003' while the WSE changes by .02'. A 0.01' difference in EG can cause a 0.10' change in WSE.

2. *CHANNEL CAPACITY*

In this option, a Normal Depth elevation (see 3. *NORMAL DEPTH*) is input and the program computes the corresponding discharge. (In the Normal Depth option, the discharge is input and the program computes a normal depth elevation). The Manning's equation is used as the formula for determining the (normal) discharge.

$$Q = 1.486 \ A \ (R^{.667}) \ S^{.5} \ / \ N$$

Where Q is the discharge (in cfs), A is the cross-section area (in square feet), R is the hydraulic radius (in feet), S is the energy slope (in feet/feet), and N is the Manning's roughness value.

After the cross-section information (ground points, channel stations, streambed slope, normal depth elevation(s), etc.) has been input, the program simply solves for the area (A) and hydraulic radius (R) below the normal depth elevation (specified by the user) and computes the (normal) discharge directly using the Manning's equation. This is not an iterative process. The screen will display the (normal) discharge (which represents the channel capacity) along with other variables.

3. *NORMAL DEPTH*

The standard formula for determining normal depth in a cross-section is the Manning's formula. Water is flowing at normal depth when the energy grade and the hydraulic grade (water surface) slopes are the same as the stream bed slope. Normal depth profiles occur, in general, when the flow is uniform, steady, one-dimensional, and is not affected by downstream obstructions or flow changes. The standard Manning's equation is:

$$Q = 1.486 \ A \ (R^{.667}) \ S^{.5} \ /N$$

Where Q is the discharge (in cfs), A is the cross-section area (in square feet), R is the hydraulic radius (in feet), S is the energy slope (in feet/feet), and N is the Manning's roughness value.

The exact method for computing normal depth for a given discharge at a particular cross-section, is to assume that S is equal to the downstream streambed slope and to solve iteratively for the depth (this obviously assumes N is known). The following represents the process that the Normal Depth option of QUICK-2 goes through to calculate normal depth.

After the cross-section information (ground points, channel stations, discharge, streambed slope, etc.) has been input, the program starts computing discharge using the Manning's equation at an initial depth of 0.1 foot above the lowest point in the cross-section, and from that point in 0.5 foot intervals. At some point, the computed discharge will exceed the given target discharge. The program then uses a converging technique to compute a discharge (with a corresponding normal depth) that is within 1% of the given discharge. At this point the screen will display the actual normal depth water surface elevation (along with other variables).

The calculations performed by the program for a given cross-section are listed below. The calculations include the iterations that the program goes through to arrive at normal depth.

```
ELMIN= 92.5
WSE  = 92.6        Q=  260        Computed Q=  .023579   below target Q

WSE=  93.1         Q=  260        Computed Q=  2.803083  below
WSE=  93.6         Q=  260        Computed Q=  14.11313  below
WSE=  94.1         Q=  260        Computed Q=  38.33264  below
WSE=  94.6         Q=  260        Computed Q=  80.01045  below
WSE=  95.1         Q=  260        Computed Q=  146.9773  below
WSE=  95.6         Q=  260        Computed Q=  245.9516  below

WSE=  96.1         Q=  260        Computed Q=  369.2461  above target Q

WSE=  95.65697     Q=  260        Computed Q=  258.7531  within 1%
```

We assume that ... Normal depth = 95.66 for a Discharge (Q) of 260 cfs

4. *STEP-BACKWATER*

The **Energy Equation** which represents one-dimensional, uniform, and steady flow in open channels is shown below.

$$(1) \quad WSE_d + HV_d = WSE_u + HV_u + HL + OL$$

Where WSE_d is the water surface elevation at the downstream cross-section, HV_d is the velocity head at the downstream cross-section, WSE_u is the water surface elevation at the upstream cross-section, HV_u is the velocity head at the upstream cross-section, HL is the friction loss between the two cross-sections, and OL is the eddy (contraction or expansion) loss between the two cross-sections.

Velocity Head, HV, is calculated as follows:

$$HV = (\alpha)\ V^2\ /\ 2g$$

Where (α) is alpha the velocity coefficient, V is velocity (Q/A), and g is the gravitational constant. Alpha (α) is calculated as follows:

$$(\alpha) = \frac{(A^2)}{(K^3)} \left| \frac{Kl^3}{Al^2} + \frac{Kc^3}{Ac^2} + \frac{Kr^3}{Ar^2} \right|$$

Where A and K are the total area and conveyance below the water surface, respectively; and Kl, Kc, Kr and Al, Ac, Ar, are the conveyance and area in the left overbank, channel, and right overbank, respectively.

Friction Loss, HL, is calculated as follows:

$$HL = Lw\ (\ Q_d + Q_u\ )^2\ /\ (\ K_d + K_u\ )^2$$

Where Lw is the discharge weighted reach length between cross-sections, Q_d is the discharge at the downstream cross-section, Q_u is the discharge at the upstream cross section, K_d is the conveyance at the downstream cross-section, and K_u is the conveyance at the upstream cross-section. This is derived from the Average Conveyance Friction slope equation.

The Discharge Weighted Reach Length, Lw, is calculated as follows:

$$Lw = \{(Ll * Ql) + (Lc * Qc) + (Lr * Qr)\}\ /\ Qa$$

Where Qa is the average total discharge between cross-sections; and, Ll, Lc, Lr, and Ql, Qc, Qr, represent the reach length and average discharge between cross-sections for the left overbank, channel, and right overbank, respectively.

Eddy Loss, OL, is calculated as follows:

$$OL = (Ce\ or\ Cc) * ABS\ \left| HV_d - HV_u \right|$$

Where Ce is the expansion coefficient, Cc is the contraction coefficient, HV_d is the velocity head at the downstream cross-section, and HV_u is the velocity head at the upstream cross-section. When HV_u is greater than HV_d Ce is utilized. When HV_u is greater than or equal to HV_d Cc is utilized.

After the cross-section information for the first cross-section has been input, either a known water surface elevation is input to start the calculations or the water surface elevation could have been determined by the Normal or Critical Depth options or by another source or method. The program then computes all pertinent variables for the first cross-section that will be needed for an energy balance with the next upstream cross-section. After this the user must put in the appropriate information for the next cross-section (i.e., ground points, channel stations, reach lengths, contraction and expansion coefficients, etc.). Once this is done the program performs a series of trial iterations to make sure that the Energy Equation (1) listed previously will balance to within .014 foot. The sequence of trial elevations is listed below.

1ST TRIAL:

Uses the depth of water (DP) of the previous cross-section added to the lowest elevation (ELMIN) within the current cross-section. If DP + ELMIN is less than the previous WSE (i.e., adverse slope condition) then the program uses the previous WSE for the 1st trial at the current cross-section.

2ND TRIAL:

Uses the average of the computed WSE and the WSE assumed in Trial number 1.

3RD TRIAL AND ON ...:

Uses a formula designed to help converge quickly to balance the energy equation as shown below:

Trial WSE = WSE-(WSE+HV-DG-HL-OL)/(1-((Q/QC)^2)+((1.5*HL)/(A/W)))

Where WSE, HV, HL, OL, QC, A, and W are the latest computations of water surface elevation, velocity head, friction loss, eddy loss, critical discharge, total area, and total wetted perimeter, respectively; and, DG is the computed energy grade elevation from the previous cross-section; and, Q is the discharge at the current cross-section.

For most energy balances between cross-sections that are not at or near critical flow, the program will balance the energy equation within 5 trials.

The calculations performed by the program for an energy balance between two cross-sections are listed below. The calculations include the iterations that the program goes through to arrive at the energy balance.

WSE Assumed	WSE Calculated	Difference	Trial #
98.75	98.32489	+.4251099	1
98.53744	98.32472	+.2127228	2
98.32476	98.32513	-.00037	3

We assume that the correct WSE = 98.32

Note: Energy balance in this case was accurate to .00037 foot.

Appendix 1: Definition of Variables

ACH   – Area within the specified channel below the water surface elevation

ALOB – Area within the specified left overbank below the water surface elevation

AROB – Area within the specified right overbank below the water surface elevation

ALPHA – Velocity head coefficient

AREA or **Area** – Total area within the cross-section below the water surface elevation

AVG.VEL or **Velocity** – Average Velocity within the entire cross-section

Base Width – Channel bottom width of a trapezoidal or rectangular cross-section

Bottom Width – Channel bottom width of a trapezoidal or rectangular cross-section

CC   – Contraction Coefficient

CE   – Expansion Coefficient

CH-SLOPE – Slope of the streambed, Channel Slope

CHAN-VEL or **ChanVel** – Velocity within the main channel of cross-section

Critical Slope – Slope of the Energy Grade line at Critical Flow

CWSEL – Computed water surface elevation within a cross-section

Depth – Max depth of water in the cross-sect as measured below the water surface elevation

Diameter – Width or Height of a circular pipe

Discharge – The rate of the flow of a volume of water within a cross-section, usually expressed in cubic feet per second (cfs)

EG or **EG ELEV** – Energy grade elevation, expressed as, WSE + HV

EG-Slope – Energy grade slope

ELEV – Elev of a ground pt of a cross-sect, as ref to some datum (i.e., NGVD, NAVD, etc.)

ELMIN – Lowest elevation in a cross section

Flow Regime – Type of water surface profile (Supercritical regimes are not computed)
  M1: EG-Slope <= Ch-Slope and FR# < .8   **M2**: EG-Slope >   Ch-Slope and FR# < .8
  C1: EG-Slope <= Ch-Slope and FR# >= .8   **C3**: EG-Slope >   Ch-Slope and FR# >= .8

Flow Type – either, Supercritical, Critical or Subcritical

Froude#, **Froude No.**, **Froud#** or **FR#** – Froude number, used to determine the flow type (i.e., **sub**- (FR# < 1), **critical** (FR# = 1) or **super-critical** (FR# > 1) flow)

HL – Friction loss between cross sections

HV – Velocity head

Hyd Radius or **Hyd R** – Hydraulic Radius: equal to (Area / Wet Perimeter)

KRATIO - Ratio of upstream total conveyance to downstream total conveyance

L Side Slope - Ratio of the slope of the left side of a channel in terms of Horizontal distance in feet to 1 foot Vertical.

Manning's n - Coefficient used to account for the friction caused by earthen, vegetative, and/or man-made surfaces within a floodplain cross-section.

Max Discharge - The maximum flow possible within a circular pipe, (usually occurring at .94 * Diameter).

NCHL, NLOB, NROB - Manning's "N" value for the specified channel, left overbank, and right overbank, respectively.

OL - Expansion/contraction loss

Q - Total discharge in the cross-section

QC - Critical discharge within entire cross-section for a specific water surface elevation

QCH - Discharge within the specified channel of a cross-section

QIC - Critical discharge within the entire cross-section for a specific water surface elevation, assuming that critical flow is limited to the channel, even if flow is occurring in the overbanks

QLOB, QROB - Discharge within the specified left overbank, and right overbank, respectively, of a cross-section

R Side Slope - Ratio of the slope of the right side of a channel in terms of Horizontal distance in feet to 1 foot Vertical.

SECNO - Cross section number or identifier

Slope or **EG-Slope** - Energy grade slope

STAT-L, STAT-R - Station, within a cross-section, of the left edge, and right edge, respectively, of the water surface

STAT - Station of a ground point of a cross-section

STCHL, STCHR, ST-MIDCH - Station of the left bank, right bank, and mid-point, respectively, of a cross-section

Top Width or **Top Wid** - Top width of the water surface within a cross-section

Velocity - Average Velocity within the entire cross-section

Wet Perimeter or **Wet Per** - actual width of ground within a cross-section below the water surface elevation.

WS ELEV or **CWSEL** - Water surface elevation within a cross-section

XLCH, XLOB, XROB - Distance between cross-sections as measured along the channel, left overbank, and right overbank, respectively.

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NOTES