United States Department of Agriculture
Natural Resources Conservation Service

EFH2 Computer Program

Estimating Runoff and Peak Discharge

User's Manual

August 2009

Photo credit NRCSIA99447

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Preface

The purpose of this User's Manual is to assist the new or occasional user develop input data and run the **EFH2 Computer Program**.

EFH2 is a single event rainfall-runoff model used to estimate runoff volume and peak discharge for small single subarea watersheds. **EFH2** is based on procedures defined in the Natural Resources Conservation Service (NRCS) National Engineering Handbook, Part 650, (NEH 650), *Engineering Field Handbook* (EFH); Chapter 2, *Estimating Runoff and Peak Discharge* (NEH 650.02) and the National Engineering Handbook, Part 630, *Hydrology* (NEH 630).

EFH2 is a Windows® version of the **EFM2** DOS computer program, originally developed by the Soil Conservation Service (SCS, now NRCS) in October 1990.

Problems with the **EFH2 Computer Program** should be reported to the NRCS State Conservation Engineer within your State.

Acknowledgements

The original DOS version of the EFM2 computer program was developed by **William Merkel**, Hydraulic Engineer, NRCS, Washington, D.C.; **Corey Wright**, IT Specialist, NRCS, CO; and **Ralph Roberts**, Computer programmer, Agricultural Research Service (ARS), MD. The first EFH2 Windows® computer program was developed by **Owen Kvittem,** NRCS, retired.

The User's Manual was developed by **Quan D. Quan**, Hydraulic Engineer, NRCS, West National Technology Support Center (WNTSC); **Claudia C. Hoeft**, National Hydraulic Engineer, NRCS, Washington, D.C.; **Geoffery Cerrelli,** Hydraulic Engineer, NRCS, PA; **Helen Fox Moody**, Hydraulic Engineer, NRCS, WNTSC; and **William Merkel**, Hydraulic Engineer, NRCS, WNTSC.

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Introduction

What is EFH2?

EFH2 is a computer program used to predict runoff volume and peak discharge from small single subarea watersheds. EFH2 predictions are based on design rainfall events associated with specific design rainfall intensity storm patterns, or distributions. The computational procedures used in **EFH2** are described in the Natural Resources Conservation Service (NRCS) National Engineering Handbook, Part 650, *Engineering Field Handbook* (EFH), Chapter 2, *Estimating Runoff and Peak Discharge* (NEH 650.02). Details on the computational procedures are found in the NRCS National Engineering Handbook, Part 630, *Hydrology* (NEH 630).

System Requirements

EFH2 is designed to install and operate on computers with Windows® 95, or later, operating systems. Less than 1 MB of hard drive space is required for program installation.

The program window displays best at a screen resolution of 1076 x 768 pixels or higher. Lower resolutions or reduced screen sizes may cut off some text.

Program Limits

EFH2 is applicable to single subarea watersheds where:

- The watershed can accurately be represented by a single runoff curve number between 40 and 98.
- The watershed drainage area is between 1 and 2,000 acres.
- The watershed hydraulic length is between 200 and 26,000 feet.
- The average watershed slope is between 0.5 and 64 percent. Slopes from 0.1 to 0.49 percent may be used with caution but a warning message will be generated. An error message will be generated by entering slopes greater than 64 percent.
- No valley or reservoir routing is required.
- Urban land use within the watershed does not exceed 10 percent.
- The rainfall is between 0.0 and 26 inches.

Data Requirements

The following basic information about the watershed must be derived or obtained in order to use **EFH2** for hydrologic analyses:

1) ***Watershed Drainage Area.*** The watershed must be delineated to determine its size.
2) ***Land use Information.*** Land use information is required for determining the watershed runoff curve number (CN). Land uses are described in the CN tables in **EFH2**.
3) ***Soils Information.*** Soils information (hydrologic soil groups (HSG) A, B, C, or D) is required for determining the watershed CN.
4) ***Topographic information.*** Topographic information for the watershed is required for estimating watershed time of concentration (T_c). Both average watershed slope and watershed length are needed to determine T_c using the lag method.

Obtaining this information requires some background knowledge of hydrology.

Basic Data Files

Two types of data files are used in **EFH2**, required files and optional files.

Required files

The required data files are *COVER.TXT* and *TYPE.RF*. These data files must reside in the same folder as *EFH2.EXE*. **EFH2** will not run without these required data files.

COVER.TXT. The *COVER.TXT* file consists of the runoff curve number (CN) tables found in NEH 630.09, *Hydrologic Soil-Cover Complexes*; and included in NEH 650.02. These tables list CN by HSG, cover type, and hydrologic condition for various land use types. The CN tables are used in computing a weighted CN for the watershed being evaluated. The *COVER.TXT* file must reside in the same folder as the program executable file, *EFH2.EXE*. If the *COVER.TXT* file is not available, **EFH2** will not initialize and will not operate.

***TYPE.RF*.** The *TYPE.RF* file contains regression coefficients for peak discharge curves derived from the curves found in the NEH 650.02 exhibits for the NRCS Type I, IA, II, and III rainfall distributions as well as a curve which can be used to determine peak discharges for the Delmarva (DMV) peninsula. The DMV curve was derived from a combination of historical rainfall distribution and unit hydrograph data for the DMV. The development of these curves is beyond the scope of this User's Manual because of the complexity of the procedure.

Distributions may be removed from the file to limit selection to only those distributions for which local users have a need. The *TYPE.RF* file must reside in the same folder as the *EFH2.EXE* file. **EFH2** will not operate if the *TYPE.RF* file is unavailable.

Optional files

The optional data files are the *COUNTY.XX* and *SOILS.HG* files. Optional data files can be created and edited by the user and are accessed by the program automatically if the filenames are maintained.

COUNTY.XX. The *COUNTY.XX* file is an optional data file containing rainfall volume - frequency data for up to seven return intervals by county name. The presence of a county rainfall data file simplifies use of **EFH2** by making rainfall volume data accessible by dropdown list. *COUNTY.XX* refers to a county file created for a specific location where *XX* indicates location. To accommodate State-specific files, it is suggested that the file name use the format *COUNTY.XX* where XX is the two-letter State postal abbreviation (example: *COUNTY.NE*).

When a two-letter State abbreviation is entered as part of the **EFH2** data input, a search is made for the appropriate *COUNTY.XX* file. When a match is found, the appropriate *COUNTY.XX* file is used and county names are displayed using that State file. If a match is not found for *COUNTY.XX*, then the default rainfall file *COUNTY.RF*, if available, is used. The *COUNTY.RF* file is included with the installation package and contains Maryland rainfall data. For users that require county rainfall data from more than one State, multiple rainfall files can reside in the same folder as the *EFH2.EXE* file. Separate State rainfall files are recommended because many States have counties with the same name.

A unique county rainfall file can be created using an ASCII editor and separating the columns by commas, at least one space, or at least one tab. If the rainfall data file is created using an Excel spreadsheet, use separate columns for each of the fields and save the file as a comma delimited text file. The resulting text file should be checked carefully for extra characters. The county rainfall file uses record formats by row and column as described in Table 1.

Row	Column	Description
1	1	Number of return intervals included in file (maximum 7).
	2 – 8	The return intervals (in years).
2	1	County name (all uppercase) in quotation marks ('').
	2 – 8	Rainfall volumes in inches corresponding to the return intervals in row 1, columns 2 through 8.
3 +	Same as row 2.	Continue with as many counties as needed for your State, with each county on its own row.

Table 1. *COUNTY.RF* record format

A portion of the rainfall data file for the State of Nebraska, (filename: *COUNTY.NE*) is shown in Table 2 to illustrate the rainfall file format.

```
7            1     2     5     10    25    50    100
"ADAMS"      2.00  2.65  3.50  4.15  4.80  5.60  6.10
"ANTELOPE"   2.04  2.60  3.40  4.00  4.75  5.40  5.90
"ARTHUR"     1.70  2.15  2.95  3.45  4.10  4.60  5.20
"BANNER"     1.50  1.90  2.50  2.95  3.50  4.00  4.50
"BLAINE"     1.85  2.35  3.20  3.72  4.40  5.05  5.55
"BOONE"      2.05  2.65  3.45  4.05  4.84  5.50  6.00
"BOX BUTTE"  1.58  2.00  2.65  3.10  3.65  4.15  4.70
"BOYD"       1.95  2.45  3.25  3.80  4.50  5.10  5.60
"BROWN"      1.85  2.35  3.15  3.70  4.37  5.00  5.50
```

Table 2. A portion of the rainfall data file for Nebraska (filename: *COUNTY.NE*)

If used, the county rainfall file must reside in the same folder as the *EFH2.EXE* file. If the *COUNTY.XX* file is not available, the program will operate properly, but the user will be required to enter the rainfall volume - frequency data manually.

SOILS.HG. The *SOILS.*HG file is used by the Hydrologic Soil Group (HSG) lookup tool for populating the HSG table. The *SOILS.HG* file is a three column text file which can be created using a standard ASCII editor and separating the columns by commas, a space, or at least one tab. If the soils data file is created using an Excel spreadsheet, use separate columns for each of the fields and save the file as a comma delimited text file. The resulting text file should be checked carefully for extra characters. The *SOILS.HG* file does not have a required format, so the user is free to enter whatever information he or she wishes in the three columns; however, if the maximum number of characters is exceeded, some of the information may be truncated when the SOILS.HG file is viewed in **EFH2**. A suggested format by column for the *SOILS.HG* file is illustrated in Table 3.

Column	Maximum Number of Characters	Data Description
1	40	Soil map unit name
2	10	Textural class
3	10	Hydrologic soil group

Table 3. Suggested format for SOILS.HG file

A portion of the *SOILS.HG* file developed for Texas is shown in Table 4. This data file was developed using Excel.

Abilene	L	c
Abilene	CL	c
Acadia	SIL	d
Acme	CL	c
Acme	L	c
Acove	FL-FSL	c
Acove	FSL	c
Acuff	L	b
Acuff	CL	b
Acuff	SCL	b
Acuna	SIC	c
Adaton	SIL	d
Addicks	L	d

Table 4. Portion of a *SOILS.HG* data file created for the State of Texas. (Note that the Abilene, Acme, Acove, and Accuff soils in this examples have multiple listings with different textures.)

A *SOILS.HG* file is not included with the **EFH2** installation package. If a SOILS.HG file is created, it must be saved with the filename *SOILS.HG* and stored in the **EFH2** program folder to be useable by **EFH2.** Unlike the *COUNTY.XX* file, there is no option for designating separate *SOILS.HG* files by State. The file extension.*HG* must be maintained or **EFH2** will not be able to locate the file.

NRCS does not maintain a national list of soils by hydrologic soil group in any engineering directives. Any old national lists are obsolete due to revisions and updates to soil surveys, and they should be discarded or used with caution. The most up-to-date information on assigned hydrologic soil groups is available through the NRCS **Field Office Technical Guide**, published soil survey data bases, the NRCS Soil Data Mart Web site (*http://soildatamart.nrcs.usda.gov/*), and/or the Web Soil Survey Web site (*http://websoilsurvey.nrcs.usda.gov/*).

It is at the discretion of the NRCS State Conservation Engineer whether or not a State list is developed, distributed, and maintained. Individual users might consider maintaining a small list for their own use.

Further information on HSG classification can be found in NEH 630.07, *Hydrologic Soil Groups*, and the NRCS National Soil Survey Handbook (NSSH).

User Responsibility

Results from any computer model can be sensitive to the quality of the input data. It is the user's responsibility to ensure that all input data, whether entered or implied through default values, is appropriate for the situation being analyzed.

User Interface

Data Entry

The user starts data entry on the **Basic data** tab with the Client field and progresses through each of the entry fields. The user moves between entry fields using either the Enter or Tab keys to move forward, or traverses backwards using Shift-Tab. Pressing the ESC key returns a field to its initial value if a mistake is made during entry. Calculated fields are automatically updated when sufficient valid data have been entered for making the calculation. Warning messages appear if invalid entries are made.

After the **Basic data** tab fields are populated, the user typically proceeds to the **Rainfall/Discharge data** tab to continue data entry and view results.

Help is available regarding data entry rules for State, County, Drainage Area, Runoff Curve Number, and Time of Concentration fields through the Help button or the Menu-Help.

Table 5 provides details regarding the functions of various keys on the **Basic data** tab fields, **Rainfall/Discharge data** tab fields, and the **RCN** tab fields. Note that function keys may operate slightly differently in the grid cells on the **RCN** tab than on the other tabs.

Key	***Function: Basic Data and Rainfall/Discharge Tab***	***RCN Tab***
F1	Display Help	Display Help
F10	Toggles between entry fields and menu bar	Toggles between entry fields and menu bar
ESC	Returns field value to previous value	Returns field value to previous value
Delete	Deletes the character to the right of the cursor	Clears the entire field
Backspace	Deletes the character to the left of the cursor	Delete the last (right most) character in the field
Enter	Completes data entry for the field and advances to the next field	Completes data entry for the field and advances to the next field
Tab	Completes data entry for the field and advances to the next field	Completes data entry for the field and jumps to the next tab stop on the screen
Shift Tab	Completes data entry for the field and moves cursor to the previous field	Completes data entry for the field and jumps to the previous tab stop on the screen
Arrow right	Moves the cursor one character to the right	Moves to the entry cell to the right
Arrow left	Moves the cursor one character to the left	Moves to the entry cell to the left
Arrow up	Moves the cursor one character to the left	Moves up to the entry cell above
Arrow down	Moves the cursor one character to the right	Moves down to the entry cell below
Home	Moves the cursor to the start of the field	Moves up to the last entry cell in the row above
End	Moves the cursor to the end of the field	Moves down to the first entry cell in the row below
Page up	-- no action --	Scrolls up one screen of grid cells
Page down	-- no action --	Scrolls down one screen of grid cells

Table 5. Key Functions

Tool TipHelp. Pausing the mouse pointer briefly over a field will display an abbreviated pop-up help for each data entry field.

Welcome to EFH-2 Computer Program Window

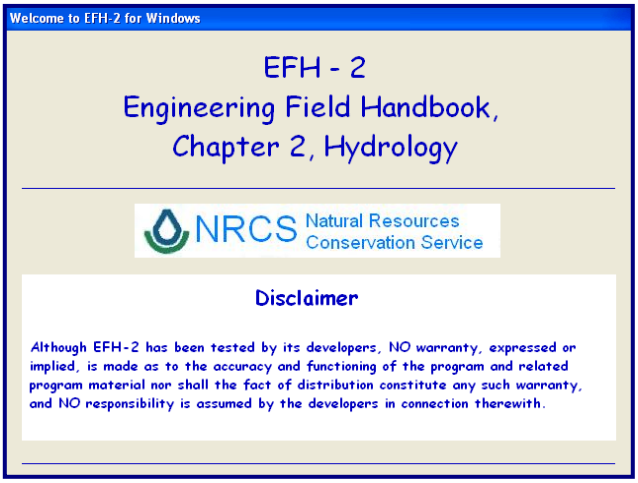

Figure 1. Welcome to EFH2 for Windows

Upon starting the **EFH2** Computer Program, the **Welcome to EFH2 for Windows** window (Figure 1) displays with the disclaimer:

> **Although EFH-2 has been tested by its developers, NO warranty, expressed or implied, is made as to the accuracy and functioning of the program and related program material nor shall the fact of distribution constitute any such warranty, and NO responsibility is assumed by the developers in connection therewith.**

Program Window

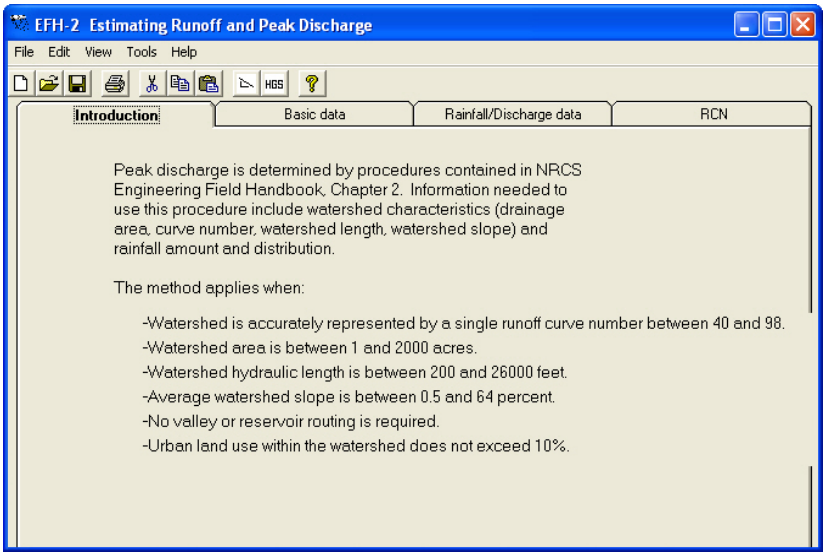

Figure 2. Introduction tab

The **EFH2** program window consists of the menu bar, the tool bar, and tabbed entry screens. The program initiates to the **Introduction** tab (Figure 2) which details the limits of the program.

EFH2 Menu Bar

Figure 3. EFH2 Menu Bar

The menu bar is a standard Windows® feature that should be familiar to all computer users. Each menu bar item (Figures 4, 5, 6, 7, and 8) has a dropdown menu with features customized for the **EFH2** application. The following is a description of each of the menu bar items' associated dropdown menu features.

Menu *File*

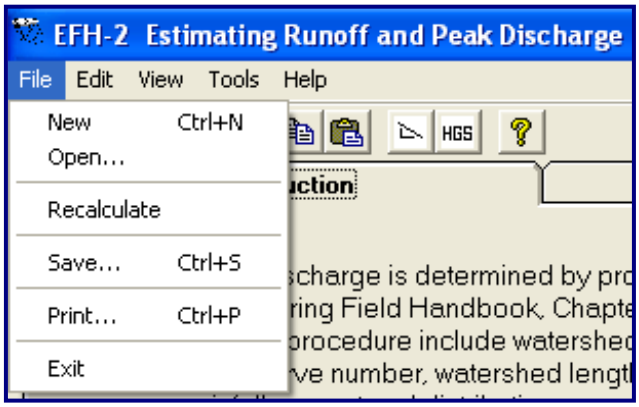

Figure 4. Menu File

Menu Item	Dropdown Choice	Explanation
File	New Ctrl+N	Clears all data from the entry fields and resets the program for entering new project data.
	Open…	Opens a standard Windows® dialog window which allows the user to open an existing file.
	Recalculate	Forces a recalculation of the output data. While the program automatically recalculates with each change in a data field, it does not recalculate upon opening an existing file, allowing the user to observe the data in an existing file without change.
	Save… Ctrl+S	Saves the current data to a file for later retrieval and editing. An EFM extension is added to the file name, identifying the file as **EFH2** data.
	Print… Ctrl+P	Prints the current data to the default Windows® printer. A dialog window opens allowing the user to change the selected printer and select desired printer parameters. Page one with basic data and discharge information will always print. Page two with runoff curve number calculations will only print if runoff curve number data has been entered or exists within an existing file.
	Exit	Terminates the application.

Table 6. Menu File Description

Printing to a file is possible. However, with most printer drivers, many unwanted characters will be embedded in the printed file. By choosing a generic text printer and selecting the "print to file" check box, an acceptable facsimile of the printout can be sent to a text file. An appropriate print driver is required to take advantage of this option.

Menu *Edit*

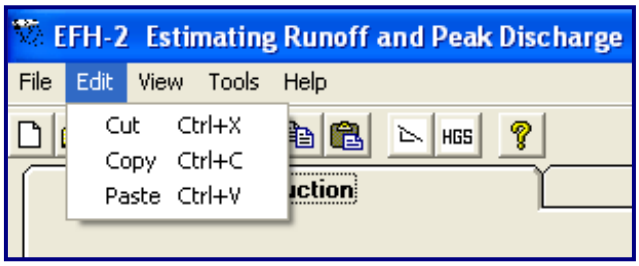

Figure 5. Menu Edit

Menu Item	Dropdown Choice		Explanation
Edit	Cut	Ctrl+X	Used to cut selected (highlighted) data from an entry field and move it to another field.
	Copy	Ctrl C	Used to copy selected (highlighted) data from an entry field.
	Paste	Ctrl+V	Used to paste, or insert, copied data to the current cursor position in a field. Data highlighted during the execution of this command will be replaced with the pasted data.

Table 7. Menu Edit Description

Menu *View*

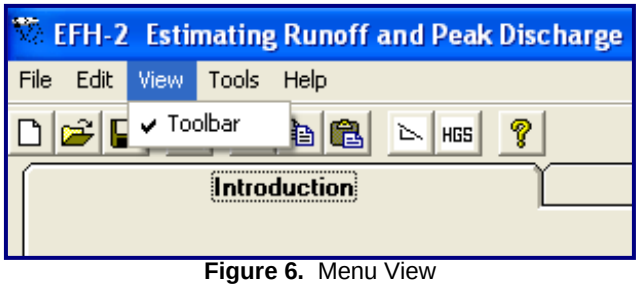

Figure 6. Menu View

Menu Item	Dropdown Choice	Explanation
View	Toolbar	Used to show, or hide, the Toolbar on the main program window.

Table 8. Menu View Description

Menu *Tools*

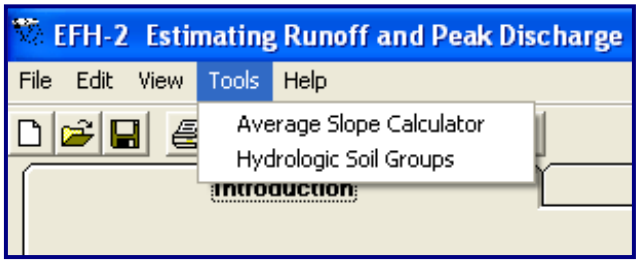

Figure 7. Menu Tools

Menu Item	Dropdown Choice	Explanation
Tools	Average Slope Calculator	Opens the **Average Slope Calculator** dialog window (See Time of concentration data and computations section for information on the **Average Slope Calculator** dialog window).
	Hydrologic Soil Groups	Opens the **Search for Hydrologic Soil Group** window. (See discussion of the **Hydrologic Soil Group** window under the **RCN** Tab section.)

Table 9. Menu Tools Description

Menu *Help*

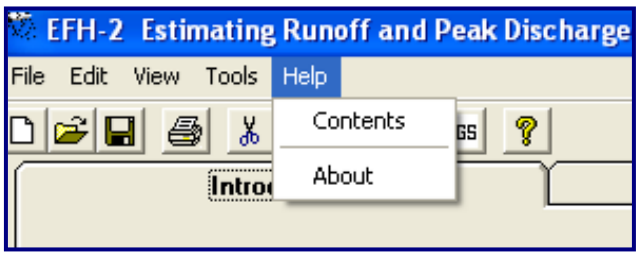

Figure 8. Menu Help

Menu Item	Dropdown Choice	Explanation
Help	Contents	Opens the program help file (Figure 9).
	About	Opens a dialog window containing general information about the **EFH2** program (Figure 10).

Table 10. Menu Help Description

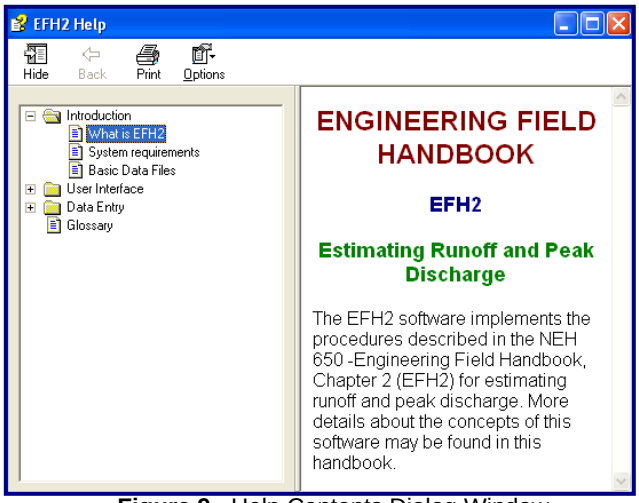

Figure 9. Help Contents Dialog Window

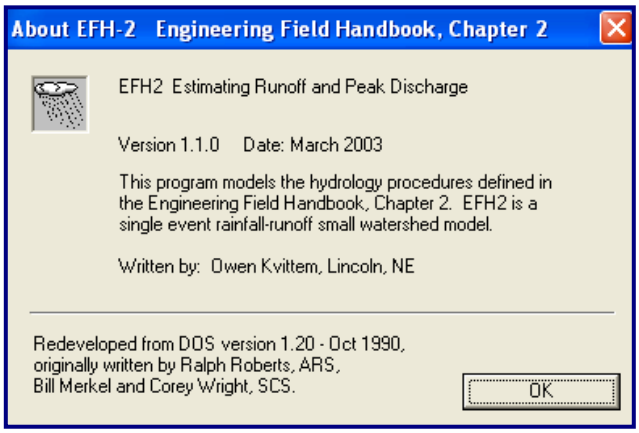

Figure 10. Help - About Dialog Window

EFH2 Toolbar

The **EFH2** Toolbar (Figure 11) is displayed directly below the menu bar. It offers quick access to the most often used program commands.

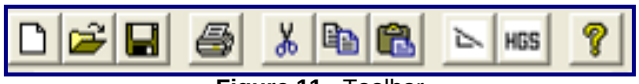

Figure 11. Toolbar

Table 11 gives a brief description of each of the toolbar buttons which correspond to the menu bar items.

	"New" command
	"Open" file command
	"Save" file command
	"Print" to printer command
	"Cut" to clipboard command
	"Copy" to clipboard command
	"Paste" from clipboard command
	"Average Slope Calculator" command
HGS	"Hydrologic Soil Group" command
	"Help" command

Table 11. Toolbar Button Descriptions

Basic data tab

Information about the project being evaluated is entered on the **Basic data** tab (Figure 12).

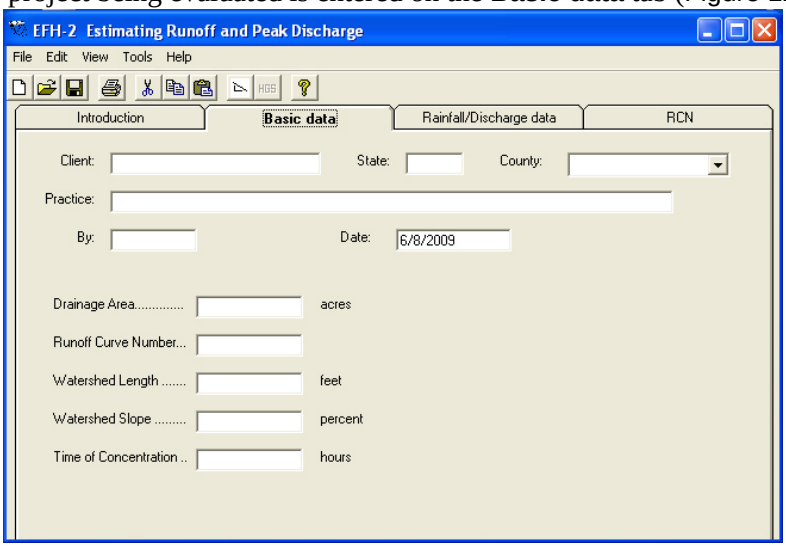

Figure 12. Basic data tab

Client and project location data, as well as Practice identification information and user (By) information, are entered directly. The remaining data are either directly entered or computed using other tabs and specific notes will appear to indicate that the values were directly entered, computed, or carried over from elsewhere. A more detailed description follows for each of the data entry fields.

General Project Information

Client *field.* Unique project identification information to enable the user to identify the project or client for which the analysis is being performed may be entered in this field.

State *field.* The State field is used to locate the *COUNTY.XX* rainfall data file for the State in which the project being evaluated is located. If no entry is made, the County field will remain blank, as will the rainfall data fields on the **Rainfall/Discharge data** tab, and the user will be required to enter the rainfall data manually. This field accepts only two character State postal abbreviations.

If the user attempts to leave this field without entering a code, an entry error message will appear (Figure 13).

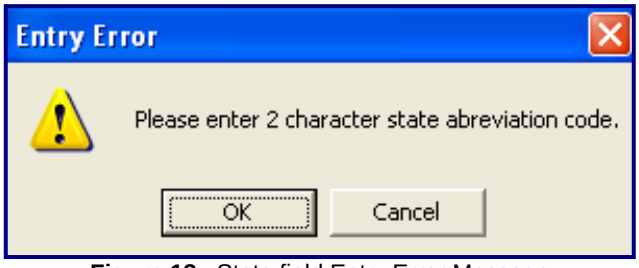

Figure 13. State field Entry Error Message

Selecting OK returns the user to the State field for correction. Selecting cancel clears the field and moves the cursor to the next data entry field. If the user enters a State abbreviation for which no rainfall data file is available (see the following discussion on County field), a warning error message (Figure 14) appears advising the user that no rainfall data file was found.

Figure 14. Rainfall data file not found warning message

County *field.* If a rainfall file is available, entering the two character State postal code in the State field will bring up the list of counties from the *COUNTY.XX* file; this list is available as a dropdown list for this field. Selecting the county name from the dropdown list reads the associated precipitation data into the appropriate fields on the **Rainfall/Discharge data** tab. Typing the first few letters of the county name will scroll the dropdown list to any matching value. The dropdown list must be displayed to select a match. Pressing ENTER will accept that match. If the full county name is typed, it must match one from the file or no data will be displayed. (See the discussion under Optional files, *COUNTY.XX* for more information on development and use of the *COUNTY.XX* file).

Practice *field.* The Practice field is an optional data field and may be used to enter additional project identification information.

By *field.* In the By field, the user may enter information identifying themselves.

Date *field.* For new files, the Date field is automatically populated using date information from the computer's system files. For opened files, the date on which the file was saved is displayed. Modifying saved files will not update the Date field. If the user wishes to update the displayed date, he or she must enter the appropriate date and save the file.

Watershed Data

Drainage Area *field.* Drainage Area may be entered directly in this field or brought over from the **Average Slope Calculator** window or the **RCN** tab, if either of those are used, with the most recent entry prevailing. For example, if the user enters 55 acres on the **Average Slope Calculator** window, but then computes runoff curve number using the **RCN** tab and enters data for 60 acres, the Drainage Area field on the Basic Data tab will display 60 acres. If the user calculates area with the RCN tab, it will display on the basic data screen with the message that it comes from the RCN calculator. If the user then uses the Slope calculator and changes the area, the changed area appears on the basic data screen, but the message attributing the area to the RCN screen remains.

There are a number of notes that might display depending upon how the Drainage Area data was entered.

- If the user enters the Drainage Area on the **Average Slope Calculator** window, the value is carried from that window to the **Basic data** tab, and no note appears to indicate the source of the data.
- If the user enters Drainage Area directly on the **Basic data** tab, the note user entered is displayed.
- If the user utilizes the **RCN** tab with the Acres option selected, upon completion of data entry and clicking the Accept button, the Accumulated Drainage Area rounded to the nearest acre is carried over to the Drainage Area field on the **Basic data** tab and the note from RCN Calculator is displayed.
- If the user utilizes the **RCN** tab with the Percentage option selected, no Drainage Area entry is carried over to the Drainage Area field and the user must enter it manually on the **Basic Data** tab or in the **Average Slope Calculator** window.

Curve Number *field.* If the user enters a runoff curve number directly in this field, the user entered note appears. Another option is to compute the curve number using the **RCN** tab. Upon completion of data entry on the **RCN** tab and clicking the Accept button, the Weighted Curve Number value is carried over to the Runoff Curve Number field on the **Basic data** tab and the from RCN Calculator note appears.

Time of concentration data and computations

If time of concentration (T_c)is known, the user may skip the Watershed length and Watershed slope fields and enter the T_c directly in the Time of Concentration field and the note user entered will display. If T_c is not known, the user must enter Watershed length and Watershed slope to compute T_c. In this case, the note calculated will appear.

Watershed length *field.* Watershed length, or flow length, is defined as the path along which water flows from the watershed divide to the outlet. For hydrologic evaluation purposes, this path is identified to be from the hydraulically most distant point along the watershed divide to the watershed outlet. In other words, it is the path runoff will take which takes the longest time to reach the outlet. If the user is computing T_c within **EFH2**, the Watershed length must be entered directly. Flow length can be measured using aerial photographs, quadrangle sheets, or Geographic Information System (GIS) techniques.

Kent (1973) developed a relationship between flow length and drainage area characteristics useful for estimating watershed flow length:

$$l = 209A^{0.6}$$

where:
l = flow length, feet
A = drainage area, acres

Watershed Slope *field.* The watershed slope, or average watershed land slope, is used in the lag equation to estimate the watershed T_c. (See NEH 650.02 and NEH 630.15, Time of Concentration, for more information on the lag method.)

Watershed slope is not to be confused with the slope of the flow path. The average land slope for small watersheds can be determined several different ways:

- using GIS techniques;
- by assuming land slope is equal to the soil map unit slope as published in the soil survey;
- by using a clinometer to measure landform slope in the field;
- by drawing three to four lines perpendicular to the contour lines in various locations on the watershed map to best represent average slope based on spacing of the contour lines (see Appendix B);
- by determining the average of the land slope from grid points using a dot counter; and
- by using the following equation from Chow (1964) and illustrated in Appendix C:

$$Y = \frac{100(CI)}{A}$$

where:
Y = average land slope, percent
C = summation of the lengths of all contour lines corresponding to the contour interval that pass through the watershed drainage area on the quad sheet, feet
I = contour interval, feet
A = drainage area, ft^2 (1 acre = 43,560 ft^2).

If using **EFH2** to compute T_c, a Watershed Slope must be entered. However, Watershed Slope may be carried over from the **Average Slope Calculator** dialogue window (Figure 15). This window is available only when the **Basic Data** tab is activated.

Data inputs are the sum of the lengths of all the contours within the drainage area boundary, the associated contour interval, and the watershed drainage area. Using this data, the average watershed slope is computed using the Chow equation.

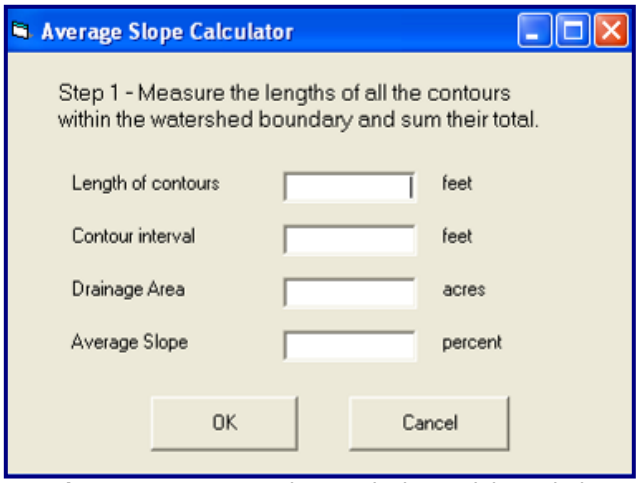

Figure 15. Average Slope Calculator Dialog Window

Upon exiting the **Average Slope Calculator** window, the values for average slope and drainage area are transferred to the **Basic data** tab entry fields. Because the maximum drainage area limitation on **EFH2** is 2,000 acres, a computed time of concentration will not display if an area greater than 2,000 acres is entered. If the user tries to exit the **Average Slope Calculator** window without revising the drainage area, the following warning message (Figure 16) will appear advising that the drainage area entered is greater than 2,000 acres, and the data will not be transferred to the **Basic data** tab.

Figure 16. Average Slope Calculator Warning Message for drainage area entry greater than 2,000 acres

Time of Concentration *field.* The user may enter time of concentration directly, or calculate it within **EFH2.** If the user determined T_c external to the program, it may be entered directly and the note user entered displays. If the user is calculating T_c within **EFH2,** as soon as sufficient valid data exist in the Runoff Curve Number, Watershed Length, and Watershed Slope fields, T_c is computed using the lag equation and displayed with the note calculated. Subsequent changes to the Runoff Curve Number, Watershed Length, or Watershed Slope fields will automatically replace the user entered data with the new calculated value. The lag equation is used to compute T_c within **EFH2**:

$$T_c = \frac{l^{0.8}(\mathrm{S}+1)^{0.7}}{1{,}140\mathrm{Y}^{0.5}}$$

where:
T_c = time of concentration, hours
l = flow length, feet
Y = average watershed land slope, percent
S = maximum potential retention, inches
$= \frac{1{,}000}{\mathrm{CN}} - 10$
CN = runoff curve number

More information on the derivation of the lag equation can be found in NEH 630.15.

Rainfall/Discharge data tab

If a *COUNTY.XX* file exists, **EFH2** automatically populates the storm data (Frequency and Storm #) fields on the **Rainfall/Discharge data** tab (Figure 17) as soon as a State and county are identified on the **Basic data** tab, but the user must select the Rainfall Type. If no *COUNTY.XX* file exists, the user must enter the Rainfall Type and storm data directly.

Peak flow and Runoff volume are computed values displayed only when sufficient data has been entered into the **Basic data** tab, into the Rainfall Type and storm data (Frequency and Storm #) on this tab, and/or on the **RCN** tab, to complete computation of the peak discharge and runoff volume utilizing the generalized tables and graphs found in NEH 650.02.

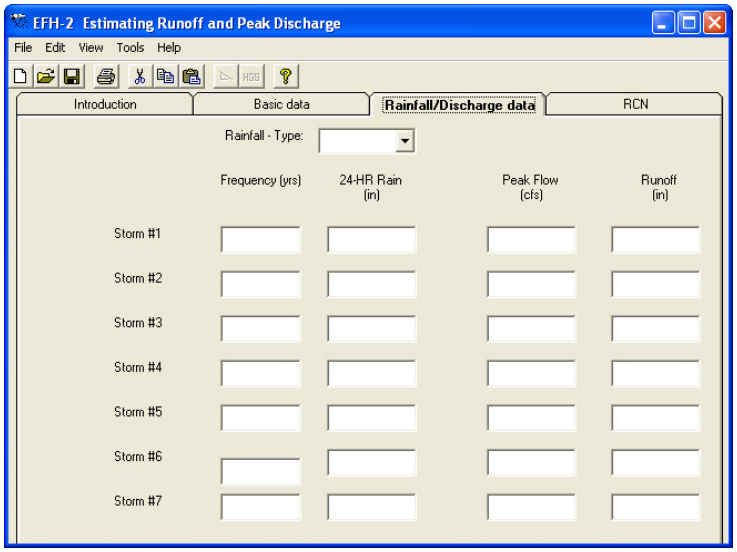

Figure 17. Rainfall/Discharge data tab

Rainfall Type *field.* The user must enter the Rainfall Type appropriate for the State in which the project is located directly. For the United States, appropriate NRCS rainfall data distribution is determined based upon the map shown in Figure 18. In some cases, based upon State-specific evaluations, States use a distribution that is different than that displayed in Figure 18.

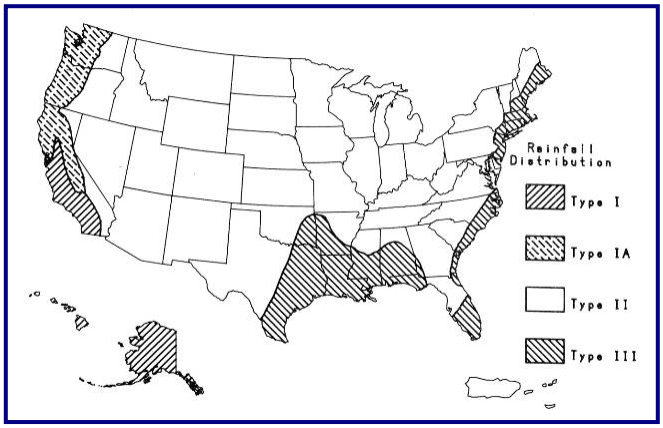

Figure 18. Approximate geographic boundaries for NRCS rainfall distributions

For watersheds located in the Delaware-Maryland-Virginia, or Delmarva, peninsula, a rainfall distribution type identified as DMV is identified. The DMV is a combination of the NRCS Type II rainfall distribution and a dimensionless unit hydrograph developed specifically for the Delmarva peninsula which yields better predictions of peak discharges for that part of the country than does use of the NRCS Type II distribution with the standard (peak rate factor = 484) unit hydrograph.

Storm Data

Rainfall volume by frequency (the Frequency and 24-HR Rain fields on the **Rainfall/Discharge data** tab) may be included for evaluation of up to 7 storms on the project watershed.

Frequency *fields.* The storm frequency by return period associated with the rainfall volume entered in the 24-HR Rain column is shown here in the Frequency column, if data is available from the *COUNTY.XX* optional data file. The user may enter the information here.

24-HR Rain *fields.* The 24-hour rainfall volume for the appropriate return interval indicated in the Frequency column is listed here. The 24-HR Rain column is populated automatically using the *COUNTY.XX* optional data file if one is included, or may be directly entered by the user. Data sources may vary depending upon when rainfall data for a particular location were last updated in the *COUNTY.XX* file. The user is encouraged to verify that the rainfall volume data are correct and appropriate for the watershed being evaluated using standard rainfall data sources.

Discharge data

The discharge data, Peak Flow and Runoff, are computed when sufficient information has been entered to identify the watershed drainage area, runoff curve number, time of concentration, and rainfall volumes for the storm or storm being evaluated.

Peak Flow *fields.* Peak Flow is the maximum discharge expected to occur per storm frequency, and is estimated using the generalized graphs found in NEH 650.02 to determine a unit peak discharge, and then multiplying that figure by the Runoff in inches as determined using the SCS/NRCS runoff equation and by the drainage area.

Runoff *fields.* Runoff volume for the watershed is determined using the SCS/NRCS runoff equation, defined in NEH 630.10, *Estimation of Direct Runoff from Storm Rainfall*. This runoff volume is multiplied by the unit peak discharge (determined using the generalized graphs found in NEH 650.02) to compute a peak flow rate, or peak discharge.

RCN Tab

Using the **RCN** tab (Figure 19), the user calculates the runoff curve number for the watershed by entering the appropriate area or percentage of area by land use description and hydrologic soil group. Some fields on this screen respond slightly differently to keystrokes than they do in previous screens. See the General data entry help screen for function details of keys.

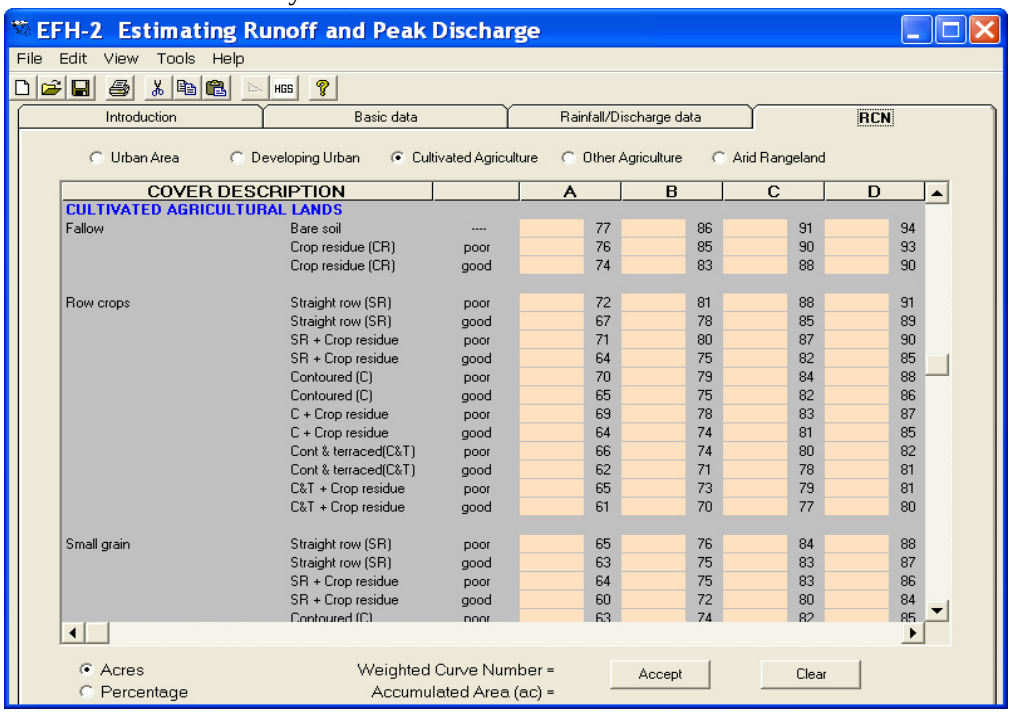

Figure 19. RCN tab

Radio Buttons. Radio buttons at the top of the entry screen allow the user to scroll to the desired part of the entry screen at the beginning of the Cover Description lists for each Land Use type. Land use types for which cover descriptions are given are:

- Urban Area;
- Developing Urban;
- Cultivated Agriculture;
- Other Agriculture; and
- Arid Rangeland.

The vertical scroll bar on the right side of the Cover descriptions and conditions allows the user to scroll down through the table entries.

COVER DESCRIPTION is a combination of a land use, treatment class, and hydrologic condition. For example, under the CULTIVATED AGRICULTURAL LANDS, Small grain COVER DESCRIPTION, there are several treatment classes listed (Straight Row (SR); SR + Crop Residue (CR); Contoured (C); C + Crop Residue; Cont & terraced (C&T); (C&T + Crop residue); with a poor and good hydrologic condition for each of the treatment classes.

The vertical scroll bar or land use category buttons are used to find and view specific cover descriptions. Drag the scroll bar up or down to change the portion of the COVER DESCRIPTION list displayed. Resizing the window to a larger window displays more lines of land cover.

Scrolling from top to bottom may be time consuming since the table is long. Clicking any of the land use categories radio buttons causes the displayed portion of the COVER DESCRIPTION list to jump directly to the beginning of that category's cover descriptions. The complete list of the Cover Descriptions for the Land Use category may be too long to display at one time. If that is the case, use the vertical scroll bar to scroll down and view additional cover descriptions.

Hydrologic Soil Groups. Once the desired cover description is in view in the table, enter the area in the appropriate hydrologic soil group column (A, B, C, or D). Multiple hydrologic soil group entries can be made for a single cover description.

If the optional *SOILS.HG* file exists, it can be viewed using the **Search for Hydrologic Soil Group dialog window** (Figure 20) to look up the hydrologic group A, B, C, or D for various soil types. Activate this file by clicking on the button labeled HGS on the toolbar. (See the discussion on Optional Files, *SOILS.HG* for more information on creating this file). If the file is not present in the EFH2 directory, clicking the HGS button brings up the window entitled "Search for Hydrologic Soil Group", but there are no entries in the window.

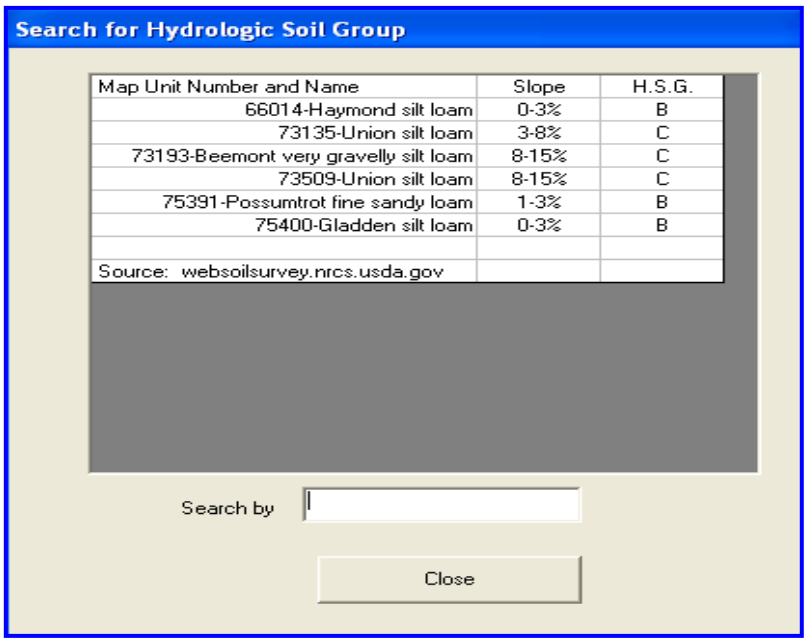

Figure 20. Hydrologic Soil Groups Window with the file populated *(Note that this user used a slightly different format than recommended in the SOILS.HG optional data file discussion.)*

Runoff Curve Numbers. A combination of a hydrologic soil group, a land use, and treatment class (cover description) is a soil-cover complex. An index value is assigned to each soil-cover complex which indicates its runoff potential during periods when the soil is not frozen and is known as a runoff curve number, RCN. or CN. RCN's are shown on the **RCN** tab in columns by hydrologic soil group for each cover description.

Units of area measurement. Acres or Percentage *(Radio buttons).* The radio buttons in the lower left portion of the screen switch between acres or percentages for data entry. The default is Acres. If the user wishes to switch to data entry in percentages, selecting the Percentage radio button PRIOR TO MAKING ANY DATA INPUTS on the RCN tab will make the change, and the Accumulated Area at the bottom of the screen will change from (ac) to being displayed as (%).

If the user has already started inputting data and then decides to change the data input from Area to Percentage, the **RCN Data Conversion** window (Figure 21) will appear asking if the data already input should be converted at all, be converted based upon the area already entered, or based upon the drainage area as input on the **Basic Data** tab.

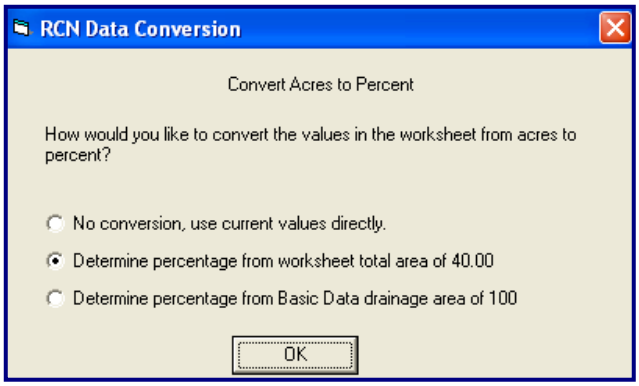

Figure 21. RCN Data Conversion window

If the user originally indicated percentages as the units for data input and then decides to switch to acres, the Acres radio button may be selected and the **RCN Data Conversion** window (Figure 21) will appear; however the option to determine percentages from the worksheet total area will not be available as an option. Repeatedly going back and forth between acres and percentages is not recommended.

Weighted Curve Number. The Weighted Curve Number for the watershed is computed automatically as the user enters land use/hydrologic soil group data and displayed at the bottom center of the **RCN** tab.

Accumulated Area. The total Accumulated Area of the watershed is calculated as the user enters land use/hydrologic soil group data and displayed at the bottom center of the window below the Weighted Curve Number. This total includes all land use descriptions used to describe the watershed drainage area. As additional areas are entered or deleted, the summary values change. If both boxes are blank, no detailed land use description data has been entered for this subarea.

Accept button. Click the Accept button to retain all data entered on the window and transfer appropriate values for drainage area and runoff curve number to the **Basic data** tab.

Clear button. Clicking on the Clear button will clear all data entries of area by land use previously entered.

References

United States Department of Agriculture, Natural Resources Conservation Service. 2009. National Engineering Handbook, Part 630, Hydrology, Chapter 7, *Hydrologic Soil Groups.* Washington, D.C. (NEH 630.07)

United States Department of Agriculture, Natural Resources Conservation Service. 2004. National Engineering Handbook, Part 630, Hydrology, Chapter 9, *Hydrologic Soil-Cover Complexes.* Washington, D.C. (NEH 630.09)

United States Department of Agriculture, Natural Resources Conservation Service. 2004. National Engineering Handbook, Part 630, Hydrology, Chapter 10, *Estimation of Direct Runoff from Storm Rainfall.* Washington, D.C. (NEH 630.10)

United States Department of Agriculture, Natural Resources Conservation Service. Draft 2009. National Engineering Handbook, Part 630, Hydrology, Chapter 15, *Time of Concentration.* Washington, D.C. (NEH 630.15)

United States Department of Agriculture, Natural Resources Conservation Service. 2007. National Engineering Handbook, Part 630, Hydrology, Chapter 16, *Hydrographs.* Washington, D.C. (NEH 630.16)

United States Department of Agriculture, Natural Resources Conservation Service. 1989, revised 1990 and 1991. National Engineering Handbook, Part 650, Engineering Field Handbook, Chapter 2, Estimating Runoff and Peak Discharges. Washington, D.C. (NEH 650.02)

U.S. Department of Agriculture, Natural Resources Conservation Service, 2007. National Soil Survey Handbook, title 430-VI. [Online] Available: http://soils.usda.gov/technical/handbook/.

Chow, Ven Te, editor-in-chief. 1964. Handbook of Applied Hydrology: A compendium of water resource technology. McGraw-Hill. New York, NY.

Kent, K.M. A Method for Estimating Volume and Rate of Runoff in Small Watersheds. 1973. United States Department of Agriculture, Soil Conservation Service, Technical Paper Number 149 (SCS-TP-149). Washington, D.C.

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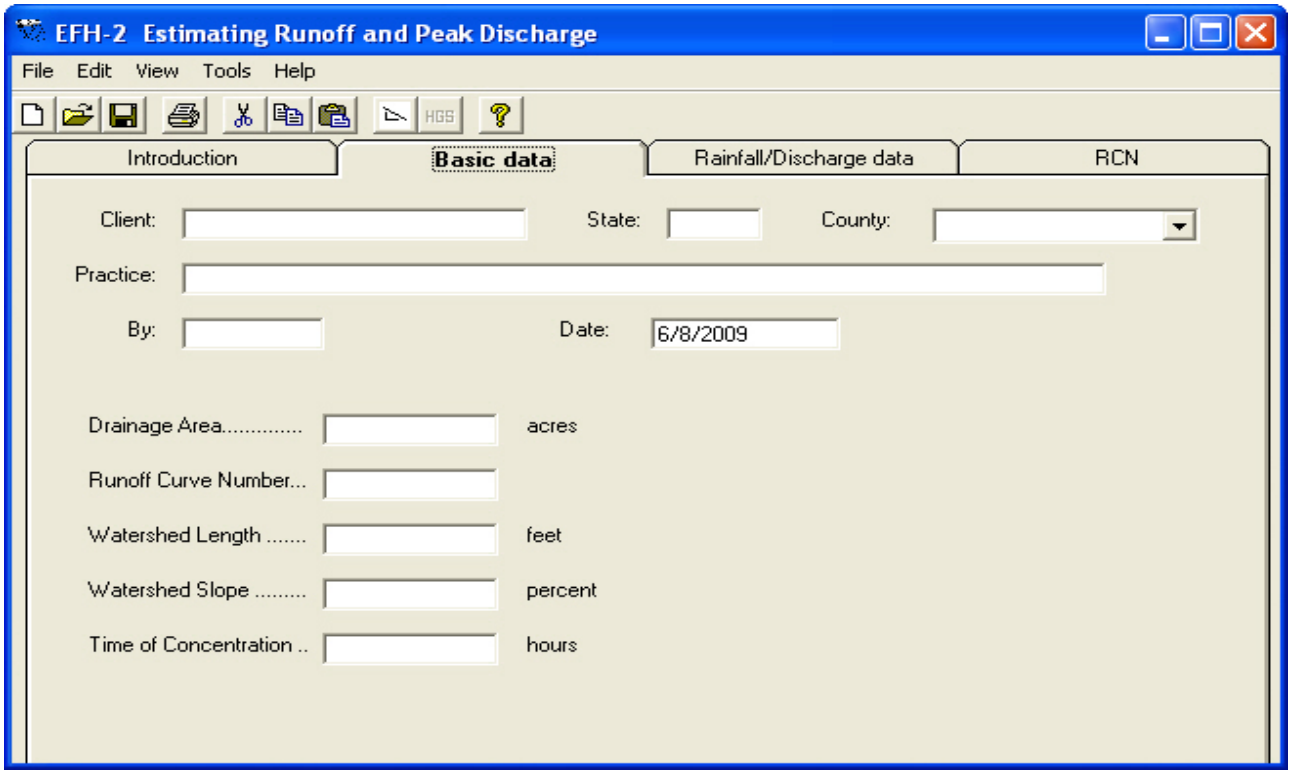
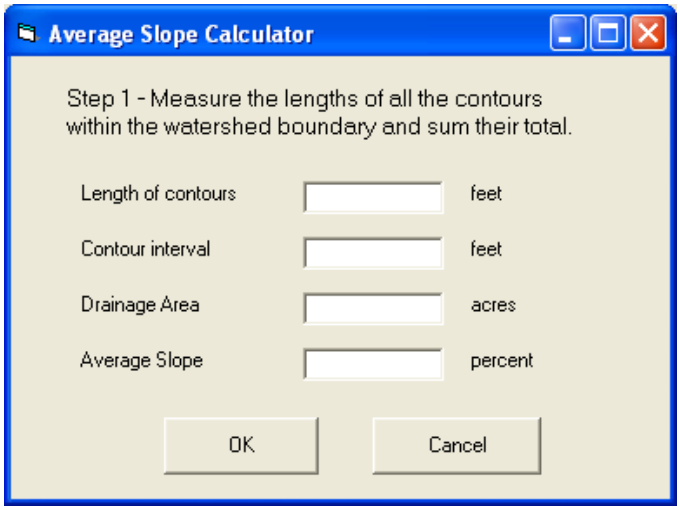
EFH2 Reference Guide

Basic data tab



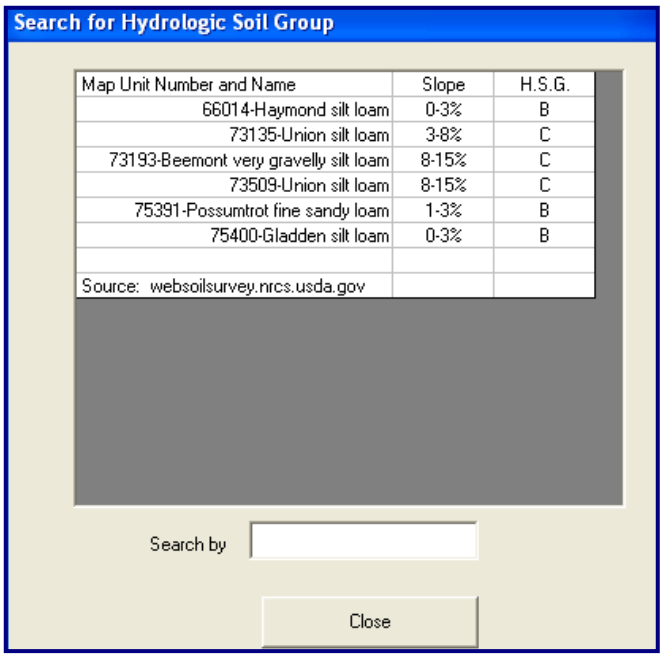
Field	*Definition*
Client	Name of the producer, participant, or landowner.
State	Two letter postal code representing the State where the project is located. Requires two letters.
County	County where project is located. May be typed in directly, but better selected from the dropdown list after the State has been entered.
Practice	Name or description of the practice for the project.
By	Initials or name of the person making the hydrologic analysis.
Date	Automatically opens with the system (today's) date. May be entered manually.
Drainage Area	Area in acres within the watershed boundary contributing to the project site. Allowable range: 1 to 2000 acres
Runoff Curve Number	Weighted NRCS curve number representing the portion of precipitation that runs off the land. Allowable range: 40 to 98
Watershed Length	Length in feet along the flow path from the hydraulically most distant point to the project site. Allowable range: 200 to 26000 feet
Watershed Slope	Average slope in percent of the all the contributing land within the watershed boundary. Allowable range: 0.5 to 64 percent Slopes from 0.1 to 0.49 percent may be used; however, the user should be very cautious with such use. Warning messages will be generated for slopes in the 0.1 to 0.49 percent range.
Time of Concentration	Time in hours for runoff to flow from the most hydraulically remote point to the project site. Calculated by the program, but may be manually calculated from the sum of the projected flow velocities of each reach along the flow path. Allowable range: 0.1 to 10 hours Calculated values outside of the allowable range are reset to the nearest limit.

Average Slope Calculator



Field	*Definition*
Length of Contours	The sum of the lengths of all the contours within the watershed
Contour interval	The difference in elevation between adjacent contours. This must be the same interval for all contour lengths measured
Drainage Area	The area in acres within the watershed boundary contributing to the project site.
Average slope	The calculated average slope in percent of all the contributing land within the watershed boundary. It is the product of the length of contours times the contour interval divided by the drainage area.

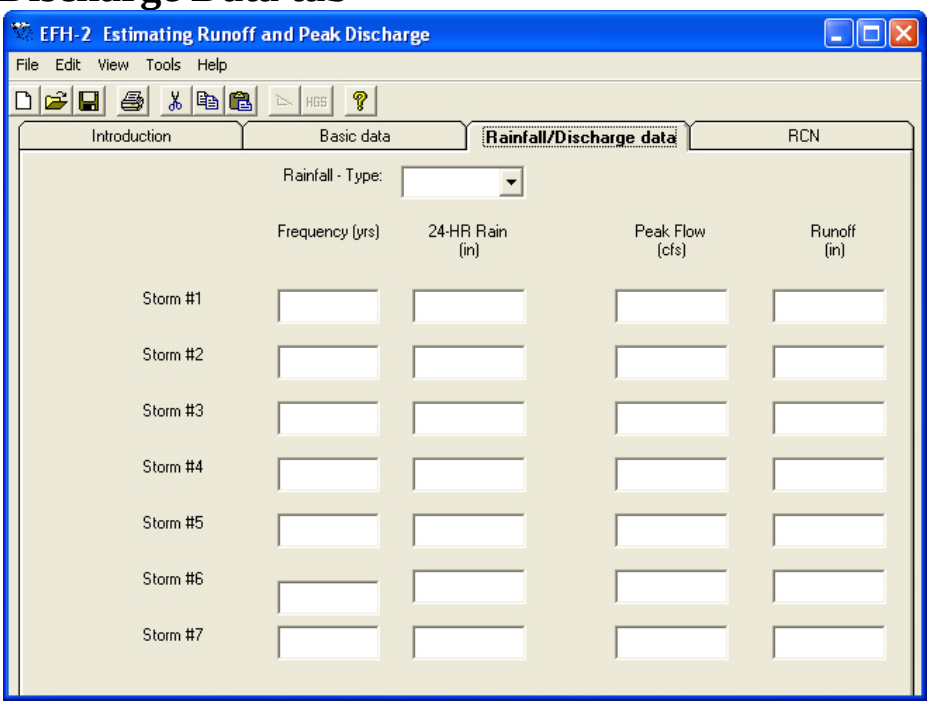
Optional hydrologic soils groups data file:



SOILS.HG. (Hydrologic Soil Group Window). Format of the *SOILS.HG* file is at the discretion of the user. Three columns may be used with whatever information the user chooses to include; however, the columns have restrictions on the numbers of characters. A suggested format for the *SOILS.HG* file, by columns, is shown:

Column	*Maximum Number of Characters*	*Data Description*
1	40	Soil map unit name
2	10	Textural class
3	10	Hydrologic soil group

Rainfall / Discharge Data tab



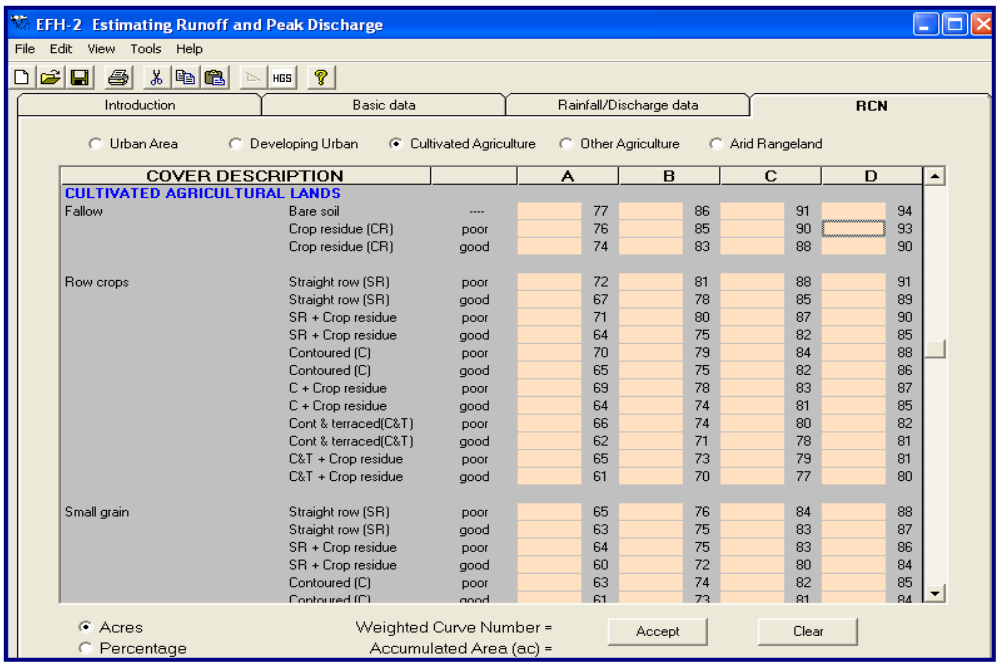
Field	*Definition*
Rainfall Type	The type of storm rainfall distribution.
Storm #	Storm identifier. Up to 7 24-hour storms of varying return intervals can be evaluated at one time.
Frequency	Recurrence interval in years for the storm.
24-HR Rain	Amount of rainfall in a 24-hour period corresponding to the recurrence interval.
Peak Flow	Maximum discharge in cubic feet per second for the runoff resulting from the defined storm.
Runoff	The volume of excess precipitation, in inches on the watershed, not absorbed by the soil nor held on the vegetation (runoff).

Optional rainfall data file format:

COUNTY.XX. A unique optional county rainfall data file may be created for State-specific rainfall volume by frequency data to replace the sample COUNTY.RF file. It is recommended that the xx in the file name be the two-letter State postal abbreviation.

Row	*Column*	*Description*
1	1	Number of return intervals included in file (maximum 7).
	2 – 8	The return intervals (in years).
2	1	County name (all uppercase) in quotation marks ('').
	2 – 8	Rainfall volumes in inches corresponding to the return intervals in row 1, columns 2 through 8.
3+	Same as row 2.	Continue with as many counties as needed for your State, with each county on its own row.

This file may be created using an ASCII editor. If using an ASCII editor, separate the columns by commas, one space, or at least one tab. If the rainfall data is in an Excel spreadsheet, use separate columns for each of the fields and save the file as a comma delimited text file. The resulting text file should be checked carefully for extra characters. The county rainfall should use the format shown here, by row and column.



RCN Tab

Key	*Function: Basic Data and Rainfall/Discharge Tab*	*RCN Tab*
F1	Display Help	Display Help
F10	Toggles between entry fields and menu bar	Toggles between entry fields and menu bar
ESC	Returns field value to previous value	Returns field value to previous value
Delete	Deletes the character to the right of the cursor	Clears the entire field
Backspace	Deletes the character to the left of the cursor	Delete the last (right most) character in the field
Enter	Completes data entry for the field and advances to the next field	Completes data entry for the field and advances to the next field
Tab	Completes data entry for the field and advances to the next field	Completes data entry for the field and jumps to the next tab stop on the screen
Shift Tab	Completes data entry for the field and moves cursor to the previous field	Completes data entry for the field and jumps to the previous tab stop on the screen
Arrow right	Moves the cursor one character to the right	Moves to the entry cell to the right
Arrow left	Moves the cursor one character to the left	Moves to the entry cell to the left
Arrow up	Moves the cursor one character to the left	Moves up to the entry cell above
Arrow down	Moves the cursor one character to the right	Moves down to the entry cell below
Home	Moves the cursor to the start of the field	Moves up to the last entry cell in the row above
End	Moves the cursor to the end of the field	Moves down to the first entry cell in the row below
Page up	-- no action --	Scrolls up one screen of grid cells
Page down	-- no action --	Scrolls down one screen of grid cells

Example Problem A

Problem Statement

A grassed waterway is planned in Field #2 of the A.B. Smith Farm in Frederick County, Maryland.

The drainage area above the site of the proposed waterway (indicated by the black dot at the waterway outlet) is 90 acres. Figure 1A shows the watershed boundary in blue and watershed time of concentration flow path in red.

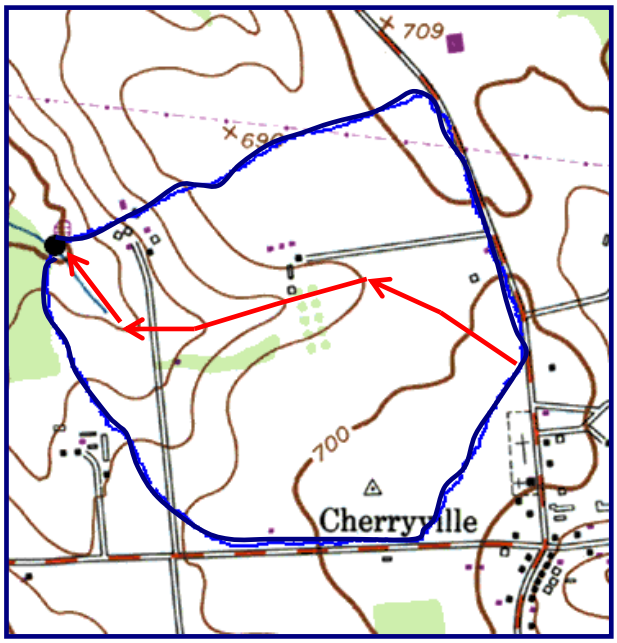


Figure 1A. Watershed boundary map showing time of concentration flow path (Example A)

The average watershed slope determined by averaging the slopes of the mapped soils is 1 percent, and the time of concentration flow path length as measured from the United States Geological Survey (USGS) topographic map is 3,400 feet.

Soils data for this watershed was used in conjunction with land use information obtained in the field to determine the appropriate Hydrologic Soil Groups shown in Figure 2A and summarized in Table 1A.

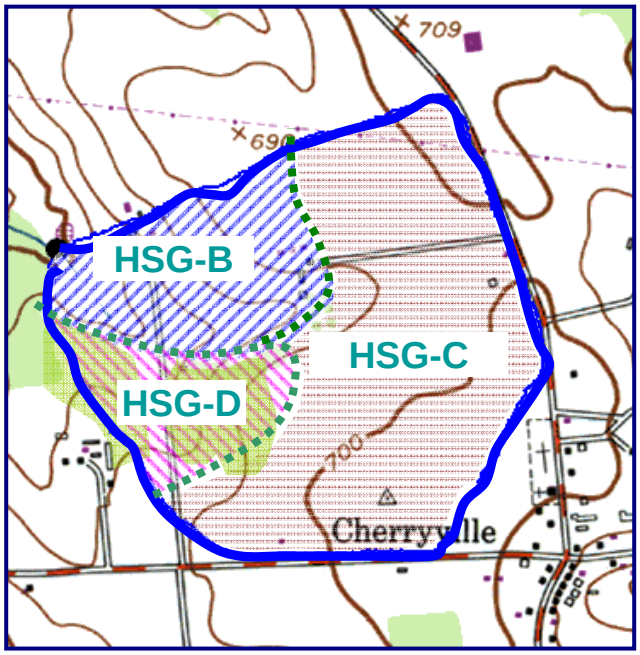


Figure 2A. HSG boundaries within the project watershed (Example A)

Hydrologic Soil Group	Cover Description	Area acres
B	Pasture, Good Condition	25
C	Straight Row Crops, Good Condition	55
D	Woods, Poor Condition	10

Table 1A. Drainage area soil-cover complexes (Example A).

Maryland uses a Type II rainfall distribution for hydrologic analyses.

Grassed waterway design is based on a 10-year peak discharge.

Determine the peak discharge for the 10-year storm event.

Solution

Step 1. Basic data tab

Enter the Client, State, County, Practice, and By information. Date will automatically fill in to the current date.

If the *COUNTY.MD* file does not exist in the **EFH2** program folder, a warning message will appear indicating that no rainfall data file was found for MD and that the program is defaulting to the *COUNTY.RF* file. Click OK if that message appears. Frederick County rainfall data is included in the *COUNTY.RF* file and Frederick will appear in the County dropdown list.

Do not enter the Drainage Area. Instead, it will be calculated along with Runoff Curve Number on the **RCN** tab.

The **Basic data** tab should appear as shown in Figure 3A upon completion of this portion of the data entry.

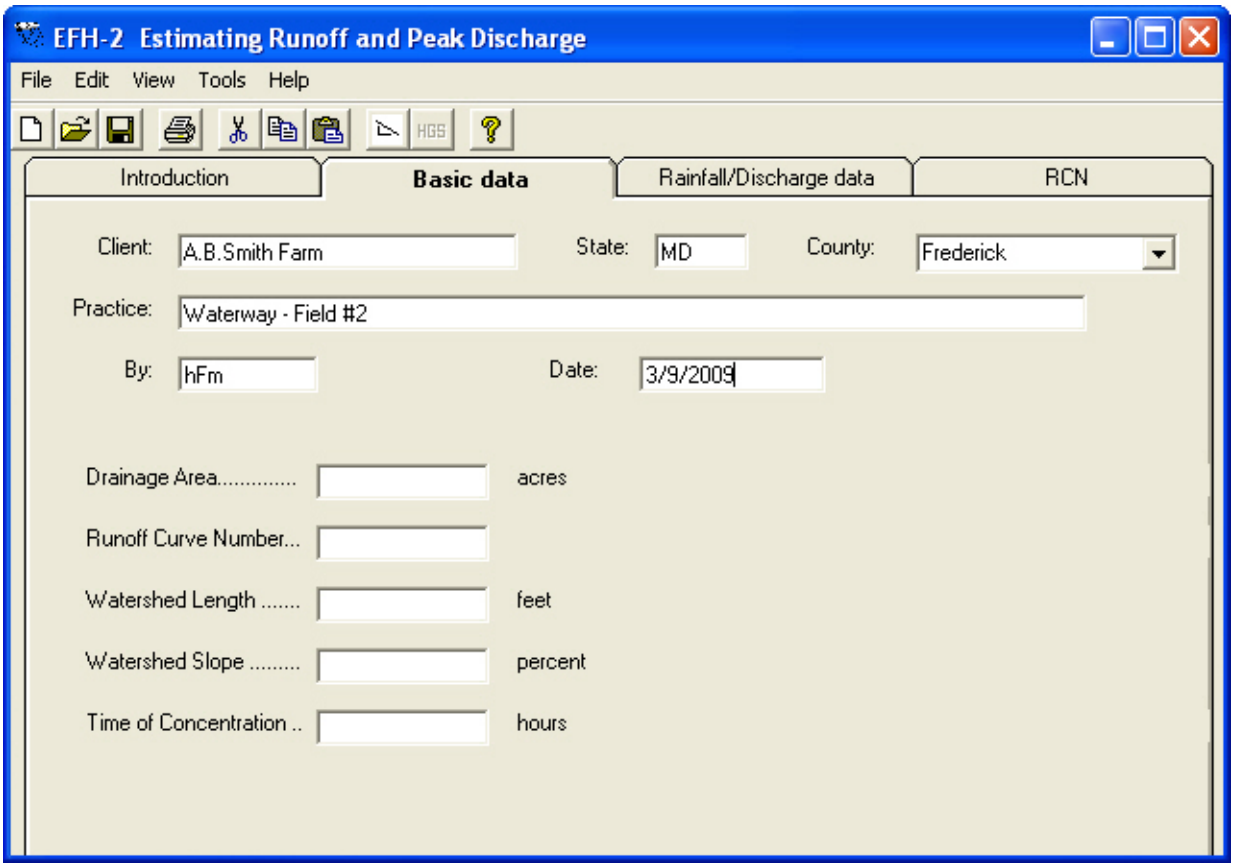


Figure 3A. Basic Data tab (Example A)

Step 2. RCN tab

Click on the **RCN** tab and enter the appropriate soil-cover complex and area information in order to calculate the runoff curve number for the watershed. Upon completion of data entry, the **RCN** tab should appear as shown in Figure 4A.

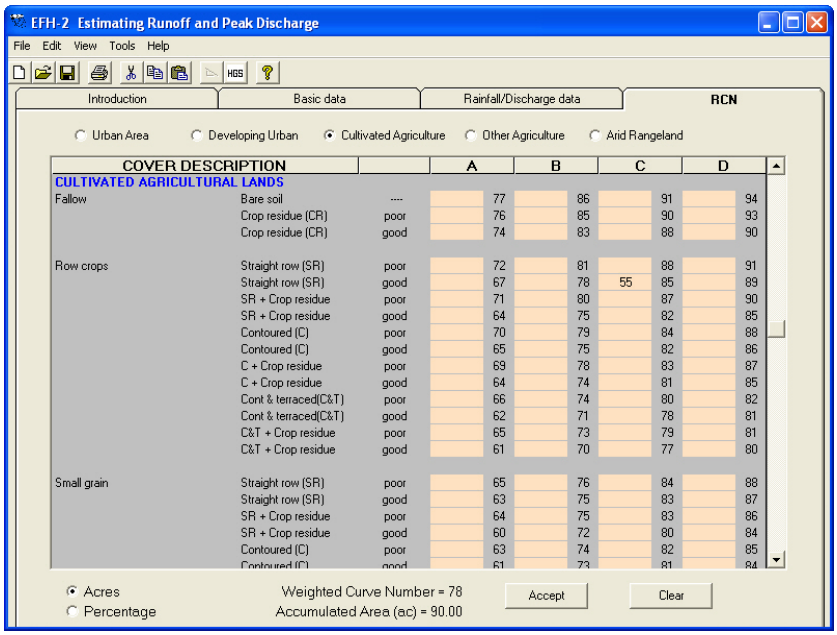


Figure 4A. RCN tab (Example A)

When data entry is complete, click Accept to automatically return to the **Basic data** tab.

Step 3. Basic data tab

Upon returning from the **RCN** tab, note the purple text indicating Drainage Area and Runoff Curve Number were developed using the RCN Calculator (Figure 5A).

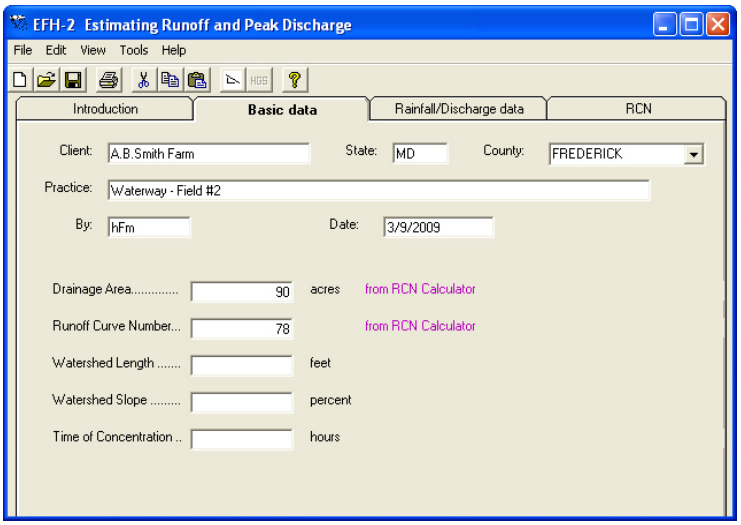


Figure 5A. Basic Data tab showing drainage area and runoff curve number carried over from RCN tab (Example A).

Enter the Watershed Length (the length of the flow path) and the Watershed Slope. The program automatically calculates Time of Concentration utilizing the lag equation and displays the information with a note in purple text indicating that the time of concentration was calculated. Alternatively, if time of concentration is already known, the user may enter it directly, upon which a note indicating that the value was user entered is displayed.

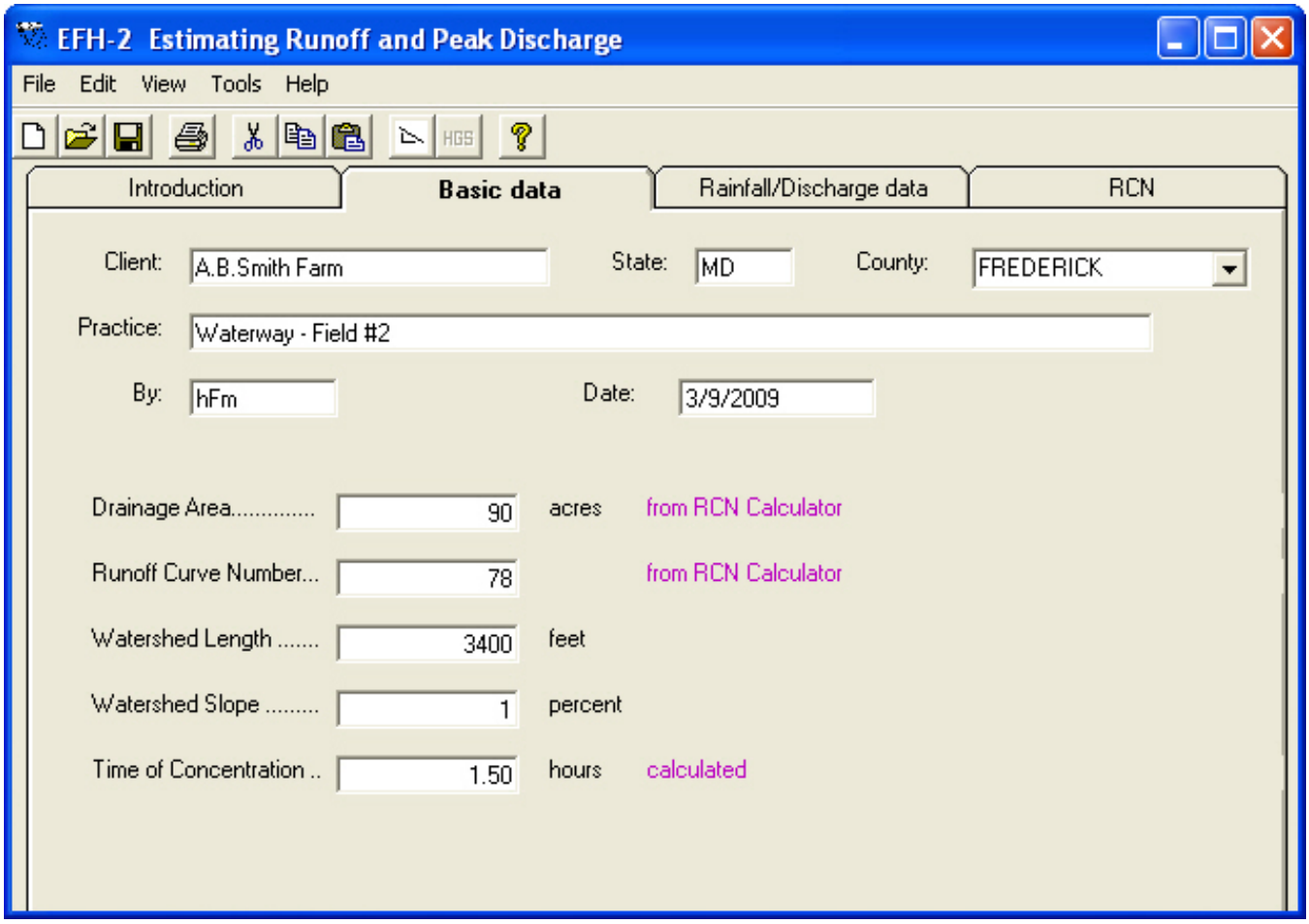


Figure 6A. Basic Data tab showing time of concentration data calculated from user input watershed length and slope (Example A)

Step 4. Rainfall/Discharge data tab

Click on the **Rainfall/Discharge data** tab. The rainfall data, rainfall volumes (24-hour rainfall amounts by Frequency and Storm #) for 7 storms are displayed for the county/State combination entered on the **Basic data** tab.

Select the Rainfall – Type II storm for Maryland.

Provided that data on the **Basic data** tab is complete, the discharge data (Peak flow and Runoff volume) for each of the 7 storms are calculated and displayed (Figure 7A). If the values are not displayed, return to the **Basic data** tab and ensure that data entry is complete.

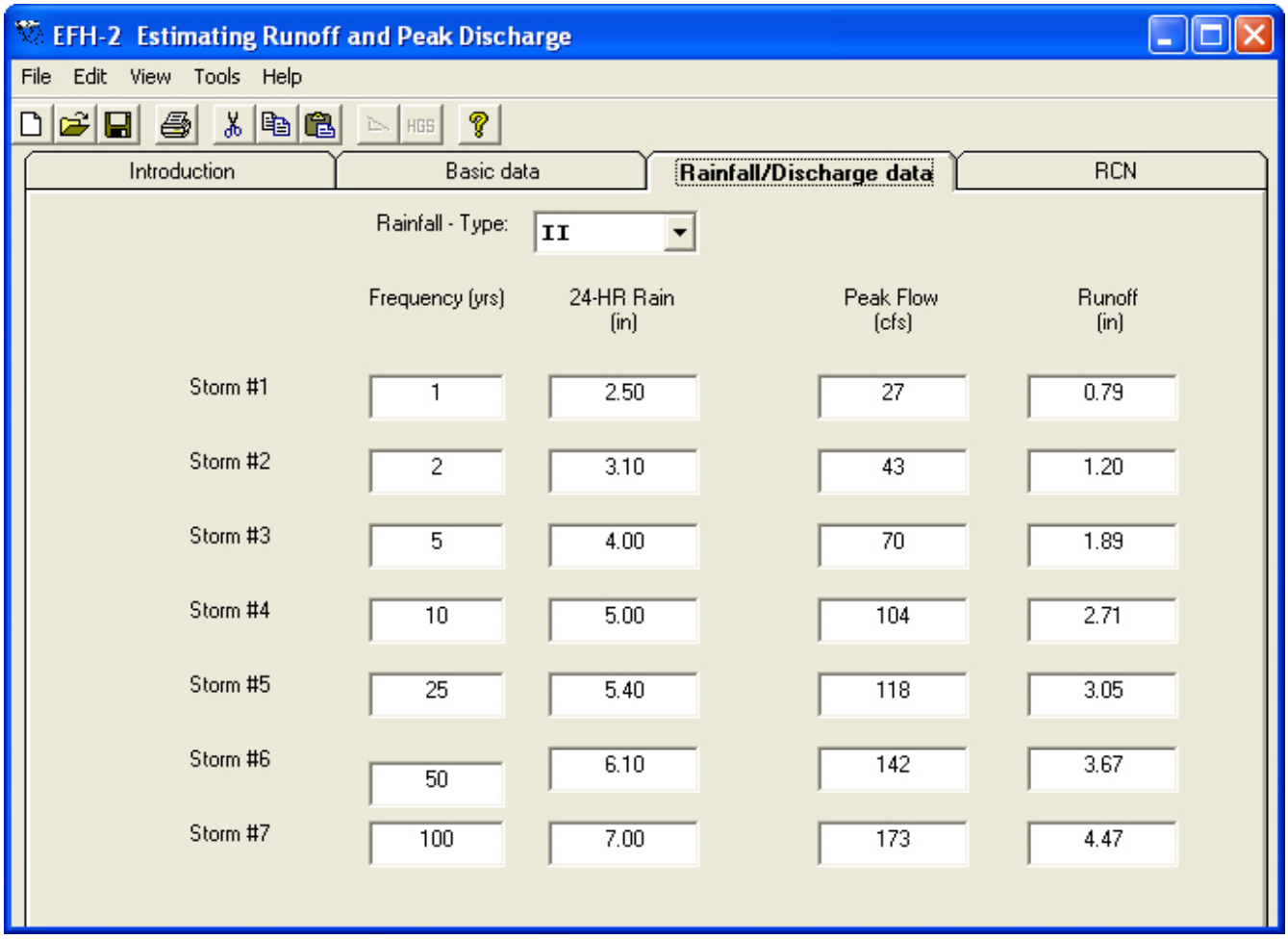


Figure 7A. Rainfall/Discharge data tab (Example A)

Conclusion

The 10-year, 24-hour rainfall event of 5.00 inches results in a peak discharge of 104 cfs and a runoff volume of 2.71 inches as shown in Figure 7A for Storm #4.

The design flow rate of 104 cfs should be used in sizing the grassed waterway.

Example Problem B

Problem Statement

A diversion is planned above a barnyard agricultural waste handling facility on the Kennedy farm in Lancaster County, Pennsylvania as shown on the Location map in Figure 1B. The diversion conservation practice standard (362) requires a minimum capacity of the 25-year peak discharge to protect against flows toward an animal waste management system.

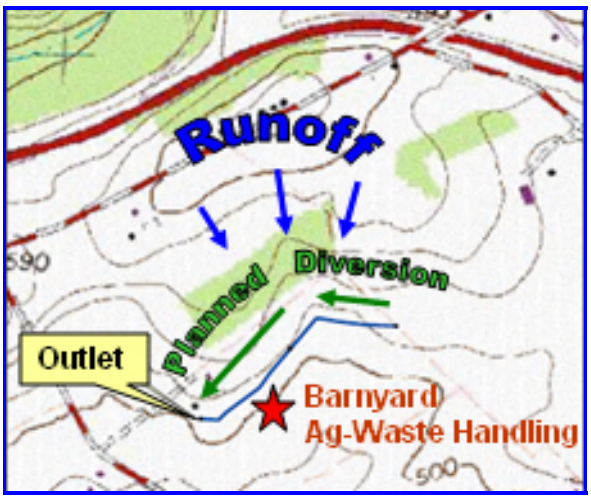


Figure 1B. Location map (Example B)

The watershed boundary (dashed red line), planned diversion location (heavy blue line), field boundaries (solid yellow lines), contours (dark gray lines), and soil boundaries (light gray lines) are shown on the aerial photo (Figure 2B). The soil-cover complexes are summarized in Table 1B for each of the fields in the watershed drainage area.

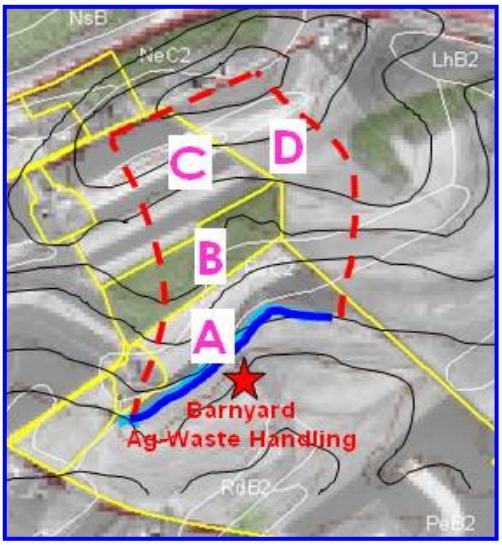


Figure 2B. Aerial photo of project area (Example B)

Field	Cover Description	HSG	Area (ac.)
A	Close Seeded Legume, Straight Row/Good Cond.	B	2.3
A	Close Seeded Legume, Straight Row/Good Cond.	C	0.8
B	Woods, Good Condition	B	8.3
B	Woods, Good Condition	C	0.7
C	Close Seeded Legume, Straight Row/Good Cond.	B	4.0
C	Small Grain, Contoured & Terraced, Crop Residue/ Good Cond.	B	2.2
C	Small Grain, Contoured & Terraced, Crop Residue/ Good Cond.	C	2.2
C	Row Crop, Contoured & Terraced, Crop Residue/ Good Cond.	B	2.0
D	Row Crop, Contoured & Terraced, Crop Residue/ Good Cond.	B	12.1
D	Row Crop, Contoured & Terraced, Crop Residue/ Good Cond.	C	2.6

Table 1B. Drainage area soil-cover complexes (Example B).

Figure 3B shows the watershed boundary (red line) and the flow path identified as the T_c flow measuring 3,300 ft.

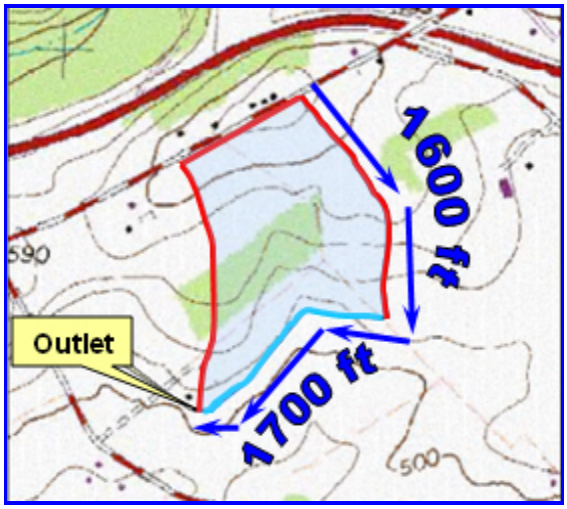


Figure 3B. Topo map showing watershed boundary and T_c flow path (Example B)

Figure 4B shows the watershed boundary (red line) and 3 lines identified for estimating the watershed average slope.

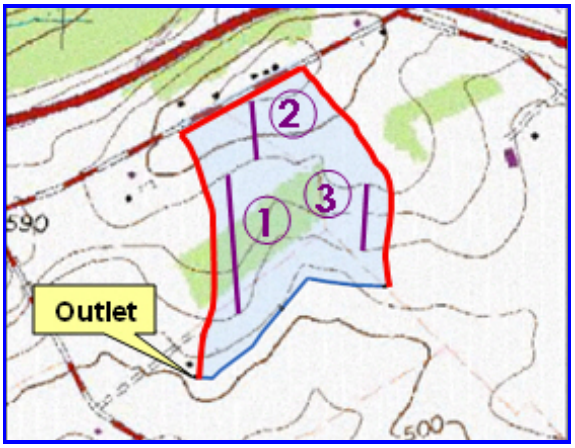


Figure 4B. Topo map showing watershed drainage area (shaded blue) and three lines for determining average watershed slope (Example B)

The average watershed slope was calculated by determining the slopes of the individual lines (computed by determining the elevation drop along the line and dividing by the length of the line) and averaging the slopes of the three individual lines as shown in the following computation.

$$\text{Slope of line \#1: } \frac{40\,\text{ft}}{900\,\text{ft}} = 0.044\ \text{ft/ft}$$

$$\text{Slope of line \#2: } \frac{40\,\text{ft}}{400\,\text{ft}} = 0.10\ \text{ft/ft}$$

$$\text{Slope of line \#3: } \frac{40\,\text{ft}}{450\,\text{ft}} = 0.088\ \text{ft/ft}$$

Average Slope: $$\frac{0.044 + 0.10 + 0.088}{3} = 0.077\ \text{ft/ft} = 7.7\%$$

The *COUNTY.PA* rainfall data file for Pennsylvania is not available. However, standard rainfall references were consulted to determine that the 25-year, 24-hour rainfall event yields 6.1 inches of rain.

Pennsylvania uses a Type II NRCS Standard Rainfall Distribution.

Solution

Step 1. Basic data *tab*

Enter the Client, Practice, and By information. Since the COUNTY.PA rainfall data file is unavailable, leave the State field blank (and select Cancel when prompted with the Entry Error to enter the State abbreviation). Type "Lancaster" into the County field. The Date field will automatically fill in to the current date.

Do not enter the Drainage Area. Instead, it will be calculated along with Runoff Curve Number on the **RCN** tab.

The **Basic data** tab should appear as shown in Figure 5B upon completion of this portion of the data entry.

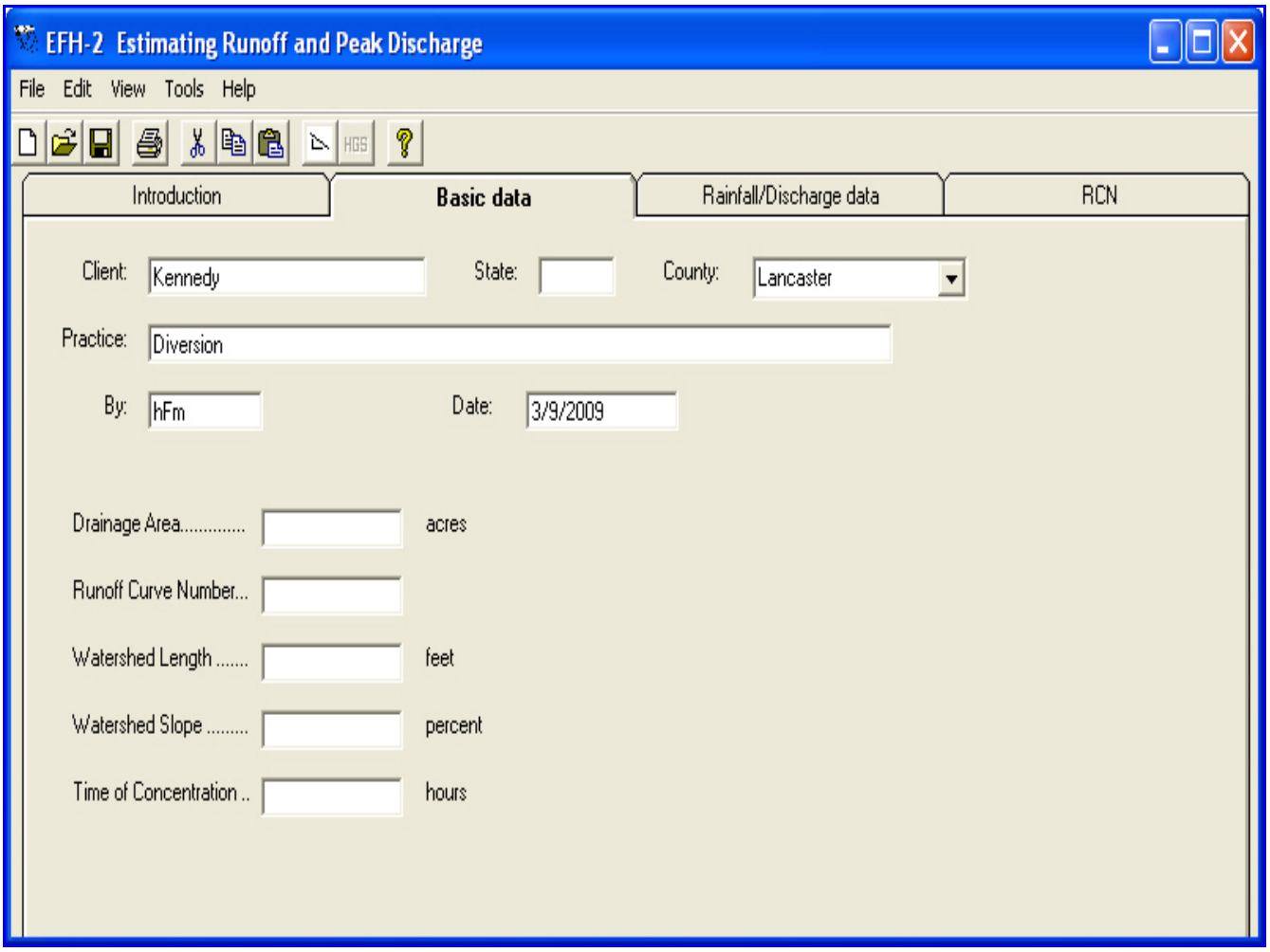
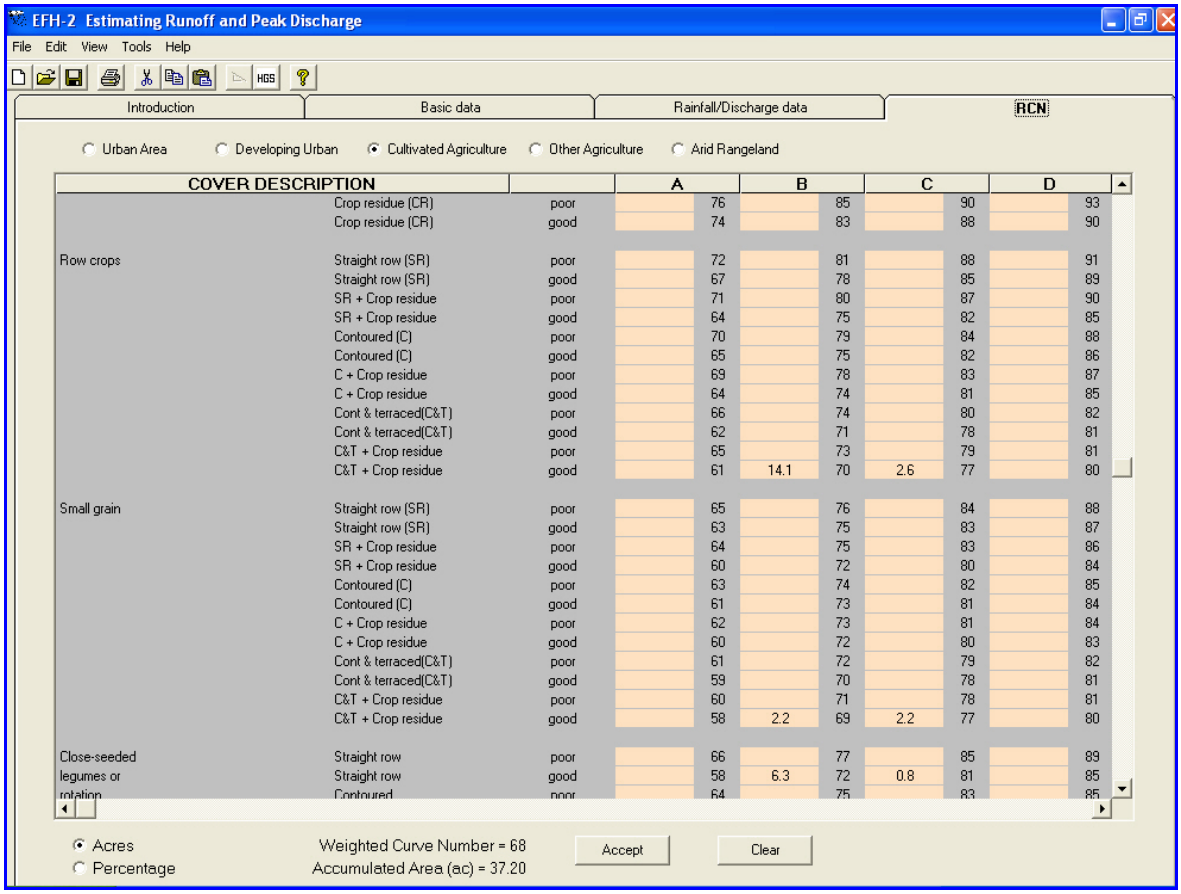


Figure 5B. Basic Data tab (Example B)

Step 2. RCN *tab*

Click on the **RCN** tab and enter the appropriate soil-cover complex and area information in order to calculate the runoff curve number for the watershed. Note that farm fields A and C, and also C and D have the same land use soil-cover complexes for part of their total acreage. The acres for these similar cover descriptions will need to have their acreage combined and reported as one value in the table.

Upon completion of data entry, the **RCN** tab should appear as shown in Figure 6B. Notice that the entry of 14.1 acres for Row Crop, Contoured and Terraced, with Crop Residue in good condition includes 2 acres in field C and 12.1 acres in field C.



COVER DESCRIPTION			A		B		C		D	
	Crop residue (CR)	poor		76		85		90		93
	Crop residue (CR)	good		74		83		88		90
Row crops	Straight row (SR)	poor		72		81		88		91
	Straight row (SR)	good		67		78		85		89
	SR + Crop residue	poor		71		80		87		90
	SR + Crop residue	good		64		75		82		85
	Contoured (C)	poor		70		79		84		88
	Contoured (C)	good		65		75		82		86
	C + Crop residue	poor		69		78		83		87
	C + Crop residue	good		64		74		81		85
	Cont & terraced(C&T)	poor		66		74		80		82
	Cont & terraced(C&T)	good		62		71		78		81
	C&T + Crop residue	poor		65		73		79		81
	C&T + Crop residue	good		61	14.1	70	2.6	77		80
Small grain	Straight row (SR)	poor		65		76		84		88
	Straight row (SR)	good		63		75		83		87
	SR + Crop residue	poor		64		75		83		86
	SR + Crop residue	good		60		72		80		84
	Contoured (C)	poor		63		74		82		85
	Contoured (C)	good		61		73		81		84
	C + Crop residue	poor		62		73		81		84
	C + Crop residue	good		60		72		80		83
	Cont & terraced(C&T)	poor		61		72		79		82
	Cont & terraced(C&T)	good		59		70		78		81
	C&T + Crop residue	poor		60		71		78		81
	C&T + Crop residue	good		58	2.2	69	2.2	77		80
Close-seeded	Straight row	poor		66		77		85		89
legumes or	Straight row	good		58	6.3	72	0.8	81		85
rotation	Contoured	poor		64		75		83		85

Figure 6B. RCN tab (Example B)

As summarized at the bottom of the **RCN** tab and shown in Figure 6B, the Weighted Curve Number computed by **EFH2** is 68; and the Accumulated Area is 37.20 acres.

When data entry is complete, click Accept to automatically return to the **Basic data** tab.

Step 3. Basic data *tab*

Upon returning from the **RCN** tab, note the purple text indicating Drainage Area and Runoff Curve Number were developed using the RCN Calculator (Figure 7B).

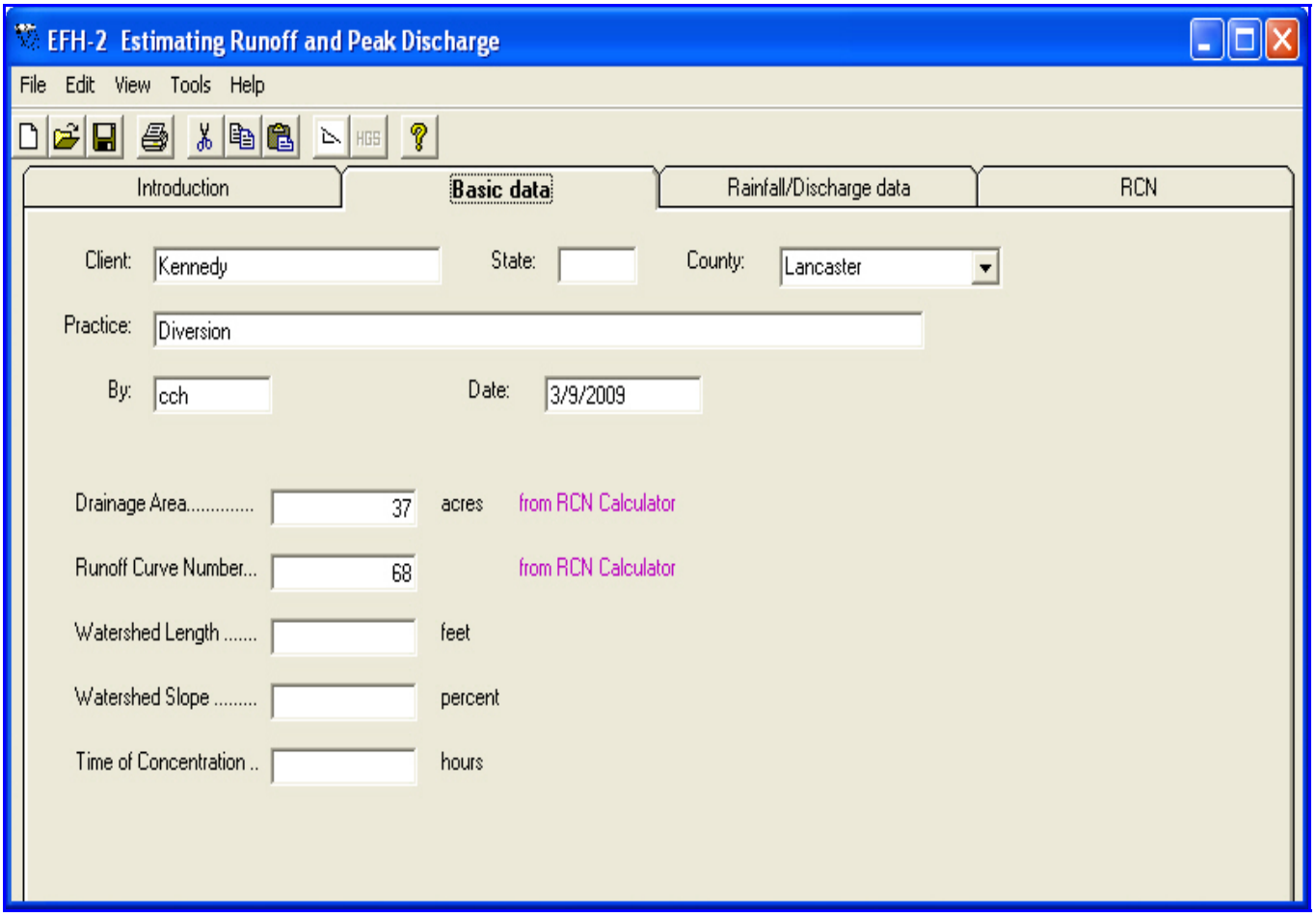


Figure 7B. Basic Data tab showing drainage area and runoff curve number carried over from RCN tab (Example B)

Enter the Watershed Length (measured previously, as described in the problem introduction, to be 3,300 feet) and the average Watershed Slope (computed as described in the problem introduction) of 7.7 percent.

The program automatically calculates Time of Concentration, using the Lag equation, to be0.698 hours and displays it as 0.70 hours with a note in purple text to indicate that the Time of Concentration was calculated as illustrated in Figure 8B.

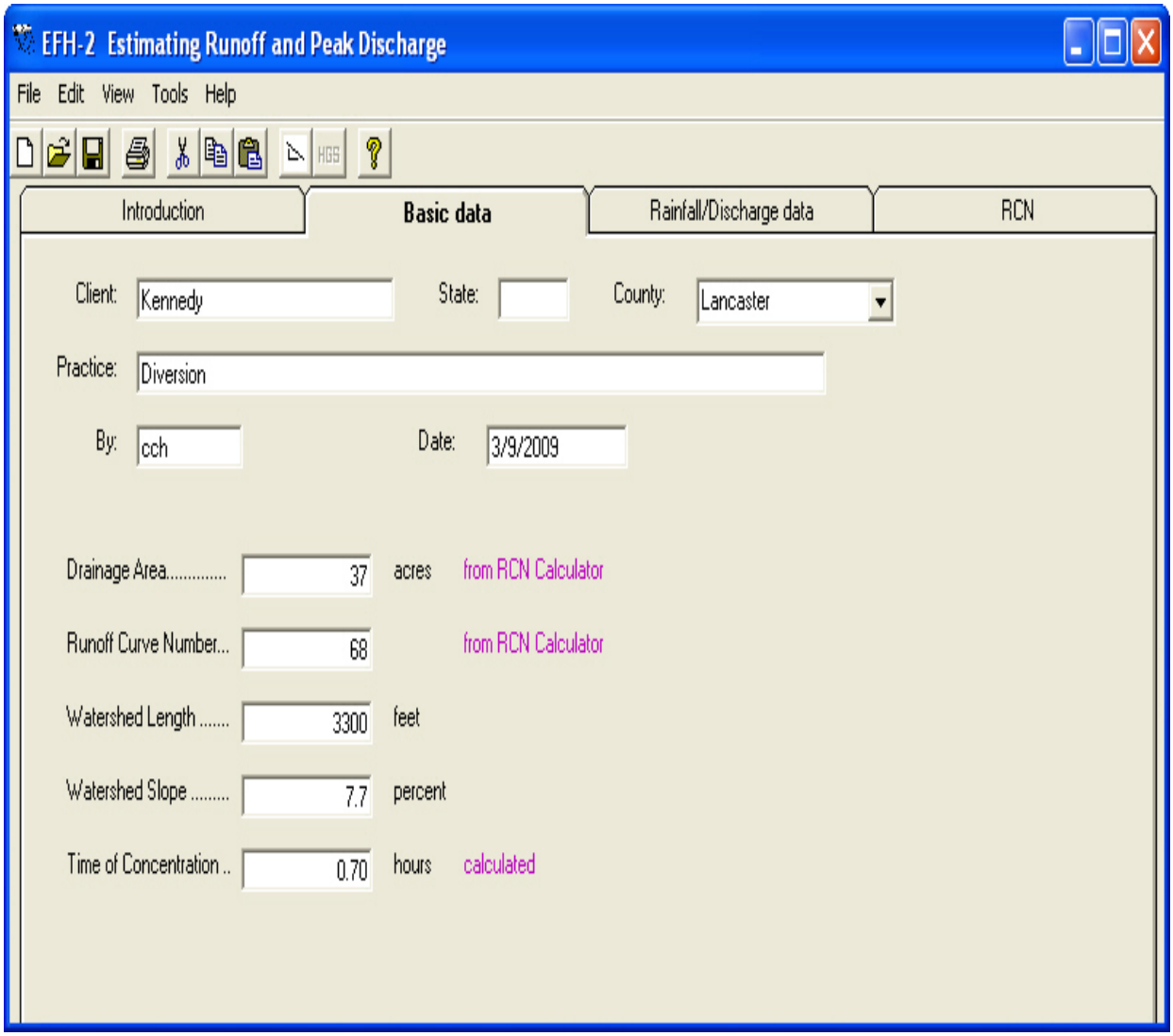


Figure 8B. Basic Data tab showing time of concentration data calculated from user input watershed length and slope (Example B)

Step 4. Rainfall/Discharge data *tab*

Click on the **Rainfall/Discharge data** tab. Since no rainfall data was available for Pennsylvania, this tab will initially display with blanks as shown in Figure 9B and data will have to be manually entered.

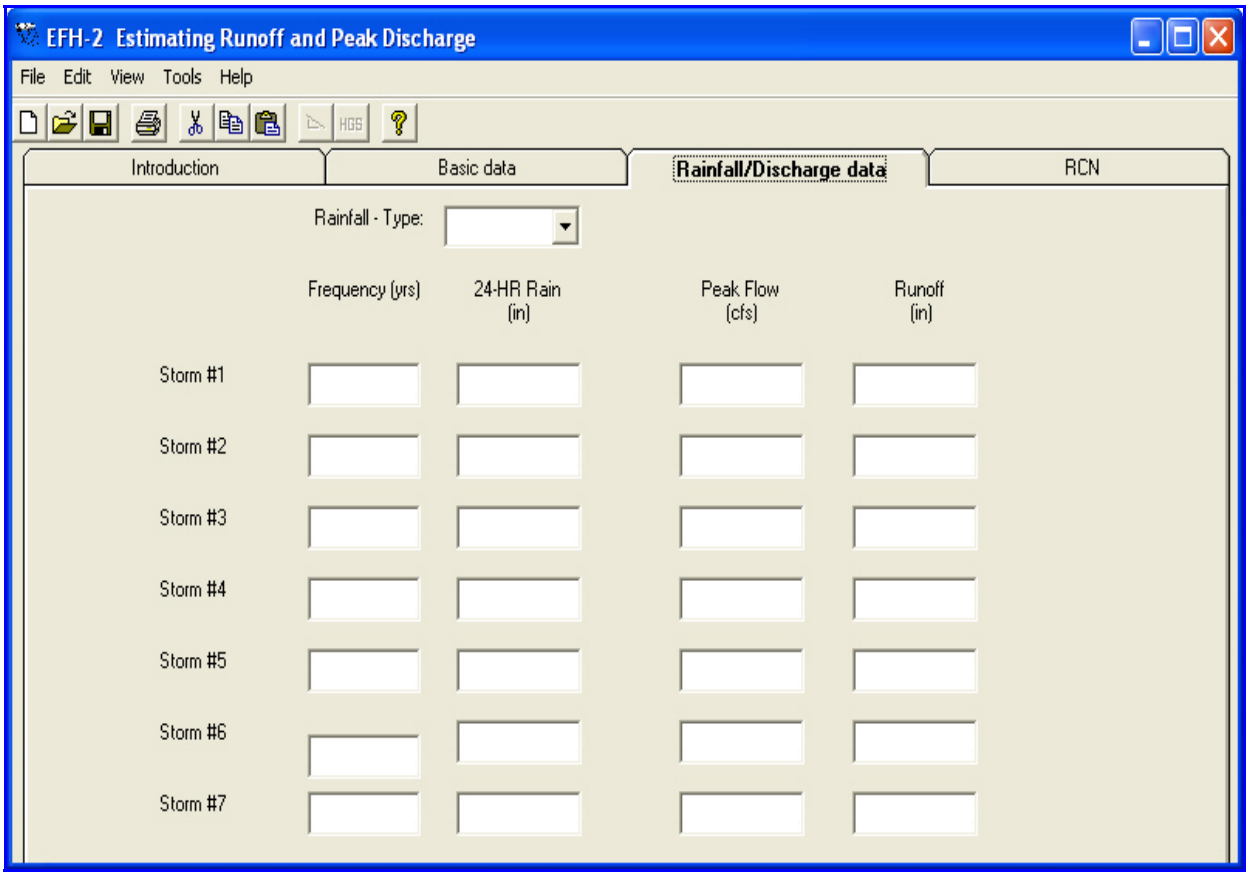


Figure 9B. Blank Rainfall/Discharge data tab (Example B)

Select the Rainfall-Type II for Pennsylvania. For Storm #1, enter 25 for Frequency and 6.1 inches for the 24-hour rain. The rainfall data (Rainfall – Type, and rainfall volumes (24-hour rainfall amounts by Frequency and Storm #) for up to 7 storms can be displayed on the **Rainfall/Discharge data** tab for the county/State combination entered on the **Basic data** tab.

Provided that data on the **Basic data** tab is complete, the discharge data (Peak flow and Runoff volume) for the 25-year storm is calculated and displayed as shown in Figure 10B. If the values are not displayed, return to the **Basic data** tab and ensure that data entry is complete.

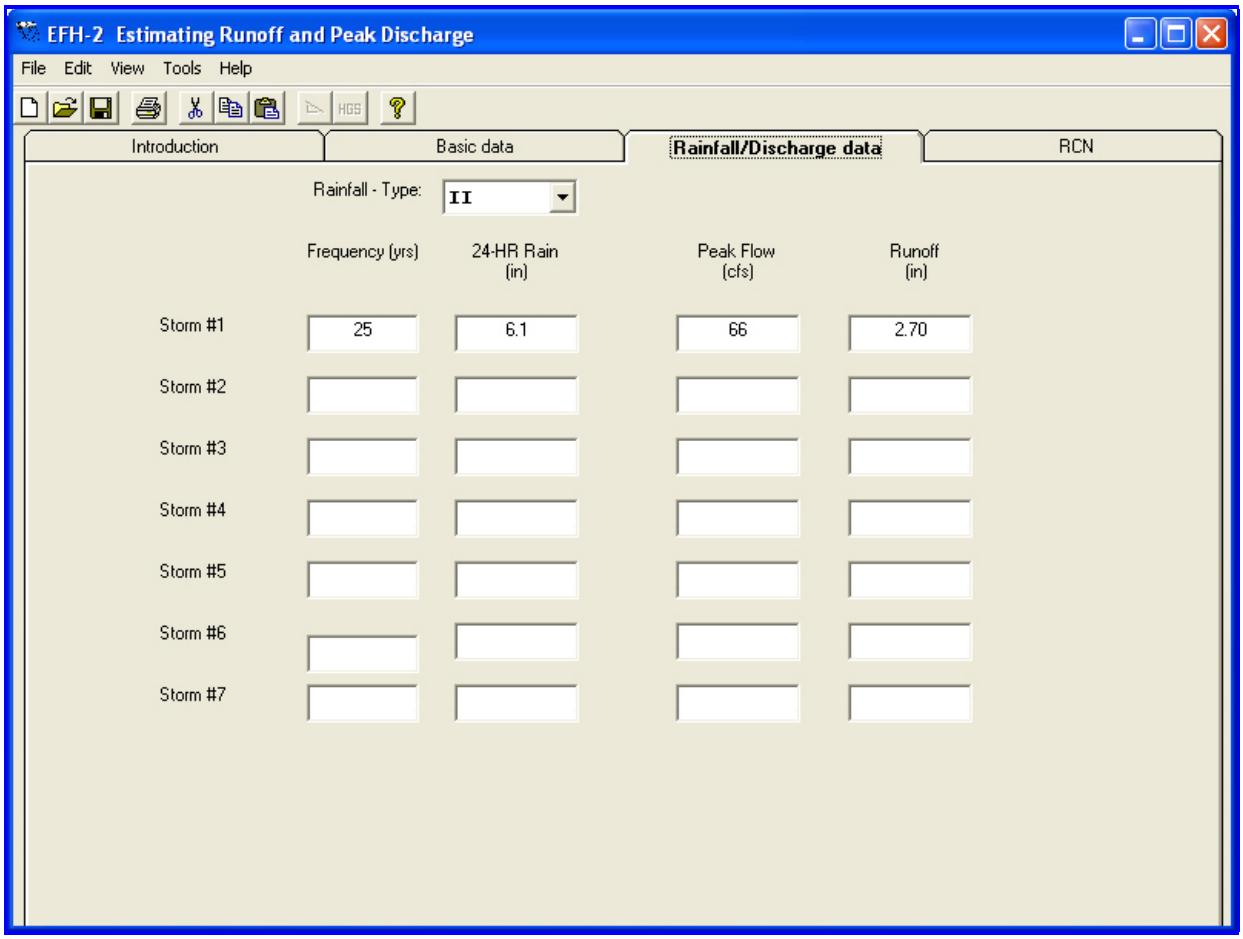


Figure 10B. Rainfall/Discharge data tab showing computed runoff volume and peak flow rate for 25-year, 24-hour rainfall event (Example B)

Conclusion

The 25-year, 24-hour rainfall of 6.1 inches results in a peak flow rate of 66 cfs and a runoff volume of 2.7 inches. The design capacity peak flow rate to use in sizing the diversion is 66 cfs.

Intentionally Blank

Example Problem C

Problem Statement

The site is the same as in Example B, except that the EHF2 Average Slope Calculator will be used to calculate the Average Watershed Slope.

From the watershed map, measure the length of the contour lines and sum them.

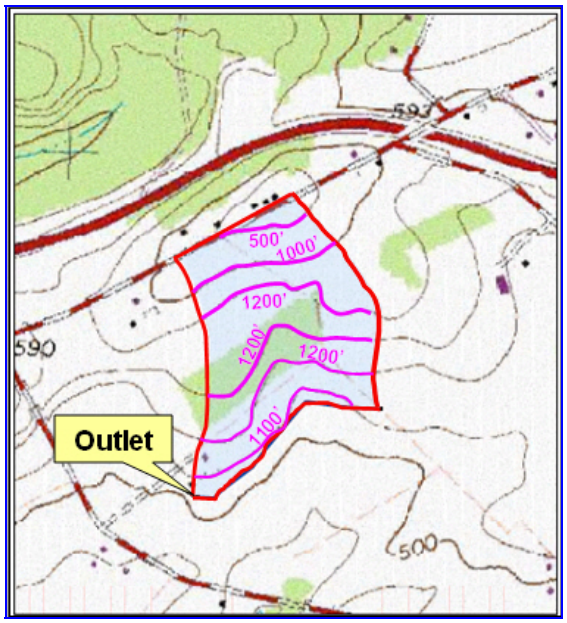


Figure 1C. Lengths of contour lines within the watershed boundary (Example C)

The total length of all the contour lines in the watershed:

500'
1,000'
1,200'
1,200'
1,200'
+ 1,100'
6,200'

The contour line interval is 20 feet. The drainage area is 37 acres.

Click on the Average Slope Calculator Button:

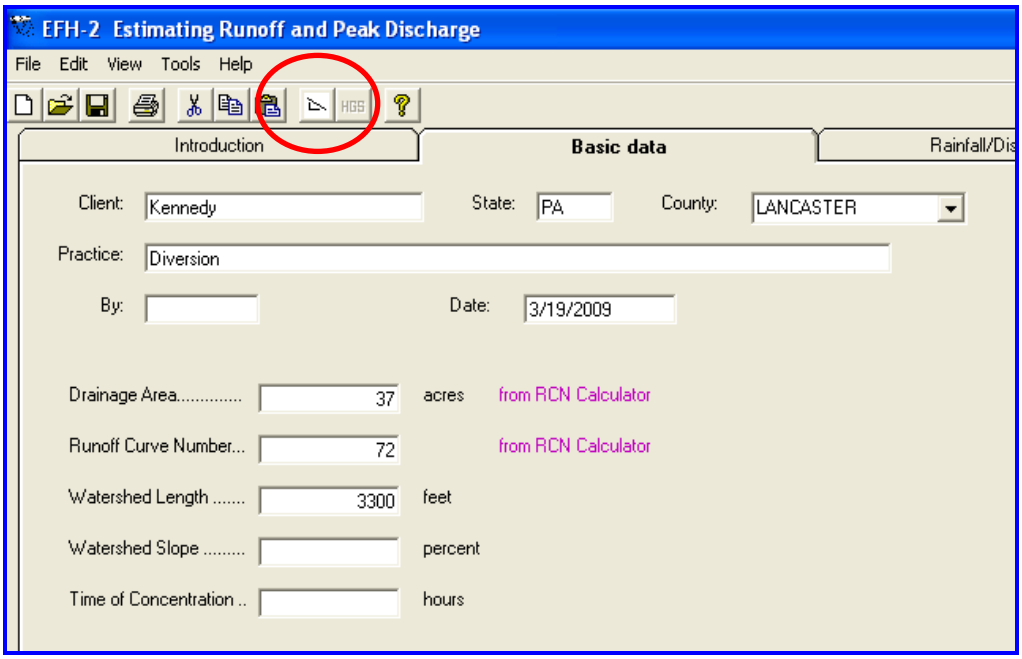


Figure 2C. Average Slope Calculator button (Example C)

Enter 6,200 feet for the length of the contours, 20 feet for the contour interval, and 37 acres for the drainage area, as calculated from the RCN tab in Example B.

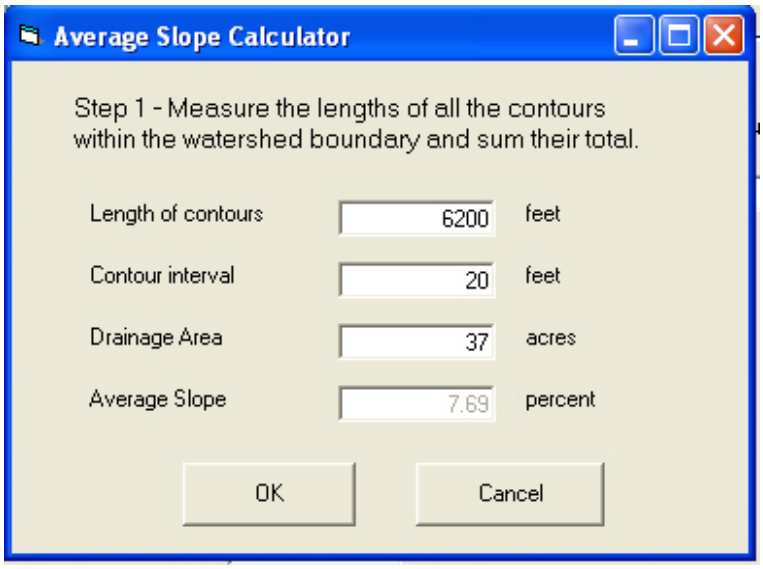


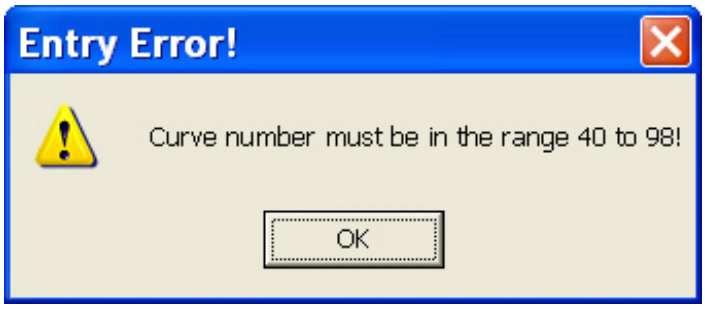
Figure 3C. Average Slope Calculator window (Example C)

The calculated slope is 7.7 percent. Proceed with the problem solution following Steps 1 through 4 in Appendix B.

Note: If the user calculates the Average slope by both the methods in Appendix B and C and compares them, they will most likely have somewhat different values. These differences can result in differences in the final answer. The user must then decide which is more appropriate to use.

Errors & Messages

EFH2 has a number of Error Messages and Warnings to assist the user in developing an error free data file. These are displayed in windows similar to the example shown below:



The Error messages and warnings are listed below, with suggestions for correcting the data file.

- **"Basic Data values are different from RCN values!"** Values on the Basic Data tab are different from those in the RCN tab. Correct one or the other and continue.
- **"Could not be found. Correct before running EFH2 program."** The missing data should be added before running the program.
- **"Curve number must be in the range 40 to 98!"** Enter curve number within the given range.
- **"Do you want the save the changes you have made to this data?"** To keep the changes, save the data; otherwise, exit the program, losing changes made since the last save.
- **"Drainage area must be greater than 1 acre!"** Enter drainage area greater than 1 acre.
- **"Drainage area must be in the range of 1 to 2000 acres!"** Drainage area for the project must be within the limits given.
- **"Drainage area must be less than 2000 acres! Use another procedure."** Use WinTR-55 or WinTR-20 for the analysis.
- **"Land use area must equal 100 percent before accepting."** While using the percentage option on the RCN tab, the user has made entries that, when added together, are less than 100 percent. Correct the entries to total 100 percent.
- **"More than 10% of watershed is urban land use. Recommend using TR55. Press Retry to revise or Cancel to Exit."** EFH2 is not recommended for use in watersheds with greater than 10 percent urban land use. Revise the data or use another program such as WinTR-55 or WinTR-20.
- **"Must enter data before accepting."** The user must enter some data on the RCN tab before clicking on the accept button. Enter some data and continue.

- **"No rainfall data file found for " & State.Text & ", using default rainfall data file (County.rf)."** A rainfall data file has not been included for the State indicated. If the County.rf file has not been developed for the State in interest, the user must then enter the rainfall frequency and depth data on the Rainfall/Discharge Tab.

- **"Please enter 2 character State abbreviation code."** The user may click on the Cancel button and continue entering data with the State and County fields left empty. They must then enter the rainfall frequency and depth data on the Rainfall/Discharge Tab.

- **"Rainfall is outside the range of 0 to 26 inches."** Keep the rainfall depths within this range or use WinTR-55, which accepts rainfalls from 0 to 50 inches in depth.

- **"The calculated TC is > 10.0 hours. TC adjusted to 10.00 hrs."** If the adjusted Tc of 10.00 hours is satisfactory, continue with the project. To use a Tc greater than 10.00 hours the user must employ another program such as WinTR-20.

- **"The calculated TC is < 0.1 hour. TC adjusted to 0.10 hrs."** If the adjusted Tc of 0.1 hour is satisfactory, continue with the project. To use a Tc less than 0.1, the user must employ another program such as WinTR-20.

- **"The Slope is exceeds the limitation (0.1 to 64%) - Please check your data"** Correct the slope to fall within the recommended limits or use a different program.

- **"Time of Concentration can not be less than 0.1 hours."** Enter a Time of Concentration greater than 0.1 hours and continue.

- **"Time of Concentration > 10 - compute aborted"** Correct Time of Concentration to be equal to or less than 10 hours.

- **"Total land use area exceeds 100 percent. Must correct to exit cell."** While using the percentage option on the RCN tab, the user has made entries that when added together exceed 100 percent. Correct the entries to total 100 percent.

- **"Total land use area exceeds 2000 acres. Must correct to exit cell."** Reduce the land use area to 2000 acres or less and continue.

- **"Type.rf file is corrupt. Correct before running EFH2 program."** Correct the type file before running the program.

- **"Unable to display Help Contents. There is no Help associated with this project."** Check that the file EFH2.chm is present in the directory where the EFH2.exe file resides. If not, download it or request your IT contact to download it.

- **"Watershed length must be in the range 200 to 26000 feet!"** Correct the watershed length value to be within this range and continue.

- **"Watershed slope is less than 0.5 percent! Results may not be valid."** Although the user may run the program with slopes less than 0.5 percent, the results should be thoroughly checked for validity.

- **"Watershed slope must be less than 64 percent!"** Correct the watershed slope to be less than 64 percent and continue.

- **"Watershed slope should be more than 0.5 percent, but must be more than 0.1 percent!"** The program will run with slopes between 0.1 and 0.5, but the user should check the results carefully.

- **"Weighted Curve Number not in range 40 to 98."** Revise the data so that the Weighted Curve Number is within the recommended limits.