Commonwealth of Virginia

Virginia Department of Transportation

Location and Design Hydraulic Application
Software User Documentation

Date: February 29, 2016
Version: 4.0

This material is the sole property of the Virginia Department of Transportation and may contain confidential information. This material may not be copied, reproduced, republished, uploaded, posted, transmitted, distributed, or used in any way for creation of derivative works including, but not limited to, documents, computer programs, prototypes, and programming code is forbidden without the express permission of VDOT ITD.

Table of Contents

1. INTRODUCTION 1

1.1 OVERVIEW 1
1.2 PURPOSE 1
1.3 ACCESSIBILITY 1
1.4 REQUIREMENTS 1

2. GENERAL FUNCTIONALITY 2

2.1 MENU 2
2.1.1 Home 2
2.1.2 Modules 2
2.1.3 Administration 2
2.1.4 Help 3
2.2 FORM CONTROLS 3
2.2.1 Textbox 3
2.2.2 Dropdown 3
2.2.3 Checkbox 3
2.2.4 Checkbox List 3
2.2.5 Radio Button 4
2.2.6 Calendar 4
2.3 MODULE FORM 5
2.3.1 Project Description 5
2.3.2 Project Details 5
2.3.3 Project Results 5
2.3.4 Scenario 5
2.3.5 Calculating Results 6
2.3.6 Printing Results 6

3. SPECIFIC MODULES 7

3.1 BRRIPRAP – SIZING RIPRAP FOR BRIDGE ABUTMENTS 8
3.1.1 Introduction 8
3.1.2 Algorithm 8
3.1.3 Details Entry 9
3.1.4 Upload Existing Input File 9
3.1.5 Results 9
3.1.6 Print Out 10
3.2 CRITSTRM – CRITICAL STORM DURATION (UTILIZING THE RATIONAL METHOD) 11
3.2.1 Introduction 11
3.2.2 Algorithm 11
3.2.3 Details Entry 11
3.2.4 Upload Existing Input File 11
3.2.5 Results 12
3.2.6 Print Out 13
3.3 DISCHAR – PEAK DISCHARGES USING ANDERSON AND SNYDER METHODS 14
3.3.1 Introduction 14
3.3.2 Algorithm 14
3.3.3 Details Entry 16
3.3.4 Upload Existing Input File 17
3.3.5 Results 17
3.3.6 Print Out 18
3.4 EPSON – LOG PEARSON TYPE III FREQUENCY CALCULATIONS 19

3.4.1 Introduction....19
3.4.2 Algorithm....19
3.4.3 Details Entry....19
3.4.4 Upload Existing Input File....21
3.4.5 Results....21
3.4.6 Print Out....22
3.5 HY-15 – DESIGN OF CHANNELS WITH FLEXIBLE LININGS....23
3.5.1 Introduction....23
3.5.2 Algorithm....23
3.5.3 Details Entry....23
3.5.4 Upload Existing Input File....24
3.5.5 Results....24
3.5.6 Print Out....25
3.6 IRRCHANL – IRREGULAR CHANNEL, STAGE-DISCHARGE....26
3.6.1 Introduction....26
3.6.2 Details Entry....26
3.6.3 Upload Existing Input File....27
3.6.4 Results....28
3.6.5 Print Out....28
3.7 PFLOW – PIPE FLOW (IN CIRCULAR PIPES)....30
3.7.1 Introduction....30
3.7.2 Algorithm....30
3.7.3 Details Entry....31
3.7.4 Upload Existing Input File....31
3.7.5 Results....32
3.7.6 Print Out....32
3.8 PQTRANS – PEAK DISCHARGE TRANSFER....33
3.8.1 Introduction....33
3.8.2 Algorithm....33
3.8.3 Details Entry....34
3.8.4 Upload Existing Input File....34
3.8.5 Results....35
3.8.6 Print Out....35
3.9 RDDITCH – FLOW IN MEDIAN AND SIDE DITCHES....37
3.9.1 Introduction....37
3.9.2 Algorithm....37
3.9.3 Details Entry....39
3.9.4 Upload Existing Input File....40
3.9.5 Results....42
3.9.6 Print Out....43
3.10 REGEQUAT – REGRESSION EQUATIONS CALCULATION....44
3.10.1 Introduction....44
3.10.2 Algorithm....44
3.10.3 Details Entry....47
3.10.4 Upload Existing Input File....48
3.10.5 Results....48
3.10.6 Print Out....49
3.11 RIPRAP – BASED ON PROCEDURES PRESENTED IN FHWA'S "HEC-11" AND "HIGHWAYS IN THE RIVER ENVIRONMENT" PUBLICATIONS....50
3.11.1 Introduction....50
3.11.2 Algorithm....50
3.11.3 Details Entry....50

3.11.4 Channel RipRap Design 51
3.11.5 Wave Action RipRap Design 52
3.11.6 Tractive Force 55
3.11.7 Upload Existing Input File 57
3.12 VIRTOC – VIRGINIA RATIONAL METHOD AND TIME OF CONCENTRATION 58
3.12.1 Introduction 58
3.12.2 Algorithm 58
3.12.3 Details Entry 63
3.12.4 Upload Existing Input File 63
3.12.5 Results 64
3.12.6 Print Out 65

4. ADMINISTRATION 66

4.1 PASSWORD 66
4.1.1 Introduction 66
4.1.2 Functionality 66

DOCUMENT CONTROL 67

1. INTRODUCTION

The web based Hydraulic Application is a replacement of the comparable DOS Based Hydraulic Programs.

Note: The application of this software product is the responsibility of the user. There are no expressed or implied warranties.

1.1 OVERVIEW

Each of the modules, previously individual programs, will be detailed in the "Specific Modules" section of this document.

1.2 PURPOSE

The purpose of this Web Application was to give a less complicated more user friendly interface for all the Hydraulic Programs, use a centralized Rainfall BDE table, and to port the programs to a more stable implementation for current Windows platforms.

1.3 ACCESSIBILITY

The Location and Design standard image includes a desktop shortcut to the Hydraulic Program. Clicking this shortcut will bring up Internet Explorer, and automatically assign the web location of the Hydraulic Application as the web address.

A link to this application can also be found on the portal under Applications, in the Design category.

1.4 REQUIREMENTS

This application was developed for use with in Internet Explorer 11.0 or above. The printer friendly option of the individual modules requires a minimum of Adobe Acrobat Reader X(10.1.3), or Excel 2007 depending on the module or administration option chosen.

2. GENERAL FUNCTIONALITY

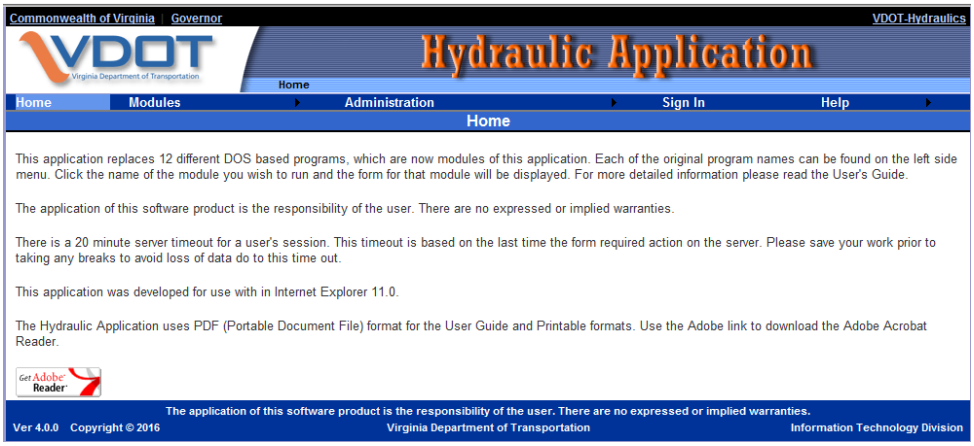


Figure **2** Home Page

2.1 MENU

Figure **2.1** Menu

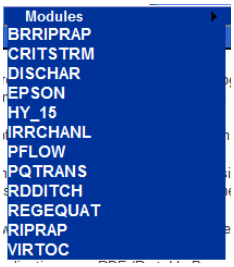
2.1.1 Home

Home displays the Application Summary.

2.1.2 Modules

Modules, is the parent menu which house all the module menu options.

2.1.2.1 Modules – Menu Options

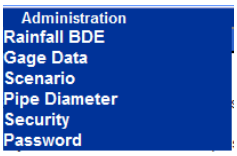


When the user clicks on a menu option to the left, the appropriate module's web form is displayed.

2.1.3 Administration

Administration, is the parent menu which house all the administration menu options.

2.1.3.1 Administration – Menu Options



When the user clicks on the menu options to the left, the appropriate administration web form is displayed.

If the user does not have sufficient access right, an error message will be displayed to the user, and access to web forms details will be denied.

2.1.4 Help

Help, is the parent menu which house all the help menu options.

2.1.4.1 Administration – Menu Options

- Online User Manual – This is an interactive online help system.
- Printable User Manual – This is an Adobe PDF format document.
- Printable Admin Manual – This option is only activated after successfully attempting to access one of the Administrative functions, that only an administrator has access too. This is an Adobe PDF format document.

2.2 Form Controls

2.2.1 Textbox

Textbox input can display one line or multiple lines of input.

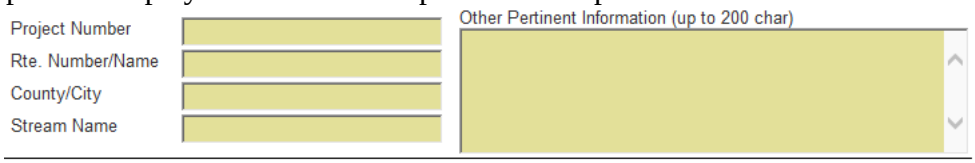


Figure 2.2.1: Sample of Textboxes

2.2.2 Dropdown

Dropdown controls allow the user to select an option.

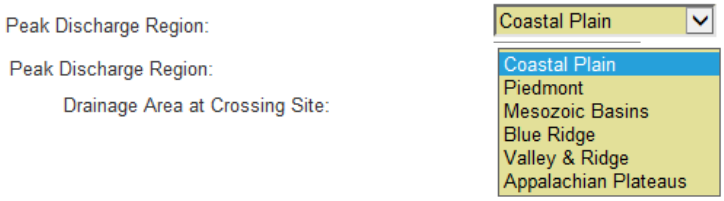


Figure 2.2.2: Sample of dropdown

2.2.3 Checkbox

This type of control allows the user to select a specific option.

Figure 2.2.3: Sample of a checkbox

2.2.4 Checkbox List

This type of control allows the user to select multiple options.

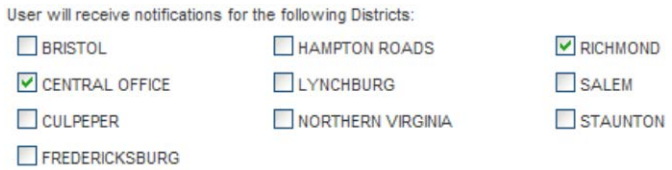


Figure 2.2.4: Sample of a checkbox list

2.2.5 Radio Button

Radio buttons require only one option to be selected.

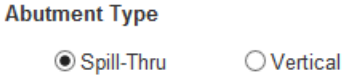


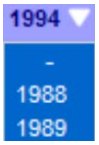
Figure 2.2.5: Sample of a Radio Button

2.2.6 Calendar

Figure 2.2.6: Sample of Calendar controls

The user may enter a date by either keying the date into the Textbox or selecting the day from the popup calendar.

- Display the calendar by clicking on the button. Once the calendar is displayed the user can…
- Use the left and right arrow buttons to step backward or forward in the calendar.
- Use the down arrow next to the month

to select a specific month.
- Use the down arrow next to the year 

to select a specific year. Within the year list there may also be "-" and a "+" character, this allows the user to step through additional years.
- Select the date to fill the textbox by clicking the specific day.

2.3 MODULE FORM

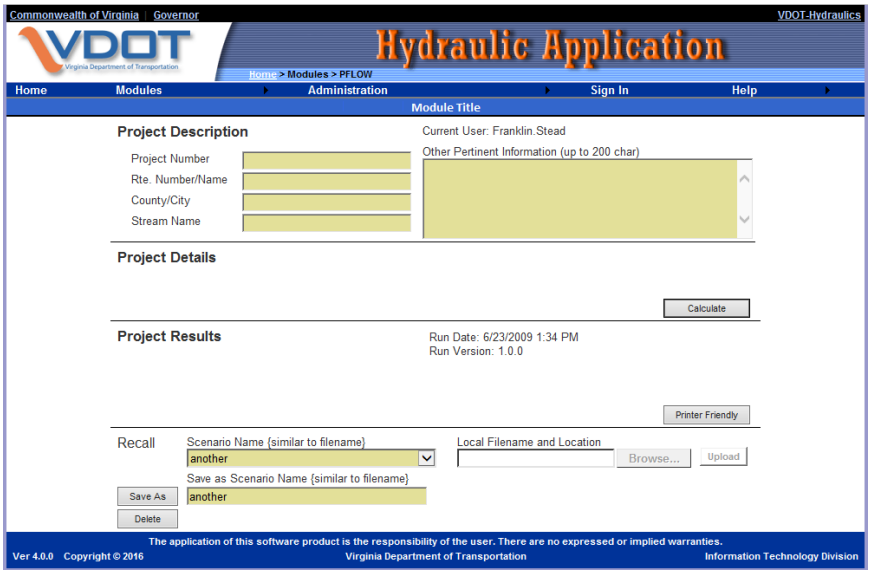


Figure **2.3** Web form standard sections

Each module form has the same general set of blocks. The next few sections will describe those areas.

2.3.1 Project Description

The Project Description block, is an optional set of fields used to provide detailed information on a printed report. This block is not required to be filled out; but it is recommended if the scenario is to be printed.

2.3.2 Project Details

The Project Details block, is where all the entry fields will be displayed. Most of the modules require that all the fields be completed and will have some validation of the data entered.

2.3.3 Project Results

The Project Results block only displays if there is result data to be displayed. Therefore upon completion of a calculation, or recall of a previously calculated scenario, this block will be displayed.

2.3.4 Scenario

The Scenario Block is an optional set of fields and functions. Since the Detail and Result data are now stored in a database, and there is no file name, the scenario term was adopted to replace the filename. The scenario name and user id uniquely identify a set of data.

2.3.4.1 Recalling an existing Scenario from the database

The user can select any scenarios that they created and saved to the database for the specific module that is current displayed from a drop down list. Upon this selection the Project Description, Project Details, and, if available, Project Results will be displayed.

2.3.4.2 Saving a Scenario

The user can save Scenarios back to the database by entering a name for the scenario next to the "Save As", and then clicking the "Save As" button. If the scenario was a recalled scenario from the database, the user may either give it a new name, creating a new scenario, or save over the old scenario.

NOTE: The only time an existing name can be overwritten is when that scenario is recalled.

NOTE: Only the current information will be saved when the "Save As" button is clicked, and no other time will the data be saved. You can use the "Save As" to save your details prior to clicking the "Calculate" button; however to save the result data, one must click "Save As" after the calculation is complete.

2.3.4.3 Deleting a Scenario

First recall the scenario. Then click the "Delete" key, this will delete the scenario from the database.

2.3.4.4 Uploading a Data File

If the module's DOS based predecessor had the ability to open a file for data input, then that module will be able to upload that file and import the data from there. Once the data is imported the user can save it to the database as a scenario, just follow the 2.2.4.2, Saving a Scenario.

2.3.5 Calculating Results

Once the user has completed the entry of all the required Project Details, the user can click the "Calculate" button. This will process the Project Details and display the Project Results.

2.3.6 Printing Results

If the user wanted to either print or save a printable copy of the scenario information, the user would click the "Printer Friendly" button. This will open a new Browser window or Tab and download a PDF form of the data.

3. SPECIFIC MODULES

This section details the specific modules available within the application. Each module was previously an individual DOS based program.

3.1 BRRIPRAP – SIZING RIPRAP FOR BRIDGE ABUTMENTS

3.1.1 Introduction

This module was developed using equations and procedures described in the Federal Highway Administration's publication entitled "BRIDGE SCOUR AND STREAM INSTABILITY COUNTERMEASURES" as revised March, 2001. The publication is more popularly known as "HYDRAULIC ENGINEERING CIRCULAR (HEC) NO. 23". It is publication no. FHWA NHI 01-003 and can be obtained at the following web address:

http://www.fhwa.dot.gov/engineering/hydraulics/pubs/hec/hec23.pdf or use the search feature at http://www.fhwa.dot.gov if the link doesn't work.

It is important that the user be aware that this module must be used in conjunction with "HEC-18". The parameters utilized in this module and how to determine them will vary from situation to situation and are only explained in that publication.

3.1.2 Algorithm

This module employs three equations presented in the "HEC-23" publication for sizing riprap protection to be placed around bridge abutments. The first equation is for the determination of the Froude Number and is as follows:

$$F_r = \frac{V}{(gy)^{0.5}}$$

Where

F_r = Froude Number

V = characteristic average velocity in the contracted opening in fps

(See "HEC-18" for explanation of "characteristic average velocity)

g = acceleration due to gravity, 32.2 fps^2

y = depth of flow in the contracted bridge opening

The Froude Number is calculated first to determine which of the two riprap equations will be employed to determine the required size. If the Froude Number is equal to or less than 0.8 the following equation (shown as "first equation" in the module) will be used:

$$\frac{D_{50}}{y} = \frac{K}{(S_S - 1)}\left[\frac{V^2}{gy}\right]$$

Where

D_{50} = the diameter of the median stone size in ft

V = same as noted above

S_S = specific gravity of rock riprap (usually 2.65)

y = same as noted above

K = 0.89 for spill-through (i.e. shelf) abutment
1.02 for vertical (i.e. solid) abutment

If the Froude Number is greater than 0.8 the following equation (shown as "second equation" in the module) will be used:

$$\frac{D_{50}}{y} = \frac{K}{(S_s - 1)}\left[\frac{V^2}{gy}\right]^{0.14}$$

Where all parameters but "K" are the same as noted above

K = 0.61 for spill-through (i.e. shelf) abutment
0.69 for vertical (i.e. solid) abutment

NOTE: The exact value of "V" will vary in accordance with the circumstances described in the "HEC-23" publication.

3.1.3 Details Entry

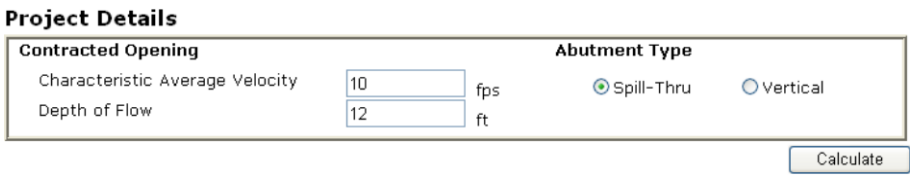


Figure **3.1.3** Details Section of web form for BRRIPRAP

The user will provide the value of "V" (the characteristic average velocity in the contracted opening), the value of "y" (depth of flow in the contracted bridge opening), and select the type of abutment (spill-through or vertical)

3.1.4 Upload Existing Input File

This module does not support the uploading of an existing input file.

3.1.5 Results

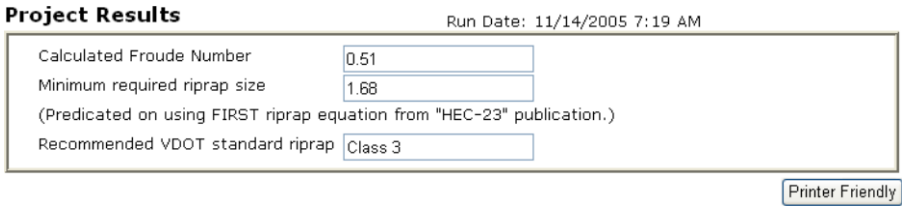
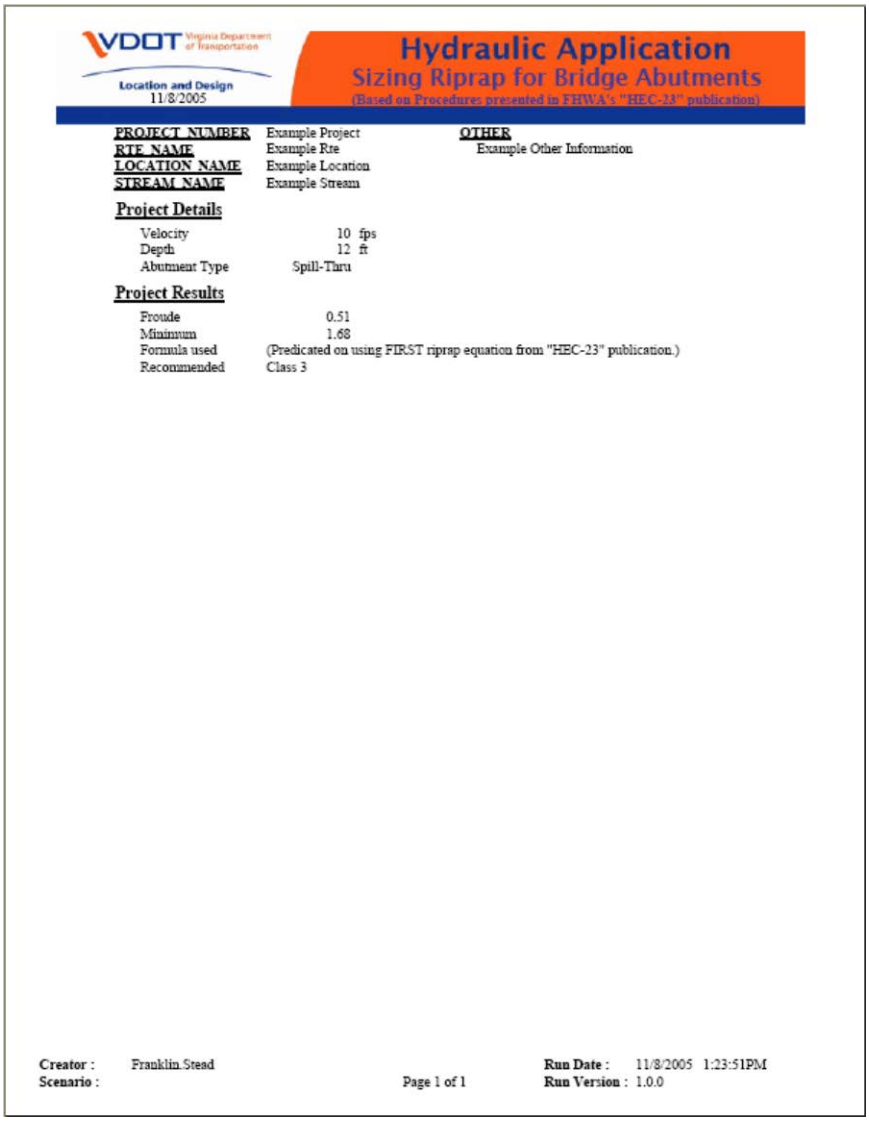


Figure **3.1.5** Results Section of web form for BRRIPRAP

Once the user has entered the required details and clicked the “Calculate” button, the Results section of the page will be displayed.

3.1.6 Print Out



VDOT Virginia Department of Transportation
Location and Design
11/8/2005

Hydraulic Application
Sizing Riprap for Bridge Abutments
(Based on Procedures presented in FHWA's "HEC-23" publication)

PROJECT NUMBER	Example Project	**OTHER**	
RTE NAME	Example Rte	Example Other Information	
LOCATION NAME	Example Location		
STREAM NAME	Example Stream		

Project Details

Velocity	10	fps
Depth	12	ft
Abutment Type	Spill-Thru	

Project Results

Froude	0.51
Minimum	1.68
Formula used	(Predicated on using FIRST riprap equation from "HEC-23" publication.)
Recommended	Class 3

Creator : Franklin.Stead
Scenario :
Page 1 of 1
Run Date : 11/8/2005 1:23:51PM
Run Version : 1.0.0

Figure **3.1.6** Printable PDF for BRRIPRAP

The user has the option to obtain a PDF file of the Scenario; this can be obtained by clicking the "Printer Friendly" button. Figure 3.1.6 is a sample output of the PDF.

3.2 CRITSTRM – CRITICAL STORM DURATION (UTILIZING THE RATIONAL METHOD)

3.2.1 Introduction

This module determines the maximum flow volume for hydrographs derived using the Rational Formula.

The need for and the process of determining the Critical Strom Duration is describe in chapter 6 (Hydrology), section 6.4.5.1.4 of the "VDOT Drainage Manual".

3.2.2 Algorithm

The Rational Formula is expressed as

Q = CiA

where:

Q = Peak rate of runoff in cubic feet per second

C = Runoff coefficient, an empirical coefficient representing a relationship between rainfall and runoff.

i = Average intensity of rainfall in inches per hour for the time of concentration (Tc) for a selected frequency of occurrence or return period.

Tc = The rainfall intensity averaging time in minutes, usually referred to as the time of concentration, equal to the time required for water to flow from the hydraulically most distant point in the watershed to the point of design.

A = The watershed area in acres.

3.2.3 Details Entry

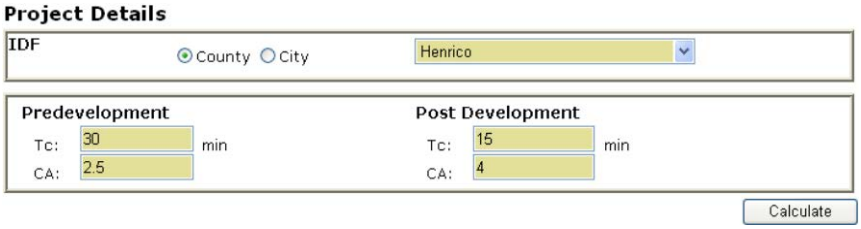


Figure **3.2.3** Details Section of web form for CRITSTRM

The user is required to select the IDF location type with the radio buttons, either "County" or "City", and then selecting the municipality from the dropdown list.

Then the user is required to enter the Tc and CA for both Predevelopment and Post Development.

3.2.4 Upload Existing Input File

This module does not support the uploading of an existing input file.

3.2.5 Results

Project Results

Run Date: 2/2/2016 9:50 AM
Run Version: 2.0.0

Duration Results (3 found)

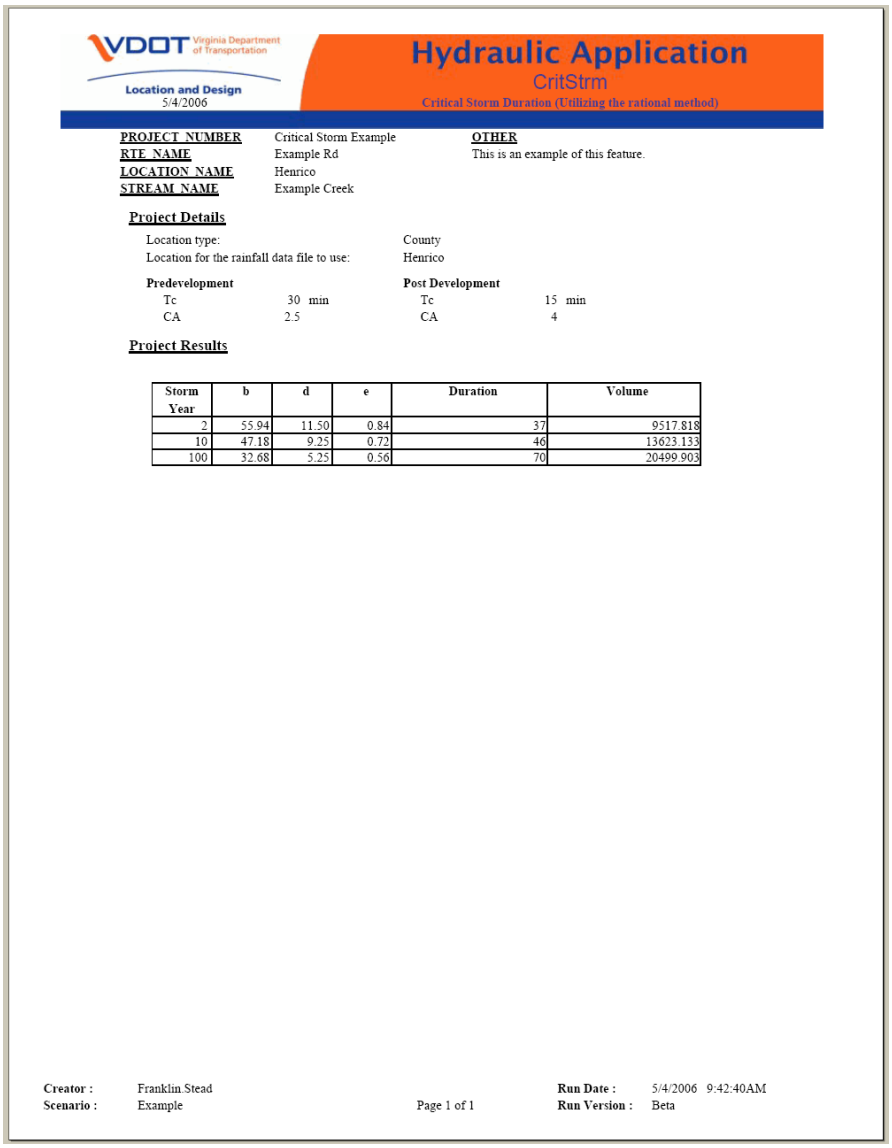
Storm Year	b	d	e	Duration (min)	Volume (cfs)
2	55.94	11.50	0.84	37	9517.818
10	47.18	9.25	0.72	46	13623.133
100	32.68	5.25	0.56	70	20499.903

Printer Friendly

Figure **3.2.5** Results Section of web form for CRITSTRM

Once the user has entered the required details and clicked the “Calculate” button, the Results section of the page will be displayed.

3.2.6 Print Out



VDOT Virginia Department of Transportation
Location and Design
5/4/2006

Hydraulic Application
CritStrm
Critical Storm Duration (Utilizing the rational method)

PROJECT_NUMBER	Critical Storm Example	**OTHER**	
RTE_NAME	Example Rd	This is an example of this feature.	
LOCATION_NAME	Henrico		
STREAM_NAME	Example Creek		

Project Details

Location type:		County	
Location for the rainfall data file to use:		Henrico	
Predevelopment		**Post Development**	
Tc	30 min	Tc	15 min
CA	2.5	CA	4

Project Results

Storm Year	b	d	e	Duration	Volume
2	55.94	11.50	0.84	37	9517.818
10	47.18	9.25	0.72	46	13623.133
100	32.68	5.25	0.56	70	20499.903

Creator : Franklin.Stead
Scenario : Example
Page 1 of 1
Run Date : 5/4/2006 9:42:40AM
Run Version : Beta

Figure **3.2.6** Printable PDF for CRITSTRM

The user has the option to obtain a PDF file of the Scenario; this can be obtained by clicking the "Printer Friendly" button. Figure 3.2.6 is a sample output of the PDF.

3.3 DISCHAR – PEAK DISCHARGES USING ANDERSON AND SNYDER METHODS

3.3.1 Introduction

This module is intended for use in computing peak discharges for watersheds of 200 acres or more. The module uses Daniel G. Anderson's method and Franklin F. Snyder's method.

Anderson's method was developed from test sites up to 570 square miles in northern Virginia. This method applies to an area of 200 acres or more. Anderson's method is entitled "EFFECTS OF URBAN DEVELOPMENT ON FLOODS IN NORTHERN VIRGINIA" and was published in 1968. A copy of the original study can be obtained from the U.S. Geological Survey by contacting:

U.S. Geological Survey
U.S. Books & Reports Sales
Federal Center
Box 25425
Denver, Colorado 80225
Phone: (303) 236-7476

Snyder's method was published in the October, 1958 in the A.S.C.E.'s "JOURNAL OF THE HYDRAULICS DIVISION". Refer to that publication for detailed explanation of this method. Application of the Snyder Method would be as indicated in Chapter VI of the VDOT "DRAINAGE MANUAL".

3.3.2 Algorithm

Since Snyder's method is covered in detail in the VDOT "DRAINAGE MANUAL" it will not be described herein. The parameters and equations utilized in the Anderson method are described below:

$$Q = R * 230 * K * A^{0.82} * T^{-0.48}$$

Where:

Q = the calculated peak discharge in cfs
R = flood frequency ratio for percentages of imperviousness ranging between 0 and 100% (obtained from formula cited below)
K = coefficient of imperviousness (obtained from formula cited below)
A = drainage area in sq. mi.
T = lag time in hours (obtained from one of the formulae cited below)

$$R = \frac{(R_n + 0.01 * I(2.5 * R_{100} - R_n))}{K}$$

Where:

R = as described above for return intervals of 2.33, 5, 10, 25, 50, and 100 years
R_n = flood frequency ratio for 0% imperviousness (i.e. completely rural).
R_{100} = flood frequency ratio for 100% imperviousness.

Years	Rn	R100
2.33	1.0	1.0
5	1.65	1.24
10	2.2	1.45
25	3.3	1.8
50	4.4	2.0
100	5.5	2.2

I = percentage of imperviousness
K = as described above and as obtained from the equation cited below
Note: With the exception of 500 year, it's R value is 1.7 * the R value from 100 year.

K = 1 + 0.015 I
Where:
K = as described above
I = percentage of imperviousness

Lag time, **T =**
for natural, rural basins: $\mathbf{4.64(L/(S^{0.5}))^{0.42}}$
for developed, partly channeled basins: $\mathbf{0.9(L/(S^{0.5}))^{0.5}}$
for completely sewered, fully developed basins: $\mathbf{0.56(L/(S^{0.5}))^{0.52}}$
Where: T = lag time in hrs.
L = basin length along the principal watercourse from the point of interest to the watershed divide in mi.
S = slope of basin along the principal watercourse from a point 10% of the total length above the site to a point 85% of the total length above the site in ft./mi.:
(El. @ 0.85L - El. @ 0.10L)/0.75L

NOTE: All formulae utilized in this module which have not been specifically addressed in this document may be found in the VDOT "DRAINAGE MANUAL".

3.3.3 Details Entry

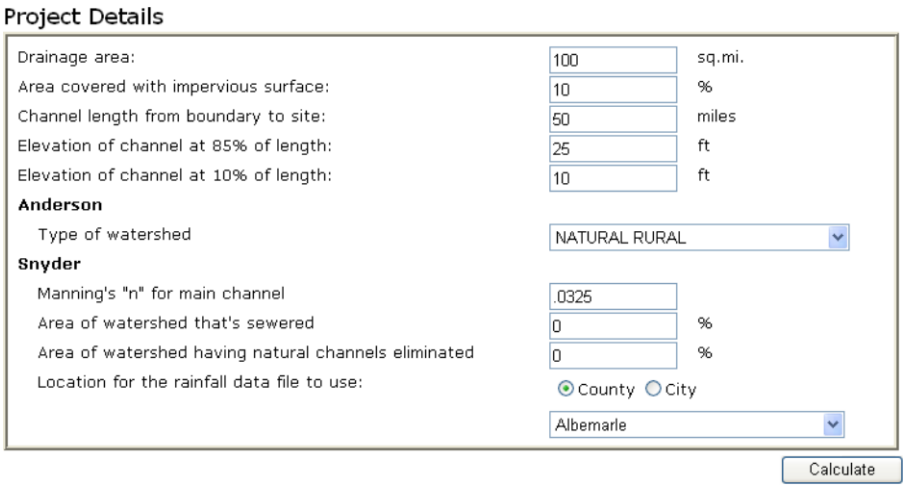


Figure **3.2.3** Details Section of web form for DISCHAR

The user is required to key…

- Drainage area, in square miles.
- Area covered with impervious surface, in percentage.
- Channel length, in miles. The length of the channel is the distance along the primary water course from the structure to the drainage area's boundary measured in miles.
- Elevation of channel at 85% length, in feet. This elevation is determined from the appropriate maps at a distance of 85 percent of the channel length from the structure. This value is used to calculate the slope of the main channel.
- Elevation of channel at 10% length, in feet. This elevation is determined from the appropriate maps at a distance of 10 percent of the channel length from the structure. This value is used to calculate the slope of the main channel.

For the Anderson method the user is required to select the “Type of watershed”. The type of watershed is selected from the three choices. A decision must be made to select the one that best fits the watershed.

NATURAL RURAL
DEVELOPED PARTLY CHANNELED
DEVELOPED AND SEWERED

For the Snyder method the user is required to key…

- Manning's "n" value for main channel. This would represent the average "n" value for the main channel between 10% and 85% of its length above the structure.
- Area of watershed that’s sewered, in percent. This would represent that portion of the entire watershed that has storm sewers (enclosed systems).
- Area of watershed having natural channels eliminated, in percent. This would represent that portion of the entire watershed in which existing, natural channels have been altered

either by straightening, enlarging, lining or otherwise improving upon their natural state in order to increase their capacity to convey flows.

…and select the IDF location type with the radio buttons, either “County” or “City”, and then selecting the municipality from the dropdown list.

Based on the location selected the module calculates the total (point) rainfall in inches for the 2, 5, 10, 25, 50 and 100 year storm events. The rainfall data was predicated on the NOAA publication "ATLAS 14". If the watershed spans more than one county, the user should select the location for the county in which the centroid of the watershed is located.

3.3.4 Upload Existing Input File

This module does not support the uploading of an existing input file.

3.3.5 Results

Project Results Run Date: 11/14/2005 7:28 AM

DISCHARGES COMPUTED BY ANDERSON'S METHOD

CALC. SLOPE =	0.40	ft./mile
CALC. LAG TIME =	29.08	HRS
Q2.33 =	2290	CFS
Q5 =	3575	CFS
Q10 =	4665	CFS
Q25 =	6811	CFS
Q50 =	8882	CFS
Q100 =	10953	CFS
Q500 =	14179	CFS

DISCHARGES COMPUTED BY SNYDER

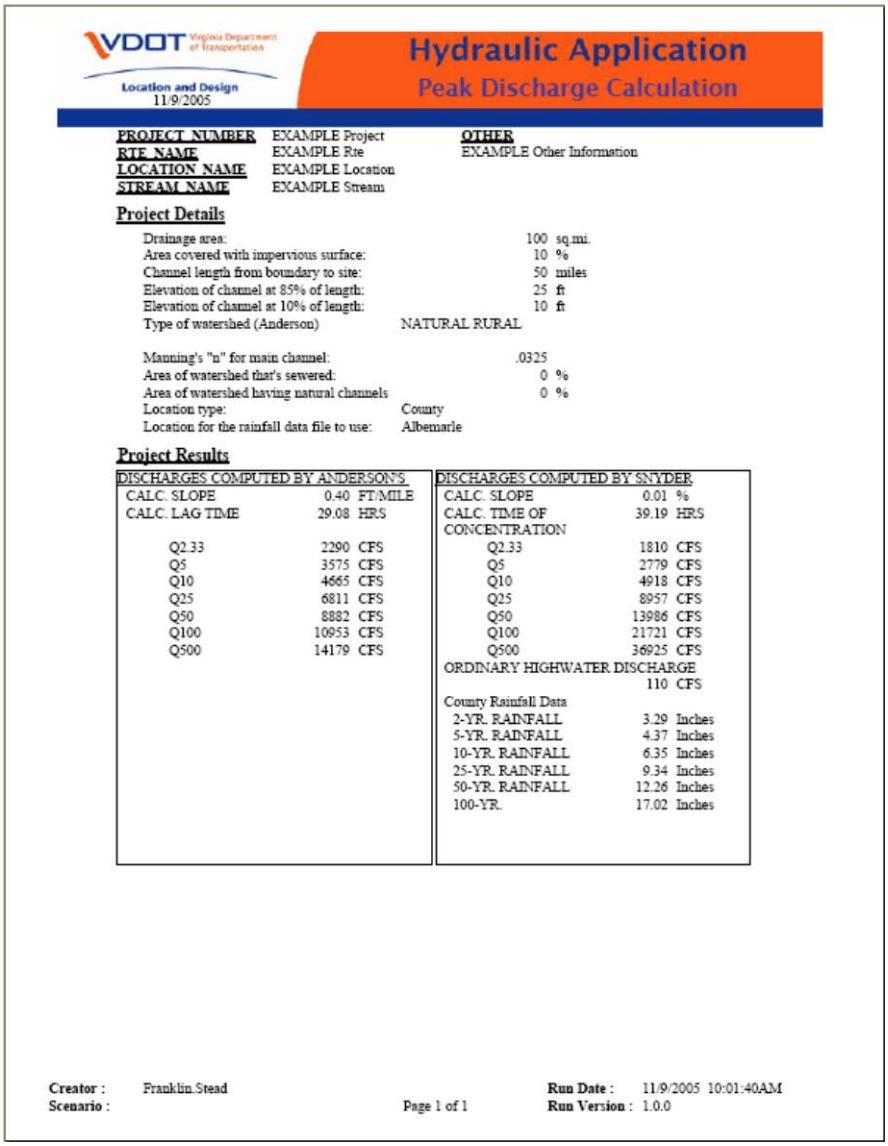
County Rainfall Data	2-YR. RAINFALL =	3.29	Inches
	5-YR. RAINFALL =	4.37	Inches
	10-YR. RAINFALL =	6.35	Inches
	25-YR. RAINFALL =	9.34	Inches
	50-YR. RAINFALL =	12.26	Inches
	100-YR. RAINFALL =	17.02	Inches
CALC. SLOPE =		0.01	%
CALC. TIME OF CONCENTRATION =		39.19	HRS
	Q2.33 =	1810	CFS
	Q5 =	2779	CFS
	Q10 =	4918	CFS
	Q25 =	8957	CFS
	Q50 =	13986	CFS
	Q100 =	21721	CFS
	Q500 =	36925	CFS
ORDINARY HIGHWATER DISCHARGE =		110	CFS

Printer Friendly

Figure **3.3.5** Results Section of web form for DISCHAR

Once the user has entered the required details and clicked the “Calculate” button, the Results section of the page will be displayed.

3.3.6 Print Out



VDOT Virginia Department of Transportation
Location and Design
11/9/2005

Hydraulic Application
Peak Discharge Calculation

PROJECT NUMBER	EXAMPLE Project	**OTHER**	
RTE NAME	EXAMPLE Rte	EXAMPLE Other Information	
LOCATION NAME	EXAMPLE Location		
STREAM NAME	EXAMPLE Stream		

Project Details

Drainage area:	100	sq.mi.
Area covered with impervious surface:	10	%
Channel length from boundary to site:	50	miles
Elevation of channel at 85% of length:	25	ft
Elevation of channel at 10% of length:	10	ft
Type of watershed (Anderson)	NATURAL RURAL	
Manning's "n" for main channel:	.0325	
Area of watershed that's sewered:	0	%
Area of watershed having natural channels	0	%
Location type:	County	
Location for the rainfall data file to use:	Albemarle	

Project Results

DISCHARGES COMPUTED BY ANDERSON'S		
CALC. SLOPE	0.40	FT/MILE
CALC. LAG TIME	29.08	HRS
Q2.33	2290	CFS
Q5	3575	CFS
Q10	4665	CFS
Q25	6811	CFS
Q50	8882	CFS
Q100	10953	CFS
Q500	14179	CFS

DISCHARGES COMPUTED BY SNYDER		
CALC. SLOPE	0.01	%
CALC. TIME OF CONCENTRATION	39.19	HRS
Q2.33	1810	CFS
Q5	2779	CFS
Q10	4918	CFS
Q25	8957	CFS
Q50	13986	CFS
Q100	21721	CFS
Q500	36925	CFS
ORDINARY HIGHWATER DISCHARGE	110	CFS
County Rainfall Data		
2-YR. RAINFALL	3.29	Inches
5-YR. RAINFALL	4.37	Inches
10-YR. RAINFALL	6.35	Inches
25-YR. RAINFALL	9.34	Inches
50-YR. RAINFALL	12.26	Inches
100-YR.	17.02	Inches

Creator : Franklin.Stead
Scenario :
Page 1 of 1
Run Date : 11/9/2005 10:01:40AM
Run Version : 1.0.0

Figure **3.3.6** Printable PDF for DISCHAR

The user has the option to obtain a PDF file of the scenario; this can be obtained by clicking the “Printer Friendly” button. Figure 3.3.6 is a sample output of the PDF.

3.4 EPSON – LOG PEARSON TYPE III FREQUENCY CALCULATIONS

3.4.1 Introduction

This module is based on "Guidelines For Determining Flood Flow Frequency, Bulletin 17B" from the US Department of the Interior. It is used as an alternative Log-Pearson type III analysis to LP3SHELL.

This module provides a statistical analysis of stream gage records in order to establish the discharge - frequency relationship. While this module will function with minimum of 4 annual gage flows, it is recognized that approximately twenty years of continuous records is required to establish a reliable gage rating. Further, the reliability of the discharge - frequency relationship is restricted to approximately 2.5 times the length of record.

3.4.2 Algorithm

See…"Guidelines For Determining Flood Flow Frequency, Bulletin 17B".

3.4.3 Details Entry

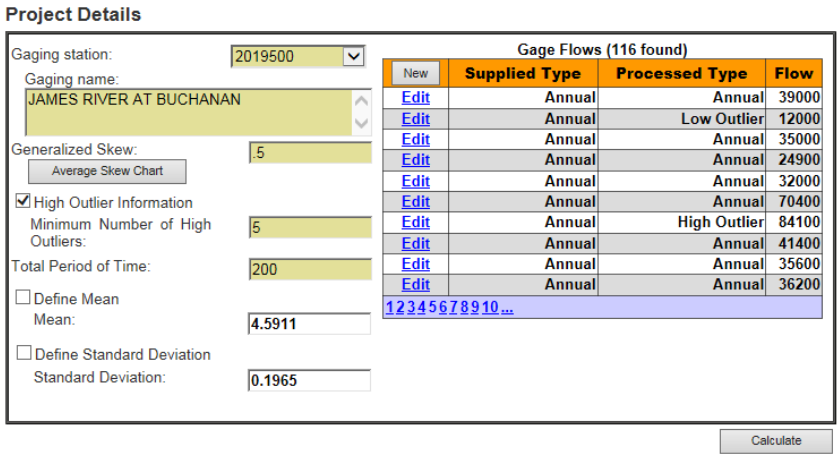


Figure **3.4.3** Details Section of web form for EPSON

This module contains several options and (optionally) makes use of external data files. The user may choose from the Gaging station dropdown to...

- manually key in the annual peak flows.
- upload the gage flows from an existing file that the user has on the local PC. See 3.4.4 Upload Existing Input File.
- retrieve the gage flows from the database of known Gage Stations.

Once the gage data is within the table, the user can then add additional gage flows, or modify existing flows (including deletion).

Note: If the user changes the Gage Station drop down, all the flows in the table will be replaced.
Note: Any modification to the Gage Flows will not update the original records in either the database or uploaded file.

If the Station Flows should contain historic data, then the user will need to modify the "Supplied Type" column from "Annual" to "Historic" for that row. There should be no exclusion of outliers that fall within the continuous record period.

Note: The "Processed Type" with in the Flow Table is assigned during calculation; this allows the user to see which flows processed as Annual, High Outlier, Low Outlier, or Historic.

The user is required to enter the "Generalized skew"; the field should be based on the Average Skew Chart.

The option of "High Outlier Information" should be checked if the user has additional information to apply to High Outliers. If selected the user is required to enter…

- the "Minimum High Outliers". The default is 0, which will only include High Outliers that fall above the calculated "High Threshold". If a number is entered, for example "5", then at least 5 flows will be assigned as High Outliers. These will be the largest flows; however they are not required to be above the "High Threshold." Also it is possible to have more than High Outliers if there are more flows that exceed the "High Threshold" than the minimum number entered.
- the "Total Period of Time", this should encompass both the annual record and the historic record.

the user also has the option to enter

- the Mean, which may be entered if the user checks "Define Mean"
- the "Standard Deviation" , which may be entered if the user checks "Define Standard Deviation"

If the user entered any flows as Historic then they are required to enter

- the "Total Period of Time", this should encompass both the annual record and the historic record.

the user also has the option to enter

- the Mean, which may be entered if the user checks "Define Mean"
- the "Standard Deviation" , which may be entered if the user checks "Define Standard Deviation"

Note: The "Processed Type" with in the Flow Table is assigned during calculation; this allows the user to see which flows processed as Annual, High Outlier, Low Outlier, or Historic.

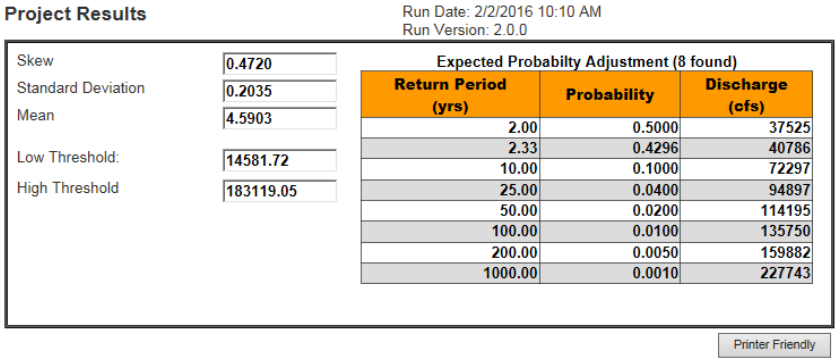
3.4.4 Upload Existing Input File

The Uploading of an existing file is different than that of the other modules. In the other modules this option uploads an existing data file storing all the necessary fields for that module. This module uses the Upload file option to upload Gage Flow records only. The file format must conform to the previous DOS based program's file format.

The user can, independently of the module, create (as well as edit) data files using a text editor or word processor; however the file must be saved in Text format.

- The first line (starting in column 1) should contain a description of the stream gage or site for which the record is being created.
- The second line should contain the number of annual peak flows to follow and the entry should be right justified on column 10, i.e. if there are 24 annual peak flows to be encoded, then the 2 should go in column 9 and the 4 in column 10.
- Starting with line three and proceeding with however many lines are subsequently needed, the annual peak flows (one to a line) should be encoded, right justified on column 10 just as described above.

3.4.5 Results



Project Results

Run Date: 2/2/2016 10:10 AM
Run Version: 2.0.0

Skew	0.4720
Standard Deviation	0.2035
Mean	4.5903
Low Threshold:	14581.72
High Threshold	183119.05

Expected Probabilty Adjustment (8 found)

Return Period (yrs)	Probability	Discharge (cfs)
2.00	0.5000	37525
2.33	0.4296	40786
10.00	0.1000	72297
25.00	0.0400	94897
50.00	0.0200	114195
100.00	0.0100	135750
200.00	0.0050	159882
1000.00	0.0010	227743

Printer Friendly

Figure **3.4.5** Results Section of web form for EPSON

Once the user has entered the required details and clicked the "Calculate" button, the Results section of the page will be displayed.

Note: If the initial Mean and/or Standard Deviation where not defined by the user the calculated initial Mean and/or Standard Deviation will be displayed in the Project Description section. Also the Processed Type for each flow will be updated.

3.4.6 Print Out

VDOT Virginia Department of Transportation
Location and Design
5/4/2006

Hydraulic Application
EPSON
Log-Pearson III

PROJECT NUMBER Epson Example
RTE NAME Epson Rd
LOCATION NAME Buchanan
STREAM NAME James River

OTHER
This is an example of this feature.

Project Details

Gage Station Name:	
Generalized Skew:	.5
Minimum High Outliers:	5
Period of Time:	200
Defined Mean:	
Defined Stadard Deviation:	

Project Results

Skew:	0.3303
Standard Deviation:	0.1938
Mean:	4.5873
Low Outlier Threshold:	14843.00
High Outlier Threshold:	174535.73

Return Period (years)	Probability	Discharge (cfs)
2.00	0.5000	37723
2.33	0.4296	40844
10.00	0.1000	69416
25.00	0.0400	88620
50.00	0.0200	104403
100.00	0.0100	121491
200.00	0.0050	140057
1000.00	0.0010	189782

JAMES RIVER AT BUCHANAN

SUPPLIED TYPE	PROCESSED TYPE	FLOW
Historic	Historic	142,000
Annual	High Outlier	85,000
Annual	Annual	85,000
Annual	Annual	36,000
Annual	Annual	22,000
Annual	Annual	49,800
Annual	Annual	38,000
Annual	Annual	40,400
Annual	Annual	25,700
Annual	Annual	51,900
Annual	Annual	23,800
Annual	Annual	59,800
Annual	Annual	76,000
Annual	Annual	43,800
Annual	Annual	20,500
Annual	Annual	36,800
Annual	Annual	24,000
Annual	Annual	41,800
Annual	Annual	49,800
Annual	Annual	35,500
Annual	Annual	38,800
Annual	Annual	25,700
Annual	Annual	39,900
Annual	High Outlier	115,000
Annual	Annual	17,900
Annual	Annual	56,100
Annual	Annual	28,800
Annual	Annual	44,600
Annual	Annual	43,000
Annual	Annual	47,800
Annual	Annual	26,800
Annual	Annual	24,400
Annual	Annual	24,200
Annual	Annual	18,800
Annual	Annual	60,000
Annual	Low Outlier	11,700
Annual	Annual	28,700
Annual	Annual	38,000
Annual	Annual	39,000
Annual	Annual	30,000
Annual	Annual	39,000
Annual	Low Outlier	12,000
Annual	Annual	35,000
Annual	Annual	24,900
Annual	Annual	32,000
Annual	Annual	70,400

Creator : Franklin Stead
Scenario :
Page 1 of 3
Run Date : 5/4/2006 10:21:57AM
Run Version : Beta

Figure **3.4.6** Printable PDF for EPSON

The user has the option to obtain a PDF file of the Scenario; this can be obtained by clicking the "Printer Friendly" button. Figure 3.4.6 is a sample output of the PDF.

3.5 HY-15 – Design of Channels with Flexible Linings

3.5.1 Introduction

Originally developed by "SIMONS, LI & ASSOCIATES, INC." This module analyzes flexible and concrete linings for trapezoidal or triangular channels in straight reaches. The module uses the design procedures of "Hydraulic Engineering Circular No. 15, 1988". The Manning's "n" value and normal depth calculated may be different than values obtained by use of charts and tables. Manning's "n" varies with the depth and is more accurately calculated by this process.

The user has the option to have the module calculate Discharge of the maximum Q for a given lining.

3.5.2 Algorithm

See "Hydraulic Engineering Circular No. 15, 1988." This publication is available in the "Hydraulics Library", under "FHWA Publication" on the "Hydraulic Design" site on "Inside VDOT."

3.5.3 Details Entry

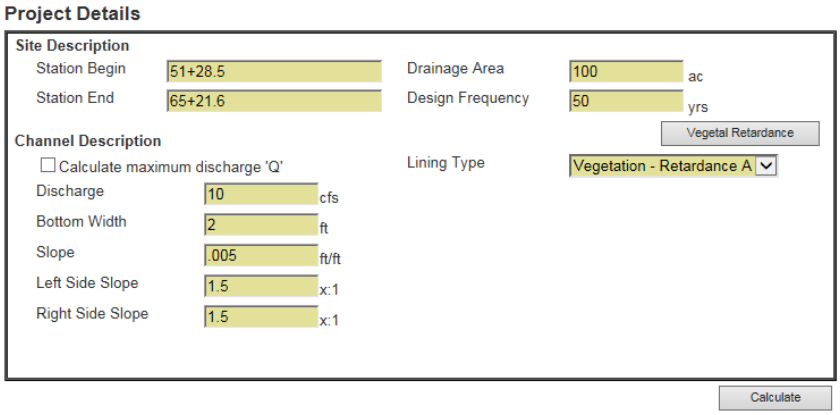


Figure **3.5.3** Details Section of web form for HY-15

The user has the option to enter in Site Description Data, since this is only used for report, it is not required.

If "Calculate maximum discharge 'Q'" is checked then the Discharge field is disabled; otherwise the user is required to enter the Discharge value.

All other fields are required to be entered.

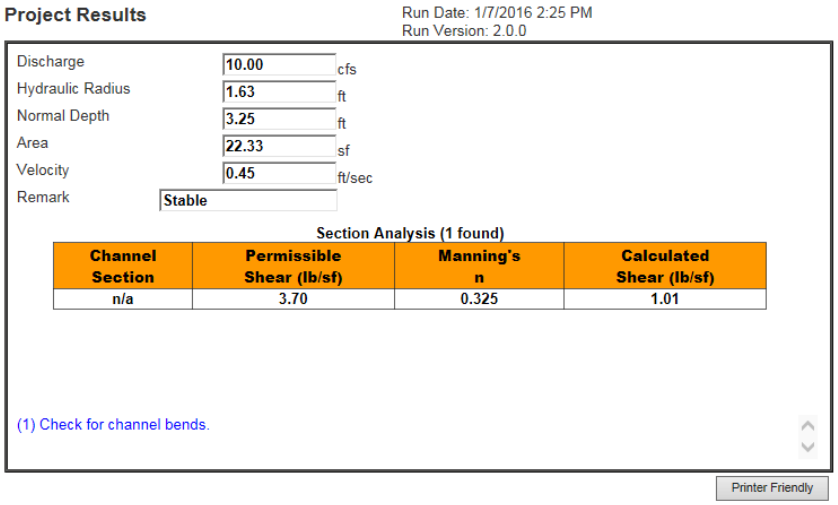
When the user selects the Lining Type there maybe an addition field required…

- Concrete, require Manning's "n" to be entered
- RipRap, requires the D50 to be entered.

3.5.4 Upload Existing Input File

This module does not support the uploading of an existing input file.

3.5.5 Results



Project Results

Run Date: 1/7/2016 2:25 PM
Run Version: 2.0.0

Discharge	10.00	cfs
Hydraulic Radius	1.63	ft
Normal Depth	3.25	ft
Area	22.33	sf
Velocity	0.45	ft/sec
Remark	Stable	

Section Analysis (1 found)

Channel Section	Permissible Shear (lb/sf)	Manning's n	Calculated Shear (lb/sf)
n/a	3.70	0.325	1.01

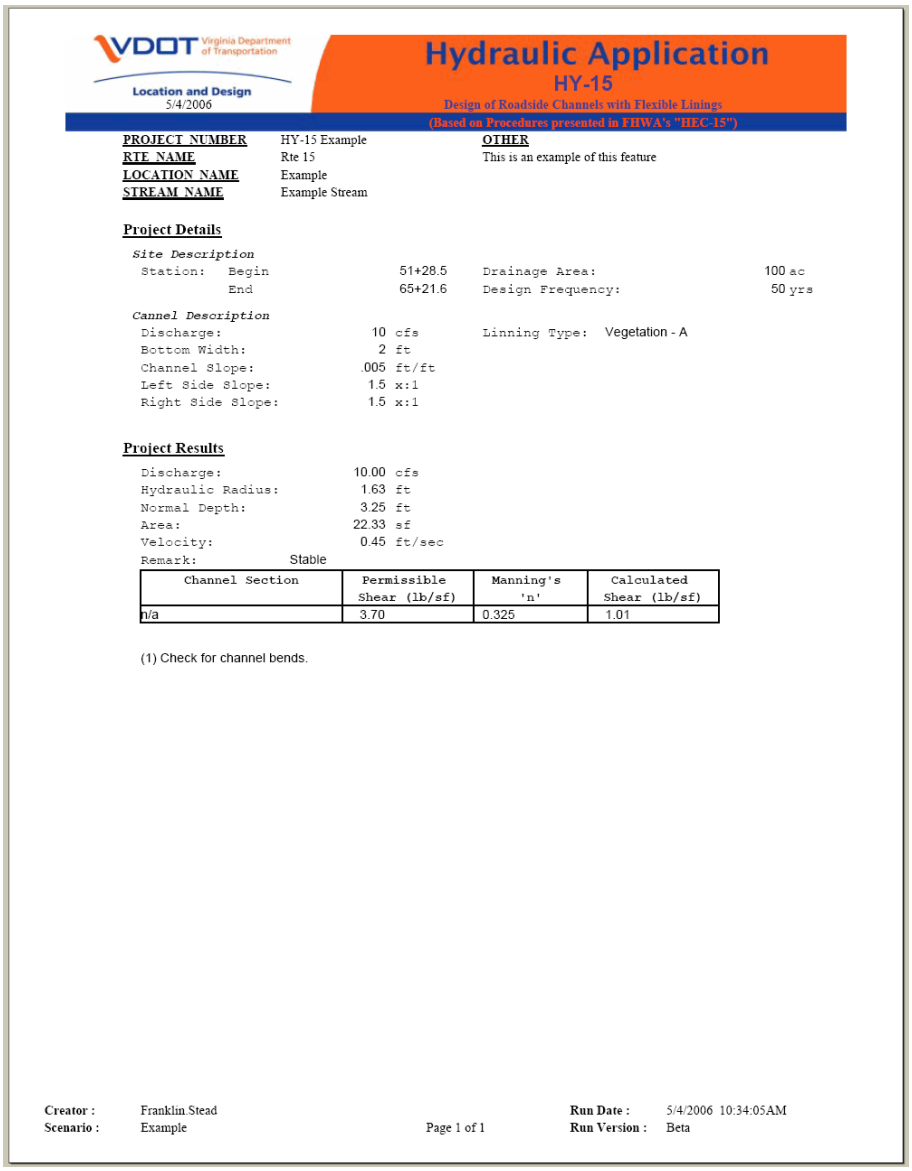
(1) Check for channel bends.

Printer Friendly

Figure **3.5.5** Results Section of web form for HY-15

Once the user has entered the required details and clicked the “Calculate” button, the Results section of the page will be displayed.

3.5.6 Print Out



VDOT Virginia Department of Transportation
Location and Design
5/4/2006

Hydraulic Application
HY-15
Design of Roadside Channels with Flexible Linings
(Based on Procedures presented in FHWA's "HEC-15")

PROJECT NUMBER	HY-15 Example	**OTHER**	
RTE NAME	Rte 15	This is an example of this feature	
LOCATION NAME	Example		
STREAM NAME	Example Stream		

Project Details

Site Description

Station:	Begin	51+28.5	Drainage Area:	100 ac
	End	65+21.6	Design Frequency:	50 yrs

Cannel Description

Discharge:	10	cfs	Linning Type:	Vegetation - A
Bottom Width:	2	ft		
Channel Slope:	.005	ft/ft		
Left Side Slope:	1.5	x:1		
Right Side Slope:	1.5	x:1		

Project Results

Discharge:	10.00	cfs
Hydraulic Radius:	1.63	ft
Normal Depth:	3.25	ft
Area:	22.33	sf
Velocity:	0.45	ft/sec
Remark:	Stable	

Channel Section	Permissible Shear (lb/sf)	Manning's 'n'	Calculated Shear (lb/sf)
n/a	3.70	0.325	1.01

(1) Check for channel bends.

Creator : Franklin Stead
Scenario : Example
Page 1 of 1
Run Date : 5/4/2006 10:34:05AM
Run Version : Beta

Figure **3.5.6** Printable PDF for HY-15

The user has the option to obtain a PDF file of the Scenario; this can be obtained by clicking the "Printer Friendly" button. Figure 3.5.6 is a sample output of the PDF.

3.6 IRRCHANL – IRREGULAR CHANNEL, STAGE-DISCHARGE

3.6.1 Introduction

This module performs normal depth calculations in irregular shaped (natural) channels using the Manning's equation.

3.6.2 Details Entry

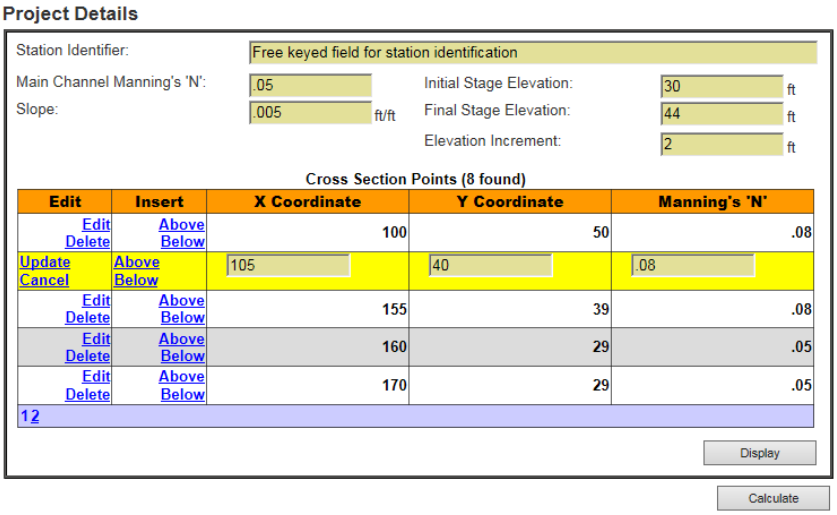


Figure **3.6.2.1** Details Section of web form for IrrChanl

- Station Identifier: Optional description of Station.
- Main Channel Manning's "N": Required so that the output can be separated into the areas left of main channel, main channel and right of main channel.
- Slope in ft/ft.
- Initial and final depths which you enter must be based on the same datum as the Y coordinates, value limitation +/- 9999.9, in ft.
    - INITIAL STAGE ELEVATION: The lowest desired elevation to begin the stage vs. discharge calculations.
    - FINAL STAGE: The highest desired elevation to end the stage vs discharge calculations.
- ELEVATION INCREMENT: The increment for the purpose of calculating stages between the initial and the final elevations.

Note: The original application would only allow for 20 output stages and the user had to take this into account when keying in the Elevation Increment, this is no longer the case.

- Cross Section Points
  Note: The Input Table is slightly different from the other modules. The Yellow highlighted row indicates that the row is in edit mode. The user will need to use the insert "Above" and "Below" links to properly place new Cross Section points, since the X, Y coordinates need to be entered in their order from Left to Right.

- The X coordinate must always increase from left to right.
- The limits on Y are +/- 9999.9.
- With each set of X and Y coordinates the value of manning's "n" between this and the previous set of coordinates is entered. The value of "n" entered with the first set of coordinates is a dummy and is not used in the calculations. Each point can have a different manning's "n" value.

Note: The original application would only allow for 21 Cross Section Points, this is no longer the case.

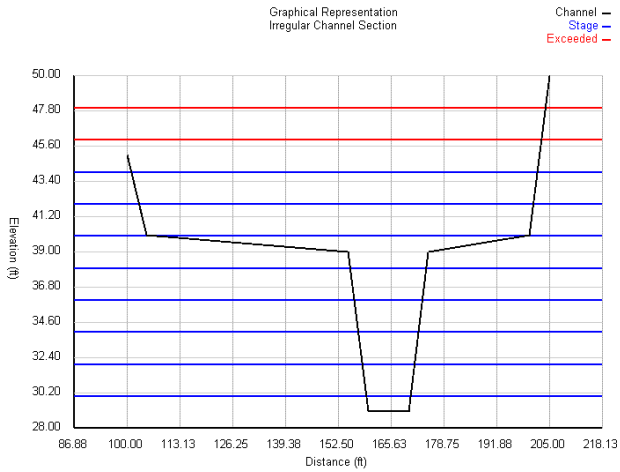


Figure **3.6.2.2** Display: Graphical Representation of the supplied Channel Section

The User has the option to display a Graphical Representation of the Channel Section, which they entered. This Representation includes the Stages in blue, or in red if the stage exceeds either bank.

3.6.3 Upload Existing Input File

The Uploading of an existing file is different than that of the other modules. In the other modules this option uploads an existing data file storing all the necessary fields for that module. This module uses the Upload file option to upload the Cross Section Points only. The file format must conform to the previous DOS based program's file format.

The user can, independently of the module, create (as well as edit) data files using a text editor or word processor; however the file must be saved in Text format. The proper text format for each line is "X,Y,N" each of these need to be in numeric form and the comma is used as the delimiter.

Note: The first "N" value in the original application was used to indicate the number of Cross Section Points. This is no longer the case, the "N" value will displayed as entered, this will cause an error requiring the user to update the "N" value to be a valid Manning's N.

3.6.4 Results

Project Results

Run Date: 5/12/2009 8:47 AM
Run Version: 1.0.0

8 Stages Calculated (1 of 2 pages)

Interim Hydraulic Parameters (8 found)

Stage Feet	Area (SQFT)				Wetted per(FT)				Hydraulic Radius		
	Left	Main	Right	Total	Left	Main	Right	Total	Left	Main	Right
30.00	0	11	0	11	0.0	12.2	0.0	12.2	0.0	0.9	0.0
32.00	0	35	0	35	0.0	16.7	0.0	16.7	0.0	2.1	0.0
34.00	0	63	0	63	0.0	21.2	0.0	21.2	0.0	3.0	0.0
36.00	0	95	0	95	0.0	25.7	0.0	25.7	0.0	3.7	0.0
38.00	0	131	0	131	0.0	30.1	0.0	30.1	0.0	4.3	0.0

1 2

Flow Characteristics (8 found)

Stage Feet	Velocity (FT/SEC)					Discharge (CFS)			
	Left	Main	Right	Average	Mean	Left	Main	Right	Total
30.00	0.00	1.90	0.00	1.90	1.90	0	20	0	20
32.00	0.00	3.42	0.00	3.42	3.42	0	118	0	118
34.00	0.00	4.34	0.00	4.34	4.34	0	271	0	271
36.00	0.00	5.03	0.00	5.03	5.03	0	475	0	475
38.00	0.00	5.60	0.00	5.60	5.60	0	731	0	731

1 2

Printer Friendly

Figure **3.6.4** Results Section of web form for IrrChanl

Once the user has entered the required details and clicked the “Calculate” button, the Results section of the page will be displayed.

Note:

- The average velocity is the summation of Q times V for all "n" regions divided by total Q.
- The mean velocity is simply total discharge divided by total area.

3.6.5 Print Out

VDOT Virginia Department of Transportation
Location and Design
4/22/2009

Hydraulic Application
Irregular Channel
Stage-Discharge

PROJECT_NUMBER test
RTE_NAME
LOCATION_NAME
STREAM_NAME

OTHER

Project Details

Station Identifier		
Main Channel Manning's 'N'	.05	
Slope	.005	ft/ft
Initial Stage Elevation	30	ft
Final Stage Elevation	44	ft
Elevation Increment	2	ft

Cross Section Points

X Coordinate (ft)	Y Coordinate (ft)	Manning's 'N'
100	50	.08
105	40	.08
155	39	.08
160	29	.05
170	29	.05
175	39	.05
200	40	.08
205	50	.08

Project Results

Interim Hydraulic Parameters

Stage Feet	Area (SQ FT)				Wetted per (FT)				HYD RAD		
	Left	Main	Right	Total	Left	Main	Right	Total	Left	Main	Right
30.00	0	11	0	11	0.0	12.2	0.0	12.2	0.0	0.9	0.0
32.00	0	35	0	35	0.0	16.7	0.0	16.7	0.0	2.1	0.0
34.00	0	63	0	63	0.0	21.2	0.0	21.2	0.0	3.0	0.0
36.00	0	95	0	95	0.0	25.7	0.0	25.7	0.0	3.7	0.0
38.00	0	131	0	131	0.0	30.1	0.0	30.1	0.0	4.3	0.0
40.00	25	170	13	208	50.0	32.4	25.0	107.4	0.5	5.3	0.5
42.00	126	210	64	400	52.2	32.4	27.3	111.9	2.4	6.5	2.3
44.00	229	250	117	596	54.5	32.4	29.5	116.3	4.2	7.7	4.0

Creator : Franklin.stead
Scenario : Test 1

Page 1 of 2

Run Date : 4/8/2009 1:59:35PM
Run Version : 1.0.0

Stage Feet	Flow Characteristics								
	Velocity (FT/SEC)					Discharge (CFS)			
	Left	Main	Right	Average	Mean	Left	Main	Right	Total
30.00	0.00	1.90	0.00	1.90	1.90	0	20	0	20
32.00	0.00	3.42	0.00	3.42	3.42	0	118	0	118
34.00	0.00	4.34	0.00	4.34	4.34	0	271	0	271
36.00	0.00	5.03	0.00	5.03	5.03	0	475	0	475
38.00	0.00	5.60	0.00	5.60	5.60	0	731	0	731
40.00	0.83	6.37	0.83	6.21	5.37	21	1083	10	1114
42.00	2.37	7.33	2.31	6.21	4.97	298	1540	147	1985
44.00	3.43	8.23	3.29	6.48	5.42	785	2059	383	3228

Creator : Franklin.stead
Scenario : Test 1

Page 2 of 2

Run Date : 4/8/2009 1:59:35PM
Run Version : 1.0.0

Figure **3.6.5** Printable PDF for IrrChanl

The user has the option to obtain a PDF file of the Scenario; this can be obtained by clicking the "Printer Friendly" button. Figure 3.6.5 is a sample output of the PDF.

3.7 PFLOW – PIPE FLOW (IN CIRCULAR PIPES)

3.7.1 Introduction

This modules function performs similar to the "Field's Wheel". It will calculate Velocity and

- "Q" for a given Depth
- Depth for a given "Q"
- Friction Slope for a given Diameter
- Diameter for a given Friction Slope

3.7.2 Algorithm

This module is based primarily on Manning's equation which is

$$V = \frac{k}{n} * R^{\frac{2}{3}} * S^{\frac{1}{2}}$$

Where:

V = flow velocity, feet (m)/second
k = conversion constant equal to 1.486 for U.S. customary units or 1.0 for SI units
n = Manning's roughness coefficient
R = hydraulic radius, feet (m)
S = slope, feet/feet (m/m)

$$R = \frac{A}{WP}$$

Where:

A = flow cross-sectional area, square feet (m^2)
WP = wetted perimeter, feet (m)

The Continuity Equation is also utilized, which is

$$Q = A * V$$

Where:

Q = flow rate, cubic feet (m)/second
A = flow cross-sectional area, square feet (m^2)
V = flow velocity, feet (m)/second

Note: Continuity Equation is also used in the form of

$$V = \frac{Q}{A}$$

3.7.3 Details Entry

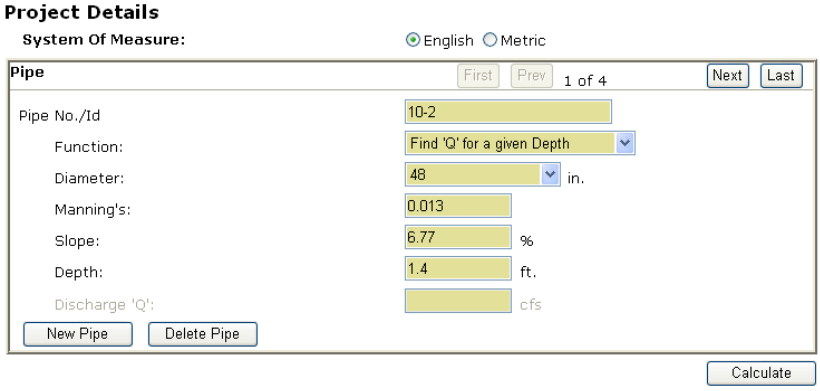


Figure **3.7.3** Details Section of web form for PFlow

The user is given the option to select a “System of Measure” either English or Metric. If there are no known pipe sizes for a particular unit of measure an error message will be displayed and the Pipe details section of the page will be disabled.

The required input fields are based on the selected Function.

- "Find 'Q' for a given Depth" requires Diameter, Manning’s, Slope, and Depth.
- "Find Depth for given 'Q'" requires Diameter, Manning’s, Slope, and Discharge 'Q'.
- "Find Diameter for a given Slope" requires Manning’s, Slope, and Discharge 'Q'.
- "Find Slope for a given Diameter" requires Diameter, Manning’s, and Discharge 'Q'.

The user has the option to key a Pipe Number of Id for the current pipe be considered

The user may key any number of pipes to be calculated; when the user clicks Calculate all the pipes that were keyed in will be calculated or recalculated. In order to add a new pipe the user needs to click the “New Pipe” button, this will create a new pipe record.

The user may use the “First”, “Prev”, “Next”, and “Last” buttons to traverse the Pipe records for the Scenario. The user may edit any of the data.

If a Pipe needs to be removed from the scenario, the user will need to be viewing that Pipe’s information and click “Delete Pipe”.

3.7.4 Upload Existing Input File

This module does not support the uploading of an existing input file.

3.7.5 Results

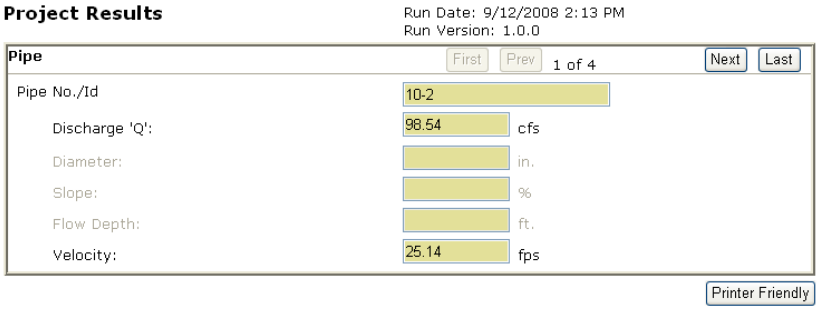
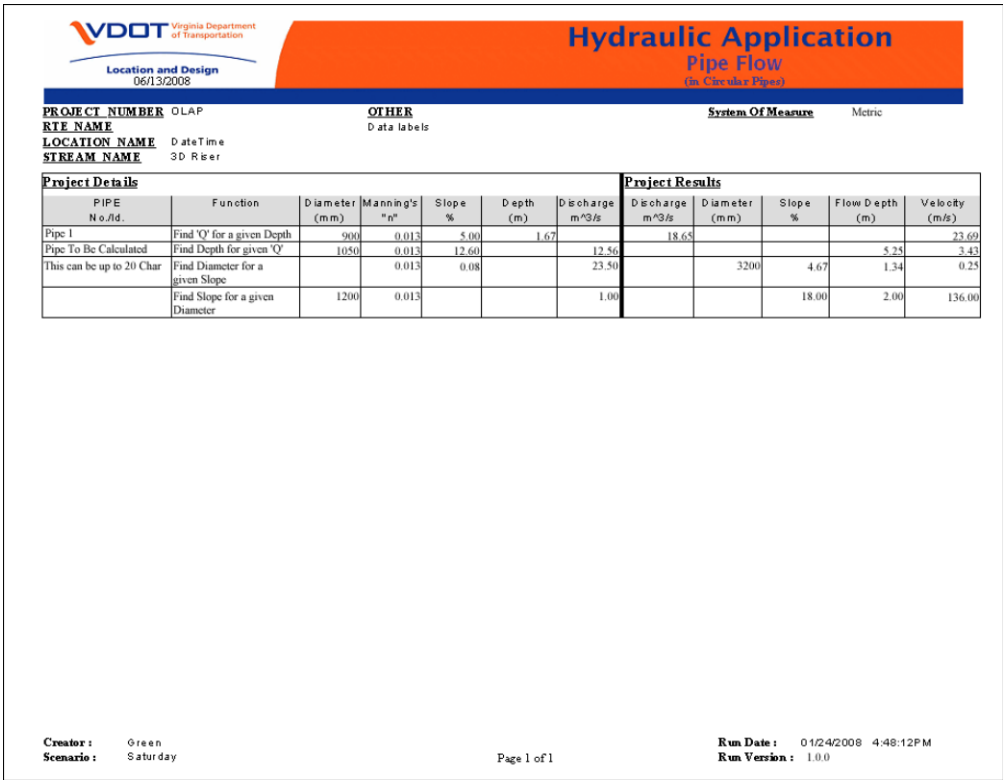


Figure **3.7.5** Results Section of web form for PFlow

Once the user has entered the required details and clicked the "Calculate" button, the Results section of the page will be displayed. Only the calculated values will be filled in.

3.7.6 Print Out



Location and Design
06/13/2008

Hydraulic Application
Pipe Flow
(in Circular Pipes)

PROJECT NUMBER OLAP
RTE NAME
LOCATION NAME DateTime
STREAM NAME 3D Riser

OTHER
Data labels

System Of Measure Metric

Project Details							Project Results				
PIPE No./Id.	Function	Diameter (mm)	Manning's "n"	Slope %	Depth (m)	Discharge m^3/s	Discharge m^3/s	Diameter (mm)	Slope %	Flow Depth (m)	Velocity (m/s)
Pipe 1	Find 'Q' for a given Depth	900	0.013	5.00	1.67		18.65				23.69
Pipe To Be Calculated	Find Depth for given 'Q'	1050	0.013	12.60		12.56				5.25	3.43
This can be up to 20 Char	Find Diameter for a given Slope		0.013	0.08		23.50		3200	4.67	1.34	0.25
	Find Slope for a given Diameter	1200	0.013			1.00			18.00	2.00	136.00

Creator : Green
Scenario : Saturday

Page 1 of 1

Run Date : 01/24/2008 4:48:12PM
Run Version : 1.0.0

Figure **3.7.6** Printable PDF for PFlow

The user has the option to obtain a PDF file of the Scenario; this can be obtained by clicking the "Printer Friendly" button. Figure 3.7.6 is a sample output of the PDF.

3.8 PQTRANS – PEAK DISCHARGE TRANSFER

3.8.1 Introduction

This module allows the user to employ peak discharges from a site for which they are known (i.e. gaging records, etc.) and utilize them as a basis for estimating peak discharges at another site on the same or similar nearby watershed. This is done by prorating the known discharges using two nationally recognized formulas developed for this purpose:

(1) USGS (U.S. Geological Survey) Transfer Formula. *As presented in the FHWA's publication "User's Manual for Hydrain Integrated Drainage Design Computer System: Version 6.1" in Volume II, "HYDRO."*

(2) NRCS (National Resource Conservation Service) Transfer Formula from their "NEH-4" publication.

3.8.2 Algorithm

3.8.2.1 USGS Formula

$$Q_U = Q_K \left(\frac{A_U}{A_K}\right)^E$$

Where:

Q_U = The calculated magnitude of the unknown peak discharge (in cfs.)
Q_K = The magnitude of the known or reference peak discharge (in cfs.)
A_U = The drainage area at the site of the unknown peak discharge (in sq. mi.)
A_K = The drainage area at the site of the known or reference discharge (in sq. mi.)
E = An exponent which usually is thought to range from 0.7 to 0.8 with 0.7 usually being the preferred value.

Note: The "PQTRANS" module gives the user the option of using his choice of exponents here; however, 0.7 is the default value.

3.8.2.2 NRCS Formula

$$Q_U = Q_K \left(\frac{A_U^{\left(\frac{0.894}{A_U^{0.48}-1}\right)}}{A_K^{\left(\frac{0.894}{A_K^{0.48}-1}\right)}}\right)$$

Where:

Q_U = The calculated magnitude of the unknown peak discharge (in cfs. per sq. mi.)
Q_K = The magnitude of the known or reference peak discharge (in cfs. per sq. mi)
A_U = The drainage area at the site of the unknown peak discharge (in sq. mi.)
A_K = The drainage area at the site of the known or reference discharge (in sq. mi.)

Note: The known peak discharges should be entered into the "PQTRANS" module using their magnitude in CUBIC FEET PER SECOND and that calculated peak discharges are shown using units of CUBIC FEET PER SECOND regardless of which formula was employed to calculate them.

3.8.3 Details Entry

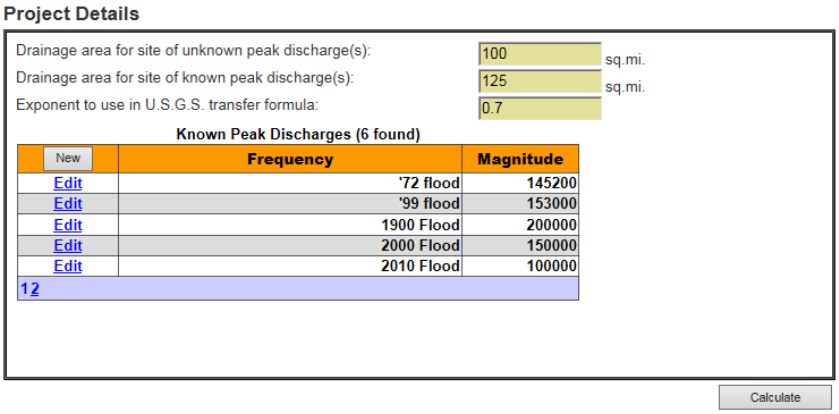


Figure **3.8.3** Details Section of web form for PQTRANS

The user is required to enter the drainage area in sq. mi. for both the site for which it is desired to calculate peak discharge values, and the site that the peak discharges are known.

Note: It is absolutely critical, whenever the user is required to provide the size of a drainage area, that it be entered in square miles since the NRCS formula is set up to work only with square miles.

By default the value for the exponent to use in the USGS Transfer Formula is 0.7. If the user wants to use another value, they should replace the 0.7 with their chosen value. This value usually ranges from 0.7 to 0.8.

Known Peak Discharges can be entered using the "New" button. Once entered the "Edit" link can be used to modify the values of the row. Once in edit mode the user will have the option to

Update – Applies changes to the row and ends editing on that row.
Delete – Deletes the row from the table.
Cancel – Cancels the changes to the row and ends editing on that row.

Frequency or some other appropriate identification is expected to be entered and the magnitude (in cfs.) of the known peak discharge that corresponds with the frequency/i.d. value is required.

3.8.4 Upload Existing Input File

This module does not support the uploading of an existing input file.

3.8.5 Results

Project Results

Run Date: 2/2/2016 10:22 AM
Run Version: 2.0.0

Peak Output (6 found)

Frequency	USGS Formula	NRCS Formula	Average of both
'72 flood	124202	128387	126295
'99 flood	130874	135284	133079
1900 Flood	171078	176842	173960
2000 Flood	128308	132632	130470
2010 Flood	85539	88421	86980

1 2

Printer Friendly

Figure **3.8.5** Results Section of web form for PQTRANS

Once the user has entered the required details and clicked the "Calculate" button, the Results section of the page will be displayed.

3.8.6 Print Out

Location and Design
5/16/2006

Hydraulic Application
PQTrans
Peak Discharge Transfer

PROJECT_NUMBER
RTE_NAME
LOCATION_NAME
STREAM_NAME

OTHER

Project Details

Drainage area for site of unknown peak discharge(s): 100
Drainage area for site of known peak discharge(s): 125
Exponent to use in U.S.G.S. transfer formula: 0.7

Project Results

Frequency	Known Magnitude	USGS Formula	NRCS Formula	Average [USGS & SCS]
72 flood	145200	124202	128387	126295
99 flood	153000	130874	135284	133079

Creator : Franklin.Stead
Scenario :
Page 1 of 1
Run Date : 5/16/2006 8:17:37AM
Run Version : 1.0.0

Figure **3.8.6** Printable PDF for PQTRANS

The user has the option to obtain a PDF file of the Scenario; this can be obtained by clicking the "Printer Friendly" button. Figure 3.8.6 is a sample output of the PDF.

3.9 RDDITCH – FLOW IN MEDIAN AND SIDE DITCHES

3.9.1 Introduction

RDDITCH was developed for use in determining the average velocity and depth of flow in highway roadside and median ditches. It is particularly useful in ascertaining locations where some sort of ditch lining (i.e. EC-2, EC-3, or paving) is needed. This module can handle multiple reaches of ditch and multiple cross sections (or stations) per reach. Either triangular or trapezoidal shapes can be considered and ditch side slopes and/or bottom width may vary from cross section to cross section. Depth and velocity of flow are calculated for the 2 yr. (50%) and 10 yr. (10%) peak flows for Manning's "n" values of

0.03 (assumed for natural, earth linings)
0.05 (assumed for protective linings, i.e. EC-2, EC-3, etc.)
0.015 (assumed for paved linings).

3.9.2 Algorithm

The module is set up in accordance with the manual procedure described in Chapter 7, section 7.5.2.2 of the VDOT Drainage Manual whereby several "widths of strip" at appropriate Rational Formula "C" factors are employed to determine a weighted "CA" value for the "length of strip" (usually 100 ft.) under consideration. The flow rates for that length of strip are determined by multiplying the weighted "CA" value by the 2 and 10 yr. rainfall intensities respectively. The module has two options in this regard:

(1) Custom, the user can enter the rainfall intensities as determined separately from an appropriate "IDF" curve
(2) City or County, the user can enter the Time of Concentration (rainfall duration) and the module will calculate the 2 yr. and 10 yr. intensities from information provided by the NOAA “Atlas-14” based “B, D, & E” values using the equation shown in appendix 6C-1 of chapter 6 in the “VDOT Drainage Manual.”

In the case of Option 1, the user would have the choice of entering an initial 2 yr. and 10 yr. intensity and having the module decrease these values by 0.1 in/hr at each subsequent section or entering new values at each or specific subsequent sections.

In the case of Option 2, the user would have the choice of entering an initial Time of Concentration and having the module increase this value by 1 min. at each subsequent section or entering a new value at each or specific subsequent sections.

By being able to change Times of Concentration or Intensity (depending on the selected option) and considering multiple "widths of strip", the user can conveniently provide for such contingencies as inflow coming in from off the Right of Way and/or pipes/culverts from under the roadway contributing flow to the ditch section.

3.9.2.1 Selecting Calculated or User Supplied "I" values

If the user is employing the option whereby a data file is to be uploaded, the data file should contain information which will indicate to the module whether "I" values are to be read or "Tc" values are to be read. If the user is keying data directly to the web form, the user will have the option to enter “Custom” “I” values by clicking the “Custom” radio button or to have the module calculated them.

If “Custom” is selected, the user must provide (or confirm) the 2-yr. and 10-yr. "I" values at each ditch station for each reach of ditch to be considered.

If "County" or "City" are selected, the user must provide (or confirm) the "Tc" value at each ditch station for each reach of ditch to be considered. The module will require the user to select the "IDF" data by selecting an appropriate municipality from the dropdown next to the IDF radio buttons.

A factor governing the decision as to whether or not to use module calculated "I" values would be whether or not there is an appropriate regional "IDF" data record available for a given project. If one is not available, the user should select the option to enter "I" values himself and manually determine those values from an independent "IDF" curve.

3.9.2.2 Selecting an Appropriate "IDF" Curve

Regardless of whether the user is uploading data from a file containing "Tc" values or has selected the "module calculated "I" values" for keyboard entry of data, the user will need to select the appropriate location of the IDF information. This is broken down into 2 location types, “City” and “County” which are selected using the IDF radio buttons. The user will then be required to select the location from the dropdown list next to the radio buttons. This dropdown list will only show the locations that are available based on the location type selected with the radio buttons. The user should select the location that is closest to the area of interest and the module will read that locations data and calculate rainfall intensities predicated on user supplied "Tc" values. The module assumes that all ditch reaches for a given input data set are in the same geographical area, so only one opportunity is provided to select an appropriate "IDF" data location.

3.9.2.3 Using Default Values to Select "Tc" or "I”

When entering input data on the web form, regardless of whether the user has elected to enter "Tc" or "I" values, the user has the option of using default values for all entries after the initial ditch station for a given ditch reach. The module requires the user to supply an initial "Tc" at the first ditch station in a reach and then increases this value by one minute for subsequent stations. The user can select the module incremented "Tc" value or key a new value. Likewise, using the user supplied "I" values option, the user is required to key an initial "I-2" and "I-10" for the first station in a given ditch reach and the module will decrease these values by 0.1 in/hr for subsequent stations. The user can select the module decremented "I" values or can key a new value. This option will be particularly useful when a station is being considered that has "side flow" coming in either from off the right of way or from a pipe coming in under the road. The

user can determine the path having the longest Time of Concentration and encode the proper "Tc" or "I" value in lieu of the module generated, default values.

3.9.3 Details Entry

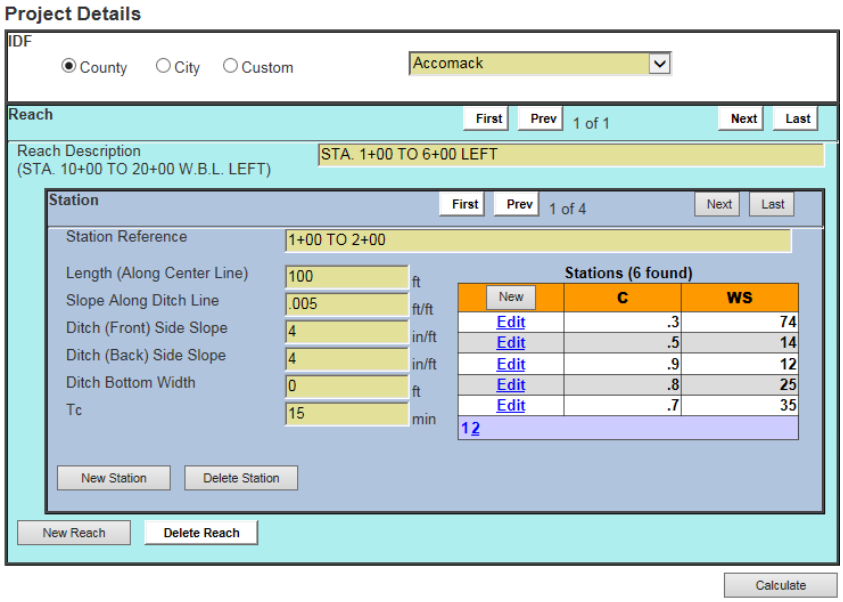


Figure **3.9.3** Details Section of web form for DISCHAR

The user should first enter the appropriate "IDF" information. This will allow the module to generate default the "TC" or the "I" values once the initial values are entered. ***NOTE: If the IDF information changes from "Custom" to one of the location types or vice-versa then the "TC" and "I" values will need to be re-keyed manually.***

The user has the option to key a description for the current reach of ditch to be considered. An example could be "STATION 10+00 TO 20+00 W.B.L. LEFT". The user also has an option to key a station description. An example could be "10+00 to 11+00". Though it is not a requirement to key this information, it is highly recommended.

The user is required to key…

- Length (along the center line), of the current ditch station in feet.
- Slope, along the ditch line, of this station in ft/ft.
- Ditch (Front) Side Slope, in in/ft. The front side slope refers to the side of the ditch closest to the pavement. This value must be entered in in/ft. For example, if the front side slope was 3:1 (4" per ft.), the user would enter a 4 here.
- Ditch (Back) Side Slope, in in/ft. The back side slope refers to the side of the ditch nearest the right of way line. This value must be entered in in/ft. For example, if the back side slope was 2:1, the user would enter a 6 here.
- Ditch bottom width, (in case of a trapezoidal ditch section) in ft. If the ditch is triangular, just leave blank or enter 0.

- If the selected IDF location type is "County" or “City” the user would be required to key the initial "Tc" value if this were the first station or to confirm the default "Tc" value if it is a subsequent station.
- If the user had elected to use "Custom" for the IDF, then the user would be required to key the initial "I-2" and "I-10" values or confirm the default "I" values if it is a subsequent station.

The user may key any number of stations per reach and any number of reaches.

In order to add a new station the user needs to click the “New Station” button, this will create a new station record with the fields defaulted to the previous station of that reach, except for the “TC” or “I” values, they would default accordingly. The user should still supply a Station Reference.

The user is required to key in at least one "sub-area" for the current station. In accordance with the manual procedure described in Chapter VII of the Drainage Manual, the user should key enough areas of a specific Rational Formula "C" factor appropriate to the current ditch station. For instance if the station contained a certain amount of area at 0.9 (for pavement), some at 0.5 (for areas inside the right of way), and some at 0.3 (for areas outside the right of way), the user would need to key 3 sub-areas. In order to do this the user will need to use the “New” button found in the grid. Key the appropriate “C” and “WS”, and then click “New” again till all 3 “sub-areas” are keyed.

The width of strip ("WS") must be entered in feet.

In order to add a new reach, the user needs to click the “New Reach” button, this will create a new reach and station with the fields of the station defaulting to the last station in the previous reach. The user should still supply a Reach Description and Station Reference.

The user may use the “First”, “Prev”, “Next”, and “Last” keys to traverse the Station and Reach data respectively. The user may edit any of the data; however the “TC” and “I” values will only default when adding a new Station or Reach, therefore if the user adjusted the “I” value on a Station it will not populate down to subsequent stations, nor will any of the other values.

If a station needs to be removed from the scenario, the user will need to be viewing that station’s information and click “Delete Station”.

If a reach needs to be removed from the scenario, the user will need to be viewing that reach’s information and then click “Delete Reach”.

3.9.4 Upload Existing Input File

This module does allow the uploading of an existing file; however the format must conform to the previous DOS based program’s file format.

Input data for this module can be created and/or edited independently of the web application by using either a text editor or word processor; but must be saved as a text file. Data entry is free format (i.e. there are no fixed length data fields). Individual input data items must be separated by at least one blank space and a line of input data items must be concluded by pressing the ENTER key. However, if the text editor utilized is one that each press of the ENTER key inserts a blank line of text, the RETURN key should not be pressed at the end of the last line of input data. There should not be any blank lines separating data items and there should not be any blank lines at the very end of the data set.

The data entry structure is basically to enter all necessary information relative to a given ditch reach and then follow it up with the same information for any and all subsequent reaches. The sequence of data input records for a given ditch reach are shown below:

Line 1: Must contain (only) either a "1" or "2".

"1" signifies that the module will read intensity data.

"2" signifies that the module will be reading Time of Concentration data.

Line 2: Must contain (only) the I.D. number of the ditch reach which corresponds to the reach description following on Line 3 (the first ditch reach entered would be no. 1, then the second would be no. 2, etc.

Line 3: Must contain (only) the ditch reach description for reach number described under Line 2 above (can be up to 80 characters in any combination and can include punctuation such as "," or ":" etc.)

Line 4: Must contain (only) the number of ditch stations contained in the current ditch reach (must be at least 1)

Line 5: Must contain (only) the station description of the first station to be analyzed under the current ditch reach (can be up to 80 characters in any combination by may not contain punctuation)

Line 6: Must contain (1st field) the number of sub areas (combinations of "widths of strip" and "C" values) to follow, (2nd field) 1st "C" value, (3rd field) 1st "WS" value, (4th field) 2nd "C" value, (5th field) 2nd "WS" value, etc.

Line 7: Must contain (1st field) the slope along the ditch, (2nd field) front or ditch side slope, (3rd field) back or cut slope, (4th field) bottom width - 0 if a triangular ditch, (5th field) - if Line 1 = 2 – Time of Concentration, (5th field) - if Line 1 = 1 - 2 yr. rainfall intensity, (6th field) - if Line 1 = 2 - length of segment along center line, (6th field) - if Line 1 = 1 - 10 yr. rainfall intensity, and (7th field) – if Line 1 = 1 - length of segment along center line.

Line 8: This line would either start an additional station for the reach number described on Line 1 and would contain a station description and the same information described on Lines 6

& 7 or this line would start an additional ditch reach and would contain the same information described on Line 1 followed by the same information described on Lines 2 thru 7 or, if no more ditch reaches or additional stations of the current reach were to be read, this line would not be needed.

It should be noted that if Line 1 contains a 1, then additional ditch reaches must contain a 1 for the first line. Likewise if Line 1 contains a 2, additional reaches also must begin with a 2 here. The module cannot switch back and forth between user supplied and module calculated "I" values from reach to reach.

An example input data set using user supplied "I" values, 2-ditch reaches, 2-stations per reach, and 2-width of strips per ditch station are shown below:

```
 1
 1
STATION 1+00 TO 3+00 W.B.L. RIGHT
 2
1+00 TO 2+00
 2  .9  12  .5  20
 .01  3  6  0  3.5  5  100
2+00 TO 3+00
 2  .9  12  .5  10
 .012  3  6  0  3.4  4.9  100
 1
 2
STATION 4+00 TO 6+00 E.B.L. LEFT
 2
4+00 TO 5+00
 2  .9  10  .5  20
 .02  3  6  0  3.5  5  100
5+00 TO 6+00
 2  .9  10  .5  15
 .02  3  6  0  3.4  4.9 100
```

3.9.5 Results

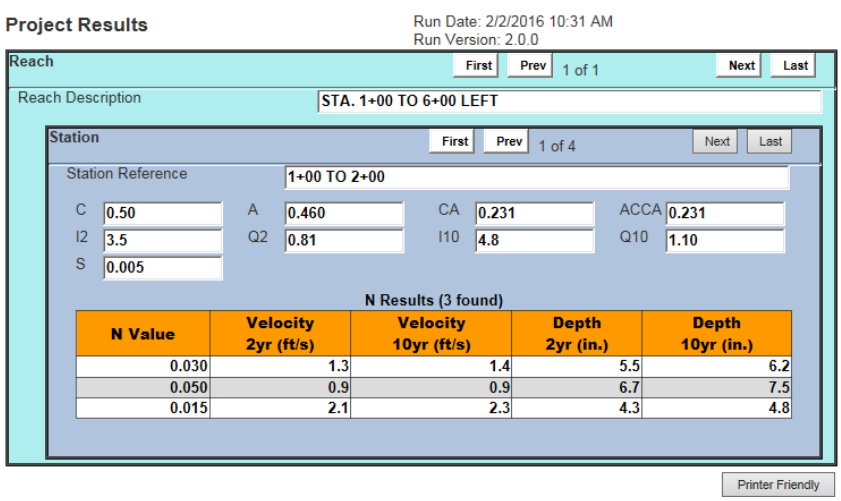
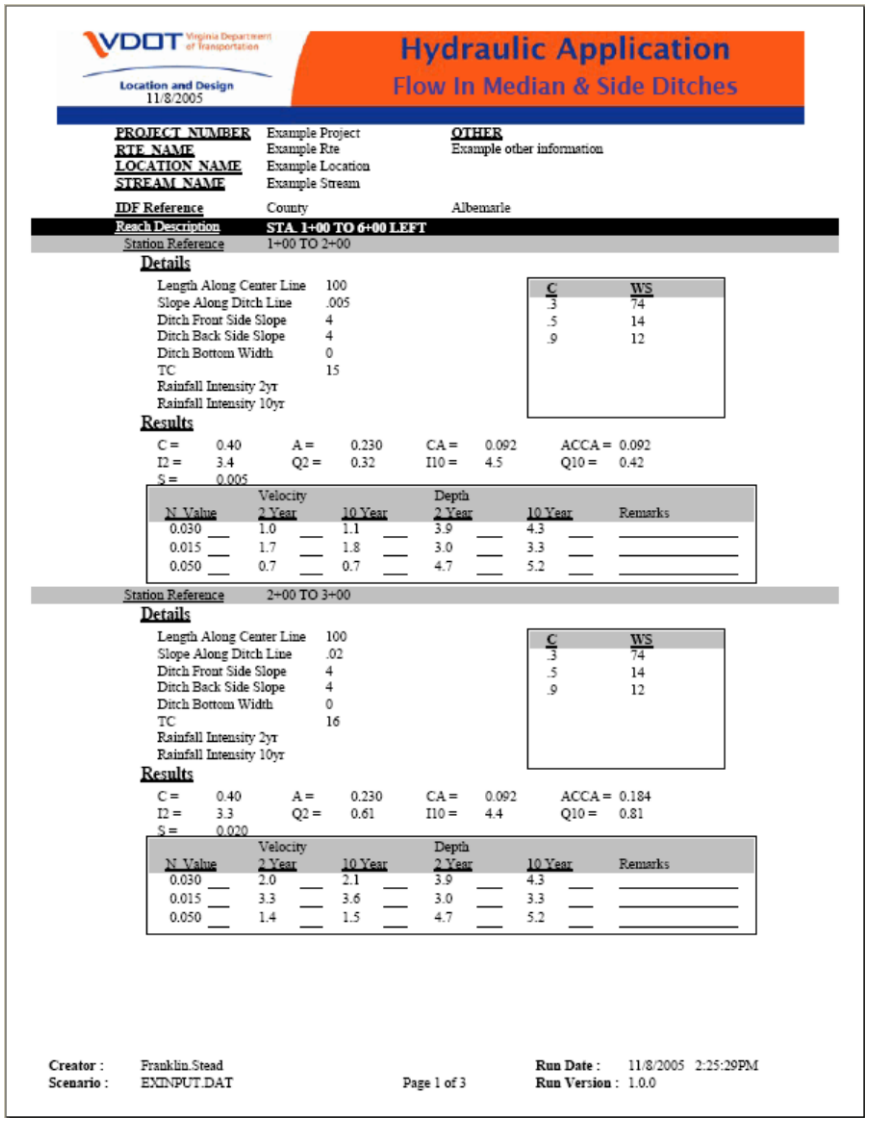


Figure **3.9.5** Results Section of web form for RDDITCH

Once the user has entered the required details and clicked the “Calculate” button, the Results section of the page will be displayed.

3.9.6 Print Out



VDOT Virginia Department of Transportation
Location and Design
11/8/2005

Hydraulic Application
Flow In Median & Side Ditches

PROJECT_NUMBER	Example Project	OTHER	
RTE_NAME	Example Rte	Example other information	
LOCATION_NAME	Example Location		
STREAM_NAME	Example Stream		
IDF Reference	County	Albemarle	
Reach Description	STA 1+00 TO 6+00 LEFT		

Station Reference 1+00 TO 2+00

Details

Length Along Center Line	100
Slope Along Ditch Line	.005
Ditch Front Side Slope	4
Ditch Back Side Slope	4
Ditch Bottom Width	0
TC	15
Rainfall Intensity 2yr	
Rainfall Intensity 10yr	

C	WS
.3	74
.5	14
.9	12

Results

C =	0.40	A =	0.230	CA =	0.092	ACCA =	0.092
I2 =	3.4	Q2 =	0.32	I10 =	4.5	Q10 =	0.42
S =	0.005						

	Velocity		Depth		
N Value	2 Year	10 Year	2 Year	10 Year	Remarks
0.030	1.0	1.1	3.9	4.3	
0.015	1.7	1.8	3.0	3.3	
0.050	0.7	0.7	4.7	5.2	

Station Reference 2+00 TO 3+00

Details

Length Along Center Line	100
Slope Along Ditch Line	.02
Ditch Front Side Slope	4
Ditch Back Side Slope	4
Ditch Bottom Width	0
TC	16
Rainfall Intensity 2yr	
Rainfall Intensity 10yr	

C	WS
.3	74
.5	14
.9	12

Results

C =	0.40	A =	0.230	CA =	0.092	ACCA =	0.184
I2 =	3.3	Q2 =	0.61	I10 =	4.4	Q10 =	0.81
S =	0.020						

	Velocity		Depth		
N Value	2 Year	10 Year	2 Year	10 Year	Remarks
0.030	2.0	2.1	3.9	4.3	
0.015	3.3	3.6	3.0	3.3	
0.050	1.4	1.5	4.7	5.2	

Creator : Franklin.Stead
Scenario : EXINPUT.DAT
Page 1 of 3
Run Date : 11/8/2005 2:25:29PM
Run Version : 1.0.0

Figure **3.9.6** Printable PDF for RDDITCH

The user has the option to obtain a PDF file of the Scenario; this can be obtained by clicking the “Printer Friendly” button. Figure 3.9.6 is a sample output of the PDF.

The PDF printer friendly form provides remarks columns and places to put check marks after information calculated for Manning's "n" values of 0.03, 0.05, and 0.015 respectively. This has been provided so the user can make pencil notes on the output indicating at what locations protective linings must be used and the type of protective lining.

3.10 REGEQUAT – REGRESSION EQUATIONS CALCULATION

3.10.1 Introduction

REGEQUAT was originally developed on the Regional Regression Equations presented in the U.S. Geological Survey's publication "Methods for Estimating the Magnitude and Frequency of Peak Discharges of Rural, Unregulated Streams in Virginia" (Water-Resources Investigations Report 94-4148). To save space, the individual Regional Regression Equations have not been reprinted in this user's manual. If you wish to see the actual equations, refer to pages 11 and 12 of the above noted publication.

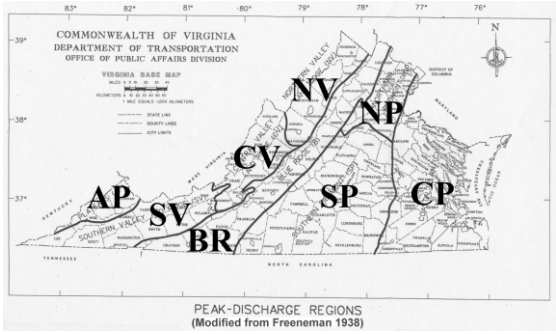
REGEQUAT has been updated to accommodate the equation changes presented in the U.S. Geological Survey's publication "Peak-Flow Characteristics of Virginia Streams" (Scientific Investigation Report 2011-5144). This update to the application was made in a way that allows the user to select which method to use, in order to accommodate projects of differing specification years and existing data.

3.10.2 Algorithm

3.10.2.1 Report 94-4148

The U.S.G.S. divided the state up into eight "Peak Discharge Regions" each of which is delineated on the state map which accompanies their publication. The regions are as follows:

- Coastal Plain (CP)
- Northern Piedmont (NP)
- Southern Piedmont (SP)
- Blue Ridge (BR)
- Northern Valley & Ridge (NV)
- Central Valley & Ridge (CV)
- Southern Valley & Ridge (SV)
- Appalachian Plateaus (AP)



3.10.2.1.1 "Area Only" equations

In each of the regions above, equations have been developed which utilize only the Drainage area in square miles at the crossing site as a variable. These equations are referred to as the "Area Only" equations.

3.10.2.1.2 "Multiple Parameter" equations

In addition to "Area Only" equations the Coastal Plain, Southern Piedmont, Northern Valley & Ridge, and Appalachian Plateaus regions each have a unique equation that take various other parameters into account. These other equations are referred to as "Multiple Parameter" equations. These additional parameters are, by region, as follows:

- Coastal Plain

Slope: Slope of the watershed in ft/mi. between 10% and 85% of the total watershed length above the crossing site.

- Southern Piedmont
  Elevation: Average basin elevation in ft. above mean sea level.
  Length: Watershed length from the crossing site (along the primary stream) to the watershed divide in mi.
- Northern Valley & Ridge
  Length: Watershed length from the crossing site (along the primary stream) to the watershed divide in mi.
  Forestation: Percentage of the watershed in forestation.
- Appalachian Plateaus
  Slope: the slope of the watershed in ft./mi. between 10% and 85% of the total watershed length above the crossing site.

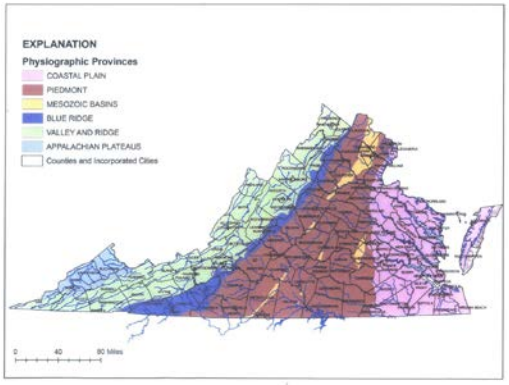
As with the "Area Only" equations, the drainage area in sq. mi. is also a parameter of the "Multiple Parameter" equations.

Both sets of equations are intended for use with natural, rural, un-regulated watersheds. Based on user supplied input information, this module will estimate 2-year through 500-year peak discharges by the "Area Only" equations in regions having only those equations. This module will estimate 2-year through 500-year peak discharges by both "Area Only" and "Multiple Parameter" equations in regions having both sets of equations.

3.10.2.2 Report 2011-5144

The U.S.G.S. divided the state up into 6 "Peak Discharge Regions" each of which is delineated on the state map which accompanies their publication. The regions are as follows:

- Coastal Plain
- Piedmont
- Mesozoic Basins
- Blue Ridge
- Valley & Ridge
- Appalachian Plateaus (AP)



In this updated edition of the of the regression equations the input data is limited to area only in square miles. The physiographic province areas have been included in the VDOT GIS Integrator. These equations are intended for use with natural, rural, un-regulated watersheds. Based on user supplied input information, this module will estimate 2-year through 500-year peak discharges.

3.10.2.3 Accounting or Urbanization

The effects of urbanization may be taken into account for either of the U.S.G.S report algorithms. The effects of Urbanization can be calculated either be the 3 parameter method or both the 3 parameter and 7 parameter methods.

3.10.2.3.1 Method from 2014-5090

The urbanization method as described in “Scientific Investigations Report 2014-5090” from the USGS, only requires one addition entry from the user, the percentage used as Basin Storage. The equations can be found in the before mention 2014-5090, specifically table 3 of that document. The urbanization adjustment is applied to the 2-year through 500-year peak discharges determined by the rural "Area Only" equations in regions having only those equations. It is only applied to the results of "Area Only", "Multiple Parameter" are not included in urbanization results.

3.10.2.3.2 3 Parameter Urbanization Method

The 3 parameter urbanization method only requires one addition entry from the user, Basin Development Factor (BDF for short). By applying the Basin Development Factor in conjunction with the (3 parameter) Urban Regression Equations as described in the VDOT "DRAINAGE MANUAL", chapter 6 (Hydrology), Section 6.4 (Design Concepts), sub-section 6.4.4.5 (Urban Regression Method), in Table 6-6. The urbanization adjustment is applied to the 2-year through 500-year peak discharges determined by the rural "Area Only" equations in regions having only those equations. It is applied to the results of both "Area Only" and "Multiple Parameter" equations in regions having both sets of equations.

3.10.2.3.3 7 Parameter Urbanization Method

In addition to the Basin Development Factor the 7 parameter urbanization method also requires the Main Channel Slope (which may already be required depending on the selected region), the percentage used as Basin Storage, the percentage of Impervious Surface, and finally the location to pull the 2yr/2hr rainfall data.

The updated VDOT "DRAINAGE MANUAL", which will include the 7 parameter urbanization equations, is pending; however it will be in chapter 6. The equations can also be found in the “AASHTO MODEL DRAINAGE MANUAL” (March, 2005) in chapter 7 (Hydrology), in section 7.15 (Urban Regression Equations), sub-section 7.15.3 in the form of the generalized equation 7.8. The individual equations are shown in Table 7-4 on the following page.

3.10.3 Details Entry

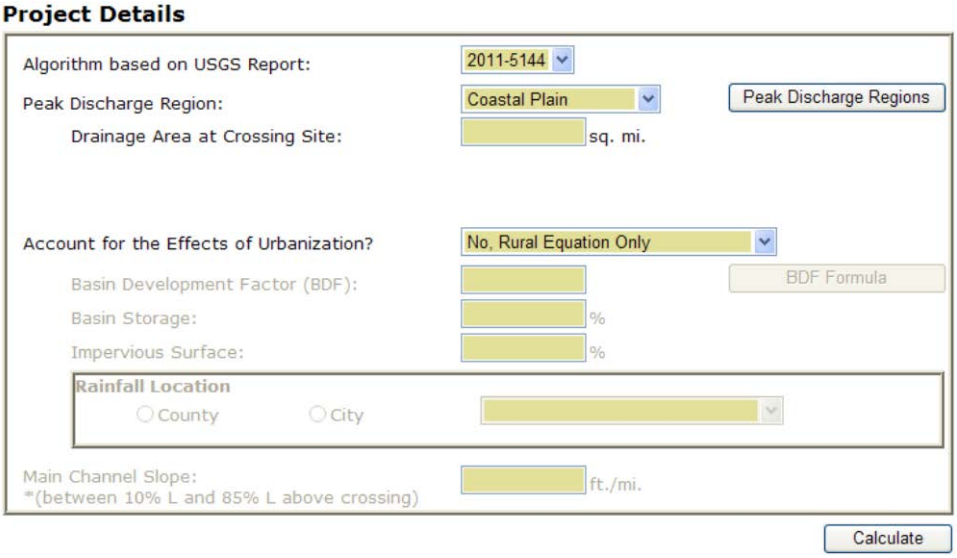


Figure **3.10.3** Details Section of web form for REGEQUAT

The user will need to select which “Algorithm based on USGS Report” will be used. This option will determine which regions will be available in the “Peak Discharge Region”.

The user will need to select the appropriate “Peak Discharge Region” from those available based on the USGS Report. If USGS Report 94-4148 then the region selection will determine which set of "Area Only" or "Area Only" and "Multiple Parameter" equations to use. The web form will be updated to solicit the appropriate input for the equation of the selected region.

The user will also need to select whether to calculate Urbanization based on the Report 2014-5090, the 3 parameter equation, the 3 and 7 parameter equation, or Rural only. This tells the module if any addition input will be required. The web form will be updated to solicit the appropriate input to calculate urbanization based on the users selection.

If the 7 Parameter Urbanization method is to be calculated then the user will need to select the appropriate location of the rainfall information. This is broken down into 2 location types, “City” and “County” which are selected using the Rainfall Location radio buttons. The user will then be required to select the municipality from the dropdown list next to the radio buttons. This dropdown list will only show the locations that are available based on the location type selected with the radio buttons. The user should select the location that is closest to the area of interest and the module will read that locations data.

The user is required to key…

- Drainage Area at Crossing Site in square miles
- Main Channel Length for both the USGS Report 94-4148 Southern Piedmont and Northern Valley Ridge regions in miles

- Mean Basin Elevation above sea level for the USGS Report 94-4148 Southern Piedmont region in feet
- Watershed Forestation for the USGS Report 94-4148 Northern Valley Ridge in percent
- Basin Development Factor (BDF) 0-12, if Urbanization is to be taken into account
- Basin Storage in percent, if Report 2014-5090 or 7 Parameter Urbanization method is selected
- Impervious Surface in percent, if 7 Parameter Urbanization method is selected.
- Main Channel Slope in ft/mi, if 7 Parameter Urbanization method is selected or if selected Region is Coastal Plain or Appalachian Plateaus.

There are 2 reference buttons the user may use.

- "Peak Discharge Regions" button opens a separate window displaying the reference map of the Peak Discharge Regions of the selected USGS Report.
- "BDF Formula" button is only accessible if Urbanization is being taken into account, and displays an excerpt from the VDOT Drainage Manual on how to determine the BDF between 0 and 12.

3.10.4 Upload Existing Input File

This module does not support the uploading of an existing input file.

3.10.5 Results

Project Results

Run Date: 7/30/2008 10:02 AM
Run Version: 1.0.1

Peak Discharges (7 found)

R.I. (yrs)	E.P. (%)	Rural Area Only Q (cfs)	Rural Multiple Q (cfs)	Urban 3P Area Only Q (cfs)	Urban 3P Multiple Q (cfs)	Urban 7P Area Only Q (cfs)	Urban 7P Multiple Q (cfs)
2	50.0	275	248	379	351	435	414
5	20.0	497	423	621	548	729	668
10	10.0	693	560	871	736	1003	886
25	4.0	991	746	1169	931	1362	1148
50	2.0	1239	889	1464	1119	1700	1384
100	1.0	1514	1046	1774	1310	2043	1619
500	0.2	2251	1458	2618	1826	2798	2128

Estimated 'Ordinary Highwater' Discharge = 6.07 CFS

Printer Friendly

Figure **3.10.5** Results Section of web form for REGEQUAT

Once the user has entered the required details and clicked the "Calculate" button, the Results section of the page will be displayed. The results grid on the web form will only display the calculated columns; all other columns will be removed from the grid.

3.10.6 Print Out

VDOT Virginia Department of Transportation
Location and Design
9/7/2012

Hydraulic Application
RegEquat
Regression Equations Calculation

PROJECT_NUMBER **OTHER**
RTE_NAME
LOCATION_NAME
STREAM_NAME

Project Details

Algorithm based on USGS Report: 2011-5144
Peak Discharge Region: Blue Ridge
Drainage Area at Crossing Site: 3.03 sq. mi.

Effects of Urbanization: Yes, with 3 & 7 Parameter Equations
Basin Development Factor (BDF): 0
Basin Storage: 0 %
Impervious Surface: 1 %
Location type: County
Location for the rainfall data file to use: Dickenson
Main Channel Slope: 276.1 ft./mi.
* (between 10% L and 85% L above crossing)

Project Results

		RURAL		URBAN			
				3 Parameter		7 Parameter	
R.I. Years	E.P. %	Area Only Q (cfs)	Multiple Q (cfs)	Area Only Q (cfs)	Multiple Q (cfs)	Area Only Q (cfs)	Multiple Q (cfs)
2	50.0	294		350		343	
5	20.0	648		688		705	
10	10.0	1001		1058		1079	
25	4.0	1570		1544		1620	
50	2.0	2121		2068		2205	
100	1.0	2948		2800		2885	
500	0.2	5598		5067		4750	

* Note : The grid output is based on the supplied Parameters, empty columns will be displayed for those values that where not required to be generated.

Estimated 'Ordinary Highwater' Discharge: 3.33 cfs

Creator : Franklin.stead **Run Date :** 8/30/2012 12:45:24PM
Scenario : AP 1.2011 Page 1 of 1 **Run Version :** 2.0.0

Figure **3.10.6** Printable PDF for REGEQUAT

The user has the option to obtain a PDF file of the Scenario; this can be obtained by clicking the "Printer Friendly" button. Figure 3.10.6 is a sample output of the PDF. The results grid for the printable report will display all possible columns, even those not calculated; however the uncalculated columns will remain empty.

3.11 RIPRAP – BASED ON PROCEDURES PRESENTED IN FHWA'S "HEC-11" AND "HIGHWAYS IN THE RIVER ENVIRONMENT" PUBLICATIONS

3.11.1 Introduction

The RipRap module is really 3 separate modules in one “Channel RipRap Design”, “Wave Action RipRap Design”, and “Tractive Force.” This modules sections will be additionally segmented by these options.

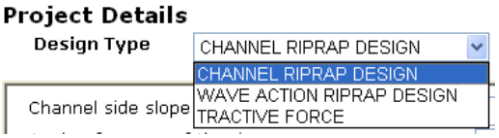
3.11.2 Algorithm

The "Channel Riprap Design" and "Wave Action Riprap Design" options are based on the procedures and equations in FHWA's HEC-11 publication dated March 1989. The Tractive Force option is based on procedures and equations in FHWA's Highways In The River Environment dated December 1988. Users of this program should be familiar with the procedures and methods outlined in these publications.

NOTE: The formulas in the Tractive Force option and those in the Riprap Design option were not coordinated and don't necessarily give corresponding answers. Normally the Tractive Force option would be used only to check the stability of the native material (if the soil is known). If the native material is unstable, use the Riprap Design option to do the design. No further checking is necessary.

3.11.3 Details Entry

The user should first select the Design Type; “Channel Riprap Design” is the default. This will update the required and option input fields.



NOTE: If the Design Type changes then the input fields will be initialized.

3.11.4 Channel RipRap Design

3.11.4.1 Details Entry

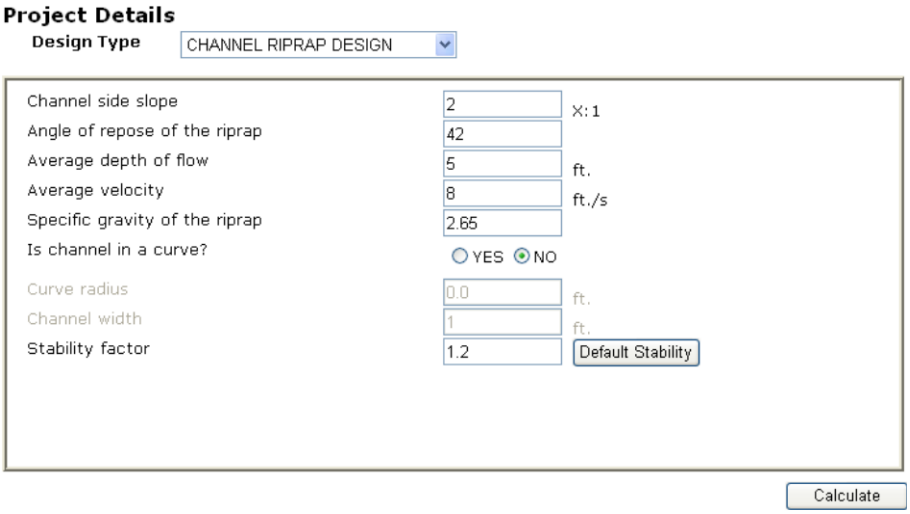


Figure **3.11.4.1** Details Section of web form for Channel RipRap Design

The user is required to key…

- Channel side slope (ratio).
- Angle of repose of the riprap (42 degrees is the default).
- Average depth of flow.
- Average velocity
- Specific gravity of the riprap (2.65 is the default).
- Is the channel in a curve radio button option ("Yes" or "No")
    - If "Yes" was selected then 2 additional fields are required
        - Curve Radius (channel's center line radius)
        - Curve Width (base width of the channel)
- Stability factor (The default value is the middle of the range for the channel configuration you selected. This value can be calculated for you by click the "Default Stability" button. For more information on this see page 31 of HEC-11.)

3.11.4.2 Results

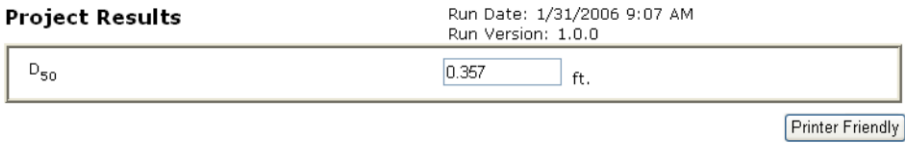
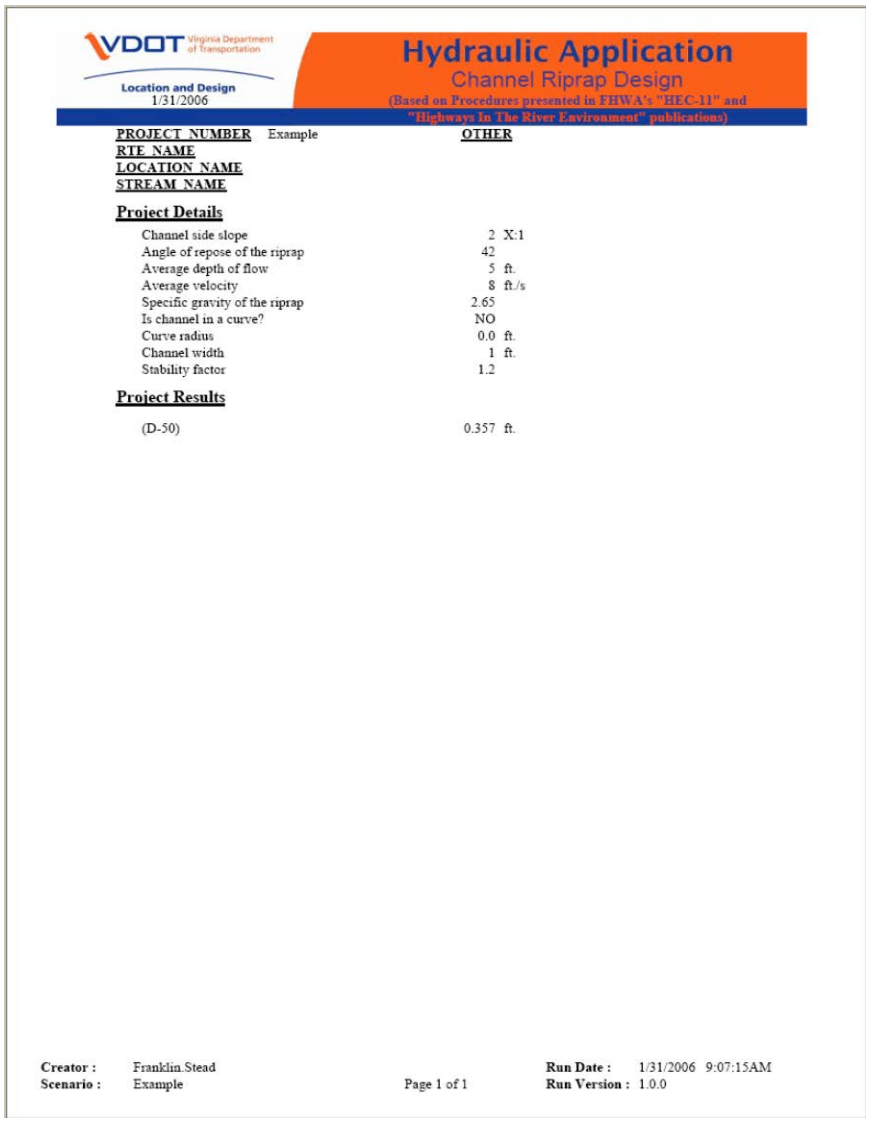


Figure **3.11.4.2** Results Section of web form for Channel RipRap Design

Once the user has entered the required details and clicked the "Calculate" button, the Results section of the page will be displayed.

3.11.4.3 Print Out



VDOT Virginia Department of Transportation

Location and Design
1/31/2006

Hydraulic Application
Channel Riprap Design
(Based on Procedures presented in FHWA's "HEC-11" and "Highways In The River Environment" publications)

PROJECT_NUMBER	Example	**OTHER**
RTE_NAME		
LOCATION_NAME		
STREAM_NAME		

Project Details

Channel side slope	2	X:1
Angle of repose of the riprap	42	
Average depth of flow	5	ft.
Average velocity	8	ft./s
Specific gravity of the riprap	2.65	
Is channel in a curve?	NO	
Curve radius	0.0	ft.
Channel width	1	ft.
Stability factor	1.2	

Project Results

(D-50)	0.357	ft.

Creator : Franklin.Stead
Scenario : Example
Page 1 of 1
Run Date : 1/31/2006 9:07:15AM
Run Version : 1.0.0

Figure **3.11.4.3** Printable PDF for Channel RipRap Design

The user has the option to obtain a PDF file of the Scenario; this can be obtained by clicking the "Printer Friendly" button. Figure 3.11.4.3 is a sample output of the PDF.

3.11.5 Wave Action RipRap Design

3.11.5.1 Algorithm

Limits on wave action riprap design

- The equation used in this Program is based on wave heights less than 5 feet and no major overtopping of the embankment.
- Wave runup is based on a depth to wave height ratio less than or equal to 3.
- Wave runup for slopes flatter than 8 to 1 are beyond this programs ability.

3.11.5.2 Details Entry

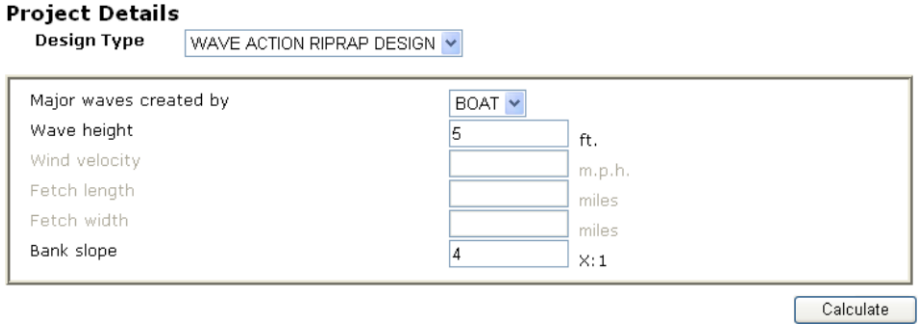


Figure **3.11.5.2** Details Section of web form for Wave Action RipRap Design

The user is required to key…

- Major waves created by option ("Boat" or "Wind")
  - If "Boat" was selected then 1 additional field is required
    - Wave height
  - If "Wind" was selected then 3 additional fields are required
    - Wind velocity (sustained design wind velocity)
    - Fetch length (The clear, unobstructed distance that the wind has to act on the water surface.)
    - Fetch width (The clear, unobstructed width of area that the wind has to act on the water surface.)
- Bank slope (ratio)

3.11.5.3 Results

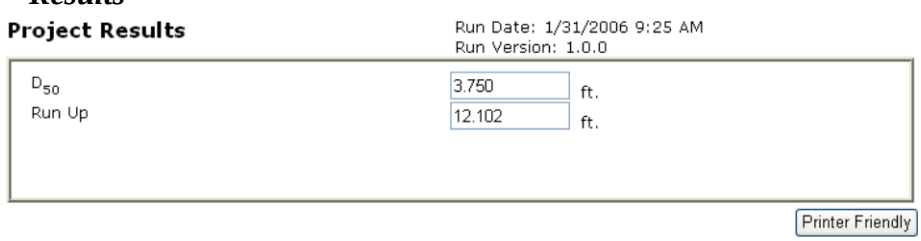
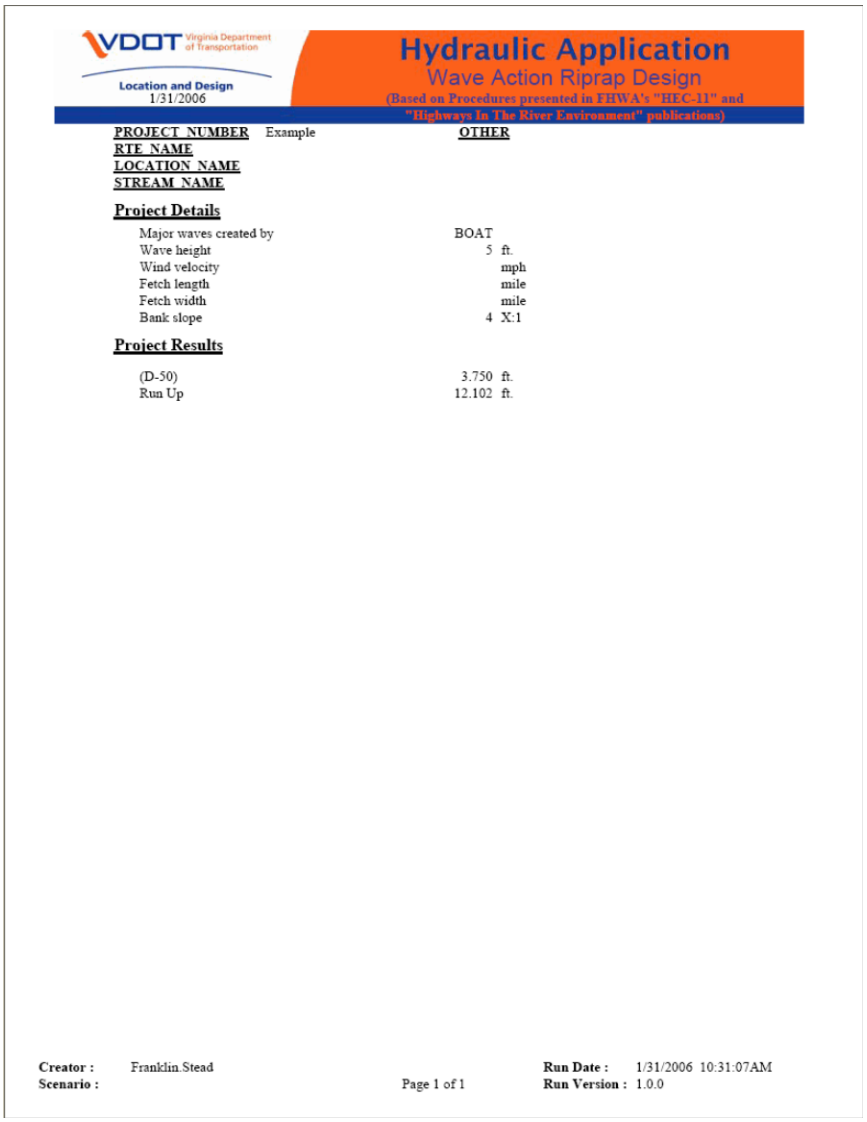


Figure **3.11.5.3** Results Section of web form for Wave Action RipRap Design

Once the user has entered the required details and clicked the "Calculate" button, the Results section of the page will be displayed.

3.11.5.4 Print Out



VDOT Virginia Department of Transportation

Location and Design
1/31/2006

Hydraulic Application
Wave Action Riprap Design
(Based on Procedures presented in FHWA's "HEC-11" and "Highways In The River Environment" publications)

PROJECT_NUMBER	Example	**OTHER**
RTE_NAME		
LOCATION_NAME		
STREAM_NAME		

Project Details

Major waves created by	BOAT	
Wave height	5	ft.
Wind velocity		mph
Fetch length		mile
Fetch width		mile
Bank slope	4	X:1

Project Results

(D-50)	3.750	ft.
Run Up	12.102	ft.

Creator : Franklin.Stead
Scenario :
Page 1 of 1
Run Date : 1/31/2006 10:31:07AM
Run Version : 1.0.0

Figure **3.11.5.4** Printable PDF for Wave Action RipRap Design

The user has the option to obtain a PDF file of the Scenario; this can be obtained by clicking the "Printer Friendly" button. Figure 3.11.5.4 is a sample output of the PDF.

3.11.6 Tractive Force

3.11.6.1 Details Entry

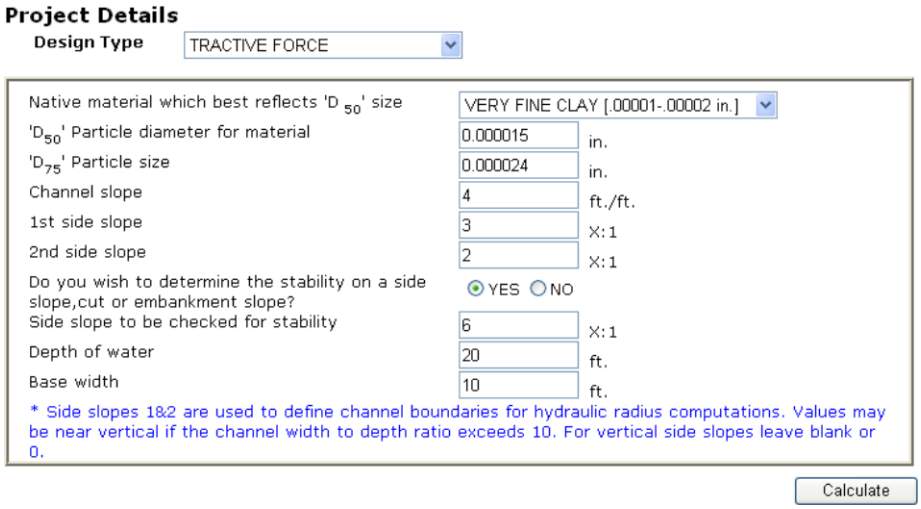


Figure **3.11.6.1** Details Section of web form for Tractive Force

The user is required to key…

- Native material which best reflects D_{50} size option.
- D_{50} particle diameter (The value shown is the average for the selected material. The user may change this value if the value is known.)
- D_{75} particle size (The value shown is the program's estimate for D_{75}. The user may change this value if the value is known.)
- Channel slope
- 1st side slope (ratio, leave blank or 0 for vertical)
- 2nd side slope (ratio, leave blank or 0 for vertical)
- Determine slope stability option ("Yes" or "No")
    - If "Yes" was selected then 1 additional fields is required
        - Side slope to be check for stability (ratio)
- Depth of water (average depth)
- Base width (average width)

NOTE: Values indicated for VDOT Standard Riprap sizes are correct as shown.

3.11.6.2 Results

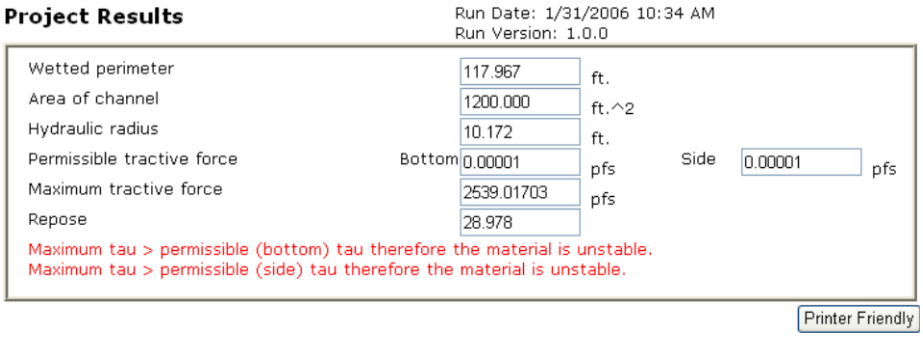


Figure **3.11.6.2** Results Section of web form for Tractive Force

Once the user has entered the required details and clicked the “Calculate” button, the Results section of the page will be displayed.

3.11.6.3 Print Out

VDOT Virginia Department of Transportation
Location and Design
1/31/2006

Hydraulic Application
Riprap - Tractive Force
(Based on Procedures presented in FHWA's "HEC-11" and "Highways In The River Environment" publications)

PROJECT_NUMBER **OTHER**
RTE_NAME
LOCATION_NAME
STREAM_NAME

Project Details

Native material which best reflects 'D-50' size	0.000015	
'D-50' Particle diameter for material	0.000015	in.
'D-75' Particle size	0.000024	in.
Channel slope	4	ft./ft
1st side slope	3	X:1
2nd side slope	2	X:1
Do you wish to determine the stability on a side slope,cut or embankment slope?	YES	
Side slope to be checked for stability	6	X:1
Depth of water	20	ft.
Base width	10	ft.

Project Results

Wetted perimeter		117.967	ft.		
Area of channel		1200.000	ft^2		
Hydraulic radius		10.172	ft.		
Permissible tractive force	Bottom	0.00001	pfs	Side	0.00001 pfs
Maximum tractive force		2539.01703	pfs		
Repose		28.978			

Maximum tau > permissible (bottom) tau therefore the material is unstable.

Maximum tau > permissible (side) tau therefore the material is unstable.

Creator : Franklin.Stead **Run Date :** 1/31/2006 10:34:15AM
Scenario : Page 1 of 1 **Run Version :** 1.0.0

Figure **3.11.6.3** Printable PDF for Tractive Force

The user has the option to obtain a PDF file of the Scenario; this can be obtained by clicking the "Printer Friendly" button. Figure 3.11.6.3 is a sample output of the PDF.

3.11.7 Upload Existing Input File

This module does not support the uploading of an existing input file.

3.12 VIRTOC – VIRGINIA RATIONAL METHOD AND TIME OF CONCENTRATION

3.12.1 Introduction

This module was designed to be a user friendly tool which allows the user to quickly and accurately calculate the peak flow for a given watershed. The VIRTOC module is designed to collect input and present output in English units. It allows the user to make choices in determining the variables used in the Rational formula. The user may enter all of the required variables or choose to calculate the Rational runoff coefficient, time of concentration or intensity. The format also allows the user to make changes in previous input values and recalculate the peak flow without leaving the program.

The user is advised that the use of VIRTOC is constrained by the assumptions of the Rational method and thus the program should not be used for watersheds over 200 ac in size. In addition, the equation which describes the IDF curves is valid only for storm durations between 5 minutes and 2 hours.

3.12.2 Algorithm

The Rational formula is used to find the peak flow for watersheds of 200 ac, or less, in size. It is not recommended for areas greater than 200 ac as the formula does not accurately predict flow for such large areas. The rational formula assumes spatial and temporal uniformity of a storm. That is, there is uniform rainfall and a uniform intensity over the entire watershed. This is more likely to be accurate for small watersheds than for very large ones, hence the 200 ac restriction.

The rational formula is presented in the following equation

$$Q = C * C_f * I * A$$

Where:

Q = peak flow, cfs
C = runoff coefficient
C_f = saturation correction factor
I = rainfall intensity, in/hr
A = (total) drainage area, acres

Note: To get the 500-yr. discharge, multiply the final calculated 100-yr. discharge by 1.7.

The Engineer can arrive at a composite "C" factor for the entire watershed or, as is more commonly done, he can determine a "C" factor for each different type of land cover and combine them into what is called a weighted "C" factor or "C_w". The weighted coefficient is calculated by the following equation

$$C_w = \frac{\sum_{i=1}^{num} A_i C_i}{\sum_{i=1}^{num} A_i}$$

Where:

C_w = weighted runoff coefficient
Ai = subwatershed area
Ci = subwatershed runoff coefficient

The "Recommended Coefficient of Runoff Values for Various Selected Land Uses" can be found by pressing the "Recommended C" in the Project Details of this module.

The Saturation Factor is intended as an adjustment to the runoff coefficient to compensate for the fact that rainfall runoff potential is increased for more severe storm events, i.e. the ground would be more saturated.

Storm Year	C_f {Saturation Factor}
2	1.0
5	1.0
10	1.0
25	1.1
50	1.2
100	1.25

Note: The final "C" value cannot exceed 1.0 (for the 25, 50, and/or 100-yr. flood events). If this is the case then C_f is 1.0.

The time of concentration for the watershed is required to determine the intensity. Again, the user has the option to enter the time of concentration or calculate the value. If the user chooses to calculate the time of concentration there are eight options for doing so. The flow is divided into overland flow and channel flow. There are four options for determining the time of overland flow and four options for determining the time of channel flow. The user may also specify 'no overland flow' or 'no channel flow.' If the user chooses both 'no overland flow' and 'no channel flow' an error message will appear when the user clicks the "Calculate" button.

Overland Flow

Kinematic Wave

The Kinematic Wave formula is shown in equation below

$$T_c = 0.93 * \left(\frac{L^{0.6} * n^{0.6}}{i^{0.4} * S^{0.3}}\right)$$

Where:

T_c = time of travel for overland flow, minutes
L = length of overland flow path, feet
n = Manning's roughness coefficient
i = rainfall intensity, in/hr
S = average slope of overland flow, ft/ft

This overland flow time of concentration method was developed from data for watersheds less than 10 acres in size. L is the straight line distance from the most distant point to the outlet measured parallel to the slope until a channel is reached.

The user is prompted to enter the length, slope and Manning's roughness coefficient.

This is an iterative method because there are two unknowns, intensity and time of concentration. This module assumes an initial estimate for intensity as the intensity for the one hour duration storm for the appropriate return period and location. The time of concentration is calculated and the intensity found from the IDF curve. If the intensity equals the one hour duration intensity then the iteration is done. If not, the intensity for the calculated time of concentration becomes the new estimate and the time of concentration is recalculated. The procedure continues until successive estimates of the time of concentration are within 0.01 minute of each other.

NRCS Curve Number

The NRCS Curve Number formula is shown in equation below

$$T_c = 60 * \frac{L^{0.8} * \left(\frac{1000}{CN} - 9\right)^{0.7}}{1900 * S^{0.5}}$$

Where:

T_c = time of travel for overland flow, minutes
L = length of overland flow path, feet
CN = NRCS curve number
S = average slope of overland flow, ft/ft

This method was developed by the National Resource Conservation Service (NRCS) from agricultural watershed data. The NRCS method assumes that time of concentration is 0.67 times the lag time.

The user is prompted for the length, slope, and CN values.

Seelye

The Seelye formula is shown in equation below

$$T_c = 0.225 * L^{0.42} * S^{-0.19} * C^{-1}$$

Where:

T_c = time of travel for overland flow, minutes
L = length of overland flow path, feet
C = Rational coefficient for overland flow
S = average slope of overland flow, ft/ft

This equation was derived by Sodonia Solle, Virginia Department of Transportation (1994), from the Seelye nomograph.

Enter overland time

The user has the option to enter the overland flow time if this information is available.

Channel Flow

Kirpich

The Kirpich formula is shown in equation below

$$T_c = 0.0078 * L^{0.77} * S^{-0.385}$$

Where:

T_c = time of travel for channel flow, minutes
L = length of channel flow path, feet
S = average slope of channel flow, ft/ft

This channel flow method was developed from data from rural Tennessee watersheds.

The user is prompted to enter the length and slope values.

Manning

The Manning formula is shown in equation below

$$T_c = 0.011186 * L * n * R^{-0.667} S^{-0.5}$$

Where:

T_c = time of travel for channel flow, minutes
L = length of channel flow path, feet
n = Manning's roughness coefficient
R = hydraulic radius=A/P, feet
A = cross sectional area of flow channel, ft^2
P = wetted perimeter, feet
S = average slope of channel flow, ft/ft

The user is prompted to enter the length, slope, Manning's roughness coefficient and the hydraulic radius. ***Note: The hydraulic radius is the cross sectional area of flow over the wetted perimeter.***

Unpaved Waterway

The Unpaved Waterway formula is shown in equation below

$$T_t = 0.01033 * L * S_C^{-0.5}$$

Where:

T_t = time of travel for channel flow, minutes
L = length of channel flow path, feet
S= average slope of channel flow, %

This formula is based on the following equations…

First equation (derived from the nomograph in Figure 3-1 of TR-55):

$$V = 1.6135\ S_c^{\ 0.5}$$

Where:

V = average channel velocity, ft/sec

S_c = average channel slope, %

Second equation (taken directly from chapter 3 of TR-55):

$$T_t = \frac{L}{3600V}$$

Where:

T_t = travel time, hrs

L = flow length, ft

V = average velocity, ft/sec (using above derived equation)

Note: Since travel time is usually expressed in minutes, the above equation can be rewritten as:

$$T_t = \frac{L}{60V}$$

Where:

T_t = travel time, min

The user is prompted to enter the length and slope.

Enter Channel Time

The user has the option to enter the channel flow time if this information is available.

Once the travel times for overland flow and channel flow have been determined, the time of concentration is found as the sum of the two. The time of concentration is then used along with the previously chosen IDF curve to determine the design storm intensity. This program restricts the value of the time of concentration to the range of 5 minutes to 2 hours. If the calculated time of concentration is less than five minutes, the program sets the design storm intensity to the value corresponding to a five minute duration. The five minute lower boundary is a constraint of the IDF curve data. The upper boundary of 2 hours is imposed, as it is the upper limit of the range for which the equation used to describe the IDF curves is valid. The equation used to describe the IDF curve is as follows:

$$I = \frac{B}{(T_C + D)^E}$$

Where:

I = design storm intensity, in/hr

T_C = design storm duration, minutes

B, D, E = Factors that define Intensity-Duration-Frequency (IDF) values.

3.12.3 Details Entry

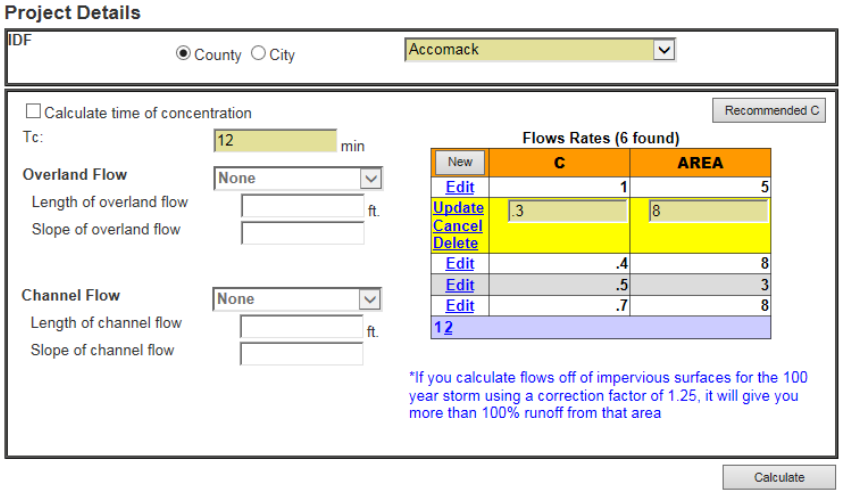


Figure **3.12.3** Details Section of web form for VIRTOC

The user will need to select the appropriate location of the IDF information. This is broken down into 2 location types, “City” and “County” which are selected using the IDF radio buttons. The user will then be required to select the municipality from the dropdown list next to the radio buttons. This dropdown list will only show the locations that are available based on the location type selected with the radio buttons. The user should select the location that is closest to the area of interest and the module will read that locations data.

The user is also required to either enter a Tc value or check the Calculate time of concentration checkbox. If the user chooses to check the Calculate time of concentration checkbox, then they are expected to fill in the required fields for Overland Flow and Channel Flow; see the Algorithm section for more details.

If the user wants the Peak Flows (Q) to be calculated, then at least one “C” and “Area” combination must be entered. If the user selects to enter more than one “C” and “Area” combinations, then the module will calculated the weighted coefficient.

3.12.4 Upload Existing Input File

This module does not support the uploading of an existing input file.

3.12.5 Results

Project Results

Run Date: 12/8/2015 12:41 PM
Run Version: 2.0.0

Storm Year Results (7 found)

Storm Year	Overland Flow Time (min)	Channel Flow Time (min)	TC (min)	Rainfall Intensity (in/hr)	Peak Flow Rate 'Q' (cfs)
2			12.00	3.87	126.59
5			12.00	4.68	152.92
10			12.00	5.23	170.94
25			12.00	5.80	208.57
50			12.00	6.29	246.93
100			12.00	6.86	280.30
500			n.a.	n.a.	476.51

Weighted runoff coef. (C) 0.574 Sum of CA value 32.70
Drainage area 57.00 ac

Printer Friendly

Figure **3.12.5** Results Section of web form for VIRTOC

Once the user has entered the required details and clicked the “Calculate” button, the Results section of the page will be displayed.

3.12.6 Print Out

VDOT Virginia Department of Transportation
Location and Design
1/31/2006

Hydraulic Application
Virtoc
Virginia Rational Method and Time of Concentration

PROJECT_NUMBER
RTE_NAME
LOCATION_NAME
STREAM_NAME

OTHER

Project Details

Location type: County
Location for the rainfall data file to use: Accomack

Tc: 30 hrs

Flow Rate

C	Area
.5	10

Overland Flow:
Length: ft
Slope: ft/ft

Channel Flow:
Length: ft
Slope: ft/ft

Project Results

Storm Year	Overland Flow Time (Min)	TC (hrs)	Rainfall Intensity (in)	Peak Flow Rate 'Q' (cfs)
2		30.00	2.40	12.02
5		30.00	2.98	14.92
10		30.00	3.38	16.90
25		30.00	3.79	20.85
50		30.00	4.16	24.95
100		30.00	4.63	28.93
500		n.a.	n.a.	49.18

Channel Flow Time: min
Weighted Run Off Coefficient 'C': 0.5000000
Drainage Area: 10.00 miles
Sum of CA value: 5.00

Creator : Franklin.Stead
Scenario :
Page 1 of 1
Run Date : 1/31/2006 10:47:10AM
Run Version : 1.0.0

Figure **3.12.6** Printable PDF for VIRTOC

The user has the option to obtain a PDF file of the Scenario; this can be obtained by clicking the "Printer Friendly" button. Figure 3.12.6 is a sample output of the PDF.

4. ADMINISTRATION

This section details the specific administration options available within the application. Each option corresponds with a navigation selection on under the administration tab.

4.1 PASSWORD

4.1.1 Introduction

External Users have the ability to assign their own password using this function.

Figure **4.1.1** Web form for Security Administration

4.1.2 Functionality

The user is required to type in the new password twice, and then press the Save button. If both password fields match, the password is updated in the database and the user is redirected to Home page.

DOCUMENT CONTROL

CHANGE HISTORY

Revision	Release Date	Description
0.1	<>	Initial Draft
1.0	11/14/05	Original, includes BRRIPRAP, DISCHAR, and RDDITCH. Also BDE Admin.
1.1	02/01/06	Added RIPRAP, LP3SHELL, and VIRTOC. Added Gage Admin. Plus various minor corrections.
1.2	05/12/06	Added CRITSTRM, EPSON, HY-15, PQTRANS. Added Password Admin. Added password functionality to Security Admin. Plus various minor corrections.
1.3	12/03/07	Added REGEQUAT.
1.4	09/15/2008	Added PFlow.
2.0	8/31/2012	Updated REGEQUAT to reflect additions for the 2011-5144 report.
4.0	2/29/2012	Upgraded interface to use site master, .Net Frame work from 3.5 to 4.5, and RegEquat 2014-5090 addition.

DOCUMENT OWNER

Franklin Stead was responsible for developing this document. Location and Design will be responsible for any modifications and Information Technology Division will be responsible for maintaining the document for the Web Application.