United States Department of Agriculture
Natural Resources Conservation Service

G W W . E X E

Vegetated Waterway Design
using
Retardance Theory

Version 5.02

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Introduction:

This program will compute the required parabolic or trapezoidal dimensions for a grassed waterway using the retardance procedure outlined in NRCS[1] TP - 61 and the NRCS National Engineering Field Handbook. Design results for multiple reaches can be maintained in computer memory at the same time so that adjustments can be easily made to improve on the overall continuity of the design. The printout provides the necessary design documentation including warnings when velocities get too high or too low and the number of acres that are within the flow area of the waterway.

Supporting Files:

The waterway design program is contained in a file called ***"GWW.EXE"***. In order to run, it must be supported by at least seven additional files on the default drive. The recommended setup follows:

BRT71EFR.EXE	This is a runtime module that is copyrighted to Microsoft Quick BASIC ™
OH_ENG.CFG	The file containing all of the specifics about your computing system such as type of printer, type of monitor, where data is saved, etc.
GWW.STD	This file contains the default values or any standard values that may apply to this program. The data in this file is controlled by the "modify defaults" portion of the program (see page 9).
GWW.ST2	Many of the values that support the program such as minimum and maximum values, formula coefficients, etc. are contained in this ASCII file. While this data can be edited using conventional text editors, it is recommended that changes be left to the experts.(See Page 13 for details related to the contents of this file.)
GWW.HLP	A file that contains help information related to this program. The program will run without this file but there will obviously be no help information available if the file is not present. Should the program be run without this file, a "dummy" file will be created with this file name containing no data. The information in the "real" file can be modified or clarified using a supporting program named *"edithelp.exe"*.

[1] NRCS - National Resources Conservation Service (formerly Soil Conservation Service)

BROWSE.COM This utility program is used so that some of the reports can be generated in a file format and then viewed on the screen in a controllable manner.

Loading GWW:

"GWW" can be loaded several ways. Make certain that you are in the subdirectory where the engineering programs reside. The main **"Ohio Engineering Menu"** can be loaded first by entering **"ENGMENU"** at the DOS prompt (C>) and then selecting the "**GWW**" program from the choice list. If the Waterway Design program does not exist in the list of programs, use a text editor like *"notepad"* or *"edit"* and enter the following line in the file named "engmenu.dat".

"gww.exe", "Waterway Design w/ Retardance"

The second option is to simply enter **"GWW"** at the DOS prompt. The program can also be executed using the procedures for launching a DOS program appropriate with the version of Windows that is being used. Typically this is done by creating a “pif” file or a “short cut”. Refer to your Windows manual if you are using Windows.

Special Keys:

In addition to the normal “arrow” keys, “Page Up” and “Page Down”, several special purpose keys are available at various times in the program. A brief description of the function of these keys follows. Additional information on these keys can be found by using the **F1** key within the program. (It should be noted that the mouse will also simulate the arrow keys, the left button simulates the return key and the right button duplicates the escape key.)

¿ This is a very important key in that inputs are not registered to the program until the **"return"** (↵) key is pressed. Failing to press the "return" key might result in an error message or it might result in computations being made without the input you thought you had made. Remember to input the requested data and then **press return (¿)** before computing, printing or saving the data. It should be noted that the **tab key** will provide the same response as the return key.

Esc The escape key is most often used to “back up” one action or level in the program. In other words, take you back from whence you cometh. For example, if you are in the data entry screen, "*Esc*" will take you back to the main GWW menu. If you are in the main GWW menu, "*Esc*" will afford you an opportunity to exit from the program.

F1 This function key will display help information if it is available. On some screens, you will be offered an option of selecting help for the particular entry where the cursor is, the entire screen or special keys.

F2 This key has been designated as the **"edit"** key. Pressing this key will afford you the opportunity to edit a previous entry or default value without completely retyping it. In this mode, the system shifts into an automatic "insert" mode and the left and right cursor keys and the backspace key, all become active. Once again, the return **(¿)** key will register your final entry.

F3 In some instances, pressing this key will cause a calculator to pop up on the screen. This is handy when you need to make a quick calculation. Pressing **F1** while the calculator is on the screen will cause a "help" window to appear that explains how to use the calculator.

F5 If noted at the bottom of the screen, pressing the F5 key will cause the report appropriate for the screen that you are on to be printed.

F9 This function key causes the computation routines to be implemented. This key can be pressed any time a solution is desired. If there is not sufficient data for a successful computation, an applicable message will be displayed. New or changed values on the input screen will clear previous computations and the F9 key will again be needed when all of the changes have been made.

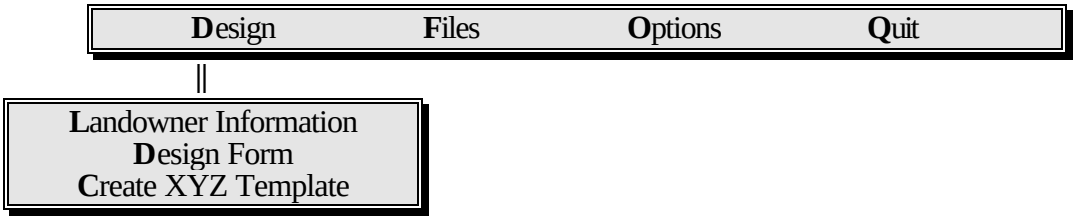
GWW Main Menu -

When the program is first activated, a menu similar to that below will be displayed. The marker identifies the function that is currently active. Pressing "F1" will display a small description of the function. Pressing "Enter" (↵) or the left mouse button will activate the current function. The first letter can also be used to activate any of the specific selections. The right and left arrow keys or the mouse can be used to move the marker.

Design	**Files**	**Options**	**Quit**
-			

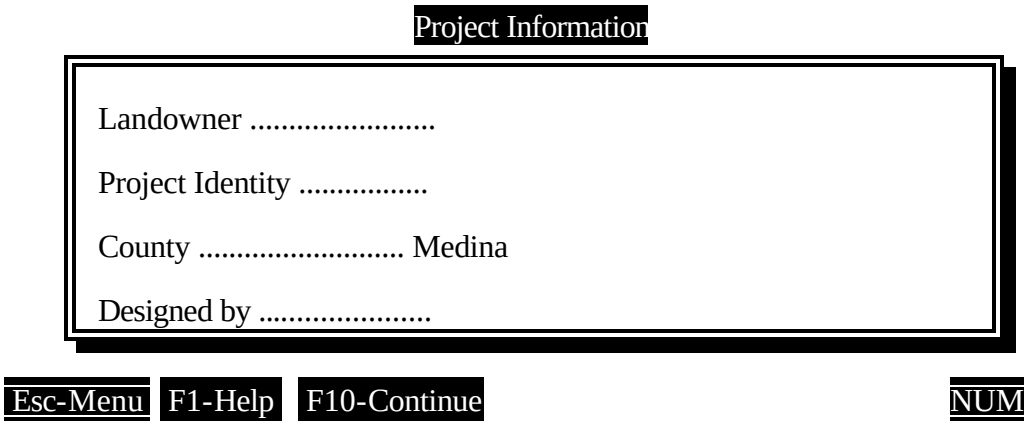
Design:

Selecting "D" for design will cause the following screen, showing the following functions that can be processed by this portion of the program, to appear.



Landowner Information -

Upon making this selection, an input screen will appear. The information solicited on this screen will be used to generate complete documentation and to identify the project on these reports as well as in the data saving process.



- Landowner - This information will be used on the print out to identify the project or facility.

- Project Identity - This information is used on the printed output to identify the project more specifically. This is a good place to name the waterway (like waterway A) or to tell which field, from the conservation plan, in which the waterway is located.

- County - This should be the name of the county that the waterway is in. If you have used the "ENG_CFG.EXE" program, your own county should appear and all you need to do is press the return. If you want to use a different county, simply enter the new county name. Once again, this information is only used to pretty up the printed output.

- Designed by - This information is again used on the printed output so that we know who to give credit for the nice waterway we are going to build.

Design Form:

Making this selection will cause a form, or set of forms, similar to the one below to appear. The contents of the form will be determined by the design options that are set. For example, if you prefer to design for depth, a width entry will be included rather than a depth entry and if you are using a depth design with a trapezoidal cross-section, an entry for sideslope will be included. There will be one entry form for each reach in the project.

Waterway Design for Wash Out

			Design Results		
Reach number		1 Design Q (cfs) …..			
Shape (T/P) ……	P	Slope (%) …….			
Design For (W/D) …..	W	Depth (ft) …….	Top (ft)	Depth (ft)	Vel (fps)
Beginning Station …..					
Ending Station ……...					
Capacity Retardance ..	C				
Velocity Retardance ..	D				

Esc-Menu F1-Help F5-Print F9-Compute PgUp/Dn-Reaches Advance-on NUM

The following discussion relates to each of the entries that can appear in any particular design window. As mentioned earlier, all of the entries will not appear on any one screen as the required inputs are determined by the design options that are selected.

- **Shape (T/P) -** The program can accommodate either a trapezoidal or parabolic cross - section. The initial entry will based on the default value that is managed by the "modify parameters" option. (see page 9) If you desire to change the value that is present, enter a "T" for a trapezoidal design or a "P" for a parabolic section. The entry form and cursor movement will automatically be adjusted according to your selection.

- **Design For (W/D) -** This option is rather straight forward. If you respond with "W" for width, then you will be asked to provide the depth of the waterway and the computer will solve for the width. If you select "D", then you will be asked to provide a preferred width and the program will solve for the depth.

- **Beginning Station -** Enter the beginning station of the design reach in feet. The program will format the entry into the typical stationing format. (12+34). This information is not an absolute necessity for the design. The program uses it to identify the reaches in the printed reports and if the information is available, it will be used to calculate the surface area involved between the design edges. This information can be used as a guide to seeding requirements.

- Ending Station - The same as the beginning station except now we are at the other end of the design reach.

- Capacity Retardance - In waterway design, retardance is a way to represent the roughness or resistance to flow of the waterway. It is represented by a letter between "A" and "E" with "A" being the most resistant to flow. For the capacity design, enter the letter that will best describe the vegetation when it is most resistant or at maximum growth. The letter selected should reflect the length and type of vegetation used in the waterway. Guidance on your selection can be found in chapter 7 of the NRCS Engineering Field Handbook.

- Velocity Retardance - This retardance value represents the vegetation when it is young or after it has been mowed. This value is used for what is commonly referred to as a "velocity or stability analysis". A "D" retardance will normally appear as a default value.

- Design Q (cfs) - Enter the discharge rate, in cubic feet per second, that you want the waterway to have capacity for. Typically this is the 10 year, 24 hour frequency storm event.

- Slope (%) - Enter the gradient of the waterway in percent, commonly referred to as the feet of elevation difference in each one hundred feet.

**** NOTE ****

The following inputs may or may not be required, depending on you whether the design is for trapezoidal or parabolic and for width or depth. If the cursor stops in any of the cells, a value needs to be entered.

- Depth (ft) - Enter the maximum desired depth of flow in the waterway in feet.

- Bottom Width (ft) - If you selected a trapezoidal section and chose to solve for "depth", a desired bottom width needs to be entered here.

- SideSlope - If you opted for a trapezoidal design, the sideslope ratio needs to be entered here. This is the amount of "run" or horizontal distance for each foot of "rise" or vertical distance. For example, you would enter a "2" to represent a 2:1 slope or a "4" to represent a 4:1 sideslope.

- Top Width (ft) - If the design is for the depth of a parabolic section, this entry would contain the desired top width.

Once all of the entries have been made, pressing the **F9** function key will begin the computation process. If the calculations are successful, the results will be displayed in the lower right corner of the reach box. If any of the results are flashing, this is an indication that the solution generated results that should

be reviewed. As an example, high or low velocities might flash because they could affect the maintenance of the waterway.

There might be other messages appearing on the screen during the computation process. Typically they will express the fact that data is missing and the computation can not continue or that the trial and error solution has reached a point where it can not reach a solution and suggesting that you try different input values.

There are a few keys that provide unique functionality on the design screen. They are discussed below:

PgUp / PgDn - These keys are used to move through the reaches. Once a "reach box" has been completely filled in, or all of the questions answered, pressing the **"PgDn"** key will add another "reach box" until the maximum number of allowable reaches have been obtained. Pressing the **"PgUp"** key will cause the design entries to move backwards through the reaches.

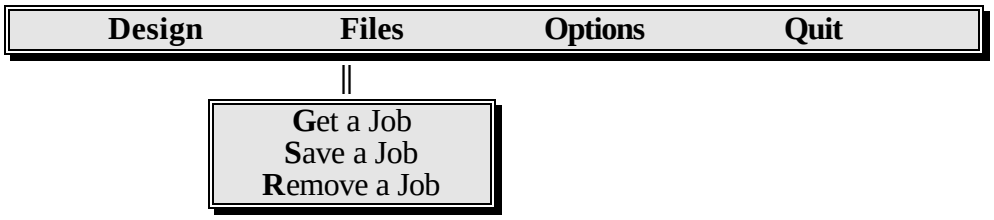
Shift F8 - Waterway design is a two fold trial and error procedure. The program takes the data that the user enters and makes several trials to arrive at a mathematically correct solution. The user then makes a judgement as to whether the solution is a practical solution. In the course of this process, the user might change the desired depth several times and each time the cursor advances one position when the new trial is entered causing the user to back up on place for each trial. The **Shift-F8** key stroke combination toggles the cursor advance features of the program. The current status will be displayed at the bottom of the screen. When the advance is "off", the cursor will not automatically advance when data is entered, even though it can be moved using the cursor control keys. This makes the trial and error solutions of the user much easier. For example, several depths can be tried and the cursor will not move at all.

Shift F9 - As mentioned above, waterway design is a trial and error solution. Occasionally the trials will lead the program into a corner and a message will be displayed indicating that the number of allowable trials have been exceeded or one of the parameters have gone out of range. If is sometimes difficult to determine why the program can not reach a satisfactory solution. The **Shift-F9** key stroke combination will open a window where a portion of the results of each trial are displayed. The computation halts until a key is pressed and then a new trial is made. By viewing the results of each trial it is many times easier to make the adjustments necessary to reach a satisfactory solution.

F5 - As has already been mentioned, the **F5** function key will initiate the generation of a complete design report for the project. Upon pressing the **F5** key, designs will be computed for all of the reaches containing data. If any of the reaches fail in the design process, a warning will appear and the printing process will be aborted. If the designs are successful, a project information screen will appear. Once this screen is complete, press **F10** to continue printing.

Create XYZ Template -

The purpose of this feature of the program is solely for those users who utilize the Ohio Cross - Section program. *("xsec.exe")* This program uses a unique way of defining the shape of a constructed cross - section or template. This selection of the waterway design program will generate a template formula that is compatible with the cross - section program for each reach that you have designed. This will negate much of the work necessary to construct the formula. On a large job, it would be possible to save the template equations and then place them in the *"template.xsc"* file that is utilized by the cross section quantities program.



Data File Management:

Get a job:
This feature allows data that has been stored or saved on previous occasions, to be retrieved. A list of the data files that are available on the designated drive will be displayed. If your data is on a different drive or in a different subdirectory than the default, pressing **Alt C** will afford an opportunity to select an alternative drive and a new list of available files will appear. Cursor to the job that is desired and press return (↵) or the left mouse button to retrieve the data.

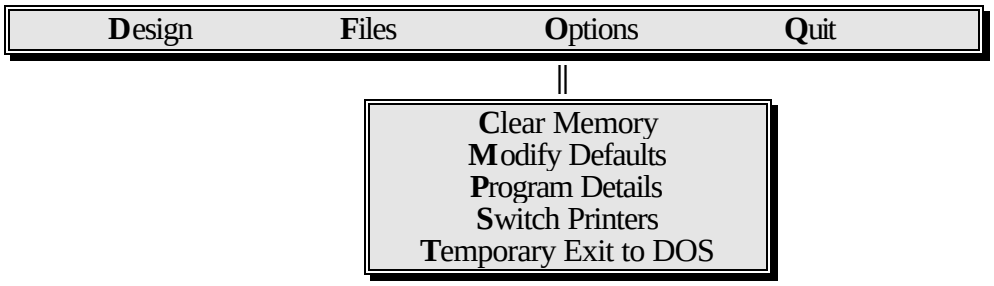
Save a job:
This selection will solicit the information required to save the data for the job that is currently in computer memory. It is wise to visit this area frequently while a large job is being entered so that portions of your work are not lost. You never can tell when the lights might go out or someone might accidentally hit the reset button.

A screen will appear that identifies the data that is to be saved. Refer to the main guide for the Ohio Engineering programs for discussion related to the file naming procedures and assistance related to the information that is requested on this screen. The code used to identify GWW data in the file naming scenario is ***"GWW"***.

Remove a job:
Many of us do not like to throw anything away but occasionally reality sets in and we concede to the need. There might be test jobs, old jobs or jobs that you don't want the boss to see, that should be removed from the system. This selection works in a similar manner to retrieving data files. Once the desired file has been selected, you will be asked to confirm your request.

It is desirable to remove data files using this procedure rather than simply erasing them with DOS commands. This procedure also will properly manage other related files and do some minor housecleaning that the DOS procedures do not know about.

Options:



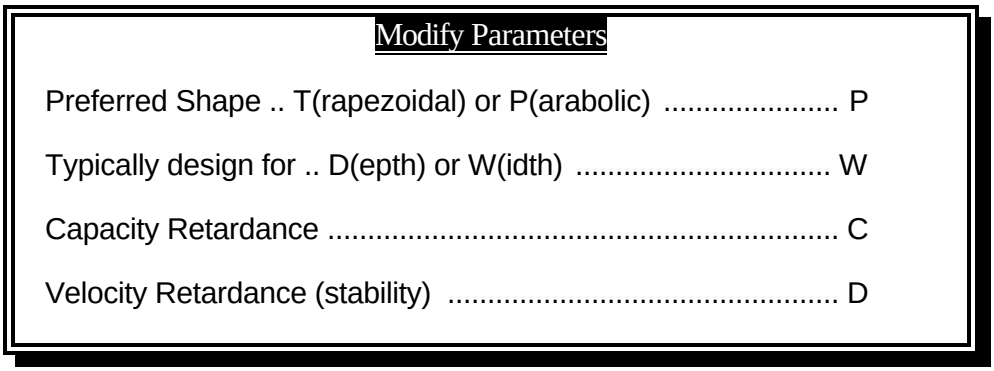
The options selection from the main menu serves two basic functions. It is an information center and it contains several features or functions that help make this program easier to use.

Clear memory:

If you get to the point that you have things so messed up that you would like to start over, this is the routine to use. It will give you a fresh start. Everything previously in memory will be gone after this operation. If there is a chance that you may change your mind, it might be wise to save the data before proceeding with this option.

Modify Parameters:

The "modify parameters" portion of the program is designed to add versatility and to allow the program to be as user friendly as possible. Selection of this option will cause the following screen to appear. The choices presented control the manner in which the program responds as data is entered. The choices made will determine the default values or values that you normally use, to automatically appear when specific screens appear.



Simply enter the options that best describe the manner in which you normally do business. Refer to the design portion of this manual if you need more explanation related to the definition of any of the parameters

Program Details:

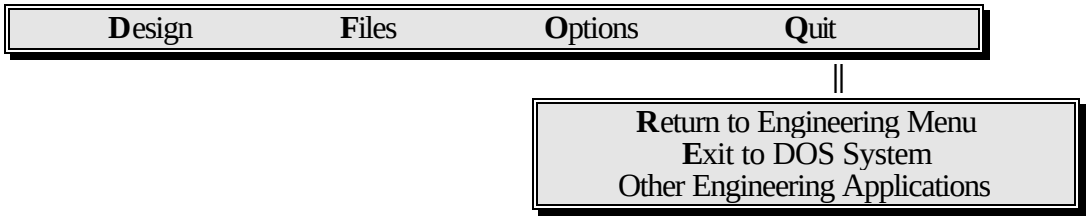
This selection will display some specifics related to the program including the date of the last revision or change. Many times there are subtle changes made to the program that do not merit changing the version number for the program. The date of these changes is normally available using this feature.

Switch Printers:

If two different printers are available on your computer system, this option will allow you to change the identity of the printer that the program uses. Basically, this action changes the value of the codes that control the manner in which the printer behaves. For example, the codes that cause the printer to print in compressed code, etc.

Temporary Exit to DOS:

Many times it would be nice or even necessary to execute a DOS command while in the program. As an example, you can't remember the subdirectory where your data is so you need to check several subdirectories or even diskettes. This option will quickly return to the system prompt and still keep your program and data in memory. When you are ready to return to the program, simply enter "exit". There is one important point to remember! Be certain that you have returned to the subdirectory that contains the engineering program before entering "exit".



Quit:

The response to “quit” can generate several responses depending upon how your particular system is set up. If the main “engmenu.exe” file is available, you might be offered an option of returning to the Engineering Menu, exiting to the operating system (which could be the DOS prompt, windows, or the batch file that originally called the animal waste program) or going directly to one of several other engineering programs. If this “engmenu.exe” file does not exist, you will simply be asked to confirm that you really do want to quit. If additional Ohio Engineering applications exist in the same subdirectory, you will also be given an opportunity to go directly to them.

In any case, you will be warned if unsaved data has been entered so that you will have at least two chances to accidentally lose your data.

*** Technical Information ***

The majority of the waterway design revolves around Manning's equation which is stated as:

$$V = \frac{1.4859 \cdot R^{\frac{2}{3}} \cdot s^{\frac{1}{2}}}{n}$$

where:

V = velocity of flow in feet per second.
R = the hydraulic radius of the section.
s = the slope of the channel in feet per feet.
n = Manning's coefficient of roughness.

The formula used to relate the retardance letter to Manning's coefficient of roughness was taken from the American Society of Agricultural Engineer's technical paper number 79-2068, written by D.M. Temple.

$$n = e^{\left[0.01329 \cdot CI \cdot \ln(VR)^2 - 0.09543 \cdot CI \cdot \ln(VR) + 0.2971 \cdot CI - 4.16\right]}$$

where:

n = Manning's coefficient of roughness
e = 2.71828
CI = retardance index
when retardance = A ; CI = 10
when retardance = B ; CI = 7.643
when retardance = C ; CI = 5.601
when retardance = D ; CI = 4.436
when retardance = E ; CI = 2.876
ln = natural logarithm
VR = product of velocity and hydraulic radius

These two equations as well as the standard hydraulic equations and geometry equations from the Engineering Field Handbook are used in reaching a solution. The program iterates the necessary variable until the velocity difference between two successive iterations is less than 0.01 feet per second. At this point, the trial is considered a successful design.

Format of Data Files:

The following information is provided for those of you who like to dig into the program files and figure out how they work or possibly make some sneaky edits to the data. The list below is a typical saved data file. Each line is followed by a line(s) contained in brackets ([]) that explain the line above. These "bracketed" lines will not be found in an actual data file. Some spaces have been added below to make it easier to read. **Keep in mind** that the quote and comma symbols are **very important** to the program.

```
"Data Version ..... ","Format 1.0"  [used to anticipate the
                                     format of the data]
"Landowner Name .... ","Washed Out"
"Designer ......... ","cwl"
"Project Identity .. ","South End of Tompkins"
"State ............ ","Ohio"
"County ........... ","Medina"
"Number of Reaches . ",2
"Stations ....... ",12345,23456
"Shape/Design4 .. ",1,0
"Retardances .... ",3,4
"Design Q ....... ",50
"Slope (%) ...... ",2
"Depth / Tw ..... ",1,0
"SS / Bw ........ ",0,0
"Stations ....... ",23456,45637      [repeated for all subsequent
                                     reaches]
"Shape/Design4 .. ",1,0
"Retardances .... ",3,4
"Design Q ....... ",50
"Slope (%) ...... ",2.1
"Depth / Tw ..... ",1.1,0
"SS / Bw ........ ",0,0
```

Values used by the program:

Shape -	0 = Trapezoidal
	1 = Parabolic
Design4 -	0 = Width
	1 = Depth
Retardance:	1 = A
	2 = B
	3 = C
	4 = D
	5 = E

Supporting Files:

GWW.STD

The following is an example of the data that is contained in the file named *"GWW.std"*. This data is maintained using the "Modify Defaults" option and any changes that are made will be saved in this file.

```
"* Design Option (Width or Depth)*"   , 0
"* Shape of Section *"                , 1
"* Capacity Retardance *"             , 3
"* Stability Retardance *"            , 4
```

GWW.ST2

The following is an example of the data that is contained in the file named *"GWW.st2"*. This data basically drives the GWW program. The purpose of maintaining the data in such a file is that it can be modified when and if a need arises. This can be accomplished using a text editor. It is **very important** that the format and integrity of the file be maintained (commas, quotes, sometimes even spaces). It is strongly recommended that an original copy of the file be maintained prior to attempting any changes. If the program behaves strangely following modifications to this file, you can always fall back on the original version.

```
"* Program Identifier / Version *"    , "OH-Ver 5.0"
"* Date of last minor edit or fix *"  , "6/25/98"
"* Minimum Design Discharge *"        , 5
"* Maximum Design Discharge *"        , 200
"* Minimum Slope *"                   , .01
"* Maximum Slope *"                   , 20
"* Maximum Design Depth *"            , 5
"* Maximum Design Width *"            , 100
"* Minimum Design Sideslope *"        , 2
"* Maximum Design Sideslope *"        , 20
"* Minimum Bottom Width *"            , 4
"* Maximum Bottom Width *"            , 60
"* Minimum Velocity for Warning *"    , 1.5
"* Maximum Velocity for Warning *"    , 5
"* Maximum Number of Computations *"  , 1000
```