United States Department of Agriculture
Natural Resources Conservation Service

W S P . E X E

Water Surface Profile Computations

Version 2.00

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Introduction:

WSP is designed to provide a representation of the water surface for an open channel flowing under subcritical conditions[1]. The program uses the standard step method for calculating the flow parameters required to determine the water surface elevations. Specific details related to this method can be found in Section 4 of the Natural Resources Conservation Service National Engineering Handbook. The program is capable of saving the design parameters so that subsequent modifications to the design are easily accessible.

Supporting Files:

The water surface profile program is contained in a file called ***"WSP.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. This file is generated and maintained by a separate program named "eng_cfg.exe". It is accessible from the "Utility" selection of the main Ohio Engineering Menu.
WSP.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 10).
WSP.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 14 for details related to the contents of this file.)
WSP.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] For applications that might involve flow conditions other than "subcritical" or more complex computations, a windows program named "HEC-RAS", developed by the Corp of Engineers is offered as an option.

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.

Program Limits:

The water surface profile program has the following limits:

45 - design reaches

500 - Computation reaches

7 - culvert entrance conditions

Loading WSP:

"WSP" 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 "**WSP**" program from the choice list. If the water surface profile 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". (Be certain that the comma and quotation marks are included.)

"wsp.exe", "Water Surface Profile Computations"

The second option is to simply enter **"WSP"** 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 WSP menu. If you are in the main WSP 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.

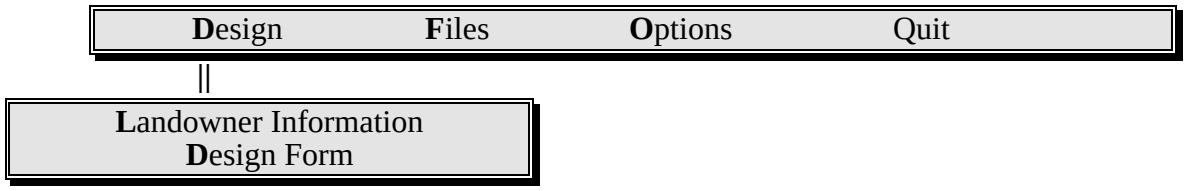
F10 Many times this is used as a “continue” key. Once the entries that are requested on a screen are filled in, this key will cause the program to continue with the function of the screen. It is important to note that this key has other functions assigned to it, so be alert to the messages on the screen.

WSP 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.

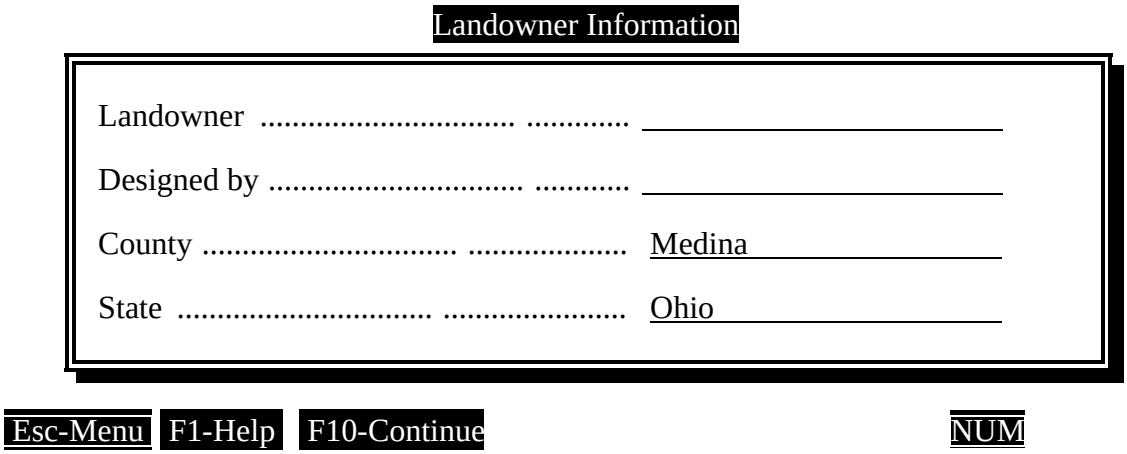
Design:

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.

- Designed by - This information is again used on the printed output and helps the lawyers identify the person responsible if the design does not work.

- County - This should be the name of the county that the project 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 or press F4 and select a county from the list presented. It is important that the county be spelled correctly because it is the "key" to selecting the proper rainfall that will eventually be used in the design.

- State – Once again, the state will default to the value that is contained in the "oh_eng.cfg" file. If by chance you have slipped across the state line to do a job, this will afford you the opportunity to change the state for reports generated for this job. Keep in mind that the state will default to the config value each time you reload the job so you will need to change the state every time you return to this job.

Design Form:

This option can be reached by pressing "D" or moving the highlight to "Design" with the cursor key or mouse and pressing "enter" or the left mouse button.

>>> B A S I C D E S I G N D A T A

Beginning Bottom Elevation ..... _____
Starting Watersurface Elevation ..... _____

Station	Q (cfs)	Grade (ft/ft)	Bottom Width	Sideslope Lt.	Sideslope Rt.	Roughness Coefficient

Esc-menu F1-help Alt-C culvert F9-compute NUM

Most of the activity of this program takes place under this option. It is under this option that the problem or situation is outlined and the computations are completed.

Following is a brief description of each entry:

- Beginning Bottom Elevation - this is the channel grade elevation at the beginning or outlet end of the channel. Most often it is the point where construction of the new channel begins.

- Starting Watersurface Elevation - everything has to start somewhere and this is where the water surface profile program begins. This entry is your best estimate of what the water surface elevation will be for your situation. The entry might be the result of a wild guess, some previous calculations or even some stream gage records. Remember that the Hydraulics Formula program ("hydr") might be of assistance in coming up with a good estimate. The computation process will dampen out any error that might be induced by a poor estimate in the first few computation reaches but it is still wise to use the best value possible.

- Station - is the station at the upstream end of a design reach that you have selected. It might be a change in grade, channel shape, hydrology, etc. The downstream station will automatically be determined by previously entered data.

- Q - is the discharge that you have chosen for the design of this particular reach. It is entered in cubic feet per second (cfs).

- Bottom Width- this is the bottom width of the channel that you want analyzed.

- Sideslope - you have the capability to enter the side slope ratio for the left and right side of the channel. If they are both the same, the first value will be replicated and you simply need to press return.

- Roughness Coefficient - this value is commonly referred to as Manning's coefficient of roughness. If your system is set up to consider composite "n" values (see modify parameters) you will have an opportunity to enter an "n" value for each side of the channel as well as the center portion. If not, the value that you enter will represent the entire channel. Guidance in the selection of appropriate values can be found in Section 5 of the National Engineering Handbook, the EFM or King's handbook.

On any reach entry line after the first one, pressing "Alt-C" will afford you the opportunity of placing a culvert in the channel. A window will open up on the screen and you will be asked to enter the following data.

- Culvert Diameter - this value represents the inside diameter of the culvert and is entered in inches.

- Pipe Length - this is the length of the pipe in feet. If you had already entered a station, it will be adjusted to reflect the length that you have entered.

- Invert Elev @ Outlet - this is the invert or flowline elevation at the outlet end of the culvert.

- Invert Elev @ Inlet - this is the invert or flowline elevation at the inlet end of the culvert.

- Channel Elev @ Inlet - this entry represents the elevation of the gradeline of the channel at the inlet end of the culvert.

- Overflow Elevation - this is the elevation in the road or the elevation at which flow will go somewhere other than through the culvert. Typically this would be a low point in the road.

- Entrance Condition - by pressing F4 when the cursor is in this position an additional window will open that contains a list of several entrance configurations. Use the cursor keys to select the desired entrance condition and press return to finalize the selection.

- F10 Continue – When all of the data has been entered in the window, pressing F10 will return you to the design screen. When leaving, you will be given an opportunity to accept or not except your culvert selections. If the data is accepted, a notation will be place in the appropriate reach on the designs screen. A "no" response will cancel the culvert scenario and allow you to continue with normal reach data entries.

Pressing the **F9** key on the basic input data screen will activate the computation routine. The results will scroll across the screen as they are computed. When the calculation process is complete, the display will return to the beginning of the data. The data can be viewed using the PgUp or PgDn keys. If the computation process needs to be stopped for any reason, this can be accomplished by pressing the **F6** key.

If the **F5** key is pressed while the results are on the screen, the data will be printed on the printer. You will initially be asked to provide the normal information about the job. When you have completed this, the job will be printed.

If the **"Alt V"** combination is pressed while the computed results are on the screen, a graphical representation of the data will be displayed on the screen. If the "**Alt P**" combination is pressed while the graphics are on the screen, the graphics will be sent to the printer.

Computation details:

Pressing "F9" begins the computation process. The computations follow the procedures contained in NRCS National Engineering Handbook, Section 5, Hydraulics, referred to as the "step method".

It is not surprising that computations begin at the beginning station. Another non-surprise is that the program begins with the starting water surface elevation. From there it begins a real computation process.

The first step is to determine the stationing interval that the user has selected. This determines the length of the first design reach. With this determined, the parameters of the first computation cross-section are determined. These parameters include bottom width, sideslopes and coefficients of roughness. It should be noted that in cases where the cross-section is different on the ends of the input reaches the parameters of the design cross-section are interpolated from the data that was entered. In other words, reaches with differing end cross-sections are treated as transition reaches. This is important to know as transition reaches are typically short. If the cross-section changes, the ends of the transition reach should be defined so that the computations match the eventual construction.

There are several basic formula used in this procedure. They are defined as follows:

$$W_p left = d + \sqrt{1 + LeftSS^2}$$

$$W_p right = d + \sqrt{1 + RightSS^2}$$

$$W_p = W_p left + bw + W_p right$$

$$Area = \frac{d \times LeftSS + 2 \times bw + d \times RightSS}{2} \times d$$

$$Vel = {Q}/{Area}$$

$$HR = {Area}/{W_p}$$

$$CompositeN = \frac{W_p}{\frac{W_p Left}{LeftNval} + \frac{Bw}{CenterNval} + \frac{W_p Right}{RightNval}}$$

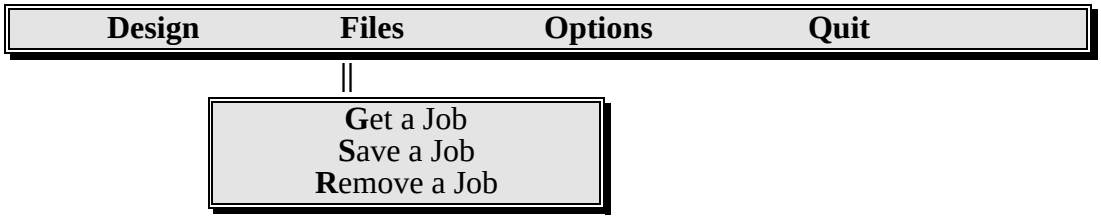
$$S_f = \frac{CompositeNval^2 \times Vel^2}{2.209 \times HR^{4/3}}$$

Where:

d	=	depth of flow in feet
Bw	=	bottom width in feet
W_p	=	wetted perimeter in feet
SS	=	sideslope ratio expressed as ##:1
N	=	Manning's coefficient of roughness
S_f	=	Friction Slope, which is a manipulation of Manning's Equation

With the water surface known at the lower end of the reach and the parameters of the cross-section known at the upper end of the reach, the program begins with a trial depth and computes the water elevation at the upper end of the reach. The depth is then adjusted in an effort to cause the computed depth match the trial depth. This process continues until the two depths become the reasonably close. At this point, the computation process moves upstream one reach and continues until the end of the project is reached.

In the process of moving upstream one reach at a time, if a culvert is encountered, the program switches to a culvert evaluation routine and computes the water elevation at the upstream end of the culvert. This evaluation is based on the equations that can be found in the user manual associated with the "hydr.exe" program. If the culvert is not capable of passing the design flow without overtopping, appropriate messages will be placed in the design results report. The program will continue with the computations but it should be noted that the results will be tainted because all the details of overtopping are not included in the evaluation.



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.

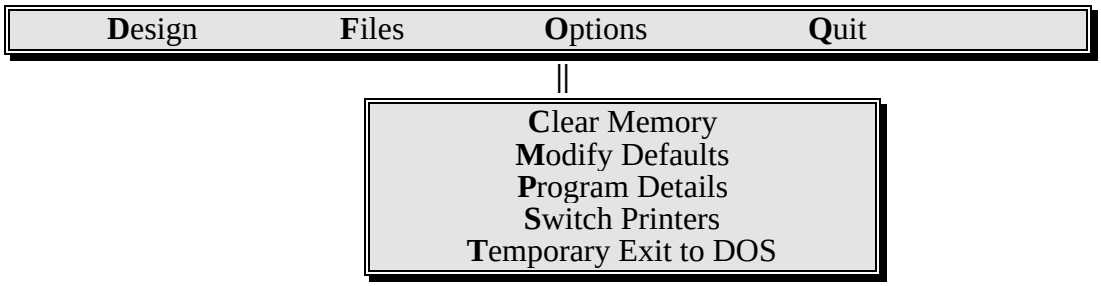
A screen will appear that identifies the data that is to be saved. Refer to the main guide for the Ohio Engineering programs for discussion related to the file naming procedures and assistance related to the information that is requested on this screen. The code used to identify WSP data in the file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

Remove a job:

Many of us do not like to throw anything away but occasionally reality sets in and we concede to the need. It is also important to remember that only 100 “WSP” jobs can be saved in one subdirectory. 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 will also 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. 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. If you have questions about the information required to answer the following situations, discuss them with your engineering staff.

- Direction of increasing station - this allows the project to be stationed in either directions and the subsequent computations will be made accordingly.

- Reach length used for computations - the program interpolates all of the reach data that was entered and computes values at intermediate stations based on this "computation reach length". The highest accuracy will normally be attained when short reaches are used but the computation time will also get longer. There is also a limit of 500 total computed points in any one job. For these reasons, you might find a need to adjust this value based on your knowledge of the job.

- Reach length used for display - this value is used to adjust the reach length on the printed report. If you have a lot of paper, use a short reach otherwise use a value that fits your need. This value is used as the default value and can be changed on the "print" screen.

- Default bottom width - the entered value will be used as a default which can be changed if need be on the input screen.

- Default sideslope - enter that value that you would use most often.

- Default coefficient of roughness - enter that value that would best represent your typical situation.

- Composite `n' value - if you respond with an "N", the system will expect only one "n" value to represent the entire cross-section. If you enter a "Y", the system will expect an "n" value for each side of the channel and one for the center section and will weigh them accordingly.

- Key Design Parameters - there are several intermediate values that are calculated during the normal computation procedure that are not normally displayed. In some situations, these values may be needed for a more complete analysis of the situation. By entering a "Y", these values will be printed during the computation process. These values include:

    - the channel parameters
    - flow depth
    - hydraulic radius
    - composite "n" values
    - flow area
    - velocity
    - normal depth
    - critical depth

- Values Saved - a "Y" response will cause the above entries to be saved in a file and be available the next time that you run the water surface profile program. If you answer "N" the values will only be used for the current job that is in the system.

- Continue - pressing return will save your values if you asked them to be and return you to the main menu.

Program Details:

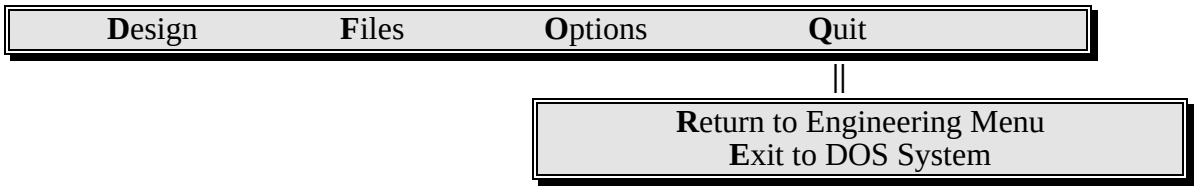
This selection will display some specifics related to the program including the date of the last revision or change. Many times there are subtle changes made to the program that do not merit changing the version number for the program. The date of these changes is normally available using this feature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

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.

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.

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 ..... ","Ver-2.00"
"Landowners Name ..... ","NPEG w/ culvert"
"County Name ..... ","Medina"
"Designer ..... ","cwl"
"Dir Increasing Sta (0=Up) ... ",1
"Use composite N (0=No;1-Yes). ",1
"Number of design reaches .... ",6
"Beginning Channel Elev. ..... ",100
"Beginning Water Elevation ... ",106
"Section Station ..... ",5000          ┐
"Section Discharge .... ",0            |
"Section Grade ........ ",0            |
"Section Bottom Width . ",6            |   Repeat for each reach.
"Section Left SS ..... ",2             |
"Section Right SS ..... ",2            |
"Section Left Nval .... ",0            |
"Section Center Nval .. ",0            |
"Section Right Nval ... ",0            |
"Section Culv / Bridge  ",""           ┘

"Section Station ..... ",2960          ┐
"Section Discharge .... ",80           |
"Section Grade ........ ",.0005        |
"Section Bottom Width . ",6            |   Example of reach containing a
"Section Left SS ..... ",2             |           culvert.
"Section Right SS ..... ",2            |
"Section Left Nval .... ",.04          |
"Section Center Nval .. ",0            |
"Section Right Nval ... ",0            |
"Section Culv / Bridge  ","C*42*40*.025*101*101*100.02*112.5*3"
```

WSP.STD:

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

```
"* Direction of Increasing Station *","D"
"* Computation Reach Length *       ",100
"* Display Reach Length *           ",50
"* Default Bottom Width *           ",4
"* Default Sideslope *              ",2
"* Default n value *                ",.04
"* Composite N value (Y/N)   *      ","Y"
"* Printed Design Report  *         ","N"
```

WSP.ST2:

The following is an example of the data that is contained in the file named *"WSP.st2"*. This data basically drives the WSP 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). <u>It is strongly recommended that an original copy of the file be maintained prior to attempting any changes.</u> If the program behaves strangely following modifications to this file, you can always fall back on the original version.

```
"* Program Release Date *           ","OH-Ver 2.0"
"* Date of last minor change *      ","8/20/01"
"* Checked Velocity (fps) *         ",4
"* Maximum Depth *                  ",10
"* Minimum Bottom Width *           ",2
"* Maximum Bottom Width *           ",100
"* Minimum Sideslope *              ",0
"* Maximum Sideslope *              ",20
"* Minimum N Value *                ",.01
"* Maximum N Value *                ",.4
"* Minimum Culvert Diameter *       ",8
"* Maximum Culvert Diameter *       ",72
"* Minimum Culvert Length *         ",1
"* Maximum Culvert Length *         ",1000
"* Entrance Type / Condition *","h1/D","k1","Q/D^5/2","k","m",  "He/D","Ke"
"Projecting .. groove edge    ", .7, .0514,  2.58,  .0045, 2,   .049,  .25
"Projecting .. square edge    ", .64,.0668,  3.5,   .0145, 1.75,.116,  .46
"Projecting .... thin edge    ", .53,.0924,  4,     .042,  1.33,.205,  .92
"Headwall  ... groove edge    ", .74,.0468,  3.3,   .0018, 2.5, .035,  .19
"Headwall  .. rounded edge    ", .74,.0419,  2.58,  .00065,2.67,.016,  .15
"Headwall  ... square edge    ", .67,.0645,  2.58,  .0098, 2,   .105,  .43
"Miter / square / 2:1 slope   ", .74,.075,   4,     .021,  1.33,.091,  .62
```