AVSWAT 2000

Biesbrouck B., Wyseure G., Van Orschoven J. and Feyen J.

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3 SOFTWARE MANUAL

3.1 INSTALL AVSWAT

1. If you have not done so, turn on your computer. Download the archive file (ftp://ftp.brc.tamus.edu/pub/swat/pc/swatav/avswat2000.zip) and extract the ArcView interface installation files with WinZip[1] to a specified directory, for example d:\temp\.

2. Start ArcView 3.x.

3. Select **Open an existing project** and click **OK.**

> A Project file (.apr) can be thought of as being a folder that stores ArcView Documents. Actually, *Projects do not contain duplicates of spatial or tabular data, but merely store "pointers" to the original data,* as well as storing the display formatting of Views, Tables, Charts, Layouts and Themes. (Learning ArcView – The NPS course. http://www.nps.gov/gis/av3_online/)
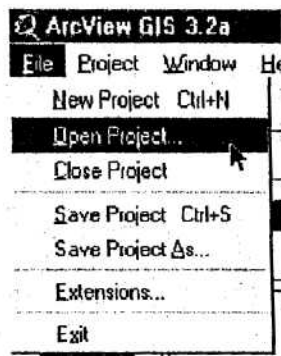
4. Move to the directory, used in step 1, containing the installation files. In this example, we used the directory d:\temp\.
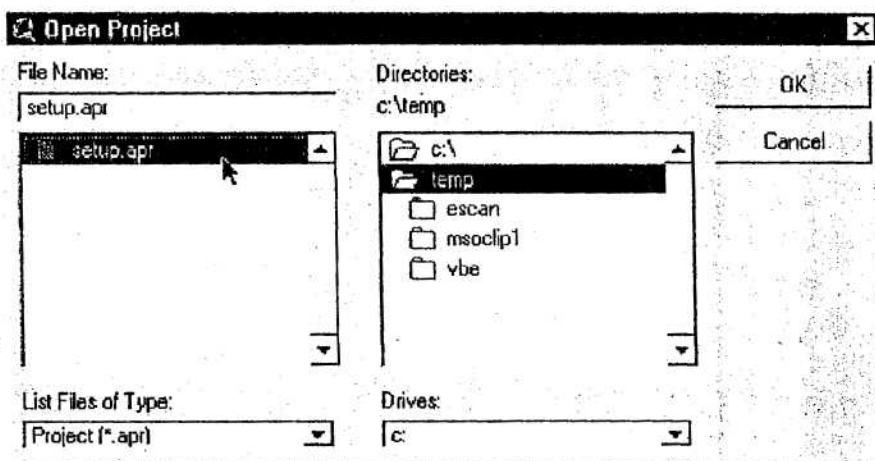
5. Choose **setup.apr** and click **OK.** This file is not an ordinary project file. In contrast with other project files, it contains no ArcView Documents, it only contains a link to the installation file of SWAT2000 ArcView (AVSWAT).

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[1] If winzip is not installed, you can download it from http://www.winzip.com/.

6. The installation program for the AVSWAT interface will be activated.

7. Follow the installation wizard step by step.

8. Delete all installation files, stored in the directory you have chosen in Step 1. In this example the directory d:\temp\ was used.

REMARK: The ArcView interface for SWAT2000 has been formatted to create a separate directory structure from previous versions. This allows users to keep both versions installed on their machine.

To uninstall:

1. Uninstall the program, using the standard uninstall tool of your Windows operating system.

2. Make sure the *Installation dir* directory and all subdirectories are removed from your machine

3. Delete file avswat.avx (../ESRI/Av_gis30/ArcView/Ext32/avswat.avx)

More information is available at the AVSWAT manual section 2 (Installing the ArcView interface) (Di Luzio M. et al. 2001).

3.2 PREPARE INPUT

3.2.1 ARCVIEW LAYERS

3.2.1.1 DEM (Digital Elevation Model)

DEM needed in SWAT is a grid. The data available for Flanders is stored in *.txt files on the network drive (\geodata\dtm_niveau_2\text\). Before you can input them in SWAT, a conversion is needed.

A grid is basically a raster. Rasters store data in a single pixel defining an area. There are different sorts of Raster Datasets: Images (DOQQ, DEM, *.img, *.bil, & *.tif...) and Arc/Info Grid (Analogous to a Coverage for raster data). (Learning ArcView – The NPS course. http://www.nps.gov/gis/av3_online/)
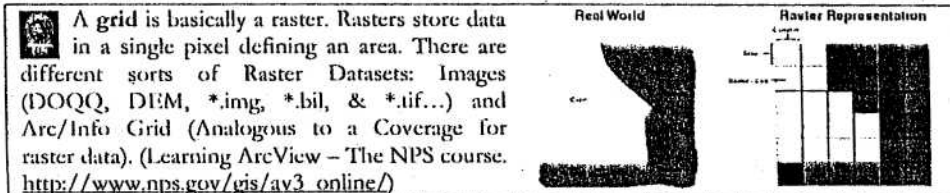
How to convert *.txt files in a useful format ?

Because *.txt files are large, it takes a while to open a file. First look to the survey layer
(\geodata\dtm_niveau_2\raster\cov\).
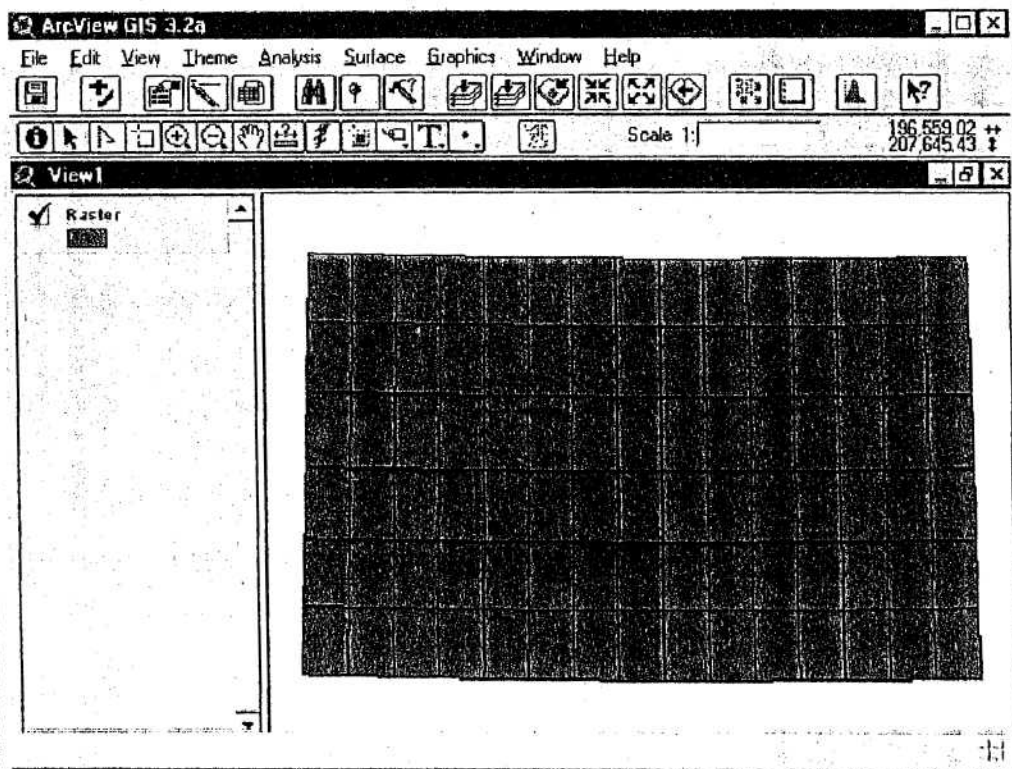
Identify the files you need and open only those files. You can identify the text files by
using the 'Identify'-tool (**❶**). After clicking on a polygon, a dialog box will appear.
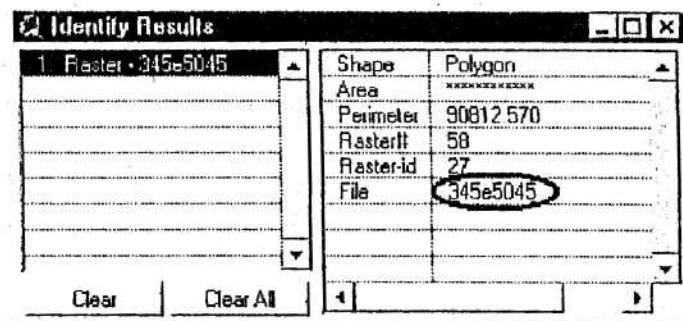
The filename will be displayed in the 'File'-record. Import all files you need as tables.

a. To do so, go to the project window and go to the 'Table'-section :
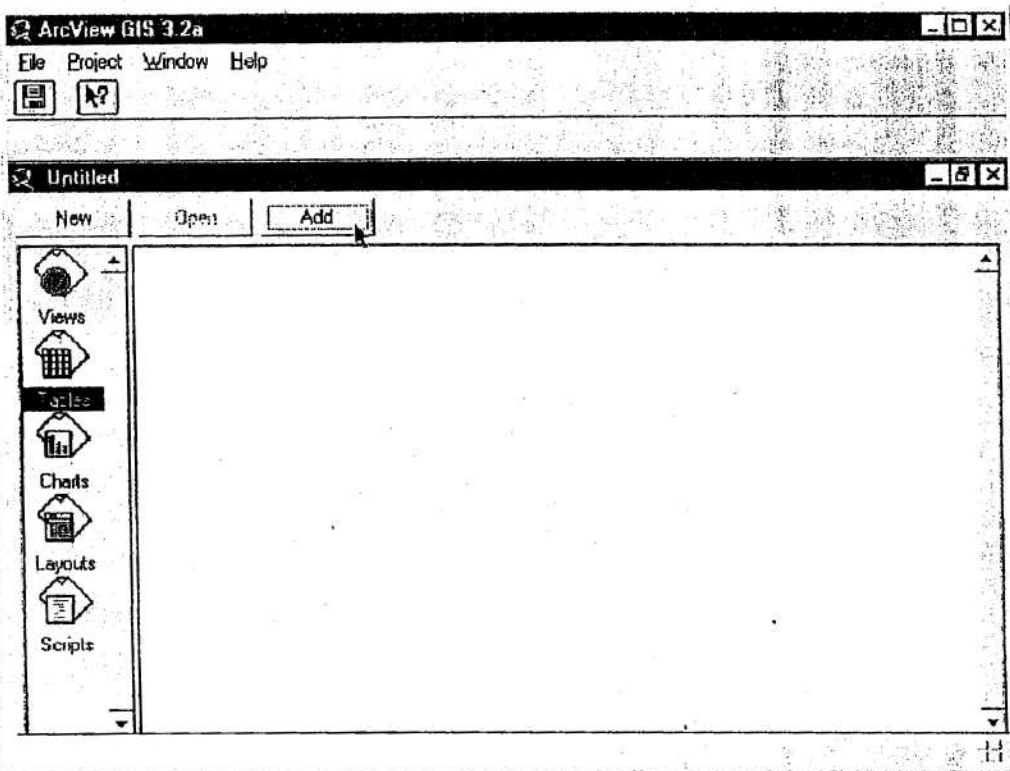
b. Click on the 'Add' button. The 'Add table' window will appear.
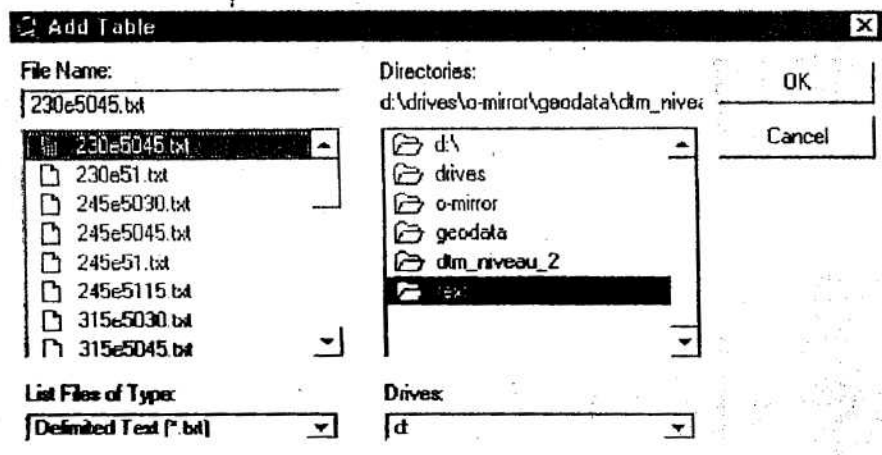
c. Select the needed files and click 'OK'.

Return to the view and add all tables as 'Event Theme'.

> If you have a table containing data about the features displayed on a view, for example, a dBASE file of business data on a state-by-state basis that you want to visualize on a view containing the states. And if you have a table containing XY coordinates, for example, a table containing latitude longitude locations taken from a GPS receiver.
> You can add this data to a view as a theme. Each record in the table will be displayed on the view as a point feature. You can then work with this theme like any other theme. This is called an 'Event theme'

a. Go to the option 'View' of the menu bar. And select the option 'Add Event theme'.
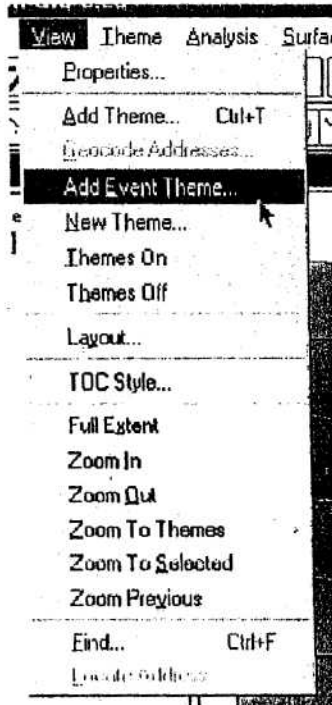
b. Complete the 'Add event theme' dialog.
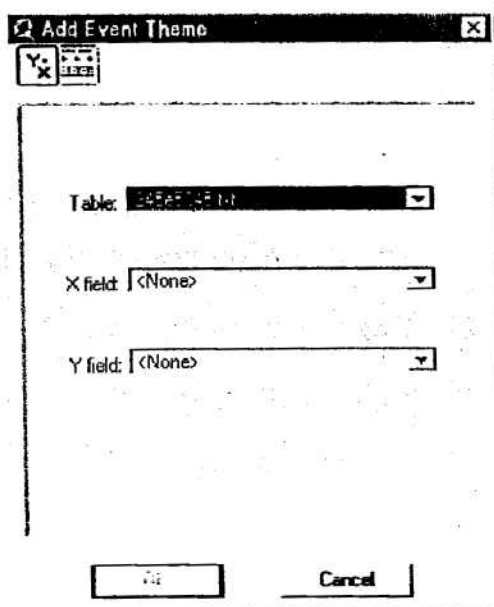
c. The table will be imported als point layer in the view.
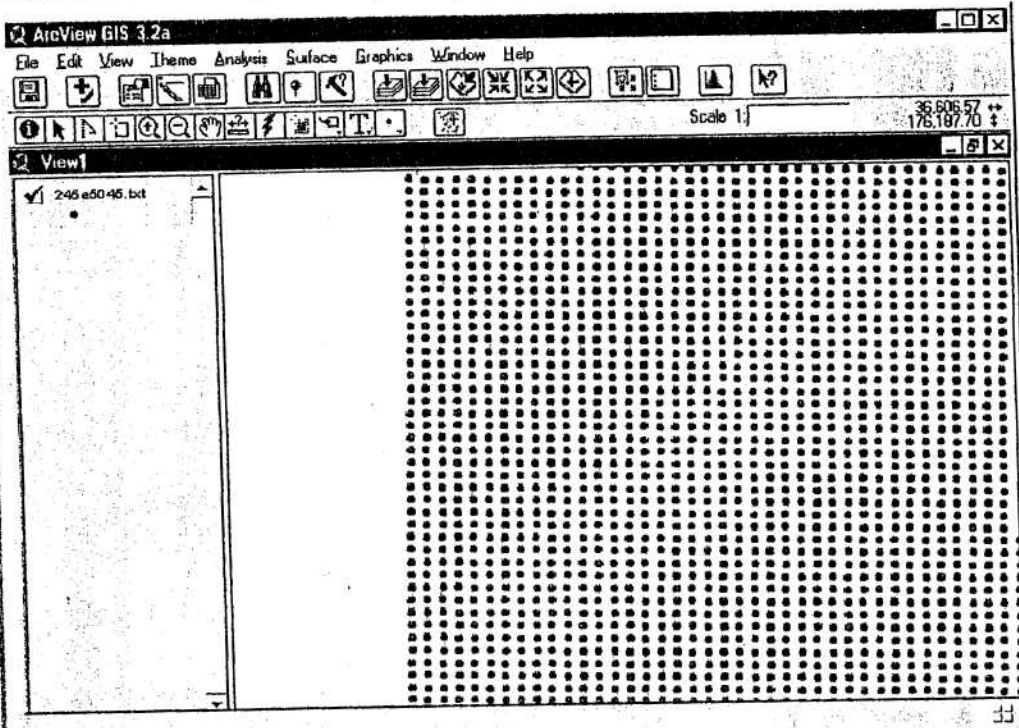
Convert those to a 'Grid'-file.

a. Make sure that the extension **'Spatial Analyst'** is activated.

b. Go to the option 'Theme' of the menubar and select 'Convert to Grid'.
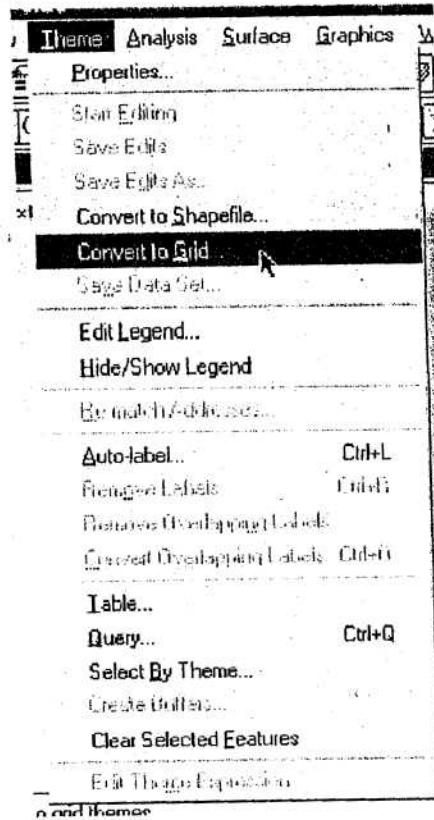
c. Complete the 'Convert' dialog, and click on 'OK'.

Convert 245e5045.txt

Grid Name
nwgrd1

Directories:
c:\temp

c:\
temp
escan

OK

Cancel

Drives:
c:
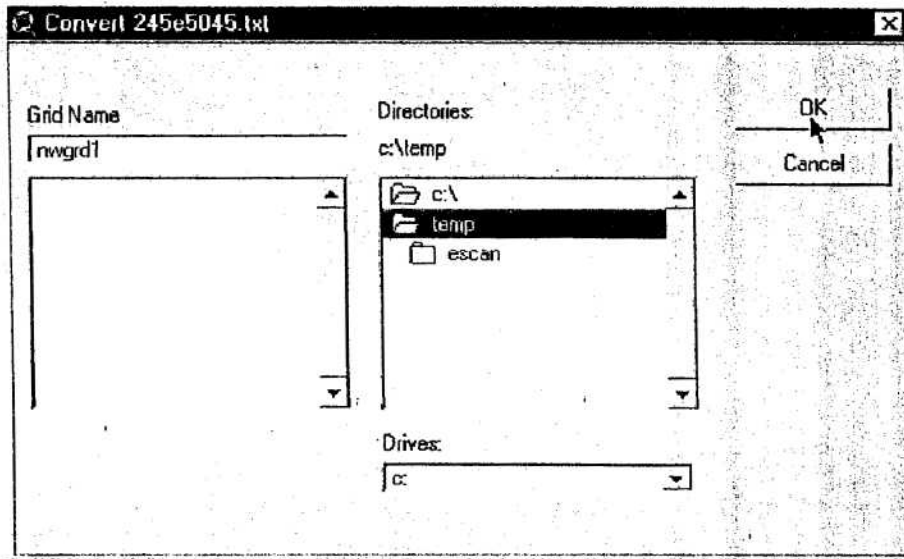
Use the height as value for those new layers.

When adding multiple textfiles, you can merge them with the 'merge'-tool of the 'geoprocessing' tool.

Using **merge** is similar to union--a new theme is created from multiple themes but their features are not intersected. Merge allows you to combine the features from two or more themes of the same geometric type. When you merge themes, you specify which theme has the same fields you want the new theme to have. If the other themes you're merging have more fields than the theme you have specified, those fields won't be in the new theme's table. If the other themes don't have the same fields as the theme you've specified, empty cells will be added to the new theme's table. You might merge several tiled county themes with census data to make a metropolitan area.

GeoProcessing is a way to create new *permanent* data based on themes in your view. In most cases you will alter the geometric properties of the features in a dataset while controlling some aspects of how its attribute data is handled.

3.2.1.2 River (Optional)

The river file can be found in \geodata\hydrografische_atlas\cov\wlasvl2. It is a line layer.

Line layers are representing objects who possess a certain length, but who are too small to be represented as polygons, for example roads, railways and rivers.

Before using the river layer, some adoptions are needed.

- If canals are present, delete them. They cross rivers and have a lot of influence on the river generation by AVSWAT.
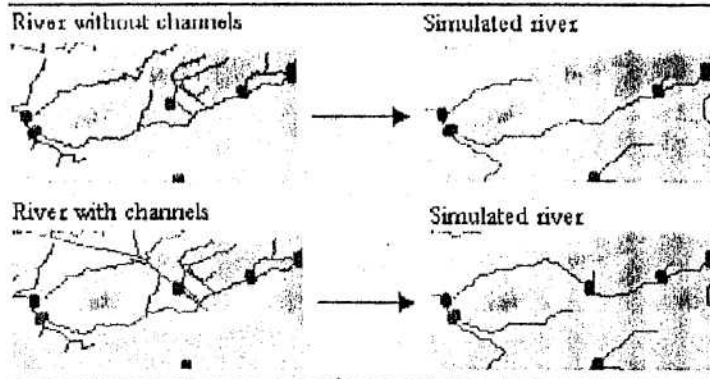
- If drainage ditches are present, cut them in two parts based on DEM information. Drainage ditches connect two different reaches. By consequence drainage ditches will influence the generation process of the stream.

3.2.1.3 Land use

The land use layer is a grid and located in \geodata\bodemgebruikskaart\lg20gr\ on the network drive.

This layer is ready to be used.

3.2.1.4 Soil

The soil layer is located in \geodata\bodemassociatiekaart on the network drive.

As the soil layer is a polygon shape file and AVSWAT can process shape and grid files, no conversion is needed. The file is ready to use. Nevertheless, when using a shape file, AVSWAT will convert this file to a grid to make this layer compatible with the land use grid (See 3.3.2.2).

> **Polygon** layers are representing objects who are too big to be represented by lines or points, for example communities and soil types.

3.2.1.5 Mask (Optional)

This grid must be made by the user.

The mask grid is differentiated into areas classified as category 0 (no data) and areas classified as any category > 0. Areas of the DEM grid for which the Mask grid has a value of 0 will not be processed for stream delineation.

3.2.2 DBASE FILES

3.2.2.1 Land use

I   LOOK-UP TABLE

The land use look up table is used to specify the SWAT land cover/plant code or SWAT urban land type code to be modeled for each category in the land use grid. Because this information can be entered manually, this table is not required to run the interface.

This table can be formatted as a dBase table.

dBase Table Format (2 fields)

Field name	Field format	Definition
VALUE	String	Number of layer category
LANDUSE	String 4 chars	Corresponding SWAT landuse or urban code

This last table is already been created for Flanders. It's named 'landuse.dbf' and can be found in the file /otherdata/swat/SWAT_DataForFlanders.zip on the network drive.

3.2.2.2 Soil

The categories specified in the soil layer will need to be linked to the soil database (US soils data only) included with the interface or to the User Soils database, a custom soil database designed to hold data for soils not included with the US soil database. The user has four options for linking the layer to the US soil database.

The option, "Name", is chosen when soils data from the User Soils database are to be utilized. The user will import SWAT soil files (.sol) or type the soil data into the User Soils database for each of the layer categories prior to creating the project. The "Name" specified for each of the layer categories is the name of the soil in the User Soils database.

To reclassify the layer categories, the information may be manually entered within the interface. Alternatively, a look up table may be loaded which has this information listed.

I   LOOK-UP TABLE

The format of the table will vary depending on the option chosen to link the soil data to the soil layer. Because this information can be entered manually, this table is not required to run the interface.

The first row of the soil look up table must contain the field names. The remaining rows will hold the required data. An example soil look up table can be found in the included dataset.

dBase Table Format: Name option (2 fields)

Field name	Field format	Definition
VALUE	String	Number of layer category
NAME	String 30 chars max	Name of the soil. The name entered into this field must correspond to the name of a soil in the User Soils Database.

This table already exists. It's named 'soil.dbf' and can be found in the file /otherdata/swat/ SWAT_DataForFlanders.zip on the network drive.

II DATA TABLE – USER SOILS DATABASE

The format of the User Soils database can be found in Soil and Water Assessment Tool, User's Manual, version 2000 (Neitsch et al., 2001).

The User Soils database for Flanders exists. It's named 'usrsoil.dbf' and can be found in the file /otherdata/swat/swat (adapted for Flanders).zip. More information about this file can be found in appendix C.

Copy 'usrsoil.dbf' into the directory <InstallationDirectoryAvSWAT>/AvSwatDB/.

3.2.2.3 Weather generation

I LOCATION TABLE

The user will provide a record for each station to be used: the "Name" field will contain the string used as the station name in the User Weather Stations database.

dBase Table Format: (4 fields)

Field name	Field format	Definition
ID	Integer	Gage identification number
NAME	String max 8 chars	Corresponding gage name string
XPR	Floating point	X coordinate in the defined projection
YPR	Floating point	Y coordinate in the defined projection

This table already exists. It's named 'wgnstations.dbf' and can be found in the file /otherdata/swat/SWAT_DataForFlanders.zip on the network drive.

II DATA TABLE : USER WEATHER STATIONS DATABASE

The format of the User Weather Stations Database can be found in Soil and Water Assessment Tool, User's Manual, version 2000 (Neitsch et al., 2001).

The User Weather Stations Database for Flanders is named 'usrwgn.dbf' and can be found in /otherdata/swat/SWAT_DataForFlanders.zip. More information about this file can be found in appendix D.

Copy 'usrwgn.dbf' into the directory: <InstallationDirectoryAvSWAT>/AvSwatDB/

3.2.2.4 Precipitation

I LOCATION TABLE

This table is formatted as a dBase table:

dBase Table Format: (5 fields)

Field name	Field format	Definition
ID	Integer	Gage identification number (not used by interface)
NAME	String max 8 chars	Corresponding table name string
XPR	Floating point	X coordinate in the defined projection
YPR	Floating point	Y coordinate in the defined projection
ELEVATION	Integer	Elevation of rain gage (m)

II DATA TABLE

The name of the precipitation data table is "*name*.dbf" where *name* is the character string entered for NAME in the rain gage location table.

This table may be formatted as a dBase table.

dBase Table Format: (2 fields)

Field name	Field format	Definition
DATE	Date (yyyymmdd)	Day of precipitation
PCP	Floating point (f5.1)	Amount of precipitation (mm)

The format of the tables for temperature (°C), Solar Radiation (MJ/m²/day), Wind Speed (m/s), Potential ET (mm) or Relative Humidity (fraction) Gage Location Table is equivalent to the format of the precipitation location table.

3.3 RUN AVSWAT

Please notice that all directories mentioned below are for home-use only. As you know, in the computer room, it's forbidden to save files on the c-drive. During the course, please save your project and all your data in that directory assigned by the docent.
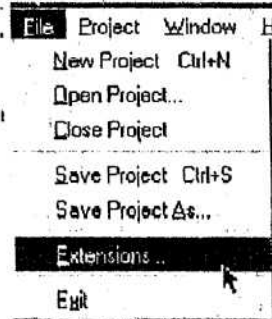
3.3.1 GET STARTED

To start the ArcView Interface from Windows

1. Start Arcview

2. On the File menu, click Extensions

> ArcView 3.x **extensions** make it easy to add new features to ArcView 3.x. Extensions are plug-ins that you can load and unload as you need them.

3. Scroll the list of available extensions until you locate AVSWAT2000. Click the box beside AVSWAT2000, a check mark will appear in the box.
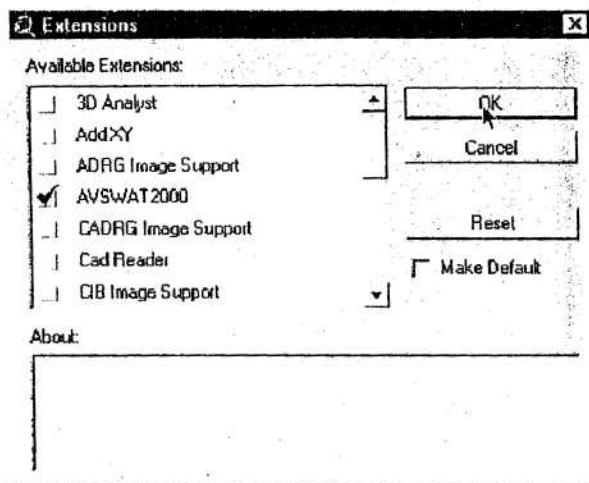
4. Select the option 'Spatial analyst' in the same way.

> The **Spatial Analyst** Extension allows you to solve spatial problems such as minimizing environmental impacts by modeling potential landscape and hydrological changes due to development, analyze GRID data, develop buffers around points or areas of interest. Spatial Analyst uses a GRID theme to analyze data. The GRID theme is the raster equivalent of the feature theme. The Spatial Analyst also presents generic spatial analysis functionality on grid and feature themes, that is added to ArcView as an extension that is loaded with Extensions in the File menu when the project window is active. The user interface components of the Spatial Analyst are loaded into the interface for views. (Learning ArcView – The NPS course. http://www.nps.gov/gis/av3_online/)

5. Click **OK**.

> Note: *Do not* check the Make Default option on the ArcView Extension dialog box. This option has a bug that prevents ArcView from starting once you have exited the program after turning on this option.

Once the extension is loaded, the SWAT ArcView main interface screen will be displayed.
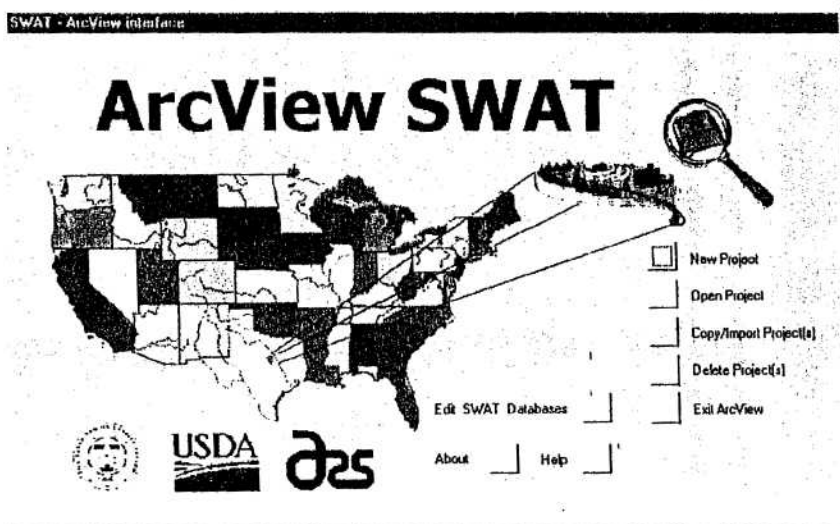
The main interface offers the user 8 options:

- Create a new SWAT project
- Open an existing SWAT project
- Copy/Import an existing SWAT project
- Delete an existing SWAT project
- Exit ArcView
- Edit SWAT Databases
- About
- Help

Three additional options are displayed on the main interface once a project has been opened or created.

- Save the active project
- Set environmental variables
- **Return to current project**

3.3.1.1 Create a new SWAT project

To create a new SWAT Project:

1. On the main interface, click the button beside New Project.

2. A browser will be displayed requesting a name for the new project. The browser shows the directory tree where data associated with the new project will be stored. The interface will default the project directory location to the installation directory. The default project name and directory location may be used or a new name/directory entered.
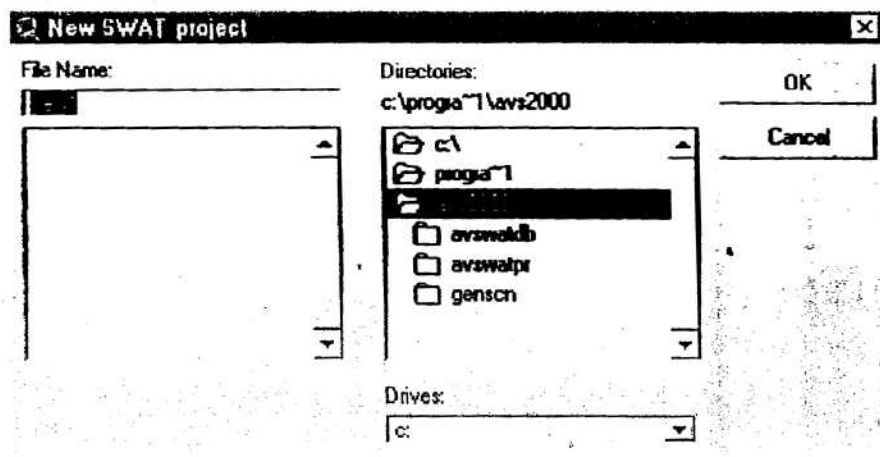
3. Change the project directory location if desired.

4. Type a project name in the text box called File Name (a default name for the project is provided).

5. Once the desired project name is displayed in the browser, click **OK**.

6. Select the desired **SWAT User Data** directory and click **OK**.

Within the directory specified in the browser, the SWAT ArcView interface creates a subdirectory to store the project files generated for SWAT. The subdirectory has the same name as the project. A project management file or log file is also created for the project and is stored in the main directory. The log file is of the file type SWAT project. The log file name is the project name with the extension ".swat".

A project window for the new SWAT will be displayed.

3.3.1.2 Open an existing SWAT project

To open an existing SWAT project:

1. On the main interface, click the button beside **Open Project**.

2. A browser will be displayed. If necessary, move to the proper directory. Click on the name of the SWAT project log file (.swat) belonging to the project you wish to open.
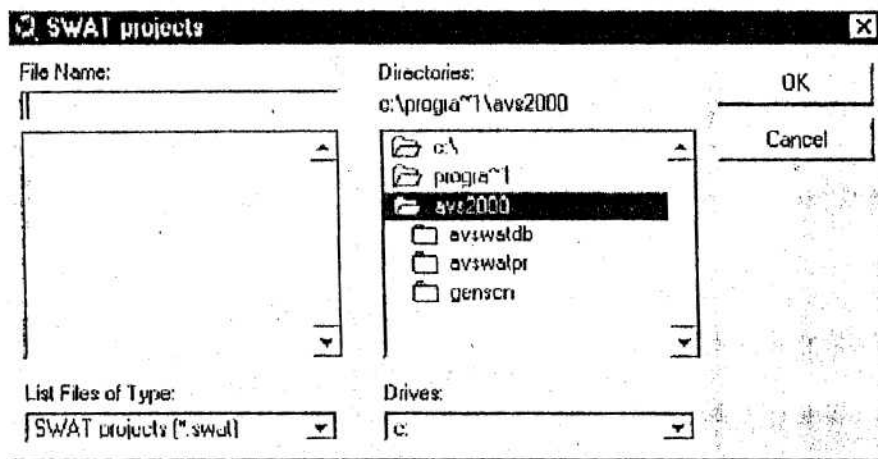
3. Once the desired project name is displayed in the text box called File Name, click **OK**.

4. A prompt box will be displayed which offers the option of making a backup copy of the project. If you wish to make a backup copy of the project, click **Yes**. If not, click **No**.

5. The project window for the SWAT project will be displayed. The layout of the window is recreated from the last time the project was saved.

> The user may also open a SWAT project without first loading the AVSWAT2000 extension. To open a project directly from ArcView, select **Open Project** on the ArcView **File** menu. A browser will be displayed. Use the directory tree to open the project directory. Within the project directory, an ArcView project (.apr) file is stored. Select this file and click **OK**. ArcView will load the SWAT interface and open the project in one step.
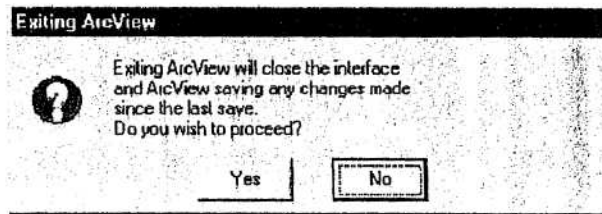
3.3.1.3 Exit ArcView

To close the SWAT ArcView interface and ArcView:

1. On the main interface, click the button beside Exit ArcView.

2. A prompt box will be displayed requesting the user to verify the command

3. To close the SWAT ArcView interface and ArcView program, click **Yes**. To abandon the exit procedure, and return to the main interface screen, click **No**.

3.3.1.4 Save the active project

To save the active SWAT project:

1. On the main interface, click the button beside Save Current Project.

2. A prompt box will appear once the project has been saved. Click **OK** to return to the main interface.

> The project *must* be saved via the Save Current Project option on the main interface menu or by the Save Current Project button (diskette symbol or File menu item) for the user to be able to fully restore the project in the interface at a future time.

3.3.1.5 Return to current project

To return to the project window of an open project:

1. On the main interface, click the button beside Return to current project.

3.3.1.6 Other options

See "ArcView Interface for SWAT2000. User's Guide." (Di Luzio M. et al. 2001).

3.3.2 WATERSHED VIEW

3.3.2.1 Watershed dileneation

I   PURPOSE

II APPLICATION

III KEY PROCEDURES

- Load the DEM

- (Optional) Define the working area (Focused Area)

- (Optional) Load the stream network to be used for the delineation

- Preprocess the DEM

- Specify the minimum sub-watershed area (critical source area)

- Review and edit the stream network points

- Run the calculation of the subbasin parameters

- (Optional) Locate the Reservoirs

When a new project is created, the Watershed Delineation dialog box will automatically be displayed. If the dialog box is not displayed, click **Automatic Delineation,** on the **AVSWAT** menu. (The **AVSWAT** menu is present only in the Watershed View.) The Watershed Delineation dialog will open.
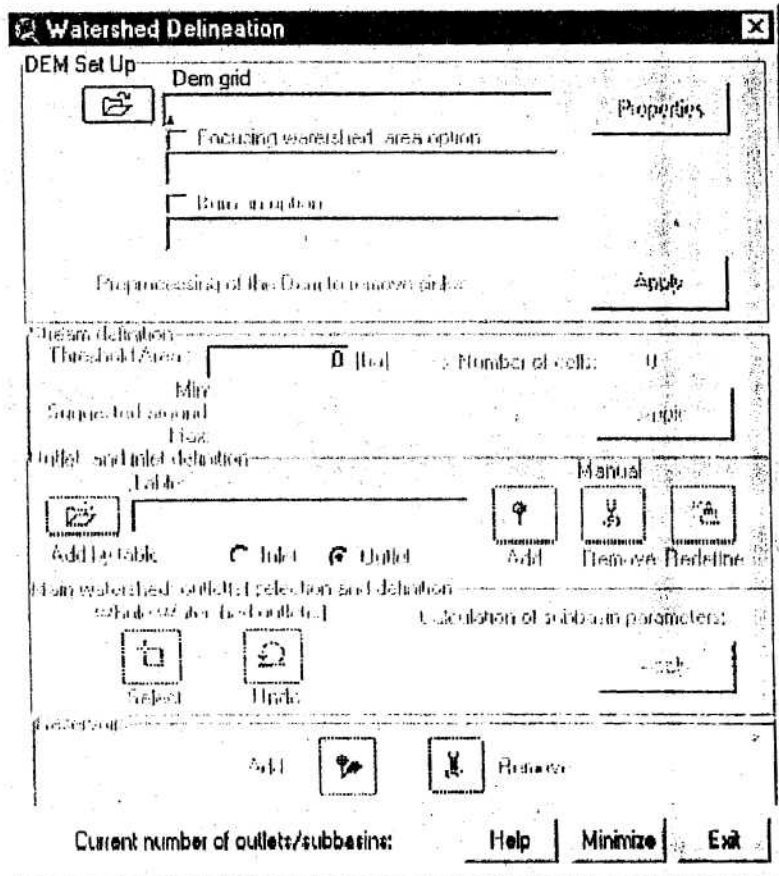
3.3.2.1.1 DEM setup

I LOAD DEM

1. To load or select the DEM grid, click the button beside the text box labeled "DEM grid".

A dialog box is opened to specify which DEM grid to use. You may select a DEM grid that previously has been added to the *Watershed View* or load a DEM.
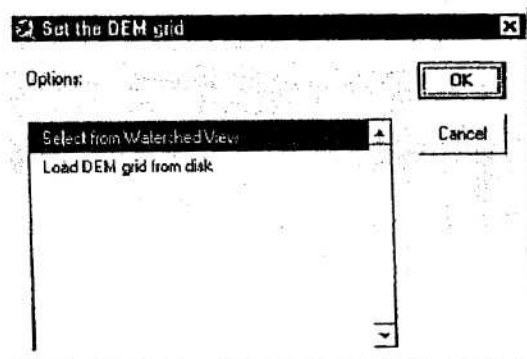
2. Select the option "Load DEM grid from disk". Click **OK** after the selection. A grid dataset file browser will appear to allow you to specify which DEM will be used.
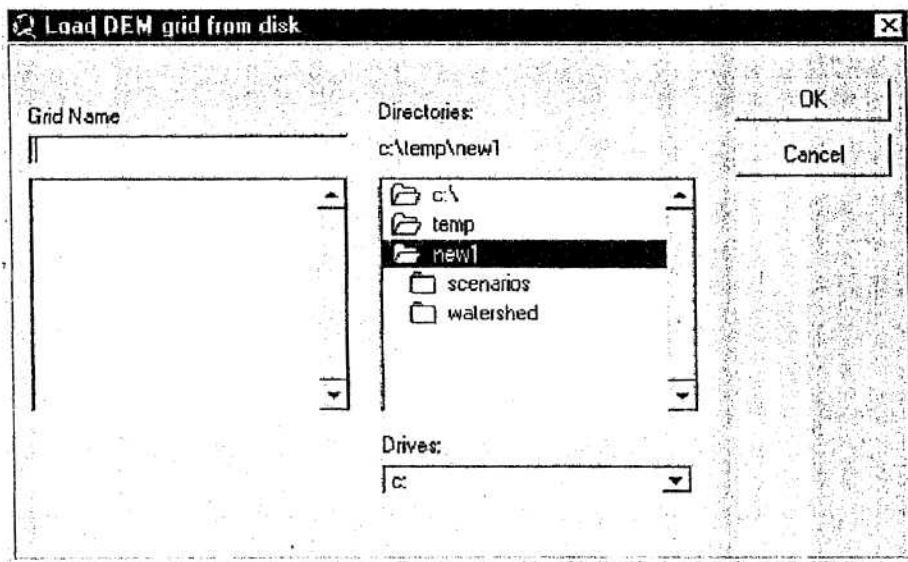
3. Select the name of the DEM grid, created in 3.2.1.1, and Click **OK** (or double click the selection.)

4. Once the DEM is loaded, the grid data set path will be shown in the text box labeled "DEM Grid". A prompt box will be displayed reminding the user to verify DEM properties.
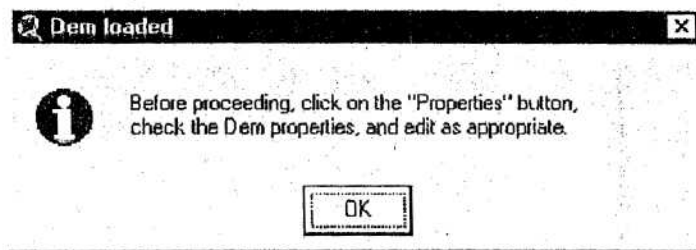
5. Click the properties button next to the DEM grid text box. The DEM properties dialog box allows DEM vertical and horizontal units of measure and the projection to be verified or edited.
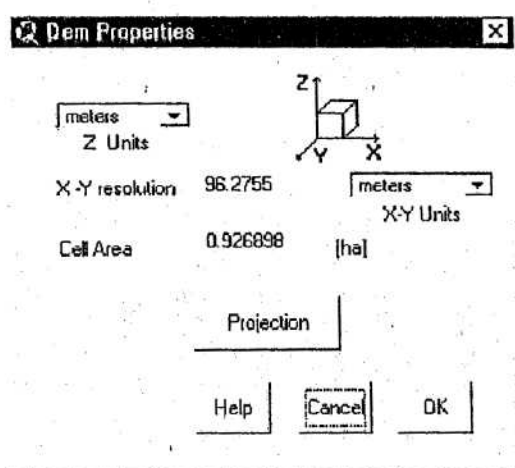
To change the units of measure, click on the arrows to display drop-down boxes

| meters ▼ | | meters ▼ |

(**Z Units** or **X-Y Units**) and select one of the listed units.

> Important! The DEM properties dialog should correctly report the horizontal and vertical units. Incorrect settings will affect the results of the watershed geomorphic parameterization.

6. To verify or edit the projection, click the projection button.

Note: The projection does not have to be defined in order to use the interface. If the projection is not defined:

- All location tables must use XPR and YPR coordinates to define the location of the objects of interest (Latitude and Longitude cannot be used to denote the locations)

- The US weather generator database cannot be used

- The PHU values (the total heat units required for plant maturity (heat units)) cannot be calculated for each individual plant in the watershed by the interface.

A prompt box will appear listing projection details for the DEM layer. When a new DEM layer is loaded, the projection will be undefined.
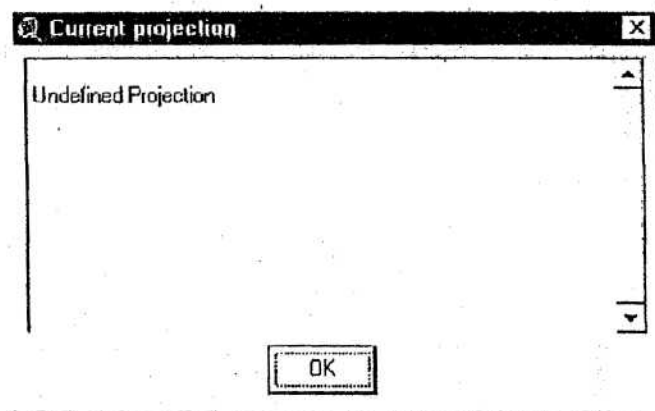
Click **OK**. A prompt box will appear.
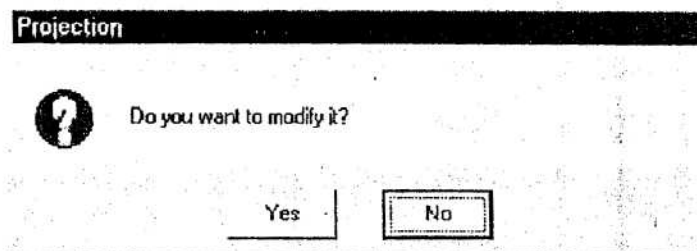
If the projection listed was correct, click **No**. To change the projection click **Yes**.
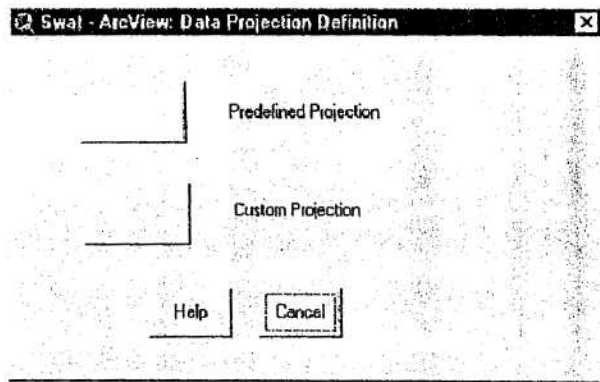
7. Choose **Custom projection**. If so, a dialog box will be displayed.
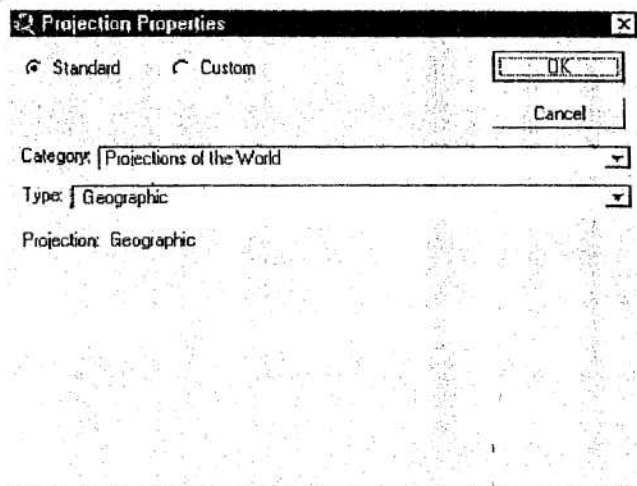
8. Scroll the drop-down menus for Category and Type to find the project layer projection and click the appropriate choices.

9. Once the projection has been selected, standard settings for the projection will be displayed in the lower portion of the dialog box. If the projection settings need to be altered, click the circle beside **custom** and type the correct values for each of the projection properties.
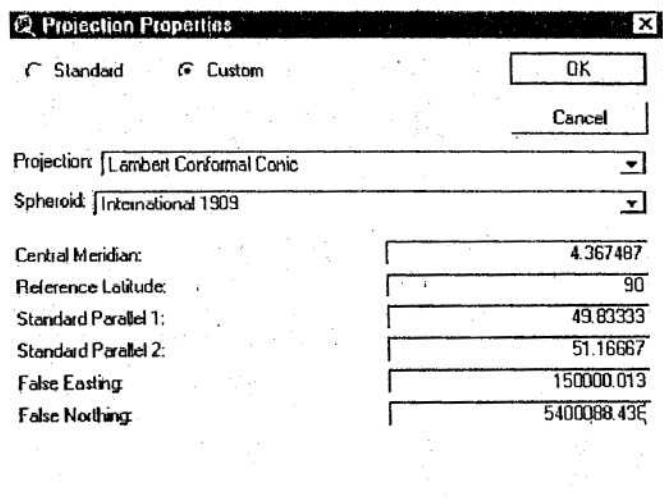
10. Once all projection properties have been set, click **OK**. This will close the projection dialog box.

11. Once the units of measure and projection are properly set, click **OK** on the properties dialog box.

12. Once the DEM properties are set the **Apply** button (labeled "Preprocessing of the DEM to remove sinks") will be enabled. The following two options need to be set before proceeding with the preprocessing of the DEM.

II   FOCUS WATERSHED AREA

13. Click the box beside Focusing watershed area option ☐ Focusing watershed area option. A check will appear in the box and a prompt dialog will open.
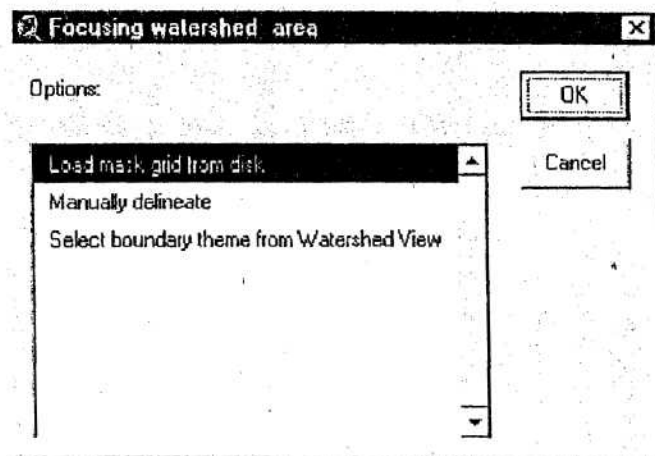
The user has three options for masking an area of the DEM layer. To activate one option, highlight the option and click **OK** or double-click the selection.

The first option, **Load mask grid from disk**, allows the user to import a grid from a disk drive. Select this option. If so a grid data set browser is opened.
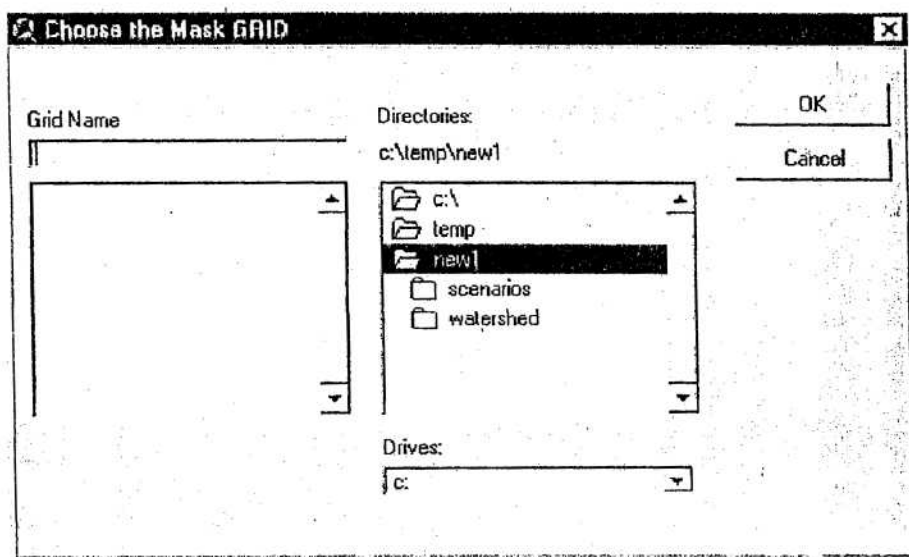
Select the name of the mask grid, created in 3.2.1.5, and click **OK** (or double click the selection). If a mask was set previously, a prompt box will appear asking if the new mask should be merged with the existing one.

Load mask grid from disk

Merge to the previous mask grid?

Yes | No
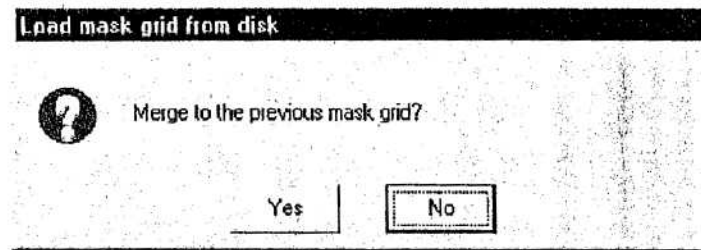
Click **Yes** to merge the new and previous mask grids.

Click **No** to skip merging.

III BURN IN A STREAM NETWORK

14. The theme must be a polyline shape file. Click the box beside Burn_in option ☐ Burn_in option. A check will appear in the box and a prompt dialog will open.

Burn_In Option

Options:

OK

Cancel

Digitized Stream Network
Reach File, V1
Reach File, V3
National Hydrography Dataset (NHD)
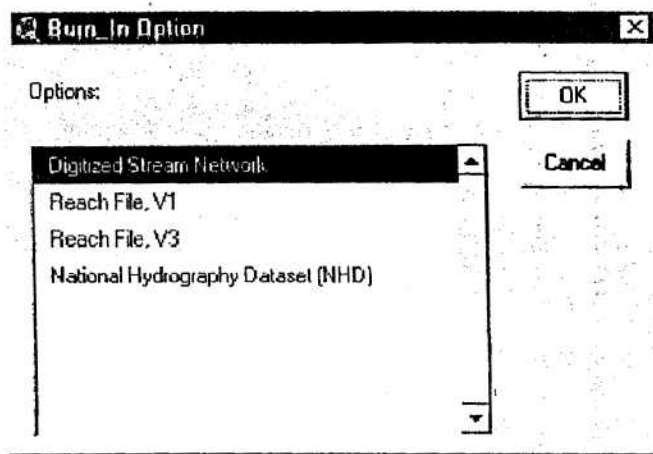
Four options are available to specify the stream network: Digitized Stream Network, Reach File V1, Reach File V3, and National Hydrography Dataset (NHD).

> Digitized Stream Network: This option is selected when the user is supplying the stream network. The interface assumes the stream network delineated in the shape file contains no errors.
>
> Reach File V1 is the oldest set of US stream network delineations, Reach File V3 is the second generation set of US stream network delineations, and NHD is the latest set of US stream network delineations. The V1 and V3 stream delineations contain many errors. When stream delineations are imported from these datasets, the user should define the source. The interface will "clean" the stream delineation.

Select the option Digitized Stream Network and click **OK** (or double click selection).

A prompt box will open and the user will select one of two options to load the stream delineation.

Digitized Stream Network

Options:

Load from disk
Select from Watershed View

OK

Cancel
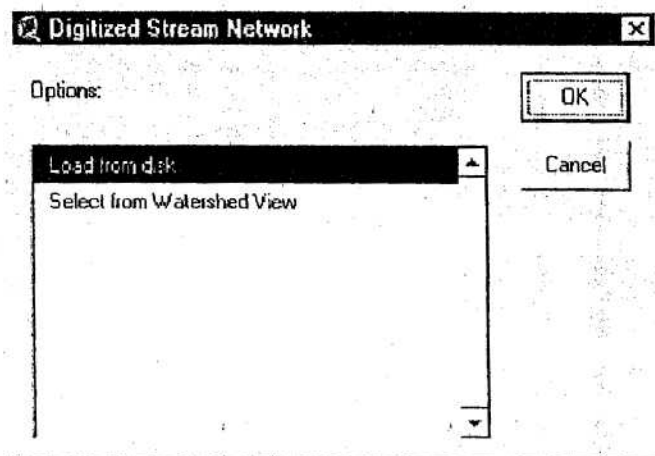
You may select a polyline theme that previously has been added to the *Watershed View* or load a polyline theme.

Select the option Load from Disk. Click **OK** after the selection. A polyline dataset file browser will appear to allow you to specify which shape file will be used.

Choose the Digitized Stream Network Stream theme(s)

Shapefile Name

Directories:
c:\temp\new1

OK

Cancel

c:\
temp
new1
scenarios
watershed

Drives:
c:
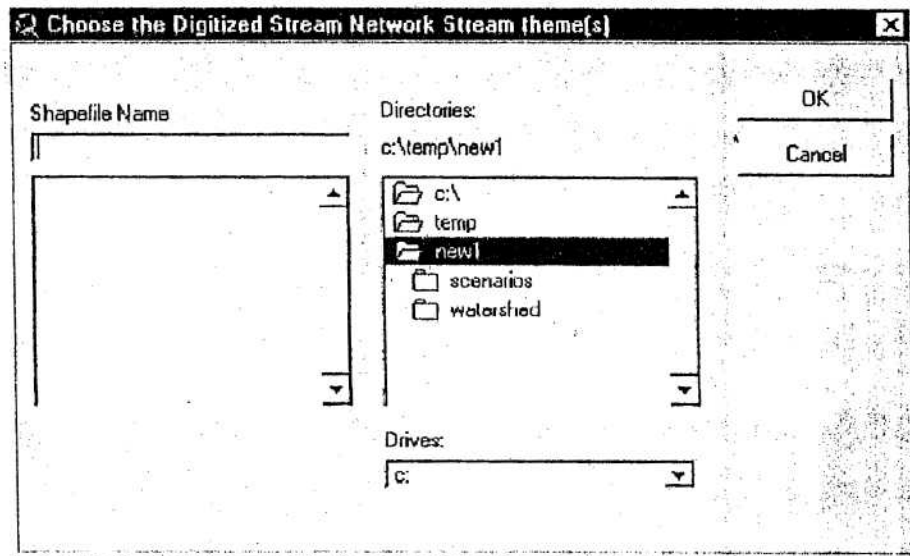
Select the name of the stream network theme, created in 3.2.1.2, (hold the Shift key for multiple selection) and click **OK**. If any of the selected shape files is not a polyline, a dialog box will report the error and the process will be stopped.

IV DEM PREPROCESSING

15. Once the DEM grid is loaded, the properties have been reviewed, and optional themes are set, click the Apply button next to the label "Preprocessing of the DEM to remove sinks".

Preprocessing of the Dem to remove sinks: Apply

The interface will process the DEM grid to remove all the non-draining zones (sinks). While processing the DEM, a prompt box will appear.

Dem preprocessing option

? Do you want the cells on the edge of the "focused area" to flow toward the inner cells?

Yes   No

Click **No** if all cells on the edge of the working zone need to flow away from the zone. This is the recommended choice.

Click **Yes** if the flow is calculated normally for edge cells with the edge being slightly lower than the cell.

A prompt box is displayed when layer preprocessing is complete. Click **OK**.

Info ✕

i   End of DEM grid preprocessing

OK
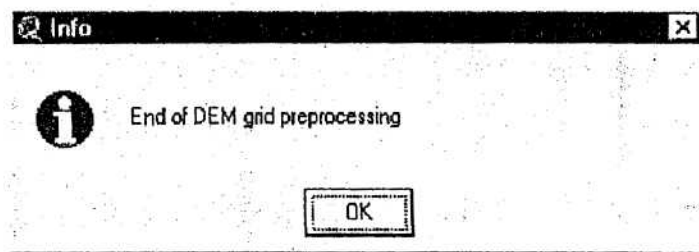
3.3.2.1.2 Stream definition

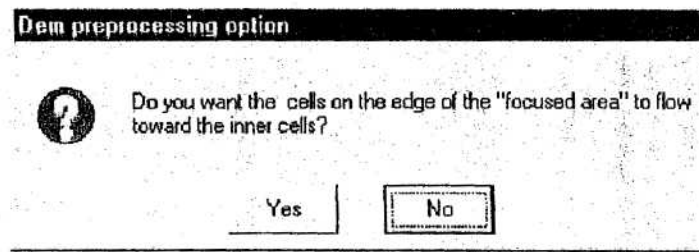In this section of the Watershed Delineation dialog box, the initial stream network and subbasin outlets are defined. The interface lists a minimum, maximum, and suggested sub-watershed area (in hectares) are shown in the stream definition section.

Stream definition
Threshold Area :   200 [ha]   --> Number of cells: 216
       Min: 37.3948
Suggested around: 700   Apply
      Max   14957.9
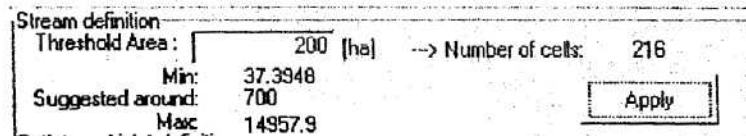
1. In the text box labeled "Threshold area", type the upstream drainage area (in hectares) required to define the beginning of a stream. The smaller the specified number of hectares, the more detailed the drainage network, delineated by the interface.

2. Click the **Apply** button.

3. Two themes are now added to the Watershed View and displayed over the DEM grid: Streams (the current synthetic drainage network) and Outlets (the respective stream junction points).
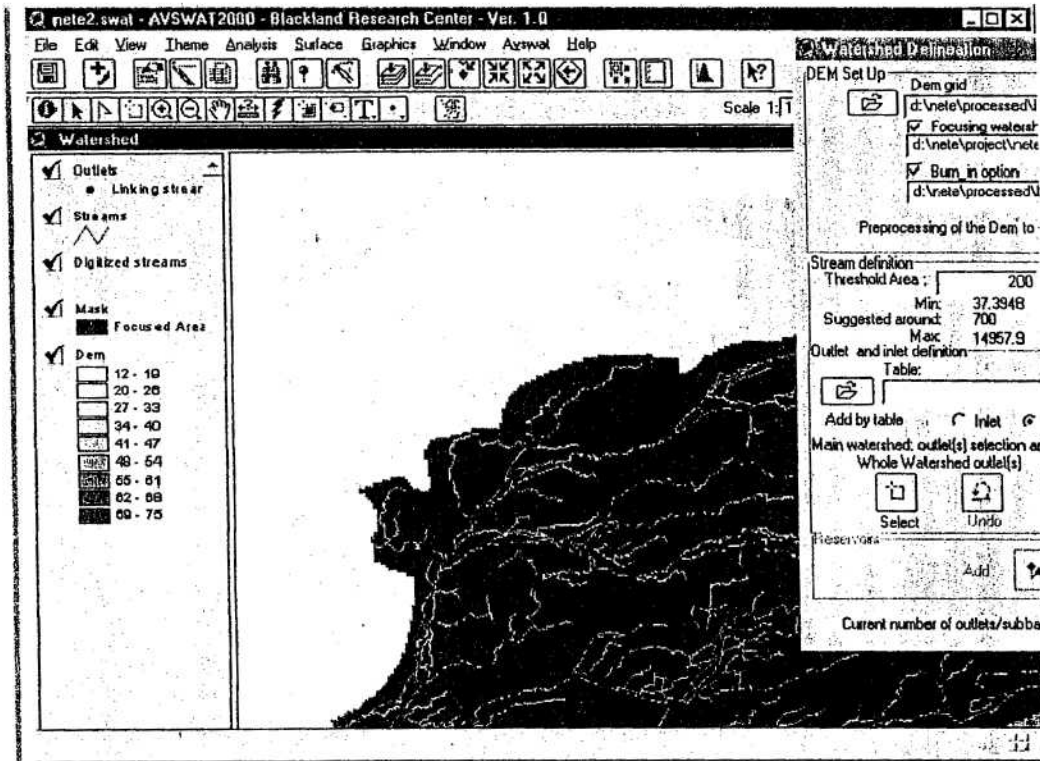
4. The user can change the threshold value and re-run the stream and outlet definition routine or proceed with the next section.

3.3.2.1.3   Outlet and inlet definition

Drainage inlets and subwatershed outlets may be added, deleted, or redefined, within the 'Outlet and inlet definition'-subsection.
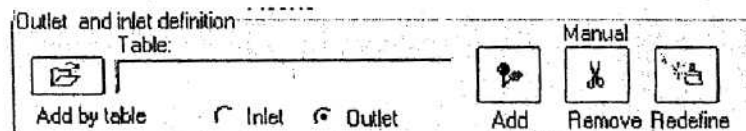
The user needs to provide discharge data records for a point-source discharge and the outlet of a draining watershed. The inlet discharge is routed through the stream network.

Inlets and outlets may be added to the stream network by importing a predefined table or manually clicking the mouse over the layer on the screen. Two radio buttons allow you to switch the current definition between inlets and outlets.

The legend for the Outlets theme in the Watershed View distinguishes the types of inlets/outlets added to the view.

The following sections described the different methods used to add inlets and outlets.

I   MANUALLY EDITING OUTLETS AND INLETS

Outlets and inlets may be manually edited using the following steps.

ADDING OUTLETS

1. In the Outlet Definition section of the DEM dialog box, make sure the option "Outlet" is selected ⊂ Inlet ⊙ Outlet .

2. Click the ☐ Add button.

3. The Watershed Delineation dialog will be minimized. Move the cursor to the desired location(s) and click the left mouse button. An outlet point will automatically snap to the closest stream line and the feature will be added to the "Outlets" theme.

4. When all desired outlets have been added, maximize the dialog box.

ADDING INLETS (See page 76 of ArcView Interface for SWAT2000. User's Guide. Di Luzio M. et al. 2001).

DELETING OUTLET

1. If necessary, zoom in on the inlet or outlet points to be deleted.

2. Click the ☐ Remove button.

3. The Watershed Delineation dialog will be minimized. Move the cursor to the location(s) you wish to remove.

4. Hold down the left mouse button and move the mouse to draw a box around the point(s) you wish to remove. Release the left mouse button.

5. A prompt box will appear, asking you to verify removal of the selected point(s). Click Yes.

REDEFINING OUTLETS/INLETS (See page 76 of ArcView Interface for SWAT2000. User's Guide. Di Luzio M. et al. 2001).

II ADDING INLETS AND OUTLETS FROM TABLES (See page 78 of ArcView Interface for SWAT2000. User's Guide. Di Luzio M. et al. 2001).

3.3.2.1.4 Main watershed outlet selection and definition

1. Click the ☐ Select button.

2. The *DEM dialog* will minimize and another dialog will appear.

Main watershed outlet(s) selection

Hold Shift Key down
for multiple selection

Click ☐ OK

once selection is complete

Help
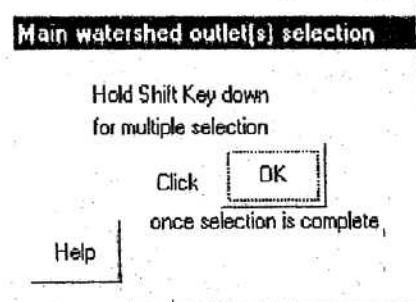
3. Press the ESC key to exit the selection.

4. To select one watershed outlet, position the cursor close to the point chosen to be the watershed outlet. Hold down the left mouse button and move the mouse to form a box on the screen around the selected outlet. Release the left mouse button.

5. To select multiple watershed outlets that are not adjacent to one another, hold down the Shift key continuously while performing the actions described in Step 4 as many times as necessary to select all the watershed outlets of interest.
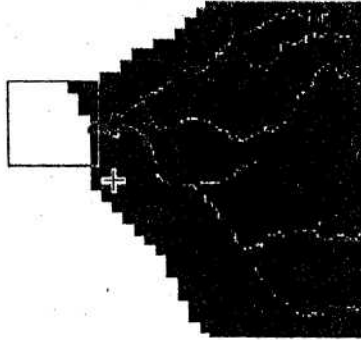
Tip: The tool allows multiple main watershed outlets to be selected. This feature allows non-hydrologically connected watersheds to be simulated at the same time.

6. Once the outlet points are selected, click **OK** on the outlet selection prompt box.

If a Point Discharge or Inlet of Draining Watershed is specified, a dialog box will report an error and processing will stop.

Otherwise a confirmation prompt pops up.
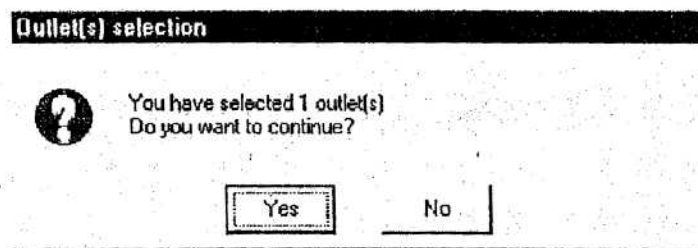
7. Click **Yes** to proceed.

Note: Repeated outlets (located in the same location) will be removed. In this case a message dialog will pop up.

8. A layer of the watershed (*Watershed* theme), sub-watersheds (*Subbasins* theme), and stream network restricted to the watershed (*Streams* theme) will appear on the screen when the interface has completed the watershed delineation.
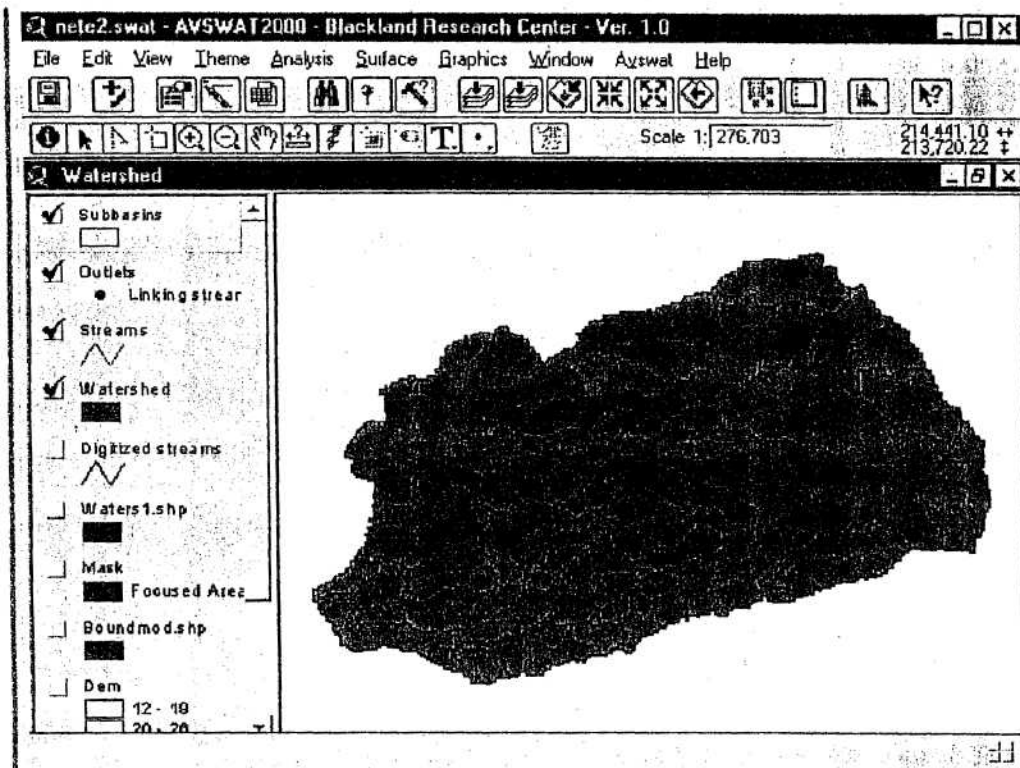
9. By clicking the **Undo** button the user can step back and repeat steps 1-7. This action removes the watershed delineation and allows outlets and inlets to be edited.

When the **Undo** button is clicked, a prompt box will appear asking the user to verify the undo operation.
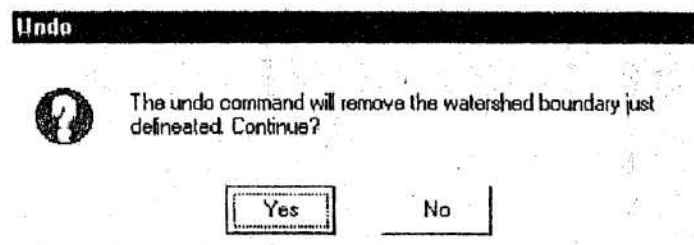
Click **Yes** to remove the watershed delineation.

Click **No** to continue with the current settings.

10. Calculation of Subbasin Parameters

This function calculates geomorphic parameters for each subbasin and the relative stream reach. The results of the calculations are stored in the table of attributes of the updated *Subbasin* and *Streams* themes.

Calculation of subbasin parameters:

a. Click the **Apply** button.

b. If the Projection for the watershed was not defined when the DEM was loaded, a message box will appear.

Click **Yes** to define the Projection or click **No** to leave the projection undefined.

Note: If the projection is left undefined, another message box will appear.

Data Projection Undefined

The data Projection is not defined
Do it now?

| Yes | No |
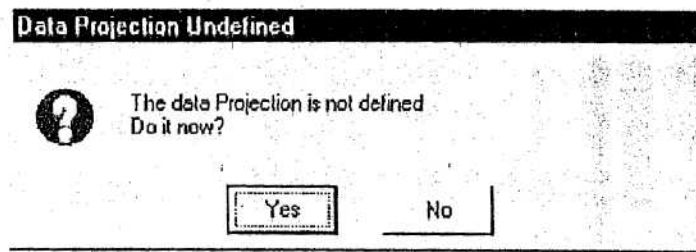
Click **Yes**. A prompt box is displayed.

Default Subbasin Centroid Latitude Value [×]

Input the value will be used for all the subbasins

OK

45.00

Cancel
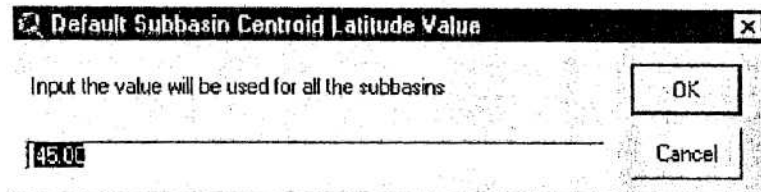
Type the latitude to be assigned to the subbasins and click **OK**.

c. When all parameters are calculated, a dialog box appears.

Info [×]

Completed the watershed delineation and stream-subbasin parameter calculations

OK
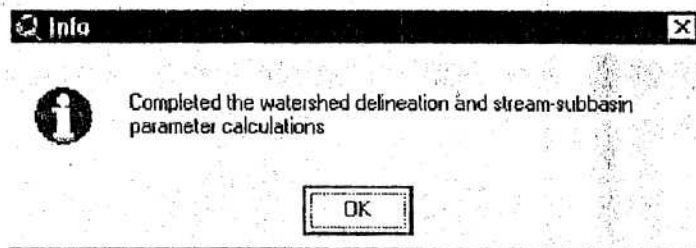
Each subbasin in the *Subbasins* theme is numbered and the label is visible in the Watershed View.

A new report named *Topographic Report* is now available.

3.3.2.1.5 Reservoirs (Optional)

The reservoir section:

Reservoirs

Add   Remove

Adding a reservoir.

1. Click the   Add   button.

2. The dialog box will be minimized and the cursor will become a crosshair. Click over the target subbasin area to add a reservoir.

3. A prompt box will be displayed asking for verification of the reservoir placement.
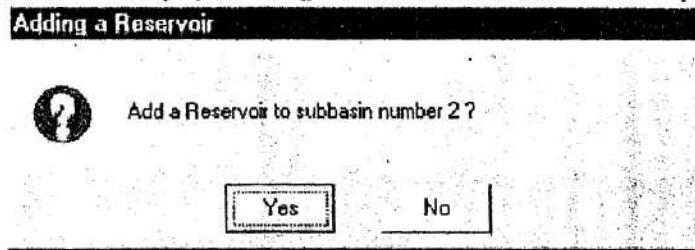
If the wrong subbasin is listed, click **No** and repeat step 2. If the correct subbasin is listed, click **Yes**. The new reservoir location will be placed at the outlet of the respective subbasin.

4. Once the first reservoir location is added, the new *Reservoirs* theme will be added to the Watershed View.

> Tip: The user is allowed to add a single reservoir location for each subbasin. Refine the outlet set if more than one reservoir location needs to be set in the current subbasin area.

Removing a reservoir(s).

1. Click the [Remove] button.

2. The *Watershed Delineation* dialog box will be minimized and the mouse cursor will become a square. Draw a square around the reservoir(s) you wish to remove by holding down the left mouse button.

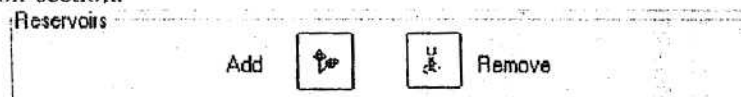3. A prompt box will be displayed asking for verification of the reservoir(s) removal.
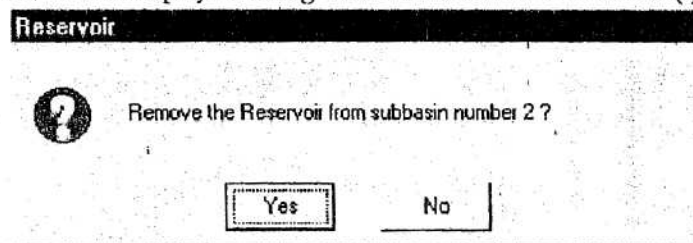
4. If the wrong subbasin is listed, click **No** and repeat step 2. If the correct subbasin is listed, click **Yes**.

5. If all the reservoir locations are removed, the *Reservoirs* theme will be removed from the Watershed View.

3.3.2.2 LandUse and soil definition

I PURPOSE

II APPLICATION

III KEY PROCEDURES

- Define the land use theme
- Reclassify the land use theme
- Define the soil theme
- Reclassify the soil theme
- Overlay land use and soil themes
- Click the Exit button

3.3.2.2.2 Get started

Initiate the *Landuse and Soil Classification and Overlay* tool by selecting **Land Use and Soil Definition** in the **AVSWAT** menu. (The **AVSWAT** menu is present only in the Watershed View.)
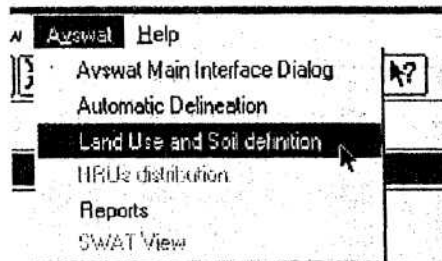
The *Definition of Landuse and Soil themes* dialog will open.
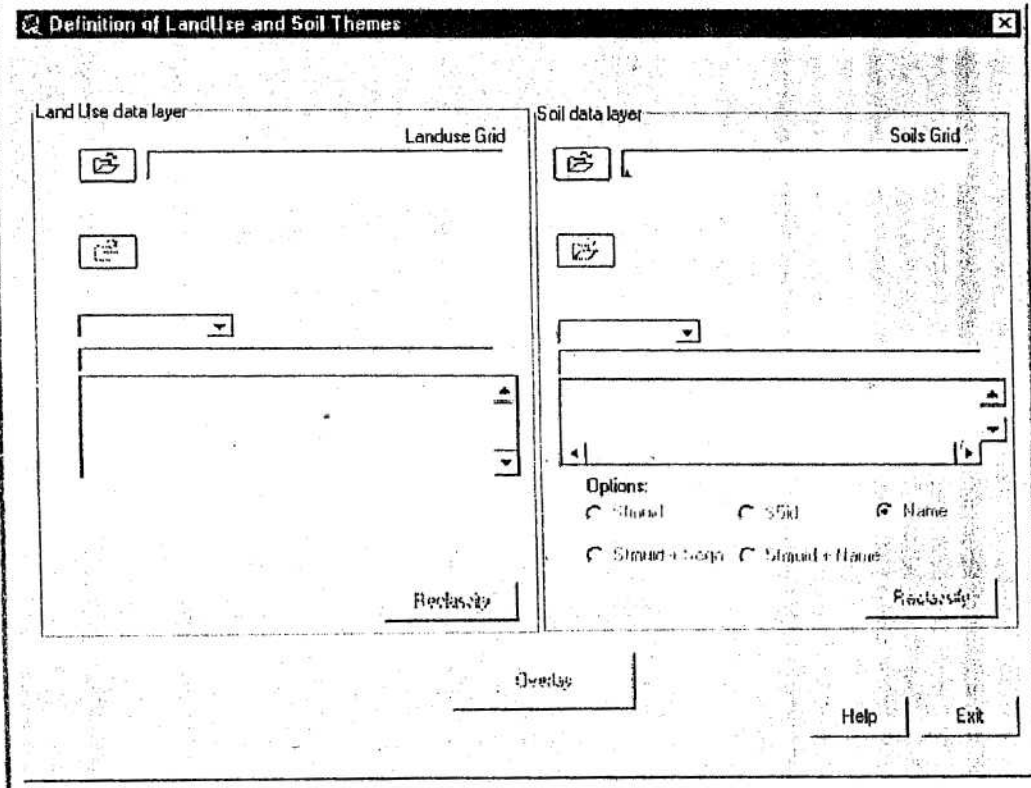
The dialog is divided into two main sections: *LandUse data layer* and *Soil data layer*.

3.3.2.2.3 Land use data layer

Define LandUse/LandCover theme:

1. Select the land use data layer by clicking the button next to the text box labeled **LandUse Grid**. A dialog box labeled *Set the LandUse Grid* will appear.

Set the Landuse grid

Options:

OK

Select Landuse theme(s) from Watershed View
Load Landuse themes(s) from disk

Cancel
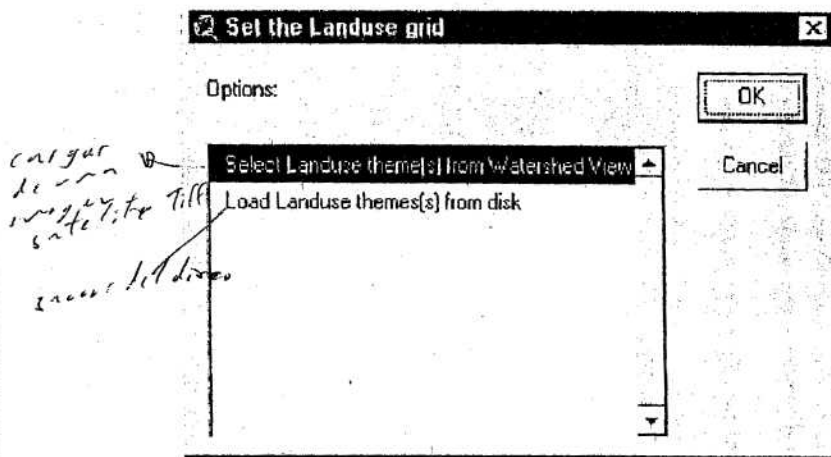
2. Highlight **Load Landuse theme(s) from disk**. Click **OK**.

3. A new dialog is displayed for the user to define the type of theme being used. Select **Grid** from the drop-down menu and click **OK**.

Select theme(s) from Disk

Format

OK

Grid

Cancel
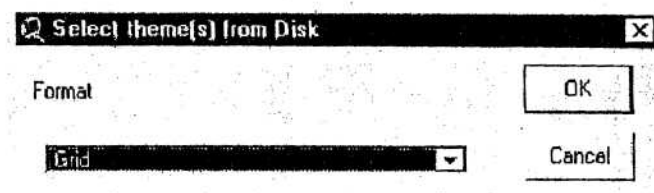
 a. If loading from the *Watershed View* a dialog box is displayed showing the list of grid themes.

 b. If loading from disk a prompt dialog pops up.

LandUse Grid Theme(s)

The data must be already projected.
Continue?

Yes   No
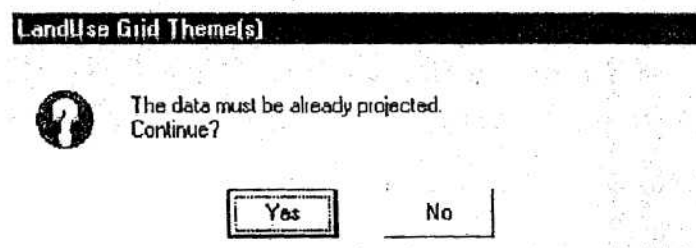
If the landuse grid is not projected, click **No** to exit. This will stop layer processing. If the landuse grid is defined in the same projection as the DEM, click **Yes** to proceed.

A browser will be displayed allowing the user to select the land use grid, created in 3.2.1.3. Click **OK**.
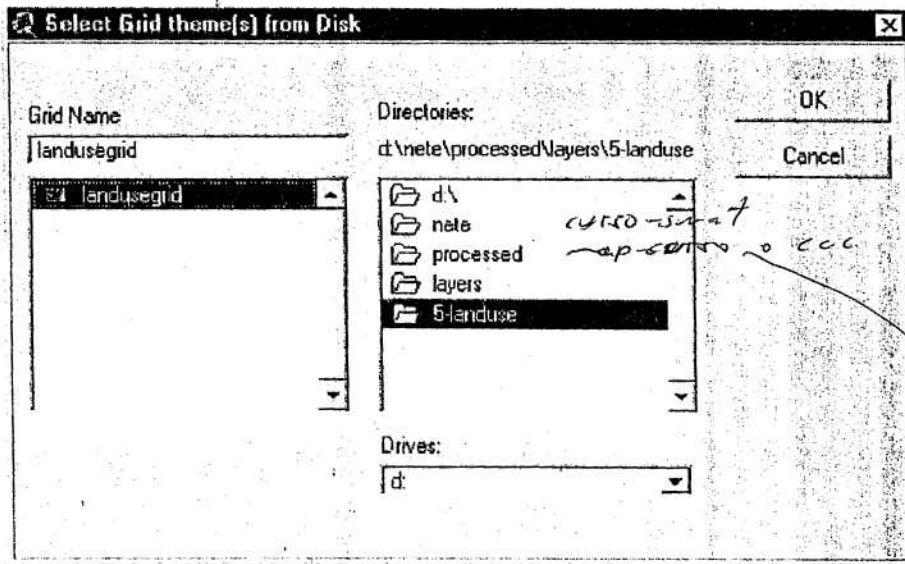
Note: The base cell size of the land use grid will be resampled to the same size as the DEM grid cell. This is required to properly overlay the different layers for comparison.

5. When this step is complete, a *Load and Clip Land Use* message box will state that the landuse theme has been processed and clipped to the watershed boundaries. The message box also reminds the user to load a look-up table or manually define the landuse classes for the theme.
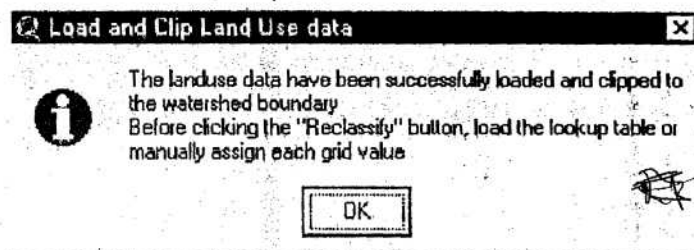
6. Click **OK** to proceed. This will return you to the *Definition of LandUse and Soil Themes* dialog box.

7. A new theme, *LanduseTmp*, is added to the *Watershed View* where the user may review the results of the layer processing. The path of the resulting grid is shown in the text box labeled **LandUse Grid**. The list box displays the landuse grid values with percent watershed area. The *LanduseSwat* attribute that defines the land cover/plant from the SWAT databases is blank and must be defined.
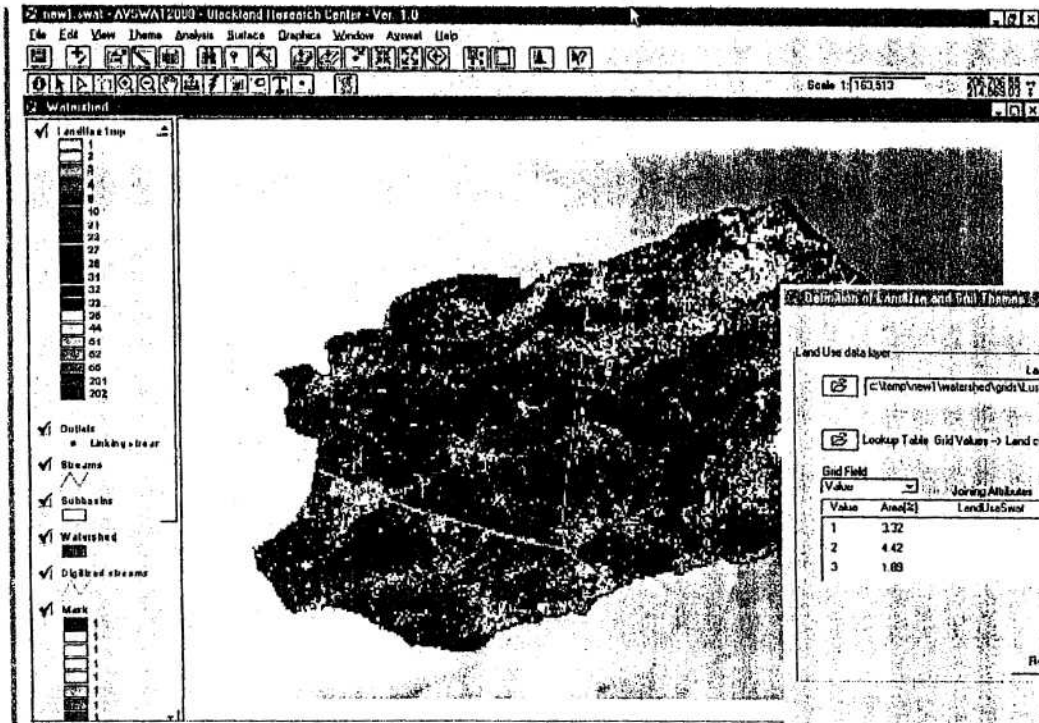
Assign codes using a look-up table:

a. To load a look-up table select the landuse look-up table by clicking on the button labeled **Look-up table Grid Values_Land cover classes.**

Lookup Table Grid Values --> Land cover classes
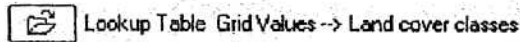
b. A dialog box will be displayed.
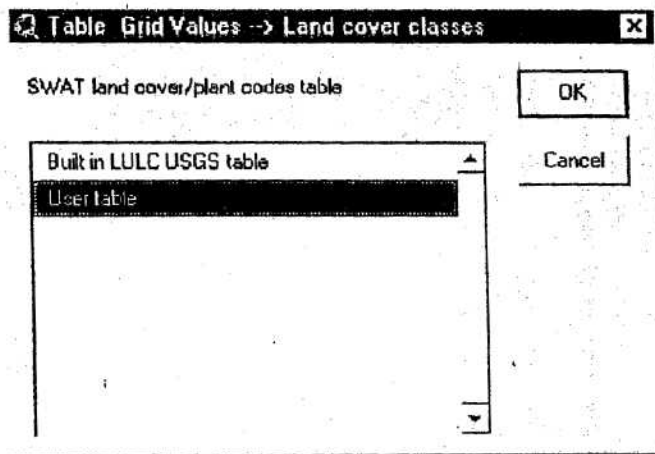
Two options are listed. Highlight **User** table. Click **OK**.

A prompt box will appear that allows the user to specify the format of the classification table. The landuse classification table may be formatted in dBase (.dbf) or ASCII (.txt).
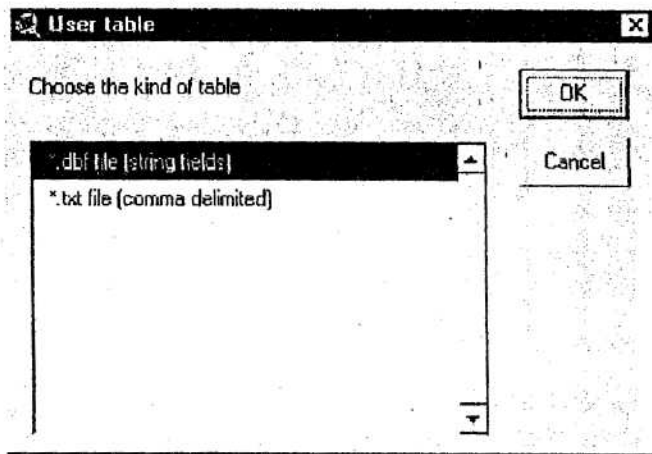
Select the .dbf format and click **OK**. A browser will appear, allowing you to select and load the look-up table from disk.
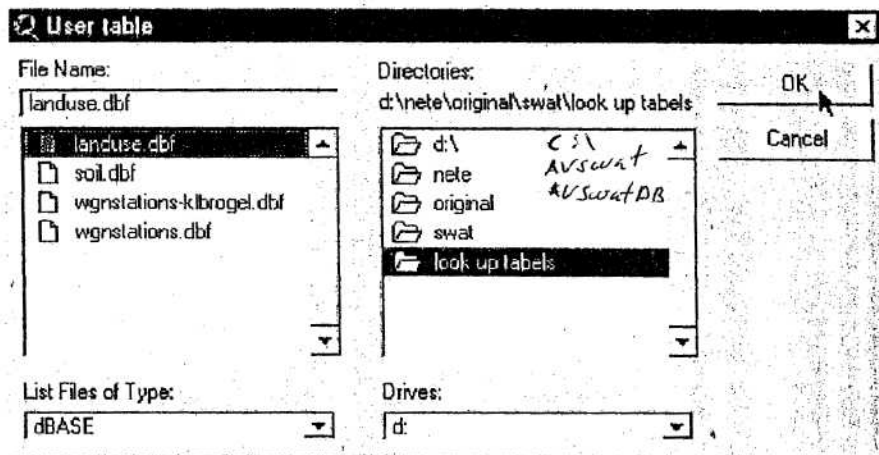
Highlight the name of the look-up table and click **OK**. The interface will insert Landuse SWAT codes from the table into the list box.

Because not all values are included in the look-up table, some values didn't get a Joining attribute. You have to assign those codes manually:

a. To manually assign land cover/plant codes or urban codes, double-click in the *LandUseSwat* spot in the *Joining Attributes* box.

b. A dialog box will pop up listing two database files from which a SWAT land type can be selected: Land Cover/Plant or Urban.

```
┌─────────────────────────────────────────────────────┐
│ ⚡ SWAT Land Use                                  [×] │
│                                                       │
│  Land Cover Data Base:              ┌───────────┐     │
│                                     │    OK     │     │
│  ┌────────────────────────────┬─┐   └───────────┘     │
│  │ Land Cover/Plant           │▼│    ┌─────────┐      │
│  └────────────────────────────┴─┘    │ Cancel  │      │
│                                       └─────────┘      │
└─────────────────────────────────────────────────────┘
```
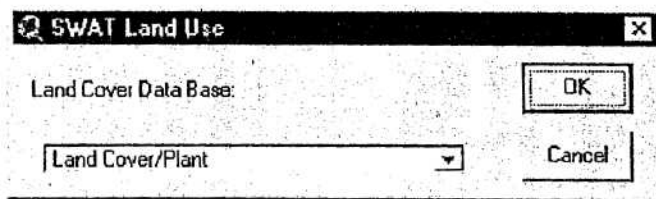
c. Highlight the desired database file by clicking on it. Click **OK** (or **Cancel** to exit). A dialog box will pop up listing the available SWAT land cover codes or the available SWAT urban land type codes.

```
┌─────────────────────────────────────────────────────┐
│ ⚡ SWAT - Land Cover/Plant                        [×] │
│                                                       │
│  Select land cover/plant code        ┌─────────┐      │
│                                       │   OK    │      │
│                                       └─────────┘      │
│  ┌────────────────────────────────┬─┐ ┌─────────┐     │
│  │ Poplar --> POPL              [▲]│ │ │ Cancel  │     │
│  │ Potato --> POTA                │ │ └─────────┘     │
│  │ Range-Brush --> RNGB           │ │                 │
│  │ Range-Grasses --> RNGE         │ │                 │
│  │ Red Clover --> CLVR            │ │                 │
│  │ Rice --> RICE                  │ │                 │
│  │ Russian Wildrye --> RYER       │ │                 │
│  │ Rye --> RYE                  [▼]│ │                 │
│  └────────────────────────────────┴─┘                 │
└─────────────────────────────────────────────────────┘
```

```
┌─────────────────────────────────────────────────────┐
│ ⚡ SWAT - Urban                                   [×] │
│                                                       │
│  Select Urban code:                  ┌─────────┐      │
│                                       │   OK    │      │
│                                       └─────────┘      │
│  ┌────────────────────────────────────┬─┐ ┌───────┐  │
│  │ Commercial --> UCOM              [▲]│ │ │Cancel │  │
│  │ Industrial --> UIDU                │ │ └───────┘  │
│  │ Institutional --> UINS             │ │            │
│  │ Residential-High Density --> URHD  │ │            │
│  │ Residential-Low Density --> URLD   │ │            │
│  │ Residential-Med/Low Density --> URML│ │           │
│  │ Residential-Medium Density --> URMD│ │            │
│  │ Transportation --> UTRN          [▼]│ │           │
│  └────────────────────────────────────┴─┘            │
└─────────────────────────────────────────────────────┘
```
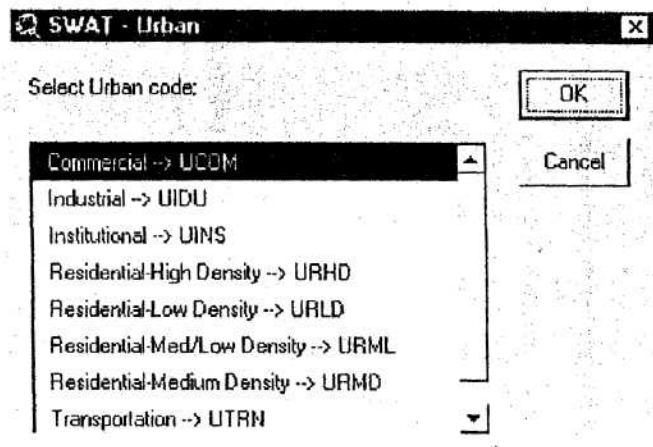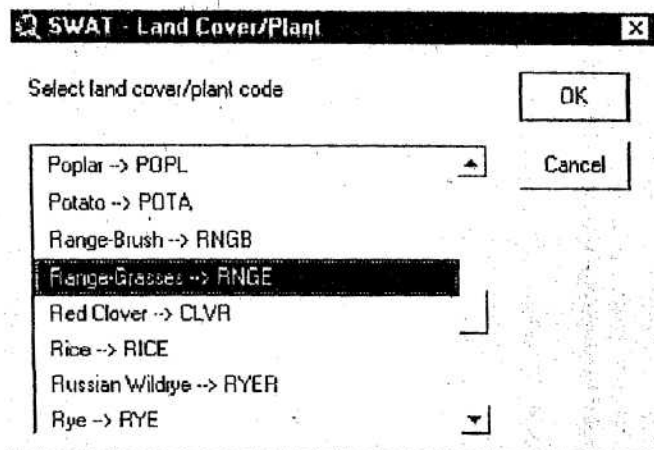
d. Scroll down the list and highlight the land cover code for the layer category by clicking on it. Click **OK** (or double click the selection). The SWAT land cover or urban code will be displayed next to the corresponding land use layer category in the Definition of *LandUse and Soil Themes* dialog box.

4. Once a *LandUse.Swat* code has been assigned to all layer categories, the **Reclassify** button will be enabled. Click the button.

5. A new theme named "SwatLanduseClass" will be displayed in the *Watershed View*.
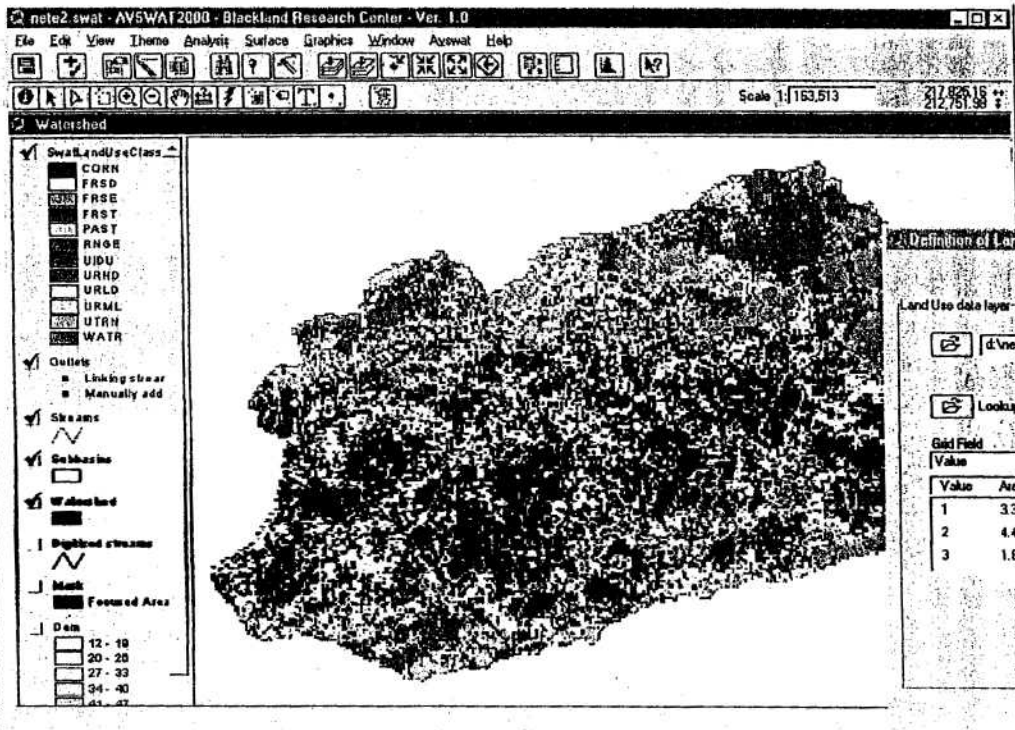
3.3.2.2.4 Soil data layer

Define Soil theme:

1. Select the soil data layer by clicking the [📂] **button next to the text box labeled Soil Grid. A dialog box labeled** *Set the Soil Grid* **will appear.**
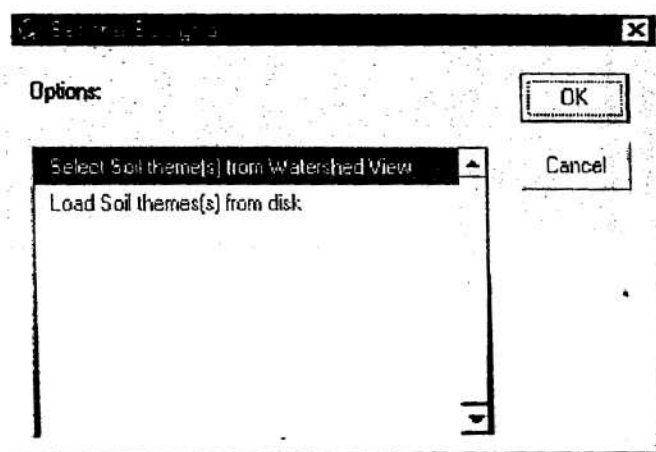
2. If the soil theme is already displayed in the *Watershed View*, **highlight Select Soil theme(s) from Watershed View. If the soil theme is not displayed, highlight Load Soil theme(s) from disk. Click OK.**

3. A new dialog is displayed for the user to define the type of theme being used. Select **Shape** from the drop-down menu and click **OK**. If the data is stored in a grid, Select Grid from the drop-down menu.

If loading from disk, a file browser pops up.

Select one or more themes (hold the Shift key for a multiple selection) and click **OK**.

The selected themes are converted in a grid theme with the cell size set to the base cell size. The base cell size is the cell size of the DEM theme.
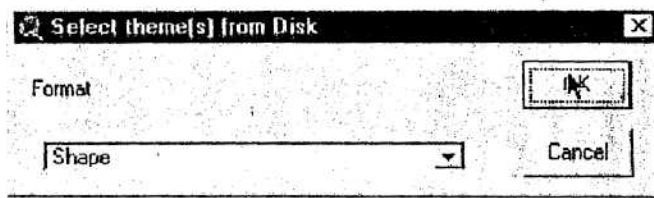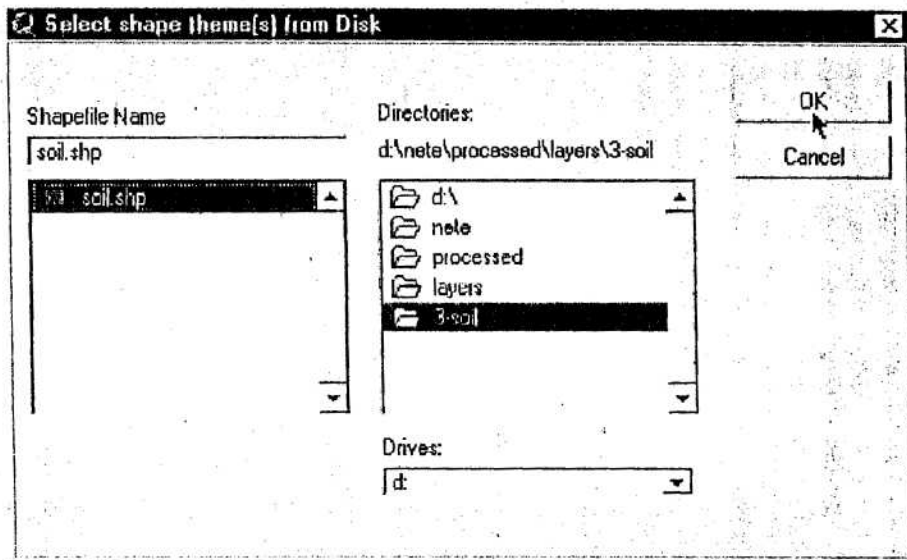
By default the interface will look for one of the follow fields (listed in order of priority) *Muid*, *Stmuid*, *Name*, *S5id*, and *Seqn* in the table of attributes of the shape themes and use these values for the conversion to grid. If one of these fields is not included, the script will look for the field types integer and string. If none of these fields are found, a dialog box will report the lack of usable fields and stop the process.

If more than one field is usable, a dialog box will list them, and you can select one and click **OK**.
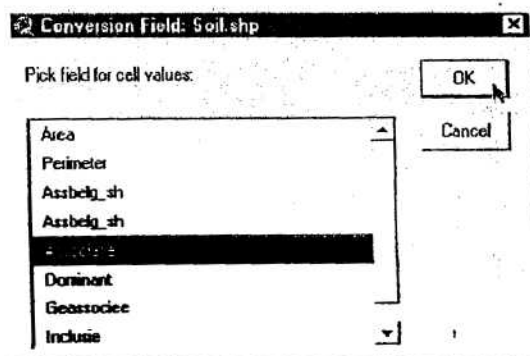
If more than one theme was selected, the interface will check all themes for the selected field. If one or more themes does not contain the field the interface will stop the loading process.

5. When this step is complete, a *Load and Clip Soil* message box will appear stating that the soil theme has been processed and clipped to the watershed boundaries. The message box also reminds the user to load a look-up table or manually define the soil classes for the theme.
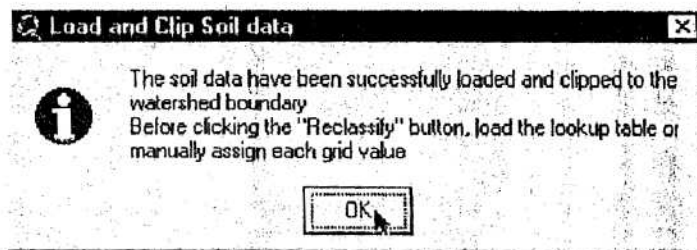
6. Click **OK** to proceed. This will return you to the *Definition of LandUse and Soil Themes* dialog box.

7. A new theme, *SoilTmp*, is added to the *Watershed View* where the user may review the results of the layer processing. The path of the resulting grid is shown in the text box labeled **Soils Grid**. The list box displays the soil grid values with percent watershed area as well as attributes that will store (some could be already populated) the soil description information.

Assign codes using a look-up table: This is analogous with the landuse layer (see 3.3.2.2.3). Use the look-up table created in 3.2.2.1.

Not all Values did get a Name. To solve this, assign the soil attribute data manually:

   a. To manually assign soil attribute data, double-click in the empty records below the *Joining Attributes* label.

For user provided soil data click the radio button labeled **Name** .

   b. Only the joining attribute records labeled *Name* are available. Double click a record.

c. A dialog box is displayed listing all soils in the User Soil database.
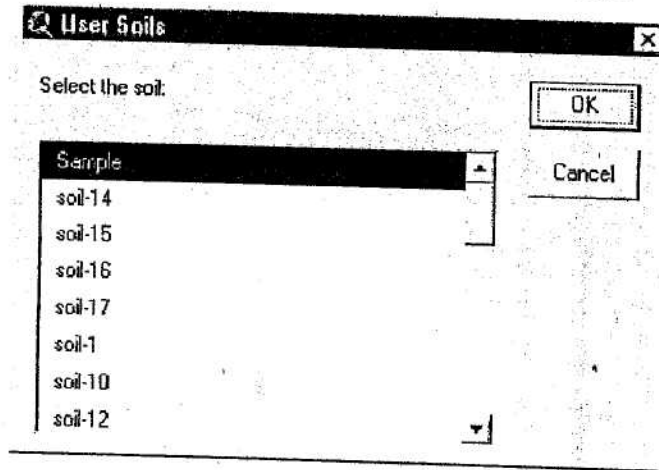
d. Select the soil and click **OK** (or double click the selection).

Tip: Input your soils entry and data sets in the *User Soils* database before you reclassify the Soil grid.

7. Once the joining attribute codes have been assigned to all layer categories, the **reclassify** button will be enabled. Click the button.
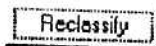
8. A new theme named "SoilClass" will be displayed in the *Watershed View*.
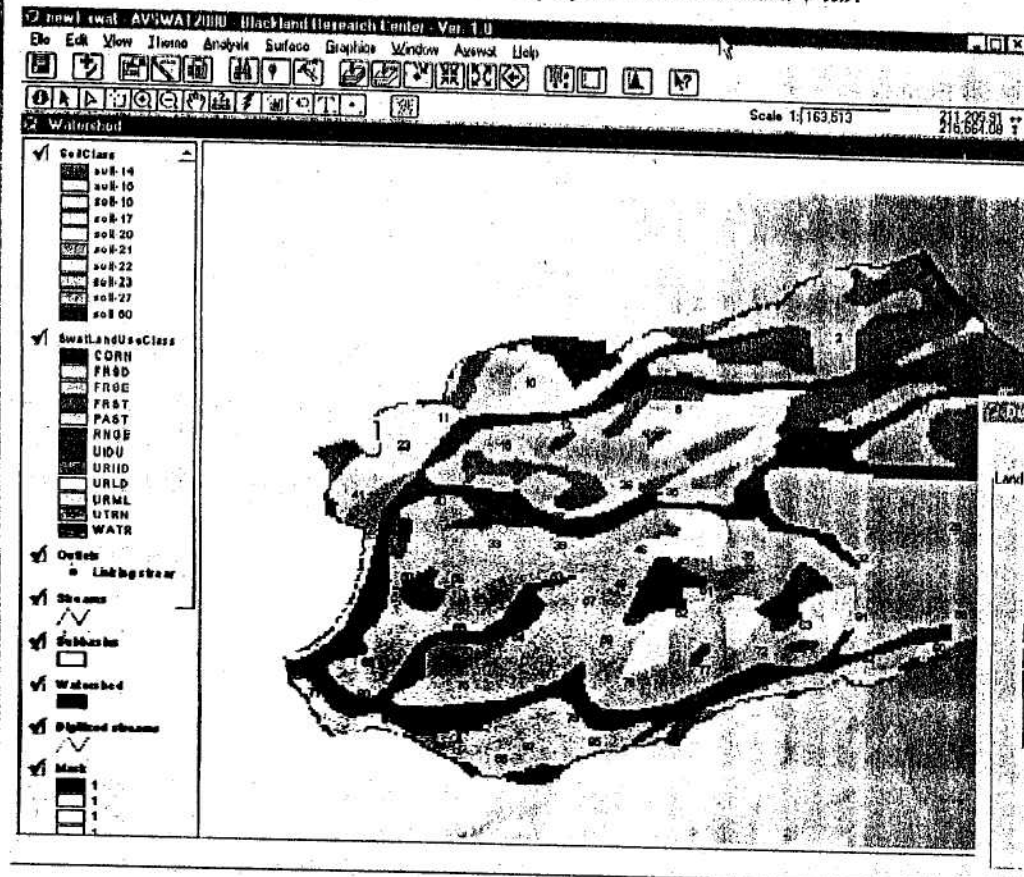
3.3.2.2.5 Overlay of landuse and soil layers

1. When both the landuse and soil grids are reclassified the button is enabled. Click the **Overlay** button.
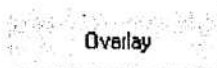
> Overlay

2. A message box signals the end of the overlay process, click **OK**.

> **Info** ☒
>
> ⓘ Overlay of landuse and soil themes completed
>
> OK
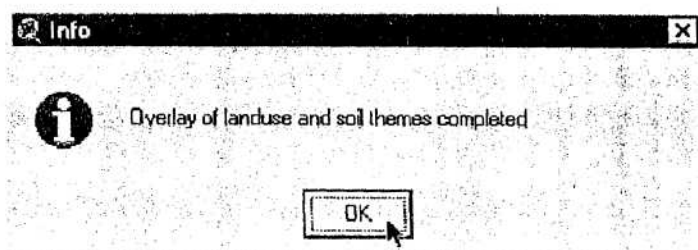
3. A report named *SWAT model: LandUse and Soil Distribution* is generated during the overlay process. This report provides a detailed description of the distribution of the landuse and soil classes in the watershed and all the sub-watersheds. To access this report, click on **Reports** under the **AVSWAT** menu. Select **SWAT model: LandUse and Soil Distribution** and click **OK**.

3.3.2.3 HRUs distribution

I **PURPOSE**

II **APPLICATION**

III **KEY PROCEDURES**

- Select single or multiple HRUs per subwatershed
- For multiple HRUs, define land use and soil threshold levels
- Click the **OK** button to determine the HRU distribution

IV **DETAILED OPERATIONS**

1. Select **HRU distribution** from the *Watershed View* menu **AVSWAT**. The *Swat Model: definition of the landuse / soil distribution* dialog box will be displayed.

> **SWAT Model: Definition of the landuse/soil distribution** ☐
>
> ◉ Dominant Land Use and Soil
>
> ○ Multiple Hydrologic Response Units
>
> Help | Exit | OK
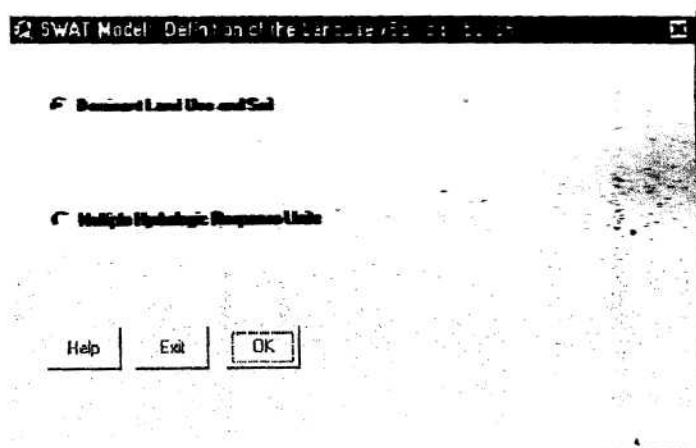
2. The dialog box has two radio buttons: **Dominant LandUse and Soil** and **Multiple Hydrologic Response Units**. The user must select the button for the method used to create HRUs.

    a. The **Dominant LandUse and Soil** option will create one HRU for each subbasin. The dominant landuse and soil class in the subbasin are simulated in the HRU. To activate this option, select the radio button.

                          ⊙ Dominant Land Use and Soil

    b. The **Multiple Hydrologic Response Units** option will create multiple HRUs within each subbasin. To activate this option, select the radio button.

                    ⊙ [Multiple Hydrologic Response Units]

Two slide bars are now visible.

Land Use [%] over Subbasin Area
0
0   20.8531

Soil Class [%] over Land Use Area
0
0   100

> Note: The creation of multiple HRUs is a two-step process. First, land uses are chosen. Once the land uses to be modeled are determined, the different soils for each land use are chosen. One HRU is created for each unique landuse/soil combination.

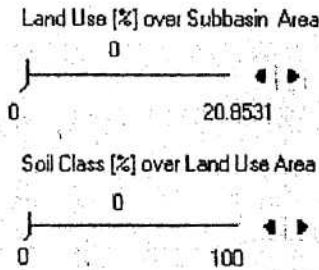For most applications, the default settings for land use threshold (20%) and soil threshold (10%) are adequate.

    i. Specify the *Landuse* threshold level by moving the pointer on the first slide bar.

Land Use [%] over Subbasin Area
20
0   20.8531
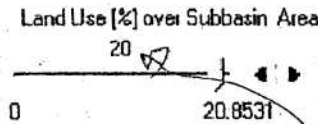
    ii. Specify the *Soil* threshold level by moving the pointer on the second slide bar.

Soil Class [%] over Land Use Area
10
0   100
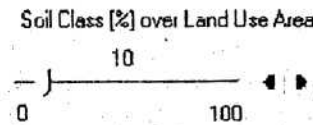
4. If the **Multiple Hydrologic Response Units** option was selected and the soil class threshold was set too high, a message dialog is displayed.

If this message is displayed, close the message box, decrease the soil threshold value, and click **OK** on the *SWAT Model: definition of the landuse/soil distribution* dialog box to repeat the HRU definition process.

5. Once the HRUs are created a message dialog pops up.


```
Q Info                                              [×]

    ⓘ    Completed HRUs distribution


                      [   OK   ]
```
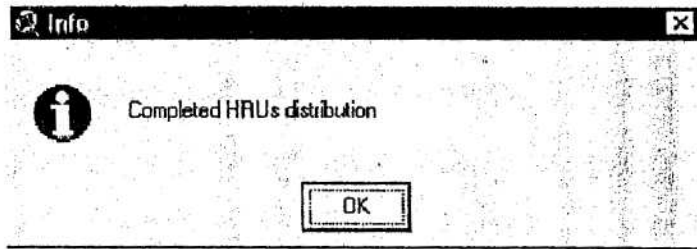
6. Click **OK**.

7. A report named *SWAT model: LandUse and Soil Distribution (after threshold application)* is generated during the HRU definition process. To access this report, click on **Reports** under the **AVSWAT** menu in the *Watershed View*. Select **SWAT model: LandUse and Soil Distribution (after threshold application)** and click **OK**.

8. An ArcView table *Distswat* is also created that provides a detailed distribution of the HRUs, landuse and soil classes in the watershed and all subwatersheds.

| Subbasin	AvSub	LandUse	Adu	Soil	AvSo
1	1121.5466	RNGE	1121.5466	soil-14	612.5370
1	1121.5466	RNGE	1121.5466	soil-15	508.0096
2	412.4696	RNGE	412.4696	soil-14	267.6142
2	412.4696	RNGE	412.4696	soil-15	144.8554
3	417.1041	FRSE	417.1041	soil-14	417.1041
4	258.6045	FRSE	258.6045	soil-14	258.6045
5	2144.8420	RNGE	2144.8420	soil-14	1282.5280
5	2144.8420	RNGE	2144.8420	soil-15	415.8367
5	2144.8420	RNGE	2144.8420	soil-20	446.4773
6	291.0460	RNGE	165.8474	soil-14	17.8955
6	291.0460	RNGE	165.8474	soil-15	34.1451
6	291.0460	RNGE	165.8474	soil-20	113.8169
6	291.0460	FRSD	125.1986	soil-14	26.0153
6	291.0460	FRSD	125.1986	soil-15	35.7710
6	291.0460	FRSD	125.1986	soil-20	63.4123
7	1230.9205	FRSD	1230.9205	soil-14	378.1511
7	1230.9205	FRSD	1230.9205	soil-15	254.6732
7	1230.9205	FRSD	1230.9205	soil-20	158.2061
7	1230.9205	FRSD	1230.9205	soil-60	439.8901
8	174.2568	FRSD	174.2568	soil-14	88.1781
8	174.2568	FRSD	174.2568	soil-20	20.9948
8	174.2568	FRSD	174.2568	soil-60	65.0839
9	303.0956	RNGE	98.6305	soil-14	28.6981
9	303.0956	RNGE	98.6305	soil-15	71.8654
9	303.0956	CORN	114.3163	soil-14	37.0670
9	303.0956	CORN	114.3163	soil-15	77.2804
9	303.0956	FRSD	89.1458	soil-14	52.4387
9	303.0956	FRSD	89.1458	soil-15	36.7071
10	658.0975	RNGE	313.3798	soil-15	77.9121

9. When the HRU distribution has been defined, the *SWAT View* is automatically created. A message box will appear notifying the user of this fact.
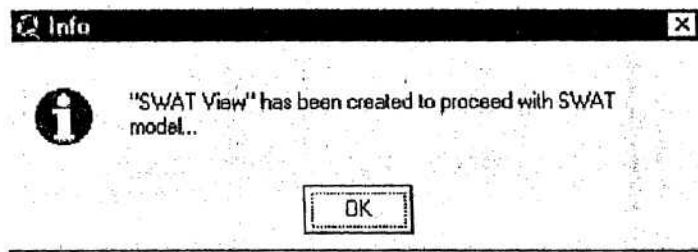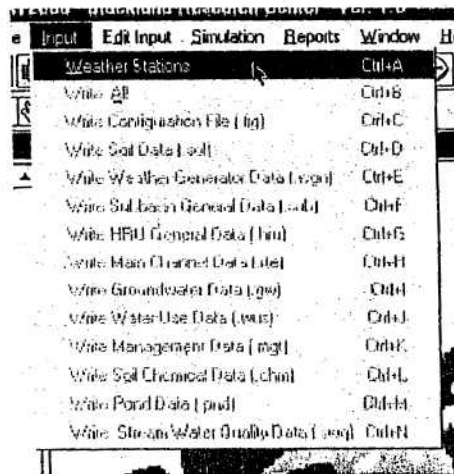

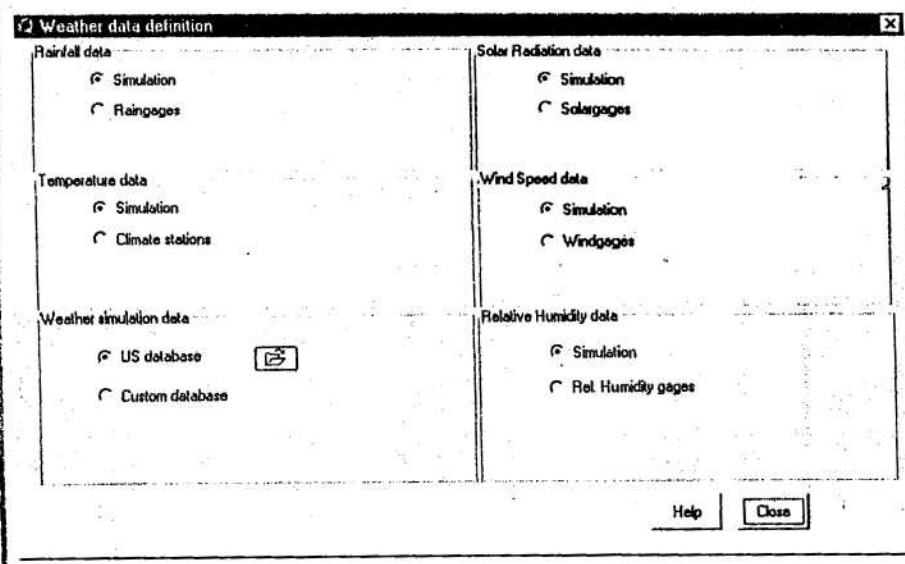Click **OK**.

10. The interface will activate the *SWAT View*.

3.3.3   SWAT VIEW

3.3.3.1   Import Weather Data

1. Select **Weather Stations** from the **Input** menu on the *SWAT View*.

The *Weather Data Definition* dialog is displayed.

2. The *Weather Data Definition* dialog is divided in six sections: *Weather simulation data, Rainfall data, Temperature data, Solar Radiation data, Wind Speed data* and *Relative Humidity data*. The first section listed, *Weather simulation data*, **must** be set. The interface will not allow the user to perform other input data processing until the *Weather simulation data*, is defined. The other five sections allow the user to choose between simulated or measured climate data for specific types of data.

I   WEATHER SIMULATION DATA

Weather station locations and weather generator data are obtained from one of two sources: the built-in *US database* or the *User Weather Stations* database. Use the custom database.

Custom database: This option is used to load custom weather generator data stored in the *User Weather Stations* database. Select the **Custom database** radio button ⦿ [Custom database]. Click the open file folder button next to the text box that appeared where the radio button was selected.

Locations table: [   ] [📂]

A file browser allows you to select the dBase location table for the weather generator stations. The location table is prepared by the user following the format described in Section 3.2.2.
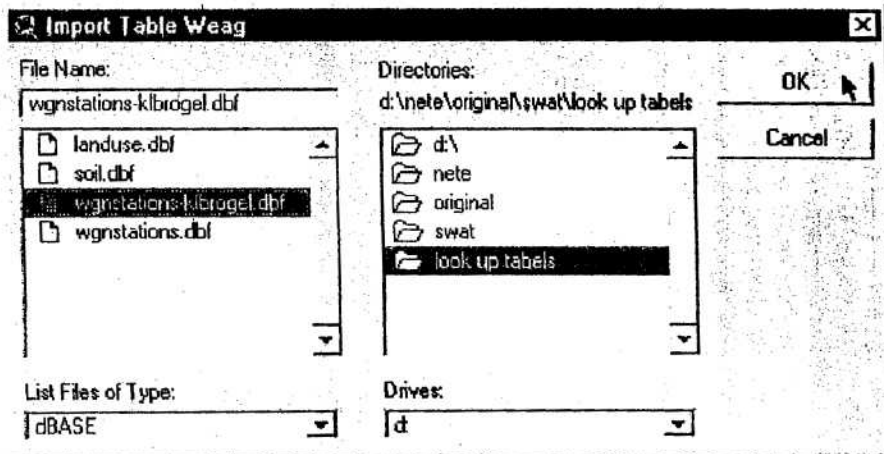
Highlight the name of the weather generator location table and click **OK** or double click the selection.

The weather locations will be loaded in the *SWAT View* as the *Weagages* point theme (with the *custom database* option, the data path will be displayed in the text box beside the button).

II   RAINFALL DATA (OPTIONAL).

To use measured precipitation data, select the **Raingages** radio button ⦿ [Raingages]. Click the open folder button next to the text box that appeared with the radio button, which was selected.

[   ] [📂]

A file browser allows you to select the dBase Precipitation gage location table. The rain gage location table must be prepared by the user following the format described in Section 3.2.2.
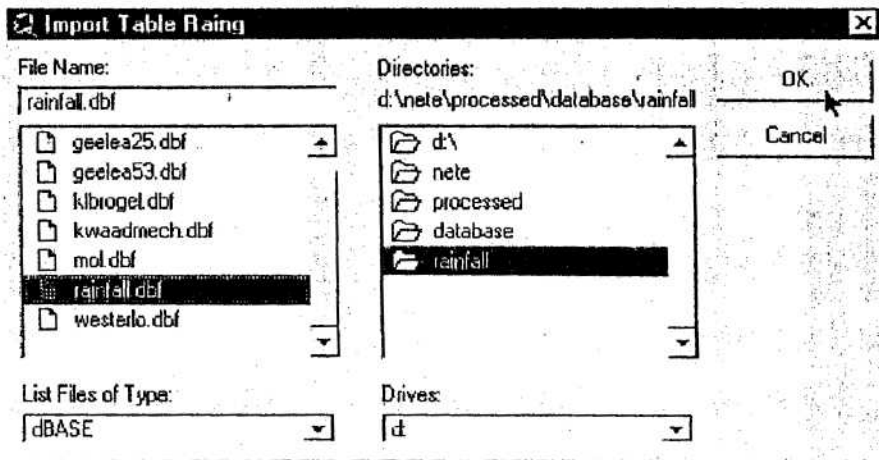
Highlight the name of the precipitation gage location table and click **OK** or double click the selection. The precipitation gage locations will be loaded in the *SWAT View* as the *Raingages* point theme and the data path will be displayed in the text box.

3. Once all weather data is specified and station locations are loaded, and **OK** button will appear in the lower right corner of the *Weather Data Definition* dialog box.
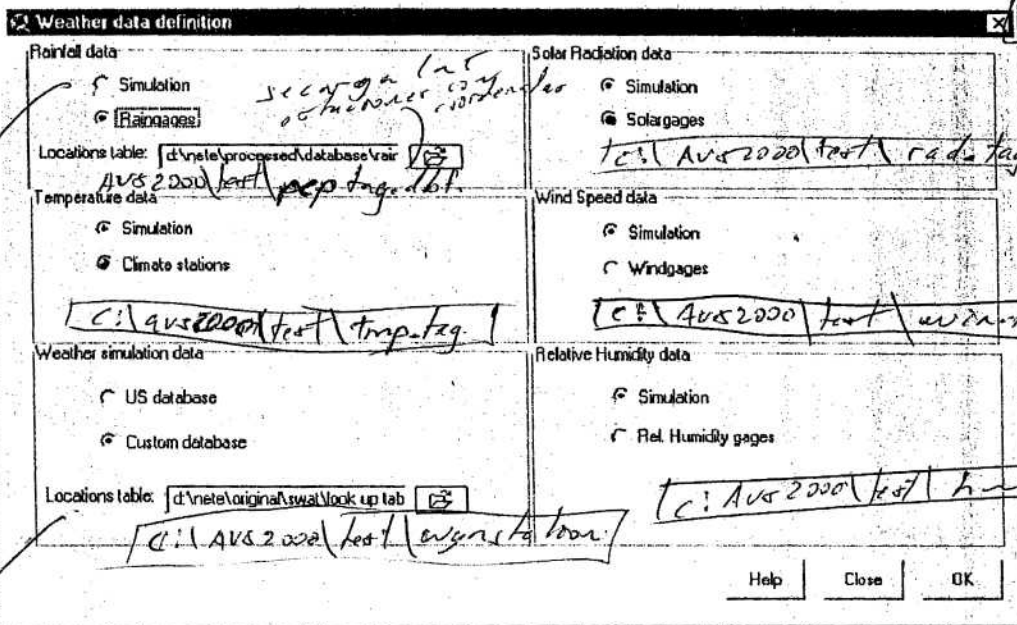
Click the **OK** button.

[handwritten annotations in Spanish throughout the page]

4. When setup of the weather database is complete, a message dialog is.
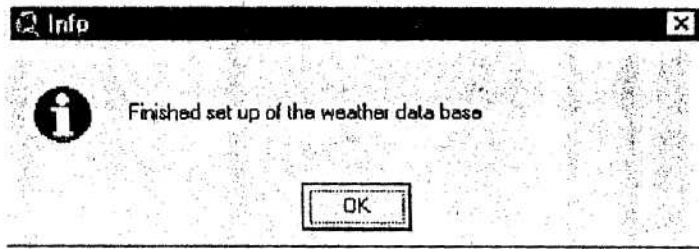
Click **OK**.

3.3.3.2 Creation of input

3.3.3.2.1 Write All

1. Select the **Write All** item from the **Input** menu on the *SWAT View* (or press Ctrl+B).

a. The Write All Inputs dialog box will appear to verify that all input is to be generated at once. Click **No** to abort. Click **Yes** to proceed.
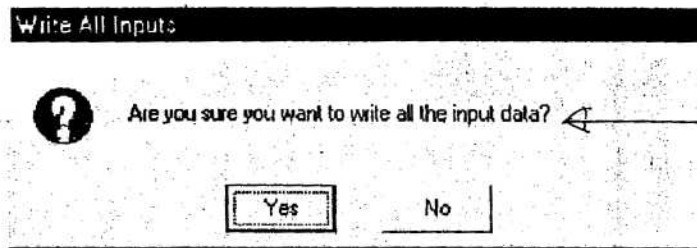
b. The Current Status of Input Data message box that lists the different databases being generated appears. As each database is completed, a check mark appears next to the database name and a beep sounds.
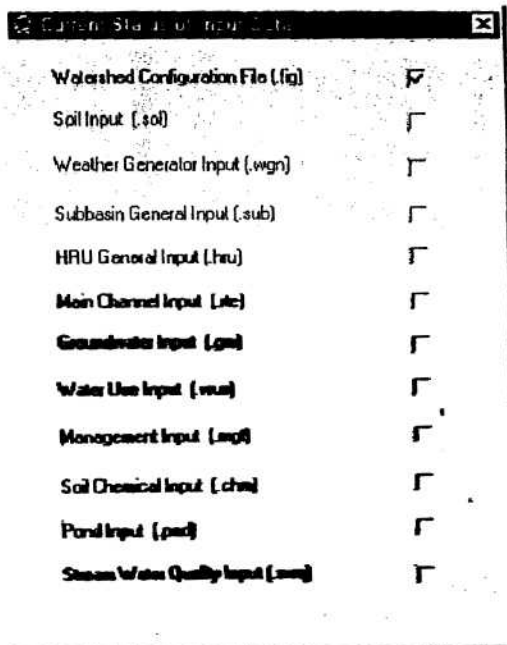
c. When writing of the *.sub* (subbasin general input) database begins, a prompt box appear offering two options for defining Manning's roughness factor for the tributary channels in all subbasins.

Manning's "n" for all the tributary channels

A default value will be set = 0.014
Do you want to change it?

Yes   No

Click **No** to accept the default value (0.014). Click **Yes** to open the Manning's Roughness Factor "n" dialog.

Manning's Roughness Factor "n"

Manning's n [0.014]

Type
  Channel Flow   ⊙
  OverLand Flow   ○

Channel Flow Condition
Excavated or dredged   ○
  Natural streams   ⊙

Condition	Default	Minimum	Maximum
Few trees, stones or brush	0.05	0.025	0.065
Heavy timber and brush	0.1	0.05	0.15

Cancel   OK

Enter the input value in the box labeled "Ov_n" or set its value by browsing the tabulated values within the dialog. Click **Cancel** to use the default value (0.014). Click **OK** to use the current value in the input box.

d. When writing of the *.rte* (main channel input) database begins, a prompt box appears offering two options for defining Manning's roughness factor for the main channels in all subbasins.

Manning's "n" for all the main channels

A default value will be set = 0.014
Do you want to change it?

Yes   No

Click **No** to accept the default value (0.014). Click **Yes** to open the Manning's Roughness Factor "n" dialog.

Enter the input value in the box labeled "Ov_n" or set its value by browsing the tabulated values within the dialog. Click **Cancel** to use the default value (0.014). Click **OK** to use the current value in the input box.

e. When writing of the *.mgt* (management input) database begins, a prompt box appears with two options for defining plant growth heat units:

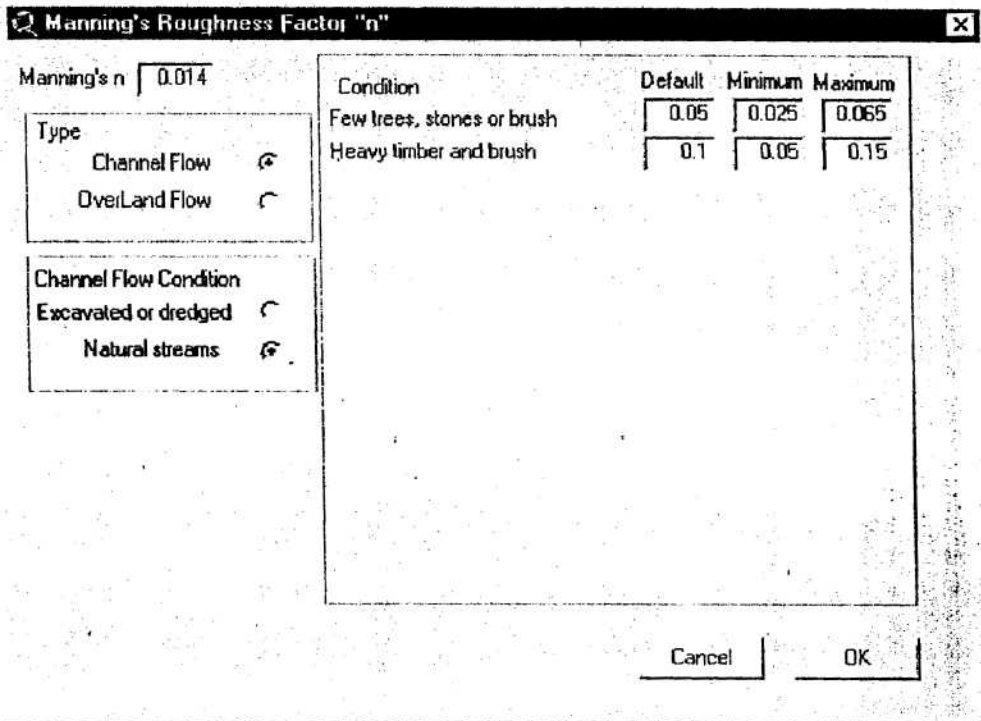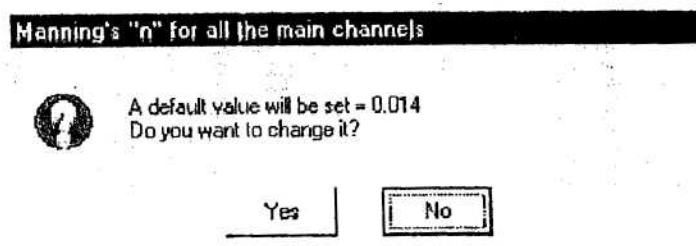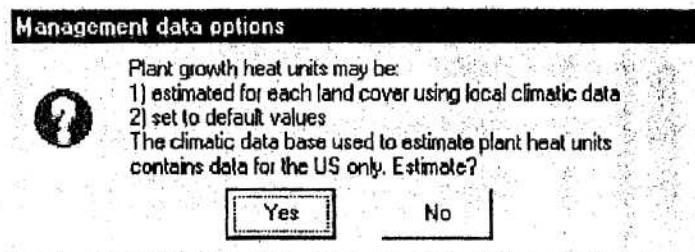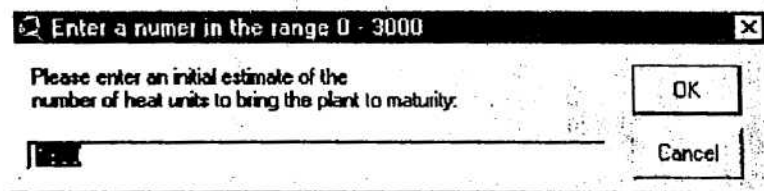**Management data options**

Plant growth heat units may be:
1) estimated for each land cover using local climatic data
2) set to default values
The climatic data base used to estimate plant heat units contains data for the US only. Estimate?

| Yes | No |

– **Yes** may be chosen only for watersheds in the United States. If you click **Yes**, the plant heat units will be calculated from local climatic parameters stored in an internal weather generator database.

– If you click **No**, a dialog box will appear asking for a default heat unit value. The default heat unit value will be used for all land cover/plants within the watershed. Click **Cancel** to abort. Click **OK** to use the current value in the input box.

Enter a numer in the range 0 - 3000

Please enter an initial estimate of the number of heat units to bring the plant to maturity.

| OK |
| Cancel |

f. When all databases have been built, a message box will be displayed.

Info

Finished writing input data
You can now proceed with the "Simulation"

| OK |
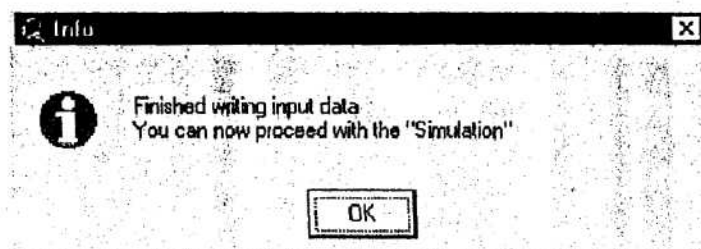
Click **OK** to proceed.

g. When all of the default inputs have been generated, you can move to the **Simulation** menu and make a SWAT run (See 3.3.3.3) or edit the default inputs using the editors activated under the Edit Inputs menu.

3.3.3.2.2 Individual write commands (See page 137 of ArcView Interface for SWAT2000. User's Guide. Di Luzio M. et al. 2001).

3.3.3.3 Run SWAT

The first command in the **Simulation** menu allows the user to set up and run the SWAT model.

1. Select **Run SWAT** from the **Simulation** menu on the SWAT View.
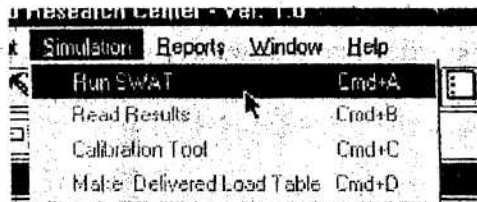
2. The Set Up and Run SWAT model simulation dialog box is displayed.
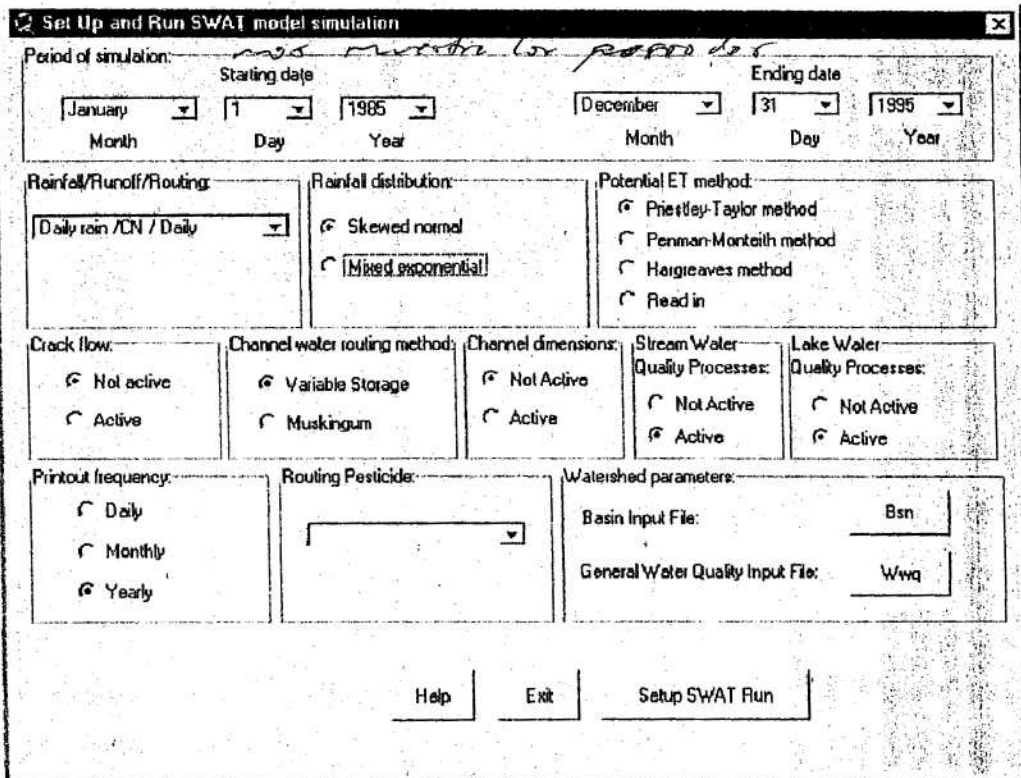
3. The dialog box contains several sections in which the user defines the option to be used in the simulation of various processes.

   a. Period of Simulation. In this section the user specifies the starting and ending dates of the simulation using the drop-down controls (click on the drop down list or use the up and down arrow keys to change the value).
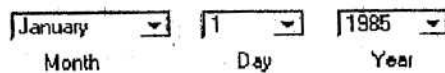
b. Rainfall/Runoff/Routing. In this section the user specifies the options to be used for precipitation time step, runoff calculation method and routing time step. The user may choose between three options:
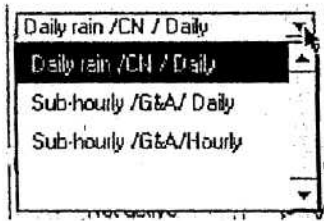
i. **Daily rain/CN/Daily** refers to daily rainfall/curve number runoff/daily routing.

ii. **Sub-hourly/G&A/Daily** refers to sub-hourly rainfall/Green & Ampt runoff/daily routing.

iii. **Sub-hourly/G&A/Hourly** refers to sub-hourly rainfall/Green & Ampt runoff/hourly routing.

c. Rainfall distribution. In this section, the user selects the distribution used to generate precipitation data. The user may choose between two options, **Skewed normal** or **Mixed exponential** using the respective radio button. When **Mixed exponential** is selected, a text box is enabled for the user to specify the exponent.
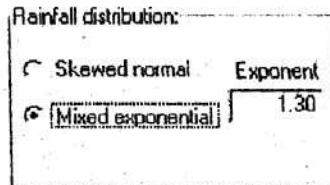
d. Potential ET method. In this section, the user selects the method used to estimate potential evapotranspiration (PET). The available options are **Priestley-Taylor**, **Penman-Monteith**, **Hargreaves** and **Read in**. When **Read in** is selected, the user must provide a file, either in dBase or txt format, containing the daily value of PET.
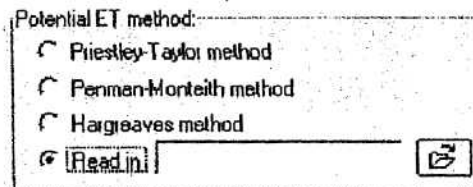
To import PET file:

i. Click the open file folder button [⬚].

ii. A prompt box is displayed.
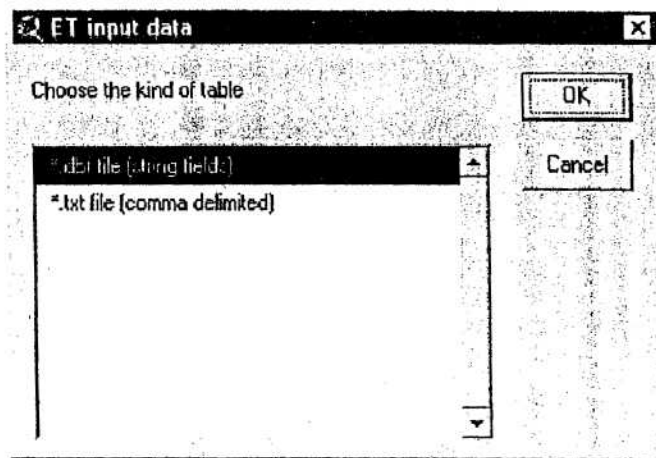
iii. Select the proper format and click **OK** (or double click selection).

iv. A browser will appear allowing the user to locate and select the file containing the daily PET values
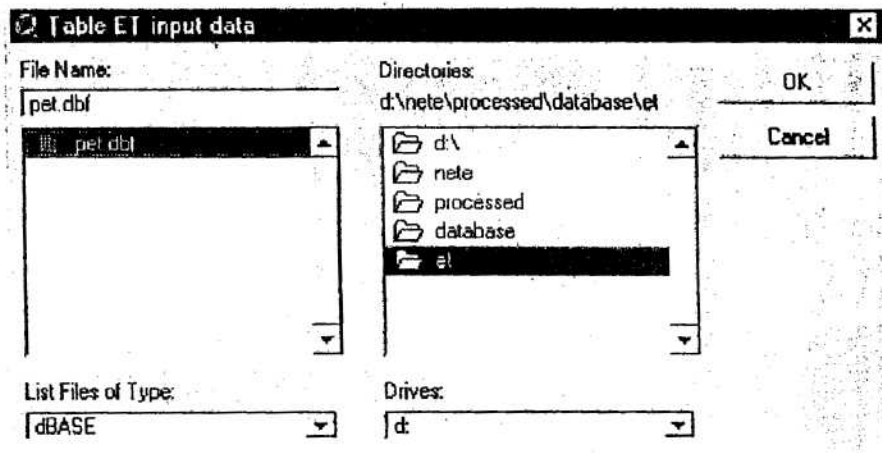
v. Highlight the name of the file and click **OK** (or double click selection).

vi. The name of the table will be displayed in the text box beside the **Read in** radio button.

e. Crack flow. In this section, the user specifies whether crack or by-pass flow will or will not be simulated. The user has two options, **Not active** or **Active**. To select an option, click the radio button adjacent to the option.

f. Channel water routing method. In this section, the user selects the method used to route water in the channel network. Two options are available, the **Variable storage** and **Muskingum** methods. To select an option, click the radio button adjacent to the option.

Channel water routing method:
- ⦿ Variable Storage
- ○ Muskingum

g. Channel degradation. In this section, the user defines whether or not channel dimensions are allowed to change during the course of the simulation due to channel degradation.

Channel dimensions:
- ⦿ Not Active
- ○ Active

h. Stream Water Quality processes. In this section, the user decides whether or not in-stream nutrient transformations are calculated.

Stream Water Quality Processes:
- ○ Not Active
- ⦿ Active

i. Lake Water Quality processes. This section controls the printing of lake water quality information. During the reformatting of output files, this variable became obsolete and the selection of a radio button has no impact on model results.

Lake Water Quality Processes:
- ○ Not Active
- ⦿ Active

j. Print out frequency. This section controls the frequency of print output. The available options are: **Daily, Monthly** and **Yearly.**

Printout frequency:
- ○ Daily
- ○ Monthly
- ⦿ Yearly

k. Routing Pesticide. In this section, the user can select the pesticide that SWAT will route through the channel network during the simulation. A drop-down control provides a list of all pesticides simulated in the HRUs.

Routing Pesticide:

1. Watershed Parameters. Within this section, the user can access parameters in two additional input files.

```
Watershed parameters:
  Basin Input File:                          Bsn
  General Water Quality Input File:          Wwq
```
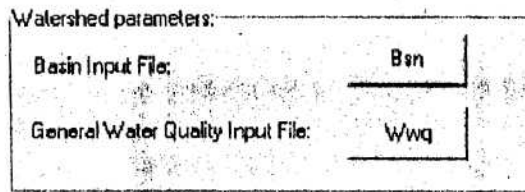
4. Once all options and parameters are defined. Click the **Setup SWAT Run** button.

```
        Setup SWAT Run
```
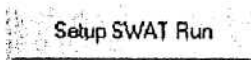
This button generates the final input files based on the settings defined in the Set Up and Run SWAT model Simulation dialog box. The main tasks performed during this process include preparing the weather input files and verifying that the provided data (reservoir outflow, point source and inlet discharge, evapotranspiration) is complete and consistent with the set period of simulation. An error massage will notify the user of any problems.

5. When the preprocessing is successfully completed, a message box is displayed.

```
User Changes
  ?   You could re-write the inputs from modified dbfs containing
      SWAT input parameters
      Procead?

          Yes          No
```
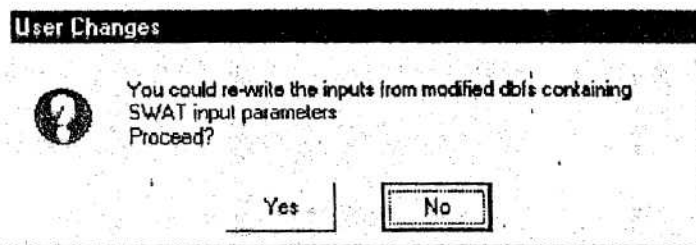
6. If some dBase files were modified without using the built-in editing tools, **click Yes** to re-write the ASCII input files used to run SWAT from the modified dBase files. If no dBase files were modified outside the editing tools, click **No**. If the user clicked **Yes**, a list of input file types is displayed.

```
User Changes                                    X
  Select the inputs you want to re-write:        OK

  .sol                                  ▲      Cancel
  .wgn
  .sub
  .hru
  .rte
  .gw
  .wus
  .mgt                                  ▼
```
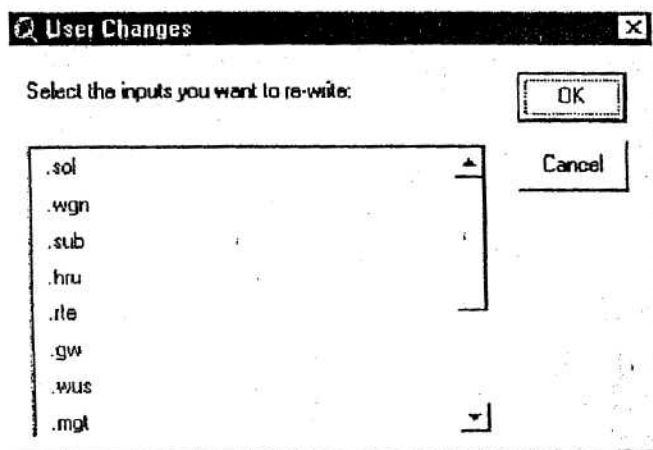
Select the input file type(s) that needs to be re-written, and click **OK** or click **Cancel** to exit the list box.

If files were re-written, a message will notify the user when all input files have been re-written.
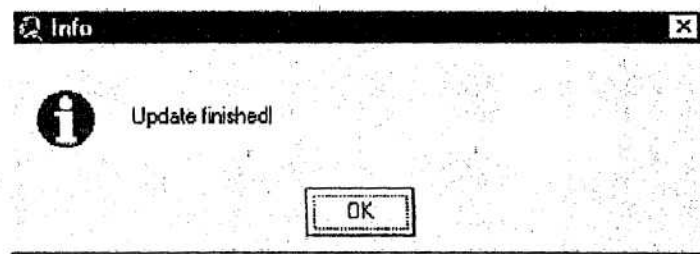
Click **OK**.

7. Once the Setup of the SWAT input files is complete, two additional buttons are displayed on the Set Up and Run SWAT model Simulation dialog box.
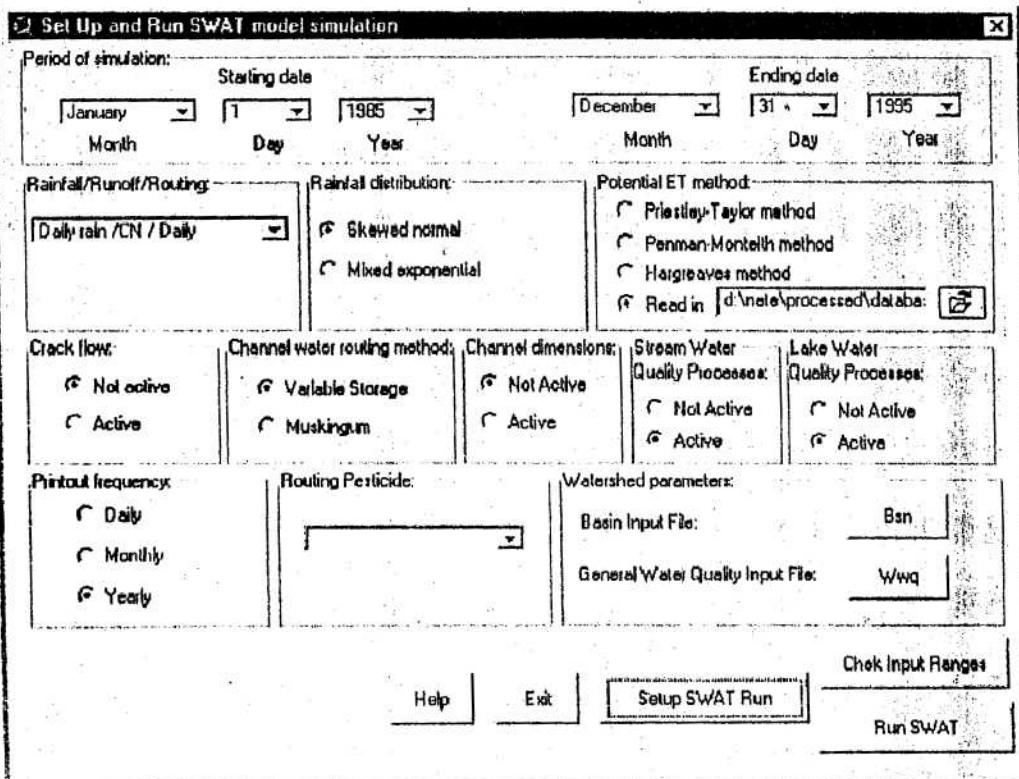
8. A tool is provided to check the ranges of all input values. The user is not required to check the ranges of input values. (See page 238 of ArcView Interface for SWAT2000. User's Guide. Di Luzio M. et al., 2001).

9. Once all the input files are built, the user can run the model. Click the **Run SWAT** button.

The simulation will start.
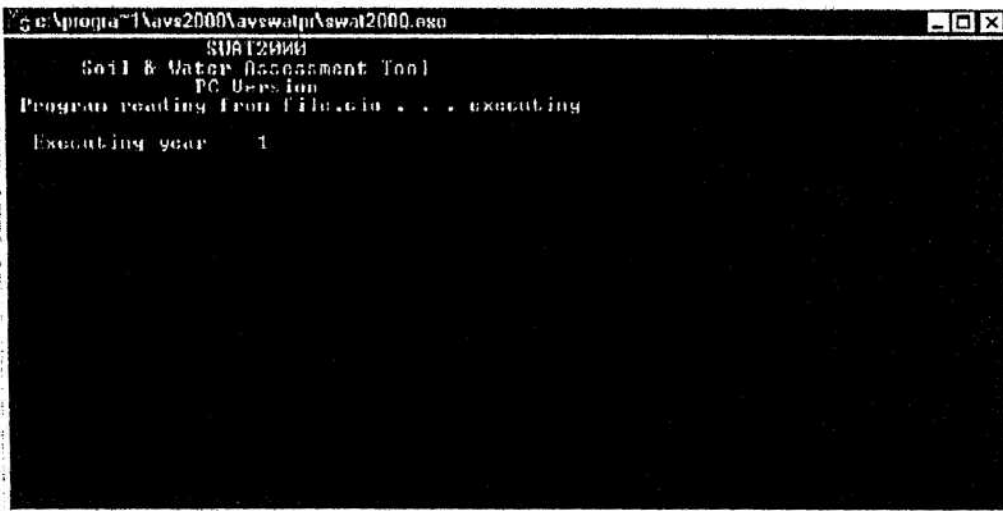
10. When the SWAT simulation terminates, one of two message boxes will be displayed:

a. If the simulation terminated before the entire simulation period was completed, a message box will notify the user of a run failure.
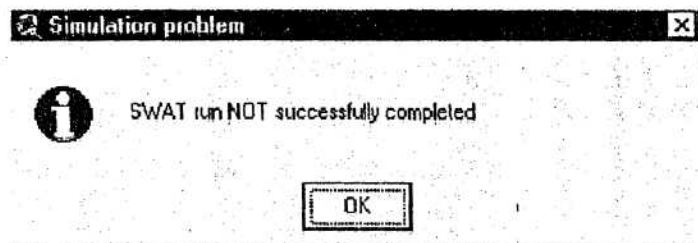
Click **OK**. Review inputs before attempting a new run.

b. If the simulation terminates properly, a message box will notify the user of a successful run.

Click **OK**. Another prompt box will be displayed.
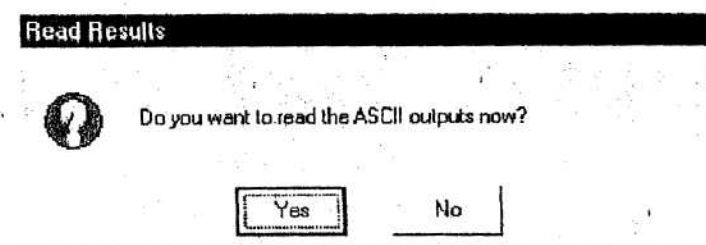
The SWAT simulation generates ASCII output files whose data that must be transferred to dBase tables for access in the interface. Click **Yes** to load the output data to dBase tables. Click **No** to defer the generation of dBase output tables to a later time. (Clicking **Yes** performs the same operations performed by the **Read Results** command in the **Simulation** menu.

3.4   ANALYZE OUTPUT

3.4.1   A QUICK LOOK

1. Select **Read Results** from the **Simulation** menu.
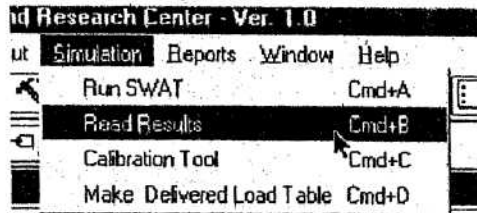
If the Calibration Tool was not used and the model did not run a calibration scenario the reading routine builds and displays the output tables.

The other SWAT output files can be viewed using the **Show list** command under the **Reports** menu.

3.4.2 CALIBRATING WATER BALANCE AND STREAM FLOW

The third command in the **Simulation** menu allows the user to perform global changes on input parameters that are commonly modified during the calibration process.

1. Select **Calibration Tool** from the **Simulation** menu:

2. The Calibration Set Up dialog box is displayed
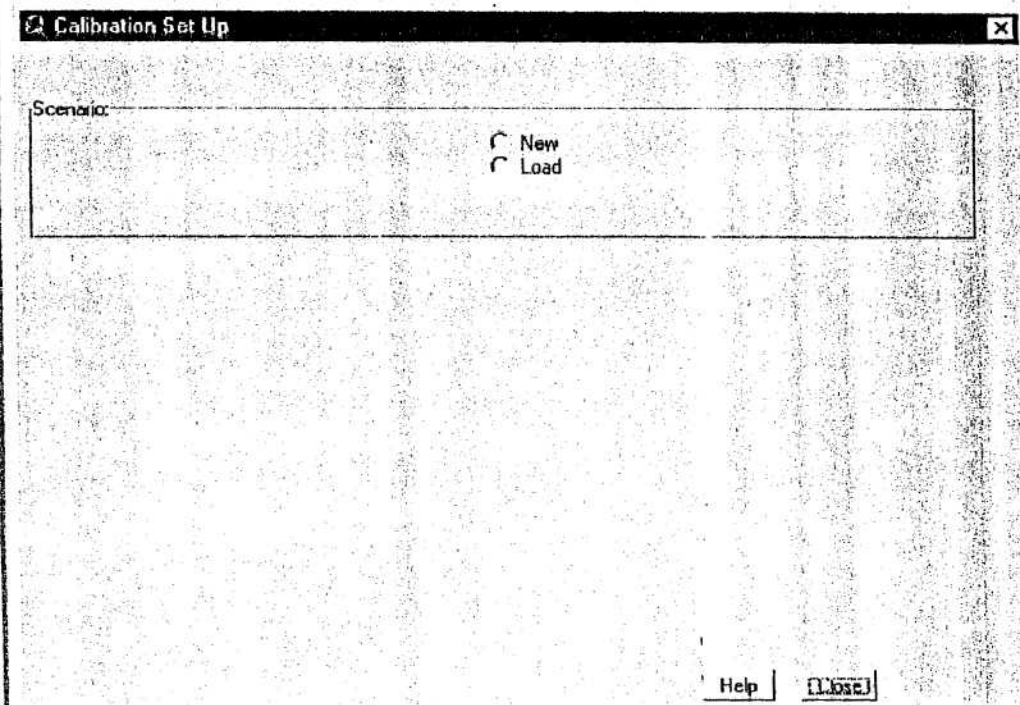
3. The user may create a new calibration scenario or load a previously saved scenario.

Create a new scenario:

    a. Click the **New** ⬤ New button in the section of the dialog box labeled 'Scenario'.

    b. Type a name for the scenario in the text box labeled **New Name**.

        New Name: [   ]

    c. Press the Enter key on the keyboard.

Load an existing scenario:

    a. Click the **Load** ⬤ Load button in the section of the dialog box labeled 'Scenario'.

    b. A list will be displayed showing all available scenarios.

        Select: [scenario01 ▲▼]

    c. Select the desired scenario from the list.

4. Once a scenario is created or loaded, a table of SWAT input parameters will be enabled.

Input File	Parameter	Variation %	Value	Lower Limit	Upper Limit
Crop.dat	USLE_C	0	0	0.001	0.5
Basin Input (.bsn)	SMFMX	0	0	0	10
Basin Input (.bsn)	SMFMN	0	0	0	10
Basin Input (.bsn)	SPCON	0	0	0.000	0.01
Basin Input (.bsn)	SPEXP	0	0	1	1.5
Basin Input (.bsn)	NPERCO	0	0	0	1
Basin Input (.bsn)	PPERCO	0	0	10	17.5

5. This table lists 27 SWAT input parameters. The name of the parameter and the related SWAT input file are listed in the table. The user can change the value of any of these parameters (alone or in combination), run SWAT for the scenario and compare the scenario results to those in the original 'default' simulation or to other scenarios.

6. Select one parameter in the table by clicking on the parameter name. Another section of the dialog box is enabled.

```
        EDIT PARAMETER VARIATION
    By Percentage
    -25 %   I I I I I I I I I I I   25 %

            |||||||||||||||||||||||
    OR              0

    By Value      [        ]
```

7. The Calibration Tool provides the user with two options for altering the value of a parameter from the value defined in the original or default scenario.

  a. **By Percentage.** Using the slider, select the percent change in value. (Note: the lower and upper limits of the percent variation are parameter dependent.)

  b. **By Value.** Type the change in value in the text box. (Note: CN2 and SOL_AWC parameter variation is allowed to vary only by value.)

8. The user can change the current upper limit and lower limit of the parameters using the respective **Upper limit** and **Lower limit** buttons.

```
Upper Limit
Lower Limit
```

When one of these buttons is clicked, a prompt box is displayed.

```
Set Upper Limit for this scenario                            [X]

The Upper Limit for USLE_C is set at 0.5 enter your new Upper     OK
Limit

[                                        ]              Cancel
```

Type the new value in the text box. Click **OK** to close the prompt box and save the change or click **Cancel** to close the prompt box without saving the change.

9. The change in parameter value may be applied to the entire watershed or to only a portion of the watershed.

  a. To apply the change to all subbasins select the radio button labeled **Apply to all sub-basins**. To apply the change to only a portion of the subbasins, select the radio button **Select sub-basins**.

    ⊙ Apply to all sub-basins
    ○ Select sub-basins

If the user decides to apply the change to only a few subbasins, a list of all subbasins in the watershed is displayed when the **Select sub-basins** radio button is chosen. Scroll the list and highlight the number of all subbasins where the change in parameter value is to be made. Hold down the Shift key to select multiple subbasins. (Note: USLE_C is a SWAT database parameter and cannot be changed only for particular subbasins.)

b. If the selected parameter is an HRU-level parameter, the user can limit the change in parameter value to specific landuses in the selected subbasins. To isolate the change in parameter value to certain landuses, click the box labeled **LandUse.**

☐ LandUse

If the box is checked, a list of landuses is displayed. Scroll the list and highlight the landuses where the change in parameter value is to be made. Hold down the Shift key to select multiple landuses. (Note: For USLE_C you must select the target landuses.)

10. Once the settings for the parameter are complete, the user has three options: save the settings for the parameter, exit the parameter editor tool without saving the settings, or erase the current settings and define other settings.

a. **To save settings.** Click the **Apply** ──Apply── button below the table of parameters. This closes the editing tools for the specific parameter and saves the settings.

b. **To exit without saving.** Click the **Cancel Apply** ──Cancel Apply── button below the table of parameters. This closes the editing tools for the specific parameter without saving the settings.

c. **To erase current settings.** Click the **Reset** ──Reset── button below the table of parameters. This resets all values back to the original settings.

11. Repeat steps 6 through 10 for as many input parameters as desired.

12. Once all parameter modifications have been made for the scenario, the user can choose whether or not parameter values in the watershed are allowed to exceed range limits after parameter modifications are applied. This is controlled by the **In Range** and **Out Range** radio buttons.

    ⊙ In Range
    ○ Out Range

When the **In Range** button is selected, the interface will apply all parameter modifications defined in the scenario and then verify that the new values are within range limits for the parameters. If the new values exceed range limits, they will be set to the closest allowed value.

When the **Out Range** button is selected, the interface will apply all parameter modifications defined in the scenario without checking that the new values are within range limits for the parameters.

13. Click **OK** to save the scenario. A subdirectory will be created in the *project name*\scenarios\default\scen directory that contains the dbf tables and SWAT input files for the scenario. The subdirectory is given the name of the scenario defined by the user.

14. A prompt box will be displayed during the save.

Note For Scenario

Do you want to write a note for this scenario?

Yes   No
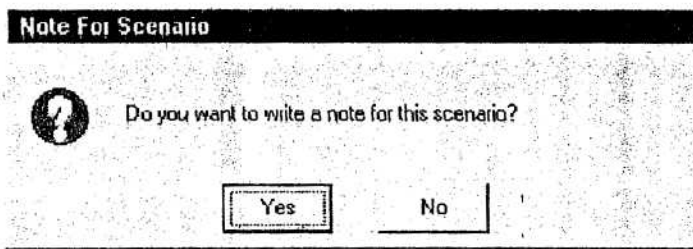
15. Click **No** to skip this option. Click **Yes** to write a note. If the user clicks **Yes** a text box is displayed.

Describe Scenario   ×
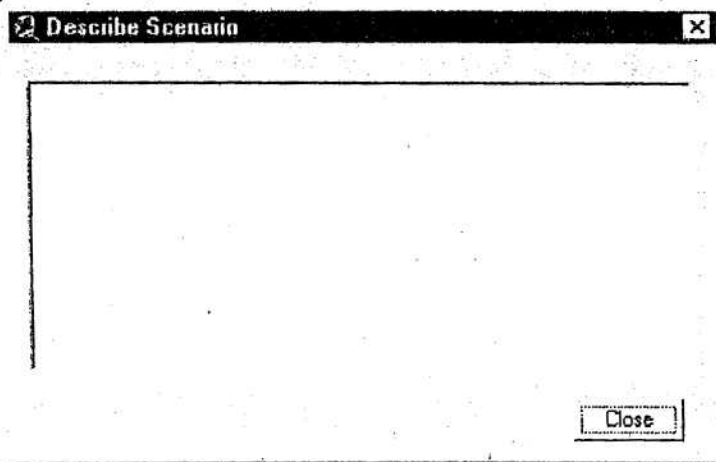
Close

Enter a note and click **Close**.

16. Once all changes are made, a prompt box is displayed.

Run SWAT

Do you want to run SWAT for this scenario?

Yes   No
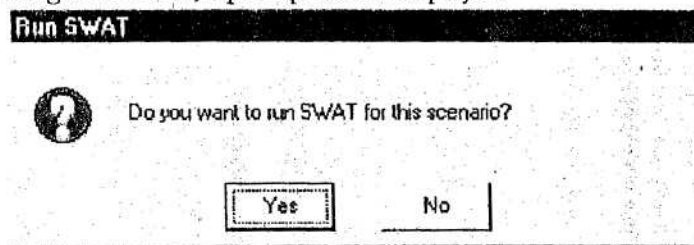
17. Click **Yes** to run a SWAT simulation for the scenario or click **No** to skip this option. If the user runs SWAT, one of two message boxes will be displayed when the SWAT simulation terminates.

   a. If the simulation terminated before the entire simulation period was completed, a message box will notify the user of a run failure.

Simulation problem   ×

SWAT run NOT successfully completed

OK

b. If the simulation terminates properly, a message box will notify the user of a successful run.

Click **OK**. Another prompt box will be displayed.
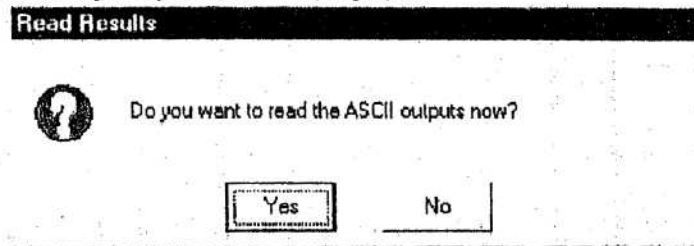
The SWAT simulation generates ASCII output files whose data that must be transferred to dBase tables for access in the interface. Click **Yes** to load the output data to dBase tables. Click **No** to defer the generation of dBase output tables to a later time. (Clicking **Yes** performs the same operations performed by the **Read Results** command in the **Simulation** menu.

18. Click **Close** to exit the Calibration Tool.

APPENDIX D: ORIGIN OF DATA STORED IN THE FILE USRWGN.DBF

LIST OF VARIABLES:

o GENERAL.

nombre estación • Name: Name Station
83 años • RAIN_YRS (years): Number of years of maximum monthly 0.5 h rainfall data (5-100)

coordenadas { • WLATITUDE (degrees): OPTIONAL: Latitude of station   *17°*
• WLONGITUDE (degrees): OPTIONAL: Longitude of station   *66°*
• WELEV (m): OPTIONAL: Elevation of station   *1350 m.*
• XPR: OPTIONAL: X-projected coordinate
• YPR: OPTIONAL: Y-projected coordinate

o MONTHLY DATA   *media máxima diaria del mes ej. enero*
• TMPMX: Average or mean daily maximum air temperature for month (°C) (-30-50)   *media media diaria del mes*
• TMPMN: Average or mean daily minimum air temperature for month (°C) (-40-40)
• TMPSTDMX: Standard deviation for average daily air temperature in month (°C) (0.1-100)
• TMPSTDMN: Standard deviation for average daily air temperature in month (°C) (0.1-30)
• PCPMM: Average or mean total monthly precipitation (mm H_2O) (0-600)
• PCPSTD: Standard deviation for the daily precipitation in month (0.1-50)
• PCPSKW: Skew coefficient for daily precipitation in month (-50-20)
• PR_W1: Probability of a wet day following a dry day in the month (0-95)
• PR_W2: Probability of a wet day following a wet day in the month (0-95)
• PCPD: Average number of days of precipitation in month (0-31)
• RAINHHMX: Maximum 0.5 hour rainfall in entire period of record for month (0-125)
• SOLARAV: Average daily solar radiation for month (MJ m^{-2} day^{-1}). (0-750)
• DEWPT: Average dew point temperature in month (-50-25)
• WNDAV: Average daily dew point temperature in month (m s^{-1}). (0-100)

SOURCE:

Most of the variables were extracted from the database 'Bliksem'. Data was found for weather stations in: Kleine Brogel, Koksijde, Sint Hubert, Ukkel en Zaventem. Following values were calculated for all weather stations.

DEWPT	TMPMN
PCPD	TMPMX
PCPMM	TMPSTDMN
PCPSKW	TMPSTDMX
PCPSTD	WLATITUDE
PR_W(1)	WLONGITUDE
PR_W(2)	WNDAV

SOLARAV was calculated for the weather stations located in Ukkel and Koksijde. Stations with missing data were given the same value as the weather station Ukkel.

RAINHUMX was calculated for the weather station Ukkel. This value was used for all other stations.

Some variables were derived from digital map: WELEV/XPR/YPR.

Because of the absence of data, the value RAIN_YRS got the standard value: 10.
More information below:

o DEWPT

The dew point temperature was calculated based on following formulas:

$$1. \frac{e_a}{0.6108} = \exp\left(\frac{17.27 . T_{dew}}{T_{dew} + 273.3}\right)$$

$$\Downarrow$$

$$2. Log\frac{e_a}{0.6108} = \frac{17.27 . T_{dew}}{T_{dew} + 273.3}$$

$$\Downarrow$$

$$3. Log\frac{e_a}{0.6108} (T_{dew} + 273.3) = 17.27 . T_{dew}$$

$$\Downarrow$$

$$4. Log\frac{e_a}{0.6108} . 273.3 = 17.27 . T_{dew} - Log\frac{e_a}{0.6108}(T_{dew})$$

$$\Downarrow$$

$$5. Log\frac{e_a}{0.6108} . 273.3 = (17.27 - Log\frac{e_a}{0.6108})(T_{dew})$$

$$\Downarrow$$

$$6. T_{dew} = \frac{Log\frac{e_a}{0.6108} . 273.3}{\left(17.27 - Log\frac{e_a}{0.6108}\right)}$$

$$\text{And} \quad e_a = \frac{RH_{mean}}{100} . 0.3054\left[\exp\left[\frac{17.27 T_{mx}}{T_{mx} + 237.3}\right] + \exp\left[\frac{17.27 T_{mn}}{T_{mn} + 237.3}\right]\right]$$

Where
- e_a Actual Vapor Pressure (kPa).
- T_{dew} Dew point temperature (°C).
- RH_{mean} Mean relative humidity (%).
- T_{max} Daily maximum temperature (°C).
- T_{min} Daily minimum temperature (°C).

o PCPD

Calculation based on following formula:

$$\overline{d}_{wet,i} = \frac{days_{wet,i}}{yrs}$$

Where $d_{wet,i}$ Average number of days of precipitation in month I.

$days_{wet,i}$ Number of wet days in month I during the entire period of record.

yrs Number of years of record.

o PCPMM

Calculation based on following formula:

$$\overline{R}_{mon} = \frac{\sum_{d=1}^{N} R_{day,mon}}{yrs}$$

Where R_{mon} Mean monthly precipitation (mm H_2O).

$R_{day,mon}$ Daily precipitation for record d in month mon (mm H_2O).

N Total number of records in month mon used to calculate the average.

yrs Number of years of daily precipitation records used in calculation.

o PCPSKW

Calculation based on following formula:

$$g_{mon} = \frac{N.\sum_{d=1}^{N}\left(R_{day,mon} - \overline{R}_{mon}\right)^3}{(N-1).(N-2).(\sigma_{mon})^3}$$

Where g_{mon} Skew coefficient for precipitation in the month.

σ_{mon} Standard deviation for daily precipitation in month mon.

R_{mon} Average precipitation for the month (mm H_2O).

$R_{day,mon}$ Amount of precipitation for record d in month mon (mm H_2O).

N Total number of daily precipitation records for month mon.

o PCPSTD

Calculation based on following formula:

$$\sigma_{mon} = \sqrt{\frac{\sum_{d=1}^{N}(R_{day,mon} - \overline{R}_{mon})^2}{N-1}}$$

Where σ_{mon} Standard deviation for daily precipitation in month mon.

R_{mon} Average precipitation for the month (mm H_2O).

$R_{day,mon}$ Amount of precipitation for record d in month mon (mm H_2O).

N Total number of daily precipitation records for month mon.

o PR_W(1)

Calculation based on following formula:

$$P_i(W/D) = \frac{days_{W/D,i}}{days_{dry,i}}$$

Where $P_i(W|D)$ Probability of a wet day following a dry day in month i.

                $days_{W|D,i}$ Number of times a wet day followed a dry day in month i for the entire period of record.

                $days_{dry,i}$ Number of dry days in month I during the entire period of record. A dry day is a day with 0 mm of precipitation.

o PR_W(2)

Calculation based on following formula:

$$P_i(W/W) = \frac{days_{W/W,i}}{days_{wet,i}}$$

Where $P_i(W|W)$ Probability of a wet day following a wet day in month i.

                $days_{W|W,i}$ Number of times a wet day followed a wet day in month i for the entire period of record.

                $days_{wet,i}$ Number of wet days in month I during the entire period of record. A wet day is a day with > 0 mm.

o RAINHHMX

Maximum 0.5 hour rainfall in entire period of record for month (mm H₂O). This value represents the most extreme 30-minute rainfall intensity recorded in the entire period of record.

o SOLARAV

Calculation based on following formula:

$$\mu rad_{mon} = \frac{\sum_{d=1}^{N} H_{day,mon}}{N}$$

Where μrad_{mon} Mean daily solar radiation for the month (MJ m^2 day^{-1}).

                $H_{day,mon}$ Total solar radiation reaching the earth's surface for day d in month mon (MJ m^2 day^{-1}).

                N Total number of daily solar radiation records for month mon.

o TMPMN

- Calculation based on following formula:

$$\mu mn_{mon} = \frac{\sum\limits_{d=1}^{N} T_{mn,mon}}{N}$$

Where

μmn_{mon} Mean daily minimum temperature for the month (°C).

$T_{mn,mon}$ Daily minimum temperature on record d in month mon (°C).

N Total number of daily minimum temperature records for month mon.

o TMPMX

Calculation based on following formula:

$$\mu mx_{mon} = \frac{\sum\limits_{d=1}^{N} T_{mx,mon}}{N}$$

Where

μmx_{mon} Average daily maximum temperature for the month (°C).

$T_{mx,mon}$ Daily maximum temperature on record d in month mon (°C).

N Total number of daily maximum temperature records for month mon.

o TMPSTDMN

Calculation based on following formula:

$$\sigma mn_{mon} = \sqrt{\frac{\sum\limits_{d=1}^{N} (T_{mn,mon} - \mu mn_{mon})^2}{N-1}}$$

Where

σmn_{mon} Standard deviation for daily minimum temperature in month mon (°C).

μmn_{mon} Mean daily minimum temperature for the month (°C).

$T_{mn,mon}$ Daily minimum temperature on record d in month mon (°C).

N Total number of daily minimum temperature records for month mon.

o TMPSTDMX

Calculation based on following formula:

$$\sigma mx_{mon} = \sqrt{\frac{\sum\limits_{d=1}^{N} (T_{mx,mon} - \mu mx_{mon})^2}{N-1}}$$

Where

σmx_{mon} Standard deviation for daily maximum temperature in month mon (°C).

μmx_{mon} Average daily maximum temperature for the month (°C).

$T_{mx,mon}$ Daily maximum temperature on record d in month mon (°C).

N Total number of daily maximum temperature records for month mon.

o WLATITUDE

No calculation needed. .

o WLONGITUDE

No calculation needed.

o WNDAV

Calculation based on following formula:

$$\mu wnd_{mon} = \frac{\sum_{d=1}^{N} \mu_{wnd,mon}}{N}$$

Where μwnd_{mon} Mean daily wind speed for the month (m s^{-1}).
     $\mu_{wnd,mon}$ Average wind speed for day d in month mon (m s^{-1}).
     N Total number of daily wind speed records for month mon.

APPENDIX E: LIST OF SYMBOLS

A_{ch}	Cross-sectional area of flow in the channel (m²).
$A_{ch,bnkfull}$	Cross-sectional area of flow in the channel when filled to the top of the bank (m²).
$Area$	Subbasin area (km²).
E	Depth rate evaporation (mm d⁻¹).
E_o	Potential evapotranspiration (mm d-1).
E_t	Maximum transpiration rate (mm d⁻¹).
G	Heat flux density to the ground (MJ m⁻² d⁻¹).
H_0	Extraterrestrial radiation (MJ m⁻² d⁻¹).
$H_{day,mon}$	Total solar radiation reaching the earth's surface for day d in month mon (MJ m⁻² day⁻¹).
H_{net}	Net radiation (MJ m⁻² d⁻¹).
HU	Number of heat units accumulated on a given day (heat units).
I_a	Initial abstractions that includes surface storage, interception and infiltration prior to runoff (mm H₂O).
K	Storage time constant for the reach (s).
$K_{0.1bnkfull}$	Storage time constant calculated for the reach segment with one-tenth of the bankfull flows (s).
K_1	Dimension coefficient needed to ensure the two terms in the numerator have the same units (for u_z in m s⁻¹, $K_1 = 8.64 \times 10^4$).
$K_{bnkfull}$	Storage time constant calculated for the reach segment with bankfull flows (s).
K_{USLE}	Soil erodibility factor.
L	Channel length from the most distant point to the subbasin outlet (km).
LAI	Leaf area index.
L_c	Average flow channel length for the subbasin (km).
L_{cen}	Distance along the channel to the subbasin centroid (km).
L_{ch}	Channel length (km).
M	Particlesize parameter.
OM	Percent organic matter (%).
P	Atmospheric pressure (kPa).
$P_i(W|D)$	Probability of a wet day following a dry day in month i.
$P_i(W|W)$	Probability of a wet day following a wet day in month i.
PHU	Potential heat units (is the total heat units required for plant maturity).
Q_{surf}	Accumulated runoff or rainfall excess (mm H₂O).
R_{ch}	Hydraulic radius for a given depth of flow (m).
R_{day}	Amount of rainfall on a given day (mm H₂O).
$R_{day,mon}$	Daily precipitation for record d in month mon (mm H₂O).
R_{mon}	Mean monthly precipitation (mm H₂O).
RH_{mean}	Mean relative humidity (%).
S	Retention parameter (mm H₂O).
SC	Storage coefficient for variable storage flow routing.
SND_{day}	Standard normal deviate calculated for the day.
$\overline{T}_{av}$	Mean air temperature for a given day (°C).
T_{base}	Plant's base or minimum temperature for growth (°C).
T_{dew}	Dew point temperature (°C).
T_{min}	Minimum air temperature for a given day (°C).
$T_{min,mon}$	Daily minimum temperature on record d in month mon (°C).
T_{max}	Maximum air temperature for a given day (°C).

$T_{mx,mon}$	Daily maximum temperature on record d in month mon (°C).
TT	Travel time (s).
V_{ch}	Volume of water stored in the channel (m^3).
V_{in}	Volume of inflow during the time step (m^3 H_2O).
V_{out}	Volume of outflow during the time step (m^3 H_2O).
V_{stored}	Change in volume of storage during the time step (m^3 H_2O).
V_{stored}	Storage volume (m^3 H_2O).
$V_{stored,1}$	Storage volume at the beginning of the time step (m^3 H_2O).
$V_{stored,2}$	Storage volume at the end of the time step (m^3 H_2O).
W_{btm}	Bottom width of the channel (m).
$W_{btm,fld}$	Bottom width of the flood plain (m).
X	Weighting factor in Muskinghum Routing.
c_k	Celerity corresponding to the flow for a specified depth (m s^{-1}).
$coef_1$	Weighting coefficients input by the user for storage time constant calculation.
$coef_2$	Weighting coefficients input by the user for storage time constant calculation.
c_p	Specific heat at constant pressure (MJ kg^{-1} °C^{-1}).
c_{perm}	Profile permeability class.
$c_{soilstr}$	Soil structure code used in soil classification.
$d_{wet,i}$	Average number of days of precipitation in month I.
$days_{dry,i}$	Number of dry days in month I during the entire period of record.
$days_{W|D,i}$	Number of times a wet day followed a dry day in month i for the entire period of record.
$days_{W|W,i}$	Number of times a wet day followed a wet day in month i for the entire period of record.
$days_{wet,i}$	Number of wet days in month I during the entire period of record.
$depth$	Depth of flow (m).
$depth_{bnkfull}$	Depth of water in the channel when filled to the top of the bank (m).
e_a	Actual Vapor Pressure (kPa).
e_z	Water vapor pressure of air at height z (kPa).
e_z^o	Saturation vapor pressure of air at height z (kPa).
f_{csand}	Factor that gives low soil erodibility factors for soils with high coarse-sand contents and high values for soils with little sand.
f_{cl-si}	Factor that gives low soil erodibility factors for soils with high clay to silt ratios.
f_{hisand}	Factor that reduces soil erodibility for soils with extremely high sand contents.
f_{orgc}	Factor that reduces soil erodibility for soils with high organic carbon content.
g_{mon}	Skew coefficient for daily precipitation in the month.
h_c	Canopy height (cm).
m	Number of days required for a plant to reach maturity.
m_c	Percent clay content (< 0.002 mm diameter particles).
m_s	Percent sand content (0.05-2.00 mm diameter particles).
m_{silt}	Percent silt content (0.002-0.05 mm diameter particles).
m_{vfs}	Percent very fine sand content (0.05-0.10 mm diameter particles).
n	Manning's roughness coefficient.
$orgC$	Percent organic carbon content of the layer (%).
q_0	Unit source area flow rate (mm hr^{-1}).
$q_{in,ave}$	Average inflow rate during the time step.
q_{ch}	Average channel flow rate (m^3 s^{-1}).

$q_{ch}^{\bullet}$	Average channel flow rate (mm hr^{-1}).
q_{in}	Inflow rate (m^3 s^{-1}).
$q_{in,1}$	Inflow rate at the beginning of the time step (m^3 s^{-1}).
$q_{in,2}$	Inflow rate at the end of the time step (m^3 s^{-1}).
q_{out}	Discharge rate (m^3 s^{-1}).
$q_{out,1}$	Outflow rate at the beginning of the time step (m^3 s^{-1}).
$q_{out,2}$	Outflow rate at the end of the time step (m^3 s^{-1}).
r_a	Diffusion resistance of the air layer (aerodynamic resistance) (s m^{-1}).
r_c	Plant canopy resistance (s m^{-1}).
r_{exp}	Exponent that should be set between 1.0 and 2.0.
rnd_1	Random numbers between 0.0 and 1.0.
rnd_2	Random numbers between 0.0 and 1.0.
slp_{ch}	Average channel slope along channel length (m m^{-1}).
t_{ch}	Channel flow time of concentration.
v_c	Average channel velocity (m s^{-1}).
yrs	Number of years of record.
z_{ch}	Inverse of the channel side slope.
z_{fld}	Inverse of the flood plain side slope.
α_{pet}	Coefficient in Priestley-Taylor equation.
μ_{mon}	Mean daily rainfall (mm H$_2$O) for the month.
$\mu_{wnd,mon}$	Average wind speed for day d in month mon (m s^{-1}).
μmn_{mon}	Mean daily minimum temperature for the month (°C).
μmx_{mon}	Average daily maximum temperature for the month (°C).
μrad_{mon}	Mean daily solar radiation for the month (MJ m^{-2} day^{-1}).
μwnd_{mon}	Mean daily wind speed for the month (m s^{-1}).
γ	Psychrometric constant (kPa °C^{-1}).
Δ	Slope of the saturation vapor pressure-temperature curve, de/dT (kPa °C^{-1}).
Δt	Length of the time step (s).
λ	Latent heat of vaporization (MJ kg^{-1}).
λE	Latent heat flux density (MJ m^{-2} d^{-1}).
ϱ_{air}	Air density (kg m^{-3}).
σ_{mon}	Standard deviation of daily rainfall (mm H$_2$O) for the month mon.
σmn_{mon}	Standard deviation for daily minimum temperature in month mon (°C).
σmx_{mon}	Standard deviation for daily maximum temperature in month mon (°C).