AVSWAT - X short Tutorial

Prepared by Mauro Di Luzio, Georgie Mitchell and Nancy Sammons for the Workshop

Watershed Modeling using SWAT2003

March 5, 2005

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Sheraton
Atlanta, Georgia

Index

Installing AVSWATX

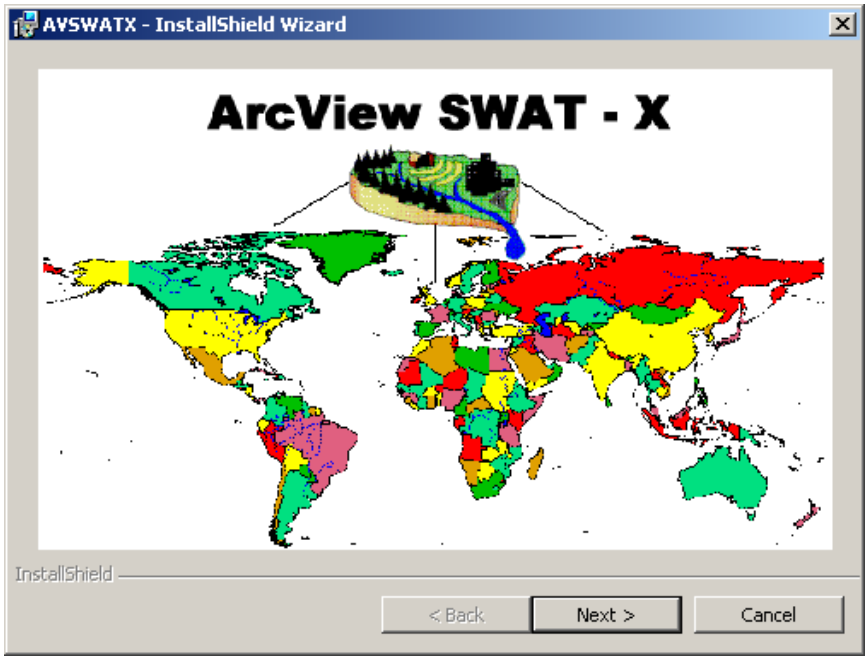
Temple, TX, February 24, 2005

Required Software

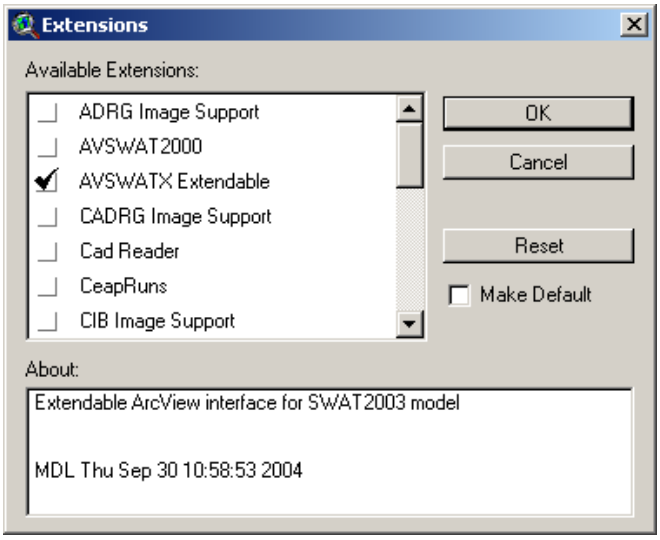
1. ArcView 3.1 or later (only up to 3.3) (3.3 recommended with Windows XP).
2. ArcView Spatial Analyst Extension (1.1 or 2.0).
3. ArcView Dialog Designer Extension (in general already installed with ArcView 3.1 and later).

Installation

1. Use the provided CD-ROM or unzip the avswatx.zip (soon distributed in the Web) in a temporary directory.
2. Double click the Start.apr project file or use ArcView to open it.
3. The opening project starts the AVSWATX Install Wizard driving through the remainder of the installation process.

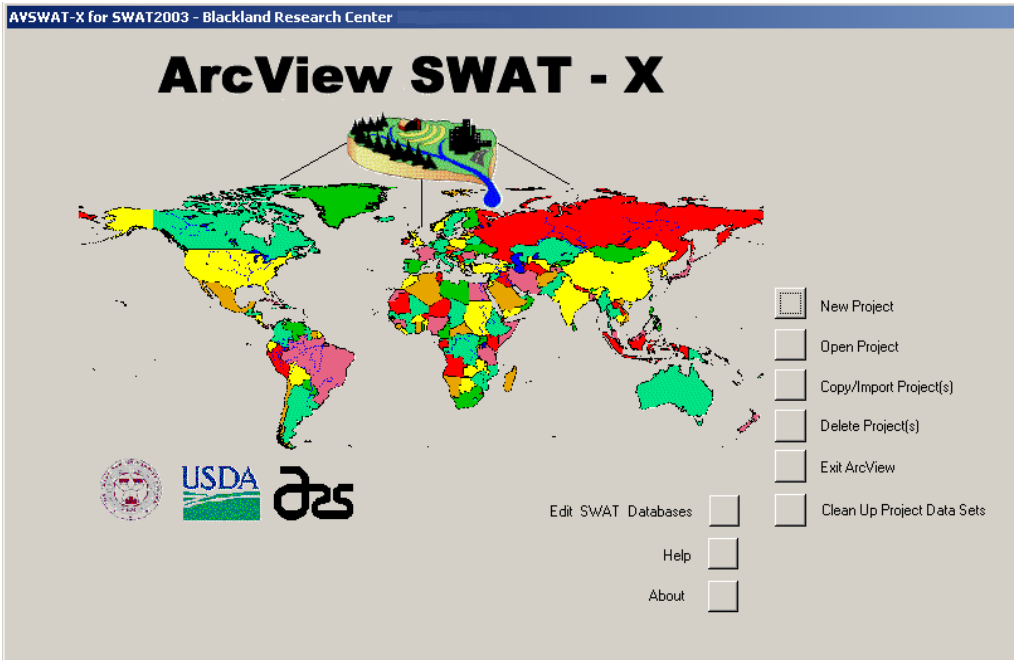


4. Once the installation is complete, open a new-empty ArcView session (do not use a working project with Tables or Views in it), select the menu *File*, menu item *Extensions*, select "*AVSWATX Extendable*", and press the *OK* button.



Note: Avoid setting the extension as default (i.e. do NOT check the Make Default Option).

5. **The main interface dialog will be displayed. Continue creating a new project (*New Project*) or opening a previous one (*Open Project*) identified by the file extension *.avsx*.**



Notes

- ***No need to uninstall AVSWAT2000***
- ***Not possible to use AVSWAT2000 projects (*.swat*) with the new AVSWATX***

Adding STATSGO Soils Data parameters by State

The installation provides soils data only for a few states, such as Texas, Pennsylvania, and Wisconsin.
For other states, data can be installed separately following these steps:

1. **At ftp://ftp.brc.tamus.edu/pub/swat/pc/soilav/ download the soils data, zipped by state.**
2. **In the AWSWATX soils directory (e.g. C:\AVSWATX\AvSwatDB\AllUs\statsgo\) create a directory for each downloaded state file, using the respective two-letter abbreviation (i.e., CO for Colorado, OK for Oklahoma, etc.).**
3. **Unzip each state file within the respective directory.**

Mauro Di Luzio, TAES- BREC

CHAPTER 1: AN APPLICATION EXAMPLE

Data for the Sabine River Watershed Headwaters in Northeast Texas has been included in the installation package as a demonstration data set. The example data set is stored in the directory :\<*Installation dir*>\AvSwatDB\Example3 which can be found on the drive that the AVSWATX was installed (Figure 1.).

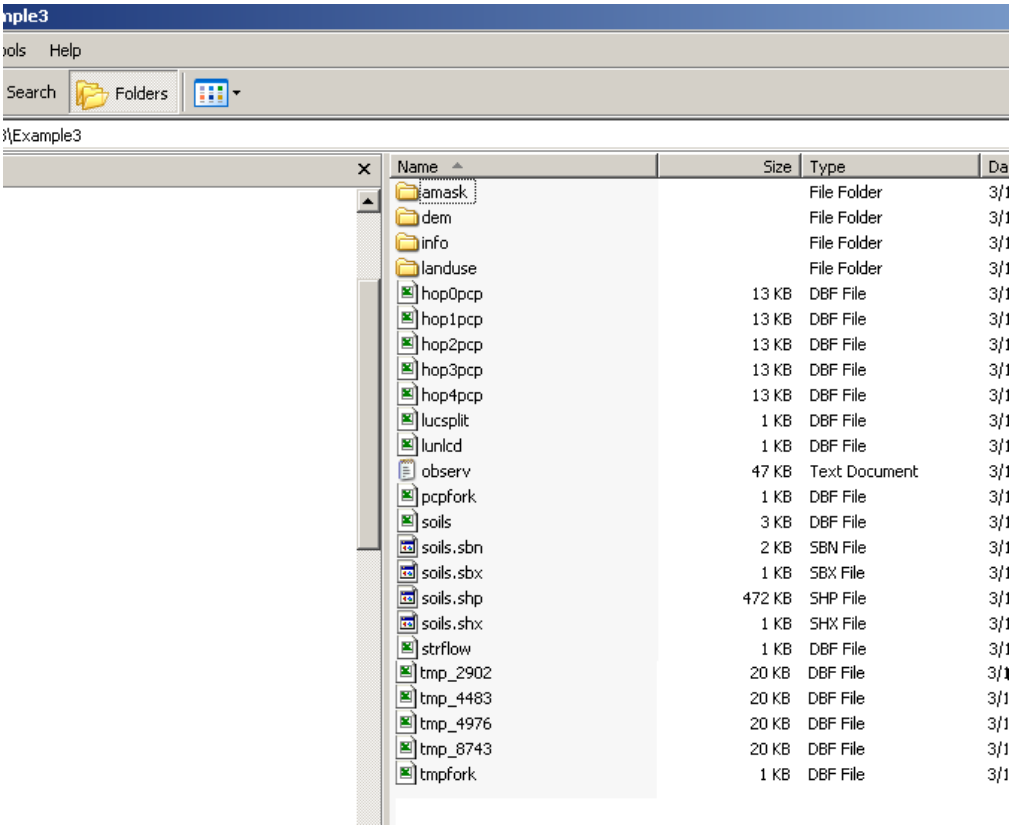


Figure 1.

The example data set includes 3 ESRI grid themes and one shape file in the same projection coordinates (a Albers Equal Area projection), and other supporting files. The 3 grid themes are:

- *Dem*: a Digital Elevation Model (DEM): The map was created with the resolution in meters (100) and the elevation in meters.
- *Amask*: a zonal mask.

- *Landuse*: a Land Cover/Land Use extracted from the USGS NLCD (National Land Cover Data set).
- *Soils*: A shape file soil map compiled from the NRCS STATSGO (Natural Resource Conservation Service database.

The DBF tables are:

- Location table for USGS stream flow gages: *strflow.dbf.*
- Location table for rain gages: *pcpfork.dbf*
- Precipitation data tables: *pcp_8743.dbf*, *pcp_2902.dbf*, *pcp_9836.dbf*, *pcp_4483.dbf*, *pcp_4976.dbf*
- Location table for temperature gages: *tmpfork.dbf*
- Temperature data tables: *tmp_2902.dbf*, *tmp_4483.dbf*, *tmp_4976.dbf*, *tmp_8743.dbf*
- Land Use look up table: *lunlcd.dbf*
- Land Use look up table: *lucsplit.dbf*
- Observation records: *observ.txt.*

SECTION 1: CREATE SWAT RUN WITH EXAMPLE DATASET

1. Start ArcView by double-clicking the icon. If an icon for the program is not present, click the Start button, then highlight Programs. From the software list displayed, highlight ESRI. The program name ArcView 3.x will be displayed. Click the program name to start ArcView. A Welcome to ArcView GIS window will pop up. Click Cancel.
2. On the File menu, click Extensions.
3. Scroll the list of available extensions until you locate AVSWATX Extendable. Check the box beside AVSWATX Extendable and click OK.

4. The main interface will be displayed (Figure 1.2).

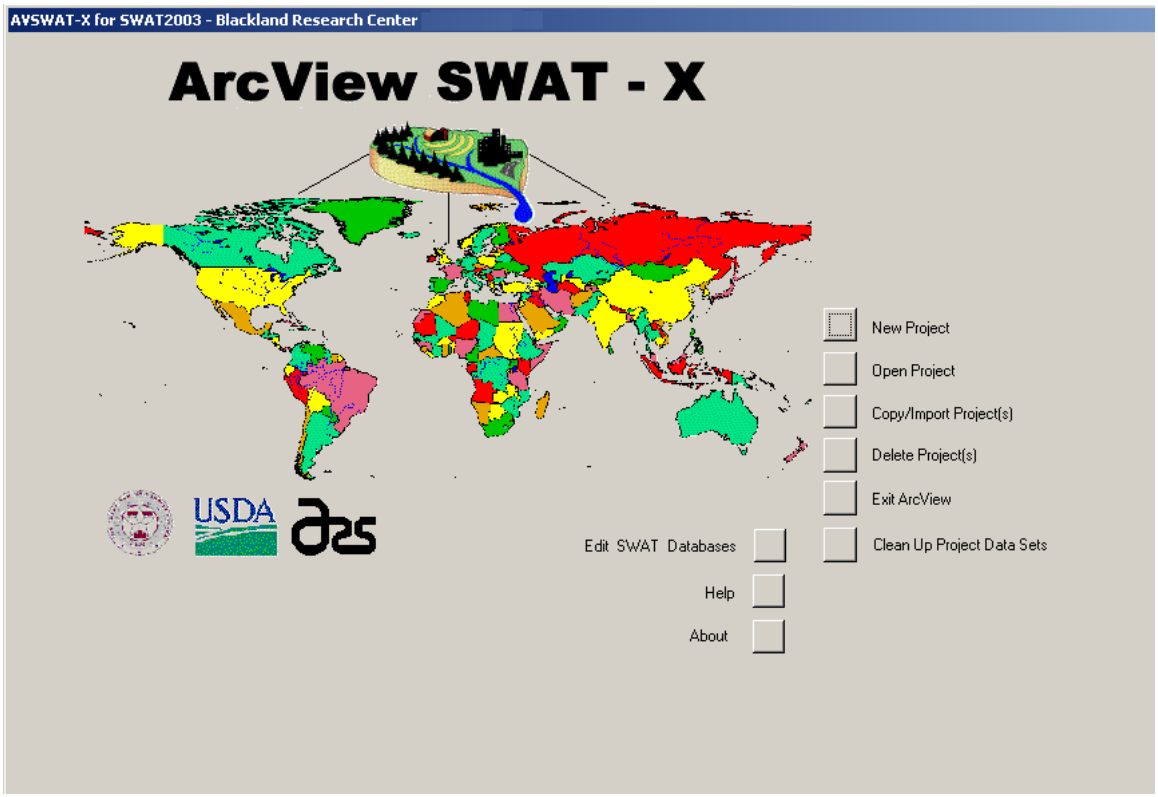


Figure 1.2

5. **Click the box beside New Project.**
6. **A browser will be displayed requesting a name for the new project. Type *sabine* in the text box labeled File Name (Figure 1.3).**

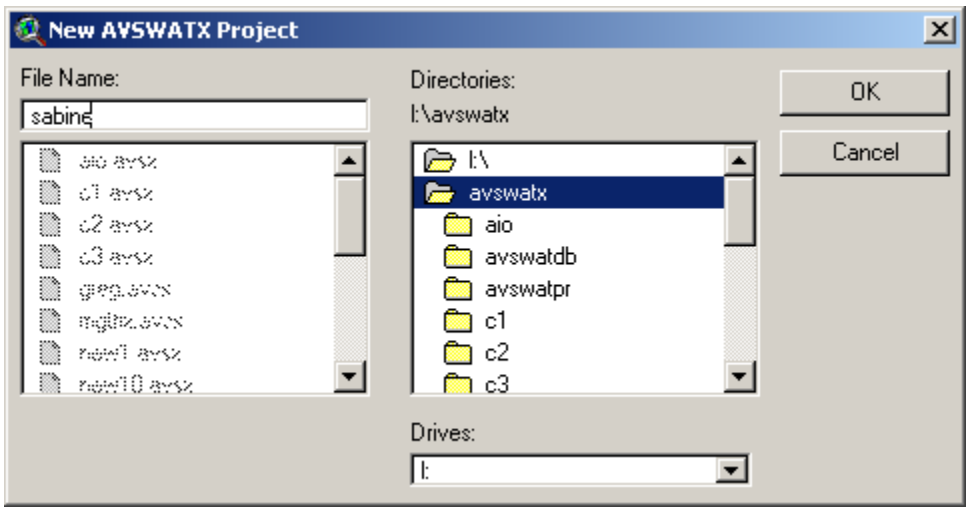


Figure 1.3

7. **Click OK.**

Note:	**Once OK is clicked, the interface creates a subdirectory called *sabine* within the active directory displayed in the directory tree on the dialog box. This directory is used to store maps and database tables created by the interface as well the input files for SWAT.**

8. **After the project name is specified, the interface brings up the Environmental Variables prompt box (Figure 1.4). This prompt box lists the directories that the interface searches for the information needed to create the SWAT input files.**

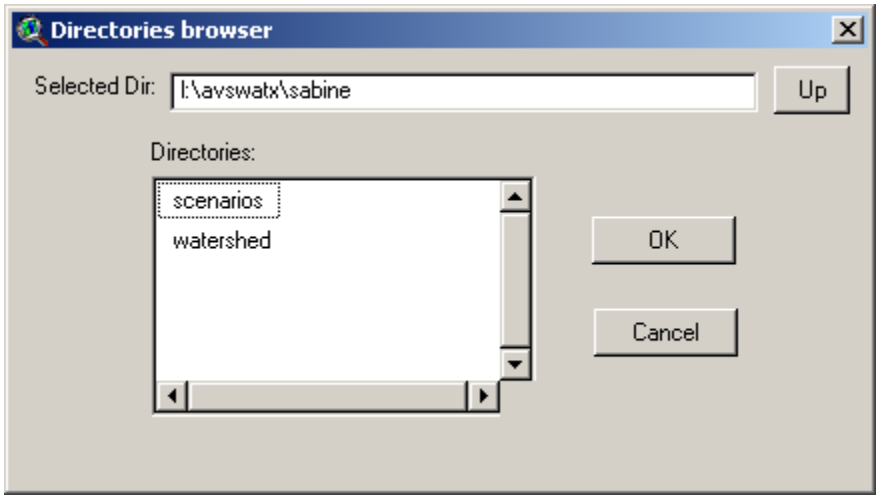


Figure 1.4

Programs used by the interface are stored in the directory listed next to SWAT Programs. This directory is defined when the interface is installed.

The directory listed next to SWAT Data Bases contains all the database (.dbf) tables used by the interface to set default input values and define the upper and lower limits for variable values. This directory also contains the soil and weather generator databases included with the interface. As with the previous directory, this directory is defined when the interface is installed.

The third directory is the SWAT User Data directory. When the interface brings up the Environmental Variables prompt box, the project directory created by the interface is listed in the text box (the interface *output* directory). This needs to be changed to the

directory where the DBF tables containing the measured precipitation and temperature data are stored.

9. The maps and database tables required for the example project are stored in :/*Installation dir*/AvSwatDB/Example1. The name in the text box may be changed by 1) typing the directory pathway in the text box, or 2) searching for the correct directory with a browser.

   To activate a browser:

   a. Click the  button to the right of the text box.

   b. A directory browser will appear with the directory listed in the text box visible (Figure 1.5).

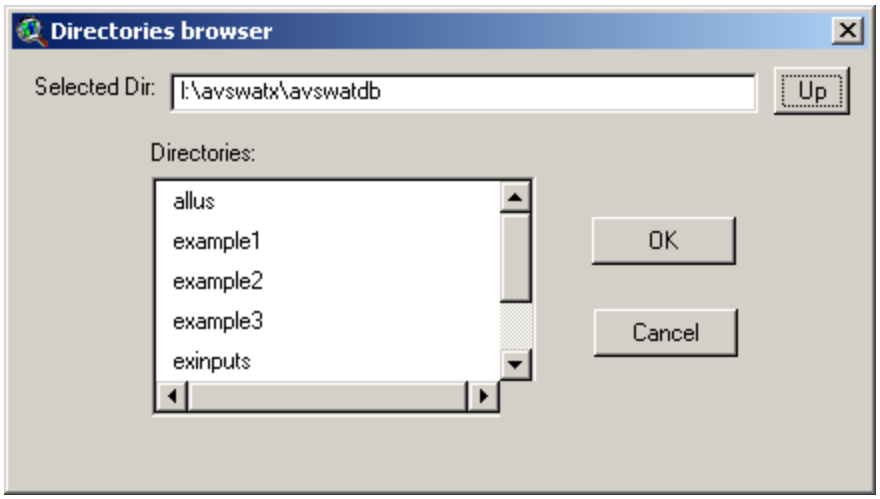


Figure 1.5

   c. Click the button labeled Up. This will make the *installation dir* directory active. You will see at least three directories listed: *avswatdb, avswatpr* and *sabine*. Select *avswatdb* by clicking on the name in the list of directories. When the *avswatdb* directory is active, several subdirectories will be listed: *allus*, *example1*, *example2*, *example3, etc.* Select *example3* by clicking on the name in the list of directories. The Directory browser will now look like Figure 1.6.

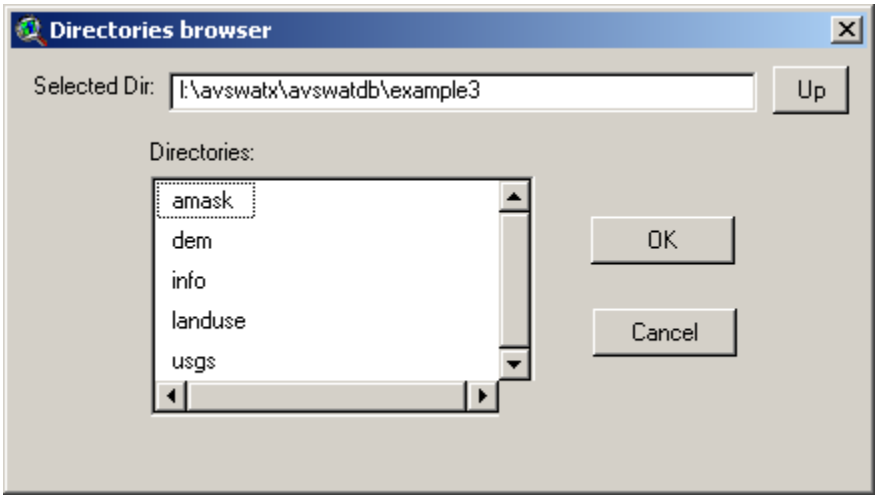


Figure 1.6

d. **Once the proper directory is listed in the text box next to Selected Dir, click the button labeled OK.**

10. **The SWAT User Data directory in the prompt box will show the directory chosen with the browser (Figure 1.7).**

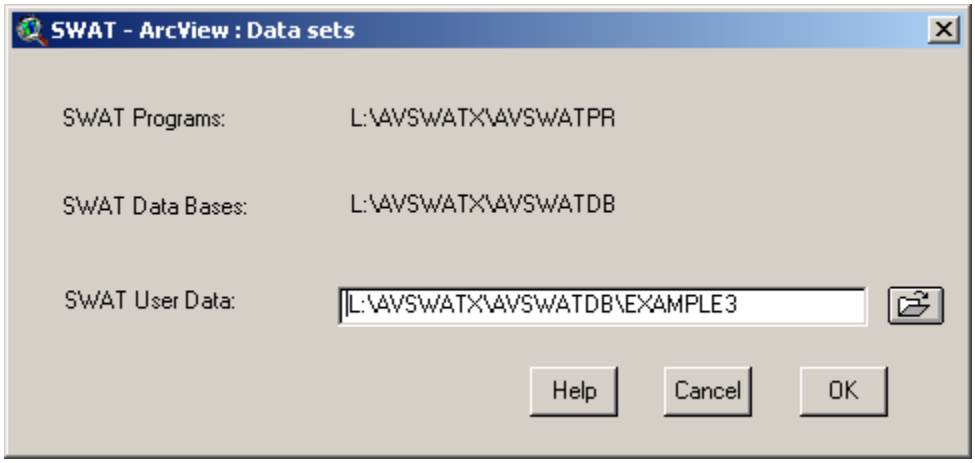


Figure 1.7

11. **Click OK to confirm the choice.**

Note:	**To access the Environmental Variables prompt box at any time, select Avswat Main Interface Dialog from the Avswatx menu to bring up the Main Interface screen and then click the button next to Environmental Variables.**

12. Once the User Data directory is defined, the interface will display the Watershed Window and automatically activate the Watershed Delineation dialog box (Figure 1.8).

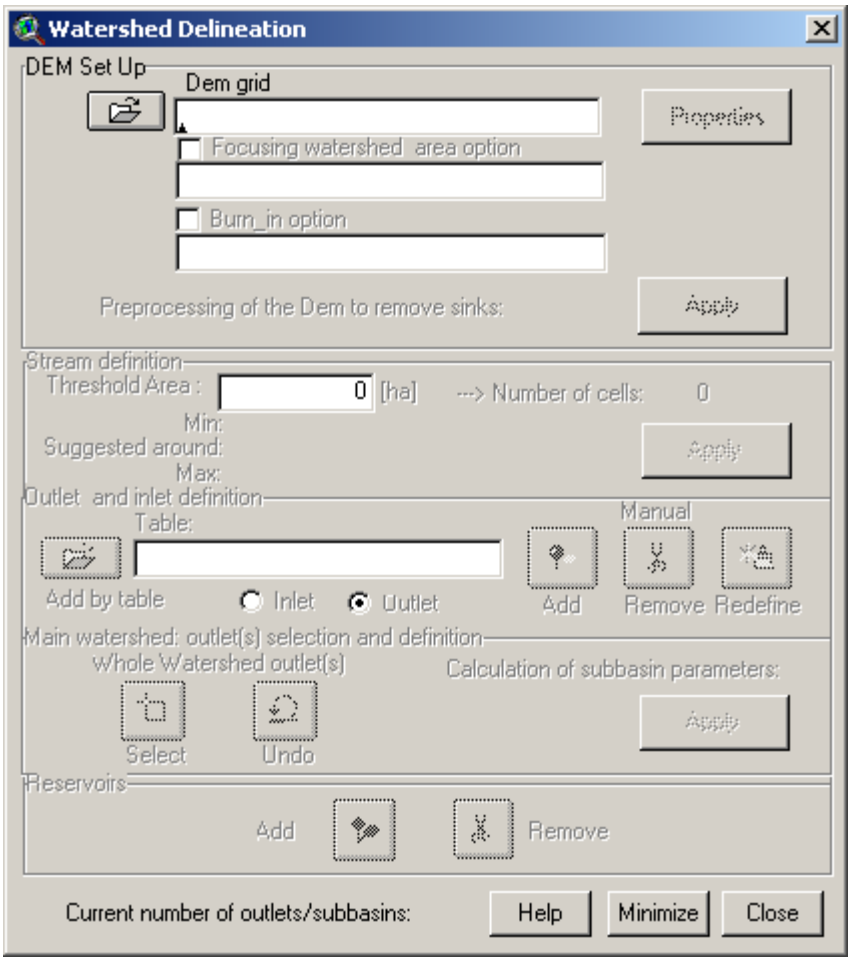


Figure 1.8

SECTION 1.1: PROCESSING THE ELEVATION MAP GRID

1. To load the example DEM, click  beside the DEM grid text box.
2. A prompt box is opened (Figure 1.9)

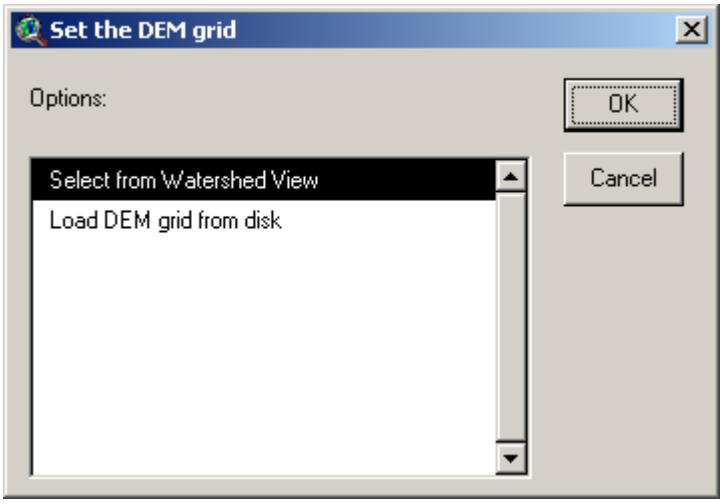


Figure 1.9

Highlight Load DEM grid from disk and click OK.

3. **A grid dataset file browser will appear with the User Data directory active (Figure 1.10).**

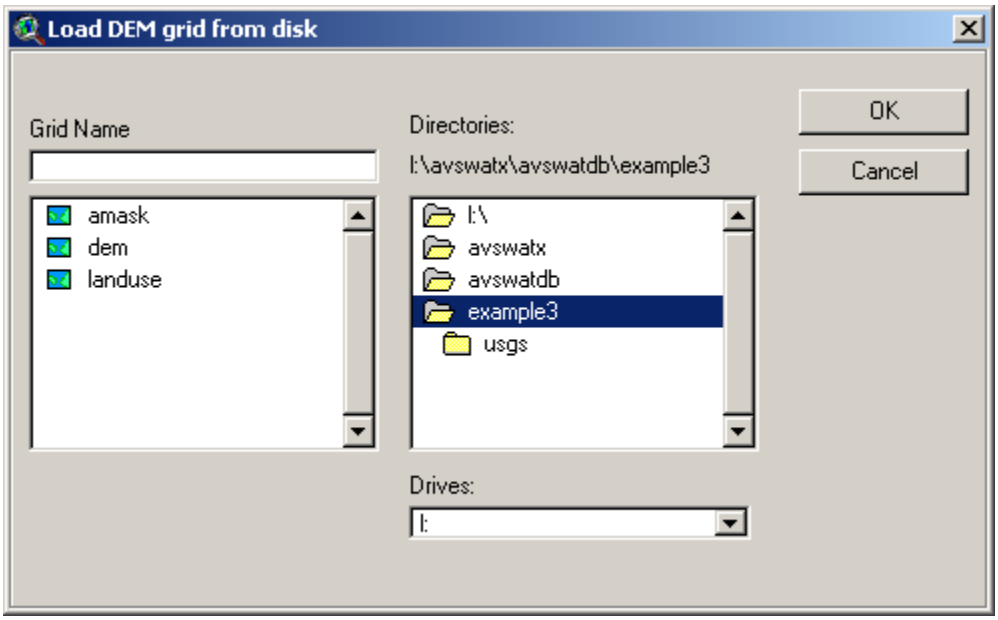


Figure 1.10

4. **Click the name of the elevation map grid (*dem*). The name of the elevation map grid will then be displayed in the text box below Grid Name on the browser. Click OK to confirm the choice.**

5. **The name of the elevation map grid will be displayed in the DEM grid text box on the Watershed dialog box and the elevation map will be displayed (Figure 1.11).**

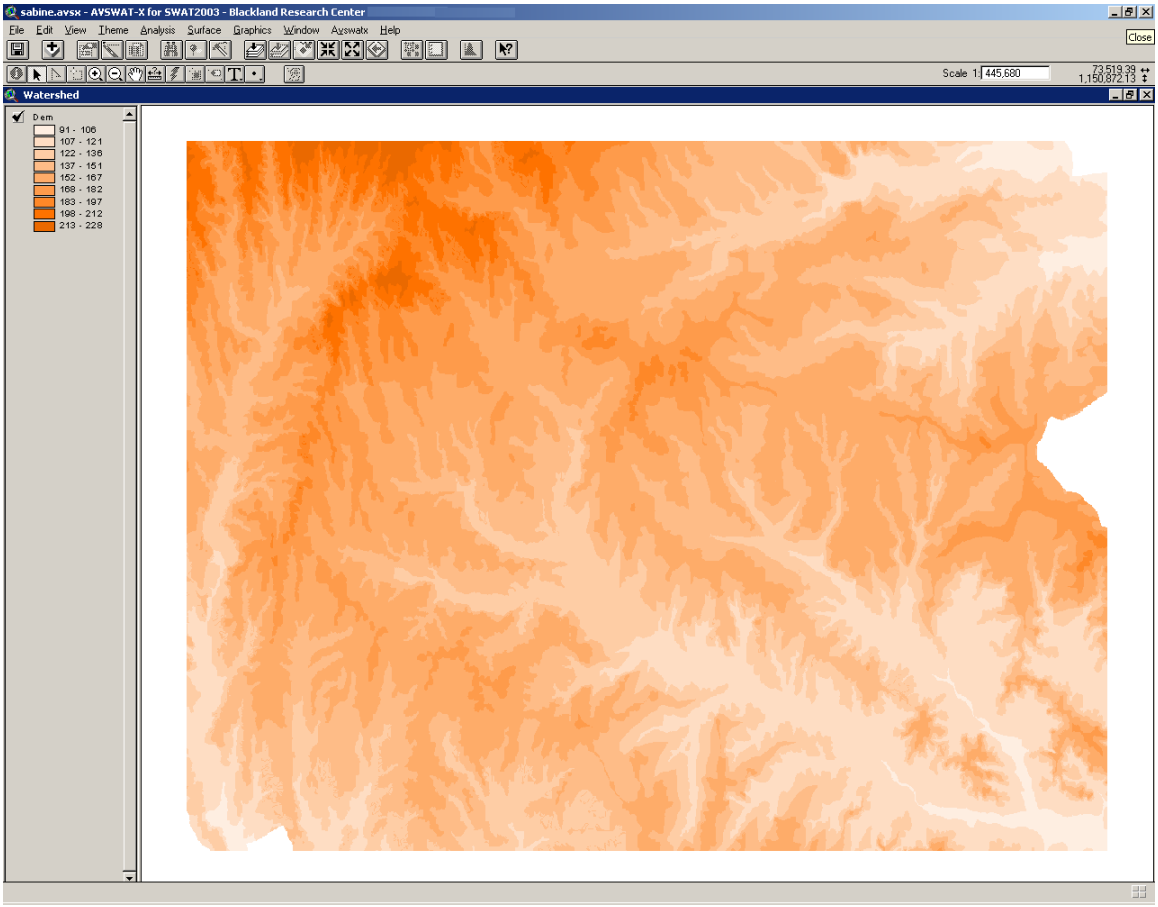


Figure 1.1

6. **A prompt box will appear reminding the user to verify DEM properties (Figure 1.12).**

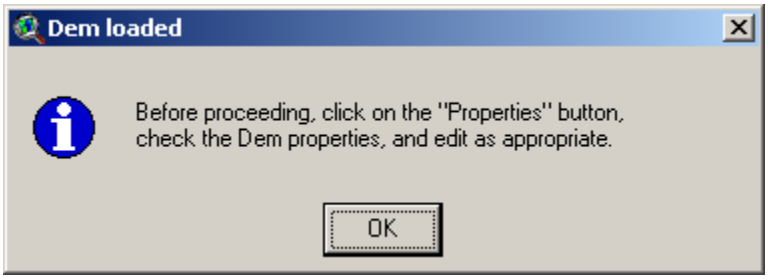


Figure 1.12

Click OK.Click the properties button  **next to the DEM grid text box. The interface will activate the map Properties prompt box (Figure 1.13).**

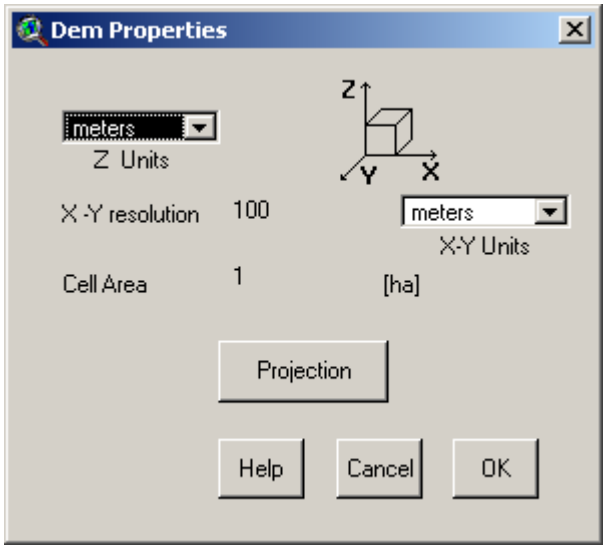


Figure 1.13

7. **The units for the X-Y and Z resolutions should be set to meters. To define the projection, click the projection button** 

. A prompt box will appear listing projection details for the DEM (Figure 1.14).

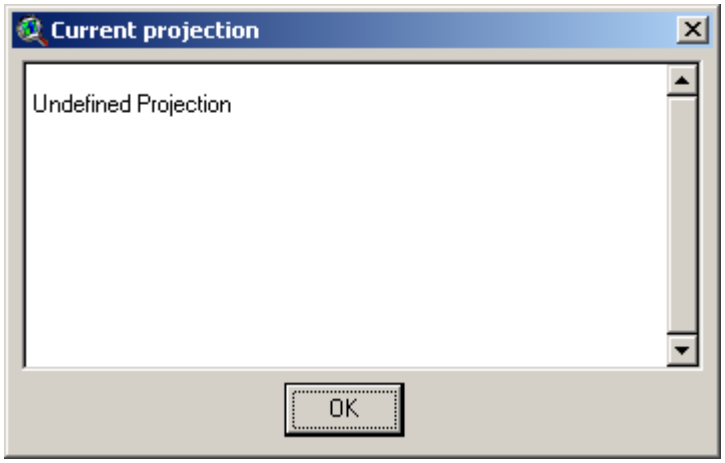


Figure 1.14

Click OK.

8. **A prompt box will appear asking if the user wishes to modify the projection information. Click Yes.**
9. **The interface will activate the map projection prompt box (Figure 1.15).**

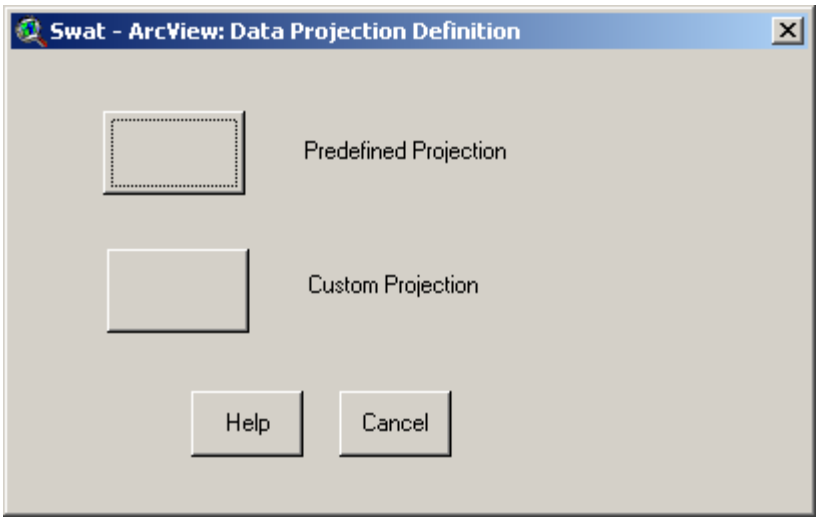


Figure 1.15

The maps in the example data set were created in the Albers Equal Area projection, which is a Predefined Projection in the interface. Click the button to the left of Predefined Projection on the map projection prompt box. A list of predefined projections will be displayed. Highlight *Albers Equal-Area (Conterminous U.S.)* by clicking on the name. Click OK to select this projection, then click OK on the DEM Properties dialog box.

The map resolution units and projection are properties of the map that are set when the map is created. While the interface can utilize maps in any projection, all maps used for a project must all be in the same projection.

10. **Optional: At this point the user may load a masking map grid and/or perform a burn-in of the stream network with a shape file containing the stream delineation for the watershed. A burn-in is useful in watersheds with very little relief (e.g. delta regions) or where the elevation map is not detailed enough to accurately predict the stream network. The example data set contains a masking map grid.**

    To load the masking map grid:

    a. **On the Watershed Delineation dialog box, check the box next to Focusing watershed area option. A check will appear in the box** ☑ Focusing watershed area option **and a prompt box will open (Figure 1.16).**

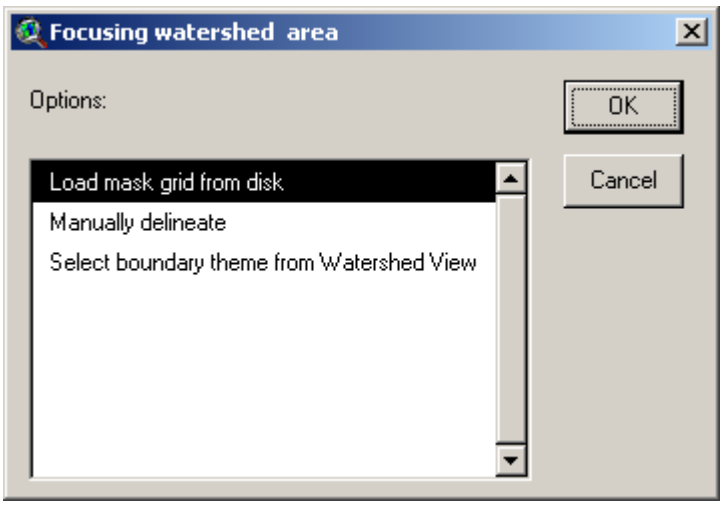


Figure 1.16

Highlight Load mask grid from disk and click OK.

b. **A browser is displayed. Click the name of the masking map grid, *amask*, and then click OK.**

c. **The masking map grid will be displayed on the screen (Figure 1.17).**

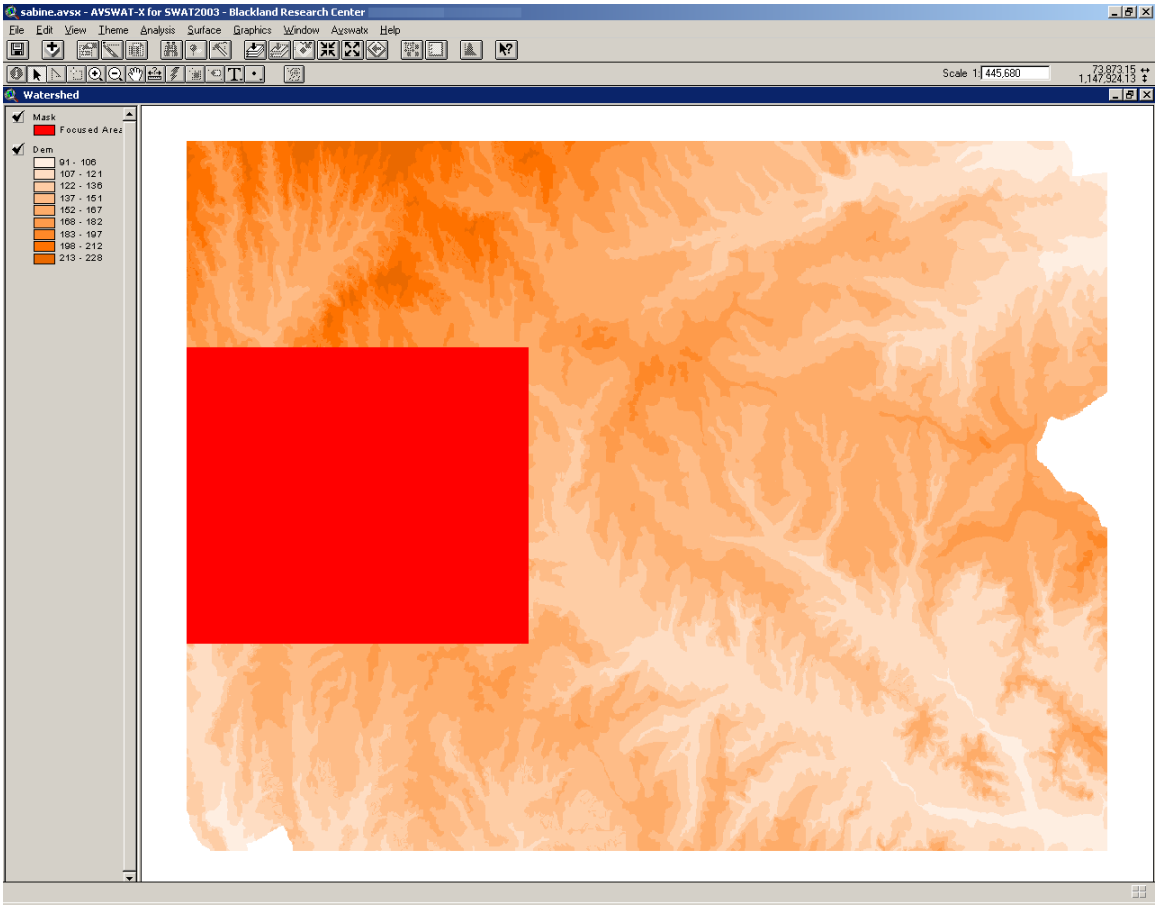
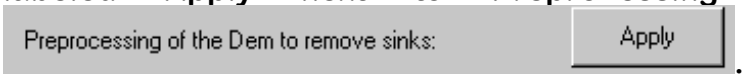


Figure 1.17

When a masking map grid is displayed, the stream network will be delineated only for the area of the DEM covered by the masking map grid.

11. **Once the elevation map is displayed, the map must be preprocessed. The preprocessing feature "smooths" the elevation grid by filling in areas of the map that drain to a point rather than drain to a channel. Preprocessing speeds up the amount of time it takes for the interface to define the channel network. To preprocess the elevation map, click the button labeled Apply next to Preprocessing of the DEM**



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While processing the DEM, a prompt box will appear (Figure 1.18).

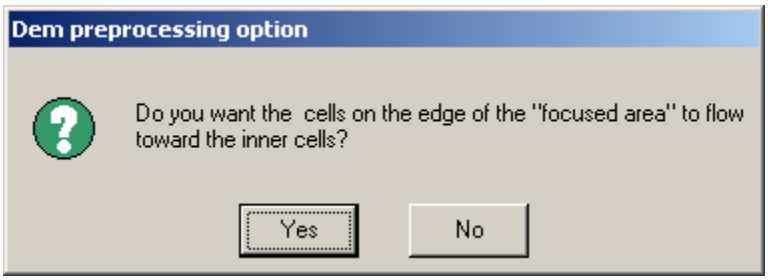


Figure 1.18

Click Yes.

12. **A prompt box will appear after the map preprocessing is complete. Click OK.**

13. **Once the elevation map has been preprocessed, the threshold area used to define the origin of a stream needs to be specified. The smaller the number, the more detailed the stream network generated by the interface. Figure 1.19 shows the stream network generated with the threshold set to 800 ha while Figure 1.20 shows the stream network generated with the threshold set to 4000 ha.**

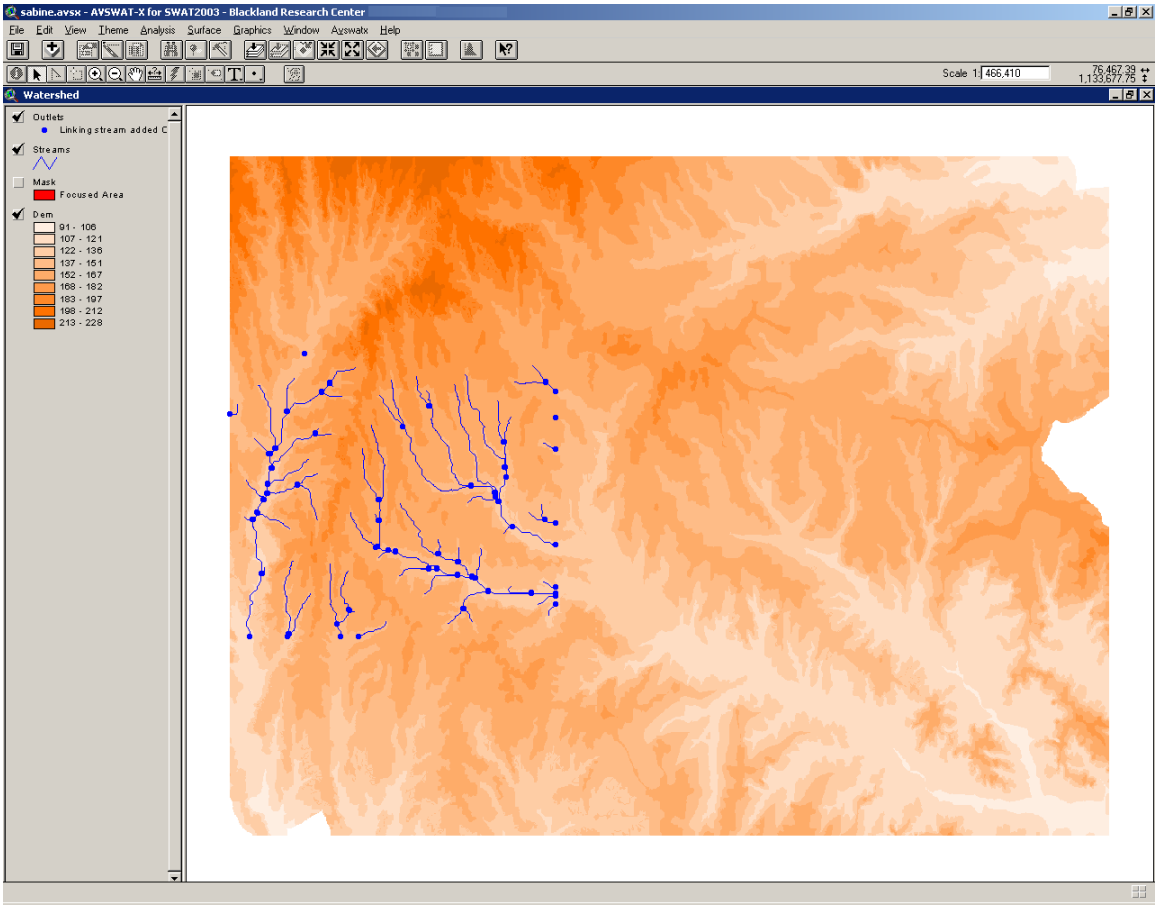

sabine.avsx - AVSWAT-X for SWAT2003 - Blackland Research Center
File Edit View Theme Analysis Surface Graphics Window Avswatx Help
Scale 1: 466,410
Watershed
Outlets
Linking stream added C
Streams
Mask
Focused Area
Dem
91 - 106
107 - 121
122 - 136
137 - 151
152 - 167
168 - 182
183 - 197
198 - 212
213 - 228

Figure 1.19

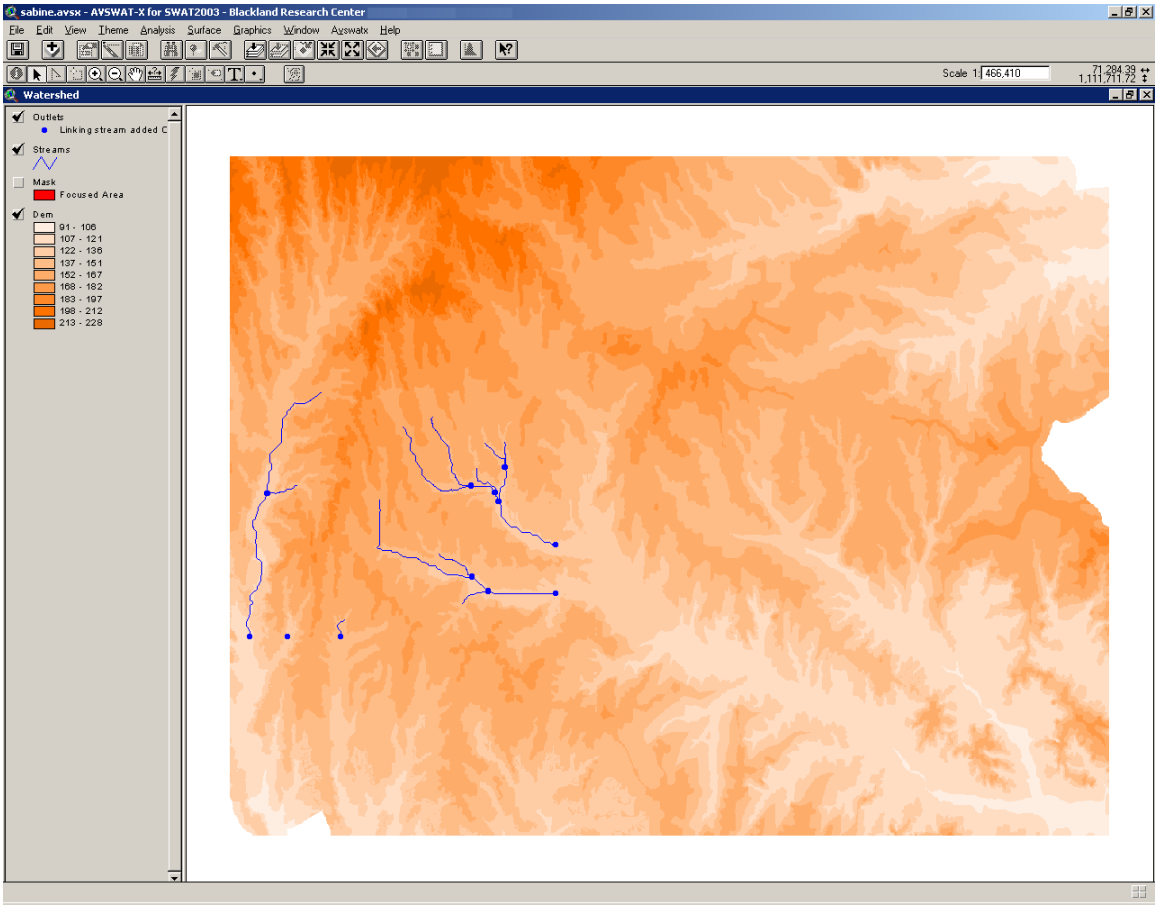


Figure 1.20

For the example project, set the threshold area to *800*. Once the proper area is displayed in the text field next to Threshold Area, click Apply.

14. The stream network will be displayed upon completion of the calculations (Figure 1.20). Subbasin outlets defined by the junction of two streams are denoted on the network by blue dots.

> The user may modify the number of subbasin outlets manually or by importing an Avenue database (.dbf) table containing outlet location coordinates. Points added via the table or manually will be snapped to the closest point on the delineated stream channels.

15. A table of locations where nutrient data was collected has been included in the example data set. To load the table, first verify that the Outlet radio button is selected 

. Then click  next to the text field labeled Table on the Watershed Delineation dialog box.

16. **A browser will be displayed (Figure 1.21).**

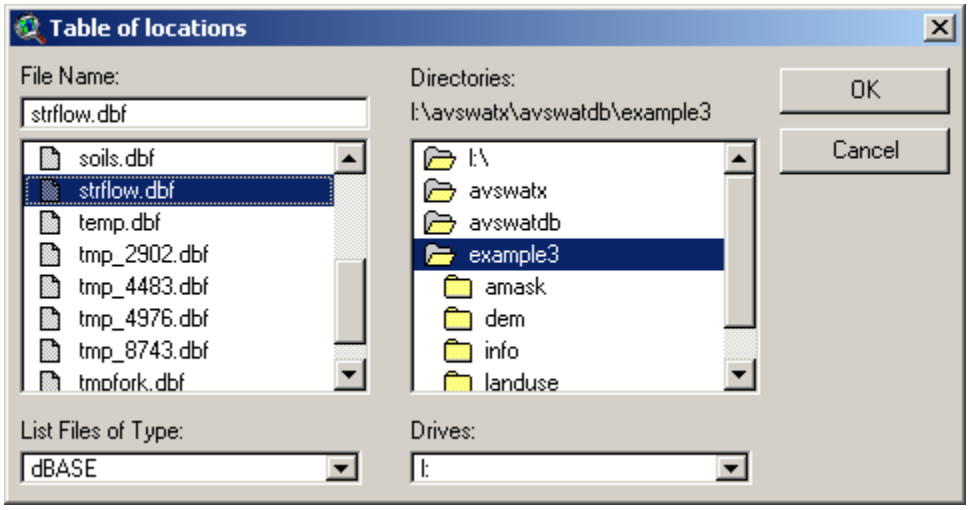


Figure 1.21

Select *strflow.dbf* from the list of tables and click OK. The subbasin outlet location loaded from the table is displayed as white dot (Figure 1.22).

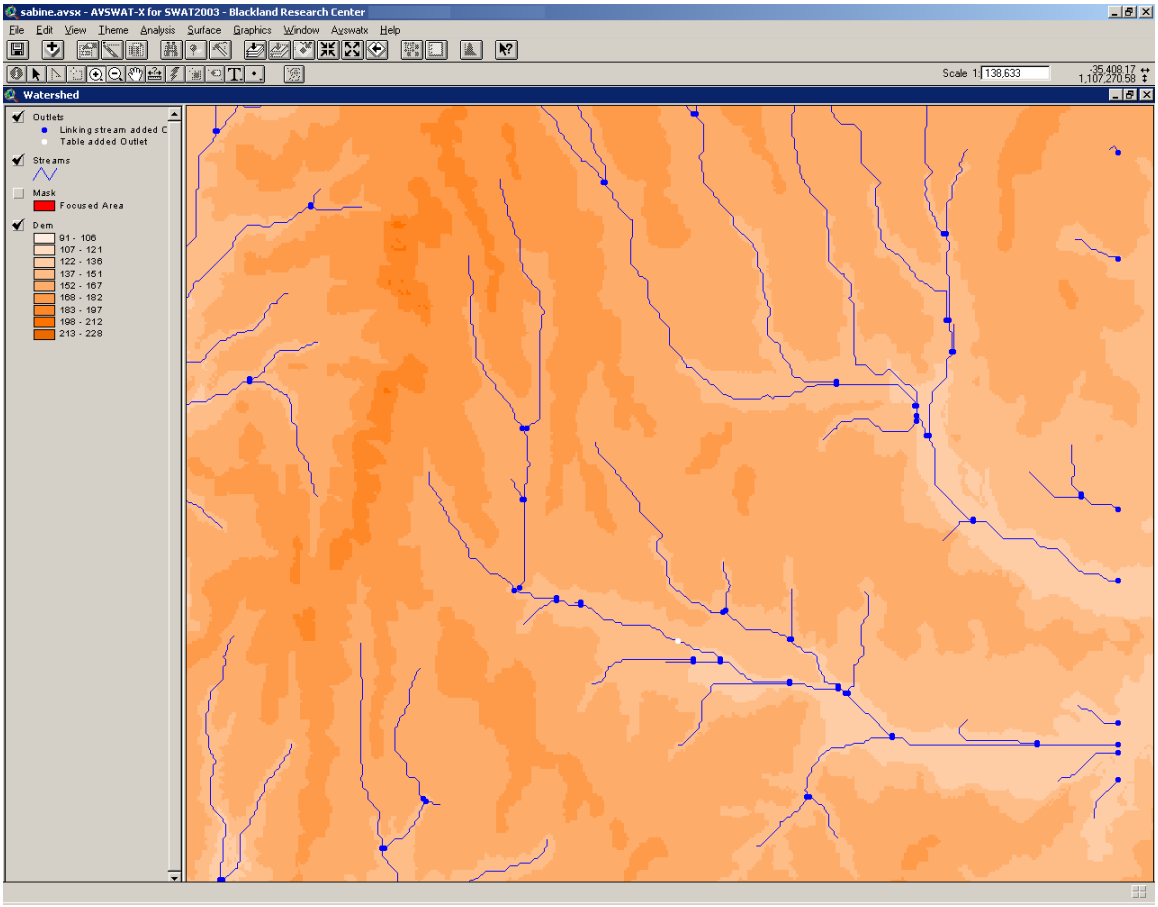


Figure 1.22

17. To manually add subbasin outlets, first verify that the Outlet radio button is selected 

. Then click the button labeled Add 

.

18. The dialog box will be minimized. Use the mouse to move around the map and click with the left mouse button to place a subbasin outlet where the mouse is positioned. Subbasin outlets added manually will be displayed as red dots. Add five outlets so that the map looks similar to Figure 1.23. (Arrows pinpoint location of red dots – arrows will not appear in display.)

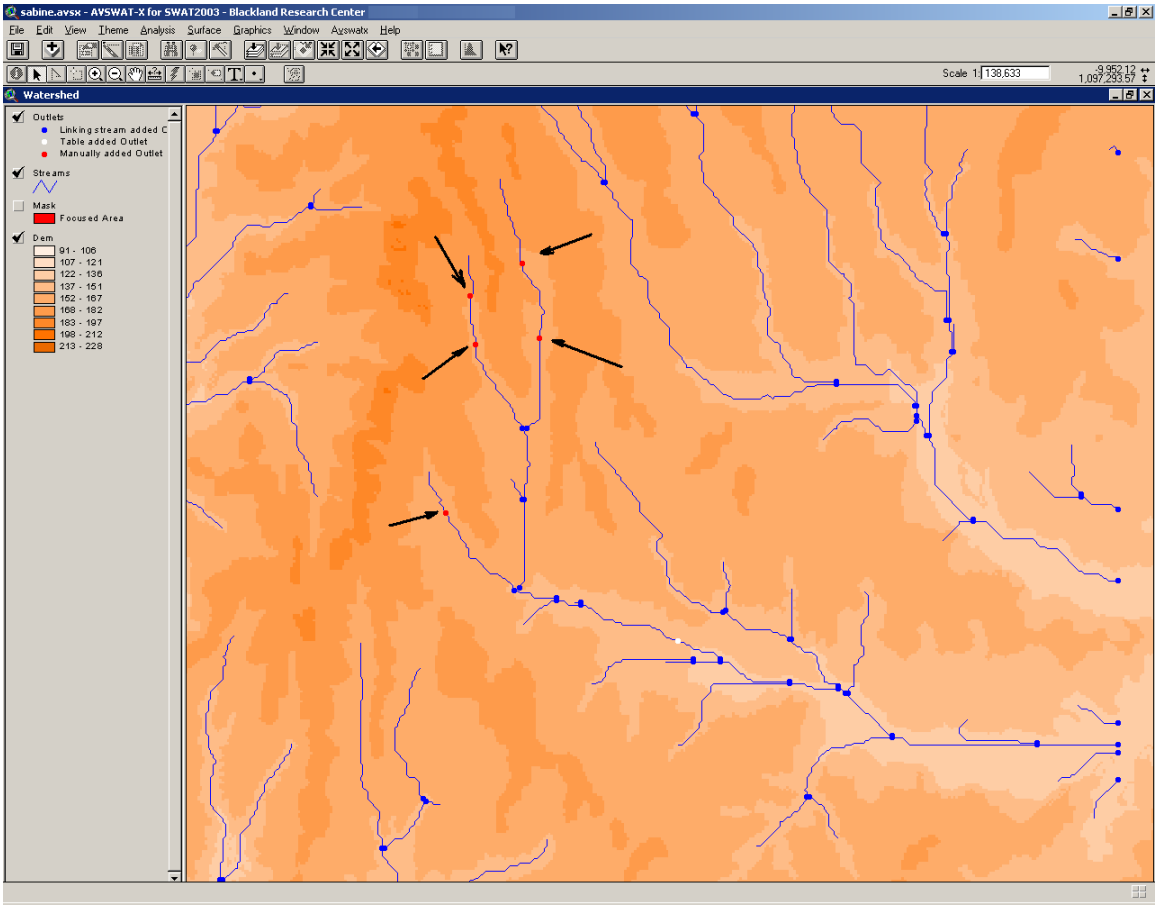


Figure 1.23

19. Once the display of subbasin outlets is satisfactory, in the Watershed Delineation dialog box the watershed outlet must be selected. Click the button above Select 

. The dialog box will be minimized and a prompt box will appear (Figure 1.24).

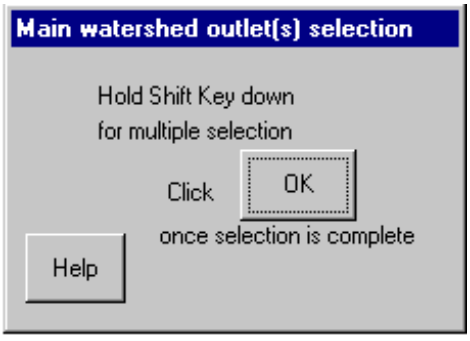


Figure 1.24

20. Select the white subbasin outlet previously imported (Figure 1.25) to be the subbasin outlet by holding down the left mouse

button and moving the mouse to form a box around the outlet dot. The outlet dot will turn yellow when it is selected.

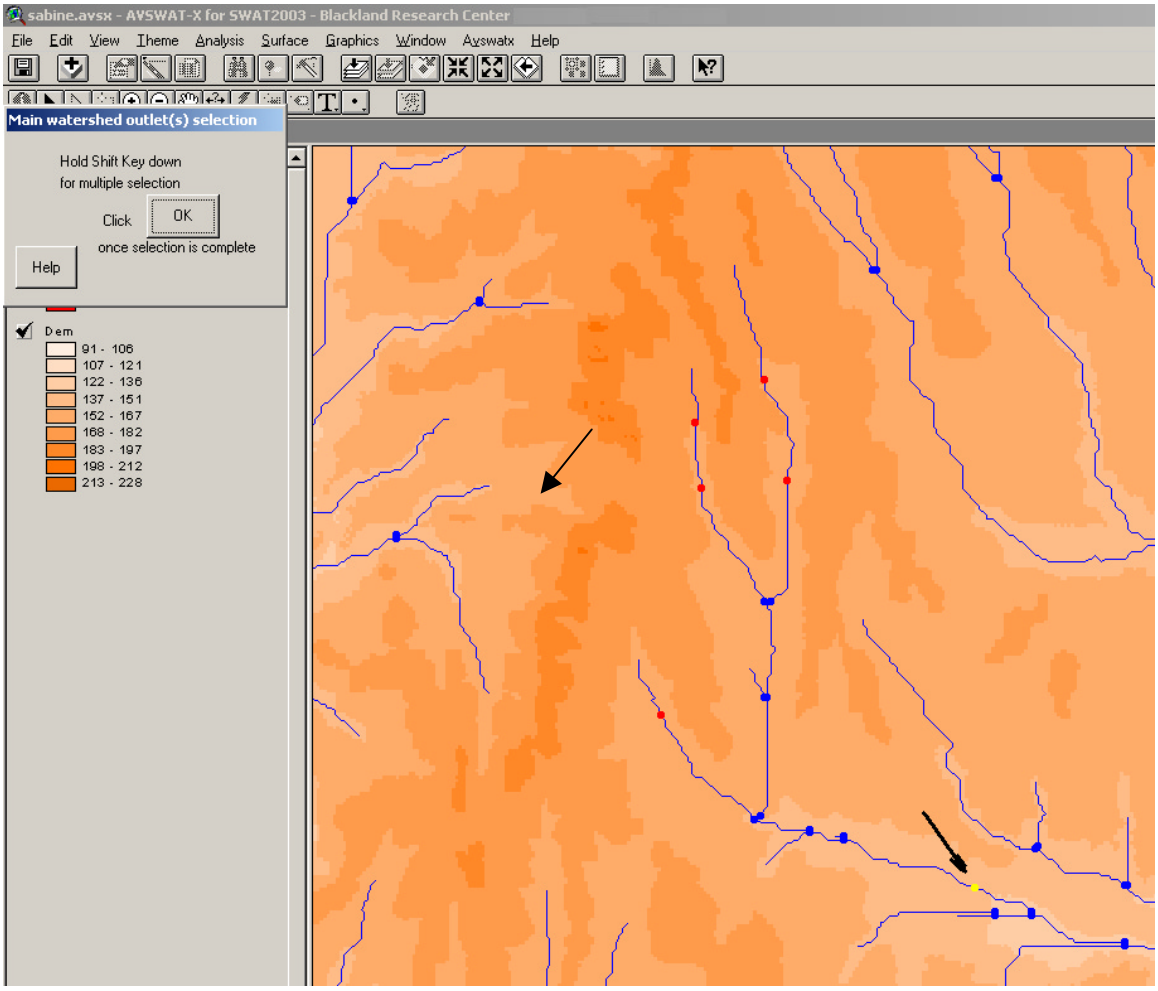


Figure 1.25

21. Click OK on the prompt box once the correct outlet is selected. Another prompt box will appear to verify the outlet choice. Click Yes to continue with the processing.

22. The subbasin delineation for the watershed will be displayed (Figure 1.26).

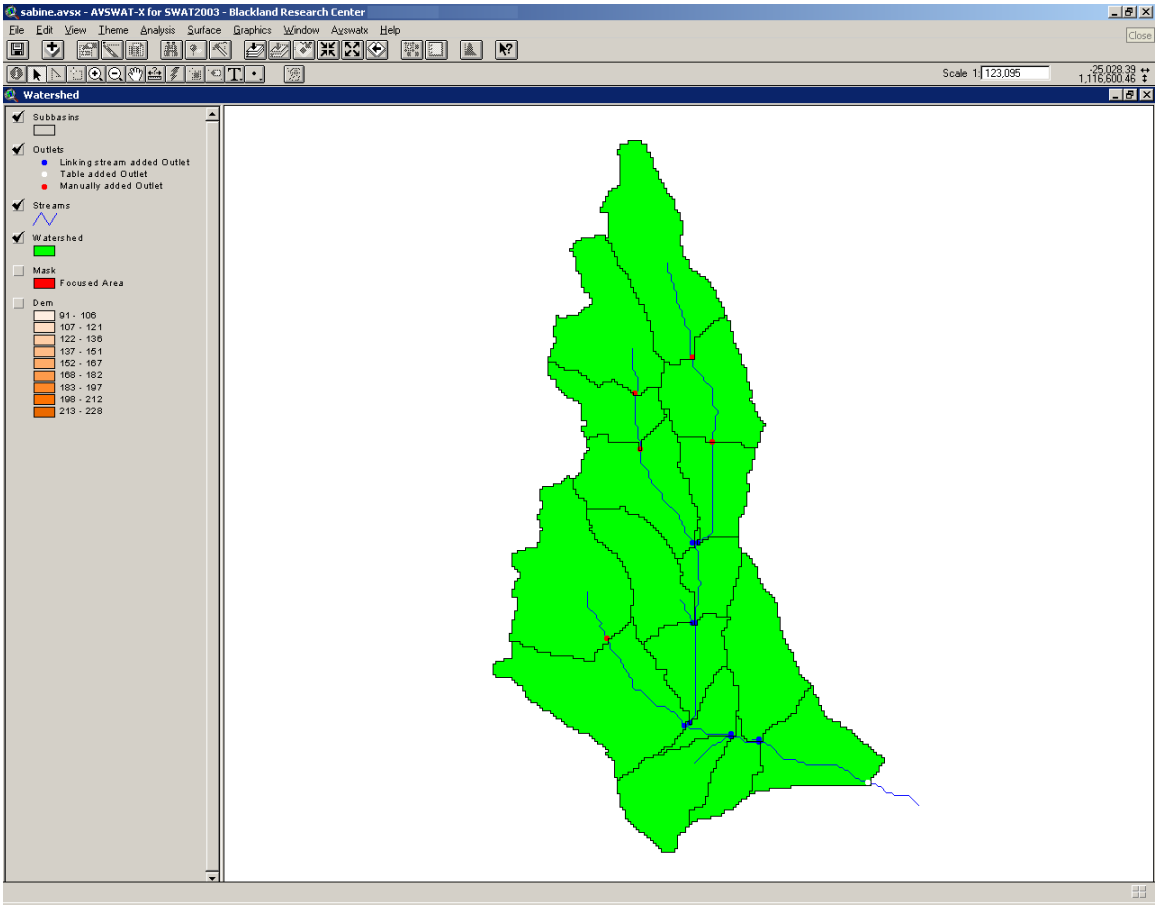
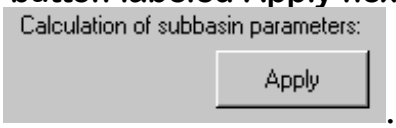


Figure 1.26

23. Click the button labeled Apply next to Calculation of subbasin parameters 

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24. Once the calculation of subbasin parameters is complete, a prompt box will appear. Click OK.

SECTION 1.2: PROCESSING THE LAND USE/SOIL MAP GRIDS

1. Select Land Use and Soil Definition in the Avswat menu (Figure 1.27).

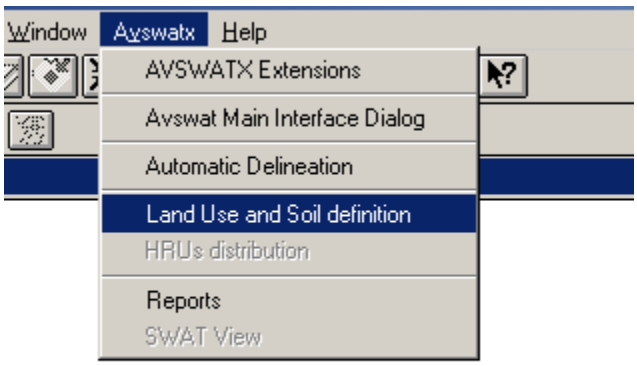


Figure 1.27

2. **The Definition of Landuse and Soil themes dialog box will open (Figure 1.28)**

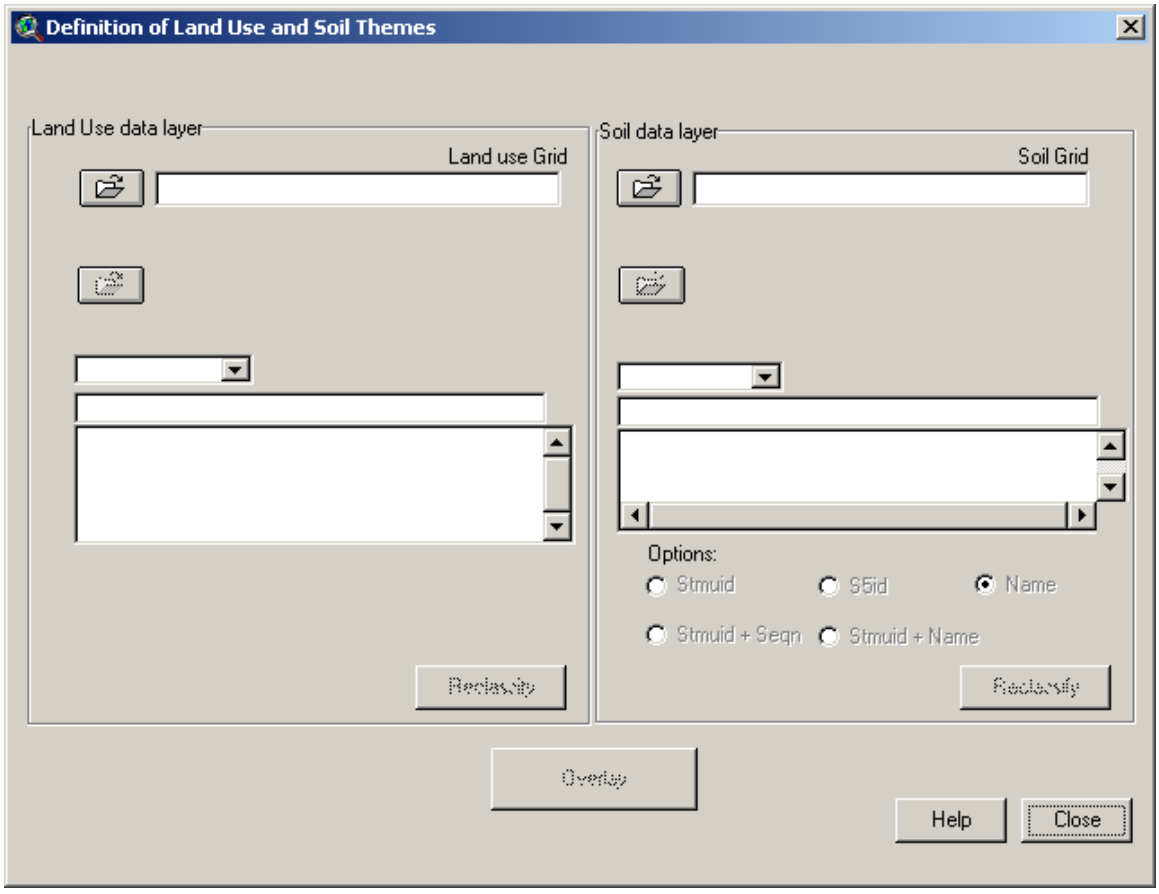


Figure 1.28

3. **To load the example land use grid, click**  **beside the Landuse Grid text field.**

4. **A prompt box will appear (Figure 1.29).**

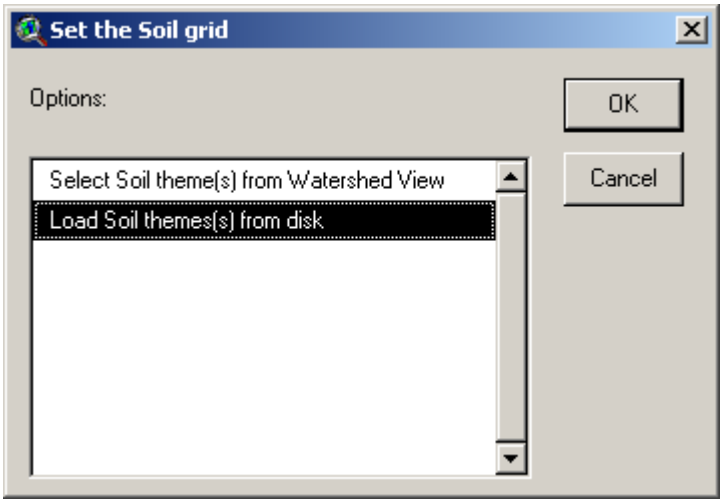


Figure 1.29

Highlight Load Landuse theme(s) from disk and click OK.

5. **Another prompt box will appear for the user to define the map format. Select Grid and click OK.**
6. **A message box will appear reminding the user that the data must be projected. Click Yes.**
7. **A browser will appear with the User Data directory active. Click the name of the land use map grid (*landuse*). Click OK to confirm the choice.**
8. **The raw land use grid will be displayed and clipped to the watershed area (Figure 1.30).**

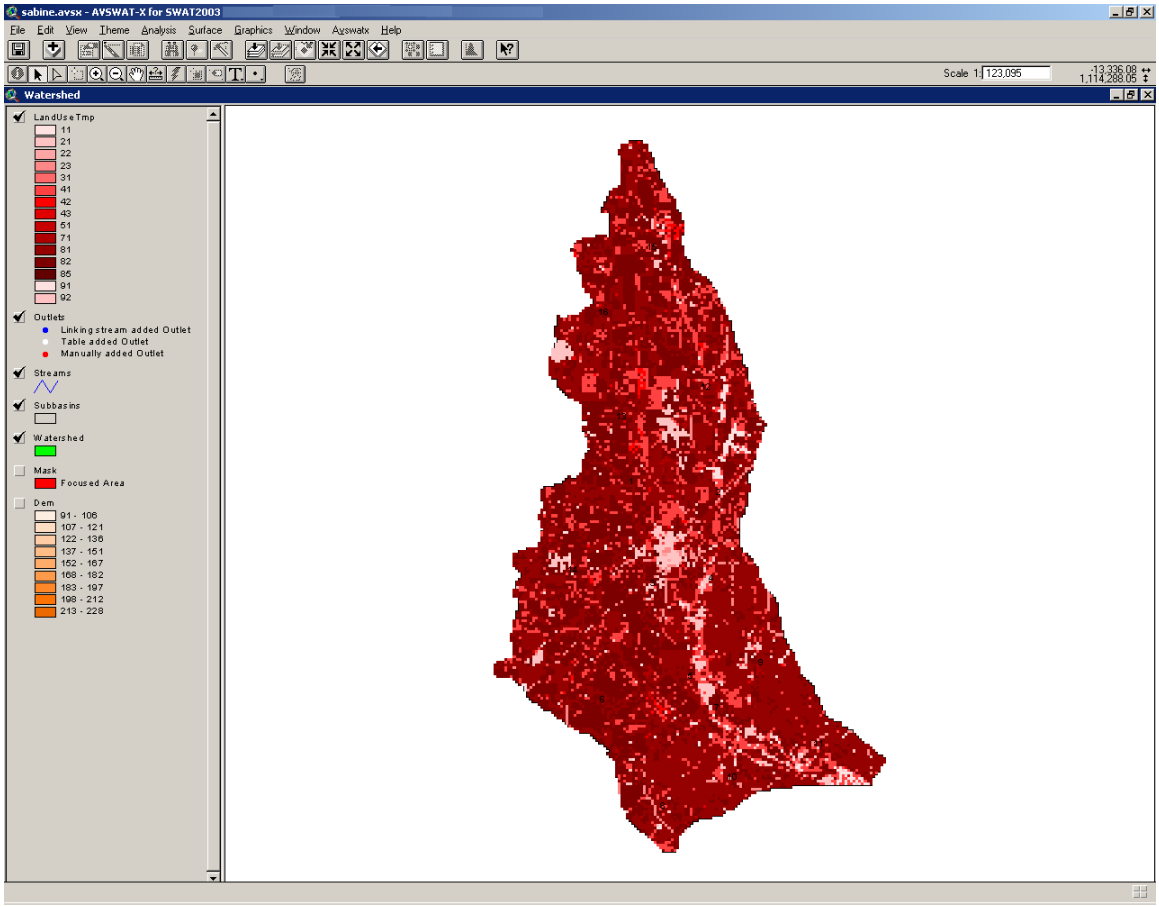


Figure 15.30

A message box will also appear reminding the user to load the look-up table for the map. Click OK.

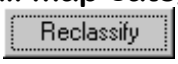
9. When the land use map grid is loaded, the interface does not know which SWAT land use code to assign to the different categories.

10. The example data set includes a custom look up table to define the SWAT land use to be modeled for each category. Click  beside LookupTable Grid Values→ Land cover classes.

11. A prompt box will be displayed for the user to select the type of table to be loaded. Highlight User table and click OK.

12. Another prompt box will appear for the user to define the format of the look up table. Select .dbf file and click OK.

13. A browser will be displayed. Click the name of the look up table (*lunlcd.dbf*). Once the correct table is selected, click OK.

14. The SWAT land use categories will be displayed on the scrollable listing on the Land Use/Soil dialog box. Once a *LandUseSwat* code has been assigned to all map categories, the Reclassify button will be enabled. Click the 

button.

15. The category display for the map will show the SWAT land use codes (Figure 1.31).

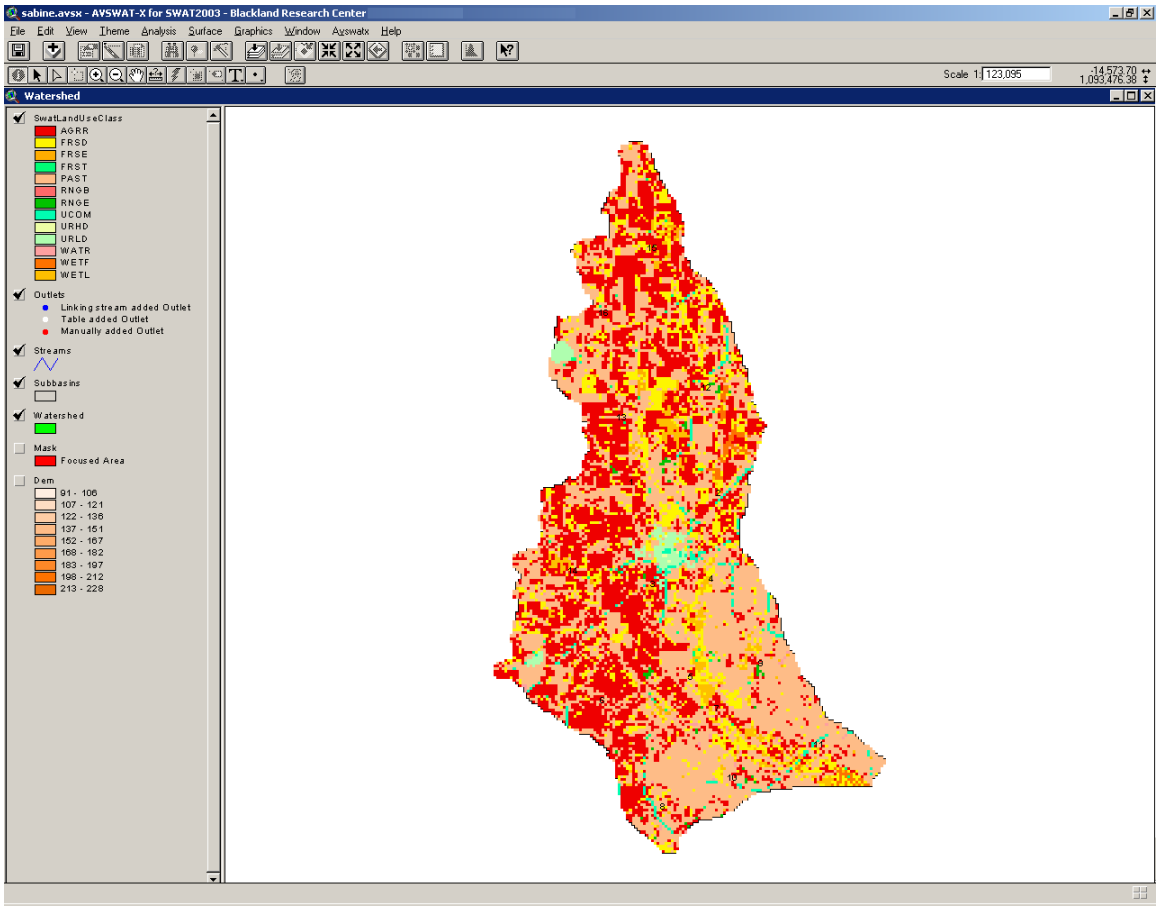


Figure 1.31

16. To load the example soil map, click  beside the Soil Grid text field.

17. A prompt box will appear (Figure 1.32).

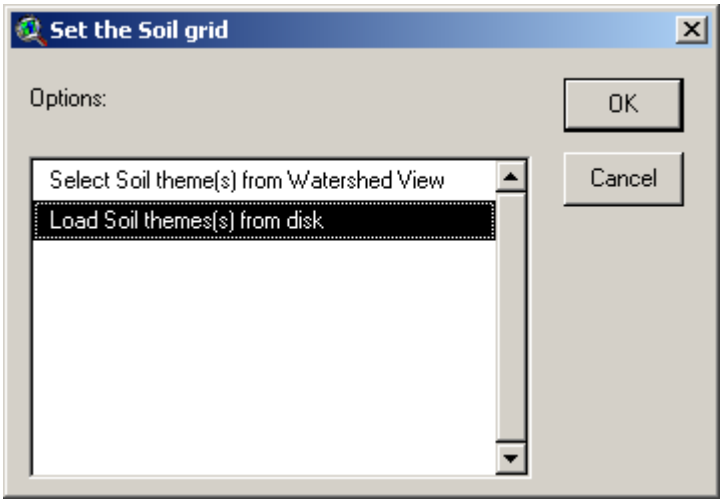


Figure 1.32

Highlight Load Soil theme(s) from disk and click OK.

18. **Another prompt box will appear for the user to define the map format. Select Shape and click OK.**

19. **A browser will appear with the User Data directory active. Click the name of the soil map (*soils*). Click OK to confirm the choice.**

20. **A message box will appear reminding the user that the data must be projected. Click Yes.**

21. **The raw soil map will be displayed and clipped to the watershed area (Figure 1.33).**

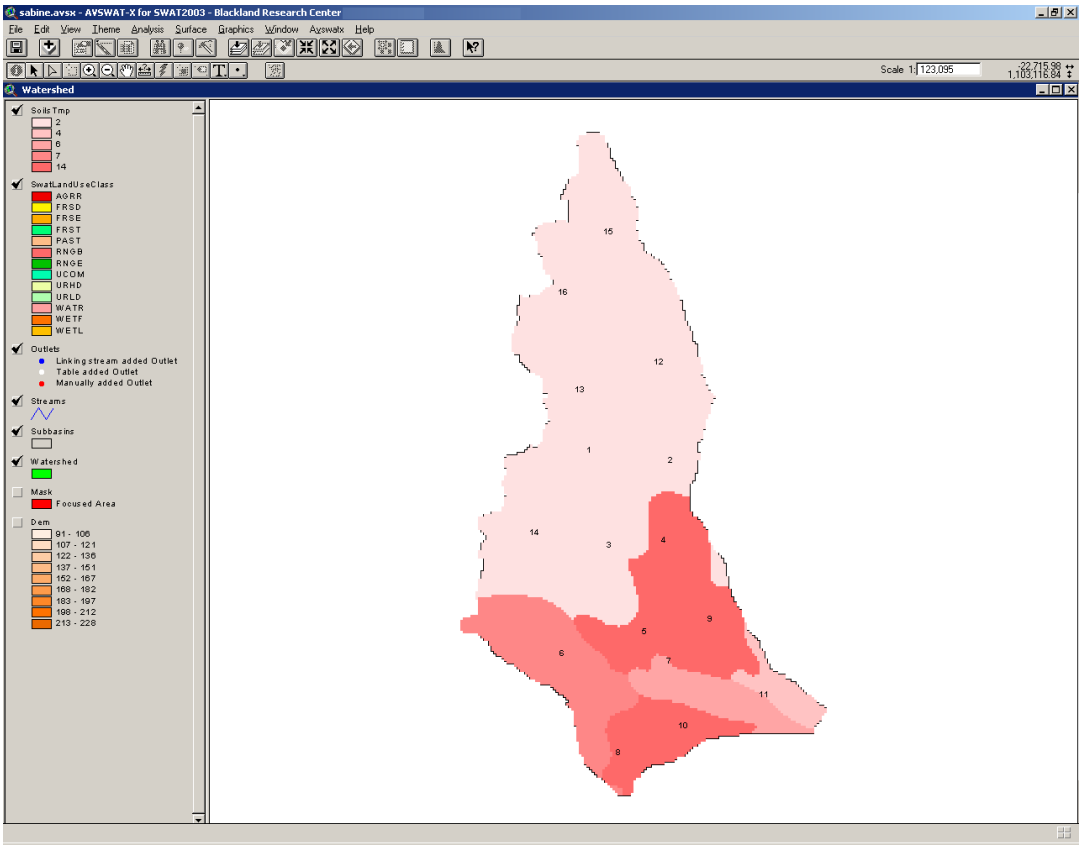
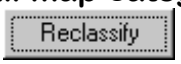


Figure 1.33

A message box will also appear reminding the user to load the look-up table for the map. Click OK.

22. **Five options for linking the soil map grid to the soil database are described in Section 6. The example data set is set up to link via STATSGO polygon numbers. On the Land Use/Soil dialog box, select the Stmuid option for linking the soil grid to the soil database** 

.

23. **The soil linkage information will be displayed in the scrollable listing on the Land Use/Soil dialog box). In this case a *Stmuid* code has been assigned automatically to all map categories, the Reclassify button will be enabled. Click the** 

button.

24. **The category display for the map will show the soil codes (Figure 1.34).**

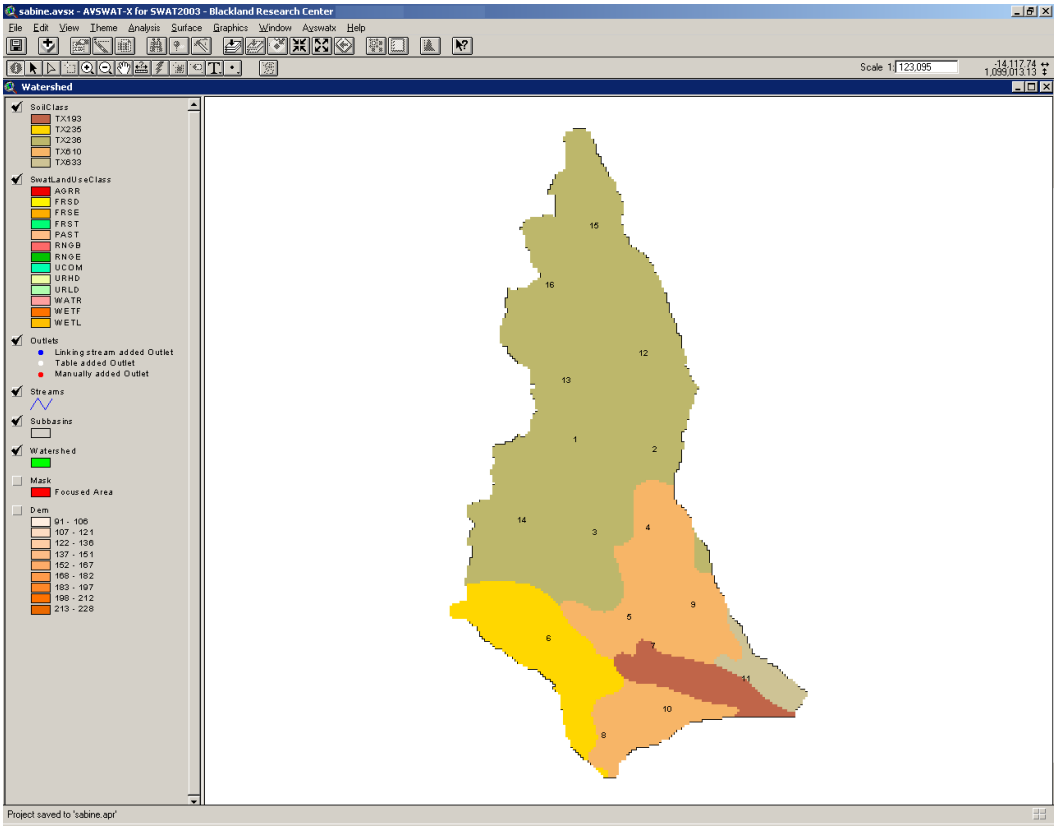


Figure 1.34

25. Once the land use and soil map grids have been loaded and reclassified, click the button labeled Overlay at the bottom of the Land Use/Soil dialog box.

26. When the overlay of the land use and soil map grids is complete, a prompt box will notify the user that the overlay process is complete. Click OK.

27. A report is generated during the overlay process. To access the report, select Reports under the Avswatx menu. From the list of reports, select *SWAT model: LandUse and Soil Distribution* and click OK.

28. Close the report after viewing.

SECTION 1.3: LAND USE/SOIL DISTRIBUTION

1. Select HRU distribution from the Avswatx menu (Figure 1.35).

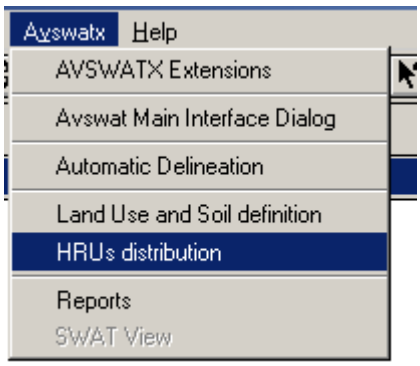


Figure 1.35

2. **The Land Use/Soil Distribution dialog box will be displayed**

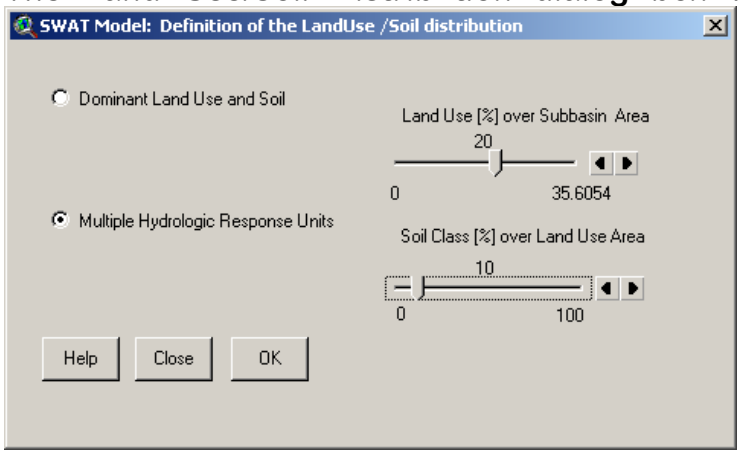


Figure 1.36

3. **Select the Multiple Hydrologic Response Units option and set the Land Use % Threshold =10, and the Soil Class % Threshold = 10 (Figure 1.36).**

   Click OK

4. **A message box will be displayed notifying the user when setup of HRUs is completed. Click OK.**

5. **A second message box is displayed notifying the user that the SWAT View is now active. Click OK. The interface will automatically switch to the SWAT View.**

6. **A report is generated during the HRU creation process. To access the report, select Show List under the Reports menu. From the list of reports, select *SWAT model: LandUse and Soil Distribution (after threshold application)* and click OK. The total number of HRUs created in the watershed is listed in the top section of the report in bold letters. The remainder of the report lists the land use and soil modeled in every subbasin and the**

percent area distribution of 1) subbasins within the watershed and 2) HRUs within the subbasins.

7. Close the report after viewing.

SECTION 1.4: WEATHER STATIONS

1. To load the example weather data, click Weather Stations under the Input menu (Figure 1.37).

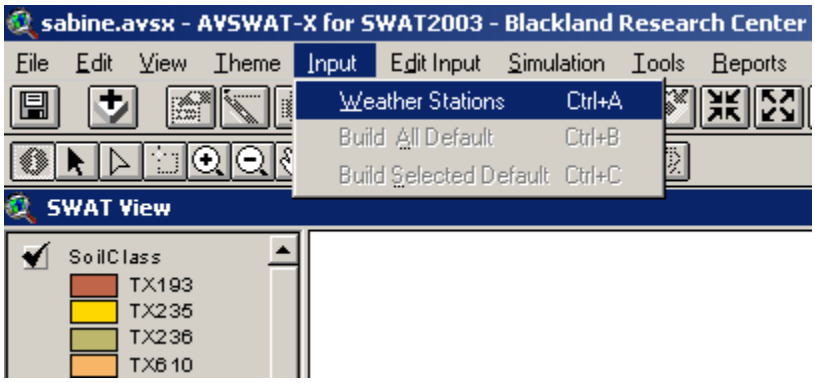


Figure 1.37

2. The Weather Data dialog box will be displayed (Figure 1.38).

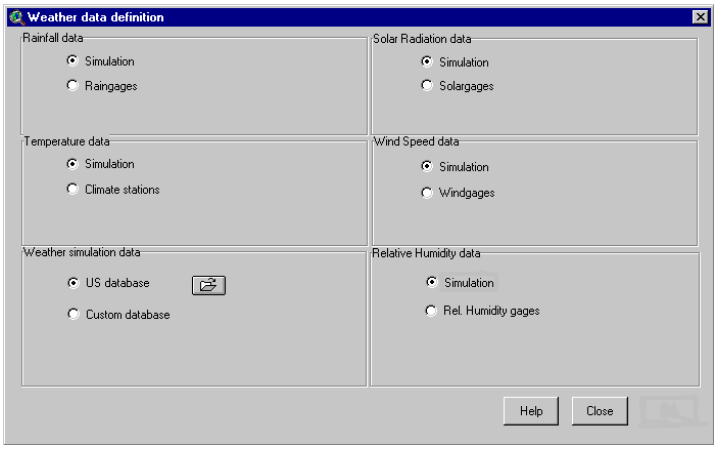


Figure 1.38

The example data set contains data files with measured precipitation and temperature for weather stations around the watershed.

3. To load the table containing the locations of the rain gage stations, click the radio button next to Raingages in the section of the dialog box labeled Rainfall data.

A text box will appear at the bottom of the Rainfall data section. Click  beside the text field.

A browser will be displayed. Click the name of the rain gage location table (*pcpfork.dbf*) then click OK.

The locations of the rain gages will be displayed as squares (Figure 1.39).

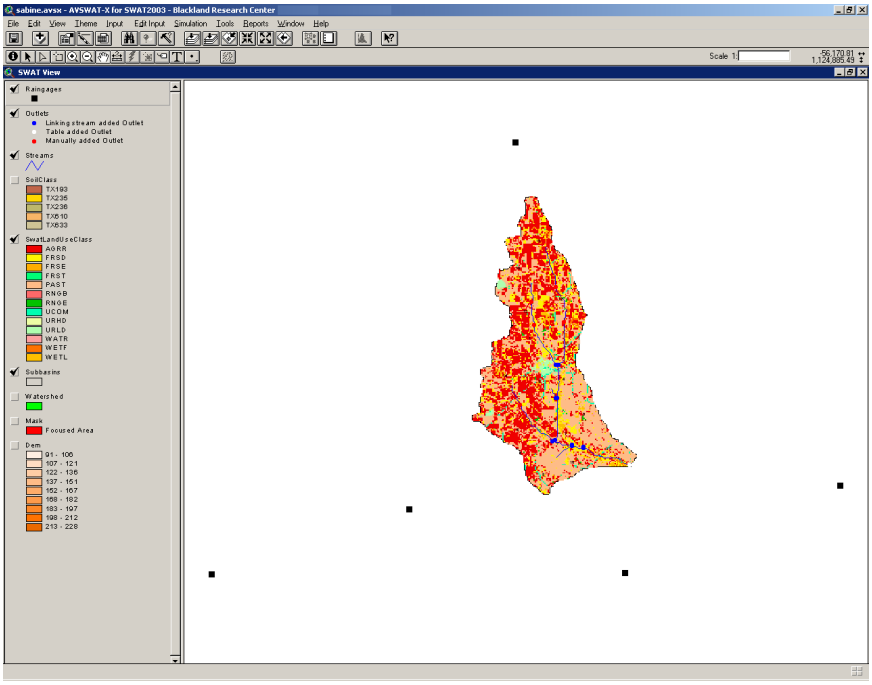


Figure 1.39

4. To load the table containing the locations of the temperature gage stations, click the radio button next to Climate stations in the section of the dialog box labeled Temperature data.

   A text box will appear at the bottom of the Temperature data section. Click  beside the text field.

   A browser will appear. Click the name of the climate station location table (*tmpfork.dbf*) and then click OK.

   The locations of the temperature gages will be displayed as triangles.

   For a SWAT simulation using measured weather data, weather simulation information is needed to fill in missing data and to generate relative humidity, solar radiation and wind speed. The example data set uses weather generator data loaded into the United States database. Click  beside the text field.

The locations of the weather generator stations will be displayed as stars.

5. Once the weather generator data is loaded, a button labeled OK will appear at the bottom of the Weather Data dialog box. Click this button. The interface will assign the different weather station data sets to the subbasins in the watershed.

6. A prompt box will appear when processing of the weather data is complete. Click OK.

SECTION 1.5: CREATE ARCVIEW DATABASES & SWAT INPUT FILES

1. On the Input menu, click Build All Default (Figure 1.40).

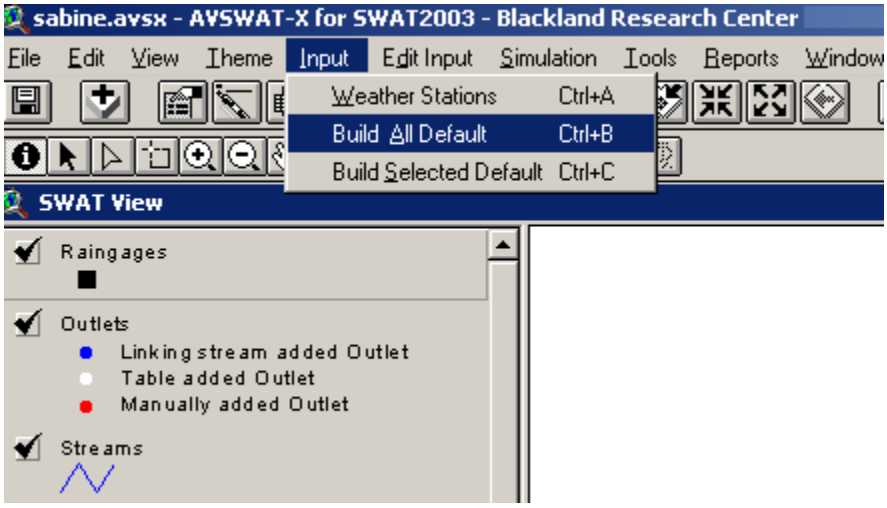


Figure 1.40

This creates the ArcView databases image of the SWAT input files containing default settings for SWAT input.

2. A message box will appear requesting the user to confirm the Write All command. Click Yes.

3. A Configuration Options box will appear click on continue.

4. When the interface reaches the point where general subbasin data is compiled, a prompt box will appear asking the user of the default Manning's n value of 0.014 for overland flow should be changed. Click No.

5. When the interface reaches the point where main channel data is compiled, a prompt box will appear asking the user of the default Manning's n value of 0.014 for channel flow should be changed. Click No.

6. When the interface reaches the point where management data is compiled, a prompt box will appear asking if plant heat units should be estimated or set to a default value. Click Yes to estimate.
7. A message box will be displayed upon completion of the SWAT input database initialization. Click OK.
8. Click the Continue button on the next prompt dialog.

SECTION 1.6 RUN SWAT

1. On the Simulation menu, click Run SWAT (Figure 1.41).

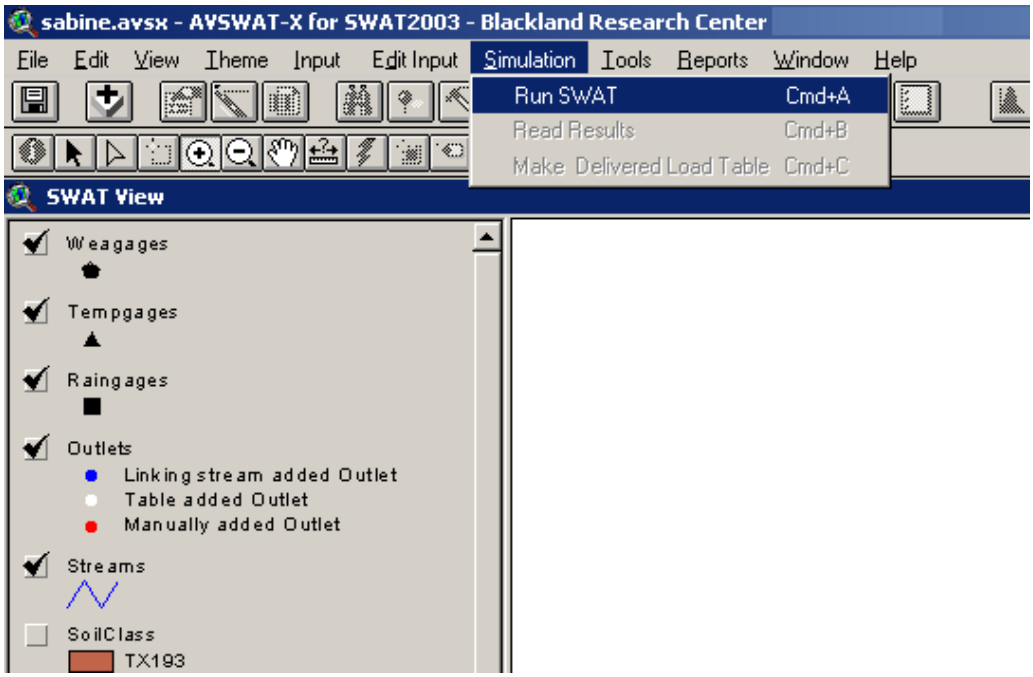


Figure 15.41

2. A dialog box will be brought up (Figure 1.42).

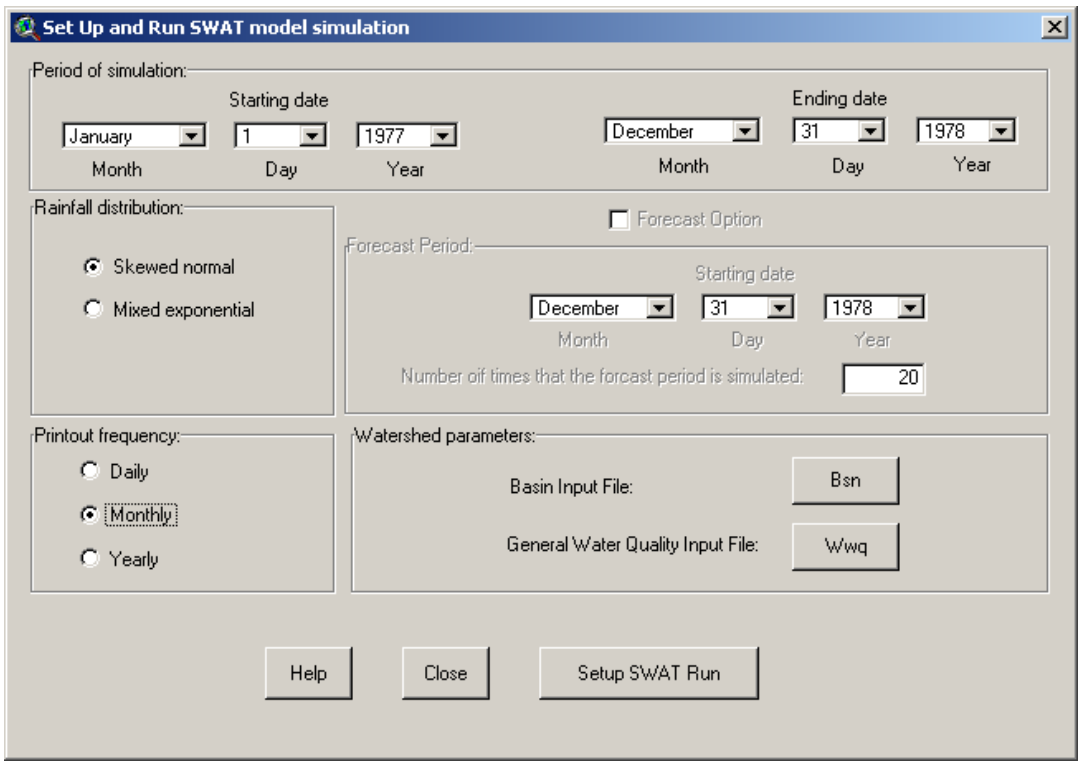


Figure 1.42

3. **The initial and final day of simulation are set to the first and last days of measured weather data. Leave those values set to 1/1/1977 and 12/31/1978. Set the Printout Frequency to Monthly. Leave all other settings as they are.**
4. **Click the button labeled Setup SWAT Run to build the climate and watershed level input files.**
5. **A prompt box will appear asking if any input files need to be rewritten from modified .dbf files. Click No.**
6. **Click the Run SWAT button.**
7. **When the SWAT run is finished, a message box will be displayed noting that the simulation was successfully completed. Click OK.**

SECTION 1.7: VIEW RESULTS

1. **A prompt box will be displayed informing about the location of the outputs and asking if the user wishes to "read" the ASCII outputs. Click Yes.**
2. **The SWAT output data is loaded into dBASE tables and displayed (Figure 1.43).**

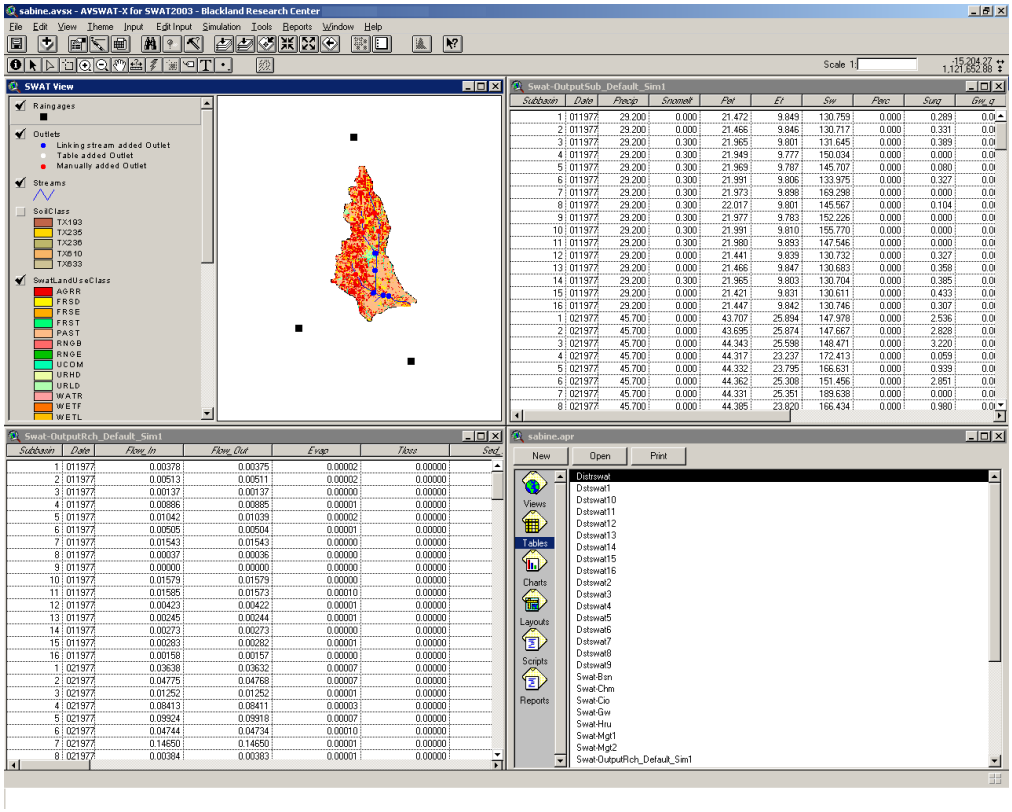


Figure 1.43

3. **To graph and map results, on the Reports menu click Map-Chart (Figure 1.44).**

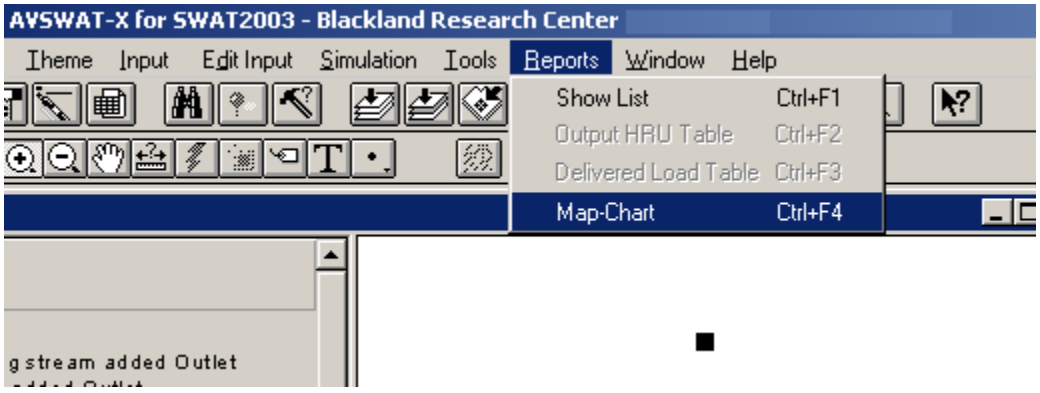


Figure 1.45

4. **Select *default* and *sim1*, click OK. (figure 1.45)**

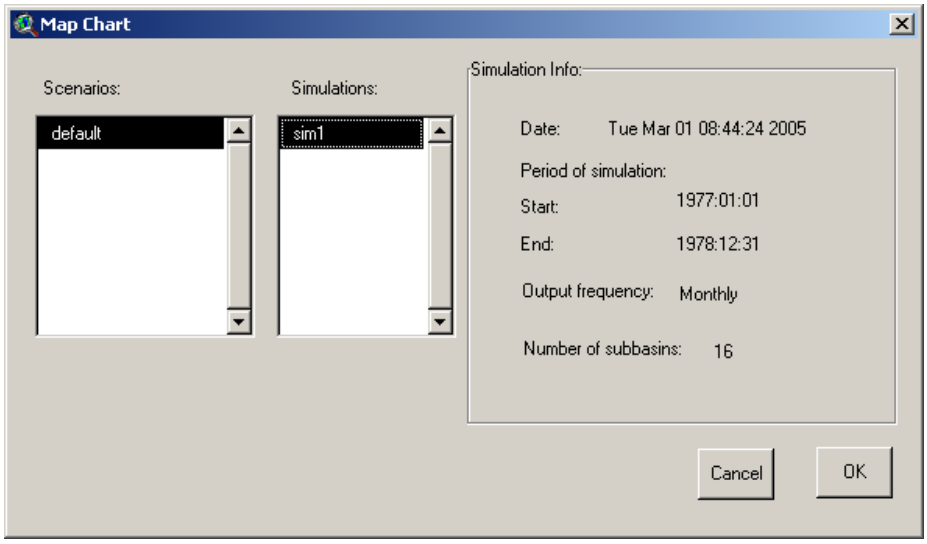


Figure 1.45

5. **Select Output Sub. Then Select, for example, the subbasin at the watershed outlet (i.e. # 11), WYLD under Variables, and 011977 through 121977 (to select multiple months hold down the Shift key while clicking the desired months). Once all the settings have been made, click OK.**

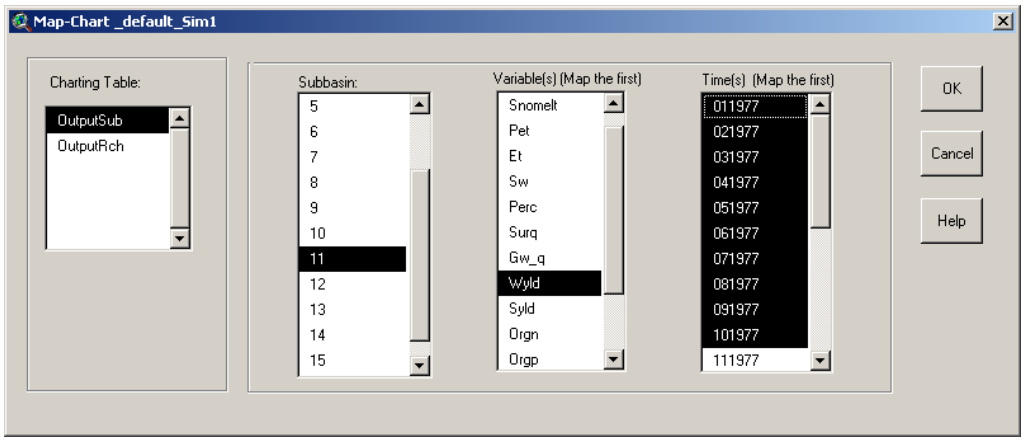


Figure 1.46

6. **A map of the WYLD for all subbasins in 01/1997 will be plotted and the water yield for the specified subbasin will be graphed (Figure 1.47).**

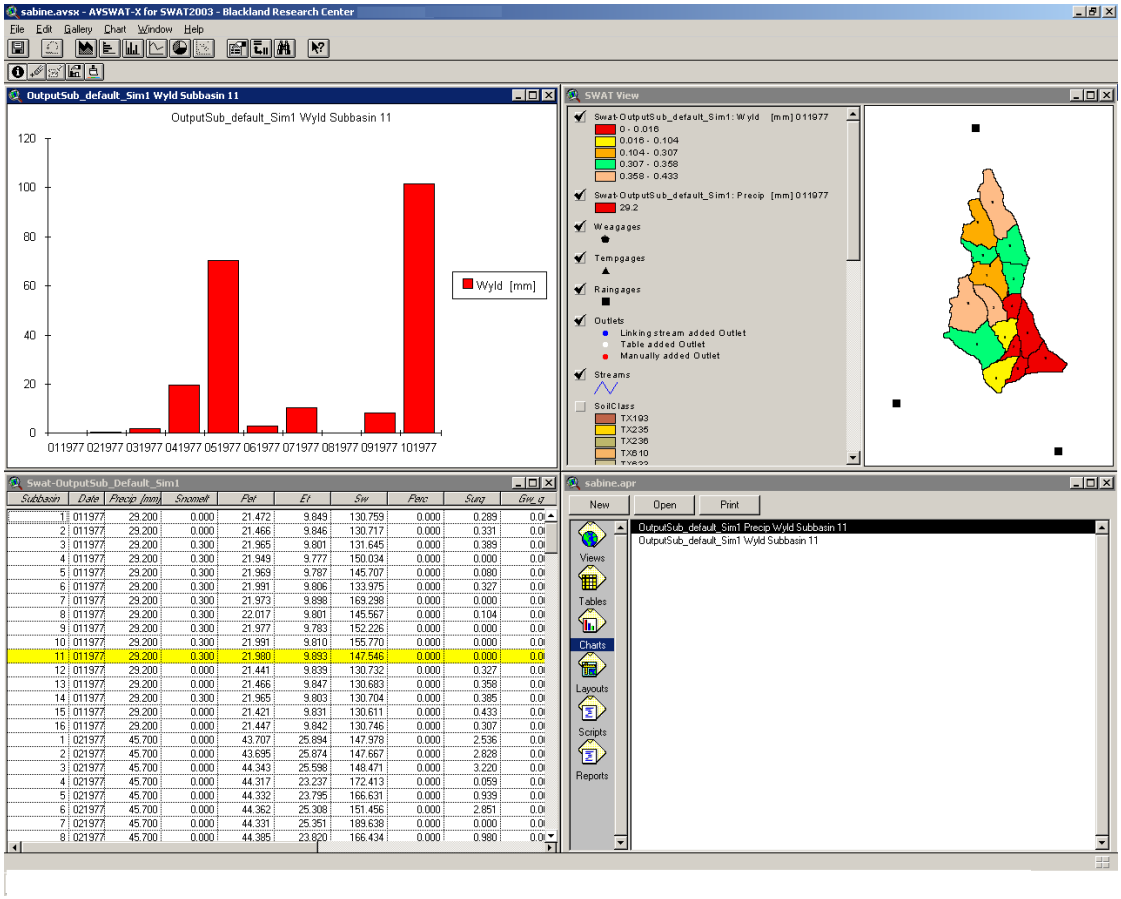


Figure 1.47

6. **To make other plots, access the dialog box by clicking Map-Chart on the Reports menu. If the ArcView menus are not listed, click the Output map and they should appear.**

7. **If desired, input data may be edited from the Edit Inputs menu. The input data at the subbasin and HRU level can be reviewed from the Subbasins data menu item (Figure 1.48).**

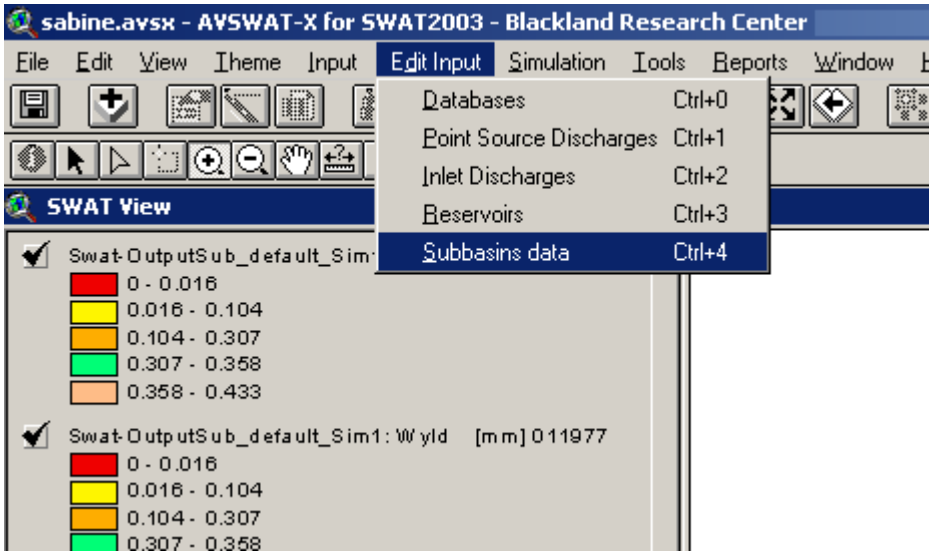


Figure 1.48

A dialog tool allows targeting any subbasin, HRU, and input file type (Figure 1.49).

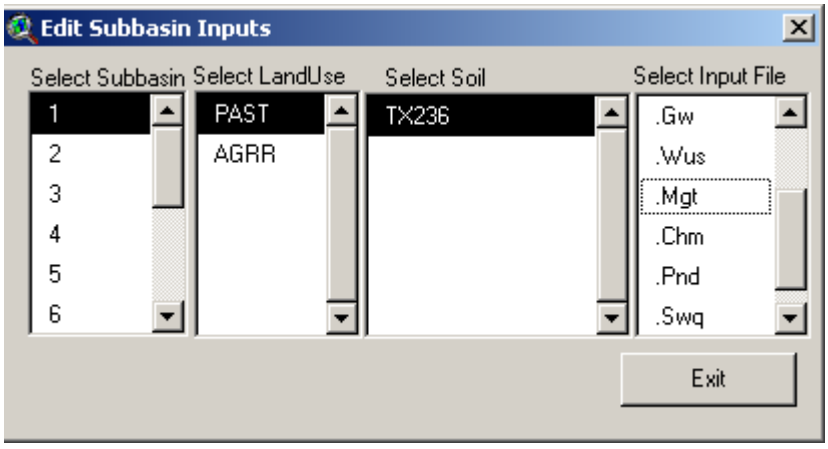


Figure 1.49

For example, explore the resources within the agricultural management tool editor (select the *mgt* input file) (Figure 1.50).

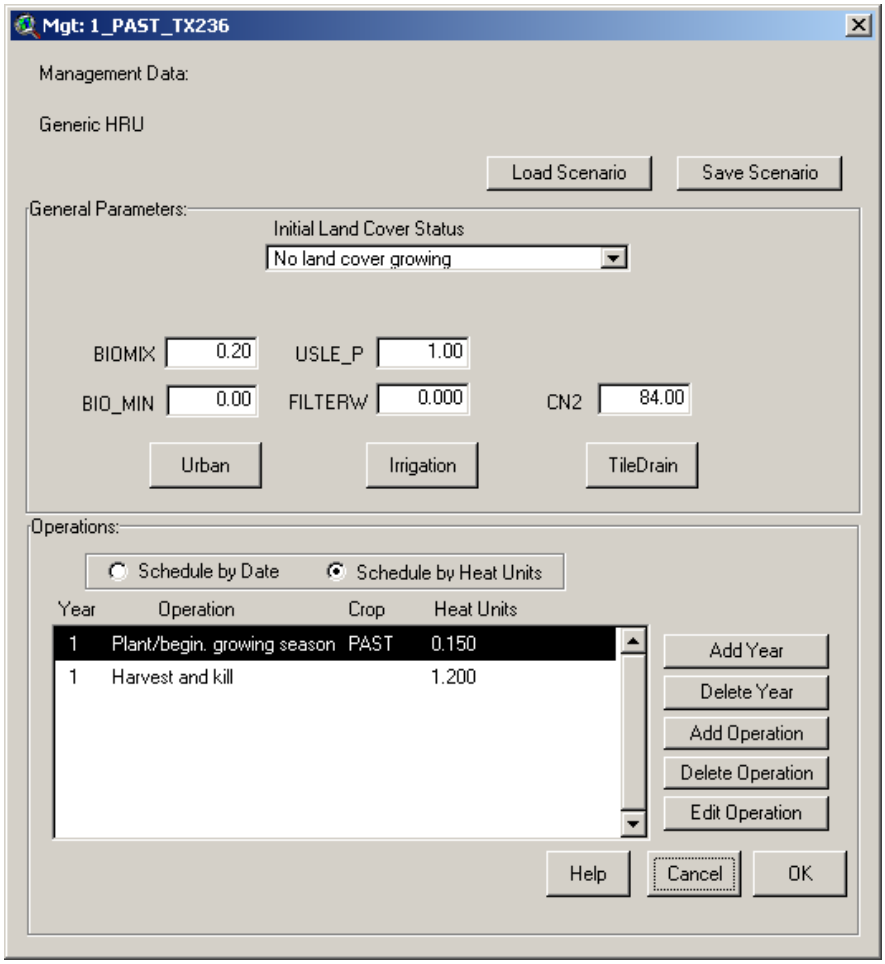


Figure 1.50

Other important input can be reviewed from the *Edit Input* menu (Figure 1.48), such as: supporting databases, point sources, inlets, and reservoirs.

After editing changes have been made, repeat the steps in Section 1..6 and 1..7 to generate and view the new output.

8. **Save your AVSWAT-X project (often while working) using the Save project button . To exit the AVSWAT-X interface, click in the map display area with the right mouse button to make the pop-up menu appear. Select Avswat Main Interface dialog on the pop-up menu. Then click the button next to Exit ArcView. A prompt box will appear to confirm the exit selection. Click Yes.**

CHAPTER 2 THE SEA (SSURGO EXTENSION FOR AVSWATX)

Introduction

The tool is developed as an addition (extension) to the SWAT model companion, the ArcView GIS interface in its latest version (AVSWAT-X), which is designed to define watershed hydrologic features; store, organize, and manipulate the related spatial and tabular data; and analyze management scenarios. Within this framework the tool expedites the otherwise complex inclusion operations of the SSURGO data, such as: (1) downloading, via the Internet (SSURGO I), up-to-date data sets (SSURGO II); (2) processing and managing variously formatted data sets in order to create the needed digital soil maps; (3) generating and/or storing the required soil physical and hydraulic model input parameters derived from pedo-transfer functions; and (4) seamlessly including them in any watershed modeling framework.

Application

1. Once delineated the watershed, or any time before importing the Land Use and Soil maps, load the SSURGO Extension for AVSWATX (SEA) using the AVSWAT-X extension manager (in the Watershed view, Avswatx menu, Avswatx Extensions menu item). (Figure 2.1)

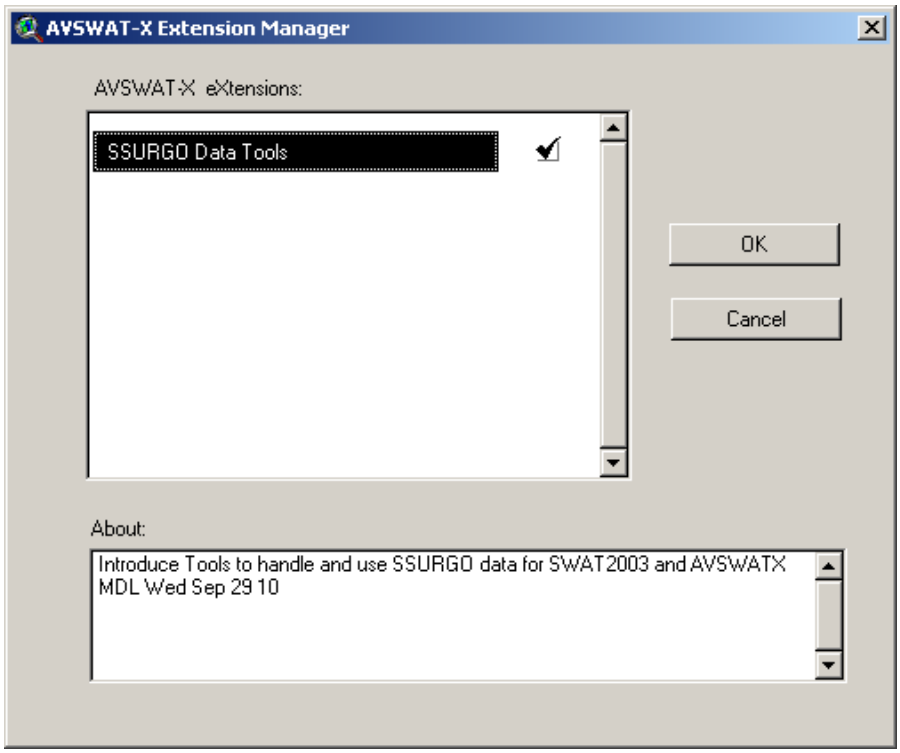


Figure 2.1

2. **Double click the listed SSURGO Data Tool item and hit OK.**
   If the project has been already set up with a land use and/or soil map a warning message will show up (Figure 2.2). Click Yes.

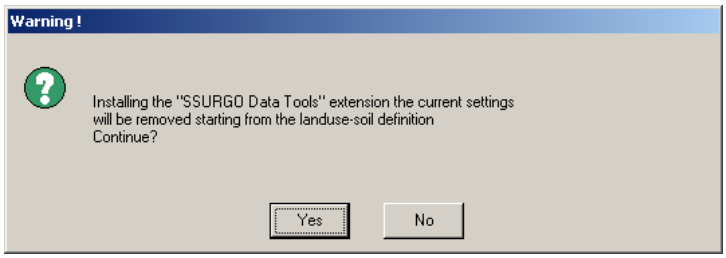


Figure 2.2

   The extension will be loaded in AVSWATX.

3. **Select the Land Use and Soil definition item from the AVSWATX menu; in the Definition of Soil and Land Use Themes dialog, click on**

the Open folder button in the Soil data layer section (top right) (Figure 2.3).

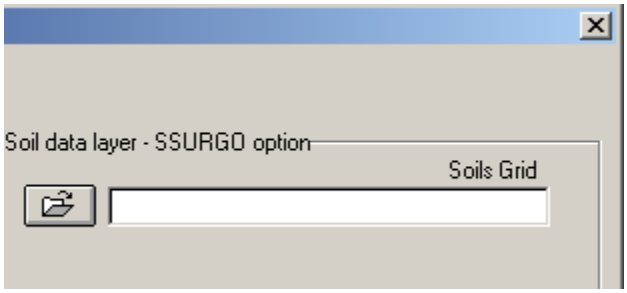


Figure 2.3

The interface will list the survey areas needed for the current study watershed. In addition will check the availability of the needed data in your disk. If the needed data are not stored in your disk, a report dialog will flag the missing Soil Survey Area(s) (Figure 2.4).

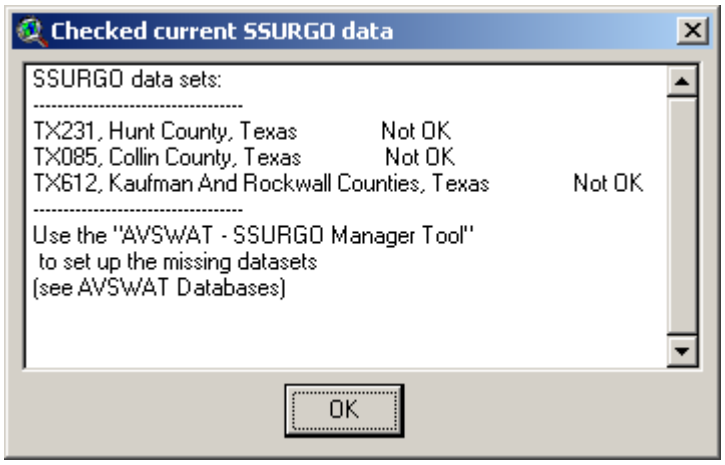


Figure 2.4

In this case, apply the SSURGO manager tool described in the next section (as exercise work on the survey area TX231) and copy the 2 folders (612 and 085) from \avswatx\AvswatDb\Workshop\ssurgo\tx to \avswatx\AvswatDb\AllUs\ssurgo\tx.

Once the data are already correctly stored in the disk the report dialog will allow you to continue (Figure 2.5 and Figure 2.6).

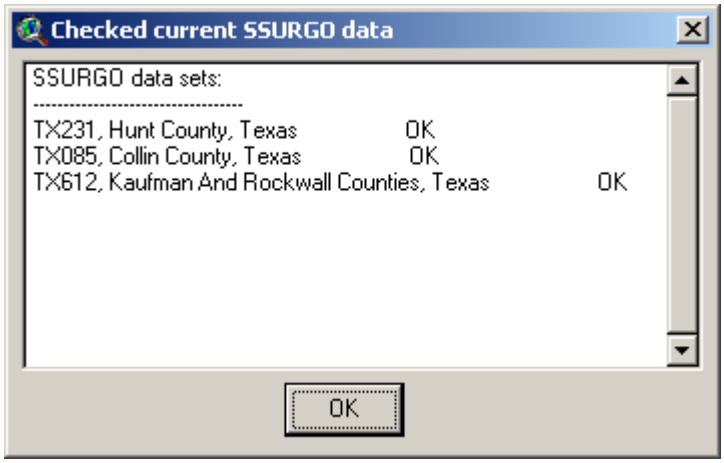


Figure 2.5

Click OK.

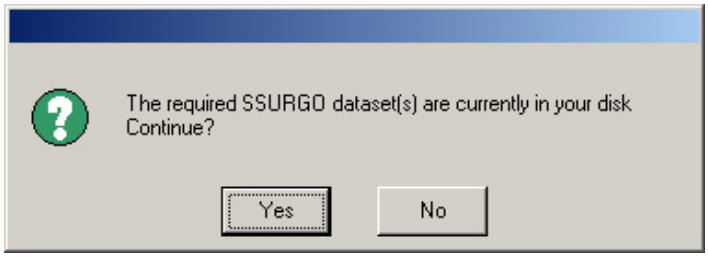


Figure 2.6

Click Yes. The survey area map will be loaded, projected, merged and clipped on the watershed (Figure 2.7).

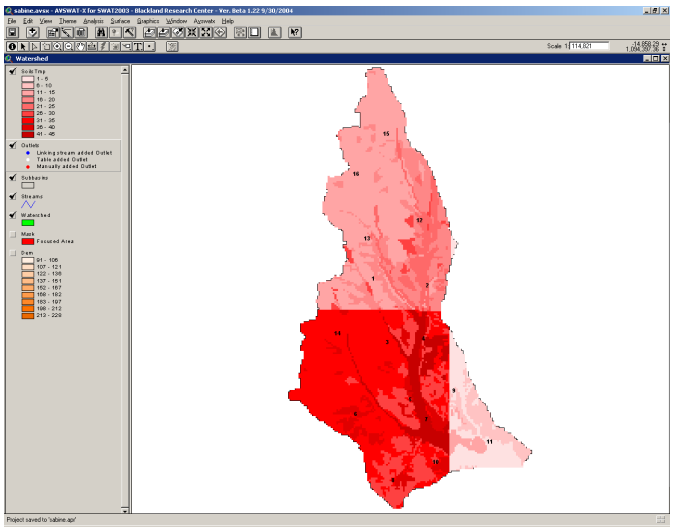


Figure 2.7

Check the Stmuid radio button (other options are available: ask me!) and click the reclassify button.

The watershed is now set up with the SSURGO data (Figure 2.8 and 2.9).

You can proceed with the usual HRUs definition tool. SSURGO soil parameters will be acquired from the databases previously populated (see next section).

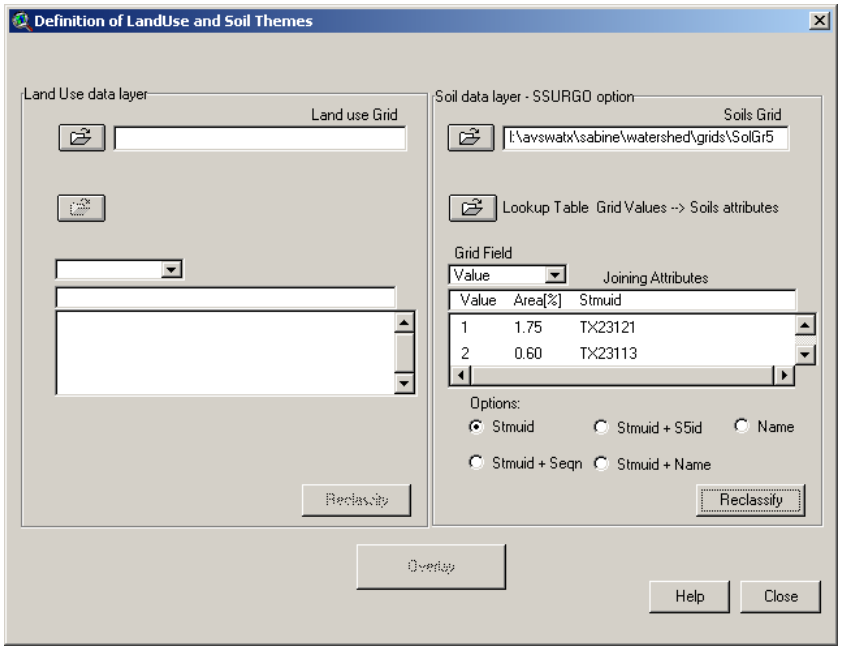


Figure 2.8

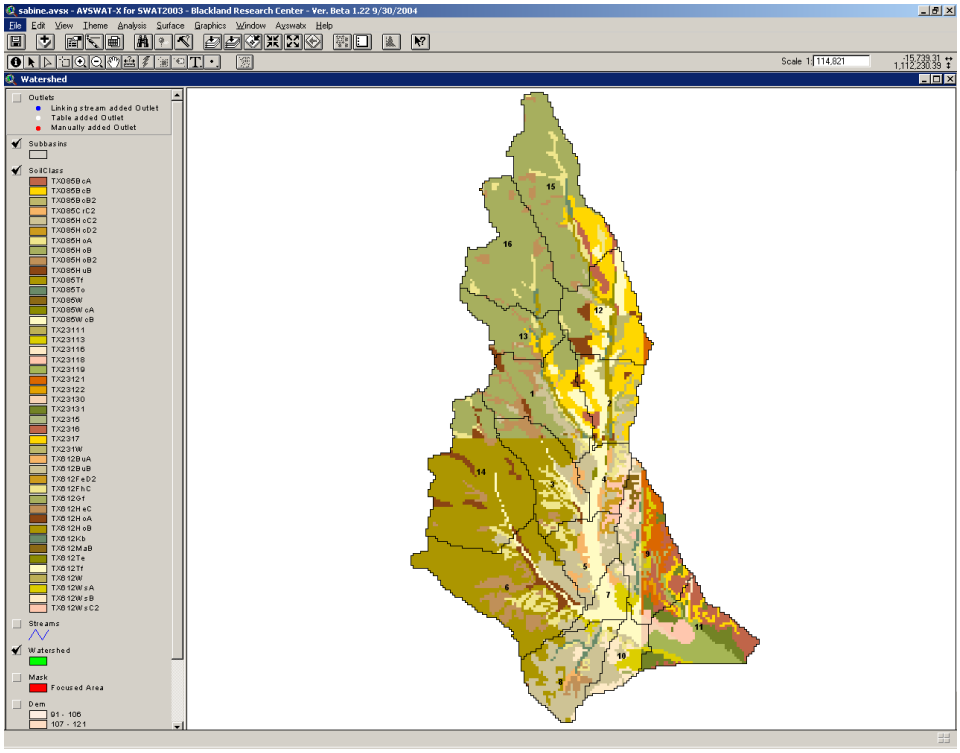


Figure 2.9

Acquisition and preparation of the SSURGO data

You should acquire and preprocess the SSURGO data packages for the Soil Survey Areas (SSAs) overlapping your study watershed (see previous section to identify them). Load the SSURGO Data manager from the list of AVSWAT Databases, double click on the SSURGO Data Manager item (Figure 2.10).

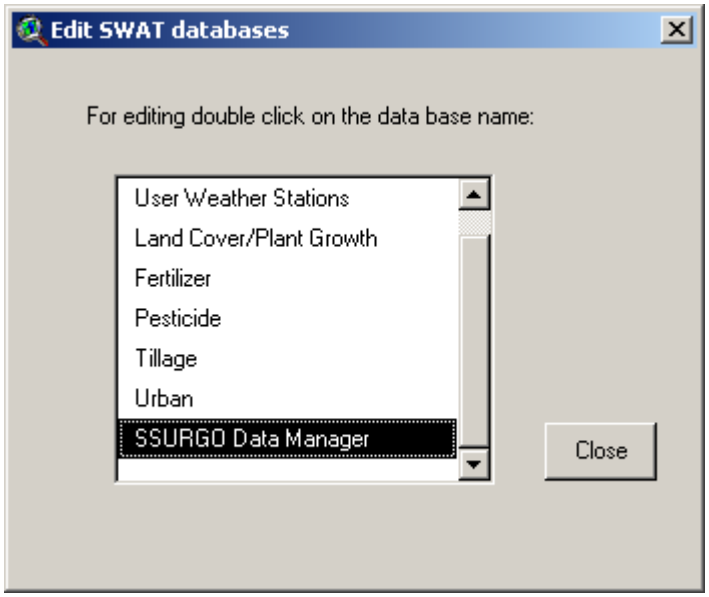


Figure 2.10

The SSURGO Data Manager dialog will open. Select the State and the Stssald (two-letter state abbreviation + soil survey area Id) (i.e. Texas and TX231) (Figure 2.11).

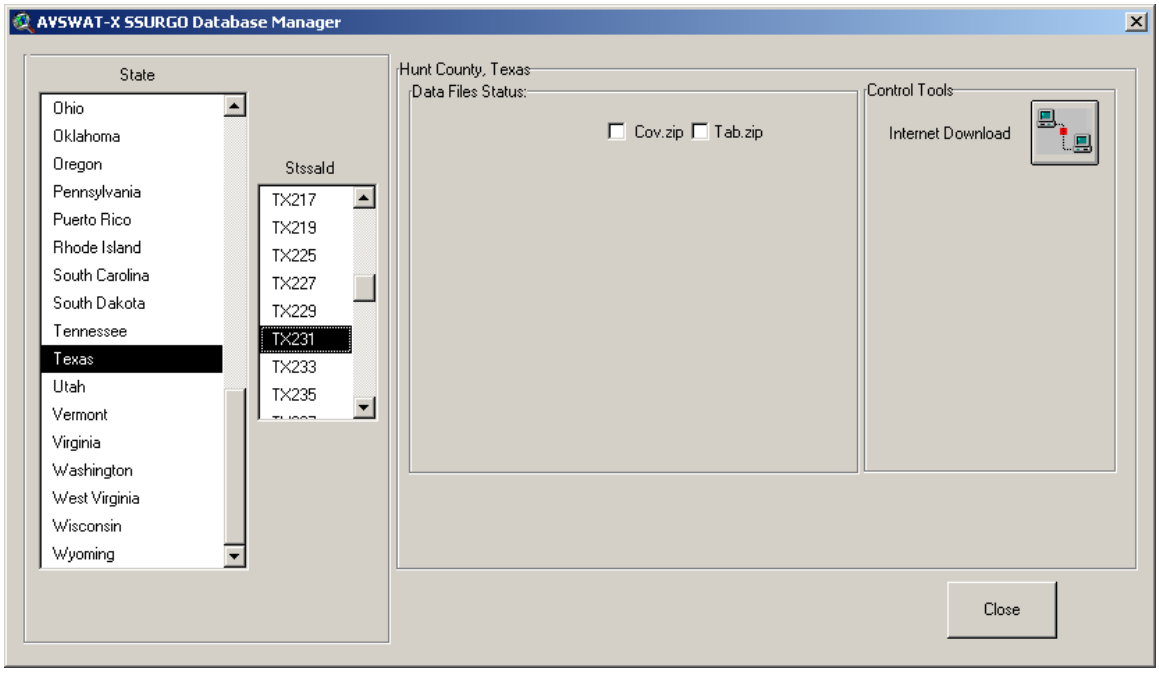


Figure 2.11

Click on the Internet Download button.

Select the Both files option (Figure 2.12).

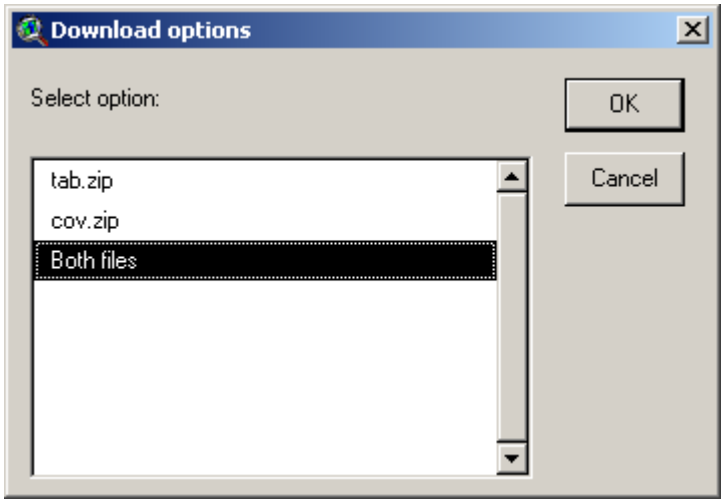


Figure 2.12

Note: You need to be connected in Internet in order to proceed. For the current workshop you may skip below. Pre-downloaded datasets are provided (see below).

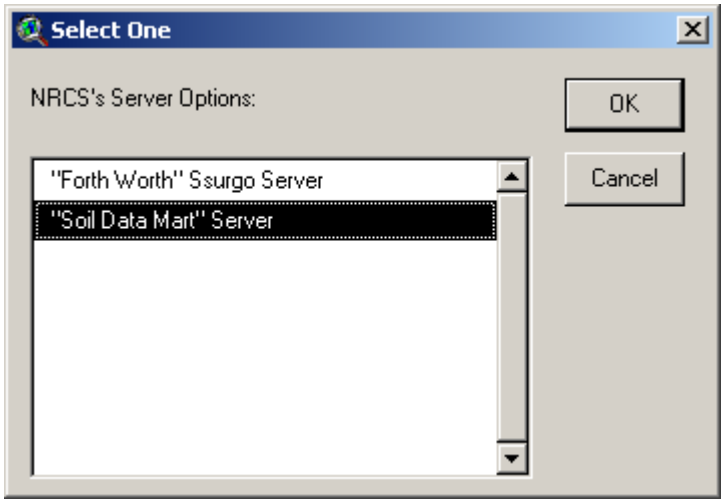


Figure 2.13

Select the Soil Data Mart Server option (all the new SSURGO data are supposed to be stored in the Soil Data Mart Server) (Figure 2.13).

Click the button Check data sets availability for the Soil survey area (i.e. TX231) (Figure 2.14).

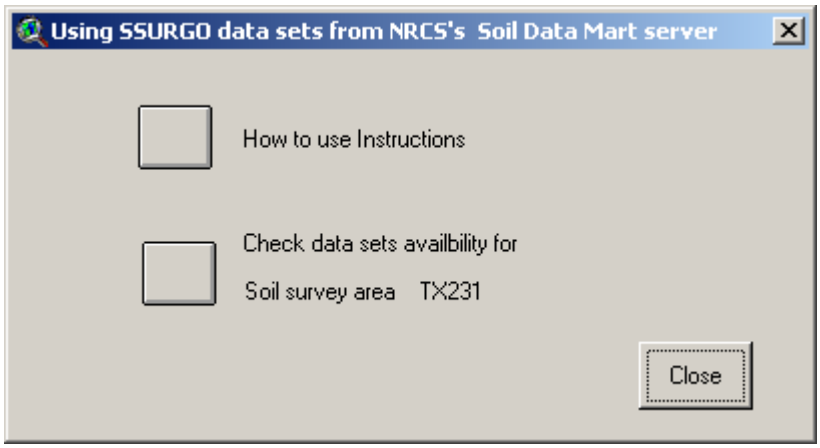


Figure 2.14

The Internet browser will be opened at the proper query page (Figure 2.15).

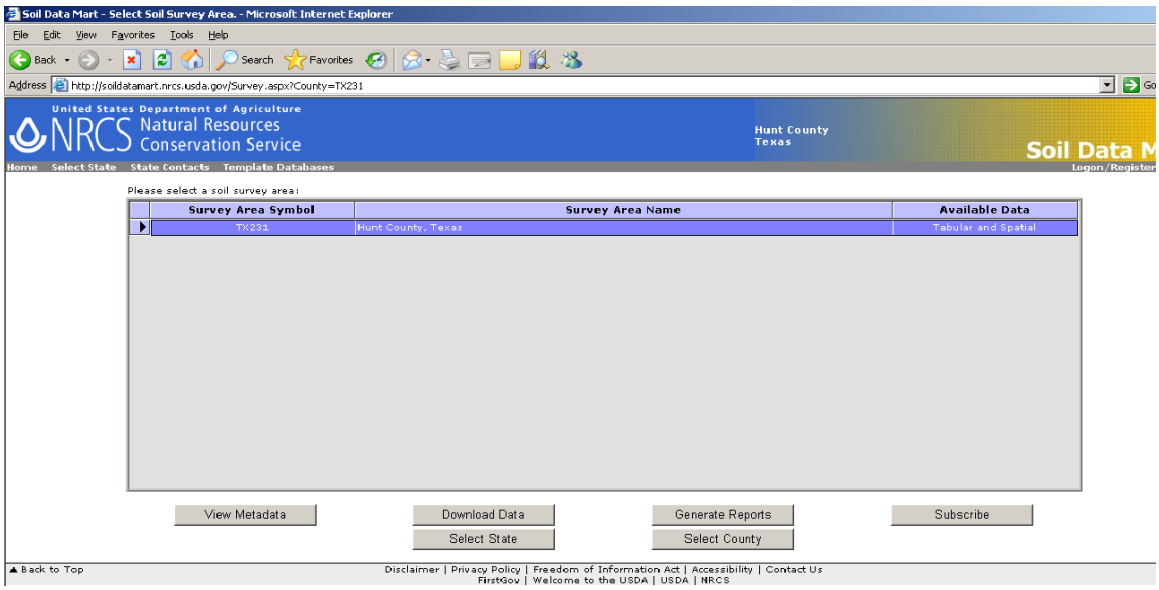


Figure 2.15

Make sure both Tabular and Spatial data are available. Otherwise you will be unable to continue.

Click the Download Data button (Figure 2.15).

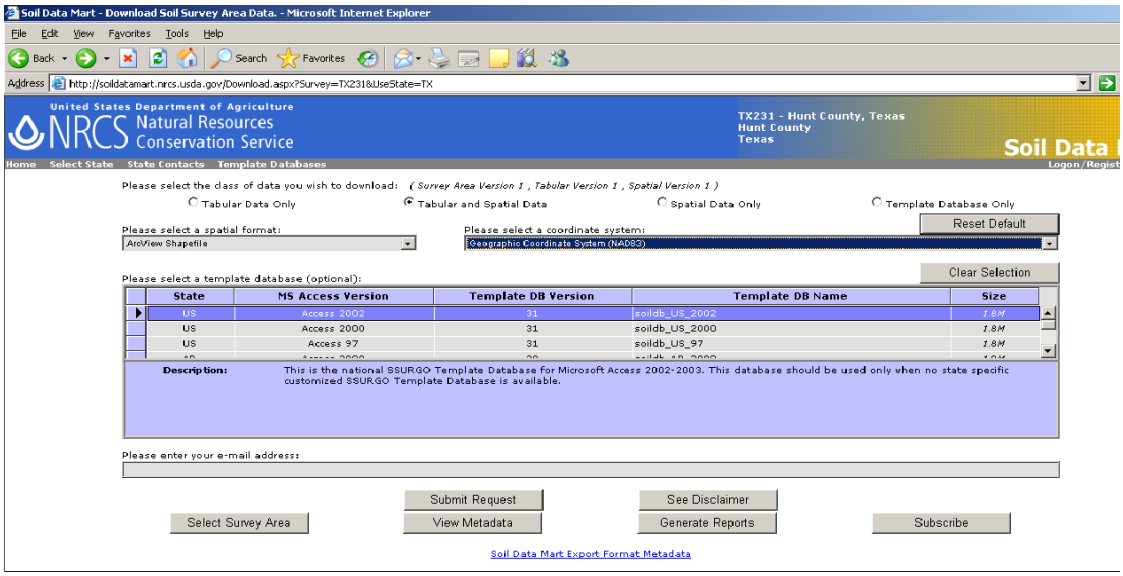


Figure 2.16

Within the new page select:

a. Tabular and Spatial data (class data);
b. ArcView Shapefile (spatial format);
c. MSAccess 2002 or 2000 (template);
d. Geographic Coordinate System (NAD83) (coordinate system) (or your working datum; i.e. NAD27)

Click the Submit Request button (do not forget to provide your email address) (Figure 2.16).

Once received the automatically generated email message, download your customized compressed file.

Note: for the workshop the data file have been pre-downloaded and stored in your \avswatx\avswatdb\workshop\ssurgo\tx231notprocessed

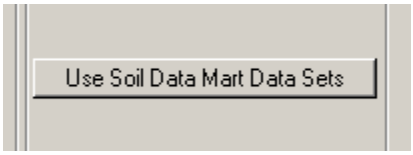
Extract (copy for the workshop) just the following files in the folder ….\avswatdb\allus\ssurgo\<StateId>\<Soil Survey Id>\sdm (do NOT keep original folder names)

i.e …..\avswatd\allus\ssurgo\tx\231\sdm

a. **soilmu_a_<stateIdSurveyId>.* files**
   (i.e. soilmu_a_TX231.dbf, soilmu_a_TX231.shx,
   soilmu_a_TX231.shp, .sbn, …sbf, …prj)
b. **comp.txt**
c. **chorizon.txt**
d. **chfrags.txt**

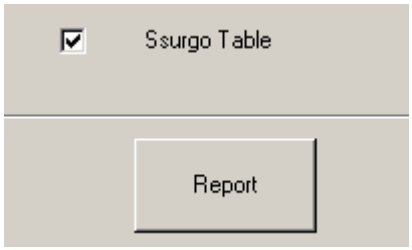
Proceed with the following steps:

a. **Click the now visible Use Soil Data Mart Data Sets button;**



b. **Click the now Visible Table Make button**

The preprocessing ends once the Ssurgo Table check box appears selected.



Review supporting information clicking on the Report button.

Useful References

Di Luzio, M., J.G. Arnold, and R. Srinivasan. 2004. Integration of SSURGO maps and soil parameters within a geographic information system and nonpoint source pollution model system. Journal of Soil and Water Conservation, 59(4): 123-133.

Di Luzio, M., J.G. Arnold, and R. Srinivasan. 2005. Effect of GIS data quality on small watershed stream flow and sediment simulations. Hydrological Processes, 19: 629-650.

CHAPTER 3: LAND USE–LAND COVER SPLITTING TOOL

Introduction

The tool is also developed as an addition (extension) of AVSWAT-X. The tool allows creating sub-classes of the original classes in the land use-land cover map and/or retaining classes from being removed using the HRUs definition tool.

Application

1. Once delineated the watershed, or any time before importing the Land Use and Soil maps, load the *Land Use – Land Cover Splitting Tool* for AVSWATX using the AVSWAT-X extension manager (in the Watershed view, Avswatx menu, Avswatx Extensions menu item). (Figure 3.1).

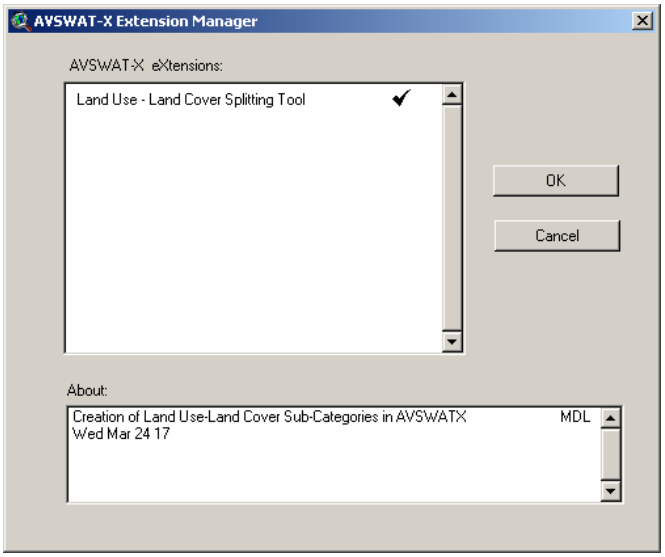


Figure 3.1

2. Double click the listed *Land Use – Land Cover Splitting Tool* item and hit OK. If the project has been already set up with a land use and/or soil map a warning message will show up (Figure 3.2). Click Yes.

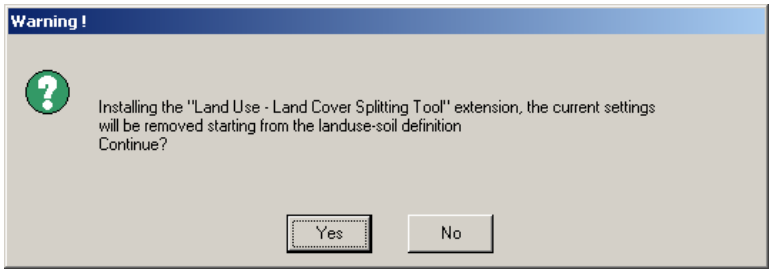


Figure 3.2

The extension will be loaded in AVSWATX.

3. Select the Land Use and Soil definition item from the AVSWATX menu; in the Definition of Soil and Land Use Themes dialog, click on the Open folder button in the Land Use data layer section (top left) (Figure 3.3).

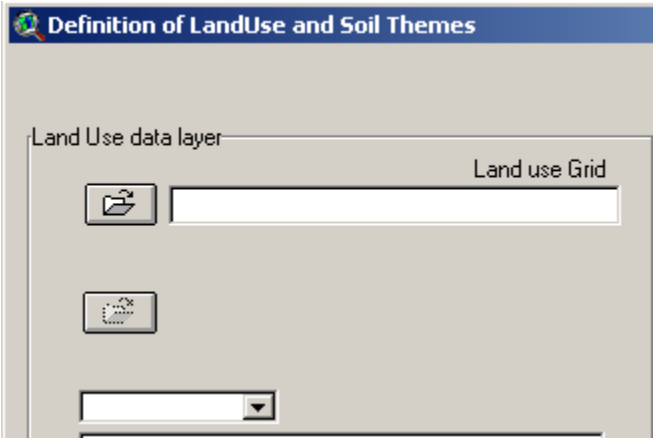


Figure 3.3

4. Like in Section1, proceed loading the Land use map in \example3 and load the same look-up table (*lunlcd.dbf*).
5. Scroll down the *Land Use Swat* list and Double click on the *AGRR* item. The Land Use Reclass Options Dialog will open (Figure 3.4).

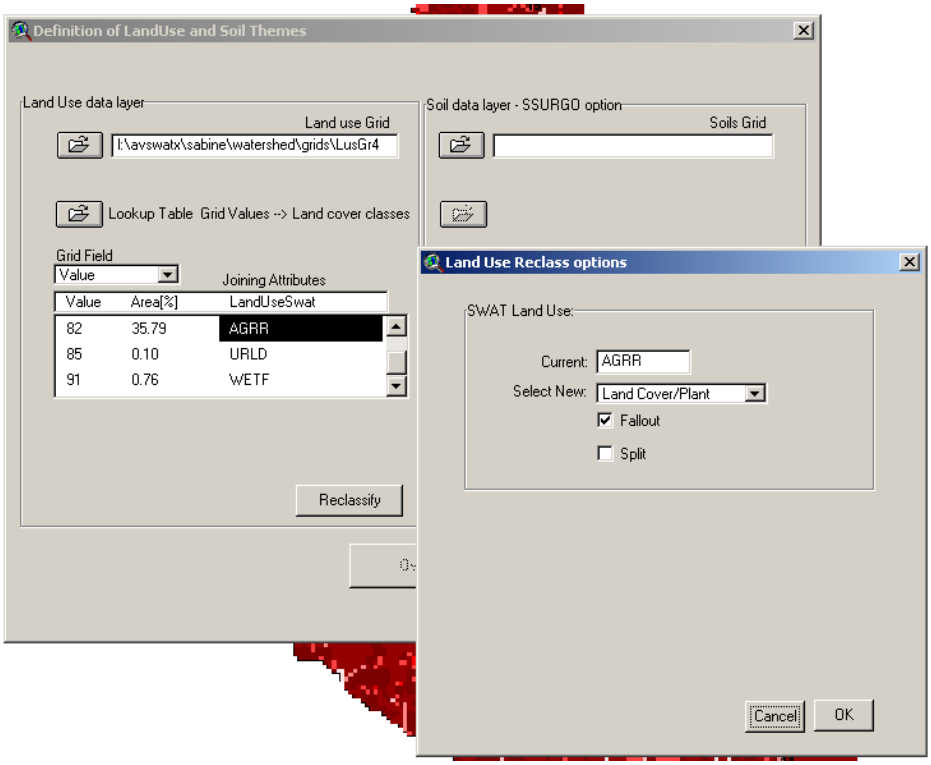


Figure 3.4

6. Select the Split check box.

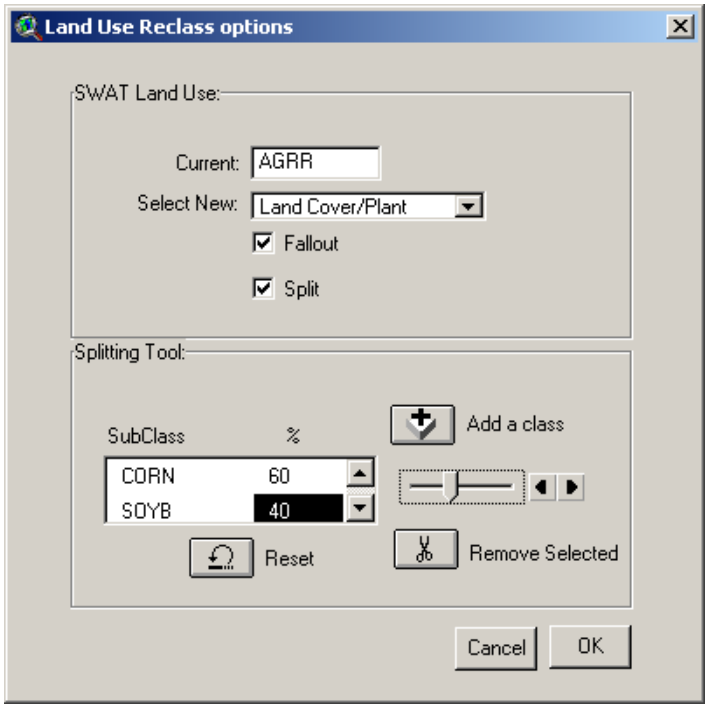
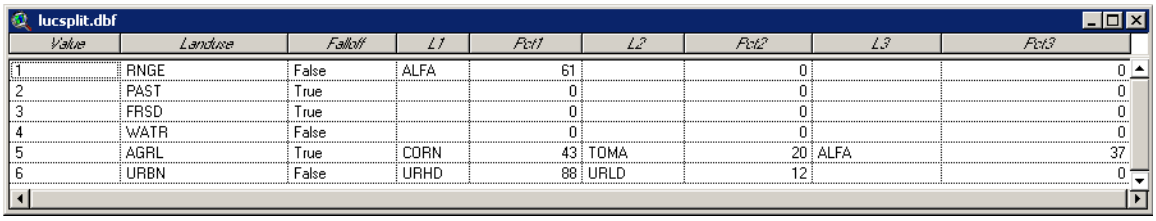


Figure 3.5

The available tools allow defining the new subclasses and their proportion (Figure 3.5).

Note 1: If the *Fallout* check box is selected, the subclasses will be sensitive to the Land Use % threshold used in the HRUs definition tools (see Section 1). Unselecting this option will determine these defining subclasses to be retained as HRUs, regardless the threshold value.

Note 2: The various settings (definition of the subclasses, splitting proportions, and fall out option) can be defined using a customized Lookup table (an example, the Lucsplit.dbf file is stored within the \example3 folder) (Figure 3.6).



Value	Landuse	Falloff	L1	Pct1	L2	Pct2	L3	Pct3
1	RNGE	False	ALFA	61		0		0
2	PAST	True		0		0		0
3	FRSD	True		0		0		0
4	WATR	False		0		0		0
5	AGRL	True	CORN	43	TOMA	20	ALFA	37
6	URBN	False	URHD	88	URLD	12		0

Figure 3.6

CHAPTER 4: SENSITIVITY ANALYSIS, AUTOMATIC CALIBRATION AND UNCERTAINTY ANALYSIS

Introduction

The tools are grouped in an addition (extension) of AVSWAT - X. The tools allow operating a sensitivity analysis of the model input parameters, applying methods for the model automatic calibration and for the assessment of the uncertainty analysis.

Application

1. Load this extension using the AVSWAT-X extension manager; in the Watershed view, Avswatx menu, (or in the SWAT View, Tools Menu) Avswatx Extensions menu item.

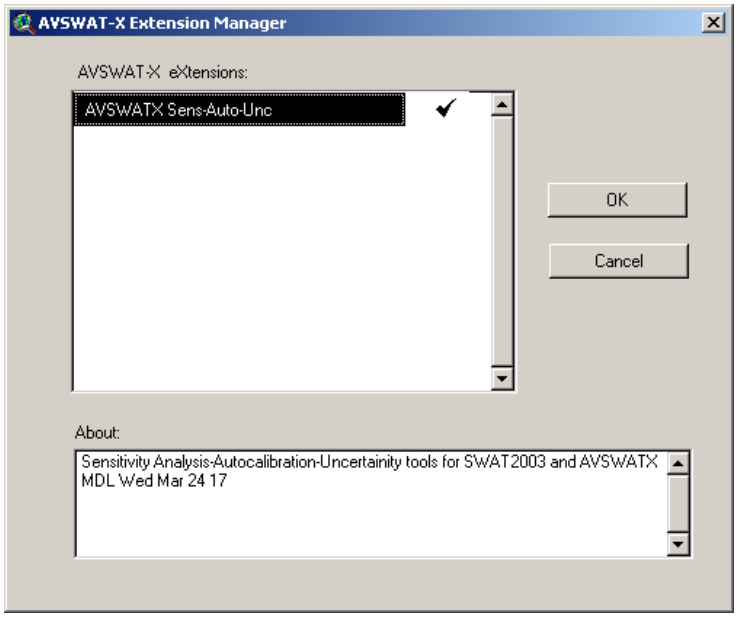


Figure 4.1

2. **Double click the listed AVSWATX Sens-Auto-Unc item (Figure 4.1) and hit OK.**

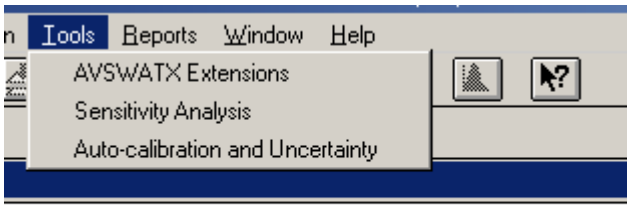


Figure 4.1

3. **Two new items are now listed (Figure 4.2): a) Sensitivity Analysis and 2) Auto-calibration and Uncertainty.**

Sensitivity Analysis

1. **A new dialog will open selecting the *Sensitivity Analysis* item. This dialog allows you to select the scenario and the simulation target of the sensitivity analysis (Figure 4.2).**

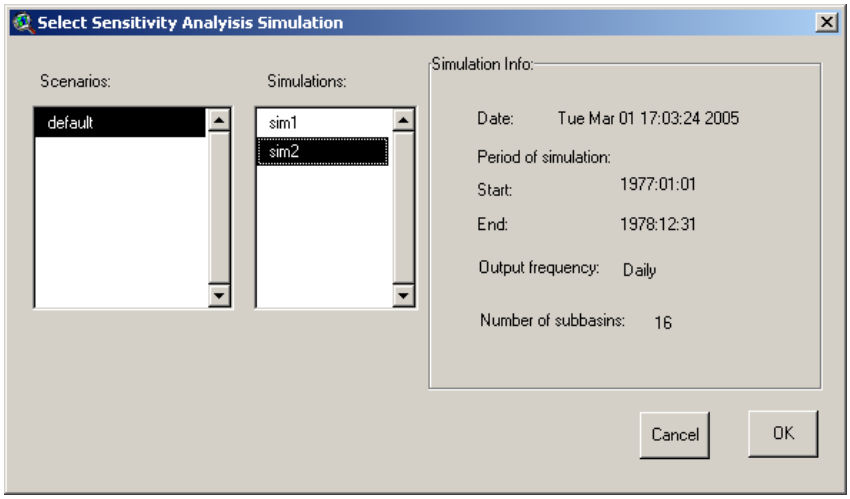


Figure 4.2

2. **Once pressed the OK button a new dialog will open (Figure 4.3).**

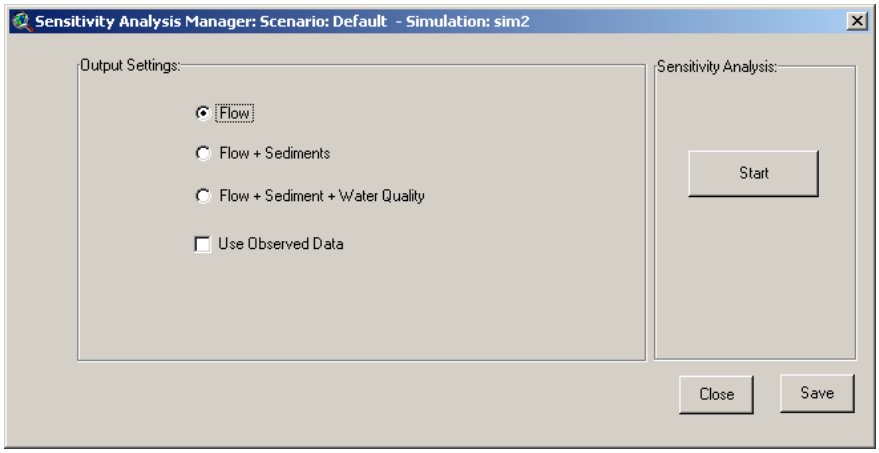


Figure 4.3

3. **The output variables are grouped in three ways, upon the simulation target (Flow, Flow+ Sediment, Flow+Sediment+Water Quality). With the (optional) usage of Observed Data will operate the sensitivity analysis on the objective function vs. using the mean average flow.**

4. **Select the Flow option and check the Use Observed Data box. A file with observation records is provided in \example3 (observ.txt). Make sure the current simulation covers the observation period, 7/1978-12/1978 (Figure 4.4).**

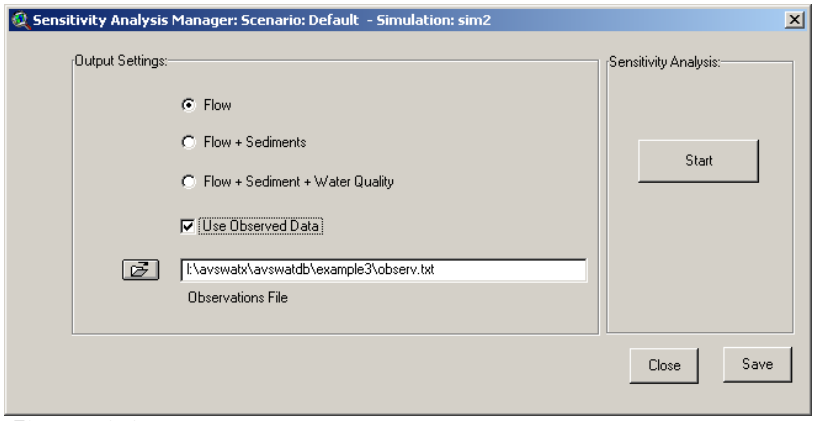


Figure 4.4

5. **Press the Save button to store the current setting, and the Start button to begin the simulation cover the observation period, 7/1978-12/1978 (Figure 4.4).**

6. **Select the target Outlet (stream section) for the analysis from another opening dialog (select the main outlet, i.e. # 11) (Figure 4.5).**

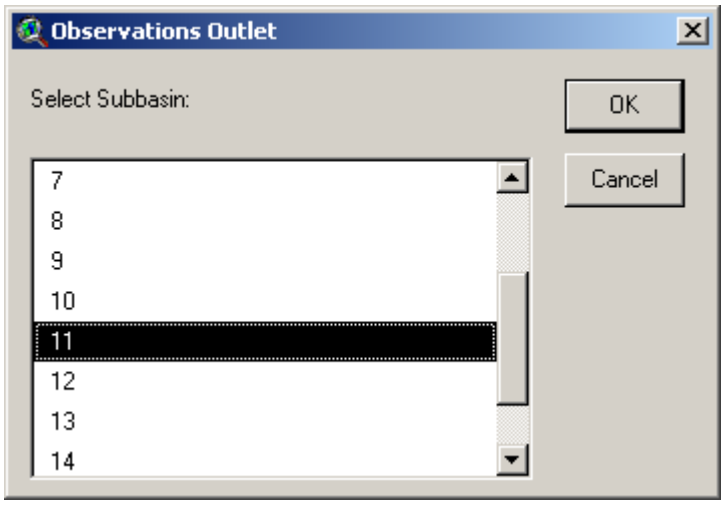


Figure 4.5

7. **A message dialog will warn about the risk of a number of long lasting iterative simulations. Press the Yes button to continue. The SWAT2003 runs will start in a DOS-window.**

Note: The interface provided the analysis using predefined sets of input variables (Table 4.1).

Par	Name	Type	Description	Location
1	ALPHA_BF	Sub	Baseflow alpha factor [days]	*.gw
2	GW_DELAY	Sub	Groundwater delay [days]	*.gw
3	GW_REVAP	Sub	Groundwater "revap" coefficient	*.gw
4	RCHRG_DP	Sub	Deep aquifer percolation fraction	*.gw
5	REVAPMN	Sub	Threshold water depth in the shallow aquifer for "revap" [mm]	*.gw
6	QWQMN	Sub	Threshold water depth in the shallow aquifer for flow [mm]	*.gw
7	CANMX	Sub	Maximum canopy storage [mm]	*.hru
8	GWNO3	Sub	Concentration of nitrate in groundwater contribution [mg N/l]	*.gw
10	CN2	Sub	Initial SCS CN II value	*.mgt
15	SOL_K	Sub	Saturated hydraulic conductivity [mm/hr]	*.sol
16	SOL_Z	Sub	Soil depth [mm]	*.sol
17	SOL_AWC	Sub	Available water capacity [mm H20/mm soil]	*.sol
18	SOL_LABP	Sub	Initial labile P concentration [mg/kg]	*.chm
19	SOL_ORGN	Sub	Initial organic N concentration [mg/kg]	*.chm
20	SOL_ORGP	Sub	Initial organic P concentration [mg/kg]	*.chm
21	SOL_NO3	Sub	Initial $N0_3$ concentration [mg/kg]	*.chm
22	SOL_ALB	Sub	Moist soil albedo	*.sol
23	SLOPE	Sub	Average slope steepness [m/m]	*.hru
24	SLSUBBSN	Sub	Average slope length [m]	*.hru
25	BIOMIX	Sub	Biological mixing efficiency	*.mgt
26	USLE_P	Sub	USLE support practice factor	*.mgt
27	ESCO	Sub	Soil evaporation compensation factor	*.hru
28	EPCO	Sub	Plant uptake compensation factor	*.hru
30	SPCON	Bas	Lin. re-entrainment parameter for channel sediment routing	*.bsn
31	SPEXP	Bas	Exp. re-entrainment parameter for channel sediment routing	*.bsn
33	SURLAG	Bas	Surface runoff lag time [days]	*.bsn
34	SMFMX	Bas	Melt factor for snow on June 21 [mm H2O/ºC-day]	*.bsn
35	SMFMN	Bas	Melt factor for snow on December 21 [mm H2O/ºC-day]	*.bsn
36	SFTMP	Bas	Snowfall temperature [ºC]	*.bsn
37	SMTMP	Bas	Snow melt base temperature [ºC]	*.bsn
38	TIMP	Bas	Snow pack temperature lag factor	*.bsn
41	NPERCO	Bas	Nitrogen percolation coefficient	*.bsn
42	PPERCO	Bas	Phosphorus percolation coefficient	*.bsn
43	PHOSKD	Bas	Phosphorus soil partitioning coefficient	*.bsn
50	CH_EROD	Sub	Channel erodibility factor	*.rte
51	CH_N	Sub	Manning's nvalue for main channel	*.rte
52	TLAPS	Sub	Temperature lapse rate [°C/km]	*.sub
53	CH_COV	Sub	Channel cover factor	*.rte
54	CH_K2	Sub	Channel effective hydraulic conductivity [mm/hr]	*.rte
60	USLE_C	Sub	Minimum USLE cover factor	crop.dat
61	BLAI	Sub	Maximum potential leaf area index	crop.dat

Table 4.1

8. **You can stop the run typing CTR+C. An example of output files is stored in \AvSwatDB\Workshop\sensitivityout. Table 4.2 lists the main output files.**

File name	Description
sensresult.out	List of parameter ranks
sensout.out	Detailed output with mean, variance and partial sensitivities
senspar.out	Parameter values of each run
sensobjf.out	Value of objective function for each run
sensrespons.out	Model output values for each run
lathyppar.out	Normalized Latin-Hypercube sampling points
oatpar.out	Normalized OAT sampling points

Table 4.2

The main output file, the sensresult.out contains the final ranking of each parameter in the analysis.

Using the interface, once the analysis is completed, this file can be reviewed pressing the Report button (Figure 4.6).

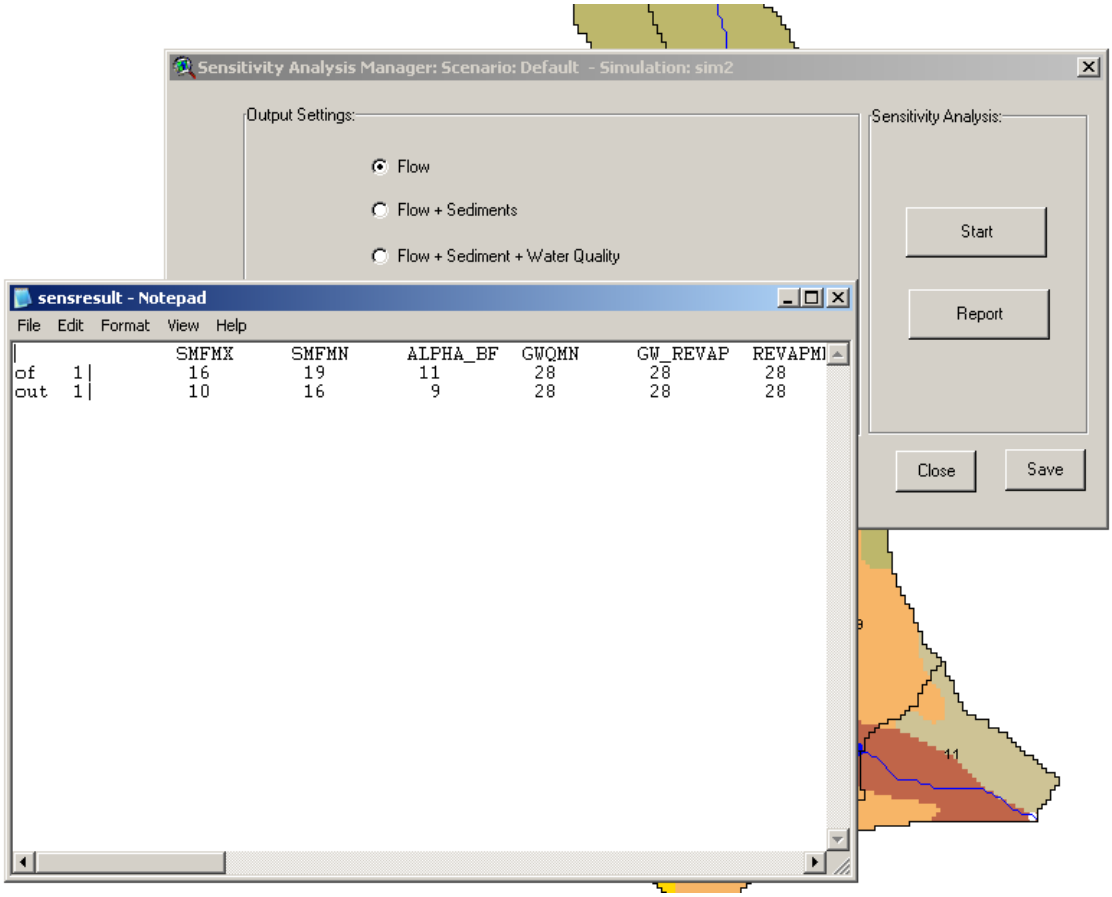


Figure 4.6

1. A new dialog will open selecting the *Auto-calibration and Uncertainty* item. This dialog allows you to select the scenario and the simulation target of the application. Select *Default* and *Sim2* (Figure 4.7).

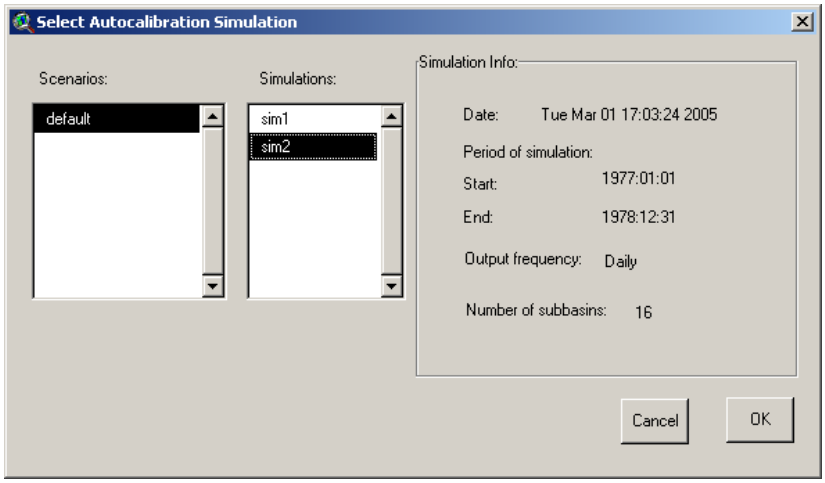


Figure 4.7

2. Once pressed the OK button a new dialog will open (Figure 4.8).

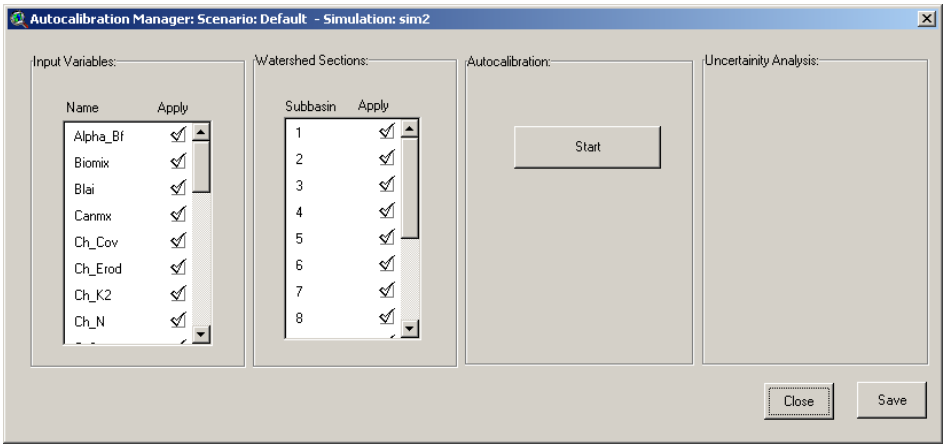


Figure 4.8

3. **Once pressed the OK button a new dialog will open (Figure 4.8).**

4. **Any listed *Input Variable* can be added to the application double clicking on the check mark on the right of the name. The Curve Number (CN2) is already added by default (leave it selected). Additional options could be specified double clicking on the variable name (Figure 4.9).**

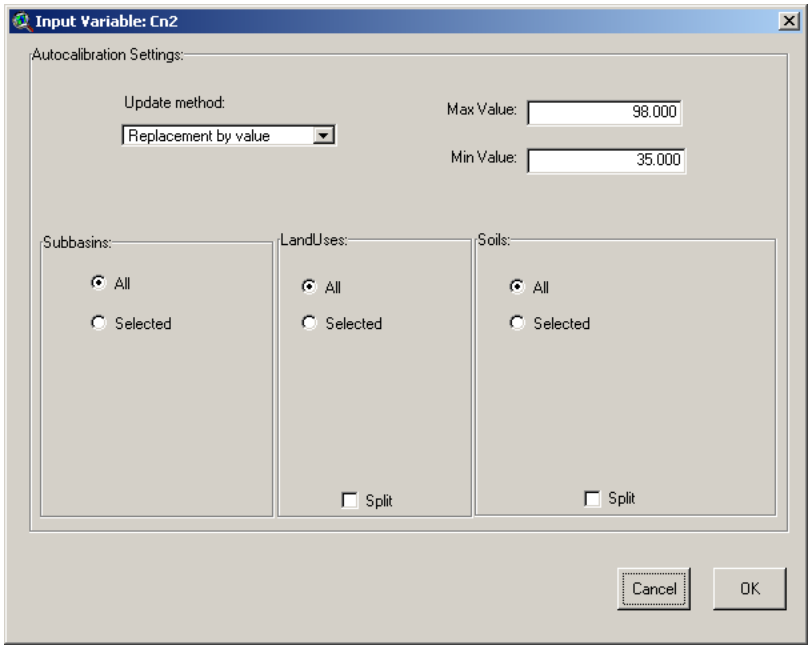


Figure 4.9

5. **Any listed *Watershed Section/Subbasin* provided with observed records can be included. Double click on the Subbasin # 11 and browse the observation file (*observ.txt*) (Figure 4.9).**

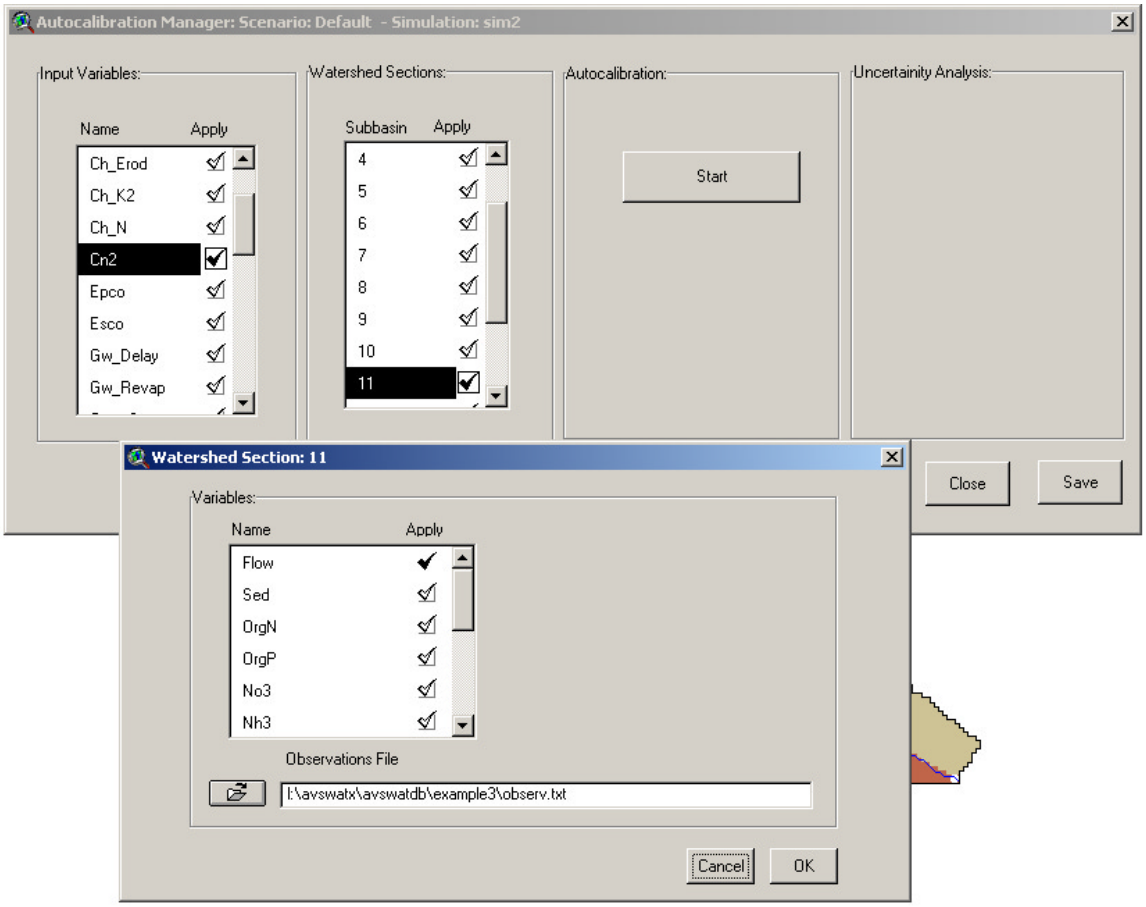


Figure 4.9

6. **Click OK and Save.Click the Start button to begin the calibration.**
7. **A message dialog will warn about the risk of a number of long lasting iterative simulations. Press the Yes button to continue. The SWAT2003 runs will start in a DOS-window.**
8. **You can stop the run typing CTR+C. An example of output files is stored in \AvSwatDB\Workshop\autocalibrationout.**
9. **Using the interface, once the calibration is completed, a set of output files can be reviewed pressing the Reports button (Figure 4.10).**

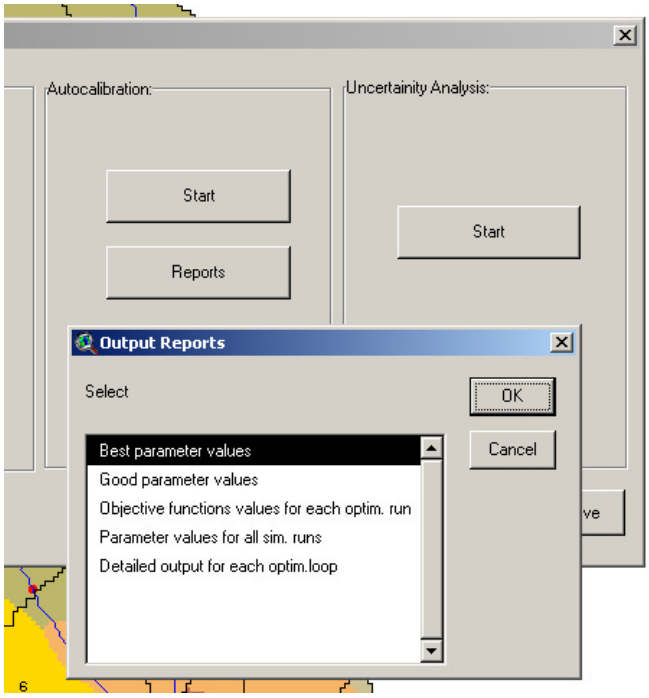


Figure 4.10

10. The *Best parameter values* (*bestpar.out*) shows the parameter set that had the lowest value for the objective function. The *Good parameter values* files (*goodpar.out*) shows the parameter sets that had acceptable values for the objective function. The *Objective functions values for each optimization run* (*sceobjf.out*) shows the objective function values for all parameter sets considered in the automatic calibration. The *Parameter values for all simulation runs* (*scepar.out*) provides the parameter sets considered in the automatic calibration. Finally, the option *Detailed output for each optimization loop* (*parasolout.out*) shows a detailed summary of the input and the results of the automatic calibration.

Uncertainty

Once successfully completed the calibration, the input for the uncertainty analysis are ready. A Start button is now visible in the Uncertainty Analysis dialog section (Figure 4.11).

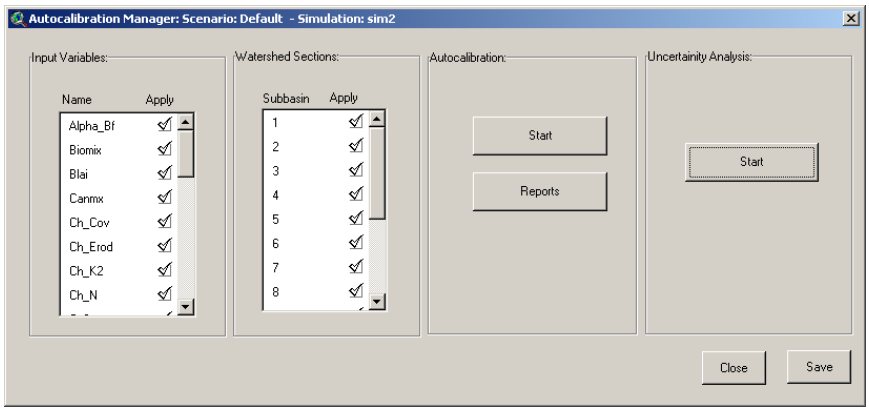


Figure 4.11

1. **Pressing the Start button, a message dialog will warn about the risk of a number of long lasting iterative simulations. Press the Yes button to continue. The SWAT2003 runs will start in a DOS-window.**

2. **Once successfully completed the uncertainty analysis, the Reports button in the uncertainty analysis section is also activated. Select this Reports button. A new dialog box will open (Figure 4.12).**

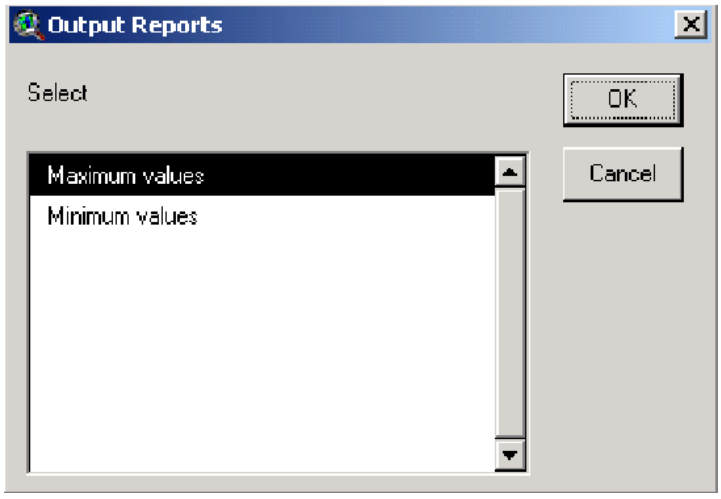


Figure 4.12

3. There are two items in dialog. *Selecting Maximum* values will open the file *maxval.out*, which contains the maximum values simulated for each day and for each output variable included in the uncertainty analysis. *Selecting Minimum* values will open the file *minval.out*, which contains the minimum values simulated for each day and for each output variable included in the uncertainty analysis.