Chapter 6 *Watershed Analysis*

Objectives:

In this chapter we will duplicate a tutorial which can be found in the GRASS 3.0 manual tutorial section. By using Digital Elevation Models (DEM's) we GRASS can calculate drainage basins for a given outlet point as well as develop a stream network from the model. Such a process is extremely valuable in predictive modelling for things such as availability of water, erosion potential, and similar phenomena which are directly related to the size of a particular watershed.

At the end of this chapter you should be able to:

1. Define the following terms:
   - DEM
   -
2. Use the following GRASS commands:
   - watershed
   - thin
3. Use the SIX steps in the watershed program to develop a watershed.

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Before we begin:

Before we start working on the data layers, execute the following commands to be sure that you have your window set correctly (resolution at 30m in this case) and the graphics display in fixed mode.

- Dcolormode fixed
- Gwindow n=4924000 s=4914010 e=600000 w=590220 res=30
- Dscreen

Orientation:

Land mangers are given the job of protecting, maintaining, and developing areas of land. In order to perform this duty, information is often needed which is related to the delineation of a watershed and its stream network. Sometimes information related to stream and divide networks is available within a GIS system. If the channel and divide networks have to be manually interpreted from topographic maps or aerial photographs, with subsequent digitization to enter the information into a GIS system, the work could be quite tedious and time consuming. If this information could instead be derived from digital elevation data which is readily available for many locations, less work would be required, and the results might be more accurate. Accuracy is of course affected by the accuracy of the original elevation data, the resolution of the data used, and the effectiveness of the routines for extracting the information. The series of programs provided within the watershed menu is effective for the delineation and segmenting of channel networks, and for identifying a watershed boundary. Work is continuing to increase the effectiveness of delineating subbasin boundaries as well. The logic for these routines is based primarily on code from Larry Band, Department of Geography, University of Toronto. The original code was changed to include the use of GRASS routines for the accessing and storing of data, and some additions were made to provide additional output.

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Getting Started:

The watershed command requires no arguments. The structure is interactive, and primarily menu-driven. Upon entry, the first input required from the user is a project name. A ***project*** file is created to hold information pertaining to map layer names and input parameter values. This is done in order to complete the process with a minimum of input required at each step, and to maintain a record of parameters used to obtain a particular result.

The user can exit from the program after completing any number of steps. Hence, the option to *Work on an existing project* allows a user to finish any remaining steps, or to redo particular steps, or both.

A new project may be created with all new inputs, or a new project can be created using inputs from a previous project.

The option to remove old files should be used to remove only miscellaneous files created as part of the watershed program. All map layers (cell files) created using this program should be removed in the usual way using command Gremove[2G]. The files which can be removed using option 4 above include those storing pit points and the miscellaneous file storing nodes information created as part of the step to code stream segments. These files should not be removed until the analysis of which they are a part is finished and over. An option is also provided to remove project files. Again, since this is a file which stores information to complete the project and which tells of the input parameters used to create a particular product, this should also not be removed prematurely. See the rest of this document for further explanation of these files and their usage.

Once an old or new project has been chosen, the user will be presented with the following menu and allowed to choose an option:

```
1.   Filtering of elevation data
2.   Locating pits
3.   Calculating drainage accumulation/
outlining watershed
4.   Creating stream network
```

The steps are presented in the order they should be used to complete the total watershed analysis for the purposes of creating all products. While input is being accepted for each individual step, the option is given whether to run the actual program. If the program has been run and completed without error, the word COMPLETE will appear on the above menu after the listing of that step.

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Example Session:

Following is an example session that can be used on the Spearfish database. The watershed command can only be reached from the quick access version of GRASS. Once you have entered GRASS, simply enter the command watershed with no arguments.

Menus as you should see them are presented here. The step which calculates drainage accumulation may take a good deal of time to complete, depending on the size of the current window.That is why we carefully set the current window before starting.

Now enter the GRASS command ***watershed*** and you should see the following on your screen.

watershed

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WELCOME TO THE WATERSHED SOFTWARE SYSTEM

This program is designed to help you follow the correct steps to obtain a GRASS raster file depicting watershed geometry using a raster elevation file (with true elevation values) as a starting point. All steps are recorded under a project name.

Choose desired option:

1. Create new project
2. Create new project based on currently existing project
3. Work on an existing project

4. Remove old files

You will need to start by choosing *Create new project*. Then enter a project name. For this example, the project name entered is demo.

PROJECT NAME: watershed

Choose desired option:

1. Filtering of elevation data
2. Locating pits
3. Calculating drainage accumulation/outlining watershed
4. Creating stream network
5. Coding stream segments/finding segment lengths
6. Finding subwatershed basins

7. Quit

You can now begin the series of steps to complete a watershed analysis. the steps are presented in this menu in the order they should be completed, so begin with step 1, *Filtering of elevation data*. Use as input the map layer elevation.

PROJECT NAME: watershed

Step1: Filtering of elevation data

Input:
Unscaled elevation map layer: **elevation**___________

Output:
Filtered elevation map layer: **elev.f1**_____________
Number of filter iterations: **1**____

Run filter program? **yes**

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Note that at each step you are given the option of running the program. If you enter *no* here, the map layer names and input parameters will be recorded under the project name, but the word *COMPLETE* will not appear on the main menu. If you choose to run the program by entering *yes*, the next time you are returned to the main menu you will see the following provided the routing completed without error.

PROJECT NAME: watershed

Choose desired option:

1. Filtering of elevation data COMPLETE
2. Locating pits
3. Calculating drainage accumulation/outlining watershed
4. Creating stream network
5. Coding stream segments/finding segment lengths
6. Finding subwatershed basins

7. Quit

Now run the next step *Locating pits*.

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PROJECT NAME: watershed Step2: Locating pits Input: Will use filtered elevation data from Step 1. Output: Will create pits file under element watershed/pits, with name of [filtered] elevation data. Run pits program? **yes**

Before running the next step, *Calculating drainage accumulation/outlining watershed*, you need to know the grid coordinates for the outlet point. For this example, UTM coordinates have been supplied.

Note that the lakes map layer is optional. There is no need for you to save this output in a cell filed unless you are interested in seeing a display of the pit points, their surrounding lake areas, and the redirected route from the pit point to the pouring point for the lake.

This step may take quite some time to complete, depending on the size of the window and the number of pit points found. Processing of the pits in this routine is length. Once the step is completed, you should exit the watershed program and check the results. If the results of this step are not meaningful, the rest of the process cannot be completed. Use Gdescribe[2G] to see if the values in the result file are large, or display the resulting map layer to see if it contains a depiction of the desired drainage basin. (This resulting map layer will need to have a color table assigned. This can be done through the use of the support[1] command. If the range of category values is large, the map layer may need to be rescaled first using the rescale[1] command in order to make a meaningful display on the color monitor screen.) If the results of this step are not satisfactory, attempt to choose a better watershed outlet point before reentering the program.

Once you have evaluated the results of this step, re-enter the watershed command, and this time choose the option to "Work on an existing project. Again, enter the project name demo, and you should receive the main menu, with the choice of steps, and the word COMPLETE after the first three options. If the results from this routine were not satisfactory, you would rerun the third step. You should have gotten meaningful results with this example, so continue by choosing option 4.

PROJECT NAME: watershed

Step4: Thinning of accumulation file

Input:
Will use drainage accumulation map layer from Step 3

Output:
Thinned network map layer: **drain.thin**________
Number of thinning iterations: **4**______
Accumulation threshold: **300**____

Run thin program? **yes**

Again, you need to check the results of this step to be sure that the stream network has been thinned to one pixel width. Once this has been accomplished, continue to the next step. If the stream network has not been thinned to one pixel width, an error message will be produced during the next step and it will not complete correctly.

PROJECT NAME: watershed

Step5: Channel segment coding

Input:
Extended thinned network map layer: **drain.thin**__________

Output:
Coded network map layer (optional): **drain.coded**_________
Nodes file will have extended network name

Run code program? **yes**

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The cell file depicting the stream network with each channel segment “coded” (given a unique category number) is an optional product. You only need to provide a map layer name for this if you wish to save the results for displaying. However, this step must be completed in order to continue to the next and final step in the series. Note that the above menu asks for an extended thinned network map layer. If you are planning to use results from this series for input into a sediment runoff routine (as through the command grass.arm-sed[1]), the stream segments may need to be extended to ridge boundaries in order to provide the kind of information needed, such as the lengths of channel segments which completely divide subbasins. The extension can be created in a manner similar to that used for creating incomplete ridge information as explained in Appendix A of this document.

PROJECT NAME: watershed

Step6: Subwatershed designation

Input:
Will use nodes file from Step 5.

Output:
Subwatershed map layer: **drain.sub**__________

Run subbasin program? **yes**

One this step is completed, you should now see the main menu with the word COMPLETE after each step (see below).

PROJECT NAME: watershed

Choose desired option:

1. Filtering of elevation data COMPLETE
2. Locating pits COMPLETE
3. Calculating drainage accumulation/outlining watershed COMPLETE
4. Creating stream network COMPLETE
5. Coding stream segments/finding segment lengths COMPLETE
6. Finding subwatershed basins COMPLETE

7. Quit

This concludes the example session.

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