

## **Watershed Analysis Lab – Heterogeneous, Un-gaged Watershed II (Cattail Creek)**

This Lab will present the more commonly used features of GISHydro2000. Most applications of TR-20 involve watersheds with various heterogeneities which require subdivision and routing. This lab assumes the completion of the homogeneous watershed lab. It therefore does not go into detail about the procedure for selecting quads, etc.

### **Task**

Estimate the peak discharge resulting from the 100-year storm for the Cattail Creek Watershed located in Howard County, Maryland, under 1997 Conditions *and ultimate development conditions*. Although USGS gages are located in the vicinity of the watershed, *treat the watershed as un-gaged*. Determine the peak discharge using the USGS regression equations and compare this value with the peak discharge predicted by TR-20. *Assume that the watershed is heterogeneous.*

### **Step One – Locate Outlet and Select Quads**

For this lab, the watershed location is contained completely in the **Woodbine** quadsheet. Try using the pick tool from the Select quads dialog box to find the quad's location. (it's located near the Western portion of Howard County).

The outlet for the watershed is located at the crossing of MD97 and Cattail Creek in Howard County.

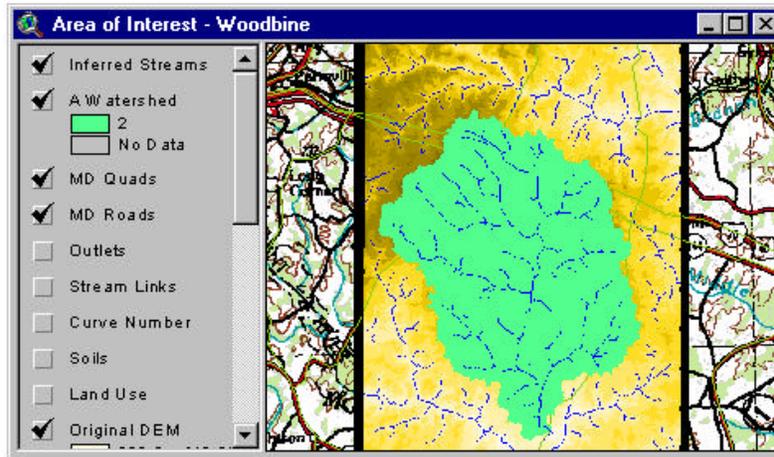
### ***Select Data Types, Begin Processing***

As for the homogeneous lab, select 30m DEM data, 1997 MOP land use, and Ragan soils. Later on, you can go back and try this example using different data types and compare results.

Choose the DEM processing options as in the homogeneous case lab. For the hydrologic condition, select "Good". When all of these options are selected, press the "Apply" button to begin processing. When processing is complete, the "Area of Interest" view will open from which future instructions will be based.

### **Step Two – Delineate the Watershed**

Use the zoom-in tool to locate the watershed outlet location described above. Select the  tool from the tool bar and click on the center of the pixel closest to the intersection of MD97 and the Cattail Creek stream. Use the 1:250,000 topographic map to aid in finding the outlet location. The watershed will be delineated and displayed in the Area of Interest View. Use the zoom-out tool to return to the previous view extent. The watershed should look like the figure below:



### **Step Three – Calculate Basin Statistics and Peak Discharges**

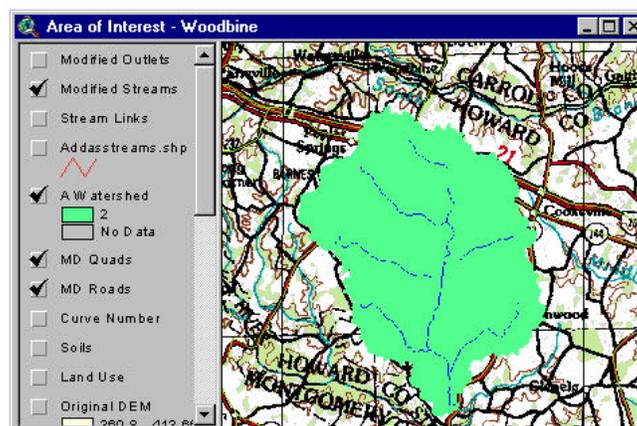
Once the watershed is delineated, select the Basin Statistics and Calculate Discharges items from the Hydro Menu. Note the predicted peak discharge for the 100-yr return period and its corresponding confidence intervals from the Tasker program.

### **Step Four – Delineate Main Channel Streams and Add Outlet Points**

For the Homogeneous Watershed Lab, this procedure was simple. For a heterogeneous watershed, we need to define the main stream and outlet points explicitly in order to achieve the desired configuration of subwatersheds.

#### *Delineate Stream Segments*

Recall the previous discussion about the short, superfluous streams visible in the “Inferred Streams” Theme. For this lab, we will again modify the stream network using the  tool. However, this time we will define the channel network with multiple segments. Use the Add Streams Tool from the toolbar to delineate the stream network to roughly approximate the figure below:



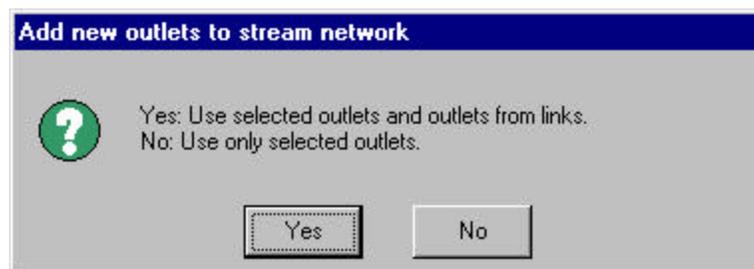
Recall that the Add Streams Tool functions by clicking in the display window at the point you wish the stream to begin. The flow path of the stream will automatically be delineated from that point to the watershed outlet. Each time you click in the display using the Add Streams Tool, a new stream segment will be drawn. If at any point you add a stream that you do not wish to include in the watershed model, make the “AddAsStreams.shp” theme active and select the Delete Theme item from the Edit menu. The procedure can then be repeated. (As streams are added with the Add Streams Tool, the changes are stored in the AddAsStreams.shp theme).

When the stream network approximates the one above, select the Add Streams item from the CRWR-PrePro menu. As in the previous lab, a dialog box will ask you if you wish to include both the new streams and the Inferred Streams, or just the new streams. Select “No” to use only the new streams. You will see the raster channel network be updated to reflect only the new channel network.

### Delineate Outlet Points

In the homogenous watershed lab, no subdivision was used so no subdivision points were necessary. For this lab we need to define where the watershed will be subdivided. Recall that GISHydro2000 places a subdivision point at the confluence of all streams. In our case, given the modified stream network this results in 10 subwatersheds.

It is often desired to place a subdivision points in-line with the stream network. This results in series sub-division such that the hydrograph from an upstream subwatershed will be routed through a lower subwatershed and combined at the lower subwatershed’s outlet with that hydrograph. GISHydro2000 allows for the placement of in-line subdivision points using the  tool or (Add Outlets tool). Select a location along the stream network on any segment of the channel network. From the toolbar, use the Add Outlets tool to mark that location in the display window. You will see a point added to the View and a new theme called “AddAsOutlets.shp” is created. As with the “AddAsStreams.shp” theme, you can add multiple outlet points and delete the theme if you wish to start over. When you have selected an outlet point (**Important: Make sure the point you selected lies in the center of a pixel on the rasterized channel network.** Zoom-in if necessary.) To incorporate the outlet point, select the Add Outlets item from the CRWR-PrePro menu. The following dialog will appear:

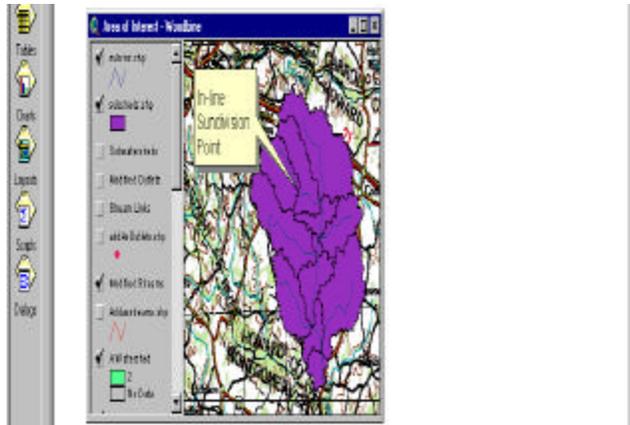


To add the outlet point you selected to the other outlet points (the confluence points from the modified stream network) select YES. (If you chose No, *only* the point you selected

would be used as a subdivision point). The Outlets theme will then be updated to reflect the new outlet location.

### **Step Five – Delineate Subwatersheds**

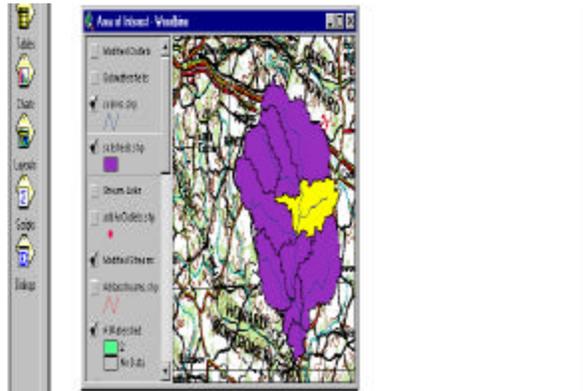
Once the stream network and outlet locations have been specified, the next step is to delineate subwatersheds. From the CRWR-PrePro Menu, select the Delineate Subwatersheds Option. Depending on where you placed your in-line subdivision location, the resulting subwatersheds theme will look like:



## ***Merge Subwatersheds***

It may be the case that once you delineate the subwatersheds, you wish to make a change to affect their number or configuration. For instance, at the center of the watershed above there is a relatively small watershed that may not warrant a subdivision of its own.

On the CRWR-PrePro Menu, there is an option to merge selected subwatersheds. To merge subwatersheds, make the “subsheds.shp” theme active (so that its legend “pops” out at you). Next, choose the  (select) tool from the toolbar. Using the select tool, click on one of the small subwatersheds *upstream* of the small one discussed above. You should see it turn yellow (if you didn’t see it turn yellow, you probably don’t have the right theme active). Next, hold down the shift key and select the subwatershed adjacent to the first one. You will see that subwatershed also turn yellow. From the CRWR-PrePro, select the merge subwatersheds option. The two selected subwatersheds will be merged into one. Repeat this process for the lower subwatershed. The resulting configuration will look like:

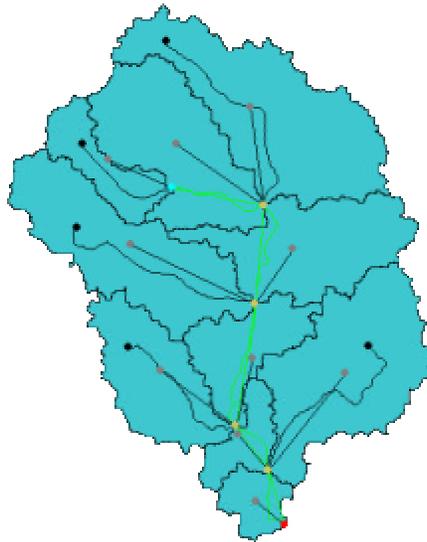


This process can be repeated until only one subwatershed remains. **Note: you can only merge subwatersheds that are adjacent and that share a common outlet.**

### **Step Six – Calculate Attributes and Generate Schematic**

Once the configuration of the watersheds is set, the next step is to calculate the attributes of the stream and subwatershed themes. Select the Calculate Attributes option from the CR-WR PrePro Menu. This step determines the drainage area, average curve number, and time of concentration for each of the subwatersheds. Two time of concentration methods are currently available. For this example, select the SCS Lag formula, when prompted.

Generate the model schematic for the watershed by selecting the Generate Schematic option from the CRWR- PrePro menu or simply press Cntrl+G. The model schematic should look like:



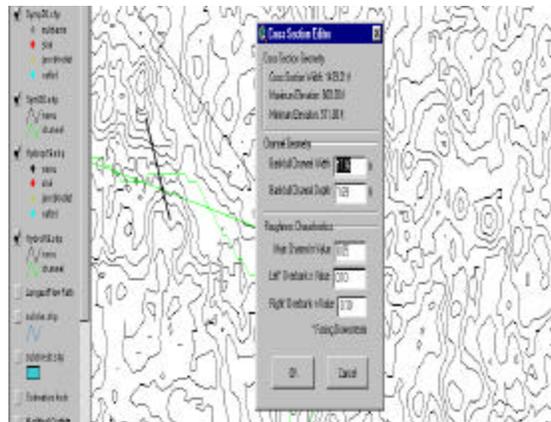
## Step Seven – Draw Cross Section Transects

In order to perform the desired reach routings for the model schematic shown above (there are five of them), it will be necessary for us to define a cross section rating table for each. Recall that the cross section rating table contains the stage-discharge-end area relationship at a section along the stream reach chosen to be representative of the overall length. To determine the rating table relationship, we need to specify, for each cross section, the geometry and roughness for both the main channel and the cross section.

The procedure for gathering this information using GISHydro2000 is to use the  tool to draw transect lines across each of the routing reaches. The transect lines are used to extract the profile of the floodplain at the selected point crossing the stream. At the intersection of the stream, a synthetic channel is incised.

Before drawing any cross sections, a useful step is to add the contour lines corresponding to the DEM. The contours aid in selecting the correct positioning of the transect line. To display the contour lines, make the “Original DEM” theme active. Next, select the Create Contours item from the Surface menu. A dialog box will ask you to specify the contour interval. Enter 20 ft and press OK. A new theme is created. Zoom-in to the northern-most routing reach, indicated by the light green lines in the schematic diagram. To draw a transect line, select the Add Transects Tool from the toolbar and drag a line across the routing reach. **Note: The transect line must cross the stream line (the schematic line does not reflect the alignment of the stream) and the transect should be completely contained within the surrounding subwatershed (i.e. don’t extend past the subwatershed divide).**

When a transect line is drawn, the Cross Section Editor dialog box is displayed as shown below:



The default channel geometry is based on a U-shaped channel scaled by the Dunne and Leopold bank-full width and depth relationships (width and depth as a function of upstream drainage area). The user can change these and the roughness values.

Repeat the transect drawing process for the remaining routing reaches. Be sure that a transect line is drawn for each routing reach. If you wish to change the transects, simply delete the theme called “AddAsTransects.shp” and begin again.

### ***Incorporate Transect Lines***

In order to incorporate the transect lines, select the Add Transect item from the TR-20 Interface Menu. This operation “joins” the transect lines to their corresponding reach lines for subsequent calculation of the reach rating tables.

### **Step Eight – TR-20 Control Panel and Execute Model**

Once the transect lines have been added, the next step is to open the TR-20 control panel from the TR-20 Interface menu. As was done for the homogeneous watershed lab, select an input and output file name and location.

For the output options, since we are only interested in the peak discharge at the watershed outlet, leave the top check box selected,

For the executive control options, enter the depth corresponding to the 100-yr storm for this watershed (approximately 8 inches). Press OK to create the TR-20 input file.

As before select Execute TR-20 from the TR-20 Interface menu to run the TR-20 model and display the output file created.

### **Step Nine – Ultimate Development Consideration**

The Maryland Hydrology Panel Policy currently being prepared requires that hydrologic structures designed for a particular return period storm take into account ultimate development conditions for the upstream watershed. Although not as streamlines as other GISHydro features, it is currently possible to consider the developed case by manually modifying the attributed schematic and re-running the model.

The schematic of the watershed created for this lab consists of two themes: syml\_.shp and symp\_.shp where the “\_” represents an arbitrary number. The attributes used to create the TR-20 input file are stored in tables associated with each of these themes. The subwatershed information is stored in the symp\_shp (or point) theme and the stream information is stored in the syml\_.shp (or line) theme. Attributes are stored in records in the attribute table corresponding to individual features (points). We can control the model parameters entered into the TR-20 input file by editing these attribute tables.

### ***Attribute Table Editing Procedure***

To open the attribute table for a theme (try the point theme), make that theme active. Select from the Theme menu, the Table item. This option opens a themes attribute table. The attribute table contains the attributes including the drainage area, curve number, and time of concentration for each subwatershed.

AreaSq	Slope	CurveNum	LagTime
0.000	0.0000	0.0000	0.0000
4.259	0.0139	72.2145	6.3245
1.045	0.0204	72.4097	3.5930
3.018	0.0163	76.1470	4.6739
2.687	0.0120	70.6916	5.6936
3.344	0.0127	68.0375	8.1914
1.447	0.0115	70.9393	5.5712
2.085	0.0140	71.8387	5.1680
3.654	0.0114	70.5574	7.2259
0.723	0.0189	76.6129	2.2834
0.629	0.0141	66.9704	3.9736

Each element in the table is given an element ID (under the “hecid” field). These IDs allow the user to locate which features they want to change and update the tables accordingly.

When the table is open, from the Edit Menu, select the Start Editing Option. The font of the field names at the top of the table will go from italics to regular. This is editing mode. Locate the subwatershed hecID you wish to modify attributes for to reflect ultimate development. Use the three table editing tools from the toolbar to select the desired record and make edits. Press the Enter key when finished typing into a particular cell. When done editing, select from the Edit Menu the Stop Editing Option.

***Generate New Schematic (Developed Condition)***

Once you update the table, it is next necessary to generate a new model schematic with the updated model parameters reflecting ultimate development conditions. First, delete or, if desired, save the other schematic themes in a separate directory. Press Cntrl+G to generate a new schematic with the updated values. You may then run TR-20 to compare the ultimate development cas

**Step Ten – Evaluate and Compare Results**

The last step is to compare the estimates of the 100-yr peak discharge with that of the regression equation estimate, and with the ultimate development estimate from TR-20. How does the discharge lie within the confidence intervals predicted? What model parameters or model configuration can be changed to alter the results?