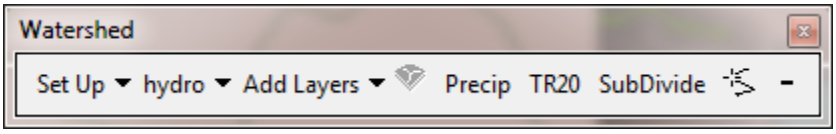
GISHydroNXT User's Manual

June 29, 2011

The Watershed Menu



This section describes the functionality related to the GISHydroNXT program built into the ArcMap project (gishydronxt.mxd) file. Descriptions of each menu/tool choice appear here. Please see the next section for an example of the use of these menu/tool choices in an actual hydrologic analysis.

- **Set Up:** These menu provide overall control of a given analysis and are general used at the outset of analysis only.
    - **Start New Project:** Initiates new analysis. This menu choice produces a dialog prompting the user for the data layers that will drive the analysis and the directory where the analysis output will be stored.
    - **ReStart:** Deletes any work done and layers created in the map area Returns the user a view of the entire state. For use when the user wishes to select a new outlet point for the analysis watershed. Retains the selected analysis data layers last specified under the "Start New Project" menu choice.
    - **Change Soil Map:** The user is presented with three soil choices: SSURGO, STATSGO, and RAGAN. The user can switch the soils layer data from the one specified in the "Start New Project" dialog at the analysis outset. The soils layer indicated here will be employed by in the analysis if the basin statistics have not yet been calculated. They are locked in after the statistics are calculated.
    - **Change Threshold:** The user is presented with a small dialog expecting a number to be entered. The number corresponds to the count (in 30m x 30m pixels to form a stream. A count of 250 is used by default. The inferred stream network will show a greater (lesser) drainage density for smaller (larger) indicated thresholds.
- **Hydro:** These menu choices work with the overall delineated watershed. A watershed must be delineated using the "Delineate Watershed" tool (described below) before these choices make sense to use. In the case of the "BasinStat_Subdivided" menu choice, the watershed must be sub-divided after using the "Subdivide" menu choice (decribed below) as well.
    - **Basin Statistics:** Determines a large list of basin properties including drainage area, channel slope, land slope, longest path, time ofconcentration, average CN, % Forest, %A Soils, %B Soils, %C Soils %D soils and 2yr, 24hr precipitation depth.

This menu choice must be executed before either the USGS or Fixed Region regression equations (see below) are executed.

- **BasinStat_Subdivided:** Determines a TR-20 required list of sub-area properties. This menu choice cannot be executed until the watershed has been sub-divided. This menu choice takes a bit of time to execute. A short dialog box will appear on completion of this menu choice indicating completion and showing where the output file has been written.
- **Basin Composition:** Creates two tables based on the contents of the overall delineated watershed. These tables are saved in the project folder: "Curve Number by Land Use" and "Soil Type by Land Use".
- **USGS Regression:** Executes the USGS regression equations developed by Dillow (1996). This menu choice cannot be executed before the overall "Basin Statistics" are determined as described above.
- **Fixed Region (Thomas 2010):** Executes the Fixed Region regression equations developed by Thomas and Moglen for the Maryland Hydrology Panel (2010). This menu choice cannot be executed before the overall "Basin Statistics" are determined as described above.

- **Add Layers:** This menu allows the user to add a number of different layers to the overall display for purposes of investigation and comparison.
  - **NLCD_2001:** Contains land use data from satellite imagery produced by the USGS for land cover that existed in year 2001.
  - **MDP_2002:** Contains land use data from the Maryland Department of Planning for land use conditions that existed in year 2002.
  - **MDP_2010:** Same as MDP_2002, but for year 2010.
  - **Ultimate Land Use:** Contains ultimate build-out land use based on zoning information in Maryland and Delaware based on zoning maps obtained from both states' planning departments.
  - **Ragan:** Contains hydrologic soils data (A, B, C, D) compiled originally by Dr. Robert M. Ragan for earlier versions of GISHydro. This is a "medium level resolution" layer which only covers land fully in the State of Maryland. Its use is not recommended except for comparison or historical purposes.
  - **SSURGO:** Contains hydrologic soils data (A, B, C, D) compiled by the Natural Resources Conservation Service (NRCS). This is a "finest level resolution" layer that covers all locations within the GISHydro domain.
  - **STATSGO:** Contains hydrologic soils data (A, B, C, D) compiled by the NRCS at a "coursest level resolution". This layer covers all locations within the GISHydro domain. It's use is of value for comparison and historical purposes.
  - **CurveNumber:** Contains the curve number layer calculated based on the land use-soils layer combination chosen by the user.

    - **Roads:** Contains a layer showing the largest state and interstate roads across the GISHydro domain. This layer is useful for orienting the user in space and for precision in indicating bridge or culvert locations.

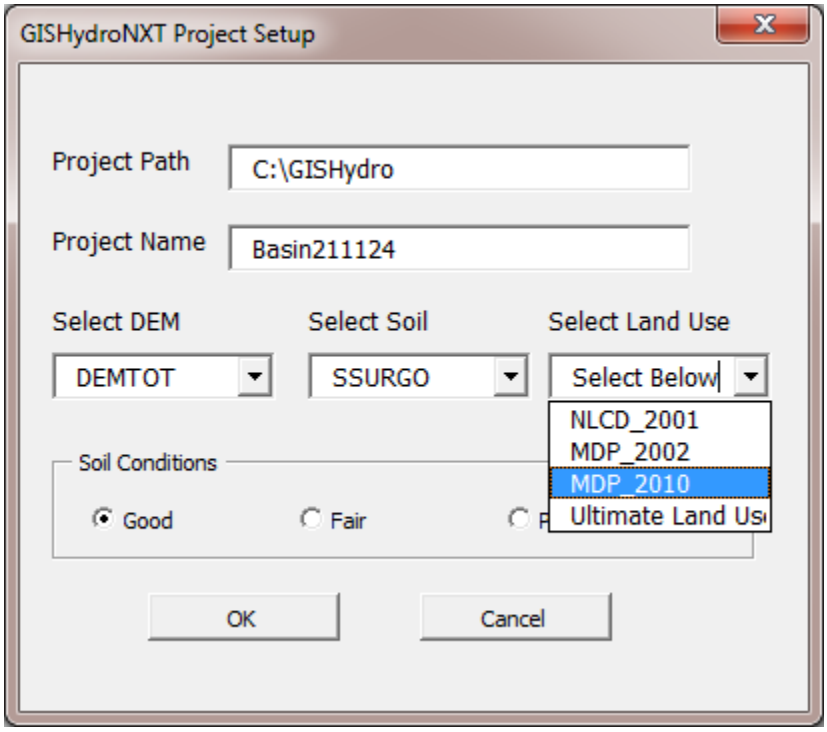
-  **"Delineate Watershed" tool:** This tool is employed by the user to indicate the location of the watershed outlet. Zoom the display to a small enough scale so that individual stream pixels can be clearly differentiated, then click on the stream pixel that most closely approximates the location of the overall watershed outlet.
- **Precip:** This menu choice allows the user to indicate which precipitation duration and frequency will be analyzed in TR20. A dialog box full of empty check boxes will appear. Click in the check boxes to select specific storms you wish to employ in your TR-20 analysis. Available storm durations are 6, 12, 24, and 48 hours and precipitation frequencies of 1, 2, 5, 10, 25, 50, 100, 200, 500 years. A results dialog will appear indicating the determined precipitation depths for the unique footprint of the study watershed for all selected storm durations and frequencies.
- **TR20:** Produces a dialog box allowing user to indicate all final "Control Panel"-like inputs to the TR-20 model including the employment of an areal reduction factor, use of the DelMarVa unit hydrograph, specific storms to use, and whether to use the single or sub-divided watershed for analysis. This is the menu choice will remain grayed out until all necessary watershed attributes have been determined.
- **SubDivide:** Produces a sub-divided watershed based on the stream definitions indicated by the user. Stream definitions can be from the "inferred stream" layer, or from selected streams drawn by the user using the "Draw Stream" tool described immediately below.
-  **"Draw Stream" tool:** Click this tool and then click in the watershed at stream origin locations within the study watershed. A separate sub-area will result based on all confluences of drawn streams. This tool provides the user with very precise control of the subdivision of the watershed being studied.
-  **"Draw Cross-Section" tool:** Once the watershed is subdivided, this tool allows the user to cut a cross-section across all routing reaches within the watershed. A routing reach is any reach downstream of stream confluence. One cross-section needs to be drawn for each routing reach as a rating curve is needed for each routing reach in TR-20.

Sample Analysis

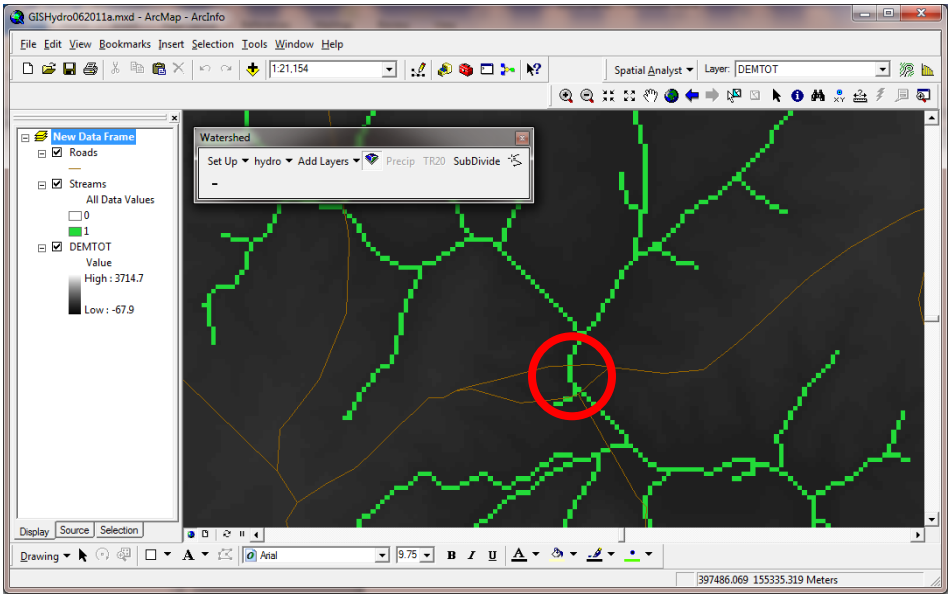
The following is a sample analysis of a watershed, the Northwest Branch of the Anacostia river near USGS Gage 01650500. The overall analysis can be divided into three major sequential categories: whole watershed calculations, sub-division analysis, and pre-TR-20 manipulations. Not all steps are mandatory. Non-mandatory steps are shown in arial text near related calculations.

Whole Watershed Calculations: This first group of manipulations within GISHydroNXT set up and focus on a watershed as a single (rather than sub-divided) entity. These calculations are naturally the first ones the user should pursue, provide a good overall assessment of the watershed and its flood behavior, and are a necessary set of steps before subdivision can be undertaken.

- **Step 1. Set up path on machine and data layers that define analysis:** Choose "Set Up: Start New Project". The dialog shown below will appear. Default values will populate for the Project Path and Project Name. The user can adjust these as desired. The user must choose a DEM, Soil, and Land Use Layer using the drop down arrows as illustrated at right. Unless otherwise indicated, the most appropriate soils layer to choose is the "SSURGO" layer, and the "MDP_2010" land use layer, with "Good" hydrologic conditions chosen.

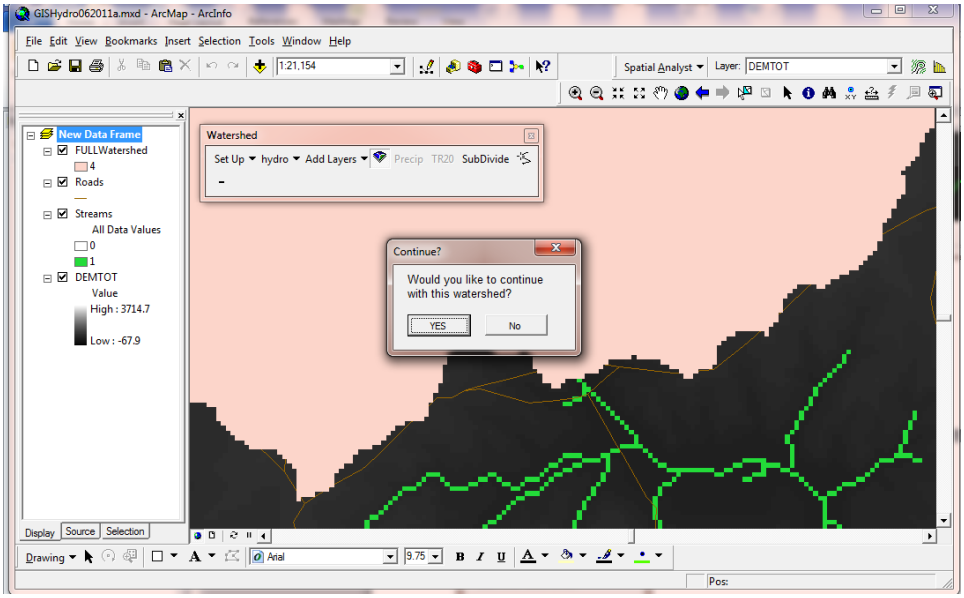


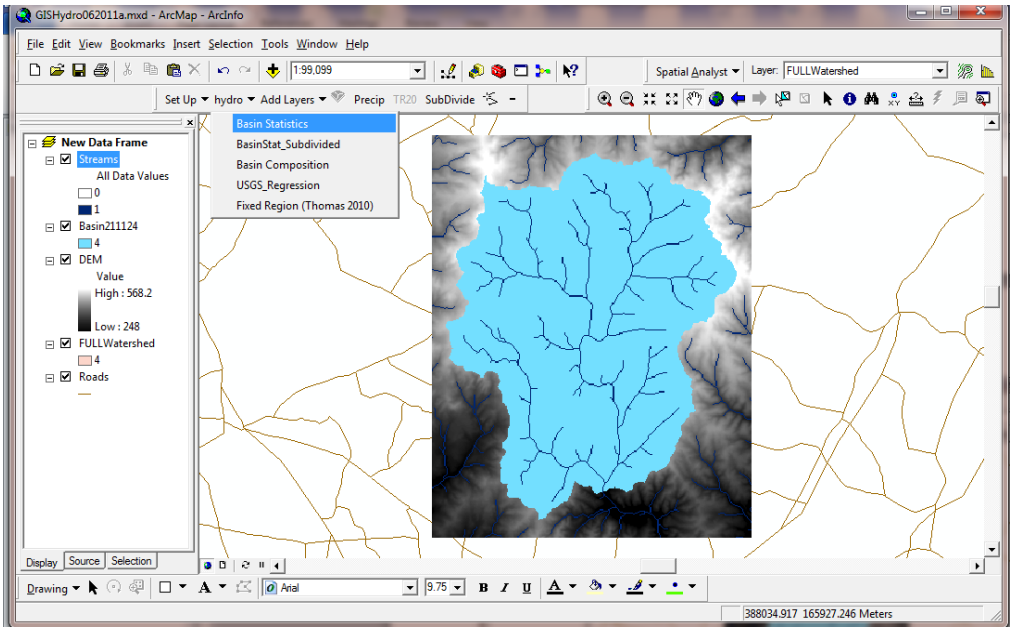
- **Step 2. Locate watershed outlet:** The watershed outlet needs to be identified by the user through the use of standard GIS navigation skills. The default road network located in the display may be all that is needed to locate the outlet, or it's possible that the user will need to load additional layers to become properly oriented



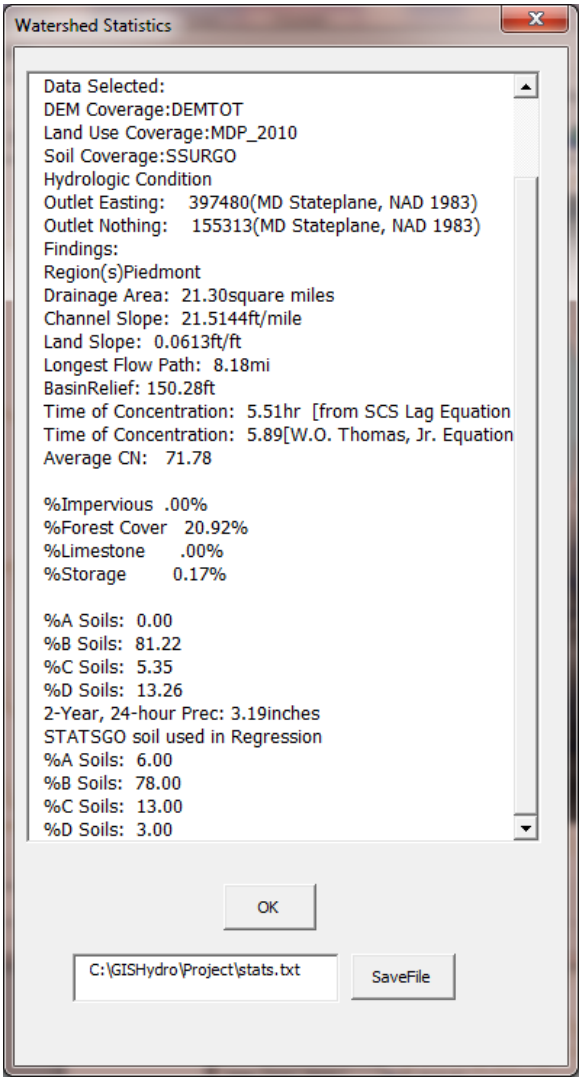
in the display. Once the location is found (see red circled area in screen capture above), the user needs to zoom in at a detailed enough scale that individual stream pixels can be distinguished.

- **Step 3. Delineate watershed:** Choose the "Delineate Watershed" tool  and then carefully click on the stream pixel that most closely approximates the location of the overall watershed outlet of the system to be studied. After clicking, the GIS will perform some internal calculations and the user will see the legend area of the ArcMap update several times. Eventually you will see the display update as shown at right with the delineated watershed (or part of it) shown and a yes/no dialog asking if the watershed delineated is correct and whether or not to continue. Respond as appropriate. The assumption in this manual is that the watershed indicated is acceptable. The resulting entire watershed can be seen more clearly by using left clicking on the watershed boundary layer in the legend and choosing "zoom to layer". Drag the streams layer to the top of the legend, and the resulting





display might look something like as shown above.

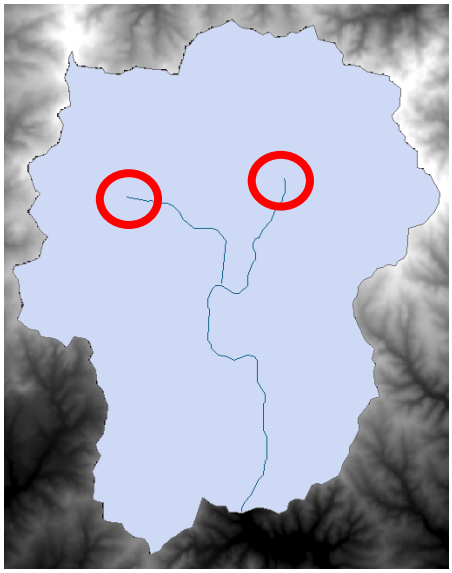


- **Step 4. Calculate watershed statistics:** Choose "hydro: Basin Statistics". The GIS will again perform calculations for a period of time, with the legend updating occasionally throughout this process. At the conclusion of this process, a dialog box such as the one shown at right will appear, indicating a long list of watershed properties. Click on the "SaveFile" button to save the output to a text file. The file will be saved in the path location indicated or the user can modify as desired. Click the "OK" button to close the dialog box.
- **Step 4a. Calculate Basin Composition:** Although not necessary for a successful analysis, once the overall watershed has been delineated, the user can choose, "hydro: Basin Composition" to determine the distribution of land uses in the watershed and the distribution of these land uses among the different hydrologic soil types. (Output for this menu choice is not shown here.)
- **Step 5. Calculate fixed region discharges:** Click on "hydro: Fixed Region (Thomas 2010). A "Done" dialog box will appear when the calculations are complete. Click on the "OK" button, and then a notepad window will open showing the output of the "Tasker" program for the Fixed Region equations. The upper part of this output shows the peak flow best estimates for the 1.25-year through 500-year floods, with a the lower part of the output giving upper and lower bounds for confidence intervals of various widths. This confidence interval output for the 67% intervals is of value when doing TR-20 calibration. The discharge window between the best estimate and the best estimate *plus* the 67% confidence interval corresponds to the calibration window prescribed by the Maryland Hydrology Panel representing a calibrated TR-20 model prediction for whatever flow frequency is being studied. (Output for this menu choice is not shown here, but the output from the Tasker program is discussed in greater length in the Maryland Hydrology Panel report.)
- **Step 5a. Calculate USGS regression (Dillow 1996) discharges:** Although not necessary for a successful analysis, similar to the directions in Step 5, the user can choose, "hydro: USGS Regression" to run the older, rural, regression equations from the USGS (Dillow,

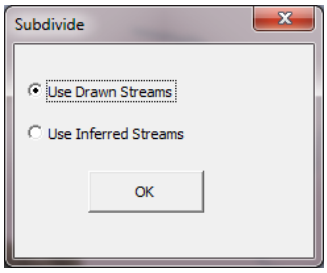
1996). These discharges may be of value for a comparative or historical analysis perspective. (Output for this menu choice is not shown here.)

Sub-division Analysis: This second group of manipulations within GISHydroNXT prepare for and execute the sub-division of the watershed into multiple sub-areas. These steps are necessary to undertake if you wish to analyze a sub-divided watershed within TR-20.

- **Step 6. Indicate streams to control sub-division:** This step is the most crucial in producing a sub-divided watershed. Before beginning this step, it is important for the user to closely examine the watershed being studied and to imagine the rough outlines of the sub-areas that will result from the sub-division step. Click on the  "Draw Stream" tool, and then slowly click once in each of the headwater sub-basins you wish to isolate (see the red circled areas in the figure at right). Be sure you do this slowly, allowing the display to update before clicking in the next headwater sub-basin. A unique sub-area will be generated upstream and downstream of each stream confluence. In the figure shown at right, the drawn streams were created by a mouse click in the red circled areas with the stream automatically being drawn from that point to the outlet of the overall system.

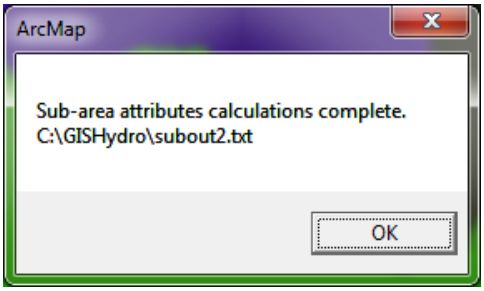


- **Step 7. Sub-divide watershed:** Once all desired streams are drawn in Step 6, click on the "SubDivide" menu choice. A dialog box as shown at right will appear. The user is expected to indicate one of the two choices necessary. Except in unusual cases, it is the best practice to choose the "Use Drawn Streams" menu choice as indicated. This gives the user precise control over the subdivision process. Using the "Use Inferred Streams" choice will likely result in far too many sub-areas, and ultimately the need for many reach routing tables, many more than can be meaningfully examined and defined. After the user indicates the choice in this dialog, click "OK" and the subdivided watershed will appear in the display after a few moments of calculation. The result is the figure shown at left. Notice that the confluence of the two drawn streams triggers a subdivision step that turns both of the mouse clicks into essentially sub-watershed identification steps by the user. The remaining area

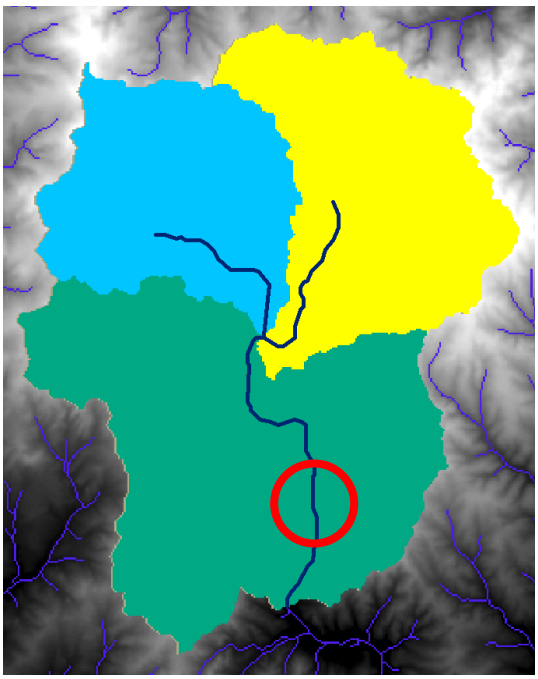


downstream of the two sub-watersheds is separate from the two upstream sub-watersheds and will contain a common "routing reach" that will require further attention in Step 9 below.

- **Step 8. Calculate sub-divided watershed characteristics:** Choose "hydro: BasinStat_Subdivided. The GIS will perform some internal calculations (could last up to about 1-2 minutes to complete). Upon finishing, a dialog box such as the one shown at right will appear, indicating completion of the attribute calculations. The text file that is created is for internal use by GISHydroNXT and is not particularly readable by the user. Click the "OK" button to proceed.

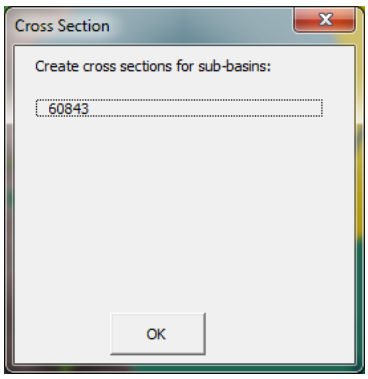


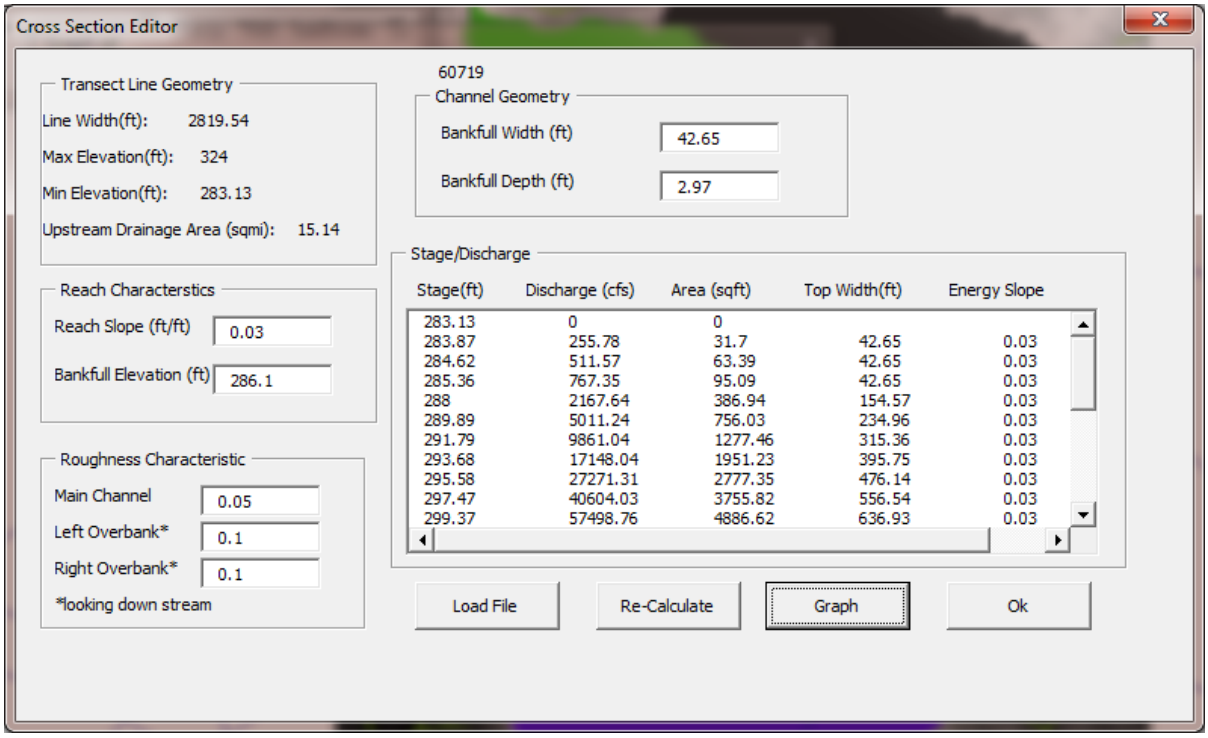
- **Step 9. Determine reach routing rating characteristics ("Cutting Cross-Sections"):** Before starting this step, the user should re-arrange the display so that the top two layers in the display are "stream" and "watersheds", respectively, as shown at right. Any stream located downstream of a confluence such as the stream in the southern (green) area in the figure, is a routing reach and a cross-section needs to be "cut" so that rating characteristics can be determined.



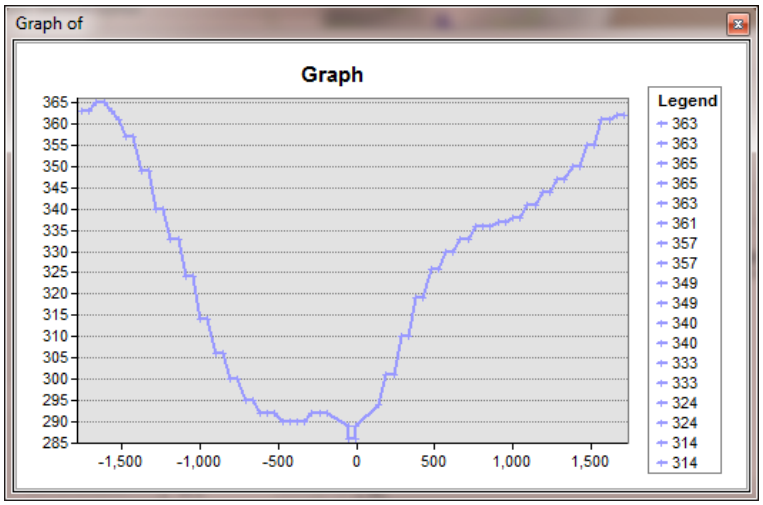
The red circled area shows the approximate location chosen for cutting the cross-section. In general, the user should strive to locate a section of stream that is "typical" of the entire reach. Ideally, this location is also in middle 50 percent of the stream reach so that the drainage area selected at this location is neither too small nor too large, but is again representative of an "average" drainage area found along the reach.

To cut a cros-section, select the "Draw Cross-Section" tool:  . A dialog such as the one shown at right will appear listing the sub-areas that contain a routing reach – in this example there is only one such sub-area. Click the "OK" button and then click on the left extreme end of the desired cross-section location, drag across the stream and double-click on the right extreme end of the desired cross-section. The GIS will then do some internal calculations and return back to the





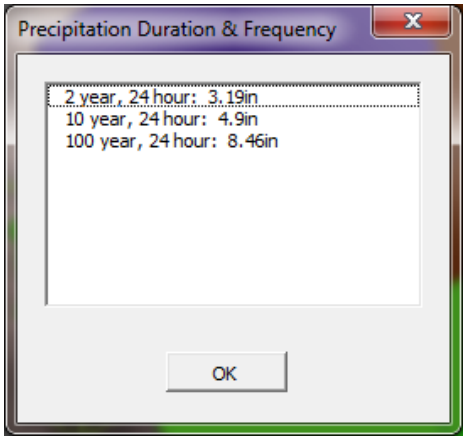
user with the dialog shown immediately above. This dialog conveys a considerable amount of information about the cross-section that has been "cut". Click on the "Graph" button to see the cross-section that has been determined – the cross-section for this reach is shown at right. This cross section and other information shown in the dialog ultimately distills to the rating table information that appears in the Stage/Discharge portion of the dialog in the right-middle of the dialog. This information is generated by employing Manning's equation,



for the cross-section provided for the reach slope indicated, and for the Manning's roughness coefficients indicated. The slope is detected by the GIS, but the roughness values initially present are default values prescribed by the Maryland Hydrology Panel. They are open to modification, provided justification for their modification is given. If changes are made to the roughness or bankfull channel geometry, click the "Re-Calculate" button to re-do the rating table information. The user should check to be sure that the largest discharge indicated in the table is larger than any of the discharges that will be generated during the TR-20 analysis.

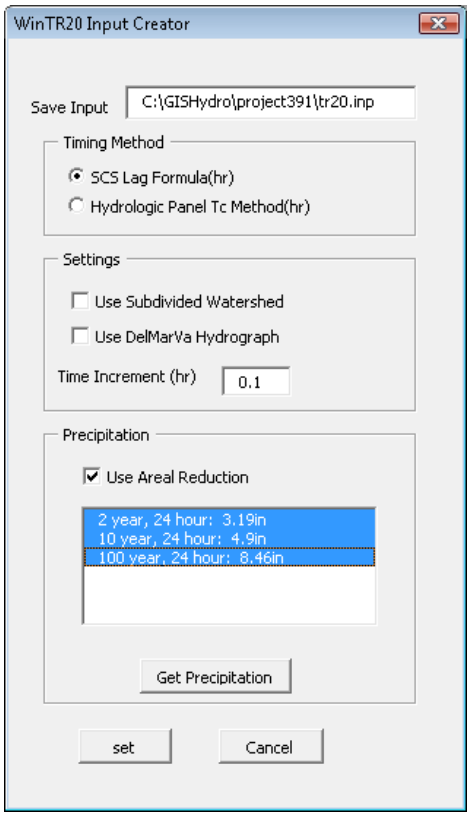
Pre-TR-20 Manipulations: Some final GIS manipulations are necessary in order to completely set up an input file suitable for analysis in TR-20. These manipulations tend to have little to do with the watershed studied itself, and more to do with additional meteorological and control information required by TR-20.

- **Step 10. Determine analysis storm depths:** TR-20 requires rainfall information to drive the runoff process. GISHydroNXT contains rainfall frequency maps for durations from 5 minutes to 48 hours, and for return frequencies from 1 year to 500 years. GISHydroNXT is configured to sample these maps to determine a symmetrical design storm based on the unique footprint of the watershed being analyzed and the storm frequencies indicated by the user. To perform this calculation, choose, "Precip". The dialog shown at right will appear. Click a check mark in all boxes for which you plan to do an rainfall-runoff analysis in TR-20. For instance, the 2-, 10-, and 100-year, 24-hour storms are indicated in the specific dialog box shown. Once you've selected all desired storms, click the "OK" button. After a few moments, a completion dialog will appear, indicating the overall depths for the selected storms. GISHydroNXT has also internally sampled the precipitation depths for all durations less than the selected storms for the frequencies selected so as to properly build a symmetric design storm for the unique watershed being analyzed.



- **Step 11. TR-20 Control Panel:** All GIS work is now complete, but there are a few additional pieces of information that are needed to write a complete TR-20 input file. This information is conveyed through the TR-20 Control Panel. To invoke this

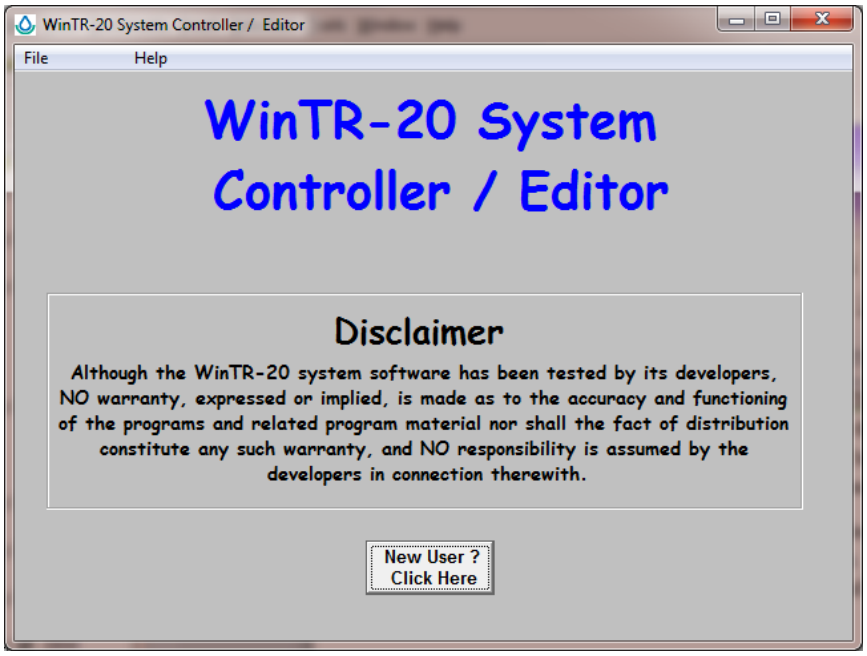
dialog, click, “TR20”. The dialog contains a number of different pieces of information. These are discussed sequentially below:



- **Save Input:** The default path and filename for the TR-20 input file is indicated in the text box. The user should take note of this so the file can be located later, or the user can use this opportunity to adjust the path and name given to the input file.
- **Select Tc Method:** Two time of concentration (Tc) methods are listed with the Tc’s indicated as calculated earlier. The user should click the radio button next to the Tc method desired.
- **Use DelMarVa Hydrograph:** If the watershed is in the Eastern or Western Coastal Plain, then the DelMarVa unit hydrograph should be used by TR-20 rather than the default NRCS unit hydrograph. Click this check box to toggle the use of this hydrograph if the default setting is not desired.
- **Use Area Reduction:** The default setting is to apply areal reduction factors. Based on the overall watershed size and the duration of storm selected, a reduction factor will be applied to the storm depths calculated in the “Precip” step described earlier. In general, this setting should be left on.
- **Use Subdivided Watershed:** The user has the option of analyzing the watershed as a single area or as a subdivided system as conveyed by the user in the earlier Steps 6-9. The default setting is to use the subdivided watershed, but this choice can be toggled off for a comparative analysis if desired.
- **Time Incrememnt (hr):** The default time increment used by TR-20 in reporting its output is 0.1 hours as indicated. The user can modify this default if desired.
- **Precipitation Depths:** The box at the bottom of the control panel lists each of the storms selected in the “Precip” step, The user must click on each of the storms for which a TR-20 analysis is desired so that the storms appear in white text/dark background. As shown in the dialog box, each of the three storms indicated in the “Precip” step has been selected for analysis by TR-20.

Once the dialog box has been edited as desired, the user should click the “set” button. The TR-20 input file will then be written. A short dialog box stating, “File Created” will appear when this step has been completed by the GIS.

- **Step 12. Executing TR-20:** The TR-20 file written in Step 11 is ready for importation and execution within the NRCS TR-20 program. Launch the winTR-20 program by choosing "All Programs: Engineering Applications: WinTR-20 version x.xx: WinTr-20. You will see a window as shown at right. In the WinTR-20 window, click "File: Open Existing WinTR-20 File". A browser window will appear. Direct the browser to the file created as the output of Step 11. The watershed, meteorology, sub-area definitions, and reach routing specifications should now be loaded into WinTR-20. The GISHydroNXT portion of the analysis is now complete. Please review the WinTR-20 documentation for additional information on the use of the WinTR-20 software.



GISHydroNXT Installation

Download

1. Go to http://www.gishydro.umd.edu
2. Click on the "Download" link along the left margin. If you have not already registered, please do so. (Registration is free).
3. Once you have registered, you will be at the GISHydro download page. You will need to download seven (7) zip files and the GISHydro.mxd project file.
4. Create a directory called "c:\gishydro\" on your local machine.
    a. Create four sub-directories off the "c:\gishydro\" directory called "BaseFiles", "Project", "Tasker", and "Temp".
    b. In the c:\gishydro directory place the file:
        i. GISHydro.mxd
    c. Unzip the following six (6) zip files from Step 3 above to the "c:\gishydro\BaseFiles" sub-directory:
        i. DEM.zip
        ii. LandUse.zip
        iii. Precip.zip
        iv. Prec.zip
        v. Soils.zip
        vi. Ancillary.zip
    d. In the c:\gishydro\tasker directory place the contents of the tasker.zip file from Step 3 above.