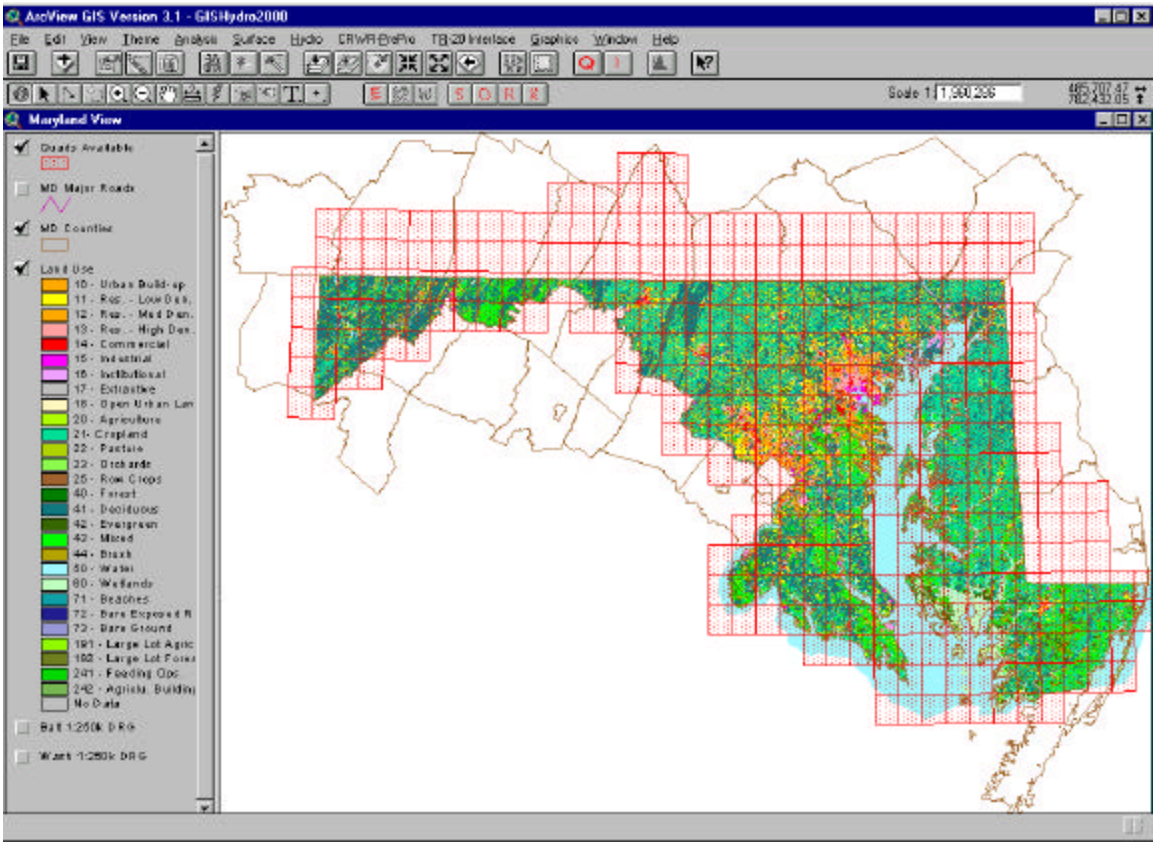
GISHydro2000 – "The New GISHYDRO"



From the mid-1980's through the present, Dr. Robert Ragan of the University of Maryland developed a QuickBasic-based program called GISHydro for use at the Maryland State Highway Administration and throughout the state. This program contained land use and soils data for the entire state of Maryland and enabled engineers to perform rapid and automated hydrologic analyses. The ArcView based project discussed in this document, GISHydro2000, was conceived in the spirit of GISHydro but designed to take advantage of a Windows-based operating system, the default industry-standard GIS, and further the automation capabilities of the original software with automated basin delineation based on DEMs. This is an evolving product, but we believe it has reached a point where it is of value in performing many types of hydrologic analyses on a routine basis.

Data / Files included

GISHydro2000 includes many different types of files and coverages. We will briefly discuss each of these in turn. As an engineer, you should take special note of the extents and the relative quality of each coverage. There is redundancy among the included files so you may wish to repeat analyses several ways using different data sets to develop an appreciation for the potential range of "correct" answers. We will try to indicate which coverage in each category is of the most superior quality, but it is often

the case that the higher quality data covers a much more limited extent of the state or region. The more extensive an area you set out to analyze, the more likely you will be forced to use poorer quality data over that area.

Data often comes in a variety of coordinate systems: UTM, State Plane, Geographic. For uniformity, we have projected all data sets to the Maryland State Plane (NAD '83) coordinate system and datum. Further, all raster data has been resampled to have a 100 foot pixel resolution (this is very close to 30 meters). The units of all data sets are in feet.

Coverages of DEMs, Land Use, and Soils are organized into files named after the USGS 7.5-minute quadrangle maps. Each complete coverage is zipped-up into a single *.zip file to minimize storage needs. The file selection script within GISHydro2000 performs the necessary calls to the software to unzip and perhaps merge multiple quadrangles together.

DEMs – Digital Elevation Models

We are all familiar with contour lines on topographic maps. A Digital Elevation Model (DEM) is simply a raster (or grid) representation of the same information. At each pixel a single representative number is used to indicate elevation over the pixel's small extent.

We currently provide three different coverages of DEMs with GISHydro2000: 30m and 90m data from the USGS and data ranging from 30m to 90m as part of the MAIA coverage. In general, the higher the data resolution, the better the quality of answers derived from it. Also, because we hold the USGS data to be of the most superior quality, if at all possible you should try to use the 30m USGS data to perform your analyses.

USGS Data

These data were either obtained directly from the USGS or from websites distributing USGS DEM data. Although the 90m data have been resampled to 100 feet (approximately 30m) their inherent quality still reflects their native 90m resolution. You will find these files in the following locations:

- \umdgis\dems\30m_dems\30m_dems.zip
- \umdgis\dems\90m_dems\90m_dems.zip

MAIA (Mid-Atlantic Integrated Assessment) Data

These data were assembled as part of a large-scale effort by the EPA. The native data resolution includes 30m, 60m, and 90m. Again, all three have been resampled to 100 feet. As we obtained this data, it was one continuous mosaic of the region and it was not possible to tell the resolution at a given location. In this regard, you should eye with suspicion any east-west or north-south "seams" in the data where the apparent level of detail in the topography seems to change. If the basin you are studying crosses such a seam, we suggest you use the USGS data instead, even if it means using the poorer resolution, 90m data. You will find these data in the following location:

- \umdgis\dems\Maia_dems\maia_dems.zip

Land Use

Land Use data has been obtained from a number of sources and its quality and resolution reflects those origins. We include seven different data sets: USGS (1970's), Ragan (1985), Ragan (1990), Maryland Office of Planning (MOP) (1990), MOP (1994), MOP (1997), and EPA – MRLC (~1992).

USGS 1970's Land Use

This data set was obtained from the USGS GeoData web page. These data are in the USGS Composite Theme Grid (CTG) data format. These files are distributed in 1^o by 2^o quadrangle blocks at a map scale of 1:250,000 with a resolution of 200 meters. The vintage of the files ranges from 1972 to 1977 depending on the quadrangle. You will find these files in the following location:

- \umdgis\lu70\lu70_grids.zip

Ragan, 1985 Land Use

These data have been converted from their original GISHydro format to be compatible with GISHydro2000. These data have an inherent resolution of 400ft by 500ft so they will look patchy in comparison to other coverages of land use. These data were originally developed from paper maps that were scanned and digitized by hand. These data cover within the state of Maryland only. You will find these files in the following location:

- \umdgis\ragan\l85_grids\l85_grids.zip

Ragan, 1990 Land Use

These data are similar to the Ragan, 1985 data but capture all updates to changes in land use between 1985 and 1990. You will find these files in the following location:

- \umdgis\ragan\lan_grids\lan_grids.zip

Maryland Office of Planning, 1990 Land Use

These data were obtained from the Maryland Office of Planning and should be used only in a manner consistent with the following disclaimer:

> *The Land Use / Land Cover data set has been provided courtesy of the Maryland Office of Planning. Any use of that data set outside of this application without the permission of the Office of Planning is prohibited. Form more information on Office of Planning data, please visit the OP web site www.op.state.md.us or call 410 767-4450.*

These data were originally in vector format with a minimum mapping unit of 10 acres. These data were converted to a raster format and sampled at 100 foot resolution. You will find that these data are consistent with the Ragan, 1985 and 1990, but a visual

inspection will quickly indicate a greater degree of detail is contained in these data. These data cover within the state of Maryland ***only***. Please note that any analysis extending beyond the boundaries of Maryland will not have complete land use definition when using MOP data. You will find these files in the following location:

- \umdgis\lu90\lu90_grids.zip

Maryland Office of Planning, 1994

These data are similar to the Maryland Office of Planning, 1990 data (and carry the same disclaimer) but capture all updates to changes in land use between 1990 and 1994. You will find these files in the following location:

- \umdgis\lu94\lu94_grids.zip

Maryland Office of Planning, 1997

These data are similar to the Maryland Office of Planning, 1990 data (and carry the same disclaimer) but capture all updates to changes in land use between 1994 and 1997. You will find these files in the following location:

- \umdgis\lu97\lu97_grids.zip

EPA – MRLC (Multi-Resolution Land Cover)

These data come from an EPA Region 3 data set with a native 30m resolution and a date of approximately 1992. These data were derived from unsupervised classification of satellite images including leaf-on and leaf-off images to distinguish between deciduous and coniferous forests. This data set is the only land use coverage that extends beyond the boundaries of the state of Maryland. As such, it will be the only coverage available to you should your region of study extend beyond the state. (It has been our finding that, because of the unsupervised classification system that was used to create these data and the lack of a "brush" land cover category, there is a tendency to over-estimate forest cover.) You will find these files in the following location:

- \umdgis\mrlc\mrlc_grids.zip

Soils

Hydrologic Soil type as defined by the NRCS is contained in three different provided coverages. These coverages are STATSGO, Ragan, and SSURGO and are discussed below. Since ArcView must work with numbers (not letters) we use A=1, B=2, C=3, and D=4 (and water =-1).

STATSGO

This coverage is actually stored as a vector format and converted to raster (100 foot resolution) on the fly within GISHydro2000. The resolution of this coverage is the poorest of the three, but these data cover the entire region of GISHydro2000, not just what lies within the Maryland borders. You will find the shapefile associated with this coverage at:

- \umdgis\maryland\statsgo_all.shp

Ragan

This coverage is similar in quality to the Ragan, 1985 and 1990 land use coverages. These data were scanned from county soil maps and hand digitized and are identical to those found in the original GISHydro. The native resolution is a 400 ft by 500 ft pixel, but has been resampled to 100 foot resolution. These data cover only within the state of Maryland. You will find these data at:

- \umdgis\ragan\scs_grids\scs_grids.zip

SSURGO

These data are of very high quality and resolution, but are available only within a selected few counties within the state of Maryland at present. These counties are: Baltimore City, Carroll, Dorchester, Montgomery, Queen Annes, Washington, and Worcester. In addition, three counties in Pennsylvania that are included in GISHydro2000 are: Adam, Somerset, and York counties. These data were converted from vector format and sampled at 100 foot resolution. Extreme care should be taken when using this data that the watershed(s) being studied lie entirely within only the counties listed above. You will find these files in the following location:

- \umdgis\ssurgo\ssurgo_soils.zip

Miscellaneous

There are a number of other odds and ends of files which make GISHydro2000 work or simply make it easier to work with. These are listed below.

National Hydrography Dataset (NHD) (formerly EPA River Reach (RF3))

The EPA publishes a data set termed “River Reach Files”, or because of a file naming convention, these files are often simply called “RF3 files”. We include these data only within the boundaries of our study region both for reference and as a tool to help guide the DEM drainage network determination (this will be discussed more later). These data are a vector ArcInfo format coverage located at:

- \umdgis\maryland\rf3_stp\

Maryland and Adjacent Counties

We provide a vector polygon coverage of the counties within Maryland and immediately bordering Maryland. This data set is located at:

- \umdgis\maryland\mdcountystp\

Maryland Physiographic Provinces

The physiographic provinces of Maryland as defined in the recent USGS Peak Discharge Regression Equations report by Dillow (1996) are contained in a vector shapefile called:

- \umdgis\maryland\mdprov.shp

Maryland Major Road Network

The centerlines of major roads within the region are contained in a vector ArcInfo format coverage called:

- \umdgis\maryland\mjr-rds_stp\

USGS Quads Coverage

This quads data set illustrates the USGS 7.5-minute boundaries for all quadrangles within the study region. This is a very important data set as it keeps track of all the information contained within the overall database. If you use the identify button to click on any one random quad, you will quickly obtain the quad name, the state(s) that lie within it, and whether or not SSURGO data is available. This vector shapefile is located at:

- \umdgis\maryland\quads83v2.shp

Digital Raster Graphics (DRG) Images

A limited number of digital raster graphics are available in the current release of GISHydro2000. We have two large-scale images covering both the Baltimore and Washington areas and one small scale image covering the Kensington 7.5-minute quadranagle:

- \umdgis\maryland\baltimore_250k_drg.tif
- \umdgis\maryland\wash._250k_drg.tif
- \umdgis\maryland\kensington.tif

Using GISHydro2000

Having completed this review of the data, we are now prepared to begin to use GISHydro2000 to extract data or perform hydrologic analyses.

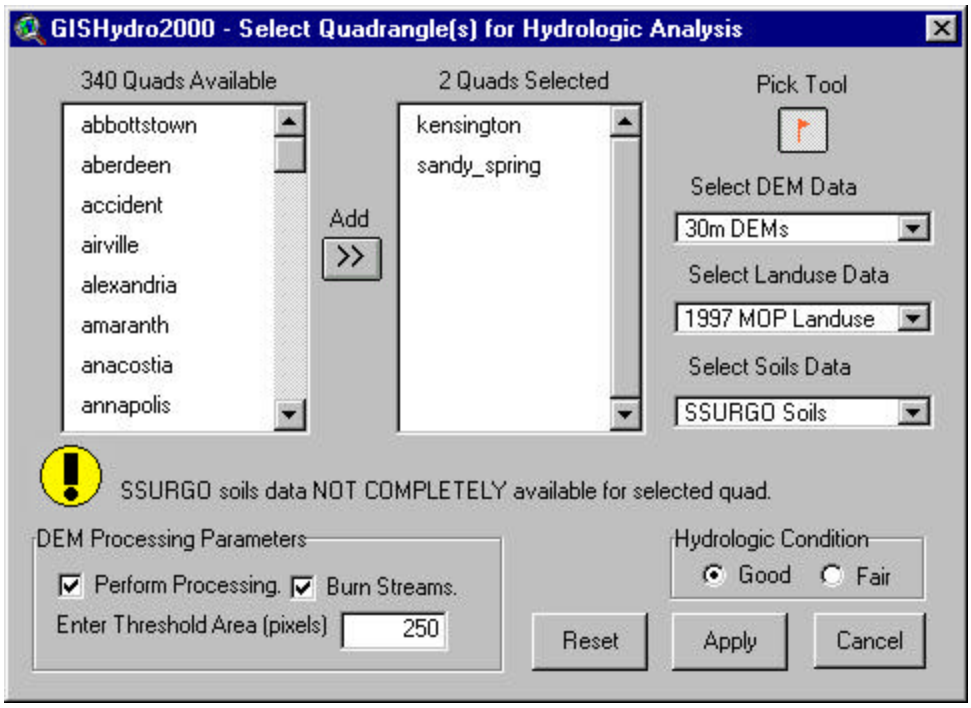
The "Maryland View" Window

The first window you will see when entering GISHydro2000 is the "Maryland View" window as shown earlier on page 6. Before sitting down to a session with GISHydro2000 you should have a good notion of the approximate location and extent of the watershed you wish to study. A very good piece of information to have on hand is the approximate location of the watershed outlet relative to the (major) road network. Poor initial estimates of the watershed extent may require second and third iterations at the "select quadrangles" step described below.

The "Select Quadrangles" Dialogue Box

To begin the quadrangle selection process, make sure the "Quads Available" theme is active. Then click on the red, "Q" button which brings up the dialogue box shown at right. You will begin by selecting one or more quadrangles of data to be

analyzed. If you know the quadrangle name, you can simply search for it in the "Quads Available" list at the upper left, or if you prefer to work more visually, you can click on the "Pick Tool" and add the quads to the "Quads Selected" list. Note that you must click the "Add" button if you are selecting quads by name from the "Quads Available" list.



The next step is to identify the data coverages you want (e.g. DEMs, Land Use, and Soils). Please note that depending on the particular quad(s) you have selected some of the choices enumerated earlier in the "Data Files Included" section, may not be available for your particular site. If this is the case, you should have seen information messages flash across the dialogue box indicating the lack of a particular type of data set. (For example, the above warning concerning the non-presence of SSURGO soils data within the entirety of the Sandy_Spring quad.) Within the confines of those data sets that are still available to you, you should use the scroll arrows for each desired data set and blacken the choice you wish to make for each data type. You can actually select "None" for any data type, but not for all three. When choosing the data coverages you want you should try to select the best available coverage as determined from the commentary provided above in the "Data Files Included" section. You may also wish to try several variations to develop a sense of the variability in your derived answer.

The "Hydrologic Condition" toggle area may be used by the engineer to control derived curve numbers. For some land uses, the NRCS indicates slightly different curve numbers depending on hydrologic conditions. By tagging the appropriate toggle (good or fair) the appropriate table is used to derive a curve numbers given the land use and soils covers selected. This option is disabled if either or both of the land use and soils coverages are set to "None".

There remains to discuss two "check" mark boxes which toggle on and off. The leftmost box, "Perform DEM Processing" controls whether in GISHydro2000 the software will determine flow directions, and drainage areas from the provided DEM. If you click this box off, you will have to perform DEM processing at a later time should you wish to automatically delineate basins. If you simply wish to extract a quad or two of data for use elsewhere (for instance, in WMS) you should click the box off. Clicking this box off can greatly speeds the process of simple data extraction. If you wish to perform DEM processing (i.e. the leftmost box is checked "on"), you additionally have

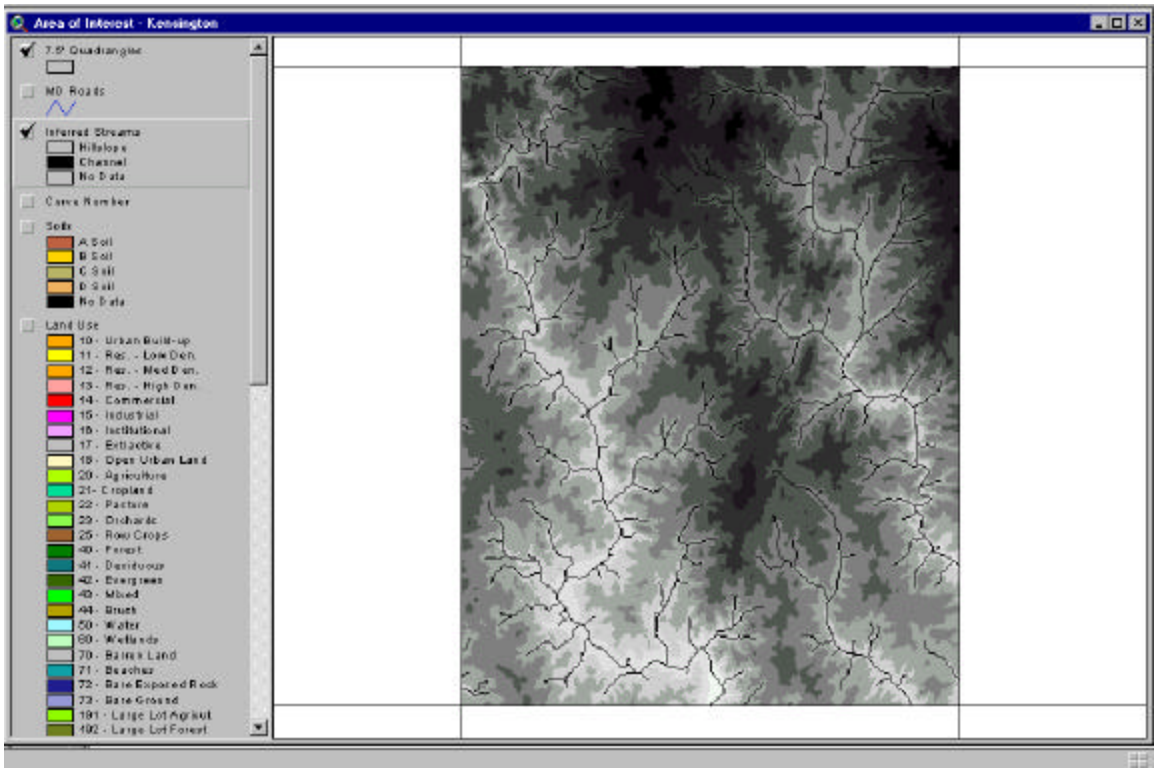
the choice of "Burning Streams" or not. If you click this box off, flow directions and drainage areas will be determined from the DEM alone. If you leave the "Burn Streams" box checked "on", the EPA-RF3 files described earlier will be used to impose the known drainage network associated with the more major streams and rivers in the state. This is the suggested course as it does not add any significant compute time to the analysis and can greatly enhance the determined flow directions and drainage areas, especially in regions of flat relief, rivers with wide floodplains, and if poor resolution DEMs must be employed.

The final choice you have control of is the "Threshold Area" determination. This is the number of pixels required to form a stream. In essence you are being asked a question about the drainage density of the area you are studying. While the answer that you give will not effect any subsequent analyses, it will have a profound effect on the appearance of the inferred channel network that will be provided. The smaller the number you specify, the more channel network you will see. The value of 250 pixels provided by default has been found to be fairly representative of streams in this region. We suggest changing it only if you have a very special purpose in mind.

The last step in the process is to click the "Apply" button. Notice that you can "Cancel" completely out of the process or click the "Reset" button to redo the process from the beginning.

The "Area of Interest" Window

Once you select the "Apply" button you have initiated a process that can take under a minute to several hours depending on the clock speed of the machine you are working on and the extent and nature of the selection process you have specified. For reference, a single quadrangle processed on a Pentium II-266MHz chip with DEM processing turned on will require on the order of 1-2 minutes to complete. In any case, eventually, you will see the "Maryland View" window give way to the "Area of Interest" view window focussed on the quad(s) you have identified. A typical "Area of Interest" view window (for the Kensington quad) is shown below:



Contents

There are a number of themes you will find automatically placed in the "Area of Interest" view window. These themes (from top to bottom) are: the 7.5' Quadrangles, MD Roads, Inferred Streams(*), Curve Number, Soils, Land Use, Original DEM, Filled DEM(*), Flow Direction(*), Flow Acc.(*), Limestone, and Mdprov.shp. The items indicated with a (*) will only be present if DEM processing has been requested. Obviously if you chose "None" for any of the basic coverage types, then the theme associated with that coverage would be missing from this view.

Performing Watershed Analysis

One possible direction you will follow at this time is to perform a watershed analysis which will consist first of delineating a watershed within the bounds of the area

of interest. From there GISHydro2000 will guide you through the process of determining watershed parameters, ultimately leading to estimates of the USGS Peak Discharge Equations as defined in Dillow (1996). Details on following this course of action will appear in a later section.

Extracting Data

The other possible direction is that you will simply wish to extract data from the "Area of Interest" view and move on to an analysis possibly using other software such as the BYU – WMS software. Extracting data is easy. You simple click on the red "E" tool and then drag a rectangular box over the subregion of the "Area of Interest" that you wish to extract. You will be prompted with two choices. The first choice is whether you wish to export to an ASCII Grid or ArcView Grid format. We suggest the ASCII Grid format for moving to WMS. The ArcView Grid format may be useful for subsequent analyses of these data external to the GISHydro2000 program but still using the ArcView GIS software. The second choice (actually three sub-choices) will be the file names and locations for all extracted data. Please be certain you control the destination of these files or you may have difficulty locating them later.

Watershed Analysis

Strictly speaking, the functionality discussed in this section is not part of GISHydro2000, but is rather a series of programs which exist as a "Hydro Extension" to ArcView. Some of these programs were developed originally by the creators of ArcView itself, and later modified at the University of Maryland, Department of Civil and Environmental Engineering to suit our needs. Most are codes generated entirely by us to facilitate the specific task of watershed characterization and peak discharge estimation.

The "Hydro Menu"

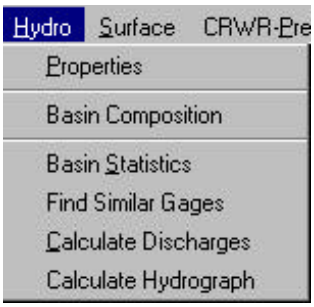
This menu choice will only be available if you have loaded the "UMDHydro (version 2.0)" extension. The most current version of this extension is available for free from the author's web page at:

- http://www.ence.umd.edu/~moglen/465/umdhydro.avx

To install this extension, place the downloaded file in the path:

- c:\esri\av_gis30\arcview\Ext32\

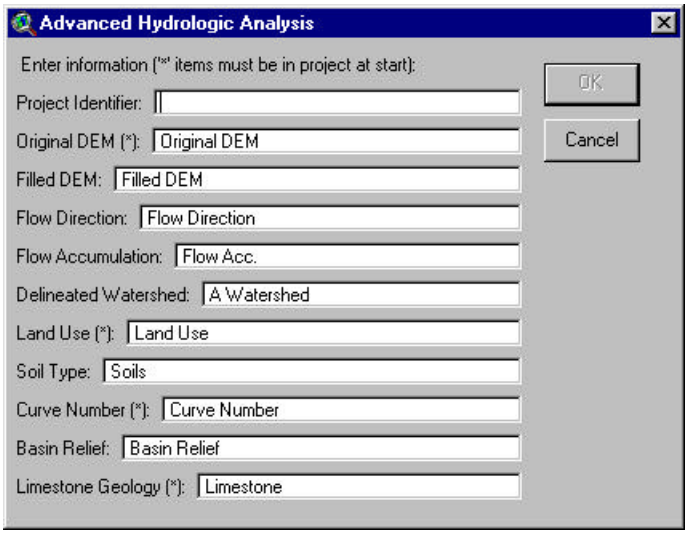
You must then choose "File: Extensions" and click the check box associated with "UMDHydro (version 2.0)" from the list provided. Click "OK" and the extension will be loaded.



The "Hydro" menu choices are shown at right. Depending on whether DEM Processing has already been performed some or all choices but the "Properties" item may be grayed out and unavailable. As each step is performed in sequence, the next "Hydro" menu choice will become active. Let us examine, in turn, each of the choices in this menu.

Setting "Properties"

Clicking on the "Properties" item of the "Hydro" menu will produce the extended file naming dialogue shown at right. The "OK" button will remain grayed out until you have entered some form of text for the the "Project Identifier". For all entries **but** the "Project Identifier" you should indicate the name of the theme that contains the property

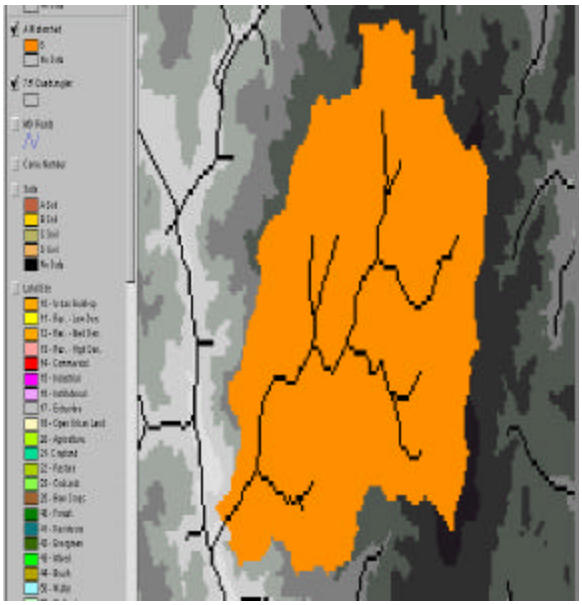


indicated. In some cases you will be telling the "Hydro" extension where to find the data it will need to work with, in other cases you will be controlling the names of output themes created by the "Hydro" extension. The provided default names are consistent with the naming scheme of GISHydro2000, but you can change any name to reflect particular studies you might wish to perform external from GISHydro2000.

- **Project Identifier:** For this item you may enter anything you want, but it is suggested you enter something meaningful to you as this information will be written so several output text files as a label.
- **Original DEM:** You should place here the name of the theme that contains the original DEM **before** any processing has occured. This is a required input to the "Hydro" extension. It cannot be created by the extension.
- **Filled DEM:** This theme will be created by the "Hydro" extension should you select the "Fill" or "Process DEM" menu selections. The Filled DEM is much the same as the Original DEM except that certain low point anomalies in the topography have been "filled" to provide for drainage everywhere throughout the extent of the data set.
- **Flow Direction:** This theme will be created by the "Hydro" extension should you select the "Flow Direction" or Process DEM" menu selections. The extension uses the Filled DEM theme to determine flow directions in one of eight directions (east, southeast, south, southwest, west, northwest, north, or northeast) for each pixel within the data set.
- **Flow Accumulation:** This theme will be created by the "Hydro" extension should you select the "Flow Accumulation" or "Process DEM" menu selections. The extension uses the Flow Direction theme to determine the cumulative area (in pixels) draining to each pixel within the data set.
- **Delineated Watershed:** Once the DEM has been processed, it is possible to delineate a watershed. The resulting theme is a raster quantity with every pixel within the basin set to a single value, and every pixel exterior to the basin set to "no data". This theme will be created by the "Hydro" extension through the use of the "W" tool .
- **Land Use:** You should place here the name of the theme containing information of land use distributions over the area being studied. This theme must be present in the view from the outset of the analysis. This is a required input to the "Hydro" extension. It cannot be created by the extension.
- **Soil Type:** You should place here the name of the theme containing information on the distribution of hydrologic soil type within the region being studied. This presence of this theme is optional to the "Hydro" extension, but it must exist for the "Basin Composition" menu choice to become active.
- **Curve Number:** This theme is the product of a table lookup operation given knowledge of the soils and land use distributions. GISHydro2000 creates this theme automatically when generating the "Area of Interest" view. This is a required input to the "Hydro" extension. It cannot be created by the extension.
- **Basin Relief:** This theme is generated by the "Hydro" extension given the "Original DEM" and "Flow Direction" themes. Selecting the "Hydro" menu choice, "Show Basin Relief" will add this theme to the view. Although basin relief is spatially distributed as indicated by the "Basin Relief" theme, in reality, the only value of any importance is the value of the "Basin Relief" theme at the watershed outlet.

- **<u>Limestone Geology:</u>** This theme is automatically added to the "Area of Interest" view or can be manually added from the file:
  - \umdgis\maryland\limestone\

  Note that this is a raster quantity so you should specify "Grid Data Source" if manually adding this theme to the view. This is a required input to the "Hydro" extension. It cannot be created by the extension.



Delineating a Watershed

Before attempting to delineate a watershed you must have successfully completed processing the DEM covering the basin you wish to study. We strongly suggest you also select the "Show Channels" item from the "Hydro" menu if they are not already included in your view. This will aid in the process of locating the pixel to select as your watershed outlet.

Say you are interested in delineating the watershed associated with the channel that is draining to the southwest as shown in the inset at right. To assure you select the correct pixel. it is a good idea to zoom in tightly on the vicinity of the outlet. Select the "W" Tool from the tool bar and then simply click the mouse on top of the pixel you wish to be the outlet of the basin. ArcView will perform some calculations for a little while, but will eventually return, having created a "Watershed" theme.

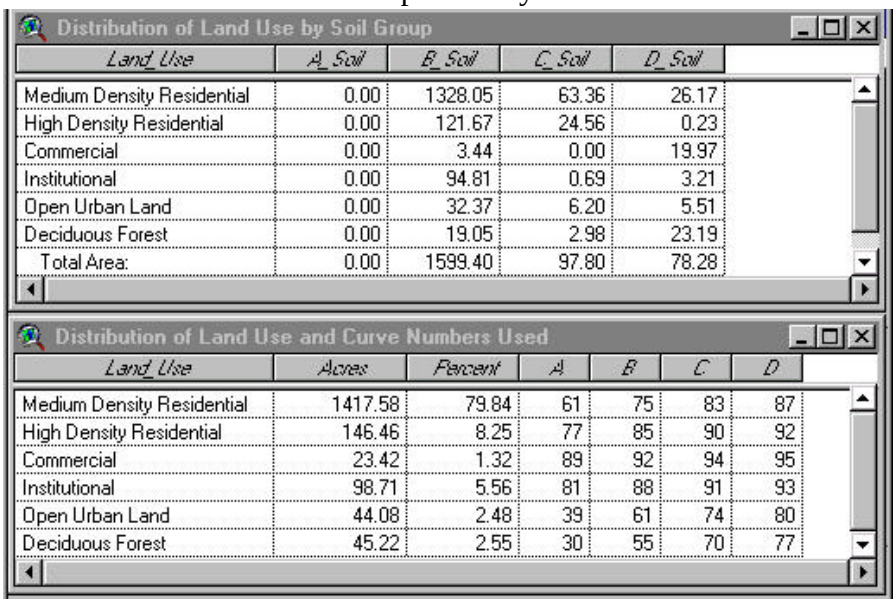
It cannot be stressed strongly enough that you closely and carefully inspect your delineated watershed to be sure it agrees well with the basin you were anticipating. You should be especially suspicious of any watershed which ends right at the border of selected data. Watersheds that extend to the border of the data often have straight boundaries. This indicates that more watershed lies beyond the boundaries of the data, and you should return to the "Select Quadrangles" dialogue box making sure to choose additional data along the area(s) where straight borders were observed.

Once you are satisfied with the watershed you have delineated you can proceed to the final steps of the analysis. The figure at above right shows the watershed delineated in this example.

Basin Composition

Selecting the "Basin Composition" item from the "Hydro" menu will generate two ArcView tables: "Distribution of Land Use by Soil Group" and "Distribution of Land Use and Curve Numbers Used" as shown below for the sample watershed shown on the previous page. These two tables are organized similarly to tables generated by the

original GISHydro program. A prompt is given by the software to additionally write out the contents of these two tables to a file specified by the user.



Distribution of Land Use by Soil Group

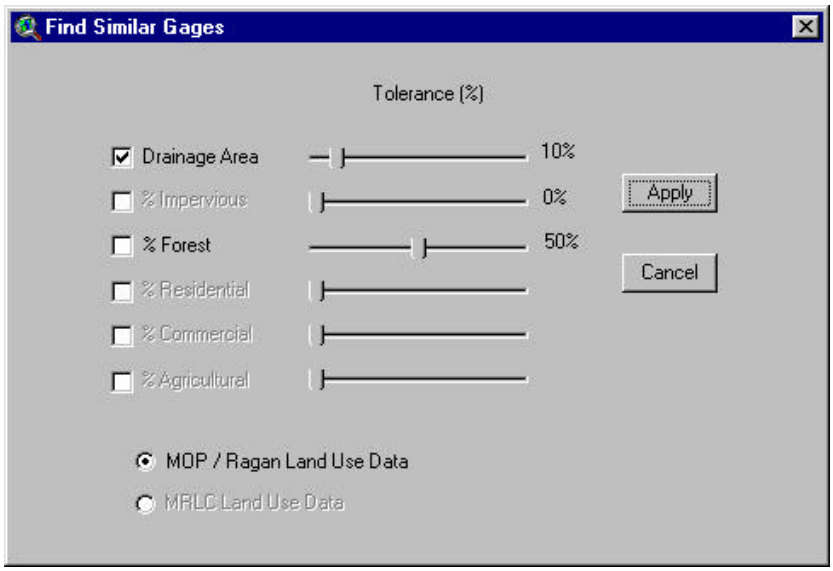
Land_Use	A_Soil	B_Soil	C_Soil	D_Soil
Medium Density Residential	0.00	1328.05	63.36	26.17
High Density Residential	0.00	121.67	24.56	0.23
Commercial	0.00	3.44	0.00	19.97
Institutional	0.00	94.81	0.69	3.21
Open Urban Land	0.00	32.37	6.20	5.51
Deciduous Forest	0.00	19.05	2.98	23.19
Total Area:	0.00	1599.40	97.80	78.28

Distribution of Land Use and Curve Numbers Used

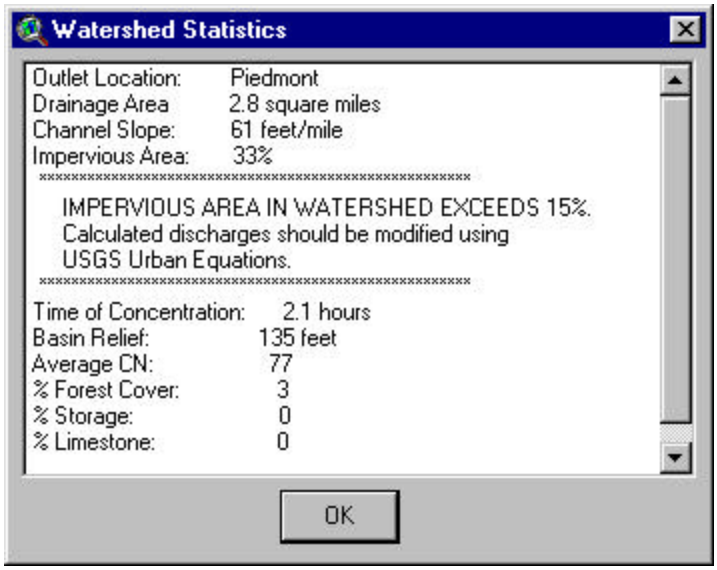
Land_Use	Acres	Percent	A	B	C	D
Medium Density Residential	1417.58	79.84	61	75	83	87
High Density Residential	146.46	8.25	77	85	90	92
Commercial	23.42	1.32	89	92	94	95
Institutional	98.71	5.56	81	88	91	93
Open Urban Land	44.08	2.48	39	61	74	80
Deciduous Forest	45.22	2.55	30	55	70	77

Find Similar Gages

This menu choice is of value for rapidly determining the subset of all U.S.G.S. stream gages located in Maryland that hold similar watershed properties to the watershed that the user has delineated. Selecting the "Find Similar Gages menu" choice will produce the dialogue box shown above. By selecting the desired search attributes and adjusting the provided slider bars appropriately, the user can develop a query of the overall Maryland stream gage database to determine those gages that are most similar to the delineated watershed. Care should be taken not to make the search criteria too strict or too lenient, lest no gages, or too many gages satisfy the search criteria, respectively. At present, the only supported search attributes are drainage area and %Forest cover. The database to support more exhaustive queries is currently under construction. All U.S.G.S. stream gages satisfying a query generated with the above box will be indicated as highlighted entries in a pop-up table, and will also be highlighted in the USGSgages theme in the "Area of Interest" view.



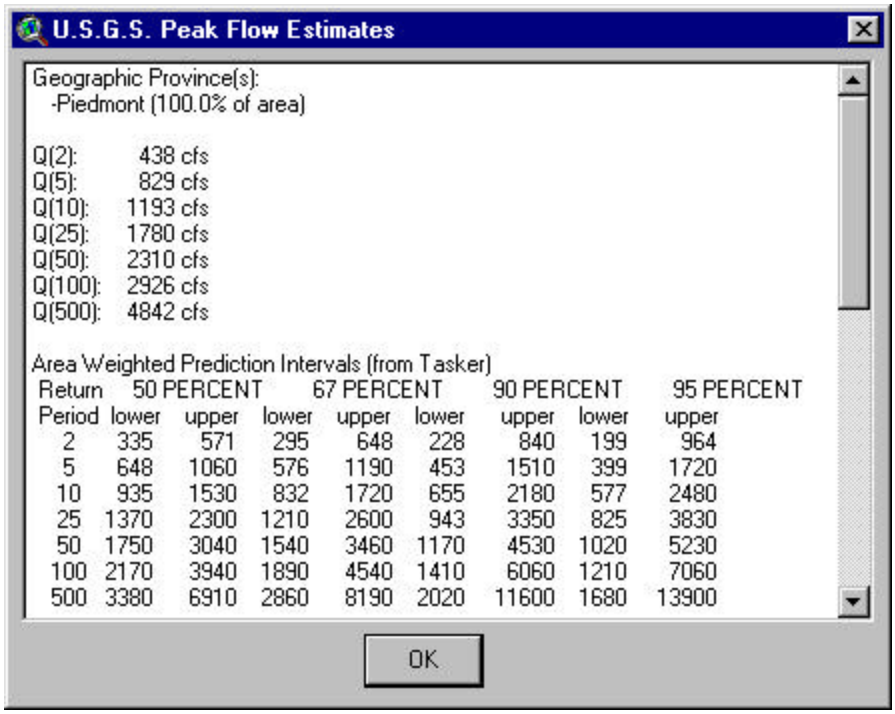
Basin Statistics



Selecting the "Basin Statistics" item from the "Hydro" menu will produce a dialogue box like the one shown at right. The information contained in this dialogue includes all the data needed to estimate peak discharges given the existing USGS Peak Discharge Equations as described in Dillow (1996). Additionally, a prompt is given by the software to write out the contents of this dialogue box to a file specified by the user. Notice that a warning will be printed in the event that the impervious area exceeds 15% of the watershed area. In this case, it will be necessary to adjust any discharges estimated using the USGS Peak Flow regression equations with the USGS Urban Equations (Sauer et al, 19xx). (We do not currently support a GIS method to perform this adjustment, because we are unable to obtain the appropriate coverages necessary to fully quantify the basin development factor (BDF). When such data becomes available, these equations will be incorporated into this package.

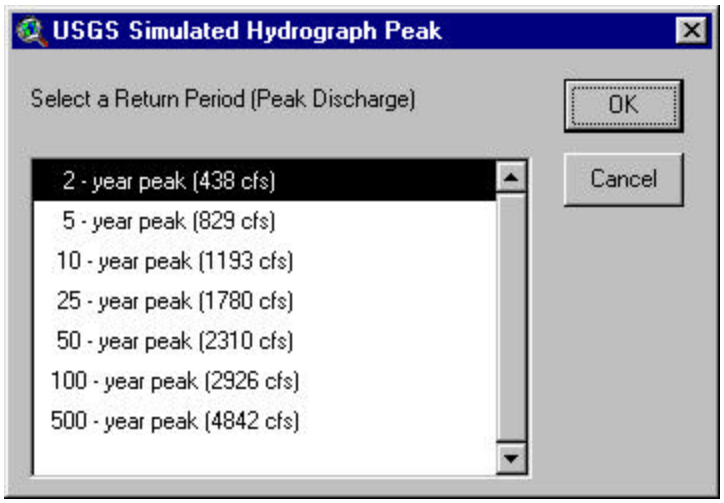
U.S.G.S. Peak Discharge Estimation

The Q_2 through Q_{500} discharges estimated from Dillow (1996) are computed automatically by selecting the "Calculate Discharges" item from the "Hydro" menu. In addition to the peak discharge estimates, confidence intervals on these estimates corresponding to 50%, 67%, 90%, and 95% are also determined from a U.S.G.S. developed program developed by Gary Tasker. In the event the watershed spans more than one geographic province area weighted estimates of both the peak discharges and the confidence intervals are determined. Not shown in the dialogue box at left is the lower half of the output which details the exact output from the Tasker program. Once the "OK" button is selected, a prompt is given by the software to write out the contents of this dialogue box to a file specified by the user. (Note: peak discharge estimates can **not** be calculated with this menu choice if the watershed outlet is determined to be outside of the boundaries of Maryland.)



U.S.G.S. Hydrograph Estimation

A second publication by Dillow (1997?) outlines a procedure to estimate hydrographs given a known flow peak (such as the peaks determined using the previous menu choice. Select the "Calculate Hydrograph" menu choice and you will be prompted by a dialogue box such as the one shown at right. You must select a hydrograph peak associated with one of the return



intervals 2 through 500 years (the 2-year return interval is shown selected at right). Once you have selected a return interval, a second dialogue box will appear such as shown at right. This box shows the determined hydrograph time and discharge values. Notice that the calculated hydrograph peak (438 cfs) corresponds with the peak estimated from the previous menu choice and offered as a selection option in the previous dialogue box. Once the "OK" button is selected, a prompt is given by the software to write out the contents of this dialogue box to a file specified by the user. In this fashion, the user can quickly import this data into another program (such as Excel) and generate a plot of this discharge hydrograph.