STATE HIGHWAY ADMINISTRATION

RESEARCH REPORT

DEVELOPMENT OF GISHYDRO2005 – PHASE 1

UNIVERSITY OF MARYLAND

FINAL REPORT

June 2006
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# Development of GISHydro 2005 – Phase 1

**Abstract**

GISHydro2000 is a GIS-based program that automates the analysis of any stream within or draining into the State of Maryland. This document describes the activities conducted over a roughly 2-year period from June 2004 to May 2006 in the continued development and maintenance of this program. Objectives of this work include:

1. Maintain and expand the Maryland spatial database of topography, land use, soils, and precipitation data.
2. Interface GISHydro2000 with the peak flow fixed region equations allowing for calculation of floods of all return frequencies, presentation of error bounds, gage weighting, and performance of calculations across physiographic boundaries.
3. Develop tools for velocity method of time of concentration calculation.
4. Develop and implement a Web-based version of GISHydro.

All of these objectives were successfully attained during the project period.

### Key Words

GIS, hydrologic model, land use, Maryland, time of concentration, TR-20, watershed analysis, web tools
Research Summary

Problem

This research project involved the continued development and evolution of the GISHydro2000 program. This program automates the hydrologic analysis of any watershed within the State of Maryland or draining into the state (except for the Susquehanna and Potomac Rivers). It is important to continually develop, maintain, and update this program as new data become available, new techniques or reporting are desired, and for compatibility with other GIS products produced or used by the State of Maryland.

Objectives

1. Maintain and expand the Maryland spatial database of topography, land use, soils, and precipitation data.
2. Interface GISHydro2000 with the peak flow fixed region equations allowing for calculation of floods of all return frequencies, presentation of error bounds, gage weighting, and performance of calculations across physiographic boundaries.
3. Develop tools for velocity method of time of concentration calculation.
4. Develop and implement a Web-based version of GISHydro.

The main deliverable of this project is a revised version of GISHydro2000 – delivered as a self-installing executable program as well as through a web interface.

Description

The tasks in this project ranged widely from maintenance to development of a new web-based version of this program. Throughout the project period, spatial data in the form of land use, soils, and precipitation information were continually added and updated to the spatial database as they became available and known to the Principal Investigator (P.I.)

A major area of effort to this program was the development of a set of tools for travel time calculation. There was a strong emphasis on developing tools that could be used interactively by the user to develop and modify travel time concentration calculations in an iterative manner. The figure shown at right is a dialogue box that helps the user define segments along the longest travel time flowpath in the watershed. Please see the appendix for more information on this tool.

Another major area of effort for this project was the development of a web-based version of GISHydro. Instructions for accessing this web-version appear in the first appendix to this report.
Results

This project attained all tasks outlined above in the objectives section. Interim versions of the GISHydro2000 program were posted at the GISHydro website and updated numerous times over the course of the project. A final version of the GISHydro2000 software was developed and posted on May 6, 2006 (subsequently updated on June 6, 2006). A small screen-shot of web-based version of GISHydro2000 access page is shown and right. More information on accessing the GISHydro2000 web version is provided in the second appendix.

Report Information

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Tasks

- **Task 1**: Make GISHydro 2005 capable of storing, retrieving, and hydrologically processing the Maryland Spatial Database. *(10% of effort)* Explore approaches to convert the “Hydro Extension” of GISHydro2000 into an equivalent version to run under the ArcGIS 9.x environment. This will entail the development of VBA scripts to manipulate grids and tables and to make use of basic hydrologic functionality within ArcGIS 9.x. Techniques learned here will be used in subsequent MSHA projects to convert GISHydro2000 from the ArcView to the ArcGIS environment.

- **Task 2**: Update land use and soils database of both GISHydro2000 and GISHydro2005 as new datasets become available during the project period. *(10% of effort)* For instance, the Maryland Department of Planning is expected to release its 2002 land use for the state during the project period.

- **Task 3**: Perform small modifications on GISHydro2000 as needed during the project period *(35% of effort)* Inevitably, there are required changes to GISHydro2000 as software bugs, reporting, or other needs arise. Additionally, the PI often fields questions from MSHA engineers on problems with specific studies being performed. This task item accounts for such efforts.

- **Task 4**: Write final report of activities accomplished during project period. *(10% of effort)* This final report will include a brief “user’s manual” style write-up illustrating a typical analysis session using the GISHydro2005 software.

- **Task 5**: Develop a preliminary web-based version of GISHydro2000. *(35% of effort)* The development of a web-based version of GISHydro2000 is an important and significant undertaking. This web version of GISHydro2000 will have all of the functionality of the current stand-alone version, but will be accessed via a web browser. The user will need only a viable internet connection in order for the web-version to be used. No local installation of the GIS software or GISHydro2000 will be needed. This web-based version is provides a crucial bridge between the current and new versions of this program.

Work Completed

**Task 1**: The University has had good success in conducting exploratory efforts into how the “Hydro” menu functionality will work. The research team was able to delineate watersheds, determine a set of watershed characteristics, run regression equations, and execute external programs. This functionality will be brought forward and will contribute to subsequent projects between SHA and the PI.

**Task 2**:  
- Land use data added: In January 2005, the P.I. added the Maryland Department of Planning 2002 land use data as the team became aware of it. This has been posted and available at the GISHydro website since February 6, 2005.
• Under the heading of changed county data the P.I. updated the Howard county ultimate development data based on new zoning information which Howard provided. This is related to the work for the MDE FEMA flood mapping project.

• Soils data added:
  o “Final SSURGO”: Howard and Kent

**Task 3:** The following is a reverse chronological listing of all maintenance and development of GISHydro2000 program that has resulted in GISHydro2000 updates over the project period:

• 5/6/2006: Revised ultimate land use files to include zoning in Delaware for areas draining to the Choptank River.

• 3/30/2006: 3 new items: 1) Gage weighting is now fully implemented for watersheds crossing physiographic provinces; 2) STATSGO soil distributions are used for regression equations; 3) Warnings are printed for watersheds near province breaks and limestone geology.

• 3/20/2006: This full installation contains the latest changes of March 4th and 13th plus a slightly modified data file for the "Tasker" program and the Fixed Region equations.

• 3/13/2006: Small changes to the file: umdghydrometric.avx file to account for changes in standard error estimates in Carpenter, Dillow, L-Moment, and Region of Influence methods for peak discharge estimation. Users only need to download/re-install this file.

• 3/4/2006: Small bug fixed: If soil type is undefined it is now treated as a "D" soil. This guarantees that area calculations in basin composition and sub-area statistics output sum to 100 percent.

• 1/9/2006: Added Delaware 2002 land use to create composite MD/DE 2002 land use dataset. Fixed two bugs: 1) channel burning now 500 feet so filling doesn't undermine true channel locations, 2) limestone percent calculation revised for when STATSGO soils are chosen.

• 12/14/2005: Small change to .apr file. Program had trouble calculating flow directions if elevations were less than zero. Just download and re-install new .apr file.

• 12/10/2005: Several Changes: Fixed "Tasker program" bug for Eastern Shore, Revised Howard County ultimate development, slight change to "Paul program" to calculate O/E ratio.


• 9/27/2005: Modified Select Quads dialog to input working directory. Fixed bug with Modify Hydrologic Condition dialog resulting from web-based version.

8/12/2005: Some changes to both the .apr and .avx files related to development of web-based version of GISHydro. Program now writes all files to "c:\temp\xxxxx" directory. Also fixed bug with "Discharge Comparison" menu choice.

7/14/2005: Added Baltimore, Cecil, Charles, and Talbot Counties "Draft SSURGO" soils data.

6/27/2005: Fixed bug in Dimensionless Hydrograph code under "Hydro: Calculate Hydrograph" to work correctly with Appalachian province watersheds.


5/17/2005: Added external executable that runs the "Gary Tasker" program to establish confidence intervals on Fixed Region equations and make adjustments for USGS gage data. Several small bugs also fixed.

2/6/2005: Added 2002 Land Use from Maryland Department of Planning. Added Tc Velocity method segment generator dialog. Documentation for this dialog is available at documentation web page.

9/18/2004: Revised .apr and .avx files slightly so user can specify any subset of storm frequencies and/or durations from the 24 available storms. See "Precipitation Depths" menu choice under "TR-20 Interface" Menu. Added "Analysis Date:" stamps to text outputs.

9/15/2004: Major Revision: The new .apr and .avx files now allow for automatic determination of precipitation depths for 2- through 500-year storms for 6, 12, and 24 hour durations. You MUST also download the separate Precipitation Installation download program.

9/8/2004: Revised umdgishydrometric.avx file to remove bug in limestone area calculation when multiple physiographic provinces are present.


6/21/2004: Revised APR to remove bug in "Calculate Attributes" menu choice.

6/15/2004: Revised APR to remove bug in "Merge Selected Subwatersheds" menu choice.

6/10/2004: Revised ultimate land use dataset.

Task 4: Progress on this item is in the form of interim documents developed during this project. These items include the documentation for the velocity method segment generator dialog and the documentation for accessing the web-based version of GISHydro. Both documents are included as appendices to this report.

Task 5: A trial web-version of this program was active during summer 2005 and a permanent web-version of GISHydro2000 has been online since early January 2006. To date (June 16, 2006), there are 68 registered users of the GISHydro2000 web-version.
Appendix 1: Documentation for Velocity Method Segment Generator
Glenn E. Moglen
February 2005 (Revised March 2005)

The purpose of this document is to provide guidance on the use of a new dialog box recently added to GISHydro2000 that allows the engineer to merge multiple pixels into single segments for computation of the time of concentration using the velocity method.

Preliminaries

Before reaching this new dialog box, the analysis proceeds in the standard way through the Hydro menu. Figure 1 shows the watershed statistics for an approximately 10 mi² watershed in the center of the East New Market quadrangle on Maryland’s eastern shore. Note that the Thomas time of concentration is 21.3 hours while the SCS Lag equation produces a \( t_c \) estimate of about 12.5 hours. This is a large disparity, but it does convey the general sense of a 10 to 20 hour time of concentration. This is a long \( t_c \) given the watershed size, but note that the overall basin relief is only 22.6 feet.

Analysis may now move to the CRWR-PrePro menu. For direct comparison to the Watershed Statistics output, this example will treat the basin as a single watershed. We proceed through the CRWR-PrePro menu by specifying only a single stream within the overall watershed which has the effect of modeling the watershed as a single sub-basin. Again, this is only for direct comparability between the \( t_c \) calculated using the velocity method approach and the \( t_c \)'s determined earlier in the Watershed Statistics dialog by the Thomas and SCS lag equations.
Figure 2 at right shows the standard “Time of Concentration Calculation” dialog as it appears for the analysis of this example watershed. Default values are chosen in all cases: this amounts to a 2-year, 24-hour precipitation depth of 3.39 inches as determined by the NOAA Atlas 14 dataset for the sheet flow portion of the time of concentration, unpaved conditions for the swale flow portion of the time of concentration and use of the National Hydrograph Dataset (NHD) streams to indicate the location (and onset) of channels for the channel flow portion of the time of concentration. Once these parameters are set and the dialog closed we select the “Calculate Attributes” menu choice which produces the raster theme, “Longest Path Sub 0”. Examining the table associated with this theme indicates an overall tc of over 38.5 hours over 392 pixels along the longest flow path. This tc is nearly twice the value determined using the SCS lag equation and more than three times the value determined using the Thomas equation.

This generally longer time of concentration is typical finding one is likely to encounter with the “pixel-based” approach to the calculation of the time of concentration within GISHydro2000. This finding is more likely to occur in relatively flat topography such as the eastern shore and is more likely to occur in larger watersheds (watersheds in excess of 5 mi^2). It is with this problem in mind that the Velocity Method Segment Generator dialog/tool was developed.

**Background on Why Merging Pixels Reduces Time of Concentration**

It’s worthwhile to take a few moments to understand how the merging of multiple pixels into a single segment of channel has the effect of reducing the calculated time of concentration. We begin by considering an idealized watershed in which the flow path controlling the time of concentration has uniform characteristics throughout. In this example, only slope will be varied although the reader should recognize that channel characteristics such as roughness or geometry also vary spatially. The elevation along the longest flow path is defined by the equation,

\[ y = x^2 \]  

(1)
where \( y \) is elevation \( x \) is position along the flow path, measured from upstream to downstream. For simplicity, we will examine a unit length of the flow path from \( x = 0 \) to \( x = 1 \). Slope along the longest flow path is simply,

\[
S = \frac{dy}{dx} = 2x
\]  

(2)

Assuming channel flow and either a Manning’s or Chezy velocity relationship,

\[
v \sim \sqrt{S}
\]  

(3)

where \( v \) is the velocity. Incremental travel time, \( dt_c \) is just the incremental distance divided by the velocity,

\[
dt_c = c \frac{dx}{\sqrt{S}} = \frac{dx}{\sqrt{2x}}
\]  

(4)

where \( c \) is a constant that is dependent on roughness and channel geometry. The total travel time is just the integral of equation 4,

\[
t_c = c \int_0^1 \frac{dx}{\sqrt{2x}} = c\sqrt{2} \cdot \left(\sqrt{1} - \sqrt{0}\right) = c\sqrt{2}
\]  

(5)

For simplicity, let’s assume that \( c=1 \), then the travel time over this unit length segment is just \( \sqrt{2} \). For contrast, Table 1 shows the travel time if the channel is treated as having one, two, or three segments over the distance from \( x = 0 \) to \( x = 1 \).

<table>
<thead>
<tr>
<th>Number of Segments</th>
<th>( x )</th>
<th>( y = x^2 )</th>
<th>( S = \frac{\Delta y}{\Delta x} )</th>
<th>( \Delta x )</th>
<th>( \Delta x \sqrt{S} )</th>
<th>( t_c = \sum \frac{\Delta x}{\sqrt{S}} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>0.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>0.5</td>
<td>0.25</td>
<td>1.5</td>
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<td>0.707</td>
<td>1.115</td>
<td></td>
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<tr>
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<td>0.5</td>
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<td>0.333</td>
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<td>0.333</td>
<td>0.333</td>
<td>0.577</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.667</td>
<td>0.444</td>
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<td>0.333</td>
<td>0.333</td>
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</tr>
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<td>1.0</td>
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<td>2.0</td>
<td>0.333</td>
<td>0.236</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Clearly, as the number of segments increases, the estimated \( t_c \) increases. Note that from equation 5 the analytical limit to the \( t_c \) (for an infinite number of segments would be \( \sqrt{2} \).
Using the *Velocity Segment Generator Dialog/Tool*

In our example watershed analysis we left off at the pixel-based velocity method time of concentration calculation of about 38.5 hours. The new Velocity Segment Generator Dialog is accessed through a new menu choice on the CRWR-PrePro menu just beneath the existing “Calculate Attributes” choice. The new choice, shown at right is, “Combine Longest Flow Path Segments”. Selecting this choice produces the dialog shown below in Figure 3. The dialog initially appears “blank” when it is first opened so the first step is to use the “Select Sub-Area” tool and select one sub-area from the watershed to be studied. In this case, the watershed is being treated as a single area so this tool is used only once. If the watershed has been sub-divided into multiple sub-areas then the tool will need to be used once for each sub-area, otherwise, the pixel-based time of concentration determined simply from the “Calculate Attributes” menu choice will be used in writing the $t_c$ to the TR-20 input file. Once the sub-area has been selected, the dialog box will update and will initially look as shown in Figure 3.

The Velocity Method Segment Generator can be divided into a left and right side. The left side is the “input” side while the right side is the “output” side. On the left side, the user can specify the merging of segments by individual pixel numbers (lower part) or the engineer can quickly merge all pixels of a particular flow type (i.e. overland, swale, or channel) into a single segment (upper part). Note that initially, there is 1 pixel...
defining the overland flow part of the longest path, 11 pixels defining the swale, and 380 pixels defining the channel. This amounts to 392 individual segments over which incremental $t_c$’s are summed to produce the overall estimate of the time of concentration. As was shown in Table 1, as the number of increments segments defining the flow path are increased, the $t_c$ tends to increase.

As a first step, let’s examine the simplest case of a longest flow path with one overland flow segment, one swale segment, and one channel segment. This can be quickly created by selecting each of the check boxes under the “Quick Merge” area and then pressing the “Recalculate $t_c$” button. The result, is the updated dialog as shown in Figure 4. Notice now that there is only 1 segment each for each of the 3 flow types and that the overall $t_c$ has been reduced to about 11.5 hours. This is a huge reduction from the 38.5 hours originally calculated and is actually about 1 hour less than the value determined using the SCS lag equation as shown in the Watershed Statistics dialog.

There are other elements that merit examination apart from just the segment generator dialog. Let’s examine the theme and associated table generated by this dialog. As stated in documentation elsewhere, selecting the “Calculate Attributes” menu choice produces the “Longest Path Sub x” raster theme where x is a number varying from 0 to n-1 where n is the total number of sub-areas within the overall watershed. By initiating the segment generator dialog, a new theme is created for each sub-area.
that is refined. These themes are called, “Tcpathx.shp” where x is a number varying from 0 to n-1 as above. This theme visually shows the longest flow path in sub-area x and also shows the 3 flow types of this longest flow path as shown in Figure 5. This figure focuses on the upstream end of the longest flow path. The solid black line corresponds to the channel portion of the longest flow path, the dashed red line corresponds to the swale, and the dotted blue line (barely visible at the extreme upstream end) is the overland portion of the longest flow path. Of course, much of the channel part of the flow path is truncated off in the figure. There is also a tabular representation of this theme as shown in Figure 6. Each row (record) in this table corresponds to an individual segment along the longest flow path. Segments are arranged in spatial order from the upstream end (record 1) to the downstream end (record m, m = 3 in Figure 6). Segments may vary according to flow type or there may be multiple segments within a single flow type. The following is a description of the contents of the entries in this table:

- **Shape**: This is a GIS concept. “Polyline” means that this table entry literally contains the geographic information of where this segment of the longest flow path is in space.
- **UpPixel**: This is the pixel number of the most upstream pixel in the indicated flow segment. These numbers correspond directly to the “Value” field in the “Longest Flow Path Sub x” theme.
- **SegName**: The segment name for the particular record in the table. A leading “O” means pure overland flow, “M” means mixed (some overland and some swale), “S” means swale, and “C” means channel. Segments are numbered consecutively from upstream to downstream so, for instance, “C2” corresponds to the second channel segment, immediately downstream from “C1”.
- **Type**: This is the type of flow. Potential entries are “Overland”, “Mixed”, “Swale”, and “Channel”
- **Downpixel**: This is the pixel number of the most downstream pixel in the indicated flow segment. These numbers correspond directly to the “Value” field in the “Longest Flow Path Sub x” theme. Notice that the downstream pixel from one segment is also the upstream pixel for the next segment in the downstream direction.
- **Avg. Area**: This number reflects the arithmetic average of the drainage area to all pixels combined to make up the flow segment. The value reported is in mi$^2$.
- **UpElev**: This is the elevation at the upstream end of the segment in feet.
- **DownElev**: This is the elevation at the downstream end of the segment in feet.
- **Slope**: The slope of the segment in ft/ft.
- **Width**: The channel width (in feet) determined using the Avg. Area reported earlier in the U.S. Fish and Wildlife hydraulic geometry equations. If the segment

<table>
<thead>
<tr>
<th>Shape</th>
<th>UpPixel</th>
<th>SegName</th>
<th>Type</th>
<th>DownPixel</th>
<th>Avg.Area</th>
<th>UpElev</th>
<th>DownElev</th>
<th>Slope</th>
<th>Width</th>
<th>Length</th>
<th>TV Length</th>
<th>UpElev</th>
<th>DownElev</th>
<th>Slope</th>
<th>Width</th>
</tr>
</thead>
<tbody>
<tr>
<td>PolyLine</td>
<td>1</td>
<td>M1</td>
<td>Mixed</td>
<td>2</td>
<td>0.001</td>
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<td>43.2</td>
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<td>0.22</td>
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<td>S1</td>
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<td>37.8</td>
<td>0.006334</td>
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<td>18</td>
<td>18</td>
<td>18</td>
<td>35</td>
<td>35</td>
<td>1.1</td>
<td>1.07</td>
</tr>
</tbody>
</table>
is not a channel then “-1.00” appears for this entry indicating that the quantity does not apply to this segment.

- **Depth:** The channel depth (in feet) determined using the Avg. Area reported earlier in the U.S. Fish and Wildlife hydraulic geometry equations. If the segment is not a channel then “-1.00” appears for this entry indicating that the quantity does not apply to this segment.

- **Xarea:** The channel cross-sectional area (in ft$^2$) determined using the Avg. Area reported earlier in the U.S. Fish and Wildlife hydraulic geometry equations. If the segment is not a channel then “-1.00” appears for this entry indicating that the quantity does not apply to this segment.

- **L_Length:** The length of the current flow segment in feet.

- **Tot_Length:** The total “running length” from the upstream end of the overall flow path to the bottom of the current segment in feet

- **Vel:** the average flow velocity in the current segment in ft/s.

- **I_Time:** the travel time of the current flow segment in hours.

- **Tot_Time:** the total “running time” from the upstream end of the overall flow path to the bottom of the current segment in hours.

Let’s now consider performing more controlled merges. We note that the “Quick Merge” demonstrated earlier produced, if anything, too small of an estimate of the overall $t_c$ value. Let’s imagine that our goal is to generate longest flow path segments such that:

- There is one (1) overland flow segment
- There is one (1) swale flow segment
- There are three (3) channel segments of roughly equal length

There is no “undo” tool for generating longest flow path segments. We can however “reset” the longest flow path to the original condition of each pixel representing a unique segment. This is done by again choosing the “Select Sub-Area” tool and selecting the sub-area for which we want to revise the $t_c$ estimate. The Velocity Segment Generator dialog will again appear as it did in Figure 3. As a first step, to obtain the one overland flow and one swale flow segment, we will choose the “Quick Merge” check boxes for just these two elements of the longest flow path. Although not shown, this results in a calculated $t_c$ only slightly reduced from the default 38.57 hours to 38.06 hours.

We now take on the task of reducing the

![Velocity Method Segment Generator](Merging the first channel segment from upstream pixel 13 to downstream pixel 140.)

**Figure 7.** Merging the first channel segment from upstream pixel 13 to downstream pixel 140.
channel flow portion of the longest flow path from 380 segments to 3 segments of roughly equal size. This would mean each segment is composed of roughly 380/3 or approximately 127 pixels. The very first channel pixel commences at UpPixel = 13, so the first segment would end at “DownPixel” = 140.

This is shown in Figure 7 at the moment before pressing the “Recalculate Tc” button. After pressing that button, the overall \( t_c \) becomes 30.18 hours and the number of channel segments is reduced to 254. We repeat this process two more times: for “UpPixel = 140 and “DownPixel” = 267” and for “UpPixel” = 267 and “DownPixel” = 393. This results in the final condition of the Velocity Method Segment Generator shown in Figure 8, where the \( t_c \) is now 12.93 hours, about 1.5 hours greater than the \( t_c \) that resulted from “Quick Merging” the channel into a single segment. Figure 9 shows the corresponding table for this flow path. This is just an example, but it illustrates how the engineer has complete control over the number and composition of longest flow path segments.

The engineer may wonder how and when the sub-area \( t_c \) values are recorded. Previously, the \( t_c \) values were set at the time that the “Calculate Attributes” menu choice was selected. This is the still the case, however, if the engineer subsequently chooses to use the Velocity Method Segment Generator any merges performed using this dialog will result in instantly updated values for \( t_c \) for the selected sub-area. The last \( t_c \) determined in any sub-area is the \( t_c \) that will ultimately be written to the TR-20 input file. Again, if the engineer is not pleased with a particular merge, the merge cannot be undone, but the \( t_c \) for that sub-area can be reset to the original condition by using the “Select Sub-Area” tool.
Guidance

We arrive now at the ultimate question of guidance. What is the “correct” value for $t_c$? Here I believe sound engineering judgment should be the guiding principle. Some things to examine or ask include:

- How does the pixel-based $t_c$ compare to the $t_c$ values determined using the “Basin Statistics” menu choice? Merging of pixels into larger segments for the longest flow path is probably indicated if the pixel-based $t_c$ is substantially greater than the $t_c$’s determined by the Will Thomas or SCS lag equations.

- Examine the “Attributes of TcPathx.shp” file and look for occurrences of unrealistically low velocities. For instance, consider Figure 10 which shows a small portion of a pixel-based channel flow path in which very small slopes and resulting very small travel velocities for the top three records shown.

- Use the “identify” tool to examine the DEM directly along the longest flow path. Is it genuinely very flat over long distances or are there only small “pockets” of flat areas? You might wish to use the “Create contours...” menu choice under the “Surface” menu in GISHydro2000 to create a contour map of the DEM for guidance in visualizing the topography. A genuinely flat area should be reflected by a segment that combines the pixels that span this area. The engineer should endeavor to merge pixels to create segments that reflect breaks in slope along the watershed.

- Examine the overall drainage network as it interacts with the longest flow path. Are there locations where significant tributaries join with the longest flow path? This is especially likely along the “channel” portion of the flow path. In such locations, the channel geometry is likely to change quickly to reflect the increased drainage area associated with the tributary. In such locations you should use the “identify” tool to identify the upstream/downstream pixel numbers along the longest flow path and then use the Velocity Method Segment Generator dialog to combine pixels into segments that begin/end at these large tributary junctions.

Ultimately, the decision of whether and to what degree to merge pixels must rest with the engineer. Simulated discharges using TR-20 (and other rainfall-runoff models)
are very sensitive to measures of representative time scales for the watershed. The time of concentration is a powerful parameter the engineer might vary during the calibration step. Owing to the structure of DEM data and its tendency to produce small slopes at a pixel-based description of the longest flow path, the engineer should pay especially close attention to small peak discharges produced by the TR-20 model. Are these modeled discharges small because of $t_c$ estimates that are much larger than those resulting from regression equations? If the answer to this question is "yes", then the combining of pixel-based segments into larger flow segments using the Velocity Method Segment Generator is probably indicated.
Appendix 2: Instructions for Using the Web-Based Version of GISHydro2000
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(last revised January 13, 2006)

There are several things you need to know to currently use GISHydro2000 from the web. These instructions will allow you to test the web-based version, however, the details of logging in may change over the next few weeks to months.

**Step 1: Obtain Login Information**

Access to the GISHydro2000 web version is free, however to control access to the web site is password protected. This is done for two reasons:

1. To provide added security to the server that is supporting the web version.
2. To help us document usage of the server.

To obtain a username and login, please contact Glenn Moglen (moglen@umd.edu) and request a login to the server. You should provide the following information with your username request:

- Your full name
- Your email address
- Your company or employer
- Your phone number

**Step 2: Download Plug-in**

The web-based version runs by using software from Citrix. In order to use this software, it is necessary to download and install a plug-in from this company. To do this, go to:


and download the file, “ica32t.exe. (There’s also a link to this at the GISHydro: Download page.)

**Step 3: Install Plug-in**

Once you have downloaded the plug-in, double click on its filename or icon and install. You should receive the following prompt window at the initiation of the installation:

![MetaFrame Presentation Server Web Client for Win32]

Click on the “Yes” window and accept all the subsequent installation wizard boxes to complete the installation.
Step 4: Set Security in Internet Explorer

It is necessary to indicate to your computer that the server that is supporting the GISHydro2000 program is a “trusted site”. To do this, in Internet Explorer select: Tools: Internet Options. Click on the “Security” tab and then click on the “Trusted Sites” Icon. Then click on the “Sites” button. In the window to the left of the “Add” button, type the URL, http://129-2-71-200.umd.edu. Then click the “Add” button and you should see the URL for this site jump to the lower window labeled “Web Sites:”. Click the “OK” buttons to accept this site and close out the change of this internet option.

Step 5: Logging into Server

At the Internet Explorer address window, type:

http://129-2-71-200.umd.edu

(alternatively, you can simply follow the link from the main GISHydro web page and follow the link from there.)

You will then see the browser appear as shown at right. Enter your user name and password obtained earlier in Step 1. Now click the “Log In” button.
Step 6: Providing Remote File Access
Click on the Windows Explorer icon (shown circled at right) to launch the windows explorer application. This will result in the shown dialog from the Citrix software. You want to choose “Full Access” to the first question. This will have the effect of mapping the drives on your local machine to the directory structure seen by the server. The effect will be as if the local drives on your machine become available drives to the server. GISHydro2000 will write all files during a given session to the “c:\temp\xxxxx” directory of the server. The value of “xxxxx” is randomly assigned but you can modify it as you wish. Thus, using Windows Explorer will allow you to copy and move files to/from the c:\temp\xxxxx directory on the server to your local machine as desired. More explanation on this temporary directory is contained under Step 8.
Step 6: Launching GISHydro2000

To launch GISHydro2000, simply click on the “GISHydro2000” icon (shown circled at right) and GISHydro2000 should start up. You are now logged in!

If you have not properly installed the plug in, when you click on the “GISHydro2000” icon, you will instead see the dialog box shown at right. If you get this dialog box, go back and review Steps 2 and 3 and make sure that they were done correctly and completely.
Step 8: File Management in GISHydro2000 Software

For security reasons and to keep files from different users and different projects separate, it is important to note a recent change to the GISHydro2000 software. As shown at right, the bottom part of the “Select Quads” dialog indicates the default path that GISHydro2000 has assigned for your analysis session. You may accept (and record) this number, or you can specify a more meaningful name of your own. Just be sure to retain the “c:\temp” part and to only use letters or numbers – do not use spaces or unusual characters such as “?”, “#”, “%” etc. All files you generate in this GISHydro2000 web session will be sent to this path or to directories located deeper along this path.

Step 9: Longevity of Files in the “c:\temp” Directory

Files written to the “c:\temp” directory should be considered temporary. You must make use of the windows explorer tool to move all work to your local machine from the server. At the time of this writing, files are automatically deleted from the “c:\temp” directory early each morning. The residence time of user files may be bumped up in the next few weeks to months, but you must maintain your own permanent version of all created files on your own local machine.

Final Comment:

The number of persons the server can simultaneously support is 10. So, (1) please log out promptly once you’ve completed your analysis, and (2) if you are unable to log in because all 10 of the licenses are already being used, please let me know. I’d like to know how often this license limit kicks in.

That’s it! I am still working on making this web-based version of GISHydro2000 work better and I expect there may be bugs because of some recent changes to make it web-compatible. Please let me know if you encounter any problems. Thank you.