Calculating Pervious Curve Numbers

A custom tool built using ArcGIS Diagrammer and ModelBuilder

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Pervious curve numbers play a major role in storm water management as a key component of hydrologic and hydraulic modeling for floodplain analysis. Curve numbers (CN) for various land-use classifications have been published by the U.S. Soil Conservation Service (SCS 1986) for each of the four hydrologic soils groups (A, B, C, and D). Curve numbers are unitless values ranging from approximately 30 (indicating high infiltration) to 100 (indicating high runoff).

Manually calculating pervious curve numbers for each subbasin in a study is simple but very time consuming. The author built a tool that automates the process of generating pervious curve numbers for polygon input data and a user-defined curve number table. In addition to building the model, thorough documentation is provided for the process so there is a high level of confidence in the accuracy of the results.

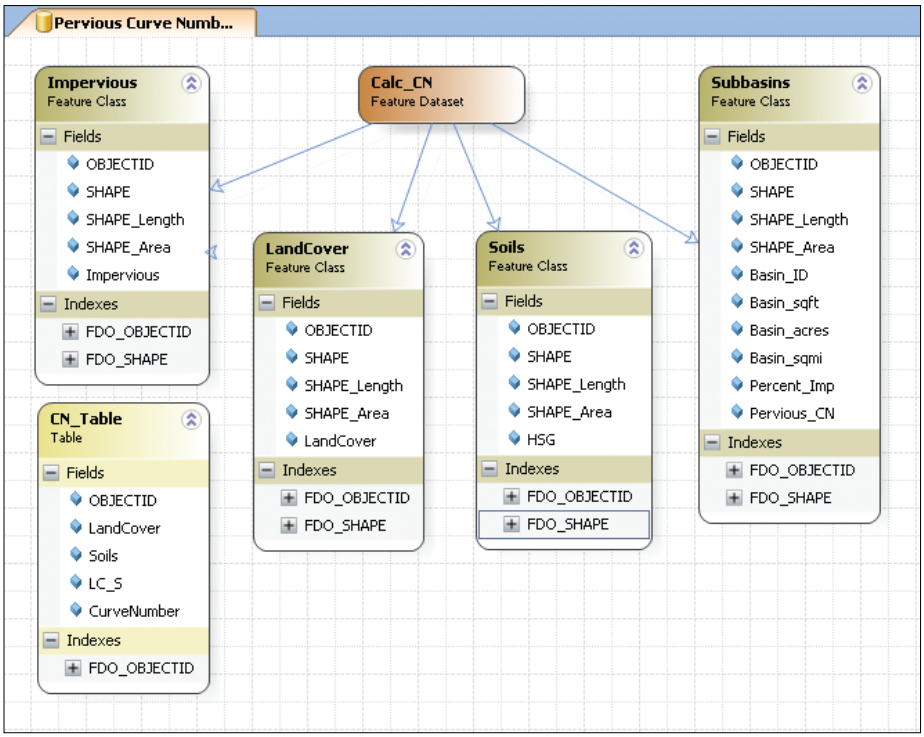
This tool was built in ArcView 9.3 for use on several projects. For this article, a representative example dataset was generated to demonstrate the application of the model. The tool includes an ArcGIS Diagrammer schema for building a personal geodatabase, a ModelBuilder model that accepts inputs from the geodatabase, and a map document with a custom toolbar to run the tool and display the final results.

Background

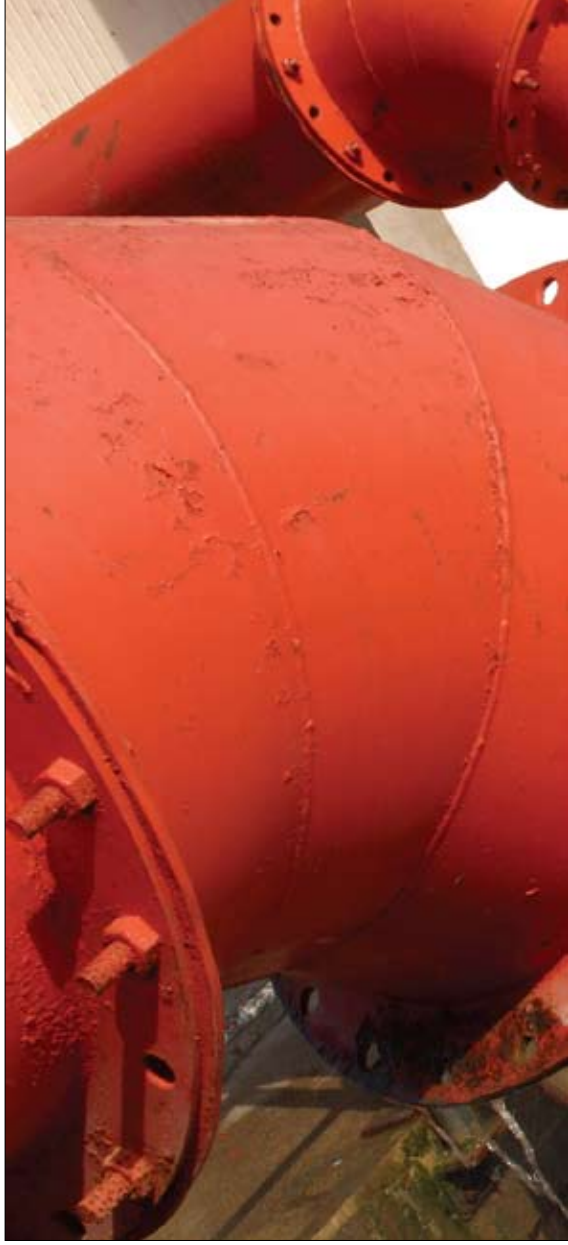
The Army Corps of Engineers Hydrologic Engineering Center develops and distributes a number of engineering software packages for performing hydrologic and hydraulic studies of watersheds and rivers. The center's latest program for performing hydrologic studies uses the Hydrologic Modeling System (HEC-HMS). There are many different calculation methods available for modeling the amount of water that will infiltrate and what will become runoff, with this software, but one of the most commonly used is the SCS Curve Number Loss Method.

This method is extremely popular because it requires few input parameters—basically the pervious curve number and the percent impervious for each subbasin studied in the model. To calculate these two parameters, five datasets are required: subbasins, land cover, soils, impervious areas, and a curve number table. Depending on the availability of data for the study area, the necessary procedures to generate the input data for this model may vary. Typical methods are as follows:

- Subbasins can be manually delineated from contour data or topographic maps based on the overland drainage divides that enclose a region draining to a single location. Boundaries should then be ground truthed to ensure the greatest accuracy and adjusted as needed.
- Land-cover data can be manually digitized from aerial photography, generating polygon features to define areas of forest, grass, brush, bare land, water, etc.
- Soils data can be downloaded from the Natural Resources Conservation Service (NRCS) Web Soil Survey (websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx) with assigned hydrologic soils group (HSG) values of A, B, C, or D for each



A sample diagram of a feature dataset with four polygon feature classes and a table in ArcGIS Diagrammer, which shows the geodatabase schema design for the example project.



A portion of the model used for the project. Calculations progress from the left with the blue inputs to the right along three primary branches to the final joins and calculations of percent impervious and pervious curve number.

soil type. Soils with a value of A have high infiltration rates while soils with D values have low infiltration rates.

- Impervious areas can also be manually digitized from aerial photography, which indicate buildings, roads, and sidewalks and other areas where water will not permeate the soil.
- Pervious curve numbers can be obtained from the standard SCS table of values (www.emrl.byu.edu/gsda/data_tips/tip_landuse_cntable.html). Using these values, the CN_Table included with the model can be updated to account for all combinations of land cover and soils types included in the input data.

When data acquisition and generation are complete, the four layers are overlaid and subdivided into polygons with unique curve numbers and impervious areas. To calculate a single pervious curve number for each subbasin, an area-weighted value is calculated from all the individual pervious area curve numbers. Percent impervious is calculated by dividing the total impervious area per subbasin by the total subbasin area.

While these calculations are straightforward, they require assimilating a large quantity of data. This is especially true if the study area has many subbasins to be analyzed. The associated time requirement was the motivating factor in creating a custom tool in ArcGIS to perform these calculations.

Using ArcGIS Diagrammer

ArcGIS Diagrammer, a relatively new productivity tool for GIS professionals, is used to create, edit, or analyze geodatabase schema. Its initial release was written to run on ArcGIS 9.2, and it can be downloaded at no charge from the ArcScripts Web site (arcscripts.esri.com/details.asp?dbid=15166). For ArcGIS-specific database schema design, this program provides a great alternative to other CASE tools such as Microsoft Visio and Rational Rose. While it may seem that ArcGIS Diagrammer has nothing to do with ModelBuilder, there are actually several benefits for using it as the starting point for a custom tool.

- It provides an opportunity to brainstorm and organize the input data requirements

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for the project and clearly define all features, fields, and data types.

- It can be used to re-create empty geodatabase schema for starting new projects. However, this requires an ArcEditor or higher license.
- It enables a model to be written for specific and known feature classes, fields, and data types. This reduces the additional inputs required by the user when running the model and increases chances of a successful run.
- Figure 1 shows a sample diagram of a feature dataset with four polygon feature classes and a table. This simple diagram demonstrates that essentially all the features and settings available for designing a personal geodatabase in ArcCatalog are also available in ArcGIS Diagrammer.

Standard fields, such as ObjectID and Shape, are automatically added by the program. Additional fields and data types can be added for each feature class and table. The feature dataset spatial reference must match the projected coordinate system of the model input data so the data will load properly into the personal geodatabase. The final step is to publish the diagram to an XML document.

Creating a New Personal Geodatabase

With an ArcEditor or higher license, the ArcGIS Diagrammer published schema can be imported in ArcCatalog into a new personal geodatabase as an XML workspace document. Using the Load Data command for each feature class in ArcCatalog, model input data can be added to the geodatabase. The loaded data must be of the correct data type and have all input attribute information required by the model.

Using ModelBuilder in the Design Process

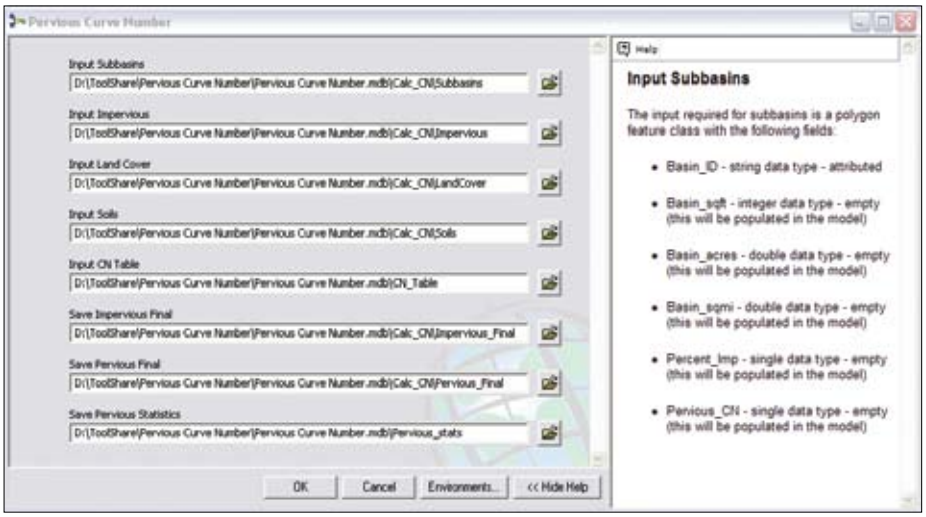
The design process in ModelBuilder is essentially the same as creating a flow diagram that follows the input data through a series of calculations until the desired output information is generated. Every tool in ArcToolbox can be used in ModelBuilder. For most functions, the flow diagram will mimic the actual tasks that would be performed manually.

In the sample dataset, the four feature classes and one table were designed in the geodatabase schema and are the input values. They are set as model parameters so that they can be changed for future projects. Three additional model parameters are set for the user to input the file path and file name for each of the model results. Also, the option Add to Display is set for each of the three model output files so when the tool is run in ArcMap, the results will be automatically loaded to the map for viewing.

This model has three calculation branches. The first branch runs several unit conversions on the subbasin areas. The second branch intersects the subbasins with the impervious areas to calculate the percent impervious of each subbasin. The third branch overlays the land cover and soils for the pervious areas and calculates the weighted average pervious curve number for each subbasin. The final step merges all three branches and joins the output calculations to the subbasin attribute table. This final table contains all input values required for the HEC-HMS model.

Proper documentation for the toolbox and the model tools is critical in ensuring the long-term reliability of the tool. At a minimum, information should be included about the

Development of this tool included attention to both metadata and documentation.



The model run dialog box features a help section that shows the information available for the subbasins input.

required inputs, how the model works, and the type of results generated.

While in the model edit session, documentation can be edited for each process in the model, which is included in the HTML help file for the tool. In ArcCatalog, the metadata editor can be used to add metadata for the tool and provide detailed information about each model input. When the model is run, this information is displayed in the help window on the right-hand side of the dialog box.

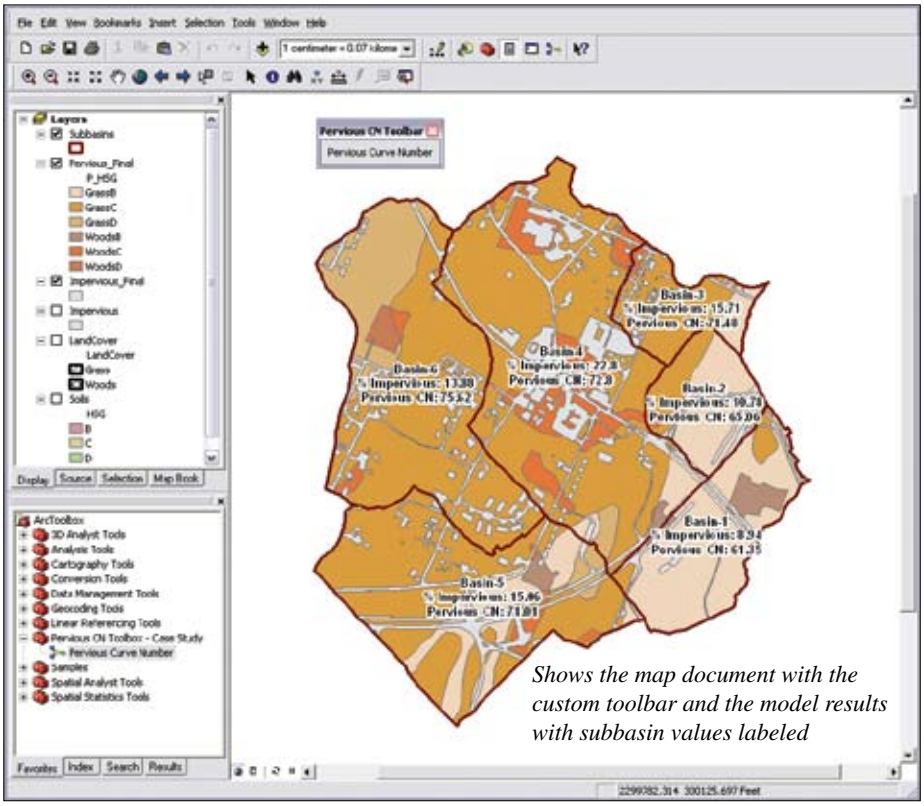
Creating a Custom Map Document

The prep work is done. The model is built, runs successfully, and is thoroughly documented. To make the tool as user-friendly as possible, use the following steps to place it on a custom toolbar in ArcMap.

1. Open ArcMap and save the blank map document.
2. Launch ArcToolbox in ArcMap and add the new toolbox.
3. Click View > Toolbars > Customize and create a new toolbar, and save it to the .mxd document.
4. On the Commands tab in the Customize dialog box, create a new UIButton control. Also, save this control to the .mxd document.
   a. Give the tool an appropriate name (e.g., Project.PerviousCurveNumber).
   b. Add the tool to the toolbar by dragging and dropping it.
   c. Right-click the tool and choose View Source to open the Visual Basic Editor.
5. Insert the block of VBA code for the GPToolCommandHelper found on the ESRI Developer Network (edndoc.esri.com/arcobjects/9.2/ComponentHelp/esriGeoprocessingUI/GeoprocessingUI_overview.htm).
   a. Delete the first two lines that declare and set the pApplication variable.
   b. Turn on the ESRI GeoprocessingUI Object Library (Tools > References).
   c. In the block of VBA code for the GPToolCommandHelper, insert the name of the model in the line of code shown here.

```
Set pGPTool = pArcToolbox.
GetToolbyNameString("<<NAME OF
YOUR SCRIPT HERE>>")
```

6. Save and close the Visual Basic Editor. Return to the new toolbar, click the button, provide the required model inputs, and view the results. At this point, the symbology can be set and labels added to enhance the readability of the results.



Shows the map document with the custom toolbar and the model results with subbasin values labeled

Summary

The techniques presented in this article incorporate an ArcGIS Diagrammer schema for building a personal geodatabase and a map document with a custom toolbar, in addition to the core ModelBuilder model, to perform pervious curve number calculations. While this is not the only method for building a custom tool, it utilizes a lot of planning and a little bit of customization to successfully improve the overall efficiency of the GIS and floodplain modeling.

For More Information

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Jennifer R. McGee is currently a water resources specialist for AMEC Earth & Environmental, Inc. Her primary duties involve performing hydrologic and hydraulic studies for floodplain mapping. She is also a graduate student in the master of engineering–GIS specialty program at the University of Colorado, Denver.

Resources Online

The author has supplied additional materials to allow readers to further explore the tool creation process outlined in this article. The archive available with the online version of this article at *ArcUser Online* (www.esri.com/arcuser) contains

- ArcGIS Diagrammer file
- ArcGIS Diagrammer published XML file
- Tool Documentation.htm
- GPToolCommandHelper VBA Code.doc
- Personal geodatabase schema
- Personal geodatabase with model input and output data
- Pervious CN Toolbox with Pervious Curve Number model
- Pervious Curve Number.mxd with Custom Toolbar and UIButton Control