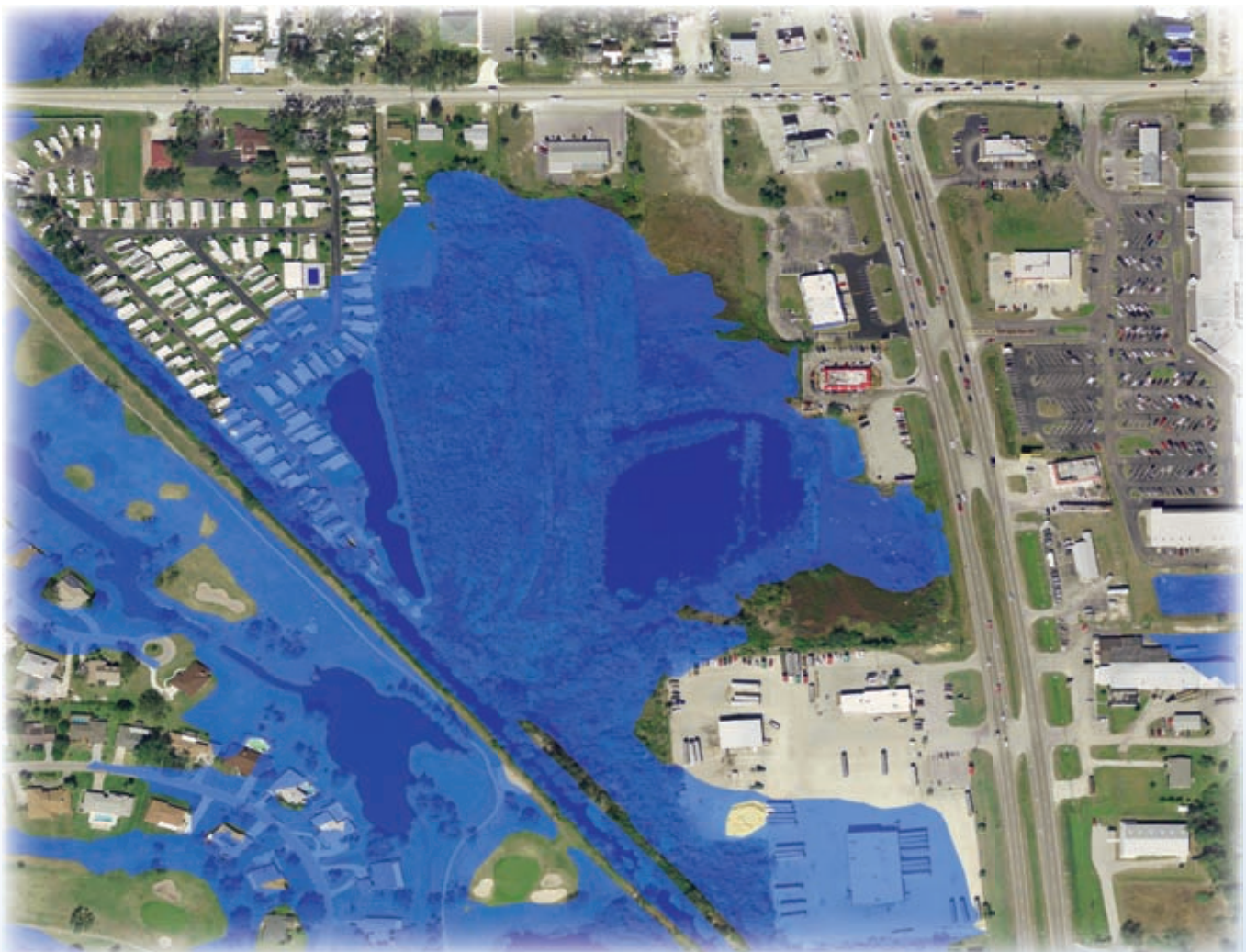


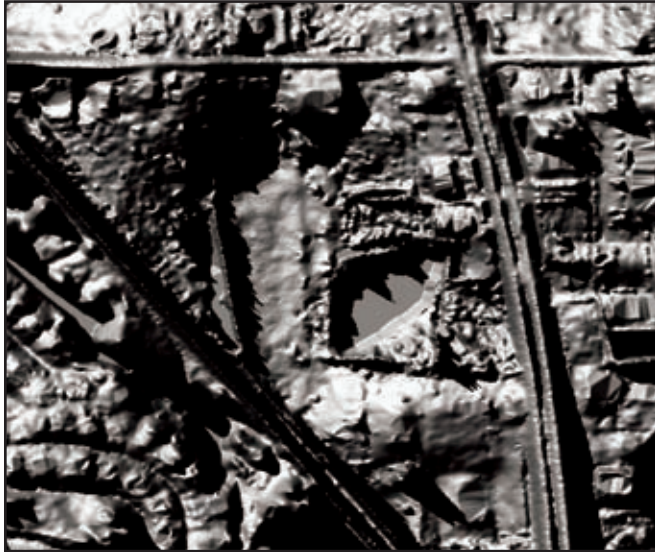
GIS Takes a Lead Role in Watershed Management

AUTOMATED TOOLS SAVE ENGINEERS TIME, HEADACHES

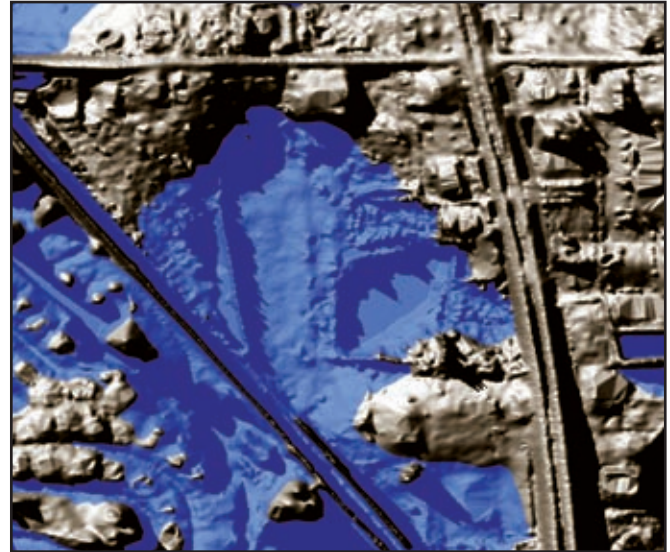
By Joe Walter, P.E.

Traditionally, the use of geographic information systems (GIS) for watershed management projects has been limited to a supporting role in mapping and related engineering activities—not often serving as a driving resource in the analytical process.





Digital elevation model.



Model with floodplain.

In planning the modeling component of the watershed management plans for the Southwest Florida Water Management District, PBS&J applied GIS technology and readily available digital data as driving tools for computer model development. This approach allowed for the establishment of more accurate, efficient and high-quality products.

Watershed studies conducted using a GIS platform have demonstrated that the spatial analysis capabilities of GIS hold the key to improved watershed modeling techniques. The analytical muscle of GIS, combined with readily available digital elevation data, can be used to automate the watershed modeling process and provide a visual representation of the watershed's response to existing conditions and proposed improvement scenarios.

Automated GIS tools also enable engineers to spend more time on the analysis and refinement of computer models and less on the laborious task of watershed parameterization for model setups. Furthermore, model results are easily converted into decision support tools that allow for the testing of multiple alternatives and refinements.

TIME-INTENSIVE TECHNIQUES

The traditional approach to watershed planning and modeling has been for an engineer to manually determine drainage patterns and paths using hard copies of

aerial and historical contour maps.

Hydrologic watershed parameters such as drainage area, curve number and time of concentration are then calculated for each individual basin either by hand or by spreadsheet, processes that can take weeks for a large project. This labor-intensive procedure is just a first step toward acquiring a basic understanding of the watershed's primary conveyances.

The next step, the setup of the computer model, would traditionally involve translating structures, bridges and cross-sectional survey data into usable hydraulic model format. This included a challenging calibration that aimed to replicate field conditions while retaining the watershed's hydraulic character.

Moreover, if after calibration the engineer discovered missing connectivity in the original model—for instance, a roadway overtopping or an interconnect between a lake and adjacent depression area—it became even more problematic to integrate the new information into the model. The solution, then, was often to effectively start much of the process over again.

In summary, the traditional approach has proven complex, time-intensive and costly.

GIS-BASED APPROACH

In contrast, the GIS-based watershed modeling process begins with

a digital representation of the ground surface topography, or a digital elevation model (DEM). Today, DEMs are increasingly available to both public and private organizations. The U.S. Geological Survey (USGS), for instance, has gathered elevation points for 5-ft elevation contours around the country. USGS publishes DEM data on its Web site, <http://edc.usgs.gov/geodata>.

Other agencies across the nation are building similar digital databases. The Southwest Florida Water Management District, for example, has flown a laser imaging detection and ranging (LIDAR) device over much of the district and made that information available to those in the watershed business. The accessibility of such elevation data makes the application of GIS that much easier.

One method for generating a DEM is through LIDAR remote sensing data. The LIDAR process generates data points spaced as little as 3 ft apart. Using GIS to analyze DEMs, an engineer can produce draft watershed delineation and drainage patterns with limited manipulation. DEMs are often associated with high-resolution aerial photography, as well. The combination of these two products enables engineers to perform a detailed desktop evaluation of watersheds before returning to ground level.

Within the first few weeks of conducting a watershed assessment, an engineer is able to have a draft of the modeling

framework along with a fairly detailed knowledge of the drainage patterns and a watershed delineation.

It is then a simple step to automatically generate the hydrologic parameters by overlaying land use and soil GIS data layers and performing area weighted averages of watershed parameters.

The bottom line? In a few weeks time, the engineer has accomplished what would have taken his or her predecessor months to complete.

FINE-TUNING THE MODEL

In a GIS environment, computer model development also becomes easier and more seamless. Rather than sending a survey crew into the field, the engineer, equipped with GPS and a laser level, can perform field investigations and verify any assumptions made in the desktop evaluation. Then the same engineer is able to collect model-specific data such as culvert

inverts, sizes and materials, along with cross-sectional data. The LIDAR data points can be used as benchmarks for field reconnaissance, too.

It is invaluable to have the engineer in the field infusing reality and context into the evaluation and calibration of watershed basin models. In addition, there is no need to decipher the survey and transfer the pertinent data into a computer model; the engineer will make the decision in the field, type the data into a handheld device and instantly upload it into a designated model format. Using the global positioning system (GPS) to identify the positional accuracy of each point surveyed makes the elevation data easy to verify using traditional survey measures, if necessary.

It is important to note that the elevations obtained using these methods are +/- 3 in., whereas survey results would be plus or minus 1/16 in. While GIS-derived elevations are not suitable for design

plan development, they are of sufficient accuracy for a watershed-level model.

BETTER VISUALIZATION

Traditionally, a one-dimensional (1-D) hydraulic profile was used to review the results of computer models. But using GIS, the 1-D hydraulic profile is converted into a two-dimensional (2-D) view during automated post-processing routines.

Early on in the process, the model will illustrate where more refinement and additional elements are needed. In subsequent and final iterations, the model will show flooding extents for existing conditions and flood reductions for design-alternative simulations.

What is difficult to see in the 1-D case becomes very apparent in the 2-D. The 2-D view of the system is able to show the paths by which water spreads out beyond the banks of the main channel and into affected areas. These automated techniques' power and potential are reshaping the way

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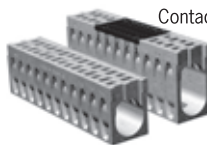
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engineers analyze watersheds and, in some cases, providing valuable information for community disaster mitigation activities.

PEACE CREEK WATERSHED MANAGEMENT PLAN

The Peace Creek Watershed in Polk County, Fla., spans over 200 sq miles and contains 136 named lakes and ponds. During the 2004-05 hurricanes, the watershed flooded with water levels reaching the 100-year flood stage.

As part of the Southwest Florida Water Management District's management plan for Peace Creek Watershed, PBS&J engineers developed a watershed-level computer model from a DEM consisting of grid cells measuring 5 ft x 5 ft.

The watershed model was developed using automated watershed delineations and hydrologic- and hydraulic-parameter generation to simulate hurricane conditions. Then, in addition to examining the traditional flood profile, engineers trans-

formed the profile views into a plan view of the flooding extent for existing conditions and flood-reducing alternatives.

Developing the views of flooding extents by hand or in computer-aided design could require several days of effort. But using GIS, engineers showed the flood elevation of all basins in the watershed in a single, few-hour process.

Using the flood-extent plan view as a tool, design alternatives were prioritized. One selected alternative, for example, included upstream and downstream changes of constricted reaches in streambed configurations so as to reduce flood levels and alleviate flooding in residential and commercial areas.

The accessibility and flexibility of these GIS-based watershed modeling solutions are key to maintaining the critical balance between the water resource needs of current and future users and protecting the public in times of extreme events.

THE GIS MOVEMENT

No longer seen as a back-office support tool, GIS has moved onto the desktops and laptops of storm water and watershed engineers. GIS is as routinely applied in day-to-day analytical activities as any traditional hydrologic solution.

In effect, the technology has created the opportunity to engineer projects, make better decisions and share information with a broad community—not just interested technical and nontechnical parties—in a clear, concise format. **SWS**

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