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GIS & Water Resources VI
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Monday, March 29
3:30 PM – 5:00 PM
SESSION 8: Hydrologic Modeling II

Development of GIS-Based Drainage Facilities Master Plans Using Local Hydrologic Methods - Justin Rogers, HDR Engineering, Inc., San Diego, CA (co-authors: Jim Zhu, Sunit Deo)

The need for drainage (flood control) facilities master plan hydrologic analysis for large areas of both urban and rural communities is common among local municipalities throughout the U.S. These master plans are used in development projections for drainage infrastructure and as a first-level analysis of existing drainage facilities. While Geographic Information Systems (GIS) based hydrology programs are readily available for standardized methods (such as the US Army Corps of Engineers HEC-HMS program and others), there is often little or no software available which will meet local hydrology criteria. For example, within the Southern California region, each county has its own separate hydrology criteria which are used to develop drainage facilities master plans within each county. This presentation will use examples from a recent master plan analysis within San Diego County, California. The San Diego County hydrology methods specify the use of the modified rational method for small drainage areas (less than one square mile) and the Natural Resources Conservation Service (NRCS) hydrograph method for larger areas, among other guidelines. The Advanced Engineering Software Company (AES) has developed a hydrology program which meets these guidelines, and includes a tabular interface to allow input from GIS-generated data to the AES hydrology modeling program. This tabular interface consists of three datasets which include subareas, links and nodes, with associated required information. The development of this tabular database is fairly simple and could be applied to other local hydrologic criteria and programs. This presentation will provide an overview of the methods used to develop the subarea-link-node structure including automated basin delineation, numbering, and junctions. It will also discuss the spatial analysis methods used to gather the required input parameters, such as land-use, soils, structures, rainfall, elevations, etc. After the hydrologic analysis, the AES program generates output in tabular format and post-processing can be performed within the GIS environment. While the AES program itself has some technical programming challenges, the concepts shown in this presentation would be applicable to development of GIS-based drainage facilities master plans in other regions.

Using GIS to Estimate Citywide Benefits from Stormwater BMPs in New York City - Francisco Brilhante, HDR Engineering, Pearl River , NY (co-authors: Marc Korpus, Carter H. Strickland, Jr.)

GIS tools and techniques can be used to measure the potential impact of policies under consideration to promote the installation of BMPs. PlaNYC 2030 adopts the reduction of CSO (combined stormwater overflow) volumes by installation of BMPs as a priority for New York City. A local law describes in detail a set of BMPs that the City will evaluate in developing its stormwater management plan. The New York City Mayor's Office for Long Term Planning and Sustainability is engaged in analysis of the costs and benefits of a range of BMPs with potential to decrease runoff and reduce CSO volumes, including improvements to public streets (rights-of-way) such as vegetated sidewalks (rain gardens), tree pits, roadside swales along highways and permeable pavements as well as improvements to buildings and homes such as blue roofs, green roofs, rain barrels and rain cisterns. Models were developed predicting the reduction of stormwater outflows by BMPs under varying conditions. The next challenge was to establish the length of public streets and highways for which streetside BMPs and swales may be introduced and the total size of residential lots at which on-site BMPs could be installed. Creative use was made of citywide GIS datasets that were originally developed for a variety of other purposes. Street centerline data created for transportation control was used to develop estimates of public right-of-way areas for which streetside BMPs could be used; New York City's MapPLUTO tax lot geographic database, developed for tax assessment, was used to create a citywide land use classification, from which it was possible to quantify areas for which residential scenarios could be applied. The analysis was then extended downward to quantify areas in each of the City's "CSO-sheds" where BMPs of these types could be installed. Implementation of this methodology required a consideration of (1) the timeliness and suitability of available geographic data, and (2) its accuracy and scale limitations. But with appropriate consideration of the accuracy limitations inherent in this type of geographic data, GIS methods, at relatively low cost, provide essential inputs for the analysis of stormwater BMP policy choices.

Performance Comparison of GIS-Based CPU, Multi-Threading and GPU Enhanced 2D Flood Models - Alfred Kalyanapu, University of Utah, Salt Lake City, UT (co-authors: Siddharth Shankar, Abe Stephens, Steven J. Burian, David R. Judi, Timothy N. McPherson)

The objective of this study is to investigate the speed and relative accuracy of 2D flood models which use three different computational frameworks: central processing unit (CPU), multi-threading (MT) and Graphics Processor Unit (GPU). The models are based on shallow water equations (SWE) and use an upwind-finite difference numerical formulation to simulate flood events. The computing approaches (MT, GPU) have been developed to increase the speed of simulation to permit greater domain sizes, more refined spatial and temporal resolution, and more simulations to be performed in the same amount of time it takes to complete a CPU simulation. The CPU and MT models have been developed on the Java platform and have been validated through comparison to observations and laboratory data. The GPU-based model is currently being developed in NVIDIA's Compute Unified Development Architecture (CUDA). All models are being developed within a geographic information system (GIS) environment, which alleviates both preprocessing and post processing of spatial datasets (e.g. topography, land use/land cover, etc.). For this study, these models are being applied to simulate a dam break event at the Taum Sauk pump-storage hydro-electric power plant in Missouri, which occurred on December 14, 2005. The first part of the study found the MT implementation to provide a significant speed up compared to the CPU model. A similar speed up and perhaps greater is expected for the GPU model. The paper will describe the model, the three computational approaches, and the results of the study of simulation speed and accuracy.

GIS Based Hydrologic Modeling Using Object Oriented Approach - Venkatesh Merwade, Purdue University, West Lafayette, IN (co-author: Kwangmin Kang)

Most grid-based distributed hydrologic models are complex in terms of data requirements, parameter estimation and computational demand. To address these issues, a simple grid-based hydrologic model is developed in a geographic information system (GIS) environment using storage-release concept. The model is named GIS Storage Release Model (GIS-StoRM). The storage-release concept uses the travel time within each cell to compute how much water is stored or released to the watershed outlet at each time step. The travel time within each cell is computed by combining the kinematic wave equation with Manning's equation. The input to GIS StoRM includes geospatial datasets such as radar rainfall data (NEXRAD), land use and digital elevation model (DEM). The structural framework for GIS StoRM is developed by exploiting geographic features in GIS as hydrologic modeling objects, which store and process geospatial and temporal information for hydrologic modeling. Hydrologic modeling objects developed in this study handle time series, raster and vector data within GIS to: (i) exchange input-output between modeling objects, (ii) extract parameters from GIS data; and (iii) simulate hydrologic processes. Conceptual and structural framework of GIS StoRM including its application to Cedar Creek watershed in northeast Indiana will be presented.

Impact of Pit Removal Methods on DEM Derived Drainage Lines in Flat Regions - Walter Collischonn, Instituto de Pesquisas Hidraulicas - Universidade Federal do Rio, Porto Alegre, RS (co-authors: Diogo Costa Buarque, Adriano Rolim da Paz, Carlos Andr Bulhes Mendes, Fernando Mainardi Fan)

Flat surfaces and spurious depressions are common features in raster Digital Elevation Models (DEM) of relatively low relief regions. Different methods have been created to overcome these features when defining flow directions and drainage networks, ranging from breaching to depression filling. The quality of the resulting streamlines is strongly related to the method used to remove pits and depressions, and to overcome flat surfaces. Most of the problems can be solved by imposing known drainage lines on the raster DEM by "stream burning" or similar techniques. However, in regions where no reliable vector drainage lines are available, one should use the best pit removal method. We used different GIS computer programs with diverse flow direction and pit removal methods, and compared the resulting river networks with drainage lines digitized over well referenced satellite images. The tests were carried out using SRTM DEM of flat regions of the Amazon basin, considering rivers with varying width and slope. In general better results were obtained by methods that breach the DEM at spurious depressions instead of filling the whole depression. Results were also shown to be dependent on river characteristics, such as width and slope.