AWRA 2010 SPRING SPECIALTY CONFERENCE
GIS and Water Resources VI
March 20 – 31, 2010
Orlando, Florida

TECHNICAL POSTER SESSION
Monday, March 29 - Tuesday, March 30, 2010

Posters will be on display Monday, from 8:30 AM – 6:30 PM (Poster Presenters will be at their posters from 5:00 PM – 6:30 PM during the Opening Networking Reception) and Tuesday from 8:30 AM – 3:30 PM

Note: The **Presenter** of each poster is in **BOLD** type immediately following the poster title.
Co-authors are then listed in parentheses.

Quantifying the Impact of Land Use Change on Non-Point Source Nitrogen Loading to Streams in the Contiguous United States - Md. Jahangir Alam, Department of Civil and Environmental Engineering, University of South Carolina, Columbia, SC (co-author: Jonathan L. Goodall)

The objective of this research is to quantify the impact of land use change in the contiguous United States on non-point source delivery of nitrogen to rivers and waterbodies. Several studies have demonstrated a relationship between land use and nonpoint source loading rates at the plot scale, however less work has been done to quantify the effects of land use change at the continental scale. Using the SPARROW (SPAtially Referenced Regressions On Watershed Attributes) model, we estimated nitrogen loadings to rivers and waterbodies under 1992 and 2001 land use classification schemes. We adjusted other sources for nitrogen when data were available (e.g. atmospheric deposition) and observed in-stream nitrogen loadings to 1992 and 2001 conditions. Land use change data were obtained from the National Land Cover Data (NLCD) Retrofit Change Product and water quality observations were obtained from the USGS National Stream Quality Accounting Network (NASQAN) program using the Consortium of Universities for the Advancement of Hydrologic Science, Inc. (CUAHSI) Hydrologic Information System (HIS). Model results show an 8% decrease in median incremental nitrogen yield from 1992 to 2001. Considering watersheds with dominate land use types, the model results showed an increase in median incremental yield of 14% for urban land use watersheds, while crop land, forest land, and grass land watersheds saw decreases in loads by 15%, 7%, and 6%, respectively. Urban watersheds had the highest median incremental yield (42 kg ha-1 yr-1 in 1992 and 48 kg ha-1 yr-1 in 2001) and crop land watersheds had the second highest median incremental yield 36 kg ha-1 yr-1 in 1992 and 31 kg ha-1 yr-1 in 2001). These results suggest focus be placed on mitigating nonpoint source nitrogen exported from urban lands.

Hydrological Effects Due to the Changes Land Use and Cover in the Basin of a Feliciano (Entre Rios Province, Argentina) - Alejandra Arbuet, Departamento de Hidrologoa - Facultad de Ingeniera y Ciencias H, Santa Fe, SF, Argentina (co-authors: Raul Pedraza, Graciela Pusineri)

The effects in peak flow and direct runoff, due to the changes in the land use and cover, were studied in A□ Feliciano (Entre R□os province) basin up to Paso Medina (5541 km2) during 1986-2006. The AGWA-KINEROS2 model under ArcView 3.2 GIS environment was used. To applied the model, basic data as the basin Digital Elevation Model and land use and cover maps were done using remote sensing and GIS techniques. The model was calibrated taking into account three rainfall-runoff events occurred under different land cover scenarios in 1986, 1996 and 2006. The land cover maps that correspond to these scenarios were determined from Landsat 5 TM images according to a classification specially. The changes in land use and cover were evaluated at two spatial scales, at a whole basin scale and at a local scale, particularly in one of the most affected subwatershed (WS#253). In both cases, woodlands and forest areas decreased and crops areas increased. The effects in peak flow and direct runoff, due to the changes in the land use and cover were evaluated. The calibrated model to each land cover scenario was used taking into account two inputs: a 5 year recurrence synthetic rainfall -with a uniform spatial distribution-, and a mean antecedent moisture condition -in order to separate from the analysis these factors effects in the runoff. The effects of two hypothetic land cover scenarios in the WS#253 subwatershed. The results of this investigation show that changes in the land use and cover produce a significant increase in peak flow and runoff. Particularly, it was found that the effects over the runoff are strongly no-linear when the increase of these variables and the respective areas with land cover changes were compared in percentage. Most of the area with changing land cover is located in soil areas in

which the erosion resistance is low and very low respectively. These soils are principally developed close to the drainage network areas, they have a high runoff potential and are strongly affected by agricultural practices -that break the soil structure and reduce the saturated hydraulic conductivity.

Natural Stream Flow Estimates for Montana: Using the NHDPlus Unit Runoff Method - Ariel Bates, U.S. Geological Survey, Denver, CO

This poster presents the methodology and results of the NHDPlus Unit Runoff Method (UROM) calculations for modeling natural streamflow in Montana. The poster does not represent actual streamflow, but rather modeled streamflow based on the UROM model. The intent of the map is to show the characteristics of Montana's drainage network and how the tributary system converges into larger and larger arteries to form the major rivers that drain the state. By reviewing this drainage pattern it is possible to better understand Montana's drainage network as well as provide a basic critique of the suitability of the UROM algorithm. The stream lines come from NHDPlus which is an integrated suite of application-ready geospatial data sets that incorporates many of the best features of the National Hydrography Dataset (NHD), and National Elevation Dataset (NED).

Finding Flooding Solutions using Interfacing Tools to Aid in Model Calibration and Public Collaboration - Cynthia Baumann, CDM, Providence, RI (co-author: Catherine Chomat)

This paper describes how GIS tools contributed to the projects' success. GIS not only facilitated model development and analysis, but it was also critical in helping local residents and municipal engineers understand the causes of flooding; the relationship between land use alterations and floodplain impacts and the potential changes in flooding extents as a result of improvements. CDM was contracted by the town of Greenwich, Connecticut to complete drainage evaluations for six watersheds that drain into Long Island Sound, covering approximately 22,000 acres. Detailed hydrologic and hydraulic models were developed for each watershed to understand current flooding problems and identify improvements that would alleviate flooding. For each watershed study, CDM participated in meetings with the Town Drainage Task Force, Flood and Erosion Control Board, community residents, and Town officials to understand community concerns and identify flooding problem areas. Based on the data collected, field investigations performed and information from residents, hydrologic and hydraulic models were developed utilizing HEC-HMS and HEC-RAS computer programs, combined with state-of-the art GIS interfacing tools. HEC-GeoHMS was used to extract watershed parameters while HEC-GeoRAS utilized the Town's GIS mapping to create river cross sections and map simulated flooding extents. Calibration of the existing conditions model was based on an actual flood event in April 2007. Based on statistical rainfall data, this event correlated to a 25-year storm and was used to calibrate the model. Figures generated using HEC-GeoRAS showing simulated flood extents were presented to residents for validation of actual flooding during that storm event. CDM evaluated different alternatives and recommended improvements to alleviate flooding. These improvements were compared using capital improvements ranking criteria developed for the project to prioritize thirty-one stormwater improvements. The GIS interfacing tools were instrumental throughout the project. Not only did the georeferencing aid in model development and analysis, but it also was critical in helping local residents and municipal engineers understand the causes of flooding; the relationship between land use development and floodplain impacts and the potential changes in flooding extents as a result of recommended improvements.

A Watershed-Based Hydrogeographic Analysis System for Forest Product Industry Stakeholders - John Beebe, NCASI , Kalamazoo, MI

The National Council for Air and Stream Improvement, also known as NCASI, uses GIS in several of its technical study programs including forestry research, wildlife assessments, habitat modeling, air and water quality investigations, and other research related to water resources and watershed management. One key assessment tool used by NCASI for water-related assessments is its Receiving Water Database (RWDB). First developed in the late 1990s, the core of the RWDB is a GIS created for river basins throughout the conterminous U.S. involving forestland and related forest product facilities. Its foundation is based on the National Hydrography Network (NHD) and other similar technical products, and is designed for processing information at local scales, for specific watersheds, as well as for regional and industry-wide assessments. The system has been utilized by NCASI member companies in total maximum daily load (TMDL) and other regulatory assessment activities. Perhaps most notably for addressing future surface water standards for nutrients and aquatic biota, the RWDB has facilitated analysis of proposed or pending water quality criteria and other water management restrictions that have potential to place restrictions on forest product stakeholders that are unreasonably disproportionate or lack scientific credibility. An overview of the purpose, development, data

sources, and example uses of the RWDB will be discussed including an industry-wide nutrient load assessment, regional water use investigations, critical flow and impaired water analyses, and other similar studies involving the interface of environmental and regulatory information.

Hydrologic Response Estimation of the Arroyo Cabrera (Spanish Central System) Flash Flood 1997 Event - Jose Maria Bodoque, University of Castilla La Mancha, Toledo, TOL, Spain (co-authors: Ballesteros-Canovas, J.A., Sánchez, M., Díez-Herrero, A., Nieto, A., Larsen, P.T.)

The arroyo Cabrera Watershed (Sierra de Gredos, Spanish Central System) is prone to castatrofic floods as the long geomorphic evidences demonstrate. On 17 December 1997, in response to a torrential rainstorm, a debris slide that subsequently evolved to a hyperconcentrated flow took place in the headwater of this watershed. Use of methods including hydrogeomorphic and precipitation-runoff models, as well as field observations enables to estimate the hydrologic response regarding this event. To this end, critical rainfall which is the minimum steady-state rainfall predicted to cause instability was determinated, by implementing a physically based model of hillslope stability. It combines steady-state hydrologic concepts with the infinite slope stability model and depends on soil mechanical and topographic factors that were estimated from a 5m grid DEM and using ArcView SHALSTAB. Since critical rainfall is defined for 24-h periods this precipitation value has been distributed in time, based on rain gauges located within the catchment, and by applying the Intensity-Duration law defined for the study site. The design hyetograph storms defined in this way were used as input in a semi-distributed model that aims to study watershed response to the 1997 storm event and whose basin model was defined from a 5m grid DEM and applying the ArcGIS 9.2 GIS extension HEC-GeoHMS. This precipitation-runoff model was previously calibrated an validated implemented automated procedures and based on both streamflow and rainfall data collected at 10-min intervals within arroyo Cabrera watershed. To this end, 7 observed hydrographs were used to calibrate the model and other 3 more for validation.

Creating Complex Chem-Box Labels in ArcGIS - Gary Bowles, Omni Environmental, Princeton, NJ (co-author: Gopi Jaligama)

As part of a recent landfill Remedial Investigation located in Camden, NJ approximately 300 environmental samples were collected, yielding over 30,000 analytical laboratory results. Industry standard Chem-Box maps, detailing analyte exceedence locations and values, were to be developed to display the data results. Creating Chem-Box maps has typically been a time consuming and tedious task. To meet tight project deadlines, Omni Environmental LLC combined the power of ArcGIS and Visual Basic to develop a time and cost saving methodology to automate the process of Chem-Box map creation. We were successful in taking digital data sheets received from the laboratory, extract all results greater than detection limits (detects), compare these to various environmental and human health criteria, import and link the data in GIS, and create color-coded Chem-Box maps, for approximately one-third of the cost and in one-quarter of the time of standard Chem-Box mapping. This presentation will review and discuss the methods and approaches employed to combine digital laboratory data and GIS and CAD data files in the creation and spatial display of Chem-Box maps using Visual Basic, Visual Basic Scripts and ArcGIS. Special attention will be given to explaining the collaboration needed to create mapping products that were satisfactory to the engineers, scientists, field crews, laboratory and GIS professionals involved in the project.

The Role of GIS in Identifying Utilities Vulnerable to Erosion from Natural Watercourses - Rayna Carmichael, AECOM Canada Ltd., Kitchener, ON, Canada (co-authos: Wolfgang Wolter

Throughout the 1960-s municipal servicing networks were predominantly installed in lowlands and valleys in most municipalities. Today, increased urbanization and general evolution of watercourses has lead to a series of isolated areas of erosion that are affecting the integrity of the installed infrastructure. As urbanization intensifies watercourse evolution will continue, therefore it is important to identify and assess the future risk to underground infrastructure. A Geographical Information System (GIS) desktop study was conducted for the Region of York, a rapidly growing community in north Toronto, Ontario, to identify potential locations of exposed infrastructure as it relates to watercourse bank erosion. The infrastructure inventory focused on water and wastewater trunks and collection systems. An initial Region driven inventory of potential erosion sites identified approximately 500 locations within 10 to 15 m of a watercourse. The primary purpose of the study was to filter these 500 sites through a series of distinguishing criteria to provide direction on the influencing risk factors associated with the watercourses. This process was completed through the use of a Multi Criteria Evaluation (MCE). Factors influencing potential risk of the infrastructure focused on: soil type, watercourse sinuosity, pipe age, distance and/or proximity to the watercourse, land use and pipe material. Criteria were ranked based on their relative

degree of risk. The MCE model identified 74 sites from the original 500 sites have potential exposure risk by all factors, and were recommended for further study. Of those 'at risk' sites ten were observed in the field. Four sites produced visible pipe exposure. These results illustrate the usefulness of MCE / GIS methods. The criteria in this study are shown to adequately identify sites at risk of watercourse erosion included infrastructure exposure making network assessment manageable and reduce the number of field assessments.

A Methodology for Forecasting Local and Regional Water Sustainability - Rebecca Carrol, USACE, Champaign, IL (co-authors: Ryan Holmes, MeLena Hessel, Laura Curvey)

Water is an increasingly scarce resource, a focus of regional conflict and cooperation, as highlighted by nationally respected groups like the Pacific Institute. Scientists expect climate change to significantly alter how much, when and where water is available. Water flows respect no political boundaries. Actions by users "upstream" or in different aquifer portions greatly impact sustainability for neighbors. To operate effectively in this context, water planners must understand current supply and demand as well as the variables that can impact the future for both. The use of Geographic Information Systems enables effective understanding of these relationships through visuals and data. A key concern for the U.S. Army is the vulnerability of military installations to critical water issues because resource shortages can compromise its mission. Using Fort Bliss in drought-prone West Texas as a case study, this project develops a regional water balance model using Excel spreadsheets with the aid of ArcGIS. The spreadsheet model provides a tool that planners can adapt to different scales for counties, cities, universities, etc. GIS plays an essential role for initial data analysis and to communicate existing conditions cartographically. Mapping technology facilitates the definition of the installation region (including social and natural features), determination of population centers, spatial apportionment of county water uses to different watersheds, and conceptualization of spatially explicit scenario factors. The project utilizes publicly available tabular and geo-referenced data for all current significant water supplies and uses. Sources include water utilities, irrigation districts, dam operators and regulators, and the U.S. Geological Survey. The methodology sums these data to show current availability and then considers population forecasts, water development plans, and environmental variables to form a number of future scenarios. These scenarios present what-ifs to aide decision makers. Users may tailor the spreadsheets in the future to include impacts of future policy decisions and ground conditions.

Putting the Information Together for Making Better Management Decisions: Water Quantity and Quality Story of the St. Johns River in NE Florida - Aisa Ceric, St. Johns River Water Management District, Palatka, FL (co-authors: Steve Winkler, Fay Baird, Tom Mirti, Kyle Knoche)

The St. Johns River Water Management District (SJRWMD) is an agency created by the Florida Legislature to preserve and manage water resources in northeast Florida. One of its core missions is to implement a regional strategy to provide sufficient water for users and the environment. Many communities in the St. Johns River (SJR) watershed have been relying on the Floridan aquifer as a source of drinking water supply. However, the aquifer is getting close to its limit of sustainable use, which has prompted the SJRWMD to evaluate the feasibility of surface water withdrawals. The SJR and its tributary the Ocklawaha River are being considered as possible alternative water supply sources. Since 2008, the SJRWMD has been engaged in an extensive scientific study to determine the feasibility and potential impacts of surface water withdrawals. This poster shows the results of data analysis performed on the historical hydrologic and water quality data collected throughout the SJR watershed using several customized tools (ArcHydstra tools, Status and Trends Mapping Tool) developed to help scientists better understand the SJR system and accurately evaluate possible environmental impacts of water withdrawal.

Application of Geographic Information System GIS and Groundwater Modeling System GMS for Management of Hardelot-Plage's Littoral, North of French - Fadi Chaaban, Laboratoire de Génie Civil et géo-Environnement LGCgE, Université des Sciences et Technologies de Lille (USTL), Villeneuve d'Ascq, France France (co-authors: B. Louche, J. El Khattabi, E. Masson, H.Darwishe, E.Carlier, Yvonne Battiau-Queney)

Abstract The beach-dune system of Hardelot-Plage (north of France) suffers a disorder due to sand-loss dunes. This problem is linked to almost constant saturation of sand beach which is the potential source of dune nutrition. The erosion marks are present and from where the coastline is always in retreat. To remedy this situation, a coupling between a geographic information system (ArcGIS 9.3) and a groundwater modeling system (GMS 6.0) was adopted in order to find the possible scenarios consisting by decreasing the piezometric surface in the sector concerned, which will make it possible to work again the beach-dune system. The GMS

provides a powerful tool for modeling hydrodynamics and it is able to solve complex problems such as the study of the of groundwater flow and seawater intrusion. The preparation of input data modeling is tedious and takes a long time. The use of GIS minimizes the effort and improves the efficiency of numerical models. The GIS provides a platform to high capacity of collection, management, manipulation, analysis, modeling and display of spatial data.

WARPLAM DSS: an Approach for the Delineation of Water Resources Planning and Management Regions using GIS - Ana Carolina Coelho Maran, Colorado State University, Fort Collins, CO (co-authors: Darrell G. Fontane; Evan Vlachos)

The lack of uniform and integrated water resources regions is a critical issue, especially in transboundary water regions and federative countries. Overlaying levels of planning and management, as a result of uncoordinated water resources regions, hamper Integrated Water Resources Management (IWRM). In addition, the process of delineating those regions has often been executed without sufficient scientific support. Despite the fact this is usually a result of political and historical circumstances, it is possible to have better results by using knowledge from prior experiences, modern techniques and improved decision support systems (DSS). In order to harmonize multiple objectives and better represent the interaction between environmental, socio-economic, political and historical aspects, it becomes imperative to define appropriate territorial limits for water resources planning and management. The present study introduces an approach to support the process of delineating water resources regions based both on recognition of more comprehensive aspects and incorporation of those aspects into a DSS. The proposed Water Resources Planning and Management Regions (WARPLAM) DSS is designed to be used by federal and state governments, international commissions and water councils. It intends to promote a common understanding about the logic behind this process, and to reinforce the principles of IWRM.Considering that river basins are the most suitable boundaries to attain IWRM goals, the DSS simulation model offers the option for decision makers to include socio-economic, political and environmental aspects into the analysis. It is based on the use of geographic information systems (GIS), expert systems (ES) and multi-criteria decision analysis (MCDA) combined with cluster analysis, dynamic programming and fuzzy analysis. WARPLAM DSS is also a very flexible solution to support the delineation of regions in multiple levels of subsidiarity and to be adaptable to regional circumstances.Among the techniques currently being applied, GIS has proven to be a valuable tool in the evaluation and analysis of natural resources problems, especially those involving spatial relationships. In addition, GIS improves the decision making process by facilitating interdisciplinary work. At last, such approach increases the efficiency of the algorithm being used in this study, by recognizing significant alternatives and faulty answers.

Identifying Potentially High-Yield Groundwater Resources using GIS - Frances Curtis, Weston Solutions Inc, West Chester, PA (co-author: Daniel Strobridge)

WESTON Solutions was contracted to conduct a study of potential areas which might provide high yield of groundwater if drilled. In order to perform the water resources evaluation, several geologic, hydrologic, and geographic data sets were obtained from various state and local agencies. The databases provided spatial information regarding bedrock geology, surficial geology, topography, water supply wells and land use throughout the region. The groundwater resources evaluation focused on the bedrock units of the Catskill Formation rather than the surficial (unconsolidated) aquifer because of the importance of the surficial aquifer to local residents and the extensive intercommunication between shallow groundwater and surface water. By restricting groundwater use to bedrock aquifers, impacts to local users and surface water bodies such as streams, wetlands and vernal pools can be minimized. The evaluation of bedrock groundwater resources was accomplished by applying GIS spatial analysis to existing hydrogeologic information to obtain potential supply well yields. The spatial analysis consisted of two primary steps. The first step was to obtain predictions of potential supply well yields, and the second step was to determine which locations were most favorable by identifying areas that could not be used based on the specific constraints. In order to predict a potential water supply well's response to prolonged pumping and its likely influence on existing nearby water supply wells, the Theis equation was used in the analysis. The Theis equation is a fundamental analytical tool that has been used in groundwater hydraulics since its introduction in 1935. This equation was used to determine potential supply well yields in addition to influences on nearby wells. Potential well yields were determined for three separate supply well depths based on the database information: 500 ft, 1000 ft, and 1500 ft. For each of these depth intervals, two different scenarios were considered: one with constraints imposed and one with the constraints lifted.

Groundwater Management in the Chalk Aquifer in Bethune (North of France): Coupling of GIS and Hydro Geological Modeling - Hanan Darwishe, Laboratoire de Génie Civil et géo-Environnement LGCgE, Université des Sciences et Technologies de Lille (USTL), Villeneuve d'Ascq, France (co-authors: B. Louche, E. Masson, J. El Khattabi, F. Chaaban, E. Carlier)

Water management, both in quality and quantity, has become a major concern to ensure the quality of life on our planet and to assure the sustainable economic development of our societies. In the north of France (Nord - Pas de Calais) , the nitrate concentrations measured in the Groundwater of chalk exceed the drinking water limit fixed at 50 mg/L by the European framework directive in the field of water (2000/60/EC). Lens Liévin's drinking water, in the region of Nord -Pas de Calais, is provided mainly by groundwater abstraction in the same sector. The physic-chemical quality of water is poor. The subject of this research is to cover drinking water for Lens Liévin. The study focuses on two wells of drinking water, located within the chalk aquifer of Béthune in the north of the region. The chalk in this zone is covered by sand and clay formations of the Cenozoic, leading to the captivity of the aquifer. The captive nature of the aquifer allows the existence of the natural process of denitrification, which leads to the rapid degradation of nitrates; it results a good water quality. In this case, the wells are vulnerable to pollution accidental and bacteriological. The problem is to determine the optimal abstraction rates which, allows at the same time, supplying the sector of Lens Liévin and keeping the captivity of Béthune's aquifer. A HBDS (Hypergraph-Based Data Structure) model was created to structure and simplify the problem. A physical data model was carried out using ARCGIS9.3 software, and all input data were prepared in GIS using a model builder. The model builder helped in spatial distribtuion of input data used in the modeling phase. A numerical model: Modflow was made in Visual Modflow's software. Two simulations were performed, first a steady state simulation in order to calibration the model, then a transit simulation from 1972 to 2008 which allowed to do additional abstraction simulations. The results of these simulations were exported and then imported to the GIS, allowing the study the impact of these additional abstraction on the denitrification phenomenon and choose the optimal abstraction rates.

GIS-Based Application of Erosion-3D Model for Identification of Potential Sediment Source Areas and Derivation of Site Related Measures to Minimize Erosion - Mengistu Defersha, Florida International University, Miami, FL (co-authors: A. Melesse, M. McClain)

The trans-boundary Mara River basin lies across Kenya and Tanzania and covers about 13,834 km2 areas. The trans-boundary Mara River basin lies across Kenya and Tanzania and covers about 13,834 km2 areas. Forests and Savannah grasslands have been cleared and turned into agricultural lands. Moreover; charcoal burning, overgrazing and expansion of agricultural activities exposed the land for degradation. Such change in land use has greatly affected the water quality of the Mara River in particular and the productivity of the basin in general. Unless the current rate of erosion is not minimized to the tolerable rate, the Mara ecosystem, which is the world wild life heritage, may not continue at its status. Considering this the paper is proposed to full fill two main objectives: To identify potential sediment source areas and to estimate the yields of sediments; and evaluate the effects of various land-uses change and management scenarios on sediment yield and runoff fluxes. To achieve these objectives, Erosion-3D model with GIS environment is implemented. The main reason for application of this model is its low input data requirement, which seems logical for area that has no good data bank. The observed sediment production and erosion data collected from nine runoff plots that had been installed at three selected sites is used for model calibration. The model allows the use of different scenarios of conservation measures for selecting those that are good in reducing erosion and sediment loads.

Interrill Erosion, Runoff and Sediment Size Distribution as Affected by Slope Steepness and Antecedent Moisture Content - Mengistu Defersha, Florida International University, Miami, FL (co-authors: Shoeb Quraishi, A. Melesse, M. McClain)

Soil erosion is a two-phase process consisting of the detachment of individual particles and their transport by erosive agents such as flowing water. The rate at which erosion occurs depends upon the individual as well as interactive effects of different parameters responsible for soil erosion. The study discusses results of a laboratory analysis conducted in Alemaya, Ethiopia, which evaluates the effect of slope steepness and antecedent moisture content on sediment yield and runoff rate. Sediment yield, splash detachment, runoff, and sediment size distribution were measured in laboratory erosion pans under simulated total duration of 90 minutes. Rainfall intensity at 120mm/hr, 70mm/hr, and 55mm/hr were applied sequentially at 9, 25, and 45% slope steepness for three soils (Alemaya Black soil, Regosols, and Cambisols) from clay to sandy clay loam in texture with wet and dry antecedent water contents. As slope steepness increased from 9 to 25% splash increased for five treatments and decreased for the remaining treatment; washed sediment increased for all

treatments. As slope increased from 25 to 45% splash decreased for five treatments but increased for one treatment, and washed sediment increased for three treatments but decreased for the other three treatments. Pre-wetting decreased splash detachment for all soil treatments and rate of reduction was high for the highly aggregated soil, Alemaya Black soil and low for the less aggregated soil Regosols. Splash sediment and sediment yield was not correlated. Change in splash with increase in slope steepness was also not correlated with change in sediment yield. Change in runoff rate with increase in slope steepness was correlated (r = 0.66) with change in sediment yield. For Alemaya Black soil and Regosols, splashed sediment size distribution was correlated with washed sediment size distribution. However, splash sediment size distribution was not correlated with sediment size distribution; (Silt + clay)% in washed sediment/ (silt + clay)% in splashed sediment was negatively correlated (r= -0.876) and (r= -0.924) with runoff rate, for Alemaya Black soil and Cambisols, respectively. (Medium sand % in washed sediment)/(Medium sand % in splashed sediment) was positively correlated with runoff rate for two soils but not for Regosols

Developing Residential Irrigable Areas Using GIS - Corey Denninger, SWFWMD - Southwest Florida Water Management District, Brooksville, FL (co-authors: Yassert Gonzalez, Kevin Wills)

Since the vast majority of homes only have one water meter, the amount of water used for outdoor irrigation is rarely available. It has been estimated that 30-50% of a homeowner's water use is for outdoor irrigation. This range may apply at a regional scale; however, its application to a small community or utility service area is problematic. It does not take into account a host of factors such as acreage, location, and the year built. In order to develop more accurate outdoor water use estimates, it is necessary that we determine the irrigable area per residential parcel. As of now, the Southwest Florida Water Management District's (SWFWMD) relies on irrigable area estimates generated by older studies conducted in other regions of Florida. Currently, there are a few methods used for determining the irrigable area including acquiring property appraiser data and removing the home square footage from the total lot square footage or to apply a ratio to the water meter data which does not separate outdoor from indoor use. Our study will develop a GIS-based model that calculates irrigable area at the parcel level. Moreover, the model will produce irrigable area estimates for residential parcel size ranges. We also propose to determine the ratio of irrigable area to non-irrigable area per lot based on the year the home was built and where it falls within our diverse geographic region. The presentation will focus on the GIS methodologies we have developed to calculate more accurate irrigable areas per parcel and how these techniques can be applied locally and regionally. This analysis will be a key component in our water conservation efforts and water supply planning.

TIN Processing for Hydraulic Analysis Using GIS - Sunit Deo, HDR Engineering, Inc, Austin, TX (co-author: Justin Rogers)

Hydraulic model accuracy is highly dependent on how well the model geometry depicts the real earth surface. Therefore, accurate preparation of terrain geometry is essential to successful hydraulic modeling. Geographic Information Systems (GIS) tools are useful in preparing terrain geometry, and the most common being triangulated irregular networks (TIN), which are a three dimensional representation of the ground. A TIN is used to generate geometric data for hydraulic models, such as cross sections for 1-dimensional model (HEC-RAS), or a grid for more complex 2- or 3-dimensional models. Additionally, a TIN can be used to map inundation limits which help visualize model results. In practice, TIN generation can be a complex and difficult process as most often, the surface data is available from various sources and in different formats. These formats include LIDAR points, topographic contours, field surveys, digital elevation models (DEMs), ESRI shapefiles, Rasters, AutoCAD files, among others. It is dependent on the user to accurately process and combine all the available data and generate a TIN that can be used for hydraulic analysis and post-processing hydraulic results. There are many aspects of available datasets such as projections, continuity, limitations, accuracy, that user must be aware of while processing the TIN. The TIN (and therefore the hydraulic model) can only be as accurate as the least accurate dataset that is used in the TIN generation. This presentation will focus on guidelines for accurate TIN processing using GIS tools when multiple datasets are available. An emphasis will be given to minimizing processing errors in TIN development. The presentation will also show how GIS, with 3D Analyst and Spatial Analyst extensions, can be used efficiently and independently in some special cases with meandering streams and where limited data are available, or where automated floodplain mapping tools give errors.

Modeling the Influence of Vegetation Dynamics on the hydrology of Mara River Basin using Semi-distributed Hydrologic Models - Shimelis Dessu, Florida International University, Miami, FL (co-authors: Assefa M. Melese, Michael McClain)

The effects of vegetation on the dynamics of hydrologic processes can be viewed as part of the responses of the watershed to moisture and energy input. This two-way eco-hydrologic dynamics is an important element to be captured by watershed scale hydrologic modeling process in a relatively higher vegetation land cover type. This study used two semi-distributed hydrologic models, Flood Early Warning System Stream Flow Model (FEWS-SFM) and Soil and Water Assessment Tool (SWAT), with respect to the influence of vegetation dynamics on the hydrologic response of the Mara River basin, Kenya/Tanzania.. These models use climate data as a forcing dynamic input and static land use/cover. From the preliminary modeling calibration process, the basin loss (FEWS-SFM) and the ground water recharge (SWAT) are the most sensitive parameters. As observed from the output hydrographs, the rising and falling limb of the simulated and calibrated hydrograph has higher discrepancy with the measured values. The beginning of wet season is where both models fail to capture the measured flow patterns, and this is the time of vegetation bloom in grasslands and agricultural lands. The US-SCS curve number method is employed in both models, where catchments are lumped in sub basins to obtain area averaged values. Being not in grid-based hydraulics, the sensitivity of change in vegetation cover in plot level are not visible unless a long time series data of all the necessary quantities are present. The analysis indicate the need to couple eco-hydrological perspective in rainfall-runoff simulation and further study is being underway to understand the whole process.

National Hydrography Dataset Plus (NHDPlus) Elevation-Derived Catchments - Tommy Dewald, U.S. Environmental Protection Agency - Office of Water, Arlington, VA

NHDPlus is a suite of geospatial data products that incorporates many of the best features of the National Hydrography Dataset (NHD), the National Elevation Dataset (NED) and the Watershed Boundary Dataset (WBD). NHDPlus is the outcome of a multi-agency effort aimed at developing NHD stream flow volume and velocity estimates to support pollution fate-and-transport models, such as the EPA Riverspill and USGS SPARROW models. NHDPlus includes a stream network with improved networking, naming, and "value-added attributes", such as stream order. NHDPlus also includes elevation-derived catchments (drainage areas) for each NHD reach, flow direction and accumulation grids, and catchment attributes (precipitation, temperature, land cover). This poster displays the national map of NHDPlus catchments with an inset map illustrating a watershed delineation and associated watershed characterization report produced using NHDPlus.

Water Resources Assessment and GIS-Based Stormwater Runoff Estimates for Artificial Recharge of Freshwater Aquifers in New Providence, Bahamas - Genevieve Diamond, Florida International University, Miami, FL (co-author: Assefa Melesse)

The Bahamas is a small island nation that is dealing with the problem of freshwater shortage. All of the country's freshwater is contained in shallow lens aquifers that are recharged solely by rainfall. The country has been struggling to meet the water demands by employing a combination of over-pumping of aquifers, transport of water by barge between islands, and desalinization of sea water. The problem is greatest on the island of New Providence where the capital city of Nassau is located. As rainfall is the single natural source of freshwater, a careful study of ways to efficiently utilize this resource is vital to any water management plan. In recent decades there has been a great deal of new development on New Providence which has created a large area of impervious surfaces and thereby a substantial amount of runoff. Government's way of dealing with the increased flooding from this runoff has been, and is, to drill more and deeper injection wells to dispose of it. However, this runoff represents a supply of freshwater that could be utilized by the island. It is the purpose of this project to quantify this runoff and to identify areas where artificial recharge of the shallow lens aquifers might be accomplished. Remote sensing images will be used to update the existing land cover maps. Since there are no natural streams on the island, ArcHydro will be used to create streams and basins to calculate runoff and identify areas suitable for artificial recharge. By using this runoff in an artificial recharge plan, it will be possible not only to make additional freshwater available but also to mitigate the frequent flooding events experienced in some parts of the island.

SWAT Model as a Decision Support Tool for Framing Adaptation Strategies in Agriculture under Changing Climate - Vellingiri Geethalakshmi, Tamilnadu Agricultural University, Coimbatore, TN, India (co-authors: A.Lakshmanan, R. Srinivasan)

In the present study SWAT model was used for the Bhavani River Basin in Tamil Nadu, India to assess the hydrological situations, crop water requirement and crop yield for base line and future climatic scenarios. Analysis of data from 1971 - 2008 indicated that the study area has bimodal rainfall pattern that receives rainfall during both southwest and northeast monsoon seasons. Rice is the predominant agricultural crop grown in the

Bhavani basin during both Kharif and Rabi seasons. The yield levels vary highly among the different rice growing areas within the basin as well as between the two seasons. Impact of increase in temperature, precipitation changes and hike in atmospheric CO2 concentration on different hydrological parameters as well as rice productivity were simulated and compared with the base year run. Increase in temperature had a great influence on crop water demand (ET) as well as atmospheric water demand (PET). Both of them gradually increased with increase in temperature. In contrast to this the other hydrological parameters such as surface flow, ground water flow, amount of water percolated into the soil, water yield and soil water content decreased with increase in temperature. It is interesting to learn that rice yields are impacted differently by increase in temperature between kharif (summer monsoon season) and Rabi seasons (Winter monsoon season). During Kharif season increase of 1□C did not have any negative impact on yield. Increase in temperature beyond 1□C led to reduction in rice yields. In contrast to this increase in temperature is exhibiting positive impact on rice yield during Rabi season. Hydrology and productivity of the crop are also influenced by the change in management decisions. From the study it is clear that the crop water requirement increases if the sowing date is advanced or delayed by two weeks. The mean rice yield of the basin also indicated that the normal sowing registered the highest yield followed by advanced sowing and then delayed sowing. SWAT model was used to assess the impact of moisture stress at different stages of crop growth under SRI system of rice cultivation.

Online Mapping Systems for Hydroclimatic Data Delivery - Stephen Gray, University of Wyoming, Laramie, WY (co-authors: Christopher Nicholson, Tony Bergantino)

Online, map-based applications have experienced an explosion in popularity over the past decade. The success of these systems is largely due to their ability to provide a spatial framework for data exploration, and for the visual context (e.g., satellite images) they offer. Here we detail the development of a new online mapping system for Wyoming that will serve as a portal for the delivery of weather, climate, and water-related data to users across the state. While capitalizing on the success of previous online mapping efforts, this new system also highlights the potential for additional applications and functionality. Known as the Wyoming Internet Map Server (WyoIMS), the system brings together real-time observations and summary products from multiple federal agencies (NOAA-NWS, NRCS, USGS) to provide "one-stop-shopping" for key climatic datasets. Likewise this system is providing a platform for data delivery, archiving, and QC/QA for a new statewide hydroclimatic monitoring network. Moving beyond the simple transfer of data, this system also allows users to access information from sources that include state libraries and various databases related to climate and water resources. Users can, for example, select individual counties, watersheds, irrigation districts, or municipalities and download a wide range of documents and reports specific to those locations. On the whole, WyoIMS has become a catalyst for the development of new climate-related products, and a foundation for decision support with applications in water resources, wildlife management, and agriculture.

GIS Needs in Permaforst Dominated Regions: An Example from Central Alaska - Mary Greene, Los Alamos National Laboratory, Los Alamos, NM (co-authors: Cathy J. Wilson, Steven P. Brumby, Jean M. Foster, Joel C. Rowland)

Quantification of the presence, pattern, and rate of thaw in permafrost in the Arctic of Alaska is a complex problem that requires integration of numerous data sources in order to be accurately described. Combination of multispectral satellite imagery, high resolution elevation data, and change detection results creates a powerful data stream with which to answer this question, but rapid analysis of large data sets such as these requires specialized structure and organization techniques. A geographic information system that stores and processes geographic, gazetteer, satellite, and automated feature extraction algorithm data is being developed to support study efforts in the Caribou Poker and Yukon Flats watersheds of central Alaska.

Vermont Public Community Water Systems Groundwater Interference Study - Eric Hanson, Vermont Rural Water Assocation, Bristol, VT

The Vermont Rural Water Association has completed an assessment of groundwater interference caused by the pumping of Public Community Water Supply (PCWS) sources throughout Vermont. This study was completed under a contract with the Vermont Department of Environmental Conservation Water Supply Division. The majority of PCWS sources in Vermont are wells completed in fractured crystalline bedrock aquifers, with a more limited number completed in sand and gravel aquifers present in some valley locations. Due to the non-homogenous, anisotropic nature of these aquifers, interference with nearby private and public wells and springs is difficult to predict unless measured in the field. Existing source evaluation reports prepared since 1980 by the environmental consulting community were reviewed to develop a geodatabase with key information about the

pumped wells and observation wells monitored during these tests. This information includes specific pumping test information, derived values such as aquifer transmissivity and storativity, the degree of interference noted at observation locations, and a determination of acceptable versus unacceptable interference. The geodatabase was developed in conjunction with a Vermont environmental consulting firm specializing in utilizing geo-spatial technologies for water resources applications. Although the review was limited to currently active or permitted drilled PCWS sources, over 200 sources and 1,100 observation points were evaluated across the state. The results of the study indicate that, overall, groundwater interference is not a chronic problem in Vermont. However, unacceptable interference - where a specific observation well source could no longer meet its intended demand - was noted in several instances in areas of higher concentrations of PCWS sources, which, in Vermont, are primarily associated with ski area development. It was also determined that cumulative interference at a given observation location is not always accurately tracked over time, as an effective method to track cumulative interference has not existed for use by state regulators. The geodatabase developed during this study, if kept updated as new PCWS sources are permitted, would allow for effective tracking of groundwater interference across Vermont.

Using Geographic Information Systems to Analyze Main Water Line Repair Data to Assist in Strategic Real Water Loss Reductions and Asset Management - Shawn Hardeman, NM Environmental Finance Center, Albuquerque, NM

For the past five years the New Mexico Environmental Finance Center (NMEFC) has been working with the Albuquerque Bernalillo Water Utility Authority (ABCWUA) analyzing 15 years worth main water repair data. The ABCWUA water distribution system consists of approximately 2,500 miles of pipe with a variety of pipe types including steel, concrete, cast iron, and polyvinyl chloride. The NMEFC started with a basic statistical analysis, sorting out repairs based on pipe type and diameter, and then compared the statistics to miles of pipe in the system. This analysis provided some very valuable insight as to which pipes in the system were most problematic and conducive to failure, and which were problem free. However, the analysis was missing the spatial component to identify where in the system the problematic and problem-free pipe types were located. This poster presentation will highlight the various methods used to organize and display historical main line repair data to assist utility managers in their decision making process. The principle behind tracking main water line repairs is to investigate the types of breaks that are occurring, the time frame in which they are occurring, trends in break data over time, the potential to prioritize pipes for replacement, and where to focus leak detection efforts. In addition, it enables the utility to make an assessment of the overall pipe condition and life-cycle based on the number of repairs per year, which helps to predict when a section of pipe needs replacement and evaluate the potential for real water losses in the water distribution system.

Hydrologic Resource Sheds and Great Lakes Applications - Chansheng He, Western Michigan University, Kalamazoo, MI (co-author: Thomas E. Croley II)

Over the past century, the watershed concept has been well understood, accepted, and used worldwide in hydrologic research and water resources management. Here, we define a similar but different concept, "resource shed" by the movement of water and materials over specific temporal and spatial scales. We generalize the concept of "resource shed" to encompass a geographic area within which water and water-borne materials including nutrients, organic matter, sediments, and pollutants are originated and transported to a particular location, at a specific time over a specific time period. While the boundary of a watershed is delineated by elevation and flow direction, and is relatively static, the boundary of a hydrological resource shed, however, is delineated by the contributing sources of water and materials to a river or lake during hydrologic events and is thus more dynamic. The concept of watershed emphasizes temporal distribution of water and materials within a given space, and the concept of resource shed focuses on both temporal and spatial distribution of water and materials within a changing space. While relatively new, the concept of resource sheds provides a new way of displaying, understanding, and discovering the transport and distribution of water and materials and has the potential of helping resource managers better track and manage source loadings in a study area. In this paper, we propose a set of analysis procedures to define resource sheds and subsequently apply the methods and the Distributed Large Basin Runoff Model to selected Great Lakes Watersheds.

The KCI Geofusion Center is an Innovative Blending of Technologies Designed to Assist in Monitoring Environmental Compliance on Construction Sites. - Christopher Heyn and Brian Maher, KCI Technologies, Inc., Sparks, MD (co-authors: Ian Botts, Ashton Lamont)

Environmental compliance monitoring on a construction site is fast paced and unmerciful. Environmental monitors need immediate and constant access to construction plans, compliance forms, permit status reports, weather reports, and a system to manage the large volume of documents. To address the coordination of these systems, KCI Technologies, Inc. has integrated several industry-standard solutions into a comprehensive web application, the KCI GeoFusion Center. The KCI GeoFusion Center aims to resolve the following specific areas of difficulty for environmental compliance projects: * Data Collection and Management: Gaining access to multiple data sources such as inspection forms, geospatial data, weather and other various datasets through one location can be difficult. * Data Analysis: Distilling the large amount of available data from multiple sources into meaningful and usable information is a significant challenge. For example, field inspectors may have access to a large amount of data but they cannot analyze the data geo-spatially and in real time. * Data Sharing: Simple and secure information exchange with internal and external users is problematic. No common infrastructure exists to allow documents, alerts, and data/information to be shared and accessed across locations. The KCI GeoFusion Center is a web-based application that leverages the proven capabilities of Google Earth to display spatial data; Microsoft SharePoint to provide document management; and standard html to provide data input capabilities. The KCI GeoFusion Center allows users to view project specific GIS data with respect to the base data of Google Earth along with GeoRSS feeds providing real-time information such as weather. Integrated with Sharepoint, standard online collaboration tools have been implemented such as group calendaring, project schedules, document sharing, and discussion boards. In addition, the integration with Google Earth allows the user to relate documents in SharePoint to spatial features on the project site. Finally, the KCI Fusion Center also includes the capability to complete custom environmental compliance forms in real-time to document water quality, erosion and sediment control, and other compliance issues.

Development of a Decision Support Tool to Ensure Safe Drinking Water in Rural Communities in Puerto Rico - Sangchul Hwang, University of Puerto Rico, Mayaguez, PR (co-author: Melissa Herrera)

In 2007, 97% of the Puerto Rico's population used improved drinking water systems from the Puerto Rico Aqueduct and Sewer Authority (PRASA) and approximately 125,130 persons of the rural areas do not have access to improved drinking water systems. This situation has intensified the efforts for innovation or improved technologies for drinking water treatment, with effluents of better quality and particularly with technologies that conform to environmental, economic, and social conditions in rural communities. This study contributes to the production of sustainable drinking water to rural communities of Puerto Rico, ensuring drinking water with low sanitary risk and water that meets drinking water bacteriological standards. This was done through the selection of communities with drinking water problems using Geographical Information Systems (GIS), and the evaluation of Experimental Drum Sand Filtration (EDSF) system as a sustainable option to solve the drinking water problem in rural areas. The identification and ranking of the communities based on the level of drinking water supply problems was done using an evaluation matrix method. The first step was to identify variables related to the drinking water problem in support of GIS, which received a quantitative value according to the positive or negative incidence with the problem. La Jurada community at Yauco, Puerto Rico, obtained the highest score. This community has a water supply system without treatment where the water is taken from a small water source and then provided directly to the community and, according to the bacteriological records, the water quality does not comply with regulations. The EDSF system tested was a good technological alternative for rural communities of Puerto Rico ensuring the physicochemical and bacteriological water quality standards.

The Hydrographic Setting for Mercury Sampling - Kathy Isham, U.S. Geological Survey, Lakewood, CO (co-author: Jeff Simley)

U.S. Geological Survey Report 2009-5109; Mercury in Fish, Bed Sediment, and Water from Streams Across the United States, 1998-2005; presented findings on Mercury (Hg) examined in top-predator fish, bed sediment, and water from streams that spanned regional and national gradients of Hg source strength and other factors thought to influence methylmercury (MeHg) bioaccumulation. Fish-Hg concentrations at 27 percent of sampled sites exceeded the U.S. Environmental Protection Agency human-health criterion of 0.3 micrograms per gram wet weight. Exceedances were geographically widespread, although the study design targeted specific sites and fish species and sizes, so results do not represent a true nationwide percentage of exceedances. The sample values are portrayed using graduated symbols overlaid on a detailed view of the high resolution National Hydrography Dataset. The upstream drainage area above the sample site is calculated and displayed as well as the hydrography within the drainage area and the calculated summation of the upstream network (arbolate sum). The downstream path below the sample site is shown for a distance equal to the maximum upstream single-path distance. The mean annual flow of the surrounding hydrography calculated using the unit runoff method (UROM) from the USEPA's NHDPlus is portrayed using line width related to cubic feet per second.

Urbanized areas from the National Atlas are also shown. This geographic portrayal of the upstream/downstream areas near the sample sites provides a good understanding of the hydrographic and hydrologic settings in which the samples were made.

Screening Watershed Health Using Spatial Datasets - Elisabeth Jenicek, USACE, Champaign, IL (co-authors: Natalie Myers, Rebecca Carrol)

Water is considered a renewable resource - but growing problems with adequate sustainable access to high quality water resources are resulting from population growth; surface and groundwater contamination; globally increased water demand for agricultural, industrial, and personal uses; rising global and regional temperatures; and rising water demands for energy production. Problems with access to fresh water supplies vary spatially and temporally, but are growing in extent and duration and will contribute towards political strife and regional instability in many parts of the world. Water issues of concern -- adequate supply, increased cost of production per unit volume, quality, habitat degradation and salinity issues -- are already impacting military installations and military operations in many locations within the nation and across the globe. These impacts will grow in scale and severity in the near and mid terms, requiring better understanding of how limited water supplies and increasing water costs could impact the Army over the next few decades. An application of the Sustainable Installations Regional Resource Assessment web-based tool evaluated the vulnerability of watersheds containing Army installations to issues of water supply and demand. SIRRA provides a screening level capability for characterizing regions based on a set of sustainability risks or stressors, drawing from existing science and measurement-based data sources which are well documented and publicly available at the national level. Although the data in SIRRA is publicly accessible, nowhere is it assembled together with analytical methods applied to determine sustainability ratings and presented in a spatial format. Data sources include the USGS, Census Bureau, DoE, FAA, FWS, BLS, and EPA. The value of a validated national tool for watershed screening is two-fold. National data sets provide sustainability indicator status for a region or local area. National maps and data sets also allow comparisons among and between regions. SIRRA can quickly provide a sustainability screening to highlight and prioritize issues that need more detailed analysis, saving time and money needed to gather similar data on a case by case basis. Advanced aggregation methods for SIRRA applications are currently under development. SIRRA data, metadata, and publications are contained in a PLONE-enabled GeoPortal.

Using Web-Based GIS to Manage Hardcopy Infrastructure Plans - Mary Johnson, Avencia Incorporated, Philadelphia, PA (co-author: Robert Cheetham)

Because most water, sewer and stormwater infrastructure systems have been in place for many years, there is a vast amount of hardcopy historic data available that is associated with these systems in some way. This includes engineering blueprints, manufacturer's information, shop drawings, and system distribution plans reflecting the overall layout of facilities in a particular location or even community-wide. Although it would certainly be possible to digitize these hardcopy plans and seamlessly apply them to one overall GIS base map, not all organizations want this, or will still find themselves going back to the hardcopy historic drawings just as frequently as before due to the high level of detail they often provide. The original installation plans can be particularly helpful in the event of an emergency, or when wastewater treatment plants, water tanks and similar facilities are upgraded or even demolished to make way for new infrastructure. Despite proven need, there are some critical drawbacks to so much dependency on hardcopy data. The plans and blueprints are often very old and in deteriorating condition. They may be haphazardly stored in old boxes or flat-files with minimal or no indexing, so that it can take considerable time and effort to locate a particular document. And worst of all, disaster recovery is nearly impossible, because so much of this data is original and often pre-dates the computer age. Even the oldest historic hardcopy plans can be safely scanned and digitized for archival or online viewing purposes. But the question of managing this data remains critical. It needs to be catalogued in some way, ideally by geographic location; it needs to be easily and continuously accessible, even for users in the field; and it needs to be in a format that is user-friendly for everyone, regardless of their GIS knowledge and expertise. This presentation will look at ways to leverage GIS technology for infrastructure management, including guidelines for organizing and digitizing hardcopy data, searching for grants and other funding strategies, keeping the data secure, and choosing comprehensive web-based solutions that provide true geographic management and visualization of archival documents.

Innovative Approaches and GIS Tools for Watershed Planning - Anwar Khan, HDR Engineering Inc., West Palm Beach, FL (co-authors: Steve Schubert, Lewis Hornung, Barry Wharton, Stephanie Morse)

This paper will describe several innovative GIS-based tools that were developed and used to support the advanced planning of the Lake Okeechobee Watershed (LOW) Project. The LOW Project is a component of the Comprehensive Everglades Restoration Plan (CERP). Its primary objective is to identify solutions that will improve water quality in Lake Okeechobee, enhance stage management in the lake, reduce damaging releases to estuaries, and restore the hydrology of isolated wetlands. A comprehensive planning process is underway to identify cost-effective solutions to address the project objectives. Several innovative, GIS-based modeling tools were developed, tested, and utilized during the planning process to assist in the formulation, evaluation, and comparison of alternative plans. Many of the tools were specifically developed to meet project needs as off-the-shelf tools were either not available or deemed to be inadequate. These tools include the Land Suitability Model (LSM), Ecological Value Model (EVM), Wetland Evaluation Analysis Tool (WEAT), Habitat Evaluation Analysis Tool (HEAT), and the Wildlife Habitat Assessment Tool (WHAT). Use of automated GIS-based applications saved considerable time and money and promoted stakeholder buy-in. Also, results could be easily duplicated, making it easier for validating planning decisions. Many of tools developed for this project have been subsequently used to support other large ecosystem restoration and watershed management studies.

Modeling the Effect of Land Use/ Land Cover Change and rainfall on the Hydrology of the Upper Mara River Basin - Liya Mango, Florida International University, Miami, FL (co-authors: A Melesse, M. McClain. D. Gann, S. Setegn)

The effect of the changes in land-use practices and rainfall (volume, distribution and source: gauge vs. remote sensing) is simulated using a semi-distributed physically-based hydrological model, Soil Water Assessment Tool (SWAT). The upper watershed of the Mara River basin in Kenya/Tanzania is used in the simulation. Mara River basin is a transboundary river basin shared between Kenya (65%) and Tanzania (35%). The Mara River originates from the Mau forest (2,932 m amsl) in Kenya flowing across the border into Tanzania and into Lake Victoria at Musoma Bay (1,134 m amsl). Land use and land cover changes especially in the upper reaches of the Mara River have had a significant impact on the water output of the Mara River. Land cover classes were obtained by digital image analysis of a Landsat Thematic Mapper (TM) satellite image of 2008 using a supervised classification algorithm. Daily rainfall data from 1996 to 2008 were acquired from two different sources: gauge and rainfall estimates (RFE). The grid and remote sensing-based RFE was converted to fit the format of SWAT by averaging selected grids and generating point rainfall files for selected areas in the watershed. The model simulated the effects of the rainfall variation as well as rainfall from the two sources in addition to land-use change scenarios for the Amala and Nyangores watersheds in the upper part of the Mara River basin. Results show that the model is sensitive to the volume and source of rainfall simulated. The two sources give different results. RFE-based simulation also performed good indicating the validity of such rainfall products. Simulation on changes in land-use also gave a result mainly impacting the base flow changes in the dray season and the peak flows during the high rainfall vents.

An Alternative Delineation of Basins Method using DEMs. Preliminary Algorithms. - Sergio Martinez, Universidad Autonoma de Aguascalientes, Aguascalientes, Ags, Mexico (co-author: Gonzalo Espinoza)

The initial motivation of this work was to have roughly identified the basin prior to perform the conventional process (via TauDEM or ArcHydro Tools) in all the cells of an unclipped DEM, promoting savings of processing time and data memory when doing the actual conventional process. Conventionally, the delineation of a basin using a DEM starts assigning a flow direction to each cell to a grid of flow directions; then, a process ending with the identification of watersheds is followed. Then, if only the basin is needed, all watersheds are dissolved into a basin. In this work it is presented a different approach that in essence begins from the exit cell of the basin and proceeds upstream until all cells that contribute their flows to the exit cell are found. Several approaches have been tested; the first and simpler algorithm has the next steps: 1) Select the exit cell. 2) Select, from the eight neighboring cells of the current cell, those cells that have the same or higher elevation than the elevation of the current cell; make that cells part of the basin. 3) Choose the next cell in the basin that has not been processed before. Go to Step 2. Repeat the process until there are not more unprocessed basin cells. This algorithm tends to delineate basins bigger that they should be; so, more algorithms were tested. A script with the last algorithm was created for running in MapWindowGIS version 4.7. The DEM grids were obtained from the Mexican Continuum of Elevations of INEGI (Instituto Nacional de Estad□stica y Geograf□a). Several delineated basins were compared with those identified by the TauDEM tools. Conclusions about the usefulness of the tested delineation algorithms are presented.

Partners in Stewardship of the National Hydrography Dataset (NHD) – David Arnold presenting for Elizabeth McCartney, U.S. Geological Survey, Rolla, MO (co-author: Barbara Ray)

The National Hydrography Dataset (NHD) is the surface water component of The National Map. The NHD is a comprehensive set of digital spatial data representing the surface water of the United States using common features such as lakes, ponds, streams, rivers, canals, and oceans. The NHD often is used by scientists, specifically in surface-water analysis using geographic information systems (GIS) technology. The NHD partnership is now turning its attention to a program of data stewardship to improve upon the existing NHD and keep it continuously updated. It is based on the input of organizations knowledgeable about the hydrography in their local area and will assure the NHD is accurate, current, and meets the objectives of the user community. The opportunity to contribute to the upkeep of the NHD is attracting many new members to the NHD partnership.

Automatic Estimation of Flood Flows in the Island of Tenerife, Spain – Francisco Olivera, Texas A&M University, College Station, TX (co-authors: Jose Fernandez-Bethencourt, Pedro Delgado-Melian, Jesus Lopez-Garcia, Martin Rodriguez-Pallares)

A Map Windows tool, TenerifeFlow, has been developed for the automatic estimation of flood flows in the island of Tenerife, Spain. This tool does not require of an external geographic information system platform to run, and is compatible with a wide range of operating systems. Tenerife is the largest island of the Canary archipelago in the Atlantic Ocean with a surface area of 785 square miles, and the water resources issues in the island are managed by the Water Council of the Island of Tenerife (Consejo Insular de Aguas de Tenerife). TenerifeFlow is being used by the Council as a means to ease the process of estimating flows using parameters that have been contrasted with hydrologic observations in the area. Its interface allows the user to identify the point at which flows are to be estimated interactively on the map or based on UTM coordinates. It automatically delineates the watershed boundary, based on a pre-loaded 5-meter digital elevation model, and calculates morphologic and hydrologic parameters of the catchment such as flow-path length, slope, curve number and time of concentration, based on also pre-loaded soils and land use data. The user is also given the option of adding his/her own data if available. Finally, TenerifeFlow estimates design storms and flood flows for different return periods based on regionally calibrated hydrologic models. Even though TenerifeFlow applies only to the Island of Tenerife, the methodology can be easily exported to other areas.

Navigability Potential of Washington Rivers and Streams Determined with Hydraulic Geometry and Geographic Information System - Theresa Olsen, U.S. Geological Survey, Tacoma, WA (co-author: Chris Magirl)

Using discharge and channel geometry measurements from U.S. Geological Survey streamflow-gaging stations and data from a geographic information system (GIS), regression relations were derived to predict river depth, top width, and bottom width as a function of mean annual discharge for rivers in the State of Washington. A new technique also was proposed to determine bottom width in channels, a parameter that has received relatively little attention in the geomorphology literature. These regression equations, when combined with estimates of mean annual discharge available in the National Hydrography Dataset, enabled the prediction of hydraulic geometry for any stream or river in the State of Washington. Predictions of hydraulic geometry were then compared to thresholds established by the Washington State Department of Natural Resources to determine navigability potential of these rivers within a GIS framework. The concept of navigability in rivers and streams in the State of Washington is the determinant factor in legal ownership of the watercourse, but, to date, the legal system has employed few quantitative techniques to aid in this determination.

Analyzing Changes in Vegetation over the last Sixty Years in Emeralda Marsh Conservation Area, Florida, USA - Sarita Pachhai Karki, Post, Buckley, Schuh & Jernigan, Inc, Jacksonville, FL (co-authors: John R. Stenberg, Walter Godwin)

This study analyzed changes in vegetation cover within Emeralda Marsh Conservation Area using aerial photo interpretation and GIS techniques over the last sixty years. The study area is approximately 6,500 acres located in the Upper Ocklawaha River Basin, east of Lake Griffin in Lake County, Florida, USA. The interpretation of aerial imagery enabled us to produce vegetation cover maps for 1941, 1987, 1996, 1999, 2001 and 2005, and corresponding statistics. Changes occurring during the periods between 1941 and 2005 were estimated using GIS tools where the two-date vegetation cover information has been integrated. Changes in vegetation cover classes and the extent of each vegetation cover are presented. Wetland vegetation cover types were combined into a single wetland class for analysis of general wetland gain or loss. The results indicated that there has been extensive loss of the dominant cover, sawgrass marsh, due to anthropogenic activities between 1941 and 1987

followed by further changes with beginning of restoration efforts in 1996. This study demonstrates that photo interpretation and GIS are valuable tools for quantifying vegetation cover change over time. This change detection is important to determine the impacts of restoration efforts in the study area.

Innovating GIS Education with a FishFinder - Travis Rayfield, Department of Geography and Environmental Engineering, United States Military Academy, West Point, NY (co-authors: William Wright, Michael Hendricks)

The purpose of this project was to develop a replicable learning experience for undergraduates from data collection through product development. We used a commercial off the shelf (COTS) Lowrance integrated depth finder and GPS to simultaneously collect horizontal (X, Y) and vertical depth values (Z) for the Lusk Reservoir at the United States Military Academy (USMA) at West Point, NY. This project employs ESRI's ArcGIS along with 3D analyst extension and spatial analyst extension to teach the principles of bathymetric mapping in introductory undergraduate GIS and Cartography courses. The raw data from the depth finder was not directly compatible with ArcGIS and as a result data manipulation in a tabular format is required prior to importing into ArcGIS. Data processing in ArcGIS included coordinate transformation, spatial interpolation from 3D points to a raster surface, generation of depth contours, as well as cartographic design principles such as labeling, visual hierarchy, and color usage. The value of this teaching approach enabled students to participate in the collection, processing, analysis, and production of a product from start to end. All students at USMA are required to memorize the capacity of the reservoir at 78 million gallons. Results of this study indicate Lusk reservoir has an increased capacity of 87.5 million gallons. This result is an increase of over 12 percent over the traditional line and plumb method. The project is ongoing and will result in student bathymetry products of 13 lakes incorporated into the Wildlife Management Program for over 16,000 acres. Many universities have lakes or water bodies in close proximity to campus that enable instructors to replicate this teaching practice with little capital or time investment.

Calibration and Validation of Arcswat Model for Prediction of Hydrological Water Balance of Rio Haina Basin, Dominica Republic - Shimelis Setegn, Florida International University (FIU), Miami, FL (co-authors: Assefa Melesse, Michael McClain, Xixi Wang)

The main objective of this study was to develop and evaluate the performance and applicability of the physically based Soil and Water Assessment Tool (SWAT) model in analyzing the influence of topography, land use, soil and weather variables on the water resources variability of the Rio Haina Basin, Dominican Republic. The 90 m resolution digital elevation model (DEM), which was obtained from SRTM, was used to analyze flow direction and flow accumulation, drainage line, sub basins and watershed delineation. The soils dataset for the entire watershed was obtained from Food and Agriculture Organization (FAO). The basin was divided in to 28 sub basin and 206 hydrological response units. The GIS interface version of SWAT (ArcSWAT) has the capability to utilize ArcGIS to facilitate input data preparation and output data generation. Eight years precipitation, minimum and maximum air temperature data were used for the simulation of the hydrology. The ability of this model to sufficiently predict stream flow was evaluated through sensitivity analysis, model calibration, and model validation. Sensitivity analysis was done to identify the most sensitive flow parameters for the specific land use and agro-climatic condition of Rio Haina watershed. These sensitive model parameters were adjusted within their allowable ranges during calibration to optimize model prediction. The model was calibrated using four years monthly hydrometric measurements. Validation of the model was also done with independent four years measured monthly stream flow. The model performance evaluation statistics such as Nash-Sutcliffe model efficiency and coefficient of determination showed that the model can produce reasonable estimates of river discharge. The study showed that the SWAT model is a useful modeling tool for analyzing the hydrological processes for the Haina River basin. The set of optimized parameters during calibration process can be taken as the representative set of best parameters for Rio Haina watershed and surrounding areas which have similar agro-climatic condition.

Analysis of Spatial Distribution of Climate Data Impact on Prediction of the Hydrology of Beles Basin, Ethiopia: Application of Remote Sensing, GIS and Hydrological Model. - Shimelis Setegn, Florida International University (FIU), Miami, FL (co-authors: Yirgalem Chebud, Assefa Melesse)

The focus of different hydrological models is to establish a relationship between various hydrological components such as precipitation, evapotranspiration, surface runoff, ground water flow and soil water movement. In recent years, distributed watershed models are increasingly used to implement alternative management strategies in the areas of water resources allocation, flood control, impact of land use and climate

changes, and finally environmental pollution control. But prediction uncertainty of distributed hydrological modeling is partly inflated by excessive extrapolation of existing ground based data. An important issue to consider in the prediction of hydrology, sediment yield and water quality is uncertainties in the predictions. Errors in the input variables such as rainfall and temperature are the main source of prediction uncertainty in modeling exercise, especially in the developing countries. With the increasing use of satellite imagery for distributed rainfall estimation, precipitation could be acquired at a reasonable spatial resolution which could be used to improve accuracy of models. Tropical Rainfall Measuring Mission (TRMM) satellite product of 3B42 retrieves 3 hourly precipitations at (0.25o) spatial resolution. The 3 hourly rainfalls from TRMM is summed up to daily precipitation level and compared with the daily rainfall measurements from ground stations. Upon calibrating with the ground measurements of 9 years data (2000-2008), the daily TRMM data was used to run the Model. Comparison of the TRMM data against the ground observation of monthly rainfall for the Ethiopian context has shown 0.9 correlations in the previous studies. The SWAT model was calibrated and validated using the climate data generated from satellite imagery. The comparison between the simulated and observed stream flow data measured at two river gauge stations shows that the model prediction performance is quite higher than that the one used with limited ground gauged data set. The prediction performance of the model was verified by a higher values (>0.7) of coefficient of determination and Nash Sutcliffe efficiency. The study has shown that with the increasing use of satellite imagery for distributed rainfall estimation acquired at a reasonable spatial resolution could improve accuracy of models prediction.

The Role of Hydrography in Popular Map Viewers - Jeff Simley, U.S. Geological Survey, Denver, CO

Mapping technology on the internet has made it possible to provide powerful, worldwide, interactive, and dynamic mapping capabilities to anyone with a computer and a internet connection. These web mapping services such as MapQuest, Google Maps, Google Earth, Virtual Earth, Bing Maps, Arc Explorer, The National Map Viewer, Yahoo Maps, and World Topo Map, all use hydrography mapping. Questions on where does this hydrography come from, how good is it, and how is it updated, are answered. Examples of the sophistication, or the lack of sophistication, of hydrography in these map services are reviewed.

A GIS-Based Vulnerability Assessment and Disaster Management Tool for Surface Water, Groundwater, and Dams - Tanya Holtz, INTERA, Inc., Austin, TX (co-authors: Abhishek Singh, Toya Jones, John Pickens, Robert M Holt, Joel Kuszmaul)

Water resources and infrastructure - dams, aquifers, streams, and reservoirs - represent "critical infrastructure and key resources" as defined by the National Infrastructure Protection Plan (NIPP) of 2009. The importance of these key resources and assets provides the motivation to develop methods for assessing their vulnerability to natural or anthropogenic threats. Improved methods using GIS-based tools capable of assessing the vulnerability of these key water resources to unintentional and/or intentional harm and the resultant consequences of that harm can be a critical contribution to the management and protection of water resources and infrastructure. With this goal, an ArcGIS-based tool - the Water Resources Vulnerability Assessment Tool (WRVAT) - has been developed in response to the need to inventory and asses the vulnerability of water resource systems (including dams). Vulnerability assessments conducted using the WRVAT consider intrinsic characteristics of the system, extrinsic threats (both accidental and intentional) to the system, and the consequences of system compromise. This work identifies existing threats and provides a methodology for more readily identifying hazards to water resources and infrastructure by determining the critical intrinsic characteristics and external threats affecting these resources and infrastructure. This research also enables more efficient and effective emergency response preparedness to possible threats and hazards associated with these key water resources (and related infrastructure). The WRVAT facilitates dynamic building and analysis of disaster scenarios to investigate resource resilience and emergency response. Analysis tools, features, and flexibilities developed within the WRVAT can be used to respond to the data needs for disaster planning and response. Disaster scenarios can be developed and evaluated using the analysis tools within the WRVAT for surface water, groundwater, and dams. The goal is to enable the WRVAT to become a unique collaborative environment that can be used by emergency planners and responders to rapidly exchange information, analyze impending and current disaster outcomes, and generate and share reports of disaster scenario analyses.

UTIMS: Utah Inundation Mapping Software - Brian Stevens, AMEC, Nashville, TN (co-authors: Sanjay Chauhan, David S. Bowles)

Flood plain mapping has become an increasingly important part of flood plain management. Flood plain mapping employs mapping software and hydraulic calculation packages to efficiently map flood plains. Modelers

often utilize automation software to develop the complex geometries required to reduce the time to develop hydraulic models. The Utah Inundation Mapping System (UTIMS) is designed to reduce the time required to develop complex geometries for use in flood plain mapping studies. The automated geometries developed by UTIMS include: flood specific river centerlines, bank lines, flow path lines, cross sections and areal averaged n-value polygons. UTIMS thus facilitates developing automated input to the US Army Corps of Engineer's HEC-RAS software. Results from HEC-RAS can be imported back to UTIMS for display and mapping. The user can also specify convergence criteria for water surface profile at selected locations along the river and thus run UTIMS and HEC-RAS iteratively until the convergence criterion is met. UTIMS develops a new flood specific geometry file for each iteration, enabling an accurate modeling of the flood-plain. Utilizing this robust and easy to operate software within the GIS environment modelers can significantly reduce the time required to develop accurate flood plain maps. The time thus saved in developing the geometries allows modelers to spend more time doing the actual modeling and analyzing results. The time thus saved can also result in faster turn around and potential cost cutting in flood-plain modeling work. In this paper the authors describe UTIMS capabilities, compare them with other available software, and demonstrate the UTIMS flood plain automation process using a case study.

LiDAR Data Used to Develop Flood Inundation Maps and Sediment Storage Metrics for Cattail Creek in Howard County, Maryland - Dennis Sugrue, US Military Academy, Cornwall on Hudson, NY (co-author: Peter Wilcock)

Upland erosion and sediment transport can be detrimental to the health of receiving waters. There are several methods to model erosion and sediment production but little is known to accurately predict the fate of sediment once it enters a stream network. The ability to better model sediment fate would assist researchers and decision makers in estimating sediment yield from upland sources. Accurate and up-to-date flood inundation mapping is a crucial step in developing predictive tools that estimate sediment storage potential on the floodplain. This study developed a series of flood inundation maps using high resolution elevation data of Cattail Creek watershed in Howard County, Maryland. We used 2m resolution LiDAR data to develop a digital elevation model in ArcGIS 9.2 from which we constructed a hydraulic model using HEC GeoRAS. We constructed a watershed model which included 27 stream reaches and 319 cross sections for the 29 square mile watershed. We ran steady state analyses on the hydraulic model and delineated floodplains with their depth of flow. We produced flood inundation maps for specified flow durations and integrated the resultant curves to produce a "floodplain duration" and "flood volume duration" metric. Flood inundation maps are sensitive to uncertainty in channel and floodplain roughness coefficients as well as estimates of bankfull discharge. We made assumptions concerning channel and bank roughness and tested sensitivity. We observed an 87% change in calculated storage metrics between low and high estimates of roughness and a 78% change between high and low estimates of bankfull discharge. We also tested sensitivity to channel constrictions such as culverts and bridges but only observed a 5% decrease in the metric when these features were removed from the model. We have developed detailed flood inundation maps and associated storage metrics from high resolution remote sensing data. However, such products require better estimates of roughness before we can accurately compare independent watersheds. Future studies to estimate roughness from LANDSAT imagery or other high resolution land cover data may provide this necessary refinement.

The Effect of Land Use/ Management on Spatial Variation of Water Quality Parameters in Yuna and Haina River Watersheds, Dominican Republic - Ashley Thomas, Florida International University, Miami, FL (co-authors: A. M. Melesse, S. Setegn, F. Nunez, J. Chalas, A.G. Castillo)

The fresh water of the Yuna River basin serves as one of the most important watersheds in the Dominican Republic. Irrigation for rice production by the Yuna River is the major crop used. The smaller portion of freshwater in the Haina River is often contaminated by cattle ranching and a portion of the water is used to supply Santo Domingo. Haina River also flows to the Caribbean Sea draining agricultural and forested areas in the upstream and urban areas in the downstream. In order to assess the water quality of the hydrological system in the Dominican Republic, the Yuna and the Haina Rivers were analyzed. Water quality parameters were collected at the different junction of the rivers in different times of the year. Parameters examined include total coliform (TC), fecal coliform (FC), pH, conductivity, total dissolved solids (TDS), pseudomonas, sediment and other nutrients. Due to irrigation inefficiency water is often discharged back into the rivers, which consequently will frequently be high in dissolved solids, FC, and other nutrients. Temporal and spatial variability of selected parameters was analyzed and comparisons from station to station on both rivers were evaluated. The analysis found that (1) FC, TC, TDS and pseudomonas showed highly spatial variability indicating some segments of the rivers as highly polluted, (2) concentration or occurrence of these parameters was highly

variable in different times of they year and (3) observed values of FC, TC, TDS and pseudomonas in some parts of the river were higher than the acceptable levels for drinking water. The analysis will be useful information to plan and implement measures to improve the water quality of the two rivers.

The Effect of Reservoir on Spatial Variation of Water Quality Parameters in Yuna River Watershed, Dominican Republic - Ashley Thomas, Florida International University, Miami, FL (co-authors: A. M. Melesse, S. Setegn, F. Nunez, J. Chalas, A.G. Castillo)

The largest reservoir in the Dominican Republic is located in the Yuna River basin, the Hatillo Reservoir. There is a high demand for irrigation and hydroelectric power so numerous dams have been built. It is believed that dams or reservoirs retain water enhancing the settlement of sediment, heavy metals and also other contaminants. An analysis of pre and post dam impacts will be assessed on the following reservoirs: the Hatillo, Cotu, and Rincon. This study is being done to quantify the impacts that dam implementation has had on different parameters associated with the Yuna River. Parameters examined include total coliform (TC), fecal coliform (FC), pH, conductivity, total dissolved solids (TDS), pseudomonas, sediment and other nutrients. Water quality data before and after the reservoir were analyzed and comparisons were made. Another factor that will be taken into account will be parameter changes from the Agricultural Development Project (AGLIPO) and the Falconbridge operation. The AGLIPO projects have put new irrigation and drainage facilities into operation to increase rice production and the Falconbrige operation addresses mining and energy conservation. Results of the analysis show the effect of dam and irrigation projects in the Yuna River on the water quality parameters is substantial.

Glacier Variability in Wyoming's Teton Range - Glenn Tootle, University of Wyoming, Laramie, WY (co-authors: Jake Edmunds, Greg Kerr)

The Teton Range (TR) in northwest Wyoming is host to 10 named glaciers. These glaciers serve as natural water reservoirs, and the continued recession of glaciers will impact agricultural water supply in the region. Initially, glacier area changes in the TR were estimated for three glaciers using un-rectified aerial photography from 1967 to 2006. The total surface area of the three glaciers was calculated to be 0.53 - 0.13 km2 in 1967 and 0.40 - 0.10 km2 in 2006, an average decrease of 34% over the 39 year period. The smallest glacier Teepe experienced the most noticeable lost, losing 60% while the Teton glacier lost 17%. Current research efforts will evaluate glacier area changes using resampled aerial photography at 10 m (SPOT), 15 m (ASTER), 22.5 m (IRS-LISS) and 30 m (Landsat) resolutions for 1967 and 2006. Applying area-volume scaling relationships for Teton, Middle Teton, and Teepe glaciers, volume loss was estimated to be 3.2 million cubic meters (MCM) over the 35 year period, which results in an estimated 4 to 10% contribution to warm season (July - September) streamflow. Current research efforts will utilize un-rectified aerial photography from 1967 to 2006 to calculate glacier volume loss and these results will be compared to the results from the area-volume scaling relationships.

DEM Generation of Lake Okeechobee and EAA - Dan Vogler, CNI- USACE Jacksonville, Jacksonville, FL (co-author: Paul Holt)

The Lake Okeechobee-EAA Topography project has produced a seamless elevation model (DEM) of Lake Okeechobee bathymetry and the surrounding Everglades Agricultural Area (EAA) in South Florida. The EAA DEM is: a 5-foot ESRI Grid - with elevation in feet in NAVD88, over 7000 km2 (> 2700 m2) in area, composed of over 2.1 billion points and 3-D break lines from LIDAR. The bathymetry DEM is composed over 1 million lidar points taken at low lake levels inside Herbert Hoover dike fused with approximately 1.2 million hydrographic survey points. A number of different interpolation algorithms for DEM generation were compared: IDW, Splining, Natural Neighbors and TIN with Bilinear or Natural Neighbors options. The natural neighbor algorithm provided the best results, also providing a smoother grid - more closely approximating the terrain across areas of sparse data. Decorrugation and removal of artifacts were implemented by applying error corrections originated with an ARC-INFO AML for the hydrographic data. A number of data fusion techniques were employed to integrate the hydrographic data from Lake Okeechobee. A series of ESRI functions were used for DEM generation using TIN and natural neighbors option on the TINRASTER command resulting in a 5 and 100-foot grid. Hydrographic data was gridded to a 100-foot grid with the natural neighbors option. All 100-foot grids were co-registered and merged with the Arc/Info gridmerge using a FIRST method using the outline of Herbert Hoover Dike as a merge line. A new stage-storage relationship of Lake Okeechobee was calculated from this 100-ft DEM yielding new data that could be utilized by USACE modelers.

Calibration of an Integrated Surface Water - Michael O. Walters, ADA Engineering, Tampa, Fl (co-authors: James L. Greco, III)

A MIKE SHE/MIKE 11 integrated model has been calibrated for the 1,100 square miles C-139 watershed and adjacent areas, in South Florida. The project area contains a surface water system of channels, farm reservoirs, and wetlands, which are formed on, and interacts directly with the water in the sediments of the surficial aquifer. The surficial aquifer is underlain by an semi-confining unit which is formed on top of the limestone Tamiami Formation aquifer. Land use consisted of farms, pasture interspersed with wetlands, flat woods, and hard woods. The model was set up to simulate the years 2006 for calibration and 2007 for verification. Hourly rainfall, daily potential evapotranspiration, and measured stage boundary with some wells were time series input to drive the model. Spatially varied vegetation characteristics, and hydrogeologic parameters of hydraulic conductivity, storage, and layer thicknesses were input over the 1000-foot grid model. Spatially varied soil properties of saturated water content, wilting point, field capacity, and saturation infiltration rates were also included in MIKE SHE. The MIKE 11 portion of the model included channel configuration and size as well as control structures and control structure logic. Model calibration and verification was by comparing flow and stage at surface water sites and groundwater wells in the surficial and Lower Tamiami aquifers, and adjusting model parameters to within a predetermined range of values. The model was calibrated and verified to within predetermined acceptable tolerances. This paper presents the methodology, model setup, and results of the calibration and verification. The model will be used to assess various alternatives for groundwater and surface water withdrawals and wetland restoration.

A GIS-Based Integrated Flood Information System - Donghai Wang, GEI Consultants, Inc., Rancho Cordova, CA (co-authors: Naser Bateni, David Parker, Arthur Hinojosa, Jeremy Arrich, Jon Ericson)

The State of California has invested a significant amount of resources to collect, share, and exchange flood information, which includes real-time data and field reports, flood warning and flood alerts, forecasting processes, flood system documentation, forecasting models and notification processes, and reservoir operations tools and information. For easy access to data analysis and visualization, the flood information is being geo-referenced, processed, and stored in geodatabases. To ensure all participating agencies in flood management have access to this flood information and the information can be easily exchanged and understood by all parties, a fully integrated data management infrastructure and a user-friendly web-based GIS application were developed. With GIS as the data access and with visualization tools, the integrated flood information system improves communication and collaboration, and provides the right kind of support to make accurate and informed decisions on flood operations.

Using an Expert Evaluation Process and GIS Tools for Selection of an Off-Line Reservoir Site in West Central and Southwest Florida - Gary Wantland, MWH Americas, Inc., Tampa, FL (co-author: Cara Rothfuss)

Regional water supply planning efforts in the west central and southwest portions of Florida must consider long-term population growth and the limitations of existing ground water resources to meet future drinking water demands. The Southwest Florida Water Management District has encouraged local governments and regional wholesale water suppliers to incorporate alternative water supply technologies such as high-flow surface water harvesting and off-line raw water storage to faciliate development of alternative, environmentally-sound, sustainable supplies. This paper will present the results of recent feasibility evaluations of potential alternative surface water supplies based on an examination of watersheds in the central and southwestern portions of the state. Challenges associated with the development of these water supplies includes □□flashy□□ stream-flow characteristics; and wide, shallow water-bodies with relatively small volumetric stream flows. The work described consists of a GIS-based multi-phase, multi-step evaluation process used to identify, characterize, evaluate and rank potential off-line reservoir sites. The evaluation of potential sites included a screening process in which the search area was progressively narrowed based on a review of physical, environmental, land use, and land acquisition factors. This analysis included using GIS tools to: ,,X Identify and characterize key features of the watersheds under consideration; ,,X Elimination of unsuitable areas using an exclusionary process; ,,X Characterization and evaluation of each site using pre-selected evaluation criteria; and ,,X Ranking of sites using a weighted scoring methodology. Site evaluation used the application of an expert-applied, judgment-based selection procedure combined with a relative / comparative scoring approach. Evaluation criteria for the assessment of potential site suitability included present land use, long range planning, physical and geologic site conditions, environmental considerations, infrastructure compatibility, safety, construction aspects and cost. Cost estimates were developed for land acquisition, reservoir construction, environmental restoration, and mitigation. Selection of sites for further evaluation was based on the information compiled using GIS tools and a

comparison/evaluation of the individual site rankings and relative cost factors. This paper will demonstrate the value of integrating GIS technology with a judgment-based methodology to create a practical tool for siting facilities in a highly sensitive environmental area.

Integrated Spatio-Temporal Modeling Using an Open Source Model Builder Application Linked to Web Processing Services Based Hydrologic Models - Ping Yang, Idaho State University, Idaho Falls, ID (co-authors: Cao Yang, Daniel P. Ames)

A number of integrated modeling frameworks and toolkits have been developed in recent years with the express purpose of facilitating either tightly or loosely linked execution of hydrologic and environmental simulation models (e.g. FRAMES, OMS, CSDMS, OpenMI). While such efforts have generally common goals, they also share common challenges associated with initializing, executing, and finalizing disparate models and supporting streamlined passing of data and model parameters between models and across appropriate modeling units both spatially and temporally. Framework specific solutions to these problems as well as particular hardware and software implementation differences result in incompatible modeling infrastructures (i.e. a model with an OpenMI interface cannot automatically be ingested in an OMS model workflow). Web processing services present an opportunity to address some of these challenges. Indeed, recent advances in web services based data processing tools (i.e. through ArcGIS Server) have presented the ability to create complex workflow based geoprocessing models. This presentation or poster will detail work we are conducting to extend the concept of linking such web processing services to include integration of hydrologic models using an ArcGIS Model Builder - style open source modeling toolkit that can potentially serve as a bridge between different integrated modeling toolkits.