Georgia Water Resources Institute

Annual Technical Report

FY 1999

Introduction

In Fiscal Year 1999, the Georgia Water Resources Institute (GWRI) was involved in a wide range of activities at the state, national, and international levels. In summary, the following GWRI activities took place in FY99: RESEARCH PROJECTS - Improvement of Water Resources Management Due to Climate Forecasts (sponsored by NOAA); - Water Resources Sector National Assessment of the Potential Consequences of Climate Variability and Change for the United States (sponsored by USGS); - Sustainability of Surficial Aquifer Resources on Endmember (Developed and Pristine) Barrier Islands near Brunswick, Georgia (sponsored by USGS); - Sediment Transport Characterization in the Georgia Piedmont (sponsored by USGS); - A Geochemical Investigation of the Source of Nitrate Contamination in Groundwaters in the Vicinity of Albany, Georgia (sponsored by USGS); - Effects of Sediment on Channel and Floodplane Storage and Resultant Flooding in Urban Streams (sponsored by USGS); - Nile Basin Impacts to Climate and Anthropogenic Changes (sponsored by the State Department); - Climate and Hydrological Forecasts for Operational Water Resources Management, a Demonstration Project (sponsored by NOAA). - Decision Support System for the Alabama-Coosa-Tallapoosa River Basin (sponsored by citizen groups, nature conservancy groups, and US EPA). RESEARCH PRODUCTS GWRI investigators organized and conducted 8 short courses, gave a total of 12 lectures at local, national and international fora, and supported 21 students through various research projects. In the reporting period, GWRI research resulted in 5 refereed journal publications, 5 conference papers, and 5 water resources research reports. The institute produced two River Basin Decision Support System software packages, one for the South Eastern US, and one for the Lake Victoria region in East Africa. A graduate student internship was establised with the USGS Georgia District, and a graduate student fellowship was sponsored by a private company. POLICY IMPACT At the state level, GWRI was involved in many ways in the ongoing tri-state compact negotiation among the states of Alabama, Florida, and Georgia, on the allocation of the waters of the Apalachicola-Chattahoochee-Flint (ACF) and Alabama-Coosa-Tallapoosa (ACT) river basins. The institute followed the negotiation process carefully and served as an independent technical advisory resource for various stakeholders (including citizen groups, nature conservancy groups, and the US Environmental Protection Agency) providing an impartial assessment of the impacts and trade-offs of the proposed allocation formulas. GWRI worked with US EPA to incorporate biological integrity requirements into the various decision support models, and commenced development of the ACT-DSS. GWRI directly assisted the three states in the negotiation process by licensing (free of charge) the ACF-DSS to the state negotiation teams, and conducted the necessary training. At the national level, GWRI coordinated the Water Resources Sector National Assessment of Climate Change and Variability in the United States. This effort will assist the US Government to assess the challenges and opportunities posed by potential climate changes, and to formulate a sustainable policy on this issue. At the international level, institute staff traveled to East Africa for a series of workshops on decision support technology that were attended by high level government officials from Kenya, Tanzania, and Uganda. The Lake Victoria Decision Support System was sponsored by the United Nations and aims to support the Governments of Kenya, Tanzania, and Uganda, in developing shared-vision water development and use agreements. ADMINISTRATIVE REORGANIZATION In Fiscal Year 1999, GWRI established a new Advisory Board. Members include representatives from state and federal agencies, citizen groups, the academia, and the private industry. The Board meets on an annual basis and advises the institute on how to accomplish its overall mission, particularly to promote a stronger interaction among the state water resources professionals, organizations, agencies, universities, and citizen groups. The following text provides more details on the FY99 research, education, technology transfer, and information dissemination activities of the Georgia Water Resources Institute.

Research Program

Basic Project Information

Basic Project Information	
Category	**Data**
Title	Improvement to Water Resources Management Due to Climate Forecasts
Project Number	B-20-640
Start Date	08/01/1997
End Date	12/31/2000
Research Category	Climate and Hydrologic Processes
Focus Category #1	Climatological Processes
Focus Category #2	Hydrology
Focus Category #3	Management and Planning
Lead Institution	Georgia Water Resources Institute

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
Aris P. Georgakakos	Professor	Georgia Institute of Technology	01

Problem and Research Objectives

This project aims at demonstrating the value of climate and hydrologic forecasts in the operation of multi-purpose reservoirs in the US.

Methodology

The methodology applied uses information provided by Global Circulation Models (GCMs) relative to precipitation and temperature. These data series have been down-scaled from 0.5X0.5 degree grid cells to reservoir catchment scale, and serve as input into distributed hydrologic watershed models to estimate reservoir inflow ensembles (consisting of both surface and subsurface flows). Next, decision systems (consisting of a suite of control/simulation models) for selected reservoirs have been developed to evaluate the consequences of various resevoir operation policies. These decision systems will be run using the generated inflow ensembles to assess the utility of GCM and hydrologic forecasts in reservoir operation.

Principal Findings and Significance

The project continues up to 31 December 2000. The previous project period has been used to prepare the required data sets and to develop the various analysis tools. During the reporting period the following tasks were accomplished: (1) Calibration of the operational NWS hydrologic forecast model for Lake Lanier inflows. (2) Development of the Canadian GCM conditional precipitation forecasts for the region. (3) Development of the ensemble flow forecast conditional on GCM forecasts and reliability analysis. (4) Development and stand-alone testing of Lake Lanier decision support system including management preferences. (5) Runs of the decision support system in an integrated fashion using as input the ensemble flow forecasts conditioned on GCM information. During the next year, these tools will be used to concuct detailed assessments on the value of climate and hydrologic forecasts for river basin management.

Descriptors

Climate Forecasts Decision Support System Hydrologic Modeling Reservoir Operation

Articles in Refereed Scientific Journals

Forthcoming

Book Chapters

Dissertations

Water Resources Research Institute Reports

Forthcoming

Conference Proceedings

Other Publications

Basic Project Information

Basic Project Information	
Category	**Data**
Title	Water Resources Sector National Assessment of the Potential Consequences of Climate Variability and Change for the United States
Project Number	B-02-631
Start Date	07/01/1998
End Date	12/31/1999
Research Category	Climate and Hydrologic Processes
Focus Category #1	Hydrology

Focus Category #2	Climatological Processes
Focus Category #3	Management and Planning
Lead Institution	Georgia Water Resources Institute

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
Aris P. Georgakakos	Professor	Georgia Institute of Technology	01

Problem and Research Objectives

Climate variability and change pose both challenges and opportunities for the US. To be better prepared, the United States has developed a national assessment process to identify and analyze the potential consequences of climate variability and change. The "Global Change Research Act of 1990" (P.L. 101-606) states that the Federal government: "shall prepare and submit to the President and the Congress an assessment which: (a) integrates, evaluates, and interprets the findings of the Program and discusses the scientific uncertainties associated with such findings, (b) analyzes the effects of global change on the natural environment, agriculture, energy production and use, land and water resources, transportation human health and welfare,human social systems, and biological diversity; and (c) analyzes current trends in global change, both human-inducted and natural, and projects major trends for the subsequent 25 to 100 years." The Georgia Water Resources Institute (GWRI) is coordinating the assessment process which involves several research institutions in the US. GWRI also conducts part of this research activity, with focus on: (1) assessing the consequences of potential climate changes on the operation of reservoir systems, and to evaluate the effectiveness of regulatory polices in mitigating such consequences (Project 1-ALPHA); (2) assessing the expected changes in regional soil moisture and crop yield over the continental U.S. under various global climate change scenarios (Project 1-BETA).

Methodology

Project 1-ALPHA: this investigation will be conducted for three large multi-objective reservoirs in the US: Lake Folsom in California, Lake Saylorville in Iowa, and the ACF river basin in Georgia (including 4 reservoirs). GCM predictions under present and projected CO2 conditions for several decades have been used to provide forcing for macroscale hydrologic models of the drainage area of the study reservoirs, resulting in daily predictions for precipitation, temperature, and potential evaporation. These parameters have been used in basin scale operational hydrologic models to produce reservoir inflow ensembles, which serve as input in reservoir decision models. Using the latter models, assessments have been performed by comparing reservoir management benefits using GCM output corresponding to present day (baseline) CO2 emissions with output corresponding to projected CO2 emissions. Sensitivity analysis using current operational practices versus adaptive reservoir regulation schemes have been performed to assess the degree to which climate change consequenses can be mitigated through suitable adjustments of reservoir regulation policies. Project 1-BETA: GCM simulations under present and projected CO2 scenarios have been used to provide large scale precipitation and temperature input to macroscale monthly hydrologic models to produce soil moisture estimates over the continental USA. These results have been used to study the character changes in droughts over the record. Agricultural crop models have been used to determine ensembles of crop yields under the various CO2 scenarios.

Principal Findings and Significance

Results 1-ALPHA: The study investigated the response of eight southeastern U.S. basins (in Georgia and Alabama) using hydrologic watershed models forced by historic (1939 to 1993) and future (1994 to 2093) climate scenarios. The latter were generated by the GCMs of the Canadian Climate Center (C) and the British Hadley Center (H), according to the guidance of the National Assessment. Compared to the historical (baseline) response, under the Canadian Climate Scenario, all basins exhibit less precipitation (ranging from 15 to 22 % of the historical values), increased evapotranspiration (16 to 22 % of the historical values), less runoff (28 to 48% of the historical values), and smaller runoff coefficients (13 to 35 % of the historical values). By contrast, under the Hadley Climate Scenario, the basins experience higher precipitation (7 to 14 % of the historical values), higher evapotranspiration (8 to 11 % of the historical values), higher runoff (7 to 21 % of the historical values), and higher runoff coefficients (1 to 10 % of the historical values). No appreciable seasonal shift was noted for any of these variables, while their variability exhibited the same tendency as the mean. Namely, higher mean runoff exhibited higher variability. In the southeastern U.S., the study found that soil moisture is expected to decline sharply (by as much as 30 to 40%) under the Canadian Climate Scenario, and somewhat increase (by 10 to 20%) under the Hadley Scenario. As will later be discussed, the soil moisture response has important implications for agriculture. The study also investigate the impacts of climate change on the Apalachicola-Chattahoochee-Flint (ACF) river basin in the southeastern U.S. Their assessment is based on a decision support system (ACF-DSS) they developed for the on-going water allocation negotiations among the states of Georgia, Alabama, and Florida. ACF-DSS is a detailed river basin management system which represents all storage reservoirs, hydropower facilities, water supply withdrawals (agricultural, municipal, and industrial), environmental flow requirements, lake recreational constraints, and navigation needs. A unique ACF-DSS feature (relative to traditional river basin models) is that its reservoir operation policies are generated dynamically using updated information on streamflow forecasts and system conditions. In this respect, it is designed to mitigate the adverse effects of climate variability and change. The model is run for the historical as well as for the Canadian and Hudley climate scenarios, and for water demands projected for the year 2050. The results indicate that under the Canadian Climate Scenario, the ACF river basin would experience severe water shortages and stresses. Specifically, water supply deficits would increase more than 50-fold in the upper part of the basin while reservoir levels would experience frequent and very severe drawdowns. Among other detrimental consequences, water level fluctuations of such magnitude would sharply diminish the ability of the lake to provide relief during droughts, generate dependable energy, and maintain its high recreational value. Under the Canadian climate scenario, the ACF system would also frequently fail to meet the low flow targets throughout the basin, degrading environmental quality and compromising ecosystem health. These adverse effects are exacerbated if the reservoirs are operated according to the historical operational practices. The ACF results underscore the uncertainty associated with climate scenarios and, therefore, emphasize the need for flexible water allocation agreements and adaptive management strategies that explicitly account for forecast uncertainty. The study also conducted a detailed hydropower assessment for the ACF river basin under historical and future (Canadian and Hadley) Climate Scenarios. The ACF-DSS represents the hydropower facilities to the turbine level and optimizes peak and off-peak energy generation subject to all other water use commitments and constraints. Relative to the historical response, the Canadian climate scenario resulted in a 33% reduction in total energy generation, a 14% reduction in peak energy generation, and a 35% reduction in off-peak energy generation. By contrast, the Hadley Climate Scenario increased total energy generation by 21%, principally as a result of secondary energy generation increases. In this assessment, all hydropower facilities were scheduled to generate at peak power for only one hour per week day. It is notable that raising the peak power requirement from one to four hours per day leads to water shortages and stresses for all scenarios comparable to those of the Canadian Climate Scenario. Thus, water use changes may be as consequential as climate changes. Furthermore, comparing traditional operational practices with dynamic operational policies for the historical period, the study estimated that adaptable policies could lead to energy generation gains as high as 20%, without any reduction accrued to other water uses. The implication of this finding is that dynamic management strategies could be effective in mitigating the adverse impacts of climate change. Another element of the study investigated the response of Lake Folsom (on the American River in Central California) to potential climate and management scenarios. Folsom's main water uses are flood control, energy generation, water supply, and maintenance of low flows for environmental quality. The modeling approach used the Canadian Climate Scenario within a decision support system that included forecast uncertainty characterization, downscaling of GCM information, ensemble hydrologic forecasting, and dynamic reservoir management in the presence of uncertainty. The assessment was based on two climate scenarios. In the first scenario, CO2 was assumed constant, equal to its present atmospheric concentration level. In the second scenario, CO2 was assumed to increase by 1% per year. The Canadian GCM suggests that Central California will experience wetter and more variable climate under a CO2 increase. As a consequence, the study estimated that Folsom's energy generation and revenues (based on present energy prices) would increase by 24%, spillage (defined as water released above turbine capacity) would increase by 80%, and potential flood damage would increase by 219 million dollars (estimated using present damage cost curves). Furthermore, the study clearly demonstrates that characterizing forecast uncertainty and using it to develop adaptive management policies can drastically improve system response from disastrous to desirable. For Lake Folsom, using a median deterministic forecast sequence (rather than the full forecast ensemble) under the Canadian 1% CO2 increase climate scenario, would cause flood damage on the order of 4.3 billion dollars, 20 times higher than that of the full forecast ensemble (219 million dollars). By contrast, an improved forecast ensemble would reduce flood damage to 26 million dollars, a 10-fold decrease. Energy generation is not adversely affected by the added flood protection. To establish an upper performance bound, a run was also conducted with perfect streamflow forecasts. In this case, flood damages are completely eliminated, energy generation attains a maximum value, and spillage is minimized. These findings appear to disagree with the results of other reported studies which seem to indicate that climate change impacts cannot be mitigated simultaneously with respect to flood control, energy generation, and possibly other water uses. The disparity is due to the use of traditional versus adaptive management policies and to the treatment of forecast uncertainty. Under a changing climate, traditional operating rules are bound to become ineffective, while adaptive forecast-control management schemes can provide reliable coping strategies. This assessment also clearly corroborates the value of improved short term and seasonal forecasts. Results 1-BETA: This study element reached several interesting conclusions for regional agricultural changes. Peanut irrigation demands (growing season extending from mid-May to late summer) increased both in the Southeast (96% increase in mean demands) and Southern Great Plains (22% to 51% increase) with a significant increase in variability in the Southeast. Durum wheat irrigation needs decreased significantly in California (82% decrease; growing season extending from mid-December to early summer) and remained at near-zero levels in the Northern Great Plains (growing season extending from early Spring to mid-summer). Soybean irrigation requirements (growing season extending from mid-May to late summer) increased significantly in the southern portion of its cultivation range (86% to 158% increase) with an accompanying increase in variability, but northern areas had only slight changes in irrigation demands (6% to 31% increase). Winter wheat irrigation needs (growing season extending from mid-Autumn to late Spring) decreased in the northern and western regions (27% to 74% decrease) and increased in the Southern Great Plains and Southeast (22% to 75% increase). Corn irrigation demands (growing season extending from mid-May to late summer) strongly decreased west of the 104th Meridian (40% to 75% decrease) and were otherwise only slightly changed. While these trends are in general agreement with the Agricultural Sector assessments, the variability estimates reported herein are consistently higher. The reason for this difference is attributed to the fact that the Agricultural Sector studies do not fully incorporate the soil moisture variability implied by the Canadian Climate Scenario. Soil moisture is both spatially and temporally variable and has a significant influence on irrigation demands and crop yields. In this regard, the need for reliable soil moisture measurements cannot be overstated. The same study also estimated that crop yields mostly increased (assuming that the previous irrigation demands are met), with notable exceptions for winter wheat in the southern regions, and corn in all areas except the extreme northern and northwestern areas. Variability in crop yields increased for almost all areas for peanuts, durum wheat, soybeans, and winter wheat, and it increased for corn in the southern areas. The assessment of the agricultural impacts in the US are in agreement with the Canadian climate scenario's trends of a wetter climate in the west, a dryer climate in the east, and warmer temperatures throughout the U.S. Depending on which particular factor is most limiting for crop growth over the growing season (i.e., water availability, temperature, or both) the US agricultural response exhibits marked regional changes in a west-to-east direction around the 104 meridian for corn, (b) a north-to-south direction around the 40 parallel for soybeans and durum wheat, and (c) a northwest-to-southeast direction for winter wheat.

Descriptors

Climate Change Decision Support System Hydrologic Models Reservoir Management

Articles in Refereed Scientific Journals

Brumbelow K. and A. Georgakakos (2000). An Assessment of Irrigation Needs and Crop for the United States under Potential Climate Changes. Journal of Geophysical Research - Atmospheres; (in review). Georgakakos A., and H. Yao. (2000a). Climate Change Impacts on the Southeastern U.S. Basins, 1, Hydrology. Water Resources Research (in review). Georgakakos A., and H. Yao. (2000a). Climate Change Impacts on the Southeastern U.S. Basins, 2, Management. Water Resources Research (in review). Yao H. and A. Georgakakos. (2000). Folsom Lake Response to Potential Climate Scenarios, 2, Reservoir Management. Journal of Hydrology (in review).

Book Chapters

Dissertations

Water Resources Research Institute Reports

Water Resources Sector Report (under review, nationally)

Conference Proceedings

Georgakakos A. , H. Yao, K. Georgakakos (1999) Vulnerability of River Basin Management to Climate Variability and Change; Proceedings of the Speciality Conference on Potential Consequences of Climate Variability and Change to Water Resources of the United States (p49-58). Georgakakos A., K. Georgakakos (1999) Issues Associated with the Use of GCM Forecast Information for the Operational Management of Multipupose Reservoirs; Proceedings of the Speciality Conference on

Potential Consequences of Climate Variability and Change to Water Resources of the United States (p75-78). Georgakakos K., D. Smith, A. Georgakakos, K. Brumbelow (1999) Sensitivity of Soil Moisture and Crop Yield to Climate Variability and Change; Proceedings of the Speciality Conference on Potential Consequences of Climate Variability and Change to Water Resources of the United States (p369-374).

Other Publications

Dr. Aris Georgakakos was a member of the Conference Planning Committee for the AWRA Speciality Conference on Potential Consequences of Climate Variability and Change to Water Resources of the United States, May 10-12, Atlanta, USA. Dr. Aris Georgakakos was a member of the Sector Assessment Team (SAT) of the Water Resources National Assessment on Climate Change and Variability for the United States.

Basic Project Information

Basic Project Information	
Category	**Data**
Title	Sustainability of Surficial Aquifer Resources on Endmember (Developed and Pristine) Barrier Islands near Brunswick, Georgia
Project Number	B-02-626
Start Date	09/01/1998
End Date	08/31/2000
Research Category	Ground-water Flow and Transport
Focus Category #1	Groundwater
Focus Category #2	Hydrogeochemistry
Focus Category #3	Water Quality
Lead Institution	Georgia Institute of Technology

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
Carolin D. Ruppel	Assistant Professor	Georgia Institute of Technology	01

Problem and Research Objectives

Three undeveloped barrier islands in coastal Georgia have been mentioned as possible sites for future developments. This has led to interests by regional planners in the impact of urbanization and ecosystem destruction on the hydrologic systems beneath these barrier islands. In fact, the availability and quality of fresh water resources on barrier islands are considered key factors controlling the sustainability of natural systems and human development, as well as the continued viability of ecosystems in adjacent wetlands. The goal of this project is to develop a baseline for monitoring future development related changes in surficial acquifer systems on the concerned islands. The project is lasted two years and is nearing its completion. The following text presents the preliminary results of the second project year.

Methodology

The framework of the project is to compare the state of the surficial aquifer on a fairly pristine barrier island to that of an aquifer on a heavily urbanized island. Sapelo Island, which has a permanent population of approximately 70 people and is closely controlled by the State of Georgia and NOAA, represents the pristine endmember in this study. Nearly adjacent St Simons Island, which is heavily urbanized, represents the endmember "perturbed" surficial aquifer system. The setup being used for this comparative study has several unique advantages. First, because the islands have exactly the same configuration of Pleistocene and Holocene sediments, marshes, and northern subsidiary islands (Blackbeard and Little St Simons, respectively), this study offers a unique opportunity to use the pristine island to establish a baseline for the state of the surficial aquifer prior to heavy development of St Simons Island. Second, because development on Sapelo Island is located in very localized areas, there is good control on the degree of anthropogenic disturbances in this setting. This allows for the quantification of the impact of these disturbances on the surficial aquifer system in a fairly precise way. The study will collect hydrologic, geophysical, and geochemical data by coupling noninvasive geophysics with standard piezometric measurement and groundwater sampling.

Principal Findings and Significance

The primary result since last October has been the delineation of high and low salinity groundwater sites adjacent to the Frederica tidal river on St. Simons Island, GA. On adjacent Sapelo Island, we had previously discovered high (lateral intrusion of saline water exceeds 30 m inland) and low (lateral intrusion of saline water less than 10 m inland) salinity sites adjacent to first and second order tidal creeks, respectively. Note that the state's current setback of septic tanks from tidal creeks is ~50 ft. (according to DNR), which is less than the scale of lateral intrusion we have documented in some coastal settings. On St. Simons Island, we conducted surveys at Fort Frederica National Monument and have obtained plat maps that should enable us to conduct surveys in the less developed central section on the northern part of the island this summer and autumn. At Fort Frederica, we found high and low salinity sites separated by a few hundred meters along the same tidal creek. Previously, in our conversations with coastal oceanographers at Skidaway, we believed that it was primarily the order of the river network that governed the salinity of sites in the adjacent uplands. Now we have discovered that a variety of factors, including low elevation, creek morphology (e.g., on the inside or outside part of river bends), and proximity to Spartina marsh may also contribute to the development of high salinity sites. We have also obtained regional EM-34 (inductive data) on St. Simons Island, but we have been unable to invert these data to date due to nonlinear effects caused by highly conductive layers at depth. Another major new result emerged from the acquisition of an extensive suite of groundwater geochemical analyses (cation, anion, and nutrient) we completed in Fall 1999 based on samples collected from most of our 30 shallow groundwater wells on Sapelo Island. Our cation and anion analyses revealed that most of the anomalous signal in our freshwater wells could be explained by various degrees of mixing with saline waters. More importantly, standard nutrient analyses conducted both at Georgia Tech and in collaboration with UGA colleague Dr. Samantha Joye revealed a critical result about Sapelo Island: Increased levels of common nutrients are observed only in monitoring wells immediately adjacent to tidal creeks, not in inland wells. Furthermore, the strength of the anomalous nutrient signal correlates precisely with the degree of saline water intrusion in a specific well. This suggests to us that any increased nutrient load occurs due to the island's interaction with the surrounding estuary, which communicates directly with the Altamaha River and the coastal zone of the mainland. Sapelo Island truly seems to constitute a very pristine system whose margins are being affected by the surrounding waters.

Descriptors

surficial aquifer system, hydro geology, groundwater hydrology, water quality, anthropogenic disturbances, barrier island

Articles in Refereed Scientific Journals

"Physical Characterization of Shallow Sediments on Sapelo Island, Georgia", by Neal, Ruppel, and Schultz, submitted to Georgia Journal of Science in August 1999.

Book Chapters

Dissertations

Water Resources Research Institute Reports

Ruppel, C. "Sustainability of Surficial Aquifer Resources on Endmember (Urbanized and Pristine) Barrier Islands near Brunswick, Georgia", Progress Report, October 1999, 10p.

Conference Proceedings

Other Publications

(published abstract for invited talk) Schultz, G., and C. Ruppel, Integrated application of non-invasive geophysical and hydrologic methods for coastal aquifer characterization, Georgia Groundwater Association and Pollution Control Association, Spring Conference, Macon, GA 2000. (published abstract) Schultz, G., and C. Ruppel, Independent constraints on hydraulic parameters and flow and transport in a coastal surficial aquifer system, EOS Trans. Amer. Geophys. Union, Fall Meeting, 1999. (published abstract) Hunter, K.S., Lee, R.Y., Boyd, B., Schultz, G., Joye, S.B., and Ruppel, C., Groundwater geochemistry at the island-estuary interface at perturbed and pristine sites on a Georgia Bight barrier island, Southeastern Section, Geol. Soc. Amer., Annual Mtg., 2000.

Basic Project Information

Basic Project Information	
Category	**Data**
Title	Sediment Transport Characterization in the Georgia Piedmont
Project Number	B-02-629-G1
Start Date	03/01/1999
End Date	02/29/2000

Research Category	Climate and Hydrologic Processes
Focus Category #1	Geomorpological and Geochemical Processes
Focus Category #2	Non Point Pollution
Focus Category #3	Sediments
Lead Institution	University of Geogia, Warnell School of Forest Resources

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
Todd C. Rasmussen	Associate Professor	University of Geogia, Warnell School of Forest Resources	01
Michael Bruce Beck	Professor	University of Geogia, Warnell School of Forest Resources	02
C. Rhett Jackson	Assistant Professor	University of Geogia, Warnell School of Forest Resources	03

Problem and Research Objectives

Sediment in streams and lakes within the Southeast adversely affects aquatic habitats and presents a substantial health hazard by reducing the clarity of water, thus reducing biologic productivity. Coarse suspended solids also bury benthic habitats, thus diminishing overall species abundance and diversity. The ecological consequences of sediments in streams have been particularly detrimental to Georgia's native aquatic species. Additional consequences result from sediment transport. Nonpoint pollutant inputs to streams such as nutrients, metals, herbicides, insecticides, and fecal coliform are highly correlated with sediment inputs. The long term human and environmental health consequences from these non point sources are clearly a matter of local, regional, and national concern. Incomplete data limit the understanding of modern and historical sediment transport rates and inventories of Georgia Piedmont streams. A better understanding of historical and modern inputs provides the opportunity for identifying alternative management strategies for nonpoint pollution control that reduce or eliminate future environmental and health risks. The project investigated a multi-pronged approach for estimating the magnitude and distribution of suspended and bedload sediments.

Methodology

The nature of the research is to study the spatial (e.g. with depth, stream order, et al) and temporal (current versus historical, baseflow versus stormflow) distribution of suspended and bedload sediments in streams. In this respect, the project has applied a methodology comprising of the following components: a) new sediment sensor technology employing real-time densimetric methods and fluorimetry; b) environmental system identification using time-series analysis; c) sand dredging operations that provide information on sediment budgets, and can be used to related changes in sediment inventories on aquatic health; d) sediment budget studies that examine the relationship between modern and historical inputs along with stream riparian management alternatieves and their effectiveness in mitigaing stream sediment inputs; e) state-of-the-art mobile laboratory facilities along with computational models that provides additional nutrient and biological water quality information;

f) application of mathematical model STAND to study sediment and water quality control alternatives

Principal Findings and Significance

The results of the first component of the project approach indicate that, although not fully conclusive, the densimetric technology in field setting is capable to measure in-situ and real-time suspended sediment concentrations in streams during storm conditions. The research showed that future work is required to improve the practicality of the field placement of the equipment, the methods of calibration, and the analysis of the results. However, the applied methodology has the potential to become a viable alternative to existing methods for continuous monitoring of sediment and sediment related pollutants. In the reporting period the main activities of project components c and d have concentrated on data collection. An extensive monitoring program has been designed and put in place for sediment sampling in different stream types. However, analysis have shown that not enough data is available at the moment of writing to determine a relationship between sediment and discharge for each stream type. Sediment sampling will continue. A mathematical model (Sediment-Transport-Associated Nutrient Dynamics - STAND) has been developed for the study of sediment associated water quality issues. The model is intended to simulate changes of water composition associated with sediment behavior. As such STAND steps beyond the classical civil-engineering river morphology models by providing the ability to also study water quality issues. STANDS has been applied for the Oconee river in Georgia. Calibration and validation results were encouraging and the model performed reasonably well. It can be concluded that STAND provides a solid basis for the further improvement and possible application in engineering practice or water quality management of the model.

Descriptors

Sediment Transport Characterization In Situ and Real Time Sediment Sampling Water Quality

Articles in Refereed Scientific Journals

Forthcoming

Book Chapters

Dissertations

Water Resources Research Institute Reports

Forthcoming

Conference Proceedings

Forthcoming

Other Publications

Basic Project Information

Basic Project Information	
Category	**Data**
Title	A Geochemical Investigation of the Source of Nitrate Contamination in Groundwaters in the Vicinity of Albany, Georgia
Project Number	B-02-629-G2
Start Date	03/01/1999
End Date	02/29/2000
Research Category	Ground-water Flow and Transport
Focus Category #1	Geomorpological and Geochemical Processes
Focus Category #2	Groundwater
Focus Category #3	Nitrate Contamination
Lead Institution	University of Georgia, Department of Geology

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
David B. Wenner	Associate Professor	University of Georgia, Department of Geology	01

Problem and Research Objectives

The presence of nitrate in groundwater in the Floridan Aquifer near Albany Georgia has prompted an investigation using nitrogen isotopic data to identify the source contamination. It is thought that the contamination originates from a farm and that nitrates were transported by groundwater flow to an adjacent residential community. This community's water supply comes from homeowner wells, some of which exceed the MCL for nitrate in drinking water. A variety of materials capable of producing this contamination, such as cattle manure, biosolids (sewage sludge), and synthetic inorganic fertilizers are present or have been used on this farm. Biosolids were utilized as fertilizers over a twelve year period from 1984 to 1996 and a cattle feed lot was in operation from 1980-1984. Synthetic inorganic fertilizers were used prior to 1984. A hydrogeologic study conducted by the Georgia Geological Survey indicated that the most probable source of groundwater contamination is a disused cattle feed lot on the suspect property. To further assist in identifying the source of contamination, d15N values were measured for dissolved nitrate from nine wells both on the farm and within the residential community. The data from the contamination plume ranged from +5.5‰ to +2.3‰. This range is consistent with the idea that the major source of contamination stems from synthetic inorganic fertilizers. This conclusion is predicated on numerous studies indicating that different nitrate sources produce different ranges of d 15N values for dissolved nitrates. Typically, nitrates derived from inorganic fertilizers range from -5‰ to + 3.5‰, soil organic material from + 3.5‰ to +7.5‰, and manure and septic system effluent from +10‰ to +20‰. There are no known study of the d15N values of nitrates derived from biosolids. To reinforce this conclusion, d15N values were measured for grasses at sites where only cattle manure and biosolids were present. Analysis of plants serve as proxies for dissolved nitrate in soils because there is little or no isotope fractionation between plants and the dissolved nitrate that they uptake. The aim of this investigation was to directly assess the d15N values of dissolved nitrates in soils derived from decomposition of cattle manure and sewage sludge. A second investigation was initiated in order to constrain the age of nitrate contamination by measuring the tritium concentration of groundwaters within the area.

Methodology

Samples of bermuda grass were collected from different parts in and adjacent to the suspect farm. These samples are listed in the table presented in the following paragraph. Composite grass samples collected from a small (1 sq. ft) area at a given location are distinguished by separate numbers. Grasses growing on thick piles of aged cattle manure from the disused cattle feed lot are identified as Feed Lot #1-5. Two separate locations where biosolids were most recently applied include 64 Ac #2 and Airport #1-5. Grass samples from control sites include: 64 Ac #1 & 4 and Hwy #1-2. The former includes samples taken from unfertilized rows along the edge of the property and the latter are from a highway right of way that was only fertilized during initial planting using inorganic fertilizers. Tritium analyses were made on 10 water samples, all from homeowner wells. All wells are sealed with cement slabs to prevent influx of surface water and are believed to be cased to at least 100 ft deep through the unconsolidated residuum. These ten samples were collected from both the suspect farm and throughout the residential community. Nitrate concentrations for these samples ranged from 0.1 to 22.0 mg/L.

Principal Findings and Significance

Nitrogen isotope data reported as d15N values for the grass samples are listed in the following table. Duplication (and in one case triplication) of analyses of a single sample are listed as individual runs. The average and standard deviation of these runs are shown as well as average and standard deviation for samples from a given locality. Sample Run1 Run2 Run3 Av SD Av SD (runs) (location) (location) HWY#1 4.2 4.2 4.2 0.0 HWY#2 -0.6 -0.3 -0.5 0.2 1.9 3.3 64Ac #1 2.0 2.5 2.3 0.4 64Ac #4 3.8 3.7 3.8 0.1 3.0 1.1 64Ac #2 9.6 10.3 10.0 0.5 10.0 - Airport #1 6.5 7.1 6.8 0.4 Airport #2 9.2 8.9 9.1 0.2 Airport #3 8.8 8.7 8.8 0.1 Airport #4 7.9 7.8 7.9 0.1 Airport #5 6.6 6.6 6.6 0.0 7.8 1.1 Fd Lot #1 9.2 8.8 9.0 0.3 Fd Lot #2 7.7 7.8 7.8 0.1 Fd Lot #3 5.5 5.4 5.5 0.1 Fd Lot #4 9.8 9.7 9.8 0.1 Fd Lot #5 11.0 11.4 11.7 11.4 0.3 8.7 2.2 These data show that sample replication, as indicated by the standard deviation, is good (± 0.2‰), although the variation among samples from a given location is relatively large (< 3.3‰). This variation may reflect the heterogeneities that exist for dissolved nitrates within the unsaturated zone throughout the locality. Despite this variation, it is clear that the d15N values of grasses grown on both the cattle manure and biosolids are isotopically enriched compared to control samples. This is perhaps best illustrated by data from two adjacent sites at the 64 Ac locality, one that was not fertilized with biosolids (average d15N for samples #1 & 4 = 3.0‰) and a second location about 50 ft. away where biosolids were recently applied (sample #2, d15N = 10.0‰). Tritium values ranged from 0 to 12.3 TU, with a mean of about 6 TU (SD = 4). The elevated tritium values probably reflect varying mixtures of old "dead" water with either modern rainfall or small amounts of high T "bomb" water. Of critical importance is the fact that one sample from the suspect farm with a nitrate concentration of about 22 mg/L has a very low tritium concentration. This suggests that the source of nitrate contamination must be at least 25-30 years old and more likely dates from the pre bomb period, which is now about 50 years old. This younger age reflects the time that post bomb rainfall with average tritium levels of at about 50 TU in 1975 would have decayed to low enough levels to be undetectable above background today. If this assertion is true, then the materials contributing to the nitrate contamination cannot be either the biosolids or cattle manure from the disused feed lot. Both of these sources were not present in any large concentration on the suspect farm prior to about 1980. Thus, the tritium data are consistent with the tentative conclusions deduced from the nitrogen isotope data, namely that the major source of nitrate contamination is from past use of inorganic nitrate fertilizers.

Descriptors

nitrate contamination hydrogeology

Articles in Refereed Scientific Journals

Book Chapters

Dissertations

Water Resources Research Institute Reports

forthcoming

Conference Proceedings

D. Wenner, A Geochemical Investigation of the Source of Nitrate Contamination in Groundwaters in the Vicinity of Albany, Georgia Conference proceedings of SYMPOSIUM ON NUTRIENT MANAGEMENT AND WATER QUALITY IN SOUTHEASTERN UNITED STATES: PROBLEMS AND SOLUTIONS; June 4-6, 2000; Tallahassee, FL

Other Publications

Basic Project Information

Basic Project Information	
Category	**Data**
Title	Effects of Sediment on Channel and Floodplain Storage and Resultant Flooding in Urban Streams
Project Number	B-02-629-G3
Start Date	03/01/1999
End Date	02/29/2000
Research Category	Climate and Hydrologic Processes
Focus Category	

Focus Category #1	Geomorpological and Geochemical Processes
Focus Category #2	Sediments
Focus Category #3	Models
Lead Institution	Georgia Institute of Technology

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
Terry W. Sturm	Associate Professor	Georgia Institute of Technology	01

Problem and Research Objectives

Continued development in urban watersheds without adequate controls on sediment production from construction activities contributes sediment load to urban streams that may affect its sediment regime. Subsequent deposition of the sediment chokes the benthic aquatic habitat, and affects storage in the channel and floodplain and thus the flooding potential of the stream. In addition, urbanization creates a greater volume of runoff and higher peak flows with a different timing than exists prior to urbanization. These higher flows may contribute to bank erosion in some stream reaches and deposition further downstream. The result is again a change in geometry and sediment regime of the natural stream with consequent adverse affects on aquatic habitat and stream water quality. furthermore, the deposited finer-grained sediments from urbanized areas may carry with them attached contaminants that are subject of resuspension during subsequent flood conditions. While much work has been done on urban hydrology to predict changes in runoff characteristics due to urbanization, much less attention has been paid to the closely related sediment effects and the changes that they cause in flooding potential and water quality of the recieving stream over the entire watershed. The research project provides a case study of an urban stream to distinguish sediment contributions from watershed development and bank erosion, resultant changes in floodpain and channel storage, and the final effect on flood routing and thus flooding potential as well as movement of sediment-bound contaminants through the watershed system. In addition, a methodology has been developed that can be applied to other urban streams to predict the effects of urban development not just on the hydrology of the watershed, but on its sedimentology as well. As a result of the study, recommendations will be made on the relative efficacy of specific control measures such as best-management practices on contruction sites to limit sediment yield, artificially-created wetlands for aditional floodplain and sediment storage, streambank stabilization, vegetative buffer zones along the stream, and strict constols on development of the floodplain. This methodology allows decision makers to make more informed watershed-wide decisions rather than piecemeal approval and disapproval of particular development projects.

Methodology

The Peachtree Creek drainage basin is located in DeKalb, Fulton, and Gwinnett Counties in the state of Georgia. The area of study for this project included the main stem of Peachtree Creek and the North and South Forks of Peachtree Creek upstream of Northside Drive. The total drainage area of the project basin is 86 square miles, in Fulton and DeKalb Counties. The sediment discharge of Peachtree Creek has changed between the 1970s and 1990s. The two main sources of this sediment include erosion of the watershed and erosion of the channel and floodplain of Peachtree Creek. The relative contribution of these sources of sediment to the total discharge has changed over time. The average annual total sediment discharge from the watershed was calculated using the flow-duration, sediment-rating curve method based on data from the USGS gaging station at Northside Drive. This method is based on the flow duration curve calculated from the gaging station records and a relationship that was developed between measured suspended sediment concentration and water discharge. In addition, a watershed model (SEDCAD) was applied to the watershed to estimate the sediment yield due to erosion from the watershed. For the runoff portion of the model, the model input included historical precipitation, watershed runoff coefficients, times of concentration for overland flow, and channel travel time. The model also has a sediment erosion component built from the modified universal soil loss equation and a sediment routing algorithm to determine sediment yield. Input for this submodel included soil types and erodibility, eroded sediment size distributions, runoff lengths and slopes, and land use. The SEDCAD model was calibrated and verified for several historical storm events in the 1970s, 1980s, and 1990s. It was then run for each storm event of each decade beginning with the largest events until the cumulative sediment yield began to level off with negligible additional contributions. Measured cross-sections of Peachtree Creek from the 1980s and 1990s were used to calculate net changes in sediment volume due to erosion and deposition in the channel and on the floodplain. These results were compared with the difference between total average annual sediment load at Northside Dr. and model results for watershed sediment yield.

Principal Findings and Significance

The sediment discharge in the 1970s was 75,500 tons/year. The sediment discharge increased in the 1980s to 88,400 tons/year and then decreased to 74,200 tons/year in the 1990s. Using the SEDCAD model, average annual sediment yields from the Peachtree Creek watershed during the 1970s, 1980s, and 1990s were calculated. The sediment yield was 40,200 tons/year during the 1970s, 45,600 tons/year in the 1980s, and 32,600 tons/year during the 1990s. Based on the analysis of the changes in cross sectional geometry between the 1980s and 1990s, the difference between the sediment yield and sediment discharge may be attributed to the amount of soil eroded from the banks and floodplain of Peachtree Creek. The relative contribution of sediment to the total discharge was similar in the 1970s and 1980s. Approximately 53 percent of the sediment discharge was due to erosion of the watershed, while 47 percent of the sediment discharge was due to erosion of the channel and floodplain. By the 1990s, 44 percent of the sediment discharge was due to erosion of the watershed and 56 percent of the sediment discharge was due to channel and floodplain erosion. The changes in the sediment yield and in the relative contribution of sediment to the total discharge were due to changes in land use in the Peachtree Creek Basin. The construction that occurred during the 1970s and 1980s caused higher rates of watershed erosion resulting in higher sediment yields. Once urbanization of the watershed was nearly completed during the 1990s, there was a reduced amount of land that could be eroded, decreasing the sediment yield. In addition, the urbanization of the watershed increased runoff rates, causing higher rates of channel and floodplain erosion. Although rivers change rapidly due to changes in hydrology on a geologic time scale, complete adjustment of river geometry may not occur during a human lifetime. Because most of the Peachtree Creek Basin was developed by the mid-1990s, channel erosion might continue for several more decades unless management practices are implemented that would reduce stream flows to pre-urbanized levels or stream banks are stabilized. This erosion could be reduced by decreasing the peak runoff and runoff volumes to the creek. Management practices would need to be retrofitted in existing developments to retain and release storm water runoff more slowly. Channel and floodplain erosion could also be reduced through stream bank stabilization with riprap, vegetation, or other bio-engineered solutions.

Descriptors

Sediment Yield Morphology Erosion Processes

Articles in Refereed Scientific Journals

Book Chapters

Dissertations

Water Resources Research Institute Reports

Conference Proceedings

Other Publications

Weber, Diana. "Relative Contribution of Sediment from Upland and Channel Erosion, " M.S. Thesis, School of Civil and Environmental Engineering, Georgia Institute of Technology, May 2000.

Basic Project Information

Basic Project Information	
Category	**Data**
Title	Nile River Basin Impacts to Climate and Anthropogenic Changes
Project Number	E-20-F73
Start Date	04/01/1999
End Date	12/31/1999
Research Category	Climate and Hydrologic Processes
Focus Category #1	Climatological Processes
Focus Category #2	Management and Planning
Focus Category #3	Hydrology
Lead Institution	Georgia Water Resources Institute

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
Aris P. Georgakakos	Professor	Georgia Water Resources Institute	01

Problem and Research Objectives

The Nile basin has an area of 3.1 million km2 and is spread over 10 countries. The discharge per unit area is small; in fact, almost all the Nile water is generated on an area covering only 20 percent of the basin, while the remainder of the basin is in arid or semi-arid regions where water supply is minimal and where evaporation and seepage losses are large. A number of Nile basin countries (e.g. Egypt and Sudan) are almost completely dependent on the Nile Basin for their water resources. A treshold figure of 1000 M3 of water availability per inhabitant per year is sometimes used to flag attention to a condition of water scarcity (FAO, 1993). Most Nilotic countries are close to water stress, if not already stressed for water. Water availability per capita decreases with increasing population. While the world's population currently increases by 1.5 percent annually, most Nile Basin countries grow twice that fast. As a result, the basin population doubles every 30 years. Thus the current population of 260-270 million people will exceed 600 million by 2025. The economies of most Nile Basin countries are heavily dependent on agriculture which accounts for more than half of the Gross Domestic Products and employs 80% of the work force. However, the lack of water supply infrastructure, the variability of the climate, and poor cultivation practices may seriously restrain economic growth when overall water demand increases, which is right now the most likely scenario. Based on the above, severe water stress conditions appear all too likely in the years to come, and the Nile Basin will have to be managed in a more comprehensive and integrated way than at present to deal with the anticipated water shortages. The aim of this project is to investigate the impact of higher demands on the Nile water resources. The project will also assess the ability of a series of potential water conservation and regulation projects to mitigate water stress conditions.

Methodology

Over the last 4 years, the Georgia Water Resources Institute has been developing a Decision Support System for the Nile River Basin under the sponsorship of the US Agency for International Development and the Food and Agriculture Organization of the United Nations. This Nile Basin Decision Support System (Nile Basin DSS) presently includes decision models for all Nile tributaries and segments. The system includes a suite of models such as streamflow forecasting models, river routing models, reservoir and hydropower models, management models, and policy assessment models. In the first step in project execution the current Nile Basin DSS will be used to establish a baseline scenario depicting the current level of water consumption, river regulation, and hydrologic regime. Next, a series of scenarios will be run to investigate the effect of potential water conservation and regulation projects as well as the impacts of higher water demands.

Principal Findings and Significance

In the reporting period GWRI has run the Nile Basin Decision Support System to establish the baseline scenario and investigate the following set of experiments: - Completion of Jonglei Phase I and II; - Regulation of the Equatorial Lakes (Victoria, Kyoga, and Albert); - Implementation of the Machar Marshes drainage project; - Gradual increase of consumption at the Lake Victoria region (Kenya, Tanzania, and Uganda) by 5 and 10 billion cubic meters of water per year; - Construction of a series of hydropower reservoirs in the Ethiopian portion of the blue Nile (Lake Tana, Karabodi, Mabil, Mendaya, and Borders); - Gradual increase of water consumption in Ethiopia by 5, 10, 15, and 20 billion cubic meters of water per year; - Implementation of the New Valley Project in Egypt; - Implementation of the Sinai Development Project in Egypt. The above runs were repeated for hydrologic regimes associated with different climate scenarios generated by the NOAA forecasting system to assess the vulnerability of the basin to changes in both water demand and water supply. In each case, the investigation aimed at assessing the performance of the system relative to the baseline scenario, using the following criteria: - hydropower production (average as well as reliability statistics); - irrigation deficits (magnitude as well as risk statistics); - spills (flood frequency); - evaporation and other losses at the different river reaches and reservoirs. The assessment demonstrates that cooperative water development and management at the sub-basin and basin levels evoke benefits for all Nile Basin nations. The basin offers exciting water development opportunities and markets for water products. Consider hydropower. With the possible exception of environmental impacts, hydropower development projects (along the Victoria and Kyoga Niles in Uganda and the Blue Nile in Ethiopia) would accrue benefits to local as well as to upstream and downstream riparians and would provide strong incentives for economic cooperation. In this regard, energy generation in Uganda could be marketed to Kenya, Tanzania, Southern Sudan and possibly other countries in the region, enabling industrial growth and economic development.Energy generation in Ethiopia could likewise benefit Sudan, Eritrea, and Egypt. Furthermore, if coordinated across national boundaries, hydropower project storage could mitigate floods and droughts basin-wide. This would require the use of shared data monitoring and acquisition systems, effective modeling tools, and a basin-wide water management process in which all major basin stakeholders are fully represented.

Descriptors

Nile Basin Decision Support System Trade-off Analysis Reservoir Control and Regulation Water Resources Planning and Management

Articles in Refereed Scientific Journals

Book Chapters

Dissertations

Water Resources Research Institute Reports

A. Georgakakos, Yao H. (2000) An Assessment of Development Options, Management Strategies, and Climate Scenarios for the Nile Basin (146 pages)

Conference Proceedings

Other Publications

Basic Project Information

Basic Project Information	
Category	**Data**
Title	Climate and Hydrologic Forecasts for Operational Water Resources Management (A Demonstration Project)
Project Number	E-20-F21
Start Date	09/01/1999
End Date	08/31/2002
Research Category	Climate and Hydrologic Processes
Focus Category #1	Management and Planning

Focus Category #2	Climatological Processes
Focus Category #3	Water Quantity
Lead Institution	Georgia Water Resources Institute

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
Aris P. Georgakakos	Professor	Georgia Water Resources Institute	01
Konstantine P. Georgakakos	Research Associate	Hydrologic Research Center	02

Problem and Research Objectives

This project aims at demonstrating the value of climate and hydrologic forecasts and integrated forecast-control systems in the context of the highly managed Tennessee Valley Authority (TVA) reservoir system. The assessment is conducted for Lake Norris. This system serves multiple uses pertaining to time scales from hourly to seasonal and can significantly benefit from long as well as short term weather forecasts. Water uses include flood protection, recreation, fish habitat preservation, and hydro and fossil power generation.

Methodology

The first step in the assessment is to use information provided by Global Circulation Models (GCMs) relative to precipitation and temperature and downscale it to the catchment scale. Downscaling will be accomplished using statistical relationships and neural network approaches. Multiple regression relationships between GCM precipitation and temperature output and the local surface data will be established for a variety of storm types and and for each season. The second step is to use a distributed hydrologic watershed model to estimate surface and subsurface inflows to the channel network. Subsequent channel routing is performed through a Muskingum-Cunge routing scheme. Ensemble inflow of lake inflows will be generated which account for precipitation and evapotranspiration uncertainty, and for hydrologic model parameter uncertainty. The third step consists of developing a nested, three-level decision model hierarchy that fully utilizes the seasonal and short term forecast ensembles and identifies release policies addressing all short and long term objectives of the Norris system. Specifically, the first decision level will be concerned with turbine dispatching and plant efficiency optimization. The second, with a time resolution of one hour and a control horizon of two weeks, will aim at maximizing the value of energy generation while meeting temperature and fish habitat suitability constraints. The third control level will have a time resolution of one day, a control horizon of several months, and the aim to leverage long term forecast information and seasonal differences in the value of power to optimize long term system performance. The fourth step is to use the integrated forecast-control system to conduct extensive assessments aiming at assessing (1) the utility of GCM and hydrologic forecasts in multipurpose reservoir management, (2) the transformation of climate forecast uncertainty through the hydrologic system and the reservoir operation process, (3) the relative sensitivity of the decision process to climate-hydrologic versus demand forecast uncertainty, and (4) the overall value of integrated forecast-control schemes in reservoir management.

Principal Findings and Significance

Section A: Activities of the Georgia Water Resources Institute During the first project year, the Georgia Water Resources Institute worked on developing the background data and modeling elements for the Lake Norris demonstration project. Reservoir management is based on a decision system that includes three coupled models pertinent to turbine commitment and load dispatching, short/mid-term energy generation scheduling (hourly time steps), and long-term reservoir management (weekly time steps). Lake Norris data were obtained from TVA and used to develop the turbine commitment and load dispatching (TC&LD) and short-term energy generation models. The purpose of the(TC&LD) model is to optimize hydro plant efficiency by determining the power load of each turbine such that a certain power level (for the entire plant) is generated at minimum discharge. This model requires the following inputs: - beginning-of-the-period reservoir elevations; - various turbine and reservoir characteristics (e.g., elevation vs. storage and tailwater vs. discharge relationships, power vs. net hydraulic head vs. discharge curves, and operational turbine ranges, among others); - turbine outage schedule; and - minimum and maximum discharge requirements. The optimization problem associated with the TC&LD model is solved via Dynamic Programming and provides the maximum possible power associated with a particular discharge level, or (equivalently) the minimum discharge that achieves a particular power level. The role of the model is (1) to develop (off-line) the optimal (best efficiency) relationship among total outflow, total power generation, and reservoir elevation for each power plant, and (2) to determine (in an operational mode) the actual turbine loads that realize the discharge assigned to a particular plant from the upper level models. The first output is the connecting link between this and the short/mid-term energy generation model. The first purpose of the short/mid-term model is to derive a near-optimal function among reservoir level, weekly release volume, and energy generation to be used by the long range control model. For a particular reservoir level and a weekly release volume, this relationship is obtained by determining the hourly plant releases that sum up to the given weekly volume and maximize energy generation. The complete function is developed by performing this off-line computation for various combinations of reservoir level and weekly release volume. This model requires the following inputs: - the optimal level-discharge-power curve derived by the previous model; - feasible reservoir level ranges; and - minimum and maximum discharge requirements. The second purpose of the short/mid-term model is to operationalize the weekly decisions of the long-term model by generating hourly release and energy generation schedules. The optimization process for this model is also carried out using dynamic programming. Both models have been developed and are currently being tested for a variety of hydrologic and operational conditions. This process is scheduled for completion by the end of the first project year (August 31, 2000). Section B: Activities of the Hydrologic Research Center (Supported through a sub-contract to GWRI) During the first project period, Hydrologic Research Center Staff in collaboration with regional National Weather Service Staff estimated the parameters of the operational Sacramento soil moisture accounting and channel routing model for both the 3,817-km2 Clinch River at Tazewell, TN, and 1,774-km2 Powell River at Cleveland, TN. Parameter estimation was accomplished using the methods and techniques described in NOAA-HRC (1999) using a quality-controlled database of daily data (precipitation, temperature, pan evaporation), (The database was developed as part of this project.) The Clinch and Powell Rivers provide the inflow to Lake Norris. Operational forecast models were used to allow the assessment of the value of climate information for the Lake Norris reservoir management in an operational environment. A flow simulation analysis based on the estimated parameters showed that no significant biases exist in reproducing the annual cycle of monthly-averaged daily flows, and the variability of the flows, as indicated by the standard deviation of daily flows in each month, is reasonably well reproduced throughout the year. Slight underestimation of daily flow variability is observed for most of the winter and spring months for both catchments. The cross-correlation of daily observed and simulated flow for both catchments is about 0.9, which implies that the operational forecast model, running in simulation mode, explains approximately 80 percent of the observed daily flow variance.

Descriptors

Climate Forecasts General Circulation Models Decision Support System Optimized Multipurpose Reservoir Operation Hydrologic Modeling

Articles in Refereed Scientific Journals

Book Chapters

Dissertations

Water Resources Research Institute Reports

Conference Proceedings

Other Publications

Basic Project Information

Basic Project Information	
Category	**Data**
Title	Decision Support System for the Alabama-Coosa-Tallapoosa (ACT) River Basin
Project Number	E-20-F71
Start Date	04/15/2000
End Date	04/30/2001
Research Category	Climate and Hydrologic Processes
Focus Category #1	Hydrology
Focus Category #2	Management and Planning
Focus Category #3	Water Quantity
Lead Institution	Georgia Water Resources Institute

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
Aris P. Georgakakos	Professor	Georgia Water Resources Institute	01

Problem and Research Objectives

The Alabama-Coosa-Tallapoosa (ACT) River Basin is shared by the states of Alabama and Georgia. The basin serves several water uses including agriculture, municipal and industrial water supply, hydropower, flood control, water quality, ecosystem protection, and recreation. The states of Alabama and Georgia have been trying to negotiate a river compact for the ACT for the last five year but so far no agreement on water allocation could be reached. Many observers attribute the slow pace of the negotiation process to the absense of a shared set of comprehensive decision support tools capable of assessing the impact of the various water allocation proposals on the system. The objective of the Alabama-Coosa-Tallapoosa Decision Support System (ACT-DSS) project is to develop an advanced simulation-optimization decision support system for the ACT basin that can be used to assess the potential of the basin and investigate the impacts of alternative water allocation and management scenarios. GWRI intends to make the ACT-DSS available to the ACT stakeholders and assist them in using the system effectively during the negotiation process. Beyond the water allocation negotiation phase the model can be used to support water management.

Methodology

The Alabama-Coosa-Tallapoosa (ACT) Decision Support Sytem will consist of three main components: (1) a streamflow forecasting module, (2) a reservoir control component, and a (3) policy assessment module. The purpose of the streamflow forecasting component is to predict upcoming reservoir inflow and provide an appreciation of the forecast uncertainty through multiple forecast traces. The ACT-DSS inflow forecast model will generate forecast traces at all system nodes based on the statistical similarities of past inflows and those of the historical record. The second component of ACT-DSS is dedicated to reservoir control. Due to the need to satisfy multiple water uses over different time scales, this component includes three modules: (1) a turbine commitment and load dispatching module applicable to each hourly time step, (2) a short range control model operating on hourly time steps over a period of one week, and (3) a mid/long range control model operating on weekly time steps over a period of several months. This model configuration aims at generating system wide reservoir release policies subject to a set of specified constraints. The optimization operations are carried out by the Extended Linear Quadratic Gaussian (ELQG) control method. The three modules of the reservoir control component constitute a multi-level control hierarchy with an operational flow that follows two directions: the lower modules are activates first and generate information regarding performance functions and bounds. The mid/long range module uses these functions to develop system-wide reservoir management policies that satisfy the stated constraints and objectives. Once the long term policies have been identified, the lower level models can be activated again to determine the best turbine operation and loads implementing these decisions consistently across all relevant time scales. The last element of the ACT-DSS is the policy assessment component. Its purpose is to replicate the actual weekly operations of the ACT system under various water allocations policies and operational scenarios. Namely, at the beginning of each week of the simulation horizon, this component invokes the inflow forecasting and reservoir control components, determines the most appropriate reservoir releases, simulates the response of the system for the upcoming week, and repeats this process at the beginning of the following decision time. At the completion of the forecast-control-simulation process, the program generates sequences of all system performance measures. These sequences can be used to compare the benefits and consequences of alternative water allocation and operation policies.

Principal Findings and Significance

Under this project, GWRI conducted an initial study on the effects of Biological Integrity Requirements (BIR) on the ACF water uses. The study indicated that the modeling tools can effectively implement BIR conditions. It also demonstrated that BIR shuld be explicitly considered in the tri-state water negotiations as they impact all other water uses. With respect to the ACT-DSS, GWRI is in the process of calibrating and testing various DSS models. No experiments have yet been run.

Descriptors

Decision Support System Reservoir Control and Operation Water Resources Management and Planning Ecological Integrity Flood and Drought Management Hydropower

Articles in Refereed Scientific Journals

Book Chapters

Dissertations

Water Resources Research Institute Reports

A. Georgakakos, Yao H. (2000) Impact of Biological Integrity Requirements on ACF Water Uses (75 pages)

Conference Proceedings

Other Publications

Information Transfer Program

As part of its Information Transfer Program, the Georgia Water Resources Institute (GWRI) conducted the following continuous education courses in FY1999: -1: Use of the Apalachicola-Chattahoochee-Flint Decision Support System; July 21-23; 5 participants; -2: River Hydraulics and Bridge Scour Analysis Using HEC-RAS; August 17-20; 14 participants; -3: The Effects of Water Hammer; September 28-29; 22 participants; -4: Hydrologic Engineering for Dam Design; October 25-27; 11 participants; -5: Embankment Dam Design; February 2-4; 21 participants. -6: Kenya: One week training workshop on use and operation of the Lake Victoria Decision Support System; approximately 20 participants coming from government agencies (water resources, meteorology, agriculture, energy), academia, and the hydropower industry. -7: Tanzania: One week training workshop on use and operation of the Lake Victoria Decision Support System; approximately 20 participants coming from government agencies (water resources, meteorology, agriculture, energy), academia, and the hydropower industry. -8: Uganda: One week training workshop on use and operation of the Lake Victoria Decision Support System; approximately 30 participants coming from government agencies (water resources, meteorology, agriculture, energy), academia, and the hydropower industry. To support the information need of basin stakeholders, the GWRI Director conducted a series of lectures in FY99: -1: City of LaGrange: A Decision Support System for the Apalachicola-Chattahoochee-Flint River Basin; -2: Georgia Department of Natural Resources / Environmental Protection Division: A Decision Support System for the Apalachicola-Chattahoochee-Flint River Basin; -3: Georgia Department of Natural Resources, Brown Bag Lecture Series: A Decision Support

System for Integrated Water Resources Management and Planning for the Apalachicola-Chattahoochee-Flint River Basin; -4: Agricultural Research Service, Watkinsville, Georgia: GWRI Modeling Tools for the South Eastern United States; -5: NOAA/OGP: Use of Climate Forecast in River Basin Management; -6: Bureau of Reclamation, Sacramento, CA: Use of Climate Forecast in River Basin Management; -7: Florida State University, Tallahassee, Fl: Use of Climate Forecast in River Basin Management; -8: Worldbank, Washington, DC: Nile Basin Scenario Analysis; -9: EPA, Atlanta, GA: Current Water Resources Technologies to Address the Needs of the Southern US; -10: NWS, Atlanta, GA: Current Water Resources Technologies to Address the Needs of the Southern US; -11: USGS, Atlanta, GA: Current Water Resources Technologies to Address the Needs of the Southern US; -12: Federal Agencies in Georgia (EPA, USGS, ACE, NWS, FWS, SEPA): Impact of Biological Integrity Requirements on ACF Water Uses.

USGS Internship Program

Student Support

Student Support					
Category	**Section 104 Base Grant**	**Section 104 RCGP Award**	**NIWR-USGS Internship**	**Supplemental Awards**	**Total**
Undergraduate	12	N/A	N/A	N/A	12
Masters	2	N/A	N/A	N/A	2
Ph.D.	2	N/A	N/A	5	7
Post-Doc.	N/A	N/A	N/A	N/A	N/A
Total	16	N/A	N/A	5	21

Awards & Achievements

NewFields, Inc. established the NewFields Fellowship for Technical Excellence in Water Resources at the Georgia Water Resources Institute. The fellowship involves $18,000 annually and aims at supporting a PhD student in integrated water resources management. GWRI Graduate Student Mr. Kelly Brumbelow received an ASCE Freeman Fellowship of $3000 for travel to the Lake Victoria region in East Africa to (1) collect data on agricultural production and irrigation practices for his research; (2) assist in the installation of the Lake Victoria Decision Support System (LVDSS) at various national agencies in Kenya, Tanzania, and Uganda; and (3) assist in the training to government officials from Kenya, Tanzania, and Uganda on the use and operation of the LVDSS.

Publications from Prior Projects

Articles in Refereed Scientific Journals

Book Chapters

Dissertations

A Decision Support System for the Apalachicola-Chattahoochee-Flint River Basin; User's Manual - Version 1.0

Water Resources Research Institute Reports

Conference Proceedings

De Marchi C. and A. Georgakakos (in press). A satellite-based rainfall estimation method for the Lake Victoria basin. Proceedings of the IAHS Remote Sensing and Hydrology 2000 Symposium, Santa Fe, New Mexico, USA, April 2000. IAHS pubblications, Wallingford, UK.

Other Publications

Georgakakos A., H. Yao, S. Bourne, K. Brumbelow, C. De Marchi, (2000) Lake Victoria Decision Support System; Version 2.0 Georgakakos A., H. Yao (1999). Apalachicola-Chattahoochee-Flint Decision Support System; Version 1.0