WATER RESOURCES MANAGEMENT AND PLANNING TOOLS FOR GEORGIA RIVER BASINS

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Abstract. This paper presents water resources management and planning tools proposed for Georgia watersheds. The proposed water resources management and planning tools consist of a hydrologic model, a water management model, and a cumulative hydrologic impact assessment or scenario analysis tool. The Hydrological Simulation Program - FORTRAN (HSPF) is selected to model streamflow data for Georgia watersheds (Bicknell et al., 2001). The same HSPF model is also selected as the water management model. The water management model is an accounting model that is used to balance water demand and water availability. Unlike the hydrologic and the water management models, the cumulative hydrologic impact analysis tool is not a model but rather an analysis technique that can be accomplished by interactively using the hydrologic and the water management models to analyze the impacts of alternative management scenarios.

INTRODUCTION

There are 14 major river basins in Georgia (DeMeo and Kundell, 2001). These river basins are the Altamaha, Chattahooche, Coosa, Flint, Ochlockonee, Oconee, Ocmulgee, Ogeechee, Satilla, Savannah, St. Marys, Suwannee, Tallapoosa, and Tennessee. Among the 14 river basins in Georgia, water management models have been developed for four river basins, which are the Coosa, Tallapoosa, Chattahooche, and Flint. Water management model development efforts are now underway for the Savannah and the Ocmulgee River Basins.

Increased demand for water and the occurrence of frequent and severe droughts in Georgia present serious water management challenges to water resources managers. Georgia receives an annual average precipitation of about 50 inches. However, during drought periods when precipitation falls far below 50 inches, rainfall dependent surface water supply sources can become critically low. Importantly, surface water is the main source of water for many urban centers that are located in the Piedmont Physiographic Province of Georgia. The headwaters of many of Georgia’s river basins are also located in the Piedmont Physiographic Province and drought impacts are particularly severe to urban centers that are located at the headwater watersheds. For instance, the Atlanta's Metropolitan Area is located in the headwaters of the Chattahooche River basin. The area of the Chattahooche River basin that is located upstream of the Atlanta Metropolitan Area is relatively small. As a result, during drought periods, the amount of flow generated by the Chattahooche headwater watershed may not adequately supply Atlanta’s water demands.

To enhance the reliability of surface water supplies during drought periods, reservoirs such as Lake Lanier, are used to store water during wet years so that the stored water can be used during dry years. Without the use of comprehensive water resources planning and management tools, it is often difficult to understand how reservoir storage and upstream water withdrawals affect downstream hydrology including the availability of water for aquatic habitats that are located downstream of a reservoir site. The objective of this paper is 1) to present water resources management and planning tools that can be used to estimate water availability using a hydrologic simulation model, 2) to compare water supply and water demand using a water management model, and 3) to assess the hydrological impacts that alternative water management policies and projects may have on streamflow using a cumulative hydrologic impact assessment tool.

HYDROLOGIC MODEL FOR GEORGIA RIVER BASINS

To manage and plan water resources, it is important to estimate the amount of surface water flowing in a stream or river at different periods of the year. Streamflow data can be obtained by either measuring flow rates using gaging stations or estimating flow rates using hydrologic simulation models. The United States Geological Survey (USGS) continuously measures streamflow data at selected stations in all of Georgia's major river basins. It is not cost effective, however, to measure streamflow data for all the subbasins of a river basin. When streamflow data are needed for firm yield analysis for a proposed water supply reservoir or a withdrawal permit, it is often difficult to obtain measured streamflow data in many small and mid-size watersheds in Georgia.

To obtain streamflow data for ungauged watersheds, an alternative to actual streamflow measurement is to estimate streamflow data using a hydrologic simulation model. Georgia Environmental Protection Division's (GAEPD) Water Resources Branch selected the HSPF model to simulate streamflow data for ungauged watersheds. The HSPF model is one the models included in the BASINS modeling system (USEPA, 1998). It requires substantial model input data that include climate, land use, topography, and soil data. The model also uses observed streamflow data for model calibration purposes. After calibrating the HSPF model, the model can be used to simulate streamflow data for all the sub-basins of a watershed. Simulated streamflow data offers water managers more flexibility because, water managers are not constrained by lack of observed data. Water managers can use a hydrologic model to simulate streamflow and use the resulting output to analyze the impact of water resources development projects and/or policies on downstream flow requirements.

WATER MANAGEMENT MODEL FOR GEORGIA RIVER BASINS

The use of a hydrologic model to simulate streamflow data for an ungauged watershed is the first step towards developing a water management model for a watershed. The selected water management model is a water accounting or water allocation model. Its main use is to allocate water among water users such as agriculture, hydropower, recreation, navigation, municipal, industrial, and instream river flow. Instream flows are designated for fish, wildlife, and habitat water use categories.

As stated earlier, the HSPF model is both the selected hydrologic and the water management model. The model has a number of attractive features that include modeling inter-basin water transfers, water withdrawals, and return lows. The model handles multiple reservoir operations and generates flow releases based on downstream flow requirements. It is also comparable to the STELLA and the HEC-5 models that are currently used for modeling the Apalachicola-Chattahoochee -Flint (ACF) and the Alabama-Coosa-Tallapoosa (ACT) River basins. The proposed water management model differs from ACT-ACF models in a number of ways. First, the water management model uses the HSPF model instead of HEC-5 or STELLA. Second, unlike ACT-ACF models that use observed streamflow data, the proposed water management model uses observed streamflow data when such data is available and uses simulated streamflow data when observed flow is not available. Third, because of its link to the hydrologic model, the proposed water management model can be updated when the condition of the watershed changes as a result of urbanization or construction of new reservoirs or when evaluating the impacts of new water withdrawal permits. The hydrologic and the water management models are dynamic models that can be jointly updated. Alternative management scenario simulations generated by the hydrologic model can be automatically transferred into the water management model using the Watershed Data Management Program (WDMutil). The WDMutil program is part of the BASINS modeling system and allows the hydrologic and the water management models to read and write files from a single data set.

CUMULATIVE HDROLOGIC IMPACT ANALYSIS TOOL

The hydrologic and the water management model are the basic components of the cumulative hydrologic impact analysis tool. The main function of this analysis tool is to analyze the impact that alternative management and development scenarios have on streamflow. Cumulative impact analysis is performed when the hydrologic and the water management models are used interactively to assess land use/land cover change, construction of new dams and reservoirs, water withdrawals, and global warming impacts on streamflow. The cumulative hydrologic impact analysis tool allows the hydrologic and the water management models to be adaptive and dynamic tools that change with time to reflect the changing watershed conditions. The cumulative hydrologic impact analysis tool is important to water managers because it enables water managers to analyze alternative scenarios and to assess the impacts of proposed policies or projects before projects are actually implemented. Figure 1 shows a flow chart of the proposed water resources management and planning tools for Georgia watersheds. This flow chart shows that inflows generated by the hydrologic model are used as input data to the water management model whereas water management input data to hydrologic model. To use the scenario analysis tool, the user has to create a base line condition. For most cases, the present condition is used as the base

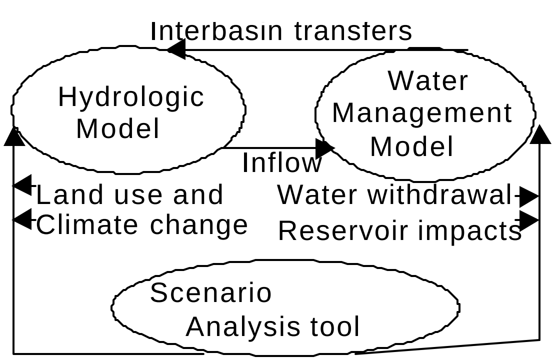

Figure 1. A flow chart showing the linkages between the two models and the scenario analyses tool.

line condition and the need for "unimpaired or naturalized" flow conditions may not be necessary. If "unimpaired or naturalized" flow conditions are needed, the hydrologic model can simulate these conditions. Once streamflow under the baseline condition is simulated, baseline condition simulations are used to compare "what-if" scenarios or alternative management scenario simulations.

SUMMARY

This paper presents proposed water resources management and planning tools for Georgia River basins. The proposed tools consist of a hydrologic model, a water management model, and a hydrologic impact analysis tool.

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