HSPF MODEL OF THE STREAMFLOW SIMULATION FOR THE LOWER FLINT RIVER WATERSHED

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REFERENCE: *Proceedings of the 2007 Georgia Water Resources Conference*, held March 27-29, 2007, at the University of Georgia

Abstract. Agricultural irrigation in southwestern Georgia started in the mid-1970s and has become one of the most important type of water use in the region. Easy access to both surface water and groundwater aquifer made it possible to have large scale irrigation operations. Much interest has been focused on the impact of such operations on in-stream flow in the lower reaches of the Flint River and its major tributaries. Using a surface water hydrological model (BASINS/HSPF) and groundwater model (MODFE), we made an effort to understand the interactions between groundwater and surface water in the Lower Flint HUC-8 Unit. The surface water hydrological model has been calibrated and validated with surface water observation.

INTRODUCTION

Lower Flint River is a major agricultural area with heavy pumping for irrigation from the ground water. The aquifer, Upper Floridan Aquifer, from which most pumps tap water, connects, sometimes tightly, to surface streams. With this kind of connection, pumping from the aquifer could tamper the flows in the main stream such as Lower Flint River and its tributaries. To estimate the impact of such activity, EPA's BASINS/HSPF model (USEPA, 2000) is utilized in the model process. With the climate and topographic information, the model simulates the local incremental runoff with the integration of other demands taken into account. The results of modeling supply detailed sub-unit flows for the water management strategies.

METHODS

Study Area of the Modeling

The Lower Flint Watershed covers counties of Dougherty, Baker, Mitchell, Decatur and small parts of other counties like Colquitt and Grady (fig. 1). The flow in the Lower Flint River Watershed includes the runoff/ground water discharge from not only its local drainage area but also the upstream influxes. The influxes include those from upper Flint River above Albany and upstream tributary of Ichawaynochaway Creek (fig. 2). For this model, these influxes were from either river gage records or modeling results of other HSPF model. The upstream influx in Flint River is from USGS gage records at Albany(USGS 02352500). The Ichawaynochaway Creek influx is from HSPF model of Ichawaynochaway Creek Watershed (Zeng et al, 2005).

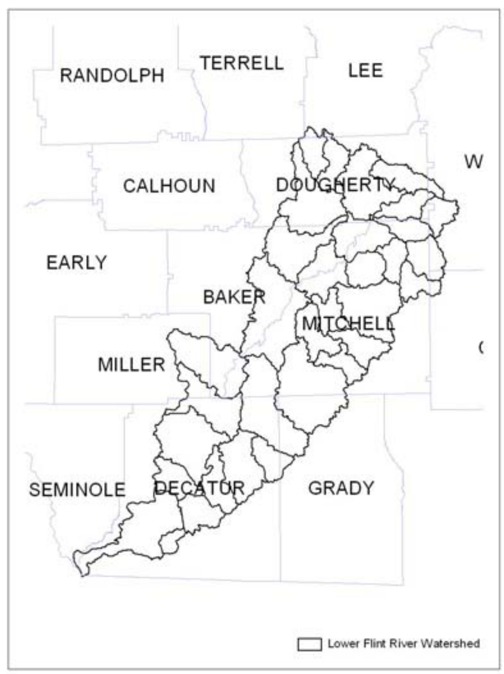

Figure 1. Modeling Area

Irrigation Data

The major irrigation source in the Lower Flint River Watershed is ground water. The major aquifer from which the water has been tapped is Upper Floridan Aquifer. The depth of the top of the aquifer under ground ranges from very shallow to more than 100 feet. In some places the stream incises directly into

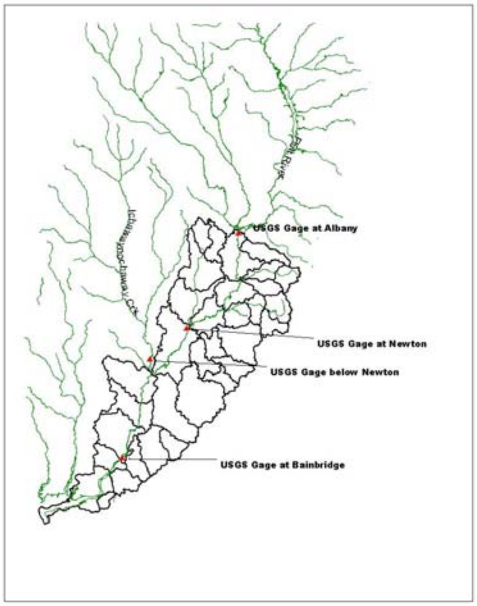

Figure 2. Upstream River and Tributaries of the Lower Flint Watershed

the limestone of the Upper Floridan Aquifer. This kind of aquifer depth and relationship to the surface streams makes pumping from the aquifer have effects on surface stream flow. Unlike pumping directly from stream, however, the mechanism of aquifer recharging from or discharging into streams are complicate so the pumping effect is not a 1 on 1 relation, i.e., pumping one gallon of water would reduce one gallon of stream flow. To consider this effect, the current model adopts the results of other studies as input of the demands. These studies are Agricultural Water Pumping from UGA (J. Hooks, et al, 2005) and ground water modeling from USGS (L. E. Jones, et al, 2006).

Basins/HSPF Model of the Area

United States Environmental Protection Agency's model, BASINS/HSPF (Better Assessment Science Integrating Point and Nonpoint Sources/Hydrologic Simulation Program Fortran) was selected to simulate the hydrologic situation of the Lower Flint River Watershed. Under the Basins framework, the watershed is divided into smaller units, called sub-basins. These sub-basins are connected together with reaches of stream. The studied area is delineated into 33 sub-basins. The delineation and data collection were conducted in Basin 3.1 platform based on ArcView GIS. This delineation almost follows the HUC12 boundary exactly for the purpose of compatibility of other studies, in addition to facilitate the existing river gages (fig. 3).

Met Data and Watershed Data

Precipitation data from several weather stations are used in the HSPF model. These stations are located at Colquitt, Albany, Camilla, Cairo, and Bainbridge (fig. 3). Some of these stations have complete precipitation records but some do not have. Therefore, some of the missing data has been compensated by adjacent weather station data. Also, the basic time unit for simulation in the model is in hours. The precipitation records of stations mentioned above are daily. To satisfy the requirement of model data input, precipitation data of these stations has been adjusted to hourly according to the trend and time distribution of the weather station at Edison, Georgia which is located out of the watershed. It is deemed reasonable because Edison is not far from the watershed. The model also needs evaporation and transpiration data but most weather stations do not have this kind of records so it was derived from daily high and low temperatures. In derivation of the transpiration, data at Camilla have been used. Land use and soil property data was collected by the ARCVIEW GIS BASINS 3.1 coverage. It indicates that about 50% of land in the Lower Flint Watershed is agricultural land, 42% of land is forest, and the rest urban, water, wetland and barren land.

Periods of Simulation and Calibration Selection

The calibration of the model is to adjust parameters to tune the simulated results to make them as close as what observed for those river gages in the modeling area. In the Lower Flint River Watershed, there are two major USGS river gages along the river, Newton and Bainbridge. Bainbridge is located close to the outlet of the watershed before the river converges into Lake Seminole, the interim point of the river converges into Apalachicola River. The flow records of river gage at Bainbridge have a long lapse. The gage stopped flow records from late 1971 until July 2001.

For the Lower Flint River Watershed HSPF modeling, the period for simulation is from 1950 to August 2003. The calibration for the Newton River Gage is from 1956 to 2003, For the Bainbridge, calibration is from 1953 to 1971. Bainbrdige Gage re-started flow records late in 2001. These new records of Bainbridge Gage are also compared to simulated flows by the model.

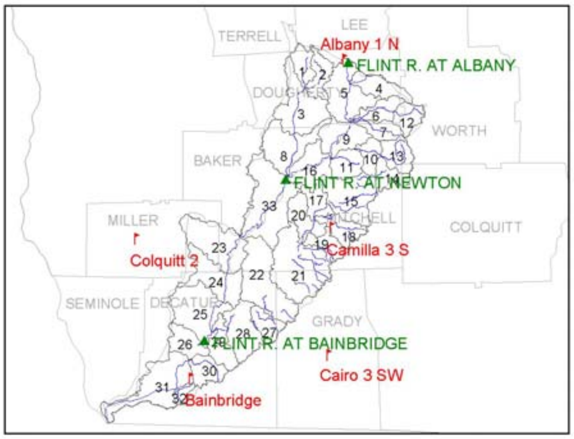

Figure 3. Lower Flint River Watershed with Met Stations and sub-basin delineations

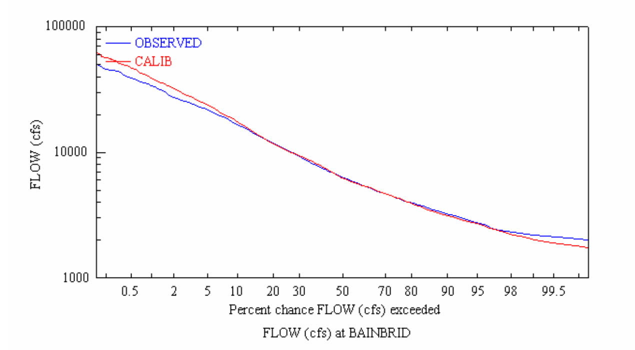

Figure 4. Duration curve of calibrated vs. observed flow at Flint River at Bainbridge (for period 1953 to 1971)

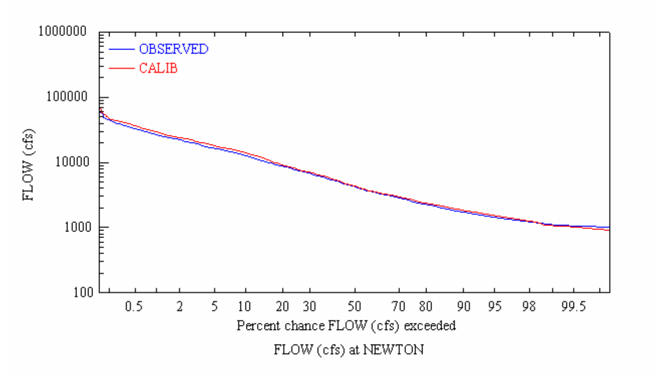

Figure 5. Duration curve for calibrated vs. observed flow at Flint River at Newton (period 1976 to 2003)

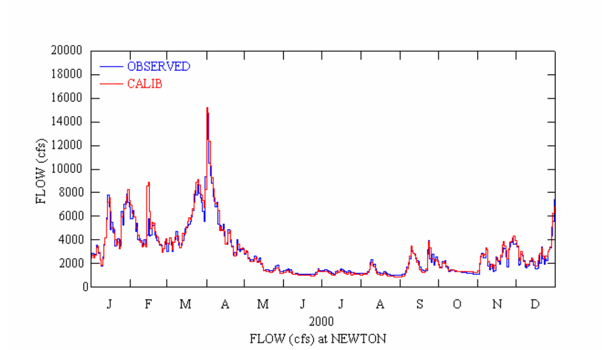

Figure 6. Flow rate at Flint River at Newton (Dry Year – 2000)

CALIBRATION RESULTS AND DISCUSSION

The objectives of the calibration process are to adjust hydraulic parameters for the sub-basins so that the simulated stream flow time series close to those observed. The fit of the calibration is estimated by three different indices, i.e., correlated coefficient (CC), coefficient of determination (COD), and Nash-Sutcliffe Model Coefficient (NS).

The calibration for the Lower Flint River Watershed at Bainbridge from 1953 to 1971 achieved the following indices: (1) CC=0.95; (2) COD=0.9; and (3) NS=0.85. For simulations with daily time intervals, the indices means that the calibration results is very good (Aqua Terra Consultants and Utah State University, 2004). For the Newton, the results are also very good. The calibration for Newton from 1956 to 2003 achieved the following indices: (1) CC=0.96; (2) COD=0.93; and (3) NS=0.90. Figures 4 and 5 are duration curves of flows for Bainbridge and Newton. They show good matches between observed and simulated data

Simulated flows by the model of some of individual years are also selected to compare to observed flow data. They are shown in figures 6, 7, 8, and 9. They are also matched well in general.

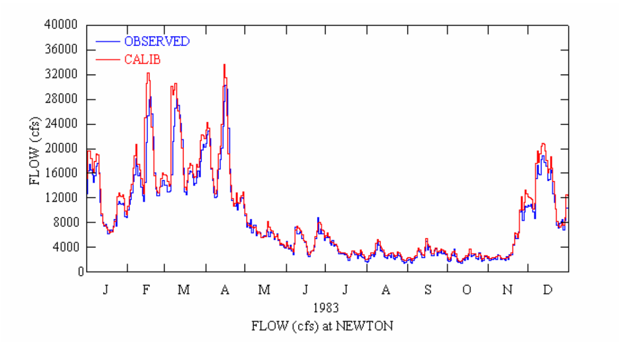

Figure 7. Flow rate at Flint River at Newton (Normal Year – 1983)

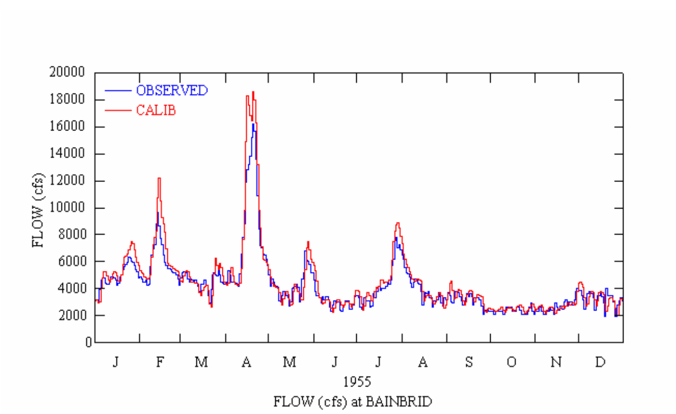

Figure 8. Flow rate at Flint River at Bainbridge (Dry Year – 1955)

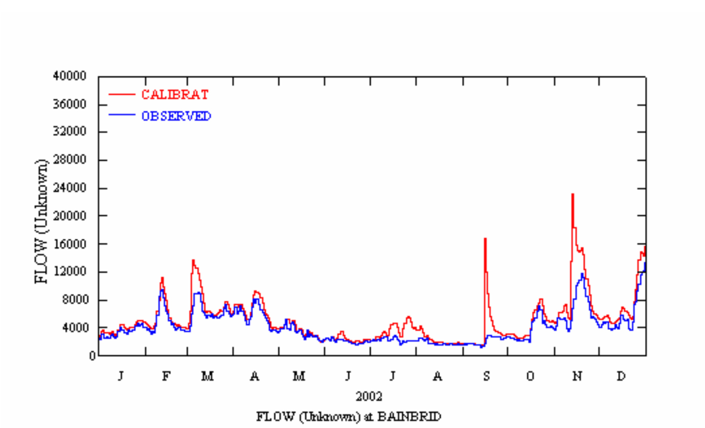

Figure 9. Flow rate at Flint River at Bainbridge (Dry Year-2002)

CONCLUSION

The Lower Flint River Watershed has been calibrated with the observed flows at Newton and Bainbridge. The results show that the current model has a successful representation of the flows in the watershed. Further local incremental flux can also be computed. The model is a useful tool for the water resources management strategies.

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