AN EVALUATION OF OBSERVED AND UNIMPAIRED FLOW AND PRECIPITATION DURING DROUGHT EVENTS IN THE ACF BASIN

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Abstract. The Apalachicola-Chattahoochee-Flint (ACF) Basin has experienced three major drought events in the past 50 years. A cumulative deficit evaluation of the drought events shows that the greatest cumulative rainfall deficit occurred during the mid 1950's event, but the greatest flow deficit occurred during the 1999–2002 drought event. An evaluation of the unimpaired flow set, being used to develop an Allocation Formula for the ACF Basin, indicates that this data set is not consistent with these findings, suggesting further evaluation may be needed to address the adequacy of the dataset as the basis for future policy decisions. Caution should be used in using and in interpreting model results from this time period.

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INTRODUCTION

The ACF Basin begins in the Piedmont of northern Georgia, and extends through middle and southern Georgia to the Florida panhandle. The 19,700 square mile basin hosts a wide variety of plant and animal species. More than 4 million human inhabitants call the ACF Basin home, relying on the streams for water supply, fisheries, recreation, waste assimilation, power generation, and irrigation. The generally high quality of life in the ACF Basin has spurred economic growth. This growth has occurred mainly in the Atlanta area.

It is this population growth and the associated increased demands on water resources that sparked the Tri-state Water Wars in 1990. Rather than resolving the issues through litigation, the states are working together to formulate a water sharing agreement. In 1997, US Congress enacted the ACF Compact, which allows Alabama, Georgia, and Florida to determine an allocation formula for the basin. The deadline for negotiations, which has been extended more than a dozen times, is currently set for July 2003. This formula will have far-reaching and long-term consequences, governing stream and reservoir management and thus affecting stream habitat, the health of fisheries, recreational uses, water availability and economic growth for the next 50 years. This paper evaluates whether the current flows in the basin have been affected by human consumption and the consistency of the U.S. Army Corps of Engineers unimpaired flow set with recently observed flow and precipitation trends during a major drought event. The unimpaired data set plays an important role in modeling associated with developing the ACF Allocation Formula.

The basis of the evaluation is an examination of flow and precipitation data. Flow data is evaluated at three locations: the USGS gage at Chattahoochee, Florida on the Apalachicola River, the Columbus, Georgia gage on the Chattahoochee River and the Newton, Georgia gage on the Flint River. The Apalachicola at Chattahoochee gage was used because it monitors below the point where the Flint and Chattahoochee Rivers converge and where the cumulative effects of human activities can be evaluated. The Chattahoochee at Columbus gage and the Flint at Newton gage are the furthest downstream gages on the rivers at which reliable, long-term observed data are available. Although gages further downriver exist on both the Chattahoochee and Flint River, these gages are affected by backwater effects from reservoirs and are not considered reliable.

Observed data, precipitation data and an unimpaired data set were evaluated to gage the effects of human activities on instream flow. The unimpaired data set is a synthesized data set prepared by the U.S. Army Corps of Engineers, Mobile District and the States of Alabama, Florida and Georgia for modeling purposes in the ACF Comprehensive Water Resources Study and ongoing negotiations between the states. The unimpaired data set was constructed by removing from observed data the influences of consumptive withdrawals and returns and reservoir management and evapo-precipitation effects at reservoirs. The observed flow data used in this paper were taken from the USGS web site (http://waterdata.usgs.gov). The unimpaired flow set used for this analysis is the most recent set available from the Corps of Engineers as of January

2003. At the time this paper was written this data set had not been approved by the three states. The precipitation data were obtained from the web site for the National Climatic Data Center (http://lwf.ncdc.noaa.gov/oa/climate/onlinerod/drought/xmgrg3.html). The precipitation data were divided by the Climate Division of the National Climate Data Center and were converted into a weighted average for the basin above the Chattahoochee gage using an Excel spreadsheet prepared by the Northwest Florida Water Management District and modified to include data from 1994 to 2001.

The analysis for this paper focuses on the low flow component of the data set for the ACF Basin. Low flows will be the aquatic bottom line for the ACF system. If low flows are insufficient, poorly timed, or too frequent, aquatic species, recreational users, discharges, and all water users could suffer negative effects. Furthermore, the ratio of reservoir storage to flow in this basin is low; the reservoir system only has the capacity to affect low to median flows in the lower parts of the basin, and cannot store adequate water to augment low flows for a long duration of time or at a large magnitude for a sustained period of time.

RESULTS

The cumulative deficit of observed flows, unimpaired flows and precipitation during three major drought events are shown in Figures 1, 2 and 3. The cumulative deficits were computed by comparing observed data that occurred during the drought events to observed average monthly values for the period of 1939 to 2001. All of the dataset comparisons begin on January 1. The drought events occurred during the mid-1950s, the mid-1980s and 1999 to 2002, so one of the events occurred before consumptive demands in the ACF basin began to grow significantly, one in the midst of the growth of consumptive demands and one when consumptive demands had reached their current level.

In developing these comparisons, it was our expectation that the unimpaired flow results would correspond to fluctuations in the rainfall data over the entire period of record. If any differences in the relative comparisons were to occur, we expected that they would be only in the observed flow data set. Affects of consumptive and evaporative losses should be apparent in the gage data. Because the unimpaired data set was only extended to December 31, 2001, in Figure 2 the 1999 to 2002 drought event is only analyzed through that date.

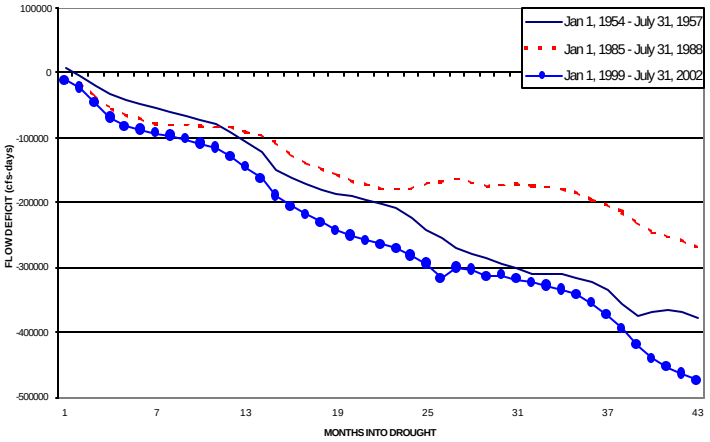

Figure 1. Observed flow cumulative deficit.

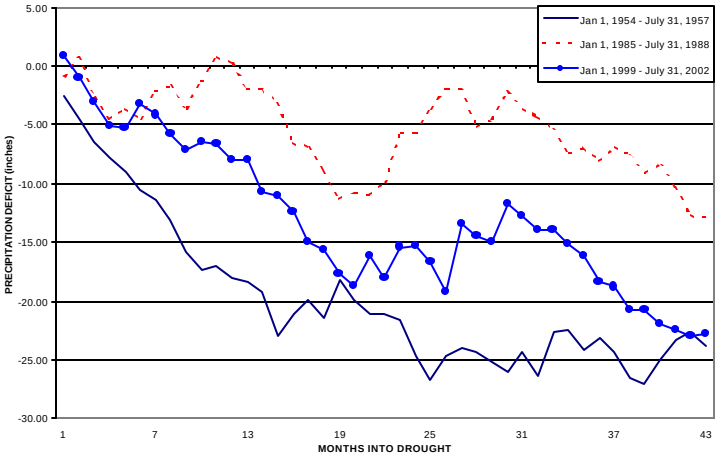

Figure 2. Cumulative precipitation deficit.

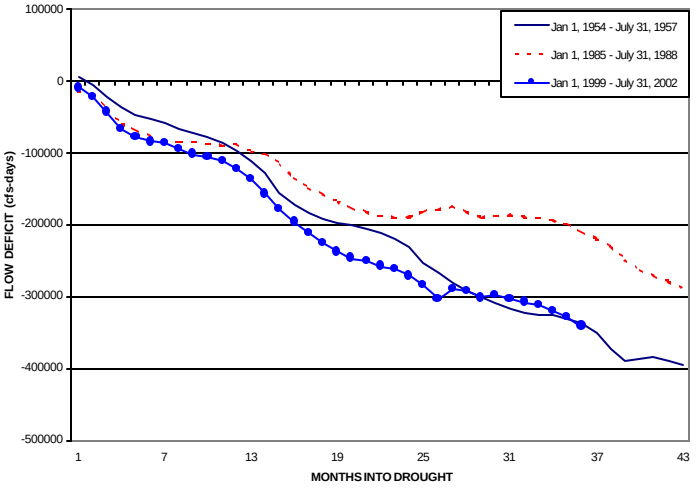

Figure 3. Unimpaired flow cumulative deficit.

DISCUSSION

In reviewing Figures 1, 2, and 3 it can be seen that in the observed flow set, the 1999 to 2002 drought event had the largest cumulative deficit in flows, even though the precipitation data indicated the 1954 to 1957 drought was the most severe drought event. The unimpaired flow set also shows the greatest deficit for the 1999 to 2002 drought event. The magnitude of the differences in the cumulative deficits in the observed data set is often in the 50,000 to 100,000 cfs-days range and the magnitude of the differences in precipitation in the five to ten inches range. The differences in the unimpaired set are of less magnitude than in the observed dataset. The unimpaired flow set should correlate to the precipitation data, not the observed flow data. The reasons for this discrepancy could be the result of 1) an undercounting of consumptive demands in the basin, 2) an undercounting of evaporative losses from the basin or 3) other errors or assumptions in the dataset used to compute the unimpaired flow set.

Consumptive Demands

The consumptive demands used in the STELLA and HEC5 models can be broken up into municipal and industrial demands and agricultural demands. These models serve as the means to technically evaluate alternative allocation formula proposals and therefore in the decision-making process of whether a specific proposal is acceptable. Municipal and industrial demands used to construct the unimpaired flow set were reported data provided by the States and are the best data available. The data were metered by the various water users and represent a reasonable estimate of consumptive water use in the basin. Agricultural demands, however, were estimated and derived from average annual withdrawals. In dry and wet years, the agricultural demand estimates were given the same value in the unimpaired data set although in reality the demand does vary; this could be a significant source of error. This potential error has been compensated for in modeling efforts, but was not addressed in the unimpaired data set. The data used to estimate agricultural demands were computed by multiplying estimated acreage of irrigation, source of irrigation water (surface or groundwater), and application rates. If the source of water was groundwater, further assumptions had to be made with regard to how agricultural withdrawals in the karst Dougherty Plain region effect surface flows. All of these estimates represent potential sources of error.

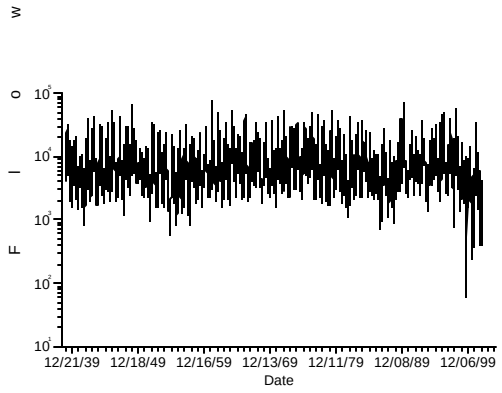

Figure 4. Unimpaired flow at Columbus gage on Chattahoochee River

Evaporative losses

In computing the evapo-precipitation effects for the unimpaired flow set, the Corps accounted only for evaporative losses at the four major storage reservoirs in the basin (U.S. Army Corps', 1997), which cover nearly 150,000 acres at full pool. However, there are approximately an additional 100,000 acres of impoundments in the ACF basin where evaporation occurs but was not accounted for in developing the unimpaired data set (Georgia Department of Transportation). About 60% of this acreage is in the Flint basin and 40% the Chattahoochee. In the summer months during a dry year this translates into a maximum of about 300 to 400 cfs-days of lost flow unaccounted for in the unimpaired flow set.

The Unimpaired Flow set

The "unimpaired flows" represent the Corps' estimate of the flow that would have occurred from 1939-2001 if no human activity had taken place. Figure 4 shows the unimpaired flow estimated for the Columbus gage on the Chattahoochee River for the 1939-2001 period, with the daily flows plotted on a log scale. One check on the hydrologic consistency of the record is to plot the flow duration curve, a plot of the (log) cumulative average daily flows on a normal probability axis. If the variation in the unimpaired flows is hydrologically correct, the flow duration curve for data in the first half of the record should be similar to a flow duration curve in the second half of the record. The data were split at the end of 1974 because this represents the approximate mid-point of the series; human influence on the watershed was also substantially different after 1974. The pre-1974 data fits a log-normal distribution (straight line), while

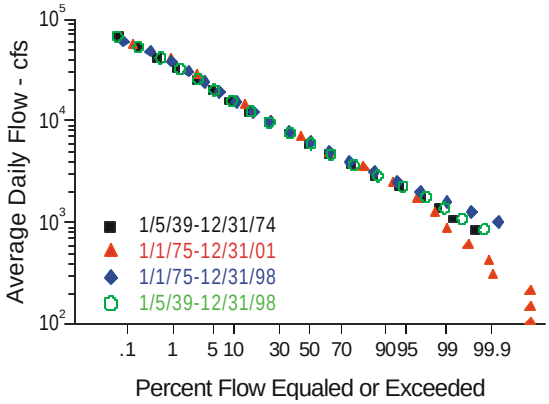

Figure 5. Unimpaired Flow duration curve for Columbus gage on Chattahoochee River

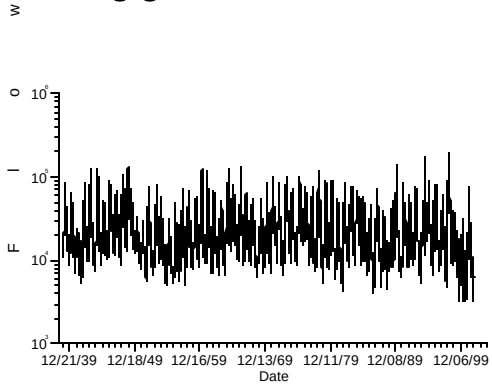

Figure 6. Unimpaired Flow at Chattahoochee gage on Apalachicola River

the 1975-2001 data do not (Figure 5). It has a number of anomalously low data points. When the years 1999-2001 are removed, the data are similar to the pre-1974 curve, demonstrating that the inconsistent data is in the last three years of record, the recent drought. To confirm this finding, the data from 1939-1998 were plotted and found to fit log-normal distribution indistinguishable from the pre-1974 curve. Similar analyses of flow trends at the Apalachicola River at Chattahoochee and Flint River at Newton gages were also conducted. The disparity in the data persists at the Chattahoochee gage site (Figure 6), but does not persist at the Newton site (Figure 7). The same trends seen in Figure 4, 5 and 6 with one-day flows persist when the data is converted running seven-day flows. This suggests that the problem associated with the unimpaired set is with the Chattahoochee basin, not the Flint Basin even though the agricultural and evaporation data earlier suggested problems with Flint basin. These results demonstrate that the one-day unimpaired flows derived for the 1998-2001 period of

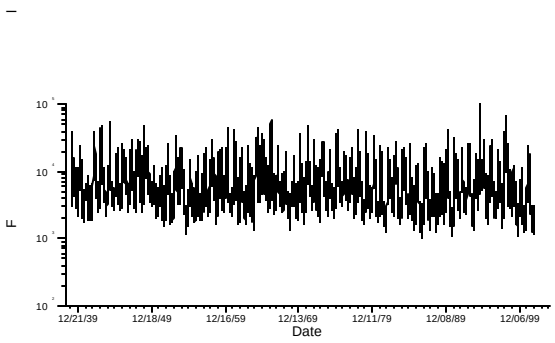

Figure 7. Unimpaired Flow at Newton gage on Flint River

drought are not reliable, especially when it is recognized that this time period did not have as great of a precipitation deficit as occurred in the 1954-1957 drought.

CONCLUSIONS

This analysis shows flows at the Apalachicola River at Chattahoochee gage during drought events have been impacted by consumptive demands and that the Corps of Engineers daily unimpaired flow at the Columbus gage for the years 1999-2001 do not totally reflect these impacts. This suggests that in making policy decisions in the Allocation Formula negotiations that caution should be used in drawing conclusions from flows in the 1999 to 2001 time period. The limits of the datasets used to develop the unimpaired flow set must be recognized in modeling exercises and in interpreting model outputs. Further analysis at additional gages is necessary to address the adequacy of the dataset as the basis for future policy decisions.

ACKNOWLEDGEMENTS

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REFERENCES

Georgia Department of Transportation, Lakes and Pond data, undated, available through Georgia GIS Data Clearinghouse.