WEAP: A COMPREHENSIVE AND INTEGRATED MODEL OF SUPPLY AND DEMAND

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Abstract: WEAP, is a menu-driven microcomputer program designed to assist policymakers in evaluating water supply policies and developing sustainable water resource plans. It operates on the basic principle of water balance accounting: water supply vs water demand. Four primary types of system components can be modelled: *demand sites*, thought of as a related set of water distribution systems; *wastewater treatment plants* that receive and discharge return flow from the demand sites; *local supplies*, or non-river based water supply components, each one managed and operated independently; and *rivers and their nodes*, representing the water resources and other river-based water uses that form a single river network managed together through a river simulation mode. The model was tested in the upper Chattahoochee River Basin, Georgia to evaluate its capability.

INTRODUCTION

The task of developing a water balance for a region, or water budget as it is sometimes called, has been the subject of research at the Hydrologic Engineering Center (HEC) for a number of years (Hayes, et al., 1980). In 1991, in cooperation with the Tellus Institute, Boston, research was begun on a computer program to assist in water balance analysis. The program Water Evaluation and Planning System (WEAP) models all water supply and demand in a region and provides information on the balance, or imbalance, of the water resources under present and future demand (Tellus Institute, 1994). Through research at HEC, improvements in the capability and flexibility of the program were identified to make it more applicable for use by the Corps of Engineers and these were added to the program by the Tellus Institute. To test the program, the upper Chattahoochee River Basin, Georgia was modelled. This test produced a tutorial document on the use of WEAP for river basin studies (U. S. Army Corps of Engineers, 1994). Observations on the capabilities of WEAP and on the upper Chattahoochee water resources are presented in this paper.

PRINCIPAL CAPABILITIES OF WEAP

WEAP creates a comprehensive and integrated picture of municipal, industrial and agricultural water use and respective supply sources. The model is useful to systematically identify all users and supply sources by amount and location; to forecast future demand; to compare supply and demand and identify potential shortages; to examine supplies and uses under different scenarios; and to assess the overall adequacy of the water resource for effective water management.

Water Supplies. All surface water supplies, groundwater supplies, and interbasin transfers may be included in the model. Major reservoirs as well as local supply reservoirs are modeled; the amount of water exchanged between a river and adjacent groundwater aquifer are accounted for. Reporting of water supply includes: total supply resources; river, groundwater and local supply sources; evaporation losses from reservoirs, rivers and tributaries; return flow; and surface and groundwater interaction.

Priorities of Water Use. Priorities can be established between competing demand for water along a main river or between local supplies such as streams, local reservoirs and groundwater.

Water Uses. Withdrawals for water treatment plants, discharges from wastewater treatment plants, return flows, groundwater pumpage, and losses, both in a distribution system and from rivers and reservoirs, are accounted for. Instream flow requirements are also modeled. Reporting of water demands includes: total demand; demand by branch level; demand by sector; demand by geographic area; demand by site;

instream demands; and demand by supply source.

Wastewater Treatment Facilities. Wastewater treatment facilities can receive wastewater as return flow from multiple demand sites, temporarily hold it, then return it to water supply sources.

Comparing Supply and Demand. Comparisons are made at a site specific level such as a water treatment or wastewater treatment plant, or at an aggregate level such as a city or county. Forecasts of future demands may be made in several ways and compared with estimated supplies under drought or other hydrologic conditions.

Mass Balance Reporting. The model can display a mass balance of withdrawals and uses at any river/tributary node, demand site, wastewater treatment facility, and supply source.

Monthly Data. All data used in the program are monthly averages. Supply data can be entered for critical drought periods, individual years, or average conditions.

Tables and Graphs. Supply and use data are displayed as tables or graphs. The graphs available include line charts, pie charts and bar charts. Network diagrams are available to show major rivers and their reservoirs, withdrawals, diversions, confluences, and tributaries. Distribution systems and their supply sources are also shown by a network diagram.

Computer Requirements. The computer program is menu driven and runs on a personal computer. The program requires 3 MB of free storage space; 640 KB of RAM, with 550 KB free for WEAP use. A typical application requires about 2 MB for data.

Software Development. WEAP was developed by the Stockholm Environment Institute - Tellus Institute, Boston, Massachusetts. The Hydrologic Engineering Center (HEC), Corps of Engineers has been working with Tellus to increase the capability of the program and applied it to the upper Chattahoochee River Basin.

UPPER CHATTAHOOCHEE OBSERVATIONS

Analysis of the supply and demand data for the upper Chattahoochee watershed provided useful information about the water resource and its use. While it was not the purpose of this test application to do a detailed analysis of the region's water resources, this could be done effectively using WEAP once the specific questions to be addressed are identified. Some general observations derived from the test follow.

Different Hydrologic Sequences

The storage levels of Lake Sidney Lanier that result from different sequences of hydrology using the historical period 1980-1989 illustrate the long-term effects of a single wet or dry year. Different arrangements of the years will result in different storage, even though the sum of the inputs for the period are the same. The sequence of years is clearly a critical element in the supply-demand comparison at specific demand sites and overall. It is useful therefore, in any supply-demand comparison, to use a range of hydrology, historical as well as synthetic, and to note the sensitivity of the results.

Local Supplies

An analysis of local supplies (streamflow) on an annual basis suggests that, within the basin, there are additional quantities of water to meet local needs, even under drought conditions. This water exceeds the water withdrawn from the unaccounted surface water supply source, suggesting that it could be used to meet unpermitted demand. Review of these local supplies on a monthly basis shows that water is available throughout the year, with more available during the wetter months.

Lake Sidney Lanier and the Upper Chattahoochee River

Lake Lanier provides a significant amount of storage (1,087,600 acre-feet) for meeting a variety of conservation purposes within the upper Chattahoochee watershed and downstream. The amount of storage available for water supply withdrawal, both from the reservoir and the river, depends upon the releases to the Chattahoochee River for hydroelectric power and other purposes. If minimum downstream requirements are set low, for example, at the 7Q10 water quality flow, then more water is available to meet water supply demand at the reservoir, however, shortages may occur at withdrawal points along the river. If the downstream requirements are high, for example, at the monthly average for the period of record, then shortages in supply may occur at the reservoir.

Withdrawal Permits

Within the next decade, several water supply facilities will need an increase in their withdrawal permit to keep pace with future demand projections. Under normal hydrologic conditions, it appears that increasing withdrawals for these systems will not adversely affect competing systems. Under drought conditions, however, the effects of increased permit amounts should be assessed on a case by case basis.

Instream Flow Requirements

The minimum downstream requirement at Fairburn gage is the dominant instream demand in the WEAP model. For the base case, the downstream requirement is set equal to the average monthly flow rates at the Fairburn gage for the 1980-1989 historical period which ranged from 2345 cfs in October to 3935 cfs in April. With these requirements, the demand sites on the upper Chattahoochee River experience supply deficits of up to 90 percent in drought years. If the minimum downstream requirement is reduced to a level approximately equal to the 7Q10 flow at the Fairburn gage (1300 cfs), the results of the supply-demand comparison are dramatically different. This is because the minimum downstream requirement is satisfied first, then the demand site withdrawals from the river. When the downstream requirement is low then there is water available from Lake Lanier to meet withdrawals along the river; when the downstream requirement is high, less water is available from Lanier to meet demand.

OBSERVATIONS ON THE WEAP MODEL

The WEAP model of the upper Chattahoochee River Basin provides a comprehensive and integrated picture of the principal water supplies and demands of the region. This picture includes,

1) the connection between river and reservoir operations and the water demand of the cities, counties and industries in the basin.

2) a comparison of instream requirements for water quality, recreation and fish and wildlife with the demand for municipal/commercial, industrial and agricultural water supply.

3) an accounting of all principal water users including their supply sources, permitted withdrawal, and discharges.

4) an accounting of all principal surface and groundwater supplies including reservoirs and water transfers.

5) an accounting of losses and water reuse in the system including transmission losses, demand site losses, infiltration to groundwater, and river/reservoir evaporation.

6) forecasts of future demand for water and the adequacy of available supplies under different hydrologic conditions.

7) identification of permitted withdrawals and the adequacy of the permit amounts to meet future demand.

8) identification of underutilized sources of water and their availability for transfer to meet future needs.

9) the sensitivity of the water system to river flow, reservoir storage, permit requirements and future demand.

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