ESTIMATING DAILY WATER USE IN THE MISSISSIPPI DELTA

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INTRODUCTION

Water level declines in the Mississippi River Alluvial Aquifer have resulted from heavy use of that aquifer by agriculture for row crop irrigation, flooding of rice fields, and maintaining levels in catfish ponds. If aquifer water levels are allowed to continue to decline, the aquifer may eventually be destroyed and an incredibly valuable natural resource of the region would be lost. To prevent this loss and its staggering impact on the environment, agriculture, and the economy of the Delta, the YMD Joint Water Management District (YMD) and Area 4 Soil and Water Conservation Districts have undertaken a project, with the technical assistance of the Natural Resources Conservation Service (NRCS), to evaluate the feasibility of developing alternative water supplies for the Delta region.

To complete the planning for alternative supplies, two major efforts were identified that would need water resource information on a daily or monthly basis. The daily information was needed for the development of an alluvial aquifer computer model and to assess the possible impacts of transporting water in interior streams of the Delta on flood carrying capacity.

First, a computer model of the alluvial aquifer is an important and necessary tool for this regional planning process. Plans for conservation programs and new water supplies will be tested to see if their implementation would stop the overdraft of the alluvial aquifer. The US Geological Survey (USGS) has agreed to assist in the development of the computer model of the alluvial aquifer in a cooperative project with YMD, NRCS, and the Office of Land and Water Resources (OLW) of the Mississippi Department of Environmental Quality. One component needed for the development of the model is the best possible spatial and temporal estimates of water withdrawals from the aquifer. Daily water use was needed so that YMD can provide monthly estimates of water pumped for each of the 12,500 permitted wells in the alluvial aquifer. The results of monthly water use by individual wells is presented in Stiles and Pennington (1966).

Second, importing water from the Mississippi or Yazoo River into the Sunflower River system is one new supply of agricultural water being evaluated. This option will place flows into the Bogue Phalia, the main channel Sunflower River, and the Quiver River during summer irrigation months. These channels already provide drainage and flood stage control for the region. Placing additional flows into these channels will impact channel needs to maintain a given level of flood protection. The Corps of Engineers (Corps) is currently evaluating flood channel needs in the Sunflower Basin. Their analysis of flood protection must now include the impact of using those channels for the dual purposes of flood control and water supply. An estimate of flows that may be introduced into the channels by possible agricultural water supplies is needed for the Corps to complete that analysis. The results of the flow analysis provided to the Corps are provided in another paper by Pennington and Stiles (1996).

Both of the described projects need water use information over daily or monthly time periods. Very little organized data is available on daily water use in the Delta. Research may report daily crop water requirements or total annual water use (Hendricks 1996), but these data do not present short term water use information, nor consider the number of acres watered in the Delta, or the impact of individual management styles of water management. The water data needs required a general broad based integrator of the many individual factors that each influence water use in the Delta.

METHODS

Summer river stages resulting from agricultural runoff were chosen as that broad indicator. In general, agricultural runoff is proportional to agricultural water use (more water use results in more runoff). By accepting this general relationship, it is possible to establish a procedure to estimate daily water requirements based on daily runoff data.

Agricultural runoff from a large area within the Delta can be estimated by stage and discharge data collected by the Corps with automated equipment located on the Sunflower River at the town of Sunflower (Lat.: 33.546944, Long.: 90.543056).

The discharge data for the Sunflower River at the town of Sunflower for May through October of 1988 is given in Figure 1. Between peaks of runoff caused by summer storm events, it is possible to see a background flow not related to storm events. This background flow begins to increase near June 1, reaching a high near August 1, and falling to a second low in early October. This background base flow corresponds to the agricultural water use season and is visible, to some degree, each year. For this analysis, that base flow is assumed to be caused by agricultural runoff and is assumed to be directly proportional to agricultural water use. The 1988 data displayed this background flow more clearly than most recent years.

It is also noted in the flow data in Figure 1, that the baseline is lower in October than when it becomes visible near June 1. Some non-agricultural water use runoff is usually still occurring near June 1, while almost no non-agricultural water use runoff is occurring in early October. If no agricultural water use runoff occurred during the summer, a gradual decrease in baseflow would be expected from June through October. This background flow needs to be accounted for and is assumed to change linearly from June 1 through early October. The background base flow starts at about 90 cfs near June 1 and declines to about 10 cfs near October 10. This is a 80 cfs change over 135 days or 0.6 cfs per day.

A set of equations was developed to numerically represent the agricultural water use-runoff data in Figure 1. First, a second order relationship was developed to approximate the agricultural runoff baseline flows. The equation was:

1. $af_i = 10D_i - 0.07D_i^2$

Where

D_i = day after May 31

af_i = cfs baseline flow for day D_i

The linear decline in the non-agricultural contribution to baseflow from June 1 to October 8 was evaluated by the following.

2. $AF_i = af_i - 0.6D_i$

Where

AF_i = cfs agricultural runoff for day D_i

0.6 = slope (cfs/day) of the linear decline in baseflow loss

The results of these calculations were used to estimate agricultural runoff and are given as the smooth curved line in Figure 1.

The fraction of total runoff occurring each day was calculated by:

3.

$$F_i = \frac{AF_i}{\sum_{i=1}^{135} AF_i}$$

Where

Fi = fraction of total runoff each day (no units)

The calculation for equation 3 was performed in a spreadsheet by calculating a column of daily values from equations 1 and 2 for each day from June 1 (I =1) to October 8 (I = 135) and summing the values for all days and then dividing the sum by the individual day's value. This daily fraction of total runoff was assumed to equal the daily fraction of summer water use pumped each day.

RESULTS

Groundwater Model Application

To use the daily water use model for the larger alluvial aquifer model, the daily fractions were summed by each month to provide a monthly fraction of total summer water use. The monthly fractions of water pumped is given in Table 1.

The acre feet of water to be pumped each month was calculated by multiplying the monthly fraction of water required by the total annual volume of water established to be pumped by each well. This was calculated for each well by:

4. $AFd_j = F_j * AAF$

Where

AAF	=	annual acre feet of water pumped by each well
F_j	=	fraction of total water pumped for each month j
Afd_j	=	acre feet pumped by each well for each month j

Corps Flood Stage Analysis Application

The acre feet of water to be imported each day was calculated by multiplying the daily fraction of water required by the total annual volume of water needed for different areas within the Sunflower River watershed.

5. $AFd_i = F_i * AAF$

Where

AAF	=	annual acre feet of surface water to import into a watershed
Afd_i	=	acre feet needed for a watershed for each day I

The daily water volumes in acre feet per day from equation 5 were converted to flows in cfs by:

6) $Q_i = 0.504AFd_i$

Where

Q_i	=	flow in cubic feet per second for day I

The constant 0.504 was derived by:

flow in af per day divided by 24 hours per day = flow in af per hour

flow in af per hour divided by 60 minutes per hour = flow in af per minute

flow in af per minute divided by 60 seconds per minute = flow in af per second

flow in af per second times 43,560 cubic feet per acre foot = flow in cfs

or

43,560 / (24 * 60 * 60) = 0.504 in units of cubic feet per acre foot per second per day

This method was used to calculate the daily flows for the major watersheds in the Sunflower River system. The results of watershed flow requirements are reported in Pennington and Stiles (1996).

REFERENCES

Stiles, Mark and Dean Pennington. 1996. Estimates of 1995 water use from the Mississippi River alluvial aquifer for each of 12,000 permitted wells. In Proceedings of the 26th Mississippi Water Resources Conference, April 2-3, 1996, edited by B. Jean Daniel, 18-25. Water Resources Research Institute: Mississippi State University.

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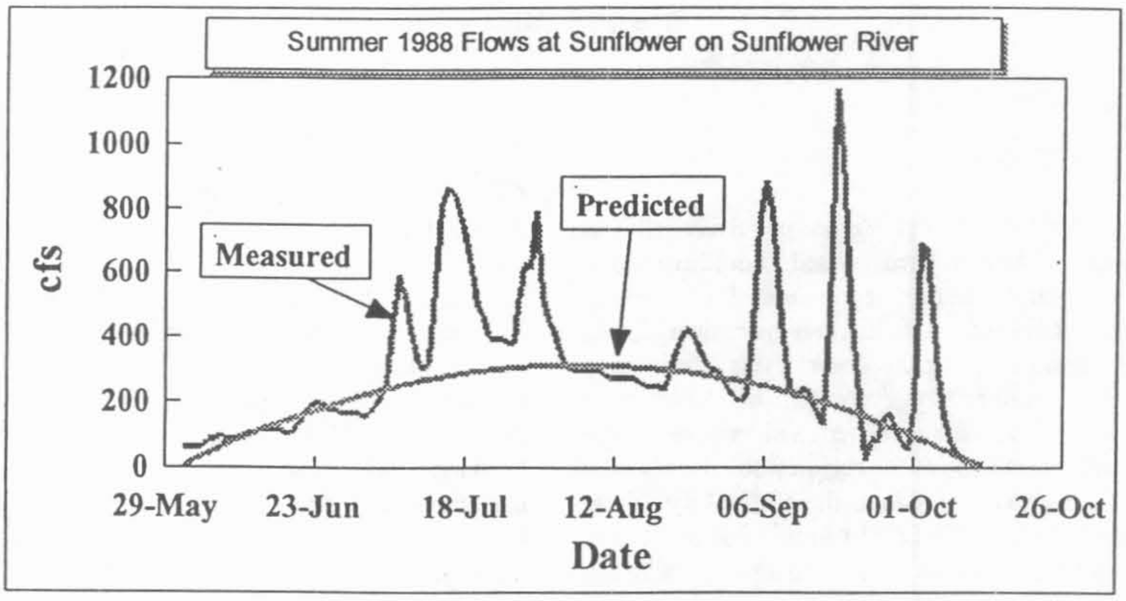

Figure 1. Discharges in Sunflower River for summer of 1988 at the town of Sunflower and the predicted runoff baseline.

Table 1. Monthly fractions of summer water use for Delta of Mississippi

Month	Monthly Fraction
June	0.15
July	0.32
August	0.33
September	0.19