

ACCOUNTING SYSTEM FOR WATER USE BY VEGETATION IN THE LOWER COLORADO RIVER VALLEY

LOWER COLORADO RIVER

The Colorado River is the principal source of water in the valley of the Colorado River between Hoover Dam and the international boundary with Mexico (fig. 1). Agricultural, domestic, municipal, industrial, hydroelectric-power generation, and recreation are the primary uses of river water in the valley. Most of the consumptive use of water from the river occurs downstream from Davis Dam, where water is diverted to irrigate crops along the river or is exported to interior regions of California and Arizona.

Most of the agricultural areas are on the alluvium of the flood plain; in a few areas, land on the alluvial terraces has been cultivated. River water is consumed mainly by vegetation (crops and phreatophytes) on the flood plain. Crops were grown on 70.3 percent of the vegetated area classified by using 1984 digital-image satellite data. Phreatophytes, natural vegetation that obtain water from the alluvial aquifer, covered the remaining vegetated areas on the uncultivated flood plain. Most of the water used for irrigation is diverted or pumped from the river. In some areas, water is pumped from wells completed in the alluvial aquifer, which is hydraulically connected to the river.

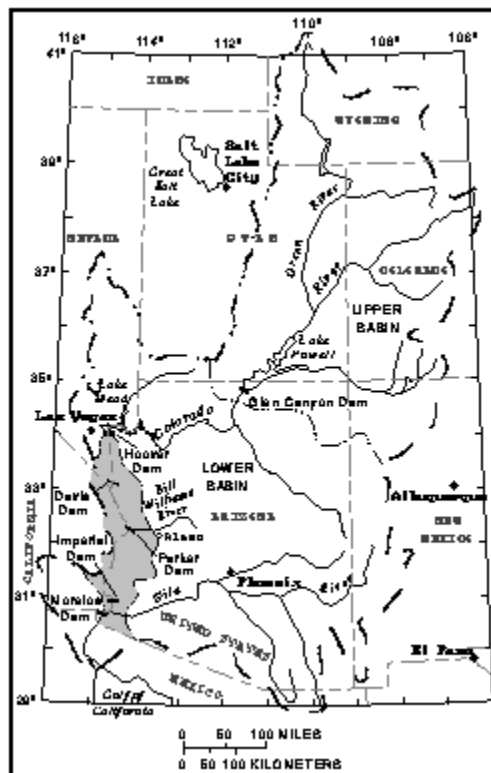


Figure 1. The Colorado River basin and area of the accounting system (shaded).

WHY ACCOUNT FOR CONSUMPTIVE USE?

Accounting for the use and distribution of water from the Colorado River is required by law. Water in the river has been apportioned among seven States and Mexico in accordance with documents and laws known collectively as "The Law of the River." The Colorado River Compact of 1922 and the U.S. Supreme Court Decree of 1964, *Arizona v. California*, hold the most significance for Arizona, California, and Nevada---the three States downstream from Hoover Dam. The Decree is specific about the responsibility of the Secretary of the Interior to provide complete, detailed, and accurate annual records of consumptive use of water diverted from the mainstream---stated separately as to each diverter from the mainstream, each point of diversion, and each of the States of Arizona, California, and Nevada.

LOWER COLORADO RIVER ACCOUNTING SYSTEM

The U.S. Geological Survey, in cooperation with the U.S. Bureau of Reclamation, developed the Lower Colorado River Accounting System (LCRAS) to estimate the annual consumptive use by vegetation of water from the lower Colorado River and to equitably distribute that use among water users between Hoover Dam and Mexico. LCRAS combines estimates of consumptive use by vegetation from a hydrologic water budget with data on vegetation types and distribution obtained from digital-image analysis of satellite data.

LCRAS is applied to the reach of the Colorado River between Hoover Dam and Morelos Dam to estimate consumptive use of river water by vegetation and to account for this use by point of diversion, diverter, and State to enable the Secretary of the Interior to meet the requirements of the Decree. Consumptive use by vegetation is apportioned to diverters by using the estimates of evapotranspiration (ET) by vegetation calculated for each diverter from the image-classification data and water-use rates. Estimates of ET are determined for each of four areas along the river; this breakdown by areas allows areal variations in weather to be considered in calculating water-use rates.

ESTIMATING CONSUMPTIVE USE BY VEGETATION

Consumptive use by vegetation is estimated as the residual in a water budget for the reach bounded by streamflow-gaging stations near Hoover and Morelos Dams. Components in the water budget include

- (1) inflow at the upstream boundary,
- (2) outflow at the downstream boundary,
- (3) change in storage in reservoirs along the budget reach,
- (4) quantity of water exported out of the study area,
- (5) consumptive use by vegetation,
- (6) evaporation from open-water surfaces,
- (7) precipitation,
- (8) surface- and subsurface-tributary inflow,
- (9) domestic, municipal, and industrial consumptive use,
- (10) surface-water flow diverted above Morelos Dam that returns to the river below Morelos Dam, and
- (11) change in storage in the alluvial aquifer.

The first five components make up more than 90 percent of the water accounted for in the budget; only consumptive use by vegetation is not measured directly. The last six components are estimated and each is commonly less than 1 percent of the inflow at the upstream boundary.

DISTRIBUTING CONSUMPTIVE USE BY VEGETATION

Water diverted from the river for exportation and for agricultural, domestic, municipal, and industrial use is allocated to users under the Decree. Computer processing of satellite data is an effective means of estimating ET by vegetation and apportioning this water use to agricultural users. Calculation of ET for individual vegetation types permits the separation of water use by crops from water use by phreatophytes. Total consumptive use by vegetation (estimated by using the water budget) is apportioned among the water users in proportion to the ET estimated for each user. Phreatophytes are considered water users and consumptive use by phreatophytes is listed separately by State.

CONSUMPTIVE USE IN 1984

For 1984, a year of high flow in the Colorado River, LCRAS estimated a total consumptive use of water from the river of about 7,129,100 acre-feet. The LCRAS accounting indicated that Arizona consumptively used about 18 percent of the total, California 67 percent, Nevada less than 1 percent, and phreatophytes and evaporation from open-water surfaces about 15 percent. About 4,283,200 acre-feet of the water was exported to California; 391,400 acrefeet was diverted to the Wellton-Mohawk area in Arizona; 1,362,600 acre-feet was used by agriculture on the flood plain of the Colorado River; 1,051,300 acre-feet was used by phreatophytes or evaporated from open-water surfaces along the river; and 40,600 acre-feet was consumed by domestic and municipal users in and adjacent to the flood plain.

EVALUATION OF THE ACCOUNTING SYSTEM

Assuming that satellite imagery continues to be available, LCRAS is an effective method of calculating and distributing consumptive use by vegetation among the users of water from the lower Colorado River. A few problems associated with the measurement or calculation of some of the components have been identified. Estimates of consumptive use by vegetation depend on the accuracy of the computations of flow in the river. Improvements in the reliability of estimated consumptive water use by vegetation depend on improvements in the computations of flow in the river and quantity of water exported. The calculation of ET by vegetation depends on (1) the correct identification from satellite imagery of the type of vegetation and the areal extent of each type of vegetation and (2) the calculated water-use rates for each type of vegetation. The most difficult and critical part of the calculation is establishing accurate water-use rates that account for both areal and temporal variability of use. The water-use rates for phreatophytes, for example, are not the same as the water-use rates for agricultural crops. The correct identification of the type of vegetation, especially where multiple crops are grown in the same field, is important because of this variation in water use by type.

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