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Hydrologic and Institutional Water Availability in the Brazos River Basin

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- Full Text

Statement of the Problem

Effective management of its surface water resources is essential to the continued growth and prosperity of the state of Texas. Rapid population and economic growth combined with depleting ground water reserves are resulting in ever-increasing demands being placed upon the surface water resources. The climate of the state is characterized by extremes of floods and droughts. Reservoirs are necessary to control and utilize the highly variable streamflow. Numerous reservoirs have been constructed to facilitate management of the water resources of the various river basins of the state. Effective control and utilization of the water resource supplied by a stream/reservoir system requires an understanding of the amount of water which can be provided under various conditions. Estimates of reservoir yield are a key element in practically all

studies and decisions involving development and management of surface water supplies.

Yield is defined as the amount of water which can be supplied by an unregulated stream, reservoir, or multiple reservoir system during a specified period of time. The stochastic nature of streamflow must be reflected in methods for quantifying yield. The approaches for expressing yield which traditionally have been used in water supply planning and management are firm yield and, to a lesser extent, reliability. Firm yield is the estimated maximum release or withdrawal rate which can be maintained continuously during a repetition of the hydrologic period-of-record. A number of definitions of reliability are cited in the technical literature. A common definition is that reliability is the percentage of time that a stream/reservoir system is able to meet a specified demand. Precise textbook definitions of firm yield and reliability can be formulated for a simple river basin with one reservoir and one water user. However, in actual practice, for a complex multiple reservoir, multiple user system, firm yield and reliability must be defined in terms of the basic assumptions and approaches used in handling various complicating factors.

Water supply planning and management involves complex institutional, environmental, hydrologic, and physical systems. Streamflow, reservoir sedimentation, evaporation, water demands, and other variables pertinent to yield determinations are highly stochastic. Measured historical data is limited in extent and accuracy. The future is always uncertain. Mathematical models only approximate the complexities of reality. Consequently, reservoir yield studies necessarily involve uncertainties and approximations.

The availability of water to particular users depends upon legal rights and contractual commitments as well as physical facilities and hydrologic conditions. Reservoir yield is subject to institutional as well as hydrologic constraints. Evaluation of the relationships between water rights and reservoir yield is particularly important at this time in Texas with the recent completion of the water rights adjudication process.

Scope of the Study

The objective of the study documented by this report was to evaluate and improve state-of-the-art capabilities for estimating reservoir yield. Institutional as well as hydrologic aspects of water availability were investigated. Evaluation of increases in yield achieved by multiple reservoir system operation, rather than separate operation of individual reservoirs, was a major emphasis of the study. The river basin was viewed as an integrated system.

The hydrologic and institutional availability of water was investigated for a case study reservoir system. However, the study approach and computer programs used are generally applicable to any reservoir system. Study findings have pertinent implications for water resources management throughout Texas and elsewhere as well as for the specific river basin studied.

Water availability is dependent upon institutional constraints and capabilities. The study included a review of water law and other institutional aspects of surface water management in Texas.

A literature review was made assessing modeling capabilities for estimating reservoir yield. The reservoir system simulation models HEC-3 and HEC-5 were adopted for use in the case study. These generalized computer programs provide comprehensive capabilities for analyzing the hydrologic aspects of reservoir system operations, but lack the capability to simulate water rights priorities. Consequently, a generalized water rights simulation computer program was developed in conjunction with the study. Other computer programs were used for developing input data and analyzing output from the HEC3, HEC-5, and water rights models.

A system of twelve reservoirs in the Brazos River Basin provided a case study. Nine multiple purpose flood control and conservation reservoirs are owned and operated by the Fort Worth District (FWD) of the U.S. Army Corps of Engineers (USACE). The

Brazos River Authority (BRA) has contracted for most of the water supply storage capacity of the nine federal projects. The BRA owns and operates three other conservation reservoirs. In addition to the 12-reservoir USACE/BRA system, Hubbard Creek Reservoir, owned by the West Central Texas Municipal Water District, was modeled in detail because of its relatively large storage capacity. The numerous other smaller reservoirs in the basin were considered primarily from the perspective of approximating their impacts on the 12 USACE/BRA reservoirs.

Individual reservoir and system firm yields were computed based on alternative conditions of reservoir sedimentation and alternative assumptions regarding multiple reservoir and multiple user interactions. The sensitivity of firm yield estimates to these and other factors was evaluated. A series of yield analyses were made from a strictly hydrologic perspective, without consideration of water rights. Yield analyses were then repeated incorporating water rights constraints. In addition to the firm yield simulations, a basinwide water rights analysis simulation study was performed. The simulations were based on monthly historical period-of-record hydrologic data. The modeling studies provided a basis for evaluating the hydrologic and institutional availability of water in the Brazos River Basin.

Organization of the Report

An overview of water law and institutions in Texas, from the perspective of surface water Management, is presented in Chapter 2. Surface water Management in the Brazos River Basin is described in Chapter 3. Chapter 4 is 8 discussion of reservoir system yield analysis models in general and the models used in the present study in particular. The Brazos River Basin simulation studies are documented by Chapters 5 through 9. Chapter 5 describes the compilation of basic data used in the study. A detailed hydrologic yield study is documented by Chapter 6. The analyses outlined in Chapter 6 were performed with HEC-3 and HEC-5 and are from a strictly hydrologic perspective, without consideration of water rights. The water rights analyses, utilizing the TAMU Water Rights Analysis Progra , are presented in Chapters 7 and 8. Chapter 7 discusses the

results of a simulation of hydrologic and water rights aspects of surface water management in the basin. Firm yields constrained by senior water rights are documented in Chapter 8. Chapter 9 provides a critical evaluation, including sensitivity analyses, of the key factors affecting firm yield estimates. The study summary and conclusions are presented as Chapter 10.

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