

# CHAPTER 1

## INTRODUCTION

“It has been well said that ‘water is the wealth of California.’ If it has been so in the past, it will be more so in the future.” *Report of the Board of Commissioners on the Irrigation of the San Joaquin, Tulare, and Sacramento Valleys of the State of California* (1873), Chapter III

The water problems of California are among the most diverse, difficult, and economically important in the nation. They always have been and perhaps they always will be so. California is the most populous, the second most urbanized, one of the fastest growing, the most agriculturally productive, and perhaps the most environmentally disturbed state. Combined with its generally semi-arid climate, California’s dynamic economy and society depend on its ability to manage water.

Growing demands for water and water-related infrastructure pose serious challenges for managing California’s water resource systems. California’s system managers are already struggling to meet increasing traditional demands while trying to devote more water and financial resources to rehabilitate and enhance environmental resources. Solutions to these problems will require substantial investments of capital and significant operational and managerial changes in the system.

This project takes an economic approach to managing and financing California’s future water supplies. This new approach combines analysis of water management and economic performance with a computer model. The computer model (CALVIN) represents California’s statewide water system, including its surface water and groundwater resources, storage and conveyance facilities, and agricultural, environmental, and urban water uses. The model suggests how to operate the system to maximize statewide economic returns from agricultural and urban water uses, given specific practical and policy limits.

Some uses of results from this economically-based modeling approach for long-term planning include:

- 1) Estimating regional and statewide economic benefits from new or enlarged storage and conveyance facilities;
- 2) Quantifying changes in economic and supply reliability from changes in system facilities and management;
- 3) Assessing the willingness to pay of different water users for specific new storage and conveyance facilities or changes in water management policies;
- 4) Exploring how system operations and economic performance might change with different forms of water transfer activity; and
- 5) Suggesting economically promising forms of coordination among regional water systems and promising forms of water transfers.

This report details this new approach and places it in the context of California's water supply problems and its structural, nonstructural, and institutional options. Examples of how the approach can be used are presented. Additional work also is outlined to take this approach beyond proof-of-concept and preliminary results. Early technical and policy conclusions are made.

## **ORIGINS OF THIS PROJECT**

The State of California Resources Agency funded an 18-month study starting in January 1998 to analyze finance options for California's future water supply. The study is entitled "Quantitative Analysis of Finance Options for California's Future Water Supply," or, the "Capitalization Project" for short. This work was undertaken by a team of University of California Davis economists and engineers.

Future California water supply costs are known to be large. Rudimentary calculations showed that with CALFED costs ranging between \$4 billion and \$16 billion and likely state and federal funding in the range of perhaps \$3 billion to \$8 billion, that there remained a substantial potential finance gap. This project began with an interest in the ability and willingness of the private sector to fund and perhaps own and operate major water facilities of statewide significance for California.

It was realized quickly that private sector involvement would require substantial revenues from any new private facilities. To realize such revenues, facility operators would have to charge for use of these facilities. Water users would ultimately pay such charges. How much could users be charged before seeking other supply or conservation alternatives? How reliable would revenues be to investors? Implicitly, there would be a market for new facility capacity, as well as a market for water to make use of new facilities. In this system, the use of new facilities would be substantially affected by the operation of existing facilities and environmental, legal, and contractual constraints on system operation. Quantitative estimates of economic value and reliability under these conditions require a more comprehensive view of the system than has previously been attempted.

With the support of the Advisory Committee, the project developed to have a broader interest in economic values of facility and management options for California's statewide water system. The following study approach has resulted.

## **STUDY APPROACH**

The study's approach includes the following tasks:

1. Review and summarize California's water problems and potential major infrastructure alternatives.
2. Identify and review the theoretical and practical approaches available for involving markets for improving California's water resource systems at local, regional, and state-wide scales.
3. Select several promising forms of market involvement for regional and state-wide water management.
4. Develop and apply regional and inter-regional water management and economic models to estimate the potential economic values and willingness-to-pay for a) new water sources and

new water storage and conveyance facilities and b) alternative water management policies. The bulk of this project was devoted to this task.

## MODELING APPROACH

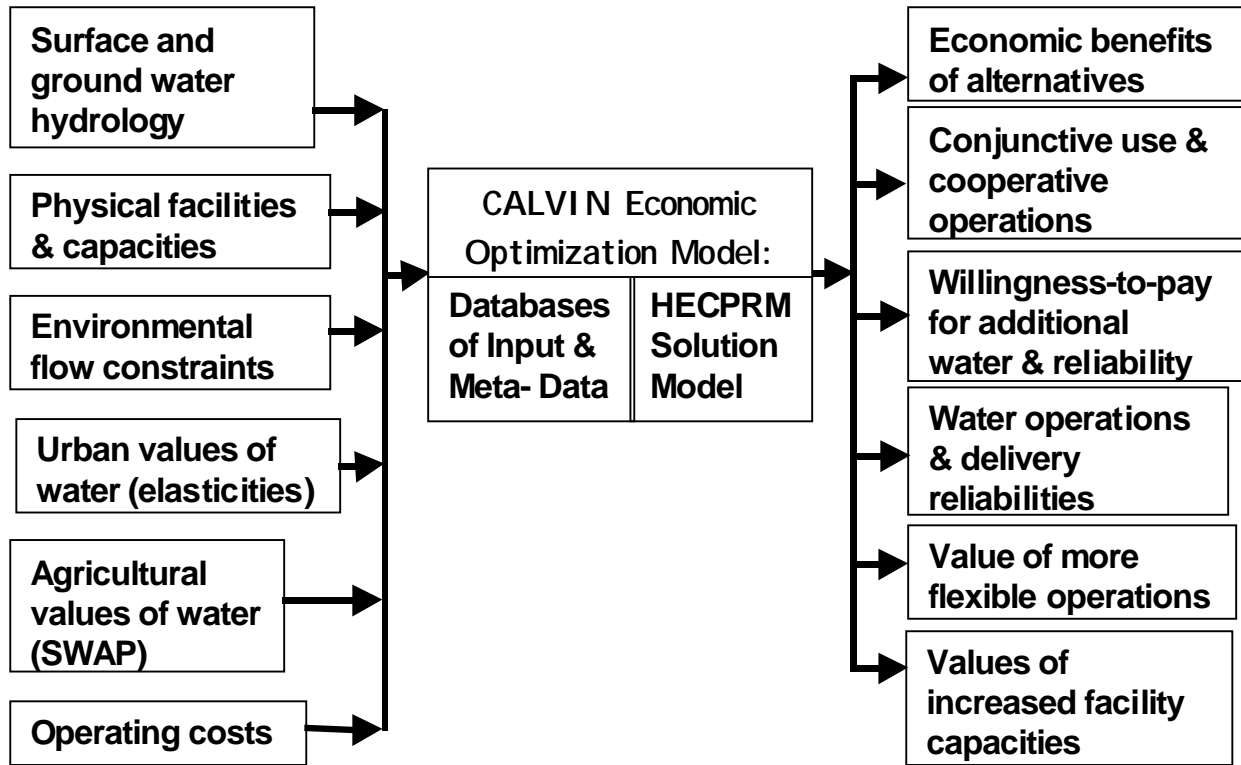
The modeling approach used here differs from that commonly used for operations planning in the Central Valley. Currently, operations models for the Central Valley are all *simulation* models which use operating rules to allocate water and operate reservoirs. This study uses an *economic optimization* modeling approach, with no operating rules or explicit water rights or contracts. Water is moved and stored only to maximize the total statewide economic benefits, limited only by physical, environmental, and policy constraints on flow and storage.

Over the planning horizon for new facilities, many changes can be made in water contracts and operating agreements. In particular, water transfers, markets, and wheeling are likely to become more common. Among the questions for this study is, “What is the economic value of more flexible and coordinated operation of California’s water system?” With additional policy constraints, operation of the system within historical operations and allocations can be examined.

This optimization modeling approach is intended to answer specific economic and management questions and point towards promising potential solutions that are unlikely to emerge from simulation modeling. It is important to realize that the economic optimization model does not replace simulation models. Optimization models usually require significant simplifications relative to simulation models. Simulation models are needed to conduct more detailed studies that test and refine planning and operating suggestions provided by optimization results. Together, these two types of models give an ability to look rigorously both at the big picture (optimization) and details (simulation). Our economic optimization model is called CALVIN (California Value Integrated Network). Values for agricultural water uses are estimated using a new model, SWAP (Statewide Water & Agricultural Production), that extends the approach of earlier CVPM models.

As illustrated in Figure 1-1, CALVIN consists of databases of model inputs and assumptions and a reservoir system optimization model. The databases store data to define a statewide network or schematic of California’s water infrastructure, including system capacities and hydrologic inflows and outflows. The databases also contain operating costs and the economic value of water use at each major agricultural and urban water use location. Lastly, these databases store management and operating policies as a series of constraints that include minimum environmental flows. These databases also include information on the origins of all input data, called metadata. The actual reservoir system optimization model is HEC-PRM (Hydrologic Engineering Center- Prescriptive Reservoir Model), a network flow optimization computer code developed by the US Army Corps of Engineers Hydrologic Engineering Center in Davis, CA. Developed specifically to examine the economic operation of large water resource systems, HEC-PRM has been applied to many systems by the US Army Corps of Engineers and the University of California, Davis.

**Figure 1-1. Data Flow for the CALVIN Model**



## ORGANIZATION OF THIS REPORT

The remainder of this report is organized as follows. Chapter 2 reviews the major water problems of statewide importance for California. Infrastructure and facility options for improving California’s water supply are presented in Chapter 3. Finance and operations options for California’s future water supplies are reviewed in Chapter 4. Chapter 5 summarizes some relevant legal issues. Chapter 6 reviews the modeling approach and describes the CALVIN model in some detail. Chapter 7 is an overview of how this modeling approach can be used to compare long-term management alternatives. Chapter 8 presents some early model results and how CALVIN model results can be used to answer economic and financial questions regarding long-term water planning and management. Chapter 9 presents some technical lessons, accomplishments, and future direction for this work. Finally, Chapter 10 provides some policy conclusions.

The main body of this report is supplemented by detailed appendices documenting the development of model inputs. These include the major economic modeling efforts for valuing agricultural and urban water use throughout the state, the system schematic, cost and capacity estimates, surface and ground water hydrology, and data management. Software and database components to these appendices are gathered in electronic form and provide a complete inventory and description of the methods and data used in this work. In principle, the results are replicable given the data, software, and method documentation provided (although not without some effort).