Future Quantitative Analysis for California Water Planning

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Introduction

Past California water plan updates were intended for water managers and those involved in making state water infrastructure decisions. However, resource issues have become more interconnected, and land use and resource planners increasingly consider water management in their analyses and decisions. Requests are increasing for the water plan to address questions that go beyond a gap analysis of water use and supply. This article describes the short-term and long-term activities being pursued by the State Department of Water Resources to improve analysis performed for the water plan.

Analytical tool and data development for California water has not kept pace with the growing public awareness of the complexity and interaction between water-related issues. A critical issue facing California is the need for better data and tools to produce useful information about environmental objectives, water quality, economic performance, social equity objectives, and groundwater and surface water interaction. Also, there is a need to integrate more effectively details associated with regional and local planning into the studies being conducted from a statewide perspective. For planning purposes, these tools and data must help planners predict a range of plausible future conditions and interactions on the statewide level and compare outcomes of potential management actions. Many of the current tools have been developed and applied in a comparative role, and their suitability for a predictive role can vary widely. Even so, planners rely on the state to provide data and information that help to describe and analyze plausible future scenarios, which they can use for planning purposes.

State government must play a leadership role in developing the overall strategy for California water management from a systemwide perspective. No tools currently exist that can be used for both predictive and comparative studies integrating all of the interactions described above. Local land use planners also rely on water management information for which the State can provide insights. Work on the water plan is being coordinated with the CALFED Storage Investigation's Common Assumptions and Water Use Efficiency Comprehensive Analysis studies. Staff from these planning processes have been meeting to coordinate information and discuss study assumptions and quantitative methodologies.

DWR initiated the Analytical Tools and Data Work Group (formerly known as the Modeling Work Group), which consists of advisory committee members, stakeholders interested in modeling, technical consultants for other planning processes, and staff from the California Bay Delta Authority and DWR. Since 2001 this work group has met more than 16 times to discuss the roles, validation, and confidence in available tools and data and the ability to perform studies and analyses for Update 2005. To address concerns, a series of workshops were convened that focused on the fundamental questions the water plan should address in general and the technical information that the tools are expected to provide in particular. Future work with our stakeholders will consider these issues including quality assurance, transparency, accessibility of information, external review processes, and integrating issues like water quality, economics, the environment, groundwater, and land use.

The work outlined in this article aims to improve the quantitative understanding of California water and of how to employ analytical tools to aid in developing and comparing solutions to California's water problems and decision-making. The work proposed here for data and tools is consistent with the three-phased approach for producing California Water Plan Update 2005, outlined in Chapter 1, Volume 1. The work on tools and data in the three-phased approach includes:

- Phase 1: Recommend the short- and long-term work as described in this article.
- Phase 2: Select appropriate analytical tools, data, and assumptions to provide technical analyses.
- Phase 3: Apply the analytical tools selected in Phase 2 and interpret results to evaluate performance of several response strategies on a regional basis given three or four plausible future scenarios. Scenarios represent future base or no-action conditions water managers could face that are beyond their control, like population growth and land use changes.

Technical Information Needs

The desire to address various crosscutting issues such as environmental objectives, land-use planning, and economics in different scenarios in this water plan and other ongoing planning efforts requires more technical and quantitative information than for previous water plans. Many discussions with the Analytical Tools and Data Work Group and the Advisory committee have focused on the specific information needed to satisfy the broad objectives of the water plan's new planning framework (see Chapter 1, Volume 1) and disclosure of all technical assumptions.

In addition to developing the new planning framework, the advisory committee and DWR invited land use and resource planners, academics, policy analysts, and technical experts to build on and affirm advisory committee understanding about issues critical for the water plan to address. These conversations have been captured in mind maps that represent a web of relationships and ideas. The mind maps are in the Technical Guide (Volume 5). In addition to traditional information needs related to evaluating water supply and demand, water plan users seek good information related to ecosystem wants and demands; economic relationships, such as the effect of tiered water pricing on demand or economic effects of transfers; water quality, such as reusing wastewater and matching water quality to use; social equity issues, such as public trust and environmental justice concerns; water use efficiency; and groundwater and surface water interaction. Further, the water plan could play a critical role linking water and land use management decisions. Land use planners need useful information about water demand as it relates to compact development and growth.

Planned Analyses

For Update 2005 and the next update the phased work plan includes three groups of analyses:

1. ***Water Portfolios*** that describe the available water sources, movement and uses by region, under several recent hydrologic conditions using actual data (1998, 2000, and 2001 in Update 2005, 1999, 2002, and 2003 in the next update). The portfolios present historic observable data and some of the causal relationships between sources and uses of water as it moves in California.
2. ***Future Scenarios*** that describe plausible base conditions of water use and water supply throughout California in 2030. The scenarios are intended to provide quantitative estimates of future water conditions based on existing observable data and defined causal relationships.

3. ***Alternative Response Packages*** of water resource management strategies that are designed to improve performance of the water management system with regards to system objectives. The expected system performance with each alternative response package in place will be analyzed under each plausible future scenario. The performance of each alternative response package will be compared using quantitative evaluation criteria. A list of evaluation criteria is shown in Table 4-5, Chapter 4 of Volume 1.

Water Portfolios

The water portfolios provide comprehensive water balance and flow diagrams for 10 hydrologic regions covering the entire state. The flow diagram characterizes the hydrologic cycle and documents sources of water, such as precipitation and inflows into the state, and tracks the water as it flows through many different uses to its ultimate destination. Since data for some categories are not measured for many regions of the state, the current water portfolios show gaps. Identifying additional data collection and management activities in Update 2005 is an important step in improving the water portfolios for future water plan updates.

There are a number of categories in the flow diagram where data are simply not available or very resource intensive to compile. Significant data gaps include:

- statewide land use data, including native vegetation, urban footprints, non-irrigated agriculture, and irrigated agriculture
- total groundwater natural recharge
- groundwater subsurface inflow and outflow
- groundwater extractions and recharge
- evaporation from land surfaces
- evapotranspiration from native vegetation and non-irrigated agriculture
- total stream flow
- total direct diversions
- natural and incidental runoff
- return flows
- conveyance losses

There are a number of data items necessary to calculate or estimate these categories. Some of the major data items needed to complete the flow diagram and water balances consist of more detailed and accessible land and water use information including information to separate applied water use versus consumptive water use. The major data items are:

- water source of supply information
- outflow data
- groundwater level data
- groundwater recharge rates
- natural riparian water requirements
- evapotranspiration rates for all types of vegetation
- detailed return flow information
- more detailed physical information about all watersheds, water systems, and groundwater basins in the state

Data are currently available only for some regions. For example, methodologies and data to estimate natural runoff are available for regions like the Sacramento River and the San Francisco Bay Region where the Delta is a control point. But in areas like the South Coast Region with no control point and substantial groundwater, the natural runoff is nearly impossible to estimate. In addition to natural obstacles, existing data are not easily aggregated or disaggregated to provide convenient access for all areas of interest, and resource constraints limit extensive data collection and management necessary to quantify and track all the water in the state.

State government should guide California in expanding data collection and management programs that already exist. Data needs are characterized by the need for detail (data monitoring in more geographic locations and for particular categories), to digitize (common electronic methods), and for a comprehensive database.

Future Scenarios

Developing quantitative estimates for several future scenarios requires using available data and presumed relationships. A list of key factors affecting future use and supply scenarios in 2030 is shown in Table 4-1 in Chapter 4 of Volume 1. Some examples of these factors include total population, population density, land use, and energy costs. Each of these factors must be predicted or quantified, and like the data needed for the water portfolios, the availability and resolution of data needed for the future scenarios varies widely. While the key factors have been identified, much work still exists to reach agreement on the relationships between the factors and the methods that will be used to quantify the factors as described in Table 4-1. The preliminary scenarios presented in Chapter 4 illustrate how this can be done, but the details for future scenarios will be revisited during the next update. Some examples of the significant complexities in predicting factors such as groundwater storage or surface water storage conditions in 2030 are shown in the Factor Complexity Diagrams in the Technical Guide.

Some of the challenges and possible approaches for forecasting urban water demand are presented in a July 2003 report titled "Water Demand Forecast Methodology for California Planning Areas: Work Plan and Model Review". (See Technical Guide.) The authors of the report offer recommendations for:

- near-term analyses given available data, and
- future development for long-term analyses.

The recommendations for future development identify additional data needs such as:

- water and sewer rate data for the utilities and time frames for data contained in DWR's Public Water Supply Survey database
- correlate local and regional demographic information with per unit water use rates by area
- correlate climate conditions with per unit use rates over time

This new information will allow DWR to update their statistical explanatory demand models by region based on some of these key factors. DWR will have to examine other factors and determine the best way to quantify those factors. DWR expects that other data gaps will emerge leading to better understanding of the type of data collection and analysis needed to support the new planning framework.

Alternative Response Packages

A significant difference in the new water plan framework will be the addition of quantitative comparisons for alternative response packages of water resource management strategies, which are are described in Volume 2. This performance comparison of various mixes of water management strategies under plausible future scenarios will provide planners unprecedented access to relevant technical information and new insights. This quantitative insight can be used to help guide investments in statewide water management actions. To help focus the quantitative analyses, a list of evaluation criteria have been identified with the advisory committee and Analytical Tools and Data Work Group that represents the technical information required to compare the response packages. A full list of the evaluation criteria are included in the Technical Guide. These evaluation criteria include information such as:

- percent of years agriculture receives all of its desired water supply
- economic benefits or losses
- statistical water supply reliability by location
- regional imports and exports
- water quality
- instream flows

While this information is expected to be extremely valuable, developing the capability to complete these performance comparisons presents a significant challenge for DWR over the next several years. Conducting quantitative performance comparisons that water managers, decision-makers, and the public want will require considerable staff, time, and money to develop and implement.

Analytical Tools

Generating quantitative estimates for most of the information contained in the water portfolios, future scenarios, and comparing performance of strategies requires the use of one or more analytical tools. The term analytical tool is defined to mean something used to study or determine the nature and relationship of the component parts of a whole. Given the broad range and scale of quantitative information desired, many analytical tools will be needed. No single analytical tool could be developed to provide all of the desired information, but rather a hierarchy of tools must be employed.

The role of an analytical tool and the method for using it varies significantly depending on the specifics of the information being generated. Given the desire to promote understanding and transparency of analysis, the update team will apply a systematic method to identify potential analytical tools, determine their proper use, and validate their application to generate all of the quantitative information needed for the water plan.

Initially, this effort will focus heavily on the need, availability, and adequacy of technical tools to perform the integrated analyses. Given the high degree of interest expressed by several members of the advisory committee and the Analytical Tools and Data Work Group, DWR proposes a systematic, step-by-step approach to develop acceptable methods to complete the quantitative analyses for both the short-term – the next update – and long-term efforts -- 10-15 years. This step-by-step approach is outlined below, and will require extensive participation from the Analytical Tools and Data Work Group.

Once the methods have been defined and agreed upon, DWR will need to set up and conduct the analytical studies, perform quality control reviews of study results, and interpret and communicate the meanings of the analytical tool outputs.

Framework to Assess an Analytical Tool

Evaluating the appropriateness of an analytical tool to produce quantitative estimates can be extremely complicated. To help make the process as effective and transparent as possible, the team will apply the following framework, described using a series of questions, for each item on the comprehensive list of technical information needs.

- What is the job at hand?
  - Describe by task if needed, highlighting the quantitative results that would assist in accomplishing the task.
- If the ideal tool to assist with the task were available, what capabilities would it have?
- Which tools are available that could produce the desired quantitative results?
- Which tool or tools represents the best fit for the specific information desired?
  - Evaluate the potential tools according to the desired capabilities.
  - Consider limitations.
  - Consider practical ability to improve each tool.
- What are the remaining limitations of the selected tool likely to be?

This process can be improved by using common, objective evaluation criteria to the extent possible for each piece of technical information being generated. The criteria used to answer the question "Which tool or tools currently represent the best fit?" will be discussed and documented before making any judgments about the suitability of the analytical tools in question.

Parts of an Analytical Tool

To understand the capabilities of an analytical tool, or to assess the validity of using an analytical tool for a specific purpose, it is helpful to consider the tool in terms of its parts:

- Conceptual model: a description or analogy used to visualize something that cannot be observed directly, such as a road map of a large area.
- Theoretical model: a system of postulates, data, and inferences presented as a description of an entity or state of affairs, such as the law of gravity.
- Numerical model: an analytical tool that employs quantitative approximations to the solutions of mathematical problems.
- Data
- Data management system
- Software
- Administrative aspects: intellectual property (proprietary vs. public domain), user support, expertise available in community to use or improve model, etc.

Describing an analytical tool using these categories promotes more precise discussions regarding the capabilities and appropriate use of analytical tools.

Information Management System

The quantitative elements of the water plan require tremendous amounts of data and information. As such, effective management of this information is a key component to the long-term success of the technical efforts. Currently available information management system technologies could be used to provide efficient, secure, and transparent access to this critical component of the ongoing state wide planning efforts.

However, the technology alone is not sufficient. A necessary part of a successful information management system is an intelligent information management framework and scheme. Ideas for a viable information management framework can be developed as the needed data, relationships, and estimates for the quantitative analyses are further described.

Resources Needed

DWR is committed to leading the way in developing the methods, analytical tools, and conducting the analyses to provide the information California needs in a transparent and responsive manner. Generating and interpreting the quantitative information described above will require persistent dedication of significant resources. The technical scope and magnitude of the desired analyses is unprecedented in California water planning. While several parts of the desired analyses have been done before, no previous quantitative study has ever been conducted so comprehensively and with such intensive stakeholder interaction. Needless to say, a team of technical experts with diverse skills will need to be engaged over a significant period of time. Technical experts will be needed who can understand the complex interaction between policy-making and technical analyses, organize technical information needs, identify and qualify subject-matter data, manage extensive data, interface with diverse stakeholders and programs like the California Bay Delta Authority, and demonstrate leadership to inspire confidence and credibility within policy and technical communities.

Major Tasks and Schedule

The following tasks and associated schedule outline the major steps DWR plans to take to provide the desired technical information in a timely manner. As shown in the schedule, DWR plans to perform these activities with frequent and detailed interactions with interested parties through the Analytical Tools and Data Work Group. This framework requires that DWR receive assistance from others to complete the tasks. The rate of progress will depend on available resources and the level of cooperative and active participation by other agencies and institutions. This systematic approach will allow DWR and others to address concerns raised about validity of existing tools and questions raised about the appropriateness of quantitative methods used for previous technical studies.

1. Generate a priority list of quantitative information needed to provide results for the evaluation criteria
2. Propose a conceptual model or models for each evaluation criteria, such as urban water supply reliability, detailing the observable data and causal relationships as they relate to:
    a. Water portfolios
    b. Future scenarios for 2030
    c. Alternative response packages

    These conceptual models will be developed sequentially by focusing on one evaluation criterion at a time. This effort will take advantage of the current scientific information available for each topic.

3. Distribute documents containing the proposed conceptual models to the Analytical Tools and Data Work Group (and other recognized experts according to the topic being discussed) and conduct workshops to revise and adopt preferred conceptual models that will be used to compute results for each evaluation criteria.
4. Once conceptual models are adopted, propose a theoretical model for each piece of required quantitative information including: postulates, data, and inferences.
5. Distribute documents containing the proposed theoretical models to the Analytical Tools and Data Work Group and conduct workshops to adopt preferred theoretical models used to compute each piece of quantitative information.
6. Establish, to the extent possible, objective criteria for evaluating the suitability of potential analytical tools for generating each piece of desired quantitative information.
7. Compare preferred theoretical models with those implemented in currently available analytical tools.
    a. Review existing analytical tools to determine if they incorporate some or all of the preferred theoretical models.
    b. As needed, determine if existing analytical tools can be modified for short-term use
8. Modify tools as needed and as possible for short-term use.
    a. Make changes to existing analytical tools to better incorporate preferred theoretical model implementation that can be accomplished by the end of 2006.
    b. Acknowledge and document where existing tools and data that will be used for the next Water Plan update fall short of the desired theoretical implementation and cannot be suitably modified by end of 2006.
    c. Prepare a document that describes how analyses for the next Water Plan update will be implemented in the short-term.
9. Develop a document that outlines requirements for new analytical tools and data to perform the preferred quantitative analyses for future updates in cooperation with the California Water and Environment Modeling Forum long-term strategic framework.
    a. Describe likely approach to obtain or develop tools that can fulfill the requirements.
    b. Develop a schedule for development and testing.
    c. Develop budget for development and testing.
10. Apply existing analytical tools to quantify all required quantitative information about future conditions for next Water Plan update by the end of 2008.
    a. Future scenarios
    b. Alternative response packages
11. Interpret and describe quantitative results for
    a. Future scenarios
    b. Alternative response packages

The Next Water Plan Update and Beyond

The tasks described above are focused towards identifying and developing trusted and acceptable quantitative methods over the next three years that can be applied as completely as possible in the short-term for the next Water Plan update, and as close to the preferred methods as possible for updates beyond the next one. As these requirements, data gaps, and preferred conceptual and theoretical models are adopted, DWR will also identify the requirements for a viable information management system. Given the magnitude and complexity of information, and the desire to coordinate and share this information at various levels of detail throughout the state, DWR likely will need to implement an enterprise-level information management system accessible via the World Wide Web.

Furthermore, as progress is made in developing better, more comprehensive data and analytical tools to analyze the water movement and interactions, DWR intends to foster development of decision support tools that increase planners' ability to fully utilize the new and improved technical information being provided in future updates.