State of California
The Resources Agency
Department of Water Resources

The State Water Project Delivery Reliability Report 2005

Public Review Draft

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Foreword

The Department of Water Resources (DWR) is issuing this report to update information presented in the *State Water Project Delivery Reliability Report – 2002*, which was finalized in 2003 after an extensive public review. DWR will update this information every two years or more frequently if new information significantly affecting the assessments warrants an earlier update.

The 2002 report was the first of this biennial series. It was welcomed by SWP contractors as the source of delivery estimates of their SWP supply that could be incorporated into their, or their sub-agencies', water supply plans. The information contained in this update was recommended by DWR in May 2005 for use by SWP contractors in developing their 2005 Urban Water Management Plans.

The information contained in the 2002 report and this update is based upon a computer simulation model, CalSim II. DWR believes CalSim II is the best available method for this assessment. Public criticism of the model has centered upon the ability of the model to simulate "real world" conditions and accurately estimate SWP deliveries. Following up on commitments in the 2002 report, DWR has completed an assessment of how well the model simulates a recent historical period and conducted a sensitivity analysis investigating the relative effect of assumptions used for input data upon the results of the simulation. The simulation of the historical period corresponds very well with the actual data. The sensitivity study and a study on the significance of the calculation interval (monthly) provide useful information in identifying areas important to CalSim II results. These studies are discussed in Chapter 3.

In addition, a peer review sponsored by the CALFED Science Program was conducted in 2003 to evaluate the strengths and weaknesses of CalSim II. The panel concluded the model is comparable to other state-of-the-art models and, specific to the type of information contained in this report, recommended calibration and verification of the model, as well as analyses of the sensitivity and uncertainty associated with the studies. The studies mentioned above and discussed in Chapter 3 address some of these concerns. DWR, with the support of U.C. Davis, is planning to develop a strategy for identifying and reducing the major sources of uncertainty in CalSim II studies and a procedure for quantifying the uncertainties. This effort should begin in 2006.

The next version of CalSim, CalSim III, is planned to be completed by early 2007. This version will include improvements in the land-use-based water budget calculations, which include refinements in the water budget boundaries, agricultural water use efficiencies, modeling wildlife refuges, and modeling the surface water-groundwater interaction. A new and improved graphical user interface will also be developed as part of this effort.

The updated SWP delivery estimates are summarized in Chapter 5. Chapter 6 contains examples of how to incorporate this information into a local water supply assessment. These examples are based upon examples contained in the *Draft Guidelines for Documentation and Integration of SWP Supplies*, which will soon be released by DWR for public review. These draft guidelines are designed to assist SWP urban contractors in estimating the amount of SWP supplies available to them and in integrating the SWP supply information with supply information from other sources to develop an overall assessment of each contractor's total water portfolio.

The release of the *Draft SWP Delivery Reliability Report – 2005* continues public involvement in this important topic and the evolution of the assessment tools. For additional information or questions about this report, please contact DWR's Bay-Delta Office at (916) 653-1099.

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Chapter 1.
Introduction

Will there be enough water? Public officials throughout California face this question with increasing frequency as growth and competing uses strain existing resources. Water supply, however, has always been an uncertain and contentious matter in our state. For many years, the Department of Water Resources (DWR) has investigated this question. At its simplest level, the question might be, “How many wells are needed for a rural town’s water supply?” or “How many people can a 100,000 acre-foot reservoir serve?” But for most areas of the state, the evaluation of water supply adequacy is not simple. The answer requires a complex analysis, taking into account multiple sources of water, a range of water demands, the timing of water uses, hydrology, available facilities, regulatory restraints, levels of demand management (water conservation) strategies, and, of course, future weather patterns.

Most water users in California live in areas that rely on multiple sources of water supply, some local and some imported. Typically, local water providers “mix and match” their supply sources to maximize water supply and quality and to minimize cost. In addition to considering available sources of supply, local water providers are planning for ways to improve the efficiency of local water uses and the operation of their water management systems. To help with this effort, DWR presents 25 different resource management strategies available to local agencies and governments and private utilities in the *California Water Plan Update 2005* (see website at http://www.waterplan.water.ca.gov).

Purpose

The State Water Project Delivery Reliability Report 2005 presents DWR’s current information regarding the annual water delivery reliability of the State Water Project (SWP) for existing and future levels of development in the water source areas, assuming historical patterns of precipitation. This report first looks at the general subject of water delivery reliability and then discusses how DWR determines delivery reliability for the SWP. A discussion of the analysis tool, the CalSim II computer simulation model, and the analyses and peer review regarding the accuracy of CalSim II and its suitability for use in this report is included. Finally, estimates of SWP delivery reliability today and in the future are provided along with examples of how to incorporate this information into local water management plans.

This delivery reliability report also responds to public comments on how DWR administers the SWP. Comments on the Monterey Amendment Environmental Impact Report stated that local planners and public officials were relying on inflated estimates of water supply from the SWP in approving new development. This report provides local officials with a single source of the most current data available on SWP delivery reliability for use in local planning decisions.

The report does not, however, analyze how specific local water agencies integrate SWP water into their water supply equation. That topic requires extensive information about local facilities, local water resources, and local water use, which is beyond the scope of this report. Moreover, such an analysis would require decisions about water supply and use that traditionally have been made at the local level. DWR believes that local officials should continue to fill this role. The examples provided in Chapter 6 are included to help local agencies incorporate the information presented in this report into local water management assessments.

Background

The original *SWP Delivery Reliability Report* was issued as a draft in August 2002. In 2002, DWR held six public meetings throughout the state to discuss the report and receive comments upon the content. The final *SWP Delivery Reliability Report* was released in early 2003. The 2005 SWP Delivery Reliability Report is an update to the report issued in 2003. DWR intends to publish biennial update of the *SWP Delivery Reliability Report* in the future.

The SWP supplies two-thirds of the state's population with a portion of its water supply and provides water to irrigate, in part, 750,000 acres of agriculture. The SWP delivers water under long-term contracts to 29 public water agencies throughout the state. They, in turn, either deliver water to water wholesalers or retailers or deliver it directly to agricultural and urban water users.

The water delivery reliability of the SWP is of direct interest to those who use SWP supplies because it is an important element in the overall water supply in those areas. Local supply reliability is of key importance to local planners and local government officials who are responsible for planning for future growth while assuring that an adequate and affordable water supply is available for the existing population and businesses. This function is usually conducted in the course of preparing a water management plan such as the Urban Water Management Plans required by Water Code section 10610. The information in this report may be used by local agencies in preparing or amending their water management plans and identifying the new facilities or programs that may be necessary to meet future water demands.

Local agencies and governments and private utilities will also find in this report information that is useful in conducting analyses mandated by legislation authored by Senator Sheila Kuehl (SB 221) and Senator Jim Costa (SB 610). These laws require water retailers to demonstrate whether their water supplies are sufficient for certain proposed subdivisions and development projects subject to the California Environmental Quality Act.

DWR published the *Guidebook for Implementation of Senate Bill 610 and Senate Bill 221 of 2001*, which includes suggestions on how local water suppliers can integrate supplies from various sources such as the SWP into their analyses. DWR has also published the *Guidebook to Assist Water Suppliers in the Preparation of a 2005 Urban Water Management Plan*, which includes suggestions on how local water suppliers can integrate supplies from other sources such as the SWP in their analyses. Both documents can be found on the DWR's Office of Water Use Efficiency home page at http://www.owue.water.ca.gov.

DWR will also soon publish *Guidelines for Documentation and Integration of SWP Supplies* to assist SWP urban contractors in determining the amount of SWP supplies available to them. These guidelines, using the information in this report (*SWP Delivery Reliability Report 2005)*, explain how to integrate the SWP supply information with supply information from other sources to develop an overall reliability assessment of each contractor's total water portfolio.

Senate Bill 221

This law amends Section 11010 of the Business and Professions Code and Section 65867.5 of the Government Code. It also adds Sections 66455.3 and 66473.7 to the Government Code.

Under the Subdivision Map Act, a legislative body of a city or county is required to deny approval of a tentative map, or a parcel map for which a tentative map is not required, if it makes any of a number of findings. Under the Planning and Zoning Law, a city, county, or city and county may not approve a development agreement unless the legislative body finds that the agreement is consistent with the general plan and any applicable specific plan. [SB 221 prohibits] approval of a tentative map, or a parcel map for which a tentative map was not required, or a development agreement for a subdivision of property of more than 500 dwelling units, except as specified, including the design of the subdivision or the type of improvement, unless the legislative body of a city or county or the designated advisory agency provides written verification from the applicable public water system that a sufficient water supply is available or, in addition, a specified finding is made by the local agency that sufficient water supplies are, or will be, available prior to completion of the project.

(From Legislative Counsel's Digest of Senate Bill No. 221, 2001-2002 session, filed with Secretary of State Oct. 9, 2001, Chapter 642:88-89)

An exception is made for the County of San Diego if the Governor's Office of Planning and Research determines certain conditions are met.

Senate Bill 610

Senate Bill 610 This law amends Section 21151.9 of the Public Resources Code, and Sections 10631, 10656, 10910, 10911, 10912, and 10915 of the Water Code. It also repeals Section 10913 and adds and expires Section 10657 of the Water Code.

This [law requires] additional information be included as part of an urban water management plan if groundwater is identified as a source of water available to the supplier. [It] requires an urban water supplier to include in the plan a description of all water supply projects and programs that may be undertaken to meet total projected water use. [It prohibits] an urban water supplier that fails to prepare or submit the plan to the [California Department of Water Resources] from receiving funding made available from specified bond acts until the plan is submitted. The law, until January 1, 2006, requires the department to take into consideration whether the urban water supplier has submitted an updated plan, as specified, in determining eligibility for funds made available pursuant to any program administered by the department.

[In addition, the law] requires a city or county that determines a project is subject to the California Environmental Quality Act to identify any public water system that may supply water for the project and to request those public water systems to prepare a specified water supply assessment, except as otherwise specified. [It requires] the assessment include, among other information, an identification of existing water supply entitlements, water rights, or water service contracts relevant to the identified water supply for the proposed project and water received in prior years pursuant to those entitlements, rights, and contracts. The [law requires] the city or county, if it is not able to identify any public water system that may supply water for the project, to prepare the water supply assessment after a prescribed consultation.

The [law prescribes] a timeframe within which a public water system is required to submit the assessment to the city or county and would authorize the city or county to seek a writ of mandamus to compel the public water system to comply with requirements relating to the submission of the assessment.

[It requires] the public water system, or the city or county, as applicable, if that entity concludes that water supplies are, or will be, insufficient, to submit the plans for acquiring additional water supplies. [It also requires] the city or county to include the water supply assessment and certain other information in any environmental document prepared for the project pursuant to the act.

(From Legislative Counsel's Digest of Senate Bill No. 610, 2001-2002 session, filed with Secretary of State Oct. 9, 2001, Chapter 643:94-95.)

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Chapter 2.
Delivery Reliability in General

What is Water Delivery Reliability?

"Water delivery reliability" means how much one can count on a certain amount of water being delivered to a specific place at a specific time.

Objectively, water delivery reliability indicates a particular amount of water that can be delivered with a certain numeric frequency. A delivery reliability analysis assesses such things as facilities, system operation, water demand, and weather projections.

Subjectively, water delivery reliability indicates an acceptable or desirable level of dependability of water deliveries to the people receiving the water. Usually, a local water agency in coordination with the public it serves determines the acceptable level of reliability and plans for new facilities, demand-management and conservation programs, or additional water supply sources to meet or maintain this level.

What Factors Determine Water Delivery Reliability?

In its simplest terms, water delivery reliability depends on three general factors:

1) Availability of water from the source (that is, the natural source or sources of the water from which the supplier draws—the particular watercourse or groundwater basin). Availability of water from the source depends on the amount and timing of precipitation and runoff, or "hydrology," which provides water to the stream or groundwater basin, and the anticipated patterns of use and consumption of this water within the source area, including water returned to the source after use.

2) Availability of means of conveyance (that is, the means for conveying the water from the source via pumps, diversion works, reservoirs, canals, etc. to its point of delivery). The ability to convey water from the source depends on the existence and physical capacity of the diversion, storage, and conveyance facilities and also on contractual, statutory, and regulatory limitations on the operation of the facilities.

3) The level and pattern of water demand in the delivery service area (destination). The level of water demand in the delivery service area is affected by the magnitude and types of water demands, level of water conservation strategies, local weather patterns, water costs, and other factors. Supply from a water system may be sufficiently reliable at a low level of demand but may become less reliable as the demand increases. In other cases under increased demand, the water supply system may be able to deliver more water than in the past and maintain its reliability because the system's facilities had not been fully utilized.

How is Water Delivery Reliability Determined?

Water Delivery Reliability is Defined for a Specific Point in Time

For this report, water delivery reliability is analyzed for 2005 conditions and for conditions projected to exist 20 years in the future (2025). These analyses must describe current conditions adequately and make predictions about the three factors described earlier and discussed here.

The Availability of Water at the Source

This factor depends on how much rain and snow there will be in any given year and what the level of development (that is, the use of water) will be in the source areas. No model or analytical tool can predict the actual, natural water supplies for any year or years in the future. Until we are able to better quantify the impacts of climate change on precipitation and runoff patterns in California, future weather patterns are usually assumed to be similar to those in the past, especially where there is a long historical rainfall record.

The State Water Project analyses contained in this report are based upon 73 years of historical records (1922-1994) for rainfall and runoff that have been adjusted to reflect the current and future levels of development in the source areas by analyzing land use patterns and projecting future land and water use. These series of data are then used to forecast the amount of water available to the SWP under current and future conditions.

The Ability to Convey Water from the Source to the Desired Point of Delivery

This factor describes the facilities available to capture and convey surface water or groundwater and the institutional limitations placed upon the facilities. The facilities and institutional limitations may be assumed to be those that currently exist. Alternatively, predictions may be made regarding planned new facilities. Assumptions made about the institutional limitations to operation—such as legal, contractual, or regulatory restrictions—often are based upon existing conditions. Future changes in conditions that affect the ability to convey water usually cannot be predicted with certainty, particularly the regulatory and other institutional constraints on water conveyance.

Although new facilities are planned to increase the water delivery capability of the SWP, the analyses contained in this report assume no additional facilities. The analyses also assume current regulatory and institutional limitations will exist 20 years in the future (2025).

The Level of Demand

This factor includes the amount and pattern of water demand on the water management system. Demand can have a significant effect upon the reliability of a water system. For example, if the demand occurs only three months in the summer, a water system with a sufficient annual supply but insufficient water storage may not be able to reliably meet the demand. If, however, the same total amount of demand is distributed over the year, the system could more easily meet the demand because the need for water storage is reduced.

Demand levels for the SWP are derived from historical data and information received from the SWP contractors. Demand on the SWP is nearing the maximum Table A amount. Each of the SWP contracts has a Table A, which lists the maximum annual delivery amount over the period of the contract. These annual amounts usually increase over time. Most contractors' Table A amounts reached a maximum in 1990. The total of all contractors' maximum Table A amounts is 4.173 million acre-feet (maf) per water year. Table A is used to define each contractor's portion of the available water supply that the Department will allocate and deliver to that contractor. The Table A amounts in any particular contract, accordingly, should not be read as a guarantee of that amount but rather as the tool in an allocation process that defines an individual contractor's "slice of the pie." The size of the "pie" itself is determined by the factors described in this report. (See Appendix C for additional explanation and listing of the maximum Table A amounts.)

There are 29 SWP contractors. Yuba City, Butte County, and the Plumas County Flood Control and Water Conservation District are north of the Delta. Their maximum Table A amounts total 0.040 maf. The maximum Table A amounts for the remaining 26 contractors, which receive their supply from the Delta, total 4.133 maf. This report focuses on SWP deliveries from the Delta because the amount of water pumped from the Delta by SWP facilities is the most significant component of the total amount of SWP deliveries. The results presented in this report regarding the percent of Table A deliveries applies to contractors north of the Delta in the same manner as those contractors receiving supply from the Delta.

Past Deliveries Cannot Accurately Predict Future Deliveries

It is worthwhile to note that actual, historical water deliveries cannot be used with a significant degree of certainty to predict future water deliveries. As discussed earlier, there are continual, significant changes over time in the determinants of water delivery: changes in water storage and delivery facilities, in water use in the source areas, in water demand in the receiving areas, and in the regulatory constraints on the operation of facilities for the delivery of water. Given the very significant historical changes that have occurred, past deliveries are not necessarily good predictors of current deliveries, much less of future deliveries.

For example, the demand 30 years ago for water from the SWP was not as high as it is currently or expected to be in the future. Because the need for SWP water then was relatively low, less water was transported through the SWP during normal and wet times than could have been if the demand had been higher. Simply put, less water was delivered in those past years because less water was needed. Conversely, the current or projected delivery capability of a water project would be less than the past if (1) demand for water from a water project was at its maximum level for many years, (2) no new facilities were built, and (3) the supply from one of its main sources of water was recently reduced because another entity with a prior water right increased its use of that source.

Many Assumptions Must Be Made in the Determination and Analysis of Water Delivery Reliability

As discussed earlier, to plan for the future, many assumptions must be made about the future. One of the most significant assumptions for water planning in general is how wet, dry and variable the weather will be. For many planning purposes, the assumption is that future patterns of weather will be like the past, and an effort is made to develop information on the longest historical period for which acceptable records exist.

Using the historical record, planners analyze the worst drought in the period of record to evaluate how the water management systems will respond. Precipitation information for the Central Valley used for this report begins in 1922 and records the area's worst multi-year drought (1928-1934), although the brief drought from 1976 through 1977 was more acutely dry. Whatever assumptions are made, every responsible water delivery reliability analysis should expressly state the assumptions, methods and data used to produce its results. It should always be understood that those numbers depend on, and are no better than, the assumptions upon which they must necessarily rest.

Because assumptions are the foundation upon which the estimates are made, it is helpful to know how each assumption affects study results. For example, what impact would a significant increase in water use in the source areas have upon the projected SWP water delivery reliability? Would it significantly reduce the amount of SWP supply, and if so, by how much? These types of questions can be answered by varying specific factors to see the impact upon the results. These studies are referred to as sensitivity analyses and can be helpful in assessing the importance of certain assumptions to the study results. In the 2002 Reliability Report, the Department committed to conducting a comprehensive sensitivity analysis for assumptions contained in the CalSim II model studies. This analysis is complete. Summaries of the findings of this and other studies of CalSim II as well as a peer review of the model are contained in this report and discussed in more detail in Appendix E.

Chapter 3. Study Approach and CalSim II Follow-up Studies

This report presents information from computer simulation studies of the operation of the SWP using the CalSim II model. CalSim II is a planning model developed by the Department of Water Resources (DWR) and the U.S. Bureau of Reclamation. It simulates the SWP and the Central Valley Project (CVP) and areas tributary to the Sacramento-San Joaquin Delta. Using historical rainfall and runoff data, which has been adjusted for changes in water and land use that have occurred or may occur in the future, the model simulates the operation of the water resources infrastructure in the Sacramento and San Joaquin river basins on a month-to-month basis. In the model, the reservoirs and pumping facilities of the SWP and CVP are operated to assure the flow and water quality requirements for these systems are met.

The month-to-month simulations are conducted over the 73-year period (1922-1994) of the adjusted historical rainfall/runoff data. This approach incorporates the over-arching assumption that the next 73 years will have the same rainfall/snowmelt amount and pattern, both within-year and from year to year, as the period 1922 through 1994. The studies do not incorporate any modifications to account for changes related to climate change or assess the risk of future seismic or flooding events significantly disrupting SWP deliveries. As tools are developed to address these risks and the resulting studies become available, the information will be incorporated into the assessment of SWP delivery reliability. The results of the CalSim II studies conducted for this update to *The State Water Project Delivery Reliability Report 2002* (DWR 2003b) represent the best available assessment of the delivery capability of the SWP.

Since the release of the 2002 report, a peer-review and several studies have been conducted regarding CalSim II. These reports include:

- An external peer review commissioned by the California Bay-Delta Authority (CALFED);
- An analysis of an historical operations simulation;
- An analysis of the effect varying selected parameters has upon model results (sensitivity analysis study); and
- An analysis of the significance of the simulation time-step to the estimated SWP delivery amounts.

A strategic plan for improvements to CalSim II that incorporates recommendations of the peer review and on-going efforts has been developed. The conclusion of the historical simulation study is that CalSim II estimates of SWP Delta deliveries are very good. The analysis of the monthly versus daily time-step concludes it is not a significant factor in estimating SWP Delta deliveries. A more comprehensive sensitivity analysis report provides insight to the parameters with the greatest potential for affecting SWP Delta deliveries. An overview of these efforts follows.

Science Program Peer Review of CalSim II

In 2003, the CALFED Science Program commissioned an external review panel to provide an independent analysis and evaluation of the strengths and weaknesses of CalSim II. The central question put to the review panel was whether the CALFED program had adopted an appropriate approach to modeling the Central Valley Project/State Water Project (CVP/SWP) system. The panel considered a variety of CalSim II issues and addressed how future model development activities could be managed to assure quality results for current and proposed applications. The panel published its results in *A Strategic Review of CALSIM II and its Uses for Water Planning, Management, and Operations in Central California* (Close and others 2003).

In general, the panel concluded that the current modeling approach was comparable to other state-of-the-art models and addressed many of the complexities of the CVP/SWP system. To balance the competing needs of those who require greater detail from the model and those who require less detail, the panel recommended steps to achieve a more comprehensive, modular, and flexible approach in modeling practices and tools. To increase user confidence in model results and to provide a basis for gauging the model's ability to produce absolute predictive results of system behavior, the panel suggested calibration and verification of the model, as well as analyses in sensitivity and uncertainty.

In what was most relevant to the subject of this report on the SWP delivery reliability, the panel summarized its observation on the accuracy of the model to estimate the delivery capability of both the CVP and SWP systems in the *Strategic Review's* Appendix F "Analysis of the November 2003 CalSim II Validation Report." Appendix F is discussed in the next section.

In August 2004, DWR and the USBR jointly responded to the questions, comments, and recommendations of the review panel in a report, *Peer Review Response: A Report by DWR/Reclamation in Reply to the Peer Review of the CalSim II Model Sponsored by the CALFED Science Program in December 2003.* (*Peer Review Response*). In their report, the agencies outline current and planned work on model development and the priorities for improving CalSim II. The *Peer Review Response* also highlights the ongoing and planned efforts to establish trust in and credibility for the model by improving documentation, conducting sensitivity and uncertainty analyses of the model parameters and results. Other efforts include enhancing the level of detail in the geographic representation of the system, and improving hydrologic input and software development.

Many of the elements of model development outlined in the *Peer Review Response* are in progress and will be implemented in the updated version of the model, CalSim III. Some of the *Strategic Review's* pressing issues regarding the reliability of CalSim II as a planning tool are addressed below.

The Ability of CalSim II to Estimate Water Deliveries

The accuracy of CalSim II in simulating "real-world" conditions was one of the major issues raised by the peer review panel. The review panel focused on the system's delivery capability as a major concern to water users as well as water managers who rely on CalSim II when making planning decisions. In Appendix F of the *Strategic Review*, the panel expresses concern that CalSim II overestimates deliveries to south-of-Delta water users. This observation is based on comparing the average deliveries for the last 10 years (1993–2002) with the average annual deliveries in a 73-year model simulation (1922–1994) conducted at the 2001 level of development.

In *Peer Review Response,* DWR and USBR (2004) conclude the concern about overestimations of south-of-Delta deliveries is unwarranted because the 73-year study referenced by the panel is not designed to mimic historical conditions; rather it is intended to determine the reliability of the SWP when the demand equals the maximum Delta Table A amount (4.133 MAF) every year. The results of the referenced study are documented in *The SWP Delivery Reliability Report 2002* (DWR 2003b) as study 3 (2021B).

A more appropriate method for assessing the ability of CalSim II to accurately model SWP operations is to compare the historical SWP deliveries with the simulated deliveries of the Historical Operations Study. DWR committed to conducting this study in *The SWP Delivery Reliability Report 2002* (DWR 2003b). The study is documented in the November 2003 Technical Memorandum Report *CALSIM-II Simulation of Historical SWP/CVP Operations* (DWR 2003a). The Historical Operations Study is designed to assess CalSim II's ability to mimic historical operations of the SWP. In this study, historical input is used where reliable data are available. In situations where reliable historical record is not readily available, reasonable assumptions and estimates are made.

Comparing the average annual historical deliveries with the simulated deliveries in the Historical Operations Study for the dry period showed reasonable results: The average annual SWP south-of-Delta Table A delivery for the 6-year drought of 1987–1992 was 1,930 taf per year, compared to 2,030 taf per year for actual historical deliveries (Figure 3-1). The simulated deliveries in Figure 3-1 were adjusted for any differences between the historical and simulated carryover storage in the SWP system reservoirs, Lake Oroville and SWP's portion of San Luis Reservoir.

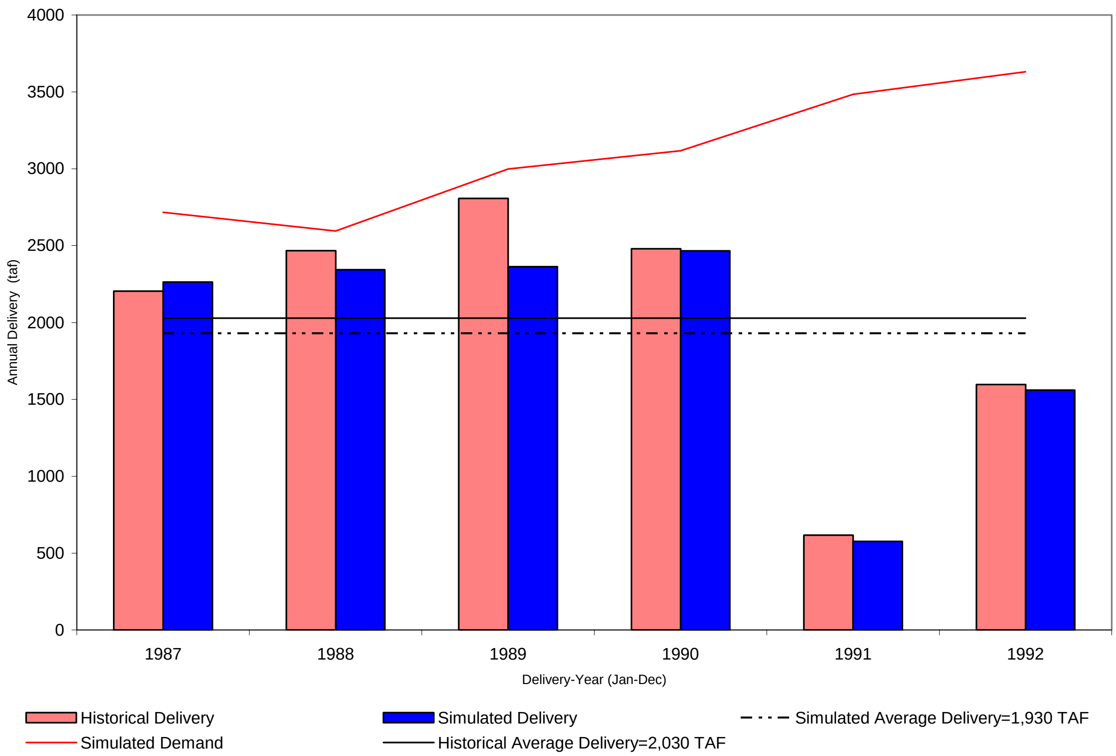

Figure 3-1 SWP south-of-Delta Table A deliveries (1987–1992 dry period)

The observed differences in the historical and simulated deliveries can be attributed to differences in the operational rules and parameters assumed in the simulation run. Some of the major operational parameters that could be different between the model run and the actual historical operations include the rule governing the amount of delivery versus the amount of storage to be carried-over into the following year (delivery-carryover storage rule), flood control rules, San Luis Reservoir operation rule, Delta outflow requirements, regulatory decisions, Delta export curtailments caused by pumping facilities outages or compliance with state and federal endangered species regulations, compliance with the provisions of the Coordinated Operations Agreement, implementation of a drought water bank, and water transfers.

In the wetter years (above-normal and wet year-types), when supply is plentiful and deliveries are mostly determined by demands, the simulated deliveries were very close to historical values. When long-term values were compared, the average annual delivery for the SWP during the 23-year period of 1975–1997 was 1,810 taf per year for the Historical Operations Study and 1,790 taf per year for the historical deliveries.

Additional details of this study are in Appendix E.

CalSim II Sensitivity Analysis Study

The sensitivity analysis is an important component of any water resources planning model evaluation. The sensitivity analysis procedures explore and quantify the impact of possible errors in input data on the model outputs and system performance measures. With a simple sensitivity analysis procedure, errors in model input parameters are generally investigated one at a time. With a more complex procedure, the investigation can be conducted by varying a set of parameters simultaneously. In the sensitivity analysis conducted in response to the recommendations in the *Strategic Review* (Close and others 2003), the simple procedure was adopted and errors in model input parameters were investigated one at a time. The objective of the analysis was twofold: (1) to examine the behavior of the model in response to variations in selected input parameters; (2) to provide a basis for CalSim II modelers for prioritizing future model development activities. The *CalSim-II Model Sensitivity Analysis* is available at website http://baydeltaoffice.water.ca.gov/index.cfm.

There are many input parameters used in the CalSim II model to define the physical characteristics of the system, as well as the regulatory environment and operational characteristics. Some input parameters are in the form of time series or monthly distribution curves, and others are simply single values. Some input parameters are estimated from the historical data, and others are values developed or calibrated by users. After consultation with model developers and project operators, 21 model input parameters in 4 major categories with reasonable ranges of variations were selected for this sensitivity analysis study. The results of the sensitivity analysis are given in more detail in Appendix E.

Examination of the results of the sensitivity analysis provides the following information on the behavior of the SWP system's delivery capability with respect to some of the key input parameters:

- The most significant input parameters affecting SWP Table A Delta deliveries are the assumed SWP Table A demands and the monthly diversion limits imposed on Banks Pumping Plant. The results show the long-term average annual SWP Table A Delta deliveries between 3.0 maf to 3.5 maf increase by 0.54 acre-foot for every acre-foot increase in Table A demands. The increase is 0.33 acre-foot for every acre-foot of increase in Table A demands for the range between 3.5 maf per year and 3.9 maf per year.
- Also, the long-term average annual SWP Table A Delta deliveries decrease by 0.48 acre-foot for every 1 acre-foot per month decrease in Bank's allowable monthly pumping limit during March 16 to December 14 period. This sensitivity study evaluates a 5 percent reduction in the capacity during this period.
- Inflow to Lake Oroville displays a moderate impact on the SWP Table A Delta deliveries. The long-term average annual SWP Table A Delta deliveries increase by 0.20 acre-foot for every acre-foot increase in annual Oroville inflows.
- The effect of changing contractors' demands for Article 21 water on Article 21 deliveries is high, as expected. The results show that for every acre-foot of change in the peak monthly demands for Article 21 water in the range between 134 taf per month and 400 taf per month, the long-term average annual Article 21 deliveries increase by 0.27 acre-foot.

Examples of parameters not significantly influencing the estimates for SWP Delta deliveries include the projected land use in the source areas and inflow into Lake Shasta and Folsom Reservoir.

Impact of Model Simulation Time-step in Estimating Projects Average Deliveries

In general, the delivery reliability of the SWP is assessed using monthly time-step CalSim II simulations. Monthly time-step simulations implicitly assume that daily hydrologic variability combined with daily physical and regulatory operating constraints are not significant to the forecast of expected average annual deliveries. In other words, it is assumed that a study with monthly inflows, reservoir releases, exports, and associated constraints would produce the same long-term average annual deliveries as a study where inflows, releases, exports, and associated constraints vary on a daily basis.

To confirm the above assumption, results were examined from a recently completed, simplified, daily time-step CalSim II simulation conducted for the California Bay-Delta Authority's Surface Storage Investigations. The assumptions for the baseline monthly and daily time-step simulations are documented in the draft report "Interim Common Model Package, Modeling Protocol and Assumptions" (CALFED 2005). The daily variability appears to have only minor impacts on SWP Table A deliveries. The results show the long-term average annual SWP Table A delivery is increased by 0.3 percent and the average annual deliveries during two 6-year droughts (1929–1934 and 1987–1992) is increased by 0.8 percent in the daily simulation.

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Chapter 4.
Computer Simulation Assumptions

The selection of the assumptions and factors that go into the estimation of future water delivery reliability is very important and must be tailored to the particular water supplier. Assumptions and factors for the State Water Project focus on Sacramento and San Joaquin river basin precipitation; water rights and uses; SWP storage and conveyance facilities, including diversion facilities in the Delta; SWP service area demand; and the statutes, regulations, and contractual provisions that govern and regulate the SWP, including coordinating operations with the federal Central Valley Project (CVP). A detailed list of the study assumptions for this report is found in Appendix A.

The results of five computer simulations are included in this report. Studies 1, 2, and 3 are from the *The State Water Project Delivery Reliability Report 2002* (DWR 2003). The results of studies 1, 2 and 3 are included in this report for comparison purposes. Studies 4 and 5 are updated studies conducted specifically for this report. A significant difference between the updated studies and the earlier studies is the assumed demands for SWP Table A and Article 21. Article 21 refers to a section of the water supply contracts that allows additional water to be delivered under certain conditions (see Chapter 5 for further discussion).The assumed demands for studies 4 and 5 were developed in discussions with SWP water contractors and stakeholders involved in the development of the analyses associated with the environmental documentation for the Monterey Agreement.

The assumptions for the studies differ in three main categories: the assumed level of water use in the source areas (the level of development), the assumed SWP Table A and Article 21 demands, and the base model assumptions. These categories are summarized in Table 4-1.

Table 4-1 Key study assumptions

Study	Study name	Level of development (year)	SWP Table A demand (maf/year)	SWP Article 21 demand (taf/month)	Model version
SWP Delivery Reliability Report (2003)					
1	2001 Study	2001	3.0–4.1	0–84, Apr–Nov 50–134, Dec–Mar	May 2002 benchmark
2	2021A Study	2021	3.3–4.1	0–84, Apr–Nov 50–134, Dec–Mar	May 2002 benchmark
3	2021B Study	2021	4.1	0–84, Apr–Nov 50–134, Dec–Mar	May 2002 benchmark
Updated Studies					
4	2005 Study	2005	2.3–3.9	0–84, Apr–Nov 100–184, Dec–Mar	2004 OCAP
5	2025 Study	2025	3.9–4.1	0–84, Apr–Nov 100–184, Dec–Mar	2004 OCAP

maf = million acre-feet

OCAP = 2004 Long-Term Central Valley Project Operations Criteria and Plan

taf = thousand acre-feet

The water use estimates for the source areas for 2001 are assumed to be representative of 2005. The water use estimates for the source areas for 2020 are assumed to be representative of 2021 and 2025 conditions.

The SWP contractors' Table A and Article 21 demands for deliveries from the Delta assumed for the five studies are shown in Table 4-1. In four of the studies, a range in Table A demands is shown because the demand is assumed to vary each year with the weather in the delivery areas. In study 3 (2021), the SWP Table A demand is maximized each year, regardless of weather. Article 21 deliveries are available on an unscheduled and interruptible basis and are not counted as part of the Table A amount. (See Chapter 5 for more discussion of Article 21.) The Article 21 demand in the updated studies (4 and 5) is higher than the earlier studies for the December through March period.

Two versions of the model are used for these studies as shown in Table 4-1. Studies 1, 2 and 3 are based on the May 2002 benchmark study version. The updated studies (4 and 5) use the most recent version, which was developed for the 2004 Long-Term Central Valley Project Operations Criteria and Plan (OCAP). The assumption differences between the May 2002 benchmark version and the 2004 OCAP version that affect the SWP simulation significantly are listed below. A complete list of the differences in key assumptions is included in Appendix A.

1. Addition of a minimum pumping level at Banks Pumping Plant of 300 cubic feet per second.
2. Addition of flow requirements for flow at the mouth of the Feather River for SWP Settlement Contractors.
3. Delivery-carryover relationship adjusted to reduce delivery targets and increase carryover in critically dry years.
4. Addition of Lake Oroville end-of-September carryover target storage rule.
5. Study 5 assumes the implementation of Freeport Regional Water Project, including modified East Bay Municipal Utility District operations on the Mokelumne River.

All studies assume current Banks Pumping Plant capacity, existing conveyance capacity of the upper Delta-Mendota Canal/California Aqueduct system, and current SWP/CVP operations agreements.

Cited Reference

[DWR] California Department of Water Resources, Bay-Delta Office. 2003. The State Water Project Delivery Reliability Report 2002. Final.

Chapter 5.
Study Results

The five CalSim II model studies in this report are described in Chapter 4. Studies 1, 2, and 3 are from the *The State Water Project Delivery Reliability Report 2002* (DWR 2003). Studies 4 and 5 are updated studies conducted specifically for this report. The results of studies 1, 2 and 3 are included in this report for comparison purposes. This chapter contains tables summarizing the estimated delivery amounts of the studies for the entire study period (1922-1994), dry years, and wet years and presents information on the estimated probability of SWP delivery amounts currently and twenty years in the future. The annual values for SWP deliveries estimated by CalSim II for the five studies are listed in tables B-3 through B-7 of Appendix B. These tables also show the annual Table A demands assumed for each study.

The results of the updated studies (4 and 5) are compared to the results of the earlier studies (1, 2 and 3) to identify and explain any significant differences in estimated delivery values. For most values, the differences are not large enough to be significant and are generally caused by differences in the assumed demands. There are, however, significant differences between the updated and earlier studies for the estimated deliveries during 1, 2 and 4-year droughts. These differences are discussed further in "Drought Years."

Article 21 Deliveries

The studies estimate delivery amounts for Table A and Article 21. As mentioned in Chapter 2, Table A is the contractual method for allocating available supply, and the total of all maximum Table A amounts for deliveries from the Delta is 4.133 million acre-feet (maf) per year. Article 21 refers to a provision in the contracts for delivering water that is available in addition to Table A amounts. (See appendix C for more detail about Table A and Appendix D for historical delivery amounts.) Article 21 of SWP contracts allows contractors to receive additional water deliveries only under specific conditions. These conditions are:

1. It is available only when it does not interfere with Table A allocations and SWP operations;
2. It is available only when excess water is available in the Delta;
3. It is available only when conveyance capacity is not being used for SWP purposes or scheduled SWP deliveries; and
4. It cannot be stored within the SWP system. In other words, the contractors must be able to use the Article 21 water directly or store it in their own system.

Water supply under Article 21 becomes available only during wet months of the year, generally December through March. Because an SWP contractor must have an immediate use for Article 21 supply or a place to store it outside of the SWP, not all SWP contractors can take advantage of this additional supply.

The importance of Article 21 water to local water supply is tied to how each contractor uses its SWP supply. For those SWP contractors who are able to store their wet weather supplies, Article 21 supply can be stored by being put directly into a reservoir or by offsetting other water that would have been withdrawn from storage, such as local groundwater. In the absence of storage, Article 21 water is not likely to contribute significantly to local water supply reliability. Incorporating supplies received under Article 21 into the assessment of water supply reliability is a local decision based on specific local circumstances, facts, and level of water supply reliability required.

This report presents information on Article 21 water separately, so local agencies can determine whether it is appropriate to incorporate this supply into their analyses.

SWP Water Deliveries under Different Hydrologic Scenarios

Tables 5-1 and 5-2 summarize the assumed Table A demands for the updated (4 and 5) and the earlier (1, 2, and 3) studies and the resulting estimates for SWP deliveries. Table 5-3 presents information on the assumed Article 21 demand and the estimated Article 21 deliveries. Tables 5-4 through 5-8 summarize values for dry and wet hydrologic periods. The estimated probabilities for a given amount of annual SWP delivery are presented in Figures 5-1 and 5-2.

Assumed Table A Demands

The average, maximum, and minimum Table A demands from the Delta for the five studies are shown in Table 5-1. Study 4 has lower assumed demands than study 1. The average demand for study 4 is 80 percent of maximum Table A compared to 90 percent of maximum Table A for study 1. The primary reason for the lower demand in study 4 is that it includes a new set of annual Table A demands for the Metropolitan Water District of Southern California (MWDSC) prepared specifically for 2003 conditions by MWDSC. The average demand for study 5 is 99.4 percent of maximum Table A and is very similar to study 3. The annual assumed demand for study 5 is less than maximum Table A in only seven wet years due to the assumption that some Table A deliveries would be replaced by supplies from the Kern River.

As explained in Chapter 2 and Appendix C, the maximum Table A amounts for the 26 contractors which receive their supply from the Delta total 4.133 maf. The demands for studies 1 and 4 assume slightly earlier conditions when the maximum Table A amounts totaled slightly less than 4.133 maf (4.114 maf and 4.112 maf, respectively). To simplify the use of this report, the calculation of demand or delivery in percent of maximum Table A is based on the maximum Delta Table A total of 4.133 maf for all five studies. This simplification has no significant effect on the annual delivery percentages for studies 1 and 4. Additional information can be found in Appendix B.

Table 5-1 SWP Table A demand from the Delta

Study	Average demand		Maximum demand		Minimum demand	
	(taf per year)	(percent of maximum Table A)	(taf per year)	(percent of maximum Table A)	(taf per year)	(percent of maximum Table A)
SWP Delivery Reliability Report (2003):						
1. 2001 Study	3,712	90%	4,114	100%	3,007	73%
2. 2021A Study	4,026	97%	4,133	100%	3,343	81%
3. 2021B Study	4,133	100%	4,133	100%	4,133	100%
Updated Studies:						
4. 2005 Study	3,290	80%	3,862	93%	2,321	56%
5. 2025 Study	4,110	99%	4,133	100%	3,898	94%

Maximum Delta Table A is 4.133 million acre-feet per year.

Table A and Article 21 Deliveries

Table 5-2 contains the average, maximum, and minimum estimates of Table A deliveries from the Delta for the five studies. Comparing the relevant updated and earlier studies shows the averages of the estimated delivery percentages and the maximum estimated deliveries do not vary significantly. Study 4 has an average delivery of 68 percent of maximum Table A compared to 72 percent for study 1. This lower delivery under current conditions is due to the lower demand level assumed for study 4. The slightly higher average delivery of 77 percent for study 5 compared to 75 percent for study 2 is attributed to the higher demand assumed for study 5 and to differences in modeling assumptions as summarized in Chapter 4 and listed in Appendix A. The average delivery for study 5 is one percentage point higher than study 3 even though study 3 has a slightly higher demand. This slightly higher value for study 5 is due to differences in modeling assumptions. Comparing the updated studies (2005 versus 2025 study levels) shows study 5 has an average delivery of 77 percent of maximum Table A compared to 68 percent for study 4, an increase of 9 percent. This average increase in delivery is due to the higher demand assumed for study 5.

The difference between the earlier studies and the updated studies for the estimated minimum Table A delivery is significant. The updated studies have a minimum delivery of 4 percent to 5 percent of maximum Table A compared to 19 to 20 percent for the studies in the *SWP Delivery Reliability Report 2002* (DWR 2003). The lower minimum delivery is primarily due to modification of the delivery-carryover storage rule. Compared to the rule used for the earlier studies, the modified rule reduces delivery by about 80 percent whenever carryover storage (sum of the end-of-September storages of Oroville Reservoir and the SWP share of San Luis Reservoir) is projected to be less than about 860 thousand acre-feet (taf). The modified rule was developed in coordination with the DWR's SWP Operations Control Office to meet the primary objective of reducing the number of years storage in Oroville Reservoir reaches a very low level. The minimum delivery occurs in 1977, the driest year in the 73-year simulation. A closer look at this estimation is done later in this chapter. It applies reasonable assumptions about the amount of Table A deliveries carried-over in San Luis Reservoir from the previous year by SWP contractors and the use of storage in San Luis Reservoir to illustrate how the estimate could be adjusted to 20% of maximum Table A while not reducing storage in Oroville Reservoir.

Table 5-2 SWP Table A delivery from the Delta

Study	Average delivery		Maximum delivery		Minimum delivery	
	(taf per year)	(percent of maximum Table A)	(taf per year)	(percent of maximum Table A)	(taf per year)	(percent of maximum Table A)
SWP Delivery Reliability Report (2003):						
1. 2001 Study	2,962	72%	3,845	93%	804	19%
2. 2021A Study	3,083	75%	4,128	100%	830	20%
3. 2021B Study	3,130	76%	4,133	100%	830	20%
Updated Studies:						
4. 2005 Study	2,818	68%	3,848	93%	159	4%
5. 2025 Study	3,178	77%	4,133	100%	187	5%

Maximum Delta Table A is 4.133 million acre-feet per year.

Average Article 21 demands and average, maximum, and minimum Article 21 deliveries for the five studies are shown in Table 5-3. All studies have the same Article 21 demand from April through November. The updated studies (4 and 5) assume a 200 taf increase in Article 21 demand for the period December through March compared to the earlier studies (50 taf per month).

Table 5-3 SWP Article 21 demand and delivery from the Delta (taf per year except as noted)

Study	Average Article 21 demand			Annual delivery from the Delta		
	Dec-Mar	Apr-Nov	Total	Average	Maximum	Minimum
SWP Delivery Reliability Report (2003):						
1. 2001 Study	504	607	1,111	130	510	0
2. 2021A Study	504	607	1,111	80	400	0
3. 2021B Study	504	607	1,111	70	400	0
Updated Studies:						
4. 2005 Study	704	607	1,311	260	1,110	0
5. 2025 Study	704	607	1,311	120	550	0

Delivery numbers rounded to the nearest 10,000 acre-feet.

The average Article 21 delivery for study 4 is 260 taf per year, an increase of 130 taf per year from the study 1 average delivery of 130 taf per year. This increase in delivery is a result of the increase in Article 21 demand of 200 taf per year in studies 4 and 5 and also due to the decrease in Table A demand in study 4 compared to study 1. Study 5 has an average Article 21 delivery of 120 taf per year, 40 taf per year more than study 2 and 50 taf per year more than study 3. These increases are the result of the higher assumed Article 21 demand.

Drought Years

Table 5-4 includes estimates of water deliveries under an assumed repetition of historical drought periods for the five studies. The years are identified as dry by the Eight River Index, a good indicator of the relative amount of water supply available to the SWP. The Eight River Index is the sum of the unimpaired runoff from the four rivers in the Sacramento Basin used to define water conditions in the basin plus the four rivers in the San Joaquin Basin, which correspondingly define water conditions in that basin. The eight rivers are the Sacramento, Feather, Yuba, American, Stanislaus, Tuolumne, Merced, and San Joaquin. Table 5-4 also includes the average deliveries for comparison purposes.

As discussed earlier in conjunction with the minimum deliveries shown in Table 5-2, the single-year drought deliveries for the updated studies are estimated at 4 percent to 5 percent of maximum Table A compared to 19 to 20 percent for the studies in the *SWP Delivery Reliability Report 2002* (DWR 2003). The 2-year drought average annual delivery decreases from 48 percent for study 1 to 41 percent for study 4. Similarly, study 5 delivery decreases to 40 percent as compared to 44 percent for studies 2 and 3. The results for a 4-year drought show a 5 percent decrease in delivery for study 4 compared to study 1 and a 6 percent decrease in delivery for study 5 compared to studies 2 and 3, for the same reason. The decreases in each of these cases are primarily due to modification of the delivery-carryover storage rule as discussed earlier.

Table 5-4 SWP average and dry year Table A delivery from the Delta

Study	SWP Table A delivery from the Delta (in percent of maximum Table A)					
	Average 1922-1994	Single dry year 1977	2-year drought 1976-1977	4-year drought 1931-1934	6-year drought 1987-1992	6-year drought 1929-1934
SWP Delivery Reliability Report (2003):						
1. 2001 Study	72%	19%	48%	37%	41%	40%
2. 2021A Study	75%	20%	44%	39%	40%	41%
3. 2021B Study	76%	20%	44%	39%	40%	41%
Updated Studies:						
4. 2005 Study	68%	4%	41%	32%	42%	37%
5. 2025 Study	77%	5%	40%	33%	42%	38%

For the updated studies, the annual delivery for the single dry year is estimated to be about the same amount whether the dry year happens now or in twenty years. This is also true for estimated annual deliveries during the multi-year drought periods. This is projected to occur even though the amount of reservoir carryover storage resulting from the increased demand is projected to be less. This result is attributable to the operation rules governing the amount of water that must be retained for carryover storage, the fact the SWP demand between 2005 and 2025 increases only slightly, and because less water is made available under Article 21.

Table 5-5 summarizes the estimates of dry year deliveries under Article 21 for the five studies. The updated studies (4 and 5) have higher deliveries than the earlier studies (1, 2 and 3) because of assumed higher Article 21 demand. Also notice the reductions in delivery for studies 2 and 3 compared to study 1 in the years 1930, 1932, 1933, and 1976. These reductions are due to the increase in Table A deliveries. The average values for Article 21 deliveries for Study 5 is lower than study 4, primarily due to the assumed higher Table A demand in study 5.

Table 5-5 Average and dry year delivery under Article 21 (taf per year)

Study:	1	2	3	4	5
Year	Study 2001	Study 2021A	Study 2021B	Study 2005	Study 2025
1929	0	0	0	0	0
1930	90	30	30	120	140
1931	0	0	0	0	0
1932	200	40	40	240	110
1933	130	10	10	510	550
1934	0	0	0	210	240
1976	110	0	0	190	0
1977	0	0	0	0	0
1987	0	0	0	550	180
1988	0	0	0	0	0
1989	0	0	0	0	90
1990	0	0	0	0	0
1991	0	0	0	0	0
1992	0	0	0	0	100
1922-1994 average	130	80	70	260	120

Numbers rounded to the nearest 10,000 acre-feet.

Wet Years

Tables 5-6 and 5-7 below summarize the model run results for historical wet years. As with drought years, the Eight River Index is used to identify the wet years. Because plenty of water is available for deliveries in wet years, variations in Table A delivery are due to variations in the demand assumed for each of the studies.

Table 5-6 SWP average and wet year Table A delivery from Delta

Study	SWP Table A delivery from the Delta (in percent of maximum Table A)					
	Average 1922-1994	Single wet year 1983	2-year wet 1982-1983	4-year wet 1980-1983	6-year wet 1978-1983	10-year wet 1978-1987
SWP Delivery Reliability Report (2003):						
1. 2001 Study	72%	73%	79%	80%	80%	80%
2. 2021A Study	75%	82%	89%	86%	87%	84%
3. 2021B Study	76%	100%	100%	91%	91%	87%
Updated Studies:						
4. 2005 Study	68%	60%	65%	69%	75%	72%
5. 2025 Study	77%	95%	97%	93%	93%	89%

Table 5-7 contains information about Article 21 deliveries for the wet period 1978–1987. The information illustrates a significant decrease in the availability of Article 21 supply between study 5 and study 4. This is primarily due to the increase in Table A demand. Article 21 deliveries are generally higher in the updated studies (4 and 5) than the earlier studies (1, 2 and 3). This is attributed to the 200 taf per year increase in Article 21 demand assumed for studies 4 and 5. In addition, the increase in Article 21 deliveries for study 4 compared to the study 1 is partially due to the lower Table A demand assumed for study 4.

Table 5-7 Average and wet year delivery under Article 21 (taf per year)

Study:	1	2	3	4	5
Year	Study 2001	Study 2021A	Study 2021B	Study 2005	Study 2025
1978	100	100	100	300	300
1979	140	90	100	160	140
1980	100	70	80	140	90
1981	120	0	0	550	70
1982	390	100	60	800	170
1983	200	200	160	400	360
1984	410	380	370	550	490
1985	0	0	0	0	0
1986	50	50	60	120	80
1987	0	0	0	550	180
1922-1994 average	130	80	70	260	120

Numbers rounded to the nearest 10,000 acre-feet.

SWP Table A Delivery Probability

The probability that a given level of SWP Table A amount will be delivered from the Delta is shown for the two current condition studies (1 and 4) in Figure 5-1 and for the three future condition studies (2, 3, and 5) in Figure 5-2. The plot lines in the figures are derived from the study results listed in tables B-3 through B-7. Each line is constructed by ranking the 73 annual Table A delivery values of the relevant study from lowest to highest and calculating the percentage of values equal to or greater than the delivery value of interest. For example, for study 4 in Figure 5-1, the value of 3.3 maf is in the 30 percent position of the ranking; therefore, it is equaled or exceeded by 30 percent (about 22) of the 73 delivery values. The delivery value of 0.16 maf, the minimum value for study 4, is equaled or exceeded by all of the delivery values.

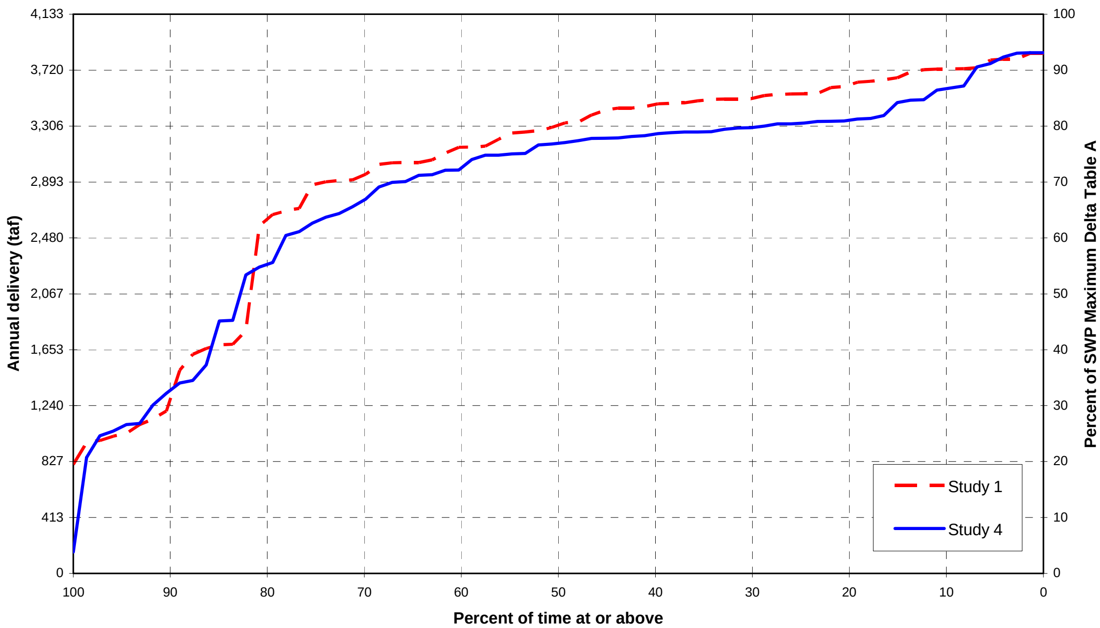

Figure 5-1 SWP Delta Table A delivery probability for year 2005

The curve for study 4 is generally lower than study 1 due to assumed lower annual demands. Neither curve reaches 100 percent because the assumed annual demands are 100 percent (99.5 percent) of the maximum Delta Table A in only two years for study 1 and the assumed maximum demand for study 4 is 93 percent of the maximum Delta Table A. In study 1, the two years with demand at 100 percent are dry years so delivery of 100 percent is not possible. The divergence of the two curves for the minimum delivery amounts (100% probability of being equaled or exceeded) is due to modification of the delivery-carryover storage rule.

Study 5 shows higher deliveries than study 3 for delivery values exceeded by up to 70 percent of the values, and mostly lower deliveries for values exceeded by 80 to 100 percent of the values. Because the assumed demands are nearly the same for these two studies, the delivery differences between study 5 and study 3 are primarily due to modification of the delivery-carryover storage relationship. The delivery-carryover relationship assumed in study 5 allows less delivery than study 3 in dry years which results in higher carryover storage and higher deliveries in normal to above normal years. Study 5 deliveries reach 100 percent 26 percent of the time, the highest percentage for the five studies.

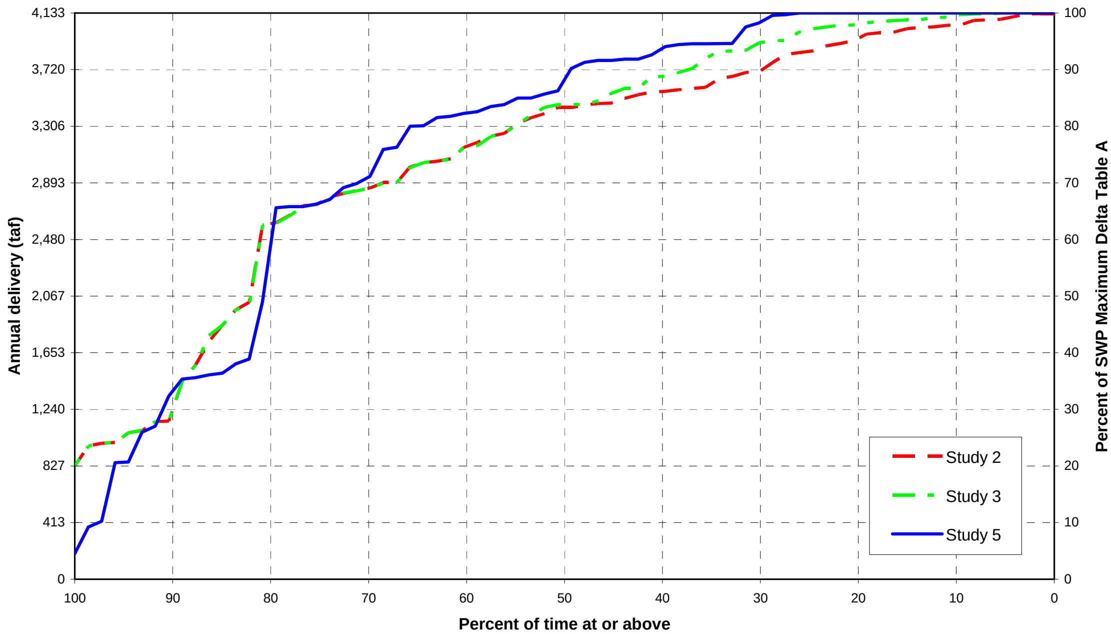

Figure 5-2 SWP Delta Table A delivery probability for year 2025

The amount of SWP Table A delivery per year, either in percent of maximum Delta Table A or in thousand acre-feet, associated with a specific degree of reliability can be estimated from Figures 5-1 and 5-2 for 2005 and 2025 conditions, respectively. The study 4 curve in Figure 5-1 is recommended to be used to represent 2005 conditions, and the study 5 curve in Figure 5-2 is recommended to be used to represent 2025 conditions. By referencing the curve for study 5 in Figure 5-2, the following can be deduced:

- In 75 percent of the years, the annual water delivery of the SWP is estimated to be at or above 2.70 maf per year (65 percent of 4.13 maf).
- In 50 percent of the years, it is estimated to be at or above 3.50 maf per year (85 percent of 4.13 maf).
- In 25 percent of the years, it is at 4.13 maf per year.

Figures 5-1 and 5-2 depict the estimated reliability for the total of SWP deliveries. Under conditions when almost all contractors are requesting their maximum Table A, like in study 5, this information can be directly applied to individual long-term water supply contracts for the SWP. For example, if a water agency has a maximum SWP Table A amount of 400 taf, at least 260 taf per year (65 percent of 400 taf) is estimated to be delivered 75 percent of the time.

Potential Adjustments to 1977 CalSim II Table A Deliveries

The CalSim II model, a planning model, is best used for estimating SWP performance over long periods of time. Considerable judgment should be applied when evaluating CalSim II results for shorter periods of time. This is especially true for estimates for a single year. The updated studies (studies 4 and 5) show that the changes in the operations criteria assumed for the SWP produce a delivery estimate of about 5 percent of maximum Delta Table A for the driest year on record (1977). This estimate is lower than the amount actually delivered from the Delta in 1977 (733 taf, 18 percent of maximum Delta Table A), as well as lower than what was shown in *SWP Delivery*

Reliability Report 2002 (DWR 2003). The discussion below presents some adjustments contractors may consider in estimating Table A deliveries under weather conditions similar to 1977.

In order to understand what led to the lower delivery estimates for 1977, it is best to start with 1975. The year 1975 is a wet year and is immediately followed by two critically dry years (1977 being the driest year on record during the last 80 years of historical hydrology). SWP Table A deliveries estimated in study 4 for 1975, 1976, and 1977 are 3.23 maf, 3.27 maf, and 159 taf, respectively. For study 5 the respective deliveries are 4.13 maf, 3.14 maf, and 187 taf. As currently practiced and allowed under the SWP water supply contracts, many of the contractors would carry over a portion of their allocated Table A water during 1975 and 1976 to succeeding years. In the case of 1977, it is reasonable to assume that up to 500 taf of 1976 allocated Table A water could be carried over to 1977. In addition, due to the slightly conservative delivery-carryover rule curve used in these studies, the minimum SWP storage in San Luis Reservoir for 1977, which occurs during the June-August period, averages about 190 taf for both studies 4 and 5. The minimum pool for the SWP share of San Luis Reservoir is just over 40 taf. In a year as critically dry as 1977, it is also reasonable to assume an additional 150 taf would be made available for deliveries bringing the SWP storage in San Luis Reservoir to minimum pool. After August, the SWP storage in San Luis Reservoir begins to rise. It is reasonable to expect additional deliveries to be made in the September-December period.

In summary, under the hydrologic conditions similar to a critically dry year like 1977, project deliveries can be expected to range from 4 or 5 to 20 percent of Table A, depending upon such factors as the delivery-carryover risk curve applied by SWP operators and the amount of allocated Table A water carried over from the previous year by SWP contractors.

Additional Analysis of Tables B-3 through B-7 in Appendix B

The information presented earlier in this chapter is helpful in analyzing the delivery reliability of a specific water system receiving a portion of its water supply from the SWP. In addition, the series of data contained in tables B-3 through B-7 are very helpful in analyzing longer periods of time that contain not only dry periods but wetter periods, which can replenish local water supplies if there is a place to store the supply. Analysis of this information can help determine if a local agency has adequate storage for capturing these supplies or if more storage could be utilized in the local water system.

Cited Reference

[DWR] California Department of Water Resources, Bay-Delta Office. 2003. The State Water Project Delivery Reliability Report 2002. Final.

Chapter 6. Examples of How to Apply Information

The following two examples illustrate how to use the information presented in this report to develop water supply assessments for a hypothetical SWP contractor. Hypothetical examples illustrating applications of the delivery probability curves and adjustments to the data for a SWP contractor that cannot convey its maximum Table A amount are provided in *The State Water Project Delivery Reliability Report 2002*. Questions regarding the use of the information contained in these reports may be directed to the Department of Water Resources' Bay-Delta Office at (916) 653-1099.

Example 1

This example uses data directly from Table 5-4 for studies 4 and 5, and employs an allocation methodology that provides a simple means of estimating supplies to each contractor. The data in the table is interpolated for 5-year increments and contained in Table 6-1. Although the percentage values are calculated using the maximum Delta Table A value, they may be directly applied to generate estimates for SWP deliveries for the entire 20-year period. This is because the Delta Table A value for 2005 is 4.114 maf/yr, 99.5 percent of the maximum Delta Table A value of 4.133 maf/yr. For comparison purposes, the percentage values for studies 1 and 4 based upon a full Table A value of 4.113 maf/yr and 4.133 maf/yr are listed in Tables B-3 and B-6. In addition, the percentages may also be used to estimate the Table A deliveries to SWP contractors in Butte and Plumas counties and Yuba City. The deliveries to these contractors would be calculated using the same method described below.

Table 6-1 shows the average percentage of maximum Delta Table A deliveries for average, single-dry year, and 2-, 4-, and 6-year multiple dry year scenarios from 2005 to 2025 in five-year increments. The maximum Table A amounts of each contractor are listed in Appendix C. Note that Table A amounts can be amended and a contractor's Table A amount over the next 20 years may be less than its maximum over some or all of this period. In this case, the contractor should use the amended Table A amounts for the corresponding years during this period. To use dry years other than those presented in Table 6-1, or to show year-to-year supplies instead of averages over a multiple-dry year period, see Example 2.

Table 6-1 SWP average and dry year Table A delivery from the Delta in five-year intervals for studies 4 and 5

Year	SWP Table A delivery from the Delta (in percent of maximum Table A)					
	Average 1922-1994	Single dry year 1977	2-year drought 1976-1977	4-year drought 1931-1934	6-year drought 1987-1992	6-year drought 1929-1934
2005	68%	4%	41%	32%	42%	37%
2010	70%	4%	41%	32%	42%	37%
2015	73%	4%	41%	33%	42%	37%
2020	75%	4%	41%	33%	42%	37%
2025	77%	5%	40%	33%	42%	38%

How to calculate supplies:

Multiply the contractor's Table A amount for a particular year by the corresponding delivery percentages for that year from Table 6-1 to get an estimated delivery amount, for the average and drought periods, for each 5 year increment from 2005 to 2025.

The following tables show the SWP Table A deliveries projected to be available to a hypothetical contractor with a maximum Table A amount of 100,000 AF, on average and for the various drought periods. For this example, the supplies shown for the multiple-dry year period are average supplies over the four-year drought from 1931-1934. Data from other year types, although not required in an urban water management plan, could also be presented this way.

Average Annual Values
(acre-feet)

Water Supply Source	2005	2010	2015	2020	2025
State Water Project (Table A)	68,000	70,000	73,000	75,000	77,000
State Water Project (Article 21)					
Groundwater					
Local Surface Water					
Transfers					
Exchanges					
Reclaimed Water					
Other (identify)					
Total					

Single Dry Year (1977 conditions)
(acre-feet)

Water Supply Source	2005	2010	2015	2020	2025
State Water Project (Table A)	4,000	4,000	4,000	4,000	5,000
State Water Project (Article 21)					
Groundwater					
Local Surface Water					
Transfers					
Exchanges					
Reclaimed Water					
Other (identify)					
Total					

Multiple Dry Year Period
1931-1934 conditions
(acre-feet per year)

Water Supply Source	2005	2010	2015	2020	2025
State Water Project (Table A)	32,000	32,000	33,000	33,000	33,000
State Water Project (Article 21)					
Groundwater					
Local Surface Water					
Transfers					
Exchanges					
Reclaimed Water					
Other (identify)					
Total					

Example 2

This example is similar to Example 1 but allows a contractor to select alternative single year or multiple-dry year sequences other than those presented in Table 6-1. This option might be selected if analyzing different hydrologic year(s) makes more sense given a contractor's other supply sources, or given the locally acceptable risk level for water delivery shortages.

This example can also be used to identify supplies projected to be available in each year of a multiple-dry year period. While the Water Code does not specifically require this, the Urban Water Management Plan Guidebook suggests showing year-to-year supplies (see the UWMP Guidebook, Section 7, Step 3).

Where to find the data

Choose a single year or multiple-year sequences from Tables B-6 and B-7 to represent single-dry year and multiple-dry year scenarios. Table B-6 contains the percent of maximum Table A deliveries under all 73 hydrologic years in the updated model study for 2005. Table B-7 contains the percent of maximum Table A deliveries under all 73 hydrologic years in the updated model study for 2025.

How to calculate supplies

Multiply the contractor's Table A amount for a particular year by the percent of maximum Table A deliveries for the selected years, to get an estimated delivery amount for the years selected, for 2005 and 2025. Values for years between 2005 and 2025 can be linearly interpolated.

The following tables show the SWP Table A deliveries projected to be available to a hypothetical contractor with a maximum Table A amount of 100,000 AF, in a single dry year and year-to-year over a multiple dry-year period. For this example, the single dry year selected is for 1988 conditions, and the multiple dry-year period selected is the three-year period from 1990-1992. In showing year-to-year supplies for the multiple-dry year period, these year-to-year supplies should be shown for each five year increment during the 20 year projection period.

Single Dry Year (1988 conditions)
(acre-feet)

Water Supply Source	2005	2010	2015	2020	2025
State Water Project (Table A)	21,000	18,000	15,000	13,000	10,000
State Water Project (Article 21)	0	0	0	0	0
Groundwater					
Local Surface Water					
Transfers					
Exchanges					
Reclaimed Water					
Other (identify)					
Total					

Multiple Dry Year Period 1990-1992
1990 conditions
(acre-feet per year)

Water Supply Source	2005	2010	2015	2020	2025
State Water Project (Table A)	27,000	25,000	24,000	22,000	21,000
State Water Project (Article 21)	0	0	0	0	0
Groundwater					
Local Surface Water					
Transfers					
Exchanges					
Reclaimed Water					
Other (identify)					
Total					

Multiple Dry Year Period 1990-1992
1991 conditions
(acre-feet per year)

Water Supply Source	2005	2010	2015	2020	2025
State Water Project (Table A)	25,000	24,000	23,000	22,000	21,000
State Water Project (Article 21)	0	0	0	0	0
Groundwater					
Local Surface Water					
Transfers					
Exchanges					
Reclaimed Water					
Other (identify)					
Total					

Multiple Dry Year Period 1990-1992
1992 conditions
(acre-feet per year)

Water Supply Source	2005	2010	2015	2020	2025
State Water Project (Table A)	34,000	34,000	35,000	35,000	35,000
State Water Project (Article 21)	0	0	0	0	0
Groundwater					
Local Surface Water					
Transfers					
Exchanges					
Reclaimed Water					
Other (identify)					
Total					

Appendices

Appendix A. 2005 Delivery Reliability Report CalSim II Modeling Assumptions

Two versions of the model are used for this report. Studies 1, 2 and 3 are based on the May 2002 benchmark study version. The updated studies (4 and 5) use the most recent version, which was developed for the 2004 Long-Term Central Valley Project Operations Criteria and Plan (OCAP). The key assumption differences between the May 2002 benchmark version and the 2004 OCAP version are listed below.

1. Temperature flow below Keswick Dam was changed from a fixed time series flow to a dynamic storage dependent flow.
2. Relaxation of criteria for flow below Nimbus Dam when Folsom Lake storage drops below 300 thousand acre-feet.
3. Navigation control point flow criteria were modified from being dependent on water year type to being dependent on CVP agricultural allocation levels. Criteria were also relaxed for very low allocation years.
4. Clear Creek Tunnel target flows were modified to match the latest Trinity EIR analysis.
5. Addition of a minimum pumping level at Banks Pumping Plant of 300 cubic feet per second.
6. Addition of a minimum pumping level at Tracy Pumping Plant of 600 cubic feet per second.
7. Addition of flow requirements for flow at the mouth of the Feather River for Settlement Contractors.
8. Delivery-carryover relationship was adjusted to reduce delivery targets and increase carryover in critically dry years.
9. Addition of Lake Oroville end-of-September carryover target storage rule.
10. Five-step study setup modified to isolate (b)(2) accounting from “with Project” conditions.
11. Modification of American River demands as described in Tables A-2 and A-3.
12. Modification of Contra Costa Water District demands to include the effect of Los Vaqueros Reservoir operations.
13. The minimum flow of the Trinity River below Lewiston Dam in study 4 ranges from 369 to 453 thousand acre-feet per year depending on water year type. All other studies used in this report assume the Trinity River minimum flow has a greater range from 369 to 815 thousand acre-feet per year. This greater range of Trinity River minimum flows represents the Trinity Environmental Impact Statement Preferred Alternative.
14. Study 5 assumes the implementation of Freeport Regional Water Project, including modified East Bay Municipal Utility District operations on the Mokelumne River.
15. Implementation of May 2003 CVPIA 3406 (b)(2) decision and other changes:
    a. Streamlining actions to simplify analysis of the results.
    b. Anadromous Fish Restoration Program table updates to better represent management of (b)(2) water under the May 2003 (b)(2) decision.

   c Action triggering modifications to attempt to meet 200 thousand-acre feet target during October through January period.

16 Environmental Water Account (EWA) changes include:

   a Streamlining actions and coordination with (b)(2) actions.

   b EWA purchase amount increase to a maximum of 250 thousand acre-feet per year.

   c Addition of storage debt carryover accounting, including debt spill at San Luis Reservoir.

   d Addition of EWA asset takeover by SWP and CVP at San Luis Reservoir when reservoir space utilized by EWA is needed for project operations.

All studies assume current Banks Pumping Plant capacity, existing conveyance capacity of the upper Delta-Mendota Canal/California Aqueduct system, and current SWP/CVP operations agreements.

The following table is a complete list of the study assumptions.

Table A-1 2005 Delivery Reliability Report CalSim II Modeling Assumptions

	Study 1 2001 Study, 2003 Report	**Study 4** 2005 Study, Updated Studies	**Study 2** 2021A Study, 2003 Report	**Study 3** 2021B Study, 2003 Report	**Study 5** 2025 Study, Updated Studies
Period of Simulation	73 years (1922-1994)	Same	Same	Same	Same
HYDROLOGY					
Level of Development (Land Use)	2001 Level, DWR Bulletin 160-98[1]	Same as Study 1	2020 Level, DWR Bulletin 160-98	Same as Study 2	Same as Study 2
Demands					
North of Delta (except American River)					
CVP	Land Use based, limited by Full Contract	Same	Same	Same	Same
SWP (FRSA)	Land Use based, limited by Full Contract	Same	Same	Same	Same
Non-Project	Land Use based	Same	Same	Same	Same
CVP Refuges	Firm Level 2	Same	Same	Same	Same
American River Basin					
Water rights	20012	20013	20204	Same as Study 2	2020, as projected by Water Forum Analysis5
CVP	20012	20013	20206	Same as Study 2	2020, as projected by Water Forum Analysis7
San Joaquin River Basin					
Friant Unit	Regression of historical	Same	Same	Same	Same
Lower Basin	Fixed annual demands	Same	Same	Same	Same
Stanislaus River Basin	New Melones Interim Operations Plan	Same	Same	Same	Same

1 2000 Level of Development defined by linearly interpolated values from the 1995 Level of Development and 2020 Level of Development from DWR Bulletin 160-98

2 1998 level demands defined in Sacramento Water Forum's EIR with a few updated entries.

3 Presented in attached Table 2001 American River Demand Assumptions.

4 Sacramento Water Forum 2025 level demands defined in Sacramento Water Forum's EIR.

5 Presented in attached Table 2020 American River Demand Assumptions

6 Sacramento Water Forum 2025 level demands defined in Sacramento Water Forum's EIR. Freeport Alternative defined in EBMUD Supplemental Water Supply Project REIR/SEIS.

7 Same as footnote 5 but modified with PCWA 35 TAF CVP contract supply diverted at the new American River PCWA Pump Station

	Study 1 2001 Study, 2003 Report	**Study 4** 2005 Study, Updated Studies	**Study 2** 2021A Study, 2003 Report	**Study 3** 2021B Study, 2003 Report	**Study 5** 2025 Study, Updated Studies
South of Delta					
CVP	Full Contract	Same	Same	Same	Same
CCWD	143 TAF/YR[8]	124 TAF/YR[8]	151 TAF/YR[8]	Same as Study 2	158 TAF/YR[8]
SWP (w/ North Bay Aqueduct)	3.0-4.1 MAF/YR	2.3-3.9 MAF/YR	3.3-4.1 MAF/YR	4.1 MAF/YR	3.9-4.1 MAF/YR
SWP Article 21 Demand	MWDSC up to 50 TAF/month, Dec-Mar, others up to 84 TAF/month	MWDSC up to 100 TAF/month, Dec-Mar, others up to 84 TAF/month	Same as Study 1	Same as Study 1	Same as Study 4
FACILITIES					
Freeport Regional Water Project	None	Same as Study 1	Same as Study 1	Same as Study 1	Included[9]
Banks Pumping Capacity	6680 cfs	Same	Same	Same	Same
Tracy Pumping Capacity	4200 cfs + deliveries upstream of DMC constriction	Same	Same	Same	Same
REGULATORY STANDARDS					
Trinity River					
Minimum Flow below Lewiston Dam	Trinity EIS Preferred Alternative (369-815 TAF/YR)	369-453 TAF/YR	Same as Study 1	Same as Study 1	Same as Study 1
Trinity Reservoir End-of-September Minimum Storage	Trinity EIS Preferred Alternative (600 TAF as able)	Same	Same	Same	Same
Clear Creek					
Minimum Flow below Whiskeytown Dam	Downstream water rights, 1963 USBR Proposal to FWS and NPS, and FWS use of CVPIA 3406(b)(2) water	Same	Same	Same	Same
Upper Sacramento River					
Shasta Lake End-of-September Minimum Storage	SWRCB WR 1993 Winter-run Biological Opinion (1900 TAF)	Same	Same	Same	Same

8 Delta diversions include operations of Los Vaqueros Reservoir and represents average annual diversion

9 Includes modified EBMUD operations of the Mokelumne River

	Study 1 2001 Study, 2003 Report	**Study 4** 2005 Study, Updated Studies	**Study 2** 2021A Study, 2003 Report	**Study 3** 2021B Study, 2003 Report	**Study 5** 2025 Study, Updated Studies
Minimum Flow below Keswick Dam	Flows for SWRCB WR 90-5 and 1993 Winter-run Biological Opinion temperature control, and FWS use of CVPIA 3406(b)(2) water	Same	Same	Same	Same
Feather River					
Minimum Flow below Thermalito Diversion Dam	1983 DWR, DFG Agreement (600 CFS)	Same	Same	Same	Same
Minimum Flow below Thermalito Afterbay outlet	1983 DWR, DFG Agreement (750 – 1700 CFS)	Same	Same	Same	Same
American River					
Minimum Flow below Nimbus Dam	SWRCB D-893 (see accompanying Operations Criteria), and FWS use of CVPIA 3406(b)(2) water	Same	Same	Same	Same
Minimum Flow at H Street Bridge	SWRCB D-893	Same	Same	Same	Same
Lower Sacramento River					
Minimum Flow near Rio Vista	SWRCB D-1641	Same	Same	Same	Same
Mokelumne River					
Minimum Flow below Camanche Dam	FERC 2916-029, 1996 (Joint Settlement Agreement) (100 – 325 CFS)	Same	Same	Same	Same
Minimum Flow below Woodbridge Diversion Dam	FERC 2916-029, 1996 (Joint Settlement Agreement) (25 – 300 CFS)	Same	Same	Same	Same
Stanislaus River					
Minimum Flow below Goodwin Dam	1987 USBR, DFG agreement , and FWS use of CVPIA 3406(b)(2) water	Same	Same	Same	Same
Minimum Dissolved Oxygen	SWRCB D-1422	Same	Same	Same	Same

	Study 1 2001 Study, 2003 Report	Study 4 2005 Study, Updated Studies	Study 2 2021A Study, 2003 Report	Study 3 2021B Study, 2003 Report	Study 5 2025 Study, Updated Studies
Merced River					
Minimum Flow below Crocker-Huffman Diversion Dam	Davis-Grunsky (180 – 220 CFS, Nov – Mar), and Cowell Agreement	Same	Same	Same	Same
Minimum Flow at Shaffer Bridge	FERC 2179 (25 – 100 CFS)	Same	Same	Same	Same
Tuolumne River					
Minimum Flow at Lagrange Bridge	FERC 2299-024, 1995 (Settlement Agreement) (94 – 301 TAF/YR)	Same	Same	Same	Same
San Joaquin River					
Maximum Salinity near Vernalis	SWRCB D-1641	Same	Same	Same	Same
Minimum Flow near Vernalis	SWRCB D-1641, and Vernalis Adaptive Management Program per San Joaquin River Agreement	Same	Same	Same	Same
Sacramento River-San Joaquin River Delta					
Delta Outflow Index (Flow and Salinity)	SWRCB D-1641	Same	Same	Same	Same
Delta Cross Channel Gate Operation	SWRCB D-1641	Same	Same	Same	Same
Delta Exports	SWRCB D-1641, FWS use of CVPIA 3406(b)(2) water and CALFED Fisheries Agencies use of EWA assets	Same	Same	Same	Same
OPERATIONS CRITERIA					
Subsystem					
Upper Sacramento River					
Flow Objective for Navigation (Wilkins Slough)	3,500 – 5,000 CFS based on Lake Shasta storage condition	3,250 – 5,000 CFS based on CVP Ag	Same as Study 1	Same as Study 1	Same as Study 4
American River					
Folsom Dam Flood Control	SAFCA, Interim re-operation of	Same	Same	Same	Same

	Study 1 2001 Study, 2003 Report	Study 4 2005 Study, Updated Studies	Study 2 2021A Study, 2003 Report	Study 3 2021B Study, 2003 Report	Study 5 2025 Study, Updated Studies
	Folsom Dam, Variable 400/670 (without outlet modifications)				
Flow below Nimbus Dam	Operations criteria corresponding to SWRCB D-893 required minimum flow	Same	Same	Same	Same
Sacramento Water Forum Mitigation Water	None	Same as Study 1	Sacramento Water Forum (up to 47 TAF/YR in dry years)10	Same as Study 2	Same as Study 2
Feather River					
Flow at Mouth	No criteria	Maintain the DFG/DWR flow target above Verona or 2800 cfs for Apr– Sep dependent on Oroville inflow and FRSA allocation	Same as Study 1	Same as Study 1	Same as Study 4
Stanislaus River					
Flow below Goodwin Dam	1997 New Melones Interim Operations Plan	Same	Same	Same	Same
San Joaquin River					
Flow near Vernalis	San Joaquin River Agreement in support of the Vernalis Adaptive Management Program	Same	Same	Same	Same
System-wide					
CVP Water Allocation					
CVP Settlement and Exchange	100% (75% in Shasta Critical years)	Same	Same	Same	Same
CVP Refuges	100% (75% in Shasta Critical years)	Same	Same	Same	Same
CVP Agriculture	100% - 0% based on supply (reduced by 3406(b)(2) allocation)	Same	Same	Same	Same
CVP Municipal & Industrial	100% - 50% based on supply (reduced by 3406(b)(2) allocation)	Same	Same	Same	Same

10 This is implemented only in the PCWA Middle Fork Project releases used in defining the CalSim II inflows to Folsom Lake

	Study 1 2001 Study, 2003 Report	Study 4 2005 Study, Updated Studies	Study 2 2021A Study, 2003 Report	Study 3 2021B Study, 2003 Report	Study 5 2025 Study, Updated Studies
SWP Water Allocation					
North of Delta (FRSA)	Contract specific	Same	Same	Same	Same
South of Delta	Based on supply; Monterey Agreement	Same	Same	Same	Same
CVP/SWP Coordinated Operations					
Sharing of Responsibility for In-Basin-Use	1986 Coordinated Operations Agreement	Same	Same	Same	Same
Sharing of Surplus Flows	1986 Coordinated Operations Agreement	Same	Same	Same	Same
Sharing of Restricted Export Capacity	Equal sharing of export capacity under SWRCB D-1641; use of CVPIA 3406(b)(2) only restricts CVP exports; EWA use restricts CVP and/or SWP exports as directed by CALFED Fisheries Agencies	Same	Same	Same	Same
Transfers					
Dry Year Program	None	Same	Same	Same	Same
Phase 8	None	Same	Same	Same	Same
MWDSC/CVP Settlement Contractors	None	Same	Same	Same	Same
CVP/SWP Integration					
Dedicated Conveyance at Banks	None	Same	Same	Same	Same
NOD Accounting Adjustments	None	Same	Same	Same	Same
CVPIA 3406(b)(2)	May 2002 benchmark study assumptions	Dept of Interior 2003 Decision	Same as Study 1	Same as Study 1	Same as Study 4
Allocation	800 TAF/YR (600 TAF/YR in Shasta Critical years)	800 TAF/YR, 700 TAF/YR in 40-30-30 Dry Years, and 600 TAF/YR in 40-30-30 Critical years	Same as Study 1	Same as Study 1	Same as Study 4
Actions	AFRP flow objectives (Oct-Jan), CVP export reduction (Dec-Jan), 1995 WQCP (up to 450	1995 WQCP, Fish flow objectives (Oct-Jan), VAMP (Apr 15- May 16)	Same as Study 1	Same as Study 1	Same as Study 4

	Study 1 **2001 Study,** **2003 Report**	**Study 4** **2005 Study,** **Updated Studies**	**Study 2** **2021A Study,** **2003 Report**	**Study 3** **2021B Study,** **2003 Report**	**Study 5** **2025 Study,** **Updated Studies**
	TAF/YR), VAMP (Apr 15- May 16) CVP export restriction, Post (May 16-31) VAMP CVP export restriction, Ramping of CVP export (Jun), Pre (Apr 1-15) VAMP CVP export restriction, CVP export reduction (Feb-Mar), Additional Upstream Releases (Feb-Sep)	CVP export restriction, 3000 CFS CVP export limit in May and June (D1485 Striped Bass continuation), Post (May 16-31) VAMP CVP export restriction, Ramping of CVP export (Jun), Upstream Releases (Feb-Sep)			
Accounting adjustments per May 2003 Interior Decision	None	No limit on responsibility for non-discretionary D1641 requirements no Reset with the Storage metric and no Offset with the Release and Export metrics	Same as Study 1	Same as Study 1	Same as Study 4
CALFED Environmental Water Account					
Actions	Total exports restricted to 4,000 cfs, 1 wk/mon, Dec-Mar (wet year: 2 wk/mon), VAMP (Apr 15- May 16) export restriction, Pre (Apr 1-15) and Post (May 16-31) VAMP export restriction, Ramping of export (Jun)	Dec-Feb reduce total exports by 50 TAF/month relative to total exports without EWA; VAMP (Apr 15- May 16) export restriction on SWP; Post (May 16-31) VAMP export restriction on SWP and potentially on CVP if B2 Post-VAMP action is not taken; Ramping of exports (Jun)	Same as Study 1	Same as Study 1	Same as Study 4
Assets	50% of use of JPOD, 50% of any CVPIA 3406(b)(2) or ERP releases pumped by SWP, flexing of Delta Export/Inflow Ratio (not explicitly modeled), dedicated 500 CFS increase of Jul – Sep Banks PP capacity, north-of-Delta (35 TAF/Yr) and south-of-Delta purchases (50 – 200 TAF/Yr), 100 TAF/Yr from south-of-Delta source shifting agreements, and 200 TAF/YR south-of-Delta groundwater	Fixed Water Purchases 250 TAF/yr, 230 TAF/yr in 40-30-30 dry years, 210 TAF/yr in 40-30-30 critical years. The purchases range from 0 TAF in Wet Years to approximately 153 TAF in Critical Years NOD, and 57 TAF in Critical Years to 250 TAF in Wet Years SOD. Variable assets include the following: used of 50% JPOD export	Same as Study 1	Same as Study 1	Same as Study 4

	Study 1 2001 Study, 2003 Report	**Study 4** 2005 Study, Updated Studies	**Study 2** 2021A Study, 2003 Report	**Study 3** 2021B Study, 2003 Report	**Study 5** 2025 Study, Updated Studies
	storage capacity	capacity, acquisition of 50% of any CVPIA 3406(b)(2) releases pumped by SWP, flexing of Delta Export/Inflow Ratio (post-processed from CalSim II results), dedicated 500 CFS pumping capacity at Banks in Jul – Sep			
Debt restrictions	No planned carryover of debt past Sep, no reset of unpaid debt, debt carried past Sep paid back by Feb	Delivery debt paid back in full upon assessment; Storage debt paid back over time based on asset/action priorities; SOD and NOD debt carryover is allowed; SOD debt carryover is explicitly managed or spilled; NOD debt carryover must be spilled; SOD and NOD asset carryover is allowed.	Same as Study 1	Same as Study 1	Same as Study 4

Table A-2 2001 American River Demand Assumptions

Location / Purveyor	ALLOCATION TYPE (MAXIMUM)					
	CVP AG	CVP MI	CVP Settlement / Exchange	Water Rights / Non-CVP / No Cuts	CVP Refuge	Total
Auburn Dam Site (D300)						
Placer County Water Agency	0	0	0	8,500	0	8,500
Total	0	0	0	8,500	0	8,500
Folsom Reservoir (D8)						
Sacramento Suburban	0	0	0	0	0	0
City of Folsom (includes P.L. 101-514)	0	0	0	20,000	0	20,000
Folsom Prison	0	0	0	2,000	0	2,000
San Juan Water District (Placer County)	0	0	0	10,000	0	10,000
San Juan Water District (Sac County) (includes P.L. 101-514)	0	11,200	0	33,000	0	44,200
El Dorado Irrigation District	0	7,550	0	0	0	7,550
El Dorado Irrigation District (P.L. 101-514)	0	0	0	0	0	0
City of Roseville	0	32,000	0	0	0	32,000
Placer County Water Agency	0	0	0	0	0	0
Total	0	50,750	0	65,000	0	115,750
Folsom South Canal (D9)						
So. Cal WC/ Arden Cordova WC	0	0	0	3,500	0	3,500
California Parks and Recreation	0	100	0	0	0	100
SMUD (export)	0	0	0	15,000	0	15,000
South Sacramento County Agriculture (export, SMUD transfer)	0	0	0	0	0	0
Canal Losses	0	0	0	1,000	0	1,000
Total	0	100	0	19,500	0	19,600

Location / Purveyor	ALLOCATION TYPE (MAXIMUM)					
	CVP AG	CVP MI	CVP Settlement / Exchange	Water Rights / Non-CVP / No Cuts	CVP Refuge	Total
Nimbus to Mouth (D302)						
City of Sacramento	0	0	0	63,335	0	63,335
Arcade Water District	0	0	0	2,000	0	2,000
Carmichael Water District	0	0	0	8,000	0	8,000
Total	0	0	0	73,335	0	73,335
Sacramento River (D162)						
Placer County Water Agency	0	0	0	0	0	0
Total	0	0	0	0	0	0
Sacramento River (D167/D168)						
City of Sacramento	0	0	0	38,665	0	38,665
Sacramento County Water Agency (SMUD transfer)	0	0	0	0	0	0
Sacramento County Water Agency (P.L. 101-514)	0	0	0	0	0	0
EBMUD (export)	0	0	0	0	0	0
Total	0	0	0	38,665	0	38,665
Total from the American River	0	50,850	0	166,335	0	217,185

Table A-3 2020 American River Demand Assumptions

Location / Purveyor	ALLOCATION TYPE (MAXIMUM)						Folsom Unimpaired Inflow (FUI)			Notes
	CVP AG	CVP MI	CVP Settlement / Exchange	Water Rights / Non-CVP / No Cuts	CVP Refuge	Total	FUI = Total TAF (Mar – Sep) + 60 TAF			
Auburn Dam Site (D300)										
Placer County Water Agency	0	35,000	0	35,500	0	70,500	70,500	70,500	70,500	1/2/3/12
Total	**0**	**35,000**	**0**	**35,500**	**0**	**70,500**	**70,500**	**70,500**	**70,500**	
Folsom Reservoir (D8)										
Sacramento Suburban	0	0	0	29,000	0	29,000	29,000	0	0	4/5/11
City of Folsom (includes P.L. 101-514)	0	7,000	0	27,000	0	34,000	34,000	34,000	20,000	1/2/3
Folsom Prison	0	0	0	5,000	0	5,000	5,000	5,000	5,000	
San Juan Water District (Placer County)	0	0	0	25,000	0	25,000	25,000	25,000	10,000	1/2/3/11
San Juan Water District (Sac County) (includes P.L. 101-514)	0	24,200	0	33,000	0	57,200	57,200	57,200	44,200	1/2/3
El Dorado Irrigation District	0	7,550	0	17,000	0	24,550	24,550	24,550	22,550	1/2/3
El Dorado Irrigation District (P.L. 101-514)	0	7,500	0	0	0	7,500	7,500	7,500	0	1/2/3
City of Roseville	0	32,000	0	30,000	0	62,000	54,900	54,900	39,800	1/2/3/11/12
Placer County Water Agency	0	0	0	0	0	0	0	0	0	11
Total	**0**	**78,250**	**0**	**166,000**	**0**	**244,250**	**237,150**	**208,150**	**141,550**	
Folsom South Canal (D9)										
So. Cal WC/ Arden Cordova WC	0	0	0	5,000	0	5,000	5,000	5,000	5,000	
California Parks and Recreation	0	5,000	0	0	0	5,000	5,000	5,000	5,000	
SMUD (export)	0	15,000	0	15,000	0	30,000	30,000	30,000	15,000	1/2/3
South Sacramento County Agriculture (export, SMUD transfer)	0	0	0	0	0	0	0	0	0	1/2/3
Canal Losses	0	0	0	1,000	0	1,000	1,000	1,000	1,000	
Total	**0**	**20,000**	**0**	**21,000**	**0**	**41,000**	**41,000**	**41,000**	**26,000**	
Nimbus to Mouth (D302)										
City of Sacramento	0	0	0	96,300	0	96,300	96,300	96,300	50,000	6/7/8
Arcade Water District	0	0	0	11,200	0	11,200	11,200	11,200	3,500	13

Location / Purveyor	ALLOCATION TYPE (MAXIMUM)						Folsom Unimpaired Inflow (FUI)			Notes
	CVP AG	CVP MI	CVP Settlement / Exchange	Water Rights / Non-CVP / No Cuts	CVP Refuge	Total	FUI = Total TAF (Mar – Sep) + 60 TAF			
Carmichael Water District	0	0	0	12,000	0	12,000	12,000	12,000	12,000	
Total	**0**	**0**	**0**	**119,500**	**0**	**119,500**	**119,500**	**119,500**	**65,500**	
Sacramento River (D162)										
Placer County Water Agency	0	0	0	0	0	0	0	0	0	
Total	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	
Sacramento River (D167/D168)										
City of Sacramento	0	0	0	34,300	0	34,300	34,300	34,300	80,600	8
Sacramento County Water Agency (SMUD transfer)	0	30,000	0	0	0	30,000				10
Sacramento County Water Agency (P.L. 101-514)	0	15,000	0	0	0	15,000				10
EBMUD (export)	0	133,000	0	0	0	133,000				
Total	**0**	**178,000**	**0**	**34,300**	**0**	**212,300**	**34,300**	**34,300**	**80,600**	
Total demands from the American River	**0**	**133,250**	**0**	**342,000**	**0**	**475,250**	**468,150**	**439,150**	**303,550**	

Notes

1/ Wet/average years for this diverter are defined as those years when the projected March through November unimpaired inflow to Folsom Reservoir is greater than 950,000 af.

2/ Drier years for this diverter are defined as those years when the projected March through November unimpaired inflow to Folsom Reservoir is less than 950,000 af but greater than 400,000 af.

3/ Driest years for this diverter are defined as those years when the projected March through November unimpaired inflow to Folsom Reservoir is less than 400,000 af.

4/ Wet/average years for this diverter are defined as those years when the projected March through November unimpaired inflow to Folsom Reservoir is greater than 1,600,000 af.

5/ Drier years for this diverter are defined as those years when the projected March through November unimpaired inflow to Folsom Reservoir is less than 1,600,000 af.

6/ Wet/average years as it applies to the City of Sacramento are time periods when the flows bypassing the E. A. Fairbairn Water Treatment Plant diversion exceed the "Hodge flows."

7/ Drier years are time periods when the flows bypassing the City's E.A. Fairbairn Water Treatment Plant diversion do not exceed the "Hodge flows."

8/ For modeling purposes, it is assumed that the City of Sacramento's total annual diversions from the American and Sacramento River in year 2030 would be 130,600 af.

10/ The total demand for Sacramento County Water Agency would be up to 78,000 af. The 45,000 af represents firm entitlements; the additional 33,000 af of demand is expected to be met by intermittent surplus supply. The intermittent supply is subject to Reclamation reduction (50%) in dry years.

11/ Water Rights Water provided by releases from PCWA's Middle Fork Project; inputs into upper American River model must be consistent with these assumptions.

12/ Demand requires "Replacement Water" as indicated below

13/ Arcade WD demand modeled as step function: one demand when FUI > 400, another demand when FUI < 400.

Appendix B. Results of Report Studies

A study to estimate the supply reliability of the State Water Project is done using a computer program that simulates the operation of the SWP on a monthly basis over a 73-year historical record of rainfall and runoff (1922–1994). The simulation model integrates all the relevant water resource components and calculates key water management parameters, such as:

- the amount of water released from reservoirs in the Sacramento-San Joaquin valleys,
- the amount of water required to maintain Delta water quality standards,
- the amount of water to be pumped from the Delta by the SWP and the Central Valley Project (CVP), and
- the amount of water that can be delivered by each of these projects.

The information required to run the simulation is referred to as the “model input.” The most significant categories of input are:

- the physical description of the water system facilities (maximum pumping or release capacity, maximum reservoir storages, etc.);
- institutional requirements (delivery contract requirements, Delta water quality standards, the operations agreement between the SWP and CVP, endangered species requirements, and other requirements of federal and state laws, etc);
- hydrology (river and stream flows adjusted for water use in the source areas); and
- the level of SWP water demand.

CalSim II is the current version of the computer simulation model used to estimate SWP delivery reliability. All versions of CalSim employ commercially available linear programming software as a solution device. The application of the software, graphical user interface, and input/output devices are discussed in the documentation for CalSim.[11]

The model studies selected for this report answer two questions.

1 “What is the estimated current delivery reliability of the SWP?” and

2 “What is the estimate for SWP deliveries in the year 2025, if there were no new facilities or improvements to existing facilities, SWP water demand increased, and the institutional requirements existing today were in place?”

Depending upon a person’s expectation of what the future holds, this estimate of SWP delivery capability could be viewed as either too low or too high. The estimate could be viewed as too low because the Department of Water Resources (DWR) is planning to have facilities in place by 2025 that will increase the reliability of the SWP. The estimate could be viewed as too high because there is the potential for exports to be required to be reduced to protect endangered Delta fish species.

The key study assumptions are shown in Table B-1 and listed in more detail in Chapter 4 and Appendix A. Additional discussions of these studies are on DWR’s Modeling Branch’s Website for the *SWP Delivery Reliability Report 2002* (DWR 2003) studies and on the US Bureau of Reclamation’s Website for Operations Criteria and Plan (OCAP) studies

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[11] CalSim documentation may be obtained through the DWR Modeling Branch’s website: http://modeling.water.ca.gov.

(http://modeling.water.ca.gov/hydro/studies/SWPReliability/index.html and http://www.usbr.gov/mp/cvo/ocap_page.html, respectively).

Table B-1 Key study assumptions

Study	Study name	Level of development (year)	SWP Table A demand (maf/year)	SWP Article 21 demand (taf/month)	Model version
SWP Delivery Reliability Report (2003)					
1	2001 Study	2001	3.0–4.1	0–84, Apr–Nov 50–134, Dec–Mar	May 2002 benchmark
2	2021A Study	2021	3.3–4.1	0–84, Apr–Nov 50–134, Dec–Mar	May 2002 benchmark
3	2021B Study	2021	4.1	0–84, Apr–Nov 50–134, Dec–Mar	May 2002 benchmark
Updated Studies					
4	2005 Study	2005	2.3–3.9	0–84, Apr–Nov 100–184, Dec–Mar	2004 OCAP
5	2025 Study	2025	3.9–4.1	0–84, Apr–Nov 100–184, Dec–Mar	2004 OCAP

maf = million acre-feet

OCAP = 2004 Long-Term Central Valley Project Operations Criteria and Plan

taf = thousand acre-feet

Study Results

The annual delivery amounts calculated by the supply reliability studies are contained in Tables B-3 through B-7 at the back of this appendix. The tables show the demand level in thousand acre-feet (taf), the amount of delivery from the Delta, and percent of full Delta Table A calculated for each year of simulation for the five studies. Delta Table A refers to the total of the Table A amounts for each of the SWP contractors receiving water from the Delta. Of the 29 SWP contractors, 26 receive their deliveries from the Delta. The total maximum Table A amount for all SWP contractors is 4.173 maf/year. Of this amount, 4.133 maf/yr is the maximum Delta Table A amount.

To simplify the use of this report, the calculation of delivery in percent of full Delta Table A is based on the maximum Delta Table A total of 4.133 maf for all five studies. The demands for studies 1 and 4 were developed assuming slightly earlier conditions when the maximum Delta Table A amounts totaled slightly less than 4.133 maf (4.114 maf and 4.112 maf, respectively). To show the effect of these minor differences in Table A totals, the annual deliveries in percent of full Delta Table A for study 1 (Table B-3) are calculated with the earlier Delta Table A total of 4.114 maf and also with the maximum Delta Table A total of 4.133 maf. Similarly, study 4 results in Table B-6 are calculated with the earlier and maximum Delta Table A totals. The tables show that most years have the same delivery percentage for both Table A totals.

These values must be interpreted within the confines of the assumptions upon which they are calculated. For example, for the year 1958 in study 5, the annual delivery is calculated to be 4,133 taf or 100 percent of maximum Delta Table A (see Table B-7). This result should be stated as follows:

> If the rainfall were the same as it was in 1958 but (1) the level of water use in the source area was increased to the level it would be in 2025; (2) SWP facilities and operation requirements were the same as they are today; and (3) SWP contractor demands were at their maximum Delta Table A level, the SWP would deliver approximately 4,133 taf or 100 percent of the maximum Delta Table A.

Actually, the conditional statement associated with the result for any particular year is even more complicated than this because the result is also dependent upon the rainfall that has occurred in previous years. For example, if the previous year (1957) were wet, runoff for 1958 for the same amount of rainfall would be greater than if 1957 were dry. In addition, reservoir storage for the beginning of 1958 would vary depending upon the weather conditions in 1957. This linkage makes each year's simulation dependent on the previous year's and, hence, links the entire historical series.

Table B-2 contains a summary of the delivery estimates for the SWP for important dry periods in history computed by the studies. Studies 4 and 5 were selected to represent the estimated 2005 and 2025 deliveries, respectively. This information can be helpful in analyzing the delivery reliability of a specific water system that receives a portion of its water supply from the SWP. The series of data contained in Tables B-3 through B-7 are also helpful in analyzing longer periods of time that contain not only dry periods but wetter periods, which can replenish water supplies.

Finally, to help analyze the chance of receiving a given level of delivery in any particular year, a probability distribution curve is useful. It simply shows the percent of the years the annual delivery estimate is at or above a given value. The probability distribution curves for the five studies are included as figures B-1 and B-2. For example, for study 5 (Figure B-2), the curve indicates that in 75 percent of the years, the annual delivery reliability is estimated to be at or above 65 percent of the maximum Delta Table A amount or 2.70 maf. Similarly, annual delivery reliability during 50 percent of the years is estimated to be at or above 85 percent of the maximum Delta Table A or 3.50 maf. The curve also shows that in 25 percent of the years, annual delivery reliability is estimated to be at 100 percent of the maximum Delta Table A.

Table B-2 SWP average and dry year Table A delivery from the Delta for studies 4 and 5

Year	SWP Table A delivery from the Delta (in percent of maximum Table A)					
	Average 1922-1994	Single dry year 1977	2-year drought 1976-1977	4-year drought 1931-1934	6-year drought 1987-1992	6-year drought 1929-1934
2005	68%	4%	41%	32%	42%	37%
2025	77%	5%	40%	33%	42%	38%

Table B-3 SWP Water Delivery from the Delta for Study 1 (taf)

Year	Model variable Table A demand	Model Table A delivery	Percent of maximum Table A - 4.114 maf	Percent of future maximum Table A - 4.133 maf	Model Article 21 supply
1922	3,407	3,389	82%	82%	175
1923	3,717	3,727	91%	90%	143
1924	3,961	1,014	25%	25%	0
1925	3,940	1,502	36%	36%	0
1926	3,777	2,951	72%	71%	0
1927	3,543	3,504	85%	85%	220
1928	3,897	3,337	81%	81%	155
1929	3,952	1,037	25%	25%	0
1930	3,922	2,697	66%	65%	92
1931	3,971	1,141	28%	28%	0
1932	3,673	1,620	39%	39%	199
1933	3,939	1,663	40%	40%	134
1934	3,981	1,689	41%	41%	0
1935	3,697	3,439	84%	83%	81
1936	3,769	3,638	88%	88%	0
1937	3,451	3,297	80%	80%	87
1938	3,418	3,439	84%	83%	470
1939	3,673	3,475	84%	84%	227
1940	3,713	3,544	86%	86%	102
1941	3,013	3,036	74%	73%	100
1942	3,583	3,599	87%	87%	513
1943	3,632	3,545	86%	86%	447
1944	3,563	3,449	84%	83%	0
1945	3,613	3,479	85%	84%	136
1946	3,710	3,724	91%	90%	3
1947	3,954	2,653	64%	64%	0
1948	3,959	2,681	65%	65%	2
1949	3,864	2,568	62%	62%	2
1950	3,812	2,909	71%	70%	0
1951	3,779	3,794	92%	92%	311
1952	3,078	3,108	76%	75%	103
1953	3,790	3,801	92%	92%	272
1954	3,833	3,803	92%	92%	98
1955	3,761	1,694	41%	41%	0
1956	3,639	3,649	89%	88%	261
1957	3,759	3,331	81%	81%	96
1958	3,481	3,492	85%	84%	441
1959	4,055	3,506	85%	85%	265
1960	4,114	1,795	44%	43%	0
1961	4,114	2,873	70%	70%	0
1962	3,689	3,158	77%	76%	21
1963	3,634	3,630	88%	88%	223
1964	3,907	3,262	79%	79%	5
1965	3,586	3,256	79%	79%	98
1966	3,722	3,731	91%	90%	147
1967	3,439	3,424	83%	83%	497
1968	3,792	3,548	86%	86%	402
1969	3,157	3,151	77%	76%	100
1970	3,714	3,727	91%	90%	406
1971	3,837	3,845	93%	93%	0
1972	4,012	3,057	74%	74%	2
1973	3,611	3,592	87%	87%	261
1974	3,650	3,664	89%	89%	297
1975	3,720	3,737	91%	90%	415
1976	4,014	3,150	77%	76%	110
1977	3,948	804	20%	19%	0
1978	3,126	3,036	74%	73%	100
1979	3,527	3,509	85%	85%	140
1980	3,197	3,208	78%	78%	100
1981	3,834	3,532	86%	85%	124
1982	3,451	3,471	84%	84%	386
1983	3,007	3,036	74%	73%	200
1984	3,692	3,706	90%	90%	408
1985	3,753	3,540	86%	86%	0
1986	3,345	3,023	73%	73%	51
1987	3,905	2,894	70%	70%	0
1988	4,026	968	24%	23%	0
1989	4,097	2,903	71%	70%	0
1990	3,961	1,101	27%	27%	0
1991	3,957	983	24%	24%	0
1992	3,880	1,199	29%	29%	0
1993	3,559	3,505	85%	85%	133
1994	3,739	3,272	80%	79%	9
Average	3,712	2,962	72%	72%	134
Maximum	4,114	3,845	93%	93%	513
Minimum	3,007	804	20%	19%	0

Table B-4 SWP Water Delivery from the Delta for Study 2 (taf)

Year	Model variable Table A demand	Model Table A delivery	Percent of maximum Table A - 4.133 maf	Model Article 21 supply
1922	4,133	4,043	98%	0
1923	4,133	3,670	89%	0
1924	3,980	972	24%	0
1925	4,133	1,445	35%	0
1926	4,133	2,856	69%	113
1927	4,133	4,032	98%	124
1928	4,133	3,255	79%	3
1929	3,971	1,070	26%	0
1930	4,133	2,734	66%	27
1931	4,133	1,086	26%	0
1932	4,116	1,855	45%	39
1933	4,133	1,966	48%	6
1934	4,133	1,564	38%	0
1935	3,907	3,562	86%	59
1936	4,133	3,655	88%	5
1937	4,133	3,189	77%	65
1938	4,133	4,128	100%	192
1939	3,948	3,443	83%	1
1940	4,133	3,856	93%	22
1941	3,481	3,472	84%	0
1942	3,881	3,894	94%	378
1943	4,120	3,591	87%	375
1944	3,711	3,443	83%	2
1945	3,948	3,574	86%	123
1946	3,969	3,772	91%	0
1947	3,973	2,602	63%	0
1948	4,133	2,587	63%	2
1949	3,996	2,656	64%	0
1950	4,133	2,895	70%	0
1951	4,094	3,994	97%	230
1952	3,510	3,538	86%	100
1953	4,063	3,989	97%	236
1954	4,133	3,830	93%	6
1955	3,995	1,735	42%	0
1956	4,133	4,127	100%	129
1957	4,029	3,069	74%	3
1958	3,942	3,910	95%	335
1959	4,133	3,477	84%	167
1960	4,133	2,021	49%	0
1961	4,133	2,815	68%	0
1962	3,933	3,153	76%	2
1963	4,133	4,046	98%	134
1964	4,030	3,050	74%	0
1965	3,966	3,234	78%	3
1966	4,046	3,844	93%	61
1967	4,033	3,979	96%	167
1968	4,128	3,583	87%	398
1969	3,583	3,556	86%	93
1970	4,004	3,929	95%	398
1971	4,133	4,082	99%	0
1972	4,133	2,727	66%	0
1973	4,119	3,699	89%	211
1974	4,090	4,107	99%	147
1975	4,113	4,088	99%	209
1976	4,032	2,789	67%	0
1977	4,133	830	20%	0
1978	3,898	3,706	90%	100
1979	4,133	3,512	85%	89
1980	3,751	3,462	84%	74
1981	4,133	3,400	82%	0
1982	4,009	4,027	97%	101
1983	3,343	3,370	82%	200
1984	4,061	4,079	99%	379
1985	3,905	3,326	80%	0
1986	3,898	3,011	73%	52
1987	3,923	2,837	69%	0
1988	4,045	992	24%	0
1989	4,133	2,895	70%	0
1990	4,133	1,151	28%	0
1991	4,133	999	24%	0
1992	4,133	1,155	28%	0
1993	4,133	4,018	97%	156
1994	4,133	3,042	74%	0
Average	4,026	3,083	75%	78
Maximum	4,133	4,128	100%	398
Minimum	3,343	830	20%	0

Table B-5 SWP Water Delivery from the Delta for Study 3 (taf)

Year	Model fixed Table A demand	Model Table A delivery	Percent of maximum Table A - 4.133 maf	Model Article 21 supply
1922	4,133	4,043	98%	0
1923	4,133	3,670	89%	0
1924	4,133	972	24%	0
1925	4,133	1,446	35%	0
1926	4,133	2,856	69%	113
1927	4,133	4,031	98%	124
1928	4,133	3,255	79%	3
1929	4,133	1,070	26%	0
1930	4,133	2,734	66%	27
1931	4,133	1,086	26%	0
1932	4,133	1,855	45%	39
1933	4,133	1,967	48%	6
1934	4,133	1,564	38%	0
1935	4,133	3,729	90%	59
1936	4,133	3,669	89%	0
1937	4,133	3,165	77%	71
1938	4,133	4,129	100%	197
1939	4,133	3,444	83%	1
1940	4,133	3,856	93%	22
1941	4,133	4,084	99%	0
1942	4,133	4,122	100%	75
1943	4,133	3,584	87%	318
1944	4,133	3,465	84%	3
1945	4,133	3,547	86%	123
1946	4,133	3,801	92%	0
1947	4,133	2,597	63%	0
1948	4,133	2,586	63%	2
1949	4,133	2,654	64%	0
1950	4,133	2,893	70%	0
1951	4,133	3,996	97%	222
1952	4,133	4,133	100%	14
1953	4,133	3,931	95%	244
1954	4,133	3,860	93%	33
1955	4,133	1,779	43%	0
1956	4,133	4,126	100%	111
1957	4,133	3,067	74%	3
1958	4,133	4,063	98%	306
1959	4,133	3,467	84%	97
1960	4,133	2,007	49%	0
1961	4,133	2,818	68%	0
1962	4,133	3,153	76%	2
1963	4,133	4,046	98%	134
1964	4,133	3,050	74%	0
1965	4,133	3,233	78%	3
1966	4,133	3,853	93%	56
1967	4,133	4,069	98%	115
1968	4,133	3,584	87%	398
1969	4,133	4,078	99%	13
1970	4,133	3,933	95%	358
1971	4,133	4,082	99%	0
1972	4,133	2,725	66%	0
1973	4,133	3,699	89%	211
1974	4,133	4,133	100%	143
1975	4,133	4,102	99%	211
1976	4,133	2,775	67%	0
1977	4,133	830	20%	0
1978	4,133	3,915	95%	100
1979	4,133	3,493	85%	98
1980	4,133	3,465	84%	75
1981	4,133	3,387	82%	0
1982	4,133	4,133	100%	63
1983	4,133	4,133	100%	160
1984	4,133	4,101	99%	369
1985	4,133	3,322	80%	0
1986	4,133	3,006	73%	62
1987	4,133	2,835	69%	0
1988	4,133	993	24%	0
1989	4,133	2,895	70%	0
1990	4,133	1,151	28%	0
1991	4,133	999	24%	0
1992	4,133	1,155	28%	0
1993	4,133	4,018	97%	156
1994	4,133	3,042	74%	0
Average	4,133	3,130	76%	68
Maximum	4,133	4,133	100%	398
Minimum	4,133	830	20%	0

Table B-6 SWP water delivery from the Delta for Study 4 (taf)

Year	Model variable Table A demand	Model Table A delivery	Percent of maximum Table A - 4.112 maf	Percent of future maximum Table A - 4.133 maf	Model Article 21 supply
1922	3,750	3,743	91%	91%	104
1923	3,251	3,251	79%	79%	106
1924	3,489	1,244	30%	30%	0
1925	3,353	1,870	45%	45%	0
1926	3,393	2,981	72%	72%	54
1927	3,860	3,845	93%	93%	213
1928	3,458	3,384	82%	82%	134
1929	2,907	1,108	27%	27%	0
1930	3,326	2,855	69%	69%	117
1931	2,933	1,018	25%	25%	0
1932	3,139	1,406	34%	34%	242
1933	3,427	1,330	32%	32%	512
1934	3,470	1,541	37%	37%	206
1935	3,798	3,769	92%	91%	229
1936	3,596	3,573	87%	86%	0
1937	3,492	3,362	82%	81%	80
1938	3,344	3,344	81%	81%	714
1939	3,262	3,262	79%	79%	349
1940	3,239	3,219	78%	78%	154
1941	2,526	2,527	61%	61%	246
1942	3,167	3,167	77%	77%	918
1943	3,104	3,104	75%	75%	623
1944	3,090	3,091	75%	75%	0
1945	3,112	3,101	75%	75%	359
1946	3,215	3,215	78%	78%	249
1947	3,422	3,292	80%	80%	0
1948	3,395	2,942	72%	71%	0
1949	3,313	2,264	55%	55%	0
1950	3,465	3,199	78%	77%	0
1951	3,497	3,497	85%	85%	388
1952	2,585	2,588	63%	63%	275
1953	3,323	3,323	81%	80%	513
1954	3,294	3,294	80%	80%	523
1955	3,228	2,207	54%	53%	0
1956	3,581	3,586	87%	87%	324
1957	3,235	3,235	79%	78%	257
1958	2,980	2,980	72%	72%	1,106
1959	3,547	3,480	85%	84%	366
1960	3,555	1,865	45%	45%	0
1961	3,580	2,659	65%	64%	97
1962	3,690	3,262	79%	79%	0
1963	3,823	3,818	93%	92%	202
1964	3,492	3,323	81%	80%	0
1965	3,059	3,059	74%	74%	177
1966	3,282	3,282	80%	79%	518
1967	2,950	2,946	72%	71%	923
1968	3,324	3,329	81%	81%	552
1969	2,636	2,632	64%	64%	275
1970	3,257	3,257	79%	79%	552
1971	3,341	3,341	81%	81%	0
1972	3,457	3,342	81%	81%	414
1973	3,097	3,092	75%	75%	384
1974	3,184	3,184	77%	77%	854
1975	3,229	3,229	79%	78%	903
1976	3,471	3,265	79%	79%	189
1977	3,421	159	4%	4%	0
1978	3,623	3,603	88%	87%	300
1979	3,512	3,501	85%	85%	160
1980	2,715	2,709	66%	66%	138
1981	3,358	3,358	82%	81%	546
1982	2,890	2,890	70%	70%	801
1983	2,497	2,498	61%	60%	400
1984	3,227	2,766	67%	67%	552
1985	3,214	3,214	78%	78%	0
1986	2,321	2,297	56%	56%	120
1987	2,896	2,896	70%	70%	546
1988	2,967	856	21%	21%	0
1989	3,551	3,174	77%	77%	0
1990	3,628	1,099	27%	27%	0
1991	3,425	1,052	26%	25%	0
1992	3,366	1,426	35%	34%	0
1993	3,862	3,848	94%	93%	159
1994	3,689	3,306	80%	80%	0
Average	3,290	2,818	69%	68%	262
Maximum	3,862	3,848	94%	93%	1,106
Minimum	2,321	159	4%	4%	0

Table B-7 SWP water delivery from the Delta for Study 5 (taf)

Year	Model variable Table A demand	Model Table A delivery	Percent of maximum Table A -4.133 maf	Model Article 21 supply
1922	4,133	4,133	100%	21
1923	4,133	4,133	100%	0
1924	4,133	382	9%	0
1925	4,133	1,491	36%	190
1926	4,133	2,721	66%	279
1927	4,133	4,133	100%	301
1928	4,133	3,379	82%	0
1929	4,133	1,118	27%	0
1930	4,133	2,738	66%	141
1931	4,133	1,072	26%	0
1932	4,133	1,572	38%	112
1933	4,133	1,337	32%	547
1934	4,133	1,471	36%	242
1935	4,133	4,061	98%	218
1936	4,133	3,729	90%	0
1937	4,133	3,369	82%	70
1938	4,133	4,133	100%	200
1939	4,133	3,450	83%	0
1940	4,133	4,116	100%	114
1941	3,898	3,908	95%	0
1942	4,133	4,133	100%	123
1943	4,133	3,787	92%	487
1944	4,133	3,542	86%	0
1945	4,133	3,889	94%	118
1946	4,133	3,828	93%	0
1947	4,133	2,771	67%	0
1948	4,133	2,940	71%	0
1949	4,133	2,025	49%	0
1950	4,133	3,400	82%	0
1951	4,133	4,133	100%	252
1952	3,898	3,912	95%	0
1953	4,133	4,133	100%	296
1954	4,133	4,133	100%	0
1955	4,133	1,505	36%	0
1956	4,133	4,133	100%	352
1957	4,133	3,565	86%	0
1958	4,133	4,133	100%	229
1959	4,133	3,787	92%	107
1960	4,133	1,607	39%	0
1961	4,133	2,712	66%	299
1962	4,133	3,311	80%	1
1963	4,133	4,133	100%	161
1964	4,133	2,889	70%	0
1965	4,133	3,465	84%	47
1966	4,133	4,133	100%	178
1967	4,133	4,133	100%	157
1968	4,133	3,797	92%	465
1969	3,898	3,910	95%	63
1970	4,133	4,122	100%	493
1971	4,133	4,133	100%	0
1972	4,133	2,721	66%	0
1973	4,133	4,032	98%	259
1974	4,133	4,133	100%	69
1975	4,133	4,133	100%	134
1976	4,133	3,137	76%	0
1977	4,133	187	5%	0
1978	3,898	3,902	94%	300
1979	4,133	3,773	91%	144
1980	3,898	3,513	85%	86
1981	4,133	3,797	92%	71
1982	4,133	4,133	100%	171
1983	3,898	3,909	95%	357
1984	4,133	4,133	100%	490
1985	4,133	3,413	83%	0
1986	3,898	2,857	69%	83
1987	4,133	3,307	80%	183
1988	4,133	423	10%	0
1989	4,133	3,513	85%	91
1990	4,133	855	21%	0
1991	4,133	850	21%	0
1992	4,133	1,461	35%	102
1993	4,133	4,133	100%	255
1994	4,133	3,153	76%	0
Average	4,110	3,178	77%	124
Maximum	4,133	4,133	100%	547
Minimum	3,898	187	5%	0

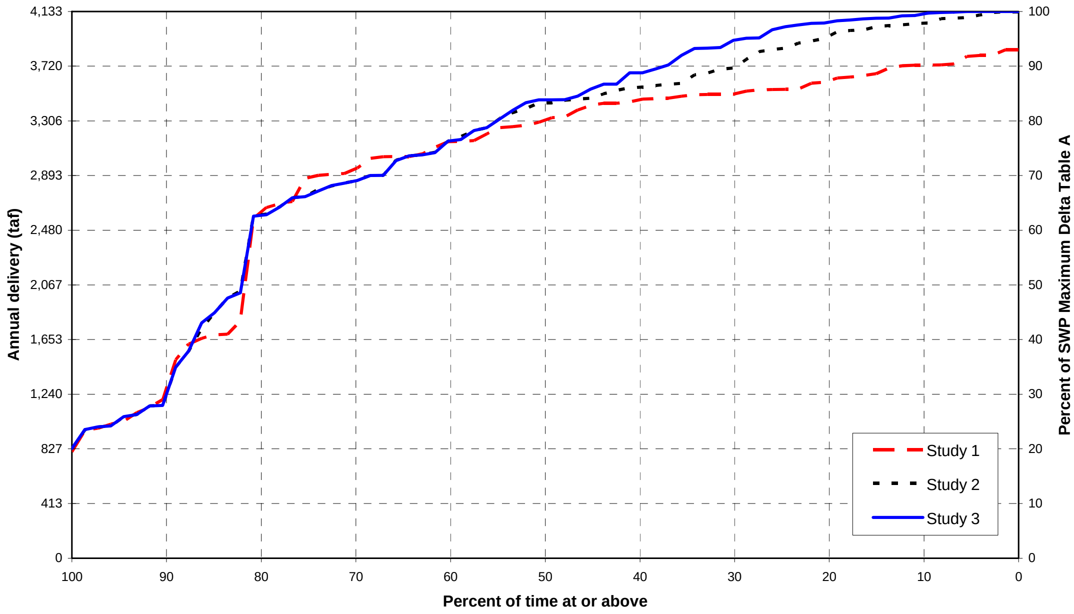

Figure B-1 SWP Delta Table A delivery probability for studies 1, 2 and 3

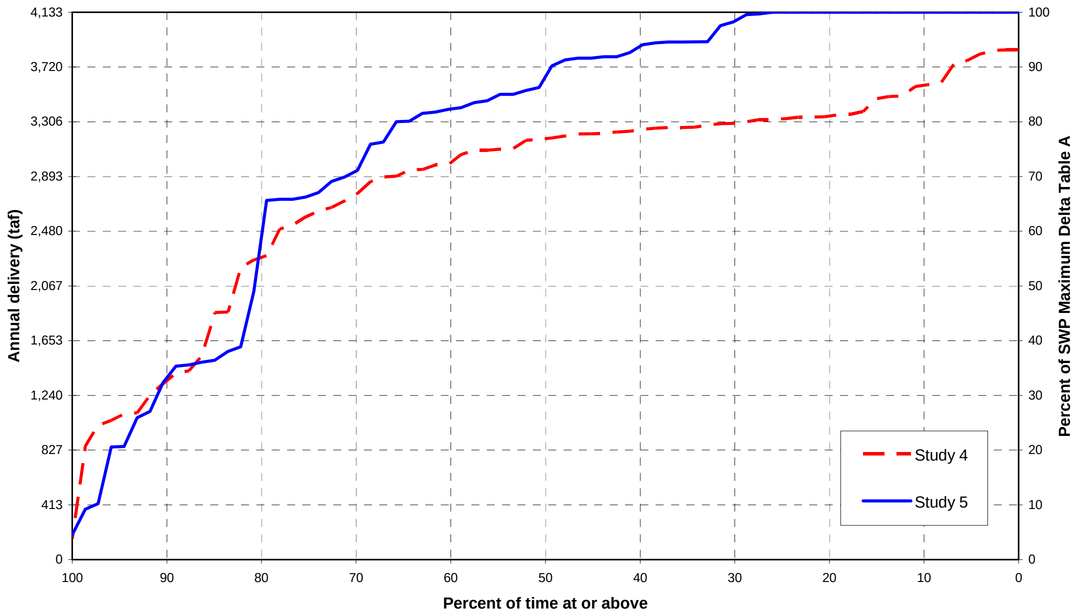

Figure B-2 SWP Delta Table A delivery probability for studies 4 and 5

Appendix C. State Water Project Table A Amounts

What is State Water Project Table A?

The contracts between the Department of Water Resources and the 29 State Water Project water contractors define the terms and conditions governing the water delivery and cost repayment for the SWP. Table A is an exhibit to these contracts. Comprehension of Table A is important in understanding the information in this report. To understand the table, it is necessary to understand how the contracts work.

All water-supply related costs of the SWP are paid by the contractors, and Table A serves as a basis for allocating some of the costs among the contractors. In addition, Table A plays a key role in the annual allocation of available supply among contractors. When the SWP was being planned, the amount of water projected to be available for delivery to the contractors was 4.2 million acre-feet (maf) per year. This was referred to as the minimum project yield, and it was recognized that in some years the project would be unable to deliver that amount and in other years project supply could exceed that amount. The 4.2 maf number was used as the basis for apportioning available supply to each contractor and as a factor in calculating each contractor's share of the project's costs. This apportionment is accomplished by Table A in each contract. Table A lists by year and acre-feet the portion of the 4.2 maf deliverable to each contractor. Other contract provisions permit changes to an individual contractor's Table A under special circumstances. The total of the maximums in all the contracts now equals 4.173 maf.

A copy of the consolidated Table A from all the contracts follows this explanation. The amounts listed in Table A cannot be viewed as an indication of the SWP water delivery reliability, nor should these amounts be used to support an expectation that a certain amount of water will be delivered to a contractor in any particular time span. Table A is simply a tool for apportioning available supply and cost obligations under the contract. In this report, reference to "Table A amounts" means the amounts listed in Table A. Contractors also receive other classifications of water from the project, as distinguished from Table A (for example, Article 21 water, and turnback pool water). These other contract provisions are discussed in Appendix D.

Table C-1 Maximum Annual SWP Table A Amounts

SWP Contractors	Maximum Table A
DELIVERED FROM THE DELTA	
North Bay	
Napa County FC&WCD	29,025
Solano County WA	47,756
Subtotal	**76,781**
South Bay	
Alameda County FC&WCD, Zone 7	80,619
Alameda County WD	42,000
Santa Clara Valley WD	100,000
Subtotal	**222,619**
San Joaquin Valley	
Oak Flat WD	5,700
County of Kings	9,305
Dudley Ridge WD	57,343
Empire West Side ID	3,000
Kern County WA	998,730
Tulare Lake Basin WSD	95,922
Subtotal	**1,170,000**
Central Coastal	
San Luis Obispo County FC&WCD	25,000
Santa Barbara County FC&WCD	45,486
Subtotal	**70,486**
Southern California	
Antelope Valley-East Kern WA	141,400
Castaic Lake WA	95,200
Coachella Valley WD	121,100
Crestline-Lake Arrowhead WA	5,800
Desert WA	50,000
Littlerock Creek ID	2,300
Mojave WA	75,800
Metropolitan WDSC	1,911,500
Palmdale WD	21,300
San Bernardino Valley MWD	102,600
San Gabriel Valley MWD	28,800
San Gorgonio Pass WA	17,300
Ventura County FCD	20,000
Subtotal	**2,593,100**
DELTA SUBTOTAL	**4,132,986**
Feather River	
County of Butte	27,500
Plumas County FC&WCD	2,700
City of Yuba City	9,600
Subtotal	**39,800**
GRAND TOTAL	**4,172,786**

Appendix D. Recent State Water Project Deliveries

SWP Contract Water Types

The State Water Project contracts define several classifications of water available for delivery to contractors under specific circumstances. All classifications are considered “project” water. Many contractors make frequent use of these additional water types to increase or decrease the amount available to them under Table A.

Table A Water

Each contract’s Table A is the amount in acre-feet that is used to determine the portion of available supply to be delivered to that contractor. Table A water is water delivered according to this apportionment methodology and is given first priority for delivery.

Article 21 Water

Article 21 of the contracts permits delivery of water excess to delivery of Table A and some other water types to those contractors requesting it. It is available under specific conditions discussed in Chapter 5. Article 21 water is apportioned to those contractors requesting it in the same proportion as their Table A.

Turnback Pool Water

Contractors may choose to offer their allocated Table A water excess to their needs to other contractors through two pools in February and March. Contributing contractors receive a reduction in charges, and taking contractors pay extra.

Carryover Water

Pursuant to the long-term water supply contracts, the Department of Water Resources (DWR) has offered contractors the opportunity to carry over a portion of their allocated water approved for delivery in the current year for delivery during the next year. The carryover program was designed to encourage the most effective and beneficial use of water and to avoid obligating the contractors to use or lose the water by December 31 of each year. The water supply contracts state the criteria of carrying over Table A water from one year to the next. Normally, carryover water is water that has been exported during the year, has not been delivered to the contractor during that year, and has remained stored in the SWP share of San Luis Reservoir to be delivered during the following year. Storage for carryover water no longer becomes available to the contractors if it interferes with storage of SWP water for project needs.

Updated Historical Deliveries

The tables in this appendix list annual historical deliveries by various water classifications for each contractor for 1995 through 2004. Similar delivery tables for years 1995 through 2002 are included in the *State Water Project Delivery Reliability Report 2002*. Amounts listed for these years are slightly different due to accounting adjustments made by DWR’s State Water Project Analysis Office.

1995

	Table A	Art. 21	Turnback	Carryover	Total
County of Butte	203				203
Plumas County FC&WCD	308				308
City of Yuba City	910				910
Napa County FC&WCD	5,182				5,182
Solano County WA	21,345				21,345
Alameda County FC&WCD, Zone 7	30,091				30,091
Alameda County WD	17,793				17,793
Santa Clara Valley WD	28,756				28,756
Oak Flat WD	5,169				5,169
County of Kings	4,000				4,000
Dudley Ridge WD	57,700			2,986	60,686
Empire West Side ID	957	106		568	1,631
Kern County WA	1,089,063	59,671		2,795	1,151,529
Tulare Lake Basin WSD	71,679	4,553		25,637	101,869
Antelope Valley-East Kern WA	47,286				47,286
Castaic Lake WA (+Rch 31A, 5 & 7)	25,660			1,573	27,233
Coachella Valley WD	23,100				23,100
Crestline-Lake Arrowhead WA	409				409
Desert WA	38,100				38,100
Littlerock Creek ID	480				480
Mojave WA	3,722				3,722
Metropolitan WDSC	396,600			19,442	416,042
Palmdale WD	6,961				6,961
San Bernardino Valley MWD	696				696
San Gabriel Valley MWD	12,922				12,922
Totals	**1,889,092**	**64,330**	**0**	**53,001**	**2,006,423**
Total South of Delta	**1,887,671**	**64,330**	**0**	**53,001**	**2,005,002**

1996

	Table A	Art. 21	Turnback	Carryover	Total
County of Butte	257				257
Plumas County FC&WCD	360				360
City of Yuba City	820				820
Napa County FC&WCD	4,893				4,893
Solano County WA	29,144			855	29,999
Alameda County FC&WCD, Zone 7	18,903				18,903
Alameda County WD	19,662				19,662
Santa Clara Valley WD	88,829			1,021	89,850
Oak Flat WD	4,904				4,904
County of Kings	4,000				4,000
Dudley Ridge WD	52,491	4,457			56,948
Empire West Side ID	1,371			497	1,868
Kern County WA	1,117,060	15,653		52,350	1,185,063
Tulare Lake Basin WSD	118,500	8,537	71,268	38,570	236,875
San Luis Obispo County FC&WCD	100				100
Antelope Valley-East Kern WA	56,356				56,356
Castaic Lake WA (+Rch 31A, 5 & 7)	32,500				32,500
Coachella Valley WD	23,100		39,119		62,219
Crestline-Lake Arrowhead WA	485				485
Desert WA	38,100		64,522		102,622
Littlerock Creek ID	494				494
Mojave WA	7,427				7,427
Metropolitan WDSC	553,259			40,121	593,380
Palmdale WD	11,434				11,434
San Bernardino Valley MWD	6,064				6,064
San Gabriel Valley MWD	15,989				15,989
Totals	**2,206,502**	**28,647**	**174,909**	**133,414**	**2,543,472**
Total South of Delta	**2,205,065**	**28,647**	**174,909**	**133,414**	**2,542,035**

1997

	Table A	Art. 21	Turnback	Carryover	Total
County of Butte	185				185
Plumas County FC&WCD	231				231
City of Yuba City	1,005				1,005
Napa County FC&WCD	4,341				4,341
Solano County WA	35,530				35,530
Alameda County FC&WCD, Zone 7	27,522				27,522
Alameda County WD	24,063				24,063
Santa Clara Valley WD	95,601				95,601
Oak Flat WD	5,238				5,238
Dudley Ridge WD	51,623	7,141	12,544		71,308
Kern County WA	1,092,543	10,264			1,102,807
Tulare Lake Basin WSD	21,156	1,213			22,369
San Luis Obispo County FC&WCD	1,199				1,199
Santa Barbara County FC&WCD	7,439				7,439
Antelope Valley-East Kern WA	61,752	641			62,393
Castaic Lake WA (+Rch 31A, 5 & 7)	27,712				27,712
Coachella Valley WD	23,100		35,000		58,100
Crestline-Lake Arrowhead WA	651				651
Desert WA	38,100		15,000		53,100
Littlerock Creek ID	444				444
Mojave WA	10,374				10,374
Metropolitan WDSC	738,990				738,990
Palmdale WD	11,861				11,861
San Bernardino Valley MWD	9,654				9,654
San Gabriel Valley MWD	16,002	2,173			18,175
Ventura County FCD	1,850				1,850
Totals	**2,308,166**	**21,432**	**62,544**	**0**	**2,392,142**
Total South of Delta	**2,306,745**	**21,432**	**62,544**	**0**	**2,390,721**

1998

	Table A	Art. 21	Turnback	Carryover	Total
County of Butte	527				527
City of Yuba City	1,054				1,054
Napa County FC&WCD	5,359				5,359
Solano County WA	21,377	9,982		407	31,766
Alameda County FC&WCD, Zone 7	17,941				17,941
Alameda County WD	19,075				19,075
Santa Clara Valley WD	62,526			884	63,410
Oak Flat WD	4,401				4,401
County of Kings	3	12			15
Dudley Ridge WD	52,919	984		1,747	55,650
Empire West Side ID				542	542
Kern County WA	856,906			1,684	858,590
Tulare Lake Basin WSD	11,367	9,310			20,677
San Luis Obispo County FC&WCD	3,592				3,592
Santa Barbara County FC&WCD	18,618				18,618
Antelope Valley-East Kern WA	52,926				52,926
Castaic Lake WA (+Rch 31A, 5 & 7)	20,093				20,093
Coachella Valley WD	23,100		55,000		78,100
Crestline-Lake Arrowhead WA	187				187
Desert WA	38,100		20,000		58,100
Littlerock Creek ID	404				404
Mojave WA	3,925				3,925
Metropolitan WDSC	359,213			33,672	392,885
Palmdale WD	8,752				8,752
San Bernardino Valley MWD	1,878				1,878
San Gabriel Valley MWD	9,310				9,310
Ventura County FCD	1,850				1,850
Totals	**1,595,403**	**20,288**	**75,000**	**38,936**	**1,729,627**
Total South of Delta	**1,593,822**	**20,288**	**75,000**	**38,936**	**1,728,046**

1999

	Table A	Art. 21	Turnback	Carryover	Total
County of Butte	286				286
City of Yuba City	1,096				1,096
Napa County FC&WCD	4,550	754			5,304
Solano County WA	37,753				37,753
Alameda County FC&WCD, Zone 7	46,000	2,910			48,910
Alameda County WD	34,871	2,781			37,652
Santa Clara Valley WD	67,465	15,480			82,945
Oak Flat WD	4,871				4,871
County of Kings	4,000				4,000
Dudley Ridge WD	51,870	4,990	6,566		63,426
Empire West Side ID	3,000	176			3,176
Kern County WA	1,077,755	58,241	42,154		1,178,150
Tulare Lake Basin WSD	118,500	49,898	121,337		289,735
San Luis Obispo County FC&WCD	3,743				3,743
Santa Barbara County FC&WCD	20,137				20,137
Antelope Valley-East Kern WA	69,073				69,073
Castaic Lake WA (+Rch 31A, 5 & 7)	32,899				32,899
Coachella Valley WD	23,100		27,380		50,480
Crestline-Lake Arrowhead WA	1,132				1,132
Desert WA	38,100		20,000		58,100
Littlerock Creek ID	342				342
Mojave WA	5,144				5,144
Metropolitan WDSC	829,777	22,840			852,617
Palmdale WD	13,278				13,278
San Bernardino Valley MWD	12,874				12,874
San Gabriel Valley MWD	18,000				18,000
Ventura County FCD	1,850				1,850
Totals	**2,521,466**	**158,070**	**217,437**	**0**	**2,896,973**
Total South of Delta	**2,520,084**	**158,070**	**217,437**	**0**	**2,895,591**

2000

	Table A	Art. 21	Turnback	Carryover	Total
County of Butte	586				586
City of Yuba City	901				901
Napa County FC&WCD	3,136	297		1,525	4,958
Solano County WA	32,882	1,040		1,417	35,339
Alameda County FC&WCD, Zone 7	53,877	3,740			57,617
Alameda County WD	33,598	2,380			35,978
Santa Clara Valley WD	70,433	18,381		13,174	101,988
Oak Flat WD	4,494			14	4,508
County of Kings	3,600				3,600
Dudley Ridge WD	38,673	7,454	12,193	2,884	61,204
Empire West Side ID	1,271	528			1,799
Kern County WA	825,856	78,908	233,202	13,193	1,151,159
Tulare Lake Basin WSD	98,595	56,818	27,073	15,827	198,313
San Luis Obispo County FC&WCD	3,962				3,962
Santa Barbara County FC&WCD	22,741				22,741
Antelope Valley-East Kern WA	83,577				83,577
Castaic Lake WA (+Rch 31A, 5 & 7)	40,680				40,680
Coachella Valley WD	20,790	17,820	3,713		42,323
Crestline-Lake Arrowhead WA	1,194				1,194
Desert WA	34,290	17,820	6,124		58,234
Mojave WA	9,135				9,135
Metropolitan WDSC	1,273,729	103,124		169,529	1,546,382
Palmdale WD	8,221			839	9,060
San Bernardino Valley MWD	18,399				18,399
San Gabriel Valley MWD	14,000	475			14,475
Ventura County FCD	4,050				4,050
Totals	**2,702,670**	**308,785**	**282,305**	**218,402**	**3,512,162**
Total South of Delta	**2,701,183**	**308,785**	**282,305**	**218,402**	**3,510,675**

2001

	Table A	Art. 21	Turnback	Carryover	Total
County of Butte	513				513
City of Yuba City	1,065				1,065
Napa County FC&WCD	4,293	996	82	1,723	7,094
Solano County WA	17,756	2,304		1,021	21,081
Alameda County FC&WCD, Zone 7	22,307		308	5,990	28,605
Alameda County WD	13,695	10	107	4,192	18,004
Santa Clara Valley WD	35,689			12,233	47,922
Oak Flat WD	2,089		22	101	2,212
County of Kings	1,560				1,560
Dudley Ridge WD	18,467	933	347	6,815	26,562
Empire West Side ID		253		1,107	1,360
Kern County WA	363,204	23,233	6,502	92,052	484,991
Tulare Lake Basin WSD	40,830	8,755	769	7,889	58,243
San Luis Obispo County FC&WCD	4,184		99		4,283
Santa Barbara County FC&WCD	14,285	396	296		14,977
Antelope Valley-East Kern WA	45,071		899		45,970
Castaic Lake WA (+Rch 31A, 5 & 7)	30,471	850	618		31,939
Coachella Valley WD	9,009		91		9,100
Crestline-Lake Arrowhead WA	1,057				1,057
Desert WA	14,859		151		15,010
Mojave WA	4,433				4,433
Metropolitan WDSC	686,545	10,415	7,949	200,000	904,909
Palmdale WD	8,170			2,257	10,427
San Bernardino Valley MWD	26,488				26,488
San Gabriel Valley MWD	6,534				6,534
Ventura County FCD	1,850				1,850
Totals	**1,374,424**	**48,145**	**18,240**	**335,380**	**1,776,189**
Total South of Delta	**1,372,846**	**48,145**	**18,240**	**335,380**	**1,774,611**

2002

	Table A	Art. 21	Turnback	Carryover	Total
County of Butte	419				419
City of Yuba City	1,181				1,181
Napa County FC&WCD	2,022	827	283	3,743	6,875
Solano County WA	28,223	2,242			30,465
Alameda County FC&WCD, Zone 7	40,707	1,484	556	8,113	50,860
Alameda County WD	24,250	83	862	2,331	27,526
Santa Clara Valley WD	55,896	202	2,053	3,311	61,462
Oak Flat WD	3,841	50	76	134	4,101
County of Kings	2,800		54		2,854
Dudley Ridge WD	38,688	1,861	1,177	1,994	43,720
Empire West Side ID	1,278	26		101	1,405
Kern County WA	670,884	21,951	20,543	15,680	729,058
Tulare Lake Basin WSD	73,785	3,749	2,289	5,385	85,208
San Luis Obispo County FC&WCD	4,355				4,355
Santa Barbara County FC&WCD	24,166	436	324	3,455	28,381
Antelope Valley-East Kern WA	53,907		1,008	3,256	58,171
Castaic Lake WA (+Rch 31A, 5 & 7)	61,880	280		6,657	68,817
Coachella Valley WD	16,170	111	474		16,755
Crestline-Lake Arrowhead WA	2,189				2,189
Desert WA	26,670	189	781		27,640
Mojave WA	4,346				4,346
Metropolitan WDSC	1,273,205	9,624	14,335	97,940	1,395,104
Palmdale WD	8,359		437		8,796
San Bernardino Valley MWD	68,268			3,801	72,069
San Gabriel Valley MWD	18,353			4,698	23,051
Ventura County FCD	4,998				4,998
Totals	**2,510,840**	**43,115**	**45,252**	**160,599**	**2,759,806**
Total South of Delta	**2,509,240**	**43,115**	**45,252**	**160,599**	**2,758,206**

2003

	Table A	Art. 21	Turnback	Carryover	Total
County of Butte	551				551
City of Yuba City	1,324				1,324
Napa County FC&WCD	6,026	376	180	1,055	7,637
Solano County WA	25,135	2,280		1,918	29,333
Alameda County FC&WCD, Zone 7	30,695		656	13,099	44,450
Alameda County WD	31,086		354	5,150	36,590
Santa Clara Valley WD	90,620	936	841	14,104	106,501
Oak Flat WD	4,059	19	48	140	4,266
County of Kings	3,600	58	34		3,692
Dudley Ridge WD	49,723	1,928	482	1,452	53,585
Empire West Side ID	1,074	175		187	1,436
Kern County WA	841,697	27,891	8,419	22,380	900,387
Tulare Lake Basin WSD	94,376	6,243	938	4,284	105,841
San Luis Obispo County FC&WCD	4,417	36			4,453
Santa Barbara County FC&WCD	24,312	339	43	2,274	26,968
Antelope Valley-East Kern WA	52,730		250	7,049	60,029
Castaic Lake WA (+Rch 31A, 5 & 7)	49,895	991	90	4,760	55,736
Coachella Valley WD	14,045	204	194		14,443
Crestline-Lake Arrowhead WA	1,563				1,563
Desert WA	23,168	330	321		23,819
Mojave WA	10,907			3,528	14,435
Metropolitan WDSC	1,550,356	17,622	16,920	134,845	1,719,743
Palmdale WD	9,701			1,846	11,547
San Bernardino Valley MWD	25,371	200		1,844	27,415
San Gabriel Valley MWD	13,034	200			13,234
San Gorgonio Pass WA	116				116
Ventura County FCD	5,000				5,000
Totals	**2,964,581**	**59,828**	**29,770**	**219,915**	**3,274,094**
Total South of Delta	**2,962,706**	**59,828**	**29,770**	**219,915**	**3,272,219**

2004

	Table A	Art. 21	Turnback	Carryover	Total
County of Butte	1,440				1,440
City of Yuba City	1,434				1,434
Napa County FC&WCD	5,030	1,450	52	1,602	8,134
Solano County WA	15,991	7,787		47	23,825
Alameda County FC&WCD, Zone 7	38,895			11,466	50,361
Alameda County WD	20,959		214	6,714	27,887
Santa Clara Valley WD	52,867	2,983	508		56,358
Oak Flat WD	4,324		29	276	4,629
County of Kings	5,850	3,157	46		9,053
Dudley Ridge WD	36,676	7,393	291	1,886	46,246
Empire West Side ID	1,310	626		1,626	3,562
Kern County WA	641,368	86,513	5,075	38,729	771,685
Tulare Lake Basin WSD	58,125	15,299	489	5,638	79,551
San Luis Obispo County FC&WCD	4,096	69			4,165
Santa Barbara County FC&WCD	29,358		122		29,480
Antelope Valley-East Kern WA	50,532			9,199	59,731
Castaic Lake WA (+Rch 31A, 5 & 7)	46,358	1,618		35,785	83,761
Coachella Valley WD	8,631		89	6,745	15,465
Crestline-Lake Arrowhead WA	2,006				2,006
Desert WA	9,966		102	11,122	21,190
Mojave WA	13,176				13,176
Metropolitan WDSC	1,195,807	91,601	10,223	215,000	1,512,631
Palmdale WD	10,549			1,613	12,162
San Bernardino Valley MWD	35,523			20,631	56,154
San Gabriel Valley MWD	15,600				15,600
San Gorgonio Pass WA	837				837
Ventura County FCD	5,250				5,250
Totals	**2,311,958**	**218,496**	**17,240**	**368,079**	**2,915,773**
Total South of Delta	**2,309,084**	**218,496**	**17,240**	**368,079**	**2,912,899**

Appendix E. Technical Memorandum Report Summaries: Historical SWP/CVP Operations Simulation and CalSim II Model Sensitivity Analysis

Study

This appendix presents summaries of the findings of the *CalSim II Simulation of Historical SWP/CVP Operations* and a *CalSim II Model Sensitivity Analysis Study*. The entire reports are available at the websites listed at the end of this appendix.

1. CalSim II Simulation of Historical SWP/CVP Operations Technical Memorandum Report

Objective of Study

The purpose of the Historical Operations Study is to evaluate the ability of CalSim II to represent CVP and SWP operations, in general, and the delivery capability of the projects, in particular, through the monthly simulation of recent historical conditions.

Study Description

The period of simulation for the Historical Operations Study is water years 1975 to 1998. This 24-year period includes the 1976-77 and 1987-92 droughts, as well as the driest (1977) and the wettest (1983) years on record. The version of CalSim II used for this study is the benchmark study dated 30 September 2002, but with some inputs changed to reflect the historically changing conditions rather than a fixed level of development. Model inflows correspond to the historical flow from gage records, or are estimated from a hydrologic mass balance, or stream-flow correlation. Land use-based demands are calculated for annual varying land use, as determined from DWR's land surveys and county commissioners' reports. The operational logic has been revised to reflect the changing regulatory environment. The historical regulations have been simplified into three periods:

- October 1974 – September 1992: represented by State Water Resources Control Board (SWRCB) Water Right Decision 1485 (D-1485),
- October 1992 – September 1994: represented by D-1485 and the 1993 National Marine Fisheries Service (NMFS) winter-run Chinook salmon biological opinion (minimum carryover storage in Lake Shasta, and temperature related minimum instream flows downstream of Keswick Reservoir),
- October 1994 – September 1998: represented by SWRCB Water Right Decision 1641 (D-1641) and the 1993 winter-run biological opinion.

The Historical Operations Study is limited in geographical scope to a dynamic operation of the Sacramento Valley, the Delta, and the CVP-SWP facilities south of the Delta. Delta inflows from the San Joaquin Valley and East Side streams are constrained to their historical values. Imports from the Trinity River system are similarly constrained.

Results and Discussion

The key performance measures in evaluating CalSim II are considered to be SWP and CVP deliveries, project storage operations, and stream flows. During the study period of water years 1975-1998, SWP demands were historically much lower than current or projected level of demands. Simulation of historically wet years, when the system was not supply constrained, may therefore be a poor indicator of the model's ability to accurately simulate future levels of development. Particular attention is therefore placed on model results during the six-year drought of 1987-1992. Results for four key performance parameters are summarized in the table below.

The table below shows that simulated SWP Table A and CVP south-of-Delta deliveries during the drought are less than historical values. Differences are, however, within 5 percent. Comparison of Sacramento Valley inflow to the Delta (flow at Freeport) is a good measure of how well the Sacramento Valley hydrology is simulated by CalSim II. Simulated Delta inflows are 0.3 percent greater than historical. Comparison of the Net Delta Outflow Index, a measure of how well the Sacramento-San Joaquin Delta is represented by CalSim II, appears favorable. Simulated values are 3.5 percent greater than historical during the 1987-1992 period. The table also shows that simulated long-term (1975-1998) average deliveries compare quite well and are within 7 percent of historical values.

	Dry-period average 1987-1992				Long-term average			
Performance parameter	Simulated	Historical taf/yr	Difference	%	Simulated	Historical taf/yr	Difference	%
SWP south-of-Delta Table A deliveries	1,930	2,030	-100	-4.9	1,810	1,790	20	1.1
CVP south-of-Delta deliveries	2,230	2,320	-90	-3.9	2,650	2,490	160	6.4
Sacramento Valley inflow to the Delta	9,700	9,670	30	0.3	19,830	19,920	-90	-0.5
Net Delta Outflow Index	5,270	5,090	180	3.5	19,070	19,690	-620	-3.1

The total volume of surface water to be held in storage or routed through the model network is the same as historical. Model inflows to the Delta can deviate from historical due to three reasons: storage regulation, groundwater pumping to supplement surface water diversions, and stream-aquifer interaction.

Differences in Delta inflows are primarily caused by differences in project storage regulation (i.e. Lake Shasta, Lake Oroville and Folsom Lake). Storage operations in CalSim II are driven by two sets of rule curves. The first set of rule curves determines how much of the available project water will be held as carryover storage and how much will be delivered to meet contractors' current-year demands. The second set of rule curves determines when and how-much water will be transferred from north of Delta storage to San Luis Reservoir. These two sets of rule curves are fixed throughout the period of simulation. The rule curves have been determined in prior simulations of CalSim II. They are subjective in nature, but balance the conflicting objectives to maximize long-term average annual deliveries, to maintain water deliveries during the critically dry period 1928-34, and to keep water levels in project reservoirs above minimum levels while meeting minimum flow requirements. Secondly, differences in Delta inflows are due to differences in upstream surface water diversions and return flows. The historical consumptive water demand must be met by the model. Differences in Delta inflow, after accounting for differences in upstream storage regulation, therefore reveal how well CalSim II matches the historical mix of surface water and groundwater to meet demands. Lastly inflows to the Delta are influenced by the stream-aquifer interaction.

For a given south-of-Delta demand and a given Delta inflow, differences in model and historical project exports are indicative of how well the model represents the regulatory operating constraints to which the projects must comply, and how the model simulates storage operations in the San Luis Reservoir.

Conclusions from the study can be framed in the form of answers to some frequently asked questions about CalSim II.

Does CalSim II overestimate the projects' ability to export water from the Delta?

For the supply constrained years 1987-1992, model exports from the Delta average 4,450 taf/yr compared to a historical six-year average of 4,460 taf/yr. This suggests that CalSim II's simulation of the Delta operations is representative of actual historical conditions.

Does CalSim II overestimate the availability of surface water in the Delta by meeting Sacramento Valley in-basin use through excessive groundwater pumping?

The mix of surface water and groundwater used by the model to meet Sacramento Valley consumptive demands depends primarily on project water allocation decisions and levels of minimum groundwater pumping that are specified in the model. Over the 24-year period average annual net groundwater extraction in CalSim II as compared to estimates based on the Central Valley Groundwater Surface water Model (CVGSM) is lower by 378 taf. The average annual net stream inflow from groundwater in CalSim II is 190 taf greater than estimated by the CVGSM for the same period. The combined effect of dynamically modeling groundwater operations in CalSim II (pumping, recharge and stream-aquifer interaction) leads to 188 taf/yr less water being available to the Delta. For the 1987-1992 period the combined effect results in 46 taf/yr additional water being available to the Delta.

How well does CalSim II represent stream flows?

Differences in long-term average annual flows at key stream locations are typically 1.2 percent or less. It is noted that differences are larger for the Sacramento River at the Ord Ferry gage. At this location a proportion of the water diverted upstream returns downstream so that simulated river flows are sensitive to assumed model water use efficiencies.

How well does CalSim II simulate the Sacramento Valley system?

The net Sacramento Valley accretion is calculated as the Sacramento Valley Delta inflow less releases from Whiskeytown Reservoir, Keswick Reservoir, Lake Oroville and Folsom Lake. The historical 24-year average annual net accretion is 5,950 taf/yr compared with a model value of 5,920 taf/yr.

Do different reservoir operating rules in CalSim II translate into differences in project deliveries?

Simulated month-to-month and year-to-year model results can vary significantly from historical operations. This is primarily due to differences in storage operations. However when averaged over a longer period, model operations (stream flows and deliveries) are very close to historical.

2. CalSim II Model Sensitivity Analysis Study Technical Memorandum Report

Background

The sensitivity analysis is an important component of any water resources planning model evaluation. It enhances understanding of the model, builds greater public confidence, and expands public acceptance of the model. The sensitivity analysis explores and quantifies the effects of various inputs on the model outputs. With a simple sensitivity analysis procedure, variations of model input parameters are generally investigated one at a time. With a more complex procedure, the investigation is conducted by changing a set of input parameters simultaneously. For this study, the simple sensitivity study procedure is used.

The *Sensitivity Analysis Study* responds to the commitment in *The State Water Project Delivery Reliability Report 2002* to conduct such a study and to issues raised during the public review of that report. The sensitivity analysis study is also one of the recommendations by the CalSim II peer review sponsored by the CALFED Science Program in December 2003. The review panel recommended such a study would help identify key input parameters that have significant effects on the model output, and to provide a systematic way to measure the sensitivity of the model output to variations of key input parameters.

Study Objectives

There are three objectives of the CalSim II Sensitivity Analysis Study:

- to examine the behavior of the SWP-CVP system performance in response to variations in selected input parameters within CalSim-II
- to help SWP contractors and others understand the impact of key assumptions within CalSim II on the SWP delivery capability
- to aid CalSim II modelers for prioritizing future model development activities on the basis of sensitivities of input parameters

Study Description

The development of the CalSim II model is an ongoing effort. DWR and Reclamation periodically release updated versions of the model. This study uses the modified benchmark study of September 30, 2002, under the D-1641 regulatory environment as the base study.

The CalSim II model uses many input parameters to define the physical characteristics of the system, as well as the regulatory environment and operational parameters. Input parameters include time series, single dimensionless coefficients, or monthly distribution curves. Some input parameters are estimated from the historical data and others are user-input or calibrated values. After discussions with model developers and project operators, 21 model input parameters in four major categories and their reasonable ranges of variations were selected for this study. Similarly, there are many output variables in different categories, including reservoir storage, flows at key locations, Delta outflows, project exports and deliveries that characterize the overall outcome of any particular simulation run. After discussions with model users, project operators, and model developers, 22 key output variables that cover various aspects of the SWP-CVP system performance were selected.

In this study, two performance measures – Sensitivity Index (SI) and Elasticity Index (EI) – are used to quantify the model output sensitivity with respect to a certain model input parameter. The SI is a first-order derivative of a model output variable with respect to an input parameter. It can be used to measure the magnitude of change in an output variable per unit change in the magnitude of an input parameter from its base value. The EI is a dimensionless expression of sensitivity that measures the relative change in an output variable to a relative change in an input parameter. As an example, assuming SI = 0.5 and EI = 0.25 for the output variable of total Delta outflow with respect to the input parameter of Oroville inflow, means that for one thousand acre-feet (taf) increase in Oroville inflow, total Delta outflow increases by 0.5 taf; and for 1 percent increase in Oroville inflow, total Delta outflow increases by 0.25 percent, respectively.

Study Results and Discussions

The complete results of the study showing sensitivity and elasticity indices for each one of the selected output variables are listed in terms of their long-term (1922–1994) averages with respect to variations of input parameters. Table E-1 highlights the behavior of some of the key output variables that define the important aspects of SWP–CVP system performance. In Table E-1, the top row is the list of model input parameters and the left-most column is the list of model output variables. In general, each cell in the table contains two numbers except cells in Columns 8 and 9.

The number inside parentheses is the SI value and the number outside parentheses is the EI value. Signs in front of SI and EI values can be either positive or negative. In general, the positive sign indicates that the output variable changes in the same direction as the input parameter. For example, as shown in the Row 1 of Column 1 in the table, when SWP Table A demand increases, SWP total delivery, which is the sum of SWP Delta delivery and FRSA delivery, increases as well (SI = +0.39). SWP Delta Delivery is defined as SWP Table A deliveries to South-of-Delta plus deliveries to North Bay (Solano and Napa Counties) contractors. FRSA delivery is defined as the sum of deliveries to the Settlement Contractors in Feather River Service Area (FRSA) and Table A deliveries to Butte and Yuba Counties. The negative sign indicates that the output variable changes in the opposite direction as the input parameter. For example, as shown in the Row 5 of Column 1 in the table, when SWP Table A demand increases, Article 21 delivery decreases (SI = -0.13). In order to highlight relative sensitivity of the various input parameters, a color coded cell background has been used. A red color cell background represents a relatively higher sensitivity or (SI >= 0.2); yellow background represents a moderate sensitivity or (0.1 <= SI <= 0.2); and white background shows a lower sensitivity or (SI <= 0.1).

An examination of Row 3 of Table E-1 highlights the behavior of SWP Delta delivery with respect to changes in some of the key input parameters. It shows that the SWP Table A demand, the Banks pumping limit, and the Oroville inflow affect SWP Delta delivery the most. Folsom inflow and historical land use display moderate effects on the SWP Delta delivery. A positive SI of 0.52 for the SWP Table A demand indicates that the SWP Delta delivery will increase by an average of 0.52 taf if the SWP Table A demand increases by 1 taf; and a positive EI of 0.55 for the SWP Table A demand indicates that the SWP Delta delivery will increase by an average of 0.55 percent if the SWP Table A demand increases by one percent. Similarly, a positive SI of 0.20 for the Oroville inflow indicates that the SWP Delta delivery will increase by an average of 0.20 taf if the Oroville inflow increases by 1 taf; and a positive EI of 0.26 for the Oroville inflow indicates that the SWP Delta delivery will increase by an average of 0.26 percent if the Oroville inflow increases by one percent.

No SI values are computed for input parameters of the SWP Delivery-Carryover Curve and the SWP San Luis Rule-curve (see Columns 8 and 9) because the equivalent changes in the commensurate units of taf are difficult to define for these two parameters. A more detailed discussion of their impact on the SWP Delta delivery is presented in the Memorandum Report.

Table E-1 Summary Excerpt of Elasticity Index (EI) and Sensitivity Index (SI) for Selected Variables

	Model Output Response	Model Input Parameters											
		SWP Table A Demand	Article 21 Demand	Banks Pumping Limit	Historical Land Use	Projected Land Use	Crop ET	Basin Efficiency	SWP Delivery-Carryover Curve	SWP San Luis Rule Curve	Shasta Inflow	Oroville Inflow	Folsom Inflow
		1	2	3	4	5	6	7	8	9	10	11	12
1	SWP Total Delivery	0.31 (0.39)[1]	0.01 (0.16)	0.15 (1.45)	0.09 (-0.13)	-0.05 (-0.03)		-0.15 (0.10)	-0.01	0.02	0.07 (0.05)	0.18 (0.19)	0.05 (0.14)
2	CVP total Delivery	-0.01 (-0.01)	[2]	-0.01 (-0.12)	0.10 (-0.18)	0.14 (0.11)	0.16 (0.09)	-0.32 (0.26)			0.25 (0.22)	0.05 (0.07)	0.03 (0.09)
3	SWP Delta Delivery	0.55 (0.52)	0.00 (-0.01)	0.07 (0.48)	0.12 (-0.13)	-0.09 (-0.04)	-0.21 (-0.08)	-0.17 (0.08)	-0.02		0.08 (0.04)	0.26 (0.20)	0.05 (0.12)
4	FRSA Delivery	-0.01 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.17 (0.02)	0.78 (0.08)	-0.17 (0.02)	0.00		0.00 (0.00)	0.01 (0.00)	0.00 (0.00)
5	Article 21 Delivery	-2.62 (-0.13)	0.15 (0.17)	2.63 (0.96)		-0.45 (-0.01)		0.30 (-0.01)	0.08	0.46	0.34 (0.01)	-0.51 (-0.02)	0.16 (0.02)
6	CVP SOD Delivery	-0.01 (-0.01)		-0.02 (-0.10)	0.15 (-0.15)	-0.25 (-0.11)	-0.27 (-0.09)	-0.10 (0.04)			0.38 (0.18)	0.08 (0.06)	0.04 (0.08)
7	CVP NOD Delivery	0.00 (0.00)		0.00 (-0.02)	0.03 (-0.03)	0.59 (0.21)	0.66 (0.18)	-0.59 (0.22)			0.10 (0.04)	0.02 (0.01)	0.01 (0.01)
8	Total Delta Outflow	-0.08 (-0.35)	0.00 (-0.16)	-0.04 (-1.48)	0.07 (-0.36)	-0.09 (-0.22)	-0.18 (-0.30)	-0.07 (0.15)	0.00	0.00	0.27 (0.69)	0.20 (0.74)	0.07 (0.75)
9	Banks Export	0.35 (0.37)	0.01 (0.16)	0.20 (1.63)	0.11 (-0.14)	-0.11 (-0.06)	-0.20 (-0.08)	-0.14 (0.08)	-0.01	0.02	0.10 (0.06)	0.21 (0.18)	0.05 (0.14)
10	Tracy Export	-0.01 (-0.01)		-0.02 (-0.10)	0.16 (-0.15)	-0.25 (-0.10)	-0.28 (-0.09)	-0.10 (0.04)			0.39 (0.18)	0.09 (0.06)	0.04 (0.08)
11	Banks SWP Export	0.37 (0.38)	0.01 (0.16)	0.18 (1.46)	0.11 (-0.13)	-0.10 (-0.05)	-0.20 (-0.08)	-0.14 (0.07)	-0.01	0.02	0.08 (0.05)	0.22 (0.18)	0.06 (0.14)
12	Banks CVP Export	-0.53 (-0.02)	0.00 (0.00)	0.79 (0.17)	0.42 (-0.01)	-0.37 (-0.01)	-0.43 (0.00)	-0.31 (0.00)	0.00	0.02	0.86 (0.01)	0.04 (0.00)	

Note: (1) Values inside parentheses are SI and outside are EI.
(2) Blank cells indicate that SI and EI are non-monotonic functions of the input parameters and their averages are not meaningful. See Chapters 2 and 4 for details.

High Sensitivity	0.2 < |SI|
Moderate Sensitivity	0.1 <= |SI| <= 0.2
Low Sensitivity	|SI| < 0.1

Future Work

This sensitivity study is mainly focused on Sacramento Valley hydrology, Sacramento-San Joaquin Delta water quality, and SWP operations. Additional sensitivity studies focused on San Joaquin Valley hydrology and CVP operations may be done in the near future by Reclamation.

A simple sensitivity analysis procedure has been used for this study. In order to evaluate the combined effect of varying two or more input parameters on the model outputs, future studies with a more complex sensitivity analysis procedure, which investigates changes in a set of input parameters simultaneously, may be needed.

Linear programming solution methodology used in the CalSim II model has the potential to produce an array of sensitivity analyses as a by-product of the linear programming analysis automatically. Discussion of these results will provide a degree of transparency to model users and an internal diagnostic tool that the current CalSim II does not provide. Studying these by-products of the linear programming solution procedure will be considered during the development of the next generation of the CalSim II model.

The CALFED report, *A Strategic Review of CalSim-II and its Use for Water Planning, Management, and Operations in Central California* (December 2003), recommends a model uncertainty analysis be conducted. An uncertainty analysis is not the same as a sensitivity analysis. It takes a set of randomly chosen input values (that can include parameter values), passes them through a model to obtain the probability distributions (or statistical measures of the probability distributions) of the resulting outputs, while a sensitivity analysis attempts to determine the relative change in model output values given modest changes in model input values. The uncertainty analysis would help users of the model understand better the risks of various decisions and the confidence they can have in various model predictions. DWR is currently working on a contract with University of California, Davis to develop a strategy for the identification and reduction of the major sources of uncertainty in CalSim II modeling studies, and implement a recommended procedure for the quantification of uncertainties in a CalSim II study.

Websites for the Memorandum Reports:

1. [DWR] California Department of Water Resources, Bay-Delta Office. 2003. CalSim II Simulation of Historical SWP/CVP Operations. Technical Memorandum Report. Availability: http://science.calwater.ca.gov/pdf/CalSimII_Simulation.pdf

2. [DWR] California Department of Resources, Bay-Delta Office. 2005. CalSim II Model Sensitivity Analysis Study. Technical Memorandum Report. Availability: http://baydeltaoffice.water.ca.gov/

Appendix F. Guidelines for Review of Proposed Permanent Transfers of SWP Annual Table A Amounts

A copy of Notice to State Water Project Contractors Number 03-09 entitled "Guidelines for Review of Proposed Permanent Transfers of State Water Project Annual Table A Amounts" is shown below. These guidelines are being included per the Settlement Agreement, dated May 5, 2003, reached in the *Planning and Conservation League et al. v. Department of Water Resources, 83 Cal. App. 4th 892 (2000)*.

STATE OF CALIFORNIA • RESOURCES AGENCY • DEPARTMENT OF WATER RESOURCES

NOTICE TO

STATE WATER PROJECT CONTRACTORS

NUMBER: 03-09

DATE: 7/3/03

SUBJECT: Guidelines for Review of Proposed Permanent Transfers of State Water Project Annual Table A Amounts

FROM: INTERIM DIRECTOR, DEPARTMENT OF WATER RESOURCES

The Department of Water Resources is issuing the following guidelines prepared in connection with the Settlement Agreement, dated May 5, 2003, reached in *Planning and Conservation League et al. v. Department of Water Resources, 83 Cal. App. 4^{th} 892 (2000)*. These guidelines are effective upon the superior court's approval of the Settlement Agreement on May 20, 2003.

1. Purpose: The purpose of these guidelines is to describe the process for DWR's review of proposed permanent transfers of State Water Project Annual Table A Amounts and, by so doing, provide disclosure to SWP contractors and to the public of DWR's process and policy for approving permanent transfer of SWP Annual Table A Amounts. Such disclosure should assist contractors in developing their transfer proposals and obtaining DWR review expeditiously, and assist the public in participating in that review.

2. Coverage: These guidelines will apply to DWR's approval of proposed permanent transfers of water among existing SWP contractors and, if and when appropriate, to proposed permanent transfers of water from an existing SWP contractor to a new SWP contractor.

3. Interpretation: These guidelines are in furtherance of the State policy in favor of voluntary water transfers and shall be interpreted consistent with the law, including but not limited to Water Code Section 109, the Burns-Porter Act, the Central Valley Project Act, the California Environmental Quality Act, area of origin laws, the public trust doctrine, and with existing contracts and bond covenants. These guidelines are not intended to change or augment existing law.

4. Revisions: Revisions may be made to these guidelines as necessary to meet changed circumstances, changes in the law or long-term water supply contracts, or to address conditions unanticipated when the guidelines are adopted. Revisions shall be in accordance with the Settlement Agreement.

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5. Distribution: The transfer guidelines shall be published by DWR in the next available edition of Bulletin 132, and also as part of the biennial disclosure of SWP reliability as described in the Settlement Agreement.

6. Contract Amendment: Permanent transfers of SWP water are accomplished by amendment of each participating contractor's long-term water supply contract. The amendment consists of amending the Table A upwards for a buying contractor and downwards for a selling contractor. The amendment shall be in conformity with all provisions of the long-term water supply contracts, applicable laws, and bond covenants. Other issues to be addressed in the contract amendment will be subject to negotiation among DWR and the two participating contractors. The negotiations will be conducted in public, pursuant to the Settlement Agreement and Notice to State Water Project Contractors Number 03-10.

7. Financial Issues: The purchasing contractor must demonstrate to DWR's satisfaction that it has the financial ability to assume payments associated with the transferred water. If the purchasing entity was not a SWP contractor as of 2001, special financial requirements pertain as described below, as well as additional qualifications.

8. Compliance with CEQA: Consistent with CEQA, the State's policy to preserve and enhance environmental quality will guide DWR's consideration of transfer proposals (Public Resources Code Section 21000). Identification of the appropriate lead agency will be based on CEQA, the CEQA Guidelines, and applicable case law, including *PCL v. DWR*. CEQA requires the lead agency at a minimum to address the feasible alternatives to the proposed transfer and its potentially significant environmental impacts (1) in the selling contractor's service area; (2) in the buying contractor's service area; (3) on SWP facilities and operations; and (4) on the Delta and areas of origin and other regions as appropriate. Impacts that may occur outside of the transferring SWP contractors' service areas and on fish and wildlife shall be included in the environmental analysis. DWR will not approve a transfer proposal until CEQA compliance is completed. The lead agency shall consult with responsible and trustee agencies and affected cities and counties and, when DWR is not the lead agency, shall provide an administrative draft of the draft EIR or Initial Study/Negative Declaration to DWR prior to the public review period. A descriptive narrative must accompany a checklist, if a checklist is used. The lead agency shall conduct a public hearing on the EIR during the public comment period and notify DWR's State Water Project Analysis Office of the time and place of such hearing in addition to other notice required by law.

9. Place of Use: The purchasing contractor must identify the place and purpose of use of the purchased water, including the reasonable and beneficial use of the water.

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Typically, this information would be included in the environmental documentation. If a specific transfer proposal does not fit precisely into any of the alternatives listed below, DWR will use the principles described in these Guidelines to define the process to be followed. The information to be provided under this paragraph is in addition to the CEQA information described in Paragraph 8 of these guidelines.

a. If the place of use is within the contractor's service area, the contractor should disclose the purpose of the transferred water, such as whether the water is being acquired for a specific development project, to enhance overall water supply reliability in the contractor's service area, or some other purpose. If the transferred water is for a municipal purpose, the contractor should state whether the transfer is consistent with its own Urban Water Management Plan or that of its member unit(s) receiving the water.

b. If the place of use is outside the contractor's service area, but within the SWP authorized place of use, and service is to be provided by an existing SWP contractor, then, in addition to Paragraph 9(a) above, the contractor should provide DWR with copies of LAFCO approval and consent of the water agency with authority to serve that area, if any. In some instances, DWR's separate consent is required for annexations in addition to the approval for the transfer.

c. If the place of use is outside the SWP authorized place of use and service is to be provided by an existing SWP contractor, the contractor should provide information in Paragraph 9(a) and 9(b). Prior to approving the transfer, DWR will consider project delivery capability, demands for water supply from the SWP, and the impact, if any, of the proposed transfer on such demand. If DWR approves the transfer, DWR will petition State Water Resources Control Board for approval of expansion of authorized place of use. Water will not be delivered until the place of use has been approved by the SWRCB and will be delivered in compliance with any terms imposed by the SWRCB.

d. If the place of use is outside the SWP authorized place of use and service is not to be provided by an existing SWP contractor, DWR will consider the transfer proposal as a proposal to become a new SWP contractor. Prior to adding a new SWP contractor, DWR will consider project delivery capability, demands for water supply from the SWP, and the impact, if any, of the proposed transfer on such demand. DWR will consult with existing SWP contractors regarding their water supply needs and the proposed transfer. In addition to the information in Paragraph 9(a), 9(b), and 9(c), the new contractor should provide information similar to that provided by the original SWP contractors in the 1960's Bulletin 119 feasibility report addressing hydrology, demand for water supply, population growth, financial feasibility, etc.

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DWR will evaluate these issues independently and ordinarily will act as lead agency for CEQA purposes. In addition, issues such as area of origin claims, priorities, environmental impacts and use of water will be addressed. The selling contractor may not be released from financial obligations. The contract will be subject to a CCP 860 validation action initiated by the new contractor. If DWR approves the transfer, DWR will petition the SWRCB for approval of expansion of authorized place of use. Water will not be delivered until the place of use has been approved by the SWRCB and will be delivered in compliance with any terms imposed by the SWRCB.

10. DWR Discretion: Consistent with the long-term water supply contract provisions, CEQA, and other provisions of law, DWR has discretion to approve or deny transfers. DWR's exercise of discretion will incorporate the following principles:

   a. As required by CEQA, DWR as an agency with statewide authority will implement feasible mitigation measures for any significant environmental impacts resulting from a transfer if such impacts and their mitigation are not addressed by other public agencies and are within DWR's jurisdiction.

   b. DWR will invoke "overriding considerations" in approving a transfer only as authorized by law, including but not limited to CEQA, and, to the extent applicable, the public trust doctrine and area of origin laws.

If you have any questions or need further information, please contact Dan Flory, Chief of DWR's State Water Project Analysis Office, at (916) 653-4313 or Nancy Quan of his staff at (916) 653-0190.