Appendix 2

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Assumptions Used in DWRSIM Modeling of Various Alternatives

Dates of DWRSIM Modeling Requests from SWRCB to the DWR

Alternatives	DWRSIM Study	Dates		
		Original Request	Revisions	
Flow				
1	467	February 15, 1996	April 8, 1997	
2	468	February 15, 1996	April 8, 1997	
3	506	February 15, 1996*	March 14, 1997	April 8, 1997
4	507	February 15, 1996*	March 14, 1997	April 8, 1997
5	513	January 10, 1997	March 5, 1997	April 30, 1998
6	485	November 15, 1996	December 4, 1996	
7	519	November 15, 1996**	July 23, 1997	
8	622a	February 20, 1998	March 10, 1998	
Joint POD				
1	467	February 15, 1996		
2	469*	February 15, 1996		
3	501	August 6, 1996***		
4	501a	August 6, 1996***		
5	524	August 6, 1996***		
6	525	August 6, 1996***		
7	526	August 6, 1996***		
8	526a	August 6, 1996***		
9	634	February 20, 1998	March 10, 1998	
Cumulative Impacts				
	492	November 15, 1996	January 14, 1997	

* Flow Alternatives 3 and 4 were originally modeled as DWRSIM study 469.

** Flow Alternative 7 was originally modeled as DWRSIM study 482.

*** Dates indicate requests from the DWR to the SWRCB.

DWR PLANNING SIMULATION MODEL (DWRSIM) ASSUMPTIONS FOR SWRCB BASE STUDY WITH D-1485 DELTA STANDARDS (FLOW ALTERNATIVE 1 AND JOINT POINT OF DIVERSION ALTERNATIVE 1) 1995C6FSWRCB-467

In addition to meeting D-1485 Delta standards, Base Study 467 meets selected upstream ESA requirements and CVPIA flow criteria.

I. New Model Features

A new DWRSIM version with the following enhancements is employed:

- A new SWP and CVP south-of-Delta delivery logic uses (i) runoff forecast information and uncertainty (not perfect foresight), (ii) a delivery versus carryover risk curve and (iii) a standardized rule (Water Supply Index versus Demand Index Curve) to estimate the total water available for delivery and carryover storage. The new logic updates delivery levels monthly from January 1 through May 1 as water supply parameters become more certain. Refer to Leaf and Arora (1996) for additional information on the new delivery logic.

- An expanded network schematic includes more details in the Delta and along the DMC and SWP-CVP Joint Reach facility.

- A network representation of the San Joaquin River basin was adapted from USBR's SANJASM model. The San Joaquin River basin schematic was expanded to include (i) the Tuolumne River upstream to Hetch Hetchy and Cherry/Eleanor Reservoirs, (ii) the Merced River upstream to Lake McClure, (iii) the Chowchilla and Fresno Rivers upstream to Eastman and Hensley Lakes, respectively, and (iv) the San Joaquin River upstream to Millerton Lake.

- Contra Costa Water District's "G" model is used to relate Delta flows and salinities. Refer to Denton (1993) for additional information on the procedure.

- References:

    - Leaf, R.T. and Arora, S.K. (1996). "Annual Delivery Decisions in the Simulation of the California State Water Project and Federal Central Valley Project using DWRSIM." Proceedings 1996 North American Water and Environment Congress, ASCE, C.T. Bathala, Ed.

    - Denton, R.A. (1993). "Accounting for Antecedent Conditions in Seawater Intrusion Modeling - Applications for the San Francisco Bay-Delta." Proceedings 1993 National Conference on Hydraulic Engineering, ASCE, H.W. Shen, Ed.

II. Instream Flow Requirements

- Trinity River minimum fish flows below Lewiston Dam are maintained at 340 TAF/year for all years, based on a May 1991 letter agreement between the USBR and the U.S. Fish and Wildlife Service.

- Sacramento River navigation control point (NCP) flows are maintained at 5,000 cfs in wet and above normal water years and 4,000 cfs in all other years. This criteria is relaxed to 3,500 cfs when Shasta carryover storage drops below 1.9 MAF and is further relaxed to 3,250 cfs when Shasta carryover storage drops below 1.2 MAF.

- Feather River fishery flows are maintained per an agreement between DWR and the Calif. Dept. of Fish & Game (August 26, 1983). In normal years these minimum flows are 1,700 cfs from October through March and 1,000 cfs from April through September. Lower minimum flows are allowed in low runoff years and when Oroville storage drops below 1.5 MAF. A maximum flow restriction of 2,500 cfs for October and November is maintained per the agreement criteria.

- Stanislaus River minimum fish flows below New Melones Reservoir range from 98 TAF/year up to 302 TAF/year, according to the interim agreement (dated June 1987) between the USBR and the Calif. Dept. of Fish & Game. The actual minimum fish flow for each year is based on the water supply available for that year. Additional minimum flow requirements are imposed in June through September (15.2 - 17.4 TAF per month) to maintain dissolved oxygen levels in the Stanislaus River. Channel capacity below Goodwin Dam is assumed to be 8,000 cfs. CVP contract demands above Goodwin Dam are met as a function of New Melones Reservoir storage and inflow per an April 26, 1996 letter from USBR to SWRCB.

- Tuolumne River minimum fishery flows below New Don Pedro Dam are maintained per an agreement between Turlock and Modesto Irrigation Districts, City of San Francisco, Dept. of Fish & Game and others (FERC Agreement 2299). Base flows range from 50 cfs to 300 cfs. Base and pulse flow volumes depend on time of the year and water year type.

- Instream flow requirements are maintained in accordance with CVPIA criteria (see Item III) at the following locations: below Keswick Dam on the Sacramento River, below Whiskeytown Dam on Clear Creek and below Nimbus Dam on the American River.

III. CVPIA Flow Criteria

The following CVPIA flow criteria are in accordance with an April 26, 1996 letter from USBR to SWRCB:

- Flow objectives between 3,250 cfs and 5,500 cfs are maintained below Keswick Dam on the Sacramento River. Flow requirements during October through April are triggered by Shasta carryover storage.

- Flow objectives between 52 cfs and 200 cfs are maintained below Whiskeytown Dam on Clear Creek, depending on month and year type.

- Flow objectives between 250 cfs and 4,500 cfs are maintained below Nimbus Dam on the American River. Flow requirements during October through February are triggered by Folsom carryover storage. Flow requirements during March through September are triggered by previous month storage plus remaining water year inflows.

IV. Trinity River Imports

Imports from Clair Engle Reservoir to Whiskeytown Reservoir (up to a 3,300 cfs maximum) are specified according to USBR criteria. Imports vary according to month and previous month Clair Engle storage.

V. Hydrology (HYD-C06F)

A new 1995 level hydrology, HYD-C06F, was developed similar to HYD-C06B described in a June 1994 memorandum report entitled "Summary of Hydrologies at the 1990, 1995, 2000, 2010 and 2020 Levels of Development for Use in DWRSIM Planning Studies" published by DWR's Office of State Water Project Planning. HYD-CO6B was based on DWR Bulletin 160-93 land use projections and simulates the 71 year period 1922-92. HYD-C06F, developed through consultation with USBR to address differences in San Joaquin basin hydrology, simulates two additional years (through 1994) and includes the following major modifications compared to HYD-C06B:

- Stand-alone HEC-3 models of the American, Yuba and Bear River subsystems were updated and extended through 1994. Yuba River minimum fishery flows below Bullards Bar Dam were not modified to reflect new FERC requirements. According to consultants for the Yuba County Water Agency, water supply impacts of the new requirements are not substantially different from those modeled in HYD-C06B.

- Mokelumne River minimum fishery flows below Camanche Dam are modeled in HYD-C06F per an agreement between EBMUD, U.S. Fish and Wildlife Service, and Calif. Dept. of Fish & Game (FERC Agreement 2916). Base flows range from 100 cfs to 325 cfs from October through June, depending on time of the year and water year type. Base flows are maintained at 100 cfs from July through September for all water year types. Water year types are determined by reservoir storage and unimpaired runoff. For the months of April through June, additional pulse flows are maintained up to 200 cfs depending on water year type and reservoir storage.

- Historical 1993-94 land use was estimated by linear interpolation between 1990 and 2000 normalized projected levels.

VI. Pumping Plant Capacities, Coordinated Operation & Wheeling

- SWP Banks Pumping Plant average monthly capacity with 4 new pumps is 6,680 cfs (or 8,500 cfs in some winter months) in accordance with USACE October 31, 1981 Public Notice criteria. Pumping is limited to 3,000 cfs in May and June and 4,600 cfs in July to comply with D-1485 criteria for striped bass survival. Additionally, per a January 5, 1987 interim agreement between DWR and the Calif. Department of Fish & Game, SWP

pumping is limited to 2,000 cfs in any May or June in which storage withdrawals from Oroville Reservoir are required.

- CVP Tracy Pumping Plant capacity is 4,600 cfs, but constraints along the Delta Mendota Canal and at the relift pumps (to O'Neil Forebay) can restrict export capacity as low as 4,200 cfs. Pumping is limited to 3,000 cfs in May and June in accordance with D-1485 criteria for striped bass survival.

- CVP/SWP sharing of responsibility for the coordinated operation of the two projects is maintained per the Coordinated Operation Agreement. Storage withdrawals for in-basin use are split 75 percent CVP and 25 percent SWP. Unstored flows for storage and export are split 55 percent CVP and 45 percent SWP.

- Wheeling of CVP water through SWP facilities to San Luis Reservoir is permitted as needed to offset the CVP Tracy Pumping Plant's compliance with D-1485 criteria in May and June. SWP pumping capacity is made available so that CVP wheeling is completed in July and August of each year.

- CVP water is not wheeled to meet Cross Valley Canal demands.

- Enlarged East Branch aqueduct capacities are assumed from Alamo Powerplant to Devil Canyon Powerplant.

VII. Target Reservoir Storage

- Shasta Reservoir carryover storage is maintained at or above 1.9 MAF in all normal water years for winter-run salmon protection per the NMFS biological opinion. However, in critical years following critical years, storage is allowed to fall below 1.9 MAF to 1.2 MAF (and lower in extremely dry years).

- Folsom Reservoir storage capacity was reduced from 1010 TAF down to 975 TAF due to sediment accumulation as calculated from a 1992 reservoir capacity survey.

- Folsom flood control criteria are in accordance with the December 1993 USACE report "Folsom Dam And Lake Operation Evaluation". This criteria uses available storage in upstream reservoirs such that the maximum flood control reservation varies from 400 TAF to 670 TAF.

VIII. SWP Demands, Deliveries & Deficiencies

- Deficiencies are imposed as needed per Monterey Agreement criteria and are calculated from the following 1996 Table A entitlements assuming zero entitlements and deliveries to Santa Barbara and San Luis Obispo Counties through the Coastal Aqueduct:

```
Agricultural Entitlements     1,175 TAF/year
M & I Entitlements            2,869 TAF/year
Recreation & Losses              64 TAF/year
Total Entitlements            4,108 TAF/year
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- Maximum SWP Contractor deliveries are designed to vary in response to local wetness indexes. As such, maximum deliveries are reduced in the wetter years, assuming greater availability of local water supplies.

    1. Deliveries to San Joaquin Valley agricultural contractors are reduced in wetter years using the following index developed from annual Kern River inflows to Lake Isabella:

	Dry/Avg.	Above	Wet
Kern River flow (TAF/year)	<1,000	1,000-1,400	1,400
Max. Ag delivery (TAF)	1,175	1,100	915

    2. Deliveries to Metropolitan Water District of Southern California are reduced in wetter years using the 10-station, two-year average precipitation index:

	Dry	Avg.	Above	Wet
S. Calif. Precipitation (in/yr)	<15	15-17.9	18-20.9	20.9
Max. MWDSC delivery (TAF)	1,433	1,183	883	783

    3. Maximum deliveries to all other SWP M&I Contractors are NOT adjusted for a wetness index, and are set at 857 TAF/year in all years. As a result of the use of these wetness indexes, the total maximum delivery to all SWP Contractors varies by year, ranging between 3,529 TAF in the dry-average years down to 2,619 TAF in the wetter years, as follows:

	Dry/Avg.	Avg.	Above	Wet
Max. Ag delivery	1,175	1,175	1,100	915
Max. MWDSC delivery	1,433	1,183	883	783
Max. Other M&I delivery	857	857	857	857
Fixed Losses & Recreation	64	64	64	64
Total Maximum SWP Delivery	3,529	(total varies)		2,619

    A range of maximum SWP deliveries is possible as the two wetness indexes are independent of each other. Thus a given year may be classified as "average" for agricultural deliveries by the Kern River flow index, and at the same time be classified as "above average" or "wet" for MWDSC deliveries by the Southern California precipitation index.

- When available, "interruptible" water is delivered to SWP south-of-Delta contractors in accordance with the following assumptions based on the Monterey Amendment White Paper redraft dated September 28, 1995:

    1. Interruptible water results from direct diversions from Banks Pumping Plant. It is not stored in San Luis Reservoir for later delivery to contractors.

    2. A contractor may accept interruptible water in addition to its monthly scheduled entitlement water. Therefore, the contractor may receive water above its Table A amount for the year. Interruptible water deliveries do not impact entitlement water

allocations.

3. If demand for interruptible water is greater than supply in any month, the supply is allocated in proportion to the Table A entitlements of those contractors requesting interruptible water. The maximum demand assumed for interruptible water is 84 TAF per month.

IX. CVP Demands, Deliveries & Deficiencies

- 1995 level CVP demands, including canal losses but excluding wildlife refuges are assumed as follows (see Item IXB below for refuge demands):

```
Contra Costa Canal          =      140 TAF/year
DMC and Exchange            =      1,561
CVP San Luis Unit           =      1,260
San Felipe Unit             =      196
Cross Valley Canal          =      128
Total CVP Delta Exports     =      3,285 TAF/year
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  Including wildlife refuges, total CVP demand is 3,563 TAF/year. CVP Delta export demands are reduced in certain wet years (in the San Joaquin River Basin) when "James" bypass flows are available in the Mendota Pool.

- Sacramento Valley refuge demands are modeled implicitly in the hydrology through rice field and duck club operations. Sacramento Valley refuges include Gray Lodge, Modoc, Sacramento, Delevan, Colusa and Sutter. Level II refuge demands in the San Joaquin Valley are explicitly modeled at an assumed level of 288 TAF/year. San Joaquin refuges include Grasslands, Volta, Los Banos, Kesterson, San Luis, Mendota, Pixley, Kern and those included in the San Joaquin Basin Action Plan.

- CVP South-of-Delta deficiencies are imposed when needed by contract priority. Contracts are classified into four groups: agricultural (Ag), municipal and industrial (M&I), Exchange and Refuge. Deficiencies are imposed in accordance with the Shasta Index and sequentially according to the following rules:

  1. Ag requests are reduced up to a maximum of 50 percent.

  2. Ag, M&I and Exchange requests are reduced by equal percentages up to a maximum of 25 percent. At this point, cumulative Ag deficiencies are 75 percent.

  3. Ag, M&I and Refuge requests are reduced by equal percentages up to a maximum of 25 percent. At this point, cumulative Ag and M&I deficiencies are 100 percent and 50 percent, respectively.

  4. M&I requests are reduced until cumulative deficiencies are 100 percent.

  5. Further reductions are imposed equally upon Exchange and Refuge.

- Deficiencies in the form of "dedicated" water and "acquired" water to meet 800 TAF/year

CVPIA demands are not imposed.

X. Delta Standards

- Delta water quality standards are maintained at Contra Costa Canal intake (M&I), Emmaton and Jersey Point (agriculture), and Antioch, Chipps Island and Collinsville (fish & wildlife) in accordance with D-1485. A "buffer" was added to insure that the M&I standard at Contra Costa Canal is maintained on a daily basis. Thus, DWRSIM uses a value of 130 mg/L for the 150 mg/L standard and a value of 225 mg/L for the 250 mg/L standard. The following water quality objectives are not modeled:

    1. The 250 mg/L M&I chloride standards at Cache Slough, Clifton Court Forebay and Tracy Pumping Plant

    2. The agriculture EC standards on the Mokelumne River (at Terminous) and on the San Joaquin River (at San Andreas Landing)

    3. The fish and wildlife EC standards on the San Joaquin River (at Prisoner's Point)

- Minimum Sacramento River flow (at Rio Vista) and Delta outflow requirements (at Chipps Island) are maintained in accordance with D-1485. Water year classifications are determined using the Sacramento River Index as published in DWR Bulletin 120.

- Delta cross channel gates are closed in January through May when the Delta Outflow Index is greater than 12,000 cfs in accordance with D-1485. Additionally, the gates are closed in any month when upstream Sacramento River flows are greater than 25,000 cfs.

- The D-1422 San Joaquin River water quality objective at Vernalis (500 ppm TDS) is maintained by releasing water from New Melones Reservoir. A 70 TAF/year cap on reservoir releases is not imposed. If New Melones Reservoir storage drops to 80 TAF (per an April 26, 1996 letter from USBR to SWRCB), additional water is not provided for salinity control and the water quality standard is violated.

DWR PLANNING SIMULATION MODEL (DWRSIM) ASSUMPTIONS FOR SWRCB STUDY WITH MAY 1995 WQCP DELTA STANDARDS (FLOW ALTERNATIVE 2) 1995C6F-SWRCB-468

Base Study 467 (Flow Alternative 1) assumptions are modified as follows to meet SWRCB's May 1995 Water Quality Control Plan (Plan).

I. Water Year Classifications

- The Sacramento Valley 40-30-30 Index (as defined on page 23 of the Plan) is used to determine year types for Delta outflow criteria and Sacramento River system requirements unless otherwise specified in the Plan.
- The San Joaquin Valley 60-20-20 Index (page 24) is used to determine year types for flow requirements at Vernalis.
- The Sacramento River Index, or SRI (Footnote 6, page 20), is used to trigger relaxation criteria related to May-June Net Delta Outflow Index (NDOI) and salinity in the San Joaquin River and western Suisun Marsh.
- The Eight River Index (Footnote 13, page 20) is used to trigger criteria related to (i) January NDOI, (ii) February-June X2 standards and (iii) February export ratio.

II. Agricultural Water Quality Objectives (Table 2, page 17)

- EC standards at Vernalis are maintained as specified in the Plan (0.7 EC in April through August and 1.0 EC in September through March). A 70 TAF/year cap is not imposed on additional upstream releases from New Melones Reservoir to meet salinity requirements.
- The export area 1.0 EC standards at Clifton Court Forebay and Tracy Pumping Plant are not modeled.

III. Fish & Wildlife Water Quality Objectives: SJR Salinity (Table 3, page 18)

- The 0.44 EC standard is maintained at Jersey Point in April and May of all but critical years. Per Footnote 6 (page 20), this criteria is dropped in May if the projected SRI is less than 8.1 MAF.
- The salinity requirement at Prisoners Point is not modeled.

IV. Fish & Wildlife Water Quality Objectives: Suisun Marsh Salinity (Table 3, page 18)

- The western Suisun Marsh salinity standard is not modeled.

V. Fish & Wildlife Water Quality Objectives: Delta Outflow (Table 3, page 19)

- Minimum required NDOI (cfs) is maintained as follows:

Year Type	Oct	Nov	Dec	Jan	Feb-Jun	Jul	Aug	Sep
Wet	4,000	4,500	4,500	*	**	8,000	4,000	3,000
Above Normal	4,000	4,500	4,500	*	**	8,000	4,000	3,000
Below Normal	4,000	4,500	4,500	*	**	6,500	4,000	3,000
Dry	4,000	4,500	4,500	*	**	5,000	3,500	3,000
Critical	3,000	3,500	3,500	*	**	4,000	3,000	3,000

* January: Maintain either 4,500 cfs or 6,000 cfs if the December Eight River Index was greater than 800 TAF (per Footnote 13 page 20).

** February-June: Maintain 2.64 EC standards (X2) as described in Item V.B below.

- For February through June, outflow requirements are maintained in accordance with the 2.64 EC criteria (also known as X2) using the required number of days at Chipps Island (74 km) and Roe Island (64 km). See Footnote 14 for Table 3 (Table A) page 26.

    1. At the Confluence (81 km), the full 150 days (February 1 - June 30) of 2.64 EC is maintained in all years, up to a maximum required flow of 7,100 cfs. This requirement is dropped in May and June of any year for which the projected SRI is less than 8.1 MAF. In those years when the criteria is dropped, a minimum outflow of 4,000 cfs is maintained in May and June.

    2. The criteria -- "If salinity/flow objectives are met for a greater number of days than the requirements for any month, the excess days shall be applied to meeting the requirements for the following month" -- is not modeled. See Footnote "a" of Footnote 14 for Table 3 (Table A).

    3. The Kimmerer-Monismith monthly equation is used to calculate outflow required (in cfs) to maintain the EC standard (average monthly position in kilometers). In this equation the EC position is given and Delta outflow is solved for.

        ```
        EC position = 122.2 + [0.3278 * (previous month EC position in
        km)] - [17.65 * log10(current month Delta outflow in cfs)]
        ```

        In months when the EC standard is specified in more than one location (e.g. 19 days at the confluence and 12 days at Chipps Island), required outflow for the month is computed as a flow weighted average of the partial month standards.

- C. Additional details on the 2.64 EC criteria are modeled as follows:

    1. The trigger to activate the Roe Island standard is set at 66.3 km from the previous month, as an average monthly value.

    2. The maximum required monthly outflows to meet the 2.64 EC standard are capped at the following limits: 29,200 cfs for Roe Island; 11,400 cfs for Chipps Island; and 7,100 cfs for the Confluence.

3. Relaxation criteria for the February Chipps Island standard is a function of the January Eight River Index as follows:

    1. X2 days = 0 if the Index is less than 0.8 MAF

    2. X2 days = 28 if the Index is greater than 1.0 MAF

    3. X2 days vary linearly between 0 and 28 if the Index is between 0.8 MAF and 1.0 MAF

VI. Fish & Wildlife Water Quality Objectives: River Flows (Table 3, page 19)

- Minimum Sacramento River flow requirements (cfs) at Rio Vista are maintained as follows:

Year Type	Sep	Oct	Nov	Dec
Wet	3,000	4,000	4,500	4,500
Above Normal	3,000	4,000	4,500	4,500
Below Normal	3,000	4,000	4,500	4,500
Dry	3,000	4,000	4,500	4,500
Critical	3,000	3,000	3,500	3,500

- From February 1 through June 30, minimum flows on the San Joaquin River at Vernalis are maintained per the table below. For each period, the higher flow is required whenever the 2.64 EC Delta outflow position is located downstream of Chipps Island (<74 km). If the 2.64 EC Delta outflow position is upstream of Chipps Island (74 km), then the lower flow requirement is used.

	Minimum Flows at Vernalis (cfs)	
Year Type	Feb1-Apr14 & May16-Jun30	April15-May15
Wet	2,130 or 3,420	7,330 or 8,620
Above Normal	2,130 or 3,420	5,730 or 7,020
Below Normal	1,420 or 2,280	4,620 or 5,480
Dry	1,420 or 2,280	4,020 or 4,880
Critical	710 or 1,140	3,110 or 3,540

- For the month of October, the minimum flow requirement at Vernalis is 1,000 cfs in all years PLUS a 28 TAF pulse flow (per Footnote 19, page 21). The 28 TAF pulse (equivalent to 455 cfs monthly) is added to the actual Vernalis flow, up to a maximum of 2,000 cfs. The pulse flow requirement is not imposed in a critical year following a critical year. These two components are combined as an average monthly requirement as follows:

October Minimum Flows at Vernalis (cfs)	
Base Flow	Required Flow
<1,000	1,455
1,000-1,545	Base Flow + 455
1,545	2,000

- The above flow requirements at Vernalis are maintained primarily by releasing additional

water from New Melones Reservoir. In years when New Melones Reservoir drops to a minimum storage of 80 TAF (per April 26, 1996 letter from USBR to SWRCB), additional water is not provided to meet the Vernalis flow requirements. Pulse and salinity requirements may be violated when New Melones drops to minimum storage.

VII. Fish & Wildlife Water Quality Objectives: Export Limits (Table 3, page 19)

- A. Ratios for maximum allowable Delta exports are specified as a percentage of total Delta inflow as follows:

Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
65	65	65	65	45-35	35	35	35	35	65	65	65

  - In February the export ratio is a function of the January Eight River Index per Footnote 25, page 22 as follows:

    4. 45% if the Jan. 8-River Index is less than 1.0 MAF

    5. 35% if the Jan. 8-River Index is greater than 1.5 MAF

    6. Varies linearly between 45% and 35% if the January Eight River Index is between 1.0 MAF and 1.5 MAF.

  - For this ratio criteria, total Delta exports are defined as the sum of pumping at the SWP Banks and CVP Tracy Pumping Plants. Total Delta inflow is calculated as the sum of river flows from the Sacramento River, Yolo Bypass, total from the Eastside stream group, and San Joaquin River inflow. Delta area precipitation and consumptive uses are not used in this ratio.

- Based on Footnote 22 page 21, April and May total Delta export limitations are modeled as follows:

    7. April 15 - May 15 exports are limited to 1,500 cfs OR 100 percent of the San Joaquin River flow at Vernalis, whichever is greater.

    8. April 1-14 and May 16-31 export limits are controlled by either the export/inflow ratio (35%) or pumping plant capacity, whichever is smaller.

VIII. Fish & Wildlife Water Quality Objectives: Delta Cross Channel (Table 3, page 19)

- The Delta Cross Channel is closed 10 days in November, 15 days in December and 20 days in January for a total closure of 45 days per Footnote 26, page 22.

- The Delta Cross Channel is fully closed from February 1 through May 20 of all years and is closed an additional 14 days between May 21 and June 15 per Footnote 27, page 22.

DWR PLANNING SIMULATION MODEL (DWRSIM) ASSUMPTIONS FOR SWRCB STUDY WITH MAY 1995 WQCP DELTA STANDARDS (FLOW ALTERNATIVE 3) 1995C6F-SWRCB-506

Study 469 (Joint POD Alternative 2) assumptions are modified in accordance with the SWRCB Revised Modeling Request dated April 8, 1997. The Central Valley Project and the State Water Project are operated to achieve full compliance with all objectives in the 1995 Bay-Delta Plan.

1. San Joaquin River flows are modified with revised releases from New Melones, Don Pedro, Lake McClure, Eastman Lake and Hensley Lake as per Table No's 1 to 5 for Alternative 3, provided in the Request. These quantities of water must be released at these reservoirs and conveyed to Vernalis and the Delta.

2. San Joaquin River flows are modified by holding back monthly quantities of water which are not diverted in the San Joaquin Basin as a result of curtailment of direct diversion as per Table No's 10 to 16 for Alternative 3, provided in the Request. The values in these tables are subtracted from actual diversions at the indicated Control Points. If the values in these tables exceeded the modeled diversions, the modeled diversions are set to Zero.

3. If the additional water provided upstream of the Stanislaus is insufficient to meet the SWRCB's May 1995 Water Quality Control Plan flow objectives at Vernalis, additional releases are made from New Melones Reservoir.

4. In years when New Melones Reservoir approaches its minimum storage of 80 TAF, additional water is not provided to meet salinity requirements and violations are possible.

DWR PLANNING SIMULATION MODEL (DWRSIM) ASSUMPTIONS FOR SWRCB STUDY WITH MAY 1995 WQCP DELTA STANDARDS (FLOW ALTERNATIVE 4) 1995C6F-SWRCB-507

Study 469 (Joint POD Alternative 2) assumptions are modified in accordance with the SWRCB Revised Modeling Request dated April 8, 1997. The Central Valley Project and the State Water Project are operated to achieve full compliance with all objectives in the 1995 Bay-Delta Plan.

1. San Joaquin River flows are modified with revised releases from New Melones, Don Pedro, Lake McClure, Eastman Lake and Hensley Lake as per Table No's 1 to 5 for Alternative 4, provided in the Request. These quantities of water must be released at these reservoirs and conveyed to Vernalis and the Delta.

2. San Joaquin River flows are modified by holding back monthly quantities of water which are not diverted in the San Joaquin Basin as a result of curtailment of direct diversion as per Table No's 10 to 16 for Alternative 4, provided in the Request. The values in these tables are subtracted from actual diversions at the indicated Control Points. If the values in these tables exceeded the modeled diversions, the modeled diversions are set to Zero.

3. If the additional water provided upstream of the Stanislaus is insufficient to meet the SWRCB's May 1995 Water Quality Control Plan flow objectives at Vernalis, additional releases are made from New Melones Reservoir.

4. In years when New Melones Reservoir approaches its minimum storage of 80 TAF, additional water is not provided to meet salinity requirements and violations are possible.

DWR PLANNING SIMULATION MODEL (DWRSIM) ASSUMPTIONS FOR SWRCB STUDY WITH MAY 1995 WQCP DELTA STANDARDS (FLOW ALTERNATIVE 5) 1995C06H-SWRCB-513

Study 1995C06F-SWRCB-469 assumptions are modified in accordance with the SWRCB Revised Modeling Request dated January 10, 1997 and subsequent request of March 5, 1997. The Central Valley Project and the State Water Project are operated to achieve full compliance with all objectives in the 1995 Bay-Delta Plan.

1. This alternative applies to the following major water users.

1) Water users with storage in foothill reservoirs that control downstream flow to the Delta.

2) Water users with upstream reservoirs that have a cumulative capacity of at least 100 thousand acre-feet (TAF) and who use water primarily for consumptive uses.

2. The major tributaries with water users who meet the above criteria are listed in SWRCB's January 10, 1997 request. The minimum flow requirements for the major tributaries to the Delta based on the flow objectives and the tributaries' average unimpaired flow to the Delta, were provided by SWRCB in January 10, 1997 request. Minimum flow objectives for the three tributaries, the Yuba, Bear, and Tuolumne rivers, were revised as per SWRCB's March 5, 1997 request.

3. The flows for the Sacramento, Feather, and American rivers are assumed to be controlled by SWP and CVP reservoirs that provide export supplies and the reservoirs are not operated to meet the minimum flow requirements specified for these rivers in the January 10, 1997 memo. Instead, the project reservoirs are operated to insure that the May 1995 Water Quality Control Plan outflow objectives are achieved.

4. The 40-30-30 and 60-20-20 indices are used in applying these objectives to the Sacramento River and the San Joaquin River watersheds, respectively in October and February thru June. For the remaining months, use the 40-30-30 index for both watersheds.

5. In preparing DWRSIM study for Alternative #5, the hydrology input was modified to reflect the minimum flows imposed on selected watersheds, as outlined in the memorandums from the SWRCB to DWR dated January 10, 1997, March 5, 1997, revisions dated July 14, 1997, and conversations between DWR and SWRCB staff. The new 1995 level hydrology developed is called HYD-C06h and reflects changes made to the base 1995 level hydrology HYD-C06f.

In the Sacramento Valley and Eastside Streams areas, monthly minimum flows by water year type were imposed on the following watersheds:

Stony Creek
Yuba River
Bear River
Cosumnes River
Calaveras River
Mokelumne River

For Stony Creek, Cosumnes River, and Calaveras River watersheds, the minimum flows were built into the Depletion Analysis directly. For the Yuba River and Bear River watersheds, the minimum flows were imposed on selected control points in the respective HEC-3 models. Diversions (exports and depletions) were reduced to meet the minimum flows. For the Mokelumne River watershed, an operation for Pardee/Camanche reservoirs reflecting the SWRCB minimum flows on the Mokelumne river was obtained from EBMUD at the request of SWRCB staff. The operation was then included in the hydrology development process.

6. San Joaquin River Basin minimum flow requirements are met at the confluence of the San Joaquin River with its major tributaries modeled by DWRSIM and are carried through the system to the San Joaquin River at Vernalis. Additional minimum flows are as follows: A minimum inflow into New Don Pedro Reservoir is specified as detailed in the March 5, 1997 SWRCB memo. Existing minimum flow requirements on the Merced, Tuolumne and Stanislaus Rivers are met in addition to flows specified below. Flows are met downstream of each specified location. Deficiencies are applied to upstream demands if necessary to meet the minimum flow requirements. The table below lists the DWRSIM control point numbers where minimum flows are met and the upstream control points where deficiencies (if any) are applied.

DWRSIM Minimum Flow and Deficiency Control Points

Tributary	Minimum Flow Control Point Number	Deficiency Control Point Number
San Joaquin River	610	602
Fresno River	626	624
Chowchilla River	634	634
Merced River	649	645
Tuolumne River	665	659 & 662
Stanislaus River	675	670 & 16

7. If the additional water provided upstream of the Stanislaus is insufficient to meet the SWRCB's May 1995 Water Quality Control Plan flow objectives at Vernalis, New Melones Reservoir was operated to ensure that the Vernalis salinity objectives are met. In years when New Melones Reservoir approaches its minimum storage of 80 TAF, additional water is not provided to meet salinity requirements and violations are possible.

DWR PLANNING SIMULATION MODEL (DWRSIM) ASSUMPTIONS FOR SWRCB STUDY WITH MAY 1995 WQCP DELTA STANDARDS (FLOW ALTERNATIVE 6) 1995C6F-SWRCB-485

Study 468 (Flow Alternative 2) assumptions are modified as follows:

In addition to Vernalis X2 and pulse requirements specified in the 1995 WQCP (see December 4, 1996 memo from SWRCB to DWR), following South Delta flow requirements are also imposed at Vernalis:

Month	Flow (cfs)
June	1120
July	1400
August	1330
September	1060
November	760
December	720
January	570

Recirculation water is provided from the Delta Mendota Canal, if necessary, to meet all flow objectives at Vernalis (I.e. February-June and October WQCP requirements as well as the South Delta flow requirements outlined above).

1. While South Delta flow obligations could be shared among all San Joaquin Basin tributaries, it is assumed for simplicity that DMC recirculation water meets the entire obligation.

2. Wheeling of CVP water through SWP facilities to CVP San Luis Reservoir is permitted, as needed, without adversely impacting SWP operations.

3. When DMC conveyance capacity is limiting, CVP deliveries are reduced, as necessary, to provide recirculation water to meet Vernalis requirements on a priority.

4. Recirculation water salinity is assumed to be equal to 70 percent of Rock Slough salinity, as determined by the CCWD's G- model.

DWR PLANNING SIMULATION MODEL (DWRSIM) ASSUMPTIONS FOR SWRCB STUDY WITH MAY 1995 WQCP DELTA STANDARDS (FLOW ALTERNATIVE 7) 1995C6F-SWRCB-519

Study 468 (Flow Alternative 2) assumptions are modified as follows in accordance with the document "Hydrological and Biological Explanation of the Letter of Intent Among Export Interests and San Joaquin River Interests to Resolve San Joaquin River Issues Related to Protection of Bay-Delta Environmental Resources." and are in accordance with the SWRCB Revised Modeling Request dated July 23, 1997.

1. Additional water is provided from the San Joaquin River upstream of its confluence with the Stanislaus, if necessary, to maintain the following minimum flows at Vernalis:

Month(s)	Critical Years	Dry Years	Below Normal Years	Above Normal & Wet Years
October	1,000 cfs	1,000 cfs	1,000 cfs	1,000 cfs
November 1 - February 14	-----	-----	-----	-----
February 15- April 30	1,000 cfs	1,000 cfs	1,000 cfs	1,000 cfs
May	2,000 cfs	3,000 cfs	4,000 cfs	5,000 cfs
June - September	-----	-----	-----	-----

(a) As shown in the above schedule, April-May pulse flow requirements were placed entirely in May to compute additional water to be provided upstream of the Stanislaus River. This additional water was uniformly distributed in the period April15-May15.

(b) Responsibility to provide additional water upstream of the Stanislaus River is shared among the Tuolumne (New Don Pedro Reservoir) and Merced (Lake McClure) River basins, as per January 13, 1997 letter from Marc Van Camp to SWRCB. The order of contributions is as follows.

1. 25,000 AF - Merced Irrigation District
2. 10,000 AF - Oakdale/South San Joaquin Irrigation Districts
3. 5,000 AF - San Joaquin River Exchange Contractors
4. 10,000 AF - Modesto/Turlock Irrigation Districts
5. 6,000 AF - Merced Irrigation District
6. 2,400 AF - Oakdale/South San Joaquin Irrigation Districts
7. 1,200 AF - San Joaquin River Exchange Contractors
8. 2,400 AF - Modesto/Turlock Irrigation Districts.

Note that due to modeling complexities exchange contractors allocated share

was not modeled.
Note that Modesto/Turlock Irrigation Districts and Merced Irrigation District obligations are met directly by reoperation of New Don Pedro Reservoir and Lake McClure.

2. Stanislaus R. minimum fishery flows below Goodwin Dam are maintained as follows:

Month(s)	Critical Years	Dry & Below Normal Years	Above Normal & Wet Years
October	225 cfs	225 cfs	250 cfs
November - April	225 cfs	240 cfs	275 cfs
May	650 cfs	960 cfs	1,070 cfs
June	200 cfs	200 cfs	200 cfs
July - September	50 cfs	50 cfs	75 cfs
Annual Minimum	156,000 acre-ft	181,000 acre-ft	206,000 acre-ft

Note that May pulse requirement was uniformly distributed in the period April15-May15.

3. Tuolumne R. minimum fishery flows below New Don Pedro Dam are maintained as follows:

Month(s)	Critical Years	Dry Years	Below Normal Years	Above Normal & Wet Years
October	125 cfs	150 cfs	207 cfs	397 cfs
Nov - April (*)	150 cfs	150 cfs	180 cfs	299 cfs
May	322 cfs	725 cfs	920 cfs	1,761 cfs
June - Sept (**)	50 cfs	75 cfs	75 cfs	250 cfs
Annual Minimum	94,000 acre-ft	125,700 acre-ft	152,200 acre-ft	300,700 acre-ft

Note that May pulse requirement was uniformly distributed in the period April15-May15.

(*) February requirement in critical years is 160 cfs.
(**) June and September requirements in below normal and dry years are 76 cfs.

4. 49 TAF/yr is delivered to CVP contractors on the Stanislaus River above Goodwin Dam in wet and above normal water years. No deliveries are made in other water years.

5. Water quality releases from New Melones Reservoir are capped at 70 TAF/year.

DWR PLANNING SIMULATION MODEL (DWRSIM) ASSUMPTIONS FOR SWRCB STUDY WITH MAY 1995 WQCP DELTA STANDARDS AND VERNALIS ADAPTIVE MANAGEMENT PLAN (VAMP) ALTERNATIVE 8 (1995C06F-SWRCBDS-622A

Study 468 (Flow Alternative 2) assumptions are modified as follows in accordance with the SWRCB Modeling request dated February 20, 1998, revised March 10, 1998, for Vernalis Adaptive Management Plan (VAMP) Modeling. Note all other Accord flow requirements at Vernalis are not imposed.

A. Responsibility for meeting Vernalis objectives is allocated per Vernalis Adaptive Management Plan (VAMP) described below in Section C. The State Water Project and the Central Valley Project are responsible for meeting all other Bay-Delta objectives.

B. The Stanislaus River is operated according to the U. S. Bureau of Reclamation's New Melones Interim Operational Plan except that the minimum annual fish release cannot be less than 98 TAF.

C. Vernalis Adaptive Management Plan (VAMP) Objectives are as follows.

1. The April 15 to May 15 out-migration pulse flow target will be the Test Flow Target immediately greater than the Existing Flow at Vernalis, as given below. Test Flow Target from May 1 to May 15 is set at the same level as April 15 to April 30 target.

Existing Flow at Vernalis (cfs)	Test Flow Target (cfs)
0 to 1,999	2,000
2000 to 3,199	3,200
3,200 to 4,449	4,450
4,450 to 5,699	5,700
5,700 to 7,000	7,000

2. Double-step the Test Flow Target when the sum of the current year and the previous year 60-20-20 indicator is 7 or greater. In other words, if the existing flow is 5,000 cfs, double step to a 7,000 cfs Test Flow Target.

60-20-20 Year Type	Indicator
Wet	5
AN	4
BN	3
D	2
C	1

3. In years when the sum of the current year's 60-20-20 indicator and the two previous years indicators is 4 or less, the San Joaquin River Group will not be required to provide supplemental flows above Existing Flows.

4. Water provided for VAMP by the San Joaquin River Group during the pulse flow period of any year shall not exceed the amount of water necessary to achieve the Test Flow Target or 110,000 acre-feet, whichever is less.

5. Supplemental water provided for VAMP (up to 110,000 acre-feet) will be provided from San Joaquin River Group in the following order.

Entity	Quantity (TAF)	Cumulative (TAF)
Merced ID	25.0	
OID/SSJID	10.0	
Exchange Contr.	5.0	
MID/TID	10.0	50.0
Merced ID	11.5	
OID/SSJID	4.6	
Exchange Contr.	2.3	
MID/TID	4.6	73.0
Merced ID	8.5	
OID/SSJID	3.4	
Exchange Contr.	1.7	
MID/TID	3.4	90.0
Merced ID	10.0	
OID/SSJID	4.0	
Exchange Contr.	2.0	
MID/TID	4.0	110.0

Note that due to modeling complexities exchange contractors allocated share was not modeled.

Note that Modesto/Turlock Irrigation Districts and Merced Irrigation District obligations are met directly by reoperation of New Don Pedro Reservoir and Lake McClure.

D. Merced Irrigation District will supplement its Existing Flow during October by 12,500 acre-feet in all years.

E. Oakdale Irrigation District will provide upto 26,000 acre-feet in each year. Up to 11,000 acre-feet of this quantity is OID's contribution towards the VAMP 110,000 acre-feet described above (for the pulse flow period). The remainder of the 26,000 acre-feet is retained in the New Melones Reservoir and is available for use by the CVP any time of the year.

F. During the pulse flow period (April 15 to May 15), exports are limited to the following

quantities:

a) When Vernalis flows are less than or equal to 4,450 cfs, combined CVP + SWP exports are limited to 1,500 cfs;

b) When Vernalis flows are greater than 4,450 cfs or less than or equal to 5,700 cfs, CVP + SWP exports are limited to 2,250 cfs;

c) When Vernalis flows are greater than 5,700 cfs or less than or equal to 7,000 cfs, CVP + SWP exports are limited to either: 1,500 cfs when San Luis Reservoir is at least 2 MAF of storage on April 1, or 3,000 cfs when San Luis Reservoir storage is less;

d) When Vernalis flows are greater than 7,000 cfs, combined CVP + SWP exports may not exceed Vernalis flows.

G. In years when New Melones Reservoir approaches its minimum storage of 80 TAF, additional water is not provided to meet salinity requirements and violations are possible.

DWR PLANNING SIMULATION MODEL (DWRSIM) ASSUMPTIONS FOR SWRCB STUDY WITH MAY 1995 WQCP DELTA STANDARDS (JOINT POD ALTERNATIVE 2) 1995C6F-SWRCB-469

Study 468 (Flow Alternative 2) assumptions are modified as follows:

Additional water is provided from the San Joaquin River upstream of its confluence with the Stanislaus, if necessary, to meet salinity and pulse flow objectives at Vernalis. Additional water requirements are shared equally between the Tuolumne (Don Pedro Reservoir) and Merced (Lake McClure) River basins. If these sources are insufficient to meet objectives at Vernalis, nominal deficiencies are applied to upstream demands. Additional releases from the Tuolumne and Merced Rivers are assumed to be of fresh water quality (50 ppm TDS). Furthermore, it is assumed that these additional releases do not incur losses between the reservoirs and Vernalis.

DWR PLANNING SIMULATION MODEL (DWRSIM) ASSUMPTIONS FOR JOINT POINTS OF DIVERSION WHEELING STUDY (JOINT POD ALTERNATIVE 3) 1995C06F-SWRCBJ-501

This study meets SWRCB'S May 1995 Water Quality Control Plan (Plan) and includes selected upstream ESA requirements and CVPIA flow prescriptions. Assumptions are identical to Study 468 except CVP is authorized to use the SWP's point of diversion in the Delta to deliver contract water to the Cross Valley Canal, Musco Olive, Tracy Golf Course and the VA cemetery.

Study 469 (SWRCB Alternative 3) assumptions are modified as follows:

1. USBR would continue to provide CVP water deliveries to the Cross Valley Canal, Musco Olive, Tracy Golf Course and VA cemetery through wheeling via State Water Project Banks Pumping Plant.

2. Authorized amount of wheeling through Banks Pumping Plant is 129 taf for CVP use every year irrespective of needs.

DWR PLANNING SIMULATION MODEL (DWRSIM) ASSUMPTIONS FOR JOINT POINT OF DIVERSION COMBINED USE (JOINT POD ALTERNATIVE 4) 1995C06F-SWRCBJ-501A

This study meets SWRCB's May 1995 Water Quality Control Plan (Plan) and includes selected upstream ESA requirements and CVPIA flow prescriptions. Assumptions are identical to Study 468 except CVP is authorized to use the SWP's point of diversion in the Delta to deliver contract water to the Cross Valley Canal, Musco Olive, Tracy Golf Course and the VA cemetery.

Study 469 (SWRCB alternative 3) assumptions are modified as follows:

1. USBR would continue to provide CVP water deliveries to the Cross Valley Canal, Musco Olive, Tracy Golf Course and VA cemetery through wheeling via State Water Project Banks Pumping Plant.

2. The SWP may wheel an unlimited amount for the CVP.

3. From April 15 - May 15 (Pulse Flow Period) 50% of San Joaquin River were use in calculation of Total allowable export from Delta for all water year type.

DWR PLANNING SIMULATION MODEL (DWRSIM) ASSUMPTIONS FOR JOINT POINT OF DIVERSION COMBINED USE (JOINT POD ALTERNATIVE 5) 1995C06F-SWRCBJ-524

Study 469 (Joint POD Alternative 2) assumptions are modified as follows:

1. Combined use of SWP and CVP points of diversion in Delta is limited by SWP and CVP water rights terms and conditions that specify permitted diversion rates of the projects in delta.

2. The SWP may wheel an unlimited amount for the CVP.

DWR PLANNING SIMULATION MODEL (DWRSIM) ASSUMPTIONS FOR JOINT POINT OF DIVERSION COMBINED USE (JOINT POD ALTERNATIVE 6) 1995C06F-SWRCBJ-525

Study 519 (Flow Alternative 7) assumptions are modified as follows:

1. Combined use of the SWP and CVP points of diversion in the Delta is limited by SWP and CVP water rights terms and conditions that specify permitted diversion rates of the projects in Delta.

2. The SWP may wheel an unlimited amount for the CVP.

DWR PLANNING SIMULATION MODEL (DWRSIM) ASSUMPTIONS FOR JOINT POINT OF DIVERSION COMBINED USE (JOINT POD ALTERNATIVE 7) 1995C06F-SWRCBJ-526

Study 469 (Joint POD Alternative 2) assumptions are modified as follows:

1. Combined use of SWP and CVP points of diversion in Delta limited by SWP and CVP water rights terms and conditions that specify permitted diversion rates of the projects in Delta.

2. Diversion rates are 10,300 cfs at SWP Banks Pumping Plant.

3. The SWP may wheel an unlimited amount for the CVP

DWR PLANNING SIMULATION MODEL (DWRSIM) ASSUMPTIONS FOR JOINT POINT OF DIVERSION COMBINED USE (JOINT POD ALTERNATIVE 8) 1995C06F-SWRCBJ-526A

Study 469 (Joint POD alternative 2) assumptions are modified as follows:

1. Combined use of SWP and CVP points of diversion in Delta limited by SWP and CVP water rights terms and conditions that specify permitted diversion rates of the projects in Delta.

2. Diversion rates are 10,300 cfs at SWP Banks Pumping Plant.

3. The SWP may wheel an unlimited amount for the CVP.

4. 2020 Level (3.6 MAF) CVP Demand.

DWR PLANNING SIMULATION MODEL (DWRSIM) ASSUMPTIONS FOR SWRCB STUDY WITH MAY 1995 WQCP DELTA STANDARDS PLUS VERNALIS ADAPTIVE MANAGEMENT PLAN (VAMP) AND JOINT POINT DIVERSION (JOINT POD ALTERNATIVE 9) 1995C06F-SWRCBJP-634

Study 622A assumptions are modified as follows in accordance with the SWRCB Modeling request dated February 20, 1998, revised March 10, 1998, for Vernalis Adaptive Management Plan (VAMP) Modeling.

1. Combined use of SWP and CVP points of diversion in the Delta is limited by SWP and CVP water rights terms and conditions that specify permitted diversion rates of the projects in the Delta.

2. Use of the SWP point of diversion is further limited by the U. S. Army Corps of Engineers Public Notice 5820-A, as amended.. This notice limits the SWP Delta diversions to 6,680 cfs except from December 15 to March 15 when higher diversion rates are allowed under specified San Joaquin River flow conditions.

3. The SWP may wheel an unlimited amount for the CVP.

DWR PLANNING SIMULATION MODEL (DWRSIM) ASSUMPTIONS FOR SWRCB STUDY WITH MAY 1995 WQCP DELTA STANDARDS (CUMULATIVE IMPACTS ANALYSIS) 1995C6F-SWRCB-492

Study 492 assumptions are identical to those in the CALFED "Benchmark" Study 472 with the following exceptions: (i) Banks Pumping Plant capacity is 10,300 cfs, (ii) CVP water is wheeled to meet unmet demands when unused capacity in Banks Pumping Plant is available, and (iii) a cap on New Melones Reservoir releases for salinity control is not imposed.

I. New Model Features

A new DWRSIM version with the following enhancements is employed:

A. A new SWP and CVP south-of-Delta delivery logic uses (i) runoff forecast information and uncertainty (not perfect foresight), (ii) a delivery versus carryover risk curve and (iii) a standardized rule (Water Supply Index versus Demand Index Curve) to estimate the total water available for delivery and carryover storage. The new logic updates delivery levels monthly from January 1 through May 1 as water supply parameters become more certain. Refer to Leaf and Arora (1996) for additional information on the new delivery logic.

B. An expanded network schematic includes more details in the Delta and along the DMC and SWP-CVP Joint Reach facility.

C. A network representation of the San Joaquin River basin was adapted from USBR's SANJASM model. The San Joaquin River basin schematic was expanded to include (i) the Tuolumne River upstream to Hetch Hetchy and Cherry/Eleanor Reservoirs, (ii) the Merced River upstream to Lake McClure, (iii) the Chowchilla and Fresno Rivers upstream to Eastman and Hensley Lakes, respectively, and (iv) the San Joaquin River upstream to Millerton Lake.

D. Contra Costa Water District's "G" model is used to relate Delta flows and salinities. Refer to Denton (1993) for additional information on the procedure.

E. References:

Leaf, R.T. and Arora, S.K. (1996). "Annual Delivery Decisions in the Simulation of the California State Water Project and Federal Central Valley Project using DWRSIM." *Proceedings 1996 North American Water and Environment Congress,* ASCE, C.T. Bathala, Ed.

Denton, R.A. (1993). "Accounting for Antecedent Conditions in Seawater Intrusion Modeling - Applications for the San Francisco Bay-Delta." *Proceedings 1993 National Conference on Hydraulic Engineering*, ASCE, H.W. Shen, Ed.

II. Instream Flow Requirements

A. Trinity River minimum fish flows below Lewiston Dam are maintained at 340 TAF/year for all years, based on a May 1991 letter agreement between the USBR and the U.S. Fish and Wildlife Service.

B. Sacramento River navigation control point (NCP) flows are maintained at 5,000 cfs in wet and above normal water years and 4,000 cfs in all other years. This criterion is relaxed to 3,500 cfs when Shasta carryover storage drops below 1.9 MAF and is further relaxed to 3,250 cfs when Shasta carryover storage drops below 1.2 MAF.

C. Feather River fishery flows are maintained per an agreement between DWR and the Calif. Dept. of Fish & Game (August 26, 1983). In normal years these minimum flows are 1,700 cfs from October through March and 1,000 cfs from April through September. Lower minimum flows are allowed in low runoff years and when Oroville storage drops below 1.5 MAF. A maximum flow restriction of 2,500 cfs for October and November is maintained per the agreement criteria.

D. Stanislaus River minimum fish flows below New Melones Reservoir range from 98 TAF/year up to 302 TAF/year, according to the interim agreement (dated June 1987) between the USBR and the Calif. Dept. of Fish & Game. The actual minimum fish flow for each year is based on the water supply available for that year. Additional minimum flow requirements are imposed in June through September (15.2 - 17.4 TAF per month) to maintain dissolved oxygen levels in the Stanislaus River. Channel capacity below Goodwin Dam is assumed to be 8,000 cfs. CVP contract demands above Goodwin Dam are met as a function of New Melones Reservoir storage and inflow per an April 26, 1996 letter from USBR to SWRCB.

E. Tuolumne River minimum fishery flows below New Don Pedro Dam are maintained per an agreement between Turlock and Modesto Irrigation Districts, City of San Francisco, Dept. of Fish & Game and others (FERC Agreement 2299). Base flows range from 50 cfs to 300 cfs. Base and pulse flow volumes depend on time of the year and water year type.

F. Instream flow requirements are maintained in accordance with CVPIA criteria (see Item III) at the following locations: below Keswick Dam on the Sacramento River, below Whiskeytown

Dam on Clear Creek and below Nimbus Dam on the American River.

III. CVPIA Flow Criteria

The following CVPIA flow criteria are in accordance with an April 26, 1996 letter from USBR to SWRCB. (This information is preliminary. It is envisioned that when significant changes occur within the CVP/SWP system, the criteria will be reviewed and possibly revised):

A. Flow objectives between 3,250 cfs and 5,500 cfs are maintained below Keswick Dam on the Sacramento River. Flow requirements during October through April are triggered by Shasta carryover storage.

B. Flow objectives between 52 cfs and 200 cfs are maintained below Whiskeytown Dam on Clear Creek, depending on month and year type.

C. Flow objectives between 250 cfs and 4,500 cfs are maintained below Nimbus Dam on the American River. Flow requirements during October through February are triggered by Folsom carryover storage. Flow requirements in other months are triggered by previous month storage plus remaining water year inflows.

IV. Trinity River Imports

Imports from Clair Engle Reservoir to Whiskeytown Reservoir (up to a 3,300 cfs maximum) are specified according to USBR criteria. Imports vary according to month and previous month Clair Engle storage.

V. Hydrology (HYD-C06F)

A new 1995 level hydrology, HYD-C06F, was developed similar to HYD-C06B described in a June 1994 memorandum report entitled "Summary of Hydrologies at the 1990, 1995, 2000, 2010 and 2020 Levels of Development for Use in DWRSIM Planning Studies" published by DWR's Office of State Water Project Planning. HYD-CO6B was based on DWR Bulletin 160-93 land use projections and simulates the 71 year period 1922-92. HYD-C06F, developed through consultation with USBR to address differences in San Joaquin basin hydrology, simulates two additional years (through 1994) and includes the following major modifications compared to HYD-C06B:

A. Stand-alone HEC-3 models of the American, Yuba and Bear River subsystems were updated and extended through 1994. Yuba River minimum fishery flows below Bullards Bar Dam were not modified to reflect new FERC requirements. According to consultants for the Yuba County Water Agency, water supply impacts of the new requirements are not substantially different from those modeled in HYD-C06B.

B. Mokelumne River minimum fishery flows below Camanche Dam are modeled in HYD-C06F per an agreement between EBMUD, U.S. Fish and Wildlife Service, and Calif. Dept. of Fish & Game (FERC Agreement 2916). Base flows range from 100 cfs to 325 cfs from October through June, depending on time of the year and water year type. Base flows are maintained at 100 cfs from July through September for all water year types. Water year types are determined by reservoir storage and unimpaired runoff. For the months of April through June, additional pulse flows are maintained up to 200 cfs depending on water year type and reservoir storage.

C. Historical 1993-94 land use was estimated by linear interpolation between 1990 and 2000 normalized projected levels.

VI. Pumping Plant Capacities, Coordinated Operation & Wheeling

A. Facilities required to obtain a permit to operate Banks Pumping Plant at 10,300 cfs capacity (South Delta Improvements) are assumed.

B. CVP Tracy Pumping Plant capacity is 4,600 cfs, but physical constraints along the Delta Mendota Canal and at the relift pumps (to O'Neil Forebay) can restrict export capacity as low as 4,200 cfs.

C. CVP/SWP sharing of responsibility for the coordinated operation of the two projects is maintained per the Coordinated Operation Agreement (COA). Storage withdrawals for in-basin use are split 75 percent CVP and 25 percent SWP. Unstored flows for storage and export are split 55 percent CVP and 45 percent SWP. In months when the export-inflow ratio limits Delta exports, the allowable export is shared equally between the CVP and SWP. (The COA sharing formula is based on D-1485 operations, not on May 1995 Water Quality Control Plan operations. The sharing formula will likely be modified to conform with Water Quality Control Plan operations. Such a change has unknown, but potentially significant, operational implications.)

D. CVP water is wheeled through SWP facilities to meet unmet demands when capacity is available in Banks Pumping Plant.

E. Enlarged East Branch aqueduct capacities are assumed from Alamo Powerplant to Devil

Canyon Powerplant.

VII. Target Reservoir Storage

A. Shasta Reservoir carryover storage is maintained at or above 1.9 MAF in all normal water years for winter-run salmon protection per the NMFS biological opinion. However, in critical years following critical years, storage is allowed to fall below 1.9 MAF.

B. Folsom Reservoir storage capacity was reduced from 1010 TAF down to 975 TAF due to sediment accumulation as calculated from a 1992 reservoir capacity survey.

C. Folsom flood control criteria are in accordance with the December 1993 USACE report "Folsom Dam And Lake Operation Evaluation". This criteria uses available storage in upstream reservoirs such that the maximum flood control reservation varies from 400 TAF to 670 TAF.

VIII. SWP Demands, Deliveries & Deficiencies

A. 2020 demand level is assumed to be fixed at full entitlement of 4.2 MAF. MWDSC's monthly demand patterns assume an Eastside Reservoir and an Inland Feeder pipeline in accordance with a July 26, 1995 memorandum from MWDSC.

B. Deficiencies are imposed as needed per the draft "Monterey Agreement" criteria and are calculated from the following Table A entitlements for year 2020:

Agricultural Entitlements	1,175 TAF/year
M&I Entitlements	2,958 TAF/year
Recreation & Losses	64 TAF/year
Total Entitlements	4,197 TAF/year

C. When available, "interruptible" water is delivered to SWP south-of-Delta contractors in accordance with the following assumptions based on the Monterey Amendment White Paper redraft dated September 28, 1995:

1. Interruptible water results from direct diversions from Banks Pumping Plant. It is not stored in San Luis Reservoir for later delivery to contractors.

2. A contractor may accept interruptible water in addition to its monthly scheduled entitlement water. Therefore, the contractor may receive water above its Table A amount for the year.

Interruptible water deliveries do not impact entitlement water allocations.

3. If demand for interruptible water is greater than supply in any month, the supply is allocated in proportion to the Table A entitlements of those contractors requesting interruptible water.

IX. CVP Demands, Deliveries & Deficiencies

A. 2020 level CVP demands, including canal losses but excluding San Joaquin Valley wildlife refuges are assumed as follows (see Item IX.B below for refuge demands):

Contra Costa Canal	=	202 TAF/year
DMC and Exchange	=	1,561 TAF/year
CVP San Luis Unit	=	1,447 TAF/year
San Felipe Unit	=	196 TAF/year
Cross Valley Canal	=	128 TAF/year
Total CVP Delta Exports	=	3,534 TAF/year

Including wildlife refuges, total CVP demand is 3,822 TAF/year. The Contra Costa Canal monthly demand pattern assumes Los Vaqueros operations in accordance with a July 11, 1994 e-mail from CCWD.

B. Sacramento Valley refuge demands are modeled implicitly in the hydrology through rice field and duck club operations. Sacramento Valley refuges include Gray Lodge, Modoc, Sacramento, Delevan, Colusa and Sutter. Level II refuge demands in the San Joaquin Valley are explicitly modeled at an assigned level of 288 TAF/year. San Joaquin Valley refuges include Grasslands, Volta, Los Banos, Kesterson, San Luis, Mendota, Pixley, Kern and those included in the San Joaquin Basin Action Plan.

C. CVP south-of-Delta deficiencies are imposed when needed by contract priority. Contracts are classified into four groups: agricultural (Ag), municipal and industrial (M&I), Exchange and Refuge. Deficiencies are imposed in accordance with the Shasta Index and sequentially according to the following rules:

1. Ag requests are reduced up to a maximum of 50 percent.

2. Ag, M&I and Exchange requests are reduced by equal percentages up to a maximum of 25 percent. At this point, cumulative Ag deficiencies are 75 percent.

3. Ag, M&I and Refuge requests are reduced by equal percentages up to a maximum of 25 percent. At this point, cumulative Ag and M&I deficiencies are 100 percent and 50 percent, respectively.

4. M&I requests are reduced until cumulative deficiencies are 100 percent.

5. Further reductions are imposed equally upon Exchange and Refuge.

D. Deficiencies in the form of "dedicated" water and "acquired" water to meet 800 TAF/year CVPIA demands are not imposed.

X. Delta Standards

In the following assumptions related to Delta standards, reference is made to the SWRCB's May 1995 Water Quality Control Plan (Plan):

A. Water Year Classifications

1. The Sacramento Valley 40-30-30 Index (as defined on page 23 of the Plan) is used to determine year types for Delta outflow criteria and Sacramento River system requirements unless otherwise specified in the Plan.

2. The San Joaquin Valley 60-20-20 Index (page 24) is used to determine year types for flow requirements at Vernalis.

3. The Sacramento River Index, or SRI (Footnote 6, page 20), is used to trigger relaxation criteria related to May-June Net Delta Outflow Index (NDOI) and salinity in the San Joaquin River and western Suisun Marsh.

4. The Eight River Index (Footnote 13, page 20) is used to trigger criteria related to (i) January NDOI, (ii) February-June X2 standards and (iii) February export ratio.

B. M&I Water Quality Objectives (Table 1, page 16)

1. The water quality objective at Contra Costa Canal intake is maintained in accordance with the Plan. A "buffer" was added to insure that the standard is maintained on a daily basis. Thus, DWRSIM uses a value of 130 mg/L for the 150 mg/L standard and a value of 225 mg/L for the 250 mg/L standard.

2. The M&I water quality objectives at Clifton Court Forebay, Tracy Pumping Plant, Barker Slough and Cache Slough are not modeled.

C. Agricultural Water Quality Objectives (Table 2, page 17)

1. Water quality objectives on the Sacramento River at Emmaton and on the San Joaquin River at Jersey Point are maintained in accordance with the Plan.

2. Plan water quality objectives on the San Joaquin River at Vernalis are 0.7 EC in April through August and 1.0 EC in other months. These objectives are maintained primarily by releasing water from New Melones Reservoir. **A 70 TAF/year cap on water quality reservoir releases is not imposed. If New Melones Reservoir storage drops to 80 TAF (per an April 26, 1996 letter from USBR to SWRCB), additional water is not provided for salinity control and the water quality standard is violated.**

3. The interior Delta standards on the Mokelumne River (at Terminous) and on the San Joaquin River (at San Andreas Landing) are not modeled.

4. The export area 1.0 EC standards at Clifton Court Forebay and Tracy Pumping Plant are not modeled.

D. Fish & Wildlife Water Quality Objectives: Salinity (Table 3, page 18)

1. The 0.44 EC standard is maintained at Jersey Point in April and May of all but critical years. Per Footnote 6 (page 20), this criteria is dropped in May if the projected SRI is less than 8.1 MAF. The salinity requirement at Prisoners Point is not modeled.

2. The following EC standards are maintained at Collinsville for eastern Suisun Marsh salinity control:

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
EC - Ave. High Tide	19.0	15.5	15.5	12.5	8.0	8.0	11.0	11.0

The corresponding EC standards for other locations in the eastern and western Suisun Marsh are not modeled.

E. Fish & Wildlife Water Quality Objectives: Delta Outflow (Table 3, page 19)

1. Minimum required NDOI (cfs) is maintained as follows:

Year Type	Oct	Nov	Dec	Jan	Feb-Jun	Jul	Aug	Sep
Wet	4,000	4,500	4,500	*	**	8,000	4,000	3,000
Above Normal	4,000	4,500	4,500	*	**	8,000	4,000	3,000
Below Normal	4,000	4,500	4,500	*	**	6,500	4,000	3,000
Dry	4,000	4,500	4,500	*	**	5,000	3,500	3,000
Critical	3,000	3,500	3,500	*	**	4,000	3,000	3,000

* January: Maintain either 4,500 cfs or 6,000 cfs if the December Eight River Index was greater than 800 TAF (per Footnote 13 page 20).

** February-June: Maintain 2.64 EC standards (X2) as described below.

2. For February through June, outflow requirements are maintained in accordance with the 2.64 EC criteria (also known as X2) using the required number of days at Chipps Island (74 km) and Roe Island (64 km). See Footnote 14 for Table 3 (Table A) page 26.

a. At the Confluence (81 km), the full 150 days (February 1 - June 30) of 2.64 EC is maintained in all years, up to a maximum required flow of 7,100 cfs. This requirement is dropped in May and June of any year for which the projected SRI is less than 8.1 MAF. In those years when the criteria is dropped, a minimum outflow of 4,000 cfs is maintained in May and June.

b. The criteria -- "If salinity/flow objectives are met for a greater number of days than the requirements for any month, the excess days shall be applied to meeting the requirements for the following month" -- is not modeled. See Footnote "a" of Footnote 14 for Table 3 (Table A).

c. The Kimmerer-Monismith monthly equation is used to calculate outflow required (in cfs) to maintain the EC standard (average monthly position in kilometers). In this equation the EC position is given and Delta outflow is solved for.

EC position = 122.2 + [0.3278 * (previous month EC position in km)] -

[17.65 * $\log_{10}$(current month Delta outflow in cfs)]

In months when the EC standard is specified in more than one location (e.g. 19 days at the confluence and 12 days at Chipps Island), required outflow for the month is computed as a flow weighted average of the partial month standards.

3. Additional details on the 2.64 EC criteria are modeled as follows:

a. The trigger to activate the Roe Island standard is set at 66.3 km from the previous month, as an average monthly value.

b. The maximum required monthly outflows to meet the 2.64 EC standard are capped at the following limits: 29,200 cfs for Roe Island; 11,400 cfs for Chipps Island; and 7,100 cfs for the Confluence.

c. Relaxation criteria for the February Chipps Island standard is a function of the January Eight River Index as follows:

(i) X2 days = 0 if the Index is less than 0.8 MAF

(ii) X2 days = 28 if the Index is greater than 1.0 MAF

(iii) X2 days vary linearly between 0 and 28 if the Index is between 0.8 MAF and 1.0 MAF

F. Fish & Wildlife Water Quality Objectives: River Flows (Table 3, page 19)

1. Minimum Sacramento River flow requirements (cfs) at Rio Vista are maintained as follows:

Year Type	Sep	Oct	Nov	Dec
Wet	3,000	4,000	4,500	4,500
Above Normal	3,000	4,000	4,500	4,500
Below Normal	3,000	4,000	4,500	4,500
Dry	3,000	4,000	4,500	4,500
Critical	3,000	3,000	3,500	3,500

2. From February 1 through June 30, minimum flows on the San Joaquin River at Vernalis are maintained per the table below. For each period, the higher flow is required whenever the 2.64

EC Delta outflow position is located downstream of Chipps Island (<74 km). If the 2.64 EC Delta outflow position is upstream of Chipps Island (>74 km), then the lower flow requirement is used.

	Minimum Flows at Vernalis (cfs)	
Year Type	Feb1-Apr14 May16-June30	April15-May15
Wet	2,130 or 3,420	7,330 or 8,620
Above Normal	2,130 or 3,420	5,730 or 7,020
Below Normal	1,420 or 2,280	4,620 or 5,480
Dry	1,420 or 2,280	4,020 or 4,880
Critical	710 or 1,140	3,110 or 3,540

3. For the month of October, the minimum flow requirement at Vernalis is 1,000 cfs in all years PLUS a 28 TAF pulse flow (per Footnote 19, page 21). The 28 TAF pulse (equivalent to 455 cfs monthly) is added to the actual Vernalis flow, up to a maximum of 2,000 cfs. The pulse flow requirement is not imposed in a critical year following a critical year. These two components are combined as an average monthly requirement as follows:

October Minimum Flows at Vernalis (cfs)	
Base Flow	Required Flow
<1,000	1,455
1,000-1,545	Base Flow + 455
1,545	2,000

4. The above flow requirements at Vernalis are maintained primarily by releasing additional water from New Melones Reservoir. In years when New Melones Reservoir drops to a minimum storage of 80 TAF (per April 26, 1996 letter from USBR to SWRCB), additional water is provided equally from the Tuolumne and Merced River systems to meet the Vernalis flow requirements. If these sources are insufficient to meet objectives at Vernalis, nominal deficiencies will be applied to upstream demands.

G. Fish & Wildlife Water Quality Objectives: Export Limits (Table 3, page 19)

1. Ratios for maximum allowable Delta exports are specified as a percentage of total Delta inflow as follows:

Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
65	65	65	65	45-35	35	35	35	35	65	65	65

a. In February the export ratio is a function of the January Eight River Index per Footnote 25, page 22 as follows:

(i) 45% if the Jan. 8-River Index is less than 1.0 MAF

(ii) 35% if the Jan. 8-River Index is greater than 1.5 MAF

(iii) Varies linearly between 45% and 35% if the January Eight River Index is between 1.0 MAF and 1.5 MAF.

b. For this ratio criteria, total Delta exports are defined as the sum of pumping at the SWP Banks and CVP Tracy Pumping Plants. Total Delta inflow is calculated as the sum of river flows from the Sacramento River, Yolo Bypass, total from the Eastside stream group, and San Joaquin River inflow. Delta area precipitation and consumptive uses are not used in this ratio.

2. Based on Footnote 22 page 21, April and May total Delta export limitations are modeled as follows:

a. April 15 - May 15 exports are limited to 1,500 cfs OR 100 percent of the San Joaquin River flow at Vernalis, whichever is greater.

b. April 1-14 and May 16-31 export limits are controlled by either the export/inflow ratio (35%) or pumping plant capacity, whichever is smaller.

H. Fish & Wildlife Water Quality Objectives: Delta Cross Channel (Table 3, page 19)

1. The Delta Cross Channel (DCC) is closed 10 days in November, 15 days in December and 20 days in January for a total closure of 45 days per Footnote 26, page 22.

2. The DCC is fully closed from February 1 through May 20 of all years and is closed an additional 14 days between May 21 and June 15 per Footnote 27, page 22.