APPENDIX E - 2002

ENVIRONMENTAL CONSTRAINTS

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Unlike agricultural and urban demands, environmental demands in the CALVIN model are not represented in terms of the economic value of deliveries. Instead, environmental demands are represented as monthly minimum instream flow requirements on river, Sacramento-San Joaquin Delta reaches, carryover storage at Shasta, and minimum water supply requirements for refuge areas. These requirements vary by month and year and are intended to represent the minimum acceptable amount of water for environmental uses at their current level of development. Current environmental requirements include CVPIA actions such as B2 and Level 4 Refuge demands and the Environmental Water Account (EWA). This appendix explains CALVIN's approach and assumptions in modeling minimum instream flow requirements, refuge demands, and the associated limitations. This appendix documents an updated version of earlier representations of environmental flows in the CALVIN model.

MINIMUM INSTREAM FLOW REQUIREMENTS

Although minimum instream flow requirements are used throughout the state, CALVIN's aggregated modeling approach limits these flow constraints to those directly applicable to a canal or river reach included on the CALVIN schematic. Many minimum instream flow requirements vary monthly and by year type. Year types (wet, above normal, normal, below normal, dry, and/or critical) are classified by some type of index. A monthly pattern of flow requirements then corresponds with each year type, and a time-series of minimum flows can be constructed from year types for the 1922-1993 hydrologic sequence modeled in CALVIN. Other more complex requirements depend on concurrent storage, flow, water quality, or other conditions. These latter relationships cannot be represented dynamically in CALVIN's network flow programming formulation. Instead, a pre-determined time-series of minimum flows from a simulation of current conditions is used in CALVIN. Minimum flow requirements that are dependent concurrent conditions were taken from CALSIM II EWA BST_2001LOD_Gmodel run. Table E-1 summarizes the links in CALVIN with the minimum instream flow requirements and indicates the data source and basis of each requirement.

Table E-1. CALVIN River Reaches with Environmental Flow Constraints

River	CALVIN Links	Location	Data Source	Flow Values (cfs)			Function of
				min	max	avg	
American	D64_C8	From urban diversions to mouth	CALSIM II Arcs C301, C302 and C303	188	500	315	Year type, 40-30-30 Sacramento Basin Index[a]
American	D9 to D64	Below Nimbus Dam to urban diversions	Time-series from CALSIM II output Arc C9	250	3000	1928	Complex concurrent conditions
Calaveras	SR-NHL to C41	Release from New Hogan Dam down to month	CALSIM II Arc C92	2	2	2	Constant monthly minimum instream flow requirement
Clear Creek	SR-3_D73	Below Whiskeytown Lake	Time-series from CALSIM II output Arc C3	100	215	168	Complex concurrent conditions
Delta Outflow	Required Delta Outflow_Sink	Delta outflow into S.F. Bay	Time-series DWRSIM 514 output for CP541	3000	28468	7771	Complex concurrent conditions
Feather	C23_C25	Above Thermalito return	CALSIM II Arc C200A	600	600	600	Constant monthly minimum instream flow requirement
Feather	C25_C31	Below Thermalito return to confluence with Bear River	CALSIM II output for Arcs C203, C204, and C205	1000	1700	1294	Complex concurrent conditions
Feather	C32 to D43	From Bear River confluence to mouth	Time-series from CALSIM II input Arc C223	748	1710	1188	Complex concurrent conditions
Merced	D645_D646	Above confluence with San Joaquin R.	Time-series from CALSIM II input Arc C562	0	252	162	Year type, 60-20-20 San Joaquin Index
Merced	D649_D695	Above confluence with San Joaquin R.	Time-series from CALSIM II input Arc C567	16	228	109	Year type, 60-20-20 San Joaquin Index
Mokelumne	SR-CR to D515	Releases from Camanche Reservoir to Delta	CALSIM II Arcs C91, C502, and C503	0	467	123	Year type, 60-20-20 San Joaquin Index
Mono basin	SR-GL_ SR-ML	Aggregate of Rush, Parker, Walker, and Lee Vining Creeks	SWRCB Decision 1631	72	137	102	Mono basin projected inflow
Owens Lake	C120_SR-OL	Owens Lake Dust Mitigation requirements	Modified from GBUPCD (1998)	15	146	55	Remediation measures
Sacramento	D5_D73	Below Keswick Reservoir	Time-series from CALSIM II output Arc C3	3000	11000	5600	Complex concurrent conditions
Sacramento	D76a to C69	Below Red Bluff	CALSIM II Arc C112	3250	3900	3298	Year type, Shasta Index[b]
Sacramento	D61_C301	Navigation control point	Time-series from CALSIM	3500	5000	4545	Complex concurrent

			II output Arc C129				conditions
Sacramento	D503_D511	At Hood	Time-series from DWRSIM 514 input	5000	5000	5000	Constant Time-series, Monthly Varying
Sacramento	D507_D509	Rio Vista requirements	CALSIM II Arc C405	0	4500	1327	Year type, Sacramento Index[a]
San Joaquin	D676_D616	Below confluence with Stanislaus at Vernalis	SWRCB 1999	0	6201 cK/	1434 ck?	Complex concurrent conditions
Stanislaus	D653a_D653b	Below Goodwin	CALSIM II Arc C16	0	1500	366	New Melones Forecast and pulse flow
Trinity	D94&D40_SinkD94	Trinity Below Lewiston Dam	CALSIM II Arc C100	300	4709	835	Year type, Trinity Index[f]
Tuolumne	D662_D663	Below Turlock ID Diversion	Time-series from CALSIM II output Arc C540	50	4474	385	Complex concurrent conditions
Tuolumne	D664_D683	Above confluence with San Joaquin R.	Time-series from CALSIM II output Arc C544	50	4388	345	Complex concurrent conditions
Yuba	C83_C31	Yuba River at Marysville	SWRCB D-1644	250	1500	494	Year type, Yuba Index[b]
Yuba	C28_C29	Yuba River at Smartville	SWRCB D-1644	0	700	388	Year type, Yuba Index[b]

Notes:
[a] 40-30-30 Sacramento Basin Index: Sacramento River flows which have been weighted in consideration of certain flow periods and antecedent conditions.
[b] Shasta Index: Unimpaired inflows into Lake Shasta.
[c] Oroville Index: Unimpaired inflows into Lake Oroville.
[d] SJ 60-20-20 Index: San Joaquin River flows which have been weighted in consideration of certain flow periods and antecedent conditions.
[e] Eight River Index: The sum of the unimpaired flow of the 40-30-30 Index rivers and the 60-20-20 Index rivers.
Sources: USBR 1997a, DWR 1998b, DWR 1993 (for index definitions), SWRCB 1999 (for Vernalis)
[f] Trinity River Index: Unimpaired inflows into Clair Engle Lake.

CALVIN Approach

The decision of whether or not to place a minimum instream flow requirement on any particular river was based primarily on whether that river was given such a requirement in the Department of Water Resources' CALSIM II model (DWR 2001). While most of the minimum instream flow requirements were developed from the lookup tables in the CALSIM II input data files, some requirements depend on complex concurrent conditions and, therefore, are calculated during run-time in CALSIM II. Such dynamic calculation is not possible in CALVIN. Consequently, those minimum flow requirements were taken from the CALSIM II, EWA BST_2001LOD_Gmodel output.

For river reaches outside of the CALSIM II network, minimum instream flow requirements were applied where they are known to apply. Such is the case of the minimum instream flow requirements on the Yuba River, Mono Basin, Owens Lake, and the Salton Sea.

With the exception of the Yuba River, San Joaquin River at Vernalis, Sacramento River at Hood, and Delta minimum outflow, requirements used for minimum instream flows in the CALVIN model were developed from the minimum flow requirements specified in the input data for CALSIM II, as used in the EWA BST_2001LOD_Gmodel. Monthly minimums, year types, indices, and trigger rules for the requirements were taken from the *.*wresl* and *.*table* input files of CALSIM II. Requirements dependent on concurrent conditions were taken from CALSIM II output for the EWA BST_2001LOD_Gmodel.

In the CALVIN schematic, Delta outflow, twelve rivers, and the inflow into Mono and Owens Lakes are required to meet minimum instream flows. Many of the rivers (including the Sacramento, American, Feather, Tuolumne) have different minimum flow constraints on several reaches. Table E-1 shows the model links on which these constraints are applied and the physical location of these links. Environmental flow requirements have been placed on most major rivers north of the Delta and on nearly all major tributaries of the San Joaquin River.

Considerations for Instream Flow Requirements on Specific Rivers

In representing the various instream flow requirements, several simplifications were necessary to compensate for CALVIN's monthly time-step and network flow optimization requirements. Some watersheds require additional assumptions and calculations, which are described below.

<u>Trinity River</u>

The minimum flow requirements on the Trinity River (CALVIN link D94&D40_sink) are based on the Trinity Mainstem Fishery Restoration EIR/EIS Preferred Alternative. These requirements depend on the Trinity River Index and appear in Table E-2.

Table E-2. Trinity River Minimum Instream Flow Requirements (cfs)

Trinity Year Type	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	300	300	300	427	4570	4626	1102	450	450	373	300	300
2	300	300	300	460	4709	2526	1102	450	450	373	300	300
3	300	300	300	493	4189	2120	1102	450	450	373	300	300
4	300	300	300	540	2924	783	450	450	450	373	300	300
5	300	300	300	600	1498	783	450	450	450	373	300	300

Source: CALSIM II input file *Trinitymin.table.*

Clear Creek

Minimum instream flow requirements are applied to Clear Creek below Whiskeytown (CALVIN link SR-3_D73). The minimum instream flow requirements on Clear Creek depend, in part, on Trinity Reservoir storage. Flow stability criteria require that November and December flows equal or exceed October's flow. In addition, Clear Creek flows in the February through May period should equal or exceed January's flow. Additional fish and wildlife requirements in this reach include CVPIA (b)(2) AFRP Upstream Action #1 and Environmental Water Account (EWA) based assets and asset expenditure. Because of its dependence on complex concurrent conditions, the minimum instream flow requirements used in CALVIN were taken from CALSIM II, model run EWA BST_2001LOD_Gmodel.

Sacramento River

Shasta Lake end-of-September minimum storage

The 1993 Winter Run Biological Opinion includes provisions for minimum carryover storage in Shasta Lake (CALVIN node SR-4). USBR must maintain minimum end-of-September carryover storage in Shasta of 1.9 MAF. This carryover storage has been judged by (the National Marine Fisheries Service (NMFS) and California Department of Fish and Game (DFG) to be attainable in all but approximately ten percent of years, those considered to be critical and extremely critical water year types. In the period of record of CVP/SWP planning models, this requirement tends to be violated in 1924, the early 30's drought, 1976, 1977, and the early 90's drought, the exact years depending on the particular system operation. In CALVIN, minimum carryover storage in Shasta of 1.9 MAF was imposed in all but the years in which the requirement was not met in the CALSIM II model run EWA BST_2001LOD_Gmodel. In those years the requirement was relaxed to the value simulated in CALSIM II, model run EWA BST_2001LOD_Gmodel.

Upper Sacramento River

Several minimum flow requirements are imposed on various reaches of the Sacramento River. On the upper Sacramento River, the northernmost of these requirements is on the river reach below Keswick Dam (CALVIN link D5_D73). The Sacramento River minimum instream flow requirement below Keswick is, in part, based on the 1993 Winter-run Biological Opinion (BO), and depends on concurrent storage at Shasta Reservoir. These requirements are a proxy for temperature control requirements and do not necessarily guarantee meeting the temperature objectives stated in the 1993 BO.

As modeled in CALSIM II, the minimum flow requirement below Keswick is 3,250 cfs in the October to August period and 6,000 cfs in September. If the beginning-of-month storage at Shasta is less than 2,000 TAF, then the September requirement is relaxed to 4,500 cfs. Other relaxation criteria may be in effect based on end-of-March storage at Shasta Reservoir. Furthermore, flow stability criteria require that a fraction of the previous month's flow must be maintained when flow is below a pre-specified threshold in the November through April period. In addition to these requirements, CVPIA (b2) Upstream Action #2 and EWA water also apply in this reach. Because of the dependence on concurrent conditions, the requirements imposed on CALVIN were taken from CALSIM II, model run EWA BST_2001LOD_Gmodel.

On the Sacramento River reach between Red Bluff and Ord Ferry (CALVIN links D76a_D77, D77_D75, D75_C1, C1_C4, and C4_C69), the minimum instream flow requirement depends on the Shasta Index. The requirements are shown on Table E-3.

Table E-3. Sacramento River Minimum Instream Flow Requirements, Red Bluff to Ord Ferry (cfs)

Shasta Index	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	3250	3250	3250	3250	3250	3250	3250	3250	3900	3250	3250	3250
2	3250	3250	3250	3250	3250	3250	3250	3250	3900	3250	3250	3250
3	3250	3250	3250	3250	3250	3250	3250	3250	3900	3250	3250	3250
4	3250	3250	3250	3250	3250	3250	3250	3250	3900	3250	3250	3250
5	3000	3000	3000	3000	3250	3250	3250	3250	3250	3000	3000	3000

Source: CALSIM II input file *redbluff_base.table.*

The Navigation Control Point (NCP, CALVIN link D61_C301) is another location on the upper Sacramento River where minimum instream flow requirements are applied. The minimum instream flows in this reach do not aim at satisfying fish and wildlife requirements. Rather, these minimum flows are a result of historical requirements for commercial navigation. Although this river reach no longer supports commercial navigation, water diverters in this reach have installed pump intakes just below the historical navigation minimum flow levels of 5,000 cfs. The operations of these pumps are severely affected if flows drop to 3,500 cfs for a period of more that a few days. In CALSIM II, the minimum flows in this reach depend on Shasta Reservoir levels and the Shasta Index and are set to between 3,500 and 5,000 cfs. To maintain the cold-water pool levels at Shasta Reservoir, the minimum flows at the NCP are relaxed when Shasta storage below pre-specified threshold levels.

Lower Sacramento River

Minimum instream flow requirements on the lower Sacramento River exist at Rio Vista and Hood. The Rio Vista (CALVIN link D507_D509) minimum flow, required under the Water Quality Control Plan D-1641, depends on the Sacramento River Index and is shown on Table E-4. The requirements are changed in February.

The minimum instream flow requirement at Hood (CALVIN link D503_D511) is set to 5000 cfs.

Table E-4. Sacramento River Minimum Instream Flow Requirements, Rio Vista (cfs)

Sacramento River Index	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	0	0	0	0	0	0	0	0	3000	4000	4500	4500
2	0	0	0	0	0	0	0	0	3000	4000	4500	4500
3	0	0	0	0	0	0	0	0	3000	4000	4500	4500
4	0	0	0	0	0	0	0	0	3000	4000	4500	4500
5	0	0	0	0	0	0	0	0	3000	3000	3500	3500

Source: CALSIM II input file *riovista.table.*

Feather River

Minimum flow requirements in the Feather River are governed by the 1967 agreement between the Department of Water Resources (DWR) and the Department of Fish and Game (DFG), Concerning the Operation of the Oroville Division of the State Water Project for Management of Fish and Wildlife. This agreement was amended in 1983 as part of the FERC re-licensing process.

The 1983 agreement specifies that DWR release a minimum of 600 cfs into the Feather River from the Thermalito Diversion Dam (CALVIN link C23_C25) for fishery purposes.

Between the Thermalito complex and the confluence with the Sacramento River (CALVIN D42_D43), the agreement between DWR and DFG specify minimum flow requirements dependent both on the percent of normal runoff[1] and Lake Oroville's surface elevation. If Lake Oroville's surface elevation is greater that 733 feet MSL and the unimpaired runoff is greater than 55 percent of normal, the requirement for the October to March period is 1,700 cfs, and the April to September requirement is 1,000 cfs. If, on the other hand, the unimpaired runoff is less than 55 percent of normal, and Lake Oroville's surface elevation is greater than 733 feet MSL, the October to February requirement is 1,200 cfs and 1,000 cfs in the March to September period. When the surface elevation at Lake Oroville is lower that 733 MSL, the March through September requirement is reduced to 750 cfs and the October to February is reduced to 900 cfs.

[1] Normal runoff is defined as the mean (1911-1960) April through July unimpaired runoff of 1,942 TAF.

In addition, if during October 15 through November 30, the hourly flow is greater that 2,500 cfs, then the flow minus 500 cfs must be maintained until the following March unless the high flow was due to flood control operation or mechanical problems. This requirement is to protect any spawning that could occur in overbank areas during the higher flow rate by maintaining flow levels high enough to keep the overbank areas submerged. In practice, the flows are maintained below 2,500 cfs from October 15 to November 30 to prevent spawning in the overbank areas.

CALVIN cannot dynamically compute these requirements; therefore, the time-series of minimum flows was taken from CALSIM II, model run EWA BST_2001LOD_Gmodel.

Yuba River

The minimum flow requirements on the Yuba River are required under the SWRCB D-1644, at Marysville (CALVIN link C83_C31) and Smartville (CALVIN link C28_C29). Both flows are dependent on the Yuba River Index, and are shown on Table E-6.

Table E-6. Yuba River Minimum Instream Flow Requirements (cfs)

Periods	Wet, AN, & BN Index>790		Dry Years 630<INDEX<790		Critical Years 540<INDEX<630		Ext. Critical Years INDEX<=540	
	Smartville Gage	Marysville Gage	Smartville Gage	Marysville Gage	Smartville Gage	Marysville Gage	Smartville Gage	Marysville Gage
Sep 15 - Oct 14	700	250	500	250	400	250	400	250
Oct 15 - Apr 20	700	500	600	400	600	400	600	400
Apr 21 - Apr 30	-----	1000	-----	1000	-----	1000	-----	500
May 1 - May 31	-----	1500	-----	1500	-----	1100	-----	500
1-Jun	-----	1050	-----	1050	-----	800	-----	500
2-Jun	-----	800	-----	800	-----	800	-----	500
Jun 3 - Jun 30	-----	800	-----	800	-----	800	-----	500
1-Jul	-----	560	-----	560	-----	560	-----	500
2-Jul	-----	390	-----	390	-----	390	-----	390
3-Jul	-----	280	-----	280	-----	280	-----	280
Jul 4 - Sep 14	-----	250	-----	250	-----	250	-----	250

Source: SWRCB D-1644.

American River

Minimum flow requirements on the American River (CALVIN links D9_D85, D85_D64, and D64_C8) are governed by SWRCB D-893. These requirements are based on the 40-30-30 Index and are shown on Table E-7.

Table E-7. American River Minimum Instream Flow Requirements (cfs)

40-30-30 Index	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	250	250	250	250	250	250	250	250	375	500	500	500
2	250	250	250	188	188	188	188	188	281	375	375	500

Source: DWR 2002.

In addition to D-893, the Nimbus Dam releases are subject to CVPIA (b)(2) based AFRP actions. These requirements are based on the Folsom Lake end-of-month storage and forecasted remainder of water year Folsom Lake inflow. CALVIN cannot dynamically produce these requirements. Consequently, the time-series of requirements was taken from CALSIM II, model run EWA BST_2001LOD_Gmodel.

Mokelumne River

The minimum flow requirement on the Mokelumne River is applied on the entire length of the river, between Camanche Reservoir and the confluence with the San Joaquin River (CALVIN links SR-CR_C38, C38_C98 and C98_D517). These requirements are based on the San Joaquin River Index, and are shown on Table E-8.

Table E-8. Mokelumne River Minimum Instream Flow Requirements, (taf)

S. Joaquin River Index	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	7.7	7.5	6.6	6.6	20	27.8	0	0	0.5	6.3	17.4	13.3
2	7.7	7.5	6.6	6.6	20	27.8	0	0	0.5	6.3	17.4	13.3
3	7.7	7.5	6.6	6.6	20	27.8	0	0	0.5	6.3	17.4	13.3
4	7.7	7.5	6.6	6.6	20	27.8	0	0	0.4	3.6	11.5	8.7
5	2.6	2.4	2.5	0.4	0	0.1	0	0	0.4	0.7	5.5	4.1

Source: CALSIM II input file *minflow_EastSide.table.*

Calaveras River

The minimum flow requirement imposed on the Calaveras River applies to the reach below New Hogan Lake (CALVIN link SR-NHL_C40). It is a constant requirement of 0.1 taf per month.

Merced River

Under the a Davis-Grunsky (Contract No D-GGR17) agreement with DWR for grant funding of portions of the Merced River Development Plan, the Merced Irrigation District (MID) must provide 180 to 220 cfs flow downstream of the Crocker-Huffman Diversion Dam (CALVIN link D645_D646) to support Chinook salmon spawning runs. Additional minimum flow requirements below the Crocker-Huffman Diversion Dam are to be provided by MID pursuant to water rights adjudication (Cowell Agreement) on the Merced River. MID must make available, below the Crocker-Huffman Diversion Dam, an amount of water that could then be diverted from the river at several private ditches between Crocker-Huffman Diversion Dam and the Shaffer Bridge. These requirements appear in Table E-9.

The minimum flow at Shaffer Bridge (CALVIN D649_D695) is governed by MID's FERC licence 2179 to operate Lake McClure. Minimum flow requirements on the Merced River are shown on Table E-9. A dry year is defined by the FERC license as a forecasted April through July inflow to Lake McClure less than 450 taf.

Table E-9. Merced River Minimum Instream Flow Requirements, (cfs)

Month	Davis-Grunsky Minimum Flow below Crocker-Huffman Diversion Dam	FERC 2179 Minimum Flow at Schaffer Bridge		Cowell Agreement Entitlement
		Normal Year	Dry Year	
Oct 1 - 15	0	25	15	50
Oct 16 - 31	0	75	60	50
Nov	180 - 220	100	75	50
Dec	180 - 220	100	75	50
Jan	180 - 220	75	60	50
Feb	180 - 220	75	60	50
Mar	180 - 220	75	60	100
Apr	0	75	60	175
May	0	75	15	225
Jun	0	25	15	250
Jul	0	25	15	225
Aug	0	25	15	175
Sep	0	25	15	150

Source: DWR 2002.

Tuolumne River

The minimum flow requirement on the Tuolumne River is imposed at LaGrange Bridge. It is based on the San Joaquin Basin 60-20-20 Index. The Tuolumne minimum instream flow requirements, which include a base flow and a pulse flow, are shown on Table E-10.

Stanislaus River

The fishery flow requirements on the Stanislaus River is composed of a pre-specified minimum base flow below Goodwin Dam and a pulse flow between April 15 and May 16. The minimum flow below Goodwin Dam is governed by the 1987 agreement between USBR and DFG and the New Melones Interim Operations Plan, and is based on hydrologic conditions in the Stanislaus River basin.

The annual fishery flow allocation on the Stanislaus River varies between 0 taf to 467 taf, depending on the New Melones conditions which are computed as end-of-February storage in New Melones plus the forecasted March through September inflow into New Melones. The annual fishery allocation as a function of storage plus forecasted inflow (New Melones condition) is shown on Table E-11.

Once the annual fishery allocation is determined, another lookup table is used to compute the monthly base flow (Table E-12).

In addition to the base fishery flows, Reclamation must provide pulse flows on the Stanislaus River between April 15 and May 16. These pulse flows, also a function of the Stanislaus River annual fishery allocation, are shown on Table E-13.

Table E-10. Tuolumne River Minimum Instream Flow Requirements, (cfs)

	San Joaquin Basin 60-20-20 Index (taf)						
	< 1500	1500	2000	2200	2400	2700	> 3100
Annual Volume (ac-ft)	94,000	103,000	117,016	127,507	142,502	165,002	300,923
Oct 1 – 15 (cfs)	100	100	150	150	180	200	300
Attraction Pulse Flow Oct 1 – 15 (ac-ft)	None	None	None	None	1,676	1,736	5,950
Oct 16 - May 31 (cfs)	150	150	150	150	180	175	300
Out-migration Pulse Flow Apr 15 – May 15 (ac-ft)	11,091	20,091	32,619	37,060	35,920	60,027	89,882
Jun 1 – Sep 30 (cfs)	50	50	50	75	75	75	250

Source: DWR 2002.

Table E-11. Stanislaus River Annual Fishery Flow Allocation

New Melones Condition (taf)	0	1400	2000	2500	>3000
Annual Fishery Allocation (taf)	98	98	125	345	467

Source: CALSIM II input file *stan_yr.table.*

Table E-12. Stanislaus River Minimum Instream Flow Requirements, (cfs)

Annual Fishery Allocation	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
0	0	0	0	0	0	0	0	0	0	0	0	0
98.9	125	125	125	250	250	0	0	0	0	110	200	200
155	150	150	150	300	300	125	125	125	125	110	225	225
200.6	250	250	250	300	300	200	200	200	200	200	250	250
256.2	275	275	275	300	1500	200	200	200	200	250	275	275
311.5	300	300	300	900	900	250	250	250	250	250	300	300
410.2	350	350	350	1500	1500	800	300	300	300	350	350	350
> 466.4	400	400	400	1500	1500	825	625	525	400	350	400	400

Source: CALSIM II input file *stan_monfish.table.*

Table E-13. Stanislaus River Pulse Flow Requirements, (cfs)

Annual Fishery Allocation	Pulse Flows
0	0
98.9	500
245.7	1500

Source: CALSIM II input file *stan_pulse.table*.

The time-series of minimum flow requirements used in CALVIN was developed using the time-series of inflows to New Melones and the end-of-month storage in New Melones, as modeled in CALSIM II, model run EWA BST_2001LOD_Gmodel.

Mono Basin

From a water supply perspective, two tiers of environmental constraints exist in the Mono Basin, which aggregate the inflow from Rush, Parker, Walker, and Lee Vining Creeks. Each creek has an instream flow requirement, as directed in SWRCB Decision 1631. In addition to the instream flow requirement, the City of Los Angeles is required to maintain a Mono Lake elevation of 6,391 feet above mean sea level (msl) or accept a reduced diversion schedule as specified in SWRCB Decision 1631. Considering minimum instream flow requirements only, approximately 45 taf/yr of Mono Basin water is available for supply and power generation for the October 1921-September 1993 period. When also taking into account Mono Lake refilling needs, DWR (1998a) estimates the Mono Basin can supply the City of Los Angeles with 31 taf/yr after lake-level requirements are satisfied.

Rather than determining which SWRCB flow schedule to use, CALVIN requires Mono Lake to reach 6,391 ft above msl (or 2,939 taf according to area-elevation-capacity relationships provided in Vorster 1983) at the end of every March (the beginning of the Eastern Sierra Nevada water year). CALVIN assumes this elevation has been reached in 2020 and the City of Los Angeles can divert water from the Mono Basin subject to minimum instream flow constraints and maintaining the specified lake level.

The only outflow from Mono Lake is evaporation. Annual figures from Vorster (1983) were converted to monthly values with the assumption that Mono Lake has the same evaporation pattern as Lake Isabella on the Kern River. These figures are net evaporation, which account for precipitation and inflow to Mono Lake from sources other than Rush, Parker, Walker, and Lee Vining Creeks.

Owens Lake

As a result of recent litigation, the City of Los Angeles is required to provide air quality remediation measures in the dry Owens Lake bed. Excessive surface water withdrawals and groundwater pumping in the region have caused dust storms with very high levels of particulate matter. To alleviate this problem, Los Angeles is required to provide one of three combinations of remediation techniques: 1) shallow flooding of the lake bed requiring 4 acre-feet per acre, 2) managed vegetation requiring 2 acre-feet per acre, or 3) gravel coverage requiring no water (See Table E-14). GBUPCD (1998) assumes a mix of alternatives requiring 51 taf/yr, which is reflected in the Table E-14 calculations and is represented as a fixed diversion in CALVIN. Ono (1999), however, suggests that the City of LA might choose a combination of alternatives, lowering their total requirement to only 40 taf/yr. As shown in the table below, this is the requirement imposed in CALVIN.

Table E-14. Water Requirements for Owens Lake Remediation[a,b]

Month	Managed Vegetation (taf/month)	Shallow Flooding (taf/month)[c]	Total Owens Lake Requirement (taf/month)	CALVIN Requirements (taf/month)
October	0.7	1.9	2.5	2.04
November	0.4	1.2	1.6	1.47
December	0.4	1.2	1.6	0.95
January	0.5	1.5	2.0	1.99
February	0.9	2.7	3.6	1.24
March	1.4	4.0	5.4	1.26
April	2.0	5.7	7.7	1.6
May	2.5	7.3	9.8	2.8
June	2.9	8.2	11.1	4.2
July	2.6		2.6	6.05
August	1.9		1.9	7.69
September	1.2		1.2	8.7
TOTAL			**51**	**40**

Notes:
[a] Assuming the City of LA selected the following control measures: 8400 acres of shallow flooding, 8700 acres of managed vegetation, and 5300 acres of gravel.
[b] Assuming the same evaporation pattern as Lake Isabella on the Kern River.
[c] No flooding is required between August 1 and September 14 (the whole month of September neglected).

Sacramento-San Joaquin Delta Outflow

Minimum instream flows within the Sacramento-San Joaquin Delta have not been modeled explicitly for each river within the Delta. Instead, minimum flows through the Delta are guaranteed with a single minimum outflow requirement into the San Francisco Bay.

X2, the location of the 2 parts per thousand isohaline, is used to identify the estuarine entrapment zone. Various EPA X2 requirements greatly affect the Delta outflow constraint. CALSIM II uses various methods to calculate the X2 position, which changes the monthly total outflow constraint. Since CALVIN lacks the ability to make an X2 calculation, CALVIN's Delta outflow constraint is the minimum Delta outflow time-series resulting in DWRSIM Run 514 as fixed flow requirements.

Salton Sea

Although no water supply is available from the Salton Sea, it is included in the CALVIN schematic to maintain a physical representation and since it is a major focus of concern in the South Lahontan hydrologic region. Return flows are the only CALVIN inflows included in the Salton Sea and the only outflow is evaporation. Although the New and Alamo Rivers are represented on the network schematic diagram (Figure 6-3 and 6-4 in main 2001 report), these rivers have zero inflows since they are used for limited industrial water purposes only (Montgomery Watson 1996).

Although detailed area-elevation-capacity relationships exist for the Salton Sea, CALVIN cannot mimic the results of more detailed water balance simulation models.

Monthly figures for the Salton Sea were obtained from Hughes (1967) and Ferrari et. al. (1995). These values were given for inconsistent time increments (15-32 days), so monthly evaporation was roughly estimated based on the corresponding dates. Hughes (1967) found annual evaporation to be around 72 inches per year, while the currently accepted value is 66 inches per year. Accordingly, the values in Hughes (1967) and Ferrari et al. (1995) were normalized to equal 66 inches per year.

San Joaquin River

The Final Environmental Impact Report for Implementation of the 1995 Bay/Delta Water Quality Control Plan (SWRCB 1999) is the source for the required pulse and X2 flow data at Vernalis. Technical Appendix 4 of the SWRCB Report provides a monthly time-series (DWRSIM run 1995C06F-SWRCB-469, 11/96) of required minimum flows for water years 1922 through 1994 at the 1995 level of development. The required flows at Vernalis are based on the San Joaquin Valley 60-20-20 Index for determination of water year type and the Eight River Index. The unimpaired runoff from the four Sacramento River Index rivers and the four San Joaquin River Index rivers is summed to produce the Eight River Index (DWR 1998a). The previous month's Eight River Index (PMI) is used to indicate how many days the Delta X2 standard must be maintained at a specified location such as Chipps Island (Table E-15) during the current month. February through June are the months regulated by the X2 standard.

Table E-15. Days Maximum Daily Average EC of 2.64 mmhos/cm Must be Maintained[a]

PMI[b]	Chipps Island				
(taf)	FEB	MAR	APR	MAY	JUN
≤ 500	0	0	0	0	0
750	0	0	0	0	0
1000	28	12	2	0	0
1250	28	31	6	0	0
1500	28	31	13	0	0
1750	28	31	20	0	0
2000	28	31	25	1	0
2250	28	31	27	3	0
2500	28	31	29	11	1
2750	28	31	29	20	2
3000	28	31	30	27	4
3250	28	31	30	29	8
3500	28	31	30	30	13
3750	28	31	30	31	18
4000	28	31	30	31	23
4250	28	31	30	31	25
4500	28	31	30	31	27
4750	28	31	30	31	28
5000	28	31	30	31	29
5250	28	31	30	31	29
≥ 5500	28	31	30	31	30

Notes:
[a] The 2 ppt isohaline (X2) is measured as 2.64 mmhos/cm surface salinity.
[b] PMI is the best available estimate of the previous month's Eight River Index.
The number of days for values of the PMI between those specified are determined by linear interpolation.
Source: SWRCB 1999, Table II-4

Minimum flows at Vernalis from February through June (Table E-16) are described as meeting either high or low objectives depending on the required X2 position (Table E-15). The higher flow is required when the X2 position is at or downstream of Chipps Island, and the lower flow is allowed when the X2 position is upstream of Chipps Island. The water year type (San Joaquin 60-20-20 Index) determines the high and low flow quantities.

Table E-16. Feb-June Minimum Flows at Vernalis (cfs)

Year Type	FEB 1 - APR 14 & MAY 16 - JUN 30	APRIL 15 - MAY 15
Wet	2130 or 3420	7330 or 8620
Above Normal	2130 or 3420	5730 or 7020
Below Normal	1420 or 2280	4620 or 5480
Dry	1420 or 2280	4020 or 4880
Critical	710 or 1140	3110 or 3540

Source: SWRCB 1999, Appendix 2

Minimum flows at Vernalis during the month of October follow unique rules. For all water years, the minimum flow is 1000 cfs plus up to a 28 taf (455 cfs) pulse flow. Application of this pulse flow results in a minimum flow for October that usually depends on the actual flow at Vernalis (Table E-17). The required minimum flow ranges from 1455 cfs to a maximum of 2000 cfs, with one exception. If a critical year follows a critical year, the 28 taf pulse flow is not required and the minimum flow for October is 1000 cfs.

Table E-17. October Minimum Flows at Vernalis (cfs)

Actual Flow	Required Flow
< 1000	1455
1000 - 1545	Actual Flow + 455
≥ 1545	2000

Source: SWRCB 1999, Appendix 2

Minimum required flows at Vernalis for the months of January, July, August, September, November, and December are zero. As South Delta water quality and quantity needs are determined, these six unregulated months could be affected.

FISH AND WILDLIFE REFUGE DEMANDS

California's refuge areas have been consolidated into six refuge nodes: the Sacramento East, Sacramento West, San Joaquin, Mendota, Kern, and Pixley Refuges. Each of these areas has distinct environmental water supply requirements. The requirements for all refuges are based on Level 4 refuge requirements, as stated in the various EIR/EIS pertaining to each refuge (USBR, 1997b, c, d, e, and f). The monthly refuge requirements for these water districts can be found in the appropriate EIR/EIS. Tables E-18 and E-19 summarize CALVIN's representation of fish and wildlife Level 4 refuge demands.

Table E-18. CALVIN Deliveries to Fish and Wildlife Refuges

Aggregate Refuge	Sources	Link	Refuges Included	Deliveries (taf/month)		
				Min	Max	Avg
Kern	USBR 1997e	C95_KERN REFUGES	Kern NWR	0.5	4.4	2.4
Pixley	USBR 1997e	C60_PIXLEY NWR	Pixley NWR	0	0.8	0.5
Sac West Refuges[a]	USBR 1997d	C302_SAC W REF	Sacramento, Delevan, and Colusa NWR	1.6	22.8	11.7
Sac East Refuges[a]	USBR 1997b	C311_SAC E REF	Sutter and Gray Lodge NWR	2.8	15.0	7.0
San Joaquin	USBR 1997c	D723_San Joaquin Refuges	Volta WMA Freitas SJBAP Salt Slough SJBAP China Island SJBAP	1.8	8.9	3.9
Mendota Wildlife Area	USBR 1997f	D732_Mendota Wildlife Area	Grassland WD Los Banos WMA Kesterson NWR San Luis SWR Mendota WMA Merced NWR West Gallo SJBAP	12.1	67.0	28.8

Notes:
[a] Sacramento West and East Refuge deliveries are reported as volumes of water delivered into the refuge. Conveyance losses have already been accounted for.
SJBAP = San Joaquin Basin Action Plan
NWR = National Wildlife Refuge
SWR = State Wildlife Refuge
WMA = Wildlife Management Area

While Level 2 supply to refuges is subject to the same deficiency criteria as the exchange contractors, that is, 25 percent cut in years in which the Shasta criteria is critical, the increments to Level 4 are not subject to deficiencies. Therefore, the Level 4 refuge demand, as implemented in CALVIN, was computed as the firm Level 2 demand, subject to 25 percent decrease when the Shasta criteria is critical, plus the full increment to Level 4.

Deliveries to most refuges are subject to conveyance losses. The aggregate conveyance losses for each consolidated refuge node are shown in Table E-19. Pixley NWR is unusual in that its Firm Level 2 supply comes entirely from wells located within the refuge boundaries. Therefore, its Level 2 demand is subject to neither a deficiency nor conveyance loss. Its increment to Level 4, on the other hand, comes from surface water sources, and is thus subject to conveyance losses (15 percent).

Table E-19. Level 4 Fish and Wildlife Refuge Demands (taf/year)

Aggregate Refuge	Annual Delivery	Conveyance Loss	Annual Diversion	Percent Loss
Sacramento West Refuges	105	35	140	25%
Sacramento East Refuges	74	10.3	84.3	12%

Mendota Wildlife Area	290.5	55.4	345.9	16%
San Joaquin Area Refuges	41.7	5.4	47.1	11%
Kern	25.0	3.7	28.7	13%
Pixley	4.7	.83	5.5	15%

SUMMARY

CALVIN includes 12 minimum instream flows, 6 refuge nodes, Shasta carryover storage, minimum Bay Delta outflows and the Mono-Owens minimum as environmental requirements in the system. Average annual environmental requirements are shown in Table E-20.

Table E-20: Summary of Environmental Requirements

	Average Annual Requirement (taf/yr)
Minimum Instream Flows	
Trinity River	599
Clear Creek	122
Sacramento River below Keswick	4,069
Sacramento River bet. Red Bluff and Ord Ferry	2,393
Sacramento River at Nav. Control Point	3,293
Feather River below Oroville	434
Feather River below Thermalito return	862
Yuba River at Smartville	280
Yuba River at Marysville	358
American River below Nimbus	1,398
American River below urban diversions	228
Mokelumne River	88
Calaveras River	1
Sacramento River at Hood	3,620
Sacramento River at Rio Vista	941
Stanislaus River	265
Tuolumne River below Don Pedro Reservoir	119
Tuolumne River below Turlock ID diversion	279
Merced River below Crocker-Huffman DD	118
Merced River at Schaffer Bridge	79
San Joaquin River at Vernalis	1,031
Refuge Requirements[1]	
Sacramento West Refuge	140
Sacramento East Refuge	84
Mendota Refuges	346
San Joaquin	47
Pixley	5 .5
Kern	29
Bay Delta Outflow	
Bay Delta	5,593

Mono/Owens Requirement		
Mono Lake Inflows	74	
Owens Lake Dust Mitigation	40	
Shasta Carryover Storage	1,900	taf

[1] Including Conveyance Losses

LIMITATIONS

Environmental benefits are not modeled explicitly in CALVIN. Only the benefits associated with the included constraints, minimum instream flow constraints, and fish and wildlife refuges, may be analyzed from the perspective of urban and agricultural water users. Environmental water use is not optimized.

Environmental flows in the Sacramento-San Joaquin Delta have been simplified. Flows on individual river reaches within the Delta have not been modeled explicitly.

The environmental flow requirements for some river reaches involve complex operating rules that cannot be easily represented as a simple time-series. In many cases, therefore, the time-series used in CALVIN is based upon an assumed system operation not necessarily corresponding with the operation recommended by the model.

The refuges represented in the model are aggregations of many, much smaller refuge areas. These aggregations may allow the model to make refuge deliveries more efficiently than is actually possible.

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