Appendix A: CalSimII Modeling

Table of Contents

1.0 General CalSim II Assumptions

1.1 CalSim II Version

After careful review and comparison of the available CalSim II models, and through coordination with the United States Department of the Interior, Bureau of Reclamation's (Reclamation) CalSim II modeling team, the U.S. Army Corps of Engineers (USACE) selected the 2013 State Water Project (SWP) Delivery Reliability Report (DRR) (DWR 2013) as the base model for the Folsom Dam Water Control Manual (WCM) Update project. The 2013 DRR versions of CalSim II are the most recent publicly available models from either the California Department of Water Resources (DWR) or Reclamation. Therefore, it was considered the most reasonable base from which to develop the models used for the Folsom Dam WCM Update project.

1.2 System-Wide Assumptions

Table 1-1 summarizes assumptions for the CalSim II models (Existing and Future Condition) developed for the 2013 DRR, which were subsequently modified for use in the Folsom Dam WCM Update EIS/EIR. The assumptions made for the Folsom Dam WCM Update EIS/EIR models are also detailed in Table 1-1 for comparison to the 2013 DRR models.

Table 1-1. CalSim II Modeling Assumptions for DWR 2013 and for Folsom Dam WCM Update Models.

	2013 DRR Existing Condition[1]	**WCM Existing Condition (CEQA)**	**2013 DRR Future Condition[1]**	**WCM Future Condition (NEPA No Action)**
Planning horizon	2013	2014	Interpolation to 2033 future using data from 2013 Future No Climate Change and 2050 Future with Climate Change	Same as 2013 DRR Future Condition except the climate change
Period of simulation	82 years (1922–2003)	Same	Same	Same
HYDROLOGY				
Level of development (land use)	2005 level[2]	Same as 2013 DRR Existing Condition	2030 level[3]	Same as 2013 DRR Future Condition
DEMANDS				
North of Delta (excluding the American River)				
CVP	Land-use based, limited by contract amounts[4]	Same as 2013 DRR Future Condition	Land-use based, full build-out of contract amounts	Same as 2013 DRR Future Condition
SWP (FRSA)	Land-use based, limited by contract amounts,[5] no rice decomposition water demand	Same as 2013 DRR Existing Condition; included about 160 TAF/yr of rice decomposition water demand	Land-use based, limited by contract amounts,[5] no rice decomposition water	Same as 2013 DRR Future Condition; included about 160 TAF/yr of rice decomposition water demand
Non-Project	Land-use based, limited by water rights and SWRCB decisions for existing facilities	Same	Same	Same
Antioch Water Works	Pre-1914 water right	Same	Same	Same

	2013 DRR Existing Condition[1]	WCM Existing Condition (CEQA)	2013 DRR Future Condition[1]	WCM Future Condition (NEPA No Action)
Federal refuges	Recent historical level 2 water needs[6]	Same as 2013 DRR Future Condition	Firm level 2 water needs[6]	Same as 2013 DRR Future Condition
American River Basin				
Water rights	Year 2005[7]	Same as 2013 DRR Existing Condition except Sacramento Suburban Water District's diversion from Folsom PP set to 14.5 TAF/yr, City of Sacramento demand set to 131.5 TAF/yr	Year 2025, full water rights[7]	Same as 2013 DRR Future Condition except City of Sacramento demand set to 311.8 TAF/yr (230 TAF/yr at E. A. Fairbairn WTP), PCWA demand set to 65 TAF/yr.
CVP	2005 level[7]	2005 level[7]; included Freeport Regional Water Project, El Dorado County demands set to 0, EBMUD demands updated as provided by EBMUD	Year 2025, full contracts including Freeport Regional Water Project[7]	Same as 2013 DRR Future Condition except EBMUD demands updated as provided by EBMUD
San Joaquin River Basin[9]				
Friant Unit	Limited by contract amounts, based on current allocation policy	Same	Same	Same
Lower Basin	Land-use based, based on district level operations and constraints	Same	Same	Same
Stanislaus River Basin[10, 19]	Land-use based, based on New Melones Interim Operations Plan, up to full CVP contractor deliveries (155 TAF/yr) depending on New Melones index	Same	Same	Same
South of Delta				
CVP	Demands based on contract amounts[4]	Same	Same	Same
Federal refuges	Recent historical level 2 water needs[6]	Same as 2013 DRR Future Condition	Firm level 2 water needs[6]	Same as 2013 DRR Future Condition
CCWD	195 TAF/yr CVP contract supply and water rights[11]	Same	Same	Same
SWP [5, 12]	Demand based on full Table A amounts (4.13 MAF/year)	Same	Same	Same
Article 56	Based on 2001–2008 contract requests	Same	Same	Same

	2013 DRR Existing Condition[1]	WCM Existing Condition (CEQA)	2013 DRR Future Condition[1]	WCM Future Condition (NEPA No Action)
Article 21	MWD demand up to 200 TAF/month (December–March) subject to conveyance capacity, KCWA demand up to 180 TAF/month, and other contractor demands up to 34 TAF/month, subject to conveyance capacity	Same	Same	Same
North Bay Aqueduct	77 TAF/yr demand under SWP contracts, up to 43.7 cfs of excess flow under Fairfield, Vacaville, and Benicia Settlement Agreement	Same	Same	Same
FACILITIES				
System-wide	Existing facilities	Same	Same	Same
Sacramento Valley				
Shasta Lake	Existing 4,552 TAF capacity	Same	Same	Same
Red Bluff Diversion Dam	Diversion dam operated with gates out all year, NMFS BO (2009) Action I.3.1[19]; assume permanent facilities in place	Same	Same	Same
Colusa Basin	Existing conveyance and storage facilities	Same	Same	Same
Upper American River	PCWA American River pump station	Same	Same	Same
Lower Sacramento River	None	Freeport Regional Water Project for EBMUD diversions only	Freeport Regional Water Project	Same as 2013 Future Condition
Fremont Weir	Existing weir; no notched operation	Same as 2013 Existing Condition	Same as 2013 Existing Condition	BDCP notch operation of Fremont Weir
Delta Export Conveyance				
SWP Banks pumping capacity (South Delta)	Physical capacity is 10,300 cfs, permitted capacity is 6,680 cfs in all months and up to 8,500 cfs during Dec 15th-Mar 15th depending on Vernalis flow conditions[20]; additional capacity of 500 cfs (up to 7,180 cfs) allowed Jul-Sep for reducing impact of NMFS BO (2009) Action IV.2.1[19] on SWP[21]	Same	Same	Same

	2013 DRR Existing Condition[1]	WCM Existing Condition (CEQA)	2013 DRR Future Condition[1]	WCM Future Condition (NEPA No Action)
CVP C.W. "Bill" Jones Pumping Plant (formerly Tracy PP)	Permit capacity is 4,600 cfs in all months (allowed for by the DMC-California Aqueduct Intertie)	Same	Same	Same
Upper DMC capacity	Exports limited to 4,200 cfs plus diversion upstream from DMC constriction plus 400 cfs DMC-California Aqueduct Intertie	Same	Same	Same
Los Vaqueros Reservoir	Enlarged storage capacity (160 TAF), existing pump location, Alternate Intake Project included[14]	Same	Same	Same
San Joaquin River				
Millerton Lake (Friant Dam)	Existing, 520 TAF capacity	Same	Same	Same
Lower San Joaquin River	None	Same as 2013 DRR Future Condition	City of Stockton Delta Water Supply Project, 30 mgd capacity	Same as 2013 DRR Future Condition
South of Delta (CVP/SWP project facilities)				
South Bay Aqueduct	Existing capacity	Same as 2013 DRR Future Condition	SBA rehabilitation, 430 cfs capacity from junction with California Aqueduct to Alameda County FC&WSD Zone 7 point	Same as 2013 DRR Future Condition
California Aqueduct East Branch	Existing capacity	Same	Same	Same
REGULATORY STANDARDS				
Trinity River				
Minimum flow below Lewiston Dam	Trinity Environmental Impact Study Preferred Alternative (369-815 TAF/yr)	Same	Same	Same
Trinity Reservoir end-of-September minimum storage	Trinity Environmental Impact Study Preferred Alternative (600 TAF as able)	Same	Same	Same
Clear Creek				
Minimum flow below Whiskeytown Dam	Downstream water rights, 1963 Reclamation proposal to USFWS and NPS, predetermined Central Valley Protection Improvement Act 3406(b)(2) flows,[22] and NMFS BO (2009) Action I.1.1[19]	Same	Same	Same
Upper Sacramento River				

	2013 DRR Existing Condition[1]	WCM Existing Condition (CEQA)	2013 DRR Future Condition[1]	WCM Future Condition (NEPA No Action)
Shasta Lake end-of-September minimum storage	NMFS 2004 winter-run BO (1900 TAF in non-critical dry years), and NMFS BO (2009) Action I.2.1[19]	Same	Same	Same
Minimum flow below Keswick Dam	Flows for the SWRCB Water Rights Order 90-5, predetermined Central Valley Protection Improvement Act 3406(b)(2) flows, and NMFS BO (2009) Action I.2.2[19]	Same	Same	Same
Feather River				
Minimum flow below Thermalito Diversion Dam	2006 Settlement Agreement (700 / 800 cfs)	Same	Same	Same
Minimum flow below Thermalito Afterbay Outlet	1983 DWR, DFG Agreement (750–1700 cfs)	Same	Same	Same
Yuba River				
Minimum flow below Daguerre Point Dam	D-1644 Operations (Lower Yuba River Accord) [15]	Same	Same	Same
American River				
Minimum flow below Nimbus Dam	American River flow management as required by NMFS BO (2009) Action II.1[19]	Same as 2013 DRR Existing Condition, except CalSim II code was updated to include conference years and off-ramp conditions.	Same as 2013 DRR Existing Condition	Same as WCM Existing Condition, except CalSim II code was updated to include conference years, and off-ramp conditions.
Minimum flow at H Street Bridge	SWRCB D-893	Same	Same	Same
City of Sacramento's diversion restrictions through Fairbairn WTP	None	Hodge Restrictions if river flows are less than Hodge flow criteria	Same as 2013 DRR Existing Condition	Same as WCM Existing Condition
Lower Sacramento River				
Minimum flow near Rio Vista	SWRCB D-1641	Same	Same	Same
Mokelumne River				
Minimum flow below Camanche Dam	FERC 2916-029,[13] 1996 (Joint Settlement Agreement) (100–325 cfs)	Same	Same	Same
Minimum flow below Woodbridge Diversion Dam	FERC 2916-029, 1996 (Joint Settlement Agreement) (25–300 cfs)	Same	Same	Same

	2013 DRR Existing Condition[1]	WCM Existing Condition (CEQA)	2013 DRR Future Condition[1]	WCM Future Condition (NEPA No Action)
Stanislaus River				
Minimum flow below Goodwin Dam	1987 Reclamation, DFG agreement, and flows required for NMFS BO (2009) Actions III.1.2 and III.1.3 [19]	Same	Same	Same
Minimum dissolved oxygen	SWRCB D-1422	Same	Same	Same
Merced River				
Minimum flow below Crocker-Huffman Diversion Dam	Davis-Grunsky (180–220 cfs, Nov–Mar), and Cowell Agreement	Same	Same	Same
Minimum flow at Shaffer Bridge	FERC 2179 (25-100 cfs)	Same	Same	Same
Tuolumne River				
Minimum flow at Lagrange Bridge	FERC 2299-024, 1995 (Settlement Agreement) (94–301 TAF/yr)	Same	Same	Same
San Joaquin River				
San Joaquin River below Friant Dam/Mendota Pool	Interim San Joaquin River restoration flows	Same as 2013 DRR Existing Condition	Full San Joaquin River restoration flows	Same as 2013 DRR Future Condition
Maximum salinity near Vernalis	SWRCB D-1641	Same	Same	Same
Minimum flow near Vernalis	SWRCB D-1641 but with Vernalis Adaptive Management Plan single-step standard only, per purchase agreement between Reclamation and Merced ID. NMFS BO (2009) Action IV.2.1 Phase II flows not provided because of lack of agreement for purchasing water	Same as 2013 DRR Future Condition	SWRCB D-1641 and Vernalis Adaptive Management Plan per San Joaquin River Agreement.[17] NMFS BO (2009) Action IV.2.1 Phase II flows not provided because of lack of agreement for purchasing water	Same as 2013 DRR Future Condition
Sacramento River-San Joaquin River Delta				
Delta outflow index (flow and salinity)	SWRCB D-1641, USFWS BO (2008), Action 4 [19]	Same	Same	Same
Delta cross channel gate operation	SWRCB D-1641 with additional days closed from Oct 1-Jan 31 based on NMFS BO (2009) Action IV.1.2[19] (closed during flushing flows from Oct 1–Dec 14 unless adverse water quality conditions)	Same	Same	Same

	2013 DRR Existing Condition[1]	WCM Existing Condition (CEQA)	2013 DRR Future Condition[1]	WCM Future Condition (NEPA No Action)
South Delta exports (Jones PP and Banks PP)	SWRCB D-1641 export limits (not including VAMP period export cap under the San Joaquin River Agreement) and Vernalis flow-based export limits in Apr–May as required by NMFS BO (2009) Action IV.2.1 Phase II[19] (additional 500 cfs allowed for Jul-Sep for reducing impact on SWP)[21]	Same	Same	Same
Combined flow in Old and Middle River	USFWS BO (2008), Actions 1–3 and NMFS BO (2009), Action IV.2.3 [19]	Same	Same	Same
OPERATIONS CRITERIA: RIVER-SPECIFIC				
Upper Sacramento River				
Flow objective for navigation (Wilkins Slough)	NMFS BO (2009) Action I.4 [19]; 3,250–5,000 cfs based on CVP water supply condition	Same	Same	Same
American River				
Folsom Dam flood control	Variable 400-670 flood control diagram (without outlet modifications)	Same	Same	Same
Shasta and Folsom Reservoir balancing	Folsom Flood Control Rule for September set to 650 TAF.	Folsom Flood Control Rule for September set to 760 TAF (650 TAF for balancing purposes), releasing more water from Nimbus.	Same as 2013 DRR Existing Condition	Same as WCM Existing Condition
Feather River				
Flow at mouth of Feather River (above Verona)	Maintain the DFG/DWR flow target above Verona or 2800 cfs for April–September dependent on Oroville inflow and FRSA allocation	Same	Same	Same
Stanislaus River				
Flow below Goodwin Dam	Revised Operations Plan and NMFS BO (2009) Actions III.1.2 and III.1.3 [19]	Same	Same	Same
San Joaquin River				
Salinity at Vernalis	Grasslands Bypass Project (partial implementation)	Same as 2013 DRR Future Condition	Grasslands Bypass Project (full implementation)	Same as 2013 DRR Future Condition

	2013 DRR Existing Condition[1]	WCM Existing Condition (CEQA)	2013 DRR Future Condition[1]	WCM Future Condition (NEPA No Action)
OPERATIONS CRITERIA: SYSTEM WIDE				
CVP Water Allocation				
CVP settlement and exchange	100% (75% in Shasta critical years)	Same	Same	Same
CVP refuges	100% (75% in Shasta critical years)	Same	Same	Same
CVP agriculture	100%–0% based on supply; South of Delta allocations are additionally limited because of D-1641, USFWS BO (2008) and NMFS BO (2009) export restrictions[19]	Same	Same	Same
CVP municipal & industrial	100%–50% based on supply; South of Delta allocations are additionally limited because of D-1641, USFWS BO (2008) and NMFS BO (2009) export restrictions[19]	Same	Same	Same
SWP Water Allocation				
North of Delta (FRSA)	Contract specific	Same	Same	Same
South of Delta (including North Bay Aqueduct)	Based on supply; equal prioritization between Ag and M&I based on Monterey Agreement; allocations are limited because of D-1641, USFWS BO (2008), and NMFS BO (2009) export restrictions[19]	Same	Same	Same
CVP/SWP Coordinated Operations				
Sharing of responsibility for in-basin use	1986 Coordinated Operations Agreement (FRWP and EBMUD two-thirds of the North Bay Aqueduct diversions are considered as Delta export; one-third of the North Bay Aqueduct diversion is considered as in-basin use)	Same	Same	Same
Sharing of surplus flows	1986 Coordinated Operations Agreement	Same	Same	Same
Sharing of restricted export capacity for project-specific priority pumping	Equal sharing of export capacity under SWRCB D-1641, USFWS BO (2008) and NMFS BO (2009) export restrictions[19]	Same	Same	Same

	2013 DRR Existing Condition[1]	WCM Existing Condition (CEQA)	2013 DRR Future Condition[1]	WCM Future Condition (NEPA No Action)
Water transfers	Acquisitions by SWP contractors are wheeled at priority in Banks Pumping Plant over non-SWP users; LYRA included for SWP contractors[21]	Same	Same	Same
Sharing of restricted export capacity for lesser priority and wheeling-related pumping	Cross Valley Canal wheeling (maximum of 128 TAF/yr), CALFED ROD defined JPOD	Same	Same	Same
San Luis Reservoir	San Luis Reservoir is allowed to operate to a minimum storage of 100 TAF	Same	Same	Same
CVPIA 3406(b)(2)				
Policy decision	Per May 2003 U.S. Department of the Interior decision	Same	Same	Same
Allocation	800 TAF/yr, 700 TAF/yr in 40-30-30 dry years, and 600 TAF in 40-30-30 critical years	Same	Same	Same
Actions	Predetermined non-discretionary USFWS BO (2008) upstream fish flow objectives (Oct–Jan) for Clear Creek and Keswick Dam, non-discretionary NMFS BO (2009) actions for the American and Stanislaus Rivers, and NMFS BO (2009) actions leading to export restrictions[19]	Same	Same	Same
Accounting adjustments	No discretion assumed under USFWS BO (2008) and NMFS BO (2009),[19] no accounting	Same	Same	Same
WATER MANAGEMENT ACTIONS				
Water Transfer Supplies (long-term programs)				
Lower Yuba River Accord[21]	Yuba River acquisition reducing impact of NMFS BO export restrictions[19] on SWP	Same	Same	Same
Phase 8	None	Same	Same	Same
Water Transfers (short term or temporary programs)				
Sacramento Valley acquisitions conveyed through Banks PP[23]	Post analysis of available capacity	Same	Same	Same

Notes:

[1] These assumptions have been developed under the direction of the DWR and Reclamation management team for the BDCP Habitat Conservation Plan and EIR/EIS. Additional modifications were made by Reclamation for its May 2013 baselines and by DWR for the 2013 DRR.

[2] The Sacramento Valley hydrology used in the Existing Condition CalSim II model reflects nominal 2005 land-use assumptions. The nominal 2005 land use was determined by interpolation between the 1995 and projected 2020 land-use assumptions associated with DWR Bulletin 160-98 (DWR 1998). The San Joaquin Valley hydrology reflects 2005 land-use assumptions developed by Reclamation to support Reclamation studies.

[3] The Sacramento Valley hydrology used in the Future Condition CalSim II model reflects 2020 land-use assumptions associated with DWR Bulletin 160-98 (DWR 1998). The San Joaquin Valley hydrology reflects draft 2030 land-use assumptions developed by Reclamation to support Reclamation studies.

[4] CVP contract amounts have been reviewed and updated according to existing and amended contracts, as appropriate. Assumptions regarding CVP agricultural and M&I service contracts and settlement contract amounts are documented in the delivery specifications attachments to the BDCP CalSim assumptions document.

[5] SWP contract amounts have been updated as appropriate based on recent Table A transfers/agreements. Assumptions regarding SWP agricultural and M&I contract amounts are documented in the delivery specifications attachments to the BDCP CalSim assumptions document.

[6] Water needs for Federal refuges have been reviewed and updated, as appropriate. Assumptions regarding firm level 2 refuge water needs are documented in the delivery specifications attachments to the BDCP CalSim assumptions document. Refuge level 4 (and incremental level 4) water is not included.

[7] Assumptions regarding American River water rights and CVP contracts are documented in the delivery specifications attachments to the BDCP CalSim assumptions document. The Sacramento Area Water Forum Agreement, its dry year diversion reductions, Middle Fork Project operations, and “mitigation” water is not included.

[8] Footnote removed.

[9] The new CalSim II representation of the San Joaquin River has been included in this model package (CalSim II San Joaquin River Model) (Reclamation 2005). Updates to the San Joaquin River have been included since the preliminary model release in August 2005. The model reflects the difficulties of on-going groundwater overdraft problems. The 2030 level of development representation of the San Joaquin River Basin does not make any attempt to offer solutions to groundwater overdraft problems. In addition, a dynamic groundwater simulation is not yet developed for the San Joaquin River Valley. Groundwater extraction/ recharge and stream-groundwater interaction are static assumptions and might not accurately reflect a response to simulated actions. These limitations should be considered in the analysis of result

[10] The CalSim II model representation for the Stanislaus River does not necessarily represent Reclamation’s current or future operational policies. A suitable plan for supporting flows has not been developed for NMFS BO (2009) Action III.1.3.

[11] The actual amount diverted is reduced because of supplies from the Los Vaqueros Project. The existing Los Vaqueros storage capacity is 100 TAF, and future storage capacity is 160 TAF. Associated water rights for Delta excess flows are included.

[12] Under Existing Conditions and the Future No Action baseline, USACE assumes that SWP contractors can take delivery of all Table A allocations and Article 21 supplies. Article 56 provisions are assumed and allow for SWP contractors to manage storage and delivery conditions such that full Table A allocations can be delivered. Article 21 deliveries are limited in wet years under the assumption that demand is decreased in these conditions. Article 21 deliveries for the North Bay Aqueduct are dependent on excess conditions only; all other Article 21 deliveries also require that San Luis Reservoir be at capacity and that Banks PP and the California Aqueduct have available capacity to divert from the Delta for direct delivery.

[13] Mokelumne River flows reflect EBMUD supplies associated with the Freeport Regional Water Project.

[14] The CCWD Alternate Intake Project, an intake at Victoria Canal, operates as an alternate Delta diversion for Los Vaqueros Reservoir.

[15] D-1644 and the Lower Yuba River Accord are assumed to be implemented for Existing Condition and Future No Action baselines. The Yuba River is not dynamically modeled in CalSim II. Yuba River hydrology and availability of water acquisitions under the Lower Yuba River Accord are based on modeling performed and provided by the Lower Yuba River Accord EIS/EIR study team.

[16] Footnote removed.

[17] It is assumed that either VAMP, a functional equivalent, or D-1641 requirements would be in place in 2020.

[18] Footnote removed.

[19] In cooperation with Reclamation, NMFS, USFWS, CDFG, and DWR have developed assumptions for implementation of the USFWS BO (2008) and NMFS BO (2009) in CalSim II.

[20] Current USACE permit for Banks PP allows for an average diversion rate of 6,680 cfs in all months. The diversion rate can increase up to 1/3 of the rate of San Joaquin River flow at Vernalis during Dec 15th to Mar 15th, up to a maximum diversion of 8,500 cfs, if Vernalis flow exceeds 1,000 cfs.

[21] Acquisitions of Component 1 water under the Lower Yuba River Accord, and use of 500 cfs dedicated capacity at Banks PP during Jul–Sep are assumed to be used to reduce as much of the impact of the Apr-May Delta export actions on SWP contractors as possible.

[22] Delta actions, under USFWS discretionary use of CVPIA 3406(b)(2) allocations, are no longer dynamically operated and accounted for in the CalSim II model. The Combined Old and Middle River Flow and Delta export restrictions under the USFWS BO (2008) and the NMFS BO (2009) severely limit any discretion that would have been otherwise assumed in selecting Delta actions under the CVPIA 3406(b)(2) accounting criteria. Therefore, it is anticipated that CVPIA 3406(b)(2) account availability for upstream river flows below Whiskeytown, Keswick, and Nimbus Dams would be very limited. It appears the integration of BO RPA actions will likely exceed the 3406(b)(2) allocation in all water year types. For these baseline simulations, upstream flows on Clear Creek and the Sacramento River are predetermined based on CVPIA 3406(b)(2) operations from the August 2008 BA Study 7.0 and Study 8.0 for Existing Condition and Future No Action baselines, respectively. The procedures for dynamic operation and accounting of CVPIA 3406(b)(2) are not included in the CalSim II model.

[23] Only acquisitions of Lower Yuba River Accord Component 1 water are included.

Key:
Ag = agricultural
BA = Biological Assessment
BO = Biological Opinion
BDCP = Bay-Delta Conservation Plan
CALFED = CALFED Bay-Delta Plan
CCWD = Contra Costa Water District
CEQA = California Environmental Quality Act
cfs = cubic feet per second
CVP = Central Valley Project
CVPIA = Central Valley Project Improvement Act
DFG = California Department of Fish and Game
DMC = Delta-Mendota canal
DRR = Delivery Reliability Report
DWR = California Department of Water Resources
D-xxxx = Water Right Decision
EBMUD = East Bay Municipal Utility District
EIR = Environmental Impact Review
EIS = Environmental Impact Statement
FC&WSD = Flood Control and Water Service District
FERC = Federal Energy Regulatory Commission
FRSA = Feather River Service Area
FRWP = Freeport Regional Water Project
FWS = Fish and Wildlife Service
KCWA = Kern County Water Agency
LYRA = Lower Yuba River Accord
MAF/yr = million acre-feet per year
mgd = million gallons per day
M&I = municipal and industrial
MWD = Metropolitan Water District
NEPA = National Environmental Policy Act
NMFS = National Marine Fisheries Service
NPS = National Park Service
PCWA = Placer County Water Agency
PP = Pumping Plant
Reclamation = United States Department of the Interior, Bureau of Reclamation
ROD = Record of Decision
RPA = Reasonable and Prudent Alternative
SBA = South Bay Aqueduct
SWP = State Water Project
SWRCB = State Water Resources Control Board
TAF = thousand acre-feet
TAF/yr = thousand acre-feet per year
USACE = U.S. Army Corps of Engineers
USFWS = United States Fish and Wildlife ServiceVAMP = Vernalis Adaptive Management Plan
WCM = Folsom Dam Water Control Manual
WTP = Water Treatment Plant
yr = year

2.0 WCM Updates to CalSim II

The following is a summary of the changes made to CalSim II to adapt the model for the Folsom Dam WCM Update EIS/EIR Existing Condition and Future Condition.

2.1 Update of American River Flow Management Standard Implementation

The American River Flow Management Standard (FMS) was implemented in the 2013 DRR model; however, USACE refined its implementation to be more in line with the 2008 Lower American River Flow Management Standard Technical Report (2008 FMS Report) (Water Forum 2008).

2.1.1 Flow Management Standard

The minimum flow requirements are the cornerstone of the FMS. The FMS minimum flow requirements are comprised of the downstream compliance flows (DCF) measured at the mouth of the American River and the minimum release requirements (MRR) measured at Nimbus Dam. The minimum flow requirements do not preclude Reclamation from making higher releases at Nimbus Dam, and minimum flow requirements vary throughout the year in response to the hydrology of the Sacramento and American River basins.

To align the CalSim II code with the 2008 FMS Report, the flow trigger for the March-September MRR was corrected. USACE also refined the coding for the prescriptive adjustments to more-accurately reflect the defined criteria. In addition, USACE added conference year definitions and off-ramps to the code. The Water Resource Simulation Language (WRESL) code for the FMS implementation is shown in detail in Attachment A.1.

2.1.1.1 Downstream compliance flows

According to the State Water Resources Control Board (SWRCB) Decision 893, Reclamation will operate Folsom and Nimbus Dams and Reservoirs to provide the following minimum DCF between Nimbus Dam and the mouth of the American River:

- 250 cubic feet per second (cfs) from January 1 through September 15
- 500 cfs from September 16 through December 31

The DCF were implemented in the 2013 DWR CalSim models; however, USACE made changes to the way the minimum flows are coded in the WCM models. USACE edited the definition for the minimum flow at the mouth of the American River in the *HSt_base.wresl* file by using a value from the lookup table, *HSt_base.table*, based on maintaining flow above 250 cfs in all years to be consistent with the 2008 FMS Report.

2.1.1.2 Minimum Release Requirements

The MRR are based on a sequence of determinations. Three water availability indices are applied during different times of the year, which provides adaptive flexibility in response to changing hydrological and operational conditions: the Four Reservoir Index (FRI), the Sacramento River Index (SRI), and the Impaired Folsom Inflow Index (IFII). The FRI is calculated as the combined end-of-September storage in four reservoirs – Folsom, French Meadows, Union Valley, and Hell Hole reservoirs. The SRI is an index of forecasted water year runoff for the Sacramento River Basin. The IFII is the predicted inflow to Folsom Reservoir. These indices are used as triggers to determine minimum flows, also known as index flows, for the lower American River.

The index flow is initially determined through the appropriate water availability index. During some months, prescriptive adjustments might modify the index flow to determine the final MRR. Without a prescriptive adjustment, the MRR is equal to the index flow.

According to the 2008 FMS Report, discretionary adjustments for water conservation or fish protection may be applied from June through October. If discretionary adjustments are applied, resulting flows are referred to as the adjusted minimum release requirement (adjusted MMR). Discretionary releases are not modeled in CalSim II, but are an integral part of the FMS and, therefore, are acknowledged here.

The MRR and adjusted MRR may be suspended, and the only required flows on the American River would be the DCF during extremely dry condition exceptions. Extremely dry condition exceptions, as defined in the 2008 FMS Report, occur in conference years or off-ramp condition and are described in sections 2.1.5 and 2.1.4, respectively.

The WRESL code and WCM-related modifications implementing the FMS is presented in Attachment A.1. A full discussion of the water availability indices, index flows, prescriptive adjustments, MRR, discretionary adjustments, and adjusted MRR are presented in the 2008 FMS Report.

2.1.2 FMS Implementation Curve

The 2013 DRR implementation of FMS used forecasted impaired inflow to Nimbus as a trigger for the March-September MRR. USACE changed the trigger so that it uses impaired inflow to Folsom (per 2006 FMS) rather than impaired Nimbus inflow. This coding is discussed in Attachment A.1.1.1. The FMS implementation curves are described in detail in the 2008 FMS Report.

2.1.3 Prescriptive Adjustments

USACE revised the coding of prescriptive adjustments to better represent FMS criteria. Prescriptive adjustments for storage operations as described in the 2008 FMS Report: a key revision was an update of the methodology for forecasting end-of-May and end-of-September storage to better implement prescriptive adjustments related to forecasted storage. The coding for this update is discussed in Attachment A.1.2.

2.1.4 Off-Ramp Criteria

According to the FMS, off-ramp criteria, used to reduce flows in the lower American River, are triggered if Folsom Reservoir storage is forecasted to fall below 200 thousand acre-feet (TAF) in the subsequent 12 months. If Folsom Reservoir storage is forecasted to drop below 200 TAF, the MRR are reduced to 250 cfs from January 1 through September 15, and 500 cfs from September 16 through December 31.

The 12-month Folsom Reservoir storage forecast can only be calculated within the current water year (October–September), it cannot be calculated easily across a water year; therefore, USACE was able to partially implement this off-ramp in the FMS code in CalSim II. The WRESL code is presented in Attachment A.1.3.

2.1.5 Conference Year Criteria

Conference years occur when the projected March through November unimpaired inflow to Folsom Reservoir (UIFR) is less than 400 TAF. USACE added an off-ramp for conference years in the WCM CalSim II model. To add the off-ramp, USACE assumed a reasonable forecast for the March through November UIFR would be available in February of each year. If the forecasted UIFR was low enough and a conference year was warranted, USACE assumed a group of American River fisheries and municipal interests would meet with Reclamation to discuss the declaration of conference year. The conference year off-ramp was added to the FMS code starting in February and continuing until the following January. The code for these criteria is detailed in Attachment A.1.4.

2.1.6 Folsom Area-Capacity Curve

USACE updated the area-capacity curve for Folsom Reservoir by editing the lookup table *res_info.table* according to the data provided by Reclamation (2005) and included in Attachment A.1.5.

2.2 Update of Hodge Criteria

The City of Sacramento (City) provides water supply within the City limits and to a small area outside the City limits in the Fruitridge area. The City has existing diversion, treatment, storage, and pumping facilities on the Sacramento and American Rivers. The Sacramento River plant is located just downstream of the confluence with the American River. The E. A. Fairbairn Water Treatment Plant (FWTP) is located near Howe Avenue, about 16 miles downstream from Nimbus Dam.

2.2.1 Hodge Flow Criteria

The Hodge flow criteria are constraints for City diversions based on water year type and flow bypassing the FWTP on the American River. The Hodge flow criteria go into effect when flow in the American River drops below a pre-defined flow called the Hodge flow trigger

The Hodge flow trigger is defined as average monthly flows:

October 15 through February	2,000 cfs
March through June	3,000 cfs
July through October 14	1,750 cfs

When the American River flows bypassing the FWTP are below the Hodge flow trigger, the Hodge flow criteria is implemented. Diversion flows from the FWTP can not exceed the following criteria during the designated months:

January through May	120 cfs
June through August	155 cfs
September	120 cfs
October through December	100 cfs

For example, if flows are below 3,000 cfs in April of any year, the City can not divert more than 120 cfs from the American River at the FWTP.

The City also operates according to additional restrictions on the use of FWTP diversion capacity. In extremely dry years (i.e., years in which unimpaired flow into Folsom Reservoir is less than 400,000 acre-feet), the City will limit its diversions at the FWTP to no greater than 155 cfs and no more than 50,000 acre-feet per water year. Any additional water needs are met by diversions at other locations and/or other sources. This constraint is known as the Hodge year limitation and is only in effect in the future level of demand modeling, since demand is not high enough to warrant this limitation in the existing level of demand.

2.2.2 Implementation

The flow in the lower American River is used as a trigger to implement the Hodge flow restrictions in CalSim II. If the flow in the lower American River is below the Hodge flow trigger, Hodge flow restrictions are activated and FWTP diversions are reduced. In response to this reduction in diversion on the American River, the City diversion on the Sacramento River would increase diversions by the same amount as the American River diversion decrease. The WRESL code for this implementation is explained in more detailed in Attachment A.2.

2.3 Coordinated Operating Agreement Adjustments

2.3.1 Coordinated Operating Agreement

In 1986 the Coordinated Operating Agreement between the U.S. Government and the State of California determined the respective water supplies of the Central Valley Project (CVP) and the SWP while allowing for a negotiated sharing of Sacramento-San Joaquin Delta excess outflows and the fulfillment of in-basin obligations between the two projects.

2.3.2 Feather River Rice Decomposition

Rice farmers divert water from the Thermalito Afterbay for rice straw decomposition, in addition to irrigation. The flows from this diversion return to the Sacramento River above Verona. The rice decomposition water was not included in prior DWR CalSim II releases (2011 or 2013 DRR). This water diversion is about 160 TAF/year, delivered between October and January. Since it is a relatively large diversion and it affects CVP/SWP Coordinated Operating Agreement balance, USACE added it to the WCM CalSim II model.

A diversion node and a return flow node were created, and the continuity equations were updated to maintain the basin water balance. WRESL code was added to describe the timing and volume of the rice decomposition water, as well as the storage changes resulting from the movement of this water. The WRESL code for this implementation is explained in Attachment A.5.

2.4 Balancing of Shasta and Folsom Reservoirs

2.4.1 The Purpose of Balancing

Shasta Reservoir and Folsom Reservoir are operated in tandem to meet mutual objectives in the Delta, such as flow requirements, water quality requirements, and export demands along with their individual responsibilities of meeting water supply demands, minimum flow requirements, and temperature objectives on the Sacramento and American Rivers. CalSim II simulates releases from these reservoirs using a system of weights and priorities to balance the draw down of both reservoirs to meet all the needs of the system but without excessively reducing storage in one at the expense of the other.

2.4.2 Modification to Navigation Control Point Weight

Historical commerce on the Sacramento River resulted in the requirement to maintain a minimum flow in the Sacramento River; while there is no longer any commercial traffic on the Sacramento River, Sacramento River diverters set their pump intakes based on the historical minimum flow, and the CVP continues to maintain 5,000 cfs at the navigation control point, Wilkins Slough, to facilitate diversions. In CalSim II, the file called *ncp_relax.wresl* is used to balance the draw down in Shasta and Folsom Reservoirs. A penalty is put on the variable C129_EXC when Shasta storage is greater than 1,900 TAF. This is designed to shift releases for Delta requirements to Folsom when Shasta is low because Folsom has greater refill capacity. However, water year 1992 in the 2013 DRR CalSim II model, Folsom Reservoir storage is drawn down too far (almost to dead pool) when Shasta Reservoir storage is 1,429 TAF. USACE and Reclamation determined this imbalance in storage was too extreme and the reservoir balancing needed adjustment. USACE, in consultation with Reclamation, changed the penalty on the variable C129_EXC from 10 to 3, to create a more-reasonable reservoir storage balance. This change does not notably affect any other year within the period of record.

2.5 Modifications to S8Level5

S8Level5 is a state variable that defines a regulatory or operational (rather than physical) maximum end-of-month storage for Folsom Reservoir. S8Level5 varies monthly and is defined in the input DSS file. CalSim II always releases adequate flow to ensure storage does not exceed that month's S8Level5 volume.

2.5.1 The Role of S8Level5

From October through May, S8Level5 represents the end-of-month flood reservation for Folsom Reservoir. During those months, reservoir storage is not allowed to exceed the volume identified in S8Level5 time series.

2.5.2 Modification of September values

USACE changed the end-of-September value of S8Level5 from 650 TAF to 760 TAF. The 2013 DRR version of CalSim II used a September value of 650 TAF. This caused a large release from Folsom Reservoir that could be used to improve fisheries (spawning) flows in the fall. With a September

S8Level5 value of 760 TAF (shown in Figure 2-1), there is a gradual increase in fall releases (as demonstrated in Figure 2-2) compared to a large fluctuation between September and October (also seen in Figure 2-2) resulting from a S8Level5 version of 650 TAF. This gradual increase in fall flows creates a more favorable condition for the fishery. With the new value in September, lower American River flows are less variable in the late summer.

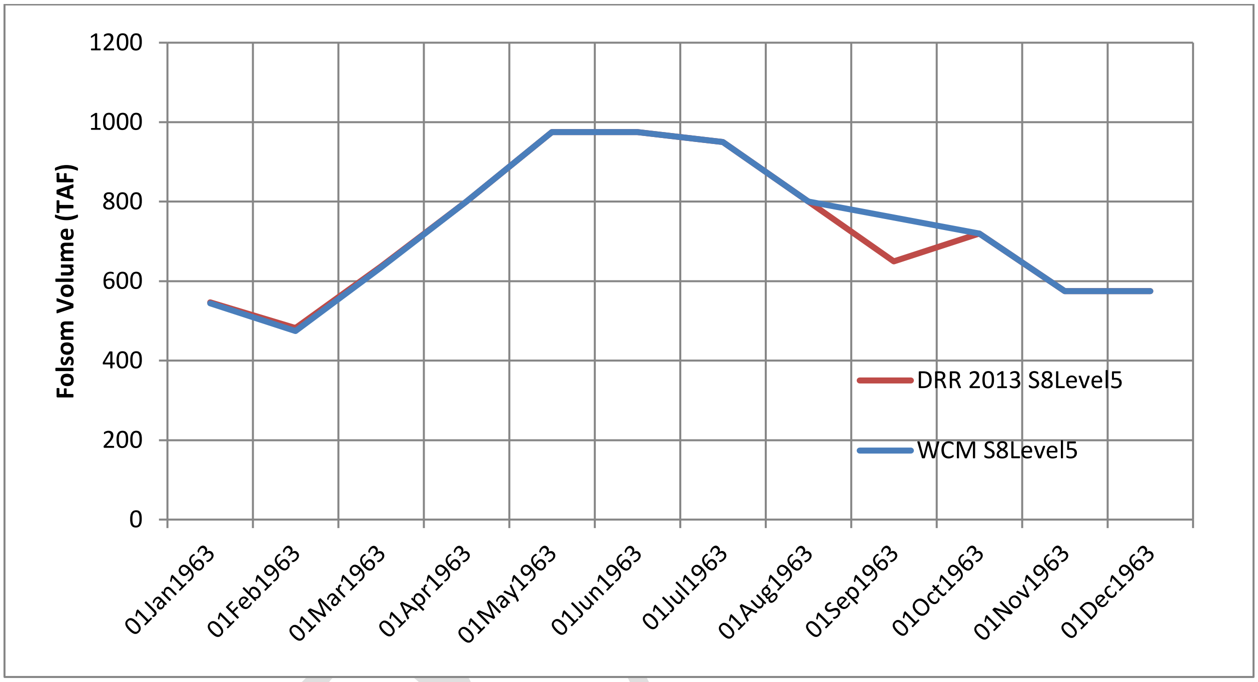


Figure 2-1. Comparison of Folsom Reservoir End-of-Month Flood Reservation Curve Volumes for the 2013 DRR and the Water Control Manual CalSim II Simulations.

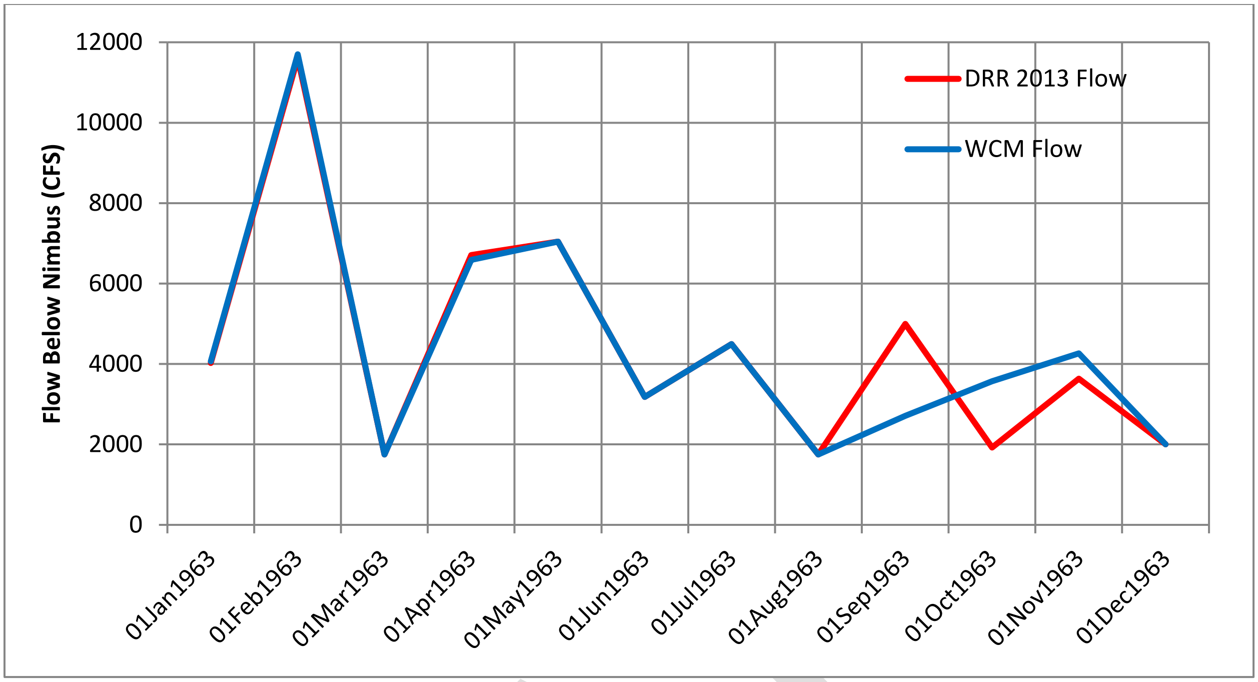


Figure 2-2. Simulated American River flow below Nimbus Dam demonstrating the effect of the end-of-September S8Level5 value between the Water Control Manual and 2013 DRR CalSim II Simulations.

2.6 EBMUD Demands

2.6.1 EBMUD Diversion at Freeport

The East Bay Municipal Utility District (EBMUD) has a water service contract with the CVP. The contracted water is available when storage in EBMUD's Mokelumne River system is less than an agreed-upon volume. CVP water supplies are delivered to EBMUD at the Freeport Regional Water Project (FRWP) with a 155 cfs maximum EBMUD diversion capacity. The CVP-EBMUD contract includes a three-year delivery cap of 165 TAF and a maximum single-year delivery of 133 TAF.

2.6.2 Modification of Freeport demands

The 2013 DRR version of CalSim II contained a node from which to deliver water to EBMUD; however, no deliveries were being made in the existing level of demand. USACE added a time series of diversions provided by EBMUD, so EBMUD diversions from FRWP were consistent with other EBMUD analyses.

2.7 American River Demands

USACE discovered an error in the representation of the City demands in the 2013 DRR. The demand time series was updated; however, the demand patterns remained the same as those in the 2013 DRR CalSim model. Table 1-1 provides a comparison between the water demands in 2013 DRR and the 2006 FMS, the Water Forum's Existing Condition.

2.7.1 Description of representation all American River Purveyor Demands

Table 2-1 shows the American River purveyor demands in the 2013 DRR and WCM CalSim II models.

Table 2-1. Comparison of Annual American River Purveyor Demands in the 2013 DRR Build and Water Control Manual Builds

Description	CalSim II Node	2013 DRR Existing Condition	Water Control Manual Existing Condition	2013 DRR Future Condition	WCM Future Condition
UPSTREAM OF FOLSOM RESERVOIR					
Placer County Water Agency (Middle Fork Project)	D300	35,500 AF	Same as 2013 DRR Existing Condition	35,500 AF	65,000 AF
FROM FOLSOM RESERVOIR					
Sacramento Suburban Water District (Placer County Water Agency water right)	D8A	17,000 AF	14,500 AF	29,000 AF	0 AF
City of Folsom	D8B	34,000 AF	Same as 2013 DRR Existing Condition	Same as 2013 DRR Existing Condition	Same as 2013 DRR Existing Condition
Water rights		27,000 AF	Same as 2013 DRR Existing Condition	Same as 2013 DRR Existing Condition	Same as 2013 DRR Existing Condition
CVP contract		7,000 AF	Same as 2013 DRR Existing Condition	Same as 2013 DRR Existing Condition	Same as 2013 DRR Existing Condition
Folsom State Prison	D8C	2,000 AF	Same as 2013 DRR Existing Condition	Same as 2013 DRR Existing Condition	Same as 2013 DRR Existing Condition
San Juan Water District (Placer County)	D8D	17,000 AF	Same as 2013 DRR Existing Condition	24,000 AF	25,000 AF
San Juan Water District (Sacramento County)	D8E	44,200 AF	Same as 2013 DRR Existing Condition	Same as 2013 DRR Existing Condition	Same as 2013 DRR Existing Condition
Water rights		33,000 AF	Same as 2013 DRR Existing Condition	Same as 2013 DRR Existing Condition	Same as 2013 DRR Existing Condition
CVP contract		11,200 AF	Same as 2013 DRR Existing Condition	Same as 2013 DRR Existing Condition	Same as 2013 DRR Existing Condition
El Dorado County Water Agency	D8I	4,000 AF	0 AF	15,000 AF	Same as 2013 DRR Future Condition
El Dorado Irrigation District	D8F	7,550 AF	Same as 2013 DRR Existing Condition	24,550 AF	Same as 2013 DRR Future Condition
Water rights		0 AF	Same as 2013 DRR Existing Condition	17,000 AF	Same as 2013 DRR Future Condition
CVP contract		7,550 AF	Same as 2013 DRR Existing Condition	Same as 2013 DRR Existing Condition	Same as 2013 DRR Existing Condition
City of Roseville	D8G	37,000 AF	Same as 2013 DRR Existing Condition	62,000 AF	Same as 2013 DRR Future Condition
Water rights		5,000 AF	Same as 2013 DRR Existing Condition	30,000 AF	Same as 2013 DRR Future Condition
CVP contract		32,000 AF	Same as 2013 DRR Existing Condition	Same as 2013 DRR Existing Condition	Same as 2013 DRR Existing Condition
Placer County Water Agency (CVP contract)	D8H	0 AF	Same as 2013 DRR Existing Condition	35,000 AF	Same as 2013 DRR Future Condition
FROM FOLSOM SOUTH CANAL					
Southern California Water Co.	D9AA	5,000 AF	Same as 2013 DRR Existing Condition	Same as 2013 DRR Existing Condition	Same as 2013 DRR Existing Condition
California Parks and Recreation	D9AB	1,000 AF	Same as 2013 DRR Existing Condition	5,000 AF	Same as 2013 DRR Future Condition
Sacramento Municipal Utility District (SMUD)	D9B	20,000 AF	Same as 2013 DRR Existing Condition	45,000 AF	Same as 2013 DRR Future Condition

Description	CalSim II Node	2013 DRR Existing Condition	Water Control Manual Existing Condition	2013 DRR Future Condition	WCM Future Condition
Water rights		15,000 AF	Same as 2013 DRR Existing Condition	Same as 2013 DRR Existing Condition	Same as 2013 DRR Existing Condition
CVP contract		5,000 AF	Same as 2013 DRR Existing Condition	30,000 AF	Same as 2013 DRR Future Condition
FROM BELOW NIMBUS DAM TO H STREET					
Sacramento Suburban Water District	D302B	0 AF	Same as 2013 DRR Existing Condition	Same as 2013 DRR Existing Condition	Same as 2013 DRR Existing Condition
Carmichael Water District	D302C	12,000 AF	Same as 2013 DRR Existing Condition	Same as 2013 DRR Existing Condition	Same as 2013 DRR Existing Condition
City of Sacramento	D302A	58,000 AF	69,200 AF	230,000 AF	Same as 2013 DRR Future Condition
SACRAMENTO RIVER BELOW THE AMERICAN RIVER CONFLUENCE					
City of Sacramento	D167A	62,300 AF	131,500 AF	230,000 AF	311,800 AF
Sacramento County Water Agency					
City of Sacramento Sacramento River diversion	D167B	15,000 AF	Same as 2013 DRR Existing Condition	30,000 AF	Same as 2013 DRR Future Condition
Freeport CVP contract	D168C	0 AF	Same as 2013 DRR Existing Condition	varied	Same as 2013 DRR Future Condition
Other water rights[2]	D168C	0 AF	Same as 2013 DRR Existing Condition	varied	Same as 2013 DRR Future Condition
EBMUD[3]	ALLOC_ D168B_EBMUD	0 AF	varied	varied	varied

1. Sacramento Suburban Water District receives 964 AF from the City of Sacramento. This water is included in the total City demand.
2. “Other” water, derived from transfers and/or other appropriated water, averaging 14,800 AF annually, but varying according to remaining unmet demand.
3. EBMUD demand is a dry year supply only. A maximum of 133,000 AF and a three-year maximum of 165,000 AF with a 155 cfs diversion capacity limitation at FRWP.

2.7.2 Placer County Water Agency

The demand for Placer County Water Agency (PCWA) increases from 35.5 TAF to 65 TAF in the WCM Future Condition scenario. This increased demand accounts for the addition of Sacramento Suburban Water District’s (SSWD) demand of 29 TAF at PCWA’s American River pump station (node D300), which is discussed in Section 2.7.3.

2.7.3 Sacramento Suburban Water District Demands

SSWD demand was changed from 29 TAF in the 2013 DRR Future Condition to zero in the WCM Future Condition scenario. This demand was moved to the PCWA pump station (D300) to account for the entire PCWA Middle Fork Project water volume of 120 TAF (as agreed upon between PCWA and Reclamation) because SSWD does not have a long-term Warren Act contract with Reclamation to receive this water from Folsom Reservoir.

SSWD’s diversion from Folsom Reservoir in the WCM Existing Condition scenario is 14.5 TAF per year in accordance with SSWD’s current Warren Act contract. This was reduced from 17 TAF that was included in the 2013 DRR Existing Condition.

2.7.4 San Juan Water District

The demand for the San Juan Water District (SJWD) was increased from 24 TAF to 25 TAF in the WCM Future Condition to reflect the delivery agreed upon in their Warren Act contract with Reclamation. SJWD's Warren Act contract provides them 25 TAF of water from PCWA's Middle Fork Project.

2.7.5 City of Sacramento Demands

The 2013 DRR Existing Condition scenario included explicit demand time series for the City's diversion facilities on the American and Sacramento Rivers, the FWTP, and the City's Sacramento River Diversion (Sac River Diversion), respectively. The 2013 DRR Future Condition included a coding revision, further described in Attachment A.2, to better simulate coordinated operations between the two diversions. The revised diversion logic was copied into the WCM Existing Condition scenario and the demand representation was modified.

The revised coding in the 2013 DRR Future Condition model allowed the Fairbairn demand volume to be combined with the Sac River Diversion volume. The revised Sac River Diversion volume in the input time series was increased by the Fairbairn demand volume, and the revised code directed the Sacramento River Plant to divert the difference between the combined demand and the Fairbairn diversion. This allowed for any shortages in Fairbairn diversions, due to Hodge criteria restrictions or otherwise, to be diverted at the Sac River Plant.

The WCM modeling also included updated demand volumes for the City to reflect a better representation of their anticipated demand.

2.7.6 El Dorado County

El Dorado County's CVP municipal and industrial demands were reduced to zero in WCM Existing Condition because the demand was incorrect. In the WCM Future Condition, their demand is 15 TAF to reflect their Warren Act contract that is expected to be finalized by that time.

2.8 Other Demands

2.8.1 CVP North of Delta Contractor Demands

The North-of-Delta CVP contractor demands from the 2013 DRR Future Condition were implemented in the WCM Update existing and future level of development models to reflect recent requests for their full contract amounts.

2.8.2 CVP Refuge Demands

The CVP refuge demands from the 2013 DRR Future Condition were implemented in the WCM existing and future level of development models to reflect recent requests for their full amounts.

2.9 VAMP Modification

The Vernalis Adaptive Management Program (VAMP) is a large-scale, long-term (12-year) management program designed to protect juvenile Chinook salmon migrating from the San Joaquin River through the Sacramento-San Joaquin Delta by setting minimum flow standards. It is also a scientific experimental program to determine how salmon survival rates change in response to alterations in San Joaquin River flows and Delta exports. VAMP was introduced in 2000 as part of the SWRCB Decision 1641 and is guided by the framework provided in the San Joaquin River Agreement and recognition of the hydrologic conditions within the watershed.

The VAMP provides for a 31-day pulse flow on the San Joaquin River during the months of April and May, along with a corresponding reduction in SWP and CVP Sacramento-San Joaquin Delta exports. The VAMP pulse flow and reduced Delta export are determined based on a forecast of the San Joaquin River flow that would occur during in the spring if the VAMP were not in place. Based upon hydrologic conditions, the target flow in a given year could either be increased to the next higher value (double-step) or the supplemental water requirement could be eliminated entirely (sequential dry-year relaxation). (San Joaquin River Group Authority 2013)

2013 DRR Existing Condition CalSim II model employs a double-step flow standard in place of the previously used single-step standard. This double-step standard was carried forward in the WCM Update model as well.

A double-step flow year occurs when the sum of the numerical indicators (Table 2-2) for the previous year's year-type and current year's forecasted 90 percent exceedance year-type is seven or greater. A sum of seven represents a general recognition of either abundant reservoir storage levels or a high probability of ample runoff. A sequential dry-year relaxation year occurs when the sum of the numerical indicators for the two previous years' year types and the current year's forecasted 90 percent exceedance year-type is four or less, an indication of extended drought conditions.

Under the San Joaquin River Agreement, the maximum amount of supplemental water to be provided to meet VAMP target flows in any given year was 110,000 acre-feet. In a double-step year, the quantity of supplemental water required can be as high as 157,000 acre-feet.

Table 2-2. San Joaquin Valley Water-Year Hydrologic Classification Numerical Indicators Used in VAMP

Water Year Hydrologic Classification	VAMP Numerical Indicator
Wet	5
Below Normal	4
Critical	3
Above Normal	2
Dry	1

2.10 Addition of CVP/SWP Facilities

Four pieces of infrastructure were added to CalSim II for the WCM project. They are described in the following sections.

2.10.1 Delta Water Supply Project

The WCM model includes the new intake and pump station that will divert water from the San Joaquin River through miles of underground pipeline to the City of Stockton's 30 million gallons per day (mgd) water treatment plant. Code for the Delta Water Supply Project existed in the 2013 DRR CalSim II model but was not yet turned on. USACE switched the code on in the WCM modeling by including the WRESL files containing the Delta Water Supply Project code and excluding the WRESL files that do not contain the Delta Water Supply Project code.

2.10.2 South Bay Aqueduct Enlargement Project

The South Bay Aqueduct was the first water delivery system completed under the SWP and has been conveying water to Alameda County since 1962 and to Santa Clara County since 1965. It was designed for a capacity of 300 cfs. Recent flow tests and studies have shown that the actual capacity is 270 cfs. The South Bay Aqueduct Enlargement Project purpose is to increase the capacity of the South Bay Aqueduct to 430 cfs to meet future water demands and provide operational flexibility to reduce State Water Project peak power consumption (DWR 2014). USACE implemented the capacity increase in CalSim II by changing transfer capacity limits in the *common/System/SystemTables_All/Channel_Table.wresl* file and the *common/ReOperations/Transfers/Transfers_Capacity_Limits.wresl* file in both Existing and Future Condition models.

2.10.3 Freeport Regional Water Project

The water intake facility and pumping plant for the FRWP are located on the Sacramento River, upstream of the town of Freeport, and will divert water and pump it through pipelines to other FRWP facilities. Water from the FRWP will go to Sacramento County Water District, Contra Costa Water District, and EBMUD. In the 2013 DRR CalSim II model for Existing and Future Condition, the demand for Contra Costa Water District is set to zero. The total CVP demand for Sacramento County Water District is delivered at FRWP, as well as some Fazio water if it cannot be delivered at the Sac River Plant. EBMUD will use 100 mgd of water from the FRWP as a supplemental water source in dry years. EBMUD has an adequate water supply during normal and wet years, but must ration water during dry years. The supplemental water source from the FRWP will help EBMUD reduce rationing during dry years.

In the WCM Update CalSim II model, demands for EBMUD and Sacramento County Water District are met at the node (D168) that represents the FRWP. The EBMUD demands have been updated according to data provided by EBMUD.

2.10.4 Fremont Weir Notch

The Freemont Weir controls the release of water into the Yolo Bypass which is about seven feet high and a mile long. The Bay-Delta Conservation Plan includes modifications of the Freemont Weir, including the creation of a gated channel to control the timing, frequency, and duration of Yolo Bypass inundation from the Fremont Weir.

The 2013 DRR CalSim II models do not include the notch in the Fremont Weir. However, because implementation of the Fremont Weir project is expected to be after 2016, it was included in the Future Condition but not the Existing Condition.

In CalSim II, *gate11flow* is the variable that represents the flow through this notch in the weir. USACE added the minimum flow through the notch by commenting out the definition of *gate11flow* in the *common\hydrology\WEIRS\ weir_steps_dailyops.wresl* file to the Future Condition model. Furthermore, USACE added the file *common\hydrology\WEIRS\weir_steps_monthops.wresl* to add the proposed notch operation of Fremont Weir into the Future Condition of the WCM model. Lastly, the lookup table, *CONV\Run\Lookup\FRENotch_OnOff.table*, determines whether or not the proposed Bay-Delta Conservation Plan notch operations are turned on or off for each day of a year. The switches are turned on for the daily operation of the Bay-Delta Conservation Plan notch between December and April of each year in the Future Condition of the WCM model.

3.0 WCM Modifications for WCM Alternatives

USACE is evaluating scenarios with three different water control diagrams (WCD) for this project.

1. Fixed-400 water control diagram developed by USACE and published in the December 1987 Water Control Manual for the Folsom Dam (USACE 1987), as shown in Figure A.6-1.
2. Variable 400-670 water control diagram developed by the Sacramento Area Flood Control Agency (SAFCA) and published in the 1994 SAFCA Folsom Dam Interim Reoperation EIR/Environmental Assessment (SAFCA and U.S. Bureau of Reclamation 1994) and currently being used for flood operation of the Folsom Lake, shown in Figure A.6-2.
3. Variable 400-600 water control diagram currently under development by USACE.

3.1 CEQA Existing Condition (E504) and NEPA No Action (J604)

The WCM Existing Condition CalSim II run represents the WCM Alternative E504, the California Environmental Quality Act (CEQA) Existing Condition. The WCM Future Condition CalSim II run represents the WCM Alternative J604, the National Environmental Policy Act (NEPA) No Action Alternative. The differences between the two runs are described in earlier sections of this report. Both the Existing Condition and No Action Alternative are based on the SAFCA's 400-670 WCD.

3.2 Modifications for Fixed-400 Run

3.2.1 How S8level Values Were Determined

USACE computed Folsom Lake top-of-conservation-pool storage volume using the Fixed-400 WCD (see Figure A.6-1). The fixed-400 WCD specifies flood control reservation in the reservoir for each month from October through May. For the months of October through January and for May, the flood control reservation is same for each year. For February, March, and April, flood control reservation varies from year to year depending on the basin wetness index.

The basin wetness index is effectively the cumulative basin average precipitation, with a built-in decay factor as described in the manual. The basin precipitation is weighted based on measurements at four precipitation gages. USACE has computed the index since water year 1989, when it came into use. For this project, basin wetness series was extended back to 1922. For periods in which the original four gages were not available, USACE adjusted the weighting scheme to allow computation of the basin wetness series using suitable replacement gages as follows:

1922 - 1954: Four gages (Auburn, Gold Run, Placerville, and Twin Lakes) were used to calculate the index using the current method (BNAP/STAP * Total Precipitation + 0.97 * previous day's parameter). For the period of overlap with the archived index, a regression was calculated between the substitute and the current index. By applying the slope and intercept to the surrogate index, current index using a different set of gages was estimated.

1954 - 1979: For this period, three of the gages (Blue Canyon, Georgetown, and Pacific House) specified in the current water control manual are available. These three were used, and the current formula was adjusted to make up for the unavailable data for the fourth site (Sly Park).

1980 - 1988: All four of the gages currently used for calculating the index are available, so current snap values were used, and the index was calculated. The archive does not include the parameter for this period.

1989 - Current: Beginning in water year 1989, the flood control parameter is available in the archive database.

Since the CalSim model has a monthly time-step, only the values at the end-of-month were used for computing S8level5. Required flood control space in Folsom was computed by HDR using USACE' top-of-conservation-pool storage values. This required flood control space was further subtracted from 975 TAF of maximum Folsom storage in CalSim to come up with the S8level5. Values for S8level4 were adjusted to match S8level5 for the months of November through March and also not to exceed S8level5 for rest of the months. Table 3-1 presents the data used in the Fixed-400 runs. In Addition, there were instances where S8level2 was dropping below 350 TAF in the CEQA/NEPA models whenever S8level5 was dropping below 350 TAF. For the fixed-400 runs, S8level5 does not drop below 350 TAF, so values for S8level2 were updated to 350 TAF for those instances.

Table 3-1. S8level5 and S8level4 Values Used in Fixed-400 Runs

Month	S8level5 from CEQA/NEPA runs	S8level5 used for Fixed-400 runs	S8level4 from CEQA/NEPA runs	S8level4 used for Fixed-400 runs
Oct	720	712	600	unchanged
Nov	Varies from 405 to 575	575	Same as S8level5 for CEQA-NEPA runs	Same as S8level5 for Fixed-400 runs
Dec	Varies from 305 to 575	575		
Jan	Varies from 318 to 575	575		
Feb	Varies from 352 to 575	Varies from 575 to 623		
Mar	Varies from 570 to 675	Varies from 636 to 700		
Apr	800	803	800	unchanged
May	975	974.77	975	974.77
Jun	975	975	600	unchanged
Jul	950	950	600	unchanged
Aug	800	800	600	unchanged
Sep	760	760	600	unchanged

3.3 Modifications for 400-600 Run

3.3.1 How Storage Credit Ratio was Determined

SAFCA's 400-670 WCD (See Figure A.6-2) defines the required flood control reservation in the Folsom Reservoir for the months of October through May. This flood control reservation varies from 400 TAF to 670 TAF, based on available space in the upstream reservoirs (French Meadows, Hell Hole, and Union Valley). The 400-670 WCD assumes that the total creditable flood control transfer space available in the upstream reservoirs can be translated 1:1 to the total creditable control transfer space variable at the Folsom Reservoir. USACE did extensive analysis of the validity of this ratio and found that a ratio of 1:0.905 of upstream credit to Folsom credit was more reasonable in representing this relationship. USACE recommends using this storage credit ratio for the 400-600 WCD.

Table 3-2. Creditable space for 400-600 Runs

Upstream Creditable Space (TAF)	Folsom Credited Space (TAF)	Folsom Total Flood Space (TAF)
0	0	600
221	200	400
Resulting "ratio" is 200/221 = about 0.905.		

3.3.2 How S8level Values were Determined

The S8level5 inputs for the 400-600 runs were developed using the upstream reservoirs' storages derived from the UARM time series in CalSim II and the HEC-ResSim US storage distribution, along with the 1.0:0.905 crediting scheme 400/600 WCD that USACE had developed.

The individual upstream reservoir storages were calculated using the UARM time series from the NEPA No Action CalSim II Model and ratio of upstream reservoirs storages from the J604 HEC-ResSim model. For the water year 2003 when HEC-ResSim upstream reservoir storages were not available, a water-year-type average of all years' storages were computed and used for 2003.

Space available in the upstream reservoir at the end of each month is compared against the maximum creditable space to come up with creditable flood control transfer space in each upstream reservoir. The storage credit ratio of 0.905 is then applied to the total upstream creditable flood control transfer space to compute the flood control transfer space at the Folsom Reservoir. For each of the values in the 82-years series, the flood control reservation is computed by interpolating the values in the 400-600 WCD. The required reservoir storage or the S8level5 is then computed by subtracting this flood control reservation from the 975 TAF of maximum Folsom Reservoir storage in CalSim. A sample calculation is provided in Table 3-3. The 400-600 WCD as developed by USACE is presented in Table 3-4.

In Addition, S8level4 and S8level2 values were also modified in a similar fashion as Fixed-400 WCD runs.

Table 3-3. Sample Calculation of Required Reservoir Storage from 400/600 Water Control Diagram

Reservoir	Storage on Jan 1 (TAF)	Storage at Spillway Crest (TAF)	Space Available (TAF)	Maximum Creditable Space (TAF)	Creditable Flood Control Transfer (TAF)
French Meadows	41.605	111.605	70	55	55
Hell Hole	82.590	207.590	125	91	91
Union Valley	144.985	224.985	80	75	75
Total creditable **Upstream** flood control transfer space (TAF)					221
Folsom flood control transfer space (TAF)					200
Flood control reservation at Folsom Lake (TAF)					400
Required reservoir storage at Folsom Lake (TAF)					575

Table 3-4. 400-600 WCD Based on 1:0.905 Upstream Credit Ratio

Upstream Credit	0	33,150	110,500	165,750	193,375	221,000
Credit at Folsom Lake	0	30,000	100,000	150,000	175,000	200,000
1-Jan	366,934	396,823	466,823	516,823	541,823	566,934
1-Mar	366,934	396,823	466,823	516,823	541,823	566,934
21-Apr	741,779	741,779	741,779	741,779	741,779	741,779
1-Jun	966,934	966,934	966,934	966,934	966,934	966,934
1-Oct	966,934	966,934	966,934	966,934	966,934	966,934
18-Nov	491,050	514,300	566,800	566,800	566,800	566,800
23-Nov	437,193	466,293	524,293	566,793	566,793	566,793
26-Nov	404,097	433,797	501,797	544,297	566,797	566,797
30-Nov	366,934	396,823	466,823	516,823	541,823	566,934
31-Dec	366,934	396,823	466,823	516,823	541,823	566,934

Note: This WCD presents Folsom Reservoir storage in acre-feet (AF).

ATTACHMENT 1

A.1 Flow Management Standard Implementation

The American River Flow Management Standard (FMS) was updated in the Folsom Dam Water Control Manual (WCM) Update CalSim II models to more accurately reflect the description of the FMS. A number of coding changes were implemented identically in both Existing and Future Condition scenarios; any differences between the Existing and Future Condition model are identified as such. Improvements from the 2013 Delivery Reliability Report (DRR) models include both the interpretation of the Impaired Folsom Inflow Index (IFII) and the prescriptive adjustments. Both were updated to adhere to the Lower American River Flow Management Standard Technical Report (Water Forum 2008). Additionally, the FMS Off-ramp and the Conference Year designation were implemented into the FMS code. These modeling improvements are detailed in the Sections that follow.

A.1.1 Implementation Curves

According to the FMS (Water Forum 2008), index flows, the initial flows below Nimbus Dam are determined by the application of three water availability indices: the Four Reservoir Index (FRI), the Sacramento River Index (SRI), and the IFII. The FRI is calculated as the combined end-of-September storage in four reservoirs – Folsom, French Meadows, Union Valley, and Hell Hole Reservoirs. The SRI is an index of forecasted water year runoff for the Sacramento River Basin. The IFII is the predicted inflow to Folsom Reservoir. USACE made no changes to the FRI or SRI calculations, but the forecasting methodology for the IFII was improved for the WCM models.

A.1.1.1 Impaired Folsom Inflow Index

March through Labor Day index flows are based upon the IFII. The IFII is an index of the forecasted volume of flow into Folsom Reservoir from May through September and is calculated using the U.S. Department of the Interior, Bureau of Reclamation’s (Reclamation) 90 percent exceedance water operations forecast for Folsom Reservoir inflow.

The IFII was selected as the index for the determination of minimum flows for March through September since it is a reasonable surrogate for available water supply and can be reasonably calculated in March.

Figure A.1-1 depicts the IFII implementation curve. If the IFII is greater than or equal to 550 thousand acre-feet (TAF), the index flow will be 1,750 cubic feet per second (cfs). If the IFII is between 375 and 550 TAF, the index flow will be between 800 and 1,750 cfs, proportional to the value of the IFII. If the IFII is less than or equal to 375 TAF, the index flow will be 800 cfs (Water Forum 2008).

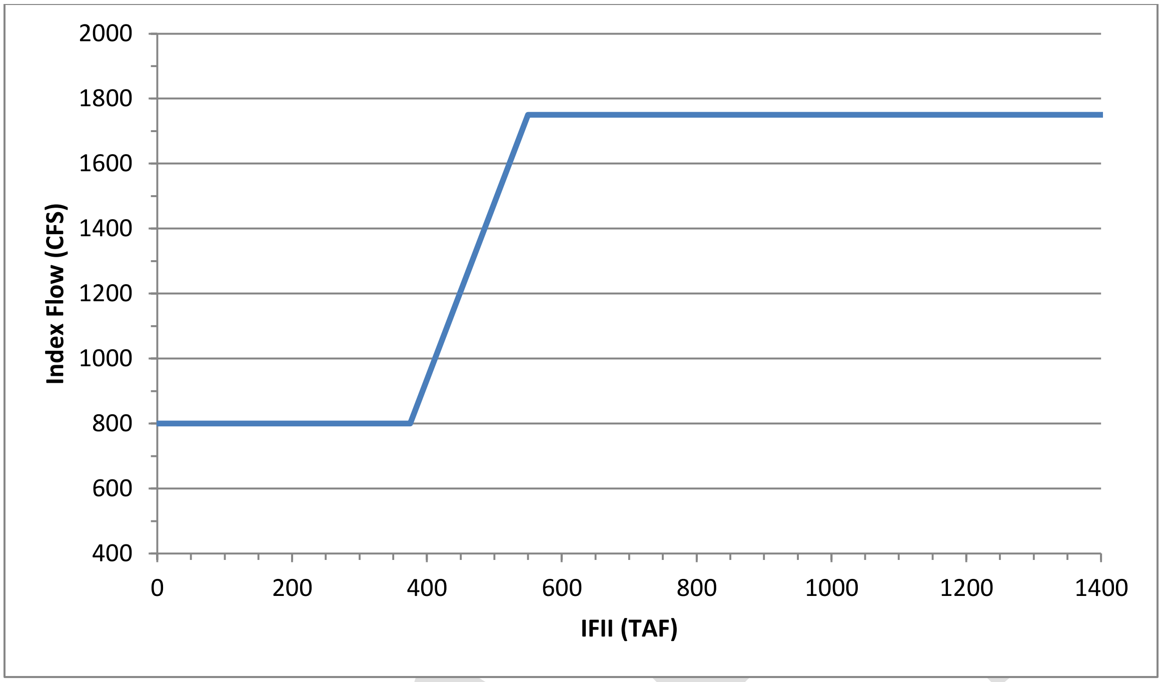


Figure A.1-1. Impaired Folsom Inflow Index Flow for March through Labor Day

The common\NorthOfDelta\American\FMStandard.wresl file contains the code to implement the FMS. In it, the variable *amerFMPTriger*, shown in box A.1.1-1, defines the trigger used to select the index flow. In October though December the trigger is defined by the FRI and is calculated as the Folsom Reservoir storage in the previous September plus the total of up-stream reservoir storage, *UARM*. In January and February, the SRI year type defines the trigger; however, *S8*, Folsom Reservoir storage, is used as a surrogate here but never used to define the index flow for the FMS. In March through September the trigger is defined by the IFII. The definition for the IFII was corrected in the WCM models to be equal to the forecasted inflow to Folsom Reservoir only. The Lake Natoma evaporation and diversions that were included in the calculation of the IFII for the 2013 DRR CalSim II model were removed.

```
                                                                    (A.1.1-1)
define amerFMPTrigger {
   case OctDec {
        condition        month>=OCT .and. month<=DEC
        value            S8(prevSEP) + UARM(prevSEP) }  ! Computes Four Reservoir Index

   case JanFeb {
        condition        month>=JAN .and. month<=FEB
        value            S8(-1) }    ! No need for a trigger in Jan-Feb since SRI year type determines
                                       standard (see code below)
   case MarSep {
        condition        always
        value            AmerFrcstInflow}   ! Computes Impaired Folsom Inflow Index
```

The sum of the inflows arcs I8 and I300 is used to forecast the impaired inflow to Folsom Reservoir for the IFII, as shown in box A.1.1-2, during the months of March through September. Every other month of the year, the IFII is equal to zero.

```
                                                                  (A.1.1-2)
define AmerFrcstInflow {
  case MAR_SEP {
          condition      month >= MAR .and. month <= SEP
          sum(i=-(month-MAY),SEP-month)  I8(i)*cfs_ (i) + I300(i)*cfs_taf(i) }
  case other {
     condition      always
     value          0.0   }
}
```

A.1.1.2. Index Curve "Trigger" Table

The implementation of the index flows is accomplished through the use of a lookup table called FMPTrigger.table (trigger table). All three implementation curves are represented in the trigger table, Table A.1-1, in the months in which they are applied in the FMS. Water years, rather than calendar years, are used in CalSim II: month 1 is October. In the WCM CalSim II models, the trigger table was updated in two ways: 1) the D-893 basement was excluded because D-893 requirement was separately added to the models in the HSt_base.wresl file; and 2) the IFII index triggers (March to September, water year months 6 to 12) were updated so that they represented the correct IFII implementation curves for the FMS. These changes are shown in Table A.1-1 where the trigger tables from 2013 DRR and WCM are shown side by side.

Table A.1-1. Comparison of the Trigger Table from 2013 DRR and the Same Table from WCM Update

2013 DRR Trigger Table			WCM Updated Trigger Table		
Month	Trigger	FMPFlow	Month	Trigger	FMPFlow
1	0	500	1	0	800
1	300	500	1	600	800
1	301	800	1	746	1750
1	600	800	1	796	1750
1	746	1750	1	848	2000
1	796	1750	1	9000	2000
1	848	2000			
1	9000	2000			
2	0	500	2	0	800
2	300	500	2	600	800
2	301	800	2	746	1750
2	600	800	2	796	1750
2	746	1750	2	848	2000
2	796	1750	2	9000	2000
2	848	2000			
2	9000	2000			
3	0	500	3	0	800
3	300	500	3	600	800
3	301	800	3	746	1750
3	600	800	3	796	1750
3	746	1750	3	848	2000

2013 DRR Trigger Table				WCM Updated Trigger Table		
3	796	1750		3	9000	2000
3	848	2000				
3	9000	2000				
4	0	250		4	0	800
4	250	800		4	514	800
4	514	800		4	714	1750
4	714	1750		4	1000	2500
4	1000	2500		4	1770	99999
4	1770	99999				
5	0	250		5	0	800
5	250	800		5	454	800
5	454	800		5	814	1750
5	814	1750		5	1000	2500
5	1000	2500		5	1770	99999
5	1770	99999				
6	0	250		6	0	800
6	100	250		6	375	800
6	101	800		6	550	1750
6	200	800		6	9000	1750
6	400	1750				
6	9000	1750				
7	0	250		7	0	800
7	100	250		7	375	800
7	101	800		7	550	1750
7	200	800		7	9000	1750
7	400	1750				
7	9000	1750				
8	0	250		8	0	800
8	100	250		8	375	800
8	101	800		8	550	1750
8	200	800		8	9000	1750
8	400	1750				
8	9000	1750				
9	0	250		9	0	800
9	100	250		9	375	800
9	101	800		9	550	1750
9	200	800		9	9000	1750
9	400	1750				
9	9000	1750				
10	0	250		10	0	800
10	100	250		10	375	800
10	101	800		10	550	1750
10	200	800		10	9000	1750
10	400	1750				
10	9000	1750				
11	0	250		11	0	800
11	100	250		11	375	800
11	101	800		11	550	1750
11	200	800		11	9000	1750
11	400	1750				
11	9000	1750				

2013 DRR Trigger Table				WCM Updated Trigger Table		
12	0	375		12	0	800
12	100	375		12	375	800
12	101	800		12	550	1750
12	200	800		12	9000	1750
12	400	1750				
12	9000	1750				

A.1.2 Determination of the Final MRR

The index flows are calculated as described in Section A.1.1 and the resultant variable, a temporary minimum release requirement (MRR) is called *minFMPAmerTmp*. The prescriptive adjustments are applied to the temporary MRR to create the final MRR in a multi-case definition for the variable *minflowFMPAmer* in the file FMStandard.WRESL. At the end of the file, the minimum in-stream flow below Nimbus is set equal to *minflowFMPAmer*. The cases that define the conference years, off-ramp and prescriptive adjustments are described in the following text and equations.

The CalSim II definition of *minflowFMPAmer*, the final MRR, begins by implementing, if applicable, the conference year and the off-ramp. These cases are shown in box A.1.2-1. If the unimpaired inflow to Folsom Reservoir from March to November (*UIFR_Yr*) is less than 400 TAF, then a conference year is implemented and flows are equal to D893 minimum flows (further described in Section A.1.3). If Folsom Reservoir storage (*S8min*) is forecast to be equal to or below 200 TAF in any of the forthcoming 12 months, an off-ramp is implemented and flows are equal to D893 minimum flows (further described in Section A.1.4).

(A.1.2-1)

```
define minflowFMPAmer {
        case confyr {
                condition   UIFR_Yr <= 400
                value       D893min  }
        case offRamp {
                condition   S8min <= 200.0
                value       D893min }
```

The FMS implementation begins in October, the first month of the water year. WRESL code is interpreted within CalSim II in the order it is written, so the MRR for October maximum flows is introduced after the determination of both conference and off-ramp years. When the FRI-based index flows (*minFMPAmerTmp*) for October are higher than 1,500 cfs, the MRR is capped at 1,500 cfs, as shown in box A.1.2-2.

(A.1.2-2)

```
    case OctMax {
                condition   month==OCT .and. minFMPAmerTmp > 1500.
                value       1500. }}
```

Spawning Flow Progression Prescriptive Adjustment

As part of the FMS, a prescriptive adjustment to the FRI-based index flows, referred to as the Chinook salmon spawning flow progression, is implemented during November, if the October through December FRI-based index flows are higher than 1,500 cfs.

The Chinook salmon spawning flow progression consists of two incremental step increases in flows. The first step (scheduled to occur on November 2) increases lower American River flows from 1,500 cfs up to the index flow minus 250 cfs. Therefore, the first-step increase will not occur unless the index flow is greater than 1,750 cfs. The second-step increase in flow occurs seven days after the first step and increases lower American River flows to the index flow.

If the index flow is 1,500 cfs or less, no spawning flow prescriptive adjustment is implemented, and the MRR is equal to the index flow and will be implemented from October 1 through December 31.

If a spawning flow progression prescriptive adjustment is implemented, then the MRR is equal to the FRI-based index flow for October, the spawning flow progression-adjusted index flows for November, and the FRI-based index flow for December (Water Forum 2008).

The equation in box A.1.2-3 shows the November maximum MRR. If the index flow (*minFMPAmerTmp)* is greater than or equal to 2,000 cfs, the spawning flow progression is implemented to bring the flows up to 2,000 cfs. Since CalSim II is a monthly time step, USACE used an average of all the daily flows during the spawning flow progression.

(A.1.2-3)

```
case NovMax {
        condition   month==NOV .and. minFMPAmerTmp >= 2000.
        value       ((1500.*1.) + (1750.*7.) + (2000.*22.))/30. }
```

If the index flow is less than or equal to 1,500 cfs in October, then the MRR is equal to the FRI-based index flow as shown in box A.1.2-4.

(A.1.2-4)

```
case OctMin {
        condition   month>=OCT .and. month<=DEC .and. minFMPAmerTmp <= 1500.
        value       (minFMPAmerTmp) }
```

The MRR is the index flow in December, if the index flow is greater than 1,500 cfs, as shown in box A.1.2-5.

(A.1.2-5)

```
case DecOther {
        condition    month==DEC .and. minFMPAmerTmp > 1500.
        value        max(minFMPAmerTmp, 1500.)}
```

If the index flow is greater than 1,500 cfs in November, the spawning flow progression prescriptive adjustment would be in effect. Since CalSim II operates in a monthly time step, an average of the daily flows is used during the spawning flow progression, as shown in box A.1.2-6. The spawning flow progression starts on the second day of November; therefore, there is one day with a flow of 1,500 cfs. For the next 7 days, the flows are either the index flow (*minFMPAmerTmp*) minus 250 cfs or 1,500 cfs, whichever is higher. Finally, for the remaining 22 days of the month, flows are either the index flows or 1,500 cfs, whichever is higher.

(A.1.2-6)

```
case NovOther {
        condition    month==NOV .and. minFMPAmerTmp > 1500.
        value        ((1500.*1.) + (max(minFMPAmerTmp - 250., 1500.)* 7.) +
                     (max(minFMPAmerTmp, 1500.)*22.)) / 30. }
```

January and February FMS flows, shown in box A.1.2-7, are based on the SRI. If the SRI in January indicates a critically dry year and the December MRR is greater than 800 cfs, then the January MRR is 85 percent of the December MRR. In February, the same condition applies; if the SRI is critical and the January MRR was greater than or equal to 800 cfs, then the February MRR is 85 percent of the January MRR.

(A.1.2-7)

```
case JanFebC {
    condition    month>=JAN .and. month<=FEB .and. sri_ytp == 5 .and. C9_fmp_mif(-1) >= 800.
    value        max(800., min(1750., (0.85 * C9_fmp_mif(-1)))) }
```

Box A.1.2-8 continues to describe the FMS for January. If the SRI indicates a below normal or dry year, and December’s Folsom Reservoir storage was greater than 300 TAF, then the MRR is December’s MRR; however, it cannot be greater than 1,750 cfs. If January’s SRI is above normal or wet, the MRR is 1,750 cfs.

(A.1.2-8)

```
case JanDBN {
        condition     month==JAN .and. S8(-1)>=300. .and. sri_ytp >= 3
        value         max(800., min(1750.,C9_fmp_mif(-1))) }
case JanANW {
        condition     month==JAN .and. S8(-1)>=300.  .and. sri_ytp <= 2
        value         1750.}
```

Box A.1.2-9 describes the FMS for February. If the SRI indicates a below normal or dry year, and January's Folsom Reservoir storage was greater than 350 TAF, then the MRR is January's MRR; however, it cannot be greater than 1,750 cfs. If February's SRI is above normal or wet, the MRR is 1,750 cfs.

(A.1.2-9)

```
case FebDBN {
        condition     month==FEB .and. S8(-1)>=350. .and. sri_ytp >= 3
        value         max(800., min(1750.,C9_fmp_mif(-1))) }
case FebANW {
        condition     month==FEB .and. S8(-1)>=350. .and. sri_ytp <= 2
        value         1750.}
```


Prescriptive Adjustments Based on End-of-Month Folsom Reservoir Storages

In addition to the SRI index flows, the January and February MRR can be modified by prescriptive adjustments based on Folsom Reservoir storage at the end of the previous month.

If the end-of-December storage is less than 300 TAF, then the January MRR is 85 percent of the December MRR, or 800 CFS, whichever is higher. Similarly, if the end-of-January Folsom Reservoir storage is less than 350 TAF, then the February MRR is 85 percent of the January MRR, or 800 CFS, whichever is higher. If an end-of-month (December or January) Folsom Reservoir storage-based prescriptive adjustment is implemented, then the MRR are equal to the resultant flows based on this adjustment.

The flood control curve can, on a rare occasion, require that more than 625 TAF of flood control space be maintained in Folsom Reservoir. Therefore, in the equations in boxes A.1.2-10 and A.1.2-11 S8Level5 is used as a constraint. In addition, 0.00001 was added to *S8(-1)* (Folsom Reservoir storage in the previous time step) to ensure January and February flows were correct even under flood control operations in case of rounding errors relating S8Level5 and S8.

(A.1.2-10)

```
case JanLoSto {
        condition     month==JAN .and. S8(-1) < 300. .and. S8Level5(-1) > S8(-1) + 0.00001
        value         max(800., min(1750.,0.85 * C9_fmp_mif(-1))) }
```

```
                                                                     (A.1.2-11)
        case FebLoSto {
                condition     month==FEB .and. S8(-1) < 350. .and. S8(-1) + 0.00001 < S8Level5(-1)
                value         max(800., min(1750.,0.85 * C9_fmp_mif(-1))) }
```

Prescriptive Adjustments Based on End-of-May Folsom Reservoir Storage

The FMS includes an end-of-May storage prescriptive adjustment, applied during the March through May period of projected dry hydrologic conditions. The prescriptive adjustment is intended to prevent an end-of-May Folsom Reservoir storage less than 700 TAF.

If an end-of-May Folsom Reservoir storage-based prescriptive adjustment is implemented, then the MRR is equal to the resultant flows based on this adjustment, and the MRR remains the same from March to May.

Equations A.1.2-16 through A.1.2-18 show the implementation of the prescriptive adjustments based on end-of-May Folsom Reservoir storage. The end-of-May Folsom Reservoir storage is forecast using the code in box A.1.2-12, and it is calculated only once, in March. The code uses the reservoir storage of the previous time step (February), adds the forecasted water balance in Folsom Reservoir (*AmerFrcstSpring*), and subtracts the forecast FMS flows below Nimbus Dam (*FMPfrcstMarMay*) for March through May. The variable *AmerFrcstSpring* is the water balance for Folsom from March to May and is shown in box A.1.2-13. It adds the inflows, diversions, and evaporation from Folsom Reservoir. Evaporation (*Evap_Folsm_MarMay)* was calculated for March through May, so it is divided by three in the *AmerFrcstSpring* definition for March.

```
                                                              (A.1.2-12)
define EOMayForecast {
        case MarForecast {
                condition     month == MAR
                 value        min(975., S8(-1)+AmerFrcstSpring-FMPfrcstMarMay) }
        case other {
                 condition    always
                value        0.   } }
```

```
                                                              (A.1.2-13)
define AmerFrcstSpring {
   case MARforecast{
           condition      month == MAR
           sum(i=-(month-MAR),MAY-month) I8(i)*cfs_taf(i) + I300(i)*cfs_taf(i)
         - min(dem_D8b_pmi_ann(i), dem1_D8b_pmi_a * perdel_cvpmi_sys) * perdem_70Fol(i)
         - min(dem_D8e_pmi_ann(i), dem1_D8e_pmi_a * perdel_cvpmi_sys) * perdem_70SJWDS(i)
         - min(dem_D8f_pmi_ann(i), dem1_D8f_pmi_a * perdel_cvpmi_sys) * perdem_70ElDor(i)
         - min(dem_D8g_pmi_ann(i), dem1_D8g_pmi_a * perdel_cvpmi_sys) * perdem_70Rose(i)
         - min(dem_D8h_pmi_ann(i), dem1_D8h_pmi_a * perdel_cvpmi_sys) * perdem_70pcwa(i)
         - min(dem_D8i_pmi_ann(i), dem1_D8i_pmi_a * perdel_cvpmi_sys) * perdem_70ElDorCo(i)
         - min(dem_D9ab_pmi_ann(i), dem1_D9ab_pmi_a * perdel_cvpmi_sys) * perdem_70CARec(i)
         - min(dem_D9b_pmi_ann(i), dem1_D9b_pmi_a * perdel_cvpmi_sys) * perdem_70SMUD(i)
```

```
        - min(dem_D300_pmi_ann(i), dem1_D300_pmi_a * perdel_cvpmi_sys) * perdem_70PCWA(i)
        - dem_D8a_wr_ann(i) * perdem_70NRWD(i)
        - dem_D8b_wr_ann(i) * perdem_70Fol(i)
        - dem_D8c_wr_ann(i) * perdem_70FolP(i)
        - dem_D8d_wr_ann(i) * perdem_70SJWDP(i)
        - dem_D8e_wr_ann(i) * perdem_70SJWDS(i)
        - dem_D8f_wr_ann(i) * perdem_70ElDor(i)
        - dem_D8g_wr_ann(i) * perdem_70Rose(i)
        - dem_D9b_wr_ann(i) * perdem_70SMUD(i)
        - dem_D9aa_wr_ann(i) * perdem_70SCWC(i)
        - dem_D300_wr_ann(i) * perdem_70PCWA(i)
        - dem_D9a_pls(i) * cfs_taf(i)
        - (Evap_Folsm_MarMay / 3.)}
case other {
   condition      always
   value          0.0   }}
```

The equation is box A.1.2-13 assumes perfect foresight for inflows, and diversions will be according to water right demands and CVP allocations. The demands and delivery patterns used in the calculation of *AmerFrctSummer* are listed in the Tables A.1-2 and A.1-3 for reference.

In equation A.1.2-13, the state variable *dem_D300_pmi_ann* is commented out in the Future Condition scenario of the WCM Update model. This variable represents the Folsom Lake demand node for Placer County Water Agency (PCWA). There is currently no intake and there are no plans for an intake to be built; therefore, the Future Condition of 2013 DRR CalSim II commented out this term and USACE similarly removed it for the WCM Update model.

Table A.1-2. Monthly Delivery Pattern for Each Water Purveyor

Delivery Pattern Name in CalSim	Water Purveyor
perdem_70smud	Sacramento Municipal Utility District Folsom South Canal
perdem_70Sac	City of Sacramento
perdem_70Fol	Folsom City
perdem_70SJWDS	San Juan Water District (Sac County)
perdem_70SJWDP	San Juan Water District (Placer County)
perdem_70Rose	Roseville City
perdem_70ArcWD	Arcade Water District
perdem_70NRWD	Northridge Water District
perdem_70Carm	Carmichael Water District
perdem_70PCWA	Placer County Water Agency
perdem_70FolP	Folsom Prison
perdem_70ElDor	El Dorado Irrigation District
perdem_70ElDorCo	El Dorado County Water Agency
perdem_70CARec	CA Parks & Recreation

Delivery Pattern Name in CalSim	Water Purveyor
perdem_70SCWC	SCWC/ACWC
perdem_70SCWA	Sac County Water Agency

Table A.1-3. Annual Demands on the American River

Annual Demand Name in CalSim	Water Purveyor
dem_D300_pmi_ann { 'TAF'}	PCWA (American Pump Station above Folsom)
dem_D300_wr_ann { 'TAF'}	PCWA (American Pump Station above Folsom)
dem_D8a_wr_ann {TAF'}	Sac Suburban (American)
dem_D8b_pmi_ann {'TAF'}	Folsom City
dem_D8b_wr_ann {TAF'}	Folsom City
dem_D8c_wr_ann {TAF'}	Folsom Prison
dem_D8d_wr_ann {TAF'}	San Juan Water District (Placer County)
dem_D8e_pmi_ann {'TAF'}	San Juan Water District (Sac County)
dem_D8e_wr_ann {TAF'}	San Juan Water District (Sac County)
dem_D8f_pmi_ann {'TAF'}	El Dorado Irrigation District
dem_D8f_wr_ann {TAF'}	El Dorado Irrigation District
dem_D8g_pmi_ann {TAF'}	Roseville City (American)
dem_D8g_wr_ann {TAF'}	Roseville City (American)
dem_D8h_pmi_ann { 'TAF'}	PCWA at Folsom
dem_D8i_pmi_ann { 'TAF'}	El Dorado County PL 101514
dem_D9aa_wr_ann { TAF'}	SCWC/ACWC
dem_D9ab_pmi_ann s {'TAF'}	Cal Parks & Recreation
dem_D9b_pmi_ann {'TAF'}	Sacramento Municipal Utility District Folsom South Canal
dem_D9b_wr_ann {'TAF'}	Sacramento Municipal Utility District Folsom South Canal

Note: demands with “pmi” in the name are Central Valley Project demands whereas demands with “wr” in the name are water right demands.

The forecast MRR from March to May, *FMPfrcstMarMay*, uses the FMS index flows to predict the MRR in order to forecast storage in Folsom Reservoir in the equation in box A.1.2-12. As shown in box A.1.2-14, *FMPfrcstMarMay* is multiplied by 92 to reflect the 92 days between March 1 and May 31 and the MRR forecast is converted from cfs to TAF.

A.1.2-14

define FMPfrcstMarMay {
value minFMPAmerTmp(92.*1.9835/1000.)}*

Folsom evaporation is estimated in the equation in box A.1.2-15 and used to forecast storage in Folsom Reservoir in the equation in box A.1.2-12. This definition was carried forward from the 2013 DRR CalSim II models. The evaporation forecast is based on average relations between storage in a prior month and evaporation. The forecast was generated using CalSim II output.

```
                                                                        A.1.2-15
define Evap_Folsm_MarMay {
        case MAR {
                condition      month == MAR
                value          0.026 * S8(-1)}
        case other {
                condition      always
                value          0.0   }
}
```

Before the end-of-May Folsom Reservoir storage prescriptive adjustment is implemented, USACE included code to discontinue the off-ramp (see Section A.1.3) in March by setting flows to the previous month's MRR or the index flow for the current time step, whichever is higher, if the previous month's flow was equal to the required D893 flows. Without this adjustment, it is possible that the off-ramp flows would be continued without off-ramp conditions.

```
                                                                        (A.1.2-16)
        case MarLowNoOffRamp{
                condition      month==MAR .and.  EOMayForecast < 700. .and.
                               C9_fmp_mif(-1) == D893min
                value          max(C9_fmp_mif(-1), minFMPAmerTmp)}
```

In the calculation of the March MRR, the end-of-May Folsom Reservoir storage prescriptive adjustment takes place if the end-of-May Folsom Reservoir storage forecast, *EOMayForecast*, (box A.1.2-14) is less than 700 TAF. When Folsom Reservoir storage is forecast to be less than 700 TAF at the end of May, then either the IFII-based index flow or the MRR from the previous time step, whichever is less, is used as the MRR in March (A.1.2-17).

```
                                                                        (A.1.2-17)
        case MarLow {
                condition      month==MAR .and.  EOMayForecast < 700.
                value          min(minFMPAmerTmp, C9_fmp_mif(-1)) }
```

If the end-of-May Folsom Reservoir storage forecast is greater than or equal to 700 TAF, the March MRR is equal to the index flow (the IFFI-based index flow) as shown in box A.1.2-18.

```
                                                                        (A.1.2-18)
        case MarOther {
                condition      month==MAR .and. EOMayForecast >= 700.
                value          minFMPAmerTmp }
```

Before the April and May MRR are calculated, USACE included code to discontinue the off-ramp (see Section A.1.3) in April and May, by setting flows to the previous month's MRR or the index flow for the current time step, whichever is higher, if the previous month's flow was equal to the required D893 flows (A.1.2-19).

```
                                                                        (A.1.2-19)
case AprMayNoOffRamp{
        condition    month>=APR .and. month<=MAY .and. C9_fmp_mif(-1) == D893min
        value        max(C9_fmp_mif(-1), minFMPAmerTmp)}
```

In April and May, USACE used the flow that was determined for March, whether it was the IFII-based index flow or the end-of-May Folsom Reservoir storage prescriptive adjustment. The code, as shown in A.1.2-20, calls the MRR in the previous time so that the March flows are repeated for both April and May.

```
                                                                        (A.1.2-20)
case APRMay {
        condition    month>=APR .and. month<=MAY
        value        C9_fmp_mif(-1)}
```

PRESCRIPTIVE ADJUSTMENT BASED ON END-OF-SEPTEMBER FOLSOM RESERVOIR STORAGE

The FMS includes an end-of-September storage prescriptive adjustment that is applied to releases in June through September when hydrologic conditions are predicted to be exceptionally dry and Folsom Reservoir storage is predicted to drop below 300 TAF. This adjustment is intended to avoid storage and cold water pool depletion in Folsom Reservoir and have adequate water supply to meet summer and fall lower American River flow requirements and water temperature objectives. The end-of-September storage forecast for Folsom Reservoir is a key component of the implementation of this prescriptive adjustment as it determines whether or not this prescriptive adjustment is applied.

Reclamation forecasts the end-of-September storage in Folsom Reservoir by June 1 of each year. This determines whether the original IFII index flow, or a June through September storage-based flow is applied to the June through September period. The June through September storage-based flow is the flow for each month that would result in an end-of-September storage of 300 TAF in Folsom Reservoir.

The June through September storage-based flow is calculated by taking into account: (1) Folsom Reservoir end-of-May storage; (2) the forecasted June through September Folsom Reservoir inflow, diversions, and evaporation; (3) the forecasted June through September Folsom South Canal diversions; and (4) the forecasted MRR from Nimbus Dam.

The volume of the forecasted FMS flows for June through September are calculated in CalSim II using the code shown in box A.1.2-21 where minFMPAmerTemp is the Index Flow.

```
                                                            (A.1.2-21)
define FMPfrcstJunSep {
              value minFMPAmerTmp*(122.*1.9835/1000.)}
```

The inflow, diversions, and evaporation from Folsom Reservoir are represented by the variable *AmerFrctSummer*, which is calculated by the code shown below in box A.1.2-22. It computes the forecasted Folsom inflow minus the diversions from Folsom Reservoir and Folsom South Canal and the evaporation from Folsom Lake during June through September of each year.

In equation A.1.2-22, the state variable *dem_D300_pmi_ann* is commented out in the Future Condition of the WCM Update CalSim II model. This is a Folsom Lake demand node for PCWA. There is currently no intake and there are no plans for an intake to be built; therefore, the Future Condition of 2013 DRR CalSim II commented out this term and USACE carried it through to the WCM Update model.

```
                                                            (A.1.2-22)
define AmerFrcstSummer {
  case JUN_SEP {
        condition      month == JUN
        sum(i=-(month-JUN),SEP-month) I8(i)*cfs_taf(i) + I300(i)*cfs_taf(i)
       - min(dem_D8b_pmi_ann(i), dem1_D8b_pmi_a * perdel_cvpmi_sys) * perdem_70Fol(i)
       - min(dem_D8e_pmi_ann(i), dem1_D8e_pmi_a * perdel_cvpmi_sys) * perdem_70SJWDS(i)
       - min(dem_D8f_pmi_ann(i), dem1_D8f_pmi_a * perdel_cvpmi_sys) * perdem_70ElDor(i)
       - min(dem_D8g_pmi_ann(i), dem1_D8g_pmi_a * perdel_cvpmi_sys) * perdem_70Rose(i)
       - min(dem_D8h_pmi_ann(i), dem1_D8h_pmi_a * perdel_cvpmi_sys) * perdem_70pcwa(i)
       - min(dem_D8i_pmi_ann(i), dem1_D8i_pmi_a * perdel_cvpmi_sys) * perdem_70ElDorCo(i)
       - min(dem_D9ab_pmi_ann(i), dem1_D9ab_pmi_a * perdel_cvpmi_sys) * perdem_70CARec(i)
       - min(dem_D9b_pmi_ann(i), dem1_D9b_pmi_a * perdel_cvpmi_sys) * perdem_70SMUD(i)
       - min(dem_D300_pmi_ann(i), dem1_D300_pmi_a * perdel_cvpmi_sys) * perdem_70PCWA(i)
       - dem_D8a_wr_ann(i) * perdem_70NRWD(i)
       - dem_D8b_wr_ann(i) * perdem_70Fol(i)
       - dem_D8c_wr_ann(i) * perdem_70FolP(i)
       - dem_D8d_wr_ann(i) * perdem_70SJWDP(i)
       - dem_D8e_wr_ann(i) * perdem_70SJWDS(i)
       - dem_D8f_wr_ann(i) * perdem_70ElDor(i)
       - dem_D8g_wr_ann(i) * perdem_70Rose(i)
       - dem_D9b_wr_ann(i) * perdem_70SMUD(i)
       - dem_D9aa_wr_ann(i) * perdem_70SCWC(i)
       - dem_D300_wr_ann(i) * perdem_70PCWA(i)
       - dem_D9a_pls(i) * cfs_taf(i)
       - (Evap_Folsm_JuneSept / 4)}
  case other {
     condition      always
     value          0.0   }}
```

This equation assumes perfect foresight for inflows and that diversions will be according to water rights and CVP allocations. The water purveyors and the delivery patterns used in the calculation of *AmerFrctSummer* are identified in the Tables A.1-2 and A.1-3.

To implement this end-of-September storage prescriptive adjustment in CalSim II, each item listed above is calculated and added up, as shown in box A.1.2-23 for the end-of-September Folsom (EOSepFolFrcst) storage forecast. If the EOSepFolFrcst is forecasted to be less than 300 TAF in June, then MRR is reduced to a flow that would result in Folsom Reservoir reaching 300 TAF at the end of September, as long as that storage-based flow was not less than the D893 required flow of 250 cfs. If the EOSepFolFrcst is projected to be greater than 300 TAF, the IFII-based index flow is used as shown in box A.1.2-24.

(A.1.2-23)

```
define EOSepFolFrcst {
  case JunForecast {
    condition     month>=JUN .and. month<=SEP
    value         min(650., S8(prevMAY)+ AmerFrcstSummer - FMPfrcstJunSep) }
  case other {
    condition     always
    value         0.   }
}
```

Of the three parameters used to forecast the end-of-September storage, only the *AmerFrcstSummer* variable is subject to variability; diversion quantities, particularly according to water rights, are computed by CalSim II each month and may not match the forecast values. Similarly, simulated evaporation is based on reservoir storage and releases from Folsom Reservoir and may not match with the forecasted evaporation.

The prescriptive adjustment for end-of-September Folsom Reservoir storage is first implemented in June a shown in the equation in box A.1.2-24. When the *EOSepFolFrcst* is forecasted to be less than 300 TAF, then MRR is reduced to a flow that would cause Folsom Reservoir storage to reach 300 TAF by September, but not less than 250 cfs, which is the D-893 required flow. If the *EOSepFolFrcst* is projected to be greater than 300 TAF, the IFII-based index flow is used as the MRR.

(A.1.2-24)

```
case JunMin {
      condition     month==JUN .and. EOSepFolFrcst < 300.
      value         min(1750., minFMPAmerTmp, (max(250.,minFMPAmerTmp-
                    (300.- EOSepFolFrcst)*1000./(1.9835*122.))))}
case Junother {
      condition     month==Jun .and. EOSepFolFrcst >= 300.
      value         minFMPAmerTmp }
```

The June and July MRR is shown in box A.1.2-25. The code discontinues the off-ramp (Section A.1.3) in those months, if it was previously effective, by setting flows to the MRR for May or the index flow for the current time step, whichever is less, if the previous month's flow was equal to the required D893 flows.

(A.1.2-25)

```
case JunJulNoOffRamp{
    condition    month>=JUN .and. month<=JUL .and. C9_fmp_mif(-1) == D893min
    value        max(C9_fmp_mif(-1), minFMPAmerTmp)}
```

MRR determination in July and August uses the flow determined for June, whether it was the IFII-based index flow or the end-of-September Folsom Reservoir storage prescriptive adjustment. The code calls the MRR in the previous time step so that the June flows are repeated for both July and August as shown in box A.1.2-26.

(A.1.2-26)

```
case JulAug {
    condition    month>=JUL .and. month<=AUG
    value        C9_fmp_mif(-1)}
```

In September, if the end-of-September Folsom Reservoir storage forecast was less than 300 TAF, the MRR continues to be the same as it was in July, as shown in A.1.2-27.

(A.1.2-27)

```
case SepMin {
    condition    month==SEP .and. EOSepFolFrcstdv(prevJUN) < 300.
    value        C9_fmp_mif(-1)}
```

Post-Labor Day through September Index Flows (Based on IFII)

The post-Labor Day through September 30 index flow will be between 800 and 1,500 cfs. For an IFII greater than or equal to 504 TAF, the index flow is 1,500 cfs. For an IFII between 375 TAF and 504 TAF, the index flow is proportional to the IFII and ranges between 800 cfs and 1,500 cfs. For an IFII less than or equal to 375 TAF, the index flow is 800 CFS as shown in Figure A.1-2. (Water Forum 2008)

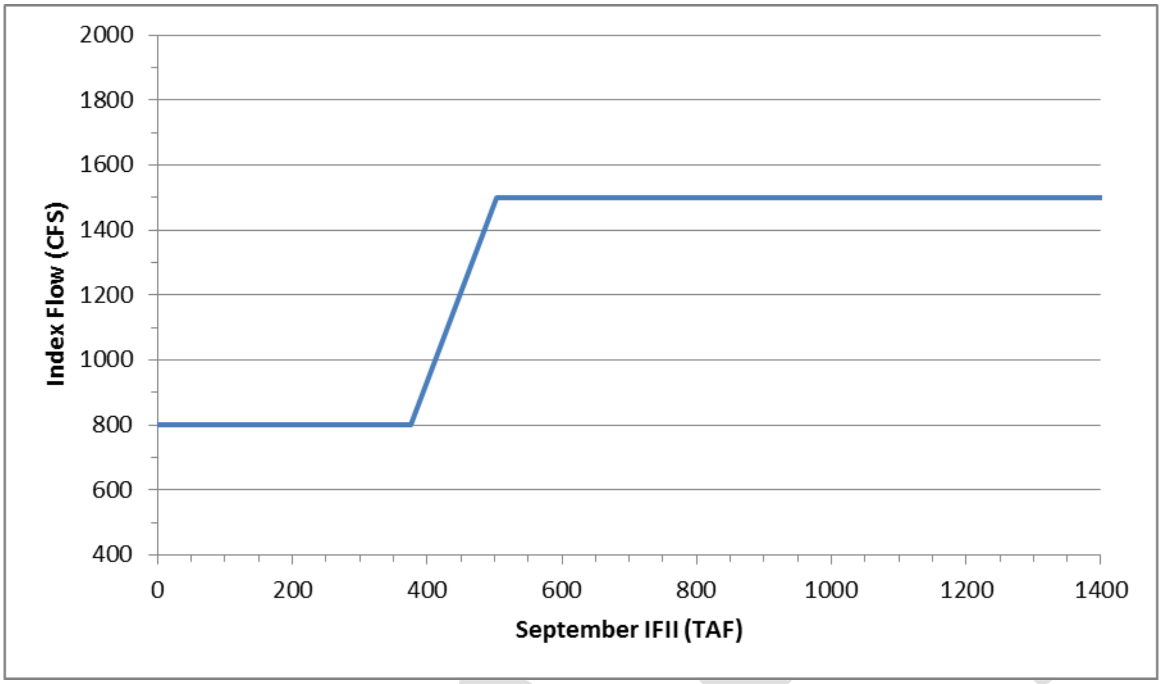


Figure A.1-2. Flow Management Standard Index Flow for Post-Labor Day through September

The September index flow uses the same index flow as March through August; however, the maximum MRR is 1,500 cfs rather than 1,750 cfs. To apply this maximum in CalSim II, USACE did not change the trigger table, *FMP_Trigger.table*, rather, it used the WRESL code to install a maximum flow of 1,500 cfs as shown in boxes A.1.2-28 and A.1.2-29.

The first case in the September WRESL code, as shown in box A.1.2-28, discontinues the off-ramp (Section A.1.3) by setting flows to the September MRR if the previous month's flow was equal to the required D893 flows.

```
                                                                    (A.1.2-28)
case SeptNoOffRamp{
        condition      month==SEP .and. EOSepFolFrcstdv(prevJUN) >= 300. .and.
                       C9_fmp_mif(-1) == D893min
        value          (((minFMPAmerTmp * 4.) + (min(minFMPAmerTmp, 1500.) * 11.) +
                       (max(500., (min(minFMPAmerTmp, 1500.))) * 15. ))/ 30.)}
```

The second case in September implements the same code as the equation A.1.2-28 but it is meant for non-off-ramp years. If the end-of-September Folsom Reservoir storage forecast (*EOSepFolFrcstdv*) is less than 300 TAF, no prescriptive adjustments are in place and the index flows (*minFMPAmerTmp*) will be the MRR. However, the first four days in September would continue to use the index flow previously applied for March through August. The next 11 days use the same index flow but cap the MRR at 1,500 cfs. In the second half of the month, the MRR is equal to the index flow but it is required to be between 500 cfs and 1,500 cfs. These daily flows are averaged out over the month to reflect CalSim II's monthly time step.

Instead of calling the variable for the index flow (*minFMPAmerTmp*), equation A.1.2-29 uses the MRR from the last time step (*C9_fmp_mif(-1)*). The resulting number will be the same because index flows are identical during March through August.

```
                                                                (A.1.2-29)
case Sept {
     condition   month==SEP .and. EOSepFolFrcstdv(prevJUN) >= 300.
     value       (((C9_fmp_mif(-1) * 4.) + (min(C9_fmp_mif(-1), 1500.) * 11.) +
                 (max(500., (min(C9_fmp_mif(-1), 1500.))) * 15. ))/ 30.) }
```

If there are no new index flows or prescriptive adjustments, the flows below Nimbus Dam will always be the MRR from the previous time step, as shown in box A.1.2-30. This case "other" with a condition of "always" was required to close the equation that defines the MRR.

```
                                                                (A.1.2-30)
case other {
     condition   always
     value       C9_fmp_mif(-1)}}
```

A.1.3 Off-Ramp Condition

The FMS includes an Off-ramp Condition when Folsom Reservoir storage is predicted to be less than 200 TAF in any of the following 12 months. This year-round, Off-ramp Condition is reassessed each month but continues in effect until Folsom Reservoir storage exceeds 200 TAF and is predicted to remain above 200 TAF for the following 12 months (Water Forum 2008). In CalSim II, the Off-ramp Condition cannot be forecasted year-round because CalSim II operates in water years (October to September) rather than in calendar years, and delivery allocations and other operations cannot always be forecasted for the following 12 months. Since forecasted releases use CVP water supply allocations determined by contract year (March through February), Folsom Reservoir storage can be forecast using a multi-month approach from March through September but requires a month-by-month approach from October through February. The code in box A.1.3-1 includes the code for calculating the Off-ramp Condition.

Since it is possible to forecast the deliveries and MRR from the beginning of the contract year to the end of the water year, March through September, USACE added the ability for CalSim II to forecast end-of-month Folsom Reservoir storage for each month between March and September, assuming perfect foresight for inflows. The code computes total inflow volume for the current month through each month between the current month and September, and subtracts total volume of releases, diversions, and evaporation for the current month through each month between the current month and September from the previous month's storage. Using this methodology, the end-of-month storage is computed for each month between the current month and September. For example, in March, the end-of-month storage is computed for March, April, May, June, July, August, and September. In April, the end-of-month storage is computed for April, May, June, July, August, and September. The process is further repeated for May, June, July, August, and September.

To implement the off-ramp condition in October through February, the end-of-month storage for each month is forecast in lieu of a multi-month forecast using a similar methodology as the multi-month forecast described above, but only considers the current month of simulation.

The off-ramp Condition is triggered if storage forecast drops below 200 TAF in any month from the current month's forecast up to the September forecast.

(A.1.3-1)

```
define S8_Sep_Init {                          !Compute the end-of-Folsom storage for September
   case MAR_SEP {
      condition      month >= MAR .and. month <= SEP
           sum(i=0,SEP-month) I8(i)*cfs_taf(i) + I300(i)*cfs_taf(i) + I9(i)*cfs_taf(i)
          - min(dem_D8b_pmi_ann(i), dem1_D8b_pmi_a * perdel_cvpmi_sys) * perdem_70Fol(i)
          - min(dem_D8e_pmi_ann(i), dem1_D8e_pmi_a * perdel_cvpmi_sys) * perdem_70SJWDS(i)
          - min(dem_D8f_pmi_ann(i), dem1_D8f_pmi_a * perdel_cvpmi_sys) * perdem_70ElDor(i)
          - min(dem_D8g_pmi_ann(i), dem1_D8g_pmi_a * perdel_cvpmi_sys) * perdem_70Rose(i)
          - min(dem_D8h_pmi_ann(i), dem1_D8h_pmi_a * perdel_cvpmi_sys) * perdem_70pcwa(i)
          - min(dem_D8i_pmi_ann(i), dem1_D8i_pmi_a * perdel_cvpmi_sys) * perdem_70ElDorCo(i)
          - min(dem_D9ab_pmi_ann(i), dem1_D9ab_pmi_a * perdel_cvpmi_sys) * perdem_70CARec(i)
          - min(dem_D9b_pmi_ann(i), dem1_D9b_pmi_a * perdel_cvpmi_sys) * perdem_70SMUD(i)
          - min(dem_D300_pmi_ann(i), dem1_D300_pmi_a * perdel_cvpmi_sys) * perdem_70PCWA(i)
          - dem_D8a_wr_ann(i) * perdem_70NRWD(i)
          - dem_D8b_wr_ann(i) * perdem_70Fol(i)
          - dem_D8c_wr_ann(i) * perdem_70FolP(i)
          - dem_D8d_wr_ann(i) * perdem_70SJWDP(i)
          - dem_D8e_wr_ann(i) * perdem_70SJWDS(i)
          - dem_D8f_wr_ann(i) * perdem_70ElDor(i)
          - dem_D8g_wr_ann(i) * perdem_70Rose(i)
          - dem_D9b_wr_ann(i) * perdem_70SMUD(i)
          - dem_D9aa_wr_ann(i) * perdem_70SCWC(i)
          - dem_D300_wr_ann(i) * perdem_70PCWA(i)
          - dem_D9a_pls(i) * cfs_taf(i)
          - minFMPAmerTmp * cfs_taf(i)
          - 6.0 } ! Evaporation estimate 6.0 TAF per month
          case other {
                 condition          always
                 value              950.0}
}

Define S8_Sep {
          case MAR_SEP {
                 condition          month >=MAR .and. month <=SEP
                 value max(90., min(S8(-1) + S8_Sep_Init,S8level5(SEP-month))) }
          case other {
                 condition          always
                 value              950.0}
```

```
}

define S8_Aug_init {
   case MAR_AUG {
      condition       month >= MAR .and. month <= AUG
            sum(i=0,AUG-month) I8(i)*cfs_taf(i) + I300(i)*cfs_taf(i) + I9(i)*cfs_taf(i)
          - min(dem_D8b_pmi_ann(i), dem1_D8b_pmi_a * perdel_cvpmi_sys) * perdem_70Fol(i)
          - min(dem_D8e_pmi_ann(i), dem1_D8e_pmi_a * perdel_cvpmi_sys) * perdem_70SJWDS(i)
          - min(dem_D8f_pmi_ann(i), dem1_D8f_pmi_a * perdel_cvpmi_sys) * perdem_70ElDor(i)
          - min(dem_D8g_pmi_ann(i), dem1_D8g_pmi_a * perdel_cvpmi_sys) * perdem_70Rose(i)
          - min(dem_D8h_pmi_ann(i), dem1_D8h_pmi_a * perdel_cvpmi_sys) * perdem_70pcwa(i)
          - min(dem_D8i_pmi_ann(i), dem1_D8i_pmi_a * perdel_cvpmi_sys) * perdem_70ElDorCo(i)
          - min(dem_D9ab_pmi_ann(i), dem1_D9ab_pmi_a * perdel_cvpmi_sys) * perdem_70CARec(i)
          - min(dem_D9b_pmi_ann(i), dem1_D9b_pmi_a * perdel_cvpmi_sys) * perdem_70SMUD(i)
          - min(dem_D300_pmi_ann(i), dem1_D300_pmi_a * perdel_cvpmi_sys) * perdem_70PCWA(i)
          - dem_D8a_wr_ann(i) * perdem_70NRWD(i)
          - dem_D8b_wr_ann(i) * perdem_70Fol(i)
          - dem_D8c_wr_ann(i) * perdem_70FolP(i)
          - dem_D8d_wr_ann(i) * perdem_70SJWDP(i)
          - dem_D8e_wr_ann(i) * perdem_70SJWDS(i)
          - dem_D8f_wr_ann(i) * perdem_70ElDor(i)
          - dem_D8g_wr_ann(i) * perdem_70Rose(i)
          - dem_D9b_wr_ann(i) * perdem_70SMUD(i)
          - dem_D9aa_wr_ann(i) * perdem_70SCWC(i)
          - dem_D300_wr_ann(i) * perdem_70PCWA(i)
          - dem_D9a_pls(i) * cfs_taf(i)
           - minFMPAmerTmp * cfs_taf(i)
          - 6.0 } ! Evaporation estimate 6.0 TAF per month
          case other {
                  condition         always
                  value             950.0}
          }

Define S8_Aug {
          case MAR_AUG {
      condition       month >= MAR .and. month <= AUG
                  value max(90., min(S8(-1) + S8_Aug_Init,S8Level5(AUG-month))) }
          case other {
                  condition         always
                  value             950.0}
          }

define S8_Jul_init {
   case MAR_Jul {
      condition       month >= MAR .and. month <= JUL
            sum(i=0,Jul-month) I8(i)*cfs_taf(i) + I300(i)*cfs_taf(i) + I9(i)*cfs_taf(i)
          - min(dem_D8b_pmi_ann(i), dem1_D8b_pmi_a * perdel_cvpmi_sys) * perdem_70Fol(i)
          - min(dem_D8e_pmi_ann(i), dem1_D8e_pmi_a * perdel_cvpmi_sys) * perdem_70SJWDS(i)
          - min(dem_D8f_pmi_ann(i), dem1_D8f_pmi_a * perdel_cvpmi_sys) * perdem_70ElDor(i)
          - min(dem_D8g_pmi_ann(i), dem1_D8g_pmi_a * perdel_cvpmi_sys) * perdem_70Rose(i)
          - min(dem_D8h_pmi_ann(i), dem1_D8h_pmi_a * perdel_cvpmi_sys) * perdem_70pcwa(i)
          - min(dem_D8i_pmi_ann(i), dem1_D8i_pmi_a * perdel_cvpmi_sys) * perdem_70ElDorCo(i)
          - min(dem_D9ab_pmi_ann(i), dem1_D9ab_pmi_a * perdel_cvpmi_sys) * perdem_70CARec(i)
          - min(dem_D9b_pmi_ann(i), dem1_D9b_pmi_a * perdel_cvpmi_sys) * perdem_70SMUD(i)
```

```
        - min(dem_D300_pmi_ann(i), dem1_D300_pmi_a * perdel_cvpmi_sys) * perdem_70PCWA(i)
        - dem_D8a_wr_ann(i) * perdem_70NRWD(i)
        - dem_D8b_wr_ann(i) * perdem_70Fol(i)
        - dem_D8c_wr_ann(i) * perdem_70FolP(i)
        - dem_D8d_wr_ann(i) * perdem_70SJWDP(i)
        - dem_D8e_wr_ann(i) * perdem_70SJWDS(i)
        - dem_D8f_wr_ann(i) * perdem_70ElDor(i)
        - dem_D8g_wr_ann(i) * perdem_70Rose(i)
        - dem_D9b_wr_ann(i) * perdem_70SMUD(i)
        - dem_D9aa_wr_ann(i) * perdem_70SCWC(i)
        - dem_D300_wr_ann(i) * perdem_70PCWA(i)
        - dem_D9a_pls(i) * cfs_taf(i)
        - minFMPAmerTmp * cfs_taf(i)
        - 6.0 }! Evaporation estimate 6.0 TAF per month
        case other {
                condition        always
                value            950.0}
}
Define S8_Jul {
        case MAR_Jul {
    condition      month >= MAR .and. month <= JUL
                value max  (90., min(S8(-1) + S8_Jul_Init,S8Level5(JUL-month))) }
        case other {
                condition        always
                value            950.0}
}

define S8_Jun_init {
   case MAR_Jun {
    condition      month >= MAR .and. month <= JUN
         sum(i=0,JUN-month) I8(i)*cfs_taf(i) + I300(i)*cfs_taf(i) + I9(i)*cfs_taf(i)
        - min(dem_D8b_pmi_ann(i), dem1_D8b_pmi_a * perdel_cvpmi_sys) * perdem_70Fol(i)
        - min(dem_D8e_pmi_ann(i), dem1_D8e_pmi_a * perdel_cvpmi_sys) * perdem_70SJWDS(i)
        - min(dem_D8f_pmi_ann(i), dem1_D8f_pmi_a * perdel_cvpmi_sys) * perdem_70ElDor(i)
        - min(dem_D8g_pmi_ann(i), dem1_D8g_pmi_a * perdel_cvpmi_sys) * perdem_70Rose(i)
        - min(dem_D8h_pmi_ann(i), dem1_D8h_pmi_a * perdel_cvpmi_sys) * perdem_70pcwa(i)
        - min(dem_D8i_pmi_ann(i), dem1_D8i_pmi_a * perdel_cvpmi_sys) * perdem_70ElDorCo(i)
        - min(dem_D9ab_pmi_ann(i), dem1_D9ab_pmi_a * perdel_cvpmi_sys) * perdem_70CARec(i)
        - min(dem_D9b_pmi_ann(i), dem1_D9b_pmi_a * perdel_cvpmi_sys) * perdem_70SMUD(i)
        - min(dem_D300_pmi_ann(i), dem1_D300_pmi_a * perdel_cvpmi_sys) * perdem_70PCWA(i)
        - dem_D8a_wr_ann(i) * perdem_70NRWD(i)
        - dem_D8b_wr_ann(i) * perdem_70Fol(i)
        - dem_D8c_wr_ann(i) * perdem_70FolP(i)
        - dem_D8d_wr_ann(i) * perdem_70SJWDP(i)
        - dem_D8e_wr_ann(i) * perdem_70SJWDS(i)
        - dem_D8f_wr_ann(i) * perdem_70ElDor(i)
        - dem_D8g_wr_ann(i) * perdem_70Rose(i)
        - dem_D9b_wr_ann(i) * perdem_70SMUD(i)
        - dem_D9aa_wr_ann(i) * perdem_70SCWC(i)
        - dem_D300_wr_ann(i) * perdem_70PCWA(i)
        - dem_D9a_pls(i) * cfs_taf(i)
        - minFMPAmerTmp * cfs_taf(i)
        - 6.0 }! Evaporation estimate 6.0 TAF per month
        case other {
```

```
                  condition          always
                  value              950.0}
}
Define S8_Jun {
         case MAR_Jun {
     condition       month >= MAR .and. month <= JUN
                  value max(90.,min(S8(-1) + S8_Jun_Init,S8Level5(JUN-month))) }
         case other {
                  condition          always
                  value              950.0}
}

define S8_May_Init {
   case MAR_May {
     condition       month >= MAR .and. month <= MAY
          sum(i=0,MAY-month) I8(i)*cfs_taf(i) + I300(i)*cfs_taf(i) + I9(i)*cfs_taf(i)
         - min(dem_D8b_pmi_ann(i), dem1_D8b_pmi_a * perdel_cvpmi_sys) * perdem_70Fol(i)
         - min(dem_D8e_pmi_ann(i), dem1_D8e_pmi_a * perdel_cvpmi_sys) * perdem_70SJWDS(i)
         - min(dem_D8f_pmi_ann(i), dem1_D8f_pmi_a * perdel_cvpmi_sys) * perdem_70ElDor(i)
         - min(dem_D8g_pmi_ann(i), dem1_D8g_pmi_a * perdel_cvpmi_sys) * perdem_70Rose(i)
         - min(dem_D8h_pmi_ann(i), dem1_D8h_pmi_a * perdel_cvpmi_sys) * perdem_70pcwa(i)
         - min(dem_D8i_pmi_ann(i), dem1_D8i_pmi_a * perdel_cvpmi_sys) * perdem_70ElDorCo(i)
         - min(dem_D9ab_pmi_ann(i), dem1_D9ab_pmi_a * perdel_cvpmi_sys) * perdem_70CARec(i)
         - min(dem_D9b_pmi_ann(i), dem1_D9b_pmi_a * perdel_cvpmi_sys) * perdem_70SMUD(i)
         - min(dem_D300_pmi_ann(i), dem1_D300_pmi_a * perdel_cvpmi_sys) * perdem_70PCWA(i)
         - dem_D8a_wr_ann(i) * perdem_70NRWD(i)
         - dem_D8b_wr_ann(i) * perdem_70Fol(i)
         - dem_D8c_wr_ann(i) * perdem_70FolP(i)
         - dem_D8d_wr_ann(i) * perdem_70SJWDP(i)
         - dem_D8e_wr_ann(i) * perdem_70SJWDS(i)
         - dem_D8f_wr_ann(i) * perdem_70ElDor(i)
         - dem_D8g_wr_ann(i) * perdem_70Rose(i)
         - dem_D9b_wr_ann(i) * perdem_70SMUD(i)
         - dem_D9aa_wr_ann(i) * perdem_70SCWC(i)
         - dem_D300_wr_ann(i) * perdem_70PCWA(i)
         - dem_D9a_pls(i) * cfs_taf(i)
         - minFMPAmerTmp * cfs_taf(i)
         - 6.0 }! Evaporation estimate 6.0 TAF per month
         case other {
                  condition          always
                  value              950.0}
}

Define S8_May {
         case MAR_May {
     condition       month >= MAR .and. month <= MAY
                  value max(90.,min(S8(-1) + S8_May_Init,S8Level5(MAY-month))) }
         case other {
                  condition          always
                  value              950.0}
}

define S8_APR_Init {
   case MAR_APR {
```

```
        condition      month >= MAR .and. month <= APR
              sum(i=0,APR-month) I8(i)*cfs_taf(i) + I300(i)*cfs_taf(i) + I9(i)*cfs_taf(i)
            - min(dem_D8b_pmi_ann(i), dem1_D8b_pmi_a * perdel_cvpmi_sys) * perdem_70Fol(i)
            - min(dem_D8e_pmi_ann(i), dem1_D8e_pmi_a * perdel_cvpmi_sys) * perdem_70SJWDS(i)
            - min(dem_D8f_pmi_ann(i), dem1_D8f_pmi_a * perdel_cvpmi_sys) * perdem_70ElDor(i)
            - min(dem_D8g_pmi_ann(i), dem1_D8g_pmi_a * perdel_cvpmi_sys) * perdem_70Rose(i)
            - min(dem_D8h_pmi_ann(i), dem1_D8h_pmi_a * perdel_cvpmi_sys) * perdem_70pcwa(i)
            - min(dem_D8i_pmi_ann(i), dem1_D8i_pmi_a * perdel_cvpmi_sys) * perdem_70ElDorCo(i)
            - min(dem_D9ab_pmi_ann(i), dem1_D9ab_pmi_a * perdel_cvpmi_sys) * perdem_70CARec(i)
            - min(dem_D9b_pmi_ann(i), dem1_D9b_pmi_a * perdel_cvpmi_sys) * perdem_70SMUD(i)
            - min(dem_D300_pmi_ann(i), dem1_D300_pmi_a * perdel_cvpmi_sys) * perdem_70PCWA(i)
            - dem_D8a_wr_ann(i) * perdem_70NRWD(i)
            - dem_D8b_wr_ann(i) * perdem_70Fol(i)
            - dem_D8c_wr_ann(i) * perdem_70FolP(i)
            - dem_D8d_wr_ann(i) * perdem_70SJWDP(i)
            - dem_D8e_wr_ann(i) * perdem_70SJWDS(i)
            - dem_D8f_wr_ann(i) * perdem_70ElDor(i)
            - dem_D8g_wr_ann(i) * perdem_70Rose(i)
            - dem_D9b_wr_ann(i) * perdem_70SMUD(i)
            - dem_D9aa_wr_ann(i) * perdem_70SCWC(i)
            - dem_D300_wr_ann(i) * perdem_70PCWA(i)
            - dem_D9a_pls(i) * cfs_taf(i)
            - minFMPAmerTmp * cfs_taf(i)
            - 6.0 } ! Evaporation estimate 6.0 TAF per month
            case other {
                    condition           always
                    value               950.0}
}
Define S8_Apr {
            case MAR_APR {
        condition      month >= MAR .and. month <= APR
                    value max(90., min(S8(-1) + S8_Apr_Init,S8Level5(APR-month))) }
            case other {
                    condition           always
                    value               950.0}
}

define S8_MAR {
    case MAR {
        condition      month == MAR
        value max(90., min(I8*cfs_taf + I300*cfs_taf + I9*cfs_taf
            - min(dem_D8b_pmi_ann, dem1_D8b_pmi_a * perdel_cvpmi_sys) * perdem_70Fol
            - min(dem_D8e_pmi_ann, dem1_D8e_pmi_a * perdel_cvpmi_sys) * perdem_70SJWDS
            - min(dem_D8f_pmi_ann, dem1_D8f_pmi_a * perdel_cvpmi_sys) * perdem_70ElDor
            - min(dem_D8g_pmi_ann, dem1_D8g_pmi_a * perdel_cvpmi_sys) * perdem_70Rose
            - min(dem_D8h_pmi_ann, dem1_D8h_pmi_a * perdel_cvpmi_sys) * perdem_70pcwa
            - min(dem_D8i_pmi_ann, dem1_D8i_pmi_a * perdel_cvpmi_sys) * perdem_70ElDorCo
            - min(dem_D9ab_pmi_ann, dem1_D9ab_pmi_a * perdel_cvpmi_sys) * perdem_70CARec
            - min(dem_D9b_pmi_ann, dem1_D9b_pmi_a * perdel_cvpmi_sys) * perdem_70SMUD
            - min(dem_D300_pmi_ann, dem1_D300_pmi_a * perdel_cvpmi_sys) * perdem_70PCWA
            - dem_D8a_wr_ann * perdem_70NRWD
            - dem_D8b_wr_ann * perdem_70Fol
            - dem_D8c_wr_ann * perdem_70FolP
            - dem_D8d_wr_ann * perdem_70SJWDP
```

```
            - dem_D8e_wr_ann * perdem_70SJWDS
            - dem_D8f_wr_ann * perdem_70ElDor
            - dem_D8g_wr_ann * perdem_70Rose
            - dem_D9b_wr_ann * perdem_70SMUD
            - dem_D9aa_wr_ann * perdem_70SCWC
            - dem_D300_wr_ann * perdem_70PCWA
            - dem_D9a_pls * cfs_taf
            - minFMPAmerTmp * cfs_taf
            - 6.0 ,S8Level5(MAR)))! Evaporation estimate 6.0 TAF per month
                                  + S8(-1)}
            case other {
                        condition           always
                        value               950.0}
}

! -- For other months (October through February), forecast each month's end-of-month storage in lieu of a
longer forecast
define S8_OctFeb {
   case OctFeb {
      condition      month >= OCT .and. month <= FEB
      value I8*cfs_taf + I300*cfs_taf + I9*cfs_taf
            - min(dem_D8b_pmi_ann, dem1_D8b_pmi_a * perdel_cvpmi_sys) * perdem_70Fol
            - min(dem_D8e_pmi_ann, dem1_D8e_pmi_a * perdel_cvpmi_sys) * perdem_70SJWDS
            - min(dem_D8f_pmi_ann, dem1_D8f_pmi_a * perdel_cvpmi_sys) * perdem_70ElDor
            - min(dem_D8g_pmi_ann, dem1_D8g_pmi_a * perdel_cvpmi_sys) * perdem_70Rose
            - min(dem_D8h_pmi_ann, dem1_D8h_pmi_a * perdel_cvpmi_sys) * perdem_70pcwa
            - min(dem_D8i_pmi_ann, dem1_D8i_pmi_a * perdel_cvpmi_sys) * perdem_70ElDorCo
            - min(dem_D9ab_pmi_ann, dem1_D9ab_pmi_a * perdel_cvpmi_sys) * perdem_70CARec
            - min(dem_D9b_pmi_ann, dem1_D9b_pmi_a * perdel_cvpmi_sys) * perdem_70SMUD
            - min(dem_D300_pmi_ann, dem1_D300_pmi_a * perdel_cvpmi_sys) * perdem_70PCWA
            - dem_D8a_wr_ann * perdem_70NRWD
            - dem_D8b_wr_ann * perdem_70Fol
            - dem_D8c_wr_ann * perdem_70FolP
            - dem_D8d_wr_ann * perdem_70SJWDP
            - dem_D8e_wr_ann * perdem_70SJWDS
            - dem_D8f_wr_ann * perdem_70ElDor
            - dem_D8g_wr_ann * perdem_70Rose
            - dem_D9b_wr_ann * perdem_70SMUD
            - dem_D9aa_wr_ann * perdem_70SCWC
            - dem_D300_wr_ann * perdem_70PCWA
            - dem_D9a_pls * cfs_taf
            - minFMPAmerTmp * cfs_taf
            - 6.0 ! Evaporation estimate 6.0 TAF per month
                                  + S8(-1)}
            case other {
                        condition           always
                        value               950.0}
}

define S8min { value min(950., S8_OctFeb, S8_Mar, S8_Apr, S8_May, S8_Jun, S8_Jul, S8_Aug, S8_Sep)}
```

This equation assumes perfect foresight for inflows and that diversions will be according to water rights and CVP allocations. The demands and delivery patterns used in the calculation of *S8_Sep_Init* are listed in Tables A.1-2 and A.1-3.

In equation box A.1.3-1 the state variable *dem_D300_pmi_ann* is commented out in the Future Condition of the WCM Update model. This is a Folsom Lake demand node for PCWA. There is currently no intake and there are no plans for an intake to be built; therefore, the Future Condition of 2013 DRR CalSim II commented out this term and USACE maintained its elimination for the WCM Update model.

The last variable in box A.1.3-1 is *S8min*. This variable will change every month according to the forecast storage in Folsom Reservoir. *S8min* is used to define the MRR below Nimbus Dam during Off-ramp Condition, as shown in box A.1.3-1.

The off-ramp condition affects 2 years out of the 82-year CalSim hydrologic record in the Existing Condition: 1991 and 1993. It affects 6 years in the Future Condition and 7 years in each Action Alternative, as shown in Table A.1-4.

Table A.1-4. Model Years During Which the Off-Ramp is Implemented

Scenario	Scenario Description	Number of Years Off Ramp is Implemented	Off Ramp Condition Active (Water Years)
E504	Existing Condition	2	1991, 1993
J604	Future Condition	6	1929, 1961, 1962, 1991, 1992, 1993
J602	Future Condition 400-600 Flood Control Curve	7	1929, 1934, 1961,1962, 1991, 1992, 1993
J603	Future Condition Fixed 400 Flood Control Curve	7	1929, 1934, 1961,1962, 1991, 1992, 1993

A.1.4 Conference Year

A conference year is designated when the forecast March through November unimpaired inflow to Folsom Reservoir (UIFR) is less than 400 TAF. The conference year designation is reassessed each month and is continued unless one of the following occurs.

- The forecast March though November UIFR exceeds 400 TAF
- The FRI is higher than 300 TAF
- Folsom Reservoir releases are made for flood control purposes
- The SRI is higher than or equal to 15.7 million acre-feet (MAF), indicating an above normal or wet year
- The IFII is higher than 205 TAF (Water Forum 2008)

USACE implemented the conference year in CalSim II with two steps: 1) defining the UIFR; and 2) adding code to the MRR calculation (as presented earlier in box A.1.2-1) to limit releases to D893 when a conference year is indicated.

To define the UIFR, a lookup table that returns the UIFR for March through November for each year was added to the models. A UIFR_YR is defined as a year that starts in February and ends in January of the following year as shown in box A.1.4-1. CalSim forecasts a conference year in February, a month in which the UIFR designation is reasonably foreseeable.

The definition of the D893 flow criteria is in box A.1.4-2. CalSim contains a lookup table called HSt_base.table that returns the minimum flow required at the mouth of the lower American River (LAR) for a given month.

The Conference Year Minimum Flow Requirements are as follows:

- From January 1 through September 15, no less than 250 cfs between Nimbus Dam and the mouth of the American River
- From September 16 through December 31, no less than 500 cfs between Nimbus Dam and the mouth of the American River (Water Forum 2008)

These flows replace the MRR below Nimbus when the UIFR is less than 400 TAF. The code used to implement D893 flows as the MRR was presented earlier in box A.1.2-1.

(A.1.4-1)

```
define UIFR_YR {
        case after_October {
            condition month >= OCT .and. month < FEB
                    select UIFR
                    from UIFR
                    where year = Wateryear - 1.}
        case rest {
            condition always
                    select UIFR
                    from UIFR
                    where year = Wateryear}
}
```

(A.1.4-2)

```
define D893min {select HStmin
        from   HSt_base
        where  month=month, AmerD893=1
}
```

Two years within the CalSim II 82-year period of record are designated as conference years: 1924 and 1977.

A.2 Folsom Area Capacity Curve

The reservoir area-capacity curve provided by Reclamation in 2005 is presented in Table A.2-1. This data, in this format, was inserted into CalSim II in the res_info.table file to replace the Folsom Lake data that had previously been used but has been superseded with newer data. The data was published in a technical report by Reclamation (U.S. Department of the Interior, Bureau of Reclamation 2005) called Folsom Lake, Area and Capacity Tables.

Table A.2-1. Folsom Reservoir Area-Capacity Table

Reservoir Number	Storage (AF)	Area (Acres)	Discharge (CFS)	Elevation (FT)
8	0	0	0	0
8	11	2	0	210
8	48449	1304	16800	305
8	93378	2090	28090	332
8	140856	2940	29930	351
8	188313	3914	31170	365
8	236442	4799	32130	376
8	282681	5466	32850	385
8	379578	6652	34130	401
8	668532	9375	132770	437
8	966823	11140	466690	466

A.3 Hodge Criteria

The WRESL code for the implementation of the Hodge criteria, shown in box A.3-1, first defines the demands at the Sacramento River water treatment plant (WTP) (node 167a) and the Fairbairn WTP on the American River (node 302a). Next, it defines the Hodge flow criteria (flows below which the Hodge limitation comes into effect) as a variable called *Hodge_Thresh*. The subsequent definition for the variable *Hodge_div_limit* contains the diversion limitations at the American River WTP if the flows in the American River at its mouth, represented with node 302, are less than the variable *Hodge_thresh*. The code is located in the *common/hydrology/demands70.wresl* file. The last two lines of code in box A.3-1 transfer the demands into new variables.

```
                                                                        (A.3-1)
define dem_D167a_wr  {value dem_D167a_wr_ann * perdem_70Sac * taf_cfs}  ! full City of Sac
entitlement
define dem_D302a_wr  {value dem_D302a_wr_ann * perdem_70Sac * taf_cfs}  ! City of Sac water right at
Fairbairn

! trigger is the hodge flow criteria for flow past Fairbairn
define Hodge_thresh {
    case OCT     { condition month == OCT          value     1879.0 }
    case NOV_FEB { condition range(month,nov,feb)   value     2000.0 }
    case MAR_JUN { condition range(month,mar,jun)   value     3000.0 }
```

```
    case JUL_SEP { condition always              value     1750.0 }
}
! If flow at 302 is below threshold, diversion limited to these values
define Hodge_div_limit {
    case OCT_DEC     { condition range(month,oct,dec) value     100.0 }
    case JUN_AUG     { condition range(month,jun,aug) value     155.0 }
    case JAN_MAY_SEP { condition always              value     120.0 }
}

define dem_d302a_wf {value dem_d302a_wr }
define dem_d167a_wf  {value dem_d167a_wr}
```

The section of code shown in box A.3-2 sets up a binary system to determine the condition for limiting diversions to the City of Sacramento (City) and determines the allocation of deliveries between the American River and Sacramento River WTPs. When flows are above the Hodge criteria (represented by the variable *Hodge_thresh* as defined in box A-2) the limitation is off and the variable *int_Hst_abv* is set to “1”. When the limitations are in effect, and flows in the LAR at the American River WTP are below the Hodge Criteria, the variable *int_Hst_blw* is set to “1”. If either variable is set to “1,” the other would be set to “0.”

Since the demand at node 167a represents the full demand for the City, delivery is limited to the full demand less whatever is diverted at Fairbairn WTP on the American River (D302A). The American River demand is lower than the Hodge limit if the Hodge criteria is controlling.

```
                                                                    (A.3-2)
define Hst_max {value 99999.*taf_cfs}
define int_Hst_abv {INTEGER std kind 'INTEGER' units 'NONE'}          ! 1 if C302 > threshold
define int_Hst_blw {alias 1. - int_Hst_abv kind 'INTEGER'units 'NONE'}  ! 1 if C302 < threshold
define Hst_above {std kind 'FLOW-HST-ABV' units 'CFS'}
define Hst_below {std kind 'FLOW-HST-BLW' units 'CFS'}
goal Hst_flow {Hst_above - Hst_below = C302 - Hodge_thresh}
goal Hst_abv_force {Hst_above < int_Hst_abv*Hst_max}
goal Hst_blw_force {Hst_below < int_Hst_blw*Hst_max}
```

In the first goal in box A.3-3, the diversion at the American River WTP is limited to either the original demand or the Hodge criteria limit. In the second goal, the same diversion is limited to the demand only, for the potential case that the demand is lower than the Hodge limit if the Hodge criteria is controlling.

```
                                                                    (A.3-3)
goal limit_d302a_np1  {d302a_np < int_Hst_abv*dem_D302a_wf + int_Hst_blw*Hodge_div_limit}
goal limit_d302a_np2  {d302a_np < dem_D302a_wf}
```

The code in box A.3-4 is the final Hodge criteria implementation. If flow in the lower American River is less than specified threshold levels, limits are placed on American River diversion to the City of Sacramento (D302A) and the balance would be moved to the Sacramento River diversion point (D167A).

(A.3-4)

```
define dem_D167a_base {value max(0., dem_d167a_wr - dem_d302a_wr)} ! this is the remainder of the entitlement
define Hodge_cut  {std kind 'reduction-cfs' units 'cfs'}

goal setHodge_cut {Hodge_cut = int_Hst_blw * max(0., dem_d302a_wr - Hodge_div_limit)}  ! how much of the demand cannot be taken at 302

goal limit_d167a_np  {d167a_np < dem_D167a_wf - d302a_np}

goal limit_d167a_np2 {
    lhs D167a_np
    rhs dem_D167a_base + Hodge_cut
    lhs<rhs penalty 50 }
```

A.4 Sacramento River Gains Node D168A

The code is intended to limit the Sacramento River diversions at node 168A to the available river gains. Prior to the implementation of this code, any water that was conserved in the LAR was often shifted into D168A, making the conservation of LAR water much less effective. Equation A.4-1 is located in the common/hydrology/demand70.wresl file.

(A.4-1)

```
goal limitD168a {D168A < I9 + I302 + I166}
```

A.5 Feather River Rice Decomposition

Rice farmers divert water from the Thermalito Afterbay for rice straw decomposition, in addition to irrigation. This rice straw decomposition water diversion and its return flows were added to CalSim II by Reclamation and the logic was provided to USACE for inclusion in the WCM Update. A diversion node and a return flow node were created for the rice decomposition water and the continuity equations along both the Feather River and Sacramento River were updated to maintain the basin water balance as shown in boxes A.5-1 through A.5-5.

The delivery node for the rice decomposition water was added to the CalSim II weight table, CONV\Run\System\SystemTables_ALL\weight_table.wresl, and given a weight of 5000 as shown in box A.5-1.

(A.5-1)

```
[D7C, 5000]
```

The return flow from the rice decomposition deliveries in the Feather River service area was defined in the common\System\SystemTables_ALL\return-table.wresl file as shown in box A.5-2

(A.5-2)

```
define R135C_dcmp {std kind 'RETURN-FLOW' units 'CFS'}
```

The delivery of rice straw decomposition water is about 160 TAF/year, delivered between October and January. The code in box A.5-3 was added to the file common\hydrology\DEMANDS\demands_69.wresl to describe the timing and volume of the rice decomposition water. The percent of decomposition water to be delivered is based on end-of-September storage in Oroville Reservoir (*S6*). The intent of releasing a percent of the demand, *dem_D7C_DCMP*, is to avoid drawing Oroville below 850 TAF. If the end-of-September Oroville Reservoir storage is greater than 1,200 TAF, all of the rice decomposition water is delivered. If the end-of-September Oroville Reservoir storage is greater than 1,100 TAF, 75 percent of the rice decomposition water is delivered; if storage is greater than 1,000 TAF, 50 percent of the rice decomposition water is delivered; if storage is greater than 900 TAF, 25 percent of the rice decomposition water is delivered; and if storage is less than 900 TAF, no rice decomposition water is delivered.

(A.5-3)

```
define decomp_allocdv {std kind 'Decomp-Alloc' units 'None'}

define decomp_alloc {
        case Oro_high {
                condition       month==OCT .and. S6(-1) > 1200.
                value           1.0      }
        case Oro_1100 {
                condition       month==Oct .and. S6(-1) > 1100.
                value           0.75     }
        case Oro_1000 {
                condition       month==Oct .and. S6(-1) > 1000.
                value           0.5      }
        case Oro_900 {
                condition       month==Oct .and. S6(-1) > 900.
                value           0.25     }
        case Oro_low {
                condition       month==Oct .and. S6(-1) <= 900.
                value           0.0      }
        case other {
                condition       always
                value           decomp_allocdv(-1)       }
}

goal setdecomp_alloc {decomp_allocdv = decomp_alloc}

goal set_D7C {D7C < dem_D7C_DCMP*taf_cfs*decomp_alloc}
```

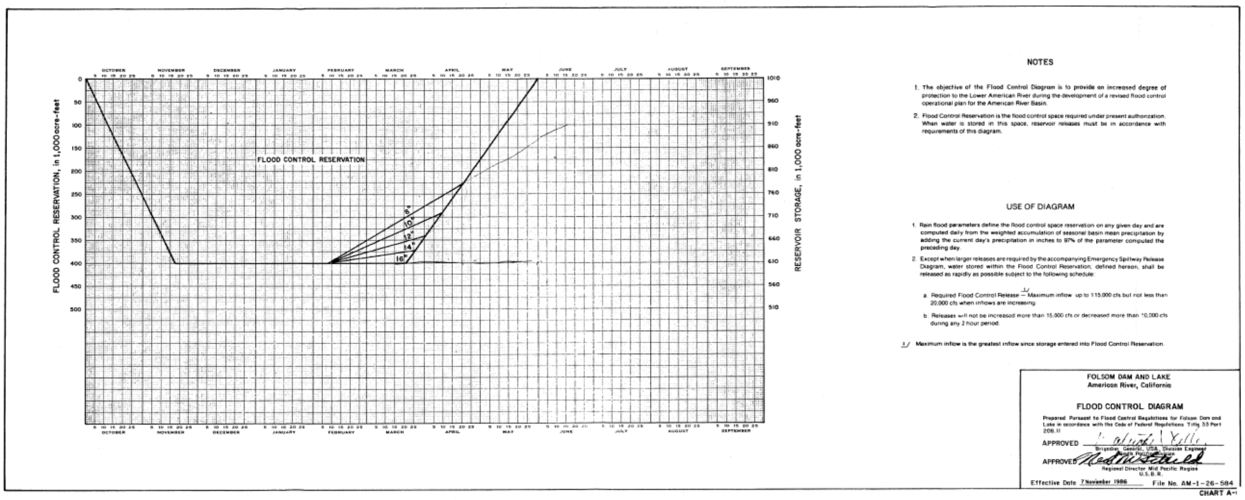
The return flow from the Feather River service area rice decomposition diversion is defined in the file common\hydrology\RETURNS\returns_nod.wresl and shown in box A.5-4. The maximum return flow, *R135C_DCMP_MAX*, is defined with the assumption that 100 percent of the *D7C* demand will be returned through node *R135C_dcmp*. The monthly demand is calculated as well as the actual deliveries. The proportion of deliveries to demand is then multiplied by the maximum return flow to determine the amount of water flowing through the return node, *R135C_dcmp*.

(A.5-4)

```
define R135C_DCMP_MAX {timeseries kind 'RETURN-FLOW' units 'taf'}

define decomp_del {
        case February {
                condition       month==FEB
                value           D7C(-1)*cfs_taf(-1)+D7C(-2)*cfs_taf(-2)+D7C(-3)*cfs_taf(-3)+
                                D7C(-4)*cfs_taf(-4)}
        case other {
                condition       always
                value           0.0     }}

define decomp_deldv {alias decomp_del kind 'DECOMP-DELIVERY' units 'taf'}

define decomp_dem {
        case February {
                condition month==FEB
                value (dem_D7C_DCMP(-1)+dem_D7C_DCMP(-2)+dem_D7C_DCMP(-
3)+dem_D7C_DCMP(-4))}
        case other{
                condition always
                value 1.0       }}

define decomp_per {
        case February {
                condition month==FEB
                value decomp_del/decomp_dem}
        case other {
                condition always
                value 0.}}

goal set_r135C_dcmp {r135c_dcmp = r135c_dcmp_max*decomp_per*taf_cfs}
```

A.6 Water Control Diagrams

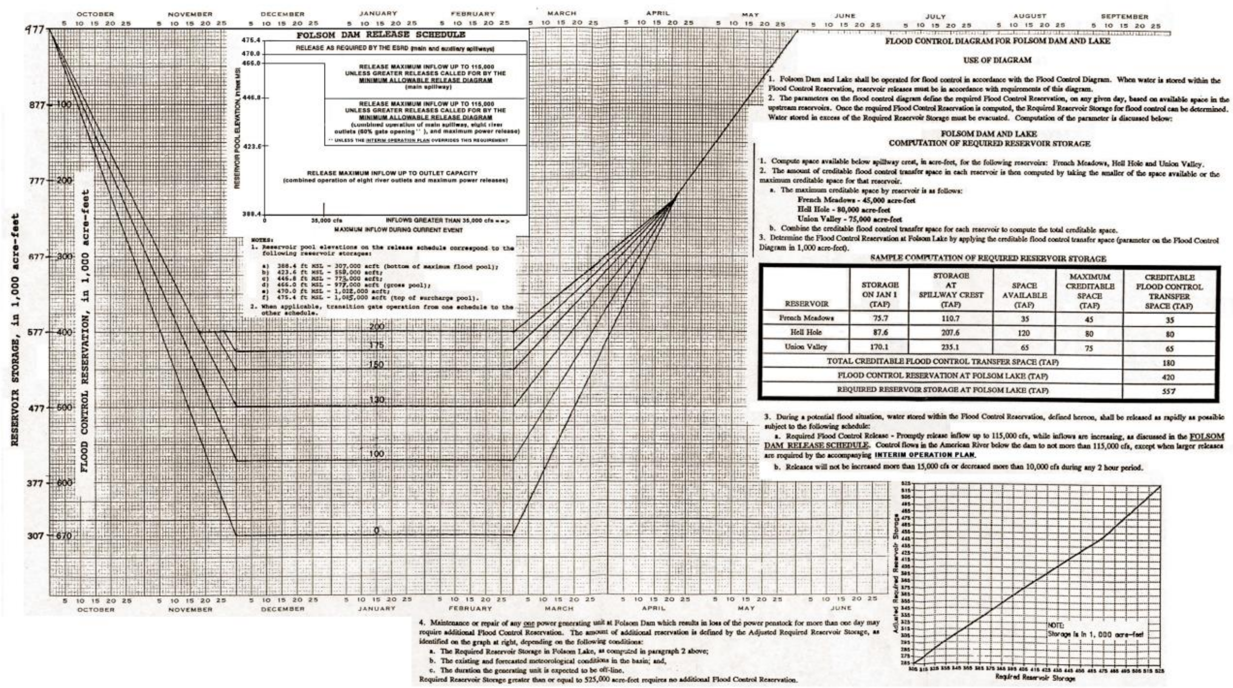
1987 water control manuals’ fixed-400 water control diagram is shown in Figure A.6-1.



Source: 1987 Water Control Manual for the Folsom Dam and Lake.

Figure A.6-1. Fixed-400 Water Control Diagram.

The Sacramento Area Flood Control Agency's variable 400-670 water control diagram is shown in Figure A.6-2.



Source: 1994 SAFCA's Interim Reoperation of Folsom Dam and Reservoir Final EIR/EA.

Figure A.6-2. Variable 400-670 Water Control Diagram.

References

[DWR] California Department of Water Resources. 2002. CalSim Water Resources Simulation Model Manual, Draft Documentation Benchmark Studies Assumptions. September 30, 2002. http://baydeltaoffice.water.ca.gov/modeling/hydrology/CalSim/Documentation/CalsimManual.pdf.

---. 2012. Technical Addendum to the State Water Project Delivery Reliability Report 2011. State of California Natural Resources Agency.

---. 2013. The State Water Project Draft Delivery Reliability Report, State of California Natural Resources Agency.

---. 2014. http://www.water.ca.gov/engineering/Projects/Current/SBA_Enlargement/

[NMFS] National Marine Fisheries Service. 2009. Biological Opinion and Conference Opinion on the Long-Term Operations of the Central Valley Project and State Water Project. URL: http://www.swr.noaa.gov/ocap.htm. June 2009.

[SAFCA] Sacramento Area Flood Control Agency and U.S. Bureau of Reclamation. 1994. Interim Reoperation of Folsom Dam and Reservoir Final Environmental Impact Report/Environmental Assessment. Prepared by SAFCA, David R. Schuster, Water Resources Management, Beak Consultants Incorporated. December 1994.

[San Joaquin River Group Authority] 2013. 2011 Annual Technical Report. San Joaquin River Agreement. Vernalis Adaptive Mangagement Plan.

[USACE] U.S. Army Corps of Engineers, Sacramento District. 1987. Folsom Dam and Lake, American River, California, Water Control Manual, Appendix Vlll to Master Water Control Manual, Sacramento River Basin, California. December.

[Reclamation] U.S. Department of the Interior, Bureau of Reclamation. 2005. Area and Capacity Tables. Folsom Lake. California Technical Service Center, Denver, Colorado.

---. 2008. Biological Assessment on the Continued Long-term Operations of the Central Valley Project and the State Water Project. URL: http://www.usbr.gov/mp/cvo/ocap_page.html

[USFWS] U.S. Fish and Wildlife Service. 2008. Biological Opinion on the Long-Term Operational Criteria and Plan (OCAP) for coordination of the Central Valley Project and State Water Project.

Water Forum. 2006. Lower American River Flow Management Standard. July 31, 2006.

---. 2008. Lower American River Flow Management Standard Technical Report. Unpublished.