Appendix S Alternative Delta Management Information

Purpose

The purpose of the OCAP BA CalLite effort is to create a process for fishery agencies (U.S. Fish and Wildlife Service [FWS], National Marine Fisheries Service [NMFS], and the California Department of Fish and Game [DFG]) to quantitatively explore tradeoffs and refine Delta management criteria to benefit and improve fishery objectives.

Objectives

The objective is to provide fishery agencies (FWS, NMFS, and DFG):

- A tool that quickly simulates various upstream and Delta management scenarios, and
- Quantitative results, from which tradeoffs can be evaluated.

Process

The CalLite screening tool was develop and used to allow for rapid exploration of a variety of water management options with the intent to narrow down potential alternatives. Screened alternatives can then be evaluated with more detailed modeling tools. In general the process of screening alternatives involves:

1. **Interactive modeling** – meeting together and running various management scenarios,
2. **Screening** - determine scenarios worthy of further investigation, and
3. **Exploring in finer detail** – implement scenarios in more detailed models such as CalSim-II, temperature, salmon mortality, and DSM2 models once preliminary criteria has been screened.

On April 17, 2008 Reclamation and DWR held a CalLite workshop with FWS, NMFS, and DFG, the first in a series of workshops with the agencies. The screening scenarios selected were based on preliminary Delta management criteria identified by FWS. These scenarios constitute “book-ends” for exploration. The “Workshop #1” scenarios include:

1. **Base**: Base model representing existing conditions (i.e. D1641 regulatory requirements are imposed, but there are no controls for Old and Middle River flow, QWEST, Net Delta Outflow, or January Export/Inflow ratio)
2. **Scenario 1**: Old and Middle River flows controlled to -5,000 cfs (January – June)
3. **Scenario 2**: Old and Middle River flows controlled to -5,000 cfs (January – February) and -750 cfs (March – June)
4. **Scenario 3**: QWEST (see Attachment V-1 for the definition of QWEST) controlled to 0 cfs (February – June), -1,000 cfs (July), and -2,000 cfs (August – January)
5. **Scenario 4**: Net Delta outflow controlled to 7,500 cfs (September – December) and Old

and Middle River controlled to -5,000 cfs (January – June)

6. **Scenario 5**: January Export/Inflow ratio controlled to 35%

Additional information provided by the fishery agencies, following the April workshop, allowed for a second round of CalLite screening. Information called “Workshop #2” includes scenarios:

1. **Base**: Base model representing existing conditions (i.e. D1641 regulatory requirements are imposed, but there are no controls for Old and Middle River flow, QWEST, Net Delta Outflow, or January Export/Inflow ratio)
2. **Scenario 1**: Old and Middle River flows controlled to -2,000 cfs (December – May)
3. **Scenario 2**: QWEST controlled to 500 cfs (June - November)
4. **Scenario 3**: QWEST controlled to 1,000 cfs (June - November)
5. **Scenario 4**: QWEST controlled to 2,000 cfs (June – November)
6. **Scenario 5**: Net Delta cutflow controlled to -10,000 cfs (June – November)
7. **Scenario 6**: January Export/Inflow ratio controlled to 35%
8. **Scenario 7:** January – June Export/Inflow ratio controlled to 17%
9. **Scenario 8**: X2 position controlled west of 75 km (June – November)
10. **Scenario 9**: Old and Middle River flows controlled to -5,000 cfs (January, February, May, and June), -2,548 cfs (March), and -2,233 (April)
11. **Scenario 10**: Delta Cross Channel closure 60 days between November – June

A third round of screening was performed, named “Workshop #3”, and includes the following scenarios:

1. **Base**: Base model representing existing conditions (i.e. D1641 regulatory requirements are imposed, but there are no controls for Old and Middle River flow, QWEST, Net Delta Outflow, or January Export/Inflow ratio)
2. **Scenario 1**: January Export/Inflow ratio controlled to 35%, QWEST controlled to 0 cfs (December – February), Old and Middle River flows controlled to -2,000 cfs (March – May), Old and Middle River flows controlled to -3,000 cfs (June), X2 position controlled west of 81 km (July – August), and X2 position controlled west of 74 km (September – November)
3. **Scenario 2**: January Export/Inflow ratio controlled to 35%, QWEST controlled to 0 cfs (December – February), QWEST controlled to 1,000 cfs (March – May), QWEST controlled to -2,000 cfs (June), X2 position controlled west of 81 km (July – August), and X2 position controlled west of 74 km (September – November)

4. **Scenario 3**: January Export/Inflow ratio controlled to 35%, Old and Middle River flows controlled to -2,000 cfs (December – February), Old and Middle River flows controlled to -2,000 cfs (March – May), Old and Middle River flows controlled to -3,000 cfs (June), X2 position controlled west of 81 km (July – August), and X2 position controlled west of 74 km (September – November)

5. **Scenario 4**: Old and Middle River flows controlled to -2,000 cfs (January), Old and Middle River flows controlled to -5,000 cfs (February), and Old and Middle River flows controlled to -2,000 cfs (March - June)

6. **Scenario 5**: QWEST flows controlled to 500 cfs (January), QWEST flows controlled to -1,000 cfs (February), and QWEST flows controlled to 0 cfs (March - June)

7. **Scenario 6**: January Export/Inflow ratio controlled to 17%, February Export/Inflow ratio controlled to 35%, March – June Export/Inflow ratio controlled to 20%

Results

The results from the three workshops are included as an electronic appendix using CalLite_v1.005b_FAM3.35. The compressed file (Filename: Workshop_1_Comparisons_061808.zip) contains the following files and information:

1. Raw output time-series for key locations (see Table 1 which lists the key locations of CalLite outputs below)
    a) **CalLite_Results_Base.xls**
    b) **CalLite_Results_W1S1.xls**
    c) **CalLite_Results_W1S2.xls**
    d) **CalLite_Results_W1S3.xls**
    e) **CalLite_Results_W1S4.xls**
    f) **CalLite_Results_W1S5.xls**
2. Summary tables and delivery logic graphics
    a) **MonthlyCompareCalLite_Base_vs_W1S1.xls**
    b) **MonthlyCompareCalLite_Base_vs_W1S2.xls**
    c) **MonthlyCompareCalLite_Base_vs_W1S3.xls**
    d) **MonthlyCompareCalLite_Base_vs_W1S4.xls**
    e) **MonthlyCompareCalLite_Base_vs_W1S5.xls**
3. Time-series, exceedence, and controlling parameters graphics
    a) **Summary Report_Base.xls**
    b) **Summary Report_W1S1.xls**
    c) **Summary Report_W1S2.xls**
    d) **Summary Report_W1S3.xls**
    e) **Summary Report_W1S4.xls**
    f) **Summary Report_W1S5.xls**

The compressed files (Filenames: Workshop_2_Comparisons_061808.zip and Workshop_3_Comparisons_061808.zip) contain similar files and information where, “W” is the workshop number, and “S” is the scenario number.

Table 1. Key reporting parameters in CalLite.

CalLite Output Parameters
Trinity Lake
Shasta Lake
Whiskeytown
Keswick
Red Bluff
Wilkins Slough
Feather River at Sac Conf.
Orovillle
Thermalito
Yuba River at Feather Conf.
Folsom
Natoma
American River at H Street
American River at Sac Conf.
Delta Cross Channel
Delta Outflow
Exports
CVP San Luis
SWP San Luis
CVP Allocation
San Joaquin River
Mokelumne River
Yolo Bypass
SWP Delivery

CalLite Output Parameters
CVP Delivery
SWP Allocation
X2
EI
Rio Vista
QWEST
Old and Middle River
Jersey Point
Emmaton
Collinsville
Rock Slough

Example results are presented in Table 2 and Figure 1 through Figure 4.

Table 2. System water balance comparison between the Base model and Workshop #1 Scenario 1.

	1922-2003			1929-1934		
	Alt	**Base**	**Diff**	**CalLite**	**Base**	**Diff**
Trinity R blw Lewiston	695	692	3	411	411	0
Trinity Export	546	549	-3	347	344	3
Clear Cr blw Whiskeytown	42	42	0	33	33	0
Sacramento R @ Keswick	6293	6297	-4	4049	4032	17
Sacramento R @ Wilkins Slough	6665	6666	-1	4096	4072	25
Feather R blw Thermalito	3172	3169	3	1642	1714	-72
American R blw Nimbus	2520	2521	0	1391	1387	4
American R @ Confluence						
Delta Inflow	**21926**	**21924**	**2**	**10107**	**10151**	**-43**
Sacramento R @ Hood	16178	16184	-6	8415	8458	-43
Yolo Bypass	1941	1933	8	110	110	0
Mokelumne R	666	666	0	202	202	0
San Joaquin R d/s Calaveras	3141	3141	0	1381	1381	0
Delta Outflow	**15273**	**14985**	**288**	**5408**	**5193**	**214**
Required	5586	5544	42	4072	4082	-10
Surplus						
Delta Diversions	**5586**	**5867**	**-281**	**3454**	**3705**	**-251**
Banks SWP	3053	3272	-219	1767	1980	-213
Banks IF						
Banks TD						

	1922-2003			1929-1934		
Banks CVP	0	0	0	0	0	0
Tracy	2533	2595	-62	1687	1725	-38
Tracy IF						
Tracy TD						
NBA						
CCWD						
Net DICU (non-project)						
North Delta (non-project)						
SWP SOD Deliveries	**3033**	**3247**	**-214**	**1744**	**1957**	**-213**
Table A	2610	2709	-99	1600	1688	-88
Article 21	142	254	-112	46	159	-113
Article 56	280	283	-3	98	110	-12
CVP SOD Deliveries	**218**	**223**	**-5**	**142**	**145**	**-3**

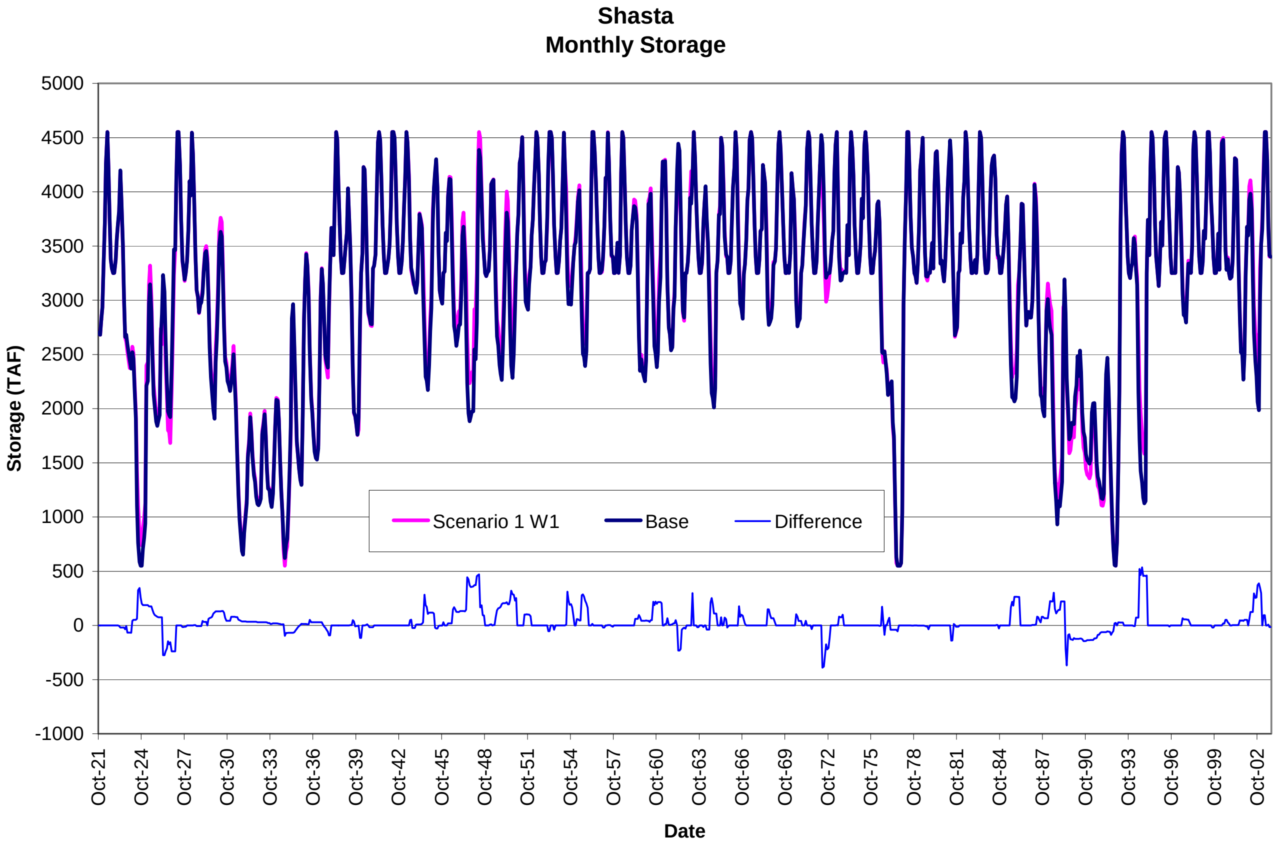


Figure 1. Shasta storage time-series comparison between the Base (D-1641) and Workshop #1 Scenario 1.

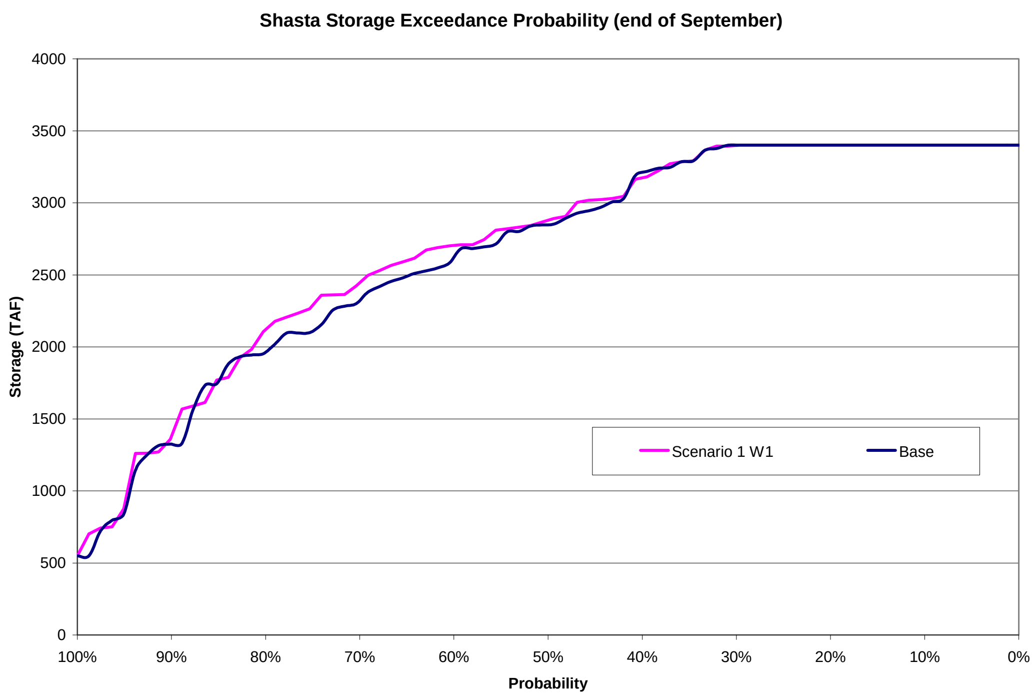
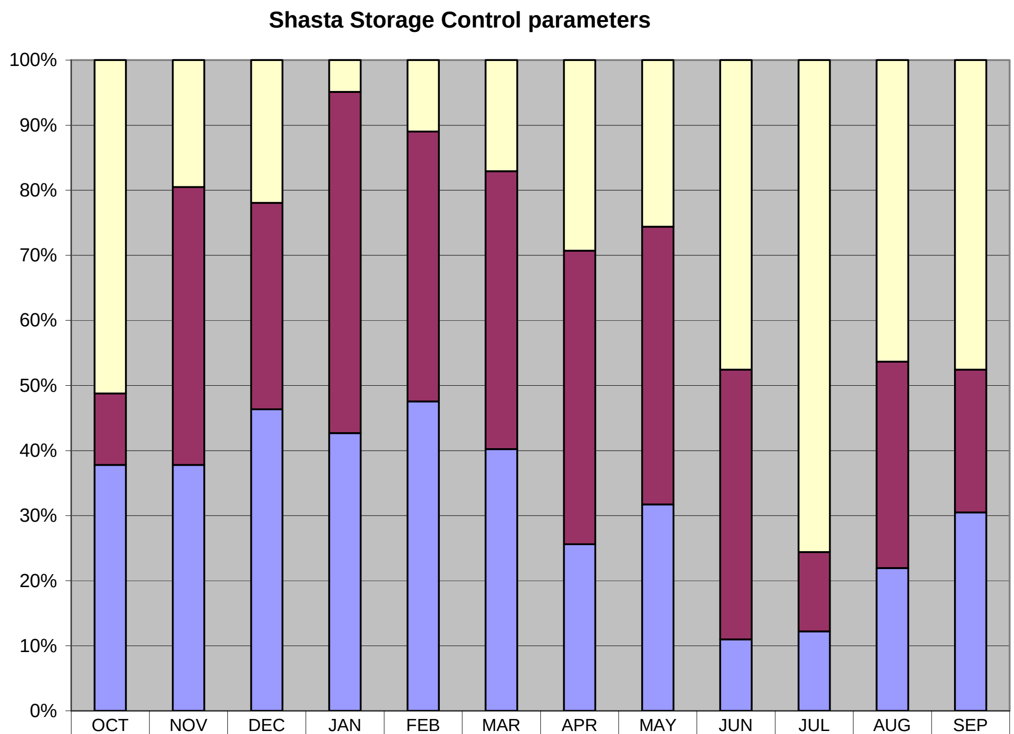


Figure 2. Stasta storage exceedance probability comparison between the Base (D-1641) and Workshop #1 Scenario 1.



	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Delta	42	16	18	4	9	14	24	21	39	62	38	39
Downstream Requirement	9	35	26	43	34	35	37	35	34	10	26	18
Flood Control	31	31	38	35	39	33	21	26	9	10	18	25

Figure 3. Shasta storage controlling parameter frequency for Workshop #1 Scenario 1.

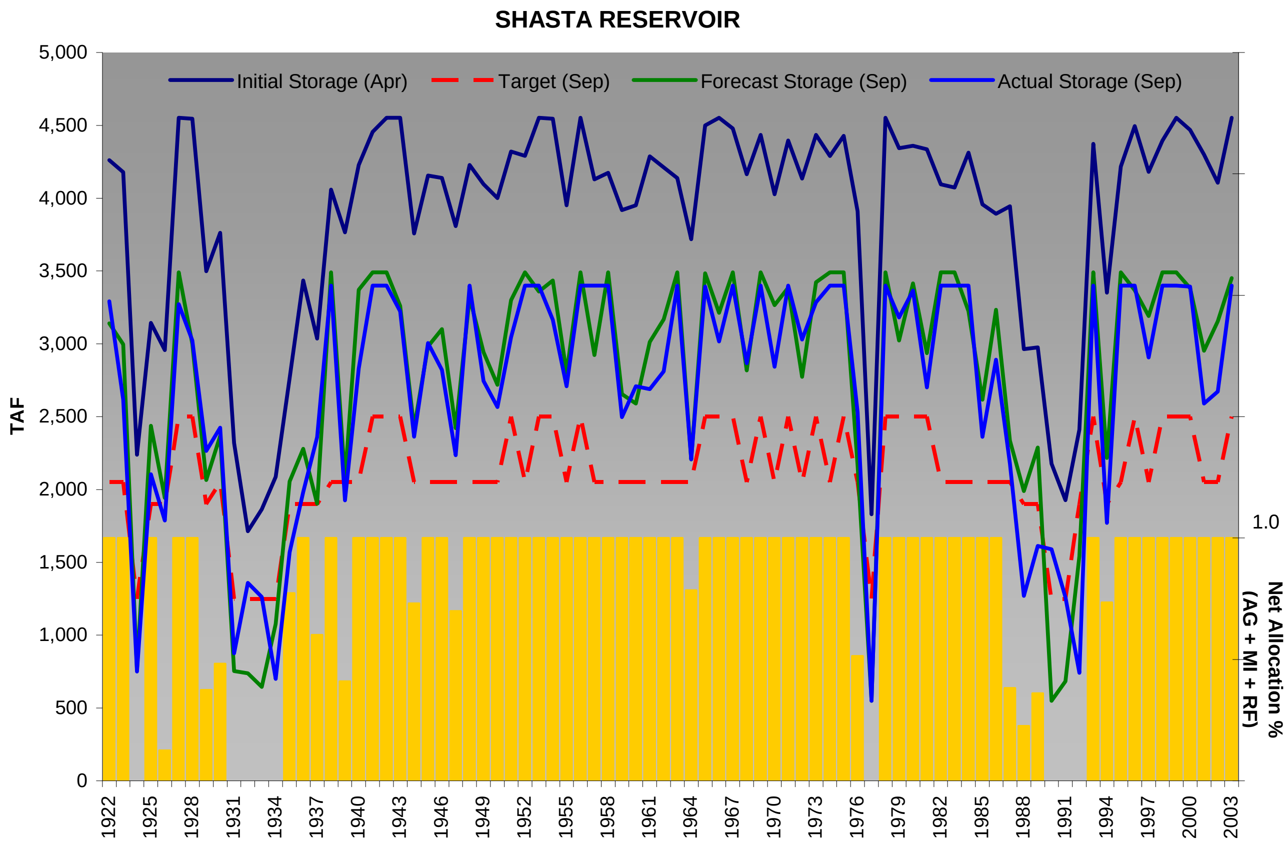


Figure 4. Shasta Reservoir summary allocation decisions for the Base model.

Modeling information on the formulation of CalLite's Delta regulatory controls is found in Attachment - CalLite Delta Facts. The CalLite model employs the QWEST estimate developed by Paul Hutton (see Attachment S1 below for details).

Future Refinements

The information presented covers Step 1 of the process. Step 2 (screening) and Step 3 (exploring in finer detail) will be accomplished after further screening efforts are completed. This information, therefore, has not addressed if these scenarios are worthy of further investigation and have not been tested in more detailed models. FWS, NMFS, and DFG will guide the next steps in this process and additional worshops are planned over the next few months.

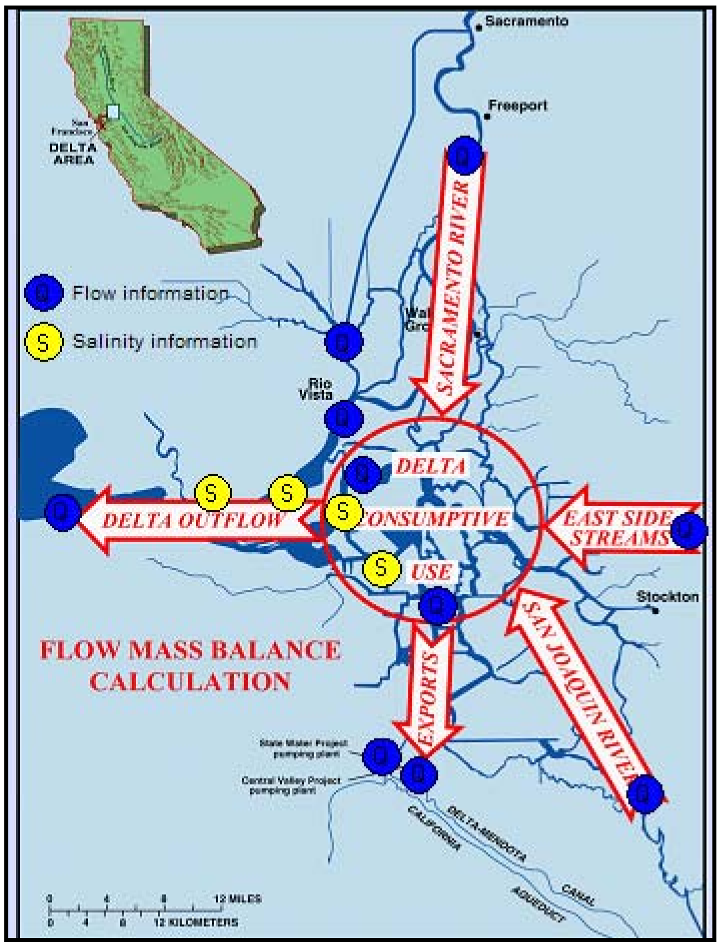
Attachment S1

CalLite Delta Regulatory Controls Fact Sheet

January 10, 2008

This brief fact sheet describes the implementation of Delta regulatory controls into the CalLite model. The regulatory controls in CalLite allow users to specify requirements for interior Delta flows, minimum river flows, Delta outflows, export restrictions, and salinity objectives. Figure 1 shows the location of the Delta regulatory controls incorporated in the CalLite model.

Figure 1. CalLite Delta regulatory control locations.



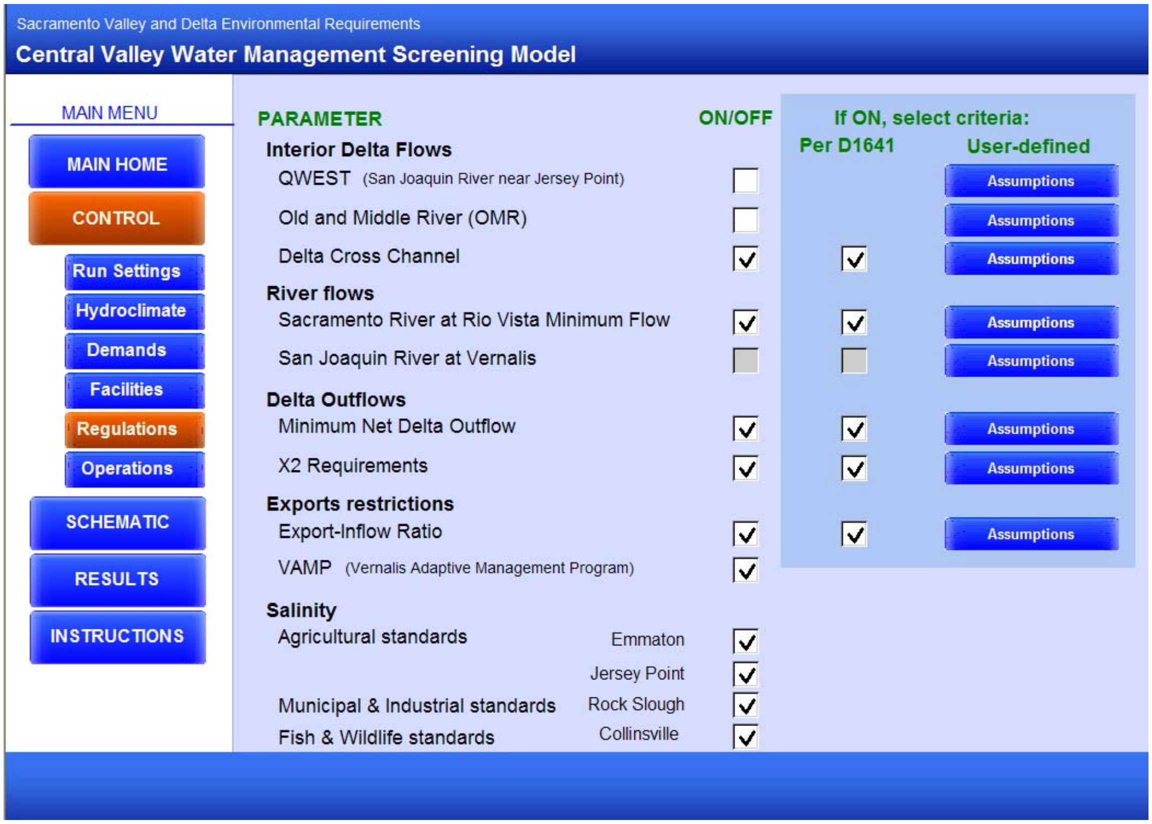
The methodology used in the implementation of Delta regulatory controls is generally similar to that used in the CALSIM II model. However, in the CalLite model, the user can switch requirements on or off, specify Decision 1641 requirements, or specify new values for these requirements. These user selections are specified through a dashboard (user-interface) as shown in Figure 2. If the user chooses to customize the constraints, then the "Assumptions" button links to an external spreadsheet for input (CalLite_ControlInput.xls).

The sections that follow describe the main Delta regulatory controls, assumptions, and method of implementation. The main controls are:

- Old and Middle R minimum flows (or max negative flows)
- Delta Cross Channel gate position
- San Joaquin R near Jersey Point minimum flow
- Sacramento R at Rio Vista minimum flow
- Minimum Delta outflow

- X2 requirements
- Export-inflow ratio
- VAMP export restrictions
- Salinity standards at Emmaton, Jersey Pt, Rock Slough, and Collinsville

Figure 2 Delta Regulatory Control dashboard in CalLite



NOTE: San Joaquin River at Vernalis minimum flow target is currently not implemented in the model.

River Flows

Sacramento River at Rio Vista Minimum Flow

This minimum flow for the Sacramento River at Rio Vista is specified by month and water year type. If natural flow is insufficient to meet the requirement, additional flow is provided through releases from CVP and SWP reservoirs. Calculations of additional releases account for upstream loss of water through the DCC and Georgianna Slough, depending on gate position.

San Joaquin River at Vernalis Minimum Flow

Currently, the CalLite model does not have an integrated San Joaquin River model. A separate stand-alone San Joaquin River model is used to provide input to this model. Thus, the minimum flow requirement at this location is not currently implemented.

Delta Outflow

Minimum Net Delta Outflow (NDO)

This minimum net Delta outflow is specified by month and water year type. If natural flow is insufficient to meet the requirement, additional flow is provided through releases from CVP and SWP reservoirs. Calculation of total required Delta outflow considers the NDO flow requirement and the X2 required outflows described below.

X2 Requirements

X2 is a measure of the distance (in km) from Golden Gate Bridge of 2 parts per thousand chloride. The X2 position is estimated using the regression model developed Jassby et. al. (1995) relating current X2 position to net Delta outflow and antecedent X2 position.

$$X2^{t} = 122.2 + 0.3278 * X2^{t-1} – 17.65 * \log(Q^{t})$$

When operated under D-1641 standards, the required outflow is calculated using a day-weighting scheme to account for the number of days in each month required at Roe Island, Chipps Island, and the Confluence. When customized standards are desired, the user enters desired monthly average X2 position by month and water year type.

Interior Delta Flows

San Joaquin River near Jersey Point (QWEST)

The San Joaquin River flow near Jersey Point, often called QWEST, is often used as an indicator of flow reversals in the lower San Joaquin River. Some have proposed minimum flow requirements based on QWEST to sustain transport flows in the westward direction. QWEST is calculated using the mass balance equation reported in IEP’s DAYFLOW database. This equation approximates QWEST as the sum of all of the eastside streams including the San Joaquin River plus the calculated cross transfer flow (flow through Georgiana Slough and the Cross Channel) minus sixty five percent of the net channel depletions minus total pumping exports:

$$Q_{WEST} = Q_{SJR} + C_{SMR} + Q_{Mokelume} + Q_{Misc} + Q_{XGEO} – 0.65 * (Q_{GCD} + Q_{PREC}) - Q_{EXPORT} – Q_{MISDV}$$

QWEST restrictions in the CalLite model are translated into a maximum export restriction through solution of the DAYFLOW equation. Export capacity under QWEST controls are currently shared equally between the SWP and CVP. In some circumstances, the QWEST target cannot be solely satisfied through export reductions. In these cases, exports are specified as zero, but no additional flow is provided through the San Joaquin River or through the DCC.

Old and Middle River Combined Flow (OMR)

Combined Old and Middle River flows restrictions are proposed as a means for reducing flow reversals in these channels and limiting Delta smelt entrainment at the SWP and CVP export facilities.

Four regression equations are available for use in approximating the OMR flows. The first, recently developed by Paul Hutton (2007), has calibrated on historic flow conditions as well as a full range of hydrodynamic simulation results using the DSM2 model. This equation relates OMR flow to south Delta diversions (including CCWD and Delta Island channel depletions) and Vernalis flow. The equation includes differing coefficients depending on Vernalis flow, head of Old River barrier (HORB) operation, and Grant Line Canal (GLC) barrier operation as shown below. This equation is reported to be the most accurate of the four, but no independent analysis has been performed.

$$Q_{OMR}\text{ (cfs)} = A * Q_{Vernalis} + B * Q_{South\ Delta\ Diversions} + C$$

$$\text{Where: } Q_{South\ Delta\ Diversions} = Q_{CCF} + Q_{Jones} + Q_{CCWD} + Q_{South\ Delta\ NCD}$$

HORB	GLC Barrier	Vernalis (cfs)	A	B	C
Out	Out	< 16,000	0.462	-0.911	120
Out	Out	16,000-28,000	0.681	-0.940	-2982
Out	Out	> 28,000	0.634	-0.940	-1654
Out	In	All	0.405	-0.940	183
In (Spring)	Out/In	All	0.079	-0.940	73
In (Fall)	Out/In	All	0.259	-0.940	-9

The three other regression equations for OMR are based on older analysis by DWR and the USGS and relate OMR flow to SWP/CVP exports and Vernalis flow. These equations include differing coefficients for OMR flow based on Vernalis flow, and the USGS2 equation includes a further adjustment for the HORB operation.

$$Q_{OMR}\text{ (cfs)} = A * Q_{Vernalis} + B * Q_{export} + C$$

$$\text{Where: } Q_{export} = Q_{CCF} + Q_{Jones}$$

OMR Eqn	Vernalis (cfs)	A	B	C
DWR	All	0.58	-0.913	0
USGS1	All	0.4486	-0.7695	-590
USGS2	<10,000 cfs (w/ barriers)	0	-0.8219	-365
USGS2	<10,000 cfs (w/o barriers)	0	-0.8738	1137

OMR Eqn	Vernalis (cfs)	A	B	C
USGS2	>10,000 cfs	0.7094	-0.7094	-4619

As with the QWEST, OMR restrictions in the CalLite model are translated into a maximum export restriction through solution of the equations above. Export capacity under OMR controls are currently shared equally between the SWP and CVP. In some circumstances, the OMR target cannot be solely satisfied through export reductions. In these cases, exports are specified as zero, but no additional flow is provided through the San Joaquin River.

Delta Cross Channel (DCC)

Operation of the Delta Cross Channel (DCC) assists in transferring fresh water from the Sacramento River across the Delta (DWR 1993). Flow from the Sacramento River into the DCC is controlled by two radial arm gates located at the Sacramento River end of the DCC. These gates can be opened and closed depending on water quality, flood protection, and fish protection requirements. Historically during periods of high salinity the DCC gate has been opened, and during periods of low salinity the DCC gate has been closed. The USBR and DWR have been operating the DCC in accordance with D-1641 since its establishment.

The operation of the DCC in CalLite is simulated as the fraction of the month that the gate remains open. Under either D-1641 or user-specified operation, the number of days "open" are specified and a fraction is computed internally depending on the number of days in the month.

The flow through the DCC and Georgianna Slough are estimated based on the regression equations that relate DCC+GEO flow to upstream Sacramento River flow and gate position.

$$Q_{dcc+geo} = 0.293*Q_{sac}+2090 \text{ cfs (DCC gates open)}$$

$$Q_{dcc+geo} = 0.133*Q_{sac}+829 \text{ cfs (DCC gates closed)}$$

The diversion from Sacramento River to the Central Delta is then calculated as:

$$Q_{dcc+geo\_open}*DCC\_FractOpen+Q_{dcc+geo\_closed}*(1-DCC\_FractOpen)$$

The DCC impact on salinity is considered in the Artificial Neural Network (ANN) flow-salinity models.

Export Limits

Maximum exports are based on conveyance restrictions, VAMP export limits, export-inflow (EI) ratio, and salinity controls. In addition, as discussed above the QWEST and OMR restrictions are translated into export maximums. The VAMP and EI ratio limits can be modified by the user and are discussed here.

Export-Inflow Ratio

EI ratio restrictions limit the combined export rate of the SWP and CVP to a specified percentage of the total Delta inflow. The EI ratio values are used to set a maximum export flow in the model. When D-1641 standards are specified the February value is computed based on the January eight river index, while all other months have a specific maximum EI ratio. When user-defined values are specified, all months have specific maximum ratios. If EI ratio limits total project exports, the export capacity is shared equally between the SWP and CVP. Unused share of the export capacity by one party can be used by the other party.

Vernalis Adaptive Management Program (VAMP) Export Limits

SWP and CVP exports are commonly restricted during the VAMP window of April 15 – May 15 to a combined rate of the maximum of 1500 cfs or the flow at Vernalis. As with other export limits, the available export capacity is shared equally between the SWP and CVP.

Salinity

The salinity at Sacramento River at Collinsville, Sacramento River at Emmaton, San Joaquin River at Jersey Point, Old River at Rock Slough are estimated in the CalLite model through implementation of the most recent ANNs developed by DWR (1995). The ANNs receive input of boundary flows, DCC gate position, exports, and tides to estimate salinity (electrical conductivity) at each of these locations. Through a linkage to the external ANNs, the CalLite model can both simulate the monthly and 14-day average salinity in the forward direction, and approximate the maximum export for a given maximum salinity in the reverse direction. The maximum export capacity is once again shared equally between the SWP and CVP. The CalLite model allows the user to turn on and off specific standards, but the ability to specify new standards is not currently enabled.

References

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Hutton, 2007. *OMR Flow Model Section 6*, ROUGH DRAFT. September 28. 2007

Jassby AD, Kimmerer WJ, Monismith SG, Armor C, Cloern JE, Powell TM, Schubel JR, Vendlinski TJ. 1995. Isohaline position as a habitat indicator for estuarine populations. Ecological Applications 5:272-289.