F.1.7 Potential Changes in Delta Exports and Outflow

Changes in SJR flow at Vernalis for LSJR Alternatives 2, 3, and 4 have been accurately estimated using the WSE model. The effects of these changes in SJR flow at Vernalis on southern Delta salinity have also been evaluated, based on approximate relationships between Vernalis flow and the salinity increases observed at the southern Delta salinity compliance stations. The changes in SJR flow at Vernalis also change flow in the Delta channels, and may change southern Delta exports and Delta outflow.

Changes in exports would affect water supply (beneficial uses) in the CVP and SWP service area south of the Delta; the salinity gradient (i.e., X2) in the western estuary (i.e., Suisun Bay and western Delta); and, could influence aquatic resources associated with salinity (i.e., low-salinity zone habitat distribution). The analysis below provides an accurate accounting of the two most likely changes in the Delta (exports and Delta outflow) that would result from changes in the LSJR flow at Vernalis. Changes in southern Delta exports associated with the LSJR alternatives are generally small. The combination of the modeled SJR flow changes and the likely export changes determine the likely changes in Delta outflow. Further evaluation of these Delta outflow and export changes will be included in the State Water Board's ongoing review of the 2006 Bay-Delta WQCP in Phases II, III and IV.

F.1.7.1 Current Operational Summary

The existing CVP and SWP Delta pumping operations are determined by several rules and objectives that guide the daily Delta operations. Many of these rules are included in D-1641 (which implemented the 1995 Bay-Delta WQCP objectives). Several additional rules have been added by the 2008 FWS BO (USFWS 2008) and the 2009 NMFS BO for the CVP and SWP Operations Criteria and Plan (OCAP) (NMFS 2009). The existing CVP and SWP Delta pumping operations are summarized in this section so that the possible changes in the southern Delta pumping can be identified for the LSJR alternatives.

Delta operations under D-1641 can be simplified into two sets of rules: 1) rules controlling the maximum allowable exports and 2) rules controlling the minimum required Delta outflow. Several objectives control the allowable exports and several objectives control the minimum Delta outflow. Both the 2008 FWS BO and the 2009 NMFS BO added pumping restrictions to limit reverse (negative) Old and Middle River (OMR) flows. There are two RPAs from the NMFS BO that apply to the SJR inflow and are associated with southern Delta pumping. The applicable Delta operational rules control the existing southern Delta pumping.

The CVP permitted pumping capacity is 4,600 cfs, which requires use of the new DMC Intertie facility in the winter months. The SWP pumping capacity is constrained by the CCF diversion limits (Rivers and Harbors Section 10) of 6,680 cfs, with additional diversions of 1/3 of the SJR flow at Vernalis (with a maximum monthly pumping of 8,500 cfs assumed in CALSIM) between December 15 and March 15. SWP pumping at the physical capacity of 10,300 cfs is not currently permitted. The export/inflow ratio limits the CVP and SWP combined pumping to 65 percent of the Delta inflow July–January, and to 35 percent of the Delta inflow February–June. The 35 percent ratio in February is increased to 45 percent if the January runoff is low. An additional pumping limit imposed by the 2009 NMFS BO was an export limit that applies in April and May (a similar export restriction during VAMP applied for 31 days). This ratio effectively limits the combined export to 1,500 cfs for SJR inflows of less than 6,000 cfs. The exports are limited to 25 percent of the SJR inflow if the inflow is greater than 6,000 cfs.

The FWS and NMFS BOs also introduced new limits on the reverse (negative) OMR flow in December–June of many years (adaptively managed based on temperature, turbidity, and fish monitoring). Because the southern Delta exports often come primarily from OMR channels north of the export facilities, the minimum OMR restrictions limit exports. For example, an OMR limit of -2,000 cfs restricts exports to about 2,000 cfs plus the head of Old River flow diverted from the SJR near Mossdale. About 50 percent of the SJR flow is diverted into Old River unless there is a physical barrier installed. The OMR limits vary each year with fish and turbidity conditions; however, CALSIM modeling has assumed a monthly OMR limit that varies generally with the water year type.

Another possible constraint on Delta exports is related to the seasonal (monthly) water supply deliveries that are assumed for south of Delta CVP and SWP contractors. The San Luis Reservoir provides about 2,000 TAF of seasonal storage for meeting the peak summer water demands. The San Luis Reservoir storage space allows relatively high exports to continue through the fall and winter period. Without the San Luis Reservoir, exports would be reduced in the fall and winter to match the monthly water demands. Once San Luis Reservoir is filled, pumping is generally reduced to the monthly water demand, with some additional SWP exports for Article 21 deliveries to contractors with local storage capacity (e.g., surface reservoirs or groundwater storage).

The minimum required Delta outflow also may limit the allowable exports. Minimum monthly outflows are specified in D-1641 for each month, which often depend on the water year type (i.e., runoff conditions). For example, a minimum monthly outflow of 3,000 cfs is specified in September of all years. A minimum monthly outflow of 8,000 cfs is specified in July of wet and above normal water year types (about half of the years).

Delta outflow is also controlled by the maximum salinity objectives specified in D-1641 for each month or period. For example, EC objectives are specified at Emmaton and Jersey Point to protect agricultural diversions, and salinity (chloride) objectives are specified at the Contra Costa Water District Rock Slough intake to protect drinking water supplies. Because Delta outflow is the major factor determining salinity within the Delta channels, these salinity objectives are satisfied by increasing Delta outflow (normally by reducing exports).

The D-1641 February–June X2 objectives are another example of salinity requirements, which are satisfied by adjusting Delta outflow. The maximum location of the 2 parts per thousand (ppt) salinity (i.e., upstream edge of estuarine salinity gradient) is specified (kilometers [km] upstream of the Golden Gate), based on the month and the unimpaired runoff in the previous month. This was formulated as an adaptive objective; the required monthly outflow increased with higher runoff conditions. D-1641 provides equivalent Delta outflows for the X2 objectives; X2 at Collinsville (81 km) can be satisfied with an outflow of 7,100 cfs and X2 at Chipps Island (75 km) can be satisfied with an outflow of 11,400 cfs. The 2008 FWS BO included an additional outflow requirement for September and October of wet and above normal water year types (about half the years). The “Fall X2” rule requires X2 to be downstream of Collinsville (7,100 cfs outflow) in above normal years and downstream of Chipps Island (11,400 cfs outflow) in wet years.

F.1.7.2 Methods to Estimate Changes in Delta Exports and Outflow

The CALSIM model does not currently include the option of using a specified fraction of the unimpaired flow as the required reservoir release flows, and cannot change Tuolumne or Merced diversions based on higher target release flows. Therefore, an approximate method for estimating the potential change in southern Delta pumping was used with the WSE model results. Changes in SJR flow at Vernalis would either change exports or change outflow. Because the WSE model does not include the Delta, there are no model results to help determine which factors would limit Delta exports. As a result, the potential change in export pumping was estimated by selecting the most likely limiting factor each month. Table F.1.7-1 summarizes the Delta regulations affecting exports and shows which regulations were used to assess whether changes in flow at Vernalis affected Delta exports or outflow. Following the table is a narrative summary of the export controls organized by month. These export controls were used to evaluate potential LSJR alternative changes.

Summary of Controls and Potential LSJR Alternative Changes

April and May. The most restrictive export regulations occur during April and May. The NMFS BO RPA 4.2.1 limits the exports to 1,500 cfs unless the SJR inflow is greater than 6,000 cfs in April and May. The maximum exports are limited to 25 percent of the SJR inflow at higher flows. It is therefore unlikely that the LSJR alternatives would result in increased exports during April or May. But if the Vernalis flow was greater than 6,000 cfs and the LSJR alternatives increased the flow to 7,000 cfs, for example, the pumping would increase by 250 cfs. Reductions in the SJR inflow would result in reduced pumping only if the pumping was greater than 1,500 cfs,

January, February, March, June, and December. In January, February, March, June, and December, the OMR regulations will likely limit exports. When OMR regulations are in effect, no extra water can be drawn from the north for exports. However, extra flow at Vernalis can be exported if it reaches the pumps by passing through the head of Old River. Because approximately 50 percent of the flow at Vernalis enters the Head of Old River, the pumping change would be 50 percent of the SJR flow increment.

July–November. From July–November, the most likely limit would be the E/I ratio of 65 percent. When a 65 percent E/I ratio is limiting, the pumping change would be 65 percent of the SJR flow increment.

In some instances, these assumptions about the export-limiting regulations would be incorrect. For example, if exports are at the minimum of 1,500 cfs, a reduction in flow at Vernalis would not cause a reduction in exports; if exports are at the maximum permitted export pumping of 11,280 cfs (11,780 cfs in July–September) then an increase in flow at Vernalis would not cause an increase in exports. Similarly, reductions in the SJR flow at Vernalis would cause a reduction in exports of the same amount if the baseline Delta outflow was equal to the minimum required Delta outflow. However, there were seldom decreases in Vernalis flow under the LSJR alternatives.

Changes in SJR flow at Vernalis would also cause changes in Delta outflow. Because the LSJR alternatives could reduce the SJR flow at Vernalis in some months and increase the SJR flow at Vernalis flow in other months, the possibility of increased and decreased Delta outflow must be considered. The most likely effect on a decrease in the SJR flow at Vernalis would be that Delta outflow would be reduced, but the reduction in outflow would be less than the reduction in SJR flow because there would be less exports (as calculated above). The change in outflow each month would be the change at Vernalis minus the change in exports.

Table F.1.7-1. Regulations that May Affect Export of Water Entering the Delta

Restriction: Regulation	January	February	March	April	May	June	July	August	September	October	November	December
Export Minimum (cfs): D-1641	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500
Export Maximum (cfs): D-1641	13,100[e]	13,100[e]	13,100/ 11,280[e]	11,280	11,280	11,280	11,780[f]	11,780[f]	11,780[f]	11,280	11,280	11,280/ 13,100[e]
Export Maximum (cfs): 2009 NMFS BO[a]				1,500	1,500							
E/I Ratio: D-1641	0.65	0.35	0.35[g]	0.35	0.35	0.35	0.65	0.65	0.65	0.65	0.65	0.65
HOR barrier in place: 2009 NMFS BO				X	X							
OMR Restrictions (cfs): 2008 FWS BO and 2009 NMFS BO[b]	0 to -5,000	0 to -5,000	0 to -5,000	0 to -5,000	0 to -5,000	0 to -5,000						0 to -5,000
Minimum Delta Outflow (cfs): D-1641	4,500[h]						4,000 to 8,000[i]	3,000 to 4,000[i]	3,000i	3,000 to 4,000[i]	3,500 to 4,500[i]	3,500 to 4,500[i]

Restriction: Regulation	January	February	March	April	May	June	July	August	September	October	November	December
Outflow for X2 Objectives (cfs): D-1641 and 2008 FWS BO		7,100-11,400[j]	7,100-11,400[j]	7,100-11,400[j]	7,100-11,400[j]	7,100-11,400[j]			7,100-11,400[k]	7,100-11,400[k]		
Western Delta Conductivity Standards for Agriculture (µS/cm): D-1641[c]				450 to 2,780	450 to 2,780	450 to 2,780	450 to 2,780	450 to 2,780				
Contra Costa Water District Drinking-Water Chloride Standards (mg/l): D-1641[d]	150 to 250	150 to 250	150 to 250	150 to 250	150 to 250	150 to 250	150 to 250	150 to 250	150 to 250	150 to 250	150 to 250	150 to 250

Footnotes:

HOR = Head of Old River

Shading indicates the regulations used for the export/outflow impact assessment.

Other factors that may control exports include:

- Delta water quality standards at other locations, although these other locations are less likely to affect exports than locations listed above.
- Capacity in San Luis Reservoir or with the water contractors (surface reservoirs or groundwater storage).

a. If SJR inflow (Vernalis) is > 6,000 cfs, exports can be increased to equal 0.25 * Vernalis.

b. Adaptively managed based on temperature, turbidity, and fish monitoring. SJR flows that pass through the Head of Old River can be diverted without affecting Old and Middle River flows. These flows are approximately equal to 0.5 * Vernalis when the Head of River barrier is not in place.

c. Value depends on location (Emmaton, Jersey Point, or San Andreas), water year type, and date. No objective after August 15. (Terminus also has similar standards, but these are unlikely to affect Delta exports). Salinity in the western Delta is largely controlled by Delta outflow, with higher Delta

Restriction: Regulation	January	February	March	April	May	June	July	August	September	October	November	December

outflow causing a reduction in seawater intrusion. Particular EC objectives can be met by maintaining sufficient Delta outflow. For example, 450 µS/cm and 2,780 µS/cm at Emmaton can be met by maintaining Delta outflow at approximately 7,500 cfs and 3,500 cfs, respectively.

d. Chlorides should stay below 150 mg/l for about half the year and below 250 mg/l at all times. Contra Costa Water District takes water from multiple locations within the Delta. Its intake at Rock Slough is the site most likely to exceed the chloride objective. Chlorides near Rock Slough can be maintained below the 150 mg/l and 250 mg/l objectives by limiting salinity intrusion from the ocean by maintaining Delta outflow above approximately 4,500 cfs and 3,500 cfs, respectively, although local agricultural drainage could cause the objectives to be exceeded regardless of Delta outflow.

e. From December 15–March 15, one-third of the SJR flow at Vernalis can be added to the SWP export limit of 6,680 cfs to bring SWP exports up to 8,500 cfs (upper limit assumed by CALSIM).

f. Extra 500 cfs allowed by USACE.

g. Increased to 0.45 if January runoff is low.

h. Increased to 6,000 cfs if December 8 river index > 800 TAF.

i. Depends on year type.

j. D-1641 criteria: Outflow needed to keep X2 at Collinsville or Chipps Island. Number of days at Chipps Island depends on previous month's river index. Outflow could be less than 7,100 cfs under drought conditions. Several other caveats exist.

k. 2008 FWS BO: 7,100 cfs (Collinsville) in above normal years and 11,400 cfs (Chipps Island) in wet years.

The most likely effect of an increase in the SJR flow at Vernalis would be that any water not exported would increase Delta outflow. It is possible that an increase in Delta outflow might allow upstream reservoir releases into the Sacramento River system to be reduced, with increased storage that could later be released for increased exports. However, a reduction in upstream reservoir releases (increase in storage) would generally not be possible if the Delta outflow was already greater than the required Delta outflow. In most spring months (February–June), the reservoir releases are controlled by maximum flood control storage or by minimum downstream flow requirements. Because the E/I ratio is only 35 percent in these months, exports can only be increased by 35 percent of the increased reservoir releases; releases of stored water for exports are unlikely in these months. With the additional FWS and NMFS restrictions on reverse OMR flow in these months, reservoir releases are almost always reduced to the minimum possible for flood control and downstream minimum requirements.

The likely changes in the baseline Delta outflow were calculated for each month for LSJR Alternatives 2, 3, and 4 to provide an initial estimate of the magnitude and frequency of the likely changes in Delta outflow. The increase in SJR flow (minus the estimated increase in exports) was assumed to be the increase in Delta outflow. These increases in Delta outflow are expected to be beneficial for estuarine habitat and fish survival.

This analysis provides a best estimate of how much of a change in flow at Vernalis would go to exports and how much would go to Delta outflow. An analysis of extremes could assume that all of the change in flow would go towards a change in Delta exports or that all of the change in flow would go towards a change in Delta outflow. The values presented here are between these two extremes. However, even if the extremes were used, the maximum potential changes in Delta exports or Delta outflow associated with the LSJR alternatives would be relatively small because of the relatively small contribution of the SJR to flow in the Delta. During water years 1995–2013, the average annual SJR flow of 3,360 TAF represented only about 14 percent of the combined average annual exports (5,185 TAF) and average annual Delta outflow (19,034 TAF) (data from DWR's DAYFLOW dataset).

F.1.7.3 Changes in Delta Exports and Outflow

Summary

The analysis of the change in exports and change in Delta outflow does not include an estimate of total Delta outflow or exports. As a result, the changes cannot be evaluated as a change in the distribution of outflow and exports. Some of the large changes are unlikely to be a concern because they would not affect the typical distribution of outflow and exports that would be expected. The primary result of interest from the Delta export and outflow analysis is the overall average change estimated for each month.

The annual and February–June cumulative distributions of SJR flow at Vernalis, change in SJR flow at Vernalis, change in southern Delta exports, and change in Delta outflow are summarized in Tables F.1.7-2a, F.1.7-2b, and F.1.7-2c. The monthly cumulative distributions of the likely changes in exports and outflow for the LSJR alternatives (20, 40, and 60 percent unimpaired flow) are described in more detail in tables below. Results for the 30 percent and 50 percent unimpaired flow are not described in detail, and only presented in the summary tables, because their results are, as expected, intermediate between the other percent unimpaired flows.

Table F.1.7-2a. Summary of Estimated Changes in SJR Flow at Vernalis (TAF)

Cumulative Distributions of Baseline and Changes in SJR Flow (TAF)			Percent of Unimpaired Flow									
	Baseline		20%		30%		40%		50%		60%	
	Annual SJR Flow (TAF)	Feb–June SJR Flow (TAF)	Annual SJR Flow Change	Feb–June SJR Flow Change	Annual SJR Flow Change	Feb–June SJR Flow Change	Annual SJR Flow Change	Feb–June SJR Flow Change	Annual SJR Flow Change	Feb–June SJR Flow Change	Annual SJR Flow Change	Feb–June SJR Flow Change
Minimum	875	364	40	17	49	25	81	53	124	96	168	140
10%	1,077	444	59	69	224	154	388	272	529	361	582	496
20%	1,386	604	65	64	214	244	387	374	546	506	745	674
30%	1,585	785	9	50	183	177	338	263	516	453	678	635
40%	1,778	935	47	-5	165	159	320	372	573	571	822	786
50%	2,041	1,103	61	118	234	357	463	633	777	845	1,112	1,016
60%	2,690	1,509	50	-22	132	162	232	417	535	654	901	1,017
70%	3,266	1,904	3	46	-35	193	146	310	447	526	733	823
80%	4,197	2,508	310	64	337	127	327	114	389	374	655	722
90%	5,542	3,554	-37	14	-84	75	-50	164	272	471	770	871
Maximum	15,907	9,415	0	0	0	72	-67	191	-167	410	-355	697
Average	2,965	1,742	59	56	149	174	294	288	469	485	693	728
	Percentage Change		2.0%	3.2%	5.0%	10.0%	9.9%	16.5%	15.8%	27.8%	23.4%	41.8%

Table F.1.7-2b. Summary of Estimated Changes in Delta Exports (TAF)

Cumulative Distributions of Changes in Delta Exports (TAF)	Percent of Unimpaired Flow									
	20%		30%		40%		50%		60%	
	Annual Exports Change	Feb–June Exports Change	Annual Exports Change	Feb–June Exports Change	Annual Exports Change	Feb–June Exports Change	Annual Exports Change	Feb–June Exports Change	Annual Exports Change	Feb–June Exports Change
Minimum	-74	-61	-132	-65	-190	-140	-263	-186	-376	-36
10%	-24	-10	-64	-7	-46	-36	-29	1	-4	45
20%	-16	-5	-15	6	3	0	28	28	58	87
30%	-1	0	1	13	29	14	62	57	100	117
40%	2	3	9	21	44	38	89	95	160	161
50%	9	8	18	30	69	58	122	119	187	196
60%	17	13	28	40	88	77	149	143	217	217
70%	32	24	52	55	125	99	174	168	268	265
80%	52	34	83	77	148	129	234	209	336	302
90%	77	60	127	118	216	202	316	307	450	439
Maximum	158	134	204	204	329	301	453	430	592	579
Average	18	16	27	41	76	67	124	128	194	211

Table F.1.7-2c. Summary of Estimated Changes in Delta Outflow (TAF)

Cumulative Distributions of Changes in Delta Outflow (TAF)	Percent of Unimpaired Flow									
	20%		30%		40%		50%		60%	
	Annual ~~Exports~~Outflow Change	Feb–June ~~Exports~~Outflow Change	Annual ~~Exports~~Outflow Change	Feb–June ~~Exports~~Outflow Change	Annual ~~Exports~~Outflow Change	Feb–June ~~Exports~~Outflow Change	Annual ~~Exports~~Outflow Change	Feb–June ~~Exports~~Outflow Change	Annual ~~Exports~~Outflow Change	Feb–June Outflow~~Exports~~ Change
Minimum	-88	-89	-88	-72	-168	-130	-189	-135	-31	64
10%	-23	-22	-9	17	-15	44	43	125	183	272
20%	-10	-4	19	45	88	81	166	189	293	338
30%	3	4	53	72	137	131	230	245	371	388
40%	14	14	78	81	166	153	282	271	432	444
50%	34	34	112	132	204	199	348	329	480	478
60%	48	50	150	151	246	234	375	377	521	503
70%	64	62	167	167	279	280	418	419	582	573
80%	89	81	207	203	372	371	537	535	698	698
90%	115	108	275	275	472	462	672	664	876	869
Maximum	300	300	437	450	590	577	836	823	1,071	1,058
Average	41	40	123	133	218	220	345	357	499	518

20 Percent Unimpaired Flow (LSJR Alternative 2)

Table F.1.7-3a shows the monthly cumulative distributions of the changes in the monthly Vernalis flows that were calculated with the WSE model of 1922–2003 (82 years) for LSJR Alternative 2. In some months, Vernalis flow increased significantly (the largest increase was 4,620 cfs in May 1978), while in other months, the flow decreased by a large amount (the largest decrease was 1,645 cfs in July 1941). The monthly flow reductions occurred most frequently in February–May, most likely due to reduced flood control releases. On average, all months, except March, July, and December, showed increased monthly flow. Annually, total flow at Vernalis increased more frequently than it decreased, with more than 70 percent of years registering an overall increase in flow. The average annual change in the SJR flow at Vernalis was an increase of 59 TAF/y, and the average change over February–June was an increase of 56 TAF/y.

Table F.1.7-3b shows the monthly cumulative distributions of the changes in monthly Delta exports, based on the monthly change in Vernalis flow under LSJR Alternative 2 and the regulations determined to control monthly exports (the shaded boxes in Table F.1.7-1). In some months, the Delta exports were estimated to increase significantly (the largest increase was 1,207 cfs in June 1932), while in other months, the exports decreased by a large amount (the largest decrease was 1,063 cfs in July 1941). The distribution of monthly export changes does not indicate whether the changes occurred in years with low baseline exports (larger effects) or in years with higher baseline exports (smaller effects). The overall changes in the monthly distributions of exports would generally be much smaller than the distribution of individual monthly export changes. Many of the large monthly export reductions would be compensated by increased exports in other months. On average, all months, except March, July, and December, showed increased exports. Annually, total Delta exports increased more frequently than they decreased, with more than 60 percent of years registering an overall increase. The average annual change in Delta exports was an increase of 18 TAF/y, and the average change over February–June was an increase of 16 TAF/y. This is relatively small compared to average historical exports of 5,185 TAF/y.

Table F.1.7-3c shows the monthly cumulative distributions of the changes in monthly Delta outflow, based on the changes in SJR flow at Vernalis and the estimated changes in Delta exports under LSJR Alternative 2. In some months, Delta outflow was estimated to increase significantly (the largest increase was 3,465 cfs in May 1978), while in other months, outflow decreased by a large amount (the largest decrease was 1,149 cfs in April 1953). Many of the large monthly reductions in outflow would be compensated by increased outflow in other months. On average, all months, except March, April, July, and December, showed increased monthly outflow. Annually, total Delta outflow increased more frequently than it decreased, with more than 70 percent of years registering an overall increase. The average annual change in Delta outflow was an increase of 41 TAF/y, and the average change over February–June was an increase of 40 TAF/y. This is relatively small compared to the average historical Delta outflow of about 19,000 TAF/y.

The results from this analysis indicate that about 31 percent of the average annual increase in the SJR flow at Vernalis would go toward an increase in exports, and 69 percent would go toward Delta outflow for LSJR Alternative 2.

Table F.1.7-3a. Cumulative Distributions of Monthly Changes in Vernalis Flow under LSJR Alternative 2

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Annual (TAF)
Minimum	-45	-100	-1,101	-808	-1,587	-1,364	-1,149	-896	-850	-1,635	-409	-499	-162
10%	0	0	0	-114	-469	-476	-479	-250	-79	0	0	0	-39
20%	0	0	0	0	-123	-190	-284	-23	0	0	0	0	-23
30%	0	0	0	0	0	0	-136	144	48	0	0	0	0
40%	0	0	0	0	0	0	0	304	163	0	0	0	32
50%	0	0	0	0	0	0	0	402	267	0	0	0	52
60%	0	0	0	0	0	0	99	517	485	0	0	0	70
70%	0	0	0	0	0	0	188	680	594	0	0	0	82
80%	0	0	0	0	109	20	250	879	930	0	0	40	110
90%	51	0	0	6	550	273	420	1,121	1,281	50	50	50	181
Maximum	139	518	1,622	1,103	2,174	1,376	1,121	4,620	2,414	535	1,081	1,125	434
Average	10	11	-19	2	28	-15	8	468	431	-24	32	43	59

Table F.1.7-3b. Cumulative Distributions of the Estimated Monthly Changes in Delta Exports under LSJR Alternative 2

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Annual
Minimum	-29	-65	-550	-404	-794	-682	-94	-101	-425	-1,063	-266	-324	-74
10%	0	0	0	-57	-235	-238	0	0	-40	0	0	0	-24
20%	0	0	0	0	-61	-95	0	0	0	0	0	0	-16
30%	0	0	0	0	0	0	0	0	24	0	0	0	-1
40%	0	0	0	0	0	0	0	0	81	0	0	0	2
50%	0	0	0	0	0	0	0	0	134	0	0	0	9
60%	0	0	0	0	0	0	0	0	242	0	0	0	17
70%	0	0	0	0	0	0	0	0	297	0	0	0	32
80%	0	0	0	0	55	10	0	25	465	0	0	26	52
90%	33	0	0	3	275	136	57	96	641	33	33	33	77
Maximum	90	337	811	552	1,087	688	270	1,155	1,207	348	702	732	158
Average	6	7	-10	1	14	-8	12	35	216	-16	21	28	18

Table F.1.7-3c. Cumulative Distributions of the Estimated Monthly Changes in Delta Outflow under LSJR Alternative 2

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Annual (TAF)
Minimum	-16	-35	-550	-404	-794	-682	-1,149	-896	-425	-572	-143	-175	-88
10%	0	0	0	-57	-235	-238	-479	-250	-40	0	0	0	-23
20%	0	0	0	0	-61	-95	-279	-23	0	0	0	0	-10
30%	0	0	0	0	0	0	-109	144	24	0	0	0	3
40%	0	0	0	0	0	0	0	238	81	0	0	0	14
50%	0	0	0	0	0	0	0	373	134	0	0	0	34
60%	0	0	0	0	0	0	89	517	242	0	0	0	48
70%	0	0	0	0	0	0	172	668	297	0	0	0	64
80%	0	0	0	0	55	10	246	870	465	0	0	14	89
90%	18	0	0	3	275	136	411	1,076	641	18	18	18	115
Maximum	49	181	811	552	1,087	688	1,121	3,465	1,207	187	378	394	300
Average	3	4	-10	1	14	-8	-4	433	216	-8	11	15	41

40 Percent Unimpaired Flow (LSJR Alternative 3)

Table F.1.7-4a shows the monthly cumulative distributions of the changes in the monthly Vernalis flows that were calculated with the WSE model of 1922–2003 (82 years) for LSJR Alternative 3. In some months, Vernalis flow increased significantly (the largest increase was 5,820 cfs in June 1932), while in other months, the flow decreased by a large amount (the largest decrease was 6,801cfs in February 1998). The monthly flow reductions occurred most frequently in December–March, most likely due to reduced flood control releases. On average, April–June and September–November showed monthly increases in Vernalis flow, while all other months had decreases. The September–November increases most likely occurred as a result of adaptive implementation flow shifting. Annually, total flow at Vernalis increased more frequently than it decreased, with more than 80 percent of years registering an overall increase in flow. The average annual change in the SJR flow at Vernalis was an increase of 294 TAF/y, and the average change over February–June was an increase of 288 TAF/y.

Table F.1.7-4b shows the monthly cumulative distributions of the changes in monthly Delta exports, based on the monthly change in Vernalis flow under LSJR Alternative 3 and the regulations determined to control monthly exports (the shaded boxes in Table F.1.7-1). In some months, the Delta exports were estimated to increase significantly (the largest increase was 2,910 cfs in June 1932), while in other months, the exports decreased by a large amount (the largest decrease was 3,401 cfs in February 1998). The distribution of monthly export changes does not indicate whether the changes occurred in years with low baseline exports (larger effects) or in years with higher baseline exports (smaller effects). The overall changes in the monthly distributions of exports would generally be much smaller than the distribution of individual monthly export changes. Many of the large monthly exports reductions would be compensated by increased exports in other months. On average, April–June and September–November showed monthly increases in Delta exports, while all other months had decreases. Annually, total Delta exports increased more frequently than they decreased, with more than 80 percent of years registering an overall increase. The average annual change in Delta exports was an increase of 76 TAF/y, and the average change over February–June was an increase of 67 TAF/y. This is relatively small compared to average historical exports of 5,185 TAF/y.

Table F.1.7-4c shows the monthly cumulative distributions of the changes in monthly Delta outflow, based on the changes in SJR flow at Vernalis and the estimated changes in Delta exports under LSJR Alternative 3. In some months, Delta outflow was estimated to increase significantly (the largest increase was 4,775 cfs in May 2003), while in other months, outflow decreased by a large amount (the largest decrease was 3,401 cfs in February 1998). Many of the large monthly reductions in outflow would be compensated by increases in outflow in other months. On average, April–June and September–November showed monthly increases in Delta outflow, while all other months had decreases. Annually, total Delta outflow increased more frequently than it decreased, with more than 80 percent of years registering an overall increase. The average annual change in Delta outflow was an increase of 218 TAF/y, and the average February–June change was an increase of 220 TAF/y. This is relatively small compared to the average historical Delta outflow of about 19,000 TAF/y. The results from this analysis indicate that about 26 percent of the average annual increase in the SJR flow at Vernalis would go toward an increase in exports, and 74 percent would go toward Delta outflow for LSJR Alternative 3.

Table F.1.7-4a. Cumulative Distributions of Monthly Changes in Vernalis Flow under LSJR Alternative 3

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Annual (TAF)
Minimum	-410	-717	-3,095	-3,216	-6,801	-3,657	-1,354	-358	-2,272	-3,084	-1,651	-2,106	-358
10%	7	0	-620	-1,311	-1,479	-1,270	-216	731	96	-254	-190	-50	-66
20%	32	0	0	-234	-445	-635	28	1,210	418	-50	-35	0	77
30%	97	0	0	-6	-65	-55	210	1,516	615	0	0	0	183
40%	157	0	0	0	0	0	447	1,820	960	0	0	0	224
50%	199	0	0	0	0	0	611	2,216	1,399	0	0	0	281
60%	232	0	0	0	47	127	790	2,622	1,803	0	0	34	334
70%	337	0	0	0	245	300	1,104	3,038	2,131	0	0	98	415
80%	566	612	0	0	669	510	1,669	3,692	2,775	50	50	481	515
90%	974	834	0	6	1,572	934	2,135	4,269	3,674	212	98	816	680
Maximum	1,651	1,021	1,368	2,861	3,521	2,881	4,333	5,447	5,820	1,211	461	1,108	915
Average	327	176	-191	-294	-16	-44	810	2,400	1,602	-29	-31	154	294

Table F.1.7-4b. Cumulative Distributions of the Estimated Monthly Changes in Delta Exports under LSJR Alternative 3

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Annual (TAF)
Minimum	-267	-466	-1,548	-1,608	-3,401	-1,828	-339	-66	-1,136	-2,005	-1,073	-1,369	-190
10%	4	0	-310	-656	-739	-635	0	0	48	-165	-124	-33	-46
20%	21	0	0	-117	-223	-318	0	0	209	-33	-23	0	3
30%	63	0	0	-3	-32	-27	0	0	308	0	0	0	29
40%	102	0	0	0	0	0	0	24	480	0	0	0	44
50%	129	0	0	0	0	0	0	178	700	0	0	0	69
60%	151	0	0	0	23	63	0	362	902	0	0	22	88
70%	219	0	0	0	123	150	30	442	1,066	0	0	64	125
80%	368	398	0	0	335	255	91	586	1,388	33	33	313	148
90%	633	542	0	3	786	467	180	835	1,837	138	64	531	216
Maximum	1,073	663	684	1,430	1,761	1,440	926	1,192	2,910	787	299	720	329
Average	212	114	-96	-147	-8	-22	50	299	801	-19	-20	100	76

Table F.1.7-4c. Cumulative Distributions of the Estimated Monthly Changes in Delta Outflow under LSJR Alternative 3

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Annual (TAF)
Minimum	-144	-251	-1,548	-1,608	-3,401	-1,828	-1,016	-358	-1,136	-1,079	-578	-737	-168
10%	2	0	-310	-656	-739	-635	-216	648	48	-89	-67	-18	-15
20%	11	0	0	-117	-223	-318	25	1,105	209	-18	-12	0	88
30%	34	0	0	-3	-32	-27	175	1,337	308	0	0	0	137
40%	55	0	0	0	0	0	395	1,631	480	0	0	0	166
50%	70	0	0	0	0	0	548	2,036	700	0	0	0	204
60%	81	0	0	0	23	63	731	2,329	902	0	0	12	246
70%	118	0	0	0	123	150	1,104	2,781	1,066	0	0	34	279
80%	198	214	0	0	335	255	1,585	3,229	1,388	18	18	169	372
90%	341	292	0	3	786	467	2,016	3,661	1,837	74	34	286	472
Maximum	578	357	684	1,430	1,761	1,440	3,454	4,775	2,910	424	161	388	590
Average	114	62	-96	-147	-8	-22	761	2,102	801	-10	-11	54	218

60 Percent Unimpaired Flow (LSJR Alternative 4)

Table F.1.7-5a shows the monthly cumulative distributions of the changes in the monthly Vernalis flows, which were calculated with the WSE model of 1922–2003 (82 years) for LSJR Alternative 4. In some months, Vernalis flow increased significantly (the largest increase was 10,173 cfs in May 1973), while in other months, the flow decreased by a large amount (the largest decrease was 9,276 cfs in July 1983). The monthly flow reductions occurred most frequently in January, July, and August, most likely due to reduced flood control releases. On average, February–June and September–November showed monthly increases in Vernalis flow, while all other months had decreases. The September–November increases most likely occurred as a result of adaptive implementation flow shifting. Annually, total flow at Vernalis increased more frequently than it decreased, with more than 90 percent of years registering an overall increase in flow. The average annual change in the SJR flow at Vernalis was an increase of 693 TAF/y, and the average change over February–June was an increase of 728 TAF/y.

Table F.1.7-5b shows the monthly cumulative distributions of the changes in monthly Delta exports, based on the monthly change in Vernalis flow under LSJR Alternative 4 and the regulations determined to control monthly exports (the shaded boxes in Table F.1.7-1). In some months, the Delta exports were estimated to increase significantly (the largest increase was 4,730 cfs in June 1932), while in other months, the exports decreased by a large amount (the largest decrease was 6,029 cfs in July 1983). The distribution of monthly export changes does not indicate whether the changes occurred in years with low baseline exports (larger effects) or in years with higher baseline exports (smaller effects). The overall changes in the monthly distributions of exports would generally be much smaller than the distribution of individual monthly export changes. Many of the large monthly exports reductions would be compensated by increased exports in other months. On average, February–June and September–November showed monthly increases in Delta exports, while all other months had decreases. Annually, total Delta exports increased more frequently than they decreased, with more than 80 percent of years registering an overall increase. The average annual change in Delta exports was an increase of 194 TAF/y, and the average change over February–June was an increase of 211 TAF/y. This is relatively small compared to average historical exports of 5,185 TAF/y.

Table F.1.7-5c shows the monthly cumulative distributions of the changes in monthly Delta outflow, based on the changes in SJR flow at Vernalis and the estimated changes in Delta exports under LSJR Alternative 4. In some months, Delta outflow was estimated to increase significantly (the largest increase was 7,990 cfs in May 1973), while in other months, outflow decreased by a large amount (the largest decrease was 4,075 cfs in December 1996). Many of the large monthly reductions in outflow would be compensated by increases in outflow in other months. On average, February–June and September–November showed monthly increases in Delta outflow, while all other months had decreases. Annually, total Delta outflow increased more frequently than it decreased, with more than 90 percent of years registering an overall increase. The average annual change in Delta outflow was an increase of 499 TAF/y, and the average change over February–June was an increase of 518 TAF/y. This is relatively small compared to the average historical Delta outflow of about 19,000 TAF/y. The results from this analysis indicate that about 28 percent of the average annual increase in the SJR flow at Vernalis would go toward an increase in exports, and 72 percent would go toward Delta outflow for LSJR Alternative 4.

Table F.1.7-5a. Cumulative Distributions of Monthly Changes in Vernalis Flow under LSJR Alternative 4

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Annual (TAF)
Minimum	-410	-2,198	-8,150	-6,963	-5,242	-2,476	-1,655	778	70	-9,276	-1,978	-2,106	-355
10%	1	0	-1,049	-2,316	-1,459	-1,567	487	2,281	941	-2,097	-402	-50	173
20%	34	0	-20	-744	-461	-208	1,032	2,843	1,463	-457	-126	-50	310
30%	97	0	0	-6	0	0	1,166	3,861	2,213	-50	-50	0	495
40%	157	0	0	-6	10	201	1,524	4,534	2,860	-50	-27	0	585
50%	199	0	0	0	276	454	1,979	4,986	3,217	0	0	0	674
60%	232	0	0	0	599	896	2,168	5,672	3,884	0	0	34	754
70%	337	0	0	0	1,018	1,187	2,657	6,309	4,788	0	0	67	880
80%	630	665	0	0	2,031	1,656	3,535	7,328	5,459	39	9	473	937
90%	1,036	842	0	6	2,850	2,115	4,462	8,209	6,446	96	72	802	1,322
Maximum	1,687	1,083	3,335	5,609	8,897	5,222	7,879	10,173	9,460	1,340	511	1,239	1,663
Average	340	171	-269	-434	638	586	2,178	5,149	3,531	-421	-98	141	693

Table F.1.7-5b. Cumulative Distributions of the Estimated Monthly Changes in Delta Exports under LSJR Alternative 4

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Annual (TAF)
Minimum	-267	-1,428	-4,075	-3,482	-2,621	-1,238	-414	0	35	-6,029	-1,285	-1,369	-376
10%	0	0	-524	-1,158	-730	-783	0	0	470	-1,363	-261	-33	-4
20%	22	0	-10	-372	-231	-104	0	73	732	-297	-82	-33	58
30%	63	0	0	-3	0	0	0	356	1,107	-33	-33	0	100
40%	102	0	0	-3	5	101	24	594	1,430	-33	-17	0	160
50%	129	0	0	0	138	227	193	861	1,608	0	0	0	187
60%	151	0	0	0	300	448	271	1,153	1,942	0	0	22	217
70%	219	0	0	0	509	594	311	1,412	2,394	0	0	44	268
80%	409	432	0	0	1,016	828	406	1,471	2,730	25	6	307	336
90%	674	547	0	3	1,425	1,058	663	1,795	3,223	62	47	521	450
Maximum	1,097	704	1,668	2,804	4,448	2,611	1,812	2,468	4,730	871	332	805	592
Average	221	111	-135	-217	319	293	252	889	1,766	-274	-63	92	194

Table F.1.7-5c. Cumulative Distributions of the Estimated Monthly Changes in Delta Outflow under LSJR Alternative 4

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Annual (TAF)
Minimum	-144	-769	-4,075	-3,482	-2,621	-1,238	-1,241	778	35	-3,247	-692	-737	-31
10%	0	0	-524	-1,158	-730	-783	419	2,024	470	-734	-141	-18	183
20%	12	0	-10	-372	-231	-104	800	2,686	732	-160	-44	-18	293
30%	34	0	0	-3	0	0	962	3,412	1,107	-18	-18	0	371
40%	55	0	0	-3	5	101	1,287	3,821	1,430	-18	-9	0	432
50%	70	0	0	0	138	227	1,668	4,243	1,608	0	0	0	480
60%	81	0	0	0	300	448	2,006	4,764	1,942	0	0	12	521
70%	118	0	0	0	509	594	2,519	5,164	2,394	0	0	23	582
80%	220	233	0	0	1,016	828	3,492	5,750	2,730	14	3	165	698
90%	363	295	0	3	1,425	1,058	3,902	6,368	3,223	34	25	281	876
Maximum	591	379	1,668	2,804	4,448	2,611	6,066	7,990	4,730	469	179	434	1,071
Average	119	60	-135	-217	319	293	1,926	4,260	1,766	-147	-34	49	499

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Attachment 1

Water Supply Effects Model Output