APPENDIX 5.J
SCENARIO 6 COMPARISON

ADMINISTRATIVE DRAFT
BAY DELTA CONSERVATION PLAN

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Appendix J
Comparison of Fish Effects between Preliminary Proposal Operations and Scenario 6 Operations

J.0 Executive Summary

This report provides a comparison of the effects of "Scenario 6"[1] operations, relative to effects of the preliminary proposal (PP) operations for 5 biological parameters. State and federal regulatory agencies developed Scenario 6 to identify "alternative operating criteria that could address concerns raised… following their review of the August 2010 preliminary draft Effects Analysis" on the PP (California Department of Water Resources et al. 2011). The agency rationale for Scenario 6 lays out five operational areas of concern that are intended to be addressed in Scenario 6, or otherwise be informed by the results of the Effects Analysis. These concerns are summarized below.

Reduced Sacramento River flows downstream of the intakes. "New North Delta diversions will reduce net Sacramento River flows near Rio Vista…although the CALSIM II modeling showed the agreed upon North Delta diversion bypass criteria [in the PP] has generally been met, identified reductions in flow remain a concern…" (California Department of Water Resources et al. 2011).

San Joaquin River migratory fish survival. "[The PP] proposed a 'non-physical barrier' and habitat restoration in the south Delta. The latter was not scheduled to come online until the late long-term time frame. This was not considered adequately protective of San Joaquin River basin salmonid fishes. There was also concern over Old and Middle River (OMR) flow levels during certain months" (California Department of Water Resources et al. 2011).

April–May OMR flows. "The original 'Big 6' version of this issue was that April–May OMR flows in the January 2010 Project Operations modeling were more negative than the flows modeled for the Existing Baseline Condition scenarios. The issue expanded to include OMR flow criteria during other months to take advantage of operational flexibility the CALSIM II modeling indicated would be afforded by dual conveyance. The goal was to increase San Joaquin River flow variability (improving OMR flows in the Delta and flows in the San Joaquin River below the Head of Old River), and maximize improvements to south Delta hydrodynamics…" (California Department of Water Resources et al. 2011).

Spring Delta outflow issues related to longfin smelt. "Changes in winter-spring Delta outflows correlate positively with changes in abundance of longfin smelt. A review of CALSIM II model output shows that the combination of new operating rules and increased conveyance capacity [in the PP] results in reduced net Delta outflows in the winter-spring period of wetter water years…instances of reduced Spring flows, food web productivity and other stressors remain a concern…"(California Department of Water Resources et al. 2011).

[1] Scenario 6 is the operational component included in Alternatives 2A, 2B, 2C, and 4, while the preliminary proposal operations are included in Alternatives 1A, 1B, 1C, and 3 in the EIR/EIS.

Fall X2. "The existing[2] U.S. Fish and Wildlife Service (USFWS) Biological Opinion (BiOp) includes a Reasonable and Prudent Alternative (RPA) element that specifies X2 location in September–October of above-normal and wet water year types. The January 2010 Project Operations did not include any action to meet or mimic the Fall X2 RPA component, raising concerns from USFWS and others whether the project operations would meet permit issuance criteria" (California Department of Water Resources et al. 2011).

Scenario 6, proposed by the agencies as an alternative to the PP criteria for evaluation in the Effects Analysis, includes modified criteria intended to address three of the five operational issues identified above: San Joaquin River migratory fish survival, April–May OMR flows, and Fall X2. Scenario 6 also includes an operable barrier at the head of Old River. Scenario 6 does not include modifications to address reduced Sacramento River flows downstream of the new intakes, or the Winter-Spring outflow issues related to longfin smelt (or the location of the north Delta intakes). The agencies' intent was to address these two issues in the development of adaptive ranges subsequent to completion of the Effects Analysis. In addition to these Delta concerns, this report also compares temperature-related egg mortality for spring-run Chinook salmon in the Sacramento River, a concern that was also raised in review of the results of the PP. The California Department of Water Resources (DWR) agreed to evaluate this alternative operational scenario compared to PP operations to estimate the benefits and effects of Scenario 6 in relation to PP. Table J.0-1 describes the various operational parameters included in the Scenario 6 modeling run.

While Scenario 6 did not include modifications for all these issues, it does show different effects from the PP relative for these issues. Therefore, this document provides a comparative analysis of the two operations scenarios (PP and Scenario 6) for all five of the issues.

To maximize efficiency for comparing and analyzing changes in habitat conditions between PP and Scenario 6, a tiered approach was used to focus the analysis (based on existing modeling tools) mainly on those issues that Scenario 6 was originally intended to address. Issues related to spring-run egg mortality were also evaluated because of concern expressed previously about the PP. The five issues examined (spring-run egg mortality, Fall X2, Winter-Spring X2, April–May south Delta operations, and flows downstream of the north Delta intakes) are primarily focused on addressing effects on spring-run and winter-run Chinook salmon, steelhead, delta smelt and longfin smelt, and as such this analysis focuses on the effects of Scenario 6 on these species. It should be noted that this comparative analysis is limited to these issues, and additional issues, including other upstream effects and effects on other species, are not specifically analyzed. This report does however provide the data outputs for reservoir storage to provide information about the physical changes/differences between the PP and Scenario 6.

The following analysis is organized by each of the five issues listed above. The analysis compared PP in the early long-term (ELT) to Scenario 6 in the ELT, and then compared PP in the late long-term (LLT) to Scenario 6 in the LLT. Where appropriate, each of these modeled scenarios was also compared to the baseline (EBC) LTT conditions to further understand the differences in scenarios and how they relate to climate change.

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[2] The Biological Opinion as was existing at the time of development of the Rationale Document referenced (April 2011).

Key conclusions for each issue are:

- **Temperature-related mortality of spring-run Chinook eggs.** Relative to the PP, Scenario 6 did not significantly reduce mortality in the mainstem of the Sacramento River, and in fact, slightly increased it in drier years under the ELT. Mortality was generally less in wet and above normal years when flows are also increased due to Fall X2 operations. Egg mortality is exacerbated by climate change (LLT) under all scenarios. In the Feather River, Scenario 6 may slightly increase the frequency of water temperature conditions unsuitable for egg survival during wet years in the high-flow channel, although most Feather River spawning occurs in the low-flow channel, which is tightly regulated and does not differ among scenario, water year type, or timestep. Increased reservoir releases in September for Delta requirements improved egg survival during wet and above normal years compared to other water years, but may have reduced available cold water for egg incubation later in the fall.

- **Sacramento River flows downstream of the North Delta intakes.** Compared to the PP, Rio Vista flows under Scenario 6 increased during July–September, decreased in October, and would have very slight decreasing trends for December–June, although minimal instances of decreases greater than 5%. These flow changes, however, had minimal biological effect on juvenile Chinook salmon because they were not migrating in those months. However, increased flows in September could benefit the early returning steelhead and the peak migrating fall-run Chinook, while substantially decreased flows in October in the LLT could result in adverse effects on these species during their peak migration period.

- **April–May OMR flows.** Relative to the PP, Scenario 6 reduced reverse OMR flows during April–May and in the fall, although reverse OMR flows were increased in February and March. Entrainment estimated as salvage (based on exports) was reduced under Scenario 6 for all fish species (as determined primarily by the salvage-density method[3]). OMR proportional entrainment of delta smelt decreased for adults (7–10%) in dry years, but increased for adults in wet years (12–15%) and juveniles for all water year types (4–15%). Although larval longfin smelt entrainment, as estimated by particle tracking modeling, was low and unchanged relative to PP, adult and juvenile longfin smelt entrainment was reduced at the State Water Project (SWP).

- **Winter-spring Delta outflow and longfin smelt.** Scenario 6 provides for slightly increased Delta outflow January to June relative to the PP, and slightly shifts X2 further west 1 km during ELT (except wet years) and below normal years in LLT, but no difference in other water years. Based on the Kimmerer et al. 2009 regression model of X2 and longfin smelt surveys[3], longfin smelt abundance would increase slightly under Scenario 6 compared to the PP, but still remain below abundance predicted for the EBC.

- **Fall X2 location and delta smelt.** Due to the inclusion of the Fall X2 RPA in Scenario 6, the X2 location is shifted to the west relative to the PP, by about 6–10 km in wet, above normal and below normal water years.

[3] Because this comparative analysis was focused on specific issues and was intended to provide a general description of the differences in operations, the methods used were limited to those that were most readily applied. The strengths and weaknesses of these methods are described in the other Effects Analysis appendices, are not addressed in this analysis, and are not accounted for in the description of these comparative results.

Table J.0-1. Proposed Operations for Effects Analysis (Scenario 6)—March 25, 2011 Working Draft

North Delta Diversion Bypass Flows					
Constant Low-Level Pumping (December–June)					
Diversions up to 6% of river flow for flows greater than 5,000 cubic feet per second (cfs). No more than 300 cfs at any one intake.					
Initial Pulse Protection					
Low level pumping maintained through the initial pulse period. For the purpose of modeling, the initiation of the pulse is defined by the following criteria: (1) Wilkins Slough flow changing by more than 45% over a five day period and (2) flow greater than 12,000 cfs. Low-level pumping continues until (1) Wilkins Slough returns to pre-pulse flows (flow on first day of 5-day increase), (2) flows decrease for 5 consecutive days, or (3) flows are greater than 20,000 cfs for 10 consecutive days. After pulse period has ended, operations will return to the bypass flow table (Sub-Table A). These parameters are for modeling purposes. Actual operations will be based on real-time monitoring of fish movement. If the first flush begins before December 1, May bypass criteria must be initiated following first flush and the second pulse period will have the same protective operation.					
Post-Pulse Operations					
After initial flush(es), go to Level I post-pulse bypass rule (see Sub-Table A) until 15 total days of bypass flows above 20,000 cfs. Then go to the Level II post-pulse bypass rule until 30 total days of bypass flows above 20,000 cfs. Then go to the Level III post-pulse bypass rule.					
South Delta Channel Flows					
Old and Middle River (OMR) Flows					
All OMR criteria required by the various fish protection triggers (density, calendar, and flow based triggers) described in USFWS and NMFS OCAP BOs were incorporated into the modeling of the baseline and the January, 2010 proposed project, as well as these newly proposed operational criteria. Whenever those triggers would result in OMRs higher than those shown below, the higher OMR requirements would be met. Combined Old and Middle River flows no less than values below[1] (cfs)					
Month	**W**	**AN**	**BN**	**D**	**C**
Jan	0	-3,500	-4,000	-5,000	-5,000
Feb	0	-3,500	-4,000	-4,000	-4,000
Mar	0	0	-3,500	-3,500	-3,000
Apr	Varies[2]	Varies[2]	Varies[2]	Varies[2]	Varies[2]
May	Varies[2]	Varies[2]	Varies[2]	Varies[2]	Varies[2]
Jun	Varies[2]	Varies[2]	Varies[2]	Varies[2]	Varies[2]
Jul	N/A	N/A	N/A	N/A	N/A
Aug	N/A	N/A	N/A	N/A	N/A
Sep	N/A	N/A	N/A	N/A	N/A
Oct	Varies[3]	Varies[3]	Varies[3]	Varies[3]	Varies[3]
Nov	Varies[3]	Varies[3]	Varies[3]	Varies[3]	Varies[3]
Dec	-5,000[4]	-5,000[4]	-5,000[4]	-5,000[4]	-5,000[4]

[1] These numbers represent the resulting average values based on the implementation of RPA-based triggers for the "most likely" scenario. OMR values assume the proposed OMR or the Reasonable and Prudent Alternative (RPA) (as modeled in the No Action Alternative), whichever provides higher OMR. Resulting operations are expected to be more positive than depicted in this table.

[2] Based on San Joaquin inflow relationship to OMR provided below in Sub-Table B.

[3] Before the D-1641 pulse = HORB open, no OMR restrictions
During the D-1641 pulse = no south Delta exports (two weeks); HORB closed
After the D-1641 pulse = -5,000 cfs OMR (through November); HORB open 50% for 2 weeks

[4] OMR restriction of -5,000 cfs for Sacramento River winter-run Chinook salmon when North Delta initial pulse flows are triggered or OMR restriction of -2,000 cfs for delta smelt when triggered.

Head of Old River Operable Barrier (HORB) Operations/Modeling assumptions (% OPEN)

Month	HORB[1]	Month	HORB[1]
Oct	50%	May	50%
Nov	100%2	Jun 1–15	50%
Dec	100%	Jun 16–30	100%
Jan	50%3	Jul	100%
Feb	50%	Aug	100%
Mar	50%	Sep	100%
April	50%		

[1] Percent of time the HORB is open. Agricultural barriers are in and operated consistent with current practices. HORB would be open 100% whenever flows are greater than 10,000 cfs at Vernalis.

[2] For modeling assumption only. Action proposed:
Before the D-1641 pulse = no OMR restrictions (HORB open)
During the D-1641 pulse = no south Delta exports for two weeks (HORB closed)
After the D-1641 pulse = -5,000 cfs OMR through November (HORB open 50% for 2 weeks)
Exact timing of the action will be based on hydrologic conditions

[3] The HORB becomes operational at 50% when salmon fry are immigrating (based on real time monitoring). This generally occurs when flood flow releases are being made.

Fremont Weir/Yolo Bypass

Weir Improvements

Sacramento Weir—No change in operations; improve upstream fish passage facilities
Lisbon Weir—No change in operations; improve upstream fish passage facilities
Fremont Weir—Improve fish passage at existing weir elevation; construct opening and operable gates at elevation 17.5 feet with fish passage facilities; construct opening and operable gates at a smaller opening with fish passage enhancement at elevation 11.5 feet

Fremont Weir Gate Operations

To provide seasonal floodplain inundation in the Yolo Bypass, the 17.5 foot and the 11.5-foot elevation gates are assumed to be opened between December 1st and March 31st. This may extend to May 15th, depending on the hydrologic conditions and the measures to minimize land use and ecological conflicts in the bypass. As a simplification for modeling, the gates are assumed opened until April 30th in all years. The gates are operated to limit maximum spill to 6,000 cfs until the Sacramento River stage reaches the existing Fremont Weir elevation. While desired inundation period is on the order of 30 to 45 days, gates are not managed to limit to this range, instead the duration of the event is governed by the Sacramento River flow conditions. To provide greater opportunity for the fish in the bypass to migrate upstream into the Sacramento River, the 11.5-foot elevation gate is assumed to be open for an extended period between September 15th and June 30th. As a simplification for modeling, the period of operation for this gate is assumed to be September 1st to June 30th. The spills through the 11.5-foot elevation gate are limited to 100 cfs to support fish passage.
Delta Cross Channel Gate Operations
Assumptions
Per State Water Board D-1641 with additional days closed from October 1–January 31 based on NMFS BO (Jun 2009) Action IV.1.2v (closed during flushing flows from October 1–December 14 unless adverse water quality conditions).
Rio Vista Minimum Instream Flows
Assumptions
September–December: Per D-1641. January–August: Minimum of 3,000 cfs.
Delta Inflow and Outflow
Delta Outflow
February–June: Per D-1641. September–November: Implement Fall X2 experiment (not included in modeling for Scenario 6)[1].
[1] Scenario 6 modeling results do not include estimates of water supply impacts for the Fall X2 experiment because a revised experimental design is not yet available.
Operations for Delta Water Quality and Residence Time
Assumptions
July–September: Prefer south Delta pumping up to 3,000 cfs before diverting from north. October–June: Prefer north Delta pumping (real-time operational flexibility).
In-Delta Agricultural and Municipal & Industrial Water Quality Requirements
Assumptions
Existing D-1641 North and Western Delta AG and MI standards. EXCEPT move compliance point from Emmaton to Three Mile Slough juncture. Maintain all water quality requirements contained in the NDWA/DWR Contract and other DWR contractual obligations.

Sub-Table A. Post-Pulse Operations for North Delta Diversion Bypass Flows		
Level I Post-Pulse Operations	Level II Post-Pulse Operations	Level III Post Pulse Operations

Sub-Table A. Post-Pulse Operations for North Delta Diversion Bypass Flows								
Based on the objectives stated above, it is recommended to implement the following operating criteria: • Bypass flows sufficient to prevent upstream tidal transport at two points of control: (1) Sacramento River upstream of Sutter Slough and (2) Sacramento River downstream of Georgiana Slough. These points are used to prevent upstream transport toward the proposed intakes and to prevent upstream transport into Georgiana Slough.			Based on the objectives stated above, it is recommended to implement the following operating criteria: • Bypass flows sufficient to prevent upstream tidal transport at two points of control: (1) Sacramento River upstream of Sutter Slough and (2) Sacramento River downstream of Georgiana Slough. These points are used to prevent upstream transport toward the proposed intakes and to prevent upstream transport into Georgiana Slough.			Based on the objectives stated above, it is recommended to implement the following operating criteria: • Bypass flows sufficient to prevent upstream tidal transport at two points of control: (1) Sacramento River upstream of Sutter Slough and (2) Sacramento River downstream of Georgiana Slough. These points are used to prevent upstream transport toward the proposed intakes and to prevent upstream transport into Georgiana Slough.		
December–April			**December–April**			**December–April**		
If Sacramento River flow is over…	But not over…	The bypass is…	If Sacramento River flow is over…	But not over…	The bypass is…	If Sacramento River flow is over…	But not over…	The bypass is…
0 cfs	5,000 cfs	100% of the amount over 0 cfs	0 cfs	5,000 cfs	100% of the amount over 0 cfs	0 cfs	5,000 cfs	100% of the amount over 0 cfs
5,000 cfs	15,000 cfs	Flows remaining after constant low level pumping (main table)	5,000 cfs	11,000 cfs	Flows remaining after constant low level pumping (main table)	5,000 cfs	9,000 cfs	Flows remaining after constant low level pumping (main table)
15,000 cfs	17,000 cfs	15,000 cfs plus 80% of the amount over 15,000 cfs	11,000 cfs	15,000 cfs	11,000 cfs plus 60% of the amount over 11,000 cfs	9,000 cfs	15,000 cfs	9,000 cfs plus 50% of the amount over 9,000 cfs
17,000 cfs	20,000 cfs	16,600 cfs plus 60% of the amount over 17,000 cfs	15,000 cfs	20,000 cfs	13,400 cfs plus 50% of the amount over 15,000 cfs	15,000 cfs	20,000 cfs	12,000 cfs plus 20% of the amount over 15,000 cfs
20,000 cfs	no limit	18,400 cfs plus 30% of the amount over 20,000 cfs	20,000 cfs	no limit	15,900 cfs plus 20% of the amount over 20,000 cfs	20,000 cfs	no limit	13,000 cfs plus 0% of the amount over 20,000 cfs
May			**May**			**May**		
If Sacramento River flow is over…	But not over…	The bypass is…	If Sacramento River flow is over…	But not over…	The bypass is…	If Sacramento River flow is over…	But not over…	The bypass is…
0 cfs	5,000 cfs	100% of the amount over 0 cfs	0 cfs	5,000 cfs	100% of the amount over 0 cfs	0 cfs	5,000 cfs	100% of the amount over 0 cfs

Sub-Table A. Post-Pulse Operations for North Delta Diversion Bypass Flows								
5,000 cfs	15,000 cfs	Flows remaining after constant low level pumping (main table)	5,000 cfs	11,000 cfs	Flows remaining after constant low level pumping (main table)	5,000 cfs	9,000 cfs	Flows remaining after constant low level pumping (main table)
15,000 cfs	17,000 cfs	15,000 cfs plus 70% of the amount over 15,000 cfs	11,000 cfs	15,000 cfs	11,000 cfs plus 50% of the amount over 11,000 cfs	9,000 cfs	15,000 cfs	9,000 cfs plus 40% of the amount over 9,000 cfs
17,000 cfs	20,000 cfs	16,400 cfs plus 50% of the amount over 17,000 cfs	15,000 cfs	20,000 cfs	13,000 cfs plus 35% of the amount over 15,000 cfs	15,000 cfs	20,000 cfs	11,400 cfs plus 20% of the amount over 15,000 cfs
20,000 cfs	no limit	17,900 cfs plus 20% of the amount over 20,000 cfs	20,000 cfs	no limit	14,750 cfs plus 20% of the amount over 20,000 cfs	20,000 cfs	no limit	12,400 cfs plus 0% of the amount over 20,000 cfs
June			**June**			**June**		
If Sacramento River flow is over…	But not over…	The bypass is…	If Sacramento River flow is over…	But not over…	The bypass is…	If Sacramento River flow is over…	But not over…	The bypass is…
0 cfs	5,000 cfs	100% of the amount over 0 cfs	0 cfs	5,000 cfs	100% of the amount over 0 cfs	0 cfs	5,000 cfs	100% of the amount over 0 cfs
5,000 cfs	15,000 cfs	Flows remaining after constant low level pumping (main table)	5,000 cfs	11,000 cfs	Flows remaining after constant low level pumping (main table)	5,000 cfs	9,000 cfs	Flows remaining after constant low level pumping (main table)
15,000 cfs	17,000 cfs	15,000 cfs plus 60% of the amount over 15,000 cfs	11,000 cfs	15,000 cfs	11,000 cfs plus 40% of the amount over 11,000 cfs	9,000 cfs	15,000 cfs	9,000 cfs plus 30% of the amount over 9,000 cfs
17,000 cfs	20,000 cfs	16,200 cfs plus 40% of the amount over 17,000 cfs	15,000 cfs	20,000 cfs	12,600 cfs plus 20% of the amount over 15,000 cfs	15,000 cfs	20,000 cfs	10,800 cfs plus 20% of the amount over 15,000 cfs
20,000 cfs	no limit	17,400 cfs plus 20% of the amount over 20,000 cfs	20,000 cfs	no limit	13,600 cfs plus 20% of the amount over 20,000 cfs	20,000 cfs	no limit	11,800 cfs plus 0% of the amount over 20,000 cfs
July–September: 5,000 cfs October–November: 7,000 cfs			July–September: 5,000 cfs October–November: 7,000 cfs			July–September: 5,000 cfs October–November: 7,000 cfs		

Sub-Table B. San Joaquin Inflow Relationship to OMR

April and May		June	
If San Joaquin flow at Vernalis is the following	Average OMR flows would be at least the following (interpolated linearly between values)	If San Joaquin flow at Vernalis is the following	Average OMR flows would be at least the following
≤ 5,000 cfs	-2,000 cfs	≤ 3,500 cfs	-3,500 cfs
6,000 cfs	+1000 cfs	3,501 to 10,000 cfs	0 cfs
10,000 cfs	+2000 cfs		
15,000 cfs	+3000 cfs	10,001 to 15,000 cfs	+1000 cfs
≥30,000 cfs	+6000 cfs	>15,000 cfs	+2000 cfs

J.0.1 Temperature-Related Spring-Run Chinook Egg Mortality

J.0.1.1 Issue

A very small fraction of the Sacramento Valley spring-run Chinook salmon population spawns naturally in the Sacramento River (4% of adult returns) and Feather River (40% of adult returns). Significant decreases in salmon egg viability occur when water temperature are in excess of 56°F. Spring-run Chinook salmon eggs are subject to potential impacts from proposed Bay Delta Conservation Plan (BDCP) operations affecting incubating success through changes in seasonal water temperatures. This analysis compared egg mortality in both the Sacramento River and Feather River for the PP (modeled as Alternative 1) and Scenario 6. While Scenario 6 was not intended to specifically address the spring-run egg mortality issue, it is evaluated because it was identified as a concern based on review of the PP.

J.0.1.2 Conclusions

In the Sacramento River, spring-run Chinook egg mortality is very high in drier years across all operations scenarios (ELT period: wet 7% PP, 14% Scenario6; below normal 24% PP, 29% Scenario 6; Dry 37% PP, 43% Scenario 6;critical 85% PP, 93% Scenario 6). Mortality is substantially increased in LLT, because climate change related increases in temperature dominate the system (below normal 54–55%, dry 75–76%, critical 96% egg mortality). Water temperatures that exceed conditions suitable for egg incubation (56°F) occur frequently in September under all scenarios (EBC2, PP and Scenario 6) and diminish over the season due to cooling air temperatures. As such, Scenario 6 does not result in substantially different egg survival in most years in the Sacramento River (5–8% increased in drier years during ELT, 5–7% decreased in wet and above normal years during LLT). Egg mortality under Scenario 6 was reduced slightly in wet and above normal water years relative to PP, likely due to September releases to meet outflow and Fall X2 requirements. Under Scenario 6 the September storage volume in Shasta Reservoir is minimally changed (5–6% reduction in wet and critical years during ELT, 6–10% reduction in wet and above normal years during LLT) compared to the PP.

In the Feather River, Chinook salmon spawning occurs mostly (60%) in the low-flow channel, where flows are tightly regulated and held constant for both the PP and Scenario 6 (and the EBC), and as such, water temperature exceeding 56°F are expected to occur at about the same frequency for the PP and S6 relative to EBC2, and more often during LLT compared to ELT. Projected flows in the Feather River high-flow channel mostly decrease at moderate levels from October–January during both the ELT and LLT periods under both operations compared to the EBC. As such, it is anticipated that water temperature exceedances in the high-flow channel will occur at the same or slightly higher frequency as in the low-flow channel.

J.0.2 Reduced Sacramento River Flows Downstream of the Intakes

J.0.2.1 Issue

"New North Delta diversions will reduce net Sacramento River flows near Rio Vista…although the CALSIM II modeling showed the agreed upon North Delta diversion bypass criteria [in the PP] has generally been met, identified reductions in flow remain a concern…" (California Department of Water Resources et al. 2011).

J.0.2.2 Conclusions

Under Scenario 6, flows at Rio Vista are unchanged from January to June. Flows increase relative to PP during July and August in all years to meet increased exports. Scenario 6 flows are substantially increased in September of wet and above normal years, and reduced in October relative to PP. This is a result of Scenario 6 releases in September meeting outflow and salinity objectives (including Fall X2) that reduce the available upstream storage and/or continue to meet salinity and outflow objectives. Additionally, PP flows are higher in October because salinity objectives would need to be met since no Fall X2 requirement is included and salinity is higher in September. The difference between Scenario 6 and PP is a tradeoff between flows in September and October, depending on the salinity condition in the Delta. Flows are slightly increased in November during LLT and relatively unchanged in December.

The only migrating anadromous species that would be present when flow differences occur would be juveniles and adults of steelhead, and fall-run Chinook adults. Scenario 6 resulted in negligible changes in flow magnitude and the proportion of Sacramento and San Joaquin-origin waters (a correlation of basin-specific olfactory cues for migrating adults) during the adult steelhead migration period. Juvenile steelhead passage flows are also negligibly changed over the entire course of their October–May outmigration season. Therefore, Scenario 6 would not result in appreciable changes for juvenile or adult steelhead migration flows. During the peak adult fall-run Chinook migration in September and October, the relative proportion of Sacramento River flows increases 6–19% under Scenario 6, although there are substantial reductions in October flows in the LLT under Scenario 6.

Another potential issue is transport flows for larval smelt. For delta smelt, Sacramento River flows at Rio Vista were largely unchanged during the larval transport period (March–June). During the longfin smelt larval transport period (January–April), flows at Rio Vista were largely unchanged except for a slight decrease (5–10%) in January of wet, above normal, below normal, and dry years. These minor differences in flow would be expected to have minimal effect on larval smelt transport.

J.0.3 April–May Old and Middle River Flows

J.0.3.1 Issue

"The original 'Big 6' version of this issue was that April–May OMR flows in the January 2010 Project Operations modeling [PP] were more negative than the flows modeled for the Existing Baseline Condition scenarios. The issue expanded to include OMR flow criteria during other months to take advantage of operational flexibility the CALSIM II modeling indicated would be afforded by dual conveyance. The goal was to increase San Joaquin River flow variability (improving OMR flows in the Delta and flows in the San Joaquin River below the Head of Old River), and maximize improvements to south Delta hydrodynamics…" (California Department of Water Resources et al. 2011).

J.0.3.2 Conclusions

Under Scenario 6, OMR net daily flow would be more natural (flowing toward the north and west, away from the south Delta export pumps) September–November (58–72%) and April–May, and would be less natural in February (2–87% decrease), March (8–88% decrease), and July–August (4–42% decrease).

Entrainment of fish was assessed by salvage density (salmon, steelhead and smelt), OMR proportional entrainment (delta smelt), and particle tracking modeling (PTM) (longfin smelt). The salvage density method assumes a linear relationship between entrainment and exports, which may be an oversimplification, and is not directly related to OMR flows.

Based on the salvage-density method, Scenario 6 was able to reduce salvage further compared to PP (at the south Delta facilities). The salvage density method represents the simplest model for estimating the total salvage that occurs at the south Delta pumping facilities; however, there are some caveats with this method. Total monthly salvage numbers are calculated by extrapolating estimates of the total number of fish salvaged based on a subsample that actually was identified, counted, and measured. An assumption of a linear relationship between entrainment and flow may be an oversimplification, so the salvage density method simply functions as descriptions of changes in flow weighted by seasonal changes in salvage density of fish.

Entrainment of steelhead and Chinook salmon, estimated as average annual salvage index at south Delta export facilities, was reduced under Scenario 6, mostly in fall and spring months when exports are reduced to address Fall X2 and OMR flow requirements. Salvage reductions were greater at SWP than Central Valley Project (CVP) facilities. Salvage reductions for each species (range for ELT and LLT scenarios, by facility) are as follows: steelhead (25–29% SWP, 10–12% CVP) winter-run Chinook (20–29% SWP, no change at CVP), spring-run Chinook (52–56% SWP, 38–39% CVP), and fall-run Chinook (46–51% SWP, 30–33% CVP).

Based on the salvage-density method, Delta smelt salvage was decreased under Scenario 6 for juveniles (28–37% SWP, 44–45% CVP) and adults (19–28% SWP, 10–12% CVP). Juvenile OMR proportional entrainment showed a 10–11% increase averaged across all water years. This increase under Scenario 6 was driven by substantially more negative OMR flows in June and July, due to increased south Delta pumping in the summer. Adult OMR proportional entrainment would increase 12–15% in wet years and decrease 7–10% in dry years under Scenario 6.

Longfin smelt had relatively low entrainment at the south Delta diversions to begin with, and any effect of operational changes would be less for longfin smelt larvae than for delta smelt because they move downstream earlier. Based on the salvage-density method, longfin smelt salvage was decreased for juveniles (15–31% SWP, relatively unchanged at CVP), and adults (53–59% SWP, 47–48% CVP). PTM analysis found only negligible differences between Scenario 6 and PP in entrainment at the south Delta facilities.

J.0.4 Spring Delta Outflow Issues Related to Longfin Smelt

J.0.4.1 Issue

"Changes in winter-spring Delta outflows correlate positively with changes in abundance of longfin smelt. A review of CALSIM II model output shows that the combination of new operating rules and increased conveyance capacity [in the PP] results in reduced net Delta outflows in the winter-spring period of wetter water years…instances of reduced Spring flows, food web productivity and other stressors remain a concern…" (California Department of Water Resources et al. 2011).

J.0.4.2 Conclusions

Scenario 6 resulted in increased Delta outflow compared to PP during this period, by increased upstream reservoir releases and reduced exports. Based on these changes, the average January–June X2 position during ELT under Scenario 6 is generally projected to be 1 km more westerly in all years except wet water years. During LLT, January–June X2 position is similar to PP (<0.5 km difference) for all but below normal water years. Longfin smelt abundance, as estimated using the X2-longfin smelt abundance relationship (Kimmerer et al. 2009), would increase slightly under Scenario 6 averaged across all water years (7–9% greater in ELT, 3–4% greater in LLT), particularly in below normal to critical years during ELT (12–13% greater) compared to the PP, but would remain less than the EBC. No appreciable difference (<5%) in modeled abundance is predicted in wet years or most years during LLT, when winter-spring X2 position shifts less than 0.5 km under Scenario 6.

J.0.5 Fall X2 and Delta Smelt Habitat

J.0.5.1 Issue

"The existing[4] U.S. Fish and Wildlife Service (USFWS) Biological Opinion (BiOp) includes a Reasonable and Prudent Alternative (RPA) element that specifies X2 location in September–October of above-normal and wet water year types. The January 2010 Project Operations did not include any action to meet or mimic the Fall X2 RPA component, raising concerns from USFWS and others whether the project operations would meet permit issuance criteria" (California Department of Water Resources et al. 2011).

J.0.5.2 Conclusions

Because the operational criteria in Scenario 6 explicitly include the Fall X2 requirement while the PP does not, Scenario 6 results, not surprisingly, provide for maintenance of Fall X2 further west relative to the PP September–December of wet and above-normal water years. The effects of this difference on delta smelt are uncertain. Changes in operations designed to manage Fall X2 location as presented in Scenario 6 were found in these analyses to result in reductions in upstream reservoir storage and changes to river flows and seasonal water temperatures that have the potential to adversely affect upstream riverine habitat conditions for salmonids.

[4] The Biological Opinion as was existing at the time of development of the Rationale Document referenced (April 2011).

Appendix J
Scenario 6 Comparison

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Acronyms and Abbreviations

BDCP	Bay Delta Conservation Plan
BiOp	Biological Opinion
cfs	cubic feet per second
CVP	Central Valley Project
D 1641	State Water Board water right Decision 1641
Delta	Sacramento–San Joaquin River Delta
DFG	California Department of Fish and Game
DPM	Delta Passage Model
DWR	California Department of Water Resources
EA	Effects Analysis
EBC	existing biological conditions
ELT	early long-term
FRFH	Feather River Fish Hatchery
LLT	late long-term
MAF	million acre-feet
NMFS	National Marine Fisheries Service
OMR	Old and Middle River
PP	preliminary proposal
PTM	particle tracking modeling
Reclamation	U.S. Bureau of Reclamation
ROAs	Restoration Opportunity Areas
RPA	Reasonable and Prudent Alternative
SRWQM	Sacramento River Water Quality Model
State Water Board	State Water Resources Control Board
SWP	State Water Project
TAF	thousands of acre-feet
USFWS	U.S. Fish and Wildlife Service

Appendix J
Scenario 6 Comparison

J.1 Introduction

J.1.1 Background and Purpose

This report provides a comparison between the preliminary proposal (PP) and Scenario 6 for five biological parameters. State and federal regulatory agencies developed Scenario 6 to identify "alternative operating criteria that could address concerns raised… following their review of the August 2010 preliminary draft Effects Analysis" on the PP (California Department of Water Resources et al. 2011). The agency rationale for Scenario 6 lays out five operational areas of concern that are intended to be addressed in Scenario 6, or otherwise be informed by the results of the Effects Analysis. These concerns are summarized below:

- **Reduced Sacramento River flows downstream of the intakes.** "New North Delta diversions will reduce net Sacramento River flows near Rio Vista…although the CALSIM II modeling showed the agreed upon North Delta diversion bypass criteria [in the PP] has generally been met, identified reductions in flow remain a concern…" (California Department of Water Resources et al. 2011).
- **San Joaquin River migratory fish survival.** "[The PP] proposed a 'non-physical barrier' and habitat restoration in the south Delta. The latter was not scheduled to come online until the late long-term time frame. This was not considered adequately protective of San Joaquin River basin salmonid fishes. There was also concern over Old and Middle River (OMR) flow levels during certain months" (California Department of Water Resources et al. 2011).
- **April–May OMR flows**. "The original 'Big 6' version of this issue was that April–May OMR flows in the January 2010 Project Operations modeling were more negative than the flows modeled for the Existing Baseline Condition scenarios. The issue expanded to include OMR flow criteria during other months to take advantage of operational flexibility the CALSIM II modeling indicated would be afforded by dual conveyance. The goal was to increase San Joaquin River flow variability (improving OMR flows in the Delta and flows in the San Joaquin River below the Head of Old River), and maximize improvements to south Delta hydrodynamics…" (California Department of Water Resources et al. 2011).
- **Spring Delta outflow issues related to longfin smelt.** "Changes in winter-spring Delta outflows correlate positively with changes in abundance of longfin smelt. A review of CALSIM II model output shows that the combination of new operating rules and increased conveyance capacity [in the PP] results in reduced net Delta outflows in the winter-spring period of wetter water years…instances of reduced Spring flows, food web productivity and other stressors remain a concern…" (California Department of Water Resources et al. 2011).

- **Fall X2.** "The existing[5] U.S. Fish and Wildlife Service (USFWS) Biological Opinion (BiOp) includes a Reasonable and Prudent Alternative (RPA) element that specifies X2 location in September–October of above-normal and wet water year types. The January 2010 Project Operations did not include any action to meet or mimic the Fall X2 RPA component, raising concerns from USFWS and others whether the project operations would meet permit issuance criteria" (California Department of Water Resources et al. 2011).

Scenario 6, proposed by the agencies as an alternative to the PP criteria for evaluation in the Effects Analysis, includes modified criteria intended to address three of the five operational issues identified above: San Joaquin River migratory fish survival, April–May OMR flows, and Fall X2. Scenario 6 also includes an operable barrier at the head of Old River. Scenario 6 does not include modifications to address reduced Sacramento River flows downstream of the new intakes, or the Winter-Spring outflow issues related to longfin smelt (or the location of the north Delta intakes). The agencies' intent was to address these two operational issues in the development of adaptive ranges subsequent to completion of the Effects Analysis. In addition to these Sacramento–San Joaquin River Delta (Delta) concerns, this report also compares temperature-related egg mortality for spring-run Chinook salmon in the Sacramento River, a concern that was also raised in review of the results of the PP. The California Department of Water Resources (DWR) agreed to evaluate this alternative operational scenario compared to PP operations to estimate the benefits and effects of Scenario 6 in relation to PP. This report provides that comparison for:

- Temperature-Related Spring-Run Egg Mortality.
- Reduced Sacramento River flows downstream of the intakes.
- April–May south Delta operations related to OMR flows.
- Winter-spring X2, Delta outflow and longfin smelt.
- Fall X2.

J.1.2 BDCP Operational Scenarios

Table J.1-1 shows the differences between the operations of each of these alternatives. In general, Scenario 6 is similar to the PP except Scenario 6 includes Fall X2 as described in the USFWS 2008 BiOp and maintains OMR flows more positively than the PP.

[5] The Biological Opinion as was existing at the time of development of the Rationale Document referenced (April 2011).

Table J.1-1. Operational Differences between Alternative 1 and Scenario 6 (BDCP CALSIM II Modeling Assumptions)

<table>
<tr><th>Regulatory Standards in Delta</th><th>Preliminary Proposal (Alternative 1)</th><th colspan="6">Scenario 6</th></tr>
<tr><td rowspan="20">Combined Flow in Old and Middle Rivers (OMR)</td><td rowspan="20">Existing conditions under USFWS BiOp (December 2008) Actions 1–3 and NMFS BiOp (June 2009) Action IV.2.3v</td><td colspan="6">More positive of the Existing Conditions and Future No Action assumptions and the assumption noted below:</td></tr>
<tr><td>Month</td><td>W</td><td>AN</td><td>BN</td><td>D</td><td>C</td></tr>
<tr><td>Jan</td><td>0</td><td>-3500</td><td>-4000</td><td>-4000</td><td>-5000</td></tr>
<tr><td>Feb</td><td>0</td><td>-3500</td><td>-4000</td><td>-4000</td><td>-4000</td></tr>
<tr><td>Mar</td><td>0</td><td>-3500</td><td>-3500</td><td>-3500</td><td>-3500</td></tr>
<tr><td rowspan="11">Apr–June</td><td colspan="5">Varies based on San Joaquin inflow relationship to OMR.</td></tr>
<tr><td></td><td colspan="2">If San Joaquin Flow at Vernalis</td><td colspan="2">Minimum Average OMR Flows</td></tr>
<tr><td rowspan="5">April and May</td><td colspan="2">≤5,000 cfs</td><td colspan="2">-2,000 cfs</td></tr>
<tr><td colspan="2">6,000 cfs</td><td colspan="2">+10,000 cfs</td></tr>
<tr><td colspan="2">10,000 cfs</td><td colspan="2">+2,000 cfs</td></tr>
<tr><td colspan="2">15,000 cfs</td><td colspan="2">+3,000 cfs</td></tr>
<tr><td colspan="2">≥30,000 cfs</td><td colspan="2">+6,000 cfs</td></tr>
<tr><td rowspan="4">June</td><td colspan="2">≤3,500 cfs</td><td colspan="2">-3,500 cfs</td></tr>
<tr><td colspan="2">3,501 to 10,000 cfs</td><td colspan="2">0 cfs</td></tr>
<tr><td colspan="2">10,001 to 15,000 cfs</td><td colspan="2">+1,000 cfs</td></tr>
<tr><td colspan="2">>15,000 cfs</td><td colspan="2">+2,000 cfs</td></tr>
<tr><td>Jul–Sep</td><td colspan="5">No Restrictions</td></tr>
<tr><td>Oct–Nov</td><td colspan="5">Varies based on San Joaquin River pulse flow condition (D-1641):
Before pulse = HORB open, no OMR restrictions.
During pulse = no south Delta exports (2 weeks), HORB closed.
After pulse = -5,000 cfs OMR (through November), HORB open 50% for 2 weeks.</td></tr>
<tr><td>Dec</td><td colspan="5">-5000 when north Delta initial pulse flows triggered, or
-2000 when delta smelt action 1 triggers</td></tr>
<tr><td colspan="6">Head of Old River Barrier (HORB) opening is restricted[1]</td></tr>
<tr><td>Fall X2 RPA Component 3 USFWS BiOp (Dec 2008)</td><td>No Fall X2 component</td><td colspan="6">Full implementation of the Fall X2 action from the current RPA.
During September and October in years when the preceding precipitation and runoff period was wet or above normal, maintain monthly average X2 no greater (more eastward) than 74 km (from the Golden Gate) in Wet WYs and 81 km in Above Normal WYs. During any November when the preceding water year was wet or above normal, all inflow into SWP/CVP reservoirs in the Sacramento Basin shall be added to reservoir releases in November to augment Delta outflow up to the Fall X2 of 74 km for Wet WYs or 81 km in Above Normal WYs. If storage increases in any November this action applies, release in December to augment the December outflow requirements.</td></tr>
<tr><td colspan="8">Notes: BiOp = Biological Opinion; cfs = cubic feet per second; CVP = Central Valley Project; HORB = Head of Old River Barrier; NMFS = National Marine Fisheries Service; OMR = Old and Middle River; RPA = Reasonable and Prudent Alternative; SWP = State Water Project; USFWS = U.S. Fish and Wildlife Service.
[1] HORB operations described in Table J.1-2.</td></tr>
</table>

Table J.1-2. Head of Old River Operable Barrier (HORB) Operations/Modeling Assumptions (% OPEN)

Period	% Open[1]
Oct	50%
Nov	100%[2]
Dec	100%
Jan	50%[3]
February–June 15th	50%
June 16–30	100%
July–September	100%

Note:
[1] Percent of time the HORB is open. Agricultural barriers are in and operated consistent with current practices. HORB would be open 100% whenever flows are greater than 10,000 cfs at Vernalis.
[2] For modeling assumption only. Action proposed:
Before the D-1641 pulse = no OMR restrictions (HORB open)
During the D-1641 pulse = no south Delta exports for two weeks (HORB closed).
After the D-1641 pulse = -5,000 cfs OMR through November (HORB open 50% for two weeks). Exact timing of the action will be based on hydrologic conditions.
[3] The HORB becomes operational at 50% when salmon fry are immigrating (based on real time monitoring). This generally occurs when flood flow releases are being made.

J.2 Methods

J.2.1 Approach for Evaluation

The PP/Scenario 6 comparative evaluation uses a 2-tiered analytical approach. In Tier 1, the effectiveness of Scenario 6 in addressing the 5 issues above is evaluated first. This document, the comparison of fish effects between PP operations and Scenario 6 operations (“PP/Scenario 6 Effects Analysis Appendix”), presents the results of this Tier 1 analysis, organized by each of the 5 issues with individual conclusions for each issue. The Tier 1 assessment focuses on spring-run and winter-run Chinook salmon, steelhead, delta smelt, and longfin smelt as primary species of interest.

Based on the results of this Tier 1 assessment, a decision will be made to either (1) select Scenario 6 as the proposed operations and analyze it compared to the various baseline scenarios in the Effects Analysis (EA) (i.e., replace the PP analysis with Scenario 6), (2) decide to continue with PP operations as the PP in the EA and evaluate Scenario 6 in the EIR/EIS only, (3) continue the comparative analysis to evaluate effects beyond issues 1–5 above to determine potential additional differences in biological effects, or (4) further revise or refine the PP or Scenario 6, and then complete additional analyses.

If Option 3 is selected, the evaluation would be expanded to a full comparison of Scenario 6 and PP (Tier 2 assessment). This would include further consideration of other metrics such as detailed analysis of entrainment risk, flows and temperatures on other rivers (Trinity River, Clear Creek, Stanislaus River etc.), changes in habitat bench inundation, and population modeling. The metrics and analysis would be strategically defined based on results of the Tier 1 assessment. The remainder of the covered species (Sacramento splittail, sturgeon and lamprey) would be addressed at that time. Table J.2-1 provides a prioritized list of potential stressors, tiered analyses and metrics.

Table J.2-1. Metrics Evaluated for Tier 1 and Tier 2 Comparative Analysis

Potential Stressor	Metrics	Data Used
Tier 1. Does Scenario 6 address the “Big 6” issues?		
1. Increased temperature-related spring-run salmon egg mortality	• Shasta and Oroville storage • Keswick release • Sacramento River flow at Red Bluff • Feather River flow (low-flow and high-flow channels)	CALSIM
	• Sacramento River water temperatures • Feather River water temperatures	USBR temp model
	• USBR egg mortality model, spring-run Chinook salmon for Sacramento River	USBR egg mortality model
2. Reduced Sacramento River flows downstream of the intakes	• Rio Vista flow	CALSIM
	• Adult attraction flows and olfactory cues	CALSIM DSM2 Fingerprinting
	• DPM—juvenile salmon survival	DPM (*methods being refined, data not available*)

Potential Stressor	**Metrics**	**Data Used**
3. April–May south Delta operations related to reverse Old and Middle River flows	• OMR flows	CALSIM
	• DPM—juvenile salmon survival	DPM (*methods being refined, data not available*)
	• Entrainment—salvage of winter and spring run Chinook salmon, steelhead, delta smelt, longfin smelt	Salvage at south Delta SWP and CVP facilities
	• Entrainment—PTM of delta smelt and longfin smelt	Post-processing of DSM2 PTM
	• Entrainment—Delta smelt OMR proportional salvage	Kimmerer proportional entrainment
4. Winter-Spring X2 and outflow related to effects on longfin smelt	• Delta inflow and outflow • X2 location (December–May)	CALSIM
	• Winter-spring X2 Longfin smelt abundance	Calculated from CALSIM
5. Fall X2 related to delta smelt habitat	• Fall X2 location (September–November)	CALSIM
Tier 2. Are there other effects of Scenario 6?		
Increased temperature-related egg mortality for other salmonids (winter-run, fall-run, steelhead) and sturgeon	• Shasta, Oroville, and Folsom storage • Keswick release • Sacramento flow at Red Bluff • Feather River low-flow and high-flow channel flow • American River at confluence	CALSIM
	• Sacramento, American, Feather Rivers water temperature	USBR temp model SRWQM
	• USBR egg mortality model for winter-run, fall-run, late fall-run Chinook salmon	USBR egg mortality model
	• SALMOD for winter-run and spring-run Chinook salmon • SacEFT for winter-run Chinook salmon	SALMOD SacEFT
	• IOS and OBAN life history models (winter-run Chinook only)	Calculated from DSM2 data
Bench habitat inundation	• Flows in lower Sacramento River • Sutter and Steamboat Sloughs	CALSIM DSM2
Inundated habitat in Yolo Bypass	• Sacramento River at Fremont Weir • Yolo Bypass inundation	CALSIM DSM2
Migrating salmon survival through Delta	• Vernalis flow • Delta inflow & outflow • OMR flow	CALSIM DSM2
	• DPM—migrating salmon survival through Delta	Delta Passage Model
Flow-related changes in other streams	• Trinity River • Clear Creek • Stanislaus River	CALSIM
Other species with adverse effects	• Scan technical appendices for other species with adverse effects under preliminary proposal (Alternative 1)	
CVP = Central Valley Project; DPM = Delta Passage Model; OMR = Old and Middle River; PTM = Particle Tracking Model; SRWQM = Sacramento River Water Quality Model; SWP = State Water Project; USBR = U.S. Bureau of Reclamation.		

To compare Scenario 6 and PP, like timesteps were compared: PP early long-term (ELT) was compared to Scenario 6 ELT, and PP late long-term (LLT) was compared to Scenario 6 LLT, which includes assumptions regarding long-term climate change. Where necessary, these modeled outputs were also compared to the existing biological conditions (EBC) to determine the net effect of the operations (i.e., without climate change).

The methods used to assess flows and the various flow-related parameters are based on CALSIM and DSM2 outputs, upstream temperature models, particle tracking modeling (PTM), multiple biological models, assumed and measured locations of fish, previous studies in the Delta, and/or professional judgment. Methods used for entrainment effects include salvage density, PTM, and OMR proportional entrainment. The methods used reflect the best available tools and data regarding fish abundance, movement, and behavior. These methods were applied to a comparison of PP with Scenario 6 at two time periods in the permit term (ELT and LLT). Assumptions of climate change and development of habitat restoration under BDCP were incorporated into these periods. Table J.2-2 provides a description of each of these conditions. For some methods, five water-year types were modeled based on the historical CALSIM record to determine the variation in flow-related effects under different flow conditions.

Table J.2-2. Definition of Analytical Conditions

Condition	Description
EBC2	This condition assumes current operations based on the 2008 USFWS and 2009 NMFS BiOps, including the Fall X2 actions called for in the USFWS BiOp.
EBC2_ELT	This condition assumes that EBC2 continues into the future and includes conditions expected in Years 11–15.
EBC2_LLT	This condition assumes that EBC2 continues into the future and includes conditions expected in Years 15–50.
PP (Alternative 1)	This condition is based on the set of BDCP operations modeling estimates that are available at this time.
Alt1_ELT	This condition reflects the preliminary proposal in Years 11–15 (prior to the implementation of the new intake facility and the full implementation of the restoration activities).
Alt1_LLT	This condition assumes full implementation of the BDCP preliminary proposal, and reflects Years 15–50.
Scenario 6	An additional operational scenario called “Scenario 6”, proposed for evaluation by the fishery agencies.
S6_ELT	This condition reflects the Scenario 6 operations in Years 11–15 (prior to the implementation of the new intake facility and the full implementation of the restoration activities).
S6_LLT	This condition assumes full implementation of the BDCP under the Scenario 6 operations, and reflects Years 15–50.
Note: BiOp = biological opinion; NMFS = National Marine Fisheries Service; SWP/CVP = State Water Project/Central Valley Project; USFWS = U.S. Fish and Wildlife Service.	

J.2.2 Metrics

This Tier 1 evaluation (comparison of PP and Scenario 6 regarding issues 1–5) examines results of hydrologic and biological modeling for these specific issues.

The primary metrics examined include:

- Shasta and Oroville reservoir storage
- Keswick release
- Sacramento River flow at Red Bluff
- Sacramento River flow at Rio Vista
- Feather River flow in low-flow channel and in high-flow channel (at Thermalito)
- American River flow at the confluence
- Delta outflow
- OMR flow
- X2 location
- San Joaquin River flow at Vernalis
- Sacramento River water temperatures
- U.S. Bureau of Reclamation (Reclamation) egg mortality model
- Delta Passage Model (DPM) juvenile salmonid survival (*methods being refined*)

The approach examines results of hydrologic modeling (CALSIM II) for specific metrics. The summary analysis is by month and water-year type. Additional consideration is given to those metrics that differ between scenarios by greater than ± 5% (assuming that the base modeling has noise and error that would obscure meaningful differences that were less than 5%) and that are physically meaningful (e.g. some minor changes at very low-flow levels can register as large percentage differences). For each metric, the analysis focused on those months that are biologically relevant to each species and lifestage. Additional analysis and modeling targeted only those metrics that showed appreciable difference or change.

The important physical and biological differences between the PP operations and Scenario 6 operations are identified and analyzed with the same methods used in the technical appendices: Appendix 5.B, *Entrainment* (Entrainment Appendix), and Appendix 5.C, *Flow, Passage, Salinity and Turbidity* (Flow Appendix).

J.3 Hydrologic Results Comparing Scenario 6 and Alternative 1

J.3.1 Modeling Operations Scenarios

The CALSIM II model (CALSIM) was used to evaluate changes in reservoir storage levels, river flows, water diversions, Delta exports, water deliveries, and Delta outflow[6]. Highlights of model assumptions are summarized here to provide sufficient background to interpret results. Further details are provided in the Flow Appendix (Section C.5.1, *CALSIM II and DSM2 Models*).

J.3.1.1 Reservoir Operations

Reservoir inflow is generally stored, unless the end-of-month storage would exceed the monthly specified maximum storage level (volume). The monthly minimum reservoir releases must be satisfied, and there may be downstream water supply demands for diversion along the river or in the Delta for export pumping or for required Delta outflow.

Although minimum reservoir storage volumes can be specified, the CALSIM model of the State Water Project (SWP) and Central Valley Project (CVP) operations does not use minimum storage levels to govern (limit) reservoir drawdown and carryover storage at the end of September. The water supply deliveries are adjusted according to the runoff and storage levels, and the water supply deficits are used indirectly to limit reservoir drawdown.

Upstream reservoirs are generally linked to each other through balancing rules and are somewhat linked to the Delta operations. However, in many months each reservoir operates independently to fill during the winter and spring and release water for the local water supply diversions and minimum river flows.

J.3.1.2 Delta Operations

The CALSIM model was also used to simulate the Delta operations by comparing the Delta inflows with the Delta flow and salinity objectives to determine the allowable Delta exports. For each month, CALSIM determines the amount of water that can be delivered or stored according to the specified priorities while satisfying all system constraints. CALSIM first satisfies any regulatory standards such as instream flow requirements, Delta Cross Channel operations, the most stringent of the salinity (State Water Resources Control Board [State Water Board] water right Decision 1641 [D-1641]) or X2 objectives by adjusting upstream reservoir releases and/or Delta exports, before determining the amount of exports that can be accommodated for meeting the south-of-Delta demands. Additional constraints on south Delta exports include the reverse OMR flow restrictions as specified in the 2008 USFWS BiOp (PP and Scenario 6) or as dependent onSan Joaquin River flows in

[6] CALSIM II model outputs were provided in two forms: (1) raw monthly average flows by water year type for 16 CALSIM nodes in *CALSIMFlowSummaryByWY_New_Scens_v1CJMv3.xlsx* and (2) summary data for flow, exports, storage and X2 in *MulStyMonthlyCompareDec2011_ALT1_S6FX2_121211_mod.xlsm.*

April and May (Scenario 6). The Fall X2 requirements in September–November added another Delta outflow requirement in wet and above normal years (this requirement is not included in EBC1 or PP modeling scenarios, but is included in the Scenario 6 and EBC2 modeling scenarios).

The BDCP proposed North Delta Intakes would be operated with bypass flow rules that govern the fraction of Sacramento River flow that can be diverted during a month. Bypass rules are designed to avoid increased upstream tidal transport from downstream channels, to protect the fish migrating past the intake facilities, and to preserve the hydrograph. The North Delta Intakes and the associated bypass rules are the major changes in Delta operations that would result from the BDCP. The bypass rules have three components:

- A low level pumping of 3% of the Sacramento River flow up to 300 cubic feet per second (cfs) at each intake (1,500 cfs total) during the December–June fish migration protection period.
- An initial pulse protection during the November–January period.
- An increasing percentage of the Sacramento River flow above a certain minimum river flow threshold (15,000 cfs from December to June, 5,000 cfs in July–September, and 7,000 cfs in October and November).

J.3.2 Flows

J.3.2.1 General Patterns

To identify the potential for biological changes resulting from changes in flows, the mean monthly flow data (CALSIM II) were compared between PP and Scenario 6 for the two implementation periods (ELT and LLT) and five water year types (wet, above normal, below normal, dry, and critical). Several upstream and Delta locations were evaluated. The flow data (CALSIM II raw monthly average and differences) are provided for the following Tier 1 priority sites:

- Sacramento River—Keswick (Table J.3-1), Red Bluff Diversion Dam (Table J.3-2), downstream of the proposed north Delta diversion (Table J.3-3), and Rio Vista (Table J.3-4).
- Feather River—low flow channel (Table J.3-5), Thermalito (high flow channel) (Table J.3-6).
- American River at confluence—(Table J.3-7).
- San Joaquin River at Vernalis—(Table J.3-8).
- Delta—OMR (Table J.3-9) and Outflow (Table J.3-10).

Color-coding is provided to highlight relative differences (percentage), with red shading indicating reduced flows or worse conditions and blue shading indicating increased flows or improved conditions. Final interpretation, however, should also consider the absolute magnitude of flow. Flow data for existing biological conditions (EBC2) are also included to provide context for understanding PP and Scenario 6, but no direct comparisons are made in this document.

In general, flow differences between Scenario 6 and PP were most apparent in July–November, especially in fall (September–November). This reflects the inclusion of Fall X2 requirement in wet and above normal years for Scenario 6 (this requirement is not included the PP modeling scenarios). Further details of flow differences are discussed in the following sections and where relevant in the analysis of each issue (Section 4).

Table J.3-1. Average Monthly Flows (cfs) by Water Year Type for Sacramento River at Keswick

M	WY	EBC2_ELT	EBC2_LLT	A1_ELT	A1_LLT	S6_ELT	S6_LLT	A1_ELTvs.S6_ELT	A1_LLTvs.S6_LLT
JAN	W	17,330	18,233	18,199	18,615	17,876	18,565	-324 (-1.8%)	-50 (-0.3%)
	AN	7,776	8,205	9,121	7,987	8,492	7,772	-628 (-6.9%)	-215 (-2.7%)
	BN	4,340	4,184	4,860	5,666	4,922	4,315	62 (1.3%)	-1,351 (-23.8%)
	D	4,098	4,096	4,136	4,371	4,118	3,745	-18 (-0.4%)	-627 (-14.3%)
	C	3,794	4,238	3,915	3,452	3,550	4,073	-365 (-9.3%)	621 (18%)
	AVG	8,829	9,215	9,416	9,503	9,174	9,179	-241 (-2.6%)	-324 (-3.4%)
FEB	W	20,349	20,853	20,557	20,844	20,522	20,779	-35 (-0.2%)	-65 (-0.3%)
	AN	15,081	15,297	16,672	16,741	15,851	15,609	-821 (-4.9%)	-1,132 (-6.8%)
	BN	6,456	5,544	6,689	6,245	6,920	6,318	231 (3.4%)	74 (1.2%)
	D	3,447	3,410	3,510	3,609	3,324	3,408	-186 (-5.3%)	-201 (-5.6%)
	C	3,394	3,372	3,366	3,586	3,514	3,364	148 (4.4%)	-222 (-6.2%)
	AVG	11,015	11,039	11,363	11,442	11,252	11,192	-111 (-1%)	-250 (-2.2%)
MAR	W	16,399	17,065	16,412	17,202	16,403	17,152	-10 (-0.1%)	-50 (-0.3%)
	AN	8,662	8,818	9,333	8,558	9,173	8,935	-160 (-1.7%)	377 (4.4%)
	BN	4,306	4,318	4,870	4,873	4,542	4,246	-328 (-6.7%)	-627 (-12.9%)
	D	3,858	3,814	3,670	3,732	3,664	3,858	-6 (-0.2%)	126 (3.4%)
	C	3,608	3,583	3,809	3,867	3,820	3,835	11 (0.3%)	-32 (-0.8%)
	AVG	8,577	8,800	8,764	8,924	8,682	8,879	-82 (-0.9%)	-45 (-0.5%)
APR	W	9,254	9,131	9,312	9,088	9,244	9,042	-68 (-0.7%)	-45 (-0.5%)
	AN	5,712	5,536	5,868	6,137	5,823	5,779	-45 (-0.8%)	-358 (-5.8%)
	BN	4,934	5,009	5,475	5,722	5,001	5,375	-475 (-8.7%)	-348 (-6.1%)
	D	5,497	5,533	5,839	6,308	5,620	5,756	-219 (-3.8%)	-552 (-8.7%)
	C	6,343	6,550	6,357	6,733	6,300	6,493	-57 (-0.9%)	-240 (-3.6%)
	AVG	6,748	6,733	6,958	7,127	6,793	6,844	-165 (-2.4%)	-282 (-4%)
MAY	W	8,183	7,149	8,357	7,871	8,301	7,752	-56 (-0.7%)	-119 (-1.5%)
	AN	7,307	7,783	8,329	8,868	8,462	9,049	133 (1.6%)	181 (2%)
	BN	6,411	6,272	7,423	7,346	6,924	7,180	-500 (-6.7%)	-166 (-2.3%)
	D	7,075	7,681	8,073	8,957	7,517	8,756	-556 (-6.9%)	-200 (-2.2%)
	C	6,900	7,316	7,224	7,586	7,172	7,496	-52 (-0.7%)	-90 (-1.2%)
	AVG	7,321	7,233	7,965	8,124	7,752	8,027	-213 (-2.7%)	-97 (-1.2%)
JUN	W	10,063	10,274	10,761	11,776	10,456	11,585	-305 (-2.8%)	-191 (-1.6%)
	AN	11,403	12,032	12,546	13,789	12,237	13,776	-309 (-2.5%)	-13 (-0.1%)
	BN	10,573	10,947	11,466	11,599	11,359	11,636	-107 (-0.9%)	37 (0.3%)
	D	11,464	11,898	12,087	12,498	12,045	12,402	-42 (-0.3%)	-96 (-0.8%)
	C	11,041	11,350	10,920	11,750	11,271	11,580	351 (3.2%)	-170 (-1.4%)
	AVG	10,797	11,160	11,457	12,195	11,339	12,093	-118 (-1%)	-102 (-0.8%)
JUL	W	13,477	14,098	13,677	14,172	13,552	14,048	-125 (-0.9%)	-124 (-0.9%)
	AN	14,541	15,098	14,605	14,686	14,608	14,688	3 (0%)	2 (0%)
	BN	13,195	13,177	13,251	12,134	13,546	12,911	294 (2.2%)	778 (6.4%)
	D	13,650	13,727	13,198	12,593	13,528	12,833	330 (2.5%)	239 (1.9%)

M	WY	EBC2_ELT	EBC2_LLT	A1_ELT	A1_LLT	S6_ELT	S6_LLT	A1_ELTvs.S6_ELT	A1_LLTvs.S6_LLT
	C	12,124	11,935	12,067	11,451	12,319	11,087	252 (2.1%)	-364 (-3.2%)
	AVG	13,424	13,689	13,400	13,155	13,520	13,248	120 (0.9%)	93 (0.7%)
AUG	W	10,447	10,491	10,402	10,302	10,479	10,275	76 (0.7%)	-27 (-0.3%)
	AN	10,835	11,641	10,524	10,580	10,834	10,874	310 (2.9%)	294 (2.8%)
	BN	9,876	10,261	10,024	9,462	10,480	9,839	456 (4.6%)	377 (4%)
	D	10,464	10,986	9,454	8,874	9,343	9,368	-111 (-1.2%)	495 (5.6%)
	C	8,380	7,348	7,719	7,004	8,169	6,896	450 (5.8%)	-108 (-1.5%)
	AVG	10,108	10,269	9,755	9,403	9,943	9,595	189 (1.9%)	192 (2%)
SEP	W	12,012	12,833	7,756	6,998	11,365	13,114	3,609 (46.5%)	6,116 (87.4%)
	AN	9,209	9,898	6,598	6,253	7,551	9,331	952 (14.4%)	3,078 (49.2%)
	BN	5,677	5,601	5,832	5,284	5,132	4,723	-700 (-12%)	-561 (-10.6%)
	D	4,982	4,469	5,299	4,722	4,543	4,874	-756 (-14.3%)	152 (3.2%)
	C	4,827	4,368	4,794	4,927	4,722	5,145	-71 (-1.5%)	217 (4.4%)
	AVG	7,926	8,094	6,285	5,794	7,273	8,153	988 (15.7%)	2,359 (40.7%)
OCT	W	6,491	7,034	6,213	8,025	6,425	6,954	213 (3.4%)	-1,071 (-13.3%)
	AN	6,090	7,152	5,835	8,462	5,876	7,470	41 (0.7%)	-992 (-11.7%)
	BN	5,835	7,072	5,774	8,950	5,705	6,578	-69 (-1.2%)	-2,371 (-26.5%)
	D	5,899	6,494	5,403	8,106	5,797	6,789	393 (7.3%)	-1,317 (-16.2%)
	C	5,452	5,752	5,776	7,875	5,590	5,997	-186 (-3.2%)	-1,878 (-23.8%)
	AVG	6,038	6,752	5,841	8,242	5,962	6,789	121 (2.1%)	-1,453 (-17.6%)
NOV	W	7,620	7,539	6,445	6,401	6,511	6,350	66 (1%)	-51 (-0.8%)
	AN	7,357	7,134	5,187	4,457	5,629	5,562	442 (8.5%)	1,105 (24.8%)
	BN	5,926	5,936	4,459	4,241	4,514	4,655	55 (1.2%)	414 (9.8%)
	D	5,439	5,406	4,926	4,319	4,638	4,604	-287 (-5.8%)	285 (6.6%)
	C	4,789	4,710	4,315	4,196	4,431	4,454	116 (2.7%)	258 (6.1%)
	AVG	6,399	6,324	5,277	4,968	5,325	5,284	49 (0.9%)	316 (6.4%)
DEC	W	12,808	11,022	14,260	11,953	13,026	10,803	-1,234 (-8.7%)	-1151 (-9.6%)
	AN	5,729	5,377	5,055	5,376	5,339	5,301	283 (5.6%)	-75 (-1.4%)
	BN	5,857	5,195	5,815	5,412	5,667	5,728	-148 (-2.5%)	316 (5.8%)
	D	3,883	3,936	4,243	4,206	4,233	4,113	-10 (-0.2%)	-93 (-2.2%)
	C	3,593	3,582	3,911	3,645	3,766	4,171	-145 (-3.7%)	526 (14.4%)
	AVG	7,278	6,557	7,758	6,958	7,359	6,692	-399 (-5.1%)	-265 (-3.8%)

	Increase >50%	Increase 25–50%	Increase 10–25%	Increase 5–10%
	Decrease >50%	Decrease 25–50%	Decrease 10–25%	Decrease 5–10%

Table J.3-2. Average Monthly Flows (cfs) by Water Year Type for Sacramento River at Red Bluff Diversion Dam

M	WY	A1_ELT	A1_LLT	S6_ELT	S6_LLT	A1_ELTvs.S6_ELT	A1_LLTvs.S6_LLT
JAN	W	30,226	30,761	29,910	30,719	-316 (-1%)	-42 (-0.1%)
	AN	17,611	16,662	16,982	16,451	-630 (-3.6%)	-211 (-1.3%)

M	WY	A1_ELT	A1_LLT	S6_ELT	S6_LLT	A1_ELTvs.S6_ELT	A1_LLTvs.S6_LLT
	BN	9,783	10,623	9,846	9,270	63 (0.6%)	-1,352 (-12.7%)
	D	7,294	7,532	7,277	6,908	-17 (-0.2%)	-624 (-8.3%)
	C	6,620	6,160	6,251	6,782	-369 (-5.6%)	622 (10.1%)
	AVG	16,401	16,560	16,162	16,239	-239 (-1.5%)	-321 (-1.9%)
FEB	W	32,915	33,458	32,880	33,393	-35 (-0.1%)	-65 (-0.2%)
	AN	26,003	26,269	25,186	25,140	-817 (-3.1%)	-1,128 (-4.3%)
	BN	12,737	12,301	12,966	12,385	230 (1.8%)	84 (0.7%)
	D	8,848	8,985	8,662	8,790	-185 (-2.1%)	-195 (-2.2%)
	C	6,380	6,595	6,527	6,362	146 (2.3%)	-233 (-3.5%)
	AVG	19,292	19,490	19,181	19,242	-111 (-0.6%)	-248 (-1.3%)
MAR	W	25,488	26,347	25,476	26,296	-11 (0%)	-51 (-0.2%)
	AN	16,878	16,160	16,722	16,542	-157 (-0.9%)	382 (2.4%)
	BN	8,994	9,018	8,667	8,384	-328 (-3.6%)	-634 (-7%)
	D	8,160	8,216	8,155	8,344	-5 (-0.1%)	127 (1.5%)
	C	6,334	6,377	6,336	6,355	3 (0%)	-22 (-0.3%)
	AVG	14,805	14,995	14,722	14,952	-83 (-0.6%)	-44 (-0.3%)
APR	W	15,136	14,796	15,068	14,752	-68 (-0.4%)	-44 (-0.3%)
	AN	10,136	10,362	10,090	10,002	-45 (-0.4%)	-360 (-3.5%)
	BN	8,767	8,990	8,300	8,649	-467 (-5.3%)	-340 (-3.8%)
	D	7,990	8,433	7,777	7,882	-213 (-2.7%)	-551 (-6.5%)
	C	7,645	8,003	7,583	7,773	-62 (-0.8%)	-230 (-2.9%)
	AVG	10,652	10,765	10,488	10,486	-164 (-1.5%)	-279 (-2.6%)
MAY	W	11,397	10,790	11,342	10,674	-54 (-0.5%)	-116 (-1.1%)
	AN	10,642	11,122	10,775	11,308	133 (1.2%)	185 (1.7%)
	BN	9,024	8,939	8,538	8,780	-486 (-5.4%)	-158 (-1.8%)
	D	9,410	10,277	8,863	10,084	-548 (-5.8%)	-193 (-1.9%)
	C	8,278	8,615	8,228	8,529	-50 (-0.6%)	-86 (-1%)
	AVG	9,989	10,092	9,780	10,000	-208 (-2.1%)	-91 (-0.9%)
JUN	W	12,286	13,210	11,983	13,024	-303 (-2.5%)	-186 (-1.4%)
	AN	13,358	14,534	13,049	14,523	-309 (-2.3%)	-11 (-0.1%)
	BN	12,172	12,287	12,080	12,332	-92 (-0.8%)	45 (0.4%)
	D	12,633	13,028	12,604	12,937	-29 (-0.2%)	-91 (-0.7%)
	C	11,413	12,227	11,766	12,061	353 (3.1%)	-166 (-1.4%)
	AVG	12,372	13,062	12,260	12,965	-112 (-0.9%)	-97 (-0.7%)
JUL	W	14,132	14,586	14,010	14,468	-122 (-0.9%)	-118 (-0.8%)
	AN	14,649	14,716	14,654	14,723	6 (0%)	7 (0%)
	BN	13,304	12,205	13,614	12,991	309 (2.3%)	786 (6.4%)
	D	13,273	12,687	13,613	12,931	340 (2.6%)	243 (1.9%)
	C	12,237	11,749	12,481	11,381	244 (2%)	-368 (-3.1%)
	AVG	13,600	13,367	13,726	13,464	125 (0.9%)	97 (0.7%)

M	WY	A1_ELT	A1_LLT	S6_ELT	S6_LLT	A1_ELTvs.S6_ELT	A1_LLTvs.S6_LLT
AUG	W	10,653	10,543	10,731	10,520	78 (0.7%)	-23 (-0.2%)
	AN	10,655	10,714	10,965	11,012	310 (2.9%)	298 (2.8%)
	BN	10,103	9,565	10,570	9,946	468 (4.6%)	380 (4%)
	D	9,591	9,034	9,487	9,531	-104 (-1.1%)	497 (5.5%)
	C	7,935	7,330	8,430	7,273	495 (6.2%)	-57 (-0.8%)
	AVG	9,929	9,600	10,128	9,802	200 (2%)	202 (2.1%)
SEP	W	8,238	7,476	11,847	13,594	3,609 (43.8%)	6,119 (81.8%)
	AN	7,024	6,680	7,974	9,758	950 (13.5%)	3,078 (46.1%)
	BN	6,184	5,649	5,486	5,090	-698 (-11.3%)	-559 (-9.9%)
	D	5,742	5,178	4,991	5,327	-750 (-13.1%)	149 (2.9%)
	C	5,161	5,393	5,135	5,661	-26 (-0.5%)	268 (5%)
	AVG	6,712	6,238	7,707	8,605	996 (14.8%)	2,367 (37.9%)
OCT	W	7,399	9,200	7,604	8,108	205 (2.8%)	-1,092 (-11.9%)
	AN	6,863	9,484	6,899	8,480	35 (0.5%)	-1,004 (-10.6%)
	BN	6,492	9,678	6,419	7,291	-73 (-1.1%)	-2,386 (-24.7%)
	D	6,206	8,902	6,582	7,565	375 (6%)	-1,336 (-15%)
	C	6,580	8,691	6,383	6,795	-197 (-3%)	-1,895 (-21.8%)
	AVG	6,784	9,183	6,895	7,712	111 (1.6%)	-1,471 (-16%)
NOV	W	9,791	9,671	9,857	9,633	65 (0.7%)	-38 (-0.4%)
	AN	7,194	6,407	7,636	7,521	442 (6.1%)	1,114 (17.4%)
	BN	6,243	5,971	6,298	6,405	55 (0.9%)	435 (7.3%)
	D	6,901	6,249	6,614	6,544	-288 (-4.2%)	294 (4.7%)
	C	5,329	5,186	5,445	5,443	116 (2.2%)	258 (5%)
	AVG	7,518	7,154	7,567	7,482	49 (0.6%)	328 (4.6%)
DEC	W	23,015	20,551	21,781	19,402	-1,234 (-5.4%)	-1,149 (-5.6%)
	AN	9,710	10,073	9,991	9,989	281 (2.9%)	-84 (-0.8%)
	BN	8,891	8,460	8,742	8,770	-149 (-1.7%)	311 (3.7%)
	D	7,408	7,372	7,401	7,278	-6 (-0.1%)	-94 (-1.3%)
	C	5,792	5,498	5,641	6,025	-151 (-2.6%)	528 (9.6%)
	AVG	12,710	11,857	12,311	11,590	-399 (-3.1%)	-267 (-2.3%)
		Increase >50%		Increase 25–50%		Increase 10–25%	Increase 5–10%
		Decrease >50%		Decrease 25–50%		Decrease 10–25%	Decrease 5–10%

Table J.3-3. Average Monthly Flows (cfs) by Water Year Type for Sacramento River Downstream of North Delta Diversion

M	WY	A1_ELT	A1_LLT	S6_ELT	S6_LLT	A1_ELTvs.S6_ELT	A1_LLTvs.S6_LLT
JAN	W	41,688	42,014	39,663	40,419	-2026 (-4.9%)	-1,595 (-3.8%)
	AN	31,531	32,151	29,937	30,852	-1,594 (-5.1%)	-1,299 (-4%)
	BN	18,739	18,962	17,973	17,663	-767 (-4.1%)	-1,298 (-6.8%)
	D	15,318	16,372	14,713	14,801	-605 (-3.9%)	-1,571 (-9.6%)

M	WY	A1_ELT	A1_LLT	S6_ELT	S6_LLT	A1_ELTvs.S6_ELT	A1_LLTvs.S6_LLT
	C	13,542	12,576	13,047	13,442	-495 (-3.7%)	866 (6.9%)
	AVG	26,376	26,698	25,165	25,562	-1,212 (-4.6%)	-1,136 (-4.3%)
FEB	W	48,290	48,632	45,744	46,712	-2,545 (-5.3%)	-1,920 (-3.9%)
	AN	38,297	37,562	37,299	36,520	-998 (-2.6%)	-1,043 (-2.8%)
	BN	24,027	24,113	23,389	23,503	-638 (-2.7%)	-610 (-2.5%)
	D	17,171	17,556	16,779	17,208	-392 (-2.3%)	-348 (-2%)
	C	13,098	13,618	13,267	12,905	169 (1.3%)	-713 (-5.2%)
	AVG	30,704	30,880	29,581	29,834	-1,124 (-3.7%)	-1,046 (-3.4%)
MAR	W	39,677	40,210	37,819	38,511	-1,858 (-4.7%)	-1,699 (-4.2%)
	AN	33,942	33,116	32,755	32,919	-1,186 (-3.5%)	-197 (-0.6%)
	BN	16,725	16,602	16,213	15,997	-513 (-3.1%)	-606 (-3.6%)
	D	16,143	16,014	15,687	15,698	-456 (-2.8%)	-316 (-2%)
	C	11,813	11,863	11,874	11,938	61 (0.5%)	75 (0.6%)
	AVG	25,675	25,682	24,734	24,952	-941 (-3.7%)	-729 (-2.8%)
APR	W	28,084	27,818	27,071	26,975	-1,012 (-3.6%)	-843 (-3%)
	AN	17,687	17,618	16,912	16,667	-776 (-4.4%)	-951 (-5.4%)
	BN	14,688	14,856	13,481	13,920	-1,207 (-8.2%)	-937 (-6.3%)
	D	12,107	12,911	11,304	11,935	-803 (-6.6%)	-976 (-7.6%)
	C	9,894	10,315	9,648	9,880	-247 (-2.5%)	-435 (-4.2%)
	AVG	18,106	18,279	17,253	17,434	-853 (-4.7%)	-844 (-4.6%)
MAY	W	20,832	17,764	20,439	17,350	-393 (-1.9%)	-414 (-2.3%)
	AN	15,274	14,932	15,246	14,639	-28 (-0.2%)	-293 (-2%)
	BN	12,249	12,411	11,629	12,188	-620 (-5.1%)	-222 (-1.8%)
	D	10,694	11,868	10,081	11,691	-612 (-5.7%)	-178 (-1.5%)
	C	7,556	7,660	7,449	7,612	-107 (-1.4%)	-49 (-0.6%)
	AVG	14,385	13,663	14,000	13,405	-385 (-2.7%)	-258 (-1.9%)
JUN	W	14,709	14,397	14,226	14,262	-483 (-3.3%)	-136 (-0.9%)
	AN	13,003	14,276	12,455	13,581	-549 (-4.2%)	-695 (-4.9%)
	BN	12,589	13,069	12,963	13,028	374 (3%)	-41 (-0.3%)
	D	11,823	11,844	12,026	11,879	203 (1.7%)	35 (0.3%)
	C	9,172	9,306	9,224	9,507	52 (0.6%)	201 (2.2%)
	AVG	12,654	12,847	12,536	12,733	-118 (-0.9%)	-115 (-0.9%)
JUL	W	14,012	15,809	15,653	16,241	1,641 (11.7%)	432 (2.7%)
	AN	15,679	15,970	18,545	18,516	2,867 (18.3%)	2,545 (15.9%)
	BN	14,935	14,056	17,916	16,620	2981 (20%)	2,565 (18.2%)
	D	14,191	12,278	14,984	13,125	793 (5.6%)	847 (6.9%)
	C	9,863	10,579	10,400	10,805	537 (5.4%)	226 (2.1%)
	AVG	13,846	13,993	15,547	15,159	1,701 (12.3%)	1,166 (8.3%)
AUG	W	8,853	9,210	9,765	9,536	912 (10.3%)	325 (3.5%)
	AN	10,618	11,175	11,900	11,496	1,281 (12.1%)	321 (2.9%)

M	WY	A1_ELT	A1_LLT	S6_ELT	S6_LLT	A1_ELTvs.S6_ELT	A1_LLTvs.S6_LLT
	BN	9,826	9,744	11,926	11,431	2,100 (21.4%)	1,687 (17.3%)
	D	10,108	10,152	9,925	10,382	-183 (-1.8%)	229 (2.3%)
	C	7,985	8,047	8,746	8,527	761 (9.5%)	480 (6%)
	AVG	9,426	9,625	10,332	10,184	906 (9.6%)	559 (5.8%)
SEP	W	8,187	7,963	17,914	19,822	9,727 (118.8%)	11,859 (148.9%)
	AN	7,893	8,249	11,786	13,394	3,893 (49.3%)	5,146 (62.4%)
	BN	7,763	7,900	8,081	8,434	318 (4.1%)	534 (6.8%)
	D	7,761	8,330	7,723	8,621	-38 (-0.5%)	292 (3.5%)
	C	7,596	8,298	7,406	8,497	-190 (-2.5%)	199 (2.4%)
	AVG	7,891	8,123	11,563	12,821	3,672 (46.5%)	4,697 (57.8%)
OCT	W	9,547	13,281	8,841	10,130	-706 (-7.4%)	-3,152 (-23.7%)
	AN	8,806	13,607	8,206	10,490	-600 (-6.8%)	-3,117 (-22.9%)
	BN	9,276	14,504	8,395	9,995	-881 (-9.5%)	-4,509 (-31.1%)
	D	8,737	12,687	8,313	9,611	-423 (-4.8%)	-3,076 (-24.2%)
	C	9,056	13,918	7,946	10,078	-1,110 (-12.3%)	-3,840 (-27.6%)
	AVG	9,142	13,500	8,425	10,038	-717 (-7.8%)	-3,462 (-25.6%)
NOV	W	13,796	13,258	14,477	13,973	681 (4.9%)	715 (5.4%)
	AN	11,261	9,667	11,978	11,369	716 (6.4%)	1,702 (17.6%)
	BN	9,286	8,487	9,212	9,556	-74 (-0.8%)	1,069 (12.6%)
	D	10,086	8,551	9,319	9,210	-768 (-7.6%)	659 (7.7%)
	C	7,998	8,074	8,224	8,303	225 (2.8%)	229 (2.8%)
	AVG	10,992	10,126	11,165	10,963	173 (1.6%)	837 (8.3%)
DEC	W	32,828	31,205	31,323	29,862	-1,506 (-4.6%)	-1,343 (-4.3%)
	AN	19,668	21,404	19,675	19,798	8 (0%)	-1,606 (-7.5%)
	BN	15,860	15,751	15,234	15,555	-626 (-3.9%)	-196 (-1.2%)
	D	14,754	14,448	14,295	13,998	-458 (-3.1%)	-450 (-3.1%)
	C	11,484	11,195	10,911	10,776	-573 (-5%)	-419 (-3.7%)
	AVG	20,914	20,525	20,147	19,671	-768 (-3.7%)	-854 (-4.2%)
		Increase >50%		Increase 25–50%		Increase 10–25%	Increase 5–10%
		Decrease >50%		Decrease 25–50%		Decrease 10–25%	Decrease 5–10%

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2 **Table J.3-4. Average Monthly Flows (cfs) by Water Year Type for Sacramento River at Rio Vista**

M	WY	EBC2_ELT	EBC2_LLT	A1_ELT	A1_LLT	S6_ELT	S6_LLT	A1_ELTvs.S6_ELT	A1_LLTvs.S6_LLT
JAN	W	75,510	78,551	70,205	72,415	67,063	68,716	-3,142 (-4.5%)	-3,699 (-5.1%)
	AN	41,416	42,919	37,937	37,439	35,559	36,090	-2,378 (-6.3%)	-1,349 (-3.6%)
	BN	20,388	19,991	18,597	18,693	17,702	17,296	-895 (-4.8%)	-1,397 (-7.5%)
	D	15,032	14,927	13,853	14,703	13,320	13,237	-533 (-3.8%)	-1,467 (-10%)
	C	12,114	12,601	11,688	10,822	11,229	11,589	-459 (-3.9%)	767 (7.1%)
	AVG	38,556	39,721	35,738	36,443	34,057	34,624	-1,681 (-4.7%)	-1,818 (-5%)
FEB	W	87,232	89,989	80,666	83,061	77,869	80,937	-2,797 (-3.5%)	-2,125 (-2.6%)

M	WY	EBC2_ELT	EBC2_LLT	A1_ELT	A1_LLT	S6_ELT	S6_LLT	A1_ELTvs.S6_ELT	A1_LLTvs.S6_LLT
	AN	53,615	55,363	50,869	50,658	48,958	48,579	-1,911 (-3.8%)	-2,078 (-4.1%)
	BN	30,231	29,442	25,883	25,747	25,135	24,564	-748 (-2.9%)	-1,182 (-4.6%)
	D	19,318	19,422	16,937	17,247	16,544	16,954	-393 (-2.3%)	-293 (-1.7%)
	C	12,074	11,956	11,366	11,812	11,515	11,220	148 (1.3%)	-592 (-5%)
	AVG	46,674	47,675	42,821	43,660	41,463	42,330	-1,359 (-3.2%)	-1,331 (-3%)
MAR	W	66,275	68,663	59,359	61,586	57,413	59,808	-1,947 (-3.3%)	-1,777 (-2.9%)
	AN	47,974	48,513	41,165	41,050	39,928	40,734	-1,237 (-3%)	-316 (-0.8%)
	BN	19,629	19,562	15,823	15,626	15,061	14,764	-762 (-4.8%)	-862 (-5.5%)
	D	17,341	17,679	14,858	14,726	14,443	14,510	-415 (-2.8%)	-216 (-1.5%)
	C	10,603	10,684	9,930	9,981	9,991	10,049	61 (0.6%)	68 (0.7%)
	AVG	36,744	37,655	32,261	32,895	31,251	32,101	-1,010 (-3.1%)	-795 (-2.4%)
APR	W	38,692	38,422	32,507	32,024	31,636	31,360	-871 (-2.7%)	-664 (-2.1%)
	AN	22,234	21,855	17,016	16,986	16,346	16,132	-669 (-3.9%)	-854 (-5%)
	BN	14,295	14,207	12,609	12,777	11,559	11,952	-1,050 (-8.3%)	-825 (-6.5%)
	D	10,216	10,299	9,806	10,550	9,107	9,676	-698 (-7.1%)	-874 (-8.3%)
	C	7,520	7,816	7,505	7,883	7,293	7,499	-212 (-2.8%)	-384 (-4.9%)
	AVG	21,306	21,211	18,201	18,291	17,463	17,566	-738 (-4.1%)	-725 (-4%)
MAY	W	24,220	20,046	17,188	14,306	16,842	13,940	-346 (-2%)	-366 (-2.6%)
	AN	15,857	14,948	12,096	11,801	12,069	11,545	-27 (-0.2%)	-256 (-2.2%)
	BN	9,862	9,355	9,298	9,443	8,764	9,257	-535 (-5.8%)	-185 (-2%)
	D	7,840	8,564	8,000	9,032	7,486	8,883	-514 (-6.4%)	-149 (-1.6%)
	C	5,656	5,554	5,252	5,350	5,162	5,304	-90 (-1.7%)	-46 (-0.9%)
	AVG	14,232	12,833	11,332	10,641	11,001	10,416	-331 (-2.9%)	-225 (-2.1%)
JUN	W	12,993	11,418	8,474	8,002	8,121	7,896	-353 (-4.2%)	-107 (-1.3%)
	AN	8,634	9,220	6,661	7,583	6,254	7,078	-407 (-6.1%)	-505 (-6.7%)
	BN	6,677	7,241	6,347	6,703	6,622	6,681	276 (4.3%)	-22 (-0.3%)
	D	6,250	6,335	5,788	5,820	5,948	5,848	161 (2.8%)	28 (0.5%)
	C	4,304	4,513	3,927	4,020	3,963	4,163	36 (0.9%)	143 (3.6%)
	AVG	8,525	8,257	6,590	6,657	6,507	6,573	-84 (-1.3%)	-84 (-1.3%)
JUL	W	11,207	12,181	6,737	7,996	7,882	8,299	1,146 (17%)	303 (3.8%)
	AN	12,544	12,927	7,935	8,132	9,947	9,931	2,013 (25.4%)	1,799 (22.1%)
	BN	11,667	11,357	7,425	6,831	9,524	8,620	2,099 (28.3%)	1,789 (26.2%)
	D	10,105	10,307	7,253	5,916	7,805	6,498	552 (7.6%)	582 (9.8%)
	C	6,866	6,596	3,964	4,453	4,329	4,574	366 (9.2%)	120 (2.7%)
	AVG	10,604	10,921	6,737	6,842	7,928	7,652	1,191 (17.7%)	810 (11.8%)
AUG	W	8,527	8,650	3,565	3,826	4,188	4,041	622 (17.5%)	215 (5.6%)
	AN	9,013	9,648	4,774	5,174	5,672	5,391	898 (18.8%)	217 (4.2%)
	BN	8,062	8,753	4,274	4,224	5,740	5,371	1,466 (34.3%)	1,148 (27.2%)
	D	7,525	7,417	4,432	4,505	4,302	4,645	-130 (-2.9%)	140 (3.1%)
	C	3,823	3,615	3,119	3,157	3,688	3,415	569 (18.3%)	258 (8.2%)
	AVG	7,610	7,806	3,988	4,142	4,622	4,507	634 (15.9%)	364 (8.8%)

M	WY	EBC2_ELT	EBC2_LLT	A1_ELT	A1_LLT	S6_ELT	S6_LLT	A1_ELTvs.S6_ELT	A1_LLTvs.S6_LLT
SEP	W	20,717	21,199	3,324	3,165	10,242	11,639	6,918 (208.2%)	8,474 (267.8%)
	AN	12,961	12,832	3,107	3,359	5,863	7,001	2,756 (88.7%)	3,642 (108.4%)
	BN	6,538	6,197	3,056	3,158	3,293	3,539	237 (7.7%)	381 (12.1%)
	D	4,432	3,644	3,031	3,477	3,018	3,701	-14 (-0.5%)	224 (6.5%)
	C	3,215	2,996	3,084	3,630	2,982	3,720	-102 (-3.3%)	91 (2.5%)
	AVG	11,025	10,896	3,147	3,329	5,766	6,676	2,619 (83.2%)	3,348 (100.6%)
OCT	W	7,867	8,287	5,367	8,615	4,744	5,676	-623 (-11.6%)	-2,940 (-34.1%)
	AN	5,518	7,207	4,132	8,846	3,651	5,943	-481 (-11.6%)	-2,904 (-32.8%)
	BN	5,416	6,976	4,486	9,224	3,864	5,632	-622 (-13.9%)	-3,592 (-38.9%)
	D	5,221	5,727	4,018	7,496	3,801	5,274	-217 (-5.4%)	-2,222 (-29.6%)
	C	4,684	4,969	4,541	9,015	3,880	5,496	-660 (-14.5%)	-3,519 (-39%)
	AVG	6,058	6,858	4,619	8,566	4,100	5,593	-518 (-11.2%)	-2,973 (-34.7%)
NOV	W	17,184	15,879	11,461	10,636	11,957	11,172	496 (4.3%)	536 (5%)
	AN	13,102	12,156	7,866	6,298	8,632	8,096	766 (9.7%)	1,798 (28.6%)
	BN	9,448	9,071	5,534	4,870	5,635	5,946	101 (1.8%)	1,076 (22.1%)
	D	8,539	8,061	6,528	5,178	5,804	5,728	-723 (-11.1%)	551 (10.6%)
	C	5,586	5,565	4,409	4,346	4,632	4,674	223 (5.1%)	329 (7.6%)
	AVG	11,671	10,946	7,808	6,898	7,968	7,684	160 (2.1%)	786 (11.4%)
DEC	W	44,292	40,431	42,647	38,576	39,423	36,394	-3,225 (-7.6%)	-2,182 (-5.7%)
	AN	20,375	19,936	18,233	19,338	18,419	18,003	186 (1%)	-1,335 (-6.9%)
	BN	15,099	14,049	14,295	13,609	13,604	13,530	-691 (-4.8%)	-80 (-0.6%)
	D	11,868	11,687	11,786	11,385	11,365	11,101	-421 (-3.6%)	-284 (-2.5%)
	C	7,341	7,186	8,051	7,752	7,572	7,660	-479 (-5.9%)	-92 (-1.2%)
	AVG	23,283	21,753	22,397	21,019	21,121	20,042	-1,276 (-5.7%)	-977 (-4.6%)

	Increase >50%	Increase 25–50%	Increase 10–25%	Increase 5–10%
	Decrease >50%	Decrease 25–50%	Decrease 10–25%	Decrease 5–10%

Table J.3-5. Average Monthly Flows (cfs) by Water Year Type for Feather River Low Flow Channel

M	WY	A1_ELT	A1_LLT	S6_ELT	S6_LLT	A1_ELTvs.S6_ELT	A1_LLTvs.S6_LLT
JAN	W	800	800	800	800	0 (0%)	0 (0%)
	AN	800	800	800	800	0 (0%)	0 (0%)
	BN	800	800	800	800	0 (0%)	0 (0%)
	D	800	800	800	800	0 (0%)	0 (0%)
	C	800	800	800	800	0 (0%)	0 (0%)
	AVG	800	800	800	800	0 (0%)	0 (0%)
FEB	W	800	800	800	800	0 (0%)	0 (0%)
	AN	800	800	800	800	0 (0%)	0 (0%)
	BN	800	800	800	800	0 (0%)	0 (0%)
	D	800	800	800	800	0 (0%)	0 (0%)
	C	800	800	800	800	0 (0%)	0 (0%)

M	WY	A1_ELT	A1_LLT	S6_ELT	S6_LLT	A1_ELTvs.S6_ELT	A1_LLTvs.S6_LLT
	AVG	800	800	800	800	0 (0%)	0 (0%)
MAR	W	800	800	800	800	0 (0%)	0 (0%)
	AN	800	800	800	800	0 (0%)	0 (0%)
	BN	800	800	800	800	0 (0%)	0 (0%)
	D	800	800	800	800	0 (0%)	0 (0%)
	C	800	800	800	800	0 (0%)	0 (0%)
	AVG	800	800	800	800	0 (0%)	0 (0%)
APR	W	700	700	700	700	0 (0%)	0 (0%)
	AN	700	700	700	700	0 (0%)	0 (0%)
	BN	700	700	700	700	0 (0%)	0 (0%)
	D	700	700	700	700	0 (0%)	0 (0%)
	C	700	700	700	700	0 (0%)	0 (0%)
	AVG	700	700	700	700	0 (0%)	0 (0%)
MAY	W	700	700	700	700	0 (0%)	0 (0%)
	AN	700	700	700	700	0 (0%)	0 (0%)
	BN	700	700	700	700	0 (0%)	0 (0%)
	D	700	700	700	700	0 (0%)	0 (0%)
	C	700	700	700	700	0 (0%)	0 (0%)
	AVG	700	700	700	700	0 (0%)	0 (0%)
JUN	W	700	700	700	700	0 (0%)	0 (0%)
	AN	700	700	700	700	0 (0%)	0 (0%)
	BN	700	700	700	700	0 (0%)	0 (0%)
	D	700	700	700	700	0 (0%)	0 (0%)
	C	700	700	700	700	0 (0%)	0 (0%)
	AVG	700	700	700	700	0 (0%)	0 (0%)
JUL	W	700	700	700	700	0 (0%)	0 (0%)
	AN	700	700	700	700	0 (0%)	0 (0%)
	BN	700	700	700	700	0 (0%)	0 (0%)
	D	700	700	700	700	0 (0%)	0 (0%)
	C	700	700	700	700	0 (0%)	0 (0%)
	AVG	700	700	700	700	0 (0%)	0 (0%)
AUG	W	700	700	700	700	0 (0%)	0 (0%)
	AN	700	700	700	700	0 (0%)	0 (0%)
	BN	700	700	700	700	0 (0%)	0 (0%)
	D	700	700	700	700	0 (0%)	0 (0%)
	C	700	700	700	700	0 (0%)	0 (0%)
	AVG	700	700	700	700	0 (0%)	0 (0%)
SEP	W	773	773	773	773	0 (0%)	0 (0%)
	AN	773	773	773	773	0 (0%)	0 (0%)

M	WY	A1_ELT	A1_LLT	S6_ELT	S6_LLT	A1_ELTvs.S6_ELT	A1_LLTvs.S6_LLT
	BN	773	773	773	773	0 (0%)	0 (0%)
	D	773	773	773	773	0 (0%)	0 (0%)
	C	773	773	773	773	0 (0%)	0 (0%)
	AVG	773	773	773	773	0 (0%)	0 (0%)
OCT	W	800	800	800	800	0 (0%)	0 (0%)
	AN	800	800	800	800	0 (0%)	0 (0%)
	BN	800	800	800	800	0 (0%)	0 (0%)
	D	800	800	800	800	0 (0%)	0 (0%)
	C	800	800	800	800	0 (0%)	0 (0%)
	AVG	800	800	800	800	0 (0%)	0 (0%)
NOV	W	800	800	800	800	0 (0%)	0 (0%)
	AN	800	800	800	800	0 (0%)	0 (0%)
	BN	800	800	800	800	0 (0%)	0 (0%)
	D	800	800	800	800	0 (0%)	0 (0%)
	C	800	800	800	800	0 (0%)	0 (0%)
	AVG	800	800	800	800	0 (0%)	0 (0%)
DEC	W	800	800	800	800	0 (0%)	0 (0%)
	AN	800	800	800	800	0 (0%)	0 (0%)
	BN	800	800	800	800	0 (0%)	0 (0%)
	D	800	800	800	800	0 (0%)	0 (0%)
	C	800	800	800	800	0 (0%)	0 (0%)
	AVG	800	800	800	800	0 (0%)	0 (0%)

Table J.3-6. Average Monthly Flows (cfs) by Water Year Type for Feather River at Thermalito

M	WY	EBC2_ELT	EBC2_LLT	A1_ELT	A1_LLT	S6_ELT	S6_LLT	A1_ELT vs. S6_ELT	A1_LLT vs. S6_LLT
JAN	W	11,528	11,896	14,103	14,399	11,597	11,116	-2,506 (-17.8%)	-3,282 (-22.8%)
	AN	3,419	2,838	5,255	4,107	3,435	2,817	-1,820 (-34.6%)	-1,290 (-31.4%)
	BN	1,692	1,441	2,462	1,584	1,403	1,483	-1,059 (-43%)	-101 (-6.4%)
	D	1,477	1,459	1,918	2,168	1,556	1,709	-362 (-18.9%)	-460 (-21.2%)
	C	1,378	1,648	1,840	1,403	1,538	1,444	-302 (-16.4%)	42 (3%)
	AVG	4,970	4,995	6,351	6,118	4,986	4,777	-1,365 (-21.5%)	-1,342 (-21.9%)
FEB	W	13,732	14,787	15,171	16,622	14,159	16,021	-1,012 (-6.7%)	-602 (-3.6%)
	AN	5,793	5,809	8,987	8,138	7,837	7,114	-1,150 (-12.8%)	-1,024 (-12.6%)
	BN	2,280	1,897	3,202	3,281	2,332	2,166	-870 (-27.2%)	-1,114 (-34%)
	D	1,642	1,659	1,964	1,866	1,612	1,617	-353 (-18%)	-249 (-13.3%)
	C	1,467	1,482	1,483	1,829	1,503	1,488	20 (1.3%)	-341 (-18.6%)
	AVG	6,166	6,444	7,320	7,699	6,608	7,063	-712 (-9.7%)	-635 (-8.3%)
MAR	W	13,977	14,772	14,314	14,988	13,730	14,470	-584 (-4.1%)	-518 (-3.5%)
	AN	8,568	8,568	9,517	10,417	9,096	9,783	-421 (-4.4%)	-634 (-6.1%)

M	WY	EBC2_ELT	EBC2_LLT	A1_ELT	A1_LLT	S6_ELT	S6_LLT	A1_ELT vs. S6_ELT	A1_LLT vs. S6_LLT
	BN	2,347	1,985	2,672	2,333	2,039	1,824	-633 (-23.7%)	-510 (-21.8%)
	D	1,521	1,762	2,481	2,172	1,742	1,915	-740 (-29.8%)	-258 (-11.9%)
	C	1,590	1,634	1,670	1,667	1,764	1,804	94 (5.6%)	137 (8.2%)
	AVG	6,653	6,902	7,176	7,396	6,673	7,015	-503 (-7%)	-380 (-5.1%)
APR	W	6,652	6,408	6,770	6,389	6,689	6,399	-81 (-1.2%)	10 (0.2%)
	AN	2,240	2,170	2,233	2,504	2,233	2,208	0 (0%)	-296 (-11.8%)
	BN	1,132	1,203	1,533	2,152	1,131	1,696	-402 (-26.2%)	-457 (-21.2%)
	D	1,448	1,470	2,103	2,681	1,686	2,284	-416 (-19.8%)	-397 (-14.8%)
	C	1,384	1,407	1,827	1,903	1,591	1,756	-236 (-12.9%)	-147 (-7.7%)
	AVG	3,150	3,084	3,464	3,627	3,244	3,400	-220 (-6.4%)	-227 (-6.2%)
MAY	W	6,380	4,740	6,492	5,415	6,370	5,235	-122 (-1.9%)	-180 (-3.3%)
	AN	3,342	3,101	4,322	4,350	4,307	4,116	-15 (-0.4%)	-235 (-5.4%)
	BN	1,316	1,749	3,128	3,667	1,567	3,052	-1,562 (-49.9%)	-616 (-16.8%)
	D	1,862	2,223	2,297	2,552	2,165	2,580	-132 (-5.8%)	28 (1.1%)
	C	1,877	1,790	1,748	1,762	1,742	1,768	-5 (-0.3%)	6 (0.3%)
	AVG	3,420	3,005	3,985	3,798	3,648	3,608	-337 (-8.5%)	-189 (-5%)
JUN	W	3,659	4,211	5,181	5,281	5,852	6,376	670 (12.9%)	1,095 (20.7%)
	AN	3,107	3,930	5,722	6,278	6,415	8,043	692 (12.1%)	1,765 (28.1%)
	BN	3,153	3,552	5,533	5,456	6,965	6,311	1,432 (25.9%)	856 (15.7%)
	D	3,432	3,284	3,593	3,496	4,246	3,865	653 (18.2%)	369 (10.6%)
	C	2,812	2,666	2,646	2,563	2,680	2,709	34 (1.3%)	146 (5.7%)
	AVG	3,318	3,628	4,601	4,667	5,307	5,521	707 (15.4%)	854 (18.3%)
JUL	W	7,835	8,577	5,365	6,392	6,895	7,045	1,530 (28.5%)	653 (10.2%)
	AN	9,434	9,488	7,157	7,576	9,384	8,900	2,227 (31.1%)	1,324 (17.5%)
	BN	8,936	8,833	6,475	6,216	8,287	7,605	1,811 (28%)	1,389 (22.3%)
	D	7,980	8,099	5,997	4,420	5,975	4,787	-22 (-0.4%)	367 (8.3%)
	C	6,144	5,217	3,224	2,936	3,352	3,378	128 (4%)	442 (15.1%)
	AVG	8,041	8,157	5,642	5,597	6,776	6,380	1,134 (20.1%)	783 (14%)
AUG	W	5,462	6,228	4,088	4,584	4,689	4,726	601 (14.7%)	142 (3.1%)
	AN	6,948	7,346	5,636	5,708	6,160	5,770	524 (9.3%)	61 (1.1%)
	BN	6,348	6,868	4,502	4,251	5,696	5,249	1,194 (26.5%)	998 (23.5%)
	D	5,633	4,990	4,265	3,859	3,838	3,620	-427 (-10%)	-240 (-6.2%)
	C	2,236	2,163	2,652	2,034	2,557	2,208	-95 (-3.6%)	174 (8.6%)
	AVG	5,396	5,634	4,214	4,159	4,577	4,356	363 (8.6%)	197 (4.7%)
SEP	W	8,400	8,327	1,263	1,172	6,737	7,231	5,474 (433.5%)	6,058 (516.9%)
	AN	7,172	6,899	1,680	1,902	5,511	5,215	3,830 (228%)	3,313 (174.2%)
	BN	3,161	3,068	1,353	1,455	1,608	1,470	255 (18.9%)	15 (1%)
	D	1,473	1,052	1,668	1,658	1,264	1,275	-404 (-24.2%)	-383 (-23.1%)
	C	1,451	1,345	1,715	1,744	1,789	1,693	74 (4.3%)	-51 (-2.9%)
	AVG	4,788	4,601	1,494	1,518	3,756	3,835	2,262 (151.4%)	2,317 (152.7%)

M	WY	EBC2_ELT	EBC2_LLT	A1_ELT	A1_LLT	S6_ELT	S6_LLT	A1_ELT vs. S6_ELT	A1_LLT vs. S6_LLT
OCT	W	3,025	3,051	3,153	3,260	3,245	3,116	92 (2.9%)	-144 (-4.4%)
	AN	2,577	2,741	3,361	3,303	2,779	3,221	-582 (-17.3%)	-83 (-2.5%)
	BN	2,820	2,862	3,211	3,043	3,012	2,747	-199 (-6.2%)	-296 (-9.7%)
	D	2,786	2,652	2,958	3,220	3,266	3,090	308 (10.4%)	-130 (-4%)
	C	2,233	2,102	2,924	3,506	2,381	2,924	-543 (-18.6%)	-582 (-16.6%)
	AVG	2,756	2,747	3,117	3,256	3,015	3,035	-102 (-3.3%)	-222 (-6.8%)
NOV	W	2,812	2,470	2,860	2,747	2,847	2,391	-13 (-0.5%)	-356 (-13%)
	AN	1,915	2,119	2,114	1,915	1,916	1,858	-198 (-9.4%)	-57 (-3%)
	BN	1,950	1,900	1,762	1,854	1,930	1,824	168 (9.5%)	-29 (-1.6%)
	D	1,729	1,664	1,801	1,811	1,764	1,737	-38 (-2.1%)	-74 (-4.1%)
	C	1,803	1,876	1,901	2,016	1,845	1,970	-56 (-2.9%)	-46 (-2.3%)
	AVG	2,148	2,058	2,191	2,160	2,170	2,011	-21 (-1%)	-149 (-6.9%)
DEC	W	5,543	3,948	7,691	5,927	5,339	4,617	-2,353 (-30.6%)	-1,310 (-22.1%)
	AN	3,344	3,344	3,382	4,443	3,479	3,096	97 (2.9%)	-1,347 (-30.3%)
	BN	2,096	2,102	2,732	2,748	2,135	2,268	-597 (-21.9%)	-480 (-17.5%)
	D	2,202	2,229	2,865	2,690	2,337	2,173	-528 (-18.4%)	-517 (-19.2%)
	C	1,781	1,694	2,759	2,889	2,237	1,684	-521 (-18.9%)	-1,204 (-41.7%)
	AVG	3,349	2,837	4,433	4,012	3,407	3,028	-1,026 (-23.1%)	-984 (-24.5%)

	Increase >50%	Increase 25–50%	Increase 10–25%	Increase 5–10%
	Decrease >50%	Decrease 25–50%	Decrease 10–25%	Decrease 5–10%

Table J.3-7. Average Monthly Flows (cfs) by Water Year Type for American River at Confluence

M	WY	A1_ELT	A1_LLT	S6_ELT	S6_LLT	A1_ELTvs.S6_ELT	A1_LLTvs.S6_LLT
JAN	W	10,021	10,932	10,029	10,936	8 (0.1%)	4 (0%)
	AN	4,968	5,764	4,930	5,766	-38 (-0.8%)	2 (0%)
	BN	2,049	2,063	1,989	1,947	-61 (-3%)	-115 (-5.6%)
	D	1,551	1,458	1,448	1,360	-103 (-6.6%)	-97 (-6.7%)
	C	1,215	1,027	1,228	1,154	12 (1%)	127 (12.3%)
	AVG	4,773	5,132	4,739	5,111	-34 (-0.7%)	-21 (-0.4%)
FEB	W	10,336	10,967	10,326	10,951	-10 (-0.1%)	-15 (-0.1%)
	AN	7,589	8,280	7,462	8,167	-127 (-1.7%)	-113 (-1.4%)
	BN	4,806	5,100	4,680	4,920	-127 (-2.6%)	-181 (-3.5%)
	D	1,682	1,835	1,665	1,882	-18 (-1.1%)	48 (2.6%)
	C	1,057	970	1,041	960	-16 (-1.5%)	-10 (-1%)
	AVG	5,732	6,104	5,683	6,061	-50 (-0.9%)	-43 (-0.7%)
MAR	W	6,301	6,832	6,303	6,834	2 (0%)	2 (0%)
	AN	5,687	5,739	5,691	5,718	5 (0.1%)	-21 (-0.4%)
	BN	2,558	2,565	2,527	2,675	-32 (-1.2%)	111 (4.3%)
	D	2,163	2,022	2,189	2,099	26 (1.2%)	78 (3.8%)
	C	749	759	769	778	19 (2.6%)	19 (2.5%)

M	WY	A1_ELT	A1_LLT	S6_ELT	S6_LLT	A1_ELTvs.S6_ELT	A1_LLTvs.S6_LLT
	AVG	3,851	3,999	3,856	4,035	4 (0.1%)	36 (0.9%)
APR	W	5,162	5,310	5,163	5,306	2 (0%)	-4 (-0.1%)
	AN	3,131	3,117	3,132	3,080	1 (0%)	-36 (-1.2%)
	BN	2,913	2,966	2,953	2,801	40 (1.4%)	-164 (-5.5%)
	D	1,717	1,802	1,630	1,630	-88 (-5.1%)	-172 (-9.5%)
	C	1,046	1,094	1,086	1,031	39 (3.8%)	-63 (-5.8%)
	AVG	3,122	3,202	3,116	3,120	-6 (-0.2%)	-82 (-2.5%)
MAY	W	5,433	4,459	5,413	4,435	-20 (-0.4%)	-24 (-0.5%)
	AN	3,125	2,708	3,148	2,768	22 (0.7%)	60 (2.2%)
	BN	2,472	2,273	2,471	2,175	-1 (0%)	-97 (-4.3%)
	D	1,558	1,901	1,484	1,867	-73 (-4.7%)	-34 (-1.8%)
	C	917	806	851	800	-66 (-7.2%)	-6 (-0.7%)
	AVG	3,078	2,733	3,049	2,710	-29 (-0.9%)	-24 (-0.9%)
JUN	W	4,743	4,261	4,494	4,214	-250 (-5.3%)	-48 (-1.1%)
	AN	3,463	3,566	3,165	3,360	-298 (-8.6%)	-206 (-5.8%)
	BN	3,282	3,483	3,082	3,267	-200 (-6.1%)	-216 (-6.2%)
	D	2,632	2,272	2,816	2,470	184 (7%)	198 (8.7%)
	C	1,382	1,026	1,040	1,036	-342 (-24.8%)	9 (0.9%)
	AVG	3,351	3,117	3,185	3,079	-167 (-5%)	-37 (-1.2%)
JUL	W	3,446	3,223	3,521	3,267	75 (2.2%)	45 (1.4%)
	AN	4,178	3,954	4,271	4,293	93 (2.2%)	339 (8.6%)
	BN	3,658	3,363	4,339	3,699	681 (18.6%)	336 (10%)
	D	2,596	2,209	2,991	2,446	394 (15.2%)	237 (10.7%)
	C	1,141	1,651	1,694	1,980	553 (48.5%)	329 (19.9%)
	AVG	3,066	2,901	3,387	3,122	321 (10.5%)	221 (7.6%)
AUG	W	2,077	1,887	2,133	1,891	55 (2.7%)	3 (0.2%)
	AN	1,684	1,534	1,766	1,490	82 (4.8%)	-44 (-2.9%)
	BN	1,834	1,362	1,886	1,525	51 (2.8%)	163 (12%)
	D	1,270	1,071	1,150	1,061	-119 (-9.4%)	-10 (-0.9%)
	C	598	744	877	605	280 (46.8%)	-139 (-18.7%)
	AVG	1,585	1,400	1,638	1,399	53 (3.3%)	0 (0%)
SEP	W	2,329	1,699	3,165	2,758	836 (35.9%)	1,060 (62.4%)
	AN	1,417	1,296	1,893	1,659	476 (33.6%)	363 (28%)
	BN	1,305	1,166	1,257	1,179	-47 (-3.6%)	13 (1.1%)
	D	1,135	949	1,168	984	32 (2.9%)	35 (3.7%)
	C	981	421	535	447	-447 (-45.5%)	26 (6.2%)
	AVG	1,561	1,197	1,830	1,600	268 (17.2%)	403 (33.7%)
OCT	W	1,415	1,695	1,470	1,343	55 (3.9%)	-352 (-20.8%)
	AN	1,334	1,855	1,369	1,506	36 (2.7%)	-349 (-18.8%)
	BN	1,502	2,042	1,622	1,770	120 (8%)	-272 (-13.3%)

M	WY	A1_ELT	A1_LLT	S6_ELT	S6_LLT	A1_ELTvs.S6_ELT	A1_LLTvs.S6_LLT
	D	1,156	1,579	1,223	1,282	67 (5.8%)	-297 (-18.8%)
	C	1,381	1,945	1,564	1,522	182 (13.2%)	-423 (-21.8%)
	AVG	1,356	1,789	1,441	1,453	85 (6.2%)	-336 (-18.8%)
NOV	W	3,208	2,504	2,862	2,424	-346 (-10.8%)	-80 (-3.2%)
	AN	2,696	2,019	2,769	2,341	73 (2.7%)	322 (16%)
	BN	2,070	1,544	1,609	1,600	-462 (-22.3%)	56 (3.6%)
	D	1,655	1,291	1,604	1,401	-51 (-3.1%)	110 (8.5%)
	C	1,823	1,540	1,576	1,360	-247 (-13.6%)	-179 (-11.6%)
	AVG	2,395	1,862	2,170	1,891	-225 (-9.4%)	29 (1.6%)
DEC	W	7,035	6,379	6,719	6,028	-316 (-4.5%)	-351 (-5.5%)
	AN	2,950	2,899	2,950	2,846	0 (0%)	-52 (-1.8%)
	BN	3,049	2,628	2,918	2,618	-132 (-4.3%)	-10 (-0.4%)
	D	1,508	1,273	1,487	1,272	-21 (-1.4%)	-1 (-0.1%)
	C	1,385	1,156	1,360	1,317	-25 (-1.8%)	161 (13.9%)
	AVG	3,717	3,344	3,586	3,247	-131 (-3.5%)	-97 (-2.9%)

		Increase >50%	Increase 25–50%	Increase 10–25%	Increase 5–10%
		Decrease >50%	Decrease 25–50%	Decrease 10–25%	Decrease 5–10%

Table J.3-8. Average Monthly Flows (cfs) by Water Year Type for San Joaquin River at Vernalis

M	WY	A1_ELT	A1_LLT	S6_ELT	S6_LLT	A1_ELTvs.S6_ELT	A1_LLTvs.S6_LLT
JAN	W	9,890	9,811	9,905	9,689	15 (0.2%)	-122 (-1.2%)
	AN	5,825	6,011	5,808	5,968	-17 (-0.3%)	-43 (-0.7%)
	BN	2,321	2,255	2,285	2,182	-36 (-1.5%)	-73 (-3.2%)
	D	2,229	2,236	2,246	2,222	17 (0.8%)	-14 (-0.6%)
	C	1,603	1,592	1,598	1,591	-4 (-0.3%)	0 (0%)
	AVG	5,065	5,067	5,062	5,009	-3 (-0.1%)	-58 (-1.1%)
FEB	W	13,995	13,196	13,998	13,181	3 (0%)	-14 (-0.1%)
	AN	7,100	6,680	7,065	6,678	-34 (-0.5%)	-2 (0%)
	BN	2,921	2,849	2,935	2,853	14 (0.5%)	4 (0.2%)
	D	2,312	2,246	2,312	2,245	0 (0%)	0 (0%)
	C	1,943	1,943	1,943	1,942	0 (0%)	-1 (-0.1%)
	AVG	6,690	6,352	6,687	6,348	-4 (-0.1%)	-4 (-0.1%)
MAR	W	15,137	15,234	15,127	15,230	-10 (-0.1%)	-4 (0%)
	AN	6,252	6,365	6,251	6,365	-1 (0%)	0 (0%)
	BN	2,615	2,476	2,614	2,476	-1 (0%)	0 (0%)
	D	2,192	2,146	2,191	2,146	-1 (0%)	0 (0%)
	C	1,689	1,688	1,689	1,688	0 (0%)	0 (0%)
	AVG	6,742	6,763	6,738	6,762	-3 (-0.1%)	-1 (0%)
APR	W	12,181	12,458	12,187	12,462	5 (0%)	4 (0%)

M	WY	A1_ELT	A1_LLT	S6_ELT	S6_LLT	A1_ELTvs.S6_ELT	A1_LLTvs.S6_LLT
	AN	5,970	6,044	5,970	6,043	-1 (0%)	-1 (0%)
	BN	4,163	3,924	4,162	3,923	-1 (0%)	-1 (0%)
	D	3,381	3,113	3,380	3,112	-2 (-0.1%)	-1 (0%)
	C	1,846	1,797	1,844	1,796	-1 (-0.1%)	-1 (0%)
	AVG	6,286	6,292	6,287	6,292	1 (0%)	0 (0%)
MAY	W	13,214	12,636	13,196	12,633	-18 (-0.1%)	-2 (0%)
	AN	5,280	5,094	5,279	5,092	-2 (0%)	-2 (0%)
	BN	3,877	3,662	3,874	3,659	-3 (-0.1%)	-2 (-0.1%)
	D	3,046	2,825	3,041	2,823	-5 (-0.2%)	-2 (-0.1%)
	C	1,821	1,799	1,819	1,797	-2 (-0.1%)	-2 (-0.1%)
	AVG	6,351	6,072	6,343	6,069	-7 (-0.1%)	-2 (0%)
JUN	W	9,254	6,822	9,253	6,820	-1 (0%)	-2 (0%)
	AN	2,784	2,682	2,784	2,680	-1 (0%)	-2 (-0.1%)
	BN	1,968	1,876	1,965	1,873	-3 (-0.2%)	-3 (-0.1%)
	D	1,368	1,295	1,362	1,292	-6 (-0.4%)	-4 (-0.3%)
	C	977	956	975	956	-2 (-0.2%)	-1 (-0.1%)
	AVG	3,971	3,209	3,969	3,207	-2 (-0.1%)	-2 (-0.1%)
JUL	W	5,906	4,350	5,904	4,348	-2 (0%)	-2 (-0.1%)
	AN	1,814	1,808	1,811	1,805	-3 (-0.1%)	-3 (-0.2%)
	BN	1,447	1,392	1,440	1,387	-7 (-0.5%)	-6 (-0.4%)
	D	1,156	1,107	1,147	1,101	-9 (-0.8%)	-6 (-0.5%)
	C	870	860	869	858	-1 (-0.1%)	-2 (-0.2%)
	AVG	2,665	2,190	2,661	2,186	-4 (-0.1%)	-3 (-0.2%)
AUG	W	3,053	2,648	3,052	2,647	-1 (0%)	-2 (-0.1%)
	AN	1,770	1,704	1,768	1,702	-2 (-0.1%)	-2 (-0.1%)
	BN	1,435	1,383	1,429	1,379	-5 (-0.4%)	-4 (-0.3%)
	D	1,279	1,230	1,273	1,226	-6 (-0.5%)	-4 (-0.3%)
	C	994	988	993	987	-1 (-0.1%)	-1 (-0.1%)
	AVG	1,863	1,715	1,860	1,712	-3 (-0.1%)	-2 (-0.1%)
SEP	W	3,308	3,129	3,306	3,128	-1 (0%)	-1 (0%)
	AN	2,224	2,167	2,223	2,166	-1 (0%)	-1 (0%)
	BN	1,805	1,752	1,803	1,750	-2 (-0.1%)	-2 (-0.1%)
	D	1,695	1,645	1,692	1,643	-3 (-0.2%)	-2 (-0.1%)
	C	1,392	1,379	1,392	1,379	0 (0%)	1 (0%)
	AVG	2,228	2,146	2,227	2,145	-1 (-0.1%)	-1 (0%)
OCT	W	2,721	2,744	2,714	2,681	-7 (-0.2%)	-63 (-2.3%)
	AN	2,638	2,596	2,638	2,595	-1 (0%)	0 (0%)
	BN	2,413	2,349	2,412	2,348	-1 (0%)	0 (0%)
	D	2,850	2,792	2,850	2,791	-1 (0%)	0 (0%)

M	WY	A1_ELT	A1_LLT	S6_ELT	S6_LLT	A1_ELTvs.S6_ELT	A1_LLTvs.S6_LLT
	C	2,163	2,032	2,163	2,028	-1 (0%)	-4 (-0.2%)
	AVG	2,568	2,521	2,565	2,502	-2 (-0.1%)	-19 (-0.8%)
NOV	W	2,516	2,418	2,516	2,415	0 (0%)	-3 (-0.1%)
	AN	3,238	3,208	3,204	3,202	-34 (-1%)	-5 (-0.2%)
	BN	2,224	1,997	2,222	1,995	-1 (-0.1%)	-2 (-0.1%)
	D	2,290	2,253	2,277	2,220	-12 (-0.5%)	-33 (-1.5%)
	C	1,912	1,898	1,911	1,898	0 (0%)	0 (0%)
	AVG	2,457	2,378	2,448	2,370	-9 (-0.4%)	-7 (-0.3%)
DEC	W	4,874	4,556	4,857	4,511	-18 (-0.4%)	-45 (-1%)
	AN	5,026	4,593	5,006	4,601	-20 (-0.4%)	7 (0.2%)
	BN	2,149	2,060	2,134	2,062	-15 (-0.7%)	1 (0.1%)
	D	2,078	2,163	2,069	2,153	-9 (-0.4%)	-10 (-0.5%)
	C	1,689	1,694	1,696	1,681	7 (0.4%)	-13 (-0.8%)
	AVG	3,407	3,230	3,395	3,214	-12 (-0.3%)	-16 (-0.5%)

	Increase >50%	Increase 25–50%	Increase 10–25%	Increase 5–10%
	Decrease >50%	Decrease 25–50%	Decrease 10–25%	Decrease 5–10%

Table J.3-9. Average Monthly Flows (cfs) by Water Year Type for Old and Middle River (OMR) (Water Year Type is San Joaquin River)

M	WY	EBC2_ELT	EBC2_LLT	A1_ELT	A1_LLT	S6_ELT	S6_LLT	A1_ELTvs.S6_ELT	A1_LLTvs.S6_LLT
JAN	W	(1,808)	(1,476)	4,150	4,159	3,804	3,567	-347 (-8.4%)	-593 (-14.2%)
	AN	(3,465)	(3,405)	(118)	205	(108)	(64)	10 (-8.7%)	-269 (-131.3%)
	BN	(4,349)	(4,124)	(2,557)	(2,079)	(1,705)	(1,320)	853 (-33.3%)	760 (-36.5%)
	D	(4,312)	(4,661)	(4,221)	(3,376)	(1,767)	(2,298)	2,454 (-58.1%)	1,078 (-31.9%)
	C	(4,076)	(3,788)	(3,990)	(2,076)	(2,828)	(2,554)	1,162 (-29.1%)	-477 (23%)
	AVG	(3,373)	(3,228)	(662)	(13)	(10)	(40)	652 (-98.5%)	-28 (221.4%)
FEB	W	(1,256)	(1,683)	7,252	6,508	6,832	6,104	-420 (-5.8%)	-404 (-6.2%)
	AN	(4,146)	(4,026)	2,247	2,119	853	878	-1,394 (-62%)	-1,241 (-58.6%)
	BN	(3,560)	(3,564)	(1,096)	(1,738)	(2,049)	(1,865)	-953 (86.9%)	-127 (7.3%)
	D	(4,089)	(3,490)	(3,034)	(2,706)	(2,962)	(2,882)	72 (-2.4%)	-176 (6.5%)
	C	(3,162)	(2,909)	(2,968)	(2,895)	(3,041)	(2,545)	-73 (2.5%)	350 (-12.1%)
	AVG	(3,006)	(2,964)	1,327	1,049	778	709	-549 (-41.4%)	-340 (-32.4%)
MAR	W	(954)	(759)	7,724	7,779	7,025	7,074	-699 (-9%)	-705 (-9.1%)
	AN	(4,339)	(4,411)	1,631	1,517	283	178	-1,348 (-82.6%)	-1,338 (-88.2%)
	BN	(4,183)	(3,576)	(1,589)	(921)	(1,709)	(1,588)	-120 (7.5%)	-667 (72.4%)
	D	(3,000)	(2,769)	(2,045)	(1,773)	(2,261)	(2,116)	-216 (10.6%)	-343 (19.4%)
	C	(2,184)	(2,040)	(1,951)	(1,544)	(2,207)	(1,993)	-257 (13.2%)	-448 (29%)
	AVG	(2,691)	(2,487)	1,622	1,844	1,051	1,129	-571 (-35.2%)	-715 (-38.8%)

M	WY	EBC2_ELT	EBC2_LLT	A1_ELT	A1_LLT	S6_ELT	S6_LLT	A1_ELTvs.S6_ELT	A1_LLTvs.S6_LLT
APR	W	2,677	2,740	4,173	4,518	3,448	3,536	-725 (-17.4%)	-982 (-21.7%)
	AN	1,104	957	(681)	(745)	369	366	1,050 (-154.2%)	1,111 (-149.1%)
	BN	163	(380)	(1,662)	(1,565)	(650)	(620)	1,012 (-60.9%)	945 (-60.4%)
	D	(786)	(702)	(2,004)	(1,667)	(1,197)	(1,473)	807 (-40.3%)	194 (-11.7%)
	C	(949)	(812)	(1,483)	(1,462)	(1,477)	(1,224)	6 (-0.4%)	238 (-16.3%)
	AVG	715	659	218	379	500	536	282 (129.5%)	157 (41.3%)
MAY	W	2,066	1,942	3,969	3,781	3,444	3,164	-524 (-13.2%)	-616 (-16.3%)
	AN	421	317	(2,007)	(1,356)	(165)	(143)	1,842 (-91.8%)	1,212 (-89.4%)
	BN	(214)	(607)	(1,299)	(1,426)	(756)	(547)	543 (-41.8%)	879 (-61.6%)
	D	(980)	(1,121)	(1,450)	(1,149)	(1,340)	(1,295)	111 (-7.6%)	-146 (12.7%)
	C	(1,207)	(1,030)	(1,181)	(965)	(1,241)	(1,160)	-60 (5.1%)	-195 (20.2%)
	AVG	262	155	104	246	402	380	298 (287.4%)	134 (54.7%)
JUN	W	(4,289)	(4,401)	(329)	(168)	966	38	1,295 (-393.9%)	206 (-122.4%)
	AN	(4,049)	(3,998)	(2,910)	(2,223)	(3,095)	(2,731)	-185 (6.4%)	-508 (22.9%)
	BN	(4,045)	(3,547)	(2,882)	(2,648)	(3,203)	(2,835)	-322 (11.2%)	-186 (7%)
	D	(2,743)	(2,572)	(2,123)	(1,966)	(2,420)	(2,090)	-297 (14%)	-124 (6.3%)
	C	(2,615)	(2,384)	(1,932)	(2,003)	(2,139)	(2,146)	-208 (10.8%)	-143 (7.1%)
	AVG	(3,632)	(3,504)	(1,834)	(1,605)	(1,630)	(1,721)	204 (-11.1%)	-116 (7.2%)
JUL	W	(8,930)	(8,906)	(4,145)	(5,522)	(5,851)	(6,162)	-1,707 (41.2%)	-640 (11.6%)
	AN	(9,346)	(8,038)	(4,967)	(4,019)	(7,040)	(5,296)	-2,073 (41.7%)	-1,278 (31.8%)
	BN	(9,824)	(9,699)	(6,006)	(5,663)	(7,321)	(6,967)	-1,315 (21.9%)	-1,304 (23%)
	D	(10,122)	(8,980)	(7,017)	(4,928)	(7,736)	(6,093)	-720 (10.3%)	-1,164 (23.6%)
	C	(7,738)	(6,853)	(3,649)	(3,174)	(4,474)	(3,606)	-825 (22.6%)	-432 (13.6%)
	AVG	(9,110)	(8,473)	(4,959)	(4,699)	(6,346)	(5,611)	-1,388 (28%)	-912 (19.4%)
AUG	W	(10,217)	(10,246)	(4,561)	(4,616)	(5,247)	(4,792)	-685 (15%)	-175 (3.8%)
	AN	(9,984)	(9,896)	(3,939)	(4,220)	(5,459)	(4,819)	-1,520 (38.6%)	-599 (14.2%)
	BN	(10,072)	(9,957)	(5,074)	(4,636)	(5,942)	(5,626)	-868 (17.1%)	-991 (21.4%)
	D	(8,476)	(7,773)	(4,949)	(4,572)	(5,635)	(5,066)	-687 (13.9%)	-494 (10.8%)
	C	(5,033)	(4,423)	(3,594)	(3,210)	(3,899)	(3,552)	-305 (8.5%)	-342 (10.7%)
	AVG	(8,861)	(8,604)	(4,394)	(4,261)	(5,197)	(4,731)	-803 (18.3%)	-470 (11%)
SEP	W	(8,138)	(7,345)	(3,960)	(4,578)	607	710	4,567 (-115.3%)	5,288 (-115.5%)
	AN	(9,035)	(8,519)	(4,906)	(4,668)	(1,371)	(1,417)	3,535 (-72%)	3,251 (-69.6%)
	BN	(8,291)	(8,000)	(4,498)	(4,583)	(2,083)	(3,059)	2,415 (-53.7%)	1,524 (-33.3%)
	D	(6,296)	(5,820)	(4,367)	(4,097)	(4,038)	(4,269)	329 (-7.5%)	-172 (4.2%)
	C	(4,952)	(4,433)	(4,248)	(3,009)	(3,869)	(2,781)	379 (-8.9%)	228 (-7.6%)
	AVG	(7,423)	(6,868)	(4,351)	(4,214)	(1,815)	(1,773)	2,536 (-58.3%)	2,441 (-57.9%)
OCT	W	(5,229)	(4,553)	(5,360)	(5,083)	(1,733)	(1,514)	3,741(-72.9%)	3,948(-78.2%)
	AN	(6,040)	(4,872)	(5,129)	(4,324)	(1,653)	(1,133)	3,476 (-67.8%)	3,190 (-73.8%)
	BN	(4,982)	(4,183)	(5,355)	(5,185)	(1,383)	(1,087)	3,972 (-74.2%)	4,098 (-79%)
	D	(4,818)	(4,660)	(5,537)	(5,390)	(1,433)	(1,157)	4,104 (-74.1%)	4,232 (-78.5%)
	C	(5,050)	(3,804)	(5,013)	(4,337)	(1,946)	(1,798)	3,067 (-61.2%)	2,539 (-58.5%)

M	WY	EBC2_ELT	EBC2_LLT	A1_ELT	A1_LLT	S6_ELT	S6_LLT	A1_ELTvs.S6_ELT	A1_LLTvs.S6_LLT
	AVG	(5,248)	(4,427)	(5,274)	(4,854)	(1,656)	(1,371)	3,618 (-68.6%)	3,483 (-71.8%)
NOV	W	(6,553)	(6,138)	(5,453)	(4,761)	(2,007)	(1,815)	3,446 (-63.2%)	2,946 (-61.9%)
	AN	(7,107)	(6,742)	(4,496)	(4,160)	(2,140)	(2,018)	2,356 (-52.4%)	2,141 (-51.5%)
	BN	(5,734)	(4,855)	(5,683)	(4,958)	(1,643)	(1,406)	4,040 (-71.1%)	3,552 (-71.6%)
	D	(5,739)	(5,582)	(5,868)	(4,976)	(1,223)	(1,222)	4,644 (-79.2%)	3,754 (-75.4%)
	C	(4,339)	(4,453)	(4,930)	(3,969)	(2,923)	(2,693)	2,008 (-40.7%)	1,276 (-32.1%)
	AVG	(5,970)	(5,636)	(5,266)	(4,555)	(2,030)	(1,867)	3,237 (-61.5%)	2,687 (-59%)
DEC	W	(6,270)	(6,110)	(3,304)	(3,746)	(3,152)	(3,350)	153 (-4.6%)	396 (-10.6%)
	AN	(5,621)	(5,758)	(2,825)	(3,692)	(2,753)	(3,303)	72 (-2.6%)	389 (-10.5%)
	BN	(7,173)	(6,901)	(6,471)	(6,291)	(5,789)	(5,737)	682 (-10.5%)	553 (-8.8%)
	D	(8,371)	(7,820)	(7,123)	(7,422)	(6,651)	(6,117)	473 (-6.6%)	1,306 (-17.6%)
	C	(5,472)	(4,661)	(5,600)	(5,410)	(5,860)	(5,148)	-260 (4.6%)	261 (-4.8%)
	AVG	(6,464)	(6,155)	(4,766)	(5,046)	(4,575)	(4,509)	191 (-4%)	537 (-10.7%)
		Note: OMR flow more positive (negative % change) is better.							

	Increase >50%	Increase 25–50%	Increase 10–25%	Increase 5–10%
	Decrease >50%	Decrease 25–50%	Decrease 10–25%	Decrease 5–10%

Table J.3-10. Average Monthly Flows (cfs) by Water Year Type for Delta Outflow

M	WY	EBC2_ELT	EBC2_LLT	A1_ELT	A1_LLT	S6_ELT	S6_LLT	A1_ELT vs. S6_ELT	A1_LLT vs. S6_LLT
JAN	W	91,158	94,620	91,537	93,735	88,075	89,743	-3,462 (-3.8%)	-3,992 (-4.3%)
	AN	48,959	51,100	47,621	48,196	46,463	47,604	-1,158 (-2.4%)	-592 (-1.2%)
	BN	22,263	22,301	21,336	21,763	22,090	21,243	754 (3.5%)	-520 (-2.4%)
	D	14,754	14,732	13,634	15,816	15,554	15,291	1,919 (14.1%)	-526 (-3.3%)
	C	12,173	12,651	11,354	12,882	12,464	13,294	1,110 (9.8%)	412 (3.2%)
	AVG	44,889	46,372	44,290	45,847	43,735	44,350	-555 (-1.3%)	-1,496 (-3.3%)
FEB	W	104,533	107,085	106,071	107,800	102,917	105,519	-3,154 (-3%)	-2,280 (-2.1%)
	AN	64,163	65,873	66,184	65,435	64,164	63,432	-2,020 (-3.1%)	-2,003 (-3.1%)
	BN	37,266	36,084	35,985	35,010	34,128	33,176	-1,857 (-5.2%)	-1,834 (-5.2%)
	D	20,936	21,461	18,637	19,127	19,084	19,767	446 (2.4%)	640 (3.3%)
	C	12,553	12,798	11,919	12,373	12,541	12,617	622 (5.2%)	245 (2%)
	AVG	55,330	56,338	55,297	55,743	53,873	54,590	-1,424 (-2.6%)	-1,153 (-2.1%)
MAR	W	81,693	84,471	82,703	84,947	80,262	82,842	-2440 (-3%)	-2106 (-2.5%)
	AN	55,754	56,737	54,328	54,848	53,426	54,465	-902 (-1.7%)	-382 (-0.7%)
	BN	22,522	22,467	21,382	21,443	20,625	19,914	-757 (-3.5%)	-1,529 (-7.1%)
	D	19,388	19,985	16,912	17,264	16,772	16,996	-140 (-0.8%)	-268 (-1.6%)
	C	11,948	12,215	11,308	11,551	11,529	11,806	222 (2%)	255 (2.2%)
	AVG	43,911	45,097	43,191	44,102	42,158	43,096	-1,033 (-2.4%)	-1,006 (-2.3%)
APR	W	54,860	54,562	48,665	48,246	48,765	48,560	100 (0.2%)	314 (0.7%)
	AN	31,183	30,576	24,174	24,457	25,036	24,901	862 (3.6%)	444 (1.8%)
	BN	21,218	20,641	16,506	16,714	18,162	18,125	1,656 (10%)	1,411 (8.4%)

M	WY	EBC2_ELT	EBC2_LLT	A1_ELT	A1_LLT	S6_ELT	S6_LLT	A1_ELT vs. S6_ELT	A1_LLT vs. S6_LLT
	D	13,450	13,413	11,417	12,324	11,989	12,682	572 (5%)	358 (2.9%)
	C	8,881	9,294	8,537	9,012	8,649	8,890	112 (1.3%)	-122 (-1.4%)
	AVG	29,833	29,603	25,542	25,754	26,124	26,221	583 (2.3%)	466 (1.8%)
MAY	W	38,276	32,880	31,850	27,984	32,714	28,585	864 (2.7%)	601 (2.1%)
	AN	23,131	21,709	17,683	16,919	19,635	18,855	1,952 (11%)	1,936 (11.4%)
	BN	14,740	13,596	11,506	12,204	13,683	13,896	2,177 (18.9%)	1,692 (13.9%)
	D	9,737	10,375	9,103	10,508	9,397	11,047	294 (3.2%)	539 (5.1%)
	C	6,341	6,286	6,037	6,196	6,098	6,263	61 (1%)	67 (1.1%)
	AVG	21,103	19,121	17,532	16,646	18,537	17,537	1,005 (5.7%)	891 (5.4%)
JUN	W	18,080	15,640	16,890	15,739	17,598	15,593	708 (4.2%)	-146 (-0.9%)
	AN	10,177	10,676	10,048	10,625	10,559	10,806	511 (5.1%)	182 (1.7%)
	BN	8,067	8,943	8,702	9,688	8,781	9,575	80 (0.9%)	-113 (-1.2%)
	D	7,123	7,689	7,512	7,844	7,389	7,821	-123 (-1.6%)	-23 (-0.3%)
	C	5,345	5,632	5,345	5,365	5,331	5,321	-13 (-0.2%)	-44 (-0.8%)
	AVG	10,945	10,560	10,743	10,706	11,026	10,656	284 (2.6%)	-51 (-0.5%)
JUL	W	10,817	11,407	9,266	9,186	9,402	9,277	136 (1.5%)	92 (1%)
	AN	10,657	12,225	8,575	8,891	9,022	9,312	447 (5.2%)	421 (4.7%)
	BN	7,613	7,668	6,482	6,388	6,819	6,822	337 (5.2%)	434 (6.8%)
	D	5,548	6,448	5,406	5,397	5,436	5,433	30 (0.6%)	35 (0.7%)
	C	4,953	5,832	4,219	5,344	4,331	5,449	112 (2.7%)	105 (2%)
	AVG	8,232	8,984	7,104	7,271	7,293	7,459	189 (2.7%)	188 (2.6%)
AUG	W	4,412	4,308	4,202	4,000	4,200	4,000	-2 (0%)	0 (0%)
	AN	4,009	4,713	4,000	4,175	4,004	4,117	4 (0.1%)	-57 (-1.4%)
	BN	4,120	5,129	3,857	4,088	3,950	4,255	92 (2.4%)	166 (4.1%)
	D	4,617	5,348	3,687	4,470	3,693	4,571	7 (0.2%)	101 (2.3%)
	C	4,141	4,433	3,396	3,919	3,644	3,989	248 (7.3%)	69 (1.8%)
	AVG	4,308	4,754	3,882	4,132	3,936	4,184	54 (1.4%)	52 (1.3%)
SEP	W	18,873	20,078	5,096	4,185	19,715	21,496	14,620 (286.9%)	17,311 (413.6%)
	AN	11,810	11,581	3,154	3,077	11,992	12,799	8,838 (280.2%)	9,721 (315.9%)
	BN	3,795	3,428	3,000	3,190	3,612	3,327	612 (20.4%)	137 (4.3%)
	D	3,067	3,021	3,000	3,979	3,000	3,975	0 (0%)	-4 (-0.1%)
	C	3,000	3,036	3,035	5,689	3,000	5,905	-35 (-1.2%)	217 (3.8%)
	AVG	9,473	9,754	3,692	4,028	9,720	10,994	6,028 (163.3%)	6,966 (173%)
OCT	W	8,133	9,520	5,830	9,685	8,842	10,423	3,012 (51.7%)	737 (7.6%)
	AN	6,500	8,982	4,161	9,717	7,319	9,893	3,157 (75.9%)	175 (1.8%)
	BN	6,206	8,054	4,448	10,487	7,735	9,859	3,287 (73.9%)	-627 (-6%)
	D	6,017	7,294	4,565	8,757	7,467	8,940	2,903 (63.6%)	182 (2.1%)
	C	4,969	6,607	4,724	10,195	6,772	8,894	2,048 (43.4%)	-1,302 (-12.8%)
	AVG	6,638	8,276	4,910	9,698	7,826	9,700	2,915 (59.4%)	2 (0%)
NOV	W	17,346	15,987	13,185	12,336	17,032	15,785	3,847 (29.2%)	3,449 (28%)

M	WY	EBC2_ELT	EBC2_LLT	A1_ELT	A1_LLT	S6_ELT	S6_LLT	A1_ELT vs. S6_ELT	A1_LLT vs. S6_LLT
	AN	12,410	11,529	8,029	6,760	10,904	10,833	2,876 (35.8%)	4,073 (60.2%)
	BN	8,694	8,681	4,932	4,493	8,045	8,258	3,114 (63.1%)	3,765 (83.8%)
	D	8,375	8,052	5,815	5,494	7,981	7,949	2,166 (37.2%)	2,455 (44.7%)
	C	5,988	5,725	4,216	5,163	5,789	6,032	1,573 (37.3%)	869 (16.8%)
	AVG	11,515	10,844	8,091	7,629	10,969	10,628	2,878 (35.6%)	2,999 (39.3%)
DEC	W	49,759	45,191	51,097	45,940	47,804	43,734	-3,293 (-6.4%)	-2,206 (-4.8%)
	AN	19,384	19,119	19,120	20,042	19,211	18,954	90 (0.5%)	-1,088 (-5.4%)
	BN	13,284	12,231	13,722	12,524	13,001	12,565	-720 (-5.2%)	41 (0.3%)
	D	8,467	8,828	8,680	8,634	8,954	9,207	274 (3.2%)	573 (6.6%)
	C	5,505	6,560	6,160	5,562	5,292	6,036	-868 (-14.1%)	474 (8.5%)
	AVG	23,546	22,113	24,149	22,347	22,928	21,691	-1,221 (-5.1%)	-656 (-2.9%)

	Increase >50%	Increase 25–50%	Increase 10–25%	Increase 5–10%
	Decrease >50%	Decrease 25–50%	Decrease 10–25%	Decrease 5–10%

J.3.2.2 Sacramento River

J.3.2.2.1 Upper Sacramento River

The CALSIM modeled mean monthly flows for Sacramento River at Keswick under Scenario 6 are generally similar from January to August, November, and December for both ELT and LLT (Table J.3-1, Figure J.3-1, Figure J.3-2). However, flows during September and October are different between PP and Scenario 6, and during ELT and LLT (Figure J.3-1 and Figure **J.3-4**). Flows at the Red Bluff Diversion Dam follow a similar pattern (Table J.3-2). The September and October flow patterns illustrate the broader effects of Delta requirements on upstream flows. In general, fall Delta water quality requirements are met by a combination of increased upstream reservoir releases and/or reduced south Delta exports. Under PP operations, south Delta exports are reduced and if necessary reservoir releases are made to meet Delta salinity standards in October. Under Scenario 6, releases are made from the reservoirs for a pulse of freshwater to meet the Fall X2 standards stipulated for September–November.

Flow patterns are also very different between the ELT and LLT. During ELT in September, flows at Keswick are elevated in wet (11,365 cfs, 47% greater) and above normal water years (7,551 cfs, 14% greater) under Scenario 6 to meet Fall X2 standards compared to PP (7,756 cfs wet years, 6,598 cfs above normal). By October, however, Delta salinity standards are met by mainly by reducing south Delta exports. Under Scenario 6, less water is required in October to maintain target X2 conditions after the initial September pulse. October flows at Keswick under Scenario 6 are similar to PP.

The pattern of flows during LLT is strikingly different due to changes in the future Delta as a result of the combination of BDCP and sea level rise. The expected restoration of thousands of acres of tidal wetlands in the Restoration Opportunity Areas (ROAs) creates more opportunity for saltwater to enter the Delta, which will increase as sea level rises. Therefore, much more freshwater is needed to push out this greater volume of higher salinity water, especially from the south Delta. Flows at Keswick during September in wetter years are greatly increased (49–87% greater) under Scenario 6 (13,114 cfs wet years, 9,331 cfs above normal years) compared to PP (6,998 cfs in wet, 6,253 cfs in above normal). October flows under Scenario 6 (5,997–7,470 cfs) decline from September levels, and are 12–26% less compared to PP (7,875–8,025 cfs) for all water year types.

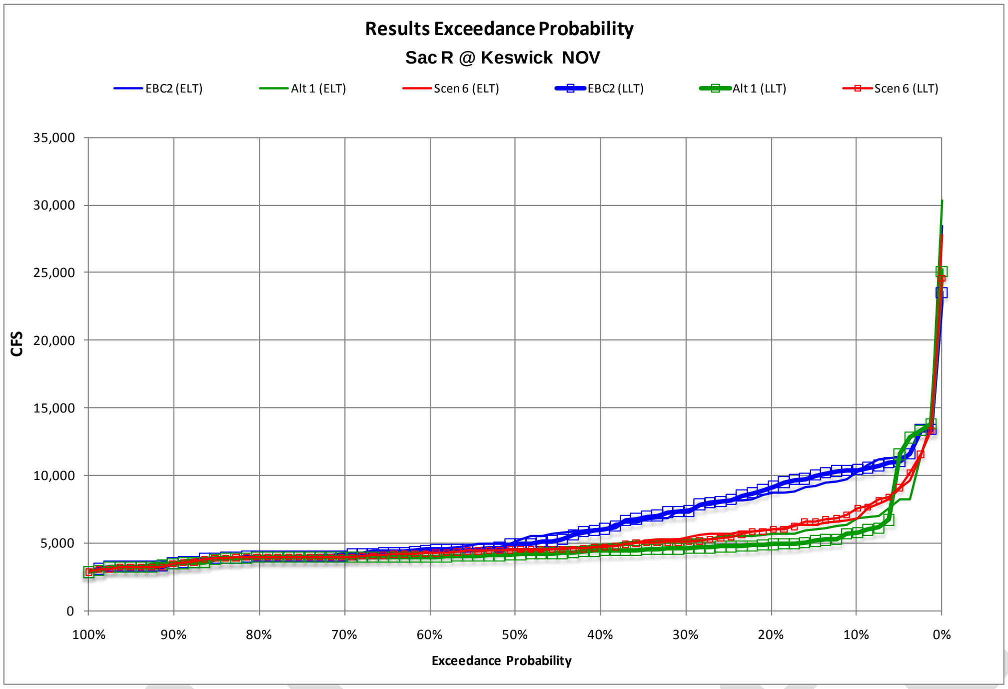

Figure J.3-1. Probability of Exceedance Plot for Alternative 1 and Scenario 6 of Mean Monthly Flow Rate of the Sacramento River at Keswick, November

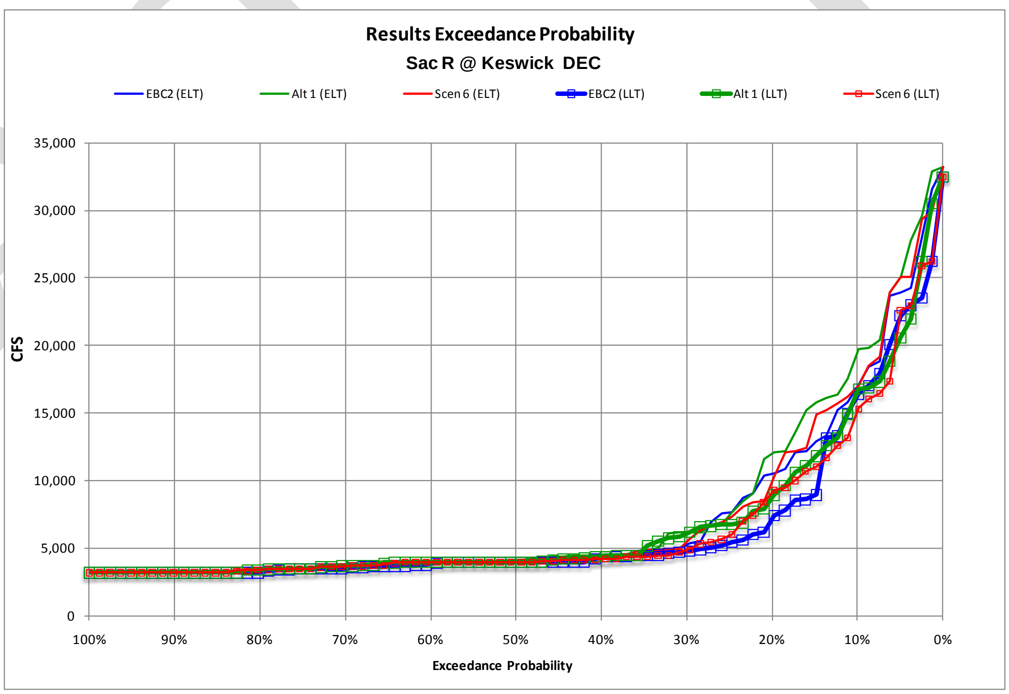

Figure J.3-2. Probability of Exceedance Plot for Alternative 1 and Scenario 6 of Mean Monthly Flow Rate of the Sacramento River at Keswick, December

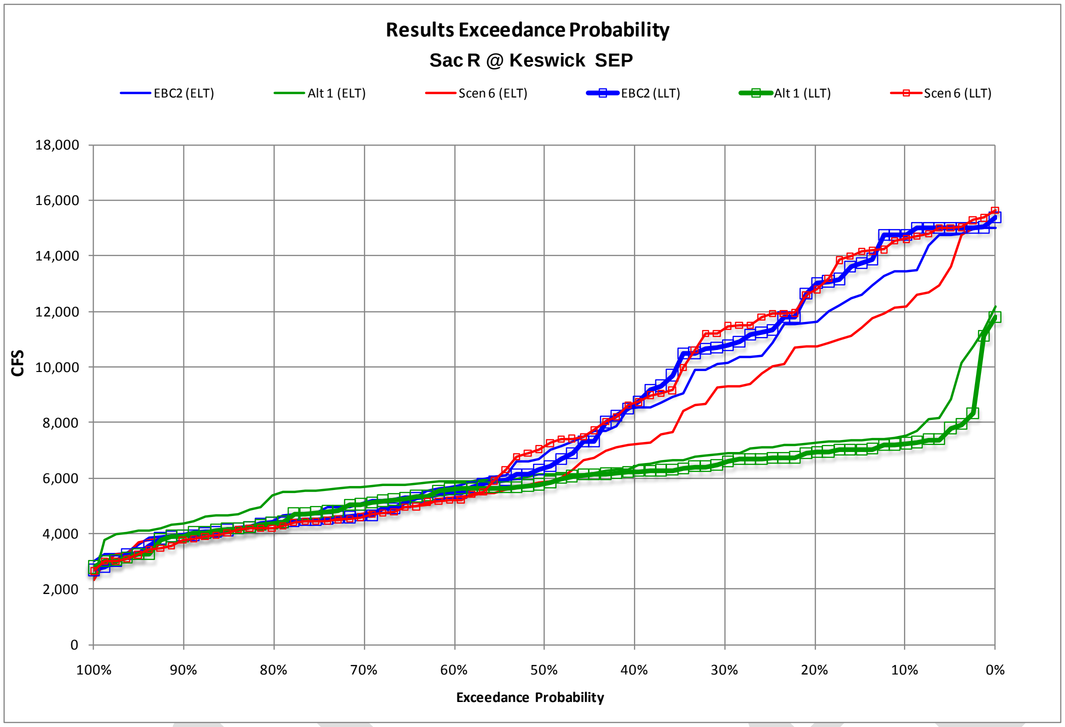

Figure J.3-3. Probability of Exceedance Plot for Alternative 1 and Scenario 6 of Mean Monthly Flow Rate of the Sacramento River at Keswick, September

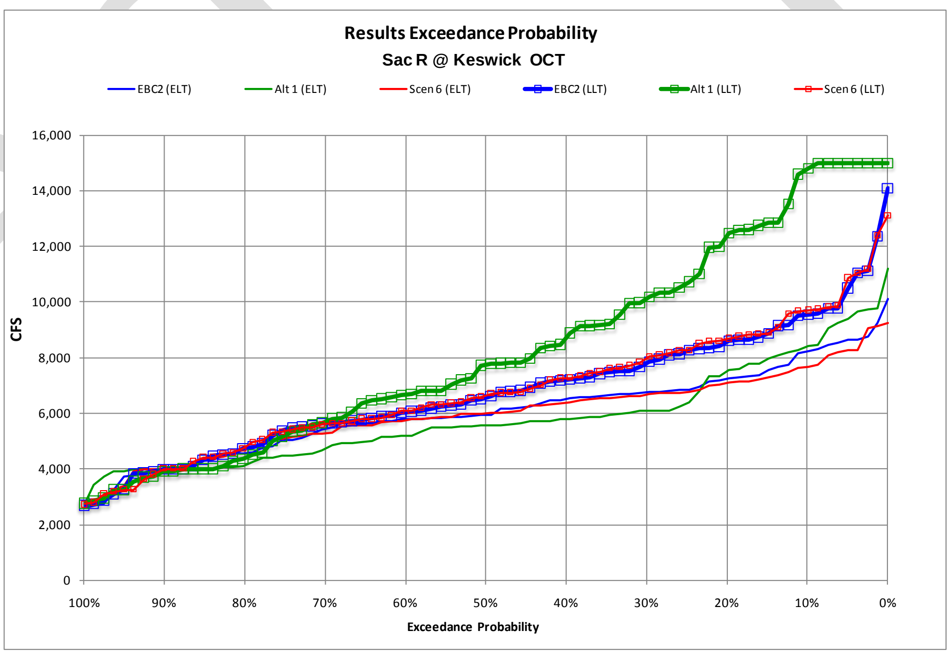

Figure J.3-4**. Probability of Exceedance Plot for Alternative 1 and Scenario 6 of Mean Monthly Flow Rate of the Sacramento River at Keswick, October**

J.3.2.2.2 Lower Sacramento River

General flow patterns in the lower Sacramento River, both downstream of North Delta diversion (Table J.3-2) and at Rio Vista (Table J.3-3), show a moderate increase in flows under Scenario 6 compared to PP during July and August for most years. In September, flows are greatly increased compared to PP in wet (119% greater) and above normal (49% greater) water years during ELT, with greater increases in LLT (wet 149% and above normal 62% greater) (Figure J.3-5). In October, lower Sacramento River flows under Scenario 6 are decreased in all water years in ELT (5–14%) and sharply decreased in LLT (23–31% reduced downstream of the North Delta Diversion and 30–39% at Rio Vista). As seen in the exceedance probability analysis, the greatest flows in September are for Scenario 6 LLT (Figure J.3-5), while in October the greatest flows are for PP LLT (Figure J.3-6). While there are minimal differences in November between PP and Scenario 6 in the ELT in the lower Sacramento River, during LLT, flows are somewhat greater under Scenario 6 for all water years, particularly at Rio Vista in above normal (29% greater) and below normal (22% greater) water years (Figure J.3-7). Flows from December to June are not much different between the two operations for ELT and LLT (Figure J.3-8).

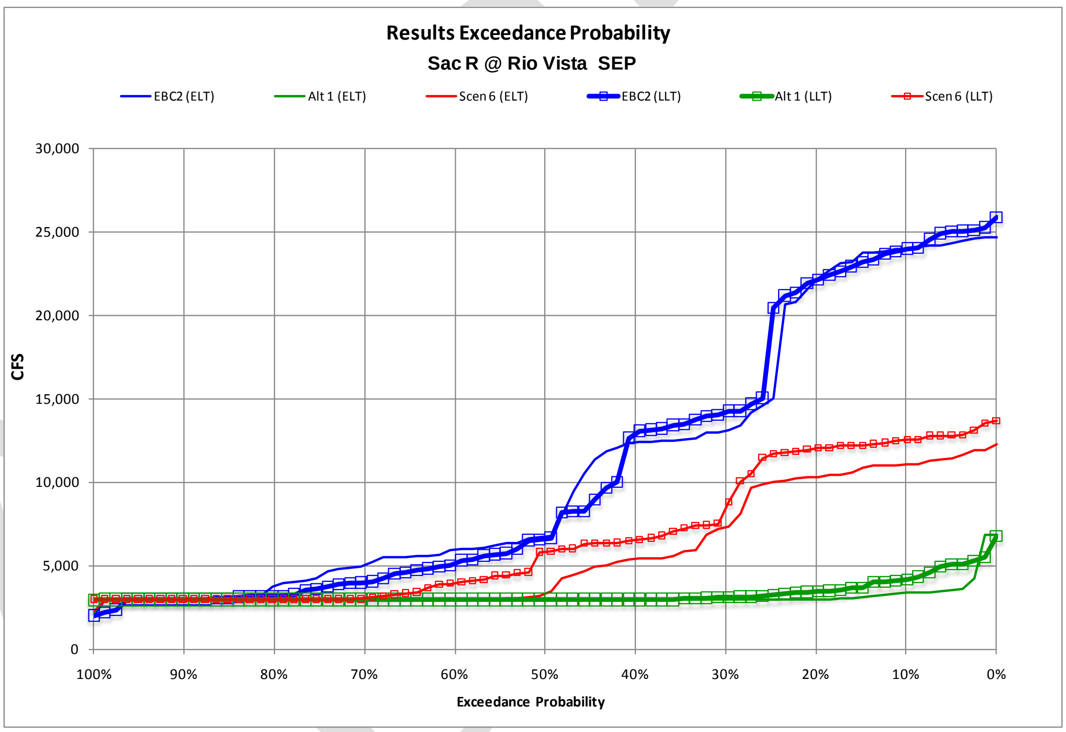

Figure J.3-5. Probability of Exceedance Plot for Alternative 1 and Scenario 6 of Mean Monthly Flow Rate of the Sacramento River at Rio Vista, September

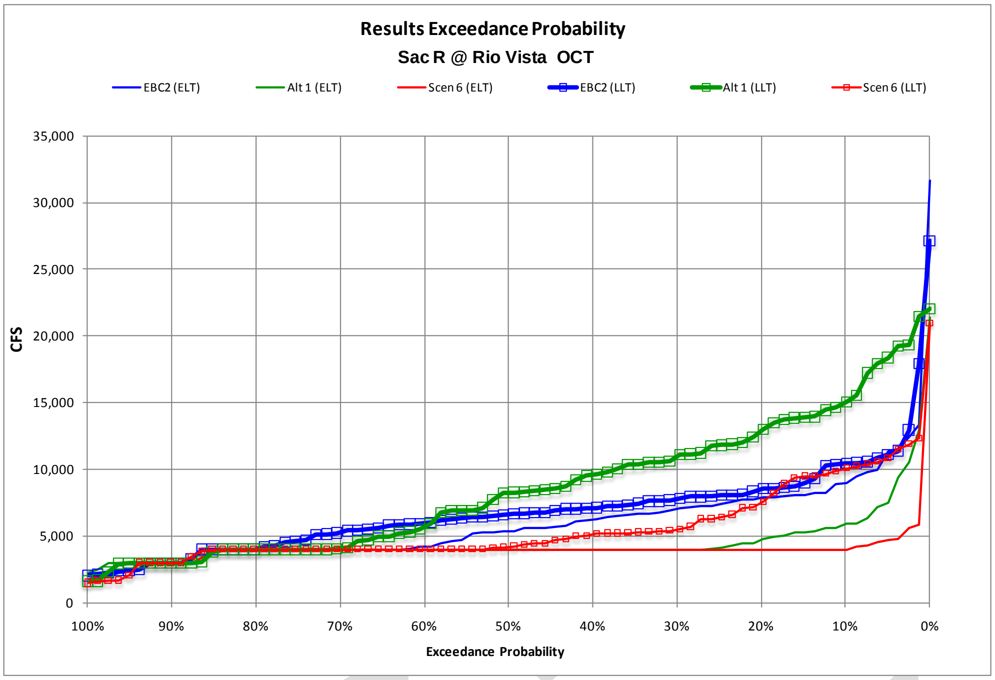

Figure J.3-6. Probability of Exceedance Plot for Alternative 1 and Scenario 6 of Mean Monthly Flow Rate of the Sacramento River at Rio Vista, October

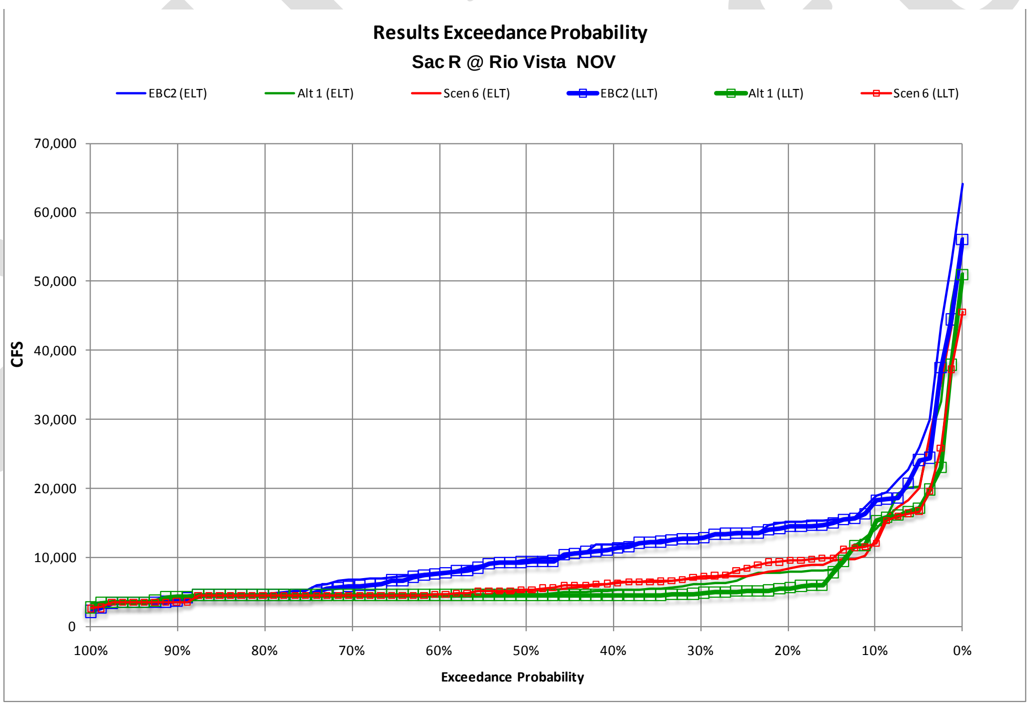

Figure J.3-7. Probability of Exceedance Plot for Alternative 1 and Scenario 6 of Mean Monthly Flow Rate of the Sacramento River at Rio Vista, November

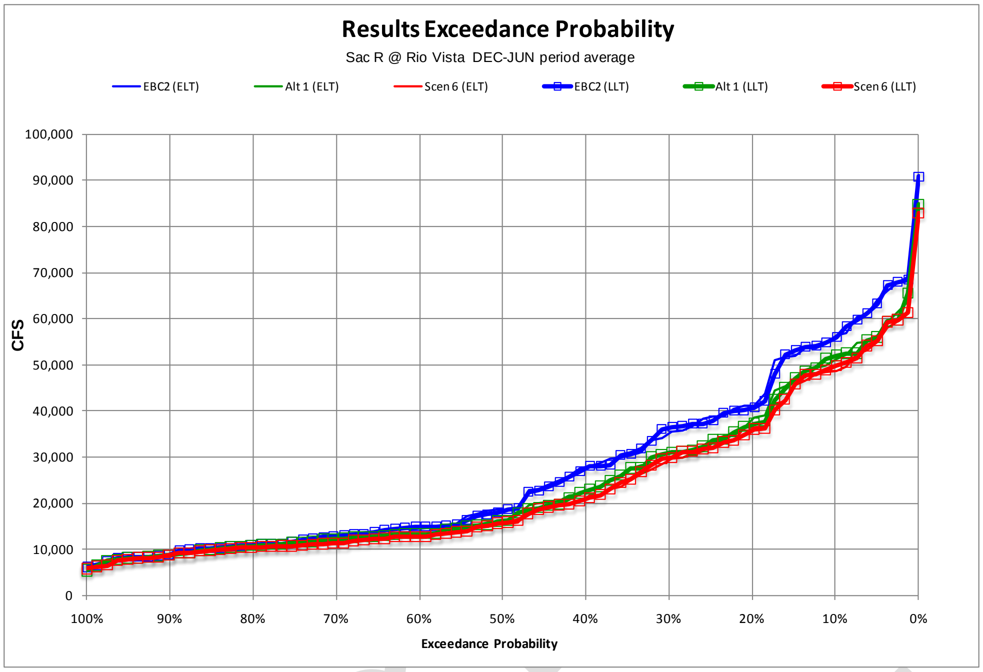

Figure J.3-8. Probability of Exceedance Plot for Alternative 1 and Scenario 6 of Mean Monthly Flow Rate of the Sacramento River at Rio Vista, December to June

J.3.2.3 Feather River

The majority of Feather River flow below Oroville Dam is diverted at Thermalito Diversion Dam to the Thermalito Forebay and Thermalito Afterbay. The remainder flows through the historical river channel (commonly referred to as the "low-flow channel") which extends from the Fish Barrier Dam downstream of the Thermalito Diversion Dam (at River Mile 67) to the Thermalito Afterbay Outlet channel (at River Mile 59). The reach of the Feather River from the Thermalito Afterbay Outlet channel to the Sacramento River is referred to as the "high-flow channel".

Flows in the Feather River low-flow channel are determined by controlled releases and do not differ across water years, operations scenario, or future period (ELT and LLT) (Table J.3-9). Flows vary slightly seasonally: 700 cfs April–August, ramping up during the spring-run Chinook spawning and egg incubation period to 773 cfs in September, and 800 cfs in October, remaining at this level through March (Table J.3-8).

Flows in the high flow channel at Thermalito under Scenario 6 are substantially greater compared to PP in September in wet (434% greater in ELT, 517% greater in LLT) and above normal years (228% greater in ELT, 174% greater in LLT) in order to meet Fall X2 requirements in the Delta (Figure J.3-9). Flows under Scenario 6 are less relative to PP in October in above normal ELT (17% decrease), and in November during wet LLT (13% decrease) and above normal ELT (9% decrease) (Figure J.3-10 and Figure J.3-11). Flows are less under Scenario 6 from December through May due to reduced carryover storage (from September releases to meet Fall X2) and export restrictions in the south Delta (Table J.3-6,Figure J.3-12). Flow increases under Scenario 6 during June to August are likely due to releases from Oroville Reservoir for increased Delta pumping during the summer, when pumping restrictions are few and water demand is high.

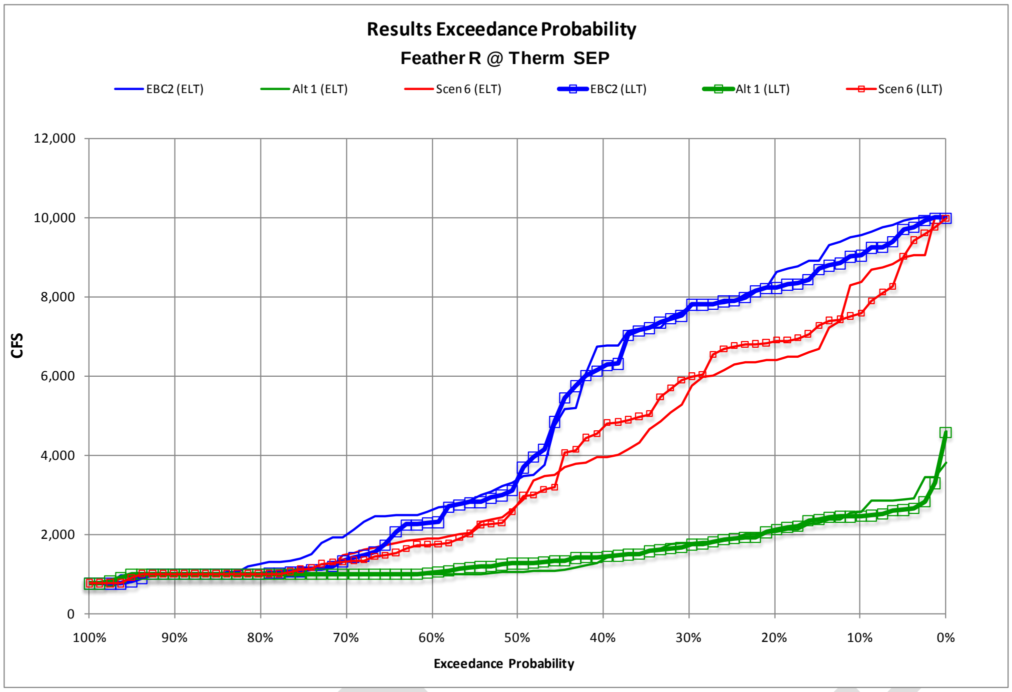

Figure J.3-9. Probability of Exceedance Plot for Alternative 1 and Scenario 6 of Mean Monthly Flow Rate of the Feather River at Thermalito, September

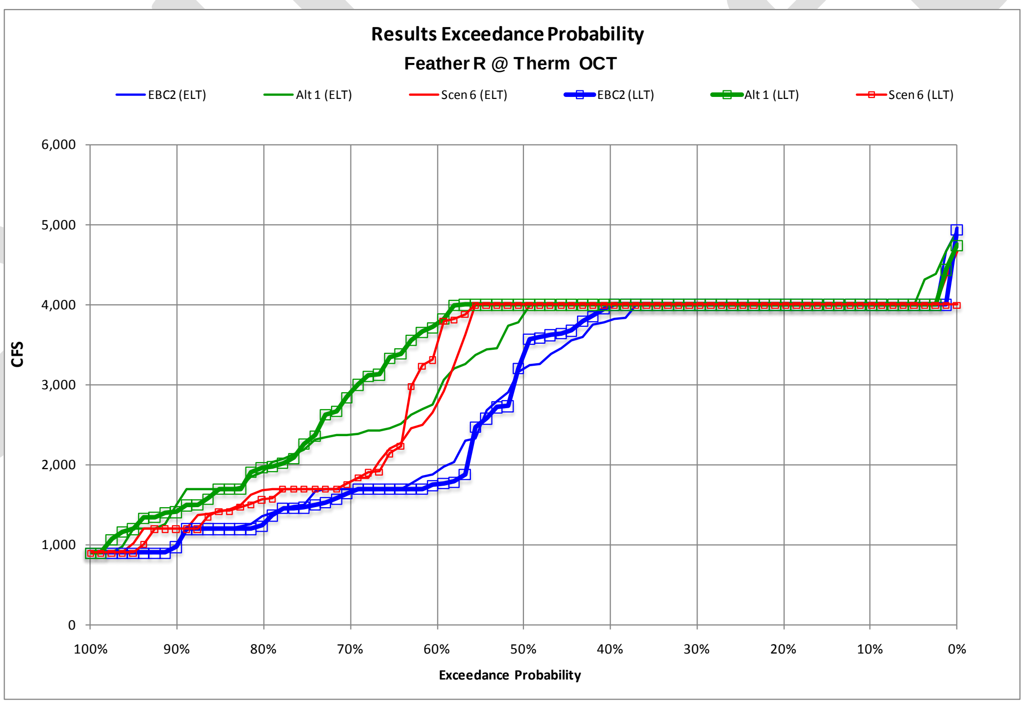

Figure J.3-10. Probability of Exceedance Plot for Alternative 1 and Scenario 6 of Mean Monthly Flow Rate of the Feather River at Thermalito, October

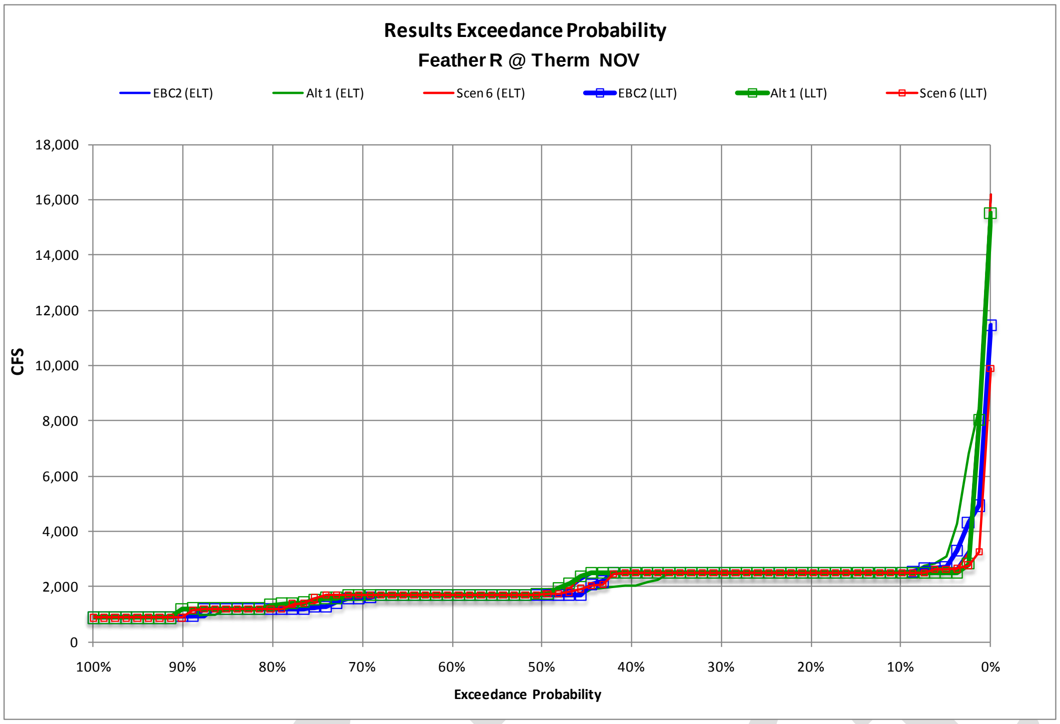

Figure J.3-11. Probability of Exceedance Plot for Alternative 1 and Scenario 6 of Mean Monthly Flow Rate of the Feather River at Thermalito, November

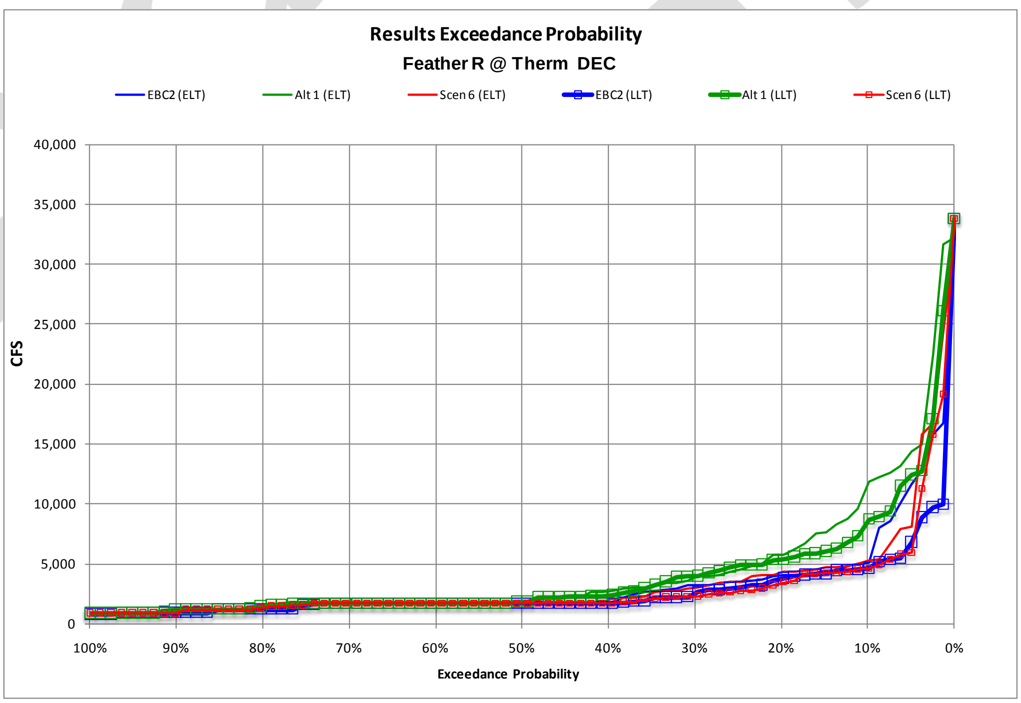

Figure J.3-12. Probability of Exceedance Plot for Alternative 1 and Scenario 6 of Mean Monthly Flow Rate of the Feather River at Thermalito, December

J.3.2.4 American River

American River flows at the confluence with the Sacramento River are not substantially different between Scenario 6 and PP from December to May (Table J.3-7). Flows decrease somewhat in June, and increase in July. In September, flows under Scenario 6 increase substantially compared to PP in wet and above normal years (28–62%) due to releases from Folsom Reservoir to meet Fall X2 requirements in the Delta. In October, flows under Scenario 6 are slightly increased during ELT, but moderately reduced compared to PP during the LLT scenario for all water year types (13–21% less). Because increased releases are made in September under Scenario 6, smaller water releases are required during October to achieve and maintain Delta salinity standards, resulting in the predicted decreases in October LLT flow compared to PP, which begins making releases in October to meet Delta salinity standards.

J.3.2.5 San Joaquin River

The CALSIM station at Vernalis on the San Joaquin River represents Delta inflow contributions from the San Joaquin River Basin. Because Scenario 6 does not directly alter operations on the San Joaquin River, there are no appreciable changes to flow at Vernalis from Scenario 6 compared to PP (Table J.3-8).

J.3.2.6 Delta

J.3.2.6.1 Old and Middle River (OMR)

Net flow rate in the Old and Middle River channels are a result of complex hydrologic relationships among tidal action, in-watershed water management actions, natural hydrology, in-Delta diversions, and operation of the export pumps in the south Delta. Changes to flow in OMR under BDCP reflect changes in water export from the south Delta pumps. Pumping from the CVP and SWP facilities can reverse the normative northerly net flow in OMR and create a generally southward flow toward the pumps. By convention, a positive OMR flow is the normative northern flow while a negative OMR flow is reversed toward the pumping facilities.

During the fall (September–November), OMR flows were strongly negative for both PP and Scenario 6. The magnitude of negative OMR flows was substantially less negative and more northerly under Scenario 6 than PP in all water year types (Table J.3-9). During the ELT period for September, differences were greatest particularly in wet (Scenario 6 607 cfs, PP -3,960 cfs), above normal (Scenario 6 -1,371 cfs, PP -4,906 cfs), and below normal years (Scenario 6 -2,083 cfs, PP -4,498 cfs) in September (Figure J.3-13). OMR flows in October were substantially less n in all water year types for October (range Scenario 6 -1,433 cfs to -1,946 cfs, PP -5,012 cfs to -5,537 cfs) (Figure J.3-14) and November (range Scenario 6 -1,223 csf to -2,923 cfs, PP -4,496 cfs to -5,868 cfs) (Figure J.3-15). A similar pattern is seen during the LLT period in fall. OMR flows in December are fairly similar (Figure J.3-16).

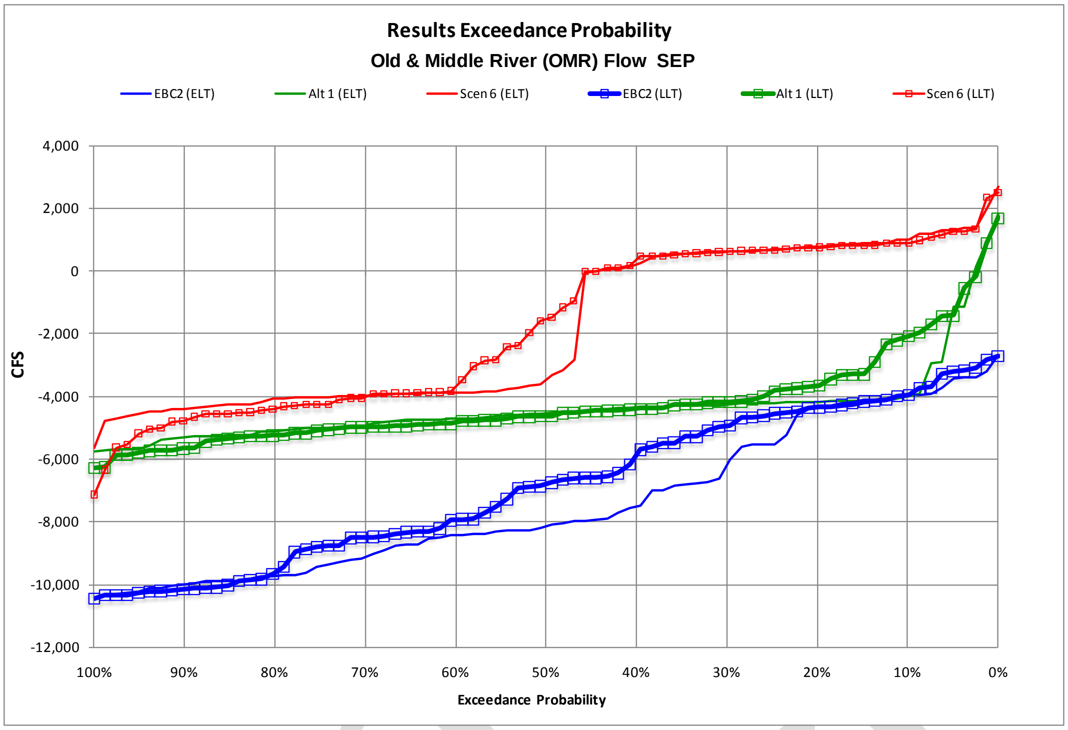

Figure J.3-13. Probability of Exceedance Plot for Alternative 1 and Scenario 6 of Mean Monthly Flow Rate of OMR, September

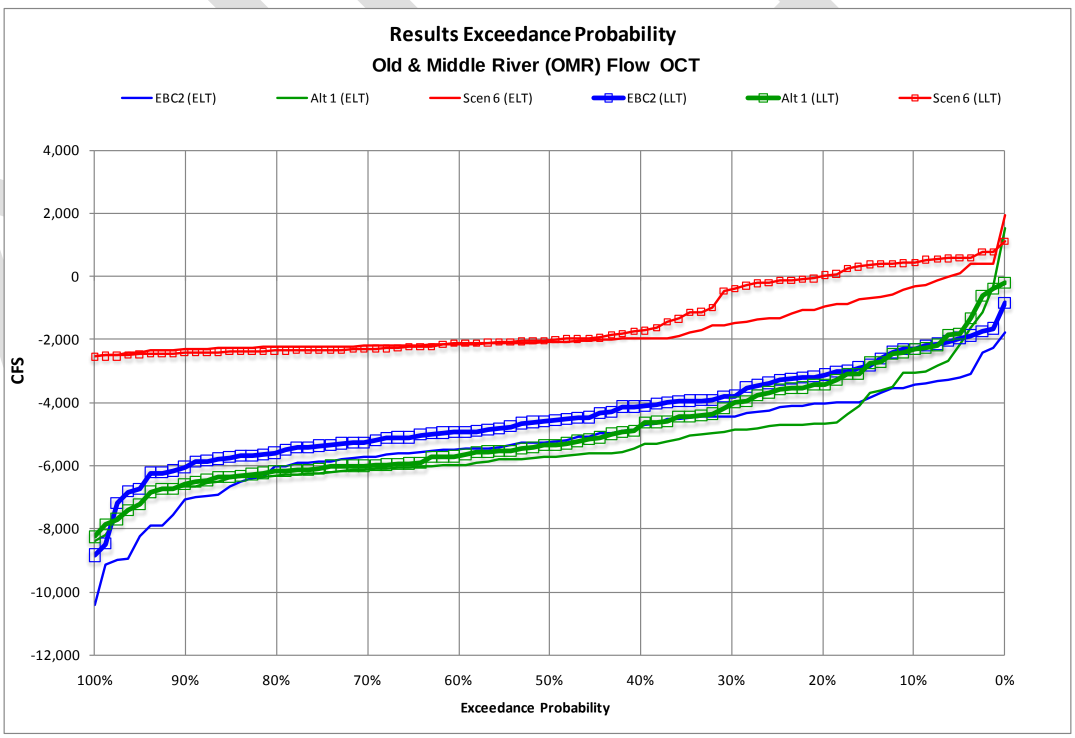

Figure J.3-14. Probability of Exceedance Plot for Alternative 1 and Scenario 6 of Mean Monthly Flow Rate of OMR, October

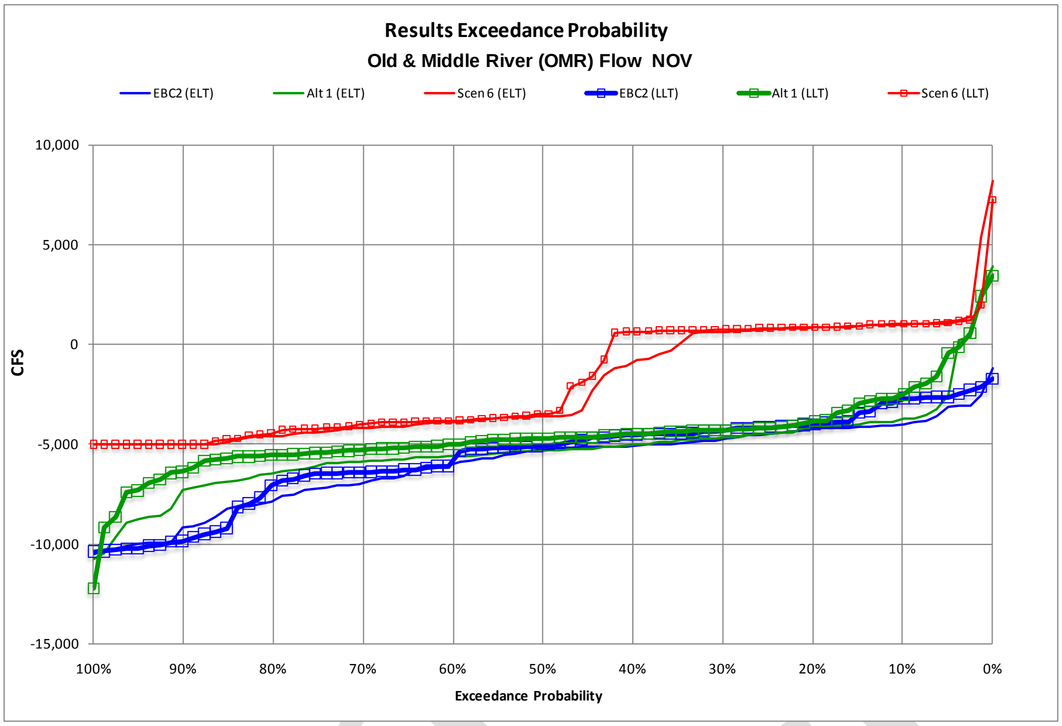

Figure J.3-15. Probability of Exceedance Plot for Alternative 1 and Scenario 6 of Mean Monthly Flow Rate of OMR, November

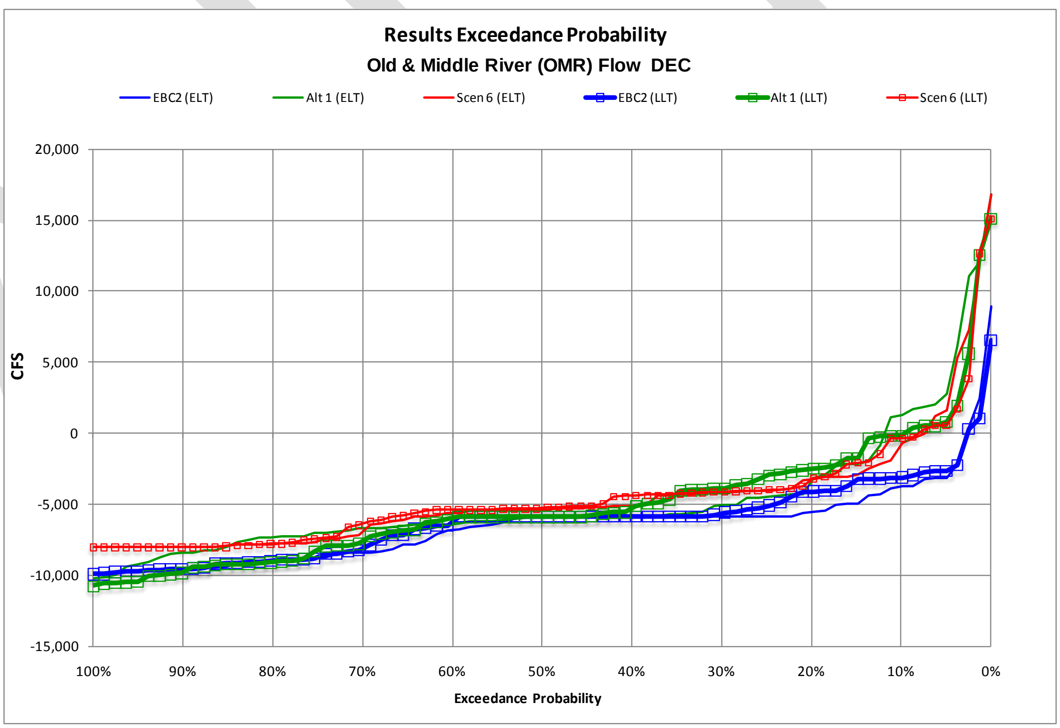

Figure J.3-16. Probability of Exceedance Plot for Alternative 1 and Scenario 6 of Mean Monthly Flow Rate of OMR, December

The OMR flows under both Scenario 6 and PP still meet the OMR flow requirements of the BiOps during the winter and spring. During wet years. OMR flows in January through May are positive for all scenarios. During February to March, when OMR flows were negative, mean monthly OMR flows were somewhat more negative under Scenario 6 (Table J.3-9,Figure J.3-17). For example, during ELT in March, OMR flows under Scenario 6 are -1,709 cfs compared to -1,589 cfs for PP in below normal years (8% more negative), and –2,261 cfs compared to -2,045 cfs for PP in dry years (11% more negative).

During April and May, when Scenario 6 is designed to improve OMR flow conditions, negative mean monthly OMR flows occur less often under Scenario 6 (50% of years) compared to PP (about 67% of years), and the magnitude of negative flows is reduced (Figure J.3-18). The improvements are seen most notably in dry to above normal years (Table J.3-9). For example, during ELT in April, OMR flows under Scenario 6 are 369 cfs compared to -681 cfs for PP in above normal years (154% less negative), and -650 cfs compared to -1,662 cfs for PP in below normal years (61% less negative).

In July and August, OMR flows under Scenario 6 are more negative for all water year types compared to PP (decreased 11–28% on average). This is a period with no pumping restrictions, and hence is a time when increased south Delta exports can occur to make up for pumping reductions during spring and fall under Scenario 6.

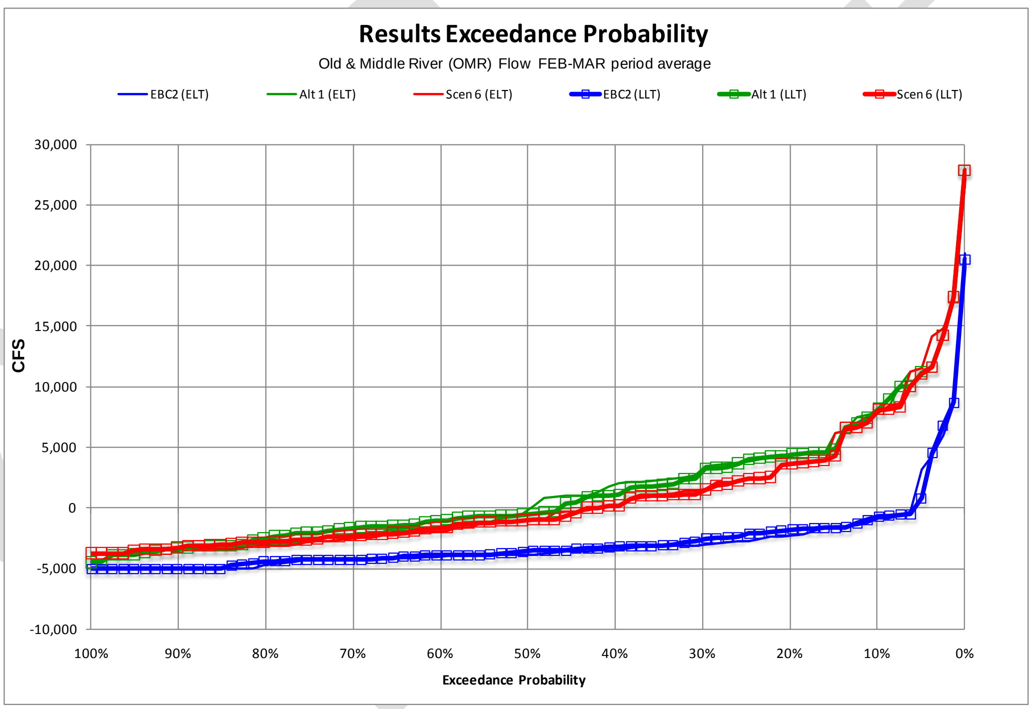

Figure J.3-17. Probability of Exceedance Plot for Alternative 1 and Scenario 6 of Mean Monthly Flow Rate of OMR, February-March

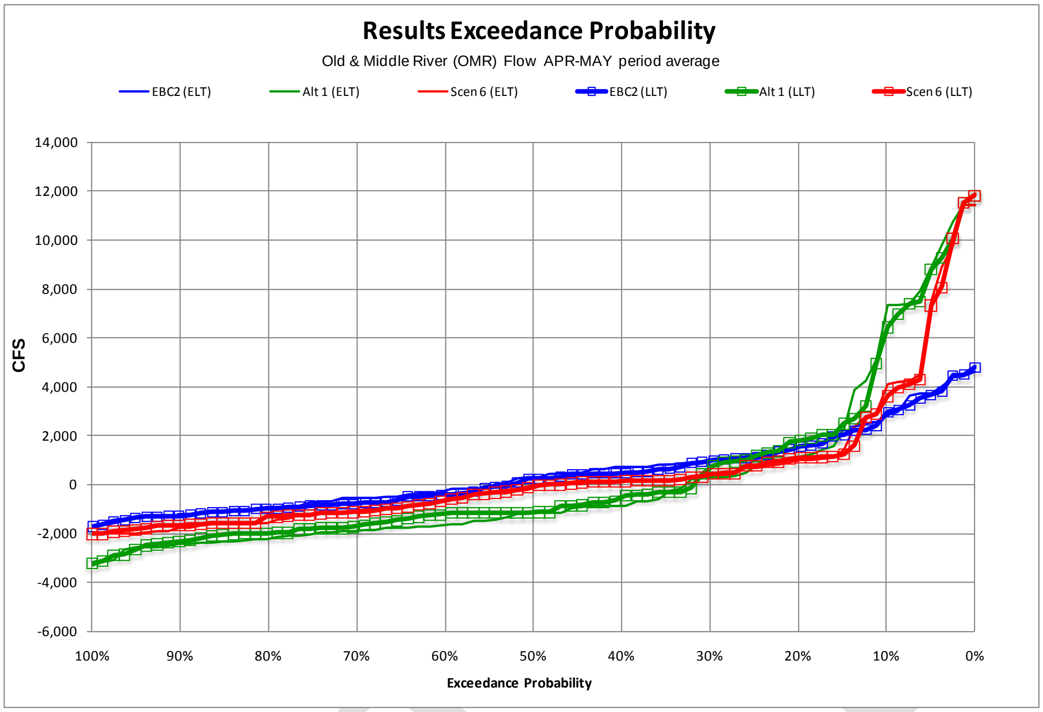

Figure J.3-18. Probability of Exceedance Plot for Alternative 1 and Scenario 6 of Mean Monthly Flow Rate of OMR, April–May

J.3.2.6.2 Delta Outflow

Delta outflow is the sum of the amount of inflow from the Sacramento River (with water released from Shasta, Oroville and Folsom Reservoirs), San Joaquin River and other minor tributaries, less the amount of water diverted (SWP/CVP export facilities, North Bay Aqueduct, and agricultural diversions) and lost to evaporation. Under Scenario 6, Delta outflow is substantially increased in the fall through the combination of increased reservoir releases in September and reduced south Delta exports to meet Fall X2 requirements.

In September, mean monthly outflow is substantially greater under Scenario 6 in wet and above normal years during the ELT and LLT (Table J.3-10 and Figure J.3-19).

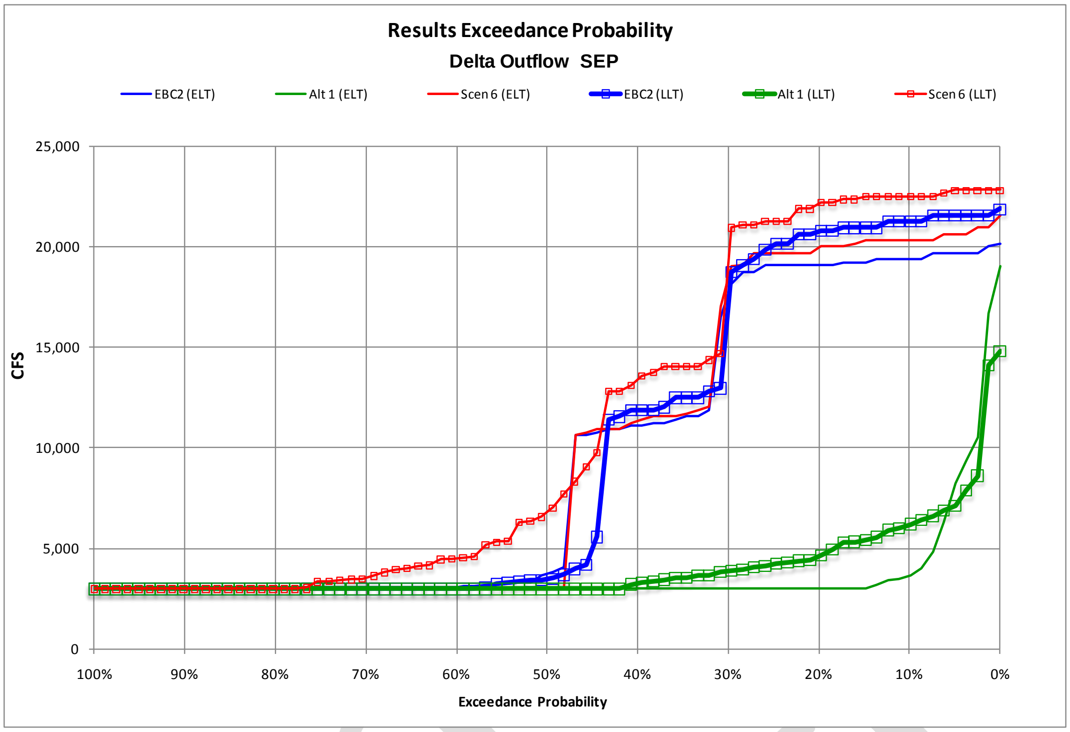

Figure J.3-19. Probability of Exceedance Plot for Alternative 1 and Scenario 6 of Mean Monthly Flow Rate of Delta Outflow, September

In October and November, mean monthly outflow during the ELT period under Scenario 6 exceed those for PP for all water year types, particularly in wet (52%), above normal (76%) and below normal (74%) water years. The improvement in outflow in October ELT is due to reduced south Delta exports to maintain the more westerly X2 position initially established in September. During the LLT period, mean monthly Delta outflow is more similar between Scenario 6 and PP because D-1641 salinity standards, which are incorporated into PP, take effect in October, resulting in operations that produce greater Delta outflow (PP monthly average for all years 9,698 cfs). Under Scenario 6, there is a complete ban on south Delta pumping during the two weeks of the D-1641 pulse flow in the San Joaquin River. The exceedance analysis reveals that Scenario 6 outflow is actually increased relative to PP for the drier years, but not for the wetter conditions (Figure J.3-20 and Figure J.3-21).

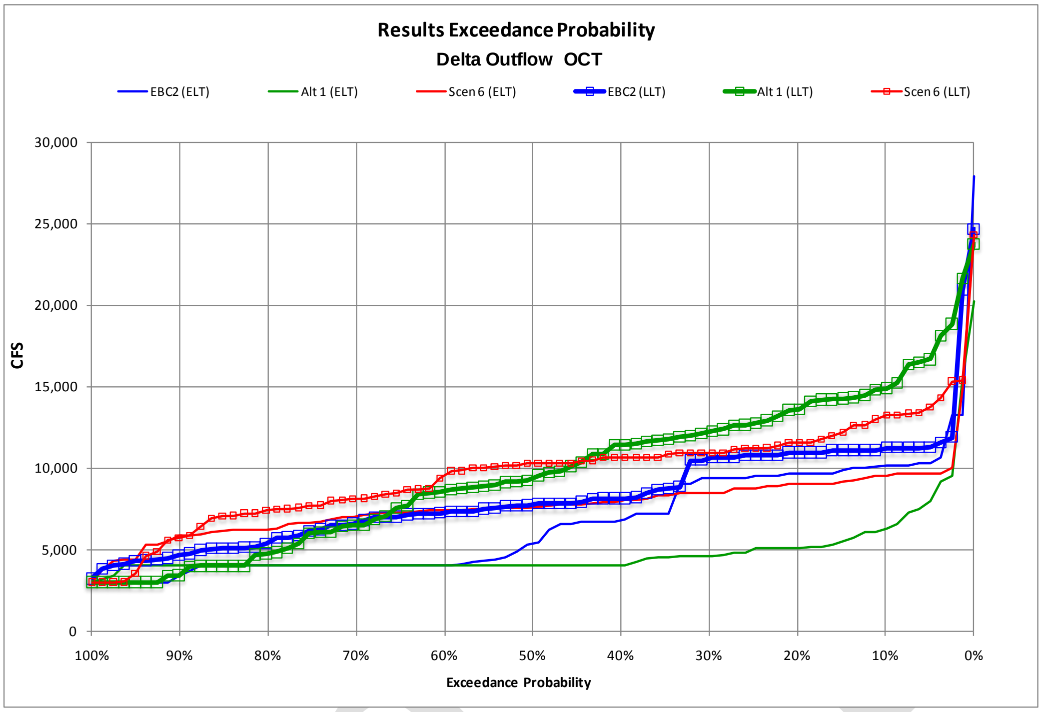

Figure J.3-20. Probability of Exceedance Plot for Alternative 1 and Scenario 6 of Mean Monthly Flow Rate of Delta Outflow, October

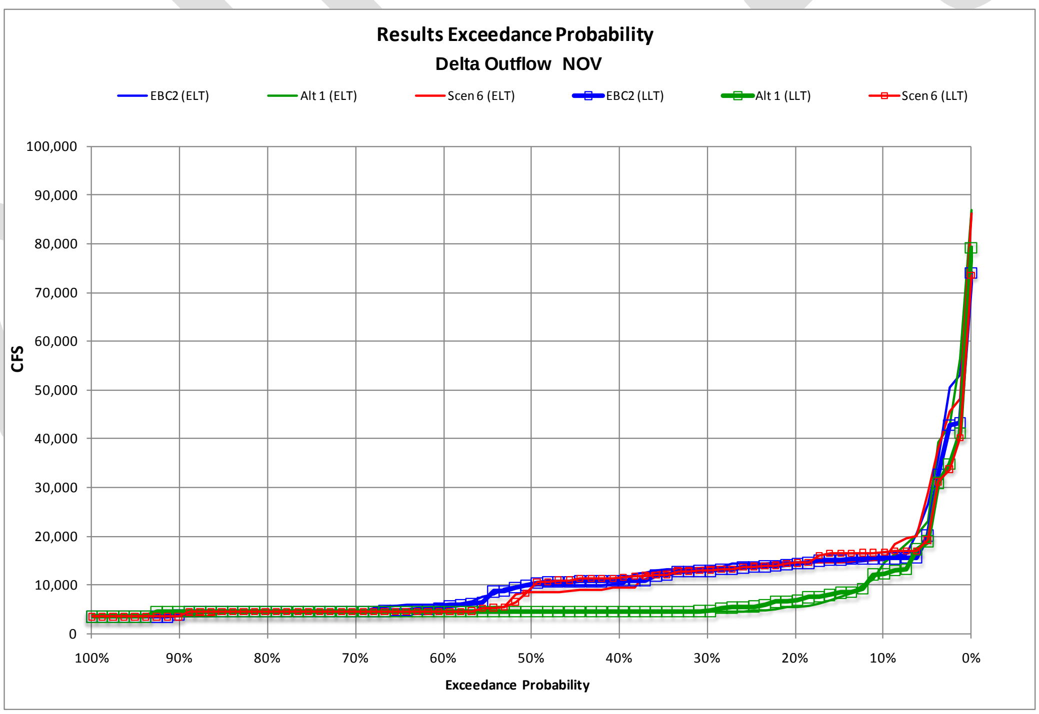

Figure J.3-21. Probability of Exceedance Plot for Alternative 1 and Scenario 6 of Mean Monthly Flow Rate of Delta Outflow, November

From December through March, Delta outflow is not much different between the two operational scenarios. In April and May, outflow is only slightly increased under Scenario 6 for above normal and below normal water years (8–19%) for both ELT and LLT (Figure J.3-22). Delta outflow June through August is generally unchanged.

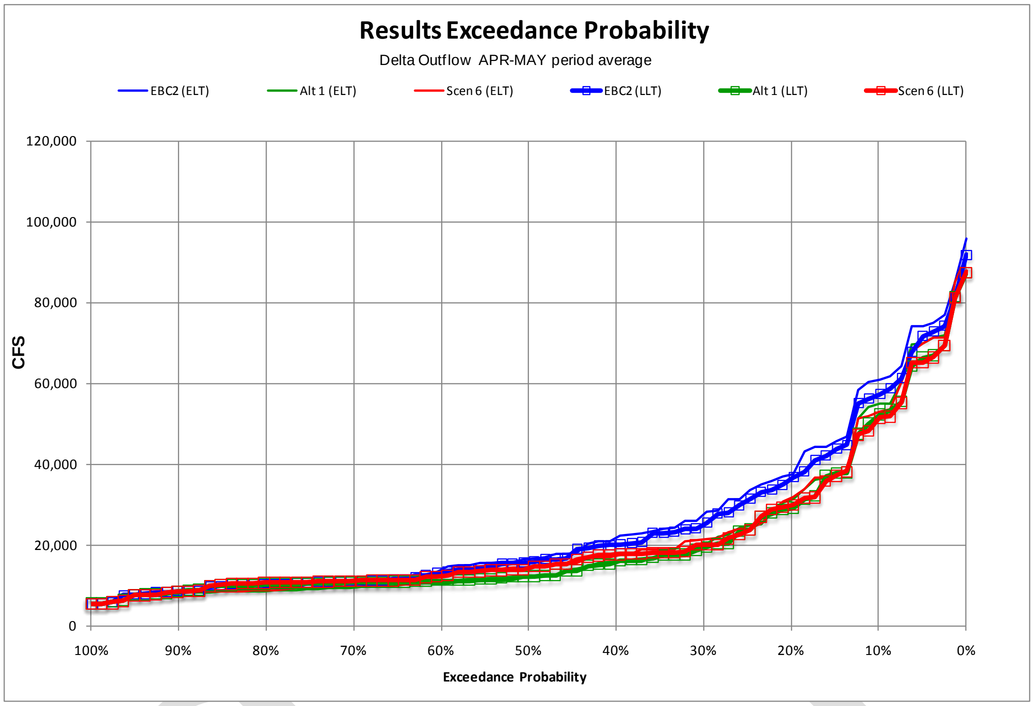

Figure J.3-22. Probability of Exceedance Plot for Alternative 1 and Scenario 6 of Mean Monthly Flow Rate of Delta Outflow, April–May.

J.3.3 Reservoir Storage

J.3.3.1 Shasta Reservoir

Reservoir storage in September provides an indicator of coldwater pool availability. For the Sacramento River, Shasta Reservoir is the source of cold water to maintain cooler stream temperatures for incubating salmon eggs downstream, particularly winter-run Chinook. Total water storage in Shasta Reservoir ranges from 2.7–3.2 million acre-feet (MAF) in wet water years to around 1 MAF during critical water years (Table J.3-11). The exceedance probability analysis shows minimal decrease in storage under Scenario 6 in the ELT and LLT, and overall lower storage during the LLT period compared to the ELT period (Figure J.3-23). This pattern is likely a result of the requirement to meet Fall X2 (in the ELT) and effects of climate change on operations for coldwater releases (in the LLT).

Table J.3-11. September Water Storage Volume (Thousand Acre Feet [TAF]) in Shasta Reservoir and Oroville Reservoir for Model Scenarios

Water Year Type	EBC2_ELT	EBC2_LLT	A1_ELT	A1_LLT	S6_ELT	S6_LLT	Difference	
							S6_ELT vs. A1_ELT	S6_LLT vs. A1_LLT
Shasta Reservoir								
Wet	3,020	2,805	3,211	3,026	3,031	2,715	-180 (-5.6%)	-311 (-10.3%)
Above Normal	2,834	2,582	2,910	2,714	2,851	2,537	-59 (-2.0%)	-177 (-6.5%)
Below Normal	2,705	2,518	2,597	2,304	2,643	2,426	46 (1.8%)	122 (5.3%)
Dry	2,253	1,944	2,273	1,900	2,283	1,905	10 (0.4%)	5 (0.3%)
Critical	990	805	1,108	802	1,050	792	-58 (-5.2%)	-10 (-1.2%)
Oroville Reservoir								
Wet	2,177	1,885	2,727	2,243	2,432	1,970	-295 (-10.8%)	-273 (-12.2%)
Above Normal	1,818	1,583	2,141	1,704	1,870	1,515	-271 (-12.7%)	-189 (-11.1%)
Below Normal	1,693	1,409	1,894	1,644	1,678	1,459	-216 (-11.4%)	-185 (-11.3%)
Dry	1,124	1,008	1,496	1,315	1,319	1,169	-177 (-11.8%)	-146 (-11.1%)
Critical	902	796	1,131	1,032	964	913	-167 (-14.8%)	-119 (-11.5%)

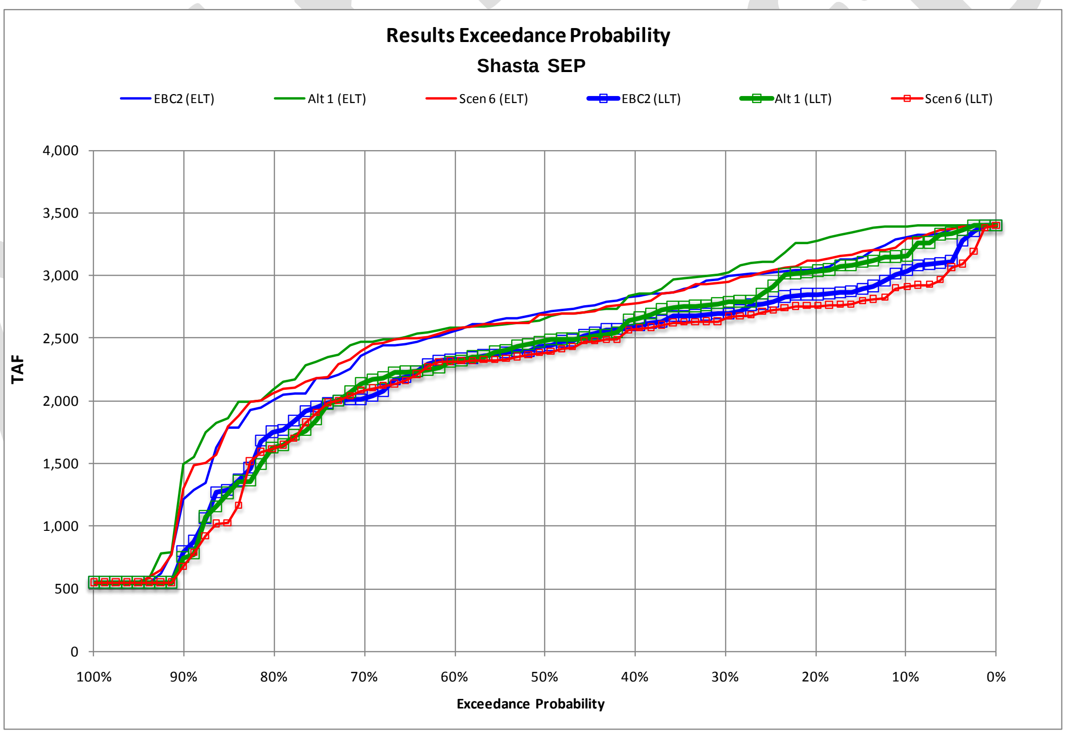

Figure J.3-23. Probability of Exceedance Plot for Alternative 1 and Scenario 6 for Shasta Reservoir Storage Volume, September

J.3.3.2 Oroville Reservoir

September water storage in Oroville Reservoir ranges from 0.9–1.1 MAF in critical water years to 2.0–2.7 MAF in wet years (Table J.3-11,Figure J.3-24). September water storage would decrease 11–15% in all years under Scenario 6 compared to PP in both the ELT and LLT (Table J.3-11). This pattern is likely due to increased Fall X2 releases under Scenario 6 in wet and above normal years. Under both Scenario 6 and the preliminary proposal (PP), storage during the LLT period is lower than during ELT.

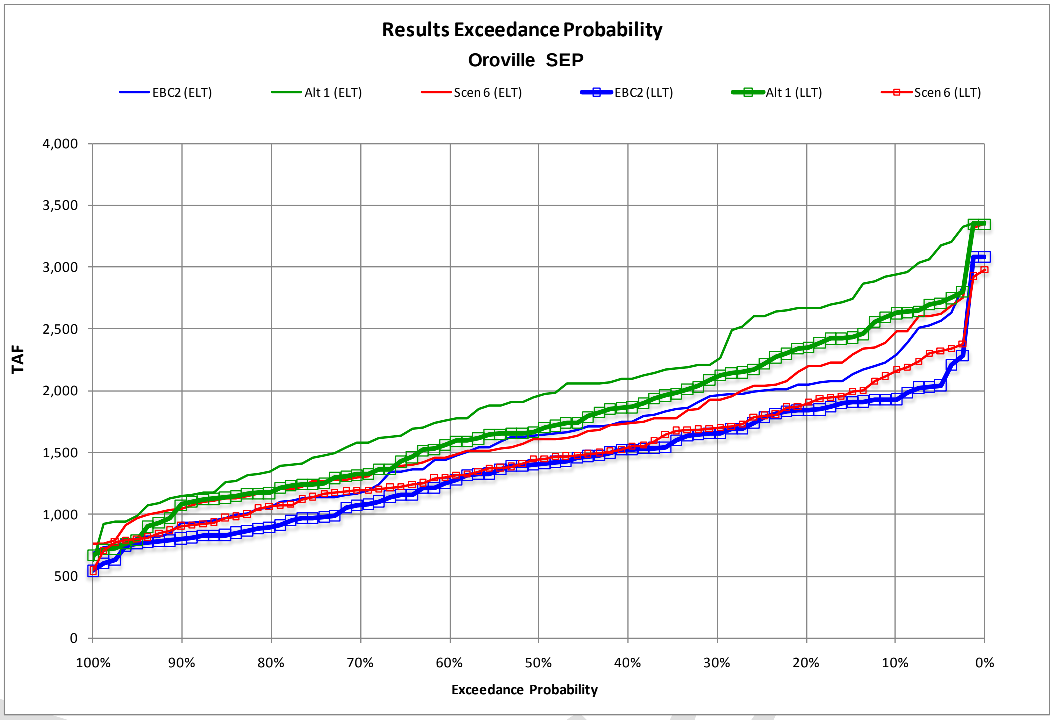

Figure J.3-24. Probability of Exceedance Plot for Alternative 1 and Scenario 6 for Oroville Reservoir Storage Volume, September

J.3.4 Delta Exports

J.3.4.1 Total Delta Exports

Long-term annual total Delta exports (thousands of acre-feet [TAF]) are reduced under Scenario 6 compared to PP, and within Scenario 6 are reduced in LLT compared to ELT (Figure J.3-25). Compared to the PP, Scenario 6 would result in approximately 450 TAF less total Delta SWP/CVP exports in the ELT and approximately 320 TAF less in the LLT. Seasonal patterns in overall Delta exports under Scenario 6 show the effect of restrictions on pumping during spring (reduced in south to improve OMR conditions) and fall (reduced in south to increase Delta outflow to meet Fall X2 standards in wet and above normal years (Figure J.3-26).

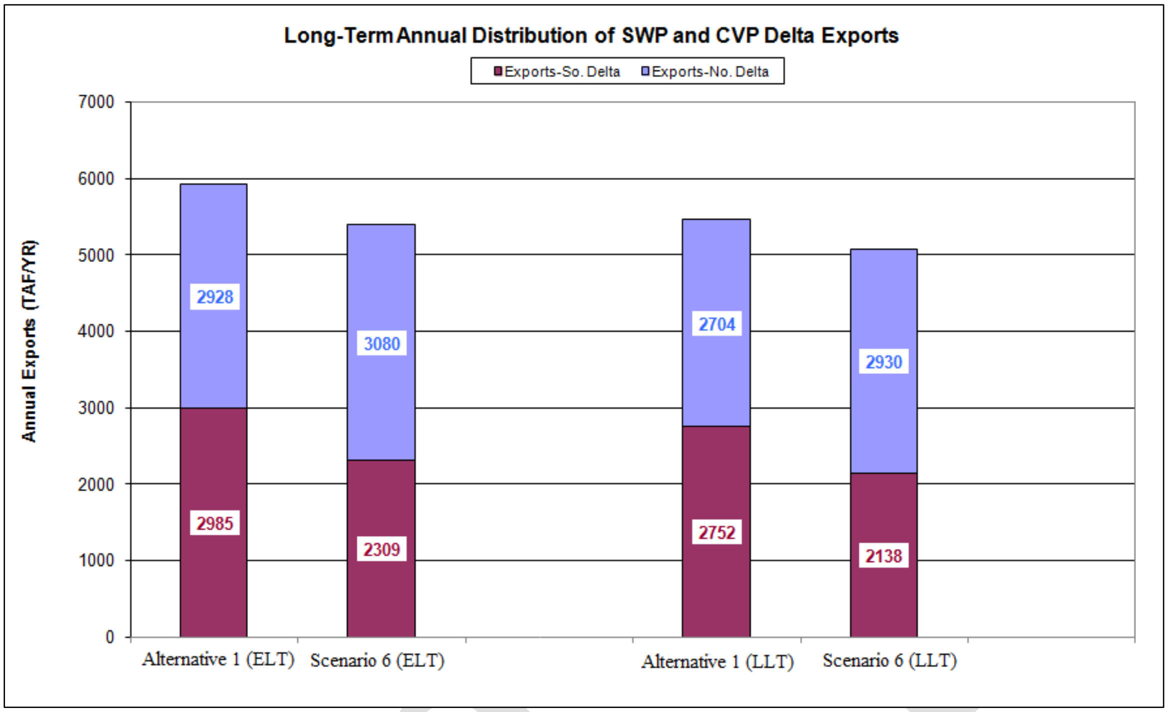

Figure J.3-25. Long-term Annual Distribution (TAF/Yr) of SWP and CVP Exports

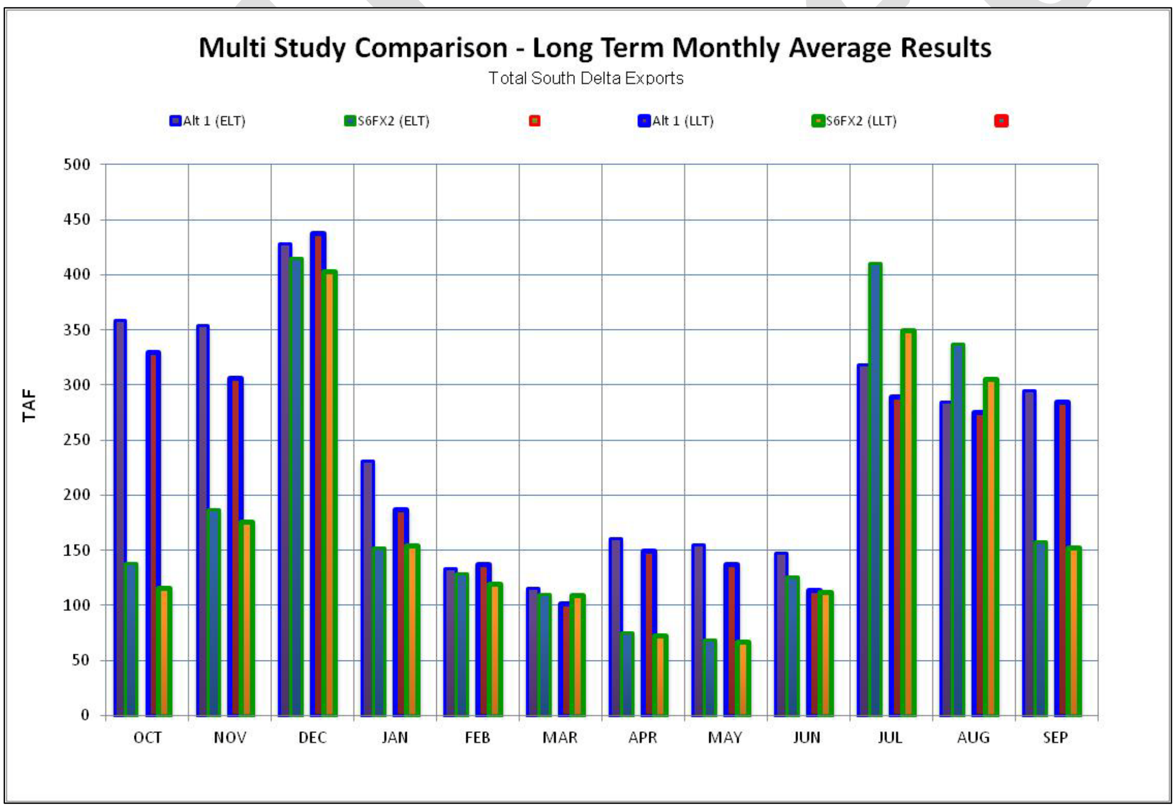

Figure J.3-26. Mean Monthly Diversions (TAF) for south Delta Exports

J.3.4.2 South Delta Exports

Annual south Delta exports are reduced 22–23% (-676 TAF in ELT;-614 TAF in ELT) under Scenario 6 (Figure J.3-25) compared to the PP. Annual average south Delta exports under Scenario 6 were moderately to highly reduced for all water year types compared to PP (Table J.3-12) with the greatest proportional reductions in wetter years: 31–34% less in wet, 27–29% less in above normal, 13–16% less in below normal, 18–21% less in dry, and 12–14% less in critical water years.

Looking at seasonal patterns, south Delta exports (Figure J.3-26) under Scenario 6 were substantially reduced in April and May of all water year types, but most especially in wet (61–69%), above normal (61–73%), and below normal years (56–65%) (In June, exports are reduced in wet ELT (36% increase) and above normal years (23% in ELT, 28% in LLT), but reduced slightly to moderately in below normal (15% in ELT, 6% in LLT), dry ELT (22%), and critical years (6% in ELT, 23% in LLT).

In July and August, when there are minimal or no restrictions on pumping, south Delta exports are increased to make up for reduced diversions in spring and fall. Exports increase in all water year types, but most substantially in above normal (48% in ELT, 44% in LLT) and below normal years (46% in ELT, 43% in LLT). In August, exports increase in all water year types except dry water years. Under Scenario 6, August exports increase most notably in below normal (43% for ELT, 35% for LLT) and critical years (19% in ELT, 16% in LLT).

In the fall exports are reduced again under Scenario 6 to contribute to increased Delta outflow to meet the Fall X2 requirements. These reductions occur in September wet and above normal years (78–98%), and in all water year types during October (53–72%) and November (15–58%). The greatest south Delta export reductions were in wetter years. These export reductions are the key factor in the improved OMR flows (i.e., more flow away from the south Delta).

Table J.3-12. Annual Delta Exports (TAF) by Water Year Types

M	WY	EBC2_ELT	EBC2_LLT	A1_ELT	A1_LLT	S6_ELT	S6_LLT	A1_ELTvs.S6_ELT	A1_LLTvs.S6_LLT
South Delta Exports	W	5,854	5,533	2,490	2,477	1,715	1,642	-775 (-31.1%)	-835 (-33.7%)
	AN	5,019	4,830	2,999	2,916	2,178	2,077	-821 (-27.4%)	-839 (-28.8%)
	BN	4,752	4,565	3,531	3,226	2,978	2,819	-553 (-15.7%)	-407 (-12.6%)
	D	4,136	3,778	3,528	3,068	2,789	2,526	-739 (-20.9%)	-542 (-17.7%)
	C	2,856	2,532	2,594	2,160	2,230	1,901	-364 (-14.0%)	-259 (-12.0%)
	AVG	4,728	4,441	2,985	2,752	2,309	2,138	-676 (-22.6%)	-614 (-22.3%)
North Delta Exports	W	0	0	4,890	4,595	5,245	5,041	355 (7.3%)	446 (9.7%)
	AN	0	0	3,894	3,777	4,087	4,120	193 (5.0%)	343 (9.1%)
	BN	0	0	2,492	2,234	2,453	2,248	-39 (-1.6%)	14 (0.6%)
	D	0	0	1,379	1,142	1,437	1,244	58 (4.2%)	102 (8.9%)
	C	0	0	544	423	575	488	31 (5.7%)	65 (15.4%)
	AVG	0	0	2,928	2,704	3,080	2,930	152 (5.2%)	226 (8.4%)

	Increase >50%	Increase 25–50%	Increase 10–25%	Increase 5–10%
	Decrease >50%	Decrease 25–50%	Decrease 10–25%	Decrease 5–10%

Table J.3-13. Mean Monthly South Delta Exports (TAF) by Water Year Types

M	WY	EBC2_ELT	EBC2_LLT	A1_ELT	A1_LLT	S6_ELT	S6_LLT	A1_ELT vs. S6_ELT	A1_LLT vs. S6_LLT
JAN	W	501	488	73	80	75	78	2 (3.4%)	-2 (-2.9%)
	AN	394	406	204	185	115	118	-89 (-43.6%)	-67 (-36%)
	BN	392	353	304	277	197	211	-106 (-35%)	-66 (-23.9%)
	D	391	387	370	297	216	226	-154 (-41.7%)	-71 (-23.9%)
	C	298	301	312	154	211	183	-101 (-32.4%)	29 (18.5%)
	AVG	413	403	232	187	153	154	-79 (-34.1%)	-33 (-17.7%)
FEB	W	537	526	3	10	5	3	2 (55.8%)	-6 (-67.7%)
	AN	405	404	72	82	69	68	-3 (-3.9%)	-14 (-16.6%)
	BN	366	361	137	154	194	185	57 (41.8%)	32 (20.5%)
	D	316	290	283	272	234	219	-49 (-17.2%)	-53 (-19.3%)
	C	265	243	248	251	224	199	-25 (-9.9%)	-52 (-20.7%)
	AVG	400	386	133	138	129	120	-4 (-3.2%)	-18 (-12.9%)
MAR	W	586	576	14	24	28	30	15 (105.6%)	6 (26.5%)
	AN	476	473	56	35	27	37	-29 (-52.5%)	2 (4.3%)
	BN	410	395	195	165	190	201	-5 (-2.5%)	37 (22.2%)
	D	255	239	221	188	201	188	-21 (-9.3%)	1 (0.3%)
	C	161	151	149	137	140	127	-9 (-6%)	-10 (-7.5%)
	AVG	405	394	116	102	110	109	-6 (-5.5%)	7 (6.9%)
APR	W	175	179	96	95	31	30	-66 (-68.1%)	-65 (-67.9%)
	AN	114	124	157	137	59	53	-97 (-62.1%)	-84 (-61.1%)
	BN	112	126	270	253	100	113	-170 (-63%)	-141 (-55.5%)
	D	116	110	207	189	124	108	-83 (-40%)	-81 (-42.8%)
	C	89	84	107	103	86	83	-21 (-19.4%)	-19 (-18.8%)
	AVG	130	133	161	150	75	73	-85 (-53.1%)	-77 (-51.6%)
MAY	W	219	210	114	104	36	41	-79 (-68.8%)	-63 (-60.9%)
	AN	113	116	181	187	58	50	-122 (-67.7%)	-137 (-73.4%)
	BN	107	120	265	211	93	93	-172 (-64.8%)	-118 (-55.7%)
	D	112	114	162	138	107	96	-55 (-33.7%)	-42 (-30.5%)
	C	90	85	79	76	69	69	-10 (-12.8%)	-7 (-9.7%)
	AVG	142	142	155	138	69	67	-86 (-55.2%)	-71 (-51.2%)
JUN	W	412	367	191	120	122	122	-69 (-36.2%)	3 (2.2%)
	AN	329	293	218	199	158	153	-60 (-27.6%)	-46 (-23.3%)
	BN	215	202	150	117	172	124	22 (14.8%)	7 (5.5%)
	D	156	125	96	80	116	83	21 (21.9%)	4 (4.5%)
	C	92	91	61	64	64	79	4 (5.9%)	15 (23.2%)
	AVG	263	234	148	114	126	112	-22 (-14.7%)	-2 (-1.6%)

M	WY	EBC2_ELT	EBC2_LLT	A1_ELT	A1_LLT	S6_ELT	S6_LLT	A1_ELT vs. S6_ELT	A1_LLT vs. S6_LLT
JUL	W	664	601	369	391	460	411	91 (24.6%)	20 (5.1%)
	AN	578	502	306	295	452	424	147 (48%)	130 (44%)
	BN	651	617	350	305	511	438	161 (46.1%)	132 (43.4%)
	D	611	578	344	240	392	291	48 (13.9%)	51 (21.4%)
	C	361	285	146	121	171	128	25 (17.3%)	8 (6.2%)
	AVG	593	538	318	289	410	350	92 (28.9%)	60 (20.8%)
AUG	W	721	708	300	307	353	325	53 (17.8%)	18 (5.9%)
	AN	711	719	340	364	416	386	76 (22.3%)	23 (6.3%)
	BN	610	602	291	272	415	365	124 (42.7%)	94 (34.5%)
	D	511	455	292	257	282	264	-10 (-3.6%)	7 (2.8%)
	C	212	175	182	151	216	176	34 (18.7%)	25 (16.3%)
	AVG	580	558	285	275	337	306	52 (18.2%)	30 (11%)
SEP	W	582	521	293	322	7	5	-286 (-97.5%)	-317 (-98.4%)
	AN	593	593	319	345	30	75	-289 (-90.5%)	-270 (-78.4%)
	BN	563	552	313	306	298	329	-15 (-4.8%)	23 (7.7%)
	D	404	340	291	266	289	285	-1 (-0.4%)	19 (7.3%)
	C	269	248	264	146	256	143	-8 (-2.9%)	-3 (-1.8%)
	AVG	495	457	295	285	159	152	-137 (-46.3%)	-132 (-46.5%)
OCT	W	410	353	358	352	130	110	-228 (-63.8%)	-242 (-68.8%)
	AN	314	246	365	315	137	113	-228 (-62.6%)	-201 (-64%)
	BN	353	327	388	331	133	93	-255 (-65.7%)	-238 (-72%)
	D	348	281	350	334	149	134	-201 (-57.5%)	-200 (-59.9%)
	C	338	261	339	288	148	134	-191 (-56.4%)	-154 (-53.4%)
	AVG	362	304	359	330	138	116	-221 (-61.6%)	-213 (-64.7%)
NOV	W	482	446	350	319	147	148	-202 (-57.9%)	-171 (-53.5%)
	AN	412	398	341	312	212	171	-128 (-37.7%)	-140 (-45%)
	BN	411	369	392	351	202	191	-190 (-48.4%)	-160 (-45.5%)
	D	353	333	374	290	194	182	-181 (-48.2%)	-108 (-37.2%)
	C	282	287	304	248	224	212	-80 (-26.2%)	-36 (-14.5%)
	AVG	402	378	354	307	188	176	-167 (-47%)	-131 (-42.7%)
DEC	W	565	558	330	355	321	338	-9 (-2.6%)	-16 (-4.6%)
	AN	582	557	440	461	443	427	3 (0.7%)	-33 (-7.2%)
	BN	561	543	478	485	472	476	-6 (-1.2%)	-9 (-1.8%)
	D	561	527	538	518	485	449	-53 (-9.9%)	-70 (-13.4%)
	C	400	322	407	423	422	368	16 (3.9%)	-55 (-13%)
	AVG	542	514	428	438	415	404	-13 (-2.9%)	-35 (-7.9%)

	Increase >50%	Increase 25–50%	Increase 10–25%	Increase 5–10%
	Decrease >50%	Decrease 25–50%	Decrease 10–25%	Decrease 5–10%

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J.3.4.3 North Delta Exports

Exports from the North Delta facilities generally increase under Scenario 6 compared to PP. Annual exports increase slightly in wet years (7% in ELT, 10% in LLT) and critical years (6% in ELT, 15% in LLT) (Figure J.3-25). There is also a 9% increase in annual exports for both above normal and dry year LLT.

Seasonally, north Delta exports under Scenario 6 were substantially increased in June and October, but decreased modestly in November and December (Table J.3-14). In June, exports increased in all water year types, except critical (no difference in ELT, 21% decrease in LLT). Exports in June went up most notably in below normal (20% for ELT/LLT) and dry years (44% for ELT, 33% for LLT). In October exports increase in both ELT and LLT, but much more substantially in LLT. In October ELT, exports increase in wet (34%), below normal (39%), dry (117%), and critical years (45%); while in October LLT, exports rise substantially in wet (98%), above normal (619%), below normal (900%), and dry (274%) water year types. The increase in north Delta exports in October under Scenario 6 partially compensates for the substantial decreases in south Delta exports, with the rest of the compensation spread out over several months by slightly increased north Delta exports. In November, north Delta exports decrease overall, but most notably in wet years (15% in ELT, 19% in LLT). In December overall average exports decrease 11%, with small decrease in wet years (8%) and larger decreases in critical years (20% in ELT, 26% in LLT).

Table J.3-14. Monthly Total North Delta Exports from Isolated Facilities (CALSIM II) in TAF

M	WY	A1_ELT	A1_LLT	S6_ELT	S6_LLT	A1_ELTvs. S6_ELT	A1_LLTvs. S6_LLT
JAN	W	616	636	656	676	40 (6%)	40 (6%)
	AN	472	468	480	472	8 (2%)	4 (1%)
	BN	209	212	208	208	-1 (0%)	-4 (-2%)
	D	118	89	126	114	8 (7%)	25 (28%)
	C	74	68	64	65	-10 (-14%)	-3 (-4%)
	AVG	337	336	351	354	14 (4%)	18 (5%)
FEB	W	539	571	656	667	117 (22%)	96 (17%)
	AN	509	563	508	561	-1 (0%)	-2 (0%)
	BN	376	387	377	392	1 (0%)	5 (1%)
	D	182	171	177	172	-5 (-3%)	1 (1%)
	C	54	51	53	54	-1 (-2%)	3 (6%)
	AVG	357	394	375	406	18 (5%)	12 (3%)
MAR	W	531	544	630	633	99 (19%)	89 (16%)
	AN	608	658	660	663	52 (9%)	5 (1%)
	BN	343	342	334	336	-9 (-3%)	-6 (-2%)
	D	238	226	225	239	-13 (-5%)	13 (6%)
	C	72	70	70	70	-2 (-3%)	0 (0%)
	AVG	379	387	413	418	34 (9%)	31 (8%)
APR	W	457	455	508	499	51 (11%)	44 (10%)
	AN	380	409	422	425	42 (11%)	16 (4%)
	BN	174	213	197	212	23 (13%)	-1 (0%)
	D	99	112	105	104	6 (6%)	-8 (-7%)
	C	39	39	38	39	-1 (-3%)	0 (0%)
	AVG	258	271	285	285	27 (10%)	14 (5%)
MAY	W	520	501	531	509	11 (2%)	8 (0%)
	AN	401	390	412	410	11 (3%)	20 (5%)
	BN	218	204	138	169	-80 (-37%)	-35 (-17%)
	D	80	87	75	89	-5 (-6%)	2 (2%)
	C	29	29	29	29	0 (0%)	0 (0%)
	AVG	283	274	273	274	-10 (-4%)	0 (0%)
JUN	W	457	443	496	506	39 (9%)	63 (14%)
	AN	390	381	431	519	41 (11%)	138 (36%)
	BN	268	240	322	288	54 (20%)	48 (20%)
	D	95	83	137	110	42 (44%)	27 (33%)
	C	32	38	33	30	1 (3%)	-8 (-21%)
	AVG	273	261	310	314	37 (14%)	53 (20%)

M	WY	A1_ELT	A1_LLT	S6_ELT	S6_LLT	A1_ELTvs. S6_ELT	A1_LLTvs. S6_LLT
JUL	W	236	169	236	189	0 (0%)	20 (12%)
	AN	221	199	200	166	-21 (-10%)	-33 (-17%)
	BN	154	110	158	118	4 (3%)	8 (7%)
	D	98	63	103	69	5 (5%)	6 (10%)
	C	31	34	68	59	37 (119%)	25 (74%)
	AVG	160	120	164	128	4 (3%)	8 (7%)
AUG	W	300	278	299	278	-1 (0%)	0 (0%)
	AN	234	196	219	209	-15 (-6%)	13 (7%)
	BN	190	126	184	130	-6 (-3%)	4 (3%)
	D	90	26	73	33	-17 (-19%)	7 (27%)
	C	7	6	8	8	1 (14%)	2 (33%)
	AVG	183	145	176	149	-7 (-4%)	4 (3%)
SEP	W	342	268	352	344	10 (3%)	76 (28%)
	AN	246	210	328	308	82 (33%)	98 (47%)
	BN	169	130	122	66	-47 (-28%)	-64 (-49%)
	D	136	60	78	33	-58 (-43%)	-27 (-45%)
	C	15	7	15	12	0 (0%)	5 (71%)
	AVG	205	152	200	175	-5 (-2%)	23 (15%)
OCT	W	185	90	248	178	63 (34%)	88 (98%)
	AN	123	16	128	115	5 (4%)	99 (619%)
	BN	109	10	152	100	43 (39%)	90 (900%)
	D	60	27	130	101	70 (117%)	74 (274%)
	C	83	0	120	58	37 (45%)	58 (>1000%)
	AVG	121	38	169	121	48 (40%)	83 (218%)
NOV	W	300	282	256	229	-44 (-15%)	-53 (-19%)
	AN	189	164	167	151	-22 (-12%)	-13 (-8%)
	BN	157	149	150	122	-7 (-4%)	-27 (-18%)
	D	107	132	136	117	29 (27%)	-15 (-11%)
	C	67	44	44	37	-23 (-34%)	-7 (-16%)
	AVG	183	174	168	147	-15 (-8%)	-27 (-16%)
DEC	W	407	359	376	332	-31 (-8%)	-27 (-8%)
	AN	122	122	132	121	10 (8%)	-1 (-1%)
	BN	124	110	113	106	-11 (-9%)	-4 (-4%)
	D	75	66	71	62	-4 (-5%)	-4 (-6%)
	C	41	38	33	28	-8 (-20%)	-10 (-26%)
	AVG	191	178	170	159	-21 (-11%)	-19 (-11%)
		Increase >50%		Increase 25–50%		Increase 10–25%	Increase 5–10%
		Decrease >50%		Decrease 25–50%		Decrease 10–25%	Decrease 5–10%

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J.4 Results Comparing Scenario 6 to Preliminary Proposal for 5 Operational Issues

J.4.1 Spring-Run Chinook Egg Mortality

J.4.1.1 Background

J.4.1.1.1 Spring-Run Chinook Salmon Distribution and Life History

Naturally-spawning populations of Central Valley spring-run Chinook salmon with consistent spawning returns are currently restricted to Butte Creek, Deer Creek, and Mill Creek (Good et al. 2005). There is a small spawning population that has been documented in Clear Creek (Newton and Brown 2005). In addition, the upper Sacramento River and upper Yuba River support small populations, but their status is not well documented. The Feather River Fish Hatchery (FRFH) produces spring-run Chinook salmon on the Feather River.

The pattern of spring-run Chinook adult returns has changed over time. Between 1969 and 1990, returns of adults to the Sacramento Valley averaged 72% to the Sacramento River mainstem, 18% to the tributaries (excluding the Feather River), and 10% to the Feather River (primarily to the FRFH). However, this distribution changed significantly after 1991. Between 1991–2010, returns of adults averaged only 4% to the Sacramento River mainstem, 56% to tributary populations (excluding the Feather River), and 40% to the FRFH (California Department of Fish and Game 2011). In the Sacramento River, approximately 73% of spring-run Chinook salmon spawning (about 3% of the total Sacramento Valley population) occurs between Keswick Dam and Balls Ferry, about 26% occurs between Balls Ferry and Jelly's Ferry, and about 2% spawn downstream of Jelly's Ferry to Tehama Bridge (Table J.4-1).

The Feather River spring-run population is predominately fish produced at the FRFH, although some natural spring-run spawning was reported during the mid 1960s and early 1980s. Approximately 60% of in-river Chinook salmon spawning occurs within the low-flow channel (i.e., upstream of the Thermalito Afterbay outlet channel) and about 40% occurs in the high-flow channel (downstream of the Thermalito Afterbay outlet channel) as far downstream as Honcut Creek (Table J.4-2). Very little information is available regarding in-river spawning by spring-run Chinook salmon. Escapement surveys do not provide separate estimates for spring-run and fall-run Chinook on the Feather River with both runs being reported as fall-run estimates. Since 1983, all returning spring-run Chinook salmon have been reported as hatchery fish (California Department of Fish and Game 2011).

Table J.4-1. Sacramento River (Revised February 27, 2007) Spring-run Chinook Spawning Distributions

Salmon Reach	No.	River Reach	Spring Spawning Distribution (%)	
			Incremental	Cumulative
Upper	1	Keswick Dam – ACID Dam	4.5	4.5
	2	ACID Dam – Highway 44	19.0	23.5
	3	Highway 44 – Upper Anderson Bridge	31.5	55.0
	4	Upper Anderson Bridge – Balls Ferry	17.5	72.5
	5	Balls Ferry – Jellys Ferry	25.5	98.0
	6	Jellys Ferry – Bend Bridge	1.5	99.5
	7	Bend Bridge – Red Bluff Diversion Dam	0.0	–
Middle	8	Red Bluff Diversion Dam – Tehama Bridge	0.5	100.0
	9	Tehama Bridge – Woodson Bridge	0.0	–
	10	Woodson Bridge – Hamilton City	0.0	–
Lower	11	Hamilton City – Ord Ferry	0.0	–
	12	Ord Ferry – Princeton	0.0	–

Source: U.S. Bureau of Reclamation 2008 OCAP Biological Assessment, Appendix L, Reclamation Salmon Mortality Model.

Table J.4-2. Feather River Chinook Spawning Distributions

Salmon Reach	No.	River Reach	Spring Spawning Distribution (%)	
			Incremental	Cumulative
Upper	1	Fish Dam – RM 65.0	20	20
	2	RM 65.0 – RM 62.0	20	40
	3	RM 62.0 – Upstream of Afterbay	20	60
Lower	4	Downstream of Afterbay – RM 55.0	10	70
	5	RM 55.0 – Gridley	10	80
	6	Gridley – RM 47.0	10	90
	7	RM 47.0 – Honcut Creek	10	100
	8	Honcut Creek – Yuba River	0	–
	9	Yuba River - Mouth	0	–

Source: U.S. Bureau of Reclamation 2008 OCAP Biological Assessment, Appendix L, Reclamation Salmon Mortality Model.
RM = River Mile.

Generally, adult spring-run Chinook salmon enter the Sacramento River system and begin migrating to their spawning grounds from late January through August with the peak migration occurring March–July. They hold in deep pools primarily from mid-April through mid-September, and spawn between mid-August and mid-October. Peak spring-run spawning occurs during September.

J.4.1.1.2 Water Temperature and Egg Incubation

Like Chinook salmon in general, spring-run egg incubation and embryo development is dependent on ambient water temperature with an optimal water temperature range presumed to be between 41°F and 56°F. Significant reduction of egg viability is expected to occur at water temperatures exceeding 57.5°F with total egg and embryo mortality anticipated to occur at water temperatures above 62°F (National Marine Fisheries Service 2009). Within the optimal water temperature range spring-run embryos are expected to hatch in 40 to 60 days, with fry emerging from the gravel from November to March (Moyle 2002).

Water temperature in the upstream spawning and egg incubation habitats for steelhead and salmon is influenced by a number of factors. The primary factors are reservoir storage and coldwater pool within the reservoir, instream flow releases to the river, and seasonal atmospheric conditions. The level of water storage in a reservoir has a strong effect on the volume of cold water (coldwater pool) in the reservoir and, therefore, the temperature of water released during the summer and early fall. The summer and early fall are the times of year when river temperatures are most likely to rise above tolerance thresholds for steelhead and salmon.

The release of cold water from Shasta Dam and reservoir management to maintain the cold water pool have addressed many temperature issues on the upper Sacramento River. However, as the river flows further downstream, particularly during the warm spring, summer and early fall months, water temperatures continue to increase until they reach thermal equilibrium with atmospheric conditions. As a result of the longitudinal gradient of seasonal water temperatures, the cold temperatures and best areas for salmon spawning and rearing are typically located immediately downstream of the dam.

J.4.1.2 Analysis

The analysis reviewed flow and water temperature data during September–January, the spring-run spawning and egg incubation periods, as well as egg mortality modeling. Spring-run Chinook egg mortality is affected by hydrologic changes and climate change-induced increases in air and water temperatures. To account for the effects of climate change in the future, results for the ELT and LLT are discussed separately.

The metrics include:

- **Reservoir storage**. Shasta and Oroville at end of September.
- **Flows**. Sacramento River flows at Keswick and Feather River flows in the low-flow channel and high-flow channel (at Thermalito).
- **Water temperature**. The occurrence of temperatures exceeding 56°F (which are too warm for egg incubation) was modeled for the Sacramento River and Feather River. Reclamation Temperature Model was used for the Feather River and the Sacramento River Water Quality Model (SRWQM) was used for the Sacramento River.
- **Chinook egg survival.** Reclamation egg mortality model for the Sacramento River.

J.4.1.2.1 Storage and Flows

The effects analysis includes a summary of the September storage in Shasta and Oroville Reservoirs in combination with a frequency of exceedance analysis for September storage. Instream flows were characterized based on results of CALSIM II hydrologic modeling and presented as both instream flows by month and water year and monthly frequency of exceedance plots to allow examination of the entire range of simulation results for each of the effects analysis conditions examined. Coldwater pool availability is largely determined by the volume of water in reservoir storage. For the purposes of this analysis, the volume of Shasta and Oroville Reservoir September storage is used as an indicator of coldwater pool availability.

J.4.1.2.2 Water Temperature

Water temperatures in stream reaches affected by the BDCP and used by spring-run Chinook salmon for spawning were simulated using two separate temperature models, as described in the Flow Appendix (Section C.5.2.1.1). Daily average temperatures in the mainstem Sacramento River in the reach downstream of Keswick Dam were estimated using the SRWQM with post-processed CALSIM II flow data. The SRWQM is used in the effects analysis to predict the effects of reservoir operations on water temperatures in the Sacramento River and Shasta and Keswick Reservoirs. Water temperatures in the Feather River were estimated using the Reclamation Temperature Model, which is limited to monthly averages.

The SRWQM data provide daily averages while the Reclamation Temperature Model provides monthly averages only, but the SRWQM is only optimized for analysis on the Sacramento River. Also, the Reclamation Temperature model is very sensitive, potentially predicting greater changes than actually observed. In situations when the model predicts temperature violations (exceeding a threshold), in reality the water managers, operating on a daily basis, are more responsive than the model assumptions and may be able to avoid exceedances in many cases.

J.4.1.2.3 Chinook Egg Mortality Model

Egg mortality in the mainstem Sacramento River was estimated for the different model scenarios using the Reclamation Salmon Mortality Model. This model estimates proportional salmon mortality for pre-spawned eggs, fertilized eggs, and pre-emergent fry of all Chinook salmon races based on water temperature output from the SRWQM for the Sacramento River and the Reclamation Temperature Model for other rivers. The daily timestep from the SRWQM may underestimate mortality in the Sacramento River (J. Hannon pers. comm. cited in the Flow Appendix). The model uses temperature exposure mortality criteria for the three life stages, spawning distribution data, and output from the river temperature models to estimate percentages of egg and fry losses of a given brood of eggs for each run of Chinook salmon.

The high sensitivity of the Reclamation Temperature model has ramifications for the Reclamation egg mortality model. If the temperature model is off by one degree, it shows a larger increase in egg mortality. Furthermore, the Reclamation Temperature and Egg Mortality models were developed for the Sacramento River, and may not apply accurately to other rivers (e.g., Feather). DWR has a separate egg mortality model for the Feather River (created when they were relicensing Oroville) that is considered by some to be better for analysis on the Feather River. Finally, other model assumptions (i.e. what reach used or how flows were regulated) may not reflect actual metrics used for day-to-day operations by the water managers.

J.4.1.3 Results

J.4.1.3.1 Sacramento River—Early Long-Term

Flows

Mean monthly flows at Keswick were examined during the Spring-run Chinook spawning and incubation period (Table J.4-3). Flows were substantially different in September (the peak spring-run spawning month). During the ELT period, in September, flows under Scenario 6 were greater in wet (46.5% more) and above normal years (14.4% more) than PP. This is likely in response to Fall X2 requirements. However, in drier conditions flows were lower under Scenario 6 for below normal (12% less) and critical water years (14.3% less) compared to PP. The general pattern was the same at the Red Bluff Diversion Dam (Table J.3-2).

Table J.4-3. Mean Monthly Flow (CALSIM) Sacramento River at Keswick

M	WY	EBC2_ELT	EBC2_LLT	A1_ELT	A1_LLT	S6_ELT	S6_LLT	A1_ELTvs.S6_ELT	A1_LLTvs.S6_LLT
SEP	W	12,012	12,833	7,756	6,998	11,365	13,114	3609(46.5%)	6116(87.4%)
	AN	9,209	9,898	6,598	6,253	7,551	9,331	952(14.4%)	3078(49.2%)
	BN	5,677	5,601	5,832	5,284	5,132	4,723	-700(-12%)	-561(-10.6%)
	D	4,982	4,469	5,299	4,722	4,543	4,874	-756(-14.3%)	152(3.2%)
	C	4,827	4,368	4,794	4,927	4,722	5,145	-71(-1.5%)	217(4.4%)
	AVG	7,926	8,094	6,285	5,794	7,273	8,153	988(15.7%)	2359(40.7%)
OCT	W	6,491	7,034	6,213	8,025	6,425	6,954	213(3.4%)	-1071(-13.3%)
	AN	6,090	7,152	5,835	8,462	5,876	7,470	41(0.7%)	-992(-11.7%)
	BN	5,835	7,072	5,774	8,950	5,705	6,578	-69(-1.2%)	-2371(-26.5%)
	D	5,899	6,494	5,403	8,106	5,797	6,789	393(7.3%)	-1317(-16.2%)
	C	5,452	5,752	5,776	7,875	5,590	5,997	-186(-3.2%)	-1878(-23.8%)
	AVG	6,038	6,752	5,841	8,242	5,962	6,789	121(2.1%)	-1453(-17.6%)
NOV	W	7,620	7,539	6,445	6,401	6,511	6,350	66(1%)	-51(-0.8%)
	AN	7,357	7,134	5,187	4,457	5,629	5,562	442(8.5%)	1105(24.8%)
	BN	5,926	5,936	4,459	4,241	4,514	4,655	55(1.2%)	414(9.8%)
	D	5,439	5,406	4,926	4,319	4,638	4,604	-287(-5.8%)	285(6.6%)
	C	4,789	4,710	4,315	4,196	4,431	4,454	116(2.7%)	258(6.1%)
	AVG	6,399	6,324	5,277	4,968	5,325	5,284	49(0.9%)	316(6.4%)
DEC	W	12,808	11,022	14,260	11,953	13,026	10,803	-1234(-8.7%)	-1151(-9.6%)
	AN	5,729	5,377	5,055	5,376	5,339	5,301	283(5.6%)	-75(-1.4%)
	BN	5,857	5,195	5,815	5,412	5,667	5,728	-148(-2.5%)	316(5.8%)
	D	3,883	3,936	4,243	4,206	4,233	4,113	-10(-0.2%)	-93(-2.2%)
	C	3,593	3,582	3,911	3,645	3,766	4,171	-145(-3.7%)	526(14.4%)
	AVG	7,278	6,557	7,758	6,958	7,359	6,692	-399(-5.1%)	-265(-3.8%)
JAN	W	17,330	18,233	18,199	18,615	17,876	18,565	-324(-1.8%)	-50(-0.3%)
	AN	7,776	8,205	9,121	7,987	8,492	7,772	-628(-6.9%)	-215(-2.7%)
	BN	4,340	4,184	4,860	5,666	4,922	4,315	62(1.3%)	-1351(-23.8%)
	D	4,098	4,096	4,136	4,371	4,118	3,745	-18(-0.4%)	-627(-14.3%)
	C	3,794	4,238	3,915	3,452	3,550	4,073	-365(-9.3%)	621(18%)
	AVG	8,829	9,215	9,416	9,503	9,174	9,179	-241(-2.6%)	-324(-3.4%)
		Increase >50%		Increase 25–50%		Increase 10–25%			Increase 5–10%
		Decrease >50%		Decrease 25–50%		Decrease 10–25%			Decrease 5–10%

Shasta Reservoir Storage

Shasta Reservoir is the source of cold water to maintain cooler stream temperatures for incubating salmon eggs downstream of Keswick Dam. The amount of coldwater available to release depends on carryover storage in September. During the ELT period, September storage in Shasta Reservoir is decreased slightly (5–6%) under Scenario 6 in wet and above normal water years (Table J.3-11).

Water Temperature

Table J.4-4 summarizes the frequency of years with monthly average water temperatures exceeding 56°F in one or more months for the upper Sacramento River, during the spring-run Chinook salmon egg incubation period (September through January) in the ELT period. Results are for all water years combined and were not broken out by water year types. Generally, the frequency of years with one or more temperature exceedance events increases with distance downstream of Keswick Dam under both scenarios.

During the ELT period, the differences between Scenario 6 and PP are projected to be more pronounced upstream at Keswick Dam, decreasing as flows move downstream to Bend Bridge. This is because the benefits of increased coldwater flows are diminished as water flows in the open river, subject to warming by surrounding air conditions. At Keswick Dam, for example, water temperatures exceeding 56°F one or more times per year under Scenario 6 are projected to be 31% more frequent than similar events under PP although such events would occur 4% less frequently than under EBC2 conditions. In contrast, water temperatures exceeding 56°F one or more times per year under PP are predicted to occur 26% less frequently than under EBC2 conditions. Further downstream at Ball's Ferry, Jelly's Ferry, and Bend Bridge, the frequency of exceedance events one or more times per year is projected to remain the same or decrease slightly (2–9%) under Scenario 6 relative to PP.

Table J.4-5 summarizes the frequency of water temperature changes anticipated for each month during the spring-run Chinook spawning and egg incubation period on the upper Sacramento River. September and October are the critical months as the spawning and egg incubation cycle progresses for spring-run Chinook. Water temperature exceedances are more prevalent early in the season (September and October) increasing with distance downstream from Keswick Dam. During the ELT period, the differences between Scenario 6 and PP are projected to be similar in terms of the number of times the spawning and egg incubation threshold of 56°F is exceeded. However, water temperature exceedances under Scenario 6 are projected to occur more frequently during September at Keswick Dam (4% more often) but less frequently downstream at Ball's Ferry, Jelly's Ferry and Bend Bridge (occurring 2 to 11% less often). In October, water temperature exceedances are generally projected to increase under Scenario 6 operations by 5 to 7 percent compared to PP operations, except at Jelly's Ferry where exceedances are projected to occur at the same frequency for both scenarios.

Table J.4-4. Results of ELT Monthly Analysis of Water Temperature Simulation in the Upper Sacramento River during the September–January Spring-Run Salmon Egg Incubation Period[1]

Number of Years with Temperatures Exceeding 56°F	EBC2_ELT	A1_ELT	S6_ELT	A1_ELT vs. EBC2_ELT		S6_ELT vs. EBC2_ELT		S6_ELT vs. A1_ELT	
				Num	% dif	Num	% dif	Num	% dif
Sacramento River at Keswick Dam									
Number of years with one or more exceedances	35	26	34	-9	-26%	-1	-4%	8	31%
Two exceedances	17	21	19	4	24%	2	10%	-2	-10%
Three exceedances	7	4	6	-3	-43%	-1	-25%	2	50%
Four exceedances	0	0	0	0	0%	0	0%	0	0%
Five or more exceedances	0	0	0	0	0%	0	0%	0	0
Number of consecutive years with one or more exceedances	28	20	25	-8	-29%	-3	-15%	5	25%
Sacramento River at Ball's Ferry									
Number of years with one or more exceedances	58	69	63	11	19%	5	7%	-6	-9%
Two exceedances	29	28	30	-1	-3%	1	4%	2	7%
Three exceedances	0	0	0	0	0%	0	0%	0	0%
Four exceedances	0	0	0	0	0%	0	0%	0	0%
Five or more exceedances	0	0	0	0	0%	0	0%	0	0%
Number of consecutive years with one or more exceedances	51	66	57	15	29%	6	9%	-9	-14%
Sacramento River at Jelly's Ferry									
Number of years with one or more exceedances	70	79	74	9	13%	4	5%	-5	-6%
Two exceedances	38	34	34	-4	-11%	-4	-12%	0	0%
Three exceedances	0	0	0	0	0%	0	0%	0	0%
Four exceedances	0	0	0	0	0%	0	0%	0	0%
Five or more exceedances	0	0	0	0	0%	0	0%	0	0%
Number of consecutive years with one or more exceedances	68	79	72	11	16%	4	5%	-7	-9%
Sacramento River at Bend Bridge									
Number of years with one or more exceedances	77	81	79	4	5%	2	2%	-2	-2%
Two exceedances	39	36	40	-3	-8%	1	3%	4	11%
Three exceedances	0	0	0	0	0%	0	0%	0	0%
Four exceedances	0	0	0	0	0%	0	0%	0	0%
Five or more exceedances	0	0	0	0	0%	0	0%	0	0%
Number of consecutive years with one or more exceedances	77	81	79	4	5%	2	2%	-2	-2%
Note: Total period of record is 81 years. Highlighted cells are negative differences.									

Table J.4-5. Frequency of Water Temperatures in the Upper Sacramento River Exceeding a 56°F Threshold during the September–January Spring-Run Chinook Salmon Egg Incubation Period, during the ELT Period

	September		October		November		December		January	
	Number[1]	%[2]	Number	%	Number	%	Number	%	Number	%
Sacramento River at Keswick										
EBC2_ELT	27	33%	32	40%	7	9%	0	0%	0	0%
A1_ELT	25	31%	25	31%	5	6%	0	0%	0	0%
S6_ELT	28	35%	31	38%	6	7%	0	0%	0	0%
Sacramento River at Balls Ferry										
EBC2_ELT	55	68%	32	40%	0	0%	0	0%	0	0%
A1_ELT	69	85%	28	35%	0	0%	0	0%	0	0%
S6_ELT	60	74%	33	41%	0	0%	0	0%	0	0%
Sacramento River at Jelly's Ferry										
EBC2_ELT	70	86%	38	47%	0	0%	0	0%	0	0%
A1_ELT	79	98%	34	42%	0	0%	0	0%	0	0%
S6_ELT	74	91%	34	42%	0	0%	0	0%	0	0%
Sacramento River at Bend Bridge										
EBC2_ELT	77	95%	39	48%	0	0%	0	0%	0	0%
A1_ELT	81	100%	36	44%	0	0%	0	0%	0	0%
S6_ELT	28	35%	31	38%	6	7%	0	0%	0	0%

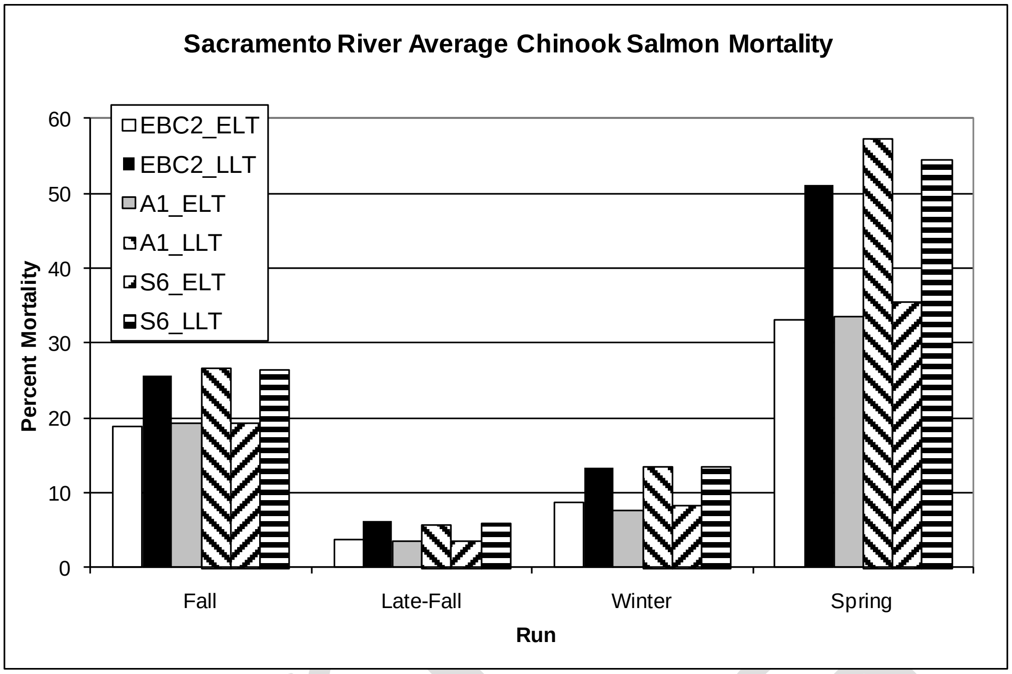
Notes:
[1] Number of years in which water temperatures exceed the 56°F threshold for successful spring-run Chinook spawning and egg incubation.
[2] Percent of total years of record modeled (81). Darker shading indicates a greater percentage of the period with temperature exceedances.

Spring-Run Chinook egg mortality

Average mortality of Chinook salmon eggs in the Sacramento River was highest for spring-run (Figure J.4-1). During the ELT period, average egg mortality was very similar between Scenario 6 (36%) and PP (33%) as well as existing biological conditions (EBC2-ELT 33%) (Table J.4-6). Modeled egg mortality varied across water years, but the general pattern was similar across all operations. The lowest mortality was in wet water year types (14–17% mortality), increasing during dry (37–43%) and critical water years (85–93%) (Table J.4-6, Figure J.4-1).

Scenario 6 has similar egg mortality compared to PP in wet and above normal years, and marginally increased egg mortality (5–8% greater than PP) in below normal, dry and critical years (Table J.4-6). One possible explanation for this result is that if the prior year is wet or above normal and Fall X2 releases are made that September (reducing the carryover in Shasta reservoir), then there is potentially greater impact on egg survival (i.e., more egg mortality) if the following year is below normal, dry or critical.

a.



b.

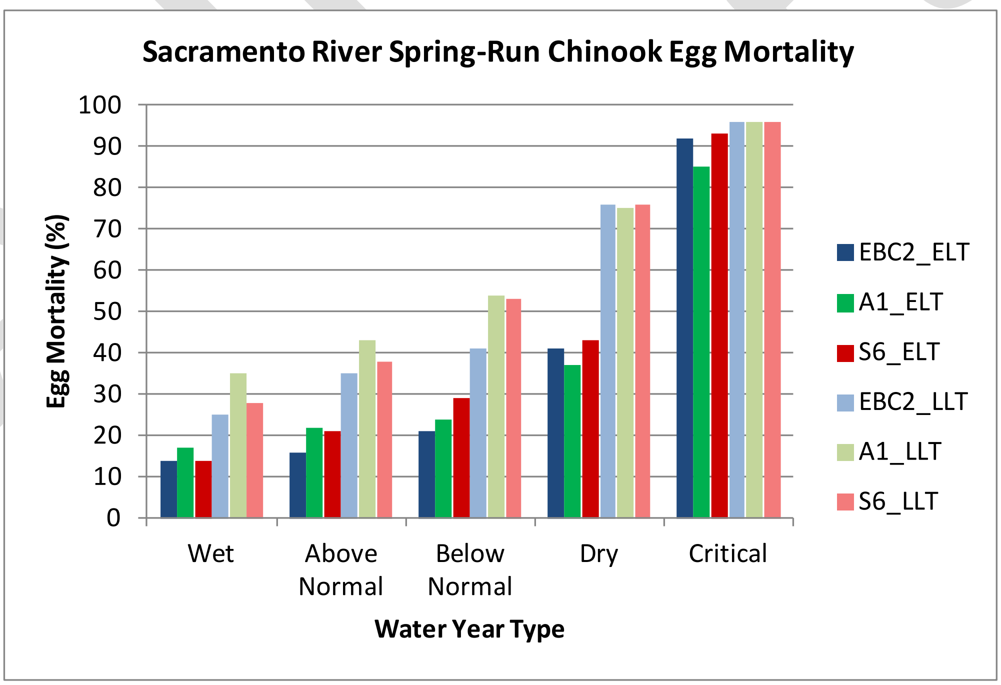


Figure J.4-1. Average Chinook Salmon Egg Mortality in the Sacramento River under each Model Scenario for (a) All Runs and (b) Spring-Run by Water Year Type

Table J.4-6. Egg Mortality Percentages (%) for Model Scenarios for Spring-Run Chinook in the Mainstem Sacramento River

River	Percent Mortality							
	EBC2_ELT	EBC2_LLT	A1_ELT	A1_LLT	S6_ELT	S6_LLT	A1_ELT v S6_ELT*	A1_LLT v S6_LLT*
Sacramento River								
Wet	14	25	17	35	14	28	3	7
Above Normal	16	35	22	43	21	38	1	5
Below Normal	21	41	24	54	29	53	-5	1
Dry	41	76	37	75	43	76	-5	1
Critical	92	96	85	96	93	96	-8	0
Average	33	51	33	57	36	55	-2	3
* Negative number = increased egg mortality under Scenario 6 (difference of percent mortality).								

J.4.1.3.2 Sacramento River—Late Long-Term

Flows

Flows at Keswick are markedly different between PP and Scenario 6 in September and October (Table J.4-3). In September flows under Scenario 6 were greater in wet (87.4%) and above normal years (49.2%), but decreased in below normal years (12% less) compared to PP. October flows for LLT were substantially reduced under Scenario 6 for all water years types (11.7–26.5% less). In November for LLT, flows under Scenario 6 were slightly greater for below normal, critical and dry years (6.1–9.8% more) and substantially greater for above normal years (24.8% more). Flow differences in December are less consistent and usually small, although there is an appreciable decrease in flow in wet years 9.6%).

Shasta Reservoir Storage

The LLT September storage in Shasta Reservoir under Scenario 6 decreased 7–10% in wet and above normal years and increased 5% in below normal water years (Table J.3-11). This is likely a result of releases made to meet Fall X2 requirements in the Delta.

Water Temperature

During the LLT period, the frequency of water temperature exceedances was greater compared to the ELT period and greater for stations further downstream from Keswick (Table J.4-7). The pattern of water temperature exceedances was more variable at Keswick Dam (Table J.4-7). The projected number of years with one exceedance or more at Keswick Dam was actually more under Scenario 6 (67 years) than for PP (58 years). However, the number of years with two exceedances at Keswick Dam under Scenario 6 are 10% less frequent than under PP (26 years vs 29 years, respectively) and the number of years with three exceedances is 16% less frequent under Scenario 6 (21 years vs. 25 years). No exceedances of four years or more were projected for either scenario.

The number of consecutive years where water temperatures exceed tolerance limits for spring-run spawning and egg incubation, along with the frequency of years with multiple months when these exceedances occur are important considerations for long-term effects on spring-run Chinook salmon.

The number of consecutive years with one or more water temperature exceedances was similar for PP and Scenario 6 at Jelly's Ferry and Bend Bridge during the LLT period (81 years vs. 80 years, respectively at both locations). At Jelly's Ferry and Bend Bridge, there was at least one temperature exceedance in virtually every year (81 years modeled). At Balls' Ferry, fewer consecutive years are projected with one or more water temperature exceedances for Scenario 6 versus PP (77 years vs. 80 years, respectively) (Table J.4-7). As described above, the most variability was projected for water temperatures at Keswick Dam. Scenario 6 was projected to have more consecutive years with one or more exceedances than PP (61 years vs. 51 years). This shows that water temperature tolerances for spring-run egg incubation are exceeded at least once between September and January in most years.

Table J.4-7. Results of LLT Monthly Analysis of Water Temperature in the Upper Sacramento River during the September–January Spring-Run Chinook Salmon Egg Incubation Period

Number of Years with Temperatures Exceeding 56°F	EBC2_LLT	A1_LLT	S6_LLT	A1_LLT vs EBC2_LLT		S6_LLT vs EBC2_LLT		S6_LLT vs. A1_LLT	
				Num	% dif	Num	% dif	Num	% dif
Sacramento River at Keswick Dam									
Number of years with one or more exceedances	59	58	67	-1	-2%	8	14%	9	16%
Two exceedances	26	29	26	3	12%	0	0%	-3	-10%
Three exceedances	19	25	21	6	32%	2	8%	-4	-16%
Four exceedances	0	0	0	0	0%	0	0%	0	0%
Five or more exceedances	0	0	0	0	0%	0	0%	0	0%
Number of consecutive years with one or more exceedances	54	51	61	-3	-6%	7	14%	10	20%
Sacramento River at Ball's Ferry									
Number of years with one or more exceedances	76	80	78	4	5%	2	3%	-2	-3%
Two exceedances	50	49	52	-1	-2%	2	4%	3	6%
Three exceedances	7	7	7	0	0%	0	0%	0	0%
Four exceedances	0	0	0	0	0%	0	0%	0	0%
Five or more exceedances	0	0	0	0	0%	0	0%	0	0%
Number of consecutive years with one or more exceedances	75	80	77	5	7%	2	3%	-3	-4%
Sacramento River at Jelly's Ferry									
Number of years with one or more exceedances	80	81	80	1	1%	0	0%	-1	-1%
Two exceedances	57	57	62	0	0%	5	9%	5	9%
Three exceedances	4	5	3	1	25%	-1	-20%	-2	-40%
Four exceedances	0	0	0	0	0%	0	0%	0	0%
Five or more exceedances	0	0	0	0	0%	0	0%	0	0%
Number of consecutive years with one or more exceedances	80	81	80	1	1%	0	0%	-1	-1%
Sacramento River at Bend Bridge									
Number of years with one or more exceedances	80	81	80	1	1%	0	0%	-1	-1%
Two exceedances	60	58	63	-2	-3%	3	5%	5	9%

Number of Years with Temperatures Exceeding 56°F	**EBC2_LLT**	**A1_LLT**	**S6_LLT**	**A1_LLT vs EBC2_LLT**		**S6_LLT vs EBC2_LLT**		**S6_LLT vs. A1_LLT**	
				Num	**% dif**	**Num**	**% dif**	**Num**	**% dif**
Three exceedances	4	5	3	1	25%	-1	-20%	-2	-40%
Four exceedances	0	0	0	0	0%	0	0%	0	0%
Five or more exceedances	0	0	0	0	0%	0	0%	0	0%
Number of consecutive years with one or more exceedances	80	81	80	1	1%	0	0%	-1	-1%
Note: Total period of record is 81 years. Highlighted cells are negative differences.									

Table J.4-8 summarizes the frequency of water temperature changes anticipated for each month during the spring-run Chinook spawning and egg incubation period on the upper Sacramento River during the LLT period. September and October are the critical months as the spawning and egg incubation cycle progresses for spring-run Chinook. As illustrated in Table J.4-8, water temperature exceedances are more prevalent early in the season (September and October) increasing with distance downstream of Keswick Dam. During the LLT period, the differences between Scenario 6 and PP are projected to be similar in terms of the number of times the spawning and egg incubation threshold of 56°F is exceeded. However, water temperature exceedances under Scenario 6 are projected to occur slightly less frequently during September (1 to 3% less often) and November (2 to 5% less often) than anticipated for PP operations. During October, Scenario 6 operations are projected to occur slightly more often (3 to 5% more) than under PP operations.

Table J.4-8. Frequency of Water Temperatures in the Upper Sacramento River Exceeding a 56°F Threshold, during LLT Period

	September		**October**		**November**		**December**		**January**	
	Num	**% dif**	**Num**	**% dif**	**Num**	**% dif**	**Num**	**% dif**	**Num**	**% dif**
Sacramento River at Keswick										
EBC2_LLT	25	31%	25	31%	5	6%	0	0%	0	0%
A1_LLT	57	70%	54	67%	26	32%	0	0%	0	0%
S6_LLT	54	67%	59	73%	22	27%	0	0%	0	0%
Sacramento River at Balls Ferry										
EBC2_LLT	69	85%	28	35%	0	0%	0	0%	0	0%
A1_LLT	80	99%	56	69%	7	9%	0	0%	0	0%
S6_LLT	76	94%	61	75%	7	9%	0	0%	0	0%
Sacramento River at Jelly's Ferry										
EBC2_LLT	79	98%	34	42%	0	0%	0	0%	0	0%
A1_LLT	81	100%	62	77%	5	6%	0	0%	0	0%
S6_LLT	80	99%	65	80%	3	4%	0	0%	0	0%
Sacramento River at Bend Bridge										
EBC2_LLT	81	100%	36	44%	0	0%	0	0%	0	0%
A1_LLT	81	100%	63	78%	5	6%	0	0%	0	0%
S6_LLT	80	99%	66	81%	3	4%	0	0%	0	0%
[1] Percent of total years of record modeled (81).										

Spring-Run Chinook Egg Mortality

On average, spring-run Chinook egg mortality during LLT is generally predicted to be slightly greater for PP (6% increase) but not appreciably different for Scenario 6 when compared to existing baseline conditions (Table J.4-6). In wetter years (wet and above normal), egg mortality under Scenario 6 is anticipated to be 5–7% less than under PP (Figure J.4-1). In drier years, there are projected to be no differences in spring-run egg mortality (Table J.4-6). By comparison, existing baseline conditions may also experience high mortality during the LLT period ranging from 25% to 96%. Spring-run egg mortality during below normal water years is projected to increase 12–13% for both PP (54% mortality) and Scenario 6 (53% mortality) compared to existing baseline conditions (41% mortality). PP, Scenario 6 and EBC2 all have equally high mortality in dry (75–76%) and critical (96% mortality) during (Table J.4-6).

J.4.1.3.3 Feather River

For purposes of this analysis, it is assumed that potential in-river spring-run Chinook salmon spawning would follow a distribution pattern similar that that described above (~60% in the low flow channel and ~40% in the high flow channel upstream of Honcut Creek) and that water temperatures of 56°F or less would be necessary for successful spawning and egg incubation.

Flows

Flows in the Feather River low-flow channel, where most in-river Chinook salmon spawning occurs, are determined by controlled releases and do not differ across water years, operations scenario, or future period (ELT and LLT) (Table J.3-6). Seasonally, the flows vary slightly: 700 cfs April–August, ramping up during the spring-run Chinook spawning and egg incubation period to 773 cfs in September, and 800 cfs in October and remaining at this level through March (Table J.3-6)

In the Feather River high-flow channel, just downstream of the Thermalito Afterbay outlet channel, monthly average flows under Scenario 6 compared to PP are greater in September, relatively similar in October and November, and decreased in December and January (Figure J.4-2, Table J.4-9). In wet and above normal water year types, September flows under Scenario 6 are much higher compared to PP in wet (443% greater in ELT, 517% in LLT) and above normal (228% ELT, 174% LLT) water year types. This is due to releases from Oroville to meet Fall X2 requirements downstream in the Delta. Moderate or little change in mean monthly flows is projected for below normal, dry and critical water year types, ranging from a 24% decrease in dry water years to a 19% increase in below normal (ELT) (Table J.4-9). Projected flows in the Feather River high flow channel mostly decrease at moderate levels from October through January during both the ELT and LLT periods under both operations.

As seen with the Sacramento River, the Feather River flows under Scenario 6 decline in December and January, likely to offset the increased releases made in September to meet Fall X2 requirements.

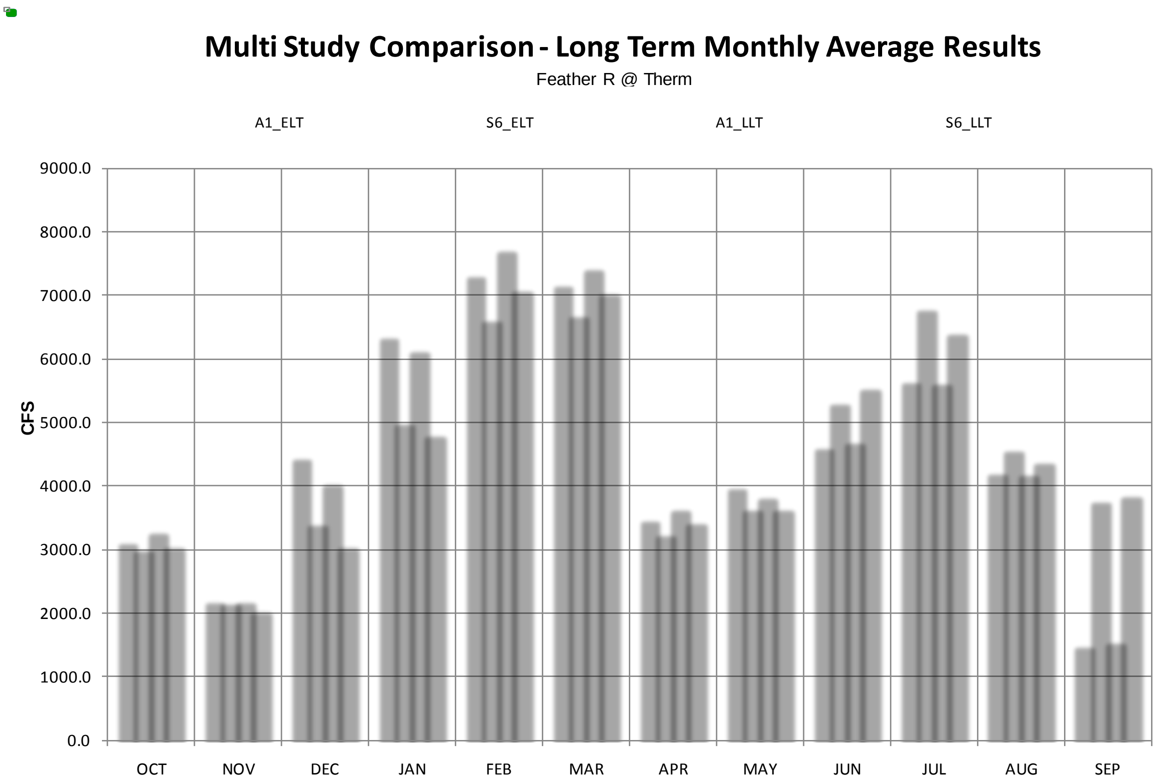


Figure J.4-2. Mean Monthly Flows (cfs) for Model Scenarios in Feather River below the Thermalito Afterbay Outlet channel (high flow channel)

Table J.4-9. Mean Monthly Flow (CALSIM II) for the Feather River at the Thermalito Afterbay Outlet channel during Spring-Run Chinook Egg Incubation

M	WY	EBC2_ELT	EBC2_LLT	A1_ELT	A1_LLT	S6_ELT	S6_LLT	A1_ELT vs. S6_ELT	A1_LLT vs. S6_LLT
SEP	W	8,400	8,327	1,263	1,172	6,737	7,231	5,474 (433.5%)	6,058 (516.9%)
	AN	7,172	6,899	1,680	1,902	5,511	5,215	3,830 (228%)	3,313 (174.2%)
	BN	3,161	3,068	1,353	1,455	1,608	1,470	255 (18.9%)	15 (1%)
	D	1,473	1,052	1,668	1,658	1,264	1,275	-404 (-24.2%)	-383 (-23.1%)
	C	1,451	1,345	1,715	1,744	1,789	1,693	74 (4.3%)	-51 (-2.9%)
	AVG	4,788	4,601	1,494	1,518	3,756	3,835	2,262 (151.4%)	2,317 (152.7%)
OCT	W	3,025	3,051	3,153	3,260	3,245	3,116	92 (2.9%)	-144 (-4.4%)
	AN	2,577	2,741	3,361	3,303	2,779	3,221	-582 (-17.3%)	-83 (-2.5%)
	BN	2,820	2,862	3,211	3,043	3,012	2,747	-199 (-6.2%)	-296 (-9.7%)
	D	2,786	2,652	2,958	3,220	3,266	3,090	308 (10.4%)	-130 (-4%)
	C	2,233	2,102	2,924	3,506	2,381	2,924	-543 (-18.6%)	-582 (-16.6%)
	AVG	2,756	2,747	3,117	3,256	3,015	3,035	-102 (-3.3%)	-222 (-6.8%)
NOV	W	2,812	2,470	2,860	2,747	2,847	2,391	-13 (-0.5%)	-356 (-13%)
	AN	1,915	2,119	2,114	1,915	1,916	1,858	-198 (-9.4%)	-57 (-3%)
	BN	1,950	1,900	1,762	1,854	1,930	1,824	168 (9.5%)	-29 (-1.6%)

M	WY	EBC2_ELT	EBC2_LLT	A1_ELT	A1_LLT	S6_ELT	S6_LLT	A1_ELT vs. S6_ELT	A1_LLT vs. S6_LLT
	D	1,729	1,664	1,801	1,811	1,764	1,737	-38 (-2.1%)	-74 (-4.1%)
	C	1,803	1,876	1,901	2,016	1,845	1,970	-56 (-2.9%)	-46 (-2.3%)
	AVG	2,148	2,058	2,191	2,160	2,170	2,011	-21 (-1%)	-149 (-6.9%)
DEC	W	5,543	3,948	7,691	5,927	5,339	4,617	-2,353 (-30.6%)	-1,310 (-22.1%)
	AN	3,344	3,344	3,382	4,443	3,479	3,096	97 (2.9%)	-1,347 (-30.3%)
	BN	2,096	2,102	2,732	2,748	2,135	2,268	-597 (-21.9%)	-480 (-17.5%)
	D	2,202	2,229	2,865	2,690	2,337	2,173	-528 (-18.4%)	-517 (-19.2%)
	C	1,781	1,694	2,759	2,889	2,237	1,684	-521 (-18.9%)	-1,204 (-41.7%)
	AVG	3,349	2,837	4,433	4,012	3,407	3,028	-1,026 (-23.1%)	-984 (-24.5%)

	Increase >50%	Increase 25–50%	Increase 10–25%	Increase 5–10%
	Decrease >50%	Decrease 25–50%	Decrease 10–25%	Decrease 5–10%

Water Temperature

Water temperatures in the low-flow channel of the Feather River are determined largely by coldwater pool storage in Oroville Reservoir and instream flow releases. Because instream flows in the low-flow channel would be the same under baseline, PP and Scenario 6 conditions, any simulated changes in water temperatures under BDCP operations would be attributed to changes in reservoir storage. Reservoir storage in September provides an indicator of coldwater pool availability. September water storage in Oroville Reservoir would decrease in under Scenario 6 for all water year types. The change is similar for both ELT and LLT. Reservoir storage under Scenario 6 would be decreased by 17% to 19% in wet water years, 19% to 20% in above normal, 13% in below normal, 11%to12% in dry, and 5% to 9% in critical water years (Table J.3-11).

Comparing PP to Scenario 6 during the ELT period, water temperature modeling for the Feather River low-flow channel shows no difference in the number of consecutive years with one of more water temperature exceedances of the 56°F criteria (80 of 80 years were projected to have at least one exceedance) (Table J.4-10). Slight differences in the number of average monthly water temperature exceedances are projected for two or three exceedances between Scenario 6 and PP during the ELT period (1 to 5 years more often for Scenario 6). Relative to EBC2 projections, there was no projected difference in number of years of one exceedance or consecutive years with one or more exceedances during the ELT period. The number of years with two exceedances decreased in both PP (16% fewer years) and Scenario 6 (14% fewer years) relative to EBC2 projections. The number of years with three exceedances decreased 22% in PP but increased 18% in Scenario 6 compared to EBC2.

Table J.4-10. ELT Monthly Analysis of Water Temperature Simulations in the Feather River Low-Flow Channel during the September–January Spring-Run Salmon Egg Incubation Period[1]

Number of Years with Temperatures Exceeding 56°F	EBC2_ELT	A1_ELT	S6_ELT	Difference: A1_ELT vs. EBC2_ELT		S6_ELT vs. EBC2_ELT		S6_ELT vs. ALT1_ELT	
				Num	%	Num	%	Num	%
Number of years with one or more exceedances	80	80	80	0	0%	0	0%	0	0%
Two exceedances	44	37	38	-7	-16%	-6	-14%	1	3%
Three exceedances	9	7	11	-2	-22%	2	18%	4	57%
Four exceedances	0	0	0	0	0%	0	0%	0	0%
Five or more exceedances	0	0	0	0	0%	0	0%	0	0%
Number of consecutive years with one or more exceedances	80	80	80	0	0%	0	0%	0	0%

[1] Time period analyzed: September 1922 to January 2002. Analysis counted exceedances over 56°F. Percentage differences can be large for years with few exceedances.

During the LLT period, the water temperature model projected no difference in the number of consecutive years with one of more water temperature exceedances of the 56°F criteria (80 of 80 years) (Table J.4-11). The number of years with two water temperature exceedances decreased under Scenario 6 (17 years vs. 26 years), but increased for 3 exceedances (50 years vs. 34 years) and 4 exceedances (4 years vs .1 year) in comparison to PP. Relative to EBC2, there were no projected differences in the number of years of one exceedance or consecutive years with one or more exceedances. The number of years with two exceedances increased under PP (30% more) and decreased under Scenario 6 (15% fewer) relative to EBC2 projections. The number of years with three exceedances also decreased in PP (29% fewer) but increased in Scenario 6 (4%) compared to EBC2. Under both scenarios, the number of years with four exceedances decreased compared to EBC2 (86% fewer for PP and 43% fewer for Scenario 6).

Table J.4-11. LLT Monthly Analysis of Water Temperature Simulations in the Feather River Low-Flow Channel during the September–January Spring-Run Salmon Egg Incubation Period[1]

Number of Years with Temperatures Exceeding 56°F	EBC2_LLT	A1_LLT	S6_LLT	Difference: A1_LLT vs EBC2_LLT		S6_LLT vs EBC2_LLT		S6_LLT vs ALT1_LLT	
				Num	%	Num	%	Num	%
Number of years with one or more exceedances	80	80	80	0	0%	0	0%	0	0%
Two exceedances	20	26	17	6	30%	-3	-15%	-9	-35%
Three exceedances	48	34	50	-14	-29%	2	4%	16	47%
Four exceedances	7	1	4	-6	-86%	-3	-43%	3	300%
Five or more exceedances	0	0	0	0	0%	0	0%	0	0%
Number of consecutive years with one or more exceedances	80	80	80	0	0%	0	0%	0	0%

[1] Time period analyzed: September 1922 to January 2002. Analysis counted exceedances over 56°F. Percentage differences can be large for years with few exceedances.

Spring-Run Egg Mortality

Spring-run Chinook salmon egg mortality is expected to be high for in-river spawners due to the generally high water temperatures expected under all conditions during the primary spawning and egg incubation month of September on the Feather River. Feather River operating conditions under either A1 or S6 are not expected to change the frequency of water temperature exceedances above threshold criteria (56°F). Table J.4-12 shows that average monthly water temperature in the Feather River low-flow channel is projected to occur 100% of the time during the month of September for both A1 and S6 during ELT and LLT periods. October water temperature exceedances are projected to occur 55–65% of the years during the ELT period and 76–91% of the years during the LLT period. Exceedances during the month of November are less frequent but still be significant. Exceedances during the month of December are only projected to occur during the LLT period. It is anticipated that water temperature exceedances in the high-flow channel of the Feather River (i.e., downstream of the Thermalito Afterbay outlet channel) will occur at the same or greater levels than those projected for the low-flow channel.

Table J.4-12. Number of Water Temperature Exceedances (>= 56°F) by Month in the Feather River Low Flow Channel (Upstream of Thermalito Afterbay Outlet) during the September–January Spring-Run Chinook Salmon Egg Incubation Period

	September		October		November		December		January	
	Num	%[1]	Num	%	Num	%	Num	%	Num	%
EBC2_ELT	80	100%	52	65%	10	13%	0	0%	0	0%
A1_ELT	80	100%	44	55%	7	9%	0	0%	0	0%
S6_ELT	80	100%	48	60%	12	15%	0	0%	0	0%
EBC2-LLT	80	100%	73	91%	57	71%	7	9%	0	0%
A1_LLT	80	100%	61	76%	35	44%	1	1%	0	0%
S6_LLT	80	100%	71	89%	54	68%	4	5%	0	0%

[1] Percent of total years of record modeled (80).

J.4.1.4 Conclusions

J.4.1.4.1 Sacramento River

In the Sacramento River, spring-run Chinook egg mortality is very high in critical years (85–93% ELT, 96% LLT) across all scenarios (existing biological conditions, PP and Scenario 6). Climate change is a dominating driver of increased egg mortality, regardless of the operational scenario. Warmer climate conditions will be a contributing factor for increased mortality in the future. This is illustrated in dry years, when egg mortality increases from 37–43% during ELT to 75–76% during LLT (across all scenarios EBC2, PP and Scenario 6). Water temperatures that exceed conditions suitable for egg incubation (56°F) occur frequently in September under all scenarios and diminish over the season due to cooling air temperatures.

Scenario 6 does not result in significantly different egg survival in most years (5–8% increased in drier years during ELT, 5–7% decreased in wet and above normal years during LLT) compared to PP. Mortality was very similar to levels observed under EBC2. Egg mortality was slightly better in wet and above normal water years, likely due to September releases to meet outflow and Fall X2 requirements under Scenario 6. Under Scenario 6 the September storage volume in Shasta Reservoir is minimally changed (5–6% reduction in wet and critical years during ELT, 6–10% reduction in wet and above normal years during LLT).

Changes in hydrology during the spring-run spawning and egg incubation period from ELT to LLT could explain projected egg mortality differences when comparing PP and Scenario 6. Increased September flows during wet and above normal water years under Scenario 6 are likely not sufficient to deplete the cold water pool in Shasta reservoir and could increase the length of river downstream with adequate water temperatures, explaining the anticipated decrease in egg mortality during these years from that anticipated for PP. Decreased flows during the drier water years (below normal, dry and critical) may preserve available cold water in Shasta reservoir but not increase the length of river downstream with adequate water temperatures, resulting in little difference in projected egg mortality under either PP or Scenario 6.

J.4.1.4.2 Feather River

In the Feather River, flows in the main spawning area (the low-flow channel) will not differ across water years, operations scenario, or future period (ELT and LLT). Flows in the Feather River high-flow channel (just downstream of the Thermalito Afterbay outlet channel) are increased under Scenario 6 in September (wet and above normal water years), the early part of the egg incubation season, becoming progressively more decreased relative to PP for most water year types from October to January. Water temperature exceeding temperature criteria for Chinook are generally expected to occur at about the same frequency for PP and Scenario 6 relative to EBC2. However, water temperature exceedances are projected to occur more often during the LLT period than the ELT period. Because water temperatures are expected to exceed threshold levels in each scenario (EBC2, A1, or S6), in-river spring-run Chinook egg mortality is expected to be high. Egg mortality of hatchery reared spring-run Chinook is not expected to change because of water temperature controls to the Feather River Fish Hatchery.

J.4.2 Reduced Sacramento River Flows below North Delta Diversion

J.4.2.1 Background

J.4.2.1.1 Juvenile Salmonid Passage

Higher instream flows have been associated with improved survival rates for downstream migration of juvenile salmonids when they coincide with the seasonal timing of outmigration (Table J.4-13). Studies in the Columbia River basin have found a positive relationship between juvenile Chinook salmon migration rate and flow levels. Juvenile salmonid survival is thought to increase as migration speed increases, due primarily to decreased cumulative predation losses. Findings by Kjelson and Brandes (1989) and Williams and Mathews (1995) both showed a logarithmic survival-flow relationship for migrating juvenile Chinook salmon.

Table J.4-13. Juvenile Salmonid Outmigration through the Delta

Species/Race	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sept	Oct	Nov	Dec
Steelhead	■	■	■	■	■					■	■	■
Winter-run Chinook salmon	■	■	■	■							■	■
Spring-run Chinook salmon	■	■	■	■	■							■
Fall-run Chinook salmon		■	■	■	■							
Late fall–run Chinook salmon	■	■	■									

J.4.2.1.2 Adult Attraction Flows

Attraction flows and olfactory cues in the west Delta for upstream anadromous migrating fish will be altered because of shifts in exports from the south Delta to the north Delta under the BDCP. Changes in flow magnitude and the relative proportions of water reaching the Delta that originates from the Sacramento or San Joaquin River watersheds could potentially affect attraction of upstream migrating adult anadromous fishes that may be cueing on scent from the natal river and sources along the way (Williams 2006).

It is assumed the strength of the olfactory cue is directly related to the percentage of water at a given location that originated from the spawning fish's natal stream. The percentage of flow that originates from the natal stream represents the attraction flow. For purposes of this analysis, the percentage of Sacramento River or San Joaquin River flows at Collinsville represents the strength of olfactory cue for spawning fish just entering the Delta as they migrate toward their natal streams in the Sacramento or San Joaquin River Basins. The timing of adult Steelhead and Chinook salmon upstream migration through the Delta varies (Table J.4-14).

Table J.4-14. Adult Salmonid Upstream Migration through the Delta

Species/Race	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sept	Oct	Nov	Dec
Steelhead	■	■	▒						▒	▒	▒	■
Winter-run Chinook salmon	■	■										■
Spring-run Chinook salmon			▒	■	■							
Fall-run Chinook salmon									■	■	▒	
Late fall–run Chinook salmon	■	■										■
Note: Black bars represent peak migration period; Grey bars represent off-peak migration period.												

J.4.2.1.3 Smelt Transport

Decreased transport flows in the lower Sacramento River due to North Delta diversions have been identified as one mechanism that could adversely affect the growth and survival of larval smelt. Compared to existing biological conditions, PP reduces Delta outflows during the winter-spring larval period for longfin smelt and delta smelt, potentially reducing downstream larval transport. Based on observed correlation of longfin smelt abundance and Delta outflow (Kimmerer et al. 2009), it has been hypothesized that there is a direct relationship between survival of longfin smelt and transport flows. The correlation is not yet understood, so there may be other factors that are truly driving changes in longfin smelt abundance. For delta smelt, no correlation between transport flows and abundance have been established, so estimates of the potential effects on abundance are based on changed potential in larval transport due to altered levels of flows.

J.4.2.2 Analysis

This analysis focused on several metrics, following methods detailed in the Flow Appendix (Section C.6.3, *Passage, Movement and Migration*).

- **Flow**. Average monthly Sacramento River flow at Rio Vista during periods of adult migration, juvenile salmonid outmigration, and larval smelt transport.
- **Proportion of flows from Sacramento and San Joaquin Rivers**. DSM2 Fingerprinting analysis.
- **Juvenile salmonid survival**. The DPM estimates survival of juvenile Chinook salmon migrating through the Delta. The model, however, is undergoing refinement and no analysis was available for this analysis. Therefore, the discussion of juvenile survival will be based solely on flow data.

J.4.2.2.1 Sacramento River Flow at Rio Vista

Potential changes in the magnitude of attraction and upstream migration flows were based on CALSIM results using a frequency of exceedance analysis, by month and water-year type, and a monthly summary by water-year type over the 82-year period of hydrologic simulation. This was conducted for flows on the mainstem Sacramento River at Rio Vista and the San Joaquin River at Vernalis. The potential effect on migrating anadromous adult covered fish species was assessed on the basis of the percentage changes in flows.

J.4.2.2.2 Proportion of Originating Flows

Upstream migrating adult salmonids may home to natal spawning grounds based on cues such as odor (Williams 2006). Water source fingerprinting output from DSM2-QUAL was used to assess the relative contribution of water from the Sacramento River or San Joaquin River near their confluence for each model scenario. Model results about the proportion of water from the Sacramento and San Joaquin Rivers can be used as a proxy to determine how manipulation of flow regimes can affect the homing abilities of adult spawning fish traversing the Delta.

In general, total Delta outflow is dominated by flows from the Sacramento River compared to contributions from the San Joaquin River under existing conditions and current modeled scenarios. Operation of the north Delta intakes will reduce Sacramento River flows downstream relative to existing conditions, while reduced exports in the south Delta generally will increase the relatively small fraction of water in the west Delta that originates from the San Joaquin River.

J.4.2.3 Results

J.4.2.3.1 Sacramento River Flows at Rio Vista

Under existing biological conditions (EBC2, not accounting for climate change), average monthly flows for the Sacramento River at Rio Vista are highest in January–March, peaking in February. Average monthly flows in February range from about 80,000 cfs in wet years; 50,600 cfs in above normal years; 29,000 cfs in below normal years; 19,400 cfs in dry years; and 12,400 cfs in critical years. Average monthly flows from May–November in EBC2 are about one-third to one-half of the

February peak levels. Average flows for PP scenarios were consistently lower than EBC2 (Flow Appendix, Section C.6.3.1.2).

From December to June, the average monthly flows for the Sacramento River at Rio Vista under Scenario 6 are negligibly reduced in early long term (no more than 8% less) and late long term (no more than 10% less) compared to PP (Table J.4-15) in any water year type. During summer (July and August), average monthly flows are greater compared to PP for most water years, due to increased reservoir releases for make-up pumping by the south Delta facilities.

In September, flows are substantially higher in wet (208% in ELT, 268% in LLT) and above normal years (89% in ELT, 108% in LLT) as a result of implementing Fall X2. In October, flows decrease relative to PP in every water year type, but more substantially in LLT. In October ELT, flows decrease a modest 5–15%, but in October LLT, flows diminish 30–39% under Scenario 6.

September and October operations are very different between PP and Scenario 6, with consequences for flows at Rio Vista. If the water year ending that September has been designated wet or above normal, the Fall X2 standard would be required to be implemented in Scenario 6. This requires additional water flows to be released in order to increase Delta outflow and move the salinity gradient toward the west. As a result, Scenario 6 operations in September effectively decrease Delta exports and increase releases from upstream reservoirs (Shasta, Oroville, and Folsom), which increases flows in the Sacramento River. Once this September pulse is provided, the reduced salinity conditions are generally maintained in October with lower outflows.

Table J.4-15. Monthly Flow (CALSIM II) Sacramento River at Rio Vista

M	WY	EBC2_ELT	EBC2_LLT	A1_ELT	A1_LLT	S6_ELT	S6_LLT	A1_ELTvs. S6_ELT	A1_LLT vs. S6_LLT
JAN	W	75,510	78,551	70,205	72,415	67,063	68,716	-3,142(-4.5%)	-3,699(-5.1%)
	AN	41,416	42,919	37,937	37,439	35,559	36,090	-2,378(-6.3%)	-1,349(-3.6%)
	BN	20,388	19,991	18,597	18,693	17,702	17,296	-895(-4.8%)	-1,397(-7.5%)
	D	15,032	14,927	13,853	14,703	13,320	13,237	-533(-3.8%)	-1,467(-10%)
	C	12,114	12,601	11,688	10,822	11,229	11,589	-459(-3.9%)	767(7.1%)
	AVG	38,556	39,721	35,738	36,443	34,057	34,624	-1,681(-4.7%)	-1,818(-5%)
FEB	W	87,232	89,989	80,666	83,061	77,869	80,937	-2,797(-3.5%)	-2,125(-2.6%)
	AN	53,615	55,363	50,869	50,658	48,958	48,579	-1,911(-3.8%)	-2,078(-4.1%)
	BN	30,231	29,442	25,883	25,747	25,135	24,564	-748(-2.9%)	-1,182(-4.6%)
	D	19,318	19,422	16,937	17,247	16,544	16,954	-393(-2.3%)	-293(-1.7%)
	C	12,074	11,956	11,366	11,812	11,515	11,220	148(1.3%)	-592(-5%)
	AVG	46,674	47,675	42,821	43,660	41,463	42,330	-1,359(-3.2%)	-1,331(-3%)
MAR	W	66,275	68,663	59,359	61,586	57,413	59,808	-1,947(-3.3%)	-1,777(-2.9%)
	AN	47,974	48,513	41,165	41,050	39,928	40,734	-1,237(-3%)	-316(-0.8%)
	BN	19,629	19,562	15,823	15,626	15,061	14,764	-762(-4.8%)	-862(-5.5%)
	D	17,341	17,679	14,858	14,726	14,443	14,510	-415(-2.8%)	-216(-1.5%)
	C	10,603	10,684	9,930	9,981	9,991	10,049	61(0.6%)	68(0.7%)
	AVG	36,744	37,655	32,261	32,895	31,251	32,101	-1,010(-3.1%)	-795(-2.4%)

M	WY	EBC2_ELT	EBC2_LLT	A1_ELT	A1_LLT	S6_ELT	S6_LLT	A1_ELTvs. S6_ELT	A1_LLT vs. S6_LLT
APR	W	38,692	38,422	32,507	32,024	31,636	31,360	-871(-2.7%)	-664(-2.1%)
	AN	22,234	21,855	17,016	16,986	16,346	16,132	-669(-3.9%)	-854(-5%)
	BN	14,295	14,207	12,609	12,777	11,559	11,952	-1,050(-8.3%)	-825(-6.5%)
	D	10,216	10,299	9,806	10,550	9,107	9,676	-698(-7.1%)	-874(-8.3%)
	C	7,520	7,816	7,505	7,883	7,293	7,499	-212(-2.8%)	-384(-4.9%)
	AVG	21,306	21,211	18,201	18,291	17,463	17,566	-738(-4.1%)	-725(-4%)
MAY	W	24,220	20,046	17,188	14,306	16,842	13,940	-346(-2%)	-366(-2.6%)
	AN	15,857	14,948	12,096	11,801	12,069	11,545	-27(-0.2%)	-256(-2.2%)
	BN	9,862	9,355	9,298	9,443	8,764	9,257	-535(-5.8%)	-185(-2%)
	D	7,840	8,564	8,000	9,032	7,486	8,883	-514(-6.4%)	-149(-1.6%)
	C	5,656	5,554	5,252	5,350	5,162	5,304	-90(-1.7%)	-46(-0.9%)
	AVG	14,232	12,833	11,332	10,641	11,001	10,416	-331(-2.9%)	-225(-2.1%)
JUN	W	12,993	11,418	8,474	8,002	8,121	7,896	-353(-4.2%)	-107(-1.3%)
	AN	8,634	9,220	6,661	7,583	6,254	7,078	-407(-6.1%)	-505(-6.7%)
	BN	6,677	7,241	6,347	6,703	6,622	6,681	276(4.3%)	-22(-0.3%)
	D	6,250	6,335	5,788	5,820	5,948	5,848	161(2.8%)	28(0.5%)
	C	4,304	4,513	3,927	4,020	3,963	4,163	36(0.9%)	143(3.6%)
	AVG	8,525	8,257	6,590	6,657	6,507	6,573	-84(-1.3%)	-84(-1.3%)
JUL	W	11,207	12,181	6,737	7,996	7,882	8,299	1,146(17%)	303(3.8%)
	AN	12,544	12,927	7,935	8,132	9,947	9,931	2,013(25.4%)	1,799(22.1%)
	BN	11,667	11,357	7,425	6,831	9,524	8,620	2,099(28.3%)	1,789(26.2%)
	D	10,105	10,307	7,253	5,916	7,805	6,498	552(7.6%)	582(9.8%)
	C	6,866	6,596	3,964	4,453	4,329	4,574	366(9.2%)	120(2.7%)
	AVG	10,604	10,921	6,737	6,842	7,928	7,652	1,191(17.7%)	810(11.8%)
AUG	W	8,527	8,650	3,565	3,826	4,188	4,041	622(17.5%)	215(5.6%)
	AN	9,013	9,648	4,774	5,174	5,672	5,391	898(18.8%)	217(4.2%)
	BN	8,062	8,753	4,274	4,224	5,740	5,371	1,466(34.3%)	1,148(27.2%)
	D	7,525	7,417	4,432	4,505	4,302	4,645	-130(-2.9%)	140(3.1%)
	C	3,823	3,615	3,119	3,157	3,688	3,415	569(18.3%)	258(8.2%)
	AVG	7,610	7,806	3,988	4,142	4,622	4,507	634(15.9%)	364(8.8%)
SEP	W	20,717	21,199	3,324	3,165	10,242	11,639	6,918(208.2%)	8,474(267.8%)
	AN	12,961	12,832	3,107	3,359	5,863	7,001	2,756(88.7%)	3,642(108.4%)
	BN	6,538	6,197	3,056	3,158	3,293	3,539	237(7.7%)	381(12.1%)
	D	4,432	3,644	3,031	3,477	3,018	3,701	-14(-0.5%)	224(6.5%)
	C	3,215	2,996	3,084	3,630	2,982	3,720	-102(-3.3%)	91(2.5%)
	AVG	11,025	10,896	3,147	3,329	5,766	6,676	2,619(83.2%)	3,348(100.6%)
OCT	W	7,867	8,287	5,367	8,615	4,744	5,676	-623(-11.6%)	-2,940(-34.1%)
	AN	5,518	7,207	4,132	8,846	3,651	5,943	-481(-11.6%)	-2,904(-32.8%)
	BN	5,416	6,976	4,486	9,224	3,864	5,632	-622(-13.9%)	-3,592(-38.9%)
	D	5,221	5,727	4,018	7,496	3,801	5,274	-217(-5.4%)	-2,222(-29.6%)
	C	4,684	4,969	4,541	9,015	3,880	5,496	-660(-14.5%)	-3,519(-39%)

M	WY	EBC2_ELT	EBC2_LLT	A1_ELT	A1_LLT	S6_ELT	S6_LLT	A1_ELTvs. S6_ELT	A1_LLT vs. S6_LLT
	AVG	6,058	6,858	4,619	8,566	4,100	5,593	-518(-11.2%)	-2,973(-34.7%)
NOV	W	17,184	15,879	11,461	10,636	11,957	11,172	496(4.3%)	536(5%)
	AN	13,102	12,156	7,866	6,298	8,632	8,096	766(9.7%)	1,798(28.6%)
	BN	9,448	9,071	5,534	4,870	5,635	5,946	101(1.8%)	1,076(22.1%)
	D	8,539	8,061	6,528	5,178	5,804	5,728	-723(-11.1%)	551(10.6%)
	C	5,586	5,565	4,409	4,346	4,632	4,674	223(5.1%)	329(7.6%)
	AVG	11,671	10,946	7,808	6,898	7,968	7,684	160(2.1%)	786(11.4%)
DEC	W	44,292	40,431	42,647	38,576	39,423	36,394	-3,225(-7.6%)	-2,182(-5.7%)
	AN	20,375	19,936	18,233	19,338	18,419	18,003	186(1%)	-1,335(-6.9%)
	BN	15,099	14,049	14,295	13,609	13,604	13,530	-691(-4.8%)	-80(-0.6%)
	D	11,868	11,687	11,786	11,385	11,365	11,101	-421(-3.6%)	-284(-2.5%)
	C	7,341	7,186	8,051	7,752	7,572	7,660	-479(-5.9%)	-92(-1.2%)
	AVG	23,283	21,753	22,397	21,019	21,121	20,042	-1,276(-5.7%)	-977(-4.6%)

	Increase >50%	Increase 25–50%	Increase 10–25%	Increase 5–10%
	Decrease >50%	Decrease 25–50%	Decrease 10–25%	Decrease 5–10%

PP flows are higher in October because salinity objectives would need to be met since no Fall X2 requirement is included and salinity is higher in September. In contrast, under Scenario 6 for those years when the preceding water year was above normal or wet, the October releases and flows would be reduced from September levels, and in fact would be lower than the October PP flows, because the Scenario 6 September pulse would have already achieved the Delta salinity reductions.

J.4.2.3.2 Juvenile Salmonid Passage

Steelhead

During the period that juvenile steelhead are in the Delta rearing and migrating (October to May), average monthly flows are similar between PP and Scenario 6 from December to May during ELT (Table J.4-15), and decrease slightly (6%) under Scenario 6 in the LLT during below normal and dry years, but are unchanged in other water year types. The greatest difference in flow occurs in October (Table J.4-15 and Figure J.3-6), when average flow levels at Rio Vista relative to PP drop about 11% in ELT and 35% in LLT compared to PP. October flows under PP in early long term are already less compared to EBC2, but are increased moderately in late long term compared to EBC, especially in drier water years. This decline in flows at Rio Vista is because of diminished upstream reservoir storage following the major flow releases in September to address Delta Fall X2. November, March, and April flows under PP are also moderately declined compared to EBC2, especially in above and below normal years. For the rest of the steelhead season, flows are not substantially changed between PP and EBC, and are not changed between Scenario 6 and PP.

Winter-Run Chinook

The juvenile Winter-run Chinook outmigration occurs between November–April. Compared to existing biological conditions, flows under PP decrease moderately in November for all water year types, and in March and April during above and below normal years (10–24% decrease). However flows between PP and EBC are similar during the rest of the Winter-run outmigration period..

Breaking the outmigration period down by months, there are certain month and water year type combinations when flows are noticeably changed under Scenario 6. In November, flows increase in above normal years (10% in ELT, 29% in LLT) and during below normal years in late long term (22% increase). In November during dry years, flows decrease 11% in early long term, but increase 11% in late long term. Flows also decrease in January dry years, but only in late long term (10% decrease).In April, there are minor changes in flow in below normal (8% in ELT, 7% in LLT) and dry years (7% in ELT, 8% in LLT).

Spring-Run Chinook

The juvenile Spring-run Chinook outmigration period occurs between December–May. Compared to existing biological conditions, flows under PP are similar throughout the Spring-run outmigration season, except in March and April during above and below normal years (10–24% decrease). Similarly, during the juvenile Spring-run outmigration timing, average Sacramento River flows at Rio Vista are similar or only slightly decreased (8% or less) under Scenario 6 compared to PP (Table J.4-15). At most, flows in January of dry water years are decreased 10%.

Fall-Run Chinook

The juvenile Fall-run Chinook downstream migration occurs between February–May. Compared to existing biological conditions, flows under PP are similar during the fall-run outmigration period, except in March and April during above and below normal years (10–24% decrease). During the migration period, average Sacramento River flows at Rio Vista are little changed in any water year type under Scenario 6. At most, flows in April and May of below normal water years are slightly decreased (6–8% for ELT/LLT).

Late Fall–Run Chinook

The juvenile Late Fall–run Chinook outmigration period occurs between January–March. During the outmigration, average Sacramento River flows at Rio Vista barely decrease in below normal years in late long term (6% decrease), but are not appreciably different in other water year types compared to PP. The slight decrease in below normal LLT years during the juvenile migration period is due to small decreases in flow in January (8% decrease) and March (6% decrease). In January, there are also slight changes in dry LLT (10% decrease) and critical LLT (7% increase).

J.4.2.3.3 Attraction Flows for Adults

Flow Magnitude and Timing

The Tier 1 priority species that migrate through the Delta include steelhead (September–March, peak December–February), winter-run Chinook salmon (peak migration December–February), and spring-run Chinook (April–May). In addition, fall-run Chinook salmon migrate during a period of major flow changes (September–October). Patterns of flow magnitude at Rio Vista are discussed below for each salmonid species' migration period.

Proportion of Flow as Migration Cues

In general, total Delta outflow is dominated by flows from the Sacramento River (about 53–73% depending on month) compared to contributions from the San Joaquin River (6% or less) under existing conditions and current modeled scenarios. However with proposed north Delta intakes, Sacramento River flows downstream of the north Delta intakes will be reduced relative to existing conditions, while reduced exports in the south Delta generally will increase the relatively small fraction of water in the west Delta that originates from the San Joaquin River. Changes in the proportion of flows are discussed below for each species' migration period.

Steelhead Adult Migration

During the adult steelhead migration season (September–March) the magnitude of Sacramento River flows at Rio Vista is substantially different under Scenario 6 during the early part of the migration season (Table J.4-15). Compared to existing biological conditions (EBC2), PP flows decrease in September (ELT and LLT) in wetter water years and fall slightly in October in above normal, below normal, and dry years during ELT (Flow Appendix). Rio Vista flows also decrease moderately in November in all water years, except wet, compared to EBC. Flows do not substantially change under PP in other months during the adult steelhead migration compared to EBC. Under Scenario 6, September flows relative to PP are much greater during wet and above normal years, while October flows are decreased as a result of Fall X2.

The total proportion of Sacramento River water at Collinsville is substantial (>60%) for every month during the steelhead migration season (September–March) (Table J.4-16). The proportion of Sacramento River water is slightly increased (1–10% greater) under Scenario 6 compared to PP for most months except February and March.

Table J.4-16. Summary of Finger Printing Analysis of the Percentage (%) of Water at Collinsville that Originated in the Sacramento River and San Joaquin River during the September–March Adult Steelhead Migration Period

Month	EBC2_ELT	EBC2_LLT	A1_ELT	A1_LLT	S6_ELT	S6_LLT	S6_ELT v A1_ELT	S6_LLT v. A1_LLT
Sacramento River								
September	65	65	53	53	60	63	7	10
October	64	68	56	64	64	68	8	4
November	64	66	57	61	63	63	6	2
December	67	66	63	63	65	65	2	2
January	75	75	72	71	73	73	1	2
February	74	72	68	67	68	67	0	0
March	77	76	69	67	68	67	-1	0
San Joaquin River								
September	0.2	0.1	1.6	1.1	1.9	1.3	0.3	0.2
October	0.2	0.3	3.0	1.8	4.7	3.7	1.7	1.9
November	0.8	1.0	3.3	3.1	6.0	5.4	2.7	2.3
December	1.0	1.0	1.5	1.5	3.1	3.0	1.6	1.5
January	1.7	1.7	2.7	2.7	3.1	3.2	0.4	0.5
February	1.5	1.5	3.6	3.4	4.0	3.8	0.4	0.4
March	2.6	2.8	6.2	6.1	6.3	6.1	0.1	0

The proportion of San Joaquin River water at Collinsville shows a similar trend, but with much lower overall percentages which exaggerate the percent change. While most months of the adult steelhead migration season show Scenario 6 with an increased proportion of San Joaquin River water compared to PP, the difference is inconsequential.

Winter-run Chinook salmon

During the adult winter-run Chinook migration season (December–February), the magnitude of Sacramento River flows at Rio Vista is similar for PP and Scenario 6 (Table J.4-15), and similar to flows under EBC2 (Flow Appendix) for both ELT and LLT periods. The proportion of Sacramento River water at Collinsville under Scenario 6 is not appreciably different under Scenario 6 compared to PP, for both the ELT and LLT scenarios (Table J.4-17).

Table J.4-17. Summary of Finger Printing Analysis of the Percentage (%) of Water at Collinsville that Originated in the Sacramento River during the December–February Adult Winter-Run Chinook Migration Period

Month	EBC2_ELT	EBC2_LLT	A1_ELT	A1_LLT	S6_ELT	S6_LLT	S6_ELT v A1_ELT	S6_LLT v. A1_LLT
Sacramento River								
December	67	66	63	63	65	65	2	2
January	75	75	72	71	73	73	1	2
February	74	72	68	67	68	67	0	0

Spring-Run Chinook Salmon

During the adult spring-run Chinook migration season, which extends from March–May, the proportion of Sacramento River water at Collinsville decreases slightly under Scenario 6 in May in early long term (6% decrease). PP flows at Rio Vista do not differ from EBC2 flows during the adult spring-run migration period (March–May) (Table J.4-15). There are no appreciable differences in other months though, in either ELT or LLT.

The total proportion of Sacramento River flow at Collsinville under Scenario 6 ranges from 67–68% in March to 58–60% in May (Table J.4-18). The proportion of Sacramento River flows under Scenario 6 is minimally decreased compared to PP.

Table J.4-18. Summary of Finger Printing Analysis of the Percentage (%) of Water at Collinsville that Originated in the Sacramento River during the March–May Adult Spring-run Chinook Migration Period

Month	EBC2_ELT	EBC2_LLT	A1_ELT	A1_LLT	S6_ELT	S6_LLT	S6_ELT v A1_ELT	S6_LLT v. A1_LLT
Sacramento River								
March	77	76	69	67	68	67	-1	0
April	76	75	68	67	67	65	-1	-2
May	67	65	64	61	60	58	-4	-3

Fall-Run Chinook adult Migration

During the peak adult fall-run Chinook migration season (September and October), the magnitude of flows at Rio Vista under PP decreases compared to existing biological conditions (EBC2) in September in wetter water years (ELT and LLT) and in October during ELT for above normal, below normal, and dry water years. Under Scenario 6, flows relative to PP are substantially greater in September of wet and above normal water years (due to Fall X2 releases) and reduced in October (5–12% less in ELT, 24–31% less in LLT) (Table J.4-15).

The proportion of Sacramento River flows under Scenario 6 is increased compared to PP (Table J.4-19). In September, the proportion of Sacramento River flows (53%) is increased proportionately by 13–19% under Scenario 6 (60–63%). October flows under Scenario 6 (63% Sacramento River) are 6–14% proportionately increased compared to PP (57% ELT, 61% LLT). The proportion of San Joaquin River flow at Collinsville also shows an increase under Scenario 6, but the changes are minimized by the overall small contribution from this source in the fall (Table J.4-19).

Table J.4-19. Summary of Finger Printing Analysis of the Percentage (%) of Water at Collinsville that Originated in the Sacramento River and San Joaquin River during the September–November Adult Fall-Run Chinook Migration Period

Month	EBC2_ELT	EBC2_LLT	A1_ELT	A1_LLT	S6_ELT	S6_LLT	S6_ELT v. A1_ELT	S6_LLT v. A1_LLT
Sacramento River								
September	65	65	53	53	60	63	7	10
October	64	68	56	64	64	68	8	4
November	64	66	57	61	63	63	6	2
San Joaquin River								
September	0.2	0.1	1.6	1.1	1.9	1.3	0.3	.2
October	0.2	0.3	3.0	1.8	4.7	3.7	1.7	1.9
November	0.8	1.0	3.3	3.1	6.0	5.4	2.7	2.3

J.4.2.3.4 Transport Flows for Larval Smelt

Delta Smelt

During the delta smelt larval period (March–June), monthly average flows at Rio Vista are fairly similar under Scenario 6 compared to PP (Table J.4-15). Compared to existing baseline conditions (EBC2), monthly average flows under PP were reduced 14–22% during the larval transport period (Appendix C). The largest reductions in flows from PP compared to existing conditions are in above normal and below normal water years. These are circumstances for which Scenario 6 provides no appreciable improvements in flow or further reduces flow (up to 8% decrease) beyond PP.

Longfin Smelt

During the longfin smelt larval period (January–April), monthly average flows at Rio Vista are under Scenario 6 are similar to PP, with relatively minor decreases (10% or less) in a few scenarios. During the ELT scenario, flows under Scenario 6 are decreased only during January (6% less in above normal) and in April and May (6–8% less in below normal and dry). During the LLT scenario, January flows are decreased 4–10% in wet to dry water years, and increased 7% in critical water years compared to PP. March and April flows are also slightly decreased during LLT in below normal (6% less) and dry water years (8%).

Based on these minor differences in flow projected during the longfin smelt larval period, downstream transport of smelt larvae would not be expected to be appreciably different under Scenario 6 compared to PP.

J.4.2.4 Conclusions

Under Scenario 6, flows at Rio Vista would be different than PP between July and December, with minor differences occurring in other months.

The observed flow decreases under Scenario 6 in October is largely a result of releases in September intended to meet outflow and salinity objectives (including Fall X2) that reduce the available storage available for October flows. The difference between Scenario 6 and PP is a tradeoff between flows in September and October, respectively, to address salinity conditions in the Delta.

Comparing the timing of these flow changes with the migration periods of steelhead and Chinook salmon, the only species that would be present when flow differences occur would be steelhead. Scenario 6 resulted in negligible changes in flow magnitude and the proportion of Sacramento and San Joaquin-origin waters (a correlate of basin-specific olfactory cues for migrating adults) during the steelhead migration period compared to PP. Therefore, Scenario 6 would not result in appreciable changes for adult steelhead migration cues compared to PP.

Another potential issue is transport flows for larval smelt. Sacramento River flows at Rio Vista were only negligibly changed (less than 5 percent) on an average monthly basis during the larval transport periods for delta smelt (March–June) and longfin smelt (January–April). It is important to note though that in January, the beginning of the longfin smelt larval period, there are some water year scenarios (wet LLT, above normal ELT, below normal LLT, and dry LLT) when Sacramento River flows are predicted to be lower under Scenario 6 (5–10%) than under the PP. Based on the overall minor differences in flow, transport of larval smelt to rearing habitat downstream would likely not be appreciably different under Scenario 6 compared to PP, however the risk to longfin smelt larvae is marginally higher compared to delta smelt.

J.4.3 South Delta Operations and OMR Flows

J.4.3.1 Analysis

J.4.3.1.1 General Approach

Results of PP and Scenario 6 for the ELT and LLT implementation periods were compared to evaluate potential differences in entrainment of steelhead, winter- and spring-run Chinook salmon, delta and longfin smelt. Differences less than 5% were considered less than appreciable. The metrics assessed include the following.

- **OMR flows**. Compare mean monthly flow data (CALSIM) for different scenarios.
- **Delta exports**. Examine mean monthly exports from CVP and SWP facilities in south Delta and proposed Isolated Facility (CALSIM).
- **Salvage index at SWP/CVP south Delta facilities.** Uses historical salvage data and CALSIM outputs (exports from CVP and SWP facilities) to estimate entrainment under various flow conditions.
- **DSM2 particle-tracking model (PTM)**. Uses both hypothetical release sites and data from trawls to estimate the movement of longfin smelt that are assumed to be influenced primarily by flows.

- **OMR proportional entrainment**. Delta smelt entrainment in proportion to OMR flows (Kimmerer et al. 2009).

The details and caveats for the fish entrainment methods are discussed below.

J.4.3.1.2 Salvage Density

The salvage density method represents the simplest model for estimating the total salvage that occurs at the south delta pumping facilities. Total monthly salvage numbers are calculated by extrapolating estimates of the total number of fish salvaged based on a subsample that actually was identified, counted, and measured. Salvage and loss data for analysis were normalized by measures of annual population abundance in the year of entrainment for winter-run Chinook (based on juvenile production estimate), spring-run Chinook salmon (adult run size), delta and longfin smelt (fall midwater trawl). No normalization was undertaken for steelhead because there are no suitable indices of annual abundance. These data provided the basic estimates of fish density (number of fish salvaged per unit of water exported) that were subsequently multiplied by simulated export data from CALSIM modeling outputs.

However, it is acknowledged that the assumption of a linear relationship between entrainment and flow may be an oversimplification given evidence of nonlinear relationships, as seen with delta smelt (Kimmerer 2008). Thus, the salvage density method simply functions as a description of changes in flow weighted by seasonal changes in salvage density of fish.

J.4.3.1.3 DSM2 Particle Tracking Model

Particle tracking analysis is dependent on assumptions of hydrology and the starting distributions for the released particles. Entrainment of longfin smelt was modeled for the south Delta diversions using a 30 day and 60 day modeling period.

The PTM hydrologic scenarios were selected to represent flows on the Sacramento River ranging from about 10,000 to 26,000 cfs and flows on the San Joaquin River ranging from 1,000 to 12,200. A final scenario (February 1940) represents Sacramento River flows of 52,300 cfs on the Sacramento River and 3,900 cfs on the San Joaquin River. This range of flows on the Sacramento River was subdivided into five parts and the range of San Joaquin River flows was modeled within each of those subdivisions. In the following sections, each PTM run is referred to by the month and year representing the start of that set of hydrologic conditions in the sections that follow. However, these runs are taken to represent a specific set of hydrologic conditions, which may occur during different months or years. These are not intended to represent the specific month and year indicated. In the figures showing entrainment under each of these hydrologic scenarios, the scenarios are arranged in order from drier to wetter conditions, moving from left to right. However, the runs to the left of and including January 1929 reflect drier periods (Delta outflow of less than 17,000 cfs), and thus may be more reflective of entrainment risk than the periods further to the right.

For longfin smelt, two starting distributions were defined based on the composition of the two starting distributions used for the larval longfin smelt PTM analysis ("Wetter" and "Drier"). These distributions are based on those used by California Department of Fish and Game (DFG) in the incidental take permit for the SWP. Historical salvage data indicates that juvenile and adult longfin smelt are generally salvaged in greater numbers at the SWP and CVP facilities in drier years. Runs were made for both starting distributions for every PTM hydrologic scenario, as the distribution of longfin smelt may change in the future. Given the uncertainty regarding larval longfin smelt distributions historically and in the future, the evaluation treats all PTM run periods equally.

J.4.3.1.4 OMR-proportional entrainment

The salvage estimates are linked to south Delta exports rather than OMR flows per se. An OMR-proportional analysis may provide additional insights into mechanisms and effects. This approach uses flow data for OMR to estimate the proportion of a population that would be entrained and has been applied to delta smelt (Kimmerer 2008), but not longfin smelt. This analysis used the Kimmerer proportional method (Kimmerer 2008).

J.4.3.2 Results

J.4.3.2.1 Old and Middle River Flows

Positive OMR flow is north, away from the south Delta export facilities near Tracy, and toward the estuary. The greatest negative OMR values are correlated with higher south Delta pumping. During the fall (September–November), the flows at OMR were substantially greater (i.e., less negative) under Scenario 6 than PP by an average increase of 57–72% (Table J.3-8, Table J.4-20, and Figure J.4-3). The OMR flows were also better under Scenario 6 in April and May. Conversely, OMR flows would be worse (more negative) under Scenario 6 during February–March (decreased 32–41% on average) and July–August (decreased 11–28% on average). June OMR flows would be slightly reduced under Scenario 6. This could be a key consideration in comparing the biological effects benefits associated with Scenario 6 and PP.

For all water year types, OMR flows during September–November would be greater (less negative) under Scenario 6 compared to PP, particularly in below normal (33–79%), above normal (52–74%), and wet years (62–116%). In January, flows in OMR would be higher in below normal (33% in ELT, 37% in LLT), dry (58% in ELT, 32% in LLT), and critical years (29% in ELT), with Scenario 6 flows predicted to be somewhat lower than PP in wet (8% in ELT, 14% in LLT) and above normal years (131% in LLT. In February and March, OMR flows would be less (i.e., more negative) under Scenario 6 than PP for most water year types, particularly above normal (62% in ELT, 59% in LLT) and below normal (87% in ELT, 7% in LLT) water year types. In April and May, which are important migration months for many juvenile fish, Scenario 6 would have greater OMR flows (i.e., more positive) compared to PP in above normal (89–154%) and below normal (42–62%) years by a substantial margin. OMR flows in April–May however appreciably decrease in wet years (13–22%), however net flow is still positive in these months during wet years. Flows in June would be greater in wet years under Scenario 6 (394% for ELT, 122% for LLT), but the remaining water year types, and all water year types in July and August, would have less flow in OMR under Scenario 6 than PP.The LLT simulations show similar results to the ELT simulations.

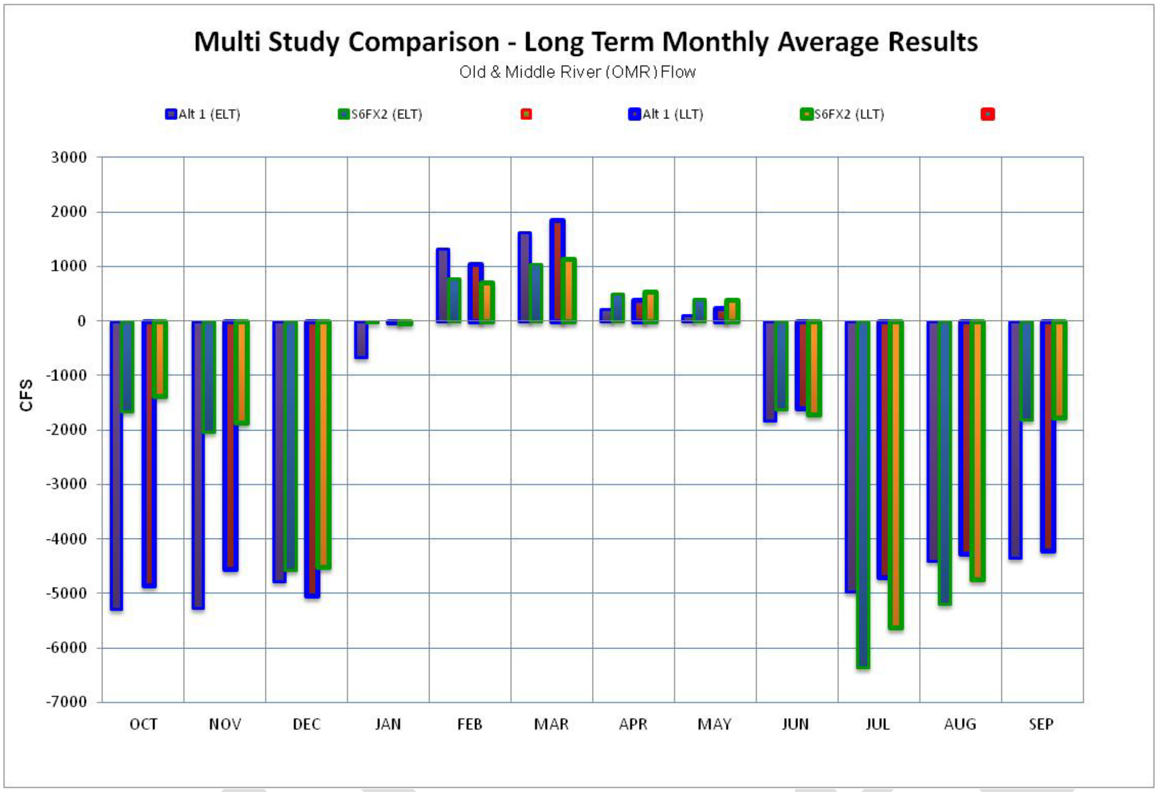


Figure J.4-3. Mean Monthly Flows (cfs) for Model Scenarios at Old and Middle Rivers

J.4.3.2.2 Delta Exports

Under Scenario 6, annual average total Delta exports decrease in all water year types for both ELT and LLT. Long-term annual average south Delta exports under Scenario 6 would be decreased 22.6% (-676 thousands of acre-feet [TAF]) for ELT and reduced 22.3% (-614 TAF) for LLT (Figure J.4-3, Table J.4-20). The percentage decreases are similar for both ELT and LLT across all the water year types. South Delta exports under Scenario 6 were substantially reduced in April and May for all water year types, especially in wet (61–69%), above normal (61–73%), and below normal years (56–65%) (Table J.4-21). This is due to protective standards enacted under Scenario 6 for the south Delta during April and May. Substantially reduced exports also occur in October and November (15–72%) in all water year types, particularly in wet (54–69%) and above normal (38–64%) water years due to Fall X2 requirements for those years.

Increases in exports under Scenario 6 occur mostly in July and August in all water year types. In July the greatest increases in exports occur in below above normal (48% in ELT, 44% in LLT), below normal years (46% in ELT, 43% in LLT); while in August the greatest increase in exports occur in below normal years (43% in ELT, 35% in LLT). This is a period when there are no restrictions on pumping.

Table J.4-20 compares the differences between Scenario 6 and PP for OMR flows and Delta exports.

Table J.4-20. Comparison between Scenario 6 and Alternative 1 for OMR Flows (cfs), South Delta Exports (TAF), and North Delta Exports (TAF)

M	WY	OMR Flows		South Delta Exports		North Delta Exports	
		A1_ELTvs. S6_ELT	A1_LLTvs. S6_LLT	A1_ELT vs. S6_ELT	A1_LLT vs. S6_LLT	A1_ELT vs. S6_ELT	A1_LLT vs. S6_LLT
JAN	W	-346(-8.4%)	-592(-14.2%)	2 (3.4%)	-2 (-2.9%)	40(6%)	40(6%)
	AN	10(-8.7%)	-269(-131.3%)	-89 (-43.6%)	-67 (-36%)	8(2%)	4(1%)
	BN	853(-33.3%)	760(-36.5%)	-106 (-35%)	-66 (-23.9%)	-1(0%)	-4(-2%)
	D	2454(-58.1%)	1078(-31.9%)	-154 (-41.7%)	-71 (-23.9%)	8(7%)	25(28%)
	C	1162(-29.1%)	-477(23%)	-101 (-32.4%)	29 (18.5%)	-10(-14%)	-3(-4%)
	AVG	652(-98.5%)	-28(221.4%)	-79 (-34.1%)	-33 (-17.7%)	14(4%)	18(5%)
FEB	W	-420(-5.8%)	-404(-6.2%)	2 (55.8%)	-6 (-67.7%)	117(22%)	96(17%)
	AN	-1394(-62%)	-1241(-58.6%)	-3 (-3.9%)	-14 (-16.6%)	-1(0%)	-2(0%)
	BN	-953(86.9%)	-127(7.3%)	57 (41.8%)	32 (20.5%)	1(0%)	5(1%)
	D	72(-2.4%)	-176(6.5%)	-49 (-17.2%)	-53 (-19.3%)	-5(-3%)	1(1%)
	C	-73(2.5%)	350(-12.1%)	-25 (-9.9%)	-52 (-20.7%)	-1(-2%)	3(6%)
	AVG	-549(-41.4%)	-340(-32.4%)	-4 (-3.2%)	-18 (-12.9%)	18(5%)	12(3%)
MAR	W	-699(-9%)	-705(-9.1%)	15 (105.6%)	6 (26.5%)	99(19%)	89(16%)
	AN	-1348(-82.6%)	-1338(-88.2%)	-29 (-52.5%)	2 (4.3%)	52(9%)	5(1%)
	BN	-120(7.5%)	-667(72.4%)	-5 (-2.5%)	37 (22.2%)	-9(-3%)	-6(-2%)
	D	-216(10.6%)	-343(19.4%)	-21 (-9.3%)	1 (0.3%)	-13(-5%)	13(6%)
	C	-257(13.2%)	-448(29%)	-9 (-6%)	-10 (-7.5%)	-2(-3%)	0(0%)
	AVG	-571(-35.2%)	-715(-38.8%)	-6 (-5.5%)	7 (6.9%)	34(9%)	31(8%)
APR	W	-725(-17.4%)	-982(-21.7%)	-66 (-68.1%)	-65 (-67.9%)	51(11%)	44(10%)
	AN	1050(-154.2%)	1111(-149.1%)	-97 (-62.1%)	-84 (-61.1%)	42(11%)	16(4%)
	BN	1012(-60.9%)	945(-60.4%)	-170 (-63%)	-141 (-55.5%)	23(13%)	-1(0%)
	D	807(-40.3%)	194(-11.7%)	-83 (-40%)	-81 (-42.8%)	6(6%)	-8(-7%)
	C	6(-0.4%)	238(-16.3%)	-21 (-19.4%)	-19 (-18.8%)	-1(-3%)	0(0%)
	AVG	282(129.5%)	157(41.3%)	-85 (-53.1%)	-77 (-51.6%)	27(10%)	14(5%)

M	WY	OMR Flows		South Delta Exports		North Delta Exports	
		A1_ELTvs. S6_ELT	A1_LLTvs. S6_LLT	A1_ELT vs. S6_ELT	A1_LLT vs. S6_LLT	A1_ELT vs. S6_ELT	A1_LLT vs. S6_LLT
MAY	W	-524(-13.2%)	-616(-16.3%)	-79 (-68.8%)	-63 (-60.9%)	11(2%)	8(0%)
	AN	1842(-91.8%)	1212(-89.4%)	-122 (-67.7%)	-137 (-73.4%)	11(3%)	20(5%)
	BN	543(-41.8%)	879(-61.6%)	-172 (-64.8%)	-118 (-55.7%)	-80(-37%)	-35(-17%)
	D	111(-7.6%)	-146(12.7%)	-55 (-33.7%)	-42 (-30.5%)	-5(-6%)	2(2%)
	C	-60(5.1%)	-195(20.2%)	-10 (-12.8%)	-7 (-9.7%)	0(0%)	0(0%)
	AVG	298(287.4%)	134(54.7%)	-86 (-55.2%)	-71 (-51.2%)	-10(-4%)	0(0%)
JUN	W	1295(-393.9%)	206(-122.4%)	-69 (-36.2%)	3 (2.2%)	39(9%)	63(14%)
	AN	-185(6.4%)	-508(22.9%)	-60 (-27.6%)	-46 (-23.3%)	41(11%)	138(36%)
	BN	-322(11.2%)	-186(7%)	22 (14.8%)	7 (5.5%)	54(20%)	48(20%)
	D	-297(14%)	-124(6.3%)	21 (21.9%)	4 (4.5%)	42(44%)	27(33%)
	C	-208(10.8%)	-143(7.1%)	4 (5.9%)	15 (23.2%)	1(3%)	-8(-21%)
	AVG	204(-11.1%)	-116(7.2%)	-22 (-14.7%)	-2 (-1.6%)	37(14%)	53(20%)
JUL	W	-1707(-41.2%)	-640(-11.6%)	91 (24.6%)	20 (5.1%)	0(0%)	20(12%)
	AN	-2073(-41.7%)	-1278(-31.8%)	147 (48%)	130 (44%)	-21(-10%)	-33(-17%)
	BN	-1315(-21.9%)	-1304(-23%)	161 (46.1%)	132 (43.4%)	4(3%)	8(7%)
	D	-720(-10.3%)	-1164(-23.6%)	48 (13.9%)	51 (21.4%)	5(5%)	6(10%)
	C	-825(-22.6%)	-432(-13.6%)	25 (17.3%)	8 (6.2%)	37(119%)	25(74%)
	AVG	-1388(-28%)	-912(-19.4%)	92 (28.9%)	60 (20.8%)	4(3%)	8(7%)
AUG	W	-685(-15%)	-175(-3.8%)	53 (17.8%)	18 (5.9%)	-1(0%)	0(0%)
	AN	-1520(-38.6%)	-599(-14.2%)	76 (22.3%)	23 (6.3%)	-15(-6%)	13(7%)
	BN	-868(-17.1%)	-991(-21.4%)	124 (42.7%)	94 (34.5%)	-6(-3%)	4(3%)
	D	-687(-13.9%)	-494(-10.8%)	-10 (-3.6%)	7 (2.8%)	-17(-19%)	7(27%)
	C	-305(-8.5%)	-342(-10.7%)	34 (18.7%)	25 (16.3%)	1(14%)	2(33%)
	AVG	-803(-18.3%)	-470(-11%)	52 (18.2%)	30 (11%)	-7(-4%)	4(3%)

M	WY	OMR Flows		South Delta Exports		North Delta Exports	
		A1_ELTvs. S6_ELT	A1_LLTvs. S6_LLT	A1_ELT vs. S6_ELT	A1_LLT vs. S6_LLT	A1_ELT vs. S6_ELT	A1_LLT vs. S6_LLT
SEP	W	4567(115.3%)	5288(-115.5%)	-286 (-97.5%)	-317 (-98.4%)	10(3%)	76(28%)
	AN	3535(72%)	3251(69.6%)	-289 (-90.5%)	-270 (-78.4%)	82(33%)	98(47%)
	BN	2415(53.7%)	1524(33.3%)	-15 (-4.8%)	23 (7.7%)	-47(-28%)	-64(-49%)
	D	329(-7.5%)	-172(4.2%)	-1 (-0.4%)	19 (7.3%)	-58(-43%)	-27(-45%)
	C	379(-8.9%)	228(-7.6%)	-8 (-2.9%)	-3 (-1.8%)	0(0%)	5(71%)
	AVG	2536(-58.3%)	2441(-57.9%)	-137 (-46.3%)	-132 (-46.5%)	-5(-2%)	23(15%)
OCT	W	3741(-72.9%)	3948(-78.2%)	-228 (-63.8%)	-242 (-68.8%)	63(34%)	88(98%)
	AN	3476(-67.8%)	3190(-73.8%)	-228 (-62.6%)	-201 (-64%)	5(4%)	99(619%)
	BN	3972(-74.2%)	4098(-79%)	-255 (-65.7%)	-238 (-72%)	43(39%)	90(900%)
	D	4104(-74.1%)	4232(-78.5%)	-201 (-57.5%)	-200 (-59.9%)	70(117%)	74(274%)
	C	3067(-61.2%)	2539(-58.5%)	-191 (-56.4%)	-154 (-53.4%)	37(45%)	58(1%)
	AVG	3618(-68.6%)	3483(-71.8%)	-221 (-61.6%)	-213 (-64.7%)	48(40%)	83(218%)
NOV	W	3446(-63.2%)	2946(-61.9%)	-202 (-57.9%)	-171 (-53.5%)	-44(-15%)	-53(-19%)
	AN	2356(-52.4%)	2141(-51.5%)	-128 (-37.7%)	-140 (-45%)	-22(-12%)	-13(-8%)
	BN	4040(-71.1%)	3552(-71.6%)	-190 (-48.4%)	-160 (-45.5%)	-7(-4%)	-27(-18%)
	D	4644(-79.2%)	3754(-75.4%)	-181 (-48.2%)	-108 (-37.2%)	29(27%)	-15(-11%)
	C	2008(-40.7%)	1276(-32.1%)	-80 (-26.2%)	-36 (-14.5%)	-23(-34%)	-7(-16%)
	AVG	3237(-61.5%)	2687(-59%)	-167 (-47%)	-131 (-42.7%)	-15(-8%)	-27(-16%)
DEC	W	153(-4.6%)	396(-10.6%)	-9 (-2.6%)	-16 (-4.6%)	-31(-8%)	-27(-8%)
	AN	72(-2.6%)	389(-10.5%)	3 (0.7%)	-33 (-7.2%)	10(8%)	-1(-1%)
	BN	682(-10.5%)	553(-8.8%)	-6 (-1.2%)	-9 (-1.8%)	-11(-9%)	-4(-4%)
	D	473(-6.6%)	1306(-17.6%)	-53 (-9.9%)	-70 (-13.4%)	-4(-5%)	-4(-6%)
	C	-260(4.6%)	261(-4.8%)	16 (3.9%)	-55 (-13%)	-8(-20%)	-10(-26%)
	AVG	191(-4%)	537(-10.7%)	-13 (-2.9%)	-35 (-7.9%)	-21(-11%)	-19(-11%)

		Increase >50%	Incr. 25–50%	Incr. 10–25%	Increase 5–10%	
		Decrease >50%	Decrease 25–50%	Decrease 10–25%	Decrease 5–10%	

Table J.4-21. Estimated Mean Annual Salvage Index (Salvage Density Method) at the SWP and CVP Salvage Facilities for Steelhead and Chinook Salmon for All Water Years[1]

Species	Facility	EBC2_ELT Avg	EBC2_LLT Avg	A1_ELT Avg	A1_LLT Avg	S6_ELT Avg	S6_LLT Avg	A1 vs. S6 ELT Num	A1 vs. S6 ELT % change	A1 vs. S6 LLT Num	A1 vs. S6 LLT % change
Steelhead	SWP	7,789	7,473	3,500	3,125	2,470	2,340	-1,029	-29	-785	-25
	CVP	1,394	1,378	590	567	521	512	-70	-12	-54	-10
Winter-Run Chinook Salmon	SWP	6,112	5,920	2,708	2,355	1,935	1,897	-773	-29	-458	-19
	CVP	844	828	328	324	320	313	-8	-2	-11	-3
Spring-Run Chinook Salmon	SWP	24,043	24,262	25,471	22,770	11,158	10,941	-14,312	-56	-11,829	-52
	CVP	15,260	15,182	11,835	11,284	7,243	6,949	-4,591	-39	-4336	-38
Fall-Run Chinook Salmon	SWP	37,103	36,197	32,661	28,117	15,942	15,241	-16,719	-51	-12,877	-46
	CVP	19,006	18,640	12,624	11,676	8,471	8,122	-4,153	-33	-3,554	-30

[1] Chinook salmon values calculated from normalized salvage densities. Steelhead numbers are not normalized because there are no suitable indices of annual abundance available.

J.4.3.2.3 Steelhead

Under existing biological conditions, salvage of steelhead is relatively high January through March, peaking during the month of February. Losses under EBC2 are highest in above normal and below normal years, and lowest in wet and critical water years (Appendix 5.B, *Entrainment*). Estimated loss of steelhead was approximately five times greater at the SWP facility compared to the CVP facility. Under the current PP, salvage of steelhead is already substantially decreased (54–85% less) compared to EBC in wet, above normal, and below normal years, but fairly similar in dry and critical years.

Under Scenario 6, salvage of steelhead was less across all water years compared to PP at both the SWP and CVP facilities (Table J.4-21). Salvage density index results for steelhead are not normalized against total population levels because currently there is no suitable index of annual abundance for this species. At the SWP, annual mean salvage of steelhead across all water years would be reduced by 25–29% under Scenario 6 compared to PP. At the CVP, annual mean salvage of steelhead across all water years would be reduced by 10–12% compared to PP.

Total salvage peaks in February under Scenario 6 and is highest most particularly in below normal, dry, and critical years. Under Scenario 6, SWP salvage in February is most substantially reduced in dry (43% in ELT, 29% in LLT), and critical (22% in ELT, 25% in LLT) water years, but increased in below normal ELT (63% increase) (Table J.4-22). CVP salvage in February improves in below normal ELT (20% decrease) but worsens in below normal LLT (84% increase) (Table J.4-23). South Delta exports in February are expected to fall in dry (17% in ELT, 19% in LLT) and critical years (10% in ELT, 21% in LLT) under Scenario 6, but increase in below normal years (42% in ELT, 21% in LLT). While exports and salvage generally fall in February, OMR flows are not improved or worse compared to PP (no difference to 87% decrease in OMR flow) in all water years, save for critical LLT years (Table J.4-20).

During the month of March, SWP steelhead salvage under Scenario 6 decreases during ELT in above normal (72%), below normal (25%), dry (15%), and critical (14%) water years, but increases during LLT in above normal (21% increase) and below normal (24% increase) years in LLT. South Delta exports in March are expected to improve slightly in ELT (6% increase), but worsen marginally in LLT (7% decrease), while March OMR flows are predicted to decrease (8–88%) for all water year types under Scenario 6 (Table J.4-20).

In April, salvage at the SWP under Scenario 6 drops in all water years (ELT and LLT), but most substantially in wet (71% for ELT and LLT), above normal (67% for ELT, 68% for LLT), and below normal (68% for ELT, 62% for LLT) water year types compared to PP (Table J.4-22). This salvage reduction is due to south Delta operation restrictions during April and May, which result in a reduction in south Delta exports (19–68% reduction) and improved OMR flows in above normal (149–154% improved OMR flow) and below normal (60–61% improved OMR flow) water year types.

Overall, under Scenario 6, steelhead salvage totals decrease substantially compared to PP in above normal and dry water years (>20%) types when salvage is high under EBC. Salvage increases slightly in below normal years compared to PP.

Table J.4-22. Estimated Mean Monthly Entrainment Index (Number of Fish Lost with 95% Confidence Interval [CI], Based on Nonnormalized Salvage Data) of Steelhead at the SWP Salvage Facilities

State Water Project (SWP)		EBC2_ELT		EBC2_LLT		A1_ELT		A1_LLT		S6_ELT		S6_LLT		A1 vs. S6 ELT		A1 vs. S6 LLT	
M	WY	Avg	95% CI	Avg	95% CI	Avg	95% CI	Avg	95% CI	Avg	95% CI	Avg	95% CI	Num	% change	Num	% change
Oct	W	40	± 9	33	± 7	37	± 8	32	± 7	13	± 3	12	± 3	-24	-66	-20	-64
	AN	4	± 2	3	± 1	4	± 2	3	± 2	2	± 1	1	± 1	-3	-61	-1	-50
	BN	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	0	0	0
	D	1	± 1	1	± 0	2	± 1	1	± 1	1	± 0	1	± 0	-1	-59	-1	-51
	C	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	0	0	0
Nov	W	10	± 4	9	± 4	7	± 3	7	± 3	3	± 2	3	± 2	-4	-55	-4	-56
	AN	26	± 15	27	± 17	26	± 14	27	± 14	14	± 9	12	± 9	-12	-45	-15	-55
	BN	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	0	0	0
	D	25	± 12	22	± 12	27	± 12	25	± 12	15	± 8	14	± 8	-12	-44	-10	-42
	C	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	0	0	0
Dec	W	39	± 9	39	± 9	21	± 6	23	± 7	19	± 5	20	± 6	-2	-7	-2	-10
	AN	318	± 112	319	± 112	257	± 97	295	± 117	231	± 81	226	± 79	-26	-10	-69	-23
	BN	99	± 18	99	± 20	92	± 27	92	± 33	78	± 19	85	± 24	-14	-16	-7	-7
	D	83	± 33	79	± 32	88	± 35	88	± 36	69	± 27	64	± 26	-19	-22	-24	-27
	C	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	0	0	0
Jan	W	1287	± 427	1242	± 414	150	± 113	173	± 109	166	± 100	196	± 110	16	11	24	14
	AN	3585	± 1471	3477	± 1403	1479	± 776	1328	± 710	856	± 493	926	± 489	-623	-42	-402	-30
	BN	431	± 72	396	± 93	389	± 128	333	± 113	208	± 70	225	± 68	-181	-47	-108	-33
	D	562	± 113	590	± 118	595	± 121	477	± 118	337	± 83	339	± 84	-258	-43	-138	-29
	C	159	± 50	175	± 35	192	± 41	89	± 44	120	± 41	113	± 48	-72	-38	24	27

State Water Project (SWP)		**EBC2_ELT**		**EBC2_LLT**		**A1_ELT**		**A1_LLT**		**S6_ELT**		**S6_LLT**		**A1 vs. S6 ELT**		**A1 vs. S6 LLT**	
M	**WY**	**Avg**	**95% CI**	**Avg**	**95% CI**	**Avg**	**95% CI**	**Avg**	**95% CI**	**Avg**	**95% CI**	**Avg**	**95% CI**	**Num**	**% change**	**Num**	**% change**
Feb	W	1568	± 281	1490	± 270	16	± 19	31	± 34	15	± 13	7	± 9	-1	-6	-24	-76
	AN	5007	± 1529	4909	± 1467	818	± 554	790	± 425	830	± 459	801	± 433	13	2	12	2
	BN	6233	± 1939	5258	± 1451	1830	± 852	2638	± 1374	2984	± 680	2267	± 879	1154	63	-371	-14
	D	2251	± 585	2035	± 548	2381	± 663	2236	± 664	1699	± 446	1525	± 431	-682	-29	-711	-32
	C	3583	± 734	3499	± 889	4110	± 1144	3806	± 746	3196	± 687	2843	± 624	-914	-22	-963	-25
Mar	W	1514	± 255	1461	± 250	58	± 34	43	± 29	75	± 43	72	± 44	17	30	29	68
	AN	2107	± 280	2154	± 346	367	± 226	110	± 121	105	± 63	134	± 86	-262	-72	23	21
	BN	3052	± 709	2827	± 701	1475	± 641	1163	± 507	1112	± 397	1439	± 453	-363	-25	275	24
	D	2440	± 485	2413	± 471	2495	± 477	2016	± 468	2115	± 404	1749	± 378	-380	-15	-268	-13
	C	642	± 212	616	± 228	659	± 282	632	± 299	565	± 130	537	± 138	-94	-14	-96	-15
Apr	W	467	± 98	478	± 99	267	± 86	265	± 83	77	± 23	76	± 23	-190	-71	-189	-71
	AN	309	± 33	343	± 34	491	± 140	437	± 143	164	± 49	139	± 50	-326	-67	-298	-68
	BN	44	± 6	53	± 9	132	± 29	122	± 25	42	± 12	47	± 9	-90	-68	-75	-62
	D	424	± 75	404	± 76	880	± 133	784	± 129	462	± 75	410	± 73	-418	-48	-374	-48
	C	191	± 58	170	± 47	264	± 67	249	± 79	194	± 61	201	± 57	-70	-27	-48	-19
May	W	354	± 88	342	± 87	192	± 57	153	± 46	52	± 14	63	± 16	-140	-73	-90	-59
	AN	174	± 36	182	± 36	328	± 108	308	± 112	106	± 39	83	± 23	-223	-68	-225	-73
	BN	74	± 11	87	± 14	218	± 70	169	± 58	65	± 12	68	± 12	-152	-70	-101	-60
	D	181	± 27	186	± 27	227	± 42	199	± 40	157	± 22	143	± 21	-70	-31	-56	-28
	C	164	± 31	148	± 48	127	± 46	133	± 51	104	± 44	106	± 38	-24	-19	-27	-21
Jun	W	224	± 50	204	± 45	103	± 31	63	± 22	73	± 21	77	± 19	-31	-30	14	23
	AN	89	± 17	74	± 12	58	± 15	47	± 10	40	± 8	38	± 7	-18	-32	-10	-20
	BN	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	1	25	2	41
	D	10	± 5	8	± 4	5	± 2	5	± 2	7	± 3	5	± 2	1	28	0	7
	C	52	± 14	45	± 14	31	± 8	35	± 12	36	± 9	35	± 15	5	14	1	2

State Water Project (SWP)		EBC2_ELT		EBC2_LLT		A1_ELT		A1_LLT		S6_ELT		S6_LLT		A1 vs. S6 ELT		A1 vs. S6 LLT	
M	WY	Avg	95% CI	Avg	95% CI	Avg	95% CI	Avg	95% CI	Avg	95% CI	Avg	95% CI	Num	% change	Num	% change
Jul	W	5	± 2	4	± 2	2	± 1	2	± 1	3	± 1	3	± 1	1	43	0	11
	AN	8	± 4	7	± 4	5	± 3	4	± 3	6	± 3	5	± 3	1	25	2	41
	BN	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	0	0	0
	D	17	± 5	16	± 5	10	± 4	7	± 3	10	± 4	7	± 3	0	-1	0	5
	C	62	± 19	46	± 20	21	± 14	13	± 8	19	± 12	11	± 10	-2	-11	-2	-14
Annual Sum	W	5514	± 714	5309	± 697	854	± 193	794	± 163	496	± 115	530	± 122	-358	-42	-263	-33
	AN	11625	± 2157	11493	± 2055	3832	± 1163	3350	± 827	2352	± 715	2366	± 662	-1480	-39	-983	-29
	BN	9933	± 2620	8720	± 2068	4136	± 1294	4518	± 1551	4488	± 884	4130	± 1039	353	9	-387	-9
	D	5995	± 1164	5755	± 1113	6709	± 1281	5838	± 1234	4871	± 930	4257	± 860	-1838	-27	-1581	-27
	C	4854	± 935	4699	± 1076	5405	± 1327	4958	± 872	4233	± 761	3847	± 722	-1172	-22	-1111	-22

Table J.4-23. Estimated Mean Monthly Entrainment Index (Number of Fish Lost with 95% Confidence Interval [CI], Based on Nonnormalized Salvage Data) of Steelhead at the CVP Salvage Facilities

Central Valley Project (CVP)		EBC2_ELT		EBC2_LLT		A1_ELT		A1_LLT		S6_ELT		S6_LLT		A1 vs. S6 ELT		A1 vs. S6 LLT	
M	WY	Avg	95% CI	Avg	95% CI	Avg	95% CI	Avg	95% CI	Avg	95% CI	Avg	95% CI	Num	% change	Num	% change
Oct	W	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	0	0	0
	AN	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	0	0	0
	BN	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	0	0	0
	D	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	0	0	0
	C	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	0	0	0
Nov	W	3	± 1	3	± 1	2	± 1	2	± 1	1	± 1	1	± 1	-1	-61	-1	-50
	AN	7	± 2	7	± 2	5	± 2	4	± 1	4	± 1	3	± 1	-1	-29	-1	-28

Central Valley Project (CVP)		**EBC2_ELT**		**EBC2_LLT**		**A1_ELT**		**A1_LLT**		**S6_ELT**		**S6_LLT**		**A1 vs. S6 ELT**		**A1 vs. S6 LLT**	
M	**WY**	**Avg**	**95% CI**	**Avg**	**95% CI**	**Avg**	**95% CI**	**Avg**	**95% CI**	**Avg**	**95% CI**	**Avg**	**95% CI**	**Num**	**% change**	**Num**	**% change**
	BN	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	0	0	0
	D	2	± 1	2	± 1	2	± 1	1	± 1	1	± 0	1	± 0	-1	-52	0	-31
	C	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	0	0	0
Dec	W	5	± 1	5	± 1	3	± 1	3	± 1	3	± 1	3	± 1	0	3	0	1
	AN	32	± 10	29	± 10	22	± 8	19	± 8	26	± 9	24	± 9	4	18	5	25
	BN	8	± 1	8	± 1	6	± 1	6	± 1	7	± 1	7	± 1	1	20	0	6
	D	2	± 1	2	± 1	2	± 1	2	± 1	2	± 1	2	± 1	0	9	0	11
	C	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	0	0	0
Jan	W	170	± 38	167	± 37	31	± 16	33	± 15	30	± 13	27	± 13	-1	-3	-6	-18
	AN	718	± 295	801	± 322	484	± 264	441	± 249	267	± 173	260	± 160	-218	-45	-180	-41
	BN	51	± 7	45	± 9	32	± 10	32	± 10	27	± 9	28	± 9	-6	-17	-4	-12
	D	48	± 12	45	± 11	41	± 11	32	± 10	24	± 8	27	± 8	-16	-40	-6	-18
	C	185	± 37	173	± 42	168	± 45	89	± 36	123	± 40	99	± 42	-45	-27	9	11
Feb	W	225	± 35	230	± 36	0	± 0	3	± 4	2	± 3	2	± 2	2	0	-2	-49
	AN	572	± 121	584	± 113	114	± 76	151	± 83	102	± 56	103	± 56	-11	-10	-48	-32
	BN	1398	± 352	1728	± 373	725	± 348	577	± 344	869	± 375	1064	± 408	144	20	486	84
	D	513	± 117	475	± 114	374	± 96	372	± 102	372	± 90	363	± 88	-2	-1	-8	-2
	C	585	± 126	501	± 135	422	± 95	486	± 152	466	± 83	415	± 118	44	10	-71	-15
Mar	W	388	± 92	393	± 93	0	± 0	23	± 21	18	± 11	22	± 13	18	0	-1	-5
	AN	343	± 41	328	± 45	15	± 17	35	± 34	22	± 13	33	± 22	7	44	-3	-7
	BN	572	± 106	583	± 135	265	± 154	247	± 116	352	± 110	297	± 119	86	33	50	20
	D	586	± 100	517	± 92	414	± 86	374	± 82	412	± 86	443	± 81	-2	0	69	18
	C	105	± 35	96	± 34	85	± 26	74	± 28	89	± 30	77	± 29	5	6	3	4
Apr	W	106	± 20	108	± 20	55	± 19	54	± 19	20	± 7	20	± 7	-36	-64	-35	-64
	AN	59	± 9	64	± 9	70	± 21	60	± 20	30	± 10	29	± 10	-39	-56	-31	-52
	BN	32	± 4	34	± 5	59	± 11	56	± 12	27	± 7	30	± 8	-32	-55	-26	-46

Central Valley Project (CVP)		**EBC2_ELT**		**EBC2_LLT**		**A1_ELT**		**A1_LLT**		**S6_ELT**		**S6_LLT**		**A1 vs. S6 ELT**		**A1 vs. S6 LLT**	
M	**WY**	**Avg**	**95% CI**	**Avg**	**95% CI**	**Avg**	**95% CI**	**Avg**	**95% CI**	**Avg**	**95% CI**	**Avg**	**95% CI**	**Num**	**% change**	**Num**	**% change**
	D	133	± 26	126	± 24	203	± 38	191	± 40	140	± 28	120	± 26	-63	-31	-71	-37
	C	41	± 5	41	± 5	44	± 8	43	± 9	39	± 7	35	± 6	-5	-12	-8	-18
May	W	52	± 9	50	± 9	26	± 6	27	± 6	10	± 2	10	± 2	-17	-64	-17	-62
	AN	37	± 6	38	± 6	50	± 15	58	± 17	16	± 4	15	± 5	-33	-67	-43	-74
	BN	30	± 2	32	± 4	60	± 10	50	± 13	26	± 5	25	± 6	-35	-58	-25	-50
	D	12	± 3	12	± 3	20	± 5	17	± 5	13	± 3	11	± 3	-7	-36	-6	-33
	C	7	± 1	7	± 0	7	± 2	6	± 1	6	± 1	6	± 1	-1	-9	0	-2
Jun	W	42	± 11	37	± 10	20	± 7	13	± 5	11	± 4	10	± 4	-9	-43	-2	-19
	AN	5	± 3	5	± 2	3	± 2	3	± 2	3	± 1	3	± 1	-1	-23	-1	-26
	BN	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	0	0	0
	D	5	± 1	4	± 0	4	± 1	3	± 0	4	± 1	3	± 0	1	18	0	2
	C	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	0	0	0
Jul	W	25	± 8	21	± 7	20	± 7	19	± 7	22	± 7	18	± 6	2	8	0	-2
	AN	2	± 1	1	± 1	1	± 1	1	± 1	2	± 1	2	± 1	1	103	1	49
	BN	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	0	0	0
	D	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	0	0	0
	C	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	0	0	0
Annual Sum	W	1016	± 100	1014	± 101	158	± 26	178	± 34	117	± 18	114	± 20	-41	-26	-64	-36
	AN	1774	± 367	1857	± 378	763	± 310	773	± 298	472	± 197	472	± 183	-292	-38	-301	-39
	BN	2091	± 441	2429	± 439	1148	± 416	969	± 370	1307	± 474	1451	± 440	159	14	482	50
	D	1301	± 219	1183	± 205	1059	± 189	992	± 174	969	± 179	970	± 169	-90	-9	-22	-2
	C	924	± 163	819	± 179	726	± 145	698	± 142	724	± 115	632	± 146	-2	0	-66	-10

J.4.3.2.4 Winter-Run Chinook Salmon

Under current existing conditions, total salvage at the SWP/CVP facilities of winter-run Chinook is high during the months of January through March, peaking in March at about 3,500 salvage winter-run Chinook. With the current PP, salvage of winter-run salmon is already substantially reduced in all water year types compared to EBC, but most especially in wet (88%), above normal (73–77%), and below normal years (51–54%). Based on estimates from the Entrainment Appendix on total population abundances, less than 1% of winter-run Chinook juveniles are salvaged at the SWP/CVP facilities under both PP and Scenario 6.

In general, estimated losses of winter-run Chinook salmon at the SWP facility were approximately five to ten times greater than those estimated for the CVP facility. Salvage density index for winter-run Chinook are normalized against total population abundance estimates, which are derived from the juvenile salmon production estimate. In combined water years, losses of winter-run Chinook salmon began to occur in December and peak in March at both SWP and CVP facilities, before sharply declining in April and May.

Across all water years, salvage of winter-run Chinook was substantially reduced under Scenario 6 at the SWP facility compared to Alternative 29% in the ELT scenario and 20% in the LLT scenario (Table J.4-21). SWP salvage losses in ELT were substantially reduced under Scenario 6 in January, during above normal (-42%), below normal (-47%), and dry years (-43%) (Table J.4-24). The improvement in salvage results in January under Scenario 6 corresponds to increases in OMR flow and decreases in south Delta exports during those water year types. In February, SWP salvage decreased substantially in dry (-29% for ELT, -32% for LLT) and critical years (-22% for ELT, -25% for LLT), but increased substantially in below normal ELT years (63%)under Scenario 6. At the CVP facilities in February, the salvage results vary from SWP trends. There is no change in dry years, a dichotomous result for critical years (10% decrease in ELT, 15% increase in LLT), and a substantial decrease in above normal years (20% for ELT, 84% for LLT) (Table J.4-25). The increase in salvage of winter-run salmon in February below normal years under Scenario 6 correlates to a substantially worse OMR flow (-87% for ELT, 7% for LLT) and large increase in south Delta exports (42% for ELT, 21% for LLT). In March at the SWP facilities, winter-run Chinook salvage decreases in all water year types for ELT (14–72% increase), but increases substantially in LLT for wet, above normal and below normal years (21–68% decrease). In March at the CVP facilities, salvage increases during above normal and below normal in ELT (33–44% increase), and during below normal and critical years in LLT (18–20%). While salvage at CVP facilities increases substantially percentage-wise during these water year types, salvage totals only increase by a few dozen winter-run Chinook. During the month of March, OMR flows are decreased under Scenario 6 in all water years, most especially in above normal and below normal LLT (72–88% decrease) (Table J.4-20).

Annually averaged salvage totals at the SWP were decreased under Scenario 6 by 16–19% in all water year types except below normal, where there was no difference. Annually averaged salvage totals across all water years at the CVP facility showed no difference (<5%) between Scenario 6 and PP (Table J.4-21). When water years are separated, improvements in salvage of winter-run Chinook salmon from Scenario 6 were greatest in wet, above normal, and dry water years. Salvage of winter-run Chinook at the SWP facilities would be greater under Scenario 6 than PP in all water year types, except in below normal water years in the LLT scenario.

Table J.4-24. Estimated Mean Monthly Entrainment Index (Number of Fish Lost with 95% Confidence Interval [CI], Based on Normalized Salvage Data) of Winter-Run Chinook Salmon at the SWP Salvage Facilities

State Water Project (SWP)		EBC2_ELT		EBC2_LLT		A1_ELT		A1_LLT		S6_ELT		S6_LLT		A1 vs. S6 ELT		A1 vs. S6 LLT	
M	WY	Avg	95% CI	Avg	95% CI	Avg	95% CI	Avg	95% CI	Avg	95% CI	Avg	95% CI	Num	% change	Num	% change
Dec	W	425	± 151	430	± 153	229	± 100	246	± 116	212	± 86	222	± 90	-17	-7	-24	-10
	AN	376	± 185	377	± 185	304	± 158	349	± 189	273	± 135	268	± 131	-31	-10	-81	-23
	BN	96	± 17	96	± 19	89	± 26	90	± 32	75	± 18	83	± 24	-14	-16	-7	-7
	D	269	± 85	257	± 84	285	± 89	286	± 92	222	± 69	208	± 66	-63	-22	-78	-27
	C	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	NA	0	NA
Jan	W	2712	± 857	2618	± 829	315	± 229	364	± 221	349	± 201	414	± 223	34	11	50	14
	AN	874	± 323	848	± 308	361	± 174	324	± 159	209	± 111	226	± 110	-152	-42	-98	-30
	BN	427	± 72	393	± 92	386	± 127	330	± 112	206	± 69	223	± 67	-180	-47	-107	-33
	D	143	± 18	150	± 19	151	± 19	121	± 23	86	± 16	86	± 16	-66	-43	-35	-29
	C	118	± 37	129	± 26	142	± 30	66	± 32	89	± 30	83	± 35	-53	-38	18	27
Feb	W	729	± 230	692	± 221	7	± 13	15	± 23	7	± 9	3	± 6	-1	-7	-11	-76
	AN	2773	± 1297	2719	± 1253	453	± 408	437	± 321	460	± 345	444	± 326	7	2	6	2
	BN	2418	± 752	2039	± 563	710	± 331	1023	± 533	1157	± 264	879	± 341	447	63	-144	-14
	D	823	± 240	744	± 225	870	± 273	817	± 274	621	± 183	557	± 177	-249	-29	-260	-32
	C	271	± 55	264	± 67	310	± 86	287	± 56	241	± 52	215	± 47	-69	-22	-73	-25
Mar	W	5958	± 1024	5748	± 1003	227	± 136	169	± 116	295	± 169	284	± 175	68	30	115	68
	AN	2067	± 727	2113	± 787	360	± 320	108	± 164	103	± 90	131	± 121	-257	-72	23	21
	BN	3604	± 838	3338	± 828	1742	± 757	1373	± 598	1313	± 468	1699	± 535	-428	-25	325	24
	D	1628	± 433	1610	± 422	1664	± 428	1345	± 409	1411	± 363	1167	± 333	-254	-15	-178	-13
	C	445	± 147	427	± 158	457	± 196	438	± 208	392	± 90	372	± 96	-65	-14	-66	-15
Apr	W	913	± 309	935	± 312	523	± 250	519	± 244	151	± 69	150	± 68	-372	-71	-369	-71
	AN	80	± 26	89	± 28	127	± 60	113	± 59	42	± 21	36	± 20	-84	-67	-77	-68
	BN	20	± 3	23	± 4	58	± 13	54	± 11	18	± 5	21	± 4	-40	-68	-33	-62
	D	76	± 12	72	± 13	158	± 21	140	± 21	83	± 12	73	± 12	-75	-48	-67	-48
	C	23	± 7	20	± 6	32	± 8	30	± 10	23	± 7	24	± 7	-9	-27	-6	-19

State Water Project (SWP)		EBC2_ELT		EBC2_LLT		A1_ELT		A1_LLT		S6_ELT		S6_LLT		A1 vs. S6 ELT		A1 vs. S6 LLT	
M	WY	Avg	95% CI	Avg	95% CI	Avg	95% CI	Avg	95% CI	Avg	95% CI	Avg	95% CI	Num	% change	Num	% change
Annual Sum	W	10739	± 1542	10426	± 1513	1302	± 376	1314	± 346	1015	± 279	1073	± 294	-288	-22	-241	-18
	AN	6169	± 2244	6145	± 2229	1604	± 842	1331	± 467	1086	± 464	1104	± 432	-518	-32	-227	-17
	BN	6620	± 1567	5955	± 1327	3149	± 957	2998	± 846	2820	± 608	2956	± 660	-329	-10	-42	-1
	D	2939	± 631	2833	± 605	3129	± 659	2710	± 639	2423	± 511	2092	± 469	-706	-23	-619	-23
	C	857	± 198	841	± 212	941	± 253	822	± 221	745	± 116	695	± 142	-196	-21	-127	-16

Table J.4-25. Estimated Mean Monthly Entrainment Index (Number of Fish Lost with 95% Confidence Interval [CI], Based on Normalized Salvage Data) of Winter-Run Chinook Salmon at the CVP Salvage Facilities

Central Valley Project (CVP)		EBC2_ELT		EBC2_LLT		A1_ELT		A1_LLT		S6_ELT		S6_LLT		A1 vs. S6 ELT		A1 vs. S6 LLT	
M	WY	Avg	95% CI	Avg	95% CI	Avg	95% CI	Avg	95% CI	Avg	95% CI	Avg	95% CI	Num	% change	Num	% change
Dec	W	100	± 17	95	± 16	64	± 15	69	± 15	66	± 13	70	± 14	2	3	1	1
	AN	21	± 10	19	± 9	14	± 8	13	± 7	17	± 9	16	± 9	3	18	3	25
	BN	49	± 4	46	± 6	37	± 9	39	± 8	45	± 5	41	± 8	7	20	2	6
	D	41	± 6	37	± 6	34	± 5	30	± 6	37	± 6	34	± 6	3	9	3	11
	C	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	NA	0	NA
Jan	W	145	± 37	143	± 36	27	± 15	28	± 15	26	± 12	23	± 12	-1	-3	-5	-18
	AN	47	± 13	52	± 14	31	± 13	29	± 12	17	± 9	17	± 8	-14	-45	-12	-41
	BN	82	± 11	72	± 14	52	± 16	52	± 15	43	± 15	45	± 14	-9	-17	-6	-12
	D	68	± 11	64	± 10	58	± 10	46	± 10	35	± 8	38	± 8	-23	-40	-8	-18
	C	36	± 7	34	± 8	33	± 9	17	± 7	24	± 8	19	± 8	-9	-27	2	11
Feb	W	183	± 35	187	± 36	0	± 0	3	± 3	2	± 2	1	± 2	2	NA	-1	-49
	AN	178	± 76	182	± 74	35	± 34	47	± 38	32	± 26	32	± 26	-4	-10	-15	-32
	BN	265	± 67	328	± 71	137	± 66	109	± 65	165	± 71	202	± 77	27	20	92	84
	D	251	± 51	233	± 51	183	± 44	182	± 47	182	± 40	178	± 40	-1	-1	-4	-2
	C	108	± 23	93	± 25	78	± 18	90	± 28	86	± 15	77	± 22	8	10	-13	-15
Mar	W	830	± 133	841	± 135	0	± 0	50	± 36	39	± 19	48	± 22	39	NA	-3	-5
	AN	304	± 116	291	± 115	14	± 22	31	± 45	20	± 18	29	± 29	6	44	-2	-7
	BN	342	± 63	348	± 81	158	± 92	148	± 69	210	± 66	177	± 71	52	33	30	20
	D	326	± 61	288	± 56	230	± 53	209	± 51	229	± 53	247	± 49	-1	0	38	18
	C	170	± 56	155	± 55	137	± 41	119	± 46	145	± 48	125	± 47	8	6	5	4

Central Valley Project (CVP)		EBC2_ELT		EBC2_LLT		A1_ELT		A1_LLT		S6_ELT		S6_LLT		A1 vs. S6 ELT		A1 vs. S6 LLT	
M	**WY**	**Avg**	**95% CI**	**Avg**	**95% CI**	**Avg**	**95% CI**	**Avg**	**95% CI**	**Avg**	**95% CI**	**Avg**	**95% CI**	**Num**	**% change**	**Num**	**% change**
Apr	W	103	± 29	105	± 29	54	± 25	53	± 25	19	± 9	19	± 9	-35	-64	-34	-64
	AN	52	± 25	56	± 26	61	± 38	53	± 36	27	± 18	25	± 18	-35	-56	-27	-52
	BN	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	NA	0	NA
	D	30	± 4	29	± 4	46	± 6	44	± 7	32	± 4	27	± 4	-14	-31	-16	-37
	C	4	± 0	4	± 0	4	± 1	4	± 1	3	± 1	3	± 1	-1	-12	-1	-18
Annual Sum	W	1362	± 136	1373	± 138	145	± 34	202	± 51	152	± 28	161	± 31	7	5	-42	-21
	AN	606	± 219	604	± 219	161	± 82	179	± 94	114	± 51	121	± 57	-47	-29	-57	-32
	BN	738	± 127	793	± 128	385	± 135	347	± 102	462	± 138	465	± 118	78	20	118	34
	D	716	± 109	650	± 104	551	± 96	510	± 87	515	± 91	524	± 85	-36	-7	13	3
	C	318	± 74	285	± 71	251	± 55	230	± 49	258	± 57	223	± 60	7	3	-7	-3

J.4.3.2.5 Spring-Run Chinook Salmon

Under existing baseline conditions, salvage of spring-run Chinook at the SWP/CVP facilities is very high between the months of March through May, peaking in April at about 18,000 spring-run salmon. Under the current PP compared to EBC, salvage is substantially reduced in wet years (54–62%), but increased greatly in below normal and dry years at the SWP (59–105%). Based on estimates from the Entrainment Appendix, about 5% of spring-run Chinook population of juveniles are salvaged at the SWP/CVP facilities.

In all water years, estimated losses of spring-run Chinook at the SWP facility were approximately two times greater than those estimated for the CVP facility. Salvage density index results for Spring-run Chinook salmon are normalized against Spring-run adult run size estimates from DFG's GrandTab datasets. Annual mean salvage of spring-run Chinook was substantially reduced under Scenario 6 compared to PP at both the SWP (52–56%) and CVP (38–39%) facilities (Table J.4-21).

In general, the greatest decrease in total salvage under Scenario 6 and PP occurs in April and May. In April, SWP salvage decreases by a large margin under all water year types but most substantially in wet (71% for ELT/LLT), above normal (67% for ELT, 68% for LLT), below normal (68% for ELT, 62% for LLT), and dry years (78% for ELT/LLT) (Table J.4-26). At the CVP facilities, salvage decreases by a similar proportion in wet (64% for ELT/LLT), above normal (56% for ELT, 52% for LLT), below normal (58% for ELT, 50% for LLT), and dry years (36% for ELT, 33% for LLT) (Table J.4-27). In May, SWP and CVP salvage are decreased in all water years, but most notably in wet and above normal years (59–74%) (Table J.4-26 and Table J.4-27). The major improvements in salvage in April and May coincide with reduced south Delta exports, especially in wet (61–68% decrease), above normal (61–73%), and below normal years (56–65%) (Table J.4-20). April and May OMR flow is also improved substantially on a monthly average basis (41–287%), with average flow direction positive and flowing northward (Table J.4-20).

Table J.4-26. Estimated Mean Monthly Entrainment Index (Number of Fish Lost with 95% Confidence Interval [CI], Based on Normalized Salvage Data) of Spring-Run Chinook Salmon at the SWP Salvage Facilities

SWP		EBC2_ELT		EBC2_LLT		A1_ELT		A1_LLT		S6_ELT		S6_LLT		A1 vs. S6 ELT		A1 vs. S6 LLT	
M	WY	Avg	95% CI	Avg	95% CI	Avg	95% CI	Avg	95% CI	Avg	95% CI	Avg	95% CI	Num	% change	Num	% change
Oct	W	45	± 17	37	± 14	41	± 15	35	± 14	14	± 6	13	± 5	-27	-66	-23	-64
	AN	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	NA	0	NA
	BN	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	NA	0	NA
	D	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	NA	0	NA
	C	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	NA	0	NA
Nov	W	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	NA	0	NA
	AN	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	NA	0	NA
	BN	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	NA	0	NA
	D	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	NA	0	NA
	C	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	NA	0	NA
Dec	W	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	NA	0	NA
	AN	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	NA	0	NA
	BN	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	NA	0	NA
	D	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	NA	0	NA
	C	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	NA	0	NA
Jan	W	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	NA	0	NA
	AN	4	± 2	4	± 2	2	± 1	2	± 1	1	± 1	1	± 1	-1	-42	-1	-30
	BN	13	± 2	12	± 3	12	± 4	10	± 3	6	± 2	7	± 2	-5	-47	-3	-33
	D	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	NA	0	NA
	C	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	NA	0	NA
Feb	W	331	± 96	315	± 92	3	± 5	7	± 10	3	± 4	2	± 3	0	-7	-5	-76
	AN	84	± 37	83	± 35	14	± 12	13	± 9	14	± 10	14	± 9	0	2	0	2
	BN	35	± 11	29	± 8	10	± 5	15	± 8	17	± 4	13	± 5	6	63	-2	-14
	D	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	NA	0	NA
	C	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	NA	0	NA
Mar	W	15049	± 4918	14519	± 4793	573	± 532	427	± 452	746	± 666	717	± 686	173	30	290	68
	AN	5435	± 1276	5558	± 1424	946	± 686	285	± 359	270	± 192	345	± 260	-676	-72	61	21
	BN	2316	± 538	2145	± 532	1119	± 487	883	± 385	844	± 301	1092	± 344	-275	-25	209	24
	D	1433	± 527	1417	± 515	1466	± 525	1184	± 484	1242	± 445	1027	± 399	-223	-15	-157	-13
	C	184	± 61	177	± 65	189	± 81	182	± 86	162	± 37	154	± 40	-27	-14	-27	-15

SWP		EBC2_ELT		EBC2_LLT		A1_ELT		A1_LLT		S6_ELT		S6_LLT		A1 vs. S6 ELT		A1 vs. S6 LLT	
M	WY	Avg	95% CI	Avg	95% CI	Avg	95% CI	Avg	95% CI	Avg	95% CI	Avg	95% CI	Num	% change	Num	% change
Apr	W	21050	± 7172	21562	± 7241	12057	± 5796	11965	± 5660	3481	± 1601	3450	± 1584	-8576	-71	-8515	-71
	AN	13137	± 4338	14591	± 4742	20888	± 10117	18601	± 9861	6998	± 3506	5924	± 3354	-13889	-67	-12676	-68
	BN	2447	± 336	2916	± 476	7302	± 1626	6766	± 1386	2305	± 677	2600	± 491	-4997	-68	-4166	-62
	D	8278	± 3030	7873	± 2997	17162	± 5790	15295	± 5397	9014	± 3155	7991	± 2942	-8148	-48	-7304	-48
	C	3746	± 1146	3327	± 930	5178	± 1312	4887	± 1556	3796	± 1205	3950	± 1113	-1382	-27	-937	-19
May	W	10652	± 2526	10293	± 2508	5773	± 1653	4599	± 1334	1554	± 398	1885	± 447	-4219	-73	-2714	-59
	AN	2617	± 433	2737	± 417	4951	± 1445	4643	± 1513	1591	± 530	1245	± 303	-3359	-68	-3398	-73
	BN	901	± 130	1053	± 174	2635	± 852	2049	± 701	791	± 150	824	± 145	-1845	-70	-1225	-60
	D	5431	± 1842	5605	± 1856	6813	± 2595	5993	± 2372	4721	± 1564	4311	± 1456	-2093	-31	-1683	-28
	C	4410	± 837	3996	± 1288	3432	± 1240	3577	± 1363	2787	± 1178	2844	± 1015	-645	-19	-733	-21
Jun	W	1587	± 554	1442	± 494	731	± 321	443	± 229	515	± 220	544	± 209	-216	-30	101	23
	AN	102	± 34	85	± 27	67	± 27	55	± 20	45	± 15	44	± 15	-21	-32	-11	-20
	BN	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	NA	0	NA
	D	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	NA	0	NA
	C	118	± 33	101	± 31	71	± 18	78	± 27	81	± 21	80	± 33	10	14	2	2
Sep	W	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	NA	0	NA
	AN	12	± 6	12	± 6	6	± 3	7	± 4	1	± 2	2	± 2	-5	-83	-5	-72
	BN	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	NA	0	NA
	D	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	NA	0	NA
	C	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	NA	0	NA
Annual Sum	W	48715	± 11742	48168	± 11708	19178	± 6408	17476	± 5999	6312	± 2002	6610	± 2011	-12865	-67	-10866	-62
	AN	21392	± 5769	23070	± 6237	26873	± 11020	23604	± 10664	8921	± 3593	7574	± 3618	-17951	-67	-16030	-68
	BN	5712	± 713	6155	± 684	11079	± 2106	9722	± 1678	3962	± 886	4535	± 639	-7116	-64	-5187	-53
	D	15142	± 5224	14896	± 5158	25441	± 8392	22473	± 7741	14976	± 4994	13329	± 4567	-10465	-41	-9143	-41
	C	8459	± 1787	7600	± 1885	8870	± 2091	8724	± 2041	6827	± 1905	7028	± 1694	-2043	-23	-1696	-19

Table J.4-27. Estimated Mean Monthly Entrainment Index (Number of Fish Lost with 95% Confidence Interval [CI], Based on Normalized Salvage Data) of Spring-Run Chinook Salmon at the CVP Salvage Facilities

Central Valley Project (CVP)		EBC2_ELT		EBC2_LLT		A1_ELT		A1_LLT		S6_ELT		S6_LLT		A1 vs. S6 ELT		A1 vs. S6 LLT	
M	WY	Avg	95% CI	Avg	95% CI	Avg	95% CI	Avg	95% CI	Avg	95% CI	Avg	95% CI	Num	% change	Num	% change
Oct	W	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	NA	0	NA
	AN	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	NA	0	NA
	BN	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	NA	0	NA
	D	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	NA	0	NA
	C	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	NA	0	NA
Jan	W	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	NA	0	NA
	AN	3	2	3	2	2	± 1	2	± 1	1	± 1	1	± 1	-1	-45	-1	-41
	BN	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	NA	0	NA
	D	4	2	4	1	3	± 1	3	± 1	2	± 1	2	± 1	-1	-40	-1	-18
	C	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	NA	0	NA
Feb	W	60	12	61	12	0	± 0	1	± 1	1	± 1	0	± 1	1	NA	0	-49
	AN	19	9	19	9	4	± 4	5	± 4	3	± 3	3	± 3	0	-10	-2	-32
	BN	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	NA	0	NA
	D	1	1	1	1	1	± 0	1	± 0	1	± 0	1	± 0	0	-1	0	-2
	C	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	NA	0	NA
Mar	W	16737	± 3938	16957	± 3991	0	± 0	1011	± 916	787	± 479	961	± 553	787	NA	-50	-5
	AN	1517	± 227	1454	± 240	68	± 79	156	± 157	98	± 60	145	± 100	30	44	-11	-7
	BN	457	± 85	466	± 108	212	± 123	197	± 93	281	± 88	237	± 95	69	33	40	20
	D	552	± 180	487	± 163	390	± 145	353	± 136	388	± 144	418	± 142	-2	0	65	18
	C	95	± 31	86	± 31	76	± 23	66	± 25	80	± 27	69	± 26	4	6	3	4

Central Valley Project (CVP)		**EBC2_ELT**		**EBC2_LLT**		**A1_ELT**		**A1_LLT**		**S6_ELT**		**S6_LLT**		**A1 vs. S6 ELT**		**A1 vs. S6 LLT**	
M	**WY**	**Avg**	**95% CI**	**Avg**	**95% CI**	**Avg**	**95% CI**	**Avg**	**95% CI**	**Avg**	**95% CI**	**Avg**	**95% CI**	**Num**	**% change**	**Num**	**% change**
Apr	W	15409	± 3305	15744	± 3359	8056	± 2995	7881	± 3029	2867	± 1054	2842	± 1042	-5189	-64	-5040	-64
	AN	4276	± 1369	4599	± 1473	5018	± 2325	4323	± 2192	2188	± 1089	2091	± 1087	-2830	-56	-2231	-52
	BN	396	± 48	419	± 62	733	± 138	700	± 147	334	± 87	376	± 95	-399	-55	-324	-46
	D	2284	± 537	2165	± 505	3472	± 804	3268	± 835	2400	± 584	2050	± 536	-1072	-31	-1218	-37
	C	1603	± 187	1588	± 193	1705	± 291	1671	± 336	1498	± 258	1368	± 237	-206	-12	-303	-18
May	W	11307	± 4182	10830	± 4036	5682	± 2666	5891	± 2704	2065	± 889	2214	± 940	-3617	-64	-3677	-62
	AN	600	± 177	613	± 177	794	± 343	934	± 392	260	± 102	248	± 104	-534	-67	-686	-74
	BN	119	± 8	127	± 16	243	± 42	199	± 53	103	± 20	99	± 24	-140	-58	-100	-50
	D	87	± 12	88	± 12	144	± 22	120	± 20	92	± 13	81	± 12	-52	-36	-39	-33
	C	1010	± 92	976	± 64	973	± 207	885	± 177	886	± 136	870	± 124	-87	-9	-15	-2
Jun	W	509	± 157	443	± 138	236	± 92	155	± 66	134	± 52	126	± 56	-102	-43	-29	-19
	AN	10	± 5	10	± 5	7	± 4	7	± 4	5	± 3	5	± 3	-2	-23	-2	-26
	BN	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	NA	0	NA
	D	2	± 1	2	± 1	2	± 1	1	± 1	2	± 1	1	± 1	0	18	0	2
	C	4	± 0	5	± 1	3	± 1	3	± 1	3	± 1	4	± 1	0	-2	1	44
Annual Sum	W	44021	± 10396	44036	± 10428	13975	± 5063	14939	± 5345	5854	± 1952	6143	± 2080	-8121	-58	-8796	-59
	AN	6425	± 1473	6698	± 1580	5893	± 2361	5427	± 2220	2555	± 1104	2494	± 1131	-3337	-57	-2933	-54
	BN	972	± 82	1012	± 111	1188	± 209	1097	± 225	718	± 146	713	± 134	-470	-40	-384	-35
	D	2931	± 704	2747	± 648	4012	± 929	3746	± 934	2885	± 708	2553	± 659	-1127	-28	-1193	-32
	C	2711	± 271	2655	± 250	2757	± 467	2625	± 470	2467	± 352	2311	± 332	-289	-11	-314	-12

J.4.3.2.6 Delta Smelt

Juveniles

Juvenile delta smelt entrainment was estimated and compared using two methods, proportional entrainment and salvage density. In general, the proportional entrainment method is considered the more precise of the two for estimating effects on delta smelt. Results from each of the methods are described below.

OMR Proportional Entrainment

Based on the Kimmerer proportional entrainment method (2008), the annual proportional entrainment loss of juvenile and larval delta smelt is estimated to be relatively low under the PP, averaging 0.057 in the early long term, and 0.051 in the late long term (Table J.4-28). Using the same method, it appears that Scenario 6 would increase entrainment levels relative to PP by about 8 to 12%, although the proportion of the total juvenile and larval delta smelt population entrained at the south delta would still be relatively low, ranging from 0.04 in wet years to 0.078–0.09 in below normal years. The largest increases in juvenile entrainment under Scenario 6 relative to PP occur in below normal (12% increase in ELT, 15% increase in LLT), dry (10% in ELT, 8% in LLT), and wet water years (13% in ELT, 14% in LLT) (Table J.4-28). The proportion of the population lost under EBC (0.088–0.099) is greater than estimated for either PP or Scenario 6.

Table J.4-28. Average Annual Proportional Loss of Juvenile and Larval Delta Smelt at SWP/CVP South Delta Export Facilities

	EBC2 (ELT)	EBC2 (LLT)	A1 (ELT)	A1 (LLT)	S6 (ELT)	S6 (LLT)	A1 vs. S6 ELT	A1 vs. S6 LLT
All	0.093	0.088	0.057	0.051	0.063	0.056	0.006(10.5%)	0.005(10.5%)
Wet	0.087	0.085	0.035	0.035	0.039	0.040	0.004(12.4%)	0.005(13.5%)
Above Normal	0.097	0.089	0.064	0.064	0.068	0.066	0.005(7.1%)	0.003(4.3%)
Below Normal	0.104	0.101	0.080	0.068	0.090	0.078	0.010(12.5%)	0.010(15.3%)
Dry	0.105	0.097	0.073	0.058	0.080	0.063	0.007(10.2%)	0.005(8.4%)
Critical	0.072	0.063	0.046	0.042	0.050	0.046	0.004(8.6%)	0.004(9.4%)

Salvage Density

The salvage density method uses exports and assumed fish presence to predict salvage at each of the south Delta facilities. The salvage density method is used for relative comparison between PP and Scenario 6, but it provides little interpretive value and is inferior to the proportional entrainment approach described above. Under existing baseline conditions, estimates of total salvage of juvenile delta smelt at the SWP/CVP facilities peak in May and June (Table J.4-29). SWP salvage (Table J.4-30) is generally estimated to be an order of magnitude greater than at the CVP facilities (Table J.4-31). In May under the current PP, combined SWP/CVP juvenile delta smelt salvage is reduced substantially as compared to EBC in the wet water years (46–54%), but increases in above normal (67–79%), below normal (88–177%), and dry water years (9–28%) compared to EBC (Table J.4-32). In contrast, salvage under the current PP decreases in June for the all water year types (23–69%).

In comparison, Scenario 6 would result in combined SWP/CVP juvenile delta smelt salvage decreases in May under all water year types (Table J.4-32 and Table J.4-33). Reductions in estimated May salvage under Scenario 6 are associated with substantially reduced south Delta exports in all water year types, but especially in wet, above normal, and below normal years (56–68% decrease) (Table J.4-32). In June, combined salvage under Scenario 6 is reduced relative to PP in wetter years (20–31%), but increased in below normal (23% for ELT), dry (28% for ELT, 7% for LLT) and critical years (13% for ELT, 5% for LLT) compared to PP (51) (Table J.4-32). South Delta exports are also reduced under Scenario 6 relative to PP in wet and (36% for ELT) above normal years (28% for ELT, 23% for LLT), but increased exports in drier years (5–23%) (Table J.4-20). June OMR flows are more negative under Scenario 6 for all water year types (6–23% decrease), except wet years (122–394% increase) (Table J.4-20).

Table J.4-29. Estimated Mean Annual Salvage Index (Salvage Density Method) at SWP and CVP Salvage Facilities for Delta Smelt for All Water Years[1]

		EBC2_ELT	EBC2_LLT	A1_ELT	A1_LLT	S6_ELT	S6_LLT	A1 vs. S6 ELT		A1 vs. S6 LLT	
Lifestage	Facility	Avg	Avg	Avg	Avg	Avg	Avg	Difference	% change	Difference	% change
Adult	SWP	9,004	8,761	4,845	4,319	3,500	3,504	-1,345	-28	-815	-19
	CVP	2,914	2,853	1,375	1,300	1,204	1,173	-171	-12	-127	-10
Juvenile	SWP	105,587	98,029	78,425	63,682	49,662	46,055	-28,763	-37	-17,627	-28
	CVP	11,821	11,439	11,139	10,176	6,117	5,737	-5,022	-45	-4,439	-44
Delta smelt were normalized using population estimates derived from fall midwater trawl index.											

Table J.4-30. Estimated Mean Monthly Entrainment Index (Number of Fish Lost with 95% Confidence Interval [CI]) of Juvenile Delta Smelt for All Model Scenarios at the SWP Salvage Facilities in May–July for All Water Years

State Water Project (SWP)		EBC2_ELT		EBC2_LLT		A1_ELT		A1_LLT		S6_ELT		S6_LLT	
M	**WY**	**Avg**	**95% CI**	**Avg**	**95% CI**	**Avg**	**95% CI**	**Avg**	**95% CI**	**Avg**	**95% CI**	**Avg**	**95% CI**
May	All	37511	± 3959	37781	± 3950	42623	± 4472	36089	± 3827	17141	± 1536	16887	± 1434
	W	69957	± 22946	67599	± 22684	37910	± 14626	30202	± 11784	10206	± 3571	12379	± 4064
	AN	22781	± 5853	23822	± 5871	43087	± 16133	40407	± 16519	13851	± 5761	10832	± 3539
	BN	14988	± 2154	17515	± 2888	43823	± 14161	34066	± 11664	13146	± 2489	13705	± 2411
	D	34190	± 9499	35289	± 9565	42895	± 13446	37732	± 12308	29720	± 8059	27139	± 7507
	C	14258	± 2707	12919	± 4164	11095	± 4010	11564	± 4406	9011	± 3807	9196	± 3280
Jun	All	62502	± 6669	55072	± 5850	33093	± 4183	25170	± 3217	29183	± 3140	26265	± 2844
	W	110854	± 35212	100703	± 31400	51049	± 20562	30928	± 14723	35961	± 14060	37980	± 13355
	AN	25858	± 5512	21391	± 4097	16807	± 4829	13780	± 3321	11477	± 2487	11018	± 2353
	BN	37466	± 6559	35331	± 7266	22853	± 7929	19952	± 7753	28042	± 4618	20376	± 5873
	D	52184	± 15042	41769	± 11918	26119	± 8517	22768	± 8204	33354	± 10779	24407	± 8335
	C	21142	± 5824	17987	± 5496	12650	± 3140	14016	± 4890	14446	± 3668	14278	± 5939
Jul	All	5573	± 827	5176	± 789	2709	± 500	2423	± 469	3338	± 612	2903	± 537
	W	12160	± 3911	11396	± 3700	5023	± 1943	6039	± 2233	7203	± 2762	6716	± 2476
	AN	628	± 296	568	± 280	345	± 215	289	± 210	431	± 259	407	± 236
	BN	114	± 3	111	± 4	58	± 22	54	± 20	80	± 28	77	± 24
	D	4663	± 1896	4520	± 1897	2792	± 1391	1822	± 1113	2762	± 1412	1920	± 1067
	C	1091	± 342	817	± 355	372	± 238	233	± 149	333	± 215	199	± 169

Table J.4-31. Estimated Mean Monthly Entrainment Index (Number of Fish Lost with 95% Confidence Interval [CI]) of Juvenile Delta Smelt for All Model Scenarios at the CVP Salvage Facilities in May–July for All Water Years

Central Valley Project (CVP)		EBC2_ELT		EBC2_LLT		A1_ELT		A1_LLT		S6_ELT		S6_LLT	
M	**WY**	**Avg**	**95% CI**	**Avg**	**95% CI**	**Avg**	**95% CI**	**Avg**	**95% CI**	**Avg**	**95% CI**	**Avg**	**95% CI**
May	All	9031	± 798	8930	± 779	9471	± 833	8864	± 808	4730	± 392	4517	± 375
	W	8169	± 2466	7825	± 2381	4105	± 1598	4256	± 1619	1492	± 530	1600	± 561
	AN	4880	± 1803	4991	± 1813	6459	± 3298	7601	± 3785	2115	± 989	2016	± 1001
	BN	3291	± 231	3522	± 448	6719	± 1162	5513	± 1455	2856	± 541	2748	± 667
	D	2359	± 306	2360	± 310	3891	± 574	3243	± 511	2478	± 348	2182	± 311
	C	3623	± 331	3502	± 229	3492	± 742	3176	± 634	3178	± 488	3122	± 445
Jun	All	2749	± 292	2474	± 261	1643	± 192	1288	± 158	1352	± 143	1191	± 136
	W	3080	± 908	2678	± 803	1431	± 535	937	± 386	812	± 301	763	± 328
	AN	1191	± 288	1142	± 267	808	± 237	823	± 233	620	± 160	606	± 158
	BN	305	± 52	284	± 46	243	± 73	170	± 71	262	± 43	187	± 57
	D	390	± 70	314	± 51	291	± 56	234	± 45	342	± 64	239	± 50
	C	1644	± 125	1874	± 410	1199	± 445	1223	± 414	1175	± 446	1767	± 520
Jul	All	41	± 4	36	± 4	26	± 3	24	± 3	36	± 4	30	± 4
	W	42	± 10	36	± 10	34	± 9	31	± 9	36	± 10	31	± 9
	AN	21	± 8	17	± 7	10	± 5	13	± 6	21	± 8	19	± 8
	BN	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0
	D	15	± 6	14	± 5	8	± 4	6	± 3	11	± 5	9	± 4
	C	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0

Table J.4-32. Estimated Absolute and Percent Differences between Model Scenarios in Juvenile Delta Smelt Entrainment Index (Number of Fish Lost) at the SWP and CVP Salvage Facilities in May–July during All Water Years

M	WY	A1_ELT vs. S6_ELT	A1_LLT vs. S6_LLT
May	Wet	-30,317 (-72%)	-20,480 (-59%)
	Above Normal	-33,580 (-68%)	-35,160 (-73%)
	Below Normal	-34,541 (-68%)	-23,126 (-58%)
	Dry	-14,587 (-31%)	-11,654 (-28%)
	Critical	-2,398 (-16%)	-2,423 (-16%)
	All	-30,223 (-58%)	-23,548 (-52%)
June	Wet	-15,707 (-30%)	6,878 (22%)
	Above Normal	-5,518 (-31%)	-2,978 (-20%)
	Below Normal	5,208 (23%)	441 (2%)
	Dry	7,286 (28%)	1645 (7%)
	Critical	1,772 (13%)	805 (5%)
	All	-4,201 (-12%)	998 (4%)
July	Wet	2,183 (43%)	677 (11%)
	Above Normal	96 (27%)	124 (41%)
	Below Normal	22 (38%)	23 (43%)
	Dry	-27 (-1%)	101 (6%)
	Critical	-39 (-10%)	-33 (-14%)
	All	639 (23%)	485 (20%)
All Years	Wet	-43,840 (-44%)	-12,925 (-18%)
	Above Normal	-39,002 (-58%)	-38,015 (-60%)
	Below Normal	-29,311 (-40%)	-22,662 (-38%)
	Dry	-7,328 (-10%)	-9,908 (-15%)
	Critical	-665 (-2%)	-1651 (-5%)
	All	-33,785 (-38%)	-22,065 (-30%)

Table J.4-33. Estimated Absolute and Percent Differences between Model Scenarios in Juvenile Delta Smelt Entrainment Index (Number of Fish Lost) at the SWP and CVP Salvage Facilities in May–July during All Water Years

Month	A1_ELT vs. S6_ELT	A1_LLT vs. S6_LLT
May	-30,223 (-58%)	-23,548 (-52%)
June	-4,201 (-12%)	998 (4%)
July	639 (23%)	485 (20%)

Adult

OMR Proportional Entrainment

Entrainment of adult delta smelt is typically highest in dry and critical water years, and lowest in wet years. . Entrainment is estimated to increase under Scenario 6 relative to PP in wet years (15% in ELT, 12% in LLT,) but decreased in dry years (10% in ELT, 7% in LLT) (Table J.4-34). There are no changes to adult entrainment in other water year types. Because the proportion of total adult delta smelt population lost to entrainment is quite low in wet years (2–3%), the increase in entrainment in wet years under Scenario 6 affects less than 0.5% of the total adult delta smelt population. Likewise the reduction in entrainment in dry years under Scenario 6 only saves around 1% of the total adult delta smelt population from potential entrainment loss.

Table J.4-34. Average Annual Proportional Loss of Adult Delta Smelt at SWP/CVP South Delta Export Facilities

	EBC2 (ELT)	EBC2 (LLT)	A1 (ELT)	A1 (LLT)	S6 (ELT)	S6 (LLT)	A1 vs. S6 ELT	A1 vs. S6 LLT
All	0.086	0.085	0.062	0.060	0.061	0.060	-0.001(-2.3%)	-0.000(-0.2%)
Wet	0.074	0.073	0.024	0.026	0.027	0.029	0.004(15.1%)	0.003(11.9%)
Above Normal	0.091	0.090	0.056	0.054	0.055	0.055	-0.001(-0.9%)	0.001(0.4%)
Below Normal	0.093	0.092	0.075	0.075	0.075	0.077	-0.001(-0.8%)	0.002(2.6%)
Dry	0.097	0.094	0.097	0.091	0.087	0.084	-0.010(-10.2%)	-0.006(-7.1%)
Critical	0.085	0.081	0.085	0.079	0.083	0.079	-0.002(-1.7%)	-0.001(-0.5%)

Salvage Density

The salvage density method uses exports and assumed fish presence to predict salvage at each of the south Delta facilities. The salvage density method tends to overstate likely delta smelt entrainment levels, but is still useful for relative comparison between PP and Scenario 6. Between December and February is the peak salvage time period for adult delta smelt (Table J.4-35 and Table J.4-36). The salvage density index for delta smelt is normalized against total population abundances estimates derived from the Fall Midwater Trawl index. Under EBC, adult delta smelt loss was estimated under this method to be greatest during above normal and below normal water years, while estimated losses in other water years are considerable lower. During dry and critical water years it was estimated that many fewer adult delta smelt would be salvaged, so the differences EBC and PP are very low.

On average across all water years, Scenario 6 was shown to reduce the mean annual salvage index relative to PP using this method at both the SWP (19–28%) and CVP (10–12%) facilities (Table J.4-29). Under Scenario 6, mean monthly salvage across all water years was decreased for all months, and most substantially in January (37% for ELT, 18% for LLT) and April (50% for ELT, 49% for LLT) (Table J.4-37). Monthly salvage by water year type decreased most substantially in below normal (32% for ELT, 18% for LLT) and above normal years (27% for ELT, 25% for LLT), especially in January and April (42–58% in ELT, 31–55% in LLT) (Table J.4-38). (). In wet years, salvage is reduced 23–30%, but total salvage is already relatively low during wet water years. Salvage of adult delta smelt is also substantially reduced in dry and critical water (15–29%), but total salvage during these drier water year types is much lower than in above and below normal years.

Table J.4-35. Estimated Mean Monthly Entrainment Index (Number of Fish Lost with 95% Confidence Interval [CI]) of Adult Delta Smelt for All Model Scenarios at the SWP Salvage Facilities in December–April for All Water Years

State Water Project (SWP)		EBC2_ELT		EBC2_LLT		A1_ELT		A1_LLT		S6_ELT		S6_LLT	
M	WY	Avg	95% CI	Avg	95% CI	Avg	95% CI	Avg	95% CI	Avg	95% CI	Avg	95% CI
Dec	All	1501	± 298	1472	± 297	1238	± 264	1306	± 289	1073	± 221	1088	± 231
	W	187	± 49	189	± 50	101	± 33	108	± 39	93	± 28	98	± 30
	AN	6996	± 3419	7017	± 3416	5664	± 2924	6498	± 3496	5081	± 2488	4986	± 2417
	BN	37	± 7	37	± 8	35	± 10	35	± 12	29	± 7	32	± 9
	D	309	± 127	295	± 124	328	± 133	329	± 137	256	± 103	239	± 98
	C	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0
Jan	All	4436	± 617	4377	± 603	2492	± 413	1969	± 348	1537	± 261	1606	± 269
	W	899	± 225	868	± 218	105	± 63	121	± 61	116	± 55	137	± 61
	AN	15795	± 7004	15318	± 6687	6517	± 3654	5852	± 3342	3770	± 2315	4081	± 2304
	BN	8673	± 1453	7976	± 1877	7830	± 2583	6699	± 2265	4185	± 1410	4522	± 1363
	D	870	± 352	913	± 369	921	± 376	738	± 340	521	± 239	525	± 243
	C	420	± 131	462	± 92	507	± 107	235	± 115	317	± 109	298	± 126
Feb	All	1832	± 121	1706	± 113	613	± 63	630	± 64	550	± 49	471	± 45
	W	1473	± 241	1400	± 232	15	± 17	30	± 30	14	± 12	7	± 8
	AN	4397	± 691	4311	± 641	718	± 371	693	± 273	729	± 297	704	± 278
	BN	2309	± 719	1948	± 538	678	± 316	977	± 509	1105	± 252	840	± 326
	D	399	± 155	361	± 144	422	± 173	397	± 171	301	± 118	271	± 112
	C	1622	± 332	1584	± 402	1860	± 518	1723	± 338	1446	± 311	1287	± 282
Mar	All	1125	± 92	1091	± 91	347	± 40	270	± 34	277	± 30	277	± 31
	W	1055	± 232	1018	± 227	40	± 28	30	± 24	52	± 35	50	± 36
	AN	781	± 366	799	± 392	136	± 146	41	± 74	39	± 41	50	± 55
	BN	4358	± 1013	4036	± 1001	2106	± 916	1661	± 724	1588	± 566	2054	± 647
	D	501	± 142	496	± 138	512	± 141	414	± 131	434	± 119	359	± 108
	C	841	± 278	807	± 298	863	± 370	828	± 392	740	± 170	703	± 181
Apr	All	110	± 15	114	± 15	154	± 21	143	± 20	63	± 9	61	± 8
	W	316	± 96	324	± 97	181	± 79	180	± 77	52	± 22	52	± 21
	AN	37	± 18	41	± 20	59	± 40	53	± 38	20	± 14	17	± 13
	BN	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0
	D	50	± 23	47	± 22	103	± 44	92	± 41	54	± 24	48	± 22
	C	42	± 13	38	± 11	58	± 15	55	± 18	43	± 14	45	± 13

Table J.4-36. Estimated Mean Monthly Entrainment Index (Number of Fish Lost with 95% Confidence Interval [CI]) of Adult Delta Smelt for All Model Scenarios at the CVP Salvage Facilities in December–April for All Water Years

Central Valley Project (CVP)		EBC2_ELT		EBC2_LLT		A1_ELT		A1_LLT		S6_ELT		S6_LLT	
M	WY	Avg	95% CI	Avg	95% CI	Avg	95% CI	Avg	95% CI	Avg	95% CI	Avg	95% CI
Dec	All	258	± 44	235	± 41	193	± 36	189	± 36	215	± 38	199	± 36
	W	8	± 2	7	± 2	5	± 1	5	± 1	5	± 1	5	± 1
	AN	534	± 254	479	± 238	367	± 199	325	± 187	432	± 222	407	± 222
	BN	131	± 11	121	± 16	99	± 24	102	± 21	119	± 13	108	± 20
	D	49	± 14	45	± 14	40	± 12	36	± 12	44	± 13	40	± 12
	C	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0
Jan	All	800	± 80	772	± 78	448	± 58	372	± 50	317	± 43	310	± 42
	W	86	± 18	85	± 18	16	± 8	16	± 7	15	± 6	14	± 6
	AN	1083	± 306	1209	± 329	731	± 299	665	± 283	402	± 202	393	± 185
	BN	896	± 120	787	± 155	567	± 172	568	± 169	471	± 161	498	± 158
	D	108	± 37	101	± 35	91	± 33	73	± 29	55	± 23	60	± 23
	C	225	± 45	210	± 51	204	± 55	108	± 44	150	± 48	120	± 51
Feb	All	710	± 37	719	± 38	235	± 22	244	± 24	251	± 22	254	± 23
	W	380	± 48	389	± 49	0	± 0	5	± 6	4	± 4	3	± 3
	AN	438	± 83	447	± 76	87	± 56	116	± 61	79	± 41	79	± 41
	BN	297	± 75	368	± 79	154	± 74	123	± 73	185	± 80	226	± 87
	D	208	± 48	192	± 47	152	± 40	150	± 42	151	± 37	147	± 37
	C	896	± 192	768	± 207	646	± 146	744	± 233	713	± 127	635	± 180
Mar	All	892	± 69	871	± 70	228	± 31	239	± 31	273	± 31	269	± 31
	W	1077	± 177	1091	± 179	0	± 0	65	± 48	51	± 25	62	± 28
	AN	288	± 88	276	± 88	13	± 19	30	± 38	19	± 15	27	± 25
	BN	589	± 109	600	± 139	273	± 158	254	± 120	362	± 113	306	± 122
	D	94	± 34	83	± 31	66	± 27	60	± 25	66	± 27	71	± 27
	C	332	± 110	302	± 108	267	± 80	233	± 89	282	± 94	243	± 92
Apr	All	253	± 25	257	± 26	271	± 31	256	± 31	149	± 17	142	± 17
	W	216	± 71	221	± 72	113	± 59	110	± 60	40	± 21	40	± 21
	AN	194	± 60	208	± 64	227	± 103	196	± 97	99	± 48	95	± 48
	BN	145	± 17	153	± 23	268	± 50	256	± 54	122	± 32	138	± 35
	D	39	± 6	37	± 6	59	± 9	56	± 10	41	± 7	35	± 7
	C	25	± 3	25	± 3	27	± 5	26	± 5	23	± 4	21	± 4

Table J.4-37. Estimated Absolute and Percent Differences between Model Scenarios in Adult Delta Smelt Entrainment Index (Number of Fish Lost) at the SWP and CVP Salvage Facilities in December–April during All Water Years

Month	A1_ELT vs. S6_ELT	A1_LLT vs. S6_LLT
December	-143 (-10%)	-209 (-14%)
January	-1086 (-37%)	-426 (-18%)
February	-48 (-6%)	-149 (-17%)
March	-25 (-4%)	37 (7%)
April	-214 (-50%)	-196 (-49%)

Table J.4-38. Estimated Absolute and Percent Differences between Model Scenarios in Adult Delta Smelt Entrainment Index (Number of Fish Lost) at the SWP and CVP Salvage Facilities in December–April during All Water Years

M	WY	A1_ELT vs. S6_ELT	A1_LLT vs. S6_LLT
December	All	-143 (-10%)	-209 (-14%)
	Wet	-7 (-7%)	-11 (-9%)
	Above Normal	-517 (-9%)	-1430 (-21%)
	Below Normal	14 (11%)	4 (3%)
	Dry	-68 (-19%)	-86 (-24%)
	Critical	0 (0%)	0 (0%)
January	All	-1086 (-37%)	-426 (-18%)
	Wet	11 (9%)	13 (10%)
	Above Normal	-3075 (-42%)	-2044 (-31%)
	Below Normal	-3740 (-45%)	-2247 (-31%)
	Dry	-436 (-43%)	-227 (-28%)
	Critical	-245 (-34%)	74 (22%)
February	All	-48 (-6%)	-149 (-17%)
	Wet	3 (19%)	-25 (-72%)
	Above Normal	3 (0%)	-27 (-3%)
	Below Normal	458 (55%)	-34 (-3%)
	Dry	-122 (-21%)	-129 (-24%)
	Critical	-347 (-14%)	-544 (-22%)
March	All	-25 (-4%)	37 (7%)
	Wet	63 (156%)	17 (18%)
	Above Normal	-92 (-61%)	7 (9%)
	Below Normal	-429 (-18%)	445 (23%)
	Dry	-78 (-14%)	-44 (-9%)
	Critical	-107 (-9%)	-115 (-11%)
April	All	-214 (-50%)	-196 (-49%)
	Wet	-202 (-69%)	-199 (-68%)
	Above Normal	-167 (-58%)	-137 (-55%)

M	WY	A1_ELT vs. S6_ELT	A1_LLT vs. S6_LLT
	Below Normal	-146 (-54%)	-118 (-46%)
	Dry	-67 (-41%)	-65 (-44%)
	Critical	-19 (-22%)	-15 (-19%)
Annual Average	All	-1515 (-24%)	-942 (-17%)
	Wet	-132 (-23%)	-204 (-30%)
	Above Normal	-3848 (-27%)	-3631 (-25%)
	Below Normal	-3843 (-32%)	-1951 (-18%)
	Dry	-772 (-29%)	-551 (-23%)
	Critical	-718 (-16%)	-601 (-15%)

J.4.3.2.7 Longfin Smelt

Juveniles

Salvage Density

The salvage density index for longfin smelt is normalized against fall midwater trawl index estimates of total longfin population abundances. Under existing baseline conditions, salvage of juvenile longfin smelt at the SWP/CVP facilities peaks during the months of April and May. Salvage of juveniles under EBC is highest during dry and critical water years in May. Loss was also highest under EBC in dry and critical water years with comparatively little salvage in occurring in wetter years. In dry years estimated increases in salvage loss under PP relative to EBC ranged from 14–32%. But in critical years, salvage decreased 5–16% in the PP relative to EBC. As compared to the PP, Scenario 6 reduced longfin smelt salvage at the south Delta facilities (Table J.4-39). Estimated salvage loss of juveniles (March–June) were considerably (1–2 orders of magnitude) greater at SWP than at CVP under all scenarios (Table J.4-40 and Table J.4-41). The reduced salvage is associated with substantially reduced (10–69%) south Delta exports in all water year types during the peak juvenile longfin smelt salvage period in April–May. In April under Scenario 6, salvage of longfin smelt was proportionally reduced most substantially in wet years (71%) and above normal years (57–60%) and dry years (43–45%) relative to PP (Table J.4-42). In May, salvage was reduced proportionally in all water years (average 53–59%), but largest reduction in total salvage occurs in dry and critical water years.

Table J.4-39. Estimated Mean Annual Salvage Index (Salvage Density Method) at SWP and CVP Salvage Facilities for Longfin Smelt for All Water Years

		EBC2_ELT	EBC2_LLT	A1_ELT	A1_LLT	S6_ELT	S6_LLT	A1 vs. S6 ELT		A1 vs. S6 LLT	
Lifestage	Facility	Avg	Avg	Avg	Avg	Avg	Avg	Num	% change	Num	% change
Juvenile	SWP	271,140	273,443	313,980	269,426	127,694	125,495	-186,286	-59	-143,931	-53
	CVP	19,513	19,489	20,237	19,025	10614	10124	-9,623	-48	-8,901	-47
Adult	SWP	2,807	2,727	1,250	1,029	869	870	-381	-31	-159	-15
	CVP	872	847	333	330	358	346	25	8	17	5

[1] Longfin smelt were normalized using population estimates derived from fall midwater trawl index.

Table J.4-40. Estimated Mean Monthly Entrainment Index (Number of Fish Lost with 95% Confidence Interval [CI]) of Juvenile Longfin Smelt for All Model Scenarios at the SWP Salvage Facilities in March–June for All Water Years

State Water Project (SWP)		EBC2_ELT		EBC2_LLT		A1_ELT		A1_LLT		S6_ELT		S6_LLT	
M	WY	Avg	95% CI	Avg	95% CI	Avg	95% CI	Avg	95% CI	Avg	95% CI	Avg	95% CI
Mar	All	843	± 195	817	± 192	260	± 78	202	± 65	208	± 59	208	± 61
	W	6	± 2	6	± 2	0	± 0	0	± 0	0	± 0	0	± 0
	AN	30	± 15	30	± 16	5	± 6	2	± 3	1	± 2	2	± 2
	BN	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0
	D	43	± 17	43	± 17	44	± 17	36	± 15	37	± 14	31	± 13
	C	4079	± 1348	3912	± 1445	4182	± 1794	4016	± 1901	3588	± 826	3409	± 877
Apr	All	34352	± 5420	35520	± 5565	48202	± 7829	44606	± 7336	19630	± 3157	19192	± 3077
	W	66291	± 30502	67902	± 30837	37970	± 24076	37681	± 23532	10962	± 6665	10866	± 6595
	AN	245	± 66	273	± 72	390	± 165	348	± 162	131	± 57	111	± 55
	BN	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0
	D	36889	± 16671	35086	± 16376	76481	± 32360	68160	± 29898	40169	± 17503	35613	± 16169
	C	44915	± 13740	39886	± 11147	62088	± 15726	58597	± 18656	45520	± 14454	47358	± 13342
May	All	231690	± 52648	233356	± 52616	263264	± 59538	222904	± 50848	105870	± 21133	104306	± 19988
	W	1192	± 571	1152	± 563	646	± 358	515	± 288	174	± 88	211	± 101
	AN	1600	± 626	1673	± 637	3027	± 1555	2838	± 1565	973	± 544	761	± 352
	BN	907	± 130	1060	± 175	2653	± 857	2062	± 706	796	± 151	830	± 146
	D	486050	± 206441	501670	± 209102	609797	± 284730	536403	± 258676	422498	± 176159	385818	± 163315
	C	460509	± 87445	417265	± 134503	358375	± 129521	373519	± 142298	291050	± 122971	297010	± 105955
Jun	All	4256	± 907	3750	± 796	2253	± 555	1714	± 426	1987	± 426	1788	± 386
	W	64	± 16	58	± 14	29	± 10	18	± 7	21	± 7	22	± 6
	AN	959	± 424	793	± 335	623	± 323	511	± 240	426	± 189	409	± 181
	BN	651	± 114	614	± 126	397	± 138	347	± 135	487	± 80	354	± 102
	D	7909	± 3323	6330	± 2639	3958	± 1838	3451	± 1743	5055	± 2330	3699	± 1785
	C	1232	± 339	1048	± 320	737	± 183	817	± 285	842	± 214	832	± 346

Table J.4-41. Estimated Mean Monthly Entrainment Index (Number of Fish Lost with 95% Confidence Interval [CI]) of Juvenile Longfin Smelt for All Model Scenarios at the CVP Salvage Facilities in March–June for All Water Years

Central Valley Project (CVP)		EBC2_ELT		EBC2_LLT		A1_ELT		A1_LLT		S6_ELT		S6_LLT	
M	WY	Avg	95% CI	Avg	95% CI	Avg	95% CI	Avg	95% CI	Avg	95% CI	Avg	95% CI
Mar	All	477	± 69	465	± 69	122	± 28	128	± 28	146	± 29	144	± 29
	W	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0
	AN	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0
	BN	151	± 28	154	± 36	70	± 41	65	± 31	93	± 29	78	± 31
	D	721	± 273	636	± 246	509	± 215	461	± 200	507	± 214	546	± 214
	C	1228	± 406	1117	± 398	986	± 297	861	± 329	1043	± 347	898	± 342
Apr	All	7746	± 1380	7865	± 1403	8298	± 1677	7842	± 1639	4557	± 934	4337	± 901
	W	13	± 4	13	± 4	7	± 4	7	± 4	2	± 1	2	± 1
	AN	627	± 285	674	± 306	736	± 450	634	± 419	321	± 208	307	± 207
	BN	325	± 39	344	± 51	601	± 113	574	± 121	274	± 71	309	± 78
	D	19770	± 8209	18739	± 7741	30049	± 12370	28283	± 12328	20773	± 8798	17741	± 7850
	C	16736	± 1951	16581	± 2011	17797	± 3041	17443	± 3513	15644	± 2691	14278	± 2473
May	All	11241	± 2399	11114	± 2350	11787	± 2506	11032	± 2411	5887	± 1197	5622	± 1145
	W	68	± 28	65	± 27	34	± 18	35	± 18	12	± 6	13	± 6
	AN	1337	± 665	1367	± 671	1769	± 1157	2082	± 1332	579	± 351	552	± 352
	BN	1038	± 73	1111	± 141	2120	± 367	1740	± 459	901	± 171	867	± 210
	D	25352	± 10208	25367	± 10253	41811	± 17606	34856	± 15052	26635	± 11014	23448	± 9751
	C	14262	± 1304	13788	± 903	13746	± 2922	12503	± 2496	12511	± 1920	12289	± 1751
Jun	All	49	± 12	44	± 11	29	± 8	23	± 6	24	± 6	21	± 5
	W	1	± 0	1	± 0	0	± 0	0	± 0	0	± 0	0	± 0
	AN	5	± 3	5	± 2	3	± 2	3	± 2	3	± 1	3	± 1
	BN	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0
	D	98	± 44	79	± 33	73	± 34	59	± 27	86	± 39	60	± 29
	C	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0

Table J.4-42. Estimated Absolute and Percent Differences between Model Scenarios in Juvenile Longfin Smelt Entrainment Index (Number of Fish Lost) at the SWP and CVP Salvage Facilities in March–June during All Water Years

M	WY Type	A1_ELT vs. S6_ELT	A1_LLT vs. S6_LLT
March	All	-28 (-7%)	21 (6%)
	Wet	0 (30%)	0 (68%)
	Above Normal	-4 (-71%)	0 (21%)
	Below Normal	23 (33%)	13 (20%)
	Dry	-9 (-2%)	80 (16%)
	Critical	-537 (-10%)	-570 (-12%)
April	All	-32314 (-57%)	-28919 (-55%)
	Wet	-27013 (-71%)	-26819 (-71%)
	Above Normal	-675 (-60%)	-564 (-57%)
	Below Normal	-327 (-54%)	-265 (-46%)
	Dry	-45588 (-43%)	-43090 (-45%)
	Critical	-18720 (-23%)	-14403 (-19%)
May	All	-163295 (-59%)	-124008 (-53%)
	Wet	-494 (-73%)	-326 (-59%)
	Above Normal	-3244 (-68%)	-3608 (-73%)
	Below Normal	-3077 (-64%)	-2105 (-55%)
	Dry	-202475 (-31%)	-161993 (-28%)
	Critical	-68560 (-18%)	-76724 (-20%)
June	All	-271 (-12%)	73 (4%)
	Wet	-9 (-30%)	4 (22%)
	Above Normal	-198 (-32%)	-103 (-20%)
	Below Normal	90 (23%)	7 (2%)
	Dry	1109 (28%)	250 (7%)
	Critical	105 (14%)	15 (2%)
Annual Average	All	-196234 (-58%)	-152996 (-53%)
	Wet	-27506 (-71%)	-27138 (-71%)
	Above Normal	-4186 (-60%)	-4297 (-63%)
	Below Normal	-3937 (-52%)	-2743 (-43%)
	Dry	-247140 (-32%)	-204842 (-30%)
	Critical	-92862 (-19%)	-91677 (-19%)

Larvae

PTM Analysis

Entrainment of longfin smelt larvae remained very low based on the larvae/PTM method, and as a result there is no meaningful difference between larval entrainment in Scenario 6 relative to PP. Loss of particles to the south Delta diversions was relatively low (less than 7% loss after 30 days and 13% loss after 60 days) for all operations (Scenario 6 and PP), hydrologic scenarios (12 runs), longfin smelt starting distributions, and model run duration (Figure J.4-4 through Figure J.4-15). Particle entrainment did not differ (<2%) between Scenario 6 and PP for 11 out of 12 hydrologic run periods, and differed only slightly for the January 1929 ELT condition (Scenario 6 was 4–7% less than PP). January 1929 represents a somewhat drier condition, but not the driest. Agricultural diversions in the Delta were the only other entrainment risk for particles, and entrainment losses were also low (less than 6% of particles after 30-days and 60-days), with no difference between PP and Scenario 6 for any hydrologic condition or starting distribution (Figure J.4-8 through Figure J.4-11). Losses to the North Bay Aqueduct were less than 0.5% for all conditions. Based on this analysis, it appears that there would be no larval entrainment at the north Delta diversions.

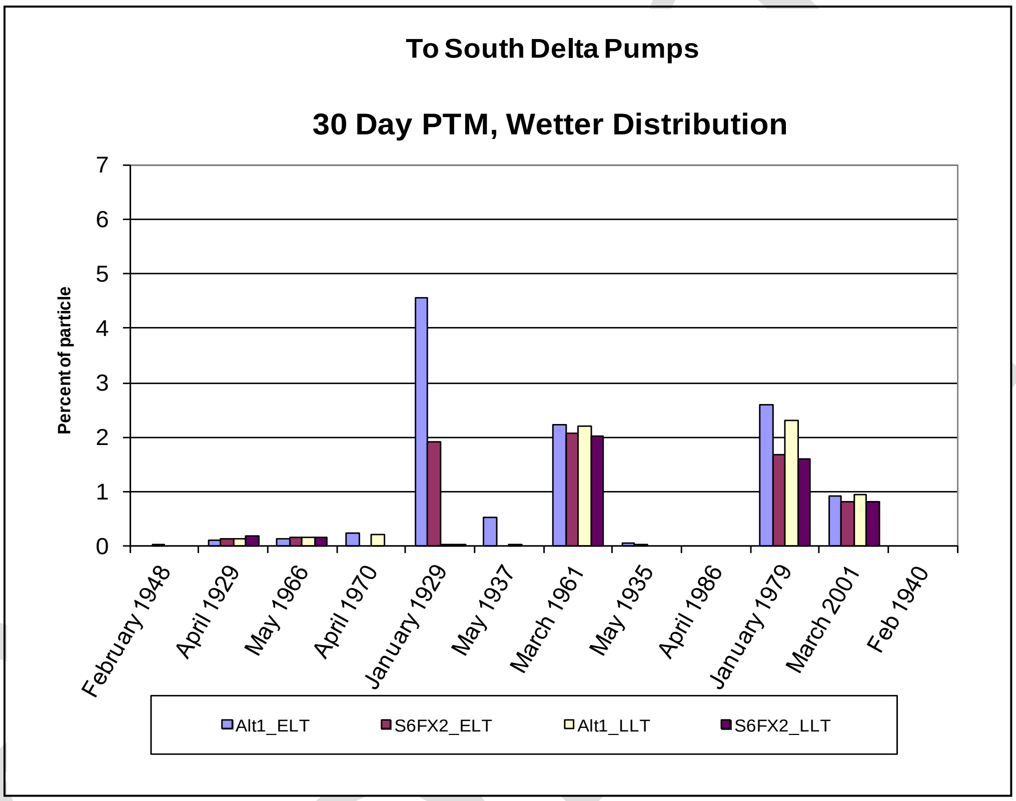


Figure J.4-4. Percentage of Particles Entrained at the South Delta Diversions after 30 Days; Wetter Starting Distribution

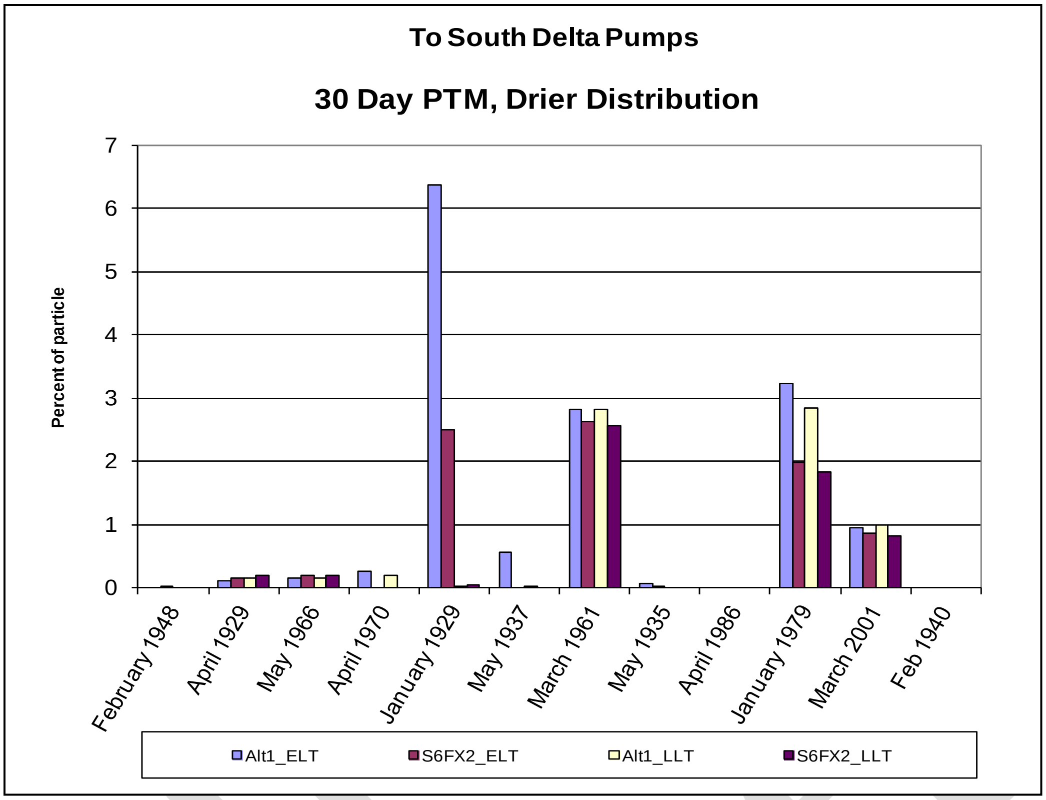


Figure J.4-5. Percentage of Particles Entrained at the South Delta Diversions after 30 Days; Drier Starting Distribution

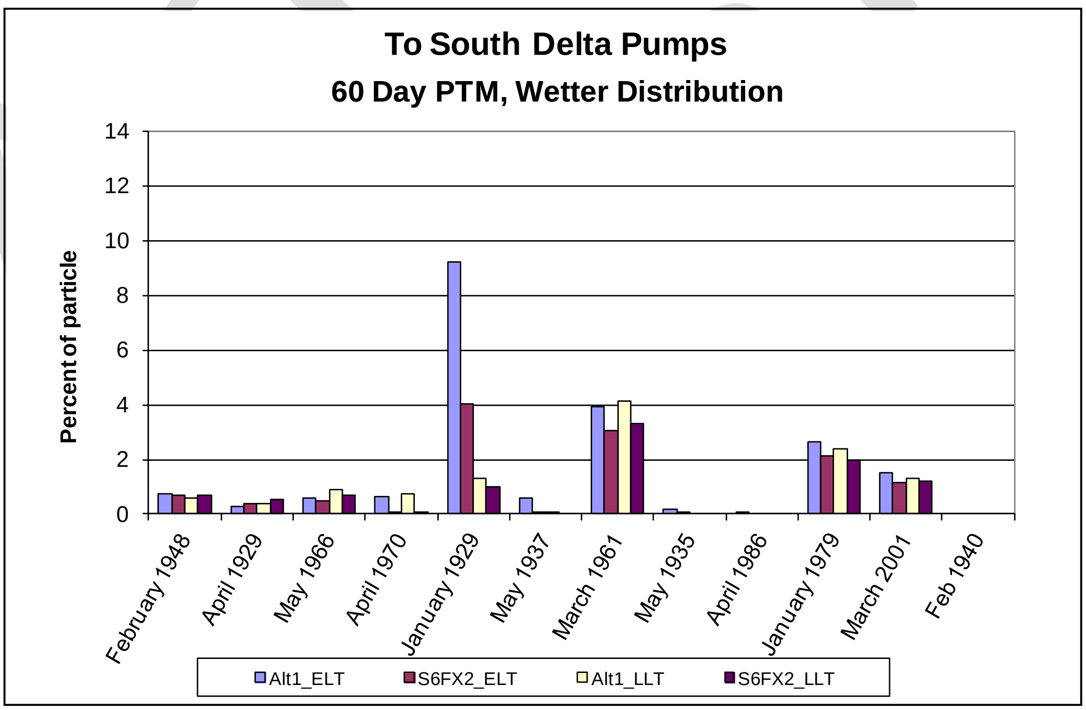


Figure J.4-6. Percentage of Particles Entrained at the South Delta Diversions after 60 days; Wetter Starting Distribution

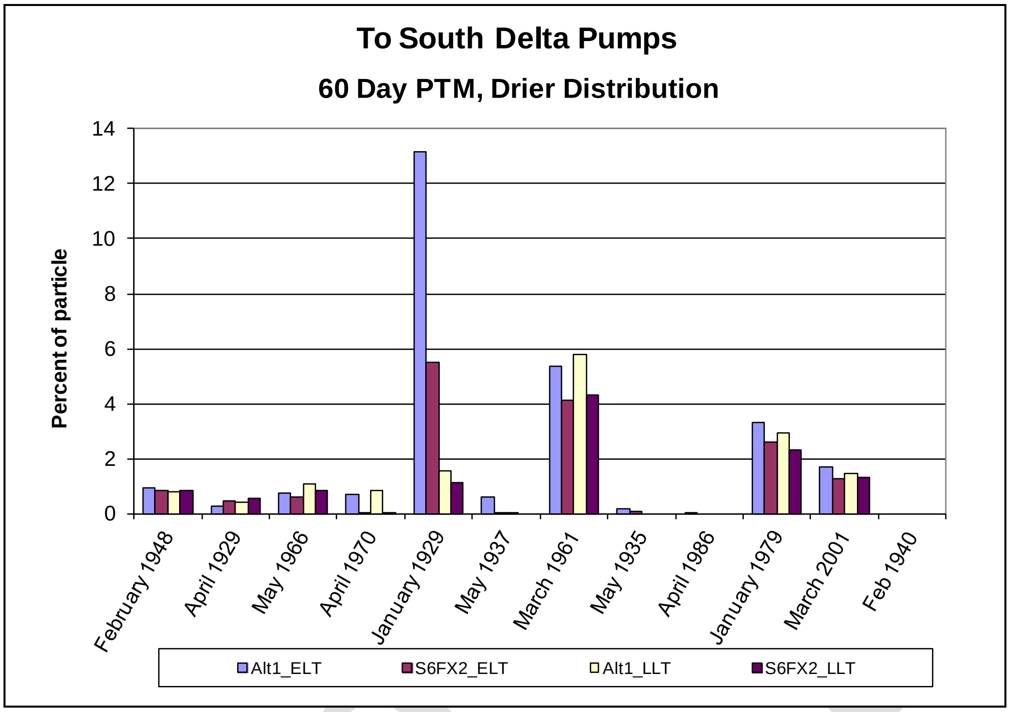


Figure J.4-7. Percentage of Particles Entrained at the South Delta Diversions after 60 Days; Drier Starting Distribution

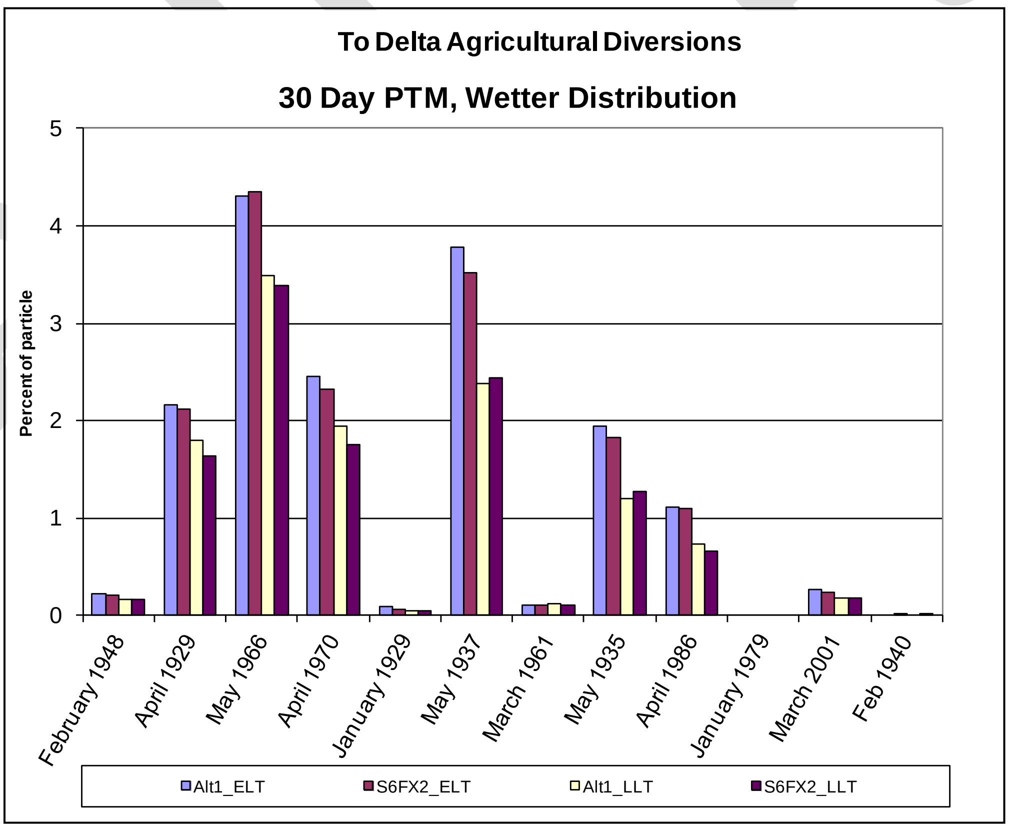


Figure J.4-8. Percentage of Particles Entrained at Delta Agricultural Diversions after 30 Days; Wetter Starting Distribution

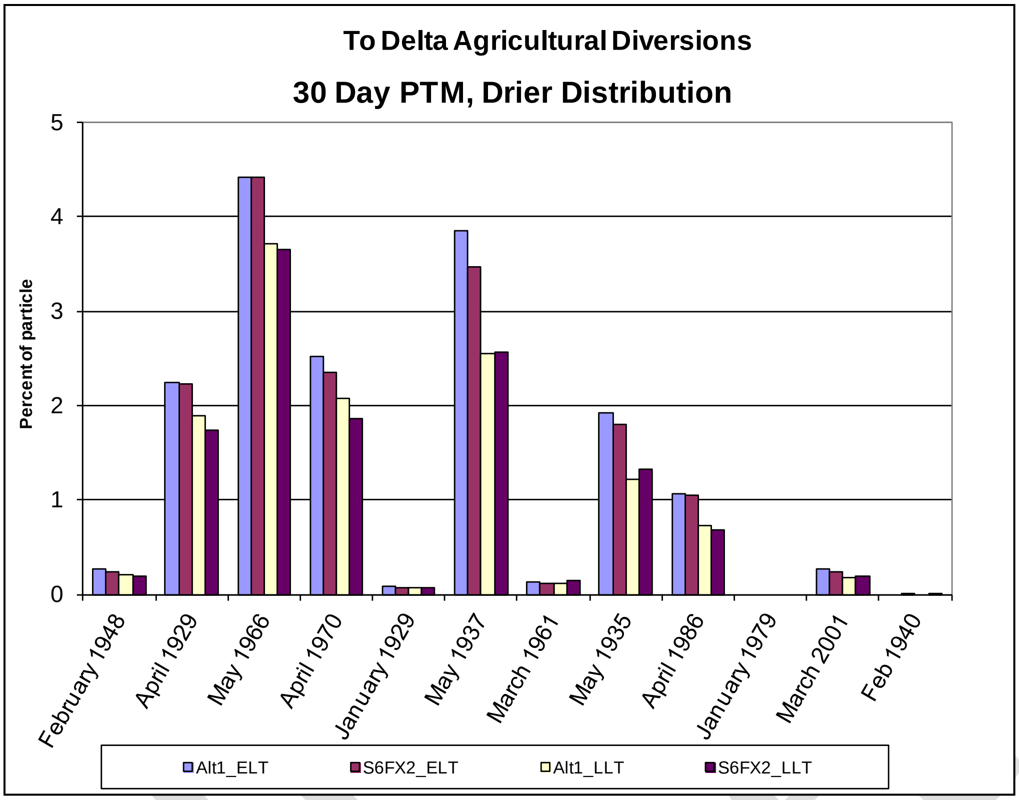


Figure J.4-9. Percentage of Particles Entrained at Delta Agricultural Diversions after 30 Days; Drier Starting Distribution

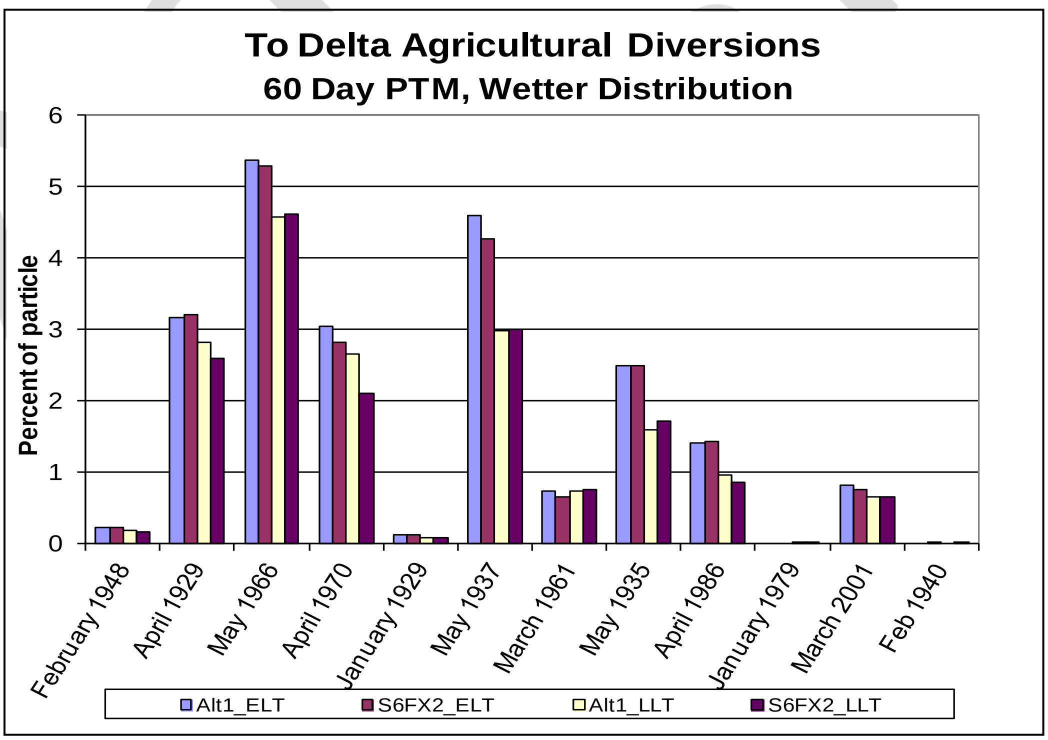


Figure J.4-10. Percentage of Particles Entrained at Delta Agricultural Diversions after 60 Days; Wetter Starting Distribution

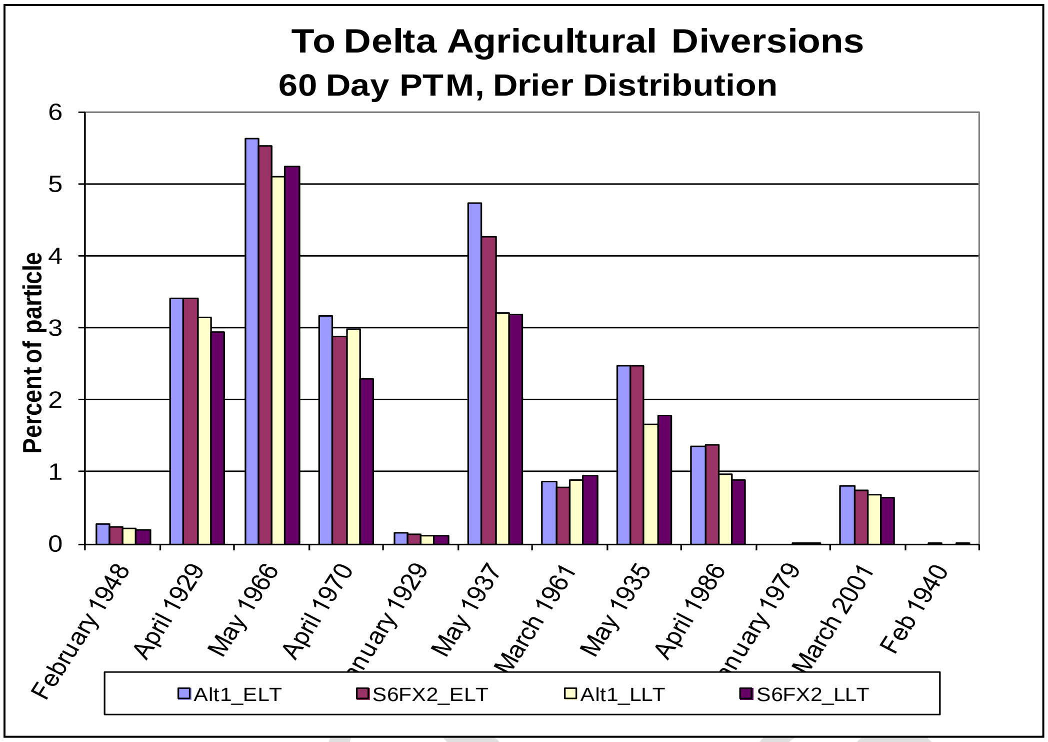


Figure J.4-11. Percentage of Particles Entrained at Delta Agricultural Diversions after 60 Days; Drier Starting Distribution

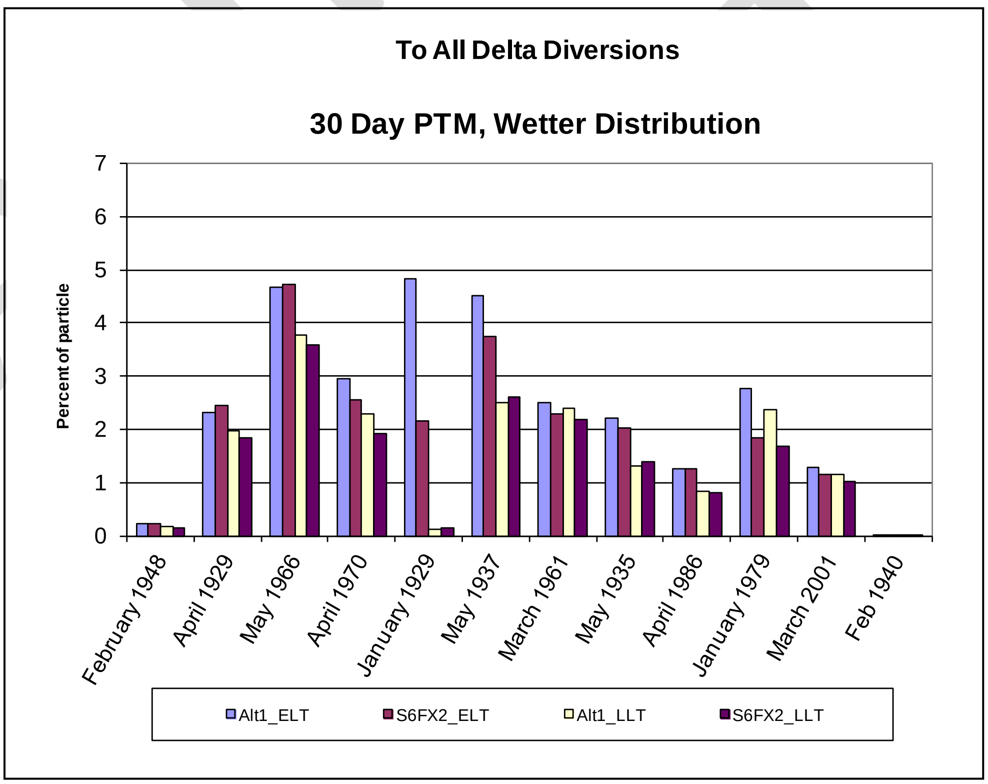


Figure J.4-12. Percentage of Particles Entrained at all Delta Diversions after 30 Days; Wetter Starting Distribution

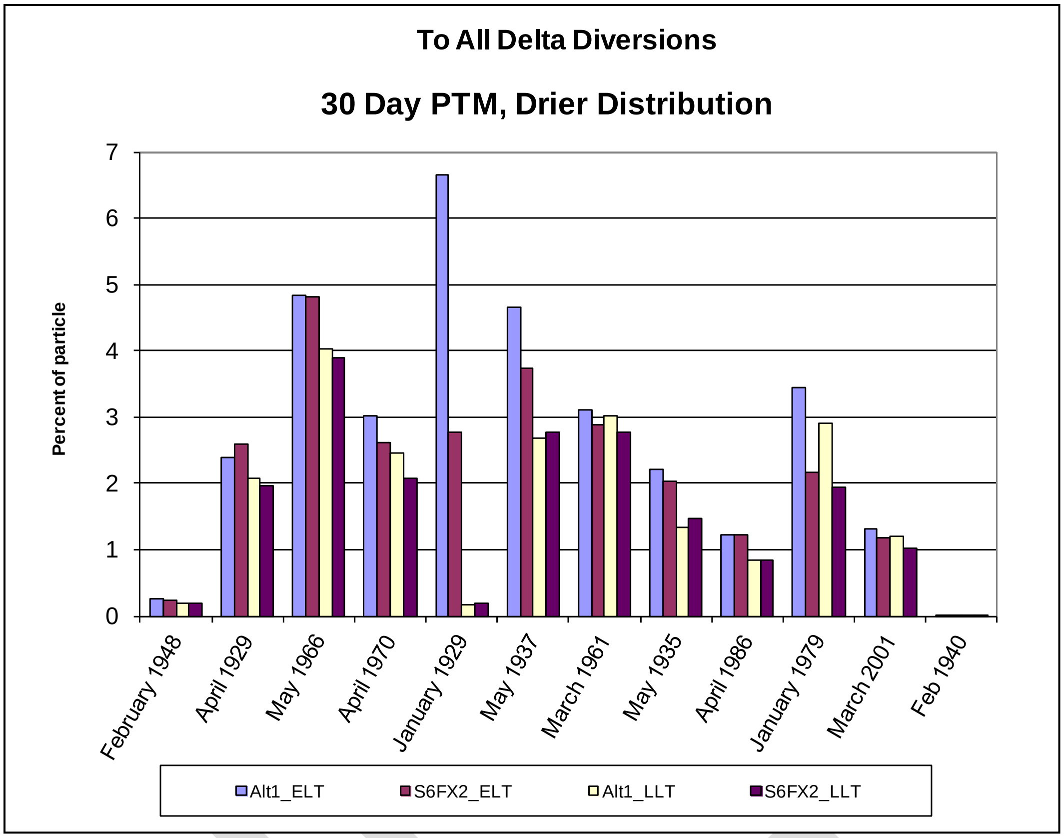


Figure J.4-13. Percentage of Particles Entrained at All Delta Diversions after 30 Days; Drier Starting Distribution

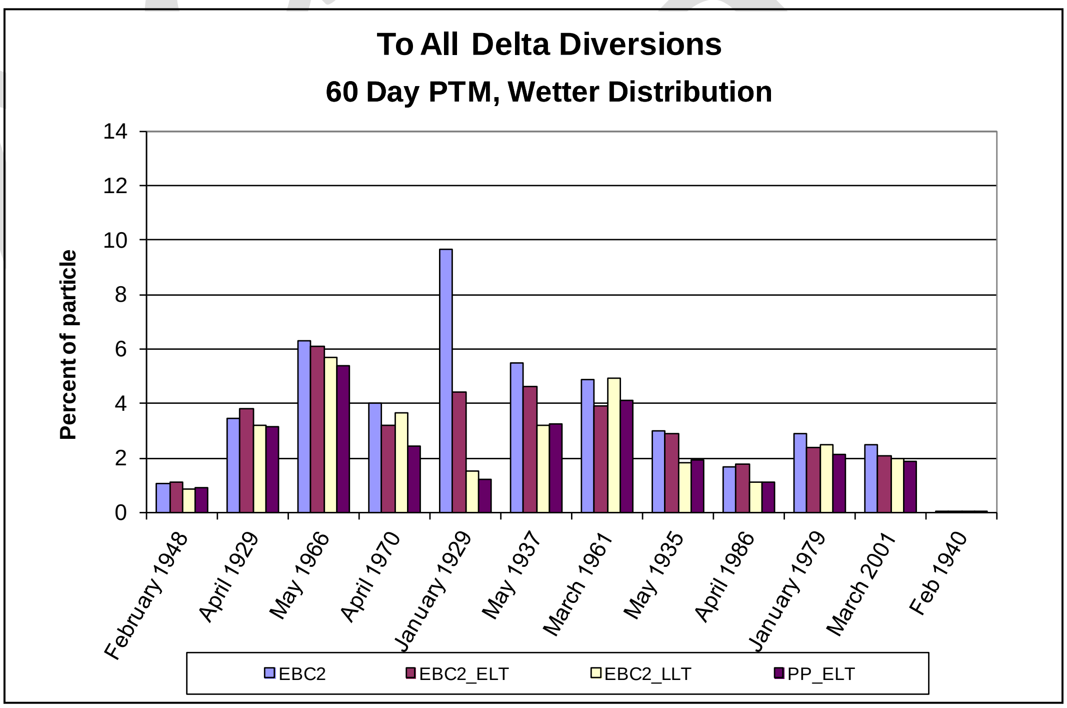


Figure J.4-14. Percentage of Particles Entrained at all Delta Diversions after 60 Days; Wetter Starting Distribution

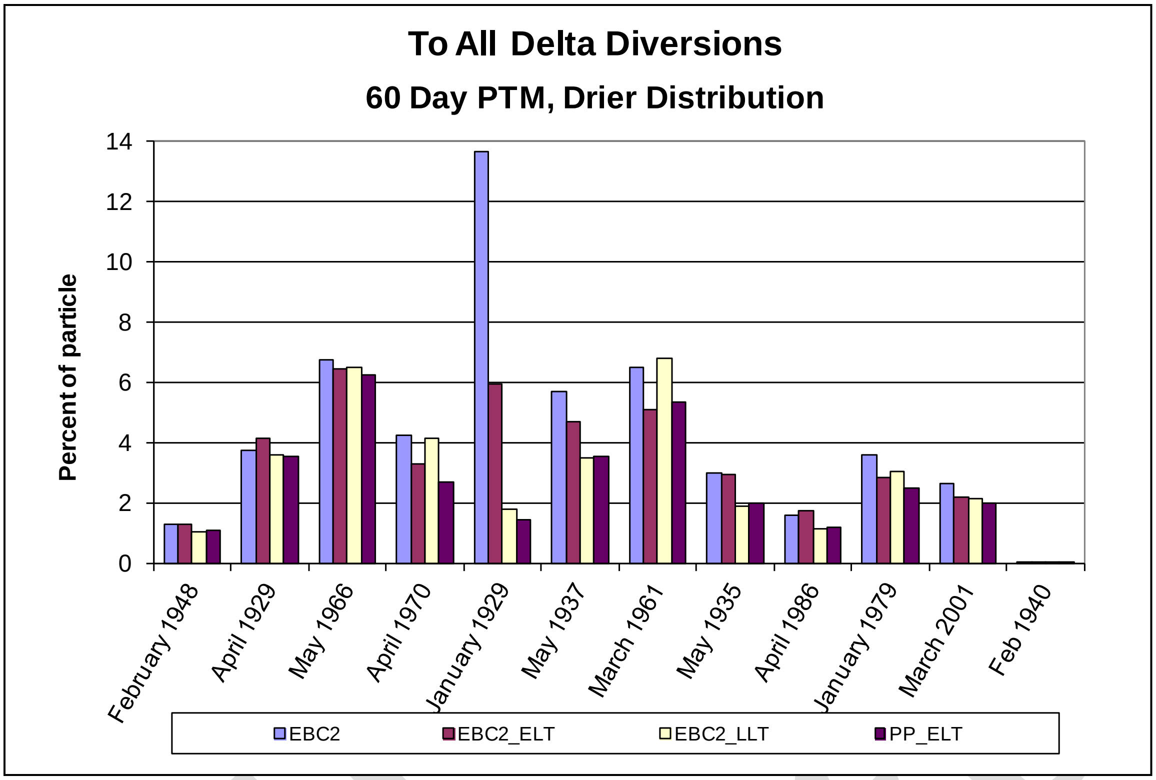


Figure J.4-15. Percentage of Particles Entrained at all Delta Diversions after 60 days; Drier Starting Distribution

Adults

Salvage Density

Generally, salvage of adult longfin smelt is much lower than that of juveniles. Under existing biological conditions, peak salvage of adult longfin smelt occurs from January–March, with highest losses occurring in January (Table J.4-43 and Table J.4-44). The salvage density index for longfin smelt is normalized against fall midwater trawl index estimates of total longfin population abundances. Salvage losses under EBC are much higher in critical water years compared to other water year types, and extremely low in wetter type years.

Compared to the PP, Scenario 6 reduces salvage of adult longfin smelt by 53–59% at the SWP facilities, and 47–48% at the CVP facilities (Table J.4-43 and Table J.4-44.). Salvage is reduced under all water year types compared to PP, with largest reductions in total salvage occurring in January (Table J.4-45). The substantial January salvage reductions estimated by this method are associated with substantial decreases in south Delta exports in all water year types (average 18–34% reduction), except critical LLT (Table J.3-13).

Table J.4-43. Estimated Mean Monthly Entrainment Index (Number of Fish Lost with 95% Confidence Interval [CI]) of Adult Longfin Smelt for All Model Scenarios at the SWP Salvage Facilities in December–March for All Water Years

State Water Project (SWP)		EBC2_ELT		EBC2_LLT		A1_ELT		A1_LLT		S6_ELT		S6_LLT	
M	WY	Avg	95% CI	Avg	95% CI	Avg	95% CI	Avg	95% CI	Avg	95% CI	Avg	95% CI
Dec	All	14	± 2	14	± 2	12	± 2	12	± 2	10	± 2	10	± 2
	W	10	± 4	10	± 4	5	± 2	6	± 3	5	± 2	5	± 2
	AN	55	± 27	55	± 27	45	± 23	51	± 28	40	± 20	39	± 19
	BN	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0
	D	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0
	C	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0
Jan	All	1435	± 256	1416	± 250	806	± 170	637	± 143	497	± 107	520	± 110
	W	46	± 14	44	± 14	5	± 4	6	± 4	6	± 3	7	± 4
	AN	495	± 244	480	± 233	204	± 126	183	± 115	118	± 79	128	± 79
	BN	1578	± 264	1451	± 341	1424	± 470	1218	± 412	761	± 256	823	± 248
	D	209	± 119	305	± 125	307	± 127	246	± 115	174	± 81	175	± 82
	C	9604	± 3002	10563	± 2098	11588	± 2446	5372	± 2639	7243	± 2480	6809	± 2872
Feb	All	515	± 115	479	± 108	172	± 52	177	± 53	154	± 42	132	± 38
	W	6	± 2	5	± 2	0	± 0	0	± 0	0	± 0	0	± 0
	AN	29	± 12	29	± 11	5	± 4	5	± 3	5	± 3	5	± 3
	BN	247	± 77	208	± 58	73	± 34	105	± 54	118	± 27	90	± 35
	D	8	± 3	7	± 3	8	± 4	8	± 4	6	± 3	5	± 2
	C	3931	± 805	3838	± 975	4509	± 1255	4176	± 819	3506	± 754	3119	± 684
Mar	All	843	± 195	817	± 192	260	± 78	202	± 65	208	± 59	208	± 61
	W	6	± 2	6	± 2	0	± 0	0	± 0	0	± 0	0	± 0
	AN	30	± 15	30	± 16	5	± 6	2	± 3	1	± 2	2	± 2
	BN	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0
	D	43	± 17	43	± 17	44	± 17	36	± 15	37	± 14	31	± 13
	C	4079	± 1348	3912	± 1445	4182	± 1794	4016	± 1901	3588	± 826	3409	± 877

Table J.4-44. Estimated Mean Monthly Entrainment Index (Number of Fish Lost with 95% Confidence Interval [CI]) of Adult Longfin Smelt for All Model Scenarios at the CVP Salvage Facilities in December–March for All Water Years

Central Valley Project (CVP)		EBC2_ELT		EBC2_LLT		A1_ELT		A1_LLT		S6_ELT		S6_LLT	
M	**WY**	**Avg**	**95% CI**	**Avg**	**95% CI**	**Avg**	**95% CI**	**Avg**	**95% CI**	**Avg**	**95% CI**	**Avg**	**95% CI**
Dec	All	142	± 26	129	± 24	106	± 21	104	± 21	118	± 22	109	± 21
	W	21	± 7	20	± 7	13	± 6	14	± 6	14	± 5	15	± 6
	AN	32	± 15	28	± 14	22	± 12	19	± 11	26	± 13	24	± 13
	BN	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0
	D	24	± 8	22	± 8	20	± 7	18	± 7	21	± 8	20	± 7
	C	1396	± 247	1053	± 337	1301	± 228	1263	± 363	1478	± 186	1062	± 357
Jan	All	91	± 9	88	± 9	51	± 7	42	± 6	36	± 5	35	± 5
	W	20	± 7	19	± 7	4	± 3	4	± 3	4	± 2	3	± 2
	AN	61	± 18	68	± 19	41	± 17	38	± 16	23	± 12	22	± 11
	BN	55	± 7	48	± 9	35	± 11	35	± 10	29	± 10	31	± 10
	D	111	± 42	104	± 40	94	± 37	75	± 33	57	± 26	62	± 26
	C	408	± 81	382	± 93	371	± 99	197	± 80	272	± 87	217	± 92
Feb	All	162	± 33	164	± 34	54	± 16	56	± 17	57	± 16	58	± 17
	W	26	± 6	27	± 7	0	± 0	0	± 1	0	± 0	0	± 0
	AN	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0
	BN	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0
	D	20	± 7	19	± 6	15	± 5	15	± 5	15	± 5	14	± 5
	C	1621	± 348	1389	± 375	1169	± 264	1345	± 421	1290	± 230	1149	± 326
Mar	All	477	± 69	465	± 69	122	± 28	128	± 28	146	± 29	144	± 29
	W	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0
	AN	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0
	BN	151	± 28	154	± 36	70	± 41	65	± 31	93	± 29	78	± 31
	D	721	± 273	636	± 246	509	± 215	461	± 200	507	± 214	546	± 214
	C	1228	± 406	1117	± 398	986	± 297	861	± 329	1043	± 347	898	± 342

Table J.4-45. Estimated Absolute and Percent Differences between Model Scenarios in Adult Longfin Smelt Entrainment Index (Number of Fish Lost) at the SWP and CVP Salvage Facilities in December–March during All Water Years

M	WY Type	A1_ELT vs. S6_ELT	A1_LLT vs. S6_LLT
December	All	10 (9%)	3 (3%)
	Wet	0 (0%)	0 (-2%)
	Above Normal	-1 (-1%)	-7 (-10%)
	Below Normal	0 (0%)	0 (0%)
	Dry	2 (9%)	2 (11%)
	Critical	178 (14%)	-201 (-16%)
January	All	-324 (-38%)	-125 (-18%)
	Wet	0 (5%)	0 (2%)
	Above Normal	-105 (-43%)	-71 (-32%)
	Below Normal	-669 (-46%)	-400 (-32%)
	Dry	-171 (-43%)	-85 (-26%)
	Critical	-4445 (-37%)	1458 (26%)
February	All	-14 (-6%)	-42 (-18%)
	Wet	0 (459%)	0 (-55%)
	Above Normal	0 (2%)	0 (1%)
	Below Normal	46 (63%)	-15 (-14%)
	Dry	-2 (-11%)	-3 (-13%)
	Critical	-882 (-16%)	-1252 (-23%)
March	All	-28 (-7%)	21 (6%)
	Wet	0 (30%)	0 (68%)
	Above Normal	-4 (-71%)	0 (21%)
	Below Normal	-669 (-46%)	-400 (-32%)
	Dry	-9 (-2%)	80 (16%)
	Critical	-537 (-10%)	-570 (-12%)
Annual Average	All	-196234 (-58%)	-152996 (-53%)
	Wet	-27506 (-71%)	-27138 (-71%)
	Above Normal	-4186 (-60%)	-4297 (-63%)
	Below Normal	-3937 (-52%)	-2743 (-43%)
	Dry	-247140 (-32%)	-204842 (-30%)
	Critical	-92862 (-19%)	-91677 (-19%)

J.4.3.3 Conclusions

J.4.3.3.1 Steelhead

Overall, Scenario 6 results in some decreases in steelhead salvage relative to PP, but results are somewhat mixed depending on the month and water year type. Steelhead salvage typically occurs from January to March, peaking in February. For the month of January, Scenario 6 reduces salvage relative to PP in above normal (30 to 45% less), below normal (12 to 47% less) and dry (18 to 43% less) water years, but increases steelhead salvage in critical water years in the LLT (27% increase at SWP, 11% increase at CVP), and in wet years at SWP (11% increase in ELT, 14% increase in LLT. In February, steelhead salvage is substantially reduced in Scenario 6 relative to PP in dry and critical years at the SWP (22 to 32%) but there is a substantial increase in salvage in below normal years in the ELT (63%). March of wetter years in the LLT also show increases in entrainment (68% in wet years, 21% in above normal years, and 24% in below normal years). By April, Scenario 6 results in substantial reduction in salvage in both SWP and CVP facilities. Overall, salvage of steelhead under Scenario 6 is reduced in above normal and dry years when salvage is a concern under EBC, but increases in below normal years. Benefits in above normal and dry years outweigh decreases in salvage in below normal years. Salvage improvements are greater at the SWP facilities that at the CVP.

J.4.3.3.2 Winter-Run Chinook

Salvage of winter-run Chinook is reduced substantially under Scenario 6 relative to PP over the average of water years (20–29%). Salvage at SWP is reduced in all water year types (16–32%), except below normal years LLT (no difference). Salvage at CVP is reduced in above normal years and wet LLT (21–32%), but decreased substantially in below normal years (20–34% decrease). In January, salvage is reduced in above normal, below normal, and dry years at both facilities. Like steelhead, salvage is increased in January critical LLT years when exports increase and OMR flows become more negative. In February at the SWP, salvage is reduced except for below normal years when salvage greatly increases (63% increase in ELT). There is likewise a sharp surge in salvage at the CVP facilities in February during below normal years (20% for ELT, 84% for LLT). This decrease coincides with increased exports (21–42% increase) and worse OMR flows (7–87% decrease). In March ELT at the SWP, salvage is decreased in all water years except wet. In the LLT, however, the situation is very different, as Scenario 6 salvage increases substantially relative to PP winter-run Chinook salmon in wet, above normal, and below normal years. In March, salvage generally is unchanged or worsened under Scenario 6 at the CVP in comparison to salvage under the PP.

J.4.3.3.3 Spring-Run Chinook

Salvage of Spring-run Chinook is increased at both SWP (52–56% improvement) and CVP facilities (38–39% improvement) under Scenario 6 relative to PP. Peak salvage occurs in March–May. In April and May, salvage is reduced in Scenario 6 at the SWP and CVP in all water year types because of substantial reductions in south Delta exports. In March, Scenario 6 salvage at SWP is actually increased in wet years (30–68%), and above and below normal years in LLT (21–24%). In March at the CVP, salvage is typically not unchanged or slightly higher under Scenario 6. Overall though, since substantially more salvage occurs in April and May under EBC, the large reductions in salvage in these months mean overall improved conditions for juvenile spring-run Chinook from Scenario 6.

J.4.3.3.4 Delta Smelt

The Kimmerer proportional entrainment method and salvage density method showed differing results for delta smelt entrainment. Using Kimmerer, entrainment loss of juvenile and larval delta smelt under Scenario 6 is estimated to increase entrainment levels relative to PP by about 8 to 12%, although the proportion of the total juvenile and larval delta smelt population entrained at the south delta would still be relatively low, ranging from 0.04 in wet years to 0.078–0.09 in below normal years. The largest increases in juvenile entrainment under Scenario 6 relative to PP occur in below normal (12% increase in ELT, 15% increase in LLT), dry (10% in ELT, 8% in LLT), and wet water years (13% in ELT, 14% in LLT) (Table J.4-28). The proportion of the population lost under EBC (0.088–0.099) is greater than estimated for either PP or Scenario 6. Similarly, entrainment of delta smelt adults is estimated to increase under Scenario 6 relative to PP in wet years (15% in ELT, 12% in LLT,) but decreased in dry years (10% in ELT, 7% in LLT) (Table J.4-34). The reduction in delta smelt adult entrainment in dry years under Scenario 6 only saves around 1% of the total adult delta smelt population from potential entrainment loss.

Under the salvage density method, salvage of juvenile and delta smelt is predicted to be less under Scenario 6 relative to PP. Overall there are substantial improvements to juvenile delta smelt salvage (25–45% improvement) and a slight to moderate improvement for adult delta smelt (10–28% improvement). In May, juvenile delta smelt salvage decreases under all water year types, but most notably in wetter water year types. In June juvenile salvage is reduced in Scenario 6 in wet years, but increased relative to PP in drier years. The worse conditions in June during drier years correlate to increased exports and more negative OMR flows. Entrainment of juvenile delta smelt increases in all water year types in Scenario 6 relative to PP, but most substantially in dry (8–10%) and below normal years (12–15%) when OMR flows are more negative during the juvenile smelt migration.

J.4.3.3.5 Longfin Smelt

Juvenile longfin smelt salvage is reduced substantially at SWP under Scenario 6 relative to PP (15–31%), but not substantially changed at the CVP. In April, salvage of longfin smelt was proportionally reduced most substantially in wet years (71%) and above normal years (57–60%) and dry years (43–45%), relative to the PP. Salvage was reduced substantially in all water years (average 53–59%), but the largest reduction in total salvage occurs in dry (hundreds of thousands of fish) and critical water years (tens of thousands of fish). Salvage of longfin smelt adults is reduced 53–59% at SWP facilities, and 47–48% at CVP. Salvage is reduced in all water year types under Scenario 6, and the greatest reductions occur in January, the peak adult salvage month under EBC. Longfin larvae entrainment at the export facilities changes little between Scenario 6 and PP, but is low already under both circumstances.

Longfin smelt had relatively low entrainment in the south Delta diversions, as modeled by PTM, and there was little or negligible difference between Scenario 6 and PP.

J.4.3.3.6 Summary

Salvage of steelhead is substantially reduced in above normal and below normal water years with Scenario 6, which represents water years when total salvage is greatest under EBC. Total steelhead salvage is reduced at both SWP and CVP facilities.

Salvage of winter-run Chinook is reduced in SWP, but not at CVP. Salvage under Scenario 6 is reduced more substantially in ELT than LLT.

Spring-run Chinook salvage is substantially reduced in April and May under all water year types, which represent the period of peak salvage under PP. The estimated mean annual salvage index for Spring-run decreases 38–56%.

Salvage of delta smelt juveniles and adults is increased or decreased under Scenario 6, depending on the method used (OMR proportional entrainment predicts increases in entrainment while the salvage-density method predicts decreases in entrainment). Under the OMR proportional entrainment method, entrainment of juvenile delta smelt increases slightly in all water year types under Scenario 6, but projected net increases in entrainment losses represent <1% of total delta smelt population. Entrainment of adult delta smelt does not change on average. There are moderate increases in adult smelt entrainment in wet years, but moderate decrease in dry years. Under the salvage-density method, juvenile salvage is decreased most substantially in above normal years, but salvage level increase in June during the drier years when south Delta exports levels increase. Adult delta smelt salvage decreases most substantially in above and below normal years.

Longfin smelt juvenile and adult salvage are decreased under Scenario 6. Improvements in juvenile salvage are mostly related to reductions in south Delta exports during April–May in drier years. Adult salvage is reduced greatly by export reductions in January, which represents period of peak of total salvage under EBC. Modeling of larval longfin smelt entrainment by PTM analysis did not reveal any differences between Scenario 6 and PP, largely because particle loss to the south Delta exports and other diversions was very low to begin with.

J.4.4 Winter–Spring X2, Delta Outflow, and Longfin Smelt

J.4.4.1 Background

X2, which reflects salinity distribution in the estuary, fluctuates mostly in response to fluctuations in outflow, although atmospheric conditions and barrier operations can also affect it. X2 is strongly influenced by tidal cycles, moving twice daily up and downstream 6–10 km from its average daily location. Lower X2 values correspond to a more westerly location of the 2 ppt isohaline and are typically correlated with higher freshwater flows in the Delta.

In the winter and early spring months, longfin smelt larvae migrate towards the low salinity zone in the Delta for rearing habitat and access to increased food availability. From January through April, longfin smelt larvae are generally present around the Sacramento River confluence and the Suisun Marsh regions. More westerly position of X2 in the Delta is typically associated with increased available rearing habitat for larval longfin smelt. Kimmerer and coauthors (2009) established a positive correlation between lower (more westerly) X2 positions and longfin smelt abundance based on abundance indices from the DFG Fall Midwater Trawl, Bay Midwater Trawl, and Bay Otter Trawl. This correlation can be used to estimate how manipulation of X2 positions, through alterations of Delta outflows, can affect the longfin smelt population.

The mechanism of this relationship, however, is not fully understood since longfin smelt populations in the past have fluctuated on a scale that cannot be adequately explained by Delta outflow or X2 position. Likewise, longfin smelt larvae have a much higher salinity tolerance range than delta smelt and are hence are not as confined to the area near the low salinity X2 zone. It is therefore hypothesized that other factors, such as food availability or water toxicity, may actually be more important factors in affecting longfin smelt populations.

J.4.4.2 Analysis

The effects of transport flows on larval longfin smelt were estimated using the following metrics:

- Delta Outflow—mean monthly and probability of exceedances.
- X2 position—mean X2 position for the period January–June.
- Longfin smelt population abundance index (Kimmerer et al. 2009).

The X2–longfin smelt abundance relationship was used to evaluate the effects of the operations scenarios on longfin smelt, under the assumption that lower X2 (farther downstream) would correspond to higher transport flows.

J.4.4.3 Results

J.4.4.3.1 Delta Outflow

In general, Delta outflow during the period important for longfin smelt (January–June) was not substantially changed under Scenario 6 compared to PP (Table J.4-46, Figure J.4-16). Flow patterns are generally similar for ELT and LLT.

In wet water years, average Delta outflows under Scenario 6 are not appreciably different during this period. In above normal water years, outflows under Scenario 6 are not different from PP for January to April and are slightly increased in May (11% in ELT/LLT) and June (5% ELT). In below normal water years, Delta outflows under Scenario 6 are fairly similar to PP, but there is a small 7% decrease in March late long term, 8–10% increase in April, and 14–19% increase in May. In dry water years, outflows under Scenario 6 are increased in January early long term (14% increase in critical water years, In January, outflow increases slightly in ELT (10% more), but is not different in LLT. Outflow is not appreciably different between the two operations for March through June.

The probability of exceedance analysis shows no difference in Delta outflows between PP and Scenario 6 (Figure J.4-16).

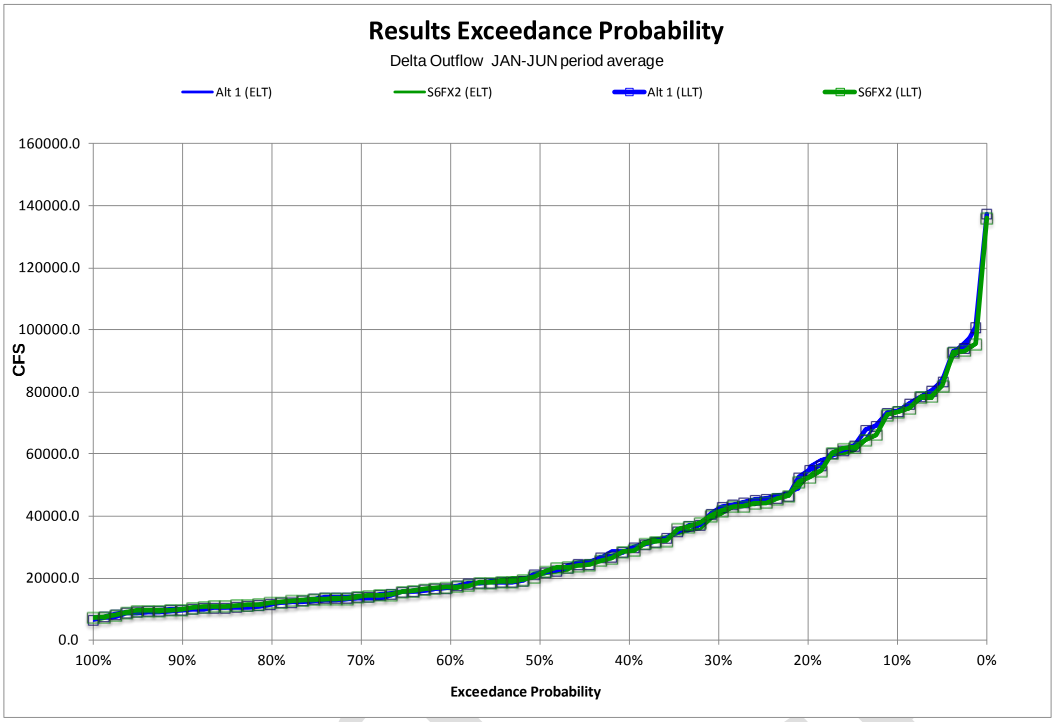


Figure J.4-16. Exceedance Probability for January through June X2 Position under Scenario 6 and Alternative 1 in the Early and Late Long-Term

Table J.4-46. Average Monthly Flows (cfs) January–June, by Water Year Type for Delta Outflow

M	WY	EBC2_ELT	EBC2_LLT	A1_ELT	A1_LLT	S6_ELT	S6_LLT	A1_ELT vs. S6_ELT	A1_LLT vs. S6_LLT
JAN	W	91,158	94,620	91,537	93,735	88,075	89,743	-3,462 (-3.8%)	-3,992 (-4.3%)
	AN	48,959	51,100	47,621	48,196	46,463	47,604	-1,158 (-2.4%)	-592 (-1.2%)
	BN	22,263	22,301	21,336	21,763	22,090	21,243	754 (3.5%)	-520 (-2.4%)
	D	14,754	14,732	13,634	15,816	15,554	15,291	1,919 (14.1%)	-526 (-3.3%)
	C	12,173	12,651	11,354	12,882	12,464	13,294	1,110 (9.8%)	412 (3.2%)
	AVG	44,889	46,372	44,290	45,847	43,735	44,350	-555 (-1.3%)	-1,496 (-3.3%)
FEB	W	104,533	107,085	106,071	107,800	102,917	105,519	-3,154 (-3%)	-2,280 (-2.1%)
	AN	64,163	65,873	66,184	65,435	64,164	63,432	-2,020 (-3.1%)	-2,003 (-3.1%)
	BN	37,266	36,084	35,985	35,010	34,128	33,176	-1,857 (-5.2%)	-1,834 (-5.2%)
	D	20,936	21,461	18,637	19,127	19,084	19,767	446 (2.4%)	640 (3.3%)
	C	12,553	12,798	11,919	12,373	12,541	12,617	622 (5.2%)	245 (2%)
	AVG	55,330	56,338	55,297	55,743	53,873	54,590	-1,424 (-2.6%)	-1,153 (-2.1%)
MAR	W	81,693	84,471	82,703	84,947	80,262	82,842	-2,440 (-3%)	-2,106 (-2.5%)
	AN	55,754	56,737	54,328	54,848	53,426	54,465	-902 (-1.7%)	-382 (-0.7%)
	BN	22,522	22,467	21,382	21,443	20,625	19,914	-757 (-3.5%)	-1,529 (-7.1%)
	D	19,388	19,985	16,912	17,264	16,772	16,996	-140 (-0.8%)	-268 (-1.6%)
	C	11,948	12,215	11,308	11,551	11,529	11,806	222 (2%)	255 (2.2%)
	AVG	43,911	45,097	43,191	44,102	42,158	43,096	-1,033 (-2.4%)	-1,006 (-2.3%)

M	WY	EBC2_ELT	EBC2_LLT	A1_ELT	A1_LLT	S6_ELT	S6_LLT	A1_ELT vs. S6_ELT	A1_LLT vs. S6_LLT
APR	W	54,860	54,562	48,665	48,246	48,765	48,560	100 (0.2%)	314 (0.7%)
	AN	31,183	30,576	24,174	24,457	25,036	24,901	862 (3.6%)	444 (1.8%)
	BN	21,218	20,641	16,506	16,714	18,162	18,125	1,656 (10%)	1,411 (8.4%)
	D	13,450	13,413	11,417	12,324	11,989	12,682	572 (5%)	358 (2.9%)
	C	8,881	9,294	8,537	9,012	8,649	8,890	112 (1.3%)	-122 (-1.4%)
	AVG	29,833	29,603	25,542	25,754	26,124	26,221	583 (2.3%)	466 (1.8%)
MAY	W	38,276	32,880	31,850	27,984	32,714	28,585	864 (2.7%)	601 (2.1%)
	AN	23,131	21,709	17,683	16,919	19,635	18,855	1,952 (11%)	1,936 (11.4%)
	BN	14,740	13,596	11,506	12,204	13,683	13,896	2,177 (18.9%)	1,692 (13.9%)
	D	9,737	10,375	9,103	10,508	9,397	11,047	294 (3.2%)	539 (5.1%)
	C	6,341	6,286	6,037	6,196	6,098	6,263	61 (1%)	67 (1.1%)
	AVG	21,103	19,121	17,532	16,646	18,537	17,537	1,005 (5.7%)	891 (5.4%)
JUN	W	18,080	15,640	16,890	15,739	17,598	15,593	708 (4.2%)	-146 (-0.9%)
	AN	10,177	10,676	10,048	10,625	10,559	10,806	511 (5.1%)	182 (1.7%)
	BN	8,067	8,943	8,702	9,688	8,781	9,575	80 (0.9%)	-113 (-1.2%)
	D	7,123	7,689	7,512	7,844	7,389	7,821	-123 (-1.6%)	-23 (-0.3%)
	C	5,345	5,632	5,345	5,365	5,331	5,321	-13 (-0.2%)	-44 (-0.8%)
	AVG	10,945	10,560	10,743	10,706	11,026	10,656	284 (2.6%)	-51 (-0.5%)
		Increase >50%		Increase 25–50%		Increase 10–25%		Increase 5–10%	
		Decrease >50%		Decrease 25–50%		Decrease 10–25%		Decrease 5–10%	

J.4.4.3.2 X2 Position January–June

During ELT, Scenario 6 results in a slight 1 km westerly shift in the January–June average X2 position compared to PP, but little or no shift during LLT (Table J.4-47, Figure J.4-17). The effect on longfin smelt would depend on the relative importance of the relationship between population abundance and X2 position, which is described below.

Table J.4-47. Mean X2 position by Water Year Type for December through May under Scenario 6 and Alternative 1 in the early and late long term

		EBC2_ELT	EBC2_LLT	A1_ELT	A1_LLT	S6_ELT	S6_LLT	A1_ELTvs.S6_ELT	A1_LLTvs.S6_LLT
DEC–MAY	W	56	59	57	58	57	59	0	0
	AN	63	65	65	66	64	66	-1	0
	BN	69	71	70	72	69	71	-1	-1
	D	75	76	76	77	75	76	-1	0
	C	81	82	81	82	81	82	-1	0
	AVG	67	69	68	69	67	69	-1	0

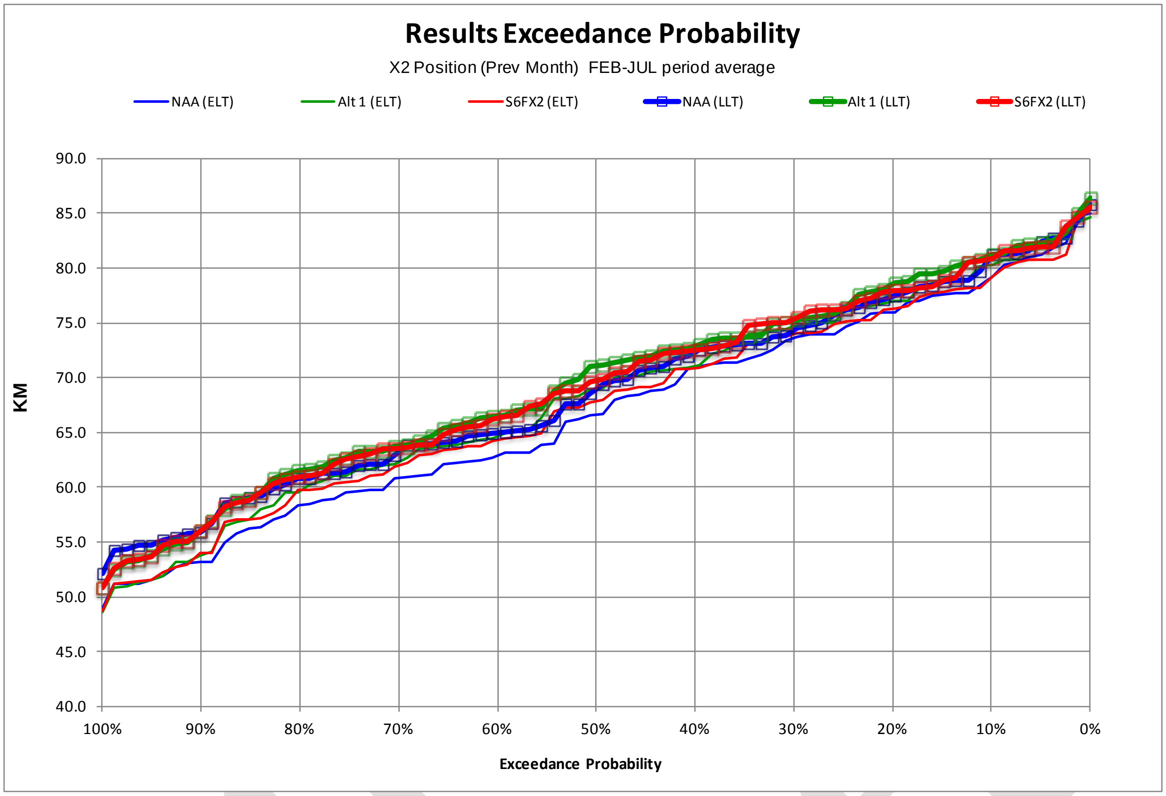


Figure J.4-17. Exceedance probability for January through June X2 position under Scenario 6 and Alternative 1 in the early and late long term

J.4.4.3.3 Longfin Smelt Abundance

Longfin smelt abundance was estimated using the Kimmerer method based on January–June X2 position (Kimmerer et al. 2009) (Table J.4-48, Table J.4-49, Table J.4-50, Table J.4-51). Peak abundances of longfin smelt occur in wet years, with substantial declines in longfin smelt population during drier years. Comparing Scenario 6 to PP results from this method suggest that under wetter conditions (80% exceedance values), the change in X2 values has the potential to increase relative abundance by 8–10% (Table J.4-48). Under drier conditions (20% exceedance values), relative abundance under Scenario 6 based on this method would be negligibly decreased 2–3% during ELT, and increased 7–8% during LLT relative to the PP (Table J.4-48).

Looking at results by water year type (Table J.4-48, Table J.4-49, Table J.4-50), longfin smelt abundance under Scenario 6 was projected to increase slightly compared to the PP (but remain lower than EBC) in above normal (7–8% increase ELT), below normal (11–13% ELT, 8–10% LLT), dry (10–12% ELT), and critical water years (9–12% ELT, 4–5% LLT). Differences in estimated abundance are not appreciable in wet years (2-3% increase) and many years during LLT because winter-spring X2 position shifts less than 0.5 km under Scenario 6 in these water year types.

Table J.4-48. Longfin Smelt Abundance Calculated Based on December through May X2 position under Scenario 6 and Alternative 1 and Relationships between Longfin Smelt Abundance Indices and X2 Developed by Kimmerer et al. 2009

Longfin Smelt Abundance by Scenario								
	EBC2_ELT	EBC2_LLT	A1_ELT	S6_ELT	A1_LLT	S6_LLT	A1_ELT vs. S6_ELT	A1_LLT vs. S6_LLT
Midwater Trawl								
20th percentile	1,586	1,347	1,417	1,535	1,176	1,275	118 (8%)	99 (8%)
80th percentile	12,112	9,171	10,513	10,286	8,407	8,970	-227 (-2%)	562 (7%)
Bay Midwater Trawl								
20th percentile	2,757	2,266	2,407	2,650	1,926	2,122	243 (10%)	196 (10%)
80th percentile	31,613	22,640	26,674	25,984	20,398	22,046	-689 (-3%)	1,648 (8%)
Bay Otter Trawl								
20th percentile	3,471	2,853	3,030	3,336	2,424	2,671	306 (10%)	247 (10%)
80th percentile	39,798	28,502	33,580	32,712	25,680	27,755	-868 (-3%)	2,075 (8%)

Table J.4-49. Estimated Longfin Smelt Relative Abundance in the Fall Midwater Trawl Based on the X2-Abundance Regression of Kimmerer et al. (2009)

WY	EBC2_ELT	EBC2_LLT	Alt 1_ELT	Alt 1_LLT	S6_ELT	S6_LLT	Alt 1_ELT vs. S6_ELT	Alt 1_LLT vs. S6_LLT
All	4,576	3,678	3,960	3,382	4,244	3,490	284 (7%)	108 (3%)
Wet	16,200	11,789	14,412	11,665	14,812	11,837	400 (3%)	172 (1%)
Above Normal	7,415	5,752	5,783	4,867	6,182	5,028	400 (7%)	160 (3%)
Below Normal	3,679	2,978	3,080	2,558	3,406	2,769	326 (11%)	211 (8%)
Dry	1,857	1,626	1,616	1,482	1,773	1,503	157 (10%)	22 (1%)
Critical	911	820	849	767	930	796	81 (9%)	29 (4%)

Table J.4-50. Estimated Longfin Smelt Relative Abundance in the Bay Midwater Trawl Based on the X2-Relative Abundance Regression of Kimmerer et al. (2009)

WY	EBC2_ELT	EBC2_LLT	Alt 1_ELT	Alt 1_LLT	S6_ELT	S6_LLT	Alt 1_ELT vs. S6_ELT	Alt 1_LLT vs. S6_LLT
All	9,831	7,563	8,265	6,838	8,981	7,102	716 (9%)	264 (4%)
Wet	44,813	30,604	38,946	30,218	40,248	30,752	1,302 (3%)	534 (2%)
Above Normal	17,544	12,937	13,019	10,587	14,105	11,006	1,087 (8%)	420 (4%)
Below Normal	7,567	5,872	6,113	4,892	6,897	5,381	784 (13%)	489 (10%)
Dry	3,331	2,840	2,819	2,540	3,150	2,585	331 (12%)	45 (2%)
Critical	1,416	1,249	1,303	1,153	1,452	1,205	150 (12%)	52 (5%)

Table J.4-51. Estimated Longfin Smelt Relative Abundance in the Bay Otter Trawl Based on the X2-Relative Abundance Regression of Kimmerer et al. (2009)

WY	EBC2_ELT	EBC2_LLT	Alt 1_ELT	Alt 1_LLT	S6_ELT	S6_LLT	Alt 1_ELT vs. S6_ELT	Alt 1_LLT vs. S6_LLT
All	12,376	9,522	10,405	8,609	11,306	8,941	901 (9%)	332 (4%)
Wet	56,417	38,528	49,031	38,042	50,670	38,714	1,639 (3%)	672 (2%)
Above Normal	22,086	16,286	16,389	13,328	17,757	13,856	1,368 (8%)	529 (4%)
Below Normal	9,526	7,393	7,696	6,159	8,683	6,774	987 (13%)	615 (10%)
Dry	4,194	3,576	3,549	3,198	3,966	3,254	416 (12%)	56 (2%)
Critical	1,783	1,572	1,640	1,452	1,828	1,517	189 (12%)	66 (5%)

J.4.4.4 Conclusions

January–June X2 position is generally projected to be similar or slightly lower (i.e., more westerly by 1 km) under Scenario 6 than PP, resulting in a slight increase in model-predicted mean abundance of larval longfin smelt under Scenario 6 averaged across all water years (7–9% greater in ELT, 3–4% greater in LLT), particularly in below normal to critical years during ELT (12–13% greater). These results suggest minor to moderate benefits to the longfin smelt population based on increasing Delta outflow during the winter to spring period compared to the PP, but as noted, abundance would still be less than under EBC. However, the strength of the relationship between longfin smelt abundance and Delta outflow (and/or X2 position) is still unknown, and therefore the impacts of a more westerly X2 position cannot be precisely predicted. Other factors such as food abundance are hypothesized to have a greater impact on longfin smelt abundance than X2 position alone. The evaluation of X2 position here focuses only on the potential effects of X2 position on longfin smelt abundance.

Summary

Average X2 position in winter-spring under Scenario 6 shifts 1 km west during ELT, but is similar to PP during the LLT period.

Longfin smelt abundances are likely to increase (1–13% increase) under Scenario 6 compared to the PP in all water years. The increase is most apparent in below normal water year types, in response to the minor shift in X2 position.

The strength of relationship between longfin smelt abundance and X2 position is unknown. Other factors such as food availability may be more important in impacting longfin smelt population size.

J.4.5 Fall X2 and Delta Smelt Habitat

J.4.5.1 Analysis

The analysis of Fall X2 is based on the location of X2 using two metrics from CALSIM II:

- Probability of exceedance for Fall X2 location at 74 km and 81 km—How frequently these standards are achieved for the modeled hydrologic period of record (82 years).
- Mean Fall X2 position (September–December period).

Because implementation of the Fall X2 criteria is determined by the classification of the previous water year type, and because Fall X2 spans the cusp of water year types, it is not advisable to subdivide monthly mean X2 location by water year types (C. Chilmakuri pers. comm.). Therefore, this analysis looks at broader patterns across the modeled hydrologic period.

J.4.5.2 Results

Scenario 6 specifically meets the wet (74 km) (Table J.4-52) and above normal (81 km, Table J.4-53) requirements for the X2 position. As stated above, this analysis is not subdivided by water year type, so results are presented using probability of exceedance graphs. The probability of exceedance analysis for September (Figure J.4-18) and October (Figure J.4-19) shows X2 at 74 km for 32–33% (Table J.4-52) and at 81 km for 46–48% of the modeled years under Scenario 6 during ELT (Table J.4-52). The pattern is very similar during the LLT period, where Scenario 6 meets the 74 km criterion 29–30% of the years and 81 km in 43–46% of years. By comparison, under PP during ELT, the 74 km criterion is achieved 2–3% of the modeled years, and the 81 km criterion is achieved 4–5% of the years. For September and October, Scenario 6 achieves 74 km 29–30% more often and 81 km 31–43% more often.

By November, the 74 km standard is achieved rarely under PP (4–6%) compared to Scenario 6 (15–26%) (Table J.4-52 andFigure J.4-20). Similarly, the 81 km standard is achieved 10–12% of the time under PP compared to 51–53% under Scenario 6. By December, the difference between PP and Scenario 6 has diminished substantially (Figure J.4-21).

Table J.4-52. Frequency of Years When X2 Position is at 74km or Further West during Fall Months[1]

Month	EBC2_ELT	EBC2_LLT	A1_ELT	A1_LLT	S6_ELT	S6_LLT	A1_ELT vs. S6_ELT	A1_LLT vs. S6_LLT
SEP	30%	36%	2%	0%	32%	29%	30%	29%
OCT	32%	30%	3%	0%	33%	30%	30%	30%
NOV	25%	15%	6%	4%	27%	15%	21%	11%
DEC	33%	31%	27%	26%	35%	28%	8%	2%
[1] Percentage for 82 year period of record.								

Table J.4-53. Frequency of Years When X2 Position is at 81km or Further West during Fall Months[1]

Month	EBC2_ELT	EBC2_LLT	A1_ELT	A1_LLT	S6_ELT	S6_LLT	A1_ELT vs. S6_ELT	A1_LLT vs. S6_LLT
SEP	45%	51%	4%	1%	46%	43%	42%	42%
OCT	48%	45%	5%	15%	48%	46%	43%	31%
NOV	53%	49%	12%	10%	53%	51%	41%	41%
DEC	50%	41%	39%	37%	54%	43%	15%	6%
[1] Percentage during the 82 year period of record.								

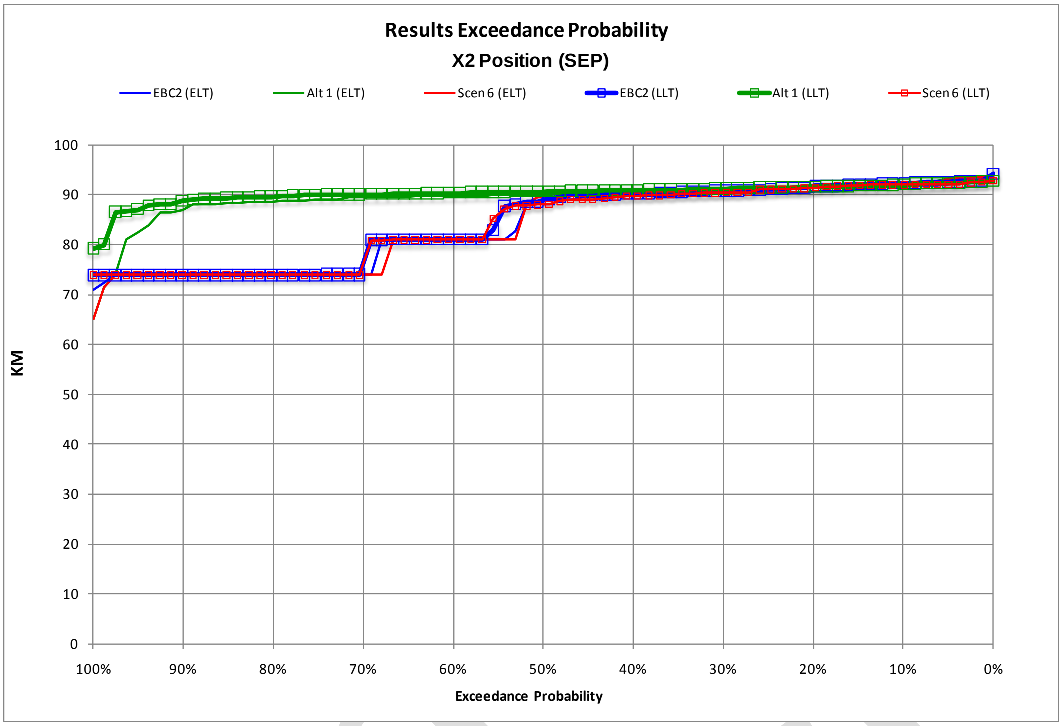


Figure J.4-18. Exceedance probabilities for X2 position in September

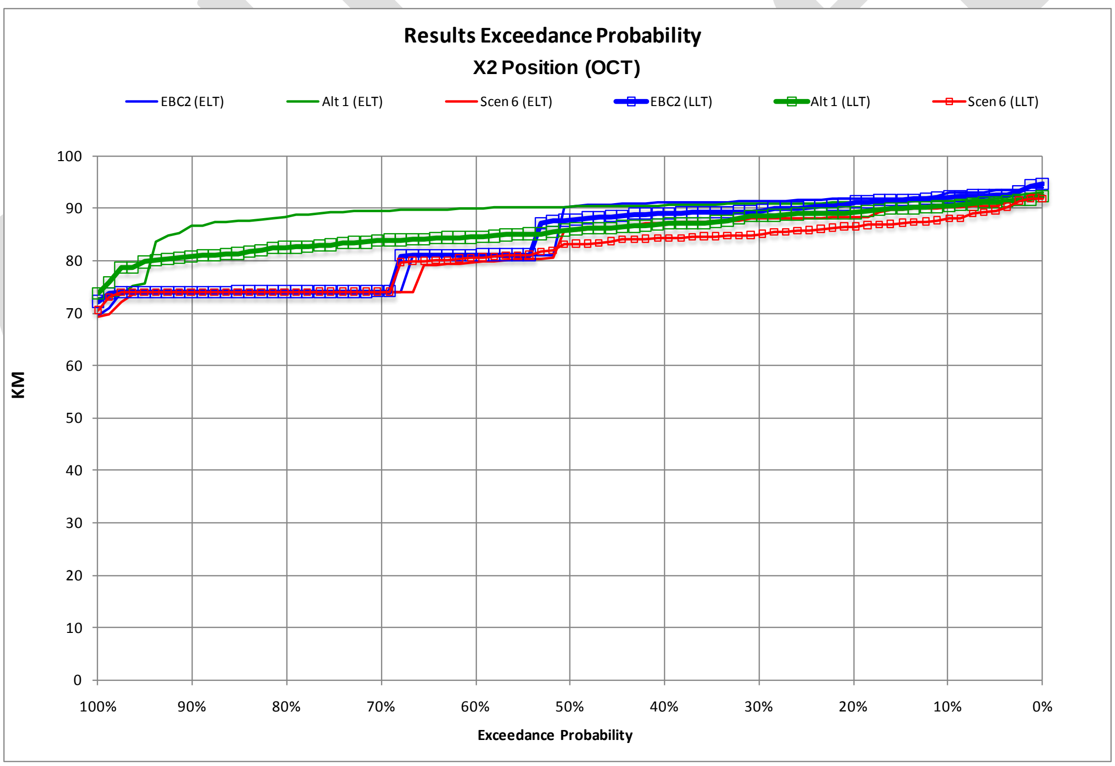


Figure J.4-19. Exceedance probabilities for X2 position in October

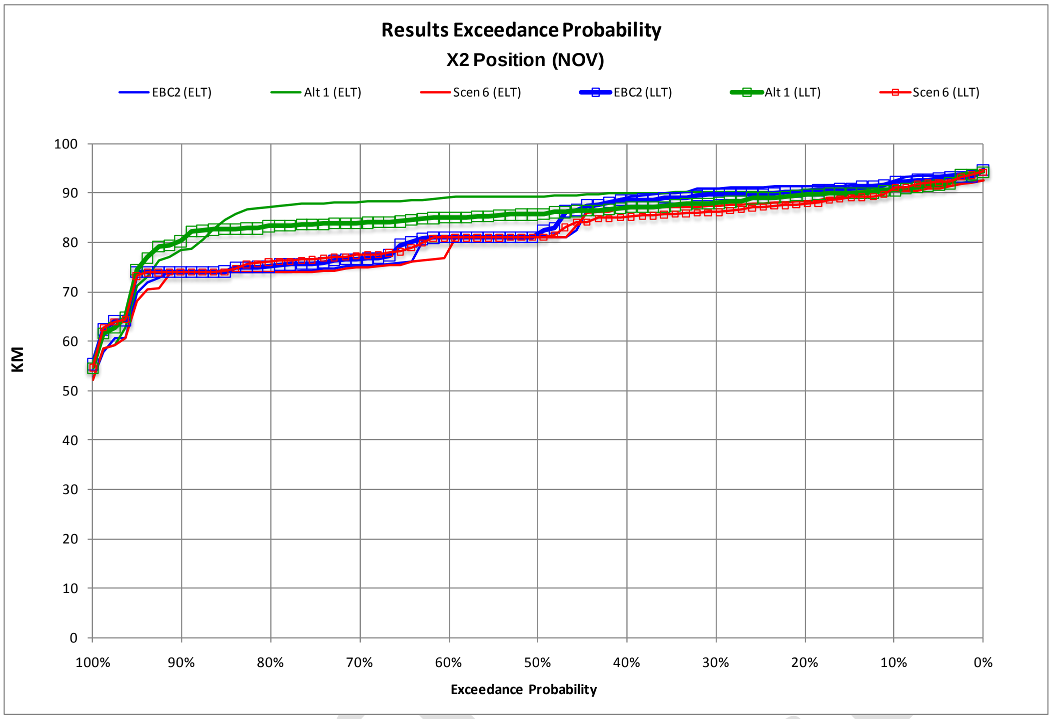


Figure J.4-20. Exceedance probabilities for X2 position in November

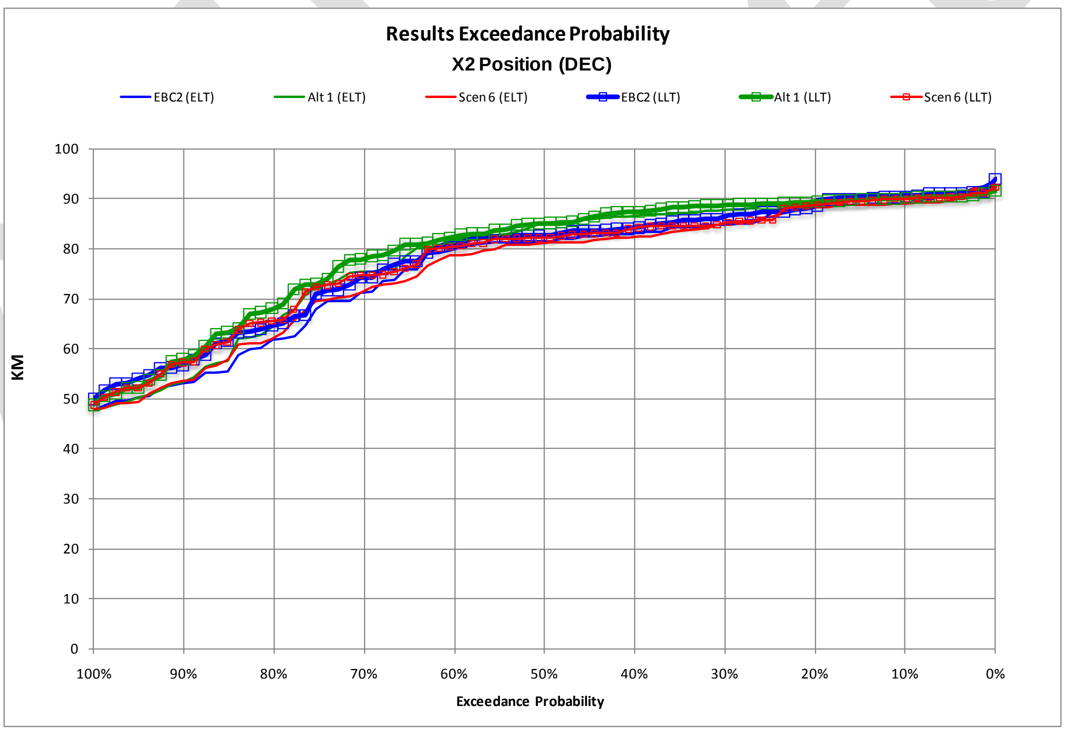
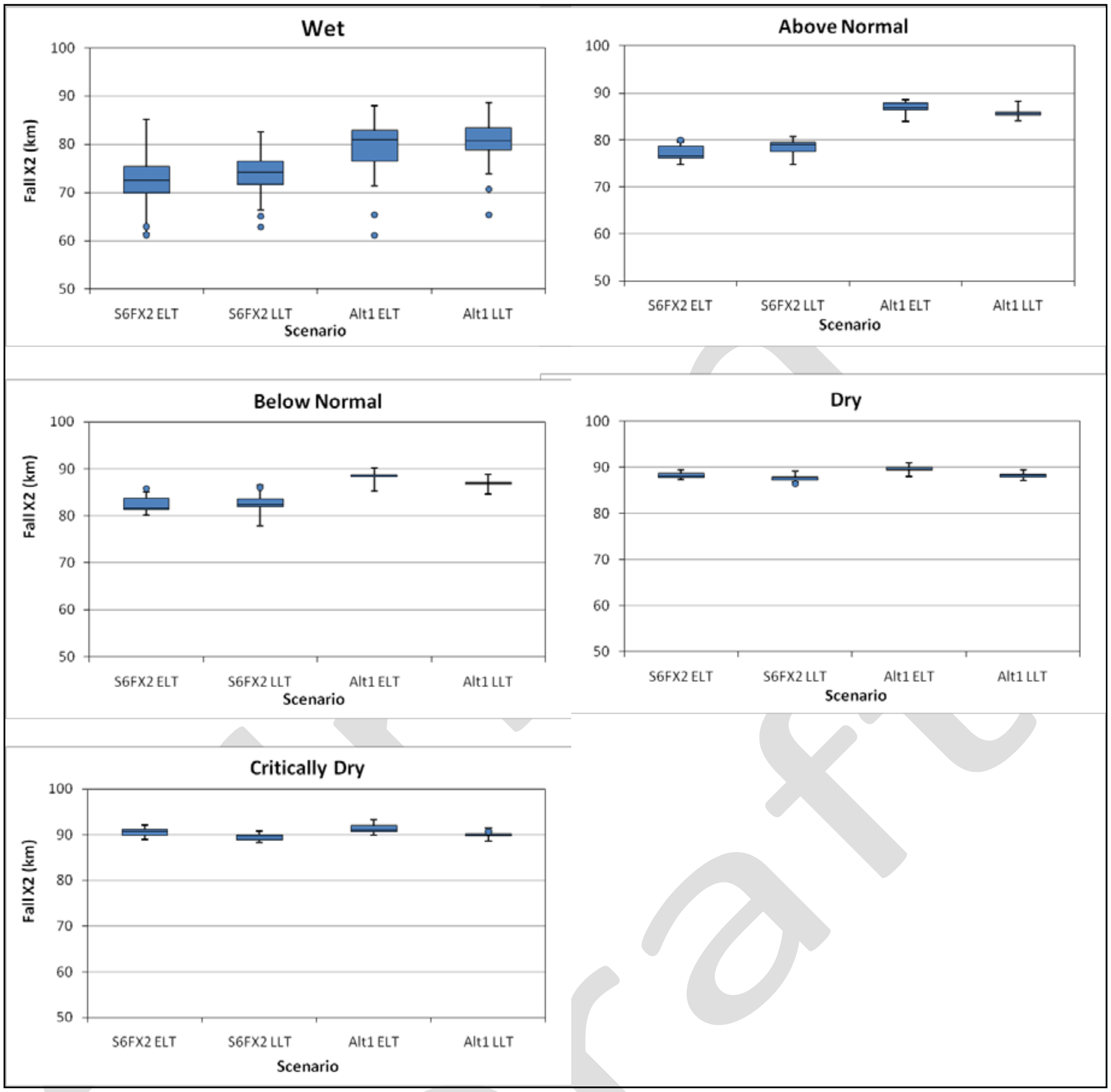


Figure J.4-21. Exceedance probabilities for X2 position in December

When analyzing mean fall (September–December) X2 position by water year type (Table J.4-54 and Figure J.4-22), the analysis finds that Scenario 6 shifts X2 position west towards San Francisco Bay by a substantial amount in wet (-8 km in ELT, -7 km in LLT), above normal (10 km in ELT, 7 km in LLT), and below normal years (6 km in ELT, 5 km in LLT). Fall X2 position in dry and critical years does not appreciably change (Table J.4-54).

Table J.4-54. Mean Monthly X2 position (km) for September through December under Scenario 6 and Alternative 1

		EBC2_ELT	EBC2_LLT	A1_ELT	A1_LLT	S6_ELT	S6_LLT	S6_ELT vs. A1_ELT	S6_LLT vs. A1_LLT
SEP–DEC	W	75	76	81	81	73	74	-8	-7
	AN	83	83	87	86	77	79	-10	-7
	BN	84	84	88	87	82	82	-6	-5
	D	84	85	90	88	88	88	-2	0
	C	88	89	91	90	91	90	0	0
	AVG	82	82	86	85	81	81	-5	-4



[1] Box shows the 25th, 50th, and 75th percentiles; whiskers represent the median ± 2 standard deviations; dots represent outliers.

Figure J.4-22. Fall (September–December) X2 Location under Each Project Scenario by Water Year Type

J.4.5.3 Conclusions

Because the operational criteria in Scenario 6 explicitly include the Fall X2 requirement while PP does not, the Scenario 6 results not surprisingly provide for maintenance of Fall X2 further west relative to the PP in September and October of wet and above normal water years. Average X2 positions (September to December) shift west by 6–10 km under those higher flow conditions. Scenario 6 improves the frequency of meeting the X2 position criterion by 11–31% for the 74 km threshold, and 31–43% for the 81 km threshold.

The shift in X2 position westward in wet and above normal years is largely explained by large reservoir releases in September during those water year types. These releases in September are substantial enough to maintain more westerly X2 position during October, even though Scenario 6 reservoir releases are less in October compared to PP.

Fall X2 position also moved west in below normal years. While unexpected because there is no Scenario 6 pulse release in below normal years, it is likely explained by decreased south Delta exports in the fall under Scenario 6 to address D-1641 requirements and improve OMR flow conditions. The degree of benefit to delta smelt from each increment of westward movement provided by Scenario 6 is uncertain.

Summary

Scenario 6 meets the Fall X2 criteria more often than PP (11–30% more often for 74 km, 31–43% more frequently for 81 km).

Under Scenario 6, X2 position shifts west substantially in wet, above normal, and below normal years in response to increase large September upstream reservoir releases in wet and above normal years and general south Delta export reductions in the fall in all water year types.

J.5 Conclusions

Scenario 6 had some success in addressing these five issues of concern.

Temperature-related mortality of spring-run Chinook eggs. Scenario 6 did not significantly reduce mortality in the mainstem of the Sacramento River. Mortality was relatively less in wet and above normal years when flows are increased under Fall X2 operations. Egg mortality is exacerbated by climate change (LLT). In the Feather River, Scenario 6 may slightly increase the frequency of water temperature conditions unsuitable for egg survival during wet years. Increased reservoir releases in September for Delta requirements improved egg survival during wet and above normal years compared to other water years, but may have reduced available cold water for egg incubation later in the fall.

Sacramento River flows downstream of the North Delta intakes. Rio Vista flows under Scenario 6 increased during July–September and decreased in October. These flow changes, however, had minimal biological effect on the target fishes, either because they were not migrating in those months or the flow changes were not substantial enough to change attraction flows and olfactory cues relative to preliminary proposal (PP).

April–May south Delta operations and OMR flows. Scenario 6 reduced reverse OMR flows during April–May and fall. OMR proportional entrainment of delta smelt decreased for adults (7–10%) in dry years, but increased for adults in wet years (12–15%) and juveniles for all water year types (4–15%). Entrainment estimated as salvage (based on exports) was substantially reduced under Scenario 6 for all fish species, although this may simply be a function of reduced south Delta exports. Larval longfin smelt entrainment, as estimated by particle tracking modeling, was low and unchanged relative to PP, but adult and juvenile entrainment was reduced.

Winter-spring Delta outflow and longfin smelt. Scenario 6 increases Delta outflow and slightly shifts X2 further west 1 km during ELT (except wet water years) and in below normal water years in LLT. Based on the Kimmerer method linking the X2 location and longfin smelt surveys, longfin smelt abundance would be expected to increase slightly relative to PP, but remains lower than under EBC.

Fall X2 location and delta smelt. Scenario 6 shifts the X2 location to the west about 6–10 km in wet, above normal and below normal water years.

J.6 References

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J.6.1 Personal Communications

C. Chilmakuri pers. comm.

J. Hannon pers. comm.