Appendix H
Fisheries Evaluation

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Abbreviations and Acronyms

°F	degrees Fahrenheit
CalSim II	California Simulation Model II
cfs	cubic feet per second
CVP	Central Valley Project
Delta	Sacramento-San Joaquin River Delta
DMC	Delta-Mendota Canal
DO	dissolved oxygen
DSM2	Delta Simulation Model II
DWSC	Stockton Deepwater Ship Channel
EIR/EIS	Environmental Impact Report/Statement
FTM	Fisheries Technical Memorandum
FTWG	Fisheries Technical Working Group
Jones Pumping Plant	C.W. "Bill" Jones Pumping Plant
PFR	Plan Formulation Report
ppt	part(s) per thousand
Reclamation	U.S. Department of the Interior, Bureau of Reclamation
SEV	severity-of-ill-effects value
SJR	San Joaquin River
SSC	suspended sediment concentration
SWP	State Water Project
TSS	total suspended solid
WQO	water quality objective

Appendix H
Fisheries

H.1 Introduction and Background

The U.S. Department of the Interior, Bureau of Reclamation (Reclamation) is evaluating the feasibility of using recirculation strategies to improve water quality and flows in the lower San Joaquin River (SJR). The Delta-Mendota Canal (DMC) Recirculation Project involves the recirculation of water from the Sacramento-San Joaquin River Delta (Delta) through export pumping and conveyance facilities to the SJR upstream of Vernalis. The purpose of this investigation is to identify and evaluate the feasibility of the alternative plans for the DMC Recirculation Project and to determine whether the project will provide greater flexibility in meeting existing water quality standards and flow objectives while reducing water demands from New Melones Reservoir.

This appendix provides an evaluation of potential effects and benefits to aquatic resources due to each of the alternative plans considered in the Plan Formulation Report (PFR) (see PFR Chapter 4 for a description of alternative plans). Potential effects and benefits to aquatic resources were evaluated based on results of hydrologic and water quality modeling presented in **Appendices A through F**.

The PFR requires that the alternative plans be compared to each other and "ranked" based on predicted effects and benefits. The PFR does not require the same level of detailed analysis as the Environmental Impact Report/Statement (EIR/EIS), but is more qualitative in nature. In developing the ranking criteria for aquatic resources in the PFR, factors with overarching importance were used to compare the alternative plans. Additional factors will be considered to evaluate potential effects in the EIR/EIS.

In ranking the alternative plans, the significance thresholds developed in collaboration with the Fisheries Technical Working Group (FTWG) were used to develop ranking criteria. The FTWG is composed of representatives from the California Department of Fish and Game, National Marine Fisheries Service, U.S. Fish and Wildlife Service, California Department of Water Resources, Anadromous Fish Restoration Program, Reclamation, and Reclamation's consultant team headed by URS, with ENTRIX leading the assessment of impacts to aquatic resources. The consultant team prepared a Fisheries Technical Memorandum (FTM) that includes a description of existing resources, methods to evaluate potential impacts, and significance criteria to be used for the EIR/EIS.

The project area (PFR **Figure 1-1**) can be defined as the SJR's lower main stem below its confluence with the Merced River and Newman Wasteway; the areas served by the Merced, Tuolumne, and Stanislaus rivers on the western side of the Sierra Nevada Mountains; Newman and Westley wasteways; and the areas served by the DMC, which includes approximately 30 water agencies. The project area also includes the southern Delta, which is a source of water supply for agricultural and urban uses within the Delta and conveys water for these uses to the Central Valley Project (CVP) and State Water Project (SWP) export facilities for use south of the Delta.

For the assessment of aquatic resources, the project area is divided into three ecoregions: the Delta, the SJR, and tributaries to the SJR, primarily the Stanislaus River. These ecoregions have different physical conditions, biological uses, and potential project effects. Therefore, the evaluation of potential effects differs within these regions. The characteristics of these three regions are described in PFR **Section 2.2.4**.

H.2 Potential Effects, Assessment Approach, and Ranking Criteria

H.2.1 Affected Resources

Biology

Existing biological resources are described in PFR **Section 2.2.4**. The species of primary management concern in this evaluation are winter-run, spring-run, and fall/late-fall run Chinook salmon, steelhead, Delta smelt, green sturgeon, splittail, longfin smelt, white sturgeon, striped bass, and American shad. Additional information can be found in the FTM. Species descriptions and fish periodicity tables can be found in **Attachment H1** of this appendix.

Factors Affecting Aquatic Biological Resources

Project-related factors affecting aquatic biological resources are described by region.

Sacramento-San Joaquin River Delta. The Delta is shown in **Figure H-1**. Details regarding the facilities and water bodies within the SJR area of analysis and the fisheries resources they support are described in PFR Section 2.2.

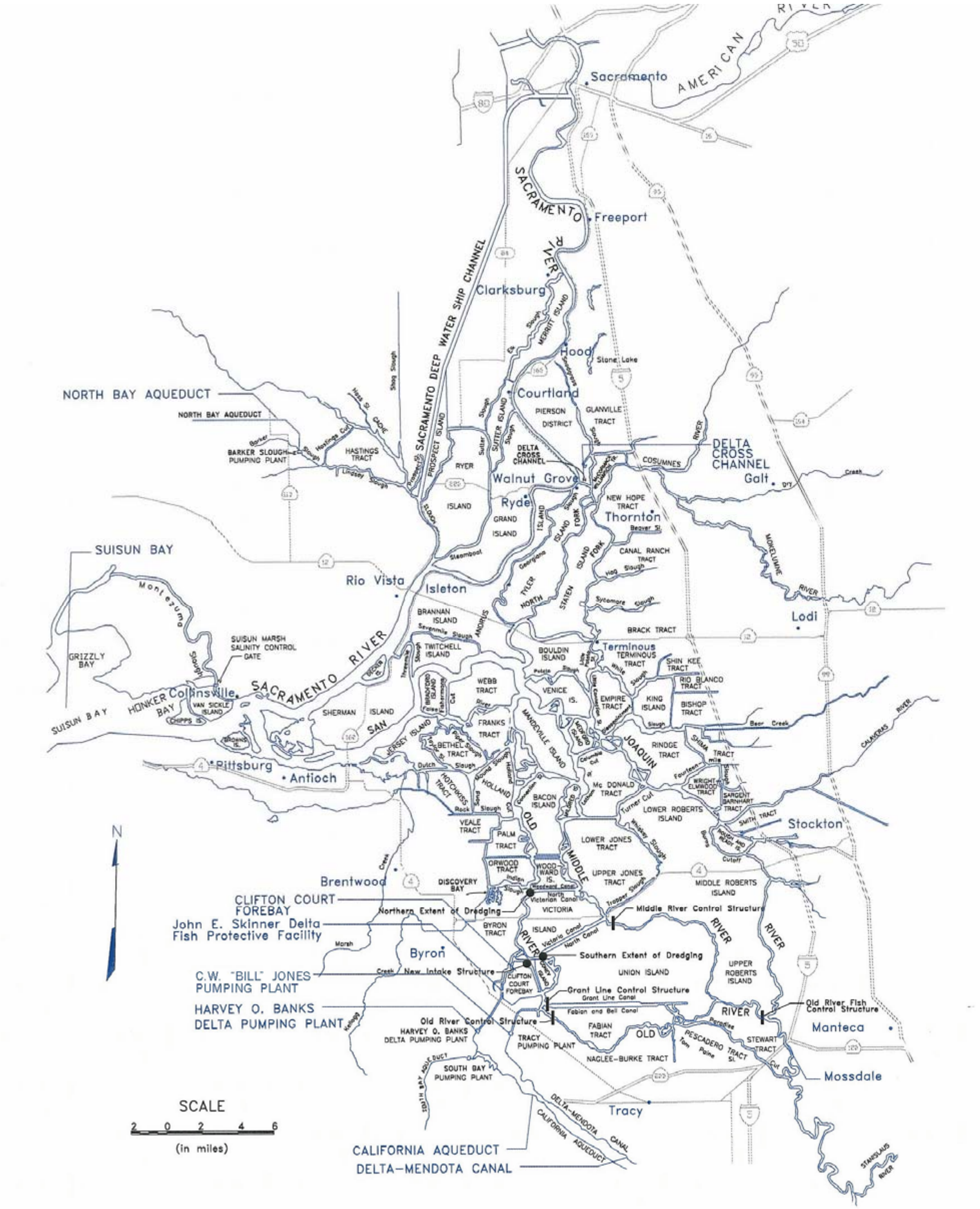


Figure H-1. Sacramento-San Joaquin River Delta

Hydrodynamics. Flows in the Delta (see **Figure H-1**) are influenced by the water management upstream and within the Delta. Water developments have altered the timing and magnitude of river flows *into* the Delta, affecting the timing and location of salinity gradients. These changes affect a variety of parameters that are used to govern operation of the Delta and many others that influence fish habitat and their populations. Regulatory requirements include, but are not limited to, Delta outflow, X2 (the 2-part-per-thousand [ppt] isocline) location, and export/inflow ratios. In addition, negative flows in Old and Middle rivers have been used as a management tool to protect Delta smelt. These parameters are described in PFR **Section 2.2**.

Entrainment. Export operations of the SWP and CVP affect fish survival within the Delta, both directly and *indirectly* (*U.S. Fish and Wildlife Service* 2005). An unknown fraction of the fish entrained by the pumps is lost, but both entrainment and loss are assumed to be proportional to salvage. Relative entrainment numbers do not necessarily represent changes in population size; however, as fish distribution within the Delta varies widely within and among water year types. This topic is described in PFR **Section 2.2.4** and in more detail in the FTM.

San Joaquin River. This area of analysis is focused primarily on the SJR between the confluence of Newman Wasteway with the SJR (just upstream of the confluence of the Merced River) downstream to where the SJR flows into the Delta, at the head of Old River. Details regarding the facilities and water bodies within the SJR area of analysis and the fisheries resources they support are described in PFR **Section 2.2**.

The lower reaches of the SJR from the Merced River to Vernalis are used by anadromous salmonids for immigration and outmigration with some seasonal rearing from February through May during the outmigration period. Spawning habitat is not available in this reach for salmonids due to unsuitable substrate, fall water temperatures, and water quality conditions. This 43-mile reach includes the confluence of the Stanislaus, Tuolumne, and Merced rivers, the main tributaries to the SJR entering from the eastern side of the valley.

Flow. Flows in the project area are influenced by the operations of dams on the tributary rivers, as well as releases from Mendota Pool on the SJR. Flow is further influenced by agricultural, municipal, and industrial withdrawals and return flows along the course of the SJR. Flow requirements are described in PFR **Section 2.2.2**, and flows under existing conditions are described in PFR **Section 2.2.1**, with further detail on flow and stage data at additional locations presented in **Appendix F, Attachment F1.**

Water Quality. The water quality regulatory requirements and existing conditions are described in PFR **Section 2.2.3**, with further detail presented in **Appendix F, Attachment F1**. This evaluation focuses on temperature and total suspended solids (TSS), as these parameters are the most likely to be affected by the project.

Stanislaus River. The Stanislaus River is governed by several different regulations and agreements. New Melones Reservoir is operated in an attempt to balance multiple objectives, including fishery flow requirements, water supply, water quality, SJR water quality, and inflow to the Delta. The DMC Recirculation Project may affect flow and water temperature and quality on the Stanislaus River downstream of New Melones Reservoir.

Flow. Flow requirements are described in PFR **Section 2.2.2**, and flows under existing conditions are described in PFR **Section 2.2.1**, with further detail on flow and stage data at additional locations presented in **Appendix F, Attachment F1**.

Water Quality. Temperature is likely the strongest factor affecting salmonid populations in the Stanislaus River, as indicated by the Operations Criteria and Plan Biological Opinion (National Marine Fisheries Service 2004), which established temperature standards, but did not establish flow standards below Goodwin Dam. The water quality regulatory requirements and existing conditions are described in PFR **Section 2.2.3**, with further detail presented in **Appendix F, Attachment F1**.

Merced and Tuolumne Rivers. The DMC Recirculation Project would have little effect on flows or water quality on the Merced and Tuolumne rivers. It may affect the anadromous fish resources of these rivers because these fish must pass through the SJR and Delta on their way to and from the ocean. Changes in water quality and composition in these waters may affect the ability of these fish to home effectively to their natal streams. Additionally, these changes in source water may result in increased straying of fish from other rivers into the Merced and Tuolumne rivers.

H.2.2 Potential Effects and Assessment Approach

Several variables related to the proposed project have the potential to either directly or indirectly affect fishery resources and the habitats upon which they rely within the project area. These variables are generally categorized into three major potential project areas of effects: (1) changes in hydrodynamics (i.e., flow, direction, timing, and magnitude); (2) changes in water quality (i.e., water temperature, dissolved oxygen (DO), heavy metals, trace elements); and (3) effects on biological characteristics of fisheries within the project area (i.e., entrainment, straying issues, habitat suitability).

In evaluating the potential effects of the alternative plans, the analyses in this section use only those time periods when recirculation would occur under each alternative plan, following the approach recommended by the FTWG to avoid masking the differences recirculation could create by averaging these differences with those periods when recirculation is not occurring. Recirculation would occur more under Alternatives C and D than under any other alternative plans (**Table H-1**). The alternative plans resulting in the least recirculation would be Alternatives A1 and A2. For any of the alternative plans, recirculation would occur more in drier years than in wetter years.

The evaluation of certain parameters was performed using a weighted index based on the frequency with which recirculation occurs under each alternative plan by water year type and month and the change in that parameter relative to the No-Action Alternative. These parameters include Delta outflow, combined export, proportion of nonsource water, and entrainment. For each water year type, monthly averages were calculated for these parameters under each alternative plan and the No-Action Alternative when recirculation was occurring under it. The difference between these monthly values was weighted by multiplying this difference by the frequency of occurrence of recirculation for that water year type. These values were then summed across all water year types and divided by the total number of years when recirculation occurred in that month.

$$\text{Monthly Weighted Index} = \Sigma_{WYT}\,(Alt_{WYT} - NAA_{WYT}) * f_{recirc,WYT}/f_{recirc,\text{All WYTs}}$$

Where: WYT = Water Year Type

Alt = Alternative value

NAA = No-Action Alternative value

f_{recirc} = number of years within simulation period when recirculation occurs in that month

These values were then summed across all water year types and divided by the total number of years when recirculation occurred in that month. The total weighted index was calculated by averaging the monthly weighted index, with

Table H-1. Recirculation: Frequency of Occurrence by Water Year Type for Each Alternative Plan for Water Years 1922–2004

Water Year Type	Oct	Nov	Dec	Jan	Feb	Mar	Apr 1-15	Apr 16-30	May 1-15	May 16-31	Jun	Jul	Aug	Sep	Annual	Years Modeled	Periods with Recirculation	Periods Modeled
Alternative A1																		
Wet	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	24	1	336
Above Normal	0	0	0	0	1	4	1	0	0	0	2	0	0	0	4	16	8	224
Below Normal	0	0	0	0	2	1	0	0	0	0	0	0	0	0	3	13	3	182
Dry	0	0	0	0	3	3	3	0	0	1	4	0	0	0	10	13	14	182
Critically Dry	0	0	0	0	0	1	3	0	0	1	1	0	0	0	5	16	6	224
All Water Years	**0**	**0**	**0**	**0**	**6**	**9**	**7**	**0**	**0**	**2**	**8**	**0**	**0**	**0**	**23**	**82**	**32**	**1148**
Alternative A2																		
Wet	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	24	1	336
Above Normal	0	0	0	0	1	5	1	0	0	0	2	0	0	0	5	16	9	224
Below Normal	0	0	0	0	3	2	0	0	0	0	0	0	0	0	4	13	5	182
Dry	0	0	0	0	4	3	3	0	0	1	4	0	0	0	10	13	15	182
Critically Dry	0	0	0	0	3	1	6	0	0	4	1	0	0	0	10	16	15	224
All Water Years	**0**	**0**	**0**	**0**	**11**	**11**	**10**	**0**	**0**	**5**	**8**	**0**	**0**	**0**	**30**	**82**	**45**	**1148**
Alternative B1																		
Wet	0	0	0	0	0	1	0	0	0	0	1	0	0	0	2	24	2	336
Above Normal	0	0	0	0	1	4	1	0	0	1	6	0	0	0	6	16	13	224
Below Normal	0	0	0	0	2	1	0	0	0	4	2	0	0	0	6	13	9	182
Dry	0	0	0	0	3	4	3	0	0	2	5	0	0	0	10	13	17	182
Critically Dry	0	0	0	0	0	1	3	4	6	1	1	0	0	0	9	16	16	224
All Water Years	**0**	**0**	**0**	**0**	**6**	**11**	**7**	**4**	**6**	**8**	**15**	**0**	**0**	**0**	**33**	**82**	**57**	**1148**
Alternative B2																		
Wet	0	0	0	0	0	1	0	0	0	0	2	0	0	0	2	24	2	336
Above Normal	0	0	0	0	1	5	1	0	0	1	11	0	0	0	6	16	13	224
Below Normal	0	0	0	0	3	2	0	0	0	4	2	0	0	0	6	13	9	182
Dry	0	0	0	0	4	4	3	0	0	2	5	0	0	0	10	13	17	182
Critically Dry	0	0	0	0	3	1	6	5	6	4	1	0	0	0	9	16	16	224
All Water Years	**0**	**0**	**0**	**0**	**11**	**13**	**10**	**5**	**6**	**11**	**21**	**0**	**0**	**0**	**33**	**82**	**57**	**1148**

Table H-1. Recirculation: Frequency of Occurrence by Water Year Type for Each Alternative Plan for Water Years 1922–2004

Water Year Type	Oct	Nov	Dec	Jan	Feb	Mar	Apr 1-15	Apr 16-30	May 1-15	May 16-31	Jun	Jul	Aug	Sep	Annual	Years Modeled	Periods with Recirculation	Periods Modeled
Alternative C																		
Wet	0	0	0	0	1	1	2	0	0	2	2	0	0	0	6	24	8	336
Above Normal	0	0	0	0	2	5	2	0	1	2	12	0	0	0	13	16	24	224
Below Normal	0	0	0	0	4	5	5	0	2	6	4	0	0	0	11	13	26	182
Dry	0	0	0	0	5	6	8	0	0	4	9	0	0	0	11	13	32	182
Critically Dry	0	0	0	0	3	1	6	9	9	4	2	0	0	0	13	16	34	224
All Water Years	**0**	**0**	**0**	**0**	**15**	**18**	**23**	**9**	**12**	**18**	**29**	**0**	**0**	**0**	**54**	**82**	**124**	**1148**
Alternative D																		
Wet	2	0	0	0	1	1	2	0	0	2	2	0	0	0	7	24	10	336
Above Normal	0	0	0	0	2	5	2	0	1	2	12	0	0	0	13	16	24	224
Below Normal	0	0	0	0	4	6	5	0	2	6	4	0	0	0	11	13	27	182
Dry	0	0	0	0	5	7	8	0	0	5	9	0	0	0	11	13	34	182
Critically Dry	0	0	0	0	5	7	10	9	9	11	2	0	0	0	14	16	53	224
All Water Years	**2**	**0**	**0**	**0**	**17**	**26**	**27**	**9**	**12**	**26**	**29**	**0**	**0**	**0**	**56**	**82**	**148**	**1148**

Notes:

The frequency of occurrence is the number of years with recirculation modeled for the given semi-monthly, monthly, or annual period for each water year type.

There are 14 periods per year and 82 water years modeled (24 Wet years, 16 Above Normal years, 13 Below Normal years, 13 Dry years, and 16 Critically Dry years).

the Vernalis Adaptive Management Plan[1] and non-Plan portions of April and May being averaged prior to averaging across months.

Weighted Index = Σ Monthly Weighted Index/M

Where: M = number of months in year when recirculation could occur

VAMP and non-VAMP periods in April and May were averaged to calculated averages for these two months individually, before averaging across months.

Sacramento-San Joaquin River Delta

By increasing flow in the lower SJR and increasing Delta exports, the project could alter the hydrodynamics of the Delta in ways that are beneficial or detrimental to certain species of fish. Direct effects of export and flow changes could include changes to the frequency, magnitude, and duration of reverse flows (defined as a southward flow direction in Old and Middle rivers), total Delta outflow, and export/inflow ratio. Flow and export changes could cause indirect effects including changes in the location of X2 and other indicators of habitat and water quality.

Changes in total exports caused by recirculation could lead to changes in the total entrainment and salvage of fish at the CVP and SWP pumping plants. Mortality rates of entrained and salvaged fish vary by species. Additional effects, not accounted for in salvage, also include increased predation along the approaches to the pumps, and losses occurring when fish are drawn from more favorable to less favorable habitat in the central and southern Delta. Increases in the entrainment and salvage of special-status and Endangered-Species-Act-listed fish species would translate to direct take.

The mixing of Sacramento River water into the SJR during recirculation, combined with potential hydrodynamic changes in the Delta, could interfere with the ability of salmon and steelhead to home to their natal streams and could lead to an increase in straying in some runs. Recirculation could interfere with salmonid homing in three ways: (1) by interfering with the proper imprinting of outmigrating smolts in the SJR, (2) by masking the scent of the SJR, or (3) by causing false attraction of fish originating in the Sacramento River to the SJR.

Within the Delta, four parameters were reviewed to rank the alternative plans for the PFR. These parameters are exports, entrainment, reverse flow, and Delta

[1] The Vernalis Adaptive Management Plan is a long-term experimental flow release program on the SJR intended to assess how salmonid emigration success from the SJR basin to San Francisco Bay can be improved. The releases under this plan generally occur in April and May. For this analysis, ENTRIX has assumed that they occur between April 16 and May 15, although in practice this timing changes from year to year.

outflow. Changes in export timing and volume are a primary project effect in the Delta. Changes in export volume and timing affect the entrainment of fish at the SWP and CVP pumps and also have a strong affect on reverse flows in Old and Middle rivers and Delta outflow. However, looking at overall export volume cannot address entrainment, as the vulnerability of a species can change by more than an order of magnitude from one month to the next, and the vulnerability of the different species varies considerably. Therefore, the effects of the alternative plans on entrainment are considered separately. Delta outflow and reverse flows in Old and Middle rivers are affected by exports, but also by Delta inflows as well as in-Delta uses. Therefore, these parameters are also included in the PFR ranking evaluation.

Delta Outflow Delta outflow is a general indication of habitat conditions in the Delta because of its effect upon salinity gradients and fish movement. It is not considered an indicator in and of itself for any of the listed species.

Delta outflow is believed to affect the dispersal of fish species, such as Delta smelt, longfin smelt, and striped bass to the estuary (closely related to X2). Delta outflow is also believed to have an important influence for outmigrating juvenile salmon and steelhead to successfully exit the Delta on the way to the ocean; however, these relationships are not well established.

Approach. Delta outflow data were compiled from Net Delta Outflow computed from California Simulation Model II (CalSim II) modeling for the 72-year simulation period in cubic feet per second (cfs) for each month on record. Delta outflow data were evaluated when recirculation occurs to determine whether outflow increases or decreases during implementation of the alternative plans relative to the No-Action Alternative.

Ranking Criteria Generally speaking, increases in Delta outflow would be considered beneficial, while decreases would be considered adverse. To evaluate project effects on Delta outflow, Delta outflow was tabulated by month and water year type and compared to the No-Action Alternative conditions. A 10% change in outflow was established as a threshold level, based on the error inherent in standard hydrologic measurements (Hirsh and Costa 2004; Gordon et al. 1992) and in the modeling process, which only approximates actual operations. The following significance criteria for the EIR/EIS are based on review of data and discussions with the FTWG.

- A reduction in Delta outflow of more than 10%, occurring with a frequency of more than 10% during any month, would be considered a significant adverse impact.

- An increase in Delta outflow of more than 10%, occurring with a frequency of more than 10% during any month, would be considered a significant benefit.
- A change in Delta outflow of less than 10%, occurring less than 10% of the time during any month, would be considered less than significant.

For the PFR, alternative plans with weighted indices for Delta outflow that differ by less than 10% in a month would be considered to have similar biological effects. A change in the weighted index of at least 10% would be considered substantial for purposes of comparing alternative plans in the PFR.

Combined Exports. Changes in export timing and volume are a primary project effect in the Delta. Changes in export volume and timing affect both the entrainment of fish at the SWP and CVP pumps and also have a strong affect on reverse flows in Old and Middle rivers and Delta outflow.

Approach To rank the alternative plans, the monthly average exports from February through June (the months when recirculation would occur) were calculated by water year type for each alternative plan using CalSim II results (**Appendix A**).

Ranking Criteria A weighted average (weighted index, described in **Section H2.2**) was calculated from the monthly averages based on the relative proportion of different water year types. Alternative plans for which the weighted index values agree to within 5% (the sensitivity levels described in the FTM[2]) were considered to have similar ecological effects for purposes of comparing alternative plans in the PFR.

Reverse Flows Reverse flows (also known as upstream flows) occur in the southern Delta when in-Delta, SWP, and CVP exports are greater than the inflow from the SJR. When this scenario occurs, water is drafted across the Delta from the Sacramento River, and/or water can be drawn upstream from eastern Suisun Bay into the Delta, creating a reverse flow in the primary conveyance channels in the southern Delta, primarily Old and Middle rivers and their interconnecting channels. Reverse flows can impact resident and anadromous fish species by drawing them into the southern Delta and increasing the potential for their entrainment into the CVP and/or SWP southern Delta pumping facilities. Reverse flows also create habitat conditions less favorable to some species in the central and southern Delta. In addition, reverse flows in the southern Delta may increase salmonid straying rates (Mesick 2001).

[2] The FTM did not address changes in exports specifically, relying instead on other parameters. However, it is used here as an overarching parameter. Because exports are linearly related to entrainment in a given month and water year type, the 5 percent sensitivity level described for entrainment is used here as well.

Approach Changes in annual patterns of reverse flow were analyzed using the Delta Simulation Model II (DSM2) model, described in **Appendix B**.

Ranking Criteria The following significance criteria for the EIR/EIS were based on the recommendations in the Pelagic Fish Action Plan (*California Department of Water Resources* and *California Department of Fish and Game* 2007) and on discussions with the FTWG:

- During January 1 through February 15, an increase in the frequency of upstream (reverse) flows greater than 4,000 cfs would be considered significant.
- During January through April 15, positive downstream flow through Old and Middle rivers should be maintained and any increase in the magnitude or frequency of upstream (reverse) flows would be considered significant.

To rank the alternative plans, the sum of flows in Middle and Old rivers was calculated, and evaluated for the selected periods. During January 1 through February 15, the number of days where the total reverse flow is greater than 4,000 cfs (a “reverse flow of greater than 4,000 cfs” is equivalent to a CalSim II modeled “flow of less than -4,000 cfs”) was enumerated for each alternative plan. The alternative plans that result in a 10% increase in the frequency of days with reverse flows of this magnitude were considered to have greater biological impacts to Delta quality than those with a lower frequency.

For the January 1 through April 15 period, the number of days reverse flow was reduced (made more positive) or increased (made more negative) relative to No-Action Alternative was enumerated. Flows within 10% of the No-Action Alternative were considered to be the same. The reverse flow index was calculated by subtracting the daily indices for adverse effects from that for beneficial effects, to calculate a net score. Values differing by more than 10% were considered to have different ecological effects.

Entrainment Index. Implementation of the alternative plans would affect the amount of water pumped at the SWP and CVP southern Delta pumping facilities. The amount of water pumped at these facilities, both directly and indirectly, affects fish survival within the Delta (U.S. Fish and Wildlife Service 2005). The number of fish lost due to pumping operations is believed to be proportional to the numbers entrained and collected by salvage for those fish large enough to be effectively salvaged (fish greater than 25 mm). Survival of fish species entrained in the CVP and SWP southern Delta pumping facilities is generally considered to be low, especially for certain species and/or life stages, such as young Delta smelt, which are believed to be underrepresented in the salvage data and are sensitive to handling impacts during and after salvage.

Mortalities of juvenile salmon and steelhead also are proportional to entrainment and salvage. In addition to salvage and entrainment at the pumping facilities, exports may also increase losses due to predation along the approaches to the pumps. These predation losses are influenced by operation of the pumps, in that exports can draw vulnerable fish into areas where predator densities are higher. Therefore, increased salvage numbers are considered to represent an overall adverse effect of an action or project upon fish resources.

The magnitude of losses resulting from export operations is a function of the magnitude of monthly water exports from each facility (CVP or SWP), the relative abundance of fish that are exposed to entrainment near the export facilities, and the vulnerability of species and life stages. When fish abundance near the export facilities, as indicated by salvage, is high and export flows also are high, fish losses are more likely to be high, as well. When export pumping is low or fish densities are low, losses would be expected to be low.

Approach An approach has been developed to evaluate the relative amount of entrainment that might be experienced at the CVP and SWP export facilities. This approach combines data developed by Reclamation on the number of fish salvaged by month and hydrologic condition (wetter or drier conditions) and the amount of water exported via the pumps as predicted by the CalSim II model, for both the Federal and State facilities. This information was used to develop an index of the relative impact to different species and life stages.

This evaluation followed Reclamation’s approach from the Operating Criteria and Plan Biological Assessment (National Marine Fisheries Service 2004) and used historical salvage data at the SWP and CVP pumping facilities for the period 1993–2004 to calculate salvage density by species and month for wetter and drier hydrologic conditions. Salvage densities were calculated by totaling species salvage by month for each export facility and dividing by the appropriate volume pumped, which provided salvage densities by species for each export facility for each month and year of the evaluation. These densities were then averaged by water year condition to derive average salvage densities by species, month, and hydrological condition; wetter years consisting of Wet and Above Normal water years, and drier conditions consisting of Below Normal, Dry, and Critically Dry water years.

The entrainment index for operational alternative plans is calculated by multiplying the volume of water pumped at a facility in a month (as determined from the CalSim II model) by the salvage density (those fish removed at the facilities for transport and release at a western Delta site) for the appropriate month and water year condition for each species. The results for the two export facilities are totaled by month and year. Average calculated salvage by month (long-term average) is produced and tabulated for the overall evaluation period by water year type. This information can then be used to evaluate the potential effects of the DMC Recirculation Project on fish species found in the Delta.

The values calculated are considered an index, as this approach will not precisely calculate the number of fish entrained by the CVP and SWP facilities or account for associated effects of pumping and salvage (i.e., predation, handling mortality). Nor will this approach calculate the loss of entrained organisms generally underrepresented in the salvage data or lost due to negative flows in Old and Middle rivers that may draw fish from more favorable to less favorable habitats. However, it seems reasonable to assume that the relationship between export rates and these factors would be the same for all alternative plans with and without the DMC Recirculation Project and, thus, that this index would provide a useful tool to assess potential project effects.

Underlying assumptions of this analysis include:

1. Historical (1993–2004) species salvage densities that include the period of the pelagic organism decline effect are adequate for this analysis and sufficiently represent likely future densities for similar hydrological conditions.

2. Simulation of alternative plans over the historic period of record is sufficiently representative of future conditions under those alternative plans.

3. Factors not included in this analysis would not unduly affect the validity of the evaluation of the comparisons of alternative plans.

The entrainment index by species, by water year category, and for all years combined, will be considered when assessing impacts. The net change in the entrainment indices (from No-Action Alternative conditions) would indicate whether the alternative plans would result in a change in the entrainment index relative to what would be expected with the No-Action Alternative. Entrainment indices for late-fall run Chinook and green and white sturgeon will not be developed as the data available are not sufficient to support this type of analysis.

Ranking Criteria Export amounts were evaluated to calculate an entrainment index for each species of concern for which reliable data are available. Increases in the entrainment index indicate an increase in the total number of that species salvaged or potentially lost to entrainment or related causes, and are considered adverse. Given the sensitivities of the species involved, a change of 5% was selected as a conservative threshold for evaluating impacts, for all species except Delta smelt. This level is considered conservative given the uncertainties of the modeling and range of variability in salvage densities recorded at the CVP and SWP facilities (BDAT accessed in October 2007). Given the extreme sensitivity of Delta smelt, any increase in Delta smelt entrainment is considered significant. Entrainment will be evaluated monthly, but the significance criteria will be applied on an annual basis for all species except Delta smelt, the significance criteria for entrainment are:

- If the entrainment index increases by 5% or more annually in comparison to No-Action Alternative conditions, the impact would be considered significant.
- If the entrainment index decreases by 5% or more annually in comparison to No-Action Alternative conditions, the impact would be considered beneficial.
- If the entrainment index changes by less than 5% in comparison to No-Action Alternative conditions, the impact would be considered less than significant.

For Delta smelt:

- An increase in Delta smelt entrainment in any month would be considered significant.
- A decrease in Delta smelt entrainment in any month would be considered beneficial

To rank the alternative plans, the monthly average exports and entrainment from February through June (the months when recirculation would occur) were calculated by water year type for each alternative plan. A weighted average (weighted index, described in **Section H2.2**) was calculated from the monthly averages based on the relative proportion of different water year types. Alternative plans for which the weighted index values agree to within 5% (the sensitivity levels described in the FTM[3]) were considered to have similar ecological effects for purposes of comparing alternative plans in the PFR.

Salmonid Straying Potential. Straying rates of Central Valley fall-/late-fall-run Chinook salmon, Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, and Central Valley steelhead could be affected by the DMC Recirculation Project. The project is expected to affect the hydrology of the lower SJR and southern Delta when recirculation is occurring, and cause higher proportions of exported Sacramento River water to be sent down the SJR. The mixing of Sacramento River water with SJR water, combined with potential changes in Delta hydrodynamics (i.e., reverse flows), could hinder the abilities of SJR Chinook salmon and steelhead juveniles and

[3] The FTM did not address changes in exports specifically, relying instead on other parameters. However, they are used here as an overarching parameter. Because exports are linearly related to entrainment in a given month and water year type, the 5 percent sensitivity level described for entrainment is used here as well.

smolts to imprint effectively during emigration. It could also affect the ability of adult Chinook salmon and steelhead from all areas to home from the ocean to their natal streams during the upstream migration period. The result could be increased straying of salmon and steelhead.

Sacramento River water is a component of the water exported at the SWP and CVP facilities, so a portion of Sacramento River water already flows down the SJR, as it is used to irrigate crops within the SJR watershed and flows into the SJR as agricultural drainage. It is not known how the chemical signature of this water (or that of native SJR water) is changed during this process.

The presence of a large component of Sacramento River water in the SJR during the emigration season could impair the imprinting of SJR salmonids. Juvenile salmonids imprint on the sequence of olfactory chemical cues encountered in the river system as they migrate downstream. For instance, a salmon migrating out of the Merced River and down the SJR would encounter olfactory cues from the SJR and each tributary, in turn, including the Tuolumne and Stanislaus rivers, as it passes downstream. These sequences are then used in reverse order as an aid to navigation when the fish returns during its upstream migration.

Adult salmonids home to their natal stream to spawn primarily using olfactory environmental cues. The unique chemical composition of streams provides the olfactory stimulus that adult salmonids search for as they migrate upstream. When these individuals return to freshwater as adults, they search for the sequence of stream confluences and chemical cues in reverse order. Once the natal stream is found, the fish use visual and tactile cues to proceed upstream to locate substrate, depth, and velocity conditions suitable for spawning (Quinn 1993, 2005).

Juveniles outmigrate in winter and spring and adults return in late summer and fall. These two periods typically have very different flow conditions, with spring conditions sometimes supported by local runoff, the beginning of the irrigation season, and the potential for recirculation flows, whereas fall conditions are dominated by low run-off conditions often composed of large amounts of agricultural return flows and low probability for recirculation flow. When juvenile salmon return as adults, if recirculation is not occurring, these fish may be induced to enter the Sacramento River, rather than the SJR, because of this missing volume of Sacramento River water (source fraction) in the fall compared to what was available in the spring. Even if the fish do eventually enter the right river, they may be confused and delayed in the Delta, which may reduce their fitness and spawning success. If the natal stream cannot be found, adult fish will at some point select a stream and proceed to find suitable spawning habitat. Some natural straying occurs within all populations of salmonids and allows for the colonization of new habitats (Quinn 2005). However, in many watersheds, such as the Central Valley, anthropogenic causes have resulted in increased straying rates.

Hatchery-origin salmon and steelhead runs in the Central Valley already exhibit high straying rates primarily due to the downstream transport and release of hatchery-reared juveniles, often many miles from the hatchery. These fish are more susceptible to false flow cues because of the lack of imprinting as a result of their being transported around their river system. Therefore, it is anticipated that any change in straying rates due to the DMC Recirculation Project would have to be large to be detectable over existing rates.

Fretwell (1989) showed experimentally that sockeye salmon could detect a source-water change greater than 10%, and a source-water change greater than 20% could cause a significant number of fish to change migration course. Fretwell's experiment took place in the Fraser River system of British Columbia and involved tracking adult sockeye as they chose between pure home streamwater and home streamwater diluted with various percentages of water from another tributary. In the experiment sockeye were observed to choose pure home streamwater over home streamwater diluted with as little as 20% tributary water in significant numbers. Although the experiment did not indicate what conditions would cause the salmon to stray completely from home streamwater, it did show the sensitivity of sockeye to a source-fraction change. Based on life history type, Chinook salmon and steelhead presumably have a similar or lesser degree of stream fidelity, and home stream sensitivity, than sockeye (Quinn 2005). Therefore, the analysis of straying effects will focus on project-affected areas that have a change in source-water fraction greater than 20%. Once these areas are identified, it must be determined whether the project has significantly altered the sequence of water sources experienced by migrating salmon and steelhead sufficiently to cause straying. Each population (run) of salmon potentially affected by the project must be analyzed individually. Fall-run Chinook are likely to be affected differently than spring- and winter-run Chinook. Hatchery fish that have been trucked downstream will be affected differently than fish that have experienced a natural downstream migration. Both juvenile and adult fish from the SJR drainage could be affected. Only adult fish originating from the Sacramento River would be affected.

Approach Personal communication with Dr. Thomas Quinn of the University of Washington, an expert on salmonid straying, indicates that little is known about how much of a change in the chemical composition of the source water or the sequence of olfactory clues can occur without inducing additional straying (Quinn, pers. comm., 2007). Consequently, only a qualitative assessment of project effects on straying was conducted. The fraction of different source waters under each alternative plan was estimated using the DSM2 model. The change in these fractions under the alternative plans relative to the No-Action Alternative will be compared. Larger changes in the composition of source water indicate a higher likelihood of induced straying. Source-water fractions were evaluated in the SJR, Old River, and Middle River along the paths that salmonids would follow to enter the SJR proper.

Source-water mixing may affect adult straying, juvenile imprinting, or both. Several different kinds of impacts may be possible based on which life history stages are affected.

Ranking Criteria Alternative plans for which the source-fraction-weighted indices change less than 20% (the sensitivity level described in the FTM) are considered to have similar ecological effects for purposes of comparing alternative plans for the PFR. A change of 20% or more from the No-Action Alternative or between alternative plans would be considered significant.

Dissolved Oxygen. DO problems have been documented in the Stockton Deepwater Ship Channel (DWSC). The effects of recirculation on these problems were assessed through comparison of flow levels with flow-DO relationships for the DWSC. As described in **Appendix F, Section F2.1.5**, when flows are reduced below approximately 2,000 cfs, DO concentrations begin to decrease below water quality objectives (WQOs). The DMC Recirculation Project is not anticipated to result in increased impairment of DO in other areas of the Delta. In these areas, low DO is associated with high biological and chemical oxygen demand resulting from operation of barriers and discharges into Delta waterways, which lead to algae blooms that increase the demand for DO. The project will not affect these factors.

Approach A relationship between DO and flow in the DWSC was determined using existing data, and this relationship was used to predict changes to DO based on flow predictions under each alternative plan. It is recognized that many other factors can affect DO levels, such as nutrient loading and algal blooms. However, the DO versus flow curves are sufficient for a comparative analysis of the alternative plans.

Ranking Criteria For purposes of comparing alternative plans, a reduction of more than 10% of periods from February to June for which the WQO is not predicted to be met would be considered a beneficial impact. A change of more than 10% between alternative plans would be considered significant. None of the alternative plans is expected to result in an increase in the number of periods when the WQO would not be met.

Other Water Quality Parameters . Other water quality parameters such as pesticides and metals will be evaluated when pilot study results are available.

San Joaquin River

Recirculation would increase flow in the lower SJR with out-of-basin water, potentially affecting both chemical and physical habitat characteristics and could, therefore, affect habitat suitability for some fish species. However, modified operations of both project and nonproject facilities (i.e., increased riparian diversions) along the lower SJR, as a result of increased flows, may reduce these potential affects. The project is generally expected to increase flows in the SJR when recirculation is occurring. This increase is expected to provide somewhat more habitat than is present under nonproject conditions.

Water quality and fish toxicity impacts to the SJR near the wasteways are of particular concern. These potential impacts would be associated with the possible mobilization of sediment and contaminants from past, present, and future agricultural drainage from the wasteways into the SJR. The “first flush” of water through the wasteways may displace resident water in the wasteways and scour accumulated fine sediment, which would increase turbidity levels and potentially introduce high contaminant and organic carbon loads into the lower SJR. The biochemical oxygen demand of the first flush may also be high enough to affect DO levels in the SJR.

As discussed in PFR **Section 2.2.4**, the targeted changes in electrical conductivity at Vernalis are for agricultural needs and not for fish and wildlife needs. These standards translate to approximately 0.5 ppt salinity. The DMC Recirculation Project would reduce salinities that range up to about 1 ppt down to about 0.5 ppt. Salinity values this low would not affect the principal management species, as these species are all euryhaline and can easily tolerate changes in salinities in this range. These small changes in salinity, by themselves would not substantially affect conditions in the lower SJR or the Delta for fish, although the flows associated with achieving these reductions could affect conditions.

By influencing the flow patterns of the lower SJR, the DMC Recirculation Project could change the characteristics of physical habitat available to fishery resources utilizing the area and subsequently affect rearing, migration, and survival. The largest effect is expected to be changes in the water composition (source fraction) of the lower SJR, through introduction of Sacramento River water. These changes have the potential to affect imprinting and straying of Chinook salmon and steelhead into, or within, the SJR basin.

Flow. Recirculation would increase SJR flows relative to the No-Action Alternative. Alternative plans resulting in a difference in the weighted flow index of at least 10% over those predicted under the No-Action Alternative would generally be expected to have greater habitat value. Similarly, a difference in the weighted flow index of at least 10% between alternative plans would be considered a substantial difference. Alternative plans for which the weighted flow index differs by less than 10% would be considered equivalent.

Salmonid Straying Potential. Most straying for upstream migrants is expected to occur in the Delta, where immigrants would be faced with commingling water sources in a tidally influenced environment and would need to select whether to move up the Sacramento River, Mokelumne River, or SJR. Migrating adults can move substantial distances up and downstream in search of their natal stream odor, sometimes resulting in delays to their upstream migration. Adults will continue to seek out their natal stream influenced by their pending maturation, which may accelerate a decision to select one river over another. At that time, once these fish have selected a course, they are likely to stay with that choice.

Once in the SJR, salmonids would need to find the Stanislaus, Tuolumne, or Merced rivers. It is possible that the addition of Sacramento River water in the SJR could affect the fish's ability to find their natal stream. A greater proportion of Sacramento River water in the SJR may also result in fish that were natal to the Sacramento River being attracted to go up the SJR. Once these fish have committed to this source, they may choose to spawn in the SJR system, possibly with SJR origin fish, rather than returning to the Delta to seek the Sacramento River.

Approach A qualitative assessment of project effects on straying was conducted based on the change in proportion of various source waters at different locations as described for the Delta. The periodicity of these changes will be compared to that of the salmon life history stages present in the Delta to determine potential impacts. This measure also incorporates the fraction of non-SJR source water in the SJR, as this is inversely related to the proportion of SJR water. This Sacramento River and Delta water may cause Sacramento River origin fish to stray up the SJR.

Salmonid straying would be evaluated as described in the Delta section. Once fish have entered the SJR, potential for straying will be qualitatively evaluated based on the source fractions of the water below the confluence of each major tributary. Once fish enter one of the tributary streams, they would no longer be influenced by Sacramento River water, and additional straying would not be expected.

Another project effect would be to introduce a proportionately larger volume of Delta and Sacramento River source water into the SJR, relative to what occurs now from agricultural runoff. As discussed in the FTM, this introduction has the potential to cause salmonids to stray from their natal streams. For the ranking analysis in the PFR, ENTRIX looked at the change in the proportion of local SJR water in the SJR below the Merced River and at Vernalis. The SJR below the Merced station was selected because it would provide the strongest signal of the potential for inducing salmonid straying. Vernalis is used because it is analogous of the water that would be present where salmonids enter the SJR and, thus, provides the source-fraction components for fish exiting the Delta on their way upstream. Under the No-Action Alternative, the water in SJR below Merced and at Vernalis is assumed to consist of SJR source water only.

Ranking Criteria Alternative plans were ranked based on the predicted change in the weighted index for the proportion of SJR water present. As the proportional change that would cause additional straying cannot be identified, a raw ranking was employed.

For purposes of comparing alternative plans in the PFR, a change in the entrainment index of more than 20% between alternative plans would be considered substantial.

Temperature

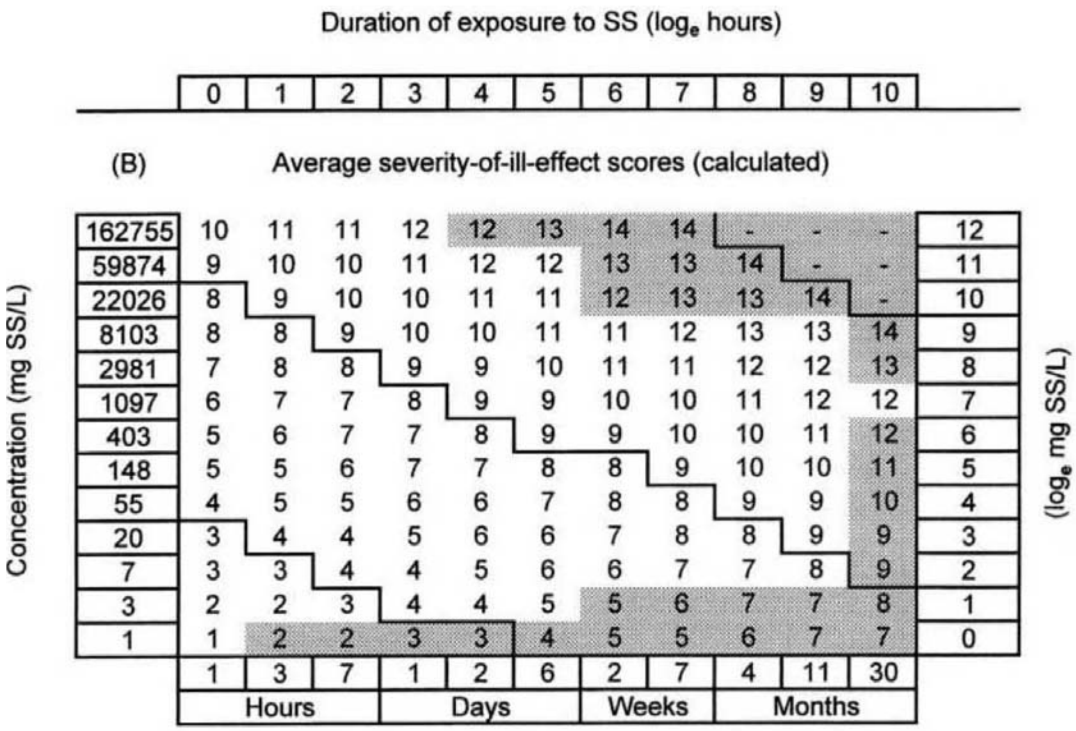
Approach The alternative plans were evaluated relative to their effect on water temperatures using the 20th percentile, median, and 90th percentile values of temperature by season. Unlike the analyses for other parameters, the temperature analysis was not limited to periods when recirculation was occurring. Because recirculation can result in changes in storage at New Melones Reservoir, the temperature of releases below the reservoir could be affected during periods when recirculation is not occurring. Thus, the temperature analyses include the entire period of record described in the temperature modeling appendix (**Appendix C**). The SJR is a migration corridor for salmonids, but is not used for spawning or primary rearing habitat. Three seasons were evaluated: January–April, when juvenile Chinook salmon and steelhead are emigrating and adult steelhead are immigrating; May–June, when emigration for both species is occurring; and October–December, when upstream migration for adult Chinook and some steelhead is occurring. While recirculation does not occur during the October–December period, changes in water storage in New Melones Reservoir resulting from recirculation could affect temperatures in this time period. The SJR at Vernalis was used for this evaluation. Water temperatures were modeled for this station using the SJR HEC-5Q temperature model, and the 20th percentile, median, and 90th percentile values for each time period were calculated. The 90th percentile value (the temperature for which 90% of datapoints are less and 10% are greater) for each water year type and location was used to compare alternative plans.

A supplemental analysis was carried out based on the difference between the modeled temperatures for the alternative plan and the No-Action Alternative for each 6-hour time step modeled, rather than the monthly values. This analysis looks at the finer resolution data and may reveal patterns of consistent temperature increases that may not be observed in the direct comparison of monthly temperature values.

Ranking Criteria A predicted change of at least 0.9 degree Fahrenheit (°F) in 90th percentile monthly water temperature is used to differentiate among alternative plans for purposes of comparing alternative plans in the PFR. A change of at least 0.9°F was never predicted to occur for any of the other percentile levels evaluated. This level of change was selected as a conservative estimate of the temperature changes that could affect salmonids.

Suspended Sediment. Turbidity is a commonly used measure of light transmittance in water, but is influenced by numerous factors that have different effects on fish (algal community composition, water color, suspended solids, etc.). During recirculation through Newman Wasteway, the flow of water down the wasteway will result in disturbance and suspension of fine sediment particles from the bed of the wasteway. These suspended sediments may adversely affect fish by reducing visibility and, thus, their feeding efficiency, and at very high concentrations, by clogging or abrading their gills. Suspended sediment concentrations can also adversely affect salmonid homing and can cause physiological stress in fish.

Approach TSS concentrations were modeled (see **Appendix D**) and evaluated relative to literature-based information (Newcombe and Jensen 1996) on the effects of suspended sediment concentrations on juvenile and adult salmonids (**Figure H-2**). The effect of recirculation on TSS in the SJR from Newman Wasteway downstream to the Tuolumne River confluence was evaluated based on the TSS model described in **Appendix D**. These values were converted to severity-of-ill-effects values (SEVs) based on the formula for adult and juvenile salmonids in Newcombe and Jensen (1996).



Duration of exposure to SS ($\log_e$ hours)

(B) Average severity-of-ill-effect scores (calculated)

Concentration (mg SS/L)	0	1	2	3	4	5	6	7	8	9	10	($\log_e$ mg SS/L)
162755	10	11	11	12	12	13	14	14	-	-	-	12
59874	9	10	10	11	12	12	13	13	14	-	-	11
22026	8	9	10	10	11	11	12	13	13	14	-	10
8103	8	8	9	10	10	11	11	12	13	13	14	9
2981	7	8	8	9	9	10	11	11	12	12	13	8
1097	6	7	7	8	9	9	10	10	11	12	12	7
403	5	6	7	7	8	9	9	10	10	11	12	6
148	5	5	6	7	7	8	8	9	10	10	11	5
55	4	5	5	6	6	7	8	8	9	9	10	4
20	3	4	4	5	6	6	7	8	8	9	9	3
7	3	3	4	4	5	6	6	7	7	8	9	2
3	2	2	3	4	4	5	5	6	7	7	8	1
1	1	2	2	3	3	4	5	5	6	7	7	0
	1	3	7	1	2	6	2	7	4	11	30	
	Hours			Days			Weeks		Months			

Figure H-2. Severity-of-Ill-Effects Scores from Suspended Sediment Concentrations from Newcombe and Jensen (1996)

Using empirical data, Newcombe and Jensen (1996) developed the following equation to calculate the severity of ill effect for juvenile and adult salmon:

$$z = 1.0642 + 0.6068(\log_e x) + 0.7384(\log_e y)$$

Where:

z = severity-of-ill-effect score

x = duration (hours)

y = concentration of suspended sediment (mg/L)

Ranking Criteria Potential effects were evaluated based on the change in TSS and duration of exposure relative to the baseline conditions. These changes will be evaluated based on the SEVs developed by Newcombe and Jensen (1996). They established four major classes of effects, as indicated by the diagonal lines on **Figure H-2** and the subheadings in **Table H-2**: (1) no effect, (2) behavioral effects, (3) sublethal effects, and (4) lethal effects. A change from one of these categories to another would be considered significant.

Table H-2. Newcombe and Jensen Table 1 – Scale of the Severity-of-Ill-Effects Values Associated with Excess Suspended Sediment

SEV	Description of Effect
Nil effect	
0	No behavioral effects
Behavioral effects	
1	Alarm reaction
2	Abandonment of cover
3	Avoidance response
	Sublethal effects
4	Short-term reduction in feeding rates: short-term reduction in feeding success
5	Minor physiological stress: increase in rate of coughing increased respiration rate
6	Moderate physiological stress
7	Moderate habitat degradation: impaired homing
8	Indications of major physiological stress: long-term reduction in feeding rate long-term reduction in feeding success poor condition
Lethal and paralethal effects	
9	Reduced growth rate: delayed hatching reduced fish density
10	0-20% mortality: increased predation moderate to severe habitat degradation
11	>20-40% mortality
12	>40-60% mortality
13	>60-80% mortality
14	>80-100% mortality

A fair degree of uncertainty exists in this analysis for two reasons:

1. Monthly averaging of TSS values. Fish are sensitive to the concentration of suspended sediments depending on the duration of their exposure. The timeframe for effects to be seen can be a matter of hours. The monthly time step used in the modeling may not be indicative of the peak suspended sediment values that occur in shorter timeframes. The use of monthly average flow values may not provide a good estimate of peak suspended sediment concentrations (SSCs).

2. Use of TSS instead of SSC. Newcombe and Jensen's work was based on SSC. TSS and SSC "are not comparable and should not be used interchangeably" (Gray et al. 2000). According to Gray et al. (2000), this difference stems from subsampling procedures usually associated with TSS laboratory methods and is less pronounced when less than 25% of the sample is sand. Because it is assumed that only the clay and silt fractions of sediment remain suspended in water entering the SJR, the difference between TSS and SSC may be negligible in this case.

Other Water Quality Parameters Other water quality parameters such as pesticides and metals will be evaluated when pilot study results are available.

Stanislaus River

For the PFR, the factors evaluated to compare alternative plans included flow and temperature in the Stanislaus River. Straying rates of Chinook salmon and steelhead using the Stanislaus River would be affected primarily in the Delta and are evaluated in that section. As the Stanislaus River enters the SJR just upstream of Vernalis, the likelihood of affecting upstream migrant fish once they have entered the SJR would be minimal. Straying from the Stanislaus River could occur if the contribution of Stanislaus River water to the SJR total flow was substantially reduced. Once these fish enter the Stanislaus River, no difference in source water or olfactory clues would result from project operations. For downstream migrants, the issues would be the same as those discussed for the SJR.

Flow The DMC Recirculation Project may cause flows in the Stanislaus River to decrease relative to existing conditions due to decreased releases from New Melones Reservoir that are currently made to meet Water Rights Decision 1641 requirements on the SJR. Decreases in flow may alter the amount of suitable habitat available to certain fish species and life stages.

Approach The modeled changes in flow resulting from the DMC Recirculation Project will be evaluated through a two-step process. Preliminary results indicate that flow changes on the Stanislaus River may be small, because compliance with other criteria often drives releases from New Melones

Reservoir. The magnitude of flow changes will be evaluated relative to the No-Action Alternative. If these changes are not substantial, their effects will be described qualitatively. If these flow changes are substantial, then the changes in the amount of physical habitat present will be evaluated using existing flow habitat relationships.

Ranking Criteria If the DMC Recirculation Project causes flows to decrease within the Stanislaus River enough to reduce the extent of suitable habitat for any life stage of salmon or steelhead, then the impact would be considered significant. The first step would be to look at the change in flow between the alternative plans and the No-Action Alternative. If this change is more than 10%, which is the accuracy with which flows can be measured (Hirsh and Costa 2004; Gordon et al. 1992), the second step would be to evaluate the change in physical habitat quantity and quality based on existing flow-habitat relationships for different lifestages of anadromous salmonids. A 20% threshold was selected based on the amount of error inherent in streamflow measurements and in the habitat suitability criteria used to generate the physical habitat index. The following thresholds were identified in the FTM:

- A reduction in quantity of available physical habitat of more than 20% would be considered a significant adverse impact.
- An increase in quantity of available physical habitat of more than 20% would be considered a benefit.

The DMC Recirculation Project would result in flow decreases on the Stanislaus River, although these decreases may be offset by the various water management criteria for the river. Flow levels affect both the amount and type of habitat available and the temperature of the river. These parameters are most important during the summer months in most California watersheds. Alternative plans that minimize flow reductions and keep summer water temperatures the coolest would be the most beneficial to fisheries resources. Temperature is likely the strongest factor affecting salmonid populations in the Stanislaus River, as indicated by the Operations Criteria and Plan Biological Opinion (National Marine Fisheries Service 2004), which established temperature standards, but did not establish flow standards, below Goodwin Dam.

For the PFR, a decrease in the weighted flow index of at least 10% between alternative plans would be considered a substantial difference. Alternative plans for which the weighted flow index differs by less than 10% would be considered equivalent.

Temperature The effects of the DMC Recirculation Project on flows in the Stanislaus River may also affect water temperatures. Water temperature increases may negatively affect salmonids.

Approach The alternative plans were evaluated relative to their effect on water temperatures using 20th percentile, median and 90th percentile values of temperature by season, as described above for the SJR. The Stanislaus River provides spawning and year-round rearing habitat for steelhead and spawning and seasonal rearing habitat for Chinook salmon for a few weeks or months prior to their emigration. So in addition to the seasons described above for the SJR, ENTRIX also evaluated temperatures changes in July–September, when juvenile Chinook salmon have left the system and young steelhead are rearing. Recirculation does not occur during this time; however, changes in storage in New Melones Reservoir resulting from recirculation have the potential to affect temperatures during this season. Two stations were used for this evaluation: Stanislaus River near Orange Blossom Bridge and at Riverbank. Water temperatures were modeled for these stations using the Stanislaus River HEC-5Q temperature model.

Other Water Quality Parameters Other water quality parameters such as pesticides and metals will be evaluated when pilot study results are available.

H.3 Results

The evaluation results for each alternative plan are summarized by region. In general, the tables in this appendix summarize the results using weighted indices or similar measures as described in **Section 2.2**. **Attachment H2** provides more detailed tables that show results by month and water year type.

H.3.1 Sacramento-San Joaquin River Delta

Delta Habitat

Changes in Delta habitat were evaluated using predicted changes from the No-Action Alternative in the weighted indices for Delta outflow, combined exports (**Table H-3**), and the frequency of reverse flows in Old and Middle rivers (**Reverse Flows The frequency of reverse flows greater than 4,000 cfs between January 1 and February 15 for the modeled period (1922–2004) is predicted to change by 4%, or less, for all modeled alternative plans relative to the No-Action Alternative (Error! Not a valid bookmark self-reference.). The effects of the alternative plans not modeled would be expected to be of similar magnitude. This low frequency of changes indicates minimal potential effects in this regard for all alternative plans.**

Table H-4).

Delta Outflow No substantial difference was observed among the alternative plans for Delta outflow (**Table H-3**). The greatest change predicted from the

No-Action Alternative was a 6% reduction in the weighted index for Delta outflow under Alternative B1. None of the alternative plans are predicted to result in a weighted index change relative to the No-Action Alternative of more than 10%; nor are any of the weighted indices for the alternative plans predicted to differ from the other alternative plans by more than 10%.

Combined Exports Combined exports under all alternative plans are predicted to increase by 5 to 11% compared to the No-Action Alternative. This change is substantive for all alternative plans based on the 5% criteria described in **Section 2.2.1**. The predicted changes under Alternatives A1, A2, C, and D are similar, ranging from 5 to 7%. Alternatives B1 and B2 are predicted to result in an 11% increase (4 to 6% greater than the other alternative plans).

Table H-3. Change in Weighted Index for Delta Outflow and Combined Exports in the Delta under Each Alternative Plan, Compared to the No-Action Alternative

	Alternative A1	Alternative A2	Alternative B1	Alternative B2	Alternative C	Alternative D
Change in Weighted Index for Delta Outflow	-4%	0%	-6%	0%	1%	2%
Change in Weighted Index for Combined Exports	7%	6%	11%	11%	5%	5%

Reverse Flows The frequency of reverse flows greater than 4,000 cfs between January 1 and February 15 for the modeled period (1922–2004) is predicted to change by 4%, or less, for all modeled alternative plans relative to the No-Action Alternative (Error! Not a valid bookmark self-reference.). The effects of the alternative plans not modeled would be expected to be of similar magnitude. This low frequency of changes indicates minimal potential effects in this regard for all alternative plans.

Table H-4. Change in Frequency of Reverse Flow in Old and Middle Rivers for Alternatives B1, B2, and D between January 1 and February 15, Compared to No-Action Alternative (1922–2004)

	Alternative B1	Alternative B2	Alternative D
Change in number of days with reverse flows above 4,000 cfs (< -4000 cfs)	0%	0%	0%
Change in Frequency at flow ranges (cfs): 0-2000	3%	4%	4%
2000-3000	1%	1%	0%
3000-4000	0%	0%	0%
4000-5000	0%	0%	0%
5000-6000	0%	0%	0%
>6000	-2%	-2%	-2%

Key:
cfs = cubic feet per second

Table H-5 shows a count of adverse and beneficial changes in combined Old and Middle River flows occurring as a result of recirculation relative to the No-Action Alternative. Beneficial changes are those that result in a 10% or more increase in flow toward Suisun Bay. Adverse changes are those that cause a 10% or greater increase in flows towards the CVP/SWP pumps (reverse flows). Flow changes of less than 10% in either direction are considered to be equivalent to the No-Action Alternative and are not counted. **Table H-5** shows that recirculation resulted in relatively few days when flows changed substantially (10% or more). Alternative D had the greatest number of days (185) with substantial flow changes, compared to a total of about 8,734 days in the modeled period (1922-2004). Thus, flows changed substantially in about 2% of the days. However, these days were sometimes grouped, some lasting as long as 44 days and, thus, could affect fish populations in individual years. These groupings were similar among the alternative plans considered. Within this context, the alternative plans would generally result in somewhat worse conditions than the No-Action Alternative during the January 1 through April 15 period. Alternatives B2 and D result in some beneficial changes in flow conditions as well, although they are not as numerous as the occasions when flows are adversely affected. Overall, all alternative plans result in minor adverse effects on reverse flows relative to the No-Action Alternative, but none performs substantially better or worse than any other.

Table H-5. Frequency of Beneficial and Adverse Changes (Number of Days) in Combined Old and Middle River Flows for Alternatives B1, B2, and D between January 1 and April 15 (1922–2004).

Frequency	Alternative B1	Alternative B2	Alternative D
Beneficial Changes	0	30	51
Adverse Changes	104	142	134
Net Score	-104	-112	-83

Entrainment

The weighted indices for entrainment of the various species are predicted to increase under all alternative plans by 3 to 16% over the No-Action Alternative (**Table H-6**). Alternatives A1, A2, C, and D, for which the entrainment index is predicted to increase by 5 to 7%, would result in potentially substantial impacts for most species evaluated. Under Alternatives B1 and B2 an 11 to 16% increase in the entrainment index is predicted; therefore, these alternative plans are expected to result in greater potential entrainment than the other alternative plans.

Salmonid Straying

Evaluation of the source-water fraction in the southern Delta found no substantial differences expected to occur relative to the No-Action Alternative (**Table H-7**). The biggest difference predicted is a 4% increase in the proportion of Sacramento River water in the SJR at Rindge Pump under Alternative D. This increase is substantially less than the 20% change that Fretwell (1989) found could cause significant number of sockeye salmon to stray. It is unlikely that such a small change would substantially affect the migratory behavior of salmonids more than is already occurring from changes in water circulation patterns within the Delta and hatchery release practices. Thus, the various alternative plans are considered to perform equivalently in the southern Delta with regard to their potential to increase straying.

Table H-6. Change in Weighted Index of Entrainment for Each Alternative Plan, Compared to the No-Action Alternative

	Alternative A1	Alternative A2	Alternative B1	Alternative B2	Alternative C	Alternative D
Pelagic Species						
Delta Smelt	7%	6%	13%	13%	6%	6%
Striped Bass	9%	8%	11%	11%	6%	5%
Longfin Smelt	4%	3%	10%	11%	5%	5%
Threadfin Shad	9%	8%	13%	14%	7%	6%
Salmonid Species						
Fall-run Chinook Salmon	5%	5%	14%	16%	7%	7%
Late Fall-run Chinook Salmon	7%	6%	10%	10%	4%	4%
Winter-run Chinook Salmon	5%	5%	13%	13%	5%	5%
Spring-run Chinook Salmon	5%	5%	13%	16%	7%	7%
Steelhead	7%	6%	13%	13%	6%	6%
Other Species						
American Shad	3%	3%	11%	13%	6%	6%
Splittail	6%	5%	12%	11%	5%	5%

Table H-7. Change in Weighted Index for Proportion of Nonsource Water in the Delta at Old and Middle Rivers near Bacon Island and at San Joaquin River near Rindge Pump–Weighted Index, Compared to No–Action Alternative

	Alternative B1	Alternative B2	Alternative D
Change in Weighted Index for Proportion of Sacramento River water at Old River (west of Bacon Island)	0%	0%	–1%
Change in Weighted Index for Proportion of San Joaquin River water at Old River (west of Bacon Island)	0%	0%	0%
Change in Weighted Index for Proportion of Sacramento River water at Middle River (near Bacon Island)	–1%	–1%	–2%
Change in Weighted Index for Proportion of San Joaquin River water at Middle River (near Bacon Island)	2%	1%	2%
Change in Weighted Index for Proportion of Sacramento River water at San Joaquin River at Rindge Pump	2%	2%	4%
Change in Weighted Index for Proportion of San Joaquin River water at San Joaquin River at Rindge Pump	–1%	–2%	–3%

Dissolved Oxygen

The DO prediction results for Alternatives B1, B2, and D are described in **Appendix F, Section F2.1.5**. Results indicate that DO is not expected to fall below the Central Valley Basin Plan WQO of 5 mg/L during Wet or Above Normal water years. However, for Below Normal, Dry, and Critically Dry water years, DO concentrations are predicted to fall below the WQO for some periods under the No-Action Alternative and the alternative plans evaluated (see **Table** H-8). Under the No-Action Alternative, DO concentrations are predicted to fall below the WQO during 17% of the periods during February through June for all 5 representative years combined. Under Alternatives B1 and B2, DO concentrations are predicted to increase from those predicted under the No-Action Alternative for all representative years combined. Under Alternative B1, DO concentrations are predicted to fall below the WQO in 9% of the periods and Alternative B2 in 9% of the periods for all 5 representative years combined. Under Alternative D, DO concentrations are predicted to increase more, so that predicted concentrations would fall below the WQO during 3% of the periods for all representative years combined.

Flows for Alternatives A1, A2, and C were not modeled at Brandt Bridge using DSM2, however, the results may be qualitatively interpolated based on the trend of the results. As flow and the number of recirculation periods increase, the percentage of recirculation periods for which the model predicts WQO (5 mg/L) is not met decreases as shown in **Table H-8**. Therefore, it is assumed that the DO results for Alternatives A1 and A2 would fall between the No-Action Alternative and Alternative B1 results and that Alternative C would be between the modeled results for Alternatives B2 and D.

Alternative D is the only alternative plan that would be considered to result in a substantial improvement to DO conditions in the DWSC, based on the 10% difference criteria.

Table H-8. Dissolved Oxygen Comparison for Alternative Plans Modeled

	No-Action Alternative	B1	B2	D
Number of periods when WQO (5 mg/L) is predicted not to be met	6	3	3	1
Percent of periods when WQO (5 mg/L) is predicted not to be met	17	9	9	3
Number of periods when WQO is predicted to be met due to recirculation	NA	3	3	5

Key:
mg/L = milligram(s) per foot
WQO = water quality objective

H.3.2 San Joaquin River

Flow

The weighted indices for flows in the SJR at Vernalis are predicted to increase by 12 to 20% from the No-Action Alternative, with the smallest changes occurring under Alternatives A1, A2, and B2 (**Table H-9**). All alternative plans provide additional habitat for fish when recirculation is occurring. This additional flow would assist juvenile salmonids during their emigration to the ocean. The increase in flow may also provide some improvements in habitat quality in the SJR. These flow changes, however, are not expected to provide substantial habitat improvements and are not consistent through time. Thus integrated over time, the alternative plans may not provide substantial benefits to fisheries resources. While all alternative plans would provide increased flows over the No-Action Alternative when recirculation is occurring, the less than 8% difference in flow among alternative plans is not substantial (less than the 10% criteria described in **Section H2.2**) and, therefore, all alternative plans are considered to perform equivalently.

Table H-9. Change in Weighted Index for Flow at San Joaquin River at Vernalis for Each Alternative Plan, Compared to No–Action Alternative

	Alternative A1	Alternative A2	Alternative B1	Alternative B2	Alternative C	Alternative D
Change in Weighted Index for Flow at San Joaquin River at Vernalis	14%	12%	19%	16%	20%	19%

Salmonid Straying

The weighted index for the proportion of Delta and Sacramento River water in the SJR below the confluence of the Merced River is predicted to increase by 31 to 61%, with the lowest values occurring under Alternatives A1 and A2 (**Table H-10**). Alternatives B2, C, and D are predicted to increase the weighted index for the proportion of non-SJR water to 50% or greater. The proportion of nonsource water at Vernalis is similar to the change in flow reported above at Vernalis, as only a small proportion of the recirculated water is of SJR origin (**Table H-9**). Based on these differences, Alternatives A1 and A2 would be preferable compared to the other alternative plans for fish straying in the SJR. The proportion of nonsource water that occurs with recirculation might lead to imprinting problems for outmigrant SJR basin salmon and steelhead, as all recirculation occurs during February through June (see **Table H-1**), which is the principal outmigration season (see PFR **Section 2.2.4**). The contribution of nonsource water during emigration may reduce the ability of these fish to find their natal streams when they return as adults. These fish may have a higher propensity to move up the Sacramento River instead, as a large proportion of the nonsource water released during recirculation would be Sacramento River water. Returning SJR adults that had not encountered the nonsource fraction during emigration may also be confused by the nonsource fraction and be more inclined to stray. Fish that migrate the farthest up river, where they would encounter the highest proportion of nonsource water, would be more prone to straying.

The nonsource fraction may also increase the propensity for returning Sacramento River adults to migrate up the SJR, as those adults detect the Sacramento River fraction in the SJR. However, the relatively small change in the proportion of Sacramento River water occurring in the southern Delta and at Vernalis indicates that these fish would likely continue to migrate up the Sacramento River.

Table H-10. Change in Weighted Index for Proportion of Nonsource Water in San Joaquin River below Merced River, Compared to No–Action Alternative

	Alternative A1	Alternative A2	Alternative B1	Alternative B2	Alternative C	Alternative D
Change in Weighted Index for Proportion of Delta and Sacramento water in San Joaquin River below Merced River	31%	33%	48%	50%	61%	60%

Temperature

The temperature modeling at Vernalis showed relatively few differences between the expected temperatures of the alternative plans relative to the No-Action Alternative. Most of the time, 90^{th} percentile temperatures were less than 0.9°F of the No-Action Alternative. The only occasion when a larger difference is predicted in the model was the 90^{th} percentile temperature for January through April in Critically Dry years under Alternative D, which differed from the No-Action Alternative by 1°F (**Table H-11**).

Table H-11. Temperature by Alternative Plan Where Difference in 90th Percentile Temperature is at Least 0.9°F

			Temperature (°F)				
Station	**Water Year Type**	**Period**	**A2**	**B2**	**C**	**D**	**No-Action Alternative**
San Joaquin River at Vernalis	Critically Dry	Jan-Apr	67.8	67.8	67.9	68.1	67.1

ENTRIX also evaluated the magnitude of differences between the alternative plans and the No-Action Alternative using the 6-hour 90th percentile temperature values from the temperature model. These differences do not directly correspond to the temperature values described above, but reflect a similar result. Few substantial temperature differences would occur. Differences were only observed at the 90th percentile level. These differences occurred in January through April in Below Normal and Dry years for Alternatives A2, B2, C, and D, and in Critically Dry years under Alternatives C and D (**Table H-12**). They also occurred in the May and June period in Critically Dry years for Alternative D (with a difference of 0.95°F) and in Above Normal years for Alternatives B2, C, and D, where the temperature difference was nearly 2°F.

Table H-12. Change in 90th Percentile Value of Temperature from the No-Action Alternative by Alternative Plan When Difference from 6-Hour No-Action Alternative Temperatures Is at Least 0.9°F

			90th Percentile Temperature Difference (°F) between Alternative Plans and No-Action Alternative			
Station	**Water Year Type**	**Period**	**A2**	**B2**	**C**	**D**
San Joaquin River at Vernalis	Below Normal	Jan- Apr	1.18	1.17	1.17	1.19
	Dry	Jan- Apr	1.13	1.14	1.13	1.18
	Critically Dry	Jan- Apr	0.68	0.73	0.96	1.22
	Above Normal	May–June	0.00	1.99	1.98	1.99
	Critically Dry	May–June	0.44	0.44	0.48	0.95

Suspended Sediment

The TSS model indicates that the TSS values for the No-Action Alternative and the alternative plans would range from 39 to 128 mg/L (**Table H-13**). These values result in SEVs (assuming all suspended sediment is inorganic) ranging from 7.6 to 8.6 over all stations, but are generally much narrower within a station. SEVs of this magnitude result in sublethal effects on adult and juvenile salmonids. They may impair homing, degrade habitat, affect feeding, and result in poor condition. These effects are shared by the alternative plans and the No-Action Alternative. Within a particular water year type, month, and location, SEVs rarely varied among alternative plans by as much as 0.5 point (**Table H-13**). All of the alternative plans would result in about the same effect on fish and are not considered to be different from the No-Action Alternative.

Table H-13. Total Suspended Solid Concentrations of Severity-of-Ill-Effects Values at Selected Locations on the San Joaquin River for Representative Water Years

Description of Alternative Plans				TSS Concentration (mg/L)						SEV Scores					
Water Year	Represen-tative Year	Month	Alternative Plan	TSS Conc. in SJR at NWW Mouth	TSS Conc. Below Confluence of NWW (100 feet)	TSS Conc. Above Merced Confluence (6,500 feet)	TSS Conc. Below Merced Conflu-ence (7,000 feet)	TSS Conc. at Tuolumne River (165,000 feet)	TSS Conc. Fully Mixed after Merced	SEVs in SJR at NWW Mouth	SEVs Below NWW Conflu-ence (100 feet)	SEVs Above Merced Confluence (6,500 feet)	SEVs Below Merced Conflu-ence (7,000 feet)	SEVs at Tuolumne River (165,000 feet)	SEVs Fully Mixed after Merced
Wet	1993	March	NAA,A1,A2	58	58	58	49	47	47	8.1	8.1	8.1	8.0	7.9	7.9
			B1,B2	101	90	70	60	49	60	8.5	8.4	8.2	8.1	8.0	8.1
			C	103	95	74	64	50	65	8.5	8.4	8.3	8.1	8.0	8.2
			D	103	95	74	64	50	65	8.5	8.4	8.3	8.1	8.0	8.2
		April 1-15	NAA,A1,A2,B1,B2	71	71	71	70	70	70	7.8	7.8	7.8	7.8	7.8	7.8
			C	122	121	112	112	86	114	8.2	8.2	8.1	8.1	7.9	8.1
			D	122	121	112	112	86	114	8.2	8.2	8.1	8.1	7.9	8.1
		May 16-31	NAA,A1,A2,B1,B2	79	79	79	70	70	70	7.9	7.9	7.9	7.8	7.8	7.8
			C,D	118	113	96	88	74	93	8.2	8.2	8.0	8.0	7.9	8.0
Above Normal	1963	Feb	NAA,A1,A2,B1,B2	60	60	60	52	50	50	8.0	8.0	8.0	7.9	7.9	7.9
			C	104	96	76	66	52	67	8.4	8.4	8.2	8.1	7.9	8.1
			D	104	96	76	66	52	67	8.4	8.4	8.2	8.1	7.9	8.1
		March	NAA	58	58	58	43	39	39	8.1	8.1	8.1	7.9	7.8	7.8
			A1,B1	116	114	98	81	49	82	8.6	8.6	8.5	8.3	8.0	8.3
			A2,B2,C	116	114	98	81	49	82	8.6	8.6	8.5	8.3	8.0	8.3
			D	116	114	97	81	49	82	8.6	8.6	8.5	8.3	8.0	8.3
		May 16-31	NAA,A1,A2,B1,B2	79	79	79	61	58	58	7.9	7.9	7.9	7.7	7.7	7.7
			C	119	117	104	90	66	92	8.2	8.2	8.1	8.0	7.8	8.0
			D	119	117	104	90	66	92	8.2	8.2	8.1	8.0	7.8	8.0
		June	NAA,A1,A2	100	100	100	64	54	54	8.5	8.5	8.5	8.1	8.0	8.0
			B1,B2,C,D	126	125	118	92	62	91	8.6	8.6	8.6	8.4	8.1	8.4
Below	2003	Feb	NAA	60	60	60	48	45	45	8.0	8.0	8.0	7.9	7.8	7.8

Table H-13. Total Suspended Solid Concentrations of Severity-of-Ill-Effects Values at Selected Locations on the San Joaquin River for Representative Water Years

Description of Alternative Plans				TSS Concentration (mg/L)						SEV Scores					
Water Year	Represen-tative Year	Month	Alternative Plan	TSS Conc. in SJR at NWW Mouth	TSS Conc. Below Confluence of NWW (100 feet)	TSS Conc. Above Merced Confluence (6,500 feet)	TSS Conc. Below Merced Conflu-ence (7,000 feet)	TSS Conc. at Tuolumne River (165,000 feet)	TSS Conc. Fully Mixed after Merced	SEVs in SJR at NWW Mouth	SEVs Below NWW Conflu-ence (100 feet)	SEVs Above Merced Confluence (6,500 feet)	SEVs Below Merced Conflu-ence (7,000 feet)	SEVs at Tuolumne River (165,000 feet)	SEVs Fully Mixed after Merced
Normal			A1,A2	113	109	88	73	51	77	8.5	8.5	8.3	8.2	7.9	8.2
			B1	114	109	89	74	52	78	8.5	8.5	8.3	8.2	7.9	8.2
			B2,C,D	115	112	92	78	53	82	8.5	8.5	8.4	8.2	8.0	8.3
		March	NAA,A1,A2,B1,B2	58	58	58	44	43	43	8.1	8.1	8.1	7.9	7.9	7.9
			C	116	113	93	78	51	83	8.6	8.6	8.4	8.3	8.0	8.3
			D	117	114	95	80	52	85	8.6	8.6	8.4	8.3	8.0	8.4
		April 1-15	NAA,A1,A2,B1,B2	71	71	71	55	54	54	7.8	7.8	7.8	7.6	7.6	7.6
			C	123	122	111	100	69	105	8.2	8.2	8.1	8.0	7.8	8.1
			D	123	122	111	100	69	105	8.2	8.2	8.1	8.0	7.8	8.1
		May 16-31	NAA,A1,A2,B1,B2	79	79	79	56	52	52	7.9	7.9	7.9	7.6	7.6	7.6
			C	120	117	102	81	58	85	8.2	8.2	8.1	7.9	7.7	8.0
			D	120	117	102	81	58	85	8.2	8.2	8.1	7.9	7.7	8.0
		June	NAA,A1,A2	100	100	100	72	70	70	8.5	8.5	8.5	8.2	8.2	8.2
			B1,B2	126	124	115	95	77	100	8.6	8.6	8.6	8.4	8.3	8.5
			C,D	128	127	122	109	83	111	8.6	8.6	8.6	8.5	8.3	8.5

Key:

NAA = No-Action Alternative
NWW = Newman Wasteway
SEV = severity-of-ill-effects value
SJR = San Joaquin River
TSS = total suspended solid

H.3.3 Stanislaus River

Flow

Conditions under Alternatives A1 and B1 are the same as under the No-Action Alternative, because under these alternative plans recirculation is used to supplement flows from New Melones Reservoir to improve compliance with Vernalis standards. The weighted flow indices decrease from 10 to 15% when recirculation is occurring under the remaining alternative plans (**Table H-14**), which may result in decreases in habitat quantity and quality under Alternatives A2, B2, C, and D. These flow changes are relatively small, and would occur at a time of year when rearing habitat is not limiting. During February through June, steelhead would be spawning and both they and Chinook salmon may be emerging from their redds and fry may be rearing in the channel. These young salmonids are found along the stream margins. The amount of stream margin habitat would not change substantially, so their habitat is unlikely to be substantially affected by these flow changes. The total amount of spawning habitat for steelhead may be affected, but the affected habitat would be the least desirable habitat along the stream margins, where spawning is least likely to occur. Therefore, the potential effects of these flow reductions on the spatial area of habitat available are not likely to be substantial. The flow reduction may also affect depths and velocities near the center of the channel, where fish are more likely to spawn. The evaluation criteria indicate that all of the alternative plans would have a similar effect, but these changes are not likely to be substantial given the small amount of flow change.

Table H-14. Change in Weighted Index for Flow at Stanislaus River at Goodwin, Compared to No–Action Alternative

	Alternative A1	Alternative A2	Alternative B1	Alternative B2	Alternative C	Alternative D
Change in Weighted Flow Index at Stanislaus at Goodwin	0%	-10%	0%	-11%	-12%	-15%

Temperature

Recirculation has minimal effect on temperature in the Stanislaus River. Most of the time, the change from the No-Action Alternative in the 90th percentile temperature values under the alternative plans is less than the 0.9°F threshold. **Table H-15** shows the temperatures on the few occasions when the temperature difference at the 90th percentile temperature values exceeded this threshold. **Attachment H2, Tables H2-109 and H2-111** provide all the exceedance temperatures for the No-Action Alternative and the alternative plans.

Alternatives A1 and B1 are not presented, because operations of New Melones Reservoir are not affected under these alternative plans. The few temperature differences of more than 0.9°F that would occur, were observed at the 90^{th} percentile level. At Orange Blossom Bridge, Alternative D resulted in a 1.1°F warmer temperature than the No-Action Alternative in January–April of Critically Dry water years (**Attachment H2, Table H2-109**). All alternative plans provide cooler temperatures than the No-Action Alternative in July–September of Critically Dry water years. At Riverbank, only Alternative D resulted in substantially warmer conditions than the No-Action Alternative (**Attachment H2, Table H2-110**), but only occurred at the 10% exceedance temperatures during January–April in Below Normal and Critically Dry water years with temperatures under Alternative D of 60.5 and 62.8°F, respectively.

Table H-15. Change in 90^{th} Percentile Value of Temperature from No-Action Alternative by Alternative Plan Where Difference in the 90^{th} Percentile Value is at Least 0.9°F

			Temperature (°F)				
Station	**Water Year Type**	**Period**	**A2**	**B2**	**C**	**D**	**No-Action Alternative**
Orange Blossom Bridge	Critically Dry	Jan-Apr	57.1	57.1	57.1	58.0	56.9
	Critically Dry	Jul-Sep	66.4	66.9	67.1	66.5	67.7
Riverbank	Below Normal	Jan-Apr	59.5	59.5	59.5	60.5	59.5
	Critically Dry	Jan-Apr	61.2	61.2	61.2	62.8	60.7

Note:
90% of the temperature observations are less than or equal to the 90^{th} percentile value.

ENTRIX also evaluated the magnitude of differences between the alternative plans and the No-Action Alternative using the 6-hour temperature values from the temperature model. These differences do not directly correspond to the temperature values described above, but reflect a similar result. Few substantial temperature differences would occur. These instances are shown in **Table H-16**, which shows the 90th percentile of the difference between the alternative plans and the No-Action Alternative based on the raw modeled values. Substantial differences from the No-Action Alternative were observed most commonly for Alternative D. They occurred during the January–April and May–June periods, usually in Critically Dry periods. Each of the other alternative plans would result in only one period when substantial temperature differences relative to the No-Action Alternative would occur.

Table H-16. Change in 90th Percentile Value of Temperature from No-Action Alternative by Alternative Plan When Difference from 6-Hour No-Action Alternative Temperatures is at Least 0.9°F

			Temperature Difference (°F) between Alternative Plans and No–Action Alternative			
Station	**Period**	**Water Year Type**	**A2**	**B2**	**C**	**D**
Orange Blossom Bridge	Jan-Apr	Critically Dry	0.3	0.3	0.3	2.0
	May-Jun	Critically Dry	0.2	0.2	0.3	1.3
	Oct-Dec	Wet	1.1	0.6	0.0	1.1
Riverbank	Jan-Apr	Below Normal	0.8	0.8	0.8	1.2
	Jan-Apr	Critically Dry	0.6	0.6	0.6	3.5
	May-Jun	Above Normal	0.0	0.9	0.9	0.9
	May-Jun	Critically Dry	0.4	0.5	0.5	2.1

H.4 Summary of Findings

Alternatives A1 and A2 are likely to have the least impact on fisheries resources. These alternative plans result in the lowest frequency of recirculation and the smallest amount of additional pumping at the CVP or SWP pumps. Alternative A2 performs slightly worse than Alternative A1, because it affects conditions on the Stanislaus River, whereas Alternative A1 does not. The additional risk to Stanislaus River fish appears to be minimal however. The impacts of these alternative plans would come mainly through potentially increased entrainment at the CVP and SWP pumps and through the introduction of Delta water into the SJR, which may cause salmonid straying.

Alternatives B1 and B2 are likely to have intermediate impacts to fisheries resources relative to the other alternative plans. Alternatives B1 and B2 would result in a slightly higher frequency of recirculation and substantially higher levels of export, which would increase the risk of entrainment relative to Alternatives A1 and A2. The net change in reverse flows would be higher under Alternatives B1 and B2 than under Alternative D. More Delta water would be released down the SJR more frequently than under Alternatives A1 and A2 and, thus, the risk of salmonid straying would be increased as well. Like Alternative A2, Alternative B2 would affect conditions on the Stanislaus River and, thus, would pose a slightly greater risk of impacting fish there than Alternative B1, although this potential appears to be minimal.

Alternatives C and D would likely have the greatest impact on fisheries resources relative to the other alternative plans. Alternatives C and D would result in recirculation occurring about twice as often than under Alternatives B1 and B2 and about three times more frequently than under Alternatives A1 and

A2. The amount of water exported at the pumps would be similar to that under Alternatives A1 and A2 as would the annual entrainment index. However, because of the increased frequency of recirculation, this entrainment would occur more frequently. These alternative plans would result in impacts more similar to those for Alternatives B1 and B2. Alternatives C and D would result in the greatest proportion of nonsource water in the SJR and, thus, would have the greatest potential impact on straying rates. Alternative D also results in slightly more adverse temperature conditions on the Stanislaus River than the other alternative plans and, thus, may be less preferable than Alternative C.

H.5 References

Bay Delta and Tributaries (BDAT) Project. 2007. Website accessed in October 2007. Available at http://bdat.ca.gov/.

California Department of Water Resources and California Department of Fish and Game. 2007. *Pelagic Fish Action Plan*.

Fretwell, M.R. 1989. Homing behavior of adult sockeye salmon in response to a hydroelectric diversion of home streamwaters at Seton Creek. *International Pacific Salmon Fisheries Commission Bulletin* XXV.

Gordon, N., T. McMahon, and B. Finlayson. 1992. *Stream Hydrology: An Introduction for Ecologists*. West Sussex, England: John Wiley and Sons.

Gray, J.R., G.D. Glysson, L.M. Torcios, and G. Schwartz. 2000. Comparability of suspended-sediment concentration and total suspended solids data. *U.S. Geological Survey Water Resources Investigation Report* 00-4191. Reston, VA.

Hirsch, R.M., and J.E. Costa. 2004. U.S. stream flow measurement and data dissemination improve. Eos 85(20): 197-203.

Mesick, C. 2001. The effects of the San Joaquin River flows and Delta export rates during October on the number of adult San Joaquin Chinook salmon that stray. In *Contributions to the Biology of Central Valley Salmonids*, edited by R.L. Brown. *California Department of Fish and Game Fish Bulletin* 179(2): 139-162.

National Marine Fisheries Service. 2004. *Biological Opinion on Long-Term Central Valley Project and State Water Project Operations Criteria and Plan*. Southwest Region. October.

Newcombe, C.P., and J.O.T. Jensen. 1996. Channel suspended sediment and fisheries: a synthesis for quantitative assessment of risk and impact. *North American Journal of Fisheries Management* 16(4): 693-719.

Quinn, T.P. 1993. A review of homing and straying of wild and hatchery-produced salmon. *Fisheries Research* 18: 29-44.

———. 2005. *The Behavior and Ecology of Pacific Salmon and Trout*. Seattle, WA: UW Press.

Quinn, T.P, University of Washington. 2007. Personal communication with C. Hogle, ENTRIX, July 6, 2007.

United States Fish and Wildlife Service. 2005. Reinitiation of Formal and Early Section 7 Endangered Species Consultation on the Coordination Operations of the Central Valley Project and State Water Project and the Operational Criteria and Plan to Address Potential Critical Habitat Issues. Sacramento Office. .February 16. Available at http://www.fws.gov/sacramento/ea/news_releases/2004%20News%20Releases/Delta_Smelt_OCAP_NR.htm.