Chapter 9
Fisheries and Aquatic Ecosystems/Hydrologic Modeling

Aquatic ecosystems in the Bay-Delta support important recreational and commercial fisheries worth millions of dollars and provide substantial intangible cultural, scientific, and social value. The role of aquatic species in ongoing conflicts over beneficial uses of water in the Bay-Delta ecosystem is testimony to their value, especially for species listed under the Federal and State Endangered Species Acts (ESAs). Conserving the values provided by aquatic species for future generations requires maintenance and enhancement of ecosystem health, but is complicated by existing and increasing human demands for water supply, flood control, and other aquatic ecosystem functions.

This chapter describes the fisheries-related resources located within the EWA area of analysis. Section 9.1, Affected Environment/Existing Conditions, defines and includes an overview of the fish species of primary management concern, as well as provides a description, on a regional basis, of the water bodies these species inhabit. Section 9.2, Environmental Consequences/Environmental Impacts, includes a discussion of the methods utilized to assess potential impacts on reservoir and riverine fish species based on their individual lifestages (adult immigration; spawning, egg incubation, and initial rearing; and juvenile rearing and emigration), outlines the impact indicators and significance criteria used in the analyses, and provides a detailed analysis of potential impacts related to implementation of the Flexible Purchase Alternative. Section 9.2, Environmental Consequences/Environmental Impacts, also presents a qualitative assessment of the Fixed Purchase Alternative, provides a comparative analysis of alternatives, and discusses potential cumulative impacts. The analysis and underlying modeling assumptions incorporate evaluation of the variable operational assets of the EWA Program. The analysis relied on both printed documents and personal communication citations, which are included in Section 9.3, References.

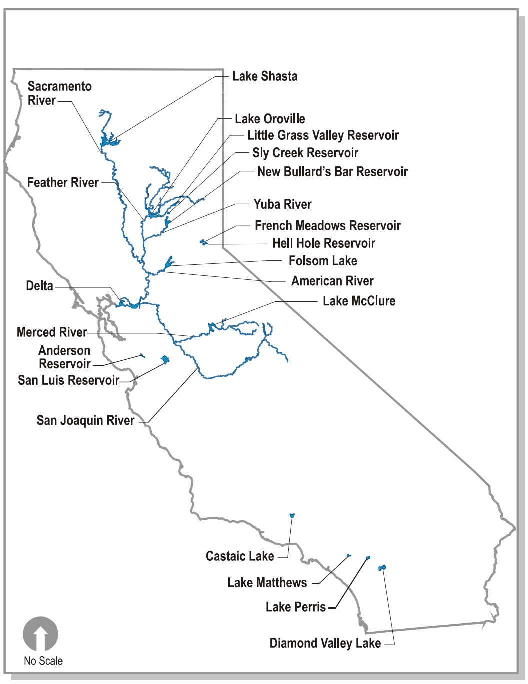

Figure 9-1
Fisheries and Aquatic Ecosystems Area of Analysis

9.1 Affected Environment/Existing Conditions

This section describes the affected environment/existing conditions related to fisheries and aquatic ecosystems in all water bodies that may be influenced by implementation of the EWA Program (Figure 9-1). This includes the Sacramento, Feather, Yuba, American, Merced, and San Joaquin rivers and associated reservoirs, the Sacramento-San Joaquin Delta, San Luis Reservoir, Anderson Reservoir, and Department of Water Resources (DWR) and Metropolitan Water District (Metropolitan WD) reservoirs in southern California. The EWA area of analysis is defined in Section 3.2 and shown on Figure 3-1. The area of analysis related to potential impacts on fisheries and aquatic ecosystems is more specifically defined in Section 9.1.1, Upstream from the Delta Region, Section 9.1.2, Sacramento-San Joaquin Delta Region, and 9.1.3, Export Service Area.

Species of primary management concern evaluated in this analysis include those that are recreationally or commercially important (fall-run Chinook salmon[1] (*Oncorhynchus tshawytscha),* steelhead (*Oncorhynchus mykiss*), American shad (*Alosa sapidissima*), and striped bass (*Morone saxatilis*)), Federal- and/or State-listed species within the area (winter- and spring-run Chinook salmon, steelhead, delta smelt (*Hypomesus transpacificus*), and Sacramento splittail (*Pogonichthys macrolepidotus*)), and candidate species under the Federal ESA (late-fall-run Chinook salmon).

Special emphasis is placed on these species to facilitate compliance with applicable laws, particularly, the State and/or Federal ESA, and to be consistent with State and Federal restoration/recovery plans and Federal biological opinions. This focus is consistent with: 1) CALFED's 2000 Ecosystem Restoration Program Plan (ERPP) and Multi-Species Conservation Strategy (MSCS); 2) the programmatic determinations for the CALFED program, which include CDFG's Natural Community Conservation Planning Act (NCCPA) approval and the programmatic biological opinions (BOs) issued by National Marine Fisheries Service (NOAA Fisheries) and USFWS; 3) USFWS's 1997 Draft Anadromous Fish Restoration Program (AFRP), which identifies specific actions to protect anadromous salmonids; 4) CDFG's 1996 Steelhead Restoration and Management Plan for California, which identifies specific actions to protect steelhead; and 5) CDFG's Restoring Central Valley Streams, A Plan for Action (1993), which identifies specific actions to protect salmonids. Improvement of habitat conditions for these species of priority management concern will likely protect or enhance conditions for other fish resources, including native resident species.

Evaluating potential impacts on fishery resources within the EWA area of analysis requires an understanding of fish species' life histories and lifestage-specific environmental requirements. Therefore, general information is provided below regarding life histories of species that occur within the EWA area of analysis.

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[1] NMFS recognizes the late-fall-run Chinook salmon in the Central Valley fall-run ESU (Moyle 2002).

Commercially, Chinook salmon are one of the most important species of anadromous fish in California. Chinook salmon have evolved a broad array of life history patterns that allow them to take advantage of diverse riverine conditions throughout the year. Four principal life history variants are recognized and are named for the timing of spawning runs: fall-run, late-fall-run, winter-run and spring-run. The Sacramento River supports all four runs of Chinook salmon. The larger tributaries to the Sacramento (American, Yuba, and Feather rivers) and rivers in the San Joaquin Basin also provide habitat for one or more of these distinct runs. A separate discussion on each of these four runs is provided below. Table 9-1 illustrates the general differences among the timing of life stages of the four Central Valley Chinook salmon runs. Slight differences in timing may occur depending on the river and are discussed in the following narratives.

Table 9-1
Generalized Life History Timing of Central Valley Chinook Salmon Runs

Run	*Adult Migration Period*	*Peak Migration Period*	*Spawning Period* [1]	*Peak Spawning Period*	*Fry Emergence Period*	*Juvenile Stream Residency*	*Juvenile Emigration Period*
Late-fall	October-April	December	Early January - April	February - March	April - June	7-13 months	June-December
Winter	December-July	March	Late April - Early August	May - June	July - October	5-10 months	July-March
Spring	Mid-February-July	April-May	Late August - October	Mid-September	November - March	3-15 months	October-April
Fall	June-December	September-October	Late September-December	October - November	December - March	1-7 months	January-July

Sources: Moyle 2002, Vogel and Marine 1991, and CDFG 1998.
[1] The time periods identified for spawning include the time required for incubation and initial rearing, prior to emergence of fry from spawning gravels.

Fall-run Chinook Salmon. In the Central Valley, fall-run Chinook salmon are the most numerous of the four salmon runs, and consequently, they continue to support commercial and recreational fisheries of significant economic importance. Fall-run Chinook salmon are currently the largest run of Chinook salmon utilizing the Sacramento River system, and are the primary run of Chinook salmon using the lower American River. The Feather, Yuba, San Joaquin, and Merced Rivers also support runs of fall-run Chinook salmon. Litigation over proposed water diversions in the American River has prompted the intensive study of fall-run Chinook salmon within the lower American River. As a result, additional information pertaining to the life history and environmental requirements specific to the lower American River fall-run population is provided below, and serves as a general guide to the remaining rivers in the regional setting.

Adult Chinook salmon begin migrating upstream annually in August and September, with immigration continuing through December in most years and January in some years. Adult Chinook salmon immigration generally peaks in November, and typically, greater than 90 percent of the run has entered the river by the end of November (CDFG 1992, 1995). The immigration timing of fall-run Chinook salmon tends to be temporally similar year-to-year because it is largely dictated by cues (photoperiod, maturation, and other season environmental cues) that exhibit little year-to-year variation.

The timing of adult Chinook salmon spawning activity is strongly influenced by water temperature. When daily average water temperatures decrease to approximately 60°F, female Chinook salmon begin to construct nests (redds) into which their eggs (simultaneously fertilized by the male) are eventually released. Fertilized eggs are subsequently buried with streambed gravel. Due to the timing of adult arrivals and occurrence of appropriate spawning temperatures, spawning activity in recent years in the lower American River, for example, has peaked during mid- to late-November (CDFG 1992, 1995).

The intragravel residence period of incubating eggs and alevins (yolk-sac fry) is highly dependent upon water temperature. The intragravel egg and fry incubation lifestage for Chinook salmon generally extends from about mid-October through March. Egg incubation survival rates are dependent on water temperature and intragravel water movement. CDFG (1980) reported egg mortalities of 80 percent and 100 percent for Chinook salmon at water temperatures of 61°F and 63°F, respectively. Egg incubation survival is highest at water temperatures at or below 56°F.

Within the EWA area of analysis, fall-run Chinook salmon fry emergence generally occurs from late-December through mid-May. In the Sacramento River basin, fall-run Chinook salmon juvenile emigration occurs from January through July (Vogel and Marine 1991; Yoshiyama et al. 1998). Emigration surveys conducted by CDFG have shown no evidence that peak emigration of Chinook salmon is related to the onset of peak spring flows in the lower American River (Snider et al. 1997). Temperatures required during emigration are believed to be about the same as those required for successful rearing, as discussed below.

Water temperatures between 45°F and 58°F have been reported to be optimal for rearing of Chinook salmon fry and juveniles (Reiser and Bjornn 1979; Rich 1987). Raleigh et al. (1986) reviewed the available literature on Chinook salmon thermal requirements and suggested a suitable rearing temperature upper limit of 75°F and a range of approximately 53.6°F to 64.4°F.

Late-fall-run Chinook Salmon. The majority of late-fall-run Chinook salmon spawn in the Sacramento River; therefore, this species account is specific to the Sacramento River (USFWS 1995a). Adult immigration of late fall-run Chinook salmon in the Sacramento River generally begins in October, peaks in December, and ends in April (Moyle 2002). Late fall-run Chinook salmon spawn during periods of high flows, when flow fluctuations can be damaging to redds constructed in high terraces, which can be exposed as water recedes (USFWS 1995a). Spawning also has been observed in tributaries to the upper Sacramento River (e.g., Battle, Cottonwood, Clear, Big Chico, Butte and Mill creeks) and the Feather and Yuba rivers, although these fish do not comprise a large proportion of the late-fall run Chinook population (S. Cantrell, pers. comm. 2003; USFWS 1995a). Spawning in the main-stem Sacramento River occurs primarily from Keswick Dam (RM 302) to Red Bluff Diversion Dam (RM 258), and generally occurs from December through April (USBR 1991b). Post-emergent fry and juveniles emigrate from their spawning and rearing grounds in the upper Sacramento River and its tributaries during the June through December period (Vogel and Marine 1991). NOAA Fisheries recognizes the late-fall-run Chinook salmon in the Central Valley fall-run ESU (Moyle 2002).

Winter-run Chinook Salmon. Of all water bodies that may be influenced by the EWA Program, winter-run Chinook salmon occur only in the Sacramento River; therefore, this species account is specific to the Sacramento River. The Sacramento River winter-run Chinook salmon evolutionarily significant unit (ESU) is listed as "endangered" under both the Federal and State ESA. Under Section 7 of the ESA, Federal agencies are required to ensure that their actions are not likely to result in the harm, destruction, or adverse affects to a listed species or its critical habitat. Similarly, Section 2080 of the Fish and Game code prohibits take (hunting, pursuing, catching, capturing, killing, or attempts to do these actions) of endangered or threatened species. CESA allows for incidental take and requires early consultation and the development of mitigation for potential impacts on species and essential habitats. In 1993, critical habitat for winter-run Chinook was designated to include the Sacramento River from Keswick Dam, (River Mile [RM] 302) to Chipps Island (RM 0) at the westward margin of the Sacramento-San Joaquin Delta. Also included are waters west of the Carquinez Bridge, Suisun Bay, San Pablo Bay, and San Francisco Bay north of the Oakland Bay Bridge (NMFS 1993).

Adult winter-run Chinook salmon immigration (upstream spawning migration) through the Delta and into the lower Sacramento River occurs from December through July, with a peak during the period extending from January through April (USFWS 1995a). Winter-run Chinook salmon primarily spawn in the main-stem Sacramento River between Keswick Dam (RM 302) and Red Bluff Diversion Dam (RM 243). Winter-run Chinook salmon spawn between late-April and mid-August, with a peak generally in June.

Winter-run Chinook salmon fry rearing in the upper Sacramento River exhibit peak abundance during September, with fry and juvenile emigration past Red Bluff Diversion Dam occurring from July through March (Vogel and Marine 1991; USBR 1992). Emigration (downstream migration) of winter-run Chinook salmon juveniles past Knights Landing, approximately 155.5 river miles downstream of the Red Bluff Diversion Dam, reportedly occurs between November and March peaking in December with some emigration continuing through May in some years (Snider and Titus 2000a; Snider and Titus 2000b). The numbers of juvenile winter-run Chinook salmon caught in rotary screw traps at the Knights Landing sampling location were reportedly dependent on the magnitude of flows during the emigration period (Snider and Titus 2000a; Snider and Titus 2000b). Additional information on the life history and habitat requirements of winter-run Chinook salmon is contained in the NOAA Fisheries Biological Opinion for this species, which was developed to specifically evaluate impacts on winter-run Chinook salmon associated with CVP and SWP operations (NMFS 1993).

Spring-run Chinook Salmon. Historically, spring-run Chinook salmon occurred in the headwaters of all major river systems in the Central Valley where natural barriers were absent. Beginning in the 1880s, harvest, water development, construction of dams that prevented access to headwater areas, and habitat degradation significantly reduced the number and range of spring-run Chinook in the Central Valley. Today, Mill, Deer, and Butte creeks in the Sacramento River system support self-sustaining, persistent populations of spring-run Chinook. The upper Sacramento, Yuba, and Feather rivers, streams that may be affected by EWA water management also are reported to support spring-run Chinook. However, documentation of these populations is weak, and these populations may be hybridized to some degree with fall-run Chinook. Due to the significantly reduced range and small size of remaining spring-run populations, the Central Valley spring-run Chinook salmon ESU is listed as "threatened" under both the State and Federal endangered species acts.

Adult spring-run Chinook salmon immigration into the Delta and lower Sacramento River occurs from mid-February through July, and peaks during April-May (Moyle 2002: CDFG 1998). Suitable water temperatures for adult upstream migration reportedly range between 38ºF and 56ºF (CDFG 1998). In addition to suitable water temperatures, adequate flows are required to provide migrating adults with olfactory and other cues needed to locate their spawning reaches (CDFG 1998).

The primary characteristic distinguishing spring-run Chinook salmon from the other runs of Chinook salmon is that adult spring-run Chinook salmon hold in areas downstream of spawning grounds during the summer months until their eggs fully develop and become ready for spawning. In streams potentially affected by the EWA Program, spring-run Chinook salmon spawn in the upper Sacramento River upstream of Red Bluff Diversion Dam, the lower Yuba River, and the lower Feather River. Spawning has been reported to primarily occur during late- August through October, peaking in mid-September (Moyle 2002). Although some portion of an annual year-class may emigrate as post-emergent fry (individuals less than 45 mm in length), most are believed to rear in the upper Sacramento river and tributaries during the winter and spring and emigrate as juveniles (individuals greater than 45 mm in length, but not having undergone smoltification) or smolts (silvery colored fingerlings having undergone the smoltification process in preparation for ocean entry). The timing of juvenile emigration from the spawning and rearing grounds varies among the tributaries of origin, and can occur during the period extending from October through April (Vogel and Marine 1991). In the Feather River, data on juvenile spring-run emigration timing and abundance have been collected sporadically since 1955 and suggests that November and December may be key months for spring-run emigration (Painter et al. 1977; DWR 1999). In Butte Creek, the bulk of emigration is reported to occur between December and January, with some emigration continuing through May (CDFG 1998). Some juveniles continue to rear in Butte Creek through the summer and emigrate as yearlings from October to February, with peak yearling emigration occurring in November and December (CDFG 1998).

Steelhead. The Central Valley steelhead ESU is listed as "threatened" under the Federal ESA, and has no State listing status. The Central Valley steelhead occurs in the Sacramento, Feather, Yuba and San Joaquin Rivers. Steelhead are produced at the Coleman Fish Hatchery on Battle Creek, the Nimbus Hatchery on the American River, and the Feather River Hatchery on the Feather River (Reynolds et al. 1990).

Most wild, indigenous populations of steelhead occur in upper Sacramento River tributaries below the Red Bluff Diversion Dam (RBDD) (including Antelope, Deer, Mill, and Butte creeks) (McEwan and Jackson 1996). Naturally spawning populations also occur in the American, Feather, and Yuba Rivers, and possibly the upper Sacramento and Mokelumne Rivers, but these populations have had substantial hatchery influence and their ancestry is not clearly known (Busby et al. 1996). Steelhead runs in the Feather and American Rivers are sustained largely by Feather River and Nimbus (American River) Hatcheries (McEwan and Jackson 1996).

Estimates of steelhead run sizes have been sporadic and limited to only a few locations over the last 50 years. The average annual run size in the Sacramento River above the mouth of the Feather River during 1953 through 1958 was estimated at 20,540 fish (Hallock 1989). Although an accurate estimate is not available, the present annual run size for the entire Sacramento River Basin, based on RBDD counts, hatchery counts, and available natural spawning escapement estimates, is probably fewer than 10,000 fish (McEwan and Jackson 1996). The most reliable indicators of recent declines in hatchery and wild stocks are trends reflected in RBDD and hatchery counts. Annual counts at the RBDD declined from an average of 11,187 adult fish in the late 1960s and 1970s to 2,202 adult fish in the 1990s. Recent counts at Coleman, Feather River, and Nimbus Hatcheries also are well below the historical average. Frank Fisher (CDFG) estimated that 10 to 30 percent of adults returning to spawn in the Sacramento River system are of hatchery origin (McEwan and Jackson 1996), although trapping by CDFG at the GCID intake since 1986 would suggest that a far greater proportion of upper Sacramento River steelhead populations are of hatchery origin (S. Cantrell 2003).

Adult steelhead immigration into Central Valley streams typically begins in December and continues into March. Steelhead immigration generally peaks during January and February (Moyle 2002). Optimal immigration temperatures have been reported to range from 46°F to 52°F (CDFG 1991). Spawning usually begins during late-December and may extend through March, but also can range from November through April (CDFG 1986). Optimal spawning temperatures have been reported to range from 39°F to 52°F (CDFG 1991). Unlike Chinook salmon, many steelhead do not die after spawning. Those that survive return to the ocean, and may spawn again in future years.

Optimal egg and fry incubation temperatures have been reported to range from 48°F to 52°F (CDFG 1991). Optimal temperatures for fry and juvenile rearing is reported to range from 45°F to 60°F (CDFG 1991). Similar to Chinook salmon, it is believed that temperatures up to 65°F are suitable for steelhead rearing. Each degree increase between 65°F and the upper lethal limit of 75°F becomes increasingly less suitable and thermally more stressful for the fish (Bovee 1978). The primary period of steelhead emigration occurs from March through June (Castleberry et al. 1991).

American Shad. American shad occur in the Sacramento River, its major tributaries, the San Joaquin River and the Delta. Because of its importance as a sport fish, American shad have been the subject of investigations by CDFG (Moyle 2002). American shad are native to the Atlantic coast and were planted in the Sacramento River in 1871 and 1881 (Moyle 2002).

Adult American shad typically enter Central Valley streams from April through early July (CDFG 1986), with the spawning migration peaking from mid-May through June (CDFG 1987). Water temperature is an important factor influencing the timing of spawning. American shad are reported to spawn at water temperatures ranging from approximately 46°F to 79°F (USFWS 1967), although optimal spawning temperatures are reported to range from about 60ºF to 70°F (Leggett and Whitney 1972; Painter et al. 1979; CDFG 1980; Bell 1986; Rich 1987). Spawning takes place mostly in the main channels of rivers; and generally about 70 percent of the spawning run is made up of first time spawners (Moyle 2002).

In contrast to salmonids, distributions of spawning American shad are determined by river flow rather than homing behavior (Painter et al. 1979). Shad have remarkable abilities to navigate and to detect minor changes in their environment (Leggett 1973). Although homing is generally assumed in the Sacramento River and its tributaries, there is some evidence that numbers of fish spawning are proportional to flows of each river at the time the shad arrive. Snider and Gerstung (1986) recommended flow levels of 3,000 to 4,000 cfs in the lower American River during May and June as sufficient attraction flows to sustain the river's American shad fishery. When suitable spawning conditions are found, American shad school and broadcast their eggs throughout the water column. The optimal temperature for egg development occurs at 62°F. At this temperature, eggs hatch in six to eight days; at temperatures near 75°F, eggs would hatch in three days (MacKenzie et al. 1985). Egg incubation and hatching, therefore, are coincident with the primary spawning period, May to June.

Striped Bass. Striped bass occur in the Sacramento River, its major tributaries, and the Delta. Substantial striped bass spawning and rearing occurs in the Sacramento River and Delta, although striped bass can typically be found upstream as far as barrier dams (Moyle 2002). Striped bass are native to the Atlantic coast. They were first introduced to the Pacific coast in 1879, when they were planted in the San Francisco Estuary (Moyle 2002).

Adult striped bass are present in Central Valley streams throughout the year, with peak abundance occurring during the spring months (DeHaven 1977, 1979; CDFG 1971). Striped bass spawn in warmer temperature ranging from 59°F to 68°F (Moyle 2002). Therefore, spawning may begin in April, but peaks in May and early-June (Moyle 2002). In the Sacramento River, most striped bass spawning is believed to occur between Colusa and the mouth of the Feather River. In years of higher flow, spawning typically occurs further upstream than usual since striped bass continue migrating upstream while waiting for temperatures to rise (Moyle 2002). No studies have definitively determined whether striped bass spawn in certain tributaries including the lower American and Feather River (CDFG 1971; CDFG 1986; DWR 2001a). However, the scarcity of sexually ripe adults among sport-caught fish indicates that minimal, if any, spawning occurs in the lower American River, and that adult fish which entered the river probably spawned elsewhere or not at all (DeHaven 1977; 1978). Successful spawning occurs in the San Joaquin River, upstream from the Delta, during years of high flow, when the large volume of runoff dilutes any salty irrigation wastewater present in the river flow. During years of low flow, spawning occurs in the Delta (Moyle 2002). Sacramento River currents carry striped bass embryos and larvae to rearing habitats in the Delta. Interactions between San Joaquin River outflow and tidal currents cause embryos and larvae to remain in the same general area where spawning occurred for rearing (Moyle 2002).

The number of striped bass entering Central Valley streams during the summer is believed to vary with flow levels and food production (CDFG 1986). For example, Snider and Gerstung (1986) suggested that flows of 1,500 cfs at the mouth during May and June would be sufficient to maintain the striped bass fishery in the lower American River. However, these investigators reported that, in any given year, the population level of striped bass in the Delta was probably the greatest factor determining the relative number of striped bass occurring in the lower American River.

Sacramento River tributaries seem to be a nursery area for young striped bass (CDFG 1971; 1986). Numerous schools of 5- to 8-inch-long fish have been reported in the river during the summer months (CDFG 1971). In addition, juvenile and sub-adult fish have been reported to be abundant in the lower American River and lower Yuba River during the fall (DeHaven 1977). Optimal water temperatures for juvenile striped bass rearing have been reported to range from approximately 61°F to 73°F (USFWS 1988).

Sacramento Splittail. Sacramento splittail are treated as a Federally listed threatened species[2], and are currently listed as a State species of special concern (Moyle et al. 1995). Splittail occur in the Sacramento River, its major tributaries, the San Joaquin River and the Delta.

Adult splittail usually reach sexual maturity in their second year, and migrate upstream in the late fall to early winter prior to spawning activities. They begin spawning in January, with peak spawning occurring from February through March, and may continue until May. Splittail reportedly spawn at water temperatures from

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[2] Under a Federal District Court ruling, the splittail rule has been remanded to USFWS. Splittail continue to be treated as a listed species, however no actions that may harm water users may be taken to protect splittail (DOI 2003).

48°F to 68°F (Wang 1986). Splittail prefer to spawn over flooded streambank vegetation or beds of aquatic plants, and the timing of their upstream movements and spawning corresponds to the historically high-flow period associated with snowmelt and runoff each spring. The mouth of the Feather River provides spawning habitat for splittail because upstream flow releases have the potential to influence the inundation of benches that could potentially serve as splittail spawning habitat. The precise timing and location of spawning varies among years, and the timing and magnitude of winter and spring runoff may play a substantial role in determining the temporal and spatial distribution of spawning in any given year. Water temperature and photoperiod also influence the timing of spawning.

Historically, splittail could be found in the upper reaches of the Sacramento River. Today, Red Bluff Diversion Dam appears to be a complete barrier to upstream movement (CDFG 1989). Splittail are believed to be present in the Sacramento River and its tributaries primarily during the adult spawning period. Juvenile splittail are not believed to use the Sacramento River or its tributaries for rearing to a great extent (USFWS 1994). However, recent studies in the Sutter Bypass have trapped large numbers of splittail, including fry through adult stages, with the yearling component suggesting that some splittail may reside and rear in the area (S. Cantrell 2003). Splittail emigration downstream into the Delta is believed to peak during the period April through August (Meng and Moyle 1995).

Delta Smelt. The USFWS listed delta smelt as a threatened species under the ESA in March 1993 (CFR 58 12854), and critical habitat for delta smelt has been designated within the area. Delta smelt also is listed as threatened under the CESA. In addition to the Delta, delta smelt have been found in the Sacramento River as far upstream as the confluence with the American River (USFWS 1994; Moyle 2002; CDFG unpublished data). This species also occurs in the San Joaquin River, downstream of Vernalis (EA Engineering, Science, and Technology 1999).

Delta smelt are a euryhaline fish, native to the Sacramento-San Joaquin estuary. As a euryhaline species, delta smelt tolerate wide-ranging salinities, but rarely occur in waters with salinities greater than 10-14 ppt (Baxter et al. 1999). Similarly, delta smelt tolerate a wide-range of water temperature, as they have been found at water temperatures ranging from 42.8-82.4°F (Moyle 2002). Delta smelt are typically found within Suisun Bay and the lower reaches of the Sacramento and San Joaquin rivers, although they are occasionally collected within the Carquinez Strait and San Pablo Bay. The delta smelt is a small slender bodied fish, with a typical adult size of 2-3 inches, although some individuals may reach lengths of 5 inches.

During the late winter and spring, delta smelt migrate upstream into freshwater areas to spawn. Shortly before spawning, adults migrate upstream from the brackish-water estuarine areas into river channels and tidally influenced backwater sloughs. Delta smelt are thought to spawn in shallow fresh or slightly brackish waters in tidally influenced backwater sloughs and channel edgewaters (Wang 1986). While most delta smelt spawning seems to take place at 44.6-59°F, gravid delta smelt and recently hatched larvae have been collected at 59-71.6°F. Thus, it is likely that spawning can take place over the entire range of 44.6-71.6°F (Moyle 2002). Females produce between 1,000 and 2,600 eggs (CDFG unpublished data), which adhere to vegetation and other hard substrate. Although spawning has not been observed in the wild, the eggs are thought to attach to substrates such as cattails, tules, tree roots, submerged branches, and other hard substrate. Larvae hatch between 10-14 days (Wang 1986) and are planktonic (float with water currents) as they are transported and dispersed downstream into the low-salinity areas within the western delta and Suisun Bay (Moyle 2002). Delta smelt grow rapidly, with the majority of smelt living only one year. Most adult smelt die after spawning in the early spring; although approximately 3-8 percent survive to age 2, it is not known if they previously spawned at age 1 or if they contribute disproportionately to delta smelt abundance (CDFG unpublished data; Moyle 2002; Brown and Kimmerer 2001). Delta smelt feed entirely on zooplankton. For the majority of their one-year life span, delta smelt inhabit areas within the western Delta and Suisun Bay characterized by salinities of approximately 2 ppt. Historically, they have been abundant in low (around 2 ppt) salinity habitats. Delta smelt occur in open surface waters and shoal areas (USFWS 1994). Critical habitat for delta smelt is defined (USFWS 1994) as:

> *"Areas and all water and all submerged lands below ordinary high water and the entire water column bounded by and contained in Suisun Bay (including the contiguous Grizzly and Honker Bays); the length of Goodyear, Suisun, Cutoff, First Mallard (Spring Branch), and Montezuma Sloughs; and the existing contiguous waters contained within the Delta."*

Because delta smelt typically have a one-year life span, their abundance and distribution have been observed to fluctuate substantially within and among years. Delta smelt abundance appears to be reduced during years characterized by either unusually dry years with exceptionally low outflows (1987 through 1991) and unusually wet years with exceptionally high outflows (1982 and 1986). Other factors thought to affect the abundance and distribution of delta smelt within the Bay-Delta estuary include entrainment in water diversions, changes in the zooplankton community resulting from introductions of non-native species, and potential effects of toxins. As a result of declines in abundance coincident with the 1987 through 1991 drought period, delta smelt were listed as a threatened species under both the State and Federal Endangered Species Acts. In recent years, the abundance of delta smelt and their geographic distribution has improved, as reflected in monitoring conducted by CDFG including summer tow-net surveys, 20 mm larval surveys, and the fall mid-water trawl surveys.

Other Fish Species. The species selected for species-specific assessments include those sensitive to changes in both river flow and water temperature throughout the year. An evaluation of effects on the above species is believed to reasonably encompass the range of potential effects upon other fish resources (specifically, those listed below) that could occur with the Flexible Purchase Alternative relative to the Baseline Condition. Furthermore, there is not sufficient information available regarding the species listed below to develop rigorous impact indicators and significance criteria similar to those developed for the above species. Therefore, because the life history requirements (e.g., spawning temperature ranges) for these species are similar to or less stringent than those for Chinook salmon, the life history and species criteria (water temperature and flow) used for Chinook salmon is thought to be more conservative and will apply to the analysis for these species. Therefore, the following species are not further evaluated in the analysis, although brief narratives are included to provide support for the above assumptions:

- Hardhead. Hardhead is a large (occasionally exceeding 600 mm standard length [SL]), native cyprinid species that generally occurs in large, undisturbed low- to mid-elevation rivers and streams of the region (Moyle 2002). The species is widely distributed throughout the Sacramento-San Joaquin River system, though it is absent from the valley reaches of the San Joaquin River. Hardhead mature following their second year. Spawning migrations, which occur in the spring, into smaller tributary streams are common. The spawning season may extend into August in the foothill streams of the Sacramento and San Joaquin river basins. Spawning behavior has not been documented, but hardhead are believed to elicit mass spawning in gravel riffles (Moyle 2002). Little is known about lifestage-specific temperature requirements of hardhead; however, temperatures ranging from approximately 65°F to 75°F are believed to be suitable (Cech et al. 1990). Hence, this species has greater thermal tolerance compared to that of the anadromous salmonids discussed above. Given hardhead's thermal tolerance, spawning and rearing preferences, and a general lack of information on spawning behavior and early life history, assessing impacts on Chinook salmon, stripped bass, and American shad are anticipated to provide a reasonable estimate of potential impacts on hardhead.

- Green sturgeon. Green sturgeon is an anadromous species, migrating from the ocean to freshwater to spawn. Adults of this species tend to be more marine-oriented than the more common white sturgeon. Nevertheless, spawning populations have been identified in the Sacramento River (Beak Consultants 1993), and most spawning is believed to occur in the upper reaches of the Sacramento River as far north as Red Bluff (Moyle et al. 1992; 1995). Adults begin their inland migration in late-February (Moyle et al. 1995), and enter the Sacramento River between February and late-July (CDFG 2001). Spawning activities occur from March through July, with peak activity believed to occur between April and June (Moyle et al. 1995). In the Sacramento River, green sturgeon presumably spawn at temperatures ranging from 46°F to 57°F (Beak Consultants 1993). Small numbers of juvenile green sturgeon have been captured and identified each year from 1993 through 1996 in the Sacramento River at the Hamilton City Pumping Plant (RM 206) (Brown 1996). Lower American River fish surveys conducted by the CDFG have not collected green sturgeon (Snider 1997). Although a green sturgeon sport fishery exists on the lower Feather River, the extent to which green sturgeon use of the Feather River is still to be determined. Green sturgeon larvae are occasionally captured in salmon outmigrant traps, suggesting the lower Feather River may be a spawning area (Moyle 2002). However, NOAA Fisheries (2002) reports that green sturgeon spawning in the Feather River is unsubstantiated. Riverine conditions (water temperature) suitable for the various life history stages of Chinook salmon are also suitable for green sturgeon, thus conservation measures targeting Chinook salmon should also benefit green sturgeon. Given the similarities between riverine conditions suitable for adult green sturgeon migration and spawning and juvenile green sturgeon rearing and those of Chinook salmon, and a general lack of definitive information on green sturgeon life history requirements in Central Valley rivers, assessing impacts on Chinook salmon are anticipated to provide a reasonable estimate of potential impacts on green sturgeon.

- White sturgeon. The species account information presented for white sturgeon is taken largely from the Draft EIR/EIS for the Interim South Delta Program (ISDP). White sturgeon generally complete their life cycle within the Delta and its major tributaries, although a few fish enter the ocean and make extensive coastal migrations (Moyle 2002). During most of the year, adults are concentrated in San Pablo and Suisun bays, where they feed principally on bottom-dwelling invertebrates. Mature adults ascend the Sacramento River and probably the San Joaquin River to spawn between February and June. Spawning peaks in March and April. Most spawning occurs between Ord Bend and Knights Landing in the Sacramento River (Kohlhorst 1976). About 10 percent of the adult population (Kohlhorst et al. 1991) migrates into the San Joaquin River between Mossdale and the mouth of the Merced River. Spawning migration may begin several months prior to the spawning period (Kohlhorst 1976; Moyle 2002). Spawning occurs at water temperatures between approximately 46°F and 66°F (Moyle 2002). Spawning occurs over rock and gravel in deep riffles or holes with swift currents.

- Longfin smelt. Longfin smelt is a euryhaline species, meaning they can tolerate a wide range of salinities. This is particularly evident in the Delta where they are found in areas ranging from almost pure seawater upstream to areas of pure freshwater. In this system, they are most abundant in San Pablo and Suisun bays (Moyle 2002). They tend to inhabit the middle to lower portion of the water column. The longfin smelt spends the early summer in San Pablo and San Francisco bays, generally moving into Suisun Bay in August. Most spawning is from February to April at water temperatures of 44.6-58.1°F (Moyle 2002). The majority of adults perish following spawning. Longfin smelt eggs have adhesive properties and are probably deposited on rocks or aquatic plants upon fertilization. Newly hatched longfin smelt are swept downstream into more brackish parts of the estuary. Strong Delta outflow is thought to correspond with longfin smelt survival, as higher flows transport longfin smelt young to more suitable rearing habitat in Suisun and San Pablo bays (Moyle 2002). Longfin smelt are rarely observed upstream of Rio Vista in the Delta (Moyle et al. 1995). Due to similarities between longfin smelt spawning temperature requirements and Chinook salmon migration, spawning, and rearing temperature requirements, longfin smelt impacts are assessed indirectly through analysis of Chinook salmon.

- Pacific lamprey. Adult Pacific lamprey likely spend their oceanic phase in nearshore coastal areas adjacent to their natal rivers (Moyle 2002). Spawning adult Pacific lamprey can be found inland to the upper reaches of most rivers draining into the Pacific Ocean. Pacific lamprey are believed to enter freshwater in the late winter and further ascend into spawning streams between early March and late June (Moyle 2002). Most upstream movement takes place at night and tends to occur in surges, although small numbers may move upstream more or less continuously over a two- to four-month period. Lampreys can move considerable distances, stopped only by major barriers such as the Friant Dam. Both sexes construct a crude nest by removing the larger stones from a gravelly area where the current is fairly swift and depths are 30-150 cm. Water temperatures are typically 53.6-64.4°F (Moyle 2002). Usually, both sexes die shortly after spawning. After hatching, ammocoetes spend a short time in the nest gravel. Eventually they swim up into the current and are washed downstream to a suitable area of soft sand and mud, where they become filter feeders. Downstream migration begins when transformation is completed, seemingly during high-outflow events in winter and spring. Juvenile Pacific lamprey freshwater residency presumably last 5-7 years (Moyle 2002).

- River lamprey. The anadromous river lamprey is found in coastal streams from San Francisco Bay to Alaska (Moyle 2002). Adults migrate back into fresh water in the fall and spawn from April to June in small tributary streams (Wang 1986). Presumably, the adults need clean, gravelly riffles in permanent streams for spawning, while the ammocoetes require sandy backwaters or stream edges in which to bury themselves, where water quality is continuously high and temperatures do not exceed 77°F. Adults die after spawning. Ammocoetes begin their transformation into adults when they are about 12 cm TL, during the summer. The process of metamorphosis may take nine to 10 months, the longest known for any lamprey. Lampreys in the final stages of metamorphosis congregate immediately upriver from salt water and enter the ocean in late spring. Adults apparently only spend three to four months in salt water, where they grow rapidly, reaching 25-31 cm TL (Moyle 2002).

- Kern brook lamprey. The Kern brook lamprey was first discovered in the Friant-Kern Canal, but it has since been found in the lower reaches of the Merced River, Kaweah River, Kings River, and San Joaquin River. Since this species was first discovered in 1976, attempts to fully document its range have been only partially successful. Isolated populations of Kern brook lamprey seem thinly distributed throughout the San Joaquin drainage, and their abundances are probably much reduced. Ammocoetes thrive in the dark siphons of the Friant-Kern Canal, but it is unlikely that there is suitable spawning habitat in the canal, so those individuals probably do not contribute to the persistence of the species. Judged from ammocoetes taken, the spawning season is estimated to be from July to September (Wang 1986).

- Sacramento perch. Sacramento perch are deep-bodied laterally compressed centrarchids. Historically, Sacramento perch were found throughout the Central

Valley, the Pajaro and Salinas rivers, and Clear Lake. The only populations today that represent continuous habitation within their native range are those in Clear Lake and Alameda Creek. Within their native range, Sacramento perch exist primarily in farm ponds, reservoirs, and lakes into which they have been introduced (Moyle 2002). Sacramento perch are often associated with beds of rooted, submerged, and emergent vegetation and other submerged objects. Sacramento perch are able to tolerate a wide range of physicochemical water conditions. This tolerance is thought to be an adaptation to fluctuating environmental conditions resulting from floods and droughts. Thus, they do well in highly alkaline water (McCarraher and Gregory 1970; Moyle 1976). Most populations today are established in warm, turbid, moderately alkaline reservoirs or farm ponds. Spawning occurs during spring and early summer and usually begins by the end of March, continuing through the first week of August (Mathews 1965; Moyle 2002). Introductions of non-native species, not necessarily habitat alterations, are foremost in the cause of Sacramento perch declines (Moyle 2002). The ability of Sacramento perch to tolerate a wide range of environmental conditions justifies using Chinook salmon analyses as an alternative.

- San Joaquin roach. The San Joaquin roach, a native freshwater minnow, is found throughout the Sacramento-San Joaquin drainage system (Moyle 2002). California roach, for which the San Joaquin roach is a subspecies, are generally found in small, warm intermittent streams, and dense populations are frequently found in isolated pools (Moyle 2002; Moyle et al. 1982). They are most abundant in mid-elevation streams in the Sierra foothills and in the lower reaches of some coastal streams (Moyle 2002). Roach are tolerant of relatively high temperatures (86-95°F) and low oxygen levels (1-2 ppm) (Taylor et al. 1982). Roach reach sexual maturity by about the second year (approximately 45 mm SL). Reproduction generally occurs from March to June, usually when temperatures exceed 60.8°F, but may be extended through late July (Moyle 2002). EWA actions are not anticipated to affect the primary habitats of the California Roach, which are generally small warm streams.

9.1.1 Upstream from the Delta Region

The following narratives describe specific conditions (e.g., species composition, distribution, time of year when the species is present) for each of the major water bodies that are evaluated in the Upstream from the Delta Region of the area of analysis. Life histories and lifestage-specific environmental requirements for several species may differ slightly among the water bodies. Any differences are noted in the discussions of the individual water bodies. If there are not any noted differences, the species life history and environmental requirements are assumed to be identical to the general discussions above.

9.1.1.1 Sacramento River Area of Analysis

The Sacramento River area of analysis includes Lake Shasta, the Sacramento River from Keswick Dam (the upstream extent of anadromous fish migration and spawning) to the Delta (at approximately Chipps Island near Pittsburg), and Butte Creek from Centerville Head Dam to the confluence with the Sacramento River. Details regarding the water bodies within the Sacramento River area of analysis and the fisheries resources they support are provided below.

9.1.1.1.1 Lake Shasta

Lake Shasta was formed when Shasta Reservoir was constructed in 1935 through 1945, and its filling in 1948 impounded the Pit, McCloud, and Sacramento rivers. Lake Shasta has a storage capacity of 4.5 million acre-feet, a capacity equal to Folsom and Oroville reservoirs combined. It has 365 miles of shoreline and a surface area of 30,000 acres. When full, the surface water elevation is 1,067 feet above mean sea level (msl) and its' maximum depth is 517 feet.

Thermal stratification, which occurs in Lake Shasta annually between April and November, establishes a warm surface water layer (epilimnion), a middle water layer characterized by decreasing temperature with increasing depth (metalimnion or thermocline), and a bottom, coldwater layer (hypolimnion) within the reservoir. In terms of aquatic habitat, the warm epilimnion of Lake Shasta provides habitat for warmwater fishes, whereas the reservoir's lower metalimnion and hypolimnion form a "coldwater pool" that provides habitat for coldwater fish species throughout the summer and fall portions of the year. Hence, Lake Shasta supports a "two-story" fishery during the stratified portion of the year (April through November), with warm-water species using the upper, warm-water layer and coldwater species using the deeper, colder portion of the reservoir.

Coldwater species include rainbow trout, brown trout, landlocked white sturgeon, and landlocked Coho salmon; and warmwater species include smallmouth bass, largemouth bass, spotted bass, black crappie, bluegill, green sunfish, channel catfish, white catfish, and brown bullhead. Other, nongame species in Lake Shasta include hardhead, golden shiner, threadfin shad, common carp, Sacramento sucker, and Sacramento pikeminnow.

Although developed primarily for irrigation, the multiple-purpose Shasta Reservoir project also provides flood control, improves Sacramento River navigation, supplies domestic and industrial water, generates electric power, conserves fish and wildlife, creates opportunities for recreation, and enhances water quality. Since construction, Shasta Dam plays a major role in maintaining ecosystem values since such a large demand exists on the water resource, meeting Bay-Delta water quality standards, and meeting requirements for the endangered winter-run Chinook salmon (USBR 1999). These regulating and other uses cause water surface elevations to fluctuate by approximately 55 feet over the course of a year, which disturb the reservoir's littoral (shallow, nearshore) habitats. Disruptions to littoral habitat also occur from shoreline wave action caused by wind and boating activity.

9.1.1.1.2 Sacramento River

The upper Sacramento River is often defined as the portion of the river from Princeton (RM 163) (the downstream extent of salmonid spawning in the Sacramento River

(Burmester 1996)) to Keswick Dam (the upstream extent of anadromous fish migration and spawning). The Sacramento River serves as an important migration corridor for anadromous fishes moving between the ocean and/or Delta and upper river/tributary spawning and rearing habitats. The upper Sacramento River is differentiated from the river's "headwaters" which lie upstream of Lake Shasta. The upper Sacramento River provides a diversity of aquatic habitats, including fast-water riffles and shallow glides, slow-water deep glides and pools, and off-channel backwater habitats.

In excess of 30 species of fish are known to use the Sacramento River. Of these, a number of both native and introduced species are anadromous. Anadromous species include Chinook salmon, steelhead, green and white sturgeon, striped bass and American shad. The upper Sacramento River is of primary importance to native anadromous species, and is presently utilized for spawning and early-life-stage rearing, to some degree, by all four runs of Chinook salmon (fall, late-fall, winter, and spring runs) and steelhead. Consequently, various life stages of the four races of Chinook salmon and steelhead can be found in the upper Sacramento River throughout the year. Other Sacramento River fishes are considered resident species, which complete their lifecycle entirely within freshwater, often in a localized area. Resident species include rainbow and brown trout, largemouth and smallmouth bass, channel catfish, sculpin, Sacramento pikeminnow, Sacramento sucker, hardhead, and common carp (USBR 1991).

The lower Sacramento River is generally defined as that portion of the river from Princeton to the Delta, at approximately Chipps Island (near Pittsburg). The lower Sacramento River is predominantly channelized, leveed and bordered by agricultural lands. Aquatic habitat in the lower Sacramento River is characterized primarily by slow-water glides and pools, is depositional in nature, and has reduced water clarity and habitat diversity, relative to the upper portion of the river.

Many of the fish species utilizing the upper Sacramento River also use the lower river to some degree, even if only as a migratory pathway to and from upstream spawning and rearing grounds. For example, adult Chinook salmon and steelhead primarily use the lower Sacramento River as an immigration route to upstream spawning habitats and an emigration route to the Delta. The lower river is also used by other fish species (e.g., Sacramento splittail and striped bass) that make little to no use of the upper river (upstream of RM 163). Overall, fish species composition in the lower portion of the Sacramento River is quite similar to that of the upper Sacramento River and includes resident and anadromous cold- and warmwater species. Many fish species that spawn in the Sacramento River and its tributaries depend on river flows to carry their larval and juvenile life stages to downstream nursery habitats. Native and introduced warmwater fish species primarily use the lower river for spawning and rearing, with juvenile anadromous fish species also using the lower river and non-natal tributaries, to some degree, for rearing.

An important component of aquatic habitat throughout the Sacramento River is referred to as Shaded Riverine Aquatic Cover. Shaded Riverine Aquatic consists of the portion of the riparian community that directly overhangs or is submerged in the river. Shaded Riverine Aquatic provides high-value feeding and resting areas and escape cover for juvenile anadromous and resident fishes. Shaded Riverine Aquatic also can provide some degree of local temperature moderation during summer months due to the shading it provides to nearshore habitats (USFWS 1980). The importance of Shaded Riverine Aquatic to Chinook salmon was demonstrated in studies conducted by the USFWS (DeHaven 1989). In early summer, juvenile Chinook salmon were found exclusively in areas of Shaded Riverine Aquatic, and none were found in nearby rip-rapped areas (DeHaven 1989).

9.1.1.1.3 Butte Creek

Butte Creek is a perennial river that originates on the western slope of the Sierra Nevada at an elevation of approximately 7,000 feet msl and flows into the Sacramento River via two separate means. Under high flow conditions Butte Creek enters the Sacramento River through Butte Slough southeast of the City of Colusa. During normal flow conditions, water is not diverted through the Butte Slough Outfall gates, but instead flows through the Sutter Bypass, which enters the Sacramento River via the Sacramento Slough southeast of the community of Knights Landing (Butte Creek Watershed Conservancy 2003).

The upper portion of Butte Creek flows from its headwaters in the Sierra Nevada through Butte Meadows to the Centerville Head Dam via Butte Creek Canyon. This portion of the creek contains several power generating dams and receives flows from numerous small tributaries as well as water diverted from the West Branch of the Feather River via the Toadtown/Hendricks Canal (Butte Creek Watershed Conservancy 2003). The various natural waterfalls in this reach historically precluded anadromous fishes from migrating higher than the vicinity of Centerville Head Dam (CDFG 1998).

Several species of fish occur in upper Butte Creek and its tributaries. The reach extending from the Centerville Head Dam, through Butte Meadows, and up to the creek's headwaters sustains a popular trout fishery maintained by the CDFG. Rainbow, brown and brook trout are common in this reach and fishing pressure is relatively high due to easy access (Butte Creek Watershed Conservancy 2003).

Below Centerville Head Dam, Butte Creek continues through Butte Creek Canyon for approximately 15 miles until its gradient shallows as it enters the Sacramento Valley southeast of the City of Chico. Numerous dams and diversions in the valley section of the river divert water for agricultural, flood protection, and wildlife uses including the Parrot-Phelan diversion, Adams Dam, Gorrill Dam, Sanborn Slough Bifurcation, Mallard Dam, and the Butte Slough outfall. The Western Canal Siphon (Butte Creek Siphon) lies in this reach between Gorrill Dam and Nelson Road. Under normal flow conditions, Butte Creek water passes through this reach and continues through the Sutter Bypass before joining the Sacramento River. It is within this reach that Butte

Creek gains flow through the return of irrigation water (Butte Creek Watershed Conservancy 2003).

The reach of Butte Creek between Centerville Head Dam and Highway 99 contains habitat for and supports spring-run, fall-run, and late- fall-run Chinook salmon, Sacramento sucker, largemouth bass, smallmouth bass, bluegill, green sunfish, redear sunfish, riffle sculpin, hardhead, roach, golden shiner, speckled dace, Sacramento pikeminnow, tule perch, brown bullhead, Pacific lamprey, rainbow trout, steelhead, brown trout, and bigscale logperch (Butte Creek Watershed Conservancy 2003). All spring-run Chinook salmon spawning and holding in Butte Creek occurs within this reach (CDFG 1998). Additional species observed in the reach between Highway 99 and the Sutter Bypass include black crappie, white crappie, golden shiner, hitch, Sacramento splittail, and wakasagi (Butte Creek Watershed Conservancy 2003).

In most years the majority of fall-run Chinook salmon spawning in Butte Creek reportedly occurs between Durham Mutual Dam near Highway 99 and the Western Canal Siphon. In some years, however, it has been observed that some fall-run Chinook spawning occurs as far upstream as the Parrot-Phelan Diversion (USFWS 2000; Butte Creek Watershed Conservancy 2003). Little evidence is available on the spawning locations of late fall-run Chinook salmon in Butte Creek. However, it has been reported that late fall-run Chinook spawning occurs upstream of the Parrot-Phelan Diversion (USFWS 2000; Butte Creek Watershed Conservancy 2003). Steelhead have also been reported to spawn upstream of the Parrot Phelan Diversion to the Centerville Head Dam (Butte Creek Watershed Conservancy 2003). The Sutter Bypass reportedly contains spawning Sacramento splittail during the months of February through April (USFWS 1995b; USFWS 2000).

Spring-run Chinook Salmon

Adult spring-run Chinook salmon enter their natal streams from mid-February through July, with peak migration occurring during May. Once in their spawning reaches, adult salmon seek deep pools with bedrock or boulder substrate in which to hold over the summer (CDFG 1998). Holding occurs in Butte Creek from the time of upstream migration until the onset of spawning (generally from mid-February through October). Adult spring-run Chinook salmon have been observed holding between the Parrot-Phelan Diversion and the Centerville Head Dam (CDFG 1998). Generally, however, most fish are found holding between the confluence of Little Butte Creek and a pool known as Quartz Bowl, located approximately one mile downstream from the Centerville Head Dam (Butte Creek Watershed Conservancy 2003).

Holding pools often have a large bubble curtain at the head with moderate water velocities (0.5 to 1.3 feet per second) throughout the remainder of the pool. The upper limit of suitable water temperatures for holding adult Chinook salmon is believed to be between 59ºF and 60ºF (CDFG 1998). During the over-summer holding period, physiological changes in the fish, including gonadal maturation, take place in preparation for spawning which generally occurs near holding pools (CDFG 1998).

Spring-run Chinook salmon spawning in Butte Creek reportedly occurs between late August and early November, with peak spawning activity occurring between late September and early October (DWR and USBR 2000). Spawning activity and redds have been observed in Butte Creek up to the Centerville Head Dam, although the Centerville Head Dam upstream limit was likely the result of unusually high river flows combined with record spring-run Chinook salmon escapement in 1998 (Butte Creek Watershed Conservancy 2003; CDFG 1998; M. Gard 2003). During most years, the documented upstream limit of migration is Quartz Bowl. During some years, such as 1998, CDFG has documented spring-run Chinook salmon spawning as far downstream as Parrott-Phelan Diversion Dam (CDFG 2002b). Unpublished data from the USFWS, however, suggests that spawning does not occur below the confluence of Butte Creek and Little Butte Creek because of unsuitable temperature regimes during peak spawning months (M. Gard 2003).

Water velocity is generally considered the most important parameter in redd selection (CDFG 1998; DWR 2000c; Butte Creek Watershed Conservancy 2003). According to CDFG (1998), suitable water velocities range from 1.2 to 3.5 feet per second, with water temperatures ranging from 40ºF to 57ºF. Suitable substrate composition is reportedly a mixture of gravel and cobble with a mean diameter of one to four inches with less than five percent fines (Butte Creek Watershed Conservancy 2003; CDFG 1998).

The incubation period for spring-run Chinook salmon eggs in Butte Creek is approximately three months (90 days), with fry emergence beginning in November and continuing through January (CDFG 1998). Because of highly variable water temperatures in different drainages, egg incubation times can differ significantly. Salmon eggs hatch in 50 days when incubated at 50ºF but require over 110 days when incubated at 40ºF (CDFG 1998). Suitable temperatures for fry emergence are slightly higher than for egg incubation. Fifty to 55ºF has been reported to be the suitable range for fry emergence (CDFG 1998).

Upon emergence, spring-run Chinook salmon fry congregate in shallow, low velocity edgewater where food supply and cover are adequate for rapid growth and rearing (CDFG 1998; Butte Creek Watershed Conservancy 2003). Rearing times for spring-run Chinook in general are highly variable, and for salmon spawning in Butte Creek, the bulk of emigration is reported to occur between December and January, with some emigration continuing through May (CDFG 1998). Some juveniles continue to rear in Butte Creek through the summer and emigrate as yearlings from October to February, with peak yearling emigration occurring in November and December (CDFG 1998). The suitable water temperature range for rearing and emigration is reported to be between 55ºF and 60ºF (CDFG 1998). The theoretical upper temperature limit for rearing and emigrating juveniles has been reported as 78.5ºF (DWR and USBR 2000).

9.1.1.2 Feather River Area of Analysis

The Feather River area of analysis includes Little Grass Valley and Sly Creek reservoirs on the South Fork Feather River; the Oroville Facilities, including Lake Oroville, the Thermalito Forebay, the Thermalito Afterbay, and the Feather River Fish Hatchery; and the lower Feather River extending from the Fish Barrier Dam to the confluence with the Sacramento River. Water assets purchased from Little Grass Valley and Sly Creek reservoirs would be transferred via a series of conveyance and storage facilities prior to release directly into Oroville Reservoir. The South Fork Feather River would not be affected by EWA actions and therefore is not included in the Feather River area of analysis. Details regarding the facilities and water bodies within the Feather River area of analysis and the fisheries resources they support are provided below.

9.1.1.2.1 Little Grass Valley and Sly Creek Reservoirs

Oroville-Wyandotte Irrigation District (ID) owns and operates Little Grass Valley and Sly Creek Reservoirs as storage facilities on the South Fork Feather River. The district uses the reservoirs mainly for water regulating purposes, though both reservoirs support coldwater fisheries. Little Grass Valley Reservoir is located on the South Fork Feather River in Plumas County, at an elevation of 5,047 feet above msl, and has a storage capacity of 94,700 acre-feet. It has a surface area of 1,615 acres and 16 miles of shoreline. Fish species present in Little Grass Valley Reservoir include rainbow, brook, and brown trout and catfish. CDFG stocks Little Grass Valley with rainbow trout monthly from June through August. Brook and brown trout are planted annually. Sly Creek Reservoir is in eastern Butte County at an elevation of 3,536 feet and has a storage capacity of 65,700 acre-feet. CDFG regularly plants the reservoir with fish, including rainbow trout, brown trout, brook trout, and kokanee salmon (DWR 2002).

9.1.1.2.2 Lake Oroville and Associated Facilities

Lake Oroville is located at the confluence of the West Branch and the North, Middle, and South Forks of the Feather River, upstream from the Yuba and Bear River tributaries, at an elevation of 900 feet above msl. Lake Oroville is the second largest reservoir in California, with a storage capacity of 3.5 million acre-feet. Like many other California foothill reservoirs, Lake Oroville is steep-sided, with large surface fluctuations and a low surface-to-volume ratio. It is a warm, monomictic reservoir that thermally stratifies in the spring, destratifies in the fall, and remains destratified throughout the winter. Due to the stratification, Lake Oroville has been said to contain a "two-story" fishery, supporting both coldwater and warmwater fisheries that are thermally segregated for most of the year. The coldwater fish use the deeper, cooler, well-oxygenated hypolimnion, whereas the warmwater fish are found in the warmer, shallower, epilimnetic, and littoral zones. Once Lake Oroville destratifies in the fall, the two fishery components mix in their habitat utilization.

Lake Oroville's coldwater fishery is primarily composed of Coho salmon and brown trout, although rainbow trout and lake trout are periodically caught. The coldwater fisheries for Coho salmon and brown trout are sustained by hatchery stocking because natural recruitment to the Lake Oroville coldwater fishery is very low. A "put-and-grow" hatchery program is currently in use, where salmonids are raised at CDFG hatcheries and stocked in the reservoir as juveniles, with the intent that these fish will grow in the reservoir before being caught by anglers (DWR 2001a).

The Lake Oroville warm water fishery is a regionally important self-reproduction fishery. The black bass fishery is the most significant, both in terms of angler effort and economic impact on the area. Spotted bass are the most abundant bass species in Lake Oroville, followed by largemouth, redeye and smallmouth bass, respectively. Catfish are the next most popular warmwater fish at Lake Oroville, with both channel and white catfish present in the lake. White and black crappie are also found in Lake Oroville, though populations fluctuate widely from year to year. Bluegill and green sunfish are the two primary sunfish species in Lake Oroville, though red ear sunfish and warmouth are also present in very low numbers. Although common carp are considered by many to be a nuisance species, they are also abundant in Lake Oroville (DWR 2001a). The primary forage fish in Lake Oroville are wakasagi and threadfin shad. Threadfin shad were intentionally introduced in 1967 to provide forage for gamefish, whereas the wakasagi migrated down from an upstream reservoir in the mid-1970s (DWR 2001a).

The Thermalito Forebay is a cold, shallow, open reservoir with minor fluctuations in surface elevations and a high surface-to-volume ratio. It remains cold throughout the year because it is supplied with water from the Diversion Pool, although pump-back operations from the Thermalito Afterbay warm the Forebay somewhat. The CDFG manages the Forebay as a put-and-take trout fishery, where catchable (about 1/2 lb.) trout are stocked biweekly. Rainbow and brook trout are the primary fish planted, although surplus Chinook yearlings reared in the Feather River Fish Hatchery were stocked in the Forebay in February 2000. The Forebay coldwater fishery is the second most popular reservoir fishery at the Oroville Facilities (DWR 2001a). Warmwater fish species found in Lake Oroville are believed to exist in the Forebay in low numbers (DWR 2001a).

The Thermalito Afterbay is a large, shallow, open reservoir with frequent water level fluctuations and a high surface-to-volume ratio. The shallow nature of the Afterbay results in very noticeable fluctuation effects with only a few feet of surface level changes. Mudflats can be exposed and a significant amount of the littoral zone can be dewatered. Water temperatures can vary widely around the Afterbay in the summer, with water in the low 60s near the tailrace channel that feeds the Afterbay, and water in the mid 80s in the backwater areas that do not readily circulate (DWR 2001a).

The diverse temperature structure of the Afterbay has provided suitable habitat for both coldwater and warmwater fish. A popular largemouth bass fishery currently exists, and large trout are sometimes caught near the inlet. No salmonid stocking currently occurs at the Afterbay, so these fish most likely passed through the Thermalito Pumping-Generating Plant from the Forebay. Though limited fish sampling has been conducted at the Afterbay, smallmouth bass, rainbow trout, brown trout, red ear sunfish, bluegill, black crappie, channel catfish, and carp have all been observed. Most of the Lake Oroville sportfish probably occur in the Afterbay to some degree (DWR 2001a).

DWR constructed the Feather River Fish Hatchery in 1967 to mitigate for salmonid spawning habitat lost due to the construction and operation of Oroville Dam/Reservoir complex. Since the late 1960s, the Feather River Fish Hatchery, operated by the CDFG, has released millions of spring and fall Chinook salmon fry, fingerlings, smolts and yearlings, and yearling steelhead. The hatchery water supply is diverted directly from the Thermalito Diversion Pool, which receives cold, hypolimnetic water (which rarely exceeds mid to high fifties (ºF)) from Lake Oroville. Because the hatchery's water supply comes from stored water in the Thermalito Diversion Pool and does not come directly from the Feather River, it is not subject to the thermal warming effects associated with downstream in-channel transport.

9.1.1.2.3 Lower Feather River

The lower Feather River commences at the Low Flow Channel, which extends eight miles from the Fish Barrier Dam (RM 67) to the Thermalito Afterbay Outlet (RM 59). (See Figure 9-2.) Under an agreement with the CDFG, flows in this reach of the river are regulated at 600 cfs, except during flood events when flows have reached as high as 150,000 cfs (DWR 1983). Average monthly water temperatures typically range from about 47°F in winter to about 65°F in summer. The majority of the Low Flow Channel flows through a single channel contained by stabilized levees. Side-channel or secondary channel habitat is extremely limited, occurring primarily in the Steep Riffle and Eye Riffle areas between RM 60-61. The channel banks and streambed consist of armored cobble as a result of periodic flood flows and the absence of gravel

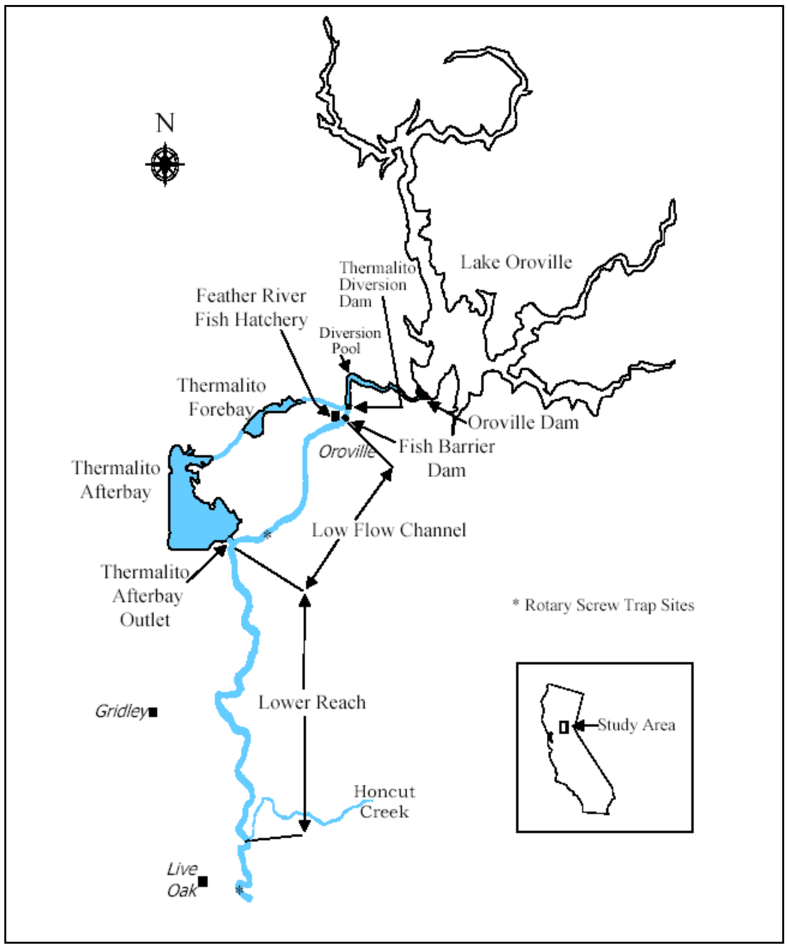

Figure 9-2
Lower Feather River

recruitment. However, there are nine major riffles with suitable spawning size gravel, and approximately 75 percent of the Chinook salmon spawning takes place in this upper reach (Sommer et al. 2001). Releases are made from the coldwater pool in Lake Oroville and this cold water generally provides suitable water temperatures for spawning in the Low Flow Channel (DWR 2001a).

The lower reach extends 15 miles from the Thermalito Afterbay Outlet (RM 59) to Honcut Creek (RM 44). Releases from the outlet vary according to operational requirements. In a normal year, total flow in the lower reach ranges from 1,750 cfs in fall to 5,000-8,000 cfs in spring. Water temperature in winter is similar to the Low Flow Channel but increases to 74°F in summer. Higher flows dramatically increase the channel width in this reach. Numerous mid-channel bars and islands braid the river channel, creating side-channel and backwater habitat. The channel is not as heavily armored, and long sections of riverbanks are actively eroding. In comparison to the Low Flow Channel, there is a greater amount of available spawning areas, which are isolated by longer and deeper pools (DWR 2001a).

The lower Feather River from the Fish Barrier Dam to Honcut Creek supports a variety of anadromous and resident fish species. The most important fish species in terms of sport fishing is the fall-run Chinook salmon, although striped bass and American shad are also common targets for anglers. Approximately 75 percent of the natural spawning for fall-run Chinook salmon currently occurs between the Fish Barrier Dam and the Thermalito Afterbay Outlet (RM 67-59), with approximately 25 percent of the spawning occurring between the Afterbay outlet and Honcut Creek (RM 59-44) (Sommer et al. 2001). The fall-run may enter the river as early as August and begin spawning in September. Spawning typically continues through December, with October and November constituting the peak spawning months.

In addition to the sportfish mentioned above, several other native and exotic fish species are found in the Feather River. The Feather River maintains spawning, rearing, and migration habitat for three special-status species: spring-run Chinook salmon, Central Valley steelhead, and Sacramento splittail (DWR 2001a). The occasional capture of larval green sturgeon in outmigrant traps suggests that green sturgeon spawn in the Feather River (Moyle 2002). However, NOAA Fisheries (2002) reports that evidence of green sturgeon spawning in the Feather River is unsubstantiated. In the Feather River, the basic life history of spring-run Chinook salmon is very similar to fall-run Chinook salmon. Spawning may occur a few weeks earlier for spring-run (as compared to fall-run), but there is no clear distinction between the two due to the disruption of spatial segregation by Oroville Dam. Fish exhibiting the typical life history of the spring-run are found holding at the Thermalito Afterbay Outlet and the Fish Barrier Dam as early as March. At present, the genetic distinctness of Feather River spring-run is still officially undetermined, although additional analysis may be conducted prior to definitive determination of the genetic distinction of spring-run Chinook salmon and fall-run Chinook salmon.

Adult steelhead typically ascend the Feather River from September through January, where spawning takes place rather quickly. The residence time of adult steelhead in the Feather River after spawning and adult steelhead post-spawning mortality is currently unknown. It appears that most of the natural steelhead spawning in the Feather River occurs in the Low Flow Channel, particularly in the upper reaches near Hatchery Ditch. It is unknown whether steelhead spawn below the Thermalito Afterbay Outlet; though, based on the spawning habitat available it is very likely that at least some steelhead spawn below the Afterbay outlet. Soon after emerging from the gravel, a small percentage of the fry appears to emigrate. The remainder of the population rears in the river for at least six months to one year. Recent studies have confirmed that juvenile rearing (and probably adult spawning) is most concentrated in small secondary channels within the low flow channel. The smaller substrate size and greater amount of cover (compared to the main river channel) likely make these side channels more suitable for steelhead spawning. Currently, this type of habitat comprises less than 1 percent of the available habitat in the low flow channel (DWR 2001a).

9.1.1.3 Yuba River Area of Analysis

The Yuba River area of analysis includes New Bullards Bar and Englebright reservoirs and the lower Yuba River, extending from Englebright Dam to the confluence with the Feather River. Details regarding the facilities and water bodies within the Yuba River area of analysis and the fisheries resources they support are provided below.

9.1.1.3.1 New Bullards Bar and Englebright Reservoirs

New Bullards Bar Reservoir is located on the North Fork Yuba River and is the largest reservoir in the Yuba River watershed (DWR 2000a) with a storage capacity of 960,000 acre-feet. When full, the reservoir has a surface area of approximately 4,800 acres (at an elevation of 1,965 feet above msl) and regulates winter and spring drainage from approximately 489 square miles of watershed on the Yuba River. The reservoir has steeply sloped sides created from the flooding of a deep canyon. New Bullards Bar Reservoir supports both coldwater and warmwater fisheries consisting of the following species: rainbow trout, kokanee salmon, brown trout, largemouth bass, smallmouth bass, crappie, sunfish, and bullhead (DWR 2000a). Although warmwater fish species are known to occur in New Bullards Bar Reservoir (crappie, largemouth and smallmouth bass, and sunfish), limited recreational fisheries exist for these warmwater fish species. New Bullards Bar Reservoir supports a very significant salmonid fishery emphasizing kokanee salmon. In fact, New Bullards Bar Reservoir is known for having the best kokanee salmon fishing throughout the State of California (Jones and Pack 2002).

Englebright Reservoir is located downstream of New Bullards Bar Reservoir, and has a storage capacity of approximately 70TAF (DWR 2002). Englebright Reservoir supports warmwater and coldwater fish species, including rainbow and brown trout, large and smallmouth bass, kokanee salmon, catfish, and sunfish (USACE 2001). Transfer water that is released from New Bullards Bar Reservoir generally passes through Englebright Reservoir without modifying Englebright Reservoir elevations (EDAW 2001). Because Englebright Reservoir would serve as a flow-through facility for EWA acquisitions, warmwater and coldwater fishery resources at this facility would not be affected by EWA actions. Therefore, a discussion of potential effects on Englebright Reservoir fishery resources is not included in this analysis.

9.1.1.3.2 Yuba River

The Yuba River Basin drains approximately 1,350 square miles of the western Sierra Nevada slope, including portions of Sierra, Placer, Yuba, and Nevada counties (CALFED 1999). The primary watercourses of the upper watershed are the South, Middle, and North Yuba Rivers, which flow into Englebright Reservoir, which then releases water into the lower Yuba River. Both the upper and lower watersheds (above and below Englebright Dam, respectively) have been extensively developed for water supply, hydropower production, and flood control. Operators of upper watershed projects include Pacific Gas and Electric Company (PG&E), Nevada ID and Oroville-Wyandotte ID. The Yuba River Development Project (YRDP), which is operated by the Yuba County Water Agency (WA), includes water project operations in both the upper and the lower watershed. This project, completed in 1969, includes New Bullards Bar Dam and Reservoir, New Colgate Powerhouse, and Englebright Reservoir.

Based on general differences in hydraulic conditions, channel morphology, geology, water conditions, and fish species distribution, Beak (1989) divided the lower Yuba River into the following four reaches. (See Figure 9-3.)

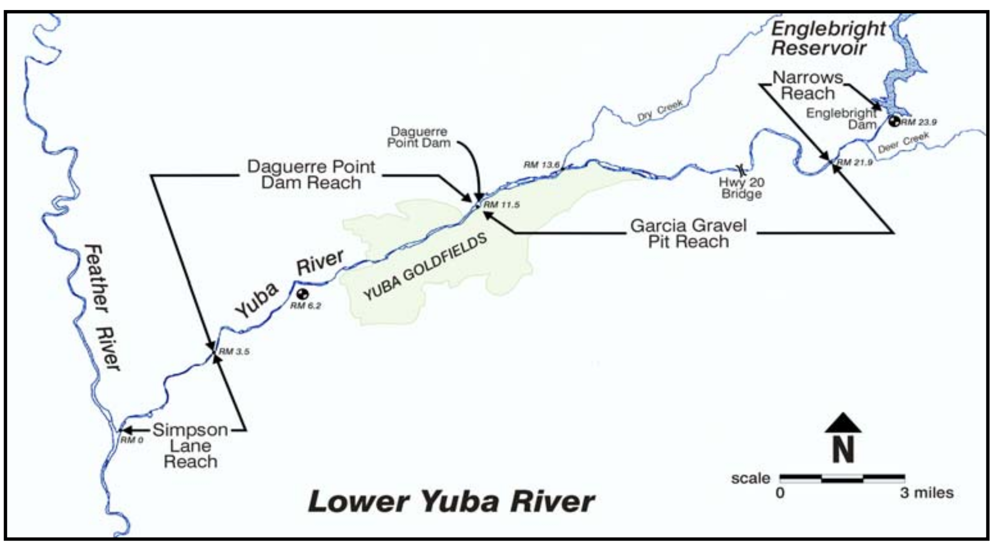

Figure 9-3
Lower Yuba River Study Reaches, Water Diversion Facilities, and USGS Gauging Stations

- **Narrows Reach** – extends from Englebright Dam to the downstream terminus of the Narrows (RM 23.9 to RM 21.9); topography is characterized by steep canyon walls;

- **Garcia Gravel Pit Reach** – extends from the Narrows downstream to Daguerre Point Dam (RM 21.9 to RM 11.5);
- **Daguerre Point Dam Reach** – extends from Daguerre Point Dam downstream to the upstream area of Feather River backwater influence (just east of Marysville; RM 11.5 to RM 3.5); and
- **Simpson Lane Reach** – begins at the upstream area of Feather River backwater influence and extends to the confluence with the Feather River (RM 3.5 to RM 0).

The lower Yuba River consists of the approximately 24-mile stretch of river extending from Englebright Dam, the first impassible fish barrier along the river, downstream to the confluence of the Feather River near Marysville. Water projects operated by PG&E, Nevada ID, and Oroville-Wyandotte ID export up to approximately 530 TAF of water per year into adjacent basins. Once exported, this water is not available to the lower Yuba River.

<u>Fall-run Chinook Salmon</u>
The fall-run Chinook salmon population in the Yuba River was substantially reduced before the 1950s by extensive mining, agriculture, urbanization, and commercial fishing. However, since 1950 natural production of fall-run Chinook salmon in the lower Yuba River has sustained or slightly increased the same average population levels despite continued and increasing out-of-basin stressors that have acted to further limit survival of Chinook salmon in the lower Sacramento River, Sacramento-San Joaquin Delta (Delta), and Pacific Ocean.

CDFG began making annual estimates of fall-run Chinook salmon spawning escapement (the number of salmon that "escape" the commercial and sport fisheries in the Pacific Ocean and return to spawn in the lower Yuba River) in 1953. From 1953 to 1971, these estimates ranged from 1,000 fish in 1957 to 37,000 fish in 1963, and averaged 12,906 fish. From 1972 to 2001, the annual average run of Chinook salmon was 15,361 fish. Assuming CDFG's traditional 15.5 percent estimated contribution to total escapement, the average for the 1972-2001 period is 14,560 fish.

The fall-run Chinook salmon population in the lower Yuba River is sustained largely by natural production. Trends in natural production can be masked by large numbers of returning hatchery spawners in rivers with major hatcheries or planting programs, or where significant straying of hatchery fish occurs. No hatchery or long-term planting program exists on the lower Yuba River. Analyses of straying of hatchery Chinook salmon in the Sacramento River Basin indicate a relatively low degree of straying hatchery spawners to the lower Yuba River (Cramer 1991; S. Cramer 2002).

<u>Spring-run Chinook Salmon</u>
Spring-run Chinook salmon had virtually disappeared from the Yuba River by 1959 (Fry 1961; Wooster and Wickwire 1970). Major in-basin factors contributing to the decline were migration barriers, hydraulic mining, and water diversions. Hydraulic mining in the Yuba River watershed from 1850 to 1885 caused extensive habitat

destruction. Between 1900 and 1941, debris dams constructed by the California Debris Commission and now owned and operated by the Corps on the lower Yuba River to retain hydraulic mining debris, completely or partially blocked the migration of Chinook salmon and steelhead to historic spawning and rearing habitats (Wooster and Wickwire 1970; CDFG 1991; Yoshiyama et al. 1996). Spring-run Chinook salmon populations were probably severely affected because of inadequate flows and high water temperatures below the dams during the summer. It is likely that native spring-run Chinook salmon were extirpated during this period. Water diversions also contributed to poor habitat conditions below the dams, especially in dry years. Today, Englebright Dam, completed in 1941 by the California Debris Commission and now owned and operated by the Corps, completely blocks spawning runs of Chinook salmon and steelhead, and is the upstream limit of fish migration.

Since the completion of New Bullards Bar Dam in 1970 by Yuba County WA, higher, colder flows in the lower Yuba River have improved conditions for over-summering and spawning of spring-run Chinook salmon in the lower Yuba River. Small numbers of Chinook salmon that exhibit spring-run characteristics have been observed (CDFG 1998). Although precise escapement estimates are not available, the USFWS testified at the 1992 SWRCB lower Yuba River hearing *"…a population of about 1,000 adult spring-run Chinook salmon now exists in the lower Yuba River"* (SWRCB 1995). In 2001, 108 adult spring-run Chinook salmon were estimated passing the fish ladders at Daguerre Point Dam on the lower Yuba River during March 1 through July 31, possibly representing the early portion of the run. During the month of September 2001, 288 Chinook salmon redds were observed. Historically, September is the peak month of spring-run Chinook salmon spawning, although some temporal overlap with fall-run Chinook salmon exists (CDFG 2002). Neither of these estimates was used to attempt to estimate the total spring-run Chinook salmon escapement in the Yuba River. The origin of these fish and their genetic relationship with fall-run Chinook salmon are unknown. The run may have originated from plants of hatchery-reared spring-run in the lower Yuba River during the 1970s. Limited observations of tagged adults during annual carcass surveys indicate that hatchery strays from the Feather River also may contribute to the run. The USFWS estimates are the best currently available estimates for spring-run Chinook salmon escapement in the Yuba River.

<u>Steelhead</u>
Historical information on Central Valley steelhead populations is limited. Steelhead ranged throughout accessible tributaries and headwaters of the Sacramento and San Joaquin Rivers before major dam construction, water development, and other watershed disturbances. Many of the freshwater habitat factors cited for declines in spring-run Chinook salmon runs generally apply to steelhead as well, because of their need for tributaries and headwater streams where cool, well-oxygenated water is available year round. Historical declines in steelhead abundance have been attributed largely to dams that eliminated access to most of their historic spawning and rearing habitat, and restricted steelhead to unsuitable habitat below the dams. Other factors that have contributed to the decline of steelhead and other salmonids include habitat

modification, over-fishing, disease and predation, inadequate regulatory mechanisms, climate variation, and artificial propagation (NMFS 1996).

CDFG estimated that only approximately 200 steelhead spawned in the lower Yuba River annually before New Bullards Bar Reservoir was completed in 1969. From 1970 to 1979, CDFG annually stocked 27,270–217,378 fingerlings, yearlings, and sub-catchables from Coleman National Fish Hatchery into the lower Yuba River (CDFG 1991). Based on angling data, CDFG estimated a run size of 2,000 steelhead in the lower Yuba River in 1975. The current status of this population is unknown, but it appears to be stable and able to support a significant sport fishery (McEwan and Jackson 1996). The Yuba River is currently managed for natural steelhead production (CDFG 1991).

9.1.1.4 American River Area of Analysis

The American River area of analysis includes French Meadows Reservoir on the Middle Fork American River and Hell Hole Reservoir on the Rubicon River; the Middle Fork American River from Ralston Afterbay to the confluence with the North Fork American River; Folsom Reservoir, Lake Natoma, and the Nimbus Fish Hatchery; and the lower American River, extending from Nimbus Dam to the confluence with the Sacramento River. Water assets purchased from Hell Hole Reservoir would be transferred via a series of conveyance and storage facilities prior to release into the Middle Fork American River. The Rubicon River below Hell Hole Reservoir would not be affected by EWA actions and therefore is not included in the American River area of analysis. Details regarding the facilities and water bodies within the American River area of analysis and the fisheries resources they support are provided below.

9.1.1.4.1 French Meadows and Hell Hole Reservoirs on the Middle Fork American and Rubicon Rivers

Placer County WA owns and operates the Middle Fork Project (MFP) on the upper American River. The principal project features consist of French Meadows and Hell Hole reservoirs. French Meadows Reservoir is located on the Middle Fork American River and has a storage capacity of 133,700 acre-feet. Hell Hole Reservoir is located on the Rubicon River, the main tributary to the Middle Fork American River, and has a storage capacity of 208,400 acre-feet. French Meadows and Hell Hole reservoirs are mid-elevation Sierra Nevada reservoirs (having elevations of approximately 5,000 feet above msl) that support coldwater recreational fisheries for resident rainbow and brown trout. CDFG stocks French Meadows with rainbows and browns in June and July and Hell Hole once a year. Warmwater fisheries also exist including smallmouth bass, catfish, and sunfish. Fish production in these reservoirs is limited by large seasonal fluctuations in water levels and low productivity compared to natural lakes. French Meadows Reservoir supports a self-sustaining population of brown trout that migrates from the reservoir to spawning areas in the Middle Fork American River above the reservoir during the fall. No physical barriers to brown trout migration are present in the Middle Fork American River within two miles above the reservoir during the fall (Jones and Stokes 2001).

9.1.1.4.2 Middle Fork American River

The Middle Fork American River originates above 7,500 feet msl, west of Squaw Peak in Placer County. The Middle Fork American River supports both warm and coldwater fish species year-round. Operation of Placer County Water Agency's Middle Fork Project, constructed in 1962 (including Ralston Afterbay), results in cooler summer and fall water temperatures, thereby improving habitat suitability for rainbow trout and brown trout for a portion of the river below Ralston Afterbay (USACE 1991; USBR 1996). Brown trout are resident stream fish, meaning they spend their entire lifecycle in fresh water. Spawning generally occurs during November and December (Moyle 1976). Brown trout fry typically hatch in seven to eight weeks, depending on water temperature, with emergence of young three to six weeks later.

Optimal riverine habitat for brown trout reportedly consists of cool to coldwater, silt-free rocky substrate, an approximate 1:1 pool-to-riffle ratio, and relatively stable water flow and temperature regimes (Raleigh et al. 1986). Moyle (1976) reported that while brown trout will survive for short periods at temperatures in excess of 80.6°F, optimum temperatures for growth range from 44.6°F to 66.2°F, with a preference for temperatures in the upper half of this range. Brown trout tend to utilize lower reaches of low to moderate gradient areas (less than one percent) in suitable, high gradient rivers (Raleigh et al. 1986).

Rainbow trout are the non-anadromous form of steelhead. As with brown trout, rainbow trout also are resident stream fish whose optimal riverine habitat reportedly consists of coldwater, silt-free rocky substrate, a 1:1 pool-to-riffle ratio, and relatively stable water flow and temperature regimes (Raleigh and Duff 1980 *in* Raleigh et al. 1984). Moyle (1976) reported that while rainbow trout will survive temperatures up to 82.4°F, optimum temperatures for growth and completion of most lifestages reportedly range from 55.4°F to 69.8°F. Rainbow trout spawning generally occurs from February to June (Moyle 1976). Rainbow trout fry emerge from spawning nests approximately 45 to 75 days after spawning, depending on water temperatures.

In addition to rainbow and brown trout, fish sampling surveys of the Middle Fork American River conducted by the USFWS in 1989 from Ralston Afterbay, downstream to the confluence with the North Fork American River, documented the presence of hitch (*Lavinia exilicauda*), Sacramento sucker (*Catostomus occidentalis*), pikeminnow (*Ptychocheilus grandis*), and riffle sculpin (*Cottus gulosus*) (USACE 1991). No Federal- or State-listed species or species proposed for listing under the Federal ESA and CESA are reported in the Middle Fork American River.

9.1.1.4.3 Folsom Reservoir

Folsom Reservoir has a maximum storage capacity of approximately 977 TAF, and has a maximum depth of approximately 266 feet. Folsom Reservoir is the most upstream CVP facility on the American River, and is located at an elevation of 466 feet above msl. Strong thermal stratification occurs within Folsom Reservoir annually between

April and November. Thermal stratification establishes a warm surface water layer (epilimnion), a middle water layer characterized by decreasing temperature with increasing depth (metalimnion or thermocline), and a bottom, coldwater layer (hypolimnion) within the reservoir. In terms of aquatic habitat, the warm epilimnion of Folsom Reservoir provides habitat for warmwater fishes, whereas the reservoir's lower metalimnion and hypolimnion form a "coldwater pool" that provides habitat for coldwater fish species throughout the summer and fall portions of the year. Hence, Folsom Reservoir supports a “two-story” fishery during the stratified portion of the year (April through November), with warm-water species using the upper, warm-water layer and coldwater species using the deeper, colder portion of the reservoir.

Native species that occur in the reservoir include hardhead and Sacramento pikeminnow. However, introduced largemouth bass, smallmouth bass, spotted bass, bluegill, crappie, and catfish constitute the primary warm-water sport fisheries of Folsom Reservoir. The reservoir’s coldwater sport species include rainbow and brown trout, kokanee salmon and Chinook salmon, all of which are currently or have been stocked by CDFG. Although brown trout are no longer stocked, a population still remains in the reservoir. These species are stream spawners and, therefore, do not reproduce within the reservoir. However, some spawning by one or more of these species may occur in the American River upstream of Folsom Reservoir.

Species-specific spawning times for those fish species that do spawn in Folsom Reservoir define the months of concern during which additional surface water diversions under the preferred program alternative could impact fish spawning and young-of-the-year rearing success. For example, largemouth and smallmouth bass spawn primarily in April and May, whereas peak spawning for sunfish and catfish generally occurs in late-May and June.

Folsom Reservoir’s coldwater pool is important not only to the reservoir’s coldwater fish species identified above, but also is important to lower American River fall-run Chinook salmon and steelhead. Seasonal releases from the reservoir’s coldwater pool provide thermal conditions in the lower American River that support annual in-river production of these salmonid species. Folsom Reservoir’s coldwater pool is not large enough to allow for coldwater releases during the warmest months (July through September) to provide maximum thermal benefits to lower American River steelhead, and coldwater releases during October and November that would maximally benefit fall-run Chinook salmon immigration, spawning, and incubation. Consequently, management of the reservoir’s coldwater pool on an annual basis is essential to providing thermal benefits to both fall-run Chinook salmon and steelhead, within the constraints of coldwater pool availability.

9.1.1.4.4 Lake Natoma

Lake Natoma was constructed to serve as a regulating afterbay for Folsom Reservoir and is located at an elevation of 132 feet above msl. Consequently, water surface elevations in Lake Natoma fluctuate from three to seven feet on a daily and weekly basis (USFWS 1991). Lake Natoma receives controlled releases from Folsom Reservoir and has a storage capacity of 9 TAF. Despite its size (an operating range of 2,800 acre-feet), Lake Natoma can influence the temperature of water flowing through it. Residence time in the lake, particularly during summer months, has a warming effect on water released from Folsom Reservoir. Water is released from Lake Natoma into the lower American River below Nimbus Dam.

Lake Natoma supports many of the same fisheries found in Folsom Reservoir (rainbow trout, bass, sunfish, and catfish). Some recruitment of warm-water and coldwater fishes likely comes from Folsom Reservoir. In addition, CDFG stocks catchable-size rainbow trout into Lake Natoma annually. Although supporting many of the same fish species found in Folsom Reservoir, Lake Natomas' limited primary and secondary production, colder epilimnetic water temperatures (relative to Folsom Reservoir), and daily elevation fluctuations are believed to reduce the size and annual production (USFWS 1991) of many of its fish populations, relative to Folsom Reservoir.

9.1.1.4.5 Nimbus Hatchery

CDFG operates the Nimbus Salmon and Steelhead Hatchery and the American River Trout Hatchery, which are at the same facility immediately downstream from Nimbus Dam. The Nimbus Salmon and Steelhead Hatchery is devoted to producing anadromous fall-run Chinook salmon and steelhead. The hatchery's fish ladder is opened to fall-run Chinook salmon annually when the average daily river temperature declines to approximately 60°F (West 2000), which generally occurs in October or early November. The fall-run Chinook salmon produced by the Nimbus Hatchery are released directly into the Delta. Immigrating adult steelhead typically begin arriving at the hatchery fish ladder in December. Peak steelhead egg collection generally occurs during January and February, but sometimes continues through March. Steelhead produced by the Nimbus Hatchery are released into the Sacramento River at either Miller Park or Garcia Bend (West 1999).

The Nimbus Hatchery receives water for its operations directly from Lake Natoma via a 60-inch-diameter pipeline. Water temperatures in the hatchery are dictated by the temperature of water diverted from Lake Natoma, which, in turn, is primarily dependent upon the temperature of water released from Folsom Reservoir, air temperature, and retention time in Lake Natoma. The temperature of water diverted from Lake Natoma for hatchery operations is frequently higher than that which is desired for hatchery production of rainbow trout, steelhead, and Chinook salmon. Under such conditions, increasing releases at Folsom Dam and/or releasing colder water from a lower elevation within Folsom Reservoir may achieve more suitable temperatures. However, seasonal releases from Folsom Reservoir's limited coldwater pool to benefit hatchery operations must be considered in conjunction with seasonal in-river benefits from such releases.

9.1.1.4.6 Lower American River

The American River drains a watershed of approximately 1,895 square miles (USBR 1996), and is a major tributary to the Sacramento River. The American River has provided over 125 miles of riverine habitat to anadromous and resident fishes. Presently, use of the American River by anadromous fish is limited to the 23 miles of river below Nimbus Dam (the lower American River).

The lower American River provides a diversity of aquatic habitats, including shallow, fast-water riffles, glides, runs, pools, and off-channel backwater habitats. The lower American River from Nimbus Dam (river mile [RM] 23) to approximately Goethe Park (RM 14) is primarily unrestricted by levees, but is bordered by some developed areas. Natural bluffs contain this reach of the river and terraces cut into the side of the channel. The river reach downstream of Goethe Park, and extending to its confluence with the Sacramento River (RM 0), is bordered by levees. The construction of levees changed the channel geomorphology and has reduced river meanders and increased depth.

At least 43 species of fish have been reported to occur in the lower American River system, including numerous resident native and introduced species, as well as several anadromous species. Although each fish species fulfills an ecological niche, several species are of primary management concern either as a result of their declining status or their importance to recreational and/or commercial fisheries. Both steelhead, listed as "threatened" under the Federal ESA, and Sacramento splittail, treated as a Federally listed threatened species, occur in the lower American River. Current recreationally and/or commercially important anadromous species include fall-run Chinook salmon, steelhead, striped bass, and American shad.

With over 125 miles of available upstream salmonid spawning habitat, the American River historically served as a regionally vital component for the reproduction and survival of fall- and spring-run Chinook salmon (Water Forum 2001). While development and dam construction extirpated the spring-run fishery, the lower American River continues to function as spawning and rearing habitat for large numbers of fall-run Chinook salmon. Today the river supports a mixed run of hatchery and naturally produced fish. During the period of 1967 through 1991 (AFRP restoration goal baseline period), lower American River fall-run Chinook salmon spawning comprised approximately 21 percent (41,040 fish) of total fall-run Chinook salmon spawning (197,740 fish) in the Sacramento Valley river system, including the Sacramento River and its tributary rivers and creeks (SWRI 2002, unpublished data). Recent escapement estimates (1992-2002) in the Central Valley, suggest the American River fall-run Chinook salmon comprise approximately 22 percent of the total fall-run Chinook salmon escapement in the Sacramento and its major tributaries (68,373 of 311,746, respectively, fall-run Chinook salmon) (PFMC 2003)

Historically, the majority of anadromous salmonid spawning and rearing habitat within the American River was located in the watershed above Folsom Dam. The lower American River currently provides spawning and rearing habitat for fall-run Chinook salmon and steelhead below Nimbus Dam. The majority of the steelhead run is believed to be of hatchery origin. However, with the exception of an emergency release during January of 1997 resulting from poor water quality caused by flooding, no steelhead have been stocked directly into the lower American River since 1990 (Barngrover 1997).

The primary factor potentially limiting fall-run Chinook salmon and steelhead production within the lower American River is believed to be high water temperatures during portions of their freshwater residency in the river. High water temperatures during the fall can delay the onset of spawning by Chinook salmon, and river water temperatures can become unsuitably high for juvenile salmon rearing during spring and steelhead rearing during summer. In addition, relatively low October and November flows, when they occur, tend to increase the amount of fall-run Chinook salmon redd superimposition, thereby potentially limiting initial year-class strength.

9.1.1.5 San Joaquin River Area of Analysis

The San Joaquin River Area of analysis includes Lake McClure and Lake McSwain on the Merced River; the Merced River from Crocker-Huffman Dam to the confluence with the San Joaquin River, and the San Joaquin River from the mouth of the Merced River to Mossdale/Vernalis. Details regarding the facilities and water bodies within the San Joaquin River Area of analysis and the fisheries resources they support are provided below.

9.1.1.5.1 Lake McClure

The Merced Irrigation District operates Lake McClure and Lake McSwain in Mariposa County. The Merced River flows from the Sierra Nevada into Lake McClure, which is formed by New Exchequer Dam. Lake McClure has a storage capacity of 1,024,500 acre-feet and is located at an elevation of 867 feet above msl. Smaller Lake McSwain has 9,730 acre-feet of storage capacity and is located just downstream of Lake McClure at an elevation of 425 feet above msl. Lake McSwain is fed from the larger McClure's cool depths. The lower water temperature of Lake McSwain provides suitable habitat for coldwater fish species.

Lake McClure supports both coldwater and warmwater fisheries. CDFG stocks Chinook salmon annually. In addition, rainbow trout and brown trout are stocked in the lake by local hatcheries. Warmwater fish present in Lake McClure include several centrarchid species, including largemouth bass, spotted bass, crappie, bluegill, catfish and shad.

9.1.1.5.2 Merced River

The Merced River drains an area of approximately 1,273 square miles east of the San Joaquin River, and produces an average unimpaired runoff of approximately 1 million acre-feet. It is one of the main tributaries to the San Joaquin River on the east side of the drainage. The Merced River is the southernmost Central Valley stream presently inhabited by anadromous salmonids. Chinook salmon are restricted during all of their freshwater life stages to utilize the lower Merced River up to Crocker-Huffman Dam, which is the upstream barrier for fish migration and the location of the Merced River Hatchery. Crocker-Huffman Dam along with three upstream dams (Merced

Falls Dam, McSwain Dam, and New Exchequer Dam, proceeding in an upstream direction) regulates flows in the lower Merced River.

Fall-run Chinook salmon is the anadromous fish species present in the Merced River. Central Valley steelhead habitat potentially exists on the Merced River below Crocker-Huffman Dam, however, there is no conclusive evidence that steelhead are present in the Merced River. Fall-run Chinook salmon, Central Valley steelhead, striped bass, American shad, and white sturgeon are the anadromous fish species present in the San Joaquin River from the Merced River confluence to Mossdale (USBR 2000).

Within the Merced River, juvenile salmon can be found between mid-January through May, depending on environmental conditions. The Merced River fall-run has been partially sustained by production of yearling fall-run Chinook salmon at the Merced River Fish Hatchery since 1970. The abundance of fall-run Chinook salmon is affected by flows, water temperature and water quality. Higher flows and lower water temperatures (51-67ºF) in the fall stimulate upstream migration of fall-run Chinook salmon. Conversely, low flows and higher water temperatures may inhibit or delay migration to spawning areas. For many years the attraction flows from the Merced River have proved inadequate during October, resulting in straying of adult Chinook salmon into agricultural drainage ditches, primarily Mud and Salt sloughs. Barriers are now installed along the San Joaquin River above and below the confluence of the Merced River to prevent Chinook salmon migration into the wrong water streams and to help guide them to the Merced.

Minimum instream flow requirements in the river are defined under Merced Irrigation District's current licenses and agreements and are intended to provide adequate flows for Chinook salmon and for the Merced River Riparian Water Users Association diversions. In addition, Merced Irrigation District is coordinating with CDFG to implement studies to assess the effects of flows on Chinook salmon in the river (Stillwater Sciences 2002).

9.1.1.5.3 San Joaquin River

The portion of the San Joaquin River from Mossdale/Vernalis to the mouth of the Merced River is the most significant for anadromous fish that use the San Joaquin River for migration and spawning. This 43-mile reach includes the confluences of the Merced, Tuolumne, and Stanislaus Rivers, the main tributaries to the San Joaquin River, entering on the east side of the drainage. Little water is contributed from the upper San Joaquin River, except during flood events (EA Engineering, Science, and Technology 1999). Flows in the San Joaquin River at Vernalis are controlled by operations of the New Exchequer, New Don Pedro, and New Melones dams resulting in average monthly flows that are uniform throughout the year, with maximum flows less than historical levels (Interior 1999).

Fall-run Chinook salmon, Central Valley steelhead, striped bass, American shad, and white sturgeon are the anadromous fish species present in the San Joaquin River from the Merced River confluence to Mossdale. Shad and striped bass migrate from the Pacific Ocean via the Delta into the San Joaquin River to spawn in the spring. Splittail, pikeminnow, and other native species are also found in the San Joaquin River. However, this portion of the San Joaquin is dominated by introduced species such as largemouth bass, silversides, green sunfish and brown bullhead. Introduced species dominate in terms of numbers and biomass.

Adult fall-run Chinook salmon enter the San Joaquin River system in October and spawn through January, with peak spawning period in November (Moyle 2002). Although timing of Chinook salmon maturation is typically variable, many San Joaquin River female fall-run Chinook salmon mature after only two years (NMFS 1999). Typically eggs are buried in the spawning gravels for parts of November, December, and January, with occasional occurrences in October and February. Hatching begins in January, and fry remain in the gravel for up to 30 days, before emerging to feed and grow in shallow, slow moving water at the edge of the river. The majority of juveniles leave the tributaries from March to the end of June, although some over-summer and emigrate October and November (EA Engineering, Science, and Technology 1999; Baker and Morhardt 2001). San Joaquin River fall-run Chinook salmon abundance is typically small and more variable than Sacramento River fall-run Chinook salmon. Annual escapement estimates range from 1,100-77,500, with half being fewer than 10,000 fish (Moyle 2002). Although the run and spawn timing of fall-run Chinook salmon in the San Joaquin River system may not reflect historical timing, environmental conditions in the San Joaquin River system represent the extreme of Chinook salmon tolerance (NMFS 1999).

Steelhead use the San Joaquin River in much the same way the fall-run Chinook salmon, although several differences between steelhead and fall-run Chinook occur. First, adult steelhead begin their spawning migration slightly later than Chinook and, therefore, stages of development for the eggs and juveniles will be approximately one month later than Chinook. Adult steelhead will not necessarily die after spawning, resulting in some adults remaining in the rivers through June. Lastly, young steelhead likely remain in the rivers throughout their first summer (EA Engineering, Science, and Technology 1999).

9.1.2 Sacramento-San Joaquin Delta Region

San Francisco Bay and the Sacramento-San Joaquin Delta (Figure 9-4) make up the largest estuary on the west coast (USEPA 1993). The Bay-Delta estuary provides habitat for a diverse assemblage of fish and macroinvertebrates. Many of the fish and macroinvertebrate species inhabit the estuary year-round, while other species inhabit the system on a seasonal basis as a migratory corridor between upstream freshwater riverine habitat and coastal marine waters, as seasonal foraging habitat, or for reproduction and juvenile rearing.

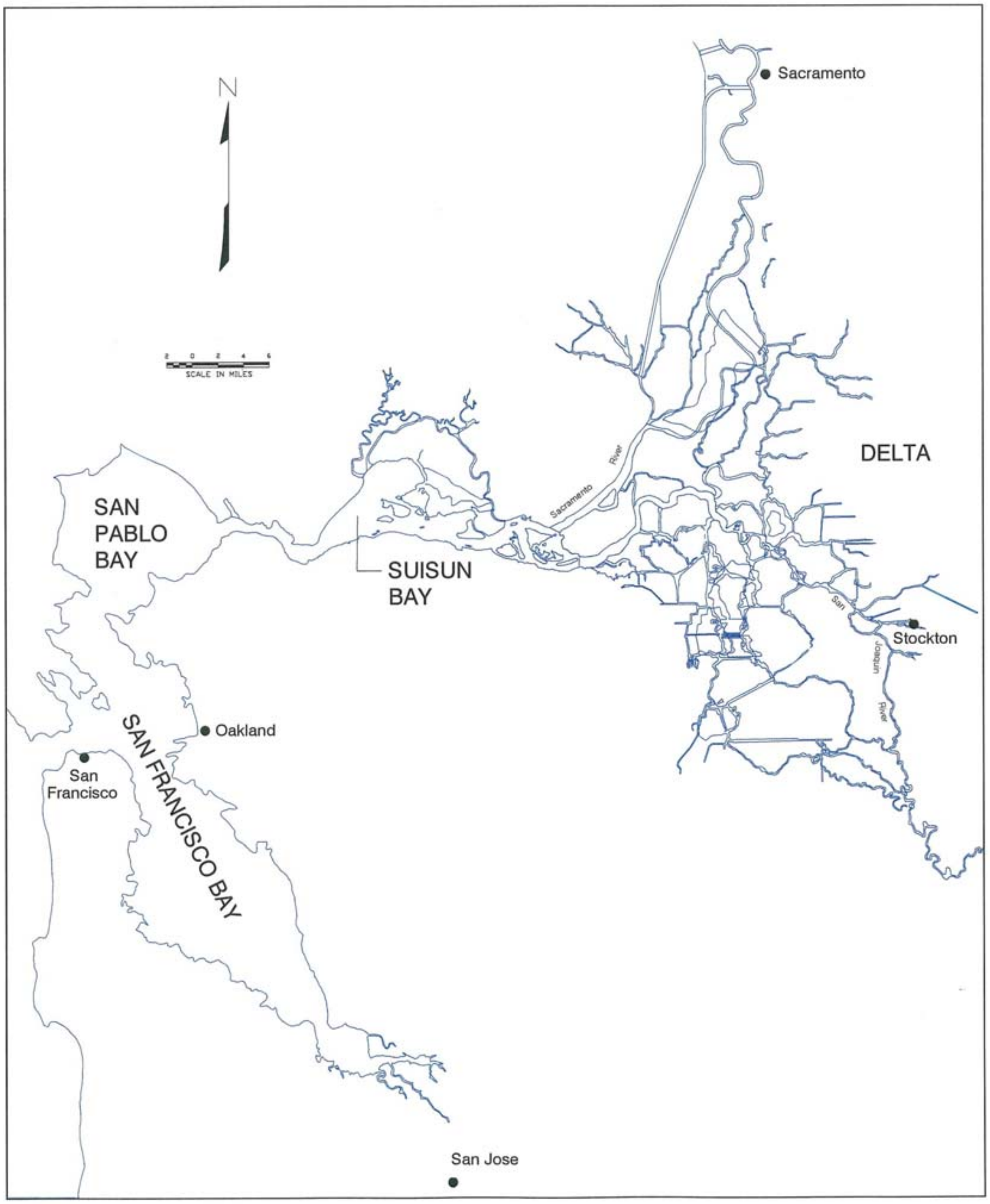

Figure 9-4
San Francisco Bay and the Sacramento-San Joaquin River Delta

Migratory (e.g., anadromous) fish species which inhabit the Bay-Delta system and its tributaries include, but are not limited to, white sturgeon, green sturgeon, Chinook salmon (including fall-run, spring-run, winter-run, and late-fall-run Chinook salmon), steelhead, American shad, Pacific lamprey and river lamprey (Moyle 2002). The Bay-Delta estuary and tributaries also support a diverse community of resident fish which includes, but is not limited to, Sacramento sucker, prickly and riffle sculpin, California roach, hardhead, hitch, Sacramento blackfish, Sacramento pikeminnow, speckled dace, Sacramento splittail, tule perch, inland silverside, black crappie, bluegill, green sunfish, largemouth bass, smallmouth bass, white crappie, threadfin shad, carp, golden shiner, black and brown bullhead, channel catfish, white catfish, and a variety of other species which inhabit the more estuarine and freshwater portions of the Bay-Delta system (Moyle 2002).

The geographic distribution of species within the estuary is determined, in part, based on salinity gradients, which range from freshwater within the Sacramento and San Joaquin River systems, to marine conditions near the Golden Gate Bridge. The abundance, distribution, and habitat use by these fish and macroinvertebrates has been monitored over a number of years through investigations conducted by CDFG, NOAA Fisheries, USFWS, DWR, and a number of other investigators. Results of these monitoring programs have shown changes in species composition and abundance within the system over the past several decades. Many of the fish and macroinvertebrate species have experienced a generally declining trend in abundance (Moyle et al. 1995) with several native species, including winter-run and spring-run Chinook salmon, steelhead, delta smelt, and Sacramento splittail (currently treated as a Federally listed threatened species) either listed or being considered for protection under the Federal or California Endangered Species Acts. Portions of the estuary have been identified as critical habitat for species such as winter-run Chinook salmon and delta smelt. A number of fish and macroinvertebrate species inhabiting the estuary also support recreational and commercial fisheries, such as fall-run Chinook salmon, Bay shrimp, Pacific herring, northern anchovy, starry flounder, striped bass, largemouth bass, sturgeon, and many others, and hence the estuary also has been identified as EFH for these species.

Many factors have contributed to the decline of fish species within the Delta (Moyle et al. 1995), including changes in hydrologic patterns resulting from water project operations, loss of habitat, contaminant input, entrainment in diversions, and introduction of non-native species. The Delta is a network of channels through which water, nutrients, and aquatic food resources are moved and mixed by tidal action. Pumps and siphons divert water for Delta irrigation and municipal and industrial use or into CVP and SWP canals. River inflow, Delta Cross Channel operations, and diversions (including agricultural and municipal diversions and export pumping) affect Delta species through changes in habitat conditions (e.g., salinity intrusion), and mortality attributable to entrainment in diversions.

The majority of land in the Delta, which covers approximately 678,200 acres, is irrigated cropland (CALFED 2000). Other terrestrial habitats include *"riparian vegetation, wetlands, and other forms of 'idle land'"* (CALFED 2000). The CALFED PEIS/EIR describes the Delta aquatic environment as comprised of *"…channels, sloughs, and other open water. Under existing conditions, most of the open water is deep-channel habitat that has been modified to provide passage for ocean-going vessels as well as efficient conveyance of fresh water from the Sacramento River through the Delta. Vegetation is removed from levees, primarily to facilitate inspection, repair, and flood fighting when necessary. Although current flood protection programs may allow for properly managed vegetation, the amount of shallow water and shaded riverine habitat throughout the Delta is* *much lower now than it was historically, largely having been replaced by a patchwork of agricultural islands and revetted levees"* (CALFED, 2000).

Seasonal and interannual variability in hydrologic conditions, including the magnitude of flows into the Bay-Delta estuary from the Sacramento and San Joaquin rivers and other tributaries and the outflow from the Delta into San Francisco Bay, have been identified as important factors affecting habitat quality and availability, and abundance for a number of fish and invertebrate species within the Bay-Delta estuary. Flows within the Bay-Delta system may affect larval and juvenile transport and dispersal, water temperatures (primarily within the upstream tributaries), dissolved oxygen concentrations (e.g., during the fall within the lower San Joaquin River), and salinity gradients within the estuary. The seasonal timing and geographic location of salinity gradients are thought to be important factors affecting habitat quality and availability for a number of species (Baxter et al. 1999). Operation of upstream storage impoundments, in combination with natural hydrologic conditions, affect seasonal patterns in the distribution of salinity within the system. Water project operations, for example, may result in a reduction in Delta inflows during the late winter and spring with an increase in Delta inflows, when compared to historical conditions, during the summer months. Objectives have been established for the location of salinity gradients during the late winter and spring to support estuarine habitat for a number of species (X_2 location), in addition to other salinity criteria for municipal, agricultural, and wetland benefits. Although a number of studies have focused on the effects of variation in salinity gradients as a factor affecting estuarine habitat during the late winter and spring (Kimmerer 2002), very little information exists on the effects of increased inflows into the Delta during summer months and the resulting changes in salinity conditions (e.g., reduced salinity when compared to historical conditions) on the abundance, growth, survival, and distribution of various fish and macroinvertebrates inhabiting the Bay-Delta system.

Despite the high degree of habitat modification that has occurred in the Delta, Delta habitats are of key importance to fisheries, as illustrated by the more than 120 fish species that rely on its unique habitat characteristics for one or more of their lifestages (USEPA 1993). Fish species found in the Delta include anadromous species, as well as freshwater, brackish water, and saltwater species. The Delta provides spawning and nursery habitat for more than 40 resident and anadromous fish species, including delta smelt, Sacramento splittail, American shad, and striped bass. The Delta also is a migration corridor and seasonal rearing habitat for Chinook salmon and steelhead. All anadromous fish of the Central Valley either migrate through the Delta to spawn and rear upstream or are dependent on the Delta to support some critical part of their life cycle. Delta smelt, which have been listed under both the State and Federal Endangered Species Acts, and Sacramento splittail, treated as a Federally listed threatened species under the Federal Endangered Species Act, reside year-round within the Delta. Species such as green sturgeon utilize the Delta as a migratory corridor, juvenile nursery, and adult foraging habitat, with spawning occurring further upstream within the mainstem Sacramento River. Longfin smelt, which have been identified as a species of special concern, inhabit the Delta estuary year-round. Other species which have been listed for protection under the State and/or Federal Endangered Species Acts, including winter-run and spring-run Chinook salmon and steelhead, utilize the estuary as a migratory corridor and as juvenile foraging habitat with spawning and egg incubation occurring further upstream within the Sacramento and San Joaquin River systems.

Delta inflow and outflow are important for species residing primarily in the Delta (e.g., delta smelt and longfin smelt) (USFWS 1994), as well as juveniles of anadromous species (e.g., Chinook salmon) that rear in the Delta prior to ocean entry. Seasonal Delta inflows affect several key ecological processes, including: 1) the migration and transport of various lifestages of resident and anadromous fishes using the Delta (USEPA, 1992); 2) salinity levels at various locations within the Delta as measured by the location of X_2; and 3) the Delta's primary (phytoplankton) and secondary (zooplankton) production.

The analysis of Delta fish species focuses on the following Federal or State listed or recreationally or commercially important fish species:

- American shad (*Alosa sapidissima*);
- Delta smelt (*Hypomesus transpacificus*);
- Fall-run and late-fall-run Chinook salmon (*Oncorhynchus tshawytscha*);
- Northern anchovy (*Engraulis mordax*);
- Sacramento splittail (*Pogonichthys macrolepidotus*);
- Spring-run Chinook salmon (*Oncorhynchus tshawytscha*);
- Starry flounder (*Platichthys stellatus*);
- Steelhead (*Oncorhynchus mykiss*);
- Striped bass (*Morone saxatilis*); and
- Winter-run Chinook salmon (*Oncorhynchus tshawytscha*).

The habitat requirements and distribution for Chinook salmon, striped bass, American shad, delta smelt, and Sacramento splittail are largely representative of the habitat requirements and distribution of other Delta fish species (Jones and Stokes 2001). Therefore, the analysis of EWA effects on the above species encompasses the range of potential effects on other Delta fishery resources.

The following section describes the aquatic habitats and fish populations within the Delta, and borrows heavily from the Interim South Delta Program (ISDP) Draft EIS/EIR (DWR and USBR 1996). This section is organized into the following components: 1) a description of the Bay-Delta estuary; 2) a description of the principle hydraulic features of the Sacramento and San Joaquin rivers and the Delta that affect aquatic resources, including components of the CVP and SWP; and 3) descriptions of the status, life history, and factors affecting abundances of selected fish and invertebrate species, focusing on those species having economic importance or those identified as species of concern by the Federal or State government.

9.1.2.1 Sacramento-San Joaquin Delta Area of Analysis

The Sacramento-San Joaquin Delta, the most upstream portion of the Bay-Delta estuary, is a triangle-shaped area composed of islands, river channels, and sloughs at the confluence of the Sacramento and San Joaquin rivers (Figure 9-4). The northern Delta is dominated by the waters of the Sacramento River, which are of relatively low salinity, whereas the relatively higher salinity waters of the San Joaquin River dominate the southern Delta. The central Delta includes many channels where waters from the Sacramento and San Joaquin rivers and their tributaries converge. The Delta Area of analysis includes the river channels and sloughs at the confluence of the Sacramento and San Joaquin rivers. Details regarding the facilities and water bodies within the Delta Area of analysis and the fisheries resources they support are provided below.

The Delta's tidally influenced channels and sloughs cover a surface area of approximately 75 square miles. These waters support a number of resident freshwater fish and invertebrate species. The waters are also used as migration corridors and rearing areas for anadromous fish species and as spawning and rearing grounds for many estuarine species. Shallow-water habitats, defined as waters less than three meters in depth (mean low water), are considered particularly important forage, reproduction, rearing, and refuge areas for numerous fish and invertebrate species.

There have been over 100 documented introductions of exotic species to the Bay-Delta estuary. These include intentionally introduced game fishes such as striped bass and American shad, as well as inadvertent introductions of undesirable organisms such as the Asian and Asiatic clams. Table 9-2 gives common and scientific names for all known native and exotic fish species found in the Delta, including species no longer present.

Table 9-2
Fishes of the Sacramento-San Joaquin Delta

Common Name	Scientific Name	Life History	Status
Pacific lamprey*	*Lampetra tridentata*	A	declining
River lamprey*	*Lampetra ayersi*	A	SC
White sturgeon*	*Acipenser transmontanus*	A	declining; fishery
Green sturgeon*	*Acipenser medirostris*	A	SC; FP
American shad	*Alosa sapidissima*	A	fishery
Threadfin shad	*Dorosoma petenense*	A	common
Steelhead*	*Oncorhynchus mykiss*	A	SC; FT; fishery
Pink salmon*	*Oncorhynchus gorbuscha*	A	SC; rare
Chum salmon*	*Oncorhynchus keta*	A	SC; rare
Coho salmon*	*Oncorhynchus kisutch*	A	SC, FT

Table 9-2
Fishes of the Sacramento-San Joaquin Delta

Common Name	***Scientific Name***	***Life History***	***Status***
Chinook salmon*	*Oncorhynchus tshawytscha*	A	fishery:
Sacramento fall-run			fishery
late-fall-run			SC
winter-run			FE, SE
spring-run			ST; FT
San Joaquin fall-run			fishery
spring-run			extinct
Longfin smelt*	*Spirinchus thaleichthys*	A-R	SC
Delta smelt*	*Hypomesus transpacificus*	R	FT, ST
Wakasagi	*Hypomesus nipponensis*	R?	invading
Thicktail chub*	*Gila crassicauda*	R	extinct
Hitch*	*Lavinia exilicauda*	R	unknown
Sacramento blackfish*	*Orthodon microlepidotus*	R	unknown
Sacramento splittail*	*Pogonichthys macrolepidotus*	R	SC, FT
Hardhead*	*Mylopharodon conocephalus*	N	SC
Sacramento pikeminnow*	*Ptychocheilus grandis*	R	common
Fathead minnow	*Pimephales promelas*	N	rare
Golden shiner	*Notemigonus chrysoleucas*	R?	uncommon
Common carp	*Cyprinus carpio*	R	common
Goldfish	*Carassius auratus*	R	uncommon
Sacramento sucker*	*Catostomus occidentalis*	R	common
Black bullhead	*Ameiurus melas*	R	common
Brown bullhead	*Ameiurus nebulosus*	R	uncommon
Yellow bullhead	*Ameiurus natalis*	R	rare?
White catfish	*Ameiurus catus*	R	abundant
Channel catfish	*Ictalurus punctatus*	R	common
Blue catfish	*Ictalurus furcatus*	R?	rare
Western mosquitofish	*Gambusia affinis*	R	abundant
Rainwater killifish	*Lucania parva*	R?	rare
Striped bass	*Morone saxatilis*	R-A	abundant
Inland silverside	*Menidia beryllina*	R	abundant
Sacramento perch*	*Archoplites interruptus*	N	SC
Bluegill	*Lepomis macrochirus*	R	common
Redear sunfish	*Lepomis microlophus*	R	uncommon
Green sunfish	*Lepomis cyanellus*	R	uncommon
Warmouth	*Lepomis gulosus*	R	uncommon
White crappie	*Pomoxis annularis*	R	common
Black crappie	*Pomoxis nigromaculatus*	R	uncommon
Largemouth bass	*Micropterus salmoides*	R	common
Smallmouth bass	*Micropterus dolomieui*	R	uncommon
Bigscale logperch	*Percina macrolepida*	R	common
Yellow perch	*Perca flavescens*	N	rare
Tule perch*	*Hysterocarpus traski*	R	common
Threespine stickleback*	*Gasterosteus aculeatus*	R	common
Yellowfin goby	*Acanthogobius flavimanus*	R	common
Chameleon goby	*Tridentiger trigonocephalus*	R	invading
Staghorn sculpin*	*Leptocottus armatus*	M	common
Prickly sculpin*	*Cottus asper*	R	abundant
Starry flounder*	*Platichthys stellatus*	M	common
Modified from USFWS 1994 *as cited in* DWR and USBR 1996.			

An asterisk (*) indicates a native species; A = anadromous; R = resident; N = non-resident visitor; M = marine; SC = species of special concern; FT = Federal threatened; ST = State threatened; FE = Federal endangered; SE = State endangered; FP = Federal proposed.

9.1.2.1.1 *Water Project Development*

California's water resources have been developed through a lengthy and complex process involving private, local, State, and Federal agencies and individuals. This development has provided water supply, flood control, and hydropower as well as improvements to navigable waters. Adverse impacts of water resources development include blocked access of anadromous fish to habitats upstream of dams, alteration or destruction of fish and wildlife habitats, changes in the seasonal timing and magnitude of streamflow, entrainment of young fish at diversions, and changes in water quality and sediment transport regimes.

The development of water storage and delivery systems affecting the Bay-Delta began in the early 1900s in response to flooding problems in the Delta and the Sacramento River basin, summer salinity problems and associated damages to Delta farm crops, and the need for water in other parts of California. In 2002, approximately 59 major reservoirs with a total storage capacity of about 27 million acre-feet of water are in operation in the Central Valley watershed. Most of these reservoirs are operated for local water supply or for flood control.

Reservoir operations have altered the timing and magnitude of river flows in the Central Valley. Before water was diverted from the Delta, annual runoff into the Estuary ranged from 19 to 29 million acre-feet (SFEP 1992 *as cited in* DWR and USBR 1996). Now, upstream users, Bay Area cities, Delta farmers, and water projects divert about half of the historical flow. The water projects store water during the winter and spring months for release later in the year, which reduces the natural flow in April, May, and June and increases the flow in late summer and fall.

9.1.2.1.2 *Salinity*

Historically during summer months, especially in dry years, salt water intruded far into the Delta (DWR 1987 *as cited in* DWR and USBR 1996). After the State and Federal water projects were built, freshwater releases from upstream reservoirs helped reduce saltwater intrusion into the Delta. However, salinity intrusion from the ocean remains a problem, and salts accumulated in agricultural drainage have increased salinities in the San Joaquin River and south Delta.

While freshwater inflows to the Delta during summer are generally higher than historical flows, winter and spring flows are typically lower because of reservoir storage and flood control. The lower inflows during the winter and spring lead to high salinities in areas such as Suisun Bay and the western Delta, which are important nursery areas for many estuarine fish species during spring. Elevated salinities reduce growth and survival of young stages of Delta fish. Salinity intrusion is often particularly severe during spring, when agricultural demand is high.

Agricultural drainage discharged from Delta islands contains dissolved minerals that increase salinities in Delta channels. The salt content of drainage water flowing down the San Joaquin River is relatively high. Use of this water by Delta farmers dramatically increases the salinity of the irrigation return flows and further increases the concentration of salts flowing into the Estuary.

Current and future efforts to control the level of salinity in the Estuary focus on fresh water flow adjustments to maintain salinity standards, use of tidal flow barriers, and reductions in agricultural drainage.

9.1.2.1.3 Flood Control Operations

Operating storage facilities for flood control changes the timing and magnitude of flows in an effort to minimize property damage and loss of life. However, dams and other structures built for flood control can block fish migration pathways and access to spawning and rearing habitat. Such structures can also prevent replenishment of spawning gravels and reduce the frequency of flushing flows that remove silt from existing gravels. Flood control has diminished fish habitat by removing woody debris and riparian vegetation and by riprapping riverbanks.

9.1.2.1.4 Unscreened Diversions

Unscreened diversions may be responsible for entraining significant numbers of juvenile fish. As of April 1997, 3,356 diversions in California’s Central Valley have been identified, approximately 98 percent of which are unscreened or screened insufficiently to protect fish (Herren and Kawasaki 2001). These diversions primarily provide irrigation water for agriculture; in the summer growing season, they can divert roughly one-quarter of the freshwater inflow into the Delta. Many of these diversions are known to entrain larval and juvenile fish. Estimates of fish losses to unscreened Delta diversions range upwards of several hundred million striped bass less than one inch long and tens of thousands of juvenile Chinook salmon (Spaar 1994 *as cited in* DWR and USBR 1996).

In recent years, efforts to screen many of these diversions have been undertaken, frequently as a result of actions taken under State and Federal Endangered Species Acts. California law requires fish screens on all new diversions and existing diversions that are relocated. Requirements are being proposed by various agencies to screen existing diversions, especially those diversions known to entrain the most fish. Other agencies propose to allow relocating diversion intakes and restricting diversion times as alternatives to expensive screening retrofits.

Fish losses also occur at the SWP and CVP export facilities in the south Delta. These losses are discussed in Section 9.1.2.2, Facilities and Operations of the SWP and CVP and their Effects on Aquatic Resources.

9.1.2.2 Facilities and Operations of the SWP and CVP and Their Effects on Aquatic Resources

9.1.2.2.1 State Water Project Facilities

State Water Project (SWP) facilities in the Delta include the North Bay Aqueduct, Clifton Court Forebay, John E. Skinner Delta Fish Protection Facility, Harvey O. Banks Delta Pumping Plant, and the intake channel to the pumping plant (Figure 9-5). The North Bay Aqueduct would be unaffected by the EWA Program alternatives and, therefore, is not discussed further. Banks Pumping Plant lifts water 244 feet to the beginning of the California Aqueduct. An open intake channel conveys water to Banks Pumping Plant from Clifton Court Forebay. The forebay provides storage for off-peak pumping and permits regulation of flows into the pumping plant. All water arriving at Banks Pumping Plant flows first through the primary intake channel of the John E. Skinner Delta Fish Protective Facility. Fish screens (louvers) across the intake channel direct fish into bypass openings leading into the salvage facilities. The main purpose of the fish facility is to reduce the number of fish adversely impacted by entrainment at the export facility and to reduce the amount of floating debris conveyed to the pumps.

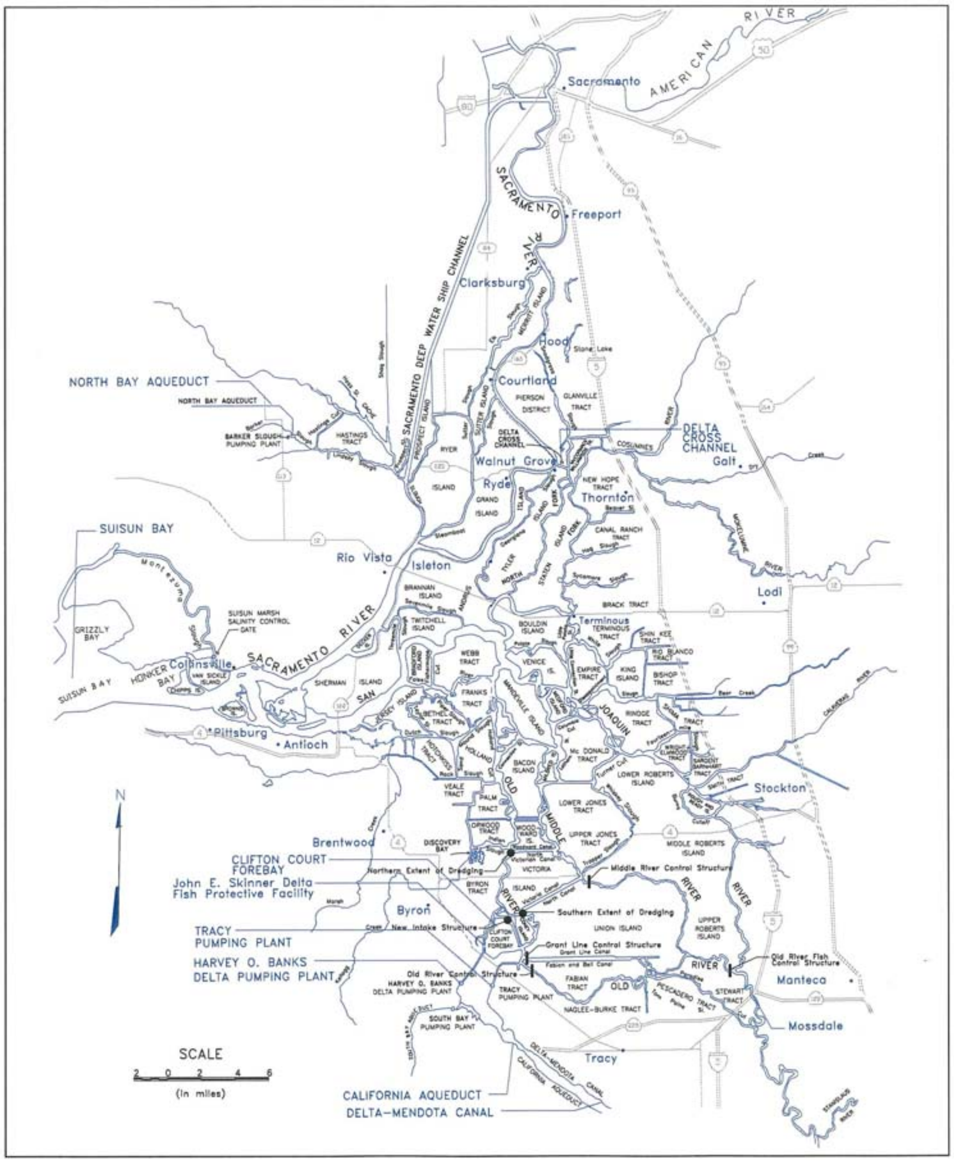

Figure 9-5
Delta Facilities

Clifton Court Forebay. Clifton Court Forebay serves as a regulating reservoir providing reliability and flexibility for the water pumping operations at the Banks Pumping Plant (DWR and USBR 1994 *as cited in* DWR and USBR 1996). The forebay has a maximum total capacity of 31 thousand acre-feet (TAF). Five radial gates are opened during a high tide to allow the forebay reservoir to fill, and are closed during a low tide to retain water that supplies the pumps.

When the gates are open at high tide, inflow can be as high as 12,000 cubic feet per second (cfs) for a short time, decreasing as water levels inside and outside the forebay reach equilibrium. This flow, at times, reaches velocities of 6-10 feet per second (fps) in the primary intake channel. Velocities decrease as water levels in the intake channel and forebay approach equilibrium. Starting in May 1994, gate operation patterns were adjusted to reduce entrainment of delta smelt into the forebay.

Fish that enter Clifton Court Forebay may take up residence in the forebay. Once in the forebay, fish may be eaten by other fish or taken by anglers (pre-screening losses); entrained by the pumps at the Banks Pumping Plant (direct losses); impinged on the fish screens at the Skinner Fish Protection Facility (direct loss); or bypassed and salvaged at the Skinner Fish Protection Facility (salvage). The California Department of Fish and Game views predation on fish entrained into the forebay as a concern insofar as it may exceed natural predation rates in Delta Channels.

Juvenile salmon, juvenile striped bass, and other species entrained into the forebay are exposed to high levels of predation before they can be salvaged at the Skinner Fish Protection Facility (DWR and USBR 1994 *as cited in* DWR and USBR 1996). CDFG has conducted studies to assess the loss rate of juvenile salmon and striped bass that cross the forebay (Schaffter 1978; Hall 1980; CDFG 1985a, 1985b, 1992a, 1993; Brown and Greene 1992 *as cited in* DWR and USBR 1996). The operation of the existing radial gates admits fish, along with water, into Clifton Court Forebay, where predation, salvage handling, and transport to another location in the Delta, entrainment, and other fates await them. The existing intake structure and gates are believed to provide cover and a feeding station for predators. Predation losses are believed to be very high. Based on studies of marked juvenile salmon released at the radial gates, mortality estimates of juvenile fall-run Chinook salmon traversing the forebay range from 63 to 98 percent.

Survival of young striped bass in Clifton Court Forebay is also low. Six percent of young-of-the-year (YOY) striped bass released at the radial gates survived passage across the forebay (CDFG 1985a *as cited in* DWR and USBR 1996).

The losses for both striped bass and salmon are attributed to predation. CDFG (1992a *as cited in* DWR and USBR 1996) identified sub-adult striped bass as the major predatory fish in Clifton Court Forebay. These fish were most abundant near the radial gates during winter and spring, when small fish may be particularly vulnerable. Predators have been periodically removed from the forebay and released in the Delta. In 1993, striped bass made up 96 percent of the predators removed, followed by white catfish and channel catfish (Liston et al. 1994 *as cited in* DWR and USBR 1996).

Loss rates of other fish species of concern, such as delta smelt, cannot be assessed accurately at this time. However, estimated salvage rates are discussed below.

John E. Skinner Fish Facility. The John E. Skinner Fish Facility includes primary and secondary louvers (screens) designed to guide fish to bypass and salvage facilities before they are drawn into the Banks Pumping Plant (Brown and Greene 1992 *as cited in* DWR and USBR 1996). The primary fish screens are composed of a series of V-shaped bays containing louver systems resembling Venetian blinds that act as a behavioral barrier to fish. The secondary fish screen is a perforated plate, positive-pressure screen, which removes fish greater than about 20 mm in length. Salvaged fish are transported in trucks to one of several Delta release sites. Despite recent improvements in salvage operations, survival of species that are more sensitive to handling, such as delta smelt, is believed to be low (DWR and USBR 1994 *as cited in* DWR and USBR 1996).

The fish screening and salvage facilities began operating in 1968 (Brown and Greene 1992 *as cited in* DWR and USBR 1996). In the early 1970s, CDFG and DWR initiated extensive evaluations of the facility that have led to improved performance and reduced fish losses. Most of this effort focused on fall-run Chinook salmon, striped bass, and American shad. Screening efficiency studies have been proposed for delta smelt, but difficulties have arisen because the fish are susceptible to losses during handling and survive poorly in captivity. Alternative approaches are being investigated. A direct loss model has been developed by DWR and CDFG to estimate losses based on operations at the SWP south Delta facilities. This model can be used to estimate the effect of changes in operations on salmon and striped bass.

DWR conducts daily fish monitoring and fish salvage operations at the SWP Skinner Fish Facility. As part of the monitoring program at the Skinner Fish Facility, operations are monitored and information recorded on water velocities that affect louver guidance efficiency for various species and lifestages of fish, species composition, the occurrence of coded-wire tag (CWT) and other marked fish released as part of experimental investigations, the length-frequency distribution for various species, and other information used to evaluate and monitor fish salvage operations. Fish entering the salvage facilities are subsampled, identified and measured, and subsequently returned to the Delta through a trucking and release operation. Using data on the species composition and numbers of fish collected in each subsample, in combination with information on estimated louver guidance efficiency, the percentage of time and volume subsampled, and estimates of pre-salvage predation mortality and losses, an expanded estimate of fish salvage is then derived and reported on both a daily and monthly basis.

Examination of the numbers of various fish species salvaged at the SWP Skinner Fish Facility and CVP Tracy Fish Facility shows high variability on a seasonal basis and between years, reflecting variation in both the life history characteristics of many of the species and their vulnerability to salvage at the facility. Information on the seasonal and interannual variability in salvage for various species, in combination with results of daily operations and monitoring, serve as one of the important focuses for application of EWA assets in an effort to help reduce loss of various fish species at the export facilities.

In general, the majority of juvenile Chinook salmon (primarily fall-run Chinook salmon) are observed in salvage operations during the late winter and early spring (February through May), although juvenile salmonids are also observed during the late fall and winter (November through January), which may include yearling spring-run and fall-run salmon, late-fall-run salmon smolts, and pre-smolt winter-run juvenile salmon. Steelhead are primarily observed in salvage during the spring months (March and April), which is consistent with the general seasonal timing for steelhead smolt out migration. Striped bass are observed in salvage operations throughout the year, with the majority of juvenile striped bass occurring during the summer months (May through July). Similarly, delta smelt are observed in the salvage operations throughout the year, with the majority of juvenile delta smelt occurring during the late spring and early summer (May through July). Larger sub-adult and adult delta smelt are typically observed in the salvage operation more predominantly during the fall, winter, and early spring. Longfin smelt are primarily observed in the salvage operations during the spring (March through May) as juveniles, although larger sub-adult longfin smelt are also observed in the salvage operations during the fall. Sacramento splittail are also observed in salvage operations throughout the year, although the majority of splittail (young-of-the-year) occur during the spring and early summer (March through July). A variety of other resident and migratory fish species are also collected as part of both SWP and CVP salvage operations.

Fish that are not bypassed by the salvage facility may survive passage through the pumps and enter the aqueduct. Fish, including striped bass and resident species, may rear in the canals and downstream reservoirs. These fish support recreational fisheries both in the aqueduct and in downstream reservoirs.

Harvey O. Banks Pumping Plant. The initial Banks Pumping Plant facilities, including seven pumps, were constructed in 1962. The pumping plant was completed in 1992 with the addition of four pumps. The total capacity of these eleven pumps is 10, 668 cfs, with two pumps rated at 375 cfs, five at 1,130 cfs, and four at 1,067 cfs. Water is pumped into the California Aqueduct, which extends 444 miles into southern California.

Total annual exports at the Banks Pumping Plant have greatly increased since construction of the initial facilities. Operation of the SWP, in combination with CVP export operations, influences the hydrologic conditions within south-Delta channels. For example, export operations have an effect on water surface elevations within the south-Delta and subsequently operations of a number of siphons and irrigation pump diversions, which is being addressed, in part, through seasonal construction and operations of temporary barriers within the south-Delta channels. Export operations also influence water currents (both the direction and velocity) within various south-

Delta channels, with the primary hydrologic effects occurring within Old and Middle rivers. Export operation effects on hydrologic conditions, and associated effects on habitat quality and availability for various fish and macroinvertebrates and the risk of entrainment and salvage at the SWP and CVP export facilities have been the subject of a number of programs. The Department of Water Resources (e.g., ISDP), State Water Resources Control Board, USFWS, NOAA Fisheries, and various experimental investigations including, but not limited to, the Vernalis Adaptive Management Plan (VAMP; San Joaquin River Group Authority 2002, 2003) and others have conducted investigations on operational effects in the south Delta. As a result of these various proceedings, a number of management actions, including seasonal reductions in SWP and CVP export rates relative to Delta inflow (export/inflow ratio) and other actions such as short-term reductions in export operations based on actual observed salvage of sensitive fish species as part of EWA actions and/or in response to biological opinions, have been implemented to reduce and/or avoid adverse effects of changes in hydrologic conditions and the vulnerability of species to salvage operations.

Currently, average daily diversions are limited during most of the year to 6,680 cfs, as set forth by U.S. Army Corps of Engineers criteria dated October 13, 1981. Diversions may be increased by one-third of San Joaquin River flow at Vernalis during mid-December to mid-March if that flow exceeds 1,000 cfs. The maximum diversion rate during this period would be 10,300 cfs, the nominal capacity of the California Aqueduct. In 2000 through 2002, the U.S. Army Corps of Engineers has authorized use of an additional 500 cfs of Banks Pumping Plant capacity in July through September, which has been used to make up export supply lost during pumping curtailments undertaken for fish protection. Permission to continue using the 500 cfs for this purpose for two more years has been requested by the EWA agencies, which would be used exclusively to divert water being transferred for the EWA Program.

Additional limitations on export pumping are imposed by the State Water Resources Control Board, under its authority to issue water rights permits for the SWP. From 1991 to 1994, exports were also restricted under the biological opinions for winter-run Chinook salmon and delta smelt. The May 1995 "Water Quality Control Plan" established further restrictions on exports (SWRCB 1995a *as cited in* DWR and USBR 1996).

South Delta Temporary Barriers. The Temporary Barriers Project, operated by DWR since 1991, has involved seasonally installing, operating, and removing temporary barriers in channels of the south Delta. The purpose of these barriers is to benefit local agricultural diversions by increasing water levels and circulation and to improve fishery conditions for up-migrating adult salmon and out-migrating smolts (DWR 1995a *as cited in* DWR and USBR 1996). A program was initiated in 1991 to assess the effects of temporary barriers on water quality, fisheries, and vegetation as a basis for predicting the effects of installing permanent barriers in the southern Delta.

The locations and periods of operation of the temporary barriers are as follows: Middle River near Victoria Canal, installed and operated from April 15 through September 30; Head of Old River, installed and operated from September 15 through November 30[3]; Grant Line Canal 1/4 mile east of Old River, installed and operated from April 15 through September 30; and Old River near Tracy, installed and operated from April 15 through September 30 (DWR 2000c). Some barriers have not been installed in some years because of varying hydrologic and hydrodynamic conditions, and concerns about endangered species.

The temporary barriers are constructed of rock and sand stockpiled for reuse when the barriers are removed. During the fall (and periodically the spring), the barrier on Old River at the confluence with the San Joaquin River (Head of Old River Barrier) is designed to impede flow from the San Joaquin River into Old River. The additional flow in the San Joaquin River helps maintain adequate dissolved oxygen concentrations for adult salmon migrating upstream (Hayes 1995 *as cited in* DWR and USBR 1996). The barrier is notched at the top in the fall to allow passage of salmon migrating up Old River to enter the San Joaquin River. During spring, the barrier remains fully closed to prevent downstream migrating salmon smolts in the San Joaquin River from entering Old River, with subsequent exposure to SWP, CVP, and agricultural diversions. In recent years, however, culverts have been installed in the barrier to improve water levels in the south Delta that allow some fish movement from the San Joaquin River into Old River. The other three temporary barriers are traversed by several buried 48-inch pipes, with flap gates on one end that allow unidirectional flow. These barriers operate by allowing water to flow through the pipes and flap gates during flood tides to fill the upstream channels. During ebb tides, the flap gates close to retain water in the channels. This operation maintains water levels and facilitates agricultural diversion of higher quality water.

The presence of the temporary barriers alters the patterns and volume of flow in south Delta channels. In particular, installation of the Old River barrier prevents San Joaquin River inflow to Old River, causing the SWP and CVP pumps to pull more water from the central Delta via Columbia Cut and Turner Cut (Resource Management International, Inc. [RMI] 1995 *as cited in* DWR and USBR 1996). Changes in the south Delta flow patterns affect the distribution and abundance of fishes in the south Delta as well as direct losses to the export facilities. The barriers may also alter survival of fall-run Chinook salmon smolts emigrating from the San Joaquin River (USBR and SJRGA 2001) and spawning migrations of adult salmon. Since the barriers provide additional cover for fish predators, predation loss of juvenile fish at the barriers is probably increased.

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[3] The Head of Old River barrier also has been installed periodically from April 15 through May 30 (in 1992, 1994, 1996, 1997, 2000, and 2003).

9.1.2.2.2 Central Valley Project Facilities

The USBR operates Central Valley Project (CVP) facilities in the Delta, including the Tracy Pumping Plant, Tracy Fish Collection Facility, and Delta Cross Channel.

Tracy Pumping Plant. The Tracy Pumping Plant is located adjacent to Clifton Court Forebay. (See Figure 9-4.) The plant pumps directly from the Old and Middle rivers. Its pumping capacity is 4,600 cfs, which is supplied to the Delta-Mendota Canal.

Tracy Fish Collection Facility. Fish salvage facilities at the Tracy Pumping Plant are composed of a system of primary and secondary louvers (Brown and Greene 1992 *as cited in* DWR and USBR 1996). Four bypasses placed equidistantly along the screen face direct fish from the primary louvers to a secondary set of louvers, where they are concentrated and bypassed to holding tanks. Salvaged fish are periodically transferred by truck to a release point in the Delta.

The Tracy pumps are usually operated continuously, and because water is drawn directly from the Delta, pumping is subject to tidal influence, causing variation in channel velocity and approach velocities to fish screens (Brown and Greene 1992 *as cited in* DWR and USBR 1996). There has never been a complete field evaluation of the efficiency of the fish protection facility, although fish loss and salvage are monitored closely. CDFG conducted efficiency tests on the primary louver system, which revealed that striped bass longer than 24 mm were effectively screened and bypassed. However, planktonic eggs, larvae, and juveniles less than 24 mm in length received no protection from entrainment (Hallock et al. 1968 *as cited in* DWR and USBR 1996). The tests also indicated that juvenile Chinook salmon would be effectively screened because they would be greater than 24 mm in length by the time they were exposed to the screens and pumps. Screening efficiency for delta smelt has yet to be determined.

Delta Cross Channel and Georgiana Slough. The Delta Cross Channel near Walnut Grove (Figure 9-5) was constructed in 1951. It conveys Sacramento River water into eastern Delta channels (including the north and south forks of the Mokelumne River) to supply the southern Delta with water for export via CVP and SWP pumps. Two radial gates near the Sacramento River entrance to the channel regulate flow through the Cross Channel. The gates can be closed to provide flood control protection to interior Delta channels.

Georgiana Slough, a natural, unregulated channel about one mile downstream of the Delta Cross Channel, can convey Sacramento River water to the San Joaquin River. Georgiana Slough is not a component of the CVP, but because of the similarities between Georgiana Slough and the Delta Cross Channel in their effects on flows and on fish, it is logical to discuss these two features together.

Approximately 25 to 40 percent of Sacramento River flow enters the central Delta through the Cross Channel when both gates are open. During moderate Sacramento River flows, about 16.5 percent of its flow is diverted through Georgiana Slough. The rate of diversion in Georgiana Slough increases when the Delta Cross Channel gates are closed. Thus, roughly 15 to 50 percent of the Sacramento River flow is diverted into the central Delta, based on mean monthly DWR estimates (DWR and USBR 1996). The hydraulic capacities of the Delta Cross Channel and Georgiana Slough physically limit the amount of flow of Sacramento River water that can be conveyed toward the pumping plants in the south Delta. This limitation can result in insufficient flows to meet pumping demand, which results in water being drawn from the San Joaquin River. When this "reverse flow" condition occurs, water is drawn from downstream areas upstream toward the pumps from the lower rivers.

The principal fisheries concern with respect to the Delta Cross Channel and Georgiana Slough is that many emigrating juvenile anadromous fish produced in the Sacramento River drainage are shunted into the central and southern Delta. A number of studies have been conducted to evaluate the effects of Delta cross-channel gate operations and the movement of juvenile salmonids from the Sacramento River into Georgiana Slough, and resulting changes in juvenile salmonid survival rates. Juvenile Chinook salmon survival investigations begun in the 1980s by USFWS using coded-wire tag mark-recapture techniques to evaluate the effects of Delta cross-channel gate operations on juvenile Chinook salmon survival (Kjelson et al. 1989 *as cited in* DWR and USBR 1996). These mark-recapture studies are continuing to date by USFWS to further investigate the effects of cross-channel gate operations and the movement of juvenile salmonids from the Sacramento River into Georgiana Slough under various export conditions during both the spring and winter periods of salmonid emigration. Additional studies have been recently conducted to examine the effects of Delta cross-channel gate operations on local hydraulic conditions and juvenile salmonid behavior using a multi-disciplinary approach involving extensive water velocity monitoring, drogue studies (studies to define water current patterns), hydroacoustic surveys, and experiments with coded wire tagged and radio tagged salmon to monitor juvenile salmonid behavior (Herbold et al. unpublished data). Other investigations, such as the application of an underwater acoustic barrier for reducing the movement of juvenile salmonids from the Sacramento River into Georgiana Slough (San Luis and Delta-Mendota Water Authority and Hanson 1996), have also been investigated in an effort to better identify management actions that would reduce potential adverse affects on juvenile salmonids and other fish species within the area. Many of these studies have demonstrated that juvenile Chinook salmon, and other species, are diverted from the Sacramento River through either the Delta cross-channel or Georgiana Slough. The migration routes through the central Delta to the ocean are longer and less direct than the Sacramento River route, exposing out migrating fish to greater predation and diversion risks. There are a large number of small, unscreened diversions in the central Delta and in other areas that entrain small fish. Fish that avoid entrainment in the small agricultural diversions may pass into the southern Delta, where they are vulnerable to mortality at the SWP or CVP export facilities. Nearly all the species of special concern are affected by Cross Channel operations, including all races of Chinook salmon, steelhead, American shad, striped bass, and green and white sturgeon. Delta smelt are potentially affected by Cross Channel operations both during upstream migrations by spawning adults and during downstream transport of larvae.

Initial studies on adult Chinook salmon movement in relation to DCC gate operations have also been conducted. Using both sonic tags and acoustic tracking, adult salmon were shown to utilize the DCC as a migration route to the Sacramento River and were not found to congregate behind DCC gates when they were closed. Further investigations designed to elucidate the relationship between adult Chinook salmon movement and DCC gate operations are forthcoming (CALFED 2001).

The Delta Cross Channel is not screened. However, the gates of the Delta Cross Channel can be operated to reduce flow from the Sacramento River into the central Delta. The Bay-Delta standards contained in SWRCB D-1641 require the gates be closed from February 1 through May 20. In addition, the Delta Cross Channel gates may be closed for up to a total of 45 days during the November 1 through January 31 period for fisheries protection as requested by USFWS, NOAA Fisheries, and CDFG. During the November through January period, the Delta Cross Channel gates may be closed on short notice and may be closed on weekends. The Delta Cross Channel gates also may be closed for a total of 14 days during the May 21 through June 15 period, per the direction of USFWS, NOAA Fisheries, and CDFG (USBR 2003). Additionally, USBR standing operation procedures call for gate closure when flow on the Sacramento River reaches the 20,000 to 25,000 cfs range.

Studies have been conducted to coordinate operation of the Delta Cross Channel gates with the abundance of vulnerable life stages of various fish species upstream (e.g., juvenile spring-run Chinook salmon) using near real-time monitoring information.

9.1.2.2.3 Other Facilities

Other major facilities in the Delta that may affect fish include the Contra Costa Canal, the North Bay Aqueduct, the Pittsburg and Antioch power plants, and the Montezuma Slough Salinity Control Structure. These projects would neither affect nor be affected by the EWA Program alternatives and therefore are not included in this discussion.

9.1.2.3 Combined Downstream Effects of the SWP and CVP Facilities

Local effects of the SWP and CVP facilities on fish, such as export losses and Cross Channel and Georgiana Slough diversions, were included in the above discussions of the facilities. In addition to these effects, however, the SWP and CVP facilities influence downstream habitat conditions. These conditions include Delta outflow, the salinity field in the western Delta and the bays, the location of X_2, and the level of flow reversals in the lower San Joaquin River.

Delta Outflow. Water development has changed the volume and timing of freshwater flows through the Estuary. Each year, diversions reduce the volume of fresh water that otherwise would flow through the Estuary. During this century, the volume of the Estuary's fresh water supply that has been depleted each year by upstream diversions, in-Delta use, and Delta exports has grown from about 1.5 million acre-feet (MAF) to nearly 16 MAF. As a result, the proportion of Delta outflow depleted by upstream and Delta diversions has grown substantially.

Water development has also greatly altered seasonal flows into and through the Estuary. Flows have decreased substantially in April, May, and June and have increased slightly during the summer and fall (SFEP 1992). Seasonal flows influence the transport of eggs and young organisms through the Delta and into San Francisco Bay. Flows during the months of April, May, and June play an especially important role in determining the reproductive success and survival of many estuarine species including salmon, striped bass, American shad, delta smelt, longfin smelt, splittail, and others (Stevens and Miller 1983; Stevens et al. 1985; Herbold 1994; Meng and Moyle 1995 *as cited in* DWR and USBR 1996).

Salinity. In many segments of the Estuary, but particularly in Suisun Bay and the Delta, salinity is controlled primarily by freshwater flow. By altering the timing and volume of flows, water development has affected salinity patterns in the Delta and in parts of San Francisco Bay (SFEP 1992 *as cited in* DWR and USBR 1996).

Under natural conditions, the Carquinez Strait/Suisun Bay area marked the approximate boundary between salt and fresh water in the estuary during much of the year. In the late summer and fall of drier years, when Delta outflow was minimal, seawater moved into the Delta from San Francisco Bay. Beginning in the 1920s, following several dry years and because of increased upstream storage and diversions, salinity intrusions became more frequent and extensive.

Since the 1940s, releases of fresh water from upstream storage facilities have increased Delta outflows during summer and fall. These flows have correspondingly limited the extent of salinity intrusion into the Delta. Reservoir releases have helped to ensure that the salinity of water diverted from the Delta is acceptable during the summer and late fall for farming, municipal, and industrial uses (SFEP 1992 *as cited in* DWR and USBR 1996).

Salinity is an important habitat factor in the Estuary. Estuarine species characteristically have optimal salinity ranges, and their survival may be affected by the amount of habitat available within the species' optimal salinity range. Because the salinity field in the Estuary is largely controlled by freshwater outflows, the level of outflow may determine the surface area of optimal salinity habitat that is available to the species (Hieb and Baxter 1993; Unger 1994 *as cited in* DWR and USBR 1996).

Entrapment Zone Location and X_2. The entrapment zone is an area of the Estuary characterized by higher levels of particulates, higher abundances of several types of organisms, and maximal turbidity. It is commonly associated with the position of the 2 ppt salinity isopleth (X_2), but actually occurs over a broader range of salinities (Kimmerer 1992 *as cited in* DWR and USBR 1996). Originally, the primary mechanism responsible for this area was thought to be gravitational circulation, a circulation pattern formed when freshwater flows seaward over a dense, landward-flowing marine tidal current. However, recent studies have shown that gravitational circulation does not occur in the entrapment zone in all years, nor is it always associated with X_2 (Burau et al. 1995 *as cited in* DWR and USBR 1996). Lateral circulation within the Estuary or chemical flocculation may play a role in the formation of the turbidity maximum of the entrapment zone.

As a consequence of higher levels of particulates, the entrapment zone may be biologically significant to some species. Mixing and circulation in this zone concentrates plankton and other organic material, thus increasing food biomass and production. Larval fish such as striped bass, delta smelt, and longfin smelt may benefit from enhanced food resources. Since about 1987, however, the introduced Asian clam population has reduced much of the primary production in the Estuary and there has been virtually no enhancement of phytoplankton production or biomass in the entrapment zone (CUWA 1994 *as cited in* DWR and USBR 1996).

Although little to no enhancement of the base of the food chain in the entrapment zone may have occurred during the past decade, this area continues to have relatively high levels of invertebrates and larval fish. Vertical migration of these organisms through the water column at different parts of the tidal cycle has been proposed as a possible mechanism to maintain high abundance in this area, but recent evidence suggests that vertical migration does not provide a complete explanation (Kimmerer *as cited in* DWR and USBR 1996).

Although recent evidence indicates that X_2 and the entrapment zone are not as closely related as previously believed (Burau et al. 1995 *as cited in* DWR and USBR 1996), X_2 continues to be used as an index of the location of the entrapment zone or area of increased biological productivity. Historically, X_2 has varied between San Pablo Bay (River km 50) during high Delta outflow and Rio Vista (River km 100) during low Delta outflow. In recent years, it has typically been located between approximately Honker Bay and Sherman Island (River km 70 to 85). X_2 is controlled directly by the volume of Delta outflow, although changes in X_2 lag behind changes in outflow. Minor modifications in outflow do not greatly alter the X_2 location. The location of X_2 during the late winter through spring (February through June) is included as a regulatory requirement in the 1995 Water Quality Control Plan.

Jassby et al. (1994 *as cited in* DWR and USBR 1996) showed that when X_2 is in the vicinity of Suisun Bay, several estuarine organisms tend to show increased abundance. However, it is by no means certain that X_2 has a direct effect on any of the species. The observed correlations may result from a close relationship between X_2 and other factors that affect these species. More information is needed to better understand these relationships.

Reverse Flows. Reverse flows (also referred to as QWEST) occur when Delta exports and agricultural demands exceed San Joaquin River inflow plus Sacramento River inflow through the Delta Cross Channel, Georgiana Slough, and Threemile Slough. The capacities of the Cross Channel, Georgiana Slough, and Threemile Slough are fixed, so if pumping rates exceed that total capacity plus flows in Old River and Eastside streams, the pumping causes Sacramento River water to flow around the west end of Sherman Island and then eastward up the San Joaquin River. This condition occurs frequently during dry years with low Delta inflows and high levels of export at the SWP and CVP pumps. Reverse flows are particularly common during summer and fall when nearly all exported water is drawn across the Delta from the Sacramento River (DWR and USBR 1994 *as cited in* DWR and USBR 1996).

There have been concerns regarding the effects of reverse flows on fish populations and their food supply (DWR and USBR 1994 *as cited in* DWR and USBR 1996). These concerns have focused mainly on planktonic egg and larval stages of species such as striped bass, delta smelt, splittail, and American shad. Even when these species do not spawn to a significant extent in the southern Delta, eggs and larvae may be transported into the area by reversed flows in the Middle and Old rivers. As discussed previously, these early life stages are generally entrained, since they are too small to be effectively screened from export waters. The effects of reverse flows on downstream migrating juvenile Chinook salmon and steelhead have also been identified as an area of concern by resource agencies. Pilot studies on the effect of Delta Cross Channel operations on the movement of juvenile Chinook salmon in the Delta indicated that yearlings will move into the Delta Cross Channel during flood tides, and can be drawn into the channel after initially migrating past the channel gates (CALFED 2001). The closure of the gates as required by D-1644 occurs during this period of Chinook salmon juvenile migration. Additional discussion regarding local effects of the SWP and CVP pumping facilities on fish associated with the Delta Cross Channel and Georgiana Slough is provided in Section 9.1.2.2.2, Central Valley Project Facilities.

9.1.3 Export Service Area

The Area of analysis for the Export Service Area consists of San Luis Reservoir, Anderson Reservoir, Castaic Lake, Lake Perris, Diamond Valley Lake, and Lake Mathews. Details regarding the facilities and water bodies within the Area of analysis for the Export Service Area and the fisheries resources they support are provided below.

9.1.3.1 San Luis Reservoir

San Luis Reservoir is located in Merced County at an elevation of 543 feet above msl and has a storage capacity of 2,039 TAF. It was constructed as a storage reservoir for the Federal CVP and the California SWP and stores runoff water via the California Aqueduct and the Delta-Mendota Canal. Water is pumped from the O'Neil Forebay into the main reservoir during the winter and spring. San Luis Reservoir provides habitat for both coldwater and warmwater fisheries. The game fish found in San Luis Reservoir include largemouth bass, crappie, sunfish, striped bass, and bullhead catfish. Fish production in San Luis Reservoir is generally limited by changes in water elevations during critical spawning periods, overall reservoir levels, and the availability of shallow near-shore rearing habitat. Los Banos Creek Reservoir was built to prevent storm runoff from flooding the canals and is known in the area for its' excellent fishing. Stocking by CDFG keep the reservoir well supplied with trout. Bass fishing derbies are often held here, and crappie and bluegill are also caught.

9.1.3.2 Anderson Reservoir

Anderson Reservoir is located in the Coyote Creek watershed of central Santa Clara County. Coyote Creek is a south-to-north trending drainage that discharges into the southern end of South San Francisco Bay. Anderson Reservoir is managed by the Santa Clara Valley Water District for water supply and flood control purposes. Anderson Reservoir is filled in the winter and spring using runoff collected from within the watershed, and from San Luis Reservoir. When full, the reservoir holds 111,198 acre-feet. At present, the District maintains a minimum pool amount of 20,000 acre-feet for summer recreation and emergency storage.

The fishery in Anderson Reservoir is self-propagating; the reservoir is not stocked and currently there are no plans for stocking it. The fish population is game fish, including trout, bass, and other predatory fish. The minimum pool size to maintain the fish population is 4,000 acre-feet.

Coyote Creek below Anderson Reservoir is habitat for fall-run Chinook salmon and steelhead trout. The Anderson Reservoir dam is a barrier to fish migration into the remaining portion of the watershed. Salmon and trout are known to spawn in the stretch of Coyote Creek near the base of the dam. Currently less than 100 salmon and trout are observed in Coyote Creek each year[4]. The District has entered into a cooperative agreement with fish management agencies (CDFG, USFWS, and NOAA Fisheries) and conservation groups to alter releases from Anderson Reservoir in a manner to benefit spawning salmon and trout.

9.1.3.3 Castaic Lake

Castaic Lake is located in Los Angeles County approximately 45 miles northwest of the City of Los Angeles, at an elevation of 1,515 feet above msl. It is the terminal reservoir on the West Branch of the State Water Project. It was designed and built by the DWR and has 323,700 acre-feet of storage capacity, 2,240 acres of surface area, and about 29 miles of shoreline. Castaic Lagoon located immediately downstream of Castaic Lake, provides a recreation pool with a constant water surface elevation and functions as a recharge facility for the downstream groundwater basin. Castaic Lake supports largemouth bass, striped bass, bluegill, rainbow trout, crappie and catfish. Castaic Lagoon supports similar species as Castaic Lake, excluding striped bass. CDFG stocks rainbow trout every other week from October through June.

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[4] Coyote Creek, Stevens Creek, and Guadalupe River Watersheds – Fisheries and Aquatic Habitat Collaborative Effort: Summary Report. February 26, 2003. (Akin, et al.)

9.1.3.4 Lake Perris

Lake Perris is located in Riverside County, approximately 65 miles southeast of downtown Los Angeles at an elevation of 1,590 feet above msl. It is the southern terminus of the State Water Project's East Branch of the California Aqueduct. The lake has ten miles of shoreline and its gross storage capacity is approximately 131,500 acre-feet. Lake Perris has 2,320 acres of surface area, with a mean depth of only 57 feet, and becomes thermally stratified during the summer months. It has a slightly larger surface area than Castaic Lake and yet has only half the capacity. Lake Perris was the first lake in Southern California to be stocked with Alabama spotted bass. Other fish include rainbow trout, channel catfish, largemouth and spotted bass, and bluegill. CDFG stocks the rainbow trout twice per month fall through spring.

9.1.3.5 Diamond Valley Lake

Diamond Valley Lake is located between Temecula and Hemet in Riverside County at an elevation of 1,756 feet above msl. The reservoir is 4.5 miles long, over two miles wide, and has a maximum depth of 260 feet. It is owned and operated by the Metropolitan WD. The reservoir is supplied by water diverted from the Delta and from the Colorado River and conveyed to the reservoir site. The reservoir completed filling in December 2002 and became operational in January 2003. Total storage capacity for Diamond Valley Lake is 800 TAF and surface area is 4,500 acres.

9.1.3.6 Lake Mathews

Lake Mathews Reservoir was completed in 1939 by the Metropolitan Water District of Southern California as the western terminus for the Colorado River Aqueduct. Lake Mathews is located within Riverside County approximately five miles southeast of Corona and three miles south of Riverside. Before the construction of Diamond Valley Reservoir, Lake Mathews was the largest reservoir operated by Metropolitan WD, and it remains the oldest. Lake Mathews holds up to 182,000 acre-feet.

The lands immediately surrounding the lake have been held by the Metropolitan WD, and human intrusions have been few. As Riverside continued to grow during the latter part of the century, surrounding areas began to be developed primarily as custom-built homes on small ranchettes. Additionally, since the 1930s, many of the surrounding lands were and continue to be used for citrus agriculture. In July 1997, the SWRCB approved a resolution project for the Drainage Water Quality Management Plan (DWQMP) for the Lake Mathews Watershed Project. As part of a mitigation plan for its water projects, and recognizing the value to wildlife of such a large, open source of water, the Metropolitan WD lands (approximately 4,000 acres) surrounding the lake were formally designated as a State Ecological Reserve in 1982.

Public access on the Reserve is limited to non-Metropolitan WD lands only, and the lake is not open for public recreation. The Reserve is open daily from dawn to dusk, but since motorized vehicles are not allowed on Reserve lands, access to these non-Metropolitan WD lands is by foot or horse travel only (CNLM 2003). Lake Mathews is not currently stocked with fish and there are no plans for stocking it in the future. The reservoir is also not open for fishing (CNLM 2003). Due to the lack of stocking and fishing activity at Lake Mathews, there is limited information available regarding the fisheries resources within this reservoir.

9.2 Environmental Consequences/Environmental Impacts

9.2.1 Assessment Methods/Hydrologic Model Summary

Extensive hydrologic, water temperature, and early lifestage salmon mortality modeling was performed to provide a quantitative basis from which to assess potential diversion-related effects of the EWA Flexible Purchase Alternative on fisheries resources and aquatic habitats within the Area of analysis. The Fixed Purchase Alternative would involve the same actions as the Flexible Purchase Alternative, but to a lesser degree. Hydrologic modeling was not completed for the Fixed Purchase Alternative because the quantity of water that could be purchased from the Upstream from the Delta Region is small (35 TAF) and differences (if any) in the modeling output would not represent meaningful changes from the Baseline Condition. Instead, potential impacts associated with implementation of the Fixed Purchase Alternative were analyzed on a qualitative basis, in relation to the hydrologic modeling results for the maximum amount of water that could be purchased under the Flexible Purchase Alternative. Data generated as part of the Flexible Purchase Alternative analysis is also used to approximate the in-Delta fishery impacts that could occur under the Flexible Purchase Alternative. Detailed information regarding the alternatives considered for analysis is provided in Chapter 2, Alternatives, Including the Proposed Action/Proposed Project. The analysis of the Flexible Purchase Alternative incorporates implementation of the variable operational assets of the EWA, including relaxation of the export/inflow (E/I) ratio, and SWP pumping of instream improvement flows upstream from the Delta utilizing CVPIA b(2) and Ecosystem Restoration Program water, as described in Attachment 1, Modeling Description.

Modeling output provided monthly values for each year of the 72-year period of record modeled for river flows, reservoir storage and elevation, and for each year of the 69-year hydrologic simulation period modeled for river water temperatures. The period of record for water temperature modeling is shorter because it is based on records through 1990, whereas the period of record for CALSIM II extends through 1993. River water temperature output was then used in Reclamation's Chinook salmon mortality models to characterize water temperature-induced losses of early lifestages of Chinook salmon under each simulated condition. Output from the salmon mortality models provided estimates of annual (rather than monthly mean) losses of emergent fry from egg potential (all eggs brought to the river by spawning adults), which is presented in terms of survival. Diversion-related resource assessments are based on comparisons made between computer model simulations that represent baseline and Flexible Purchase Alternative hydrologic conditions.

The models used in this analysis (CALSIM II, a Yuba River basin model, post-processing tool, reservoir temperature models, American and Sacramento river water temperature models, and the lower American and Sacramento river Chinook salmon early lifestage mortality models) are tools that have been developed for comparative planning purposes, rather than for predicting actual river conditions at specific locations and times. The 72-year and 69-year periods of record for CALSIM II and water temperature modeling, respectively, provide an index of the kinds of changes that would be expected to occur with implementation of a specified set of operational conditions. Reservoir storage, river flows, water temperature, and salmon survival output for the period modeled should not be interpreted or used as definitive absolutes depicting actual river conditions that will occur in the future. Rather, output for the Flexible Purchase Alternative can be compared to that for the Baseline Condition simulation to determine:

- Whether reservoir storage or river flows and water temperatures would be expected to change with implementation of the Flexible Purchase Alternative;
- The months in which potential reservoir storage and river flow and water temperature changes could occur; and,
- A relative index of the magnitude of change that could occur during specific months of particular water year types, and whether the relative magnitude anticipated would be expected to result in effects on fish resources within the regional area.

The models used, although mathematically precise, should be viewed as having "reasonable detection limits." Establishing reasonable detection limits is useful to those using the modeling output for impact assessment purposes, and prevents making inferences: 1) beyond the capabilities of the models; and 2) beyond an ability to actually measure changes. Although data from the models are reported to the nearest 1,000 acre-feet (AF), foot in elevation, cubic foot per second (cfs), tenth of a degree Fahrenheit (°F), and tenth of a percent (%) in salmon mortality, these values were rounded when interpreting differences for a given parameter between two modeling simulations. For example, two simulations having river flows at a given location within one percent of each other were considered to be essentially equivalent. Because the models also provide reservoir storage data on a monthly time step, measurable differences in reservoir storage were evaluated similarly. Similar rounding of modeled output was performed for other output parameters in order to assure the reasonableness of the impact assessments.

In-situ temperature loggers were used to collect water temperature data used for the model. These loggers typically have a precision of ±0.36°F, yielding a potential total error of 0.72°F (Sacramento River Temperature Modeling Project 1997). Therefore, modeled differences in water temperature of 0.36°F or less could not be consistently detected in the river by actual monitoring of water temperatures. In addition, as mentioned above, output from Reclamation's water temperature models provides a "relative index" of water temperatures under the various operational conditions modeled. Output values indicate whether the water temperatures would be expected to increase, remain unchanged, or decrease, and provide insight regarding the relative magnitude of potential changes under one operational condition compared to another. For the purposes of this impact assessment, modeled water temperature changes that were within 0.3°F between modeled simulations were considered to represent no measurable change (were considered to be "essentially equivalent"). A level of detection of measurable change of 0.3°F was used because: 1) model output is reported to the one-tenth degree Fahrenheit; 2) rounding the level of error associated with in-situ temperature loggers used for model temperature data up to 0.4°F would eliminate the possibility of detecting measurable change between 0.36°F and 0.4°F; and 3) rounding the level of detection down to 0.3°F is the more conservative approach in detecting a change in temperature between the modeling results. Temperature differences between modeling results of more than 0.3°F were assessed for their biological significance. This approach is considered very rigorous, because it utilizes a more conservative threshold of detection for potential water temperature changes than used in other fisheries impact assessments. For example, USFWS and Reclamation, in the Trinity River Mainstem Fishery Restoration Draft EIS/EIR (USFWS et al. 1999), used a change in long-term average water temperature of 0.5°F as a threshold of significance, and the Central Valley Regional Water Quality Control Board (RWQCB) generally uses a change of 1.0°F or more as a threshold of significance.

Attachment 1, Modeling Description, provides a more detailed discussion of the modeling process and its application to the EWA Program analysis, including: a) the primary assumptions and model inputs used to represent hydrologic, regulatory, structural and operational conditions; and b) the simulations performed from which effects were estimated.

EWA assets may be managed or purchased from facilities that are not part of the State or Federal water projects. These facilities, referred to throughout the document as "non-Project" facilities, are not included in the CALSIM II model of CVP/SWP operations. Therefore CALSIM II hydrologic modeling output is not available for these facilities. The methodologies used to predict comparative operational scenarios under Flexible Purchase Alternative and Baseline Condition is included in the discussions that follow. Organizationally, methods for the determination of potential impacts on reservoir fish species are presented first (Section 9.2.1.1), followed by discussions of riverine and Delta impact assessment methodologies (Sections 9.2.1.2 and 9.2.1.3, respectively).

9.2.1.1 Reservoir Fish Species

EWA acquisitions could result in alterations to storage and water surface elevations for CVP/SWP and non-Project reservoirs within the Area of analysis. The following reservoirs potentially could be affected by EWA acquisitions:

- Shasta
- French Meadows
- Anderson

- Little Grass Valley
- Sly Creek
- Oroville
- New Bullards Bar
- Hell Hole
- Folsom
- McClure
- San Luis
- Castaic
- Perris
- Mathews
- Diamond Valley

Fluctuations in these reservoirs, in response to day-to-day operations and changes in runoff patterns, can potentially affect reservoir fish species due to alterations in the timing and magnitude of reservoir drawdowns. Methods used to determine potential effects on reservoir fish species within CVP/SWP reservoirs are discussed below in Section 9.2.1.1.1. Methods used to determine potential impacts on reservoir fish species within non-Project reservoirs upstream from the Delta are discussed in Section 9.2.1.1.2, and reservoirs in the Export Service Area are discussed in Section 9.2.1.1.3.

9.2.1.1.1 CVP/SWP Reservoirs (Shasta, Oroville, and Folsom reservoirs)

The methodologies used to analyze potential impacts on reservoir warmwater and coldwater fish species in Project reservoirs are discussed below.

<u>Warmwater Fisheries</u>

Because warmwater fish species of Shasta, Oroville, and Folsom reservoirs (including largemouth bass, smallmouth bass, spotted bass, green sunfish, crappie, and catfish) use the warm upper layer of the reservoir and nearshore littoral habitats throughout most of the year, seasonal changes in reservoir storage, as it affects reservoir water surface elevation (feet msl), and the rates at which water surface elevation change during specific periods of the year, can directly affect the reservoir's warmwater fish resources. Reduced water surface elevations can reduce the availability of nearshore littoral habitats used by warmwater fish for spawning and rearing, thereby reducing spawning and rearing success and subsequent year-class strength. In addition, decreases in reservoir water surface elevation during the primary spawning period for nest building, warmwater fish may result in reduced initial year-class strength through warmwater fish nest "dewatering." Given the geographic and altitudinal differences among the reservoirs within the Area of analysis, warmwater fish spawning and rearing periods vary somewhat among reservoirs analyzed. For this analysis, the warmwater fish-spawning period is assumed to extend from March through June, and the warmwater fish-rearing period is assumed to extend from April through November.

Although black bass spawning may begin as early as February, or as late as May, in southern and northern California reservoirs, respectively, and may possibly extend to July in some waters, the majority of black bass spawning in California occurs from March through May (Lee 1999). However, given the geographical and altitudinal variation among the Project reservoirs, in order to examine the potential of nest dewatering events to occur, the warmwater fish spawning period is assumed to extend from March through June.

To encompass all reservoirs included in the EWA Program, the period of April through November is most appropriate for warmwater juvenile fish rearing.

To assess potential elevation-related effects on the warmwater fish of Shasta and Folsom reservoirs, the following two-phased approach was used. First, the magnitude of change (feet msl) in reservoir water surface elevation occurring each month of the primary spawning period for nest-building fish (March through June) under the Flexible Purchase Alternative was determined and compared to that modeled for the Baseline Condition. A recent study by CDFG, which examined the relationship between reservoir elevation fluctuation rates and nesting success for black bass, suggests that a reduction rate of 0.15, 0.18, and 0.39 meter per day (m/day) or greater would result in 100 percent nest mortality (or zero percent nest survival) for largemouth bass, smallmouth bass, and spotted bass, respectively (Lee et al. 1998). However, CDFG reservoir biologists suggest that, on the average, a nest survival rate of at least 20 percent is necessary to maintain the long-term population levels of high-fecundity, warmwater fish (D. Lee, pers. comm. 1998). Using nest survival curves developed by CDFG (Lee et al. 1998), reservoir fluctuation criteria were developed that would provide a minimum nest survival rate of approximately 20 percent for largemouth bass, the bass species found by CDFG to be most sensitive to reservoir elevation fluctuations.

A reduction rate of nine feet per month would represent an approximate water surface elevation decrease of 0.3 feet per day (ft/day) (0.09 m/day). If such a reduction would occur during a nesting event, it would correlate to an approximate nest survival rate of 20 percent for largemouth bass. Therefore, a decrease in Shasta, Oroville, or Folsom reservoirs water surface elevation of nine feet or more per month was selected as the threshold beyond which spawning success of nest-building, warmwater fish could potentially result in long-term population declines. To evaluate effects on largemouth bass, and ultimately warmwater fish in general, the number of times that reservoir reductions of nine feet or more per month could occur under the Flexible Purchase Alternative was compared to the number of occurrences that were modeled under the Baseline Condition.

Criteria for reservoir elevation increases (nest flooding events) have not been developed by CDFG. Because of overall reservoir fishery benefits (e.g., an increase in the availability of littoral habitat for warmwater fish rearing), greater reservoir elevations that would be associated with rising water levels would offset negative effects due to nest flooding (Lee 1999). Therefore, the likelihood of spawning-related effects from nest flooding is not addressed for reservoir fisheries.

Second, changes in the availability of nearshore littoral habitat were evaluated based on the relationship between reservoir water surface elevation and the quantity of nearshore littoral habitat containing submerged structure (submerged macrophytes and/or inundated terrestrial vegetation) (Water Forum 1999; PCWA and USBR 2002). Using this relationship, the mean number of acres of littoral habitat was estimated for each month of the primary rearing period (April through November) under the Flexible Purchase Alternative and compared to that modeled for the Baseline Condition. A relationship between water surface elevation and the quantity of submerged vegetation has not been established for Lake Oroville. Therefore, a qualitative assessment, more thoroughly described in Section 9.2.1.1.2, of the availability of littoral habitat was used for this location.

Coldwater Fisheries

During the period when Shasta, Oroville, and Folsom reservoirs are thermally stratified (April through November), coldwater fish within the reservoir reside primarily within the reservoir's metalimnion and hypolimnion where water temperatures remain suitable. Reduced reservoir storage (TAF) during this period could reduce the reservoir's coldwater pool volume, thereby reducing the quantity of habitat available to coldwater fish species during these months. Reservoir coldwater pool size generally decreases as reservoir storage decreases, although not always in direct proportion because of the influence of reservoir basin morphometry. Therefore, to assess potential storage-related effects on coldwater fish habitat availability in Shasta, Oroville, and Folsom reservoirs, end-of-month storage modeled for each year of the 72-year period of record under the Flexible Purchase Alternative was compared to end-of-month storage under the Baseline Condition for each month of the April through November period. Substantial reductions in reservoir storage were considered to result in substantial reductions in coldwater pool volume and, therefore, habitat availability for coldwater fish. Effects on the coldwater fisheries were further assessed by determining whether seasonal changes in reservoir storage, and associated changes in water-surface elevation, would be expected to indirectly affect coldwater fish species by adversely affecting the productivity of their primary prey species (threadfin shad (*Dorosoma petenense*) and wakasagi (*Hypomesis hipponensis*)).

Lake Natoma

No storage- or elevation-related impacts on fishery resources of Lake Natoma are expected to occur under the Flexible Purchase Alternative, relative to the basis of comparison. As a regulating afterbay of Folsom Reservoir, its monthly storage and elevation fluctuate significantly on a daily and hourly basis. Therefore, changes in releases from Folsom Reservoir would not significantly affect monthly mean storage or elevation, relative to the Baseline Condition. Consequently, no quantitative assessment of potential storage- or elevation-related impacts on fishery resources in this water body is warranted.

Because changes in CVP/SWP operations under the EWA alternatives could alter the temperature of water released from Folsom Dam (because of limited coldwater pool availability), and because Lake Natoma's temperature at any given time is largely dictated by the temperature of water released from Folsom Dam, these additional diversions could change seasonal water temperatures within Lake Natoma. The small changes in lake temperatures that could occur would not be expected to adversely affect the lake's warmwater fisheries. Conversely, increases in lake temperatures could adversely affect coldwater species such as rainbow trout stocked by CDFG. To assess the potential impacts of altered lake temperatures to fishery resources within the lake, monthly mean temperatures of water released from Nimbus Dam were determined for the Flexible Purchase Alternative and compared to monthly mean temperatures modeled under the Baseline Condition for each month of the year.

Temperatures of water released from Nimbus Dam were used as an "index" to represent the relative changes in Lake Natoma water temperatures that could occur under the Flexible Purchase Alternative, relative to the Baseline Condition.

9.2.1.1.2 Upstream from the Delta Region Non-Project Reservoirs

Several non-Project reservoirs upstream from the Delta could serve as potential water sources for the EWA. Because these non-Project reservoirs are not managed under the operations of either the CVP or SWP, they are not included in the CALSIM II hydrologic modeling simulations, and changes in monthly operations were evaluated using an alternate methodology. The methods used to evaluate potential impacts on fisheries resources are described in this section, and apply to the following reservoirs:

- Little Grass Valley
- Sly Creek
- New Bullards Bar
- Hell Hole
- French Meadows
- McClure

The range of fluctuation in surface water elevations for each non-Project reservoir is not expected to vary beyond annual operating ranges under the Baseline Condition, except in those facilities from which stored reservoir water would be purchased. Changes to the annual operational regimes of these reservoirs are not proposed under the EWA; however, the management of EWA assets within these facilities could result in seasonal changes in the timing of reservoir drawdown[5], which could affect rearing success and initial year-class strength of reservoir fisheries.

To evaluate the potential effects of EWA actions on reservoir fisheries, an analysis of seasonal changes in storage under baseline and Flexible Purchase Alternative conditions was performed. Median values for reservoir end-of-month storage under the Baseline Condition were obtained from historical records[6]. Estimates for reservoir storage levels under the Flexible Purchase Alternative were calculated by subtracting a portion of the acquisition quantity from the baseline median end-of-month storage levels, with the assumption that EWA acquisition amounts would be released evenly over a given period. Using reservoir specific area-capacity curves, estimates for storage changes were translated into relative changes in water surface elevations. The estimated values for changes in water surface elevations were used to conduct a qualitative analysis of the potential for increases in the frequency of nest dewatering

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[5] Limitations have been placed on the maximum volume of water potentially available to EWA from each non-Project reservoir, based upon reservoir size, operational constraints and the existing refill patterns within each basin. Additionally, EWA asset acquisitions must not result in a reduction of reservoir surface water elevation beyond the minimum reservoir drawdown levels as stated in the corresponding Federal Energy Regulatory Commission (FERC) license, where applicable. This documentation and any related material also was reviewed to ensure compliance with all appropriate regulatory requirements.

[6] Historical reservoir end-of-month storage was obtained from: DWR's California Data Exchange Center (DWR, 2002). Median values were computed because the historical period of record available for the non-Project reservoirs is substantially shorter than the period of record used for modeling simulations. Thus, mean estimates of change based on a shorter period of record are less likely to contain a representative frequency of water year types, and would be more likely to be skewed by extremely wet or dry water years.

events (decreases in water surface elevation of greater than nine feet per month during the spawning period), reductions in the availability of littoral habitat, and decreases in coldwater pool volume, to occur under the Flexible Purchase Alternative, relative to the Baseline Condition, as discussed in Section 9.2.1.1.1. Again, the time periods analyzed are March through June for spawning, and April through November for juvenile rearing.

Further discussion of using reservoir water surface elevation data to analyze impacts to warmwater fish juvenile rearing is warranted because of the assumptions that are necessary. A general relationship between mean water surface elevation and amount of littoral habitat is assumed to occur in the reservoirs for which this relationship has not been quantified (Oroville, New Bullards Bar, French Meadows, Hell Hole, Sly Creek, and McClure reservoirs). Specifically, higher mean water surface elevations are assumed to create more littoral habitat, therefore, more warmwater juvenile fish-rearing habitat. Usually, the optimum elevation for maximizing available littoral habitat for rearing is at or near the maximum reservoir elevation (Lee 1999). In most cases, the reservoir analyses are conducted when reservoir elevations are not at their maximum levels. Despite the necessary assumptions, analysis on impacts to warmwater fish rearing is conducted in order to identify potential impacts that may occur in reservoirs in which the relationship between reservoir surface elevation and amount (acres) of littoral habitat is not quantified.

9.2.1.1.3 Export Service Area Reservoirs

Several reservoirs within the Export Service Area could serve as potential water sources for the EWA, including San Luis Reservoir, Anderson Reservoir, Diamond Valley Lake, Castaic Lake, Lake Mathews, and Lake Perris, through source shifting. Changes in the seasonal timing of reservoir drawdown could affect existing fishery and aquatic resources in the reservoirs. Reduced water surface elevations could reduce the availability of nearshore littoral habitats used for warmwater fish for rearing and spawning, thereby reducing spawning and rearing success and subsequent year class strength. Reduced reservoir storage could also reduce the coldwater pool volume, thereby reducing the quantity of habitat available to coldwater fish in the reservoir.

Because reservoirs in the Export Service Area are not managed under the operations of either the CVP or SWP, they are not included in the CALSIM II hydrologic modeling simulations, and changes in monthly operations were evaluated using an alternate methodology. In order to assess whether implementation of the Flexible Purchase Alternative would affect reservoir fisheries at San Luis Reservoir, Anderson Reservoir, Diamond Valley Lake, Castaic Lake, Lake Mathews, and Lake Perris, a description of operational procedures under the Flexible Purchase Alternative and under the Baseline Condition were provided for each evaluated reservoir. Potential impacts on fisheries and aquatic resources were assessed by qualitatively comparing operations under the Flexible Purchase Alternative to operations under the Baseline Condition and assessing whether implementation of the Flexible Purchase Alternative would result in deviations from standard operating procedures.

9.2.1.2 Riverine Fish Species Hydrologic and Water Temperature Modeling

This section provides a description of the application of hydrologic and water temperature modeling output to identify potential effects on riverine fisheries and aquatic resources resulting from the implementation of the Flexible Purchase Alternative. Assessment methodologies are organized by river, from the Sacramento River south to the San Joaquin River, with further subdivisions based on species and lifestage, where appropriate. Specific impact assessment methodologies for salmonids are described in full for winter-run Chinook salmon in the Sacramento River. River-specific and run-specific differences in the application of the winter-run Chinook salmon assessment methodology are discussed for each river and/or run of Chinook salmon.

9.2.1.2.1 Sacramento River Area of Analysis

Changes in CVP/SWP operations under the EWA program could potentially alter seasonal Sacramento River flows and water temperatures, which could change the relative habitat availability for fish species that are present in the Sacramento River. The Sacramento River is utilized by a number of fish species of primary management concern, either as habitat during one or more of their life stages or as a migration corridor to upstream habitat in other river systems. For these reasons, species-specific impact assessments were warranted for this river system and were conducted for the following species of primary management concern:

- Winter-run Chinook salmon;
- Spring-run Chinook salmon;
- Fall-run Chinook salmon;
- Late-fall-run Chinook salmon
- Steelhead;
- Sacramento splittail;
- American shad; and
- Striped bass.

These species are of primary management concern due either to the importance of their commercial and/or recreational fisheries (fall-run Chinook salmon, steelhead, American shad, and striped bass) and/or because they are a species currently listed or proposed for listing under the Federal ESA and/or CESA (steelhead, winter-run and spring-run Chinook salmon, and Sacramento splittail). Because the species selected for species-specific assessments include those sensitive to changes in both river flow and water temperature throughout the year, an evaluation of effects on these species is believed to reasonably encompass the range of potential effects upon other Sacramento River fish species (e.g., green sturgeon) that could potentially be affected by EWA operations.

During some years, changes in CVP/SWP operations could potentially alter Sacramento River seasonal water temperatures. Changes in Sacramento River water temperatures that could occur as a result of the implementation of the Flexible Purchase Alternative would not be expected to be sufficiently large to adversely affect fish species present in the upper Sacramento River, with the possible exceptions of Chinook salmon and steelhead, which have low thermal tolerance. If implementation of the Flexible Purchase Alternative induced elevated water temperatures, then spawning and rearing success of these anadromous salmonids could be affected. Moreover, because: 1) thermal requirements of Chinook salmon and steelhead are generally similar; 2) the NOAA Fisheries Biological Opinion (BO) for Winter-run Chinook Salmon (NMFS 1993 as revised in 1995) has established quantitative temperature criteria for the upper Sacramento River to protect winter-run Chinook salmon; and 3) Reclamation has developed a Sacramento River Chinook Salmon Mortality Model applicable to all four runs of Chinook salmon, this assessment focused quantitatively on Chinook salmon. Impact findings for the four runs of Chinook salmon provide a technical basis from which to infer whether steelhead would be impacted by seasonal changes in water temperatures. For all runs of Chinook salmon in the Sacramento River, the time periods for the evaluation of potential effects on individual lifestages were based on life history descriptions from *Species Profiles: Life Histories and Environmental Requirements of Coastal Fishes and Invertebrates (Pacific Southwest) – Chinook Salmon* (Allen and Hassler 1986).

EWA assets may be acquired from and/or stored in Lake Shasta on the Sacramento River. In addition, implementation of the Flexible Purchase Alternative could reduce agricultural return flows to Butte Creek, a tributary of the Sacramento River. Because of differences in management, fish passage, and species distribution, the Sacramento River and Butte Creek were evaluated separately.

Sacramento River

Winter-run Chinook Salmon

The analysis of potential impacts on winter-run Chinook salmon is based upon individual life-stages (adult immigration; spawning, incubation, and initial rearing; and juvenile rearing and emigration) because each lifestage exhibits preferences for different flow and temperature conditions.

Flow-related Effects

To assess flow-related effects on winter-run Chinook salmon, long-term average and monthly mean flows released from Keswick Dam (RM 302) and in the Sacramento River at Freeport (RM 46) simulated for the Flexible Purchase Alternative were compared to those simulated for the Baseline Condition. These comparisons were conducted for each of the following lifestages and time periods:

- Adult immigration (December through July);
- Spawning, incubation, and initial rearing (April through August); and
- Juvenile rearing and emigration (August through December).

In addition to the above assessment, the NOAA Fisheries BO for winter-run Chinook salmon provides flow criteria for the Sacramento River below Keswick Dam (NMFS 1993, as revised in 1995). NOAA Fisheries requires that Reclamation maintain a minimum release from Keswick Dam of 3,250 cfs from October 1 through March 31. To evaluate the potential for changes in CVP/SWP operations under the Flexible Purchase Alternative to result in changes in the frequency in which Sacramento River flow requirements are met, an assessment of flow levels below this threshold was conducted during the applicable lifestage. Thus, releases from Keswick Dam during December through March of the adult immigration period and during October through December of the juvenile emigration period were evaluated under the Flexible Purchase Alternative and compared to those simulated under the Baseline Condition to determine potential changes in the frequency of flows below the 3,250 cfs criterion.

No specific flow criteria have been identified for fish in the lower Sacramento River. Therefore, potential flow-related effects determinations for the lower Sacramento River were based on an evaluation of the frequency and magnitude of change in modeled monthly mean flow at Freeport, relative to the Baseline Condition.

Temperature-related Effects

Water temperature-related effects on Sacramento winter-run Chinook salmon were evaluated through three distinct assessments focusing on the distinct lifestages and periods, as described above. Temperature-related effects on individual winter-run Chinook salmon lifestages were based on water temperatures in the Sacramento River at Bend Bridge, Jelly’s Ferry, and Freeport. The NOAA Fisheries BO for winter-run Chinook salmon typically manages for water temperature compliance at Bend Bridge and Jelly’s Ferry based on runoff and storage conditions in Lake Shasta. Nearly all suitable spawning habitat for winter-run Chinook salmon is believed to be upstream of Red Bluff Diversion Dam (RM 243) (NMFS 1993; CDFG 2002) Freeport is provided as an additional location for passage (immigration and emigration) considerations.

Potential changes in the frequency of exceedance of temperature criteria, as established in the Winter-run Chinook Salmon BO, also were evaluated during each applicable lifestage. The BO specifies that:

- Daily average water temperatures not in excess of 56°F are required in the Sacramento River at Bend Bridge from April 15 through September 30; and

- Daily average water temperatures not in excess of 60°F are required in the Sacramento River at Bend Bridge from October 1 through October 31.

In dry water years, the location of the temperature compliance point is moved from Bend Bridge downstream to Jelly's Ferry. For all discussions that follow, if modeling output indicates that there would be instances in which either the 56°F or the 60°F water temperature criteria would be exceeded under the Flexible Purchase Alternative, relative to the Baseline Condition, a more detailed analysis of effects by individual water-year type and location were conducted. Although the NMFS (1993) water temperature criteria are stated as daily averages, the available hydrologic and water temperature models allow only for monthly mean temperature analyses and output. Consequently, this assessment was based on monthly mean water temperature data output from Reclamation's existing models.

<u>Adult Immigration (December through July)</u>

Long-term average and monthly mean water temperatures simulated for each month of the December through July period under the Flexible Purchase Alternative were compared to those under the basis of comparison at Bend Bridge, Jelly's Ferry, and Freeport in the Sacramento River. In addition, NOAA Fisheries temperature criteria are applicable from April through July of the adult winter-run Chinook salmon immigration period. For these months, the frequency of monthly mean water temperatures greater than 56°F was determined under the Flexible Purchase Alternative and compared to the frequency of index exceedance under the Baseline Condition.

<u>Spawning, Incubation, and Initial Rearing (April through August)</u>

Long-term average and monthly mean water temperatures simulated for each month of the April through August period under the Flexible Purchase Alternative were compared to those under the basis of comparison at Bend Bridge, Jelly's Ferry, and Freeport in the Sacramento River. In addition, NOAA Fisheries temperature criteria are applicable throughout the entire winter-run Chinook salmon spawning, incubation, and initial rearing period. For these months, the frequency of monthly mean water temperatures greater than 56°F was determined under the Flexible Purchase Alternative and compared to the frequency of index exceedance under the Baseline Condition.

Additionally, Reclamation's (1991) Sacramento River Chinook Salmon Mortality Model (LSALMON2) was used to assess potential temperature-related effects on the early lifestage survival of winter-run Chinook salmon, as well as the other runs of Chinook salmon in the Sacramento River. Model output represents the percentage of potential emergent fry produced, based on all eggs brought to the river by spawning adults, that would survive under the temperature regime that would occur under each model simulation. The LSALMON 2 model calculates temperature-induced mortality (the percentage of potential emergent fry lost as a result of temperature-induced mortality of pre-spawned eggs, fertilized eggs incubating in the gravel, and pre-emergent fry).

As discussed in the Trinity River Mainstem Fishery Restoration EIS/EIR (Trinity River EIS/EIR) (USFWS et al. 1999), the mortality model uses weekly average water temperatures obtained from the Sacramento River Water Temperature Model and tracks water temperature impacts on Chinook salmon egg and larval (sac-fry) development. Algorithms are used to compute the cumulative survival of eggs spawned in a particular week through fry emergence from the spawning gravel. Temperature mortality schedules (relationships) for Chinook salmon eggs and larvae were developed that establish temperature-related instantaneous daily mortality rates for modeling salmon losses. Recent (1990 through 1996) spawning distributions for winter-run Chinook salmon were used in the salmon mortality model (USFWS et al. 1999). The model uses spatial and temporal distribution information of spawning activity specific for each salmon run in the Sacramento River. Three river reaches, including Keswick to Balls Ferry (upper), Balls Ferry to Red Bluff (middle), and downstream of Red Bluff (lower) are used in the analysis of temperature-related mortality of Chinook salmon. Within each river reach, a specific temperature-related mortality estimate is calculated. From these three partial mortality estimates, a cumulative mortality estimate, for each run, is then calculated for each water year for the simulated period of record (69 years). The complement (survival = 100 - mortality) of these calculated percent losses are discussed for impact assessment purposes. For this analysis, annual early lifestage survival estimated for the Flexible Purchase Alternative was compared to that estimated for the Baseline Condition for each year of the 69-year period of record.

Juvenile Rearing and Emigration (August through December)

The same methodology described for adult winter-run Chinook salmon spawning, egg incubation, and initial rearing was used to evaluate potential water temperature-related effects on juvenile winter-run Chinook salmon rearing and emigration with the following modifications:

- The period of assessment was August through December;
- The number of years (of the 69 years modeled) that monthly mean water temperatures would exceed the index value of 65°F were determined at Bend Bridge, Jelly’s Ferry and in the Sacramento River at Freeport;
- Mean water temperatures for the years (of the 69 years modeled) during August through October that were shown to exceed the 56°F and 60°F index values identified in the NOAA Fisheries Biological Opinion were determined at Bend Bridge and Jelly’s Ferry; and

- Reclamation's Salmon Mortality Model was not used, because it does not assess mortality beyond the emergent fry lifestage.

The temperature index values for juvenile rearing and emigration are different from the indexes for spawning and incubation because adult and juvenile winter-run Chinook salmon are believed to tolerate water temperatures up to 65°F without substantial adverse effects, whereas incubating eggs and pre-emergent fry incur substantial reductions in survival when water temperatures exceed 56°F.

<u>Spring-run Chinook Salmon</u>

To assess flow- and temperature-related effects on spring-run Chinook salmon adult immigration, spawning, egg incubation and initial rearing, and juvenile rearing and emigration, the methodology described above for Sacramento River winter-run Chinook salmon was used with the following modifications:

- The adult immigration period was evaluated from March through September;
- The spawning/incubation and initial rearing was evaluated from August through January;
- The juvenile rearing and emigration period was evaluated from December through April;
- Although 56°F is used as an index temperature for spawning, egg incubation, and initial rearing, an analysis of the exceedance of NOAA Fisheries temperature criteria was not required, as no regulatory requirement exists for Sacramento River spring-run Chinook salmon; and
- Output for spring-run Chinook salmon from Reclamation's LSALMON2 Model was used to assess potential temperature-related effects on early lifestage survival for this salmon run.

<u>Fall-run Chinook Salmon</u>

To assess flow- and temperature-related effects on fall-run Chinook salmon adult immigration, spawning, egg incubation and initial rearing, and juvenile rearing and emigration, the methodology described above for Sacramento River winter-run Chinook salmon was used with the following modifications:

- The adult immigration period was evaluated from September through November;
- The spawning/incubation and initial rearing was evaluated from October through February;
- The juvenile rearing and emigration period was evaluated from February through June;

- Although 56°F is used as an index temperature for spawning, egg incubation, and initial rearing, an analysis of the exceedance of NOAA Fisheries temperature criteria was not required, as no regulatory requirement exists for Sacramento River fall-run Chinook salmon; and
- Output for fall-run Chinook salmon from Reclamation's LSALMON2 Model was used to assess potential temperature-related effects on early lifestage survival for this salmon run.

Late-fall-run Chinook Salmon

To assess flow- and temperature-related effects on late fall-run Chinook salmon adult immigration, spawning, egg incubation and initial rearing, and juvenile rearing and emigration, the methodology described above for Sacramento River winter-run Chinook salmon was used with the following modifications:

- The adult immigration period was evaluated from October through April;
- The spawning/incubation and initial rearing was evaluated from December through April;
- The juvenile rearing and emigration period was evaluated from April through October;
- Although 56°F is used as an index temperature for spawning, egg incubation, and initial rearing, an analysis of the exceedance of NOAA Fisheries temperature criteria was not required, as no regulatory requirement exists for Sacramento River fall-run Chinook salmon; and
- Output for late fall-run Chinook salmon from Reclamation's LSALMON2 was used to assess potential temperature-related effects on early lifestage survival for this salmon run.

Steelhead

Because environmental conditions required by steelhead are not significantly different from those required by fall-run Chinook salmon, impact indicators and significance criteria for steelhead are the same as for fall-run Chinook salmon. Flow- and temperature-related impact determinations for steelhead for the periods of September through November and February through June were based on the same modeling output used to assess effects on Sacramento River fall-run Chinook salmon during this period, and are discussed concurrently with potential impacts on fall-run Chinook salmon. However, because steelhead rear within the Sacramento River Basin year-round, additional flow and temperature impact assessments for over-summer and rearing juvenile steelhead were made for the months of the year not addressed by the fall-run Chinook salmon assessments (July through September and October through March). Flow- and temperature-related effects on steelhead rearing during the July through September and October through March periods were assessed via the same methods used to assess flow- and temperature-related effects on fall-run Chinook salmon during the February through June period.

For the temperature-related effects analysis, no steelhead mortality modeling could be performed as a part of the assessment for this species, because no steelhead mortality model has been developed for the Sacramento River. A fall-run Chinook salmon mortality model is available, however, as discussed in the Trinity River EIS/EIR, mortality estimates for late fall-run Chinook salmon can be used as a conservative surrogate for steelhead mortality estimates. Because it is likely that the actual number of steelhead spawning in the mainstem Sacramento River is likely to be much less than those spawning in tributaries to the Sacramento River (USFWS et al. 1999), potential adverse effects on steelhead populations, as a result of changes in water temperatures under the Flexible Purchase Alternative, would likely be less than that estimated via the late-fall run Chinook salmon mortality output (USFWS et al. 1999).

<u>Splittail</u>

Splittail move throughout the Sacramento-San Joaquin Delta, which serves as a migration corridor to spawning habitat within the Sacramento River and its tributaries. Splittail spawning and migration activities are limited to the portion of the Sacramento River below Red Bluff Diversion Dam, although occurrence in the upper reaches of the Sacramento River is coincident with wet water year types (Moyle 2002). The Sutter and Yolo Bypasses, along the Sacramento River, are apparently important spawning areas today (Moyle 2002). Water surface elevations in the Sacramento River have the potential to influence the amount of submerged vegetation available to splittail for spawning habitat along the shoreline of the Sacramento River. The frequency, magnitude, and duration of riparian vegetation flooding, and therefore the quality and quantity of potential splittail spawning habitat, has the potential to be affected by changes in releases from Lake Shasta under the Flexible Purchase Alternative. Consequently, if flows are reduced under the Flexible Purchase Alternative, then the availability of submerged vegetation available for spawning habitat could be reduced during the splittail spawning season (February through May). As discussed in Chapter 15, Flood Control, the EWA Program would not result in changes in the frequency of bypass flooding, therefore effects on Sacramento splittail within the Sutter and Yolo Bypasses are not analyzed further.

To assess potential flow-related effects on splittail spawning habitat availability within the Sacramento River during each month of the February through May period, the frequency and magnitude of potential flow-related changes under the Flexible Purchase Alternative were determined, relative to the Baseline Condition. Typically (as done in the lower American River analysis), a measure of the amount of submerged vegetation is regressed against flow to establish a relationship between flow and available habitat. However, such a relationship for flooded riparian habitat has not been determined for the Sacramento River. Therefore, the analysis of potential effects on splittail habitat in the Sacramento River focuses on the frequency and magnitude of monthly mean flow changes below Keswick Dam and at Freeport.

Splittail reportedly spawn at water temperatures from 48°F to 68°F (Wang 1986). To evaluate potential water temperature-related effects on splittail, the frequency in which monthly mean water temperatures in the Sacramento River below Keswick Dam and at Freeport would be within this range during the February through May period was determined under the Flexible Purchase Alternative and compared to that under the Baseline Condition.

American Shad

Because the majority of American shad spawning migrations into the Sacramento River are believed to occur during May and June, potential changes in river flows during these months were evaluated for this species. To evaluate potential flow-related effects on American shad attraction, migration, and spawning, the frequency and magnitude of flow changes in the Sacramento River below Keswick Dam and at Freeport under the Flexible Purchase Alternative were evaluated, relative to the Baseline Condition.

To evaluate potential water temperature-related effects on American shad spawning, monthly mean water temperatures under the Flexible Purchase Alternative were determined and compared to those under the Baseline Condition for the months of May and June both below Keswick Dam and at Freeport in the Sacramento River. Specifically, the frequency in which monthly mean May and June water temperatures in the Sacramento River below Keswick Dam and at Freeport would be within the reported preferred range for American shad spawning (60°F to 70°F) was determined under the Flexible Purchase Alternative and compared to that under the Baseline Condition.

Striped Bass

Potential flow-related effects on the striped bass sport fishery were assessed by determining the frequency and magnitude in which flows in the Sacramento River below Keswick Dam and at Freeport under the Flexible Purchase Alternative would change, relative to the Baseline Condition, during the May and June spawning and initial rearing period.

Optimal water temperatures for juvenile striped bass spawning and initial rearing are reported to range from approximately 59°F to 68°F (Moyle 2002). Therefore, to evaluate potential water temperature-related effects on striped bass spawning and initial rearing, the frequency in which monthly mean water temperatures in the Sacramento River below Keswick Dam and at Freeport during May and June would be within this range was calculated for the Flexible Purchase Alternative and compared to the frequency within this range under the Baseline Condition.

Butte Creek

Evaluation of potential impacts on fish species of primary management concern in Butte Creek associated with implementation of the Flexible Purchase Alternative was not based on flow or water temperature modeling output, because such output is not available for Butte Creek. Also, water asset acquisition from Butte Creek is not considered as part of the EWA program. Implementation of the Flexible Purchase Alternative, however, could reduce agricultural return flows to Butte Creek.

An evaluation of potential impacts was performed by comparing the characterization, timing, and location of potential changes in agricultural return flows with the lifestage periodicity and spatial distribution of spring-run, fall-run, and late-fall-run Chinook salmon, steelhead, and splittail in Butte Creek.

9.2.1.2.2 Feather River Area of Analysis

EWA acquisitions could potentially alter seasonal flows and water temperatures in the lower Feather River due to changes in releases from the Lake Oroville. The Feather River is utilized by fish species of primary management concern that are either Federally or State listed under ESA or considered in this category for other purposes, such as their recreational or commercial importance. For these reasons, species-specific impact assessments were warranted for this river system and were conducted for the following species of primary management concern:

- Spring-run Chinook salmon;
- Fall-run Chinook salmon;
- Steelhead;
- Sacramento splittail;
- American shad; and
- Striped bass.

Because the species selected for species-specific assessments include those sensitive to changes in both river flow and water temperature throughout the year, an evaluation of impacts on these species is believed to reasonably encompass the range of potential impacts upon other Feather River fish resources (e.g., green sturgeon) that could occur under the Flexible Purchase Alternative relative to the Baseline Condition.

During some years, additional water transfers could potentially alter Feather River seasonal water temperatures. Changes in Feather River water temperatures that could occur as a result of implementation of the Flexible Purchase Alternative would not be expected to be sufficiently large to adversely affect fish species present in the lower Feather River, with the possible exceptions of Chinook salmon and steelhead. Elevated water temperatures could reduce spawning and rearing success of these anadromous salmonids because of their low thermal tolerance. For this reason, an assessment of changes to lower Feather River water temperatures focused on these fish species. Moreover, because: 1) thermal requirements of Chinook salmon and steelhead are generally similar; and 2) the NOAA Fisheries Biological Opinion on interim operations of the Central Valley Project (CVP) and State Water Project (SWP) on Federally listed threatened Central Valley spring-run Chinook salmon and Central Valley steelhead (NMFS 2001) has established quantitative temperature criteria for the lower Feather River at the Feather River Fish Hatchery and for the Low Flow Channel (monitored near Robinson Riffle (below RM 62)) to protect spring-run Chinook salmon and steelhead, the assessment methodologies focus primarily on Chinook salmon and steelhead lifestages.

<u>Spring- and Fall-run Chinook Salmon</u>
Potential fisheries impacts in the two reaches of the lower Feather River were evaluated separately because of the importance of each reach to various lifestages of anadromous salmonids (adult immigration, spawning, incubation and initial rearing, and juvenile rearing and emigration). The majority (approximately 3/4) of Chinook salmon spawning in the lower Feather River occurs in the Low Flow Channel between the Fish Barrier Dam and the Thermalito Afterbay Outlet. A lesser extent (approximately 1/4) of spawning occurs in the lower Feather River in the High Flow Channel (below the Thermalito Afterbay Outlet). Further, this reach is also an important migration corridor for both juvenile and adult fish. Although the majority of Chinook salmon spawning occurs below the Fish Barrier Dam, flows were not evaluated at this location. Because of facility operations and minimum flow requirements (600 cfs) in the Low Flow Channel, the long-term average and monthly mean flows under the Flexible Purchase Alternative between the Fish Barrier Dam and the Thermalito Afterbay Outlet would not fall below the existing minimum of 600 cfs (DWR 2001a). Oroville facility operations, either with or without implementation of the EWA program, would not allow flow releases to deviate from the existing quantity and schedule of releases that are required to ensure that 600 cfs are released down the Low Flow Channel. Therefore, potential flow-related impacts were evaluated below the Thermalito Afterbay Outlet and at the mouth of the Feather River. Because changes in water surface elevations at Lake Oroville could affect the water temperature of releases from Oroville Dam, potential water-related effects were evaluated below the Fish Barrier Dam, in addition to below the Thermalito Afterbay Outlet and at the mouth of the Feather River.

Flow-related Effects

To thoroughly assess flow-related impacts on the discrete lifestages of spring- and fall-run Chinook salmon in the lower Feather River, long-term average and monthly mean flows below the Thermalito Afterbay Outlet and at the mouth of the Feather River were evaluated under the Flexible Purchase Alternative and compared to flows simulated at these locations under the Baseline Condition for each month of the relevant salmonid lifestage.

Flows in the Low Flow Channel of the Feather River, which extends from the Fish Barrier Dam to the Thermalito Afterbay Outlet, are governed by a 1983 agreement between DWR and CDFG (DWR 1983). The agreement specifies that DWR "*shall release into the Feather River from the Thermalito Diversion Dam for fishery purposes a flow of 600 cfs*" (DWR 1983). This is the total volume of flows from the Diversion Dam outlet, Diversion Dam power plant, and the Feather River Fish Hatchery pipeline (DWR 1983). With the exception of flood events, the reach of the Feather River extending from the Fish Barrier Dam to the Thermalito Afterbay Outlet is operated at a constant flow of 600 cfs year-round and in all water year types, with any water in excess of 600 cfs released from Oroville Dam being diverted through the Thermalito Forebay/Afterbay complex and returning to the Feather River at the Thermalito Afterbay Outlet (DWR 2001a). Because the flow in this reach of the river would not change from the Baseline Condition of 600 cfs under the EWA Program alternatives, implementation of the EWA Program would not result in any changes in flow in this section of the Feather River as compared to the Baseline Condition. Therefore, further analysis of the flow-related impacts on fisheries and aquatic resources in the reach of the Feather River extending from the Fish Barrier Dam to the Thermalito Afterbay Outlet is not warranted.

Temperature-related Effects

A three-phased water temperature assessment also was performed to evaluate potential water temperature-induced impacts on the anadromous salmonid resources of the lower Feather River. First, long-term average and monthly mean water temperatures in the Low Flow Channel below the Fish Barrier Dam, below the Thermalito Afterbay Outlet, and at the mouth of the Feather River were evaluated under the Flexible Purchase Alternative were compared to monthly mean temperatures at these river locations under the Baseline Condition for each relevant salmonid lifestage.

Second, the number of years of the 69-year period modeled that water temperatures at each location would exceed the temperature criteria identified by NOAA Fisheries in its Biological Opinion for spring-run Chinook Salmon and steelhead (NMFS 2001) was determined for the Flexible Purchase Alternative and compared to the number of years that these criteria would be exceeded under the Baseline Condition. NOAA Fisheries criteria used for this component of the assessment are as follows:

- Daily average water temperatures less than or equal to 65°F are required in the Low Flow Channel of the lower Feather River from June 1 through September 30.

Additional water temperature criteria have been established through the 1983 agreement between CDFG and DWR, which stated: 1) water temperatures below the Afterbay river outlet must be suitable for fall-run Chinook salmon after September 15th; 2) water temperatures below the Afterbay river outlet must be suitable for shad, striped bass and other warmwater fish from May through August; and 3) set temperature objectives for water supplied to the Feather River Fish Hatchery as follows[7]:

- Daily average water temperatures not in excess of 60°F are required below the Thermalito Afterbay Outlet from June 16 through August 15;
- Daily average water temperatures not in excess of 58°F are required below the Thermalito Afterbay Outlet from August 16 through August 31;
- Daily average water temperatures not in excess of 56°F are required below the Thermalito Afterbay Outlet from June 1 through June 15;
- Daily average water temperatures not in excess of 55°F are required below the Thermalito Afterbay Outlet from December 1 through March 31, and May 16 through May 31;
- Daily average water temperatures not in excess of 52°F are required below the Thermalito Afterbay Outlet from September 1 through September 30; and
- Daily average water temperatures not in excess of 51°F are required below the Thermalito Afterbay Outlet from October 1 through November 30, and April 1 through May 15.

Because the hatchery's water supply comes from stored water in the Thermalito Diversion Pool and does not come directly from the Feather River, it is not subject to the thermal warming effects associated with downstream in-channel transport. Therefore, there would be no change to the source or quality of hatchery water supplies as a result of implementing the Flexible Purchase Alternative, relative to the Baseline Condition, and potential impacts on the DWR/CDFG temperature criteria will not be further evaluated in the impact analysis.

Although NMFS (2001) and other temperature criteria (DWR/CDFG 1983) are stated as daily averages, the available hydrologic and water temperature models allow only for monthly mean temperature analyses and output. Consequently, this assessment was based on monthly mean water temperature data output from Reclamation's existing models.

Third, the number of years in which monthly mean water temperatures during spring- would exceed 56°F or 65°F were evaluated under the Flexible Purchase Alternative and compared to the frequency in which water temperatures would exceed these index temperatures under the Baseline Condition. The 56°F and 65°F index temperatures were assessed to determine whether the upper end of the suitable range

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[7] A deviation of plus or minus 4°F is allowed between April 1 through November 30 (DWR 2001a).

of water temperatures for incubating eggs and juvenile salmonids, respectively, would be exceeded more frequently than under the Baseline Condition. The frequency in which water temperatures would exceed 56°F under Flexible Purchase Alternative were determined for each month of the relevant spring-run and fall-run Chinook salmon spawning and incubation periods and compared to the frequency of exceedance of this index temperature under the Baseline Condition. Similarly, the frequency in which water temperatures would exceed 65°F under Flexible Purchase Alternative were determined for each month of the relevant spring-run and fall-run Chinook salmon juvenile rearing periods and compared to the frequency of exceedance of this index temperature under the Baseline Condition. Although water temperatures are used to evaluate Chinook salmon mortality in the Sacramento and American rivers, no mortality modeling could be performed as a part of the assessments for spring- or fall-run Chinook salmon because no Chinook salmon mortality model has been developed for the Feather River.

Spring- and Fall-run Chinook Salmon Lifestages

The flow and temperature impact assessment methodologies described above were conducted for distinct time periods for each lifestage of spring- and fall-run Chinook salmon, as shown in Table 9-3.

Table 9-3
Feather River Chinook Salmon Lifestages

Species	***Lifestage***		
	Adult Immigration [1]	***Spawning, Incubation, and Initial Rearing***	***Juvenile Rearing and Emigration***
Spring-run Chinook Salmon	March through August	August through November	November through June
Fall-run Chinook Salmon	September through November	October through February	February through June

[1] The adult immigration period includes holding for spring-run Chinook salmon.

Steelhead

Because environmental conditions required by steelhead are not significantly different from those required by fall-run Chinook salmon, and because adult fall-run Chinook salmon and steelhead immigration and juvenile emigration periods in the Feather River occur during the same portions of the year, flow- and temperature-related impact determinations for these steelhead lifestages were evaluated concurrently with fall-run Chinook salmon. Additional flow and temperature analyses, using the same methodology described above, were conducted for steelhead spawning, incubation, and initial rearing (December through April). Further, additional flow and temperature impact assessments for over-summer and fall/winter juvenile steelhead rearing were made for the months of the year not addressed by the fall-run Chinook salmon assessments (July through September and October through January). Finally, because no steelhead mortality model has been developed for the Feather River, no steelhead mortality modeling could be performed as a part of the assessment for this species.

Splittail

Splittail may utilize the lower reaches of the Feather River for spawning. Water surface elevations in the lower Feather River have the potential to influence the amount of submerged vegetation available for splittail spawning. Consequently, changes in river flows that may result from the implementation of the Flexible Purchase Alternative could affect the availability of potential splittail spawning habitat within the lower Feather River by reducing the amount of riparian vegetation that would be submerged during the splittail spawning season (February through June). To assess flow-related impacts on potential splittail spawning habitat availability during each month of the February through May period, long-term average and monthly mean flows at the mouth of the Feather River were evaluated under the Flexible Purchase Alternative and compared to those under the Baseline Condition.

Splittail reportedly spawn at water temperatures from 48°F to 68°F (Wang 1986). To evaluate potential water temperature-related impacts on splittail, the frequency (of the 138 months simulated) that monthly mean water temperatures at the mouth of the lower Feather River would be within this preferred range during the period February through May was determined under the Flexible Purchase Alternative and compared to that under the basis of comparison. For the purposes of assessing temperature-related impacts on splittail in the Feather River, water temperatures at the mouth effectively represent the range of water temperatures that splittail would encounter when using the lower portion of the river for movement, spawning and initial rearing, and foraging activities.

American Shad

Attraction of American shad to the tributaries of the Sacramento River is believed to be related to the magnitude of flow from each river (Moyle 2002). As discussed in Section 9.1, spawning is influenced mostly by flow rather than other habitat characteristics. Consequently, the analysis of potential effects on American shad in the Feather River is based upon the potential for the Flexible Purchase Alternative to alter flows suitable to support American shad attraction and spawning. Because the majority of American shad spawning migrations into the lower Feather River are believed to occur during May and June, the analysis of potential flow-related effects on American shad focuses on these months. To assess flow-related impacts on American shad migration and spawning activities, the frequency and magnitude of flows at the mouth of the Feather River, below the Thermalito Afterbay Outlet, and below the Fish Barrier Dam under the Flexible Purchase Alternative were evaluated and compared to those under the Baseline Condition.

To evaluate potential water temperature-related impacts on American shad spawning, monthly mean water temperatures under the Flexible Purchase Alternative were determined and compared to those under the Baseline Condition for the months of May and June. A conservative approach for assessing potential water temperature impacts was to assume that American shad may spawn throughout the river and, therefore, to evaluate water temperature conditions at the Thermalito Afterbay Outlet and at the mouth of the Feather River. Specifically, the number of years in which monthly mean May and June water temperatures in the Feather River at the mouth and the Thermalito Afterbay Outlet would be within the reported preferred range for American shad spawning (60°F to 70°F) was determined under the Flexible Purchase Alternative and compared to that under the Baseline Condition.

Striped Bass

Potential flow-related effects on the striped bass sport fishery were assessed by determining the frequency and magnitude in which flows below the Fish Barrier Dam, below the Thermalito Afterbay Outlet, and at the mouth of the Feather River under the Flexible Purchase Alternative would be reduced, relative to the Baseline Condition, during the May and June spawning and initial rearing period. As previously discussed, optimal water temperatures for juvenile striped bass spawning and initial rearing are reported to range from approximately 59°F to 68°F. Therefore, to evaluate potential water temperature-related effects on striped bass spawning and initial rearing, the frequency in which monthly mean water temperatures in the Feather River at the three locations identified above during May and June would be within this range was calculated for the Flexible Purchase Alternative and compared to the frequency within this range under the Baseline Condition.

9.2.1.2.3 Yuba River Area of Analysis

To assess potential flow-related effects on fishery resources, comparisons were made of "with" and "without" EWA Program-related transfer flows through all scenarios. Although limited modeling output was used to help determine the potential effects of the Flexible Purchase Alternative (for additional information, refer to Attachment 1, Modeling Description), monitoring results from water transfers that occurred during 2001 and 2002 were used to evaluate potential effects. The impact assessment discusses potential relationships between instream flows, water temperatures, and fish movement and distribution in the lower Yuba River. These potential relationships, with or without the implementation of the EWA program alternatives, may (or may not) affect the attraction of non-indigenous salmonids into the lower Yuba River, as well as the extent of rearing habitat that is available to juvenile steelhead, particularly below Daguerre Point Dam.

Monitoring associated with previous water transfers from the Yuba River suggests the possibility of relationships between water release patterns and downstream movement of juvenile steelhead, as well as the attraction of non-Yuba River salmonids into the lower Yuba River, during the summer water transfer period. Movement of juvenile steelhead downstream of Daguerre Point Dam as a result of the water transfer, if it occurs, could result in the exposure of juvenile steelhead to elevated water temperatures resulting from extremely hot summer weather or reduced flows after water transfers cease. Additionally, juvenile steelhead potentially have a diminished capacity to move upstream to more suitable conditions because they are now below a potential migration barrier. Attraction of non-indigenous salmonids into the lower Yuba River may encourage genetic introgression and intra- and inter-specific competition, and may facilitate disease transmittal. The impact assessment also includes a discussion of these potential relationships. The sponsoring and cooperative effort by Yuba County WA has resulted in the availability of this preliminary information. Moreover, it is anticipated that future water transfers within the Yuba River Basin will be appropriately monitored and evaluated, in cooperation with resource management agency and non-governmental organization representatives, to avoid or minimize potential effects.

9.2.1.2.4 American River Area of Analysis

The American River Basin represents a division of the CVP that has the most, and the largest (in number and volume) reasonably foreseeable water development actions. As such, numerous basin-specific evaluations have been conducted, thereby resulting in a large amount of environmental documentation pertaining to the American River. Included in the recent body of environmental documentation is the Water Forum Agreement, the extensive regional water planning effort that establishes regional water needs for consumptive and environmental purposes through the year 2030. Reclamation has conducted another major environmental analysis, the American River Basin Cumulative Impact Report, for the same reasons that prompted the Water Forum's planning efforts. Because of the attention has been paid to it in recent years, more extensive methodologies, evaluation criteria, and analyses have been developed for fisheries resources within the American River Basin.

The EWA program may utilize sources from two reaches within the American River Basin. EWA assets may be acquired from and/or stored in two non-Project reservoirs (French Meadows and Hell Hole Reservoirs) on the Middle Fork of the American River and one Project reservoir (Folsom Reservoir) on the lower American River. Because of differences in management, fish passage, and species distribution, these reaches were evaluated separately.

Middle Fork American River

Acquisition of stored reservoir water from French Meadows and/or Hell Hole reservoirs under the Flexible Purchase Alternative could affect Middle Fork American River flows and water temperatures during portions of the year. To assess potential effects on fish species of the Middle Fork American River, median flows downstream of Ralston afterbay were assessed throughout all months of the year. By examining flows throughout the year, the analysis covers all months of the spawning, incubation, and juvenile emergence periods for brown and rainbow trout (November through April and February through September, respectively). It is assumed that the range of potential impacts on salmonids in the Middle Fork American River encompasses the range of potential impacts on other species in the Middle Fork American River (hitch, Sacramento sucker, pikeminnow, and riffle sculpin), and therefore, species-specific analyses are not conducted for other resident species within this segment of the Middle Fork American River.

Changes in releases from Hell Hole and French Meadows reservoirs could affect flows, and hence water temperatures, in the Middle Fork American River downstream of Ralston Afterbay. However, there is no temperature model currently available for the Middle Fork American River. Consequently, potential changes to water temperatures are evaluated through a qualitative discussion of Middle Fork Project operations and potential effects on fish species and other aquatic organisms.

Changes in the operation of the Middle Fork Project have the potential to affect the coldwater pool volume at Folsom Reservoir. A discussion of potential impacts on coldwater pool volume at Folsom Reservoir is included in the analysis of coldwater fisheries resources at Folsom Reservoir. (Refer to Section 9.2.5.1.4.)

Nimbus Hatchery

Because changes in Folsom Reservoir releases under the Flexible Purchase Alternative could alter water temperatures in Lake Natoma during some months, and because Nimbus Hatchery diverts its water supply directly from Lake Natoma throughout the year, the Flexible Purchase Alternative could change hatchery water temperatures during some months of the year. Nimbus Hatchery production remains relatively unaffected when hatchery temperatures remain below 60°F. However, increased disease and mortality of hatchery-reared fish often occurs when water temperatures exceed 60°F. Losses from these factors become a particular problem when hatchery water temperatures exceed 65°F for extended periods. Water temperatures exceeding 68°F for even short periods (days) are particularly detrimental to hatchery fish held at high densities, and could require the hatchery to release and/or transfer most or even all of its fish to prevent unacceptably high mortality (B. Barngrover 1997).

To assess potential water temperature-related impacts on Nimbus Hatchery operations, monthly mean temperatures of water released from Nimbus Dam under the Flexible Purchase Alternative were modeled and compared to those modeled under the basis of comparison for each month of the year. The number of years of the 69 years modeled that monthly mean Nimbus Dam release temperatures would exceed the index values of 60°F, 65°F, and 68°F under the Flexible Purchase Alternative were determined and compared to the frequency of exceedance of these temperature index values under the Baseline Condition. In addition, for each month of the year, the mean temperature of water released from Nimbus Dam for the years exceeding each of these temperature index values was determined.

Lower American River

Flows and water temperatures in the lower American River are controlled by operations of Folsom Reservoir. Folsom Reservoir, because of its proximity to the Delta, is often used by Reclamation to make releases when additional Delta outflow is required to meet Delta salinity standards. Consequently, Folsom Reservoir storage can be reduced, resulting in reduced coldwater pool volume. If the coldwater pool disappears, releases from Nimbus Dam are warmer and have the potential to exceed suitable temperature ranges for fish species of primary management concern in the lower American River. Seasonal changes in releases from Folsom Reservoir resulting from the management of EWA assets under the Flexible Purchase Alternative could affect lower American River flows and water temperatures during portions of the year. Because a number of fish species of primary management concern utilize the lower American River for one or more of their lifestages, and because potential temperature impacts are a concern under the Baseline Condition, species-specific impact assessments were warranted for the lower American River and were conducted for the following five species of primary management concern:

- Fall-run Chinook salmon;
- Steelhead;
- Splittail;
- American shad; and
- Striped bass.

These species are of primary management concern due either to the importance of their commercial and/or recreational fisheries (Chinook salmon, steelhead, American shad, and striped bass) and/or because they are a species currently listed or proposed for listing under the Federal ESA and/or CESA (steelhead, Chinook salmon, and splittail). Because the species selected for species-specific assessments include those sensitive to changes in both river flow and water temperature throughout the year, an evaluation of effects on these species is believed to reasonably encompass the range of potential effects on lower American River fish resources that could occur under the Flexible Purchase Alternative.

Fall-run Chinook Salmon

Watt Avenue represents the river location above which approximately 98 percent of fall-run Chinook salmon spawning occurs. To assess flow-related effects on adult fall-run Chinook salmon spawning, egg incubation and initial rearing, monthly mean flows at Watt Avenue and below Nimbus Dam under the Flexible Purchase Alternative were compared to monthly mean flows under the Baseline Condition for each month of the October through February period.

Changes in flows during the period March through June also were assessed at Watt Avenue to further address potential effects on fry and juvenile lifestages rearing during these months. Flows at the mouth were compared between modeling simulations to assess potential flow-related effects on adult immigration and juvenile emigration. The frequency with which specified flow levels were met was determined under the alternatives, and was compared to that under the existing condition.

Potential water temperature-related effects on lower American River fall-run Chinook salmon were evaluated through three distinct assessments focusing on distinct lifestages and periods, including: 1) adult immigration (September through November); 2) spawning/incubation and initial rearing (October through February); and 3) juvenile rearing and emigration (March through June) using the multi-step analysis described below.

Adult Immigration (September through December)

Temperature-related effects on adult immigration were based on water temperature at the mouth of the American River and at Freeport in the Sacramento River. The 69-year average water temperatures for each month of the September through November period that would occur at the American River mouth and at Freeport under the Flexible Purchase Alternative were compared to those under the Baseline Condition. In addition, monthly mean water temperatures at the American River mouth and at Freeport were compared for each month of the adult immigration period over the 69-year period of record. Therefore, a total of 207 months were included in the analysis.

Spawning/Incubation and Initial Rearing (October through February)

First, the long-term average water temperatures for each month of the October through February period that would occur below Nimbus Dam or at Watt Avenue under the Flexible Purchase Alternative were compared to the long-term average water temperatures for each of these months, at these same locations, under the Baseline Condition. Because water temperatures generally warm with increasing distance downstream during October, and because 98 percent of all spawning occurs upstream of Watt Avenue, the most conservative assessment of thermal effects (assessment of the greatest potential impacts) on Chinook salmon spawning and egg incubation during October is based on Watt Avenue temperatures. Therefore, all water temperature assessments for the month of October are based on temperatures at Watt Avenue. Conversely, because water temperatures generally cool with increasing distance downstream during the period November through January, and because water temperatures generally change little between Nimbus Dam and Watt Avenue during February, water temperature impact assessments for spawning and egg incubation during the months November through February are based on water temperatures below Nimbus Dam, thereby providing the most conservative assessment.

Second, the number of years (of the 69 years modeled) that monthly mean water temperatures would exceed 56°F below Nimbus Dam or at Watt Avenue was determined for each month of the October through February period and compared to those modeled under the Baseline Condition.

Third, for each month of the October through February period, the mean water temperature below Nimbus Dam or at Watt Avenue for the years (of the 69 years modeled) exceeding the 56°F index value was determined under the Flexible Purchase Alternative and compared to those under the Baseline Condition.

Finally, Reclamation's Lower American River Fall-Run Chinook Salmon Mortality Model was used to assess potential water temperature-related effects on the early lifestage of Chinook salmon. Annual early lifestage survival (the complement of mortality) estimated for the Flexible Purchase Alternative was compared to that estimated for the Baseline Condition for each year of the 69-year period of record.

Juvenile Rearing and Emigration (February through June)

The same methodology was used to evaluate potential water temperature-related effects on juvenile fall-run Chinook salmon rearing and emigration with the following modifications:

- The period of assessment was February through June;
- The number of years (of the 69 years modeled) that monthly mean water temperatures would exceed the index value of 65°F were determined at Watt Avenue and the lower American River mouth;
- Mean water temperatures for the years (of the 69 years modeled) that were shown to exceed the 60°F and 65°F index values were determined at Watt Avenue; and
- Reclamation's Salmon Mortality Model was not used, because it does not assess mortality beyond the emergent fry lifestage.

Because the majority of juvenile fall-run Chinook salmon and steelhead rearing is believed to occur above Watt Avenue (River Mile (RM) 9.5), and because water temperatures generally increase between Nimbus Dam and Watt Avenue during the February through June period, use of Watt Avenue water temperatures for assessing water temperature-related effects on juvenile Chinook salmon during this period provides the most conservative assessment. In addition to the assessments described above, potential water temperature-related effects on juvenile emigration through the lower portion of the river were assessed based on temperatures at the mouth using the water temperature index value described above.

<u>Steelhead</u>

Because environmental conditions required by steelhead are not significantly different from those required by fall-run Chinook salmon, flow- and temperature-related impact determinations for steelhead for the period October through June were based on the same modeling output used to assess effects on fall-run Chinook salmon during this period, with a separate analysis conducted for adult steelhead spawning and egg incubation, which occurs from December through April. However, because juvenile steelhead rear within the lower American River year-round, additional flow and water temperature impact assessments were made for the months of the year not addressed by the fall-run Chinook salmon assessments (July through September and October through January). Flow-related effects on steelhead rearing during the July through September and October through January periods were assessed via the same methods used to assess flow-related effects on fall-run Chinook salmon during the October through June period.

Temperature-related effects on juvenile steelhead rearing during the July through September and October through January periods were assessed via the same methods used to assess water temperature-related effects on juvenile fall-run Chinook salmon rearing and emigration during the March through June period. In addition, the number of months exceeding 65°F for each model simulation, as well as the average water temperature for the months exceeding this index value, also was determined for the July through September over-summer rearing period. Because no steelhead mortality model has been developed for the lower American River, no steelhead mortality modeling could be performed as a part of the assessment for this species.

Splittail

Splittail may spawn in the lower American River in extremely low numbers, with the majority of splittail spawning that could occur taking place in the lower sections of the river (downstream of RM 12). Consequently, altered river flows resulting from the management of EWA assets at Folsom Reservoir could affect the availability of potential splittail spawning habitat within the lower American River by reducing the amount of riparian vegetation that would be submerged during the splittail spawning season (February through May).

The lower American River from RM 5 to the mouth is largely influenced by the water surface elevation of the Sacramento River. Sacramento River stage often controls the water surface elevation here, and the extent to which splittail spawning habitat, particularly submerged vegetation, along this lower reach of the river channel would be available. Conversely, river stage in the portion of the river between RM 8 and RM 12, which is characterized by abundant backwater habitat, is controlled primarily by lower American River flows. The frequency and duration of riparian vegetation flooding in this area and, therefore, the quality and quantity of potential splittail spawning habitat has the potential to be impacted by reduced flows.

Field measurements conducted for the interim reoperation of Folsom Dam and Reservoir indicated that the total amount of submerged vegetation within RM 8 to RM 9 ranged from 2.4 acres at a river flow of 4,540 cfs to 35.8 acres at a river flow of 22,570 cfs (SAFCA 1999). A positive, statistically significant ($r^2=0.99$; $P<0.001$) relationship between flow and the total acreage of submerged vegetation exists between RM 8 to RM 9 in the lower American River. This relationship is defined by the equation:

$$\text{Habitat} = (0.001874 \times Q) - 6.4585$$

Where: Habitat = the total amount of submerged vegetation within the Area of analysis (acres); and
Q = flow within the Area of analysis (cfs).

The x-intercept of the linear regression line occurs at 3,456 cfs, which indicates that zero acres of submerged vegetation within the Area of analysis at river flows of approximately 3,456 cfs or less. For river flows between 3,456 cfs and 22,571 cfs, the total acreage of submerged riparian vegetation within the Area of analysis increased by approximately 1.9 acres for each 1,000 cfs increase in flow. As previously discussed, field observations determined that the first 2.4 acres of submerged vegetation primarily occurred within a narrow strip along the riverbank. This inundation zone was noted as being very shallow (generally less than two feet deep) and, therefore, unlikely to provide suitable potential habitat for splittail. Based on this observation, more than 2.4 acres of submerged vegetation must be present within the Area of analysis before potentially suitable splittail spawning habitat would be available.

To assess flow-related effects on potential splittail spawning habitat availability during each month of the February through May period, the amount of submerged vegetation in acres (dependent variable) was regressed against flow in cfs (independent variable) according to the equation described above, for each year of the 72-year period of record. Using river flows at Watt Avenue (RM 9.5), the number of acres of flooded riparian habitat between RM 8 and RM 9 was determined under the Flexible Purchase Alternative and compared to that available under the Baseline Condition.

Splittail reportedly spawn at water temperatures from 48°F to 68°F (Wang 1986). To evaluate potential water temperature-related effects on splittail, the number of years (of the 69 years modeled) that monthly mean water temperatures at Watt Avenue and the mouth would be within this preferred range during the period of February through May was determined under the Flexible Purchase Alternative, and compared to that under the Baseline Condition. For the purposes of assessing temperature-related effects on splittail in the American River, water temperatures at Watt Avenue and the mouth effectively represent the range of water temperatures that splittail would encounter when using the lower portion of the river for spawning and initial rearing.

<u>American Shad</u>
Because the majority of American shad spawning migrations into the lower American River are believed to occur during May and June, changes in river flows during these months warrant further assessment for this species. The relative number of adult American shad entering the lower American River during May and June is believed to be largely influenced by flows at the mouth. Snider and Gerstung (1986) recommended flow levels of 3,000 to 4,000 cfs during May and June as sufficient "attraction flows" to sustain the American shad fishery in the lower American River. Effects on American shad attraction flows were assessed by determining the number of years (of the 72-year period of record) in which May and June flows at the mouth would be less than 3,000 cfs under the Flexible Purchase Alternative, and compared to the frequency of flows below this value under the Baseline Condition.

To evaluate potential water temperature-related effects on American shad spawning, monthly mean water temperatures under the Flexible Purchase Alternative and the cumulative condition were determined and compared to those under the existing condition for the months of May and June. A conservative approach for assessing potential water temperature-related effects was to assume that American shad may spawn throughout the river and, therefore, to evaluate water temperature conditions below Nimbus Dam and the mouth. Specifically, the number of years (of the 69 years modeled) that mean May and June water temperatures below Nimbus Dam and the mouth would be within the reported preferred range for American shad spawning (60°F to 70°F) was determined under the Flexible Purchase Alternative and the cumulative condition and compared to that under the Baseline Condition.

Striped Bass

Although no study to date has definitively determined whether striped bass spawn in the lower American River, it is believed that little, if any, striped bass spawning occurs there (DeHaven 1978 *in* Snider and Gerstung 1986). Nevertheless, the lower American River is used by juvenile striped bass for rearing and supports a striped bass sport fishery during May and June. In addition to juvenile rearing considerations, the number of adult striped bass entering the lower American River during the summer is believed to vary with flow levels and food production. Snider and Gerstung (1986) suggested that flows of 1,500 cfs at the mouth during May and June would be sufficient to maintain the striped bass sport fishery in the lower American River. Hence, potential flow-related effects on the striped bass sport fishery were assessed by determining the number of years (of the 72-year period of record) that flows at the mouth would be less than 1,500 cfs in May and June under the Flexible Purchase Alternative, and compared to the number of years flows would be below this value under the Baseline Condition.

As discussed in the Sacramento River methodology, optimal water temperatures for striped bass spawning and initial rearing are reported to range from approximately 59°F to 68°F. Therefore, to evaluate potential water temperature-related effects on striped bass juvenile rearing, the number of years (of the 69 years modeled) that monthly mean water temperatures below Nimbus Dam and at the mouth during May and June would be within the preferred range of 59°F to 68°F was determined under the Flexible Purchase Alternative and compared to the frequency within this range under the Baseline Condition.

9.2.1.2.5 San Joaquin River Area of Analysis

EWA acquisitions potentially could alter seasonal flows in the Merced and San Joaquin Rivers due to changes in releases from McClure Reservoir during portions of the year. A number special-status and recreationally important fish species utilize the Merced and San Joaquin rivers during one or more of their lifestages. For these reasons, species-specific impact assessments were warranted for these water bodies and were conducted for the following species[8]:

- Fall-run Chinook salmon;
- Steelhead;
- Splittail;
- Striped bass;
- Delta smelt; and
- American shad.

There are successful fishery management plans already in place throughout the San Joaquin River Area of analysis that manage in-stream flows to sustain viable fish populations, such as the San Joaquin River Agreement (USBR and SJRGA 1999), which was developed to support the Vernalis Adaptive Management Plan study. The agreement identifies where the water used in the VAMP study would be obtained, specifically from willing sellers who are members of The San Joaquin River Group Authority (SJRGA). The flow objectives are designed to provide suitable habitat for spawning and rearing, as well as passage into and out of the Delta for anadromous species of fish (USBR and SJRGA 1999).

The SJRA EIS/EIR was used to develop the methodology and significance criteria utilized for the analysis of potential flow-related effects resulting from the implementation of the Flexible Purchase Alternative. Specifically, life history descriptions for fall-run Chinook salmon and steelhead adult immigration, spawning, egg incubation, and initial rearing, and juvenile rearing and emigration were used to develop the appropriate time periods for lifestage-specific impact analyses. In addition, the criteria used by the SJRGA to determine the level of impact associated with implementation of the Flexible Purchase Alternative were taken directly, as follows (USBR and SJRGA 1999):

Greater than + 10 percent change	Beneficial effect
Less than +/- 10 percent change	No significant effect
Between -11 and -25 percent change	Less than significant effect
Greater than –25 percent change	Potentially significant or significant adverse effect

8 As discussed in the Affected Environment/Environmental Setting, only fall-run Chinook salmon and striped bass are reported in the potentially affected reach of the Merced River.

Fall-Run Chinook Salmon

Fall-run Chinook salmon in the San Joaquin River typically spawn in the upper reaches of the major tributaries. In the Merced River, it is the only anadromous species present. To assess potential flow-related effects on fall-run Chinook salmon spawning, egg incubation and initial rearing, monthly-mean flows released in the Merced River below Crocker-Huffman Dam and at the mouth under the Flexible Purchase Alternative were compared to releases under the Baseline Condition for each month of the October through December adult fall-run Chinook salmon immigration and spawning period (USBR and SJRGA 1999). In the San Joaquin River, potential flow-related effects on adult fall-run Chinook salmon immigration and spawning were evaluated from October through January, in conjunction with the analysis of potential flow-related effects on steelhead (refer to the steelhead discussion, below, for a complete explanation of life history similarities). Effects on fall-run Chinook salmon in the San Joaquin River were evaluated below the confluence of the Merced River and at Vernalis. Flow changes were also assessed from January through June, when juvenile rearing and emigration occurs (USBR and SJRGA 1999). The frequency with which specified flow levels were met was determined under the Flexible Purchase Alternative, and was compared to that under the Baseline Condition.

Any changes in McClure Reservoir operations could alter water temperatures seasonally in the Merced River downstream of the reservoir. To assess potential water temperature-related effects, mean monthly water temperature data from temperature models would be required. Currently, no temperature models are available to simulate temperature conditions on the Merced or San Joaquin rivers. Consequently, the analysis of potential effects on fall-run Chinook salmon is based on potential changes in monthly mean flows. Minimum flow requirements have been established for the Merced River by both the FERC license and the Davis-Grunsky contract (USBR and SJRGA 1999). The SJRGA maintains these requirements as the minimum flow standard and monitors the effectiveness these standards have in providing suitable habitat (viable temperatures) for fish.

Steelhead

While Central Valley steelhead habitat exists below Crocker-Huffman Dam in the Merced River, there is no conclusive evidence that steelhead are actually present in the Merced River (CDFG 1996; USBR and SJRGA 1999). Therefore, this specific assessment of steelhead will pertain to the San Joaquin River from the confluence with the Merced to Mossdale. CALSIM II post-processing output for the San Joaquin River below the Merced River confluence and at Vernalis were evaluated for potential flow changes during the periods for each lifestage and compared to flows at these locations under the Baseline Condition.

Because environmental conditions required by steelhead are not significantly different from those required by fall-run Chinook salmon, and because steelhead have a similar life history to fall-run Chinook salmon in the San Joaquin Area of analysis, impact analyses for adult steelhead immigration and spawning in the San Joaquin River were conducted concurrently with those for fall-run Chinook salmon. The adult immigration and spawning period for steelhead begins slightly later than that for fall-run Chinook salmon, from November through January (USBR and SJRGA 1999). Therefore, the period of October through January was assessed for potential flow-related impacts on fall-run Chinook salmon and steelhead in the San Joaquin River. In addition, steelhead can rear year round. Thus, the over-summer rearing period of July through September and the fall/winter rearing period of October through December were evaluated for steelhead in the San Joaquin River. Finally, juvenile steelhead emigration was evaluated from November through May (USBR and SJRGA 1999). As described above for fall-run Chinook salmon, potential water temperature-related effects on steelhead cannot be directly assessed, because water temperature models are not available for the Merced and San Joaquin rivers. Consequently, the analysis of potential effects on steelhead is based on potential changes in monthly mean flows and is consistent with the methods used to assess flow-related effects on fall-run Chinook salmon.

Splittail

Splittail are confined to the lower reaches of the San Joaquin and Sacramento rivers. Splittail may spawn in the lower San Joaquin River in extremely low numbers, with the majority of splittail spawning that could occur taking place in sloughs of the Delta, Napa Marsh, Suisun Marsh, and on the inundated floodplains of large rivers during wet years (USBR and SJRGA 1999). Consequently, altered river flows under the Flexible Purchase Alternative could affect the availability of potential splittail spawning habitat within the lower reaches of the San Joaquin River by reducing the amount of submerged vegetation available during the splittail spawning season (February through May).

Typically, an analysis of potential flow-related effects on splittail spawning habitat availability during each month of the February through May period would be based on a direct relationship between flow and known quantities of submerged vegetation. However, such a relationship for flooded riparian habitat has not been determined for the San Joaquin River. Similarly, water temperature-related effects on splittail cannot be directly assessed, since temperature models are not available to simulate temperature conditions on the Merced or San Joaquin Rivers. Therefore, the analysis of potential effects of changes in San Joaquin River flows to the availability of splittail spawning habitat focuses on the frequency and magnitude of monthly mean flow changes under the Flexible Purchase Alternative, relative to the Baseline Condition.

Delta Smelt

In the San Joaquin River basin, delta smelt are known to inhabit the lower reaches of the San Joaquin River, extending from San Pablo Bay and continuing as far upstream as Mossdale. Under the Flexible Purchase Alternative, changes in flows could affect the availability of potential delta smelt spawning habitat within the lower reaches of the San Joaquin River by reducing the amount of submerged vegetation that would be available during the spawning season (January through June).

To evaluate potential effects on delta smelt at the mouth of the San Joaquin River basin, monthly mean flows in the San Joaquin River at Vernalis under the Flexible Purchase Alternative were evaluated for each month of the spawning period and compared to monthly mean flows under the Baseline Condition.

American Shad
As discussed in Section 9.1, American shad spawning is influenced mostly by flow rather than other habitat characteristics. Consequently, the analysis of potential effects on American shad in the San Joaquin River is based upon the potential for the Flexible Purchase Alternative to alter flows suitable to support American shad attraction and spawning. Because the majority of American shad spawning migrations are believed to occur during May and June, the analysis of potential flow-related effects on American shad focuses on these months. To assess flow-related impacts on American shad migration and spawning activities, the frequency and magnitude of flows in the San Joaquin River below the Merced River confluence and at Vernalis under the Flexible Purchase Alternative were evaluated and compared to those under the Baseline Condition throughout the May through June period.

Striped Bass
Potential flow-related effects on the striped bass sport fishery were assessed by determining the frequency and magnitude in which flows in the Merced River below Crocker Huffman-Dam and at the mouth, and San Joaquin River below the confluence with the Merced River and at Vernalis under the Flexible Purchase Alternative would be reduced, relative to the Baseline Condition, during the May and June spawning and initial rearing period. Because no temperature model has been developed for the San Joaquin River, the analysis of potential impacts on striped bass focuses on the potential for changes in flows under the Flexible Purchase Alternative to affect striped bass spawning and initial rearing.

9.2.1.3 Estuarine Fish Species Within the Delta Hydrologic Modeling

Hydrologic modeling results provide the technical foundation for assessing both potential beneficial and adverse effects of EWA operations on fish species and their habitat within the Delta. The assessment relies on a comparative analysis of operational and resulting environmental conditions within the Delta under assumed baseline operational criteria and operations assumed to occur in response to EWA allocations. EWA operations have the potential to affect Delta fisheries in two primary ways: 1) modifications to habitat quality and availability for various fish species within the Sacramento and San Joaquin rivers and Delta; and 2) mortality resulting from State Water Project (SWP) and Central Valley Project (CVP) export operations from the south Delta.

The evaluation of potential impacts on Delta fisheries involves two study scenarios, including: 1) the Maximum Water Purchase Scenario; and 2) the Typical Water Purchase Scenario. Although the Maximum Water Purchase Scenario represents potential worst-case impacts on fish resources upstream from the Delta, the Typical Water Purchase Scenario was developed to analyze a more likely representation of potential worst-case impacts within the Delta. Potential impacts on fish resources within the Delta with implementation of the EWA Program were analyzed under both the Maximum Water Purchase Scenario and the Typical Water Purchase Scenario, relative to the Baseline Condition. Attachment 1, Modeling Description, provides a more detailed discussion of the these two scenarios, the modeling process, and its application to the EWA Program, including: a) the primary assumptions and model inputs used to represent hydrologic, regulatory, structural and operational conditions; and b) the simulations performed from which effects were estimated.

Results of hydrologic modeling provide monthly information that can be used as part of a general evaluation of potential effects of project operations on habitat quality and availability for various fish and macroinvertebrate species inhabiting the Bay-Delta estuary. Modeling results can also be used to estimate potential salvage losses, based upon historical estimates of fish density at both the SWP and CVP salvage facilities, for use as part of these environmental analyses. Modeling parameters selected to be included as part of this analysis include:

- Hydrologic conditions within the central Delta as reflected by the calculation of QWEST;
- Export: Inflow (E/I ratio);
- Delta outflow; and
- Location of the two-part per thousand salinity isohaline (X_2) location, and
- Salvage at CVP and SWP Delta facilities.

The comparative analysis of hydrologic conditions and associated effects on fisheries are discussed below.

9.2.1.3.1 Impacts on Delta Aquatic Habitats

One of the concerns regarding water project operations on the distribution of fish and habitat conditions within the south Delta identified by resource agencies and others has been associated with changes in hydrologic conditions. One of the parameters that has been included in hydrologic modeling that has been used as a surrogate for evaluating changes in hydrologic conditions as a result of SWP and CVP export operations is a calculation of reverse flows within the lower San Joaquin River (referred to as QWEST) within the hydrologic model output. Although analyses have failed to show a strong relationship between calculated values of QWEST and the resulting biological response (e.g., increased or decreased juvenile Chinook salmon smolt survival, changes in species geographic distribution, etc.), the calculation of QWEST and an examination of the change in frequency and magnitude of negative QWEST values within the monthly modeling output has typically been used as one indicator of changes in habitat conditions.

The ratio between SWP and CVP exports and freshwater inflow to the Delta from the Sacramento and San Joaquin river systems (export/inflow ratio) has also been used as a surrogate for assessing and evaluating the effects of project operations on Bay-Delta habitat conditions and the vulnerability of fish and macroinvertebrates to salvage losses. Although no relationships between export/inflow ratios and resulting changes in biological response, such as a reduction in juvenile Chinook salmon smolt survival or a change in geographic distribution and increased vulnerability of the species to SWP or CVP salvage losses, has been established, the framework for environmental analyses has typically assumed that the higher the export rate relative to freshwater inflow, on a seasonal basis, the greater the probability that adverse affects on geographic distribution and/or the risk of salvage losses as a result of SWP and CVP export operations.

Other indices of habitat conditions typically used as part of an environmental assessment of project operations include Delta outflow and changes in the geographic distribution of low-salinity (2 ppt) gradients within Suisun Bay and the western Delta on the availability and quality of estuarine habitat, particularly during the late winter and spring months, that are thought to be important for survival and growth of a variety of fish and macroinvertebrate species.

The USFWS, CDFG, and others have established biological relationships based upon results of fisheries investigations conducted for use in evaluating the biological effects of changes in many of the habitat-related parameters affected by EWA operations. As noted above, biological relationships have not been established for some of the indices, such as QWEST and the export/inflow (E/I) ratio, and hence findings of the environmental analysis are based on a combination of established biological relationships, the best available scientific information on the life history and habitat requirements for various species, the results of hydrologic modeling analyses, and professional judgment.

Seasonal changes in the timing of CVP/SWP diversions could alter the quantity of freshwater flowing into and through the Delta. The abundance and distribution of several fish species of management concern that rely heavily upon the Delta for one or more of their lifestages, including delta smelt (Federally threatened), splittail (treated as a Federally listed threatened species), and longfin smelt (State species of special concern), can be affected by total Delta outflow, the location of X_2 (two parts per thousand (ppt) isohaline in the Delta), and the export/inflow ratio. These parameters also have the potential to affect Delta fish species to be evaluated in accordance with the Magnuson-Stevens Act. However, NOAA Fisheries has indicated that the there are no species requiring EFH consultation under the Magnuson-Stevens Act related to the EWA Program.

To evaluate potential effects on Delta fish resources due to seasonal changes in CVP/SWP diversions, changes in monthly mean Delta outflow for the 15–year period of record under the Flexible Purchase Alternative were determined for each month of the year and were compared to monthly mean Delta outflow under the Baseline Condition. The frequency and magnitude of differences in Delta outflow were evaluated relative to life history requirements for Delta fish. In addition, changes in monthly mean X_2 position were determined for all months of each year, with an emphasis on the February through June period.

Effects on delta smelt, splittail, and other Delta fishery resources were considered adverse if hydrology under the Flexible Purchase Alternative showed a substantial decrease in monthly mean Delta outflow, relative to hydrology under the Baseline Condition, during one or more months of the February through June period, if a substantial shift in the long-term monthly mean X_2 position occurred (more than one kilometer (km)), or if Delta export/inflow ratios were increased above Baseline Condition. The USFWS and Reclamation have in past documents (Draft Trinity River Mainstem Fishery Restoration EIS/EIR) applied a 10 percent modeled exceedance in changes in X_2 position during the February through June period to determine potential effects on fish populations in the Delta. Therefore, the evaluation criteria utilized in this document (1 km or more shift in X_2 position) to determine potential effects on Delta fish populations are very conservative (rigorous) relative to the significance criteria utilized by the resource agencies in previous environmental assessment documents.

9.2.1.3.2 Salvage at the SWP and CVP Export Facilities

The main purpose of the salvage operations at the SWP and CVP export facilities is to reduce the number of fish adversely impacted by entrainment (direct loss) at the export facilities. Salvage operations at the John E. Skinner Fish Protection Facility and the Tracy Fish Collection Facility are described in detail in Section 9.1.2.2, Facilities and Operations of the SWP and CVP and Their Effects on Aquatic Resources. Salvage estimates are defined as the number of fish entering a salvage facility and subsequently returned to the Delta through a trucking and release operation. Since survival of species that are sensitive to handling is believed to be low for most fish species (delta smelt), increased salvage is considered an adverse impact and decreased salvage is considered a beneficial impact on fisheries resources.

Calculations of salvage loss at the SWP and CVP, as a function of changes in the seasonal volume of water diverted, have also been used as an indicator of potential effects resulting from changes in water project operations. Export operations of the SWP and CVP directly affect mortality of fish within the Delta as a consequence of entrainment and associated stresses. The magnitude of direct losses resulting from export operations is a function of the magnitude of monthly water exports from each facility and the density (number per acre-foot) of fish vulnerable to entrainment at the facilities. Results of the hydrologic modeling provide estimates of the average monthly export operations for both the SWP and CVP under baseline and EWA operations. Extensive data are available on species-specific salvage at both the SWP and CVP facilities for use in estimating the risk of fishery losses. Average densities (number per acre-foot) were calculated monthly for both the SWP and CVP facilities for selected fish species over a range of water year conditions (e.g., wet, above normal, below normal, dry, and critical years). Data selected for use in these analyses extended over a 15-year period from 1979 to 1993. This data period was selected based on consideration of the reliability of salvage data (e.g., accurate species identification, expansion calculations, etc.) and the hydrologic model period, which extended through 1993.

SWP and CVP estimates of direct loss were calculated for the following fish species:

- Chinook salmon;
- Steelhead;
- Delta smelt;
- Striped bass; and
- Sacramento splittail.

An index of salvage was developed for purposes of evaluating the incremental effects of EWA operations on direct losses at the export facilities. The salvage index was derived using records of species-specific salvage at the SWP and CVP facilities, which was used to calculate the average monthly density (number of fish per TAF), which could then be multiplied by the calculated SWP and CVP monthly exports (in TAF) obtained from the hydrologic modeling output. The salvage index was calculated separately for the SWP and CVP export operations under both the Baseline Condition and EWA operations. The resulting salvage index was then used to determine the incremental benefits (reduced salvage) and incremental impacts (increased salvage) calculated to result from EWA operations.

Average monthly salvage densities for each species were calculated from daily salvage records over the period from 1979 through 1993 (R. Brown, unpublished data; CDFG, unpublished data). Based on the daily salvage, expanded for sub-sampling effort, a daily density estimate was calculated using the actual water volume diverted at each of the two export facilities. The daily density estimates were then averaged to calculate an average monthly density. For consistency, the average monthly density of each of the individual target species was then used to calculate the salvage index for the period from January 1979 through September 1993 using hydrologic modeling results for the baseline operation and operations under EWA. After calculating the monthly salvage index for each species assuming EWA operations, the baseline estimate was subtracted from the monthly salvage index for each species to determine the net difference in salvage estimates (EWA operations - baseline estimate = net change) that are anticipated to occur with implementation of the Flexible Purchase Alternative.

For purposes of evaluating potential impacts and benefits of EWA operations on fish salvage, the incremental difference in the annual salvage indices reflect the benefit (reduced salvage under EWA operations) as a negative index and an incremental adverse impact (increased salvage under EWA operations) as a positive index.

9.2.2 Significance Criteria

Impact indicators and evaluation criteria developed for use in assessing the significance of potential impacts upon fish resources and aquatic habitat that may result from EWA program alternatives are provided in Table 9-4. The impact indicators and significance thresholds presented in Table 9-4 are consistent with the criteria for Mandatory Findings of Significance provided in Section 15065(a) of the CEQA 2002 Guidelines. This section of the CEQA Guidelines that is specifically related to fish and wildlife resources states that a project may have a significant effect on the environment if *"the project has the potential to substantially degrade the quality of the environment, substantially reduce the habitat of a fish or wildlife species, cause a fish or wildlife population to drop below self-sustaining levels, threaten to eliminate a plant or animal community, or reduce the number or restrict the range of an endangered, rare, or threatened species."*

For the fisheries and aquatic resources impact assessment, impact indicators such as water temperature, flows, nest dewatering events, and littoral habitat availability are used to evaluate if the project will have an adverse effect on the species' habitat and range. Exceedance of monthly mean water temperatures identified by NOAA Fisheries for certain species (e.g., 56ºF at Bend Bridge from April 15 through September 30 for winter-run Chinook salmon) is one such impact indicator. Reduction of reservoir water surface elevations can reduce the availability of nearshore littoral habitat used by warmwater fish for spawning and rearing, thereby reducing spawning and rearing success and subsequent year class strength, therefore reservoir water surface elevation is another impact indicator used. In addition, decreases in reservoir water surface elevations during the primary spawning period for nest building by warmwater fish may result in reduced initial year class strength through warmwater fish nest "dewatering." Changes in river flows and water temperatures during certain periods of the year have the potential to affect spawning, fry emergence, and juvenile emigration. Therefore, changes in monthly mean river flows and water temperatures during certain times of the year (during spawning, incubation, and initial rearing) are also used as impact indicators. The rationale for development of the impact indicators and evaluation criteria detailed in Table 9-4 is provided in Section 9.2.1, Assessment Methods.

Table 9-4
Fish Resources and Aquatic Habitat Impact Indicators and Evaluation Criteria

Impact Indicators	***Evaluation Criteria***
Shasta, Oroville, and Folsom Reservoirs	
Warmwater Fisheries	
Mean number of acres of littoral habitat for each month of the primary rearing period (April through November).	Decrease in monthly mean quantity (acres) of littoral habitat (or median reservoir water surface elevation for Lake Oroville), relative to the Baseline Condition, of sufficient magnitude and frequency to adversely affect long-term population levels of warmwater fish, for a given month of this period over the 72-year period of record.
End-of-month reservoir water surface elevation (feet/msl) occurring each month of the primary spawning and rearing period for nest-building warmwater fish (March through June).	Decrease in monthly mean reservoir water surface elevation more than nine feet per month, relative to the Baseline Condition, of sufficient frequency to adversely affect long-term population levels of warmwater fish, for a given month of this period over the 72-year period of record.

Table 9-4
Fish Resources and Aquatic Habitat Impact Indicators and Evaluation Criteria

Impact Indicators	Evaluation Criteria
Coldwater Fisheries	
End-of-month storage (TAF) for each month of the April through November period.	Decrease in monthly mean reservoir storage, relative to the Baseline Condition, which also would reduce the coldwater pool, of sufficient magnitude to adversely affect long-term population levels of coldwater fish, for a given month of this period over the 72-year of record.
Little Grass Valley, Sly Creek, New Bullards Bar, French Meadows, Hell Hole, and McClure Reservoirs	
Warmwater Fisheries	
Median reservoir water surface elevation (feet/msl) occurring each month of the primary spawning and rearing period for nest-building warmwater fish (March through June).	Decrease in median reservoir water surface elevation more than nine feet per month, relative to the Baseline Condition, of sufficient frequency to adversely affect long-term population levels of warmwater fish, for a given month of this period over the historical period of record.
Median reservoir water surface elevation (feet/msl) occurring each month of the primary rearing period for nest-building warmwater fish (April through November).	Decrease in monthly mean reservoir water surface elevation resulting in loss of littoral habitat, relative to the Baseline Condition, of sufficient frequency to adversely affect rearing of warmwater fish, for a given month of this period over the 72-year period of record.
Coldwater Fisheries	
Median storage (TAF) for each month of the April through November period.	Decrease in median reservoir storage, relative to the Baseline Condition, which also would reduce the coldwater pool, of sufficient magnitude to adversely affect long-term population levels of coldwater fish, for a given month of this period over the historical period of record.
Sacramento River	
Winter-run Chinook Salmon	
Monthly mean flow (cfs) below Keswick Dam and at Freeport for each month of the adult immigration period (December through July).	Decrease in monthly mean flow, relative to the Baseline Condition, of sufficient magnitude and frequency to adversely affect adult immigration (e.g., resulting flows <3,250 cfs), for a given month of this period over the 72-year period of record.
Monthly mean water temperature (°F) at Bend Bridge, Jelly's Ferry, and Freeport for each month of the adult immigration period (December through July).	Increase in monthly mean water temperature, relative to the Baseline Condition, of sufficient magnitude and frequency to adversely affect adult immigration, for a given month of this period over the 69-year period of record.
Monthly mean flows (cfs) below Keswick Dam and at Freeport for each month of the spawning, egg incubation, and initial rearing period (April through August).	Decrease in monthly mean flow, relative to the Baseline Condition, of sufficient magnitude and frequency to adversely affect initial year-class strength, for a given month of this period over the 72-year period of record.
Monthly mean water temperatures (°F) at Bend Bridge and Jelly's Ferry for each month of the spawning, egg incubation, and initial rearing period (April through August).	Increase in monthly mean water temperature, relative to the Baseline Condition, of sufficient magnitude and frequency to result in substantial egg and alevin loss (e.g., resulting temperatures >56°F), for a given month of this period over the 69-year period of record.
Monthly mean flow (cfs) below Keswick Dam and at Freeport for each month of the juvenile rearing and emigration period (August through December).	Decrease in monthly mean flow, relative to the Baseline Condition, of sufficient magnitude and frequency to adversely affect juvenile rearing and emigration (e.g., resulting flows <3,250 cfs), for a given month of this period over the 72-year period of record.
Monthly mean water temperature (°F) at Bend Bridge, Jelly's Ferry, and Freeport for each month of the juvenile rearing and emigration period (August through December).	Increase in monthly mean water temperature, relative to the Baseline Condition, of sufficient magnitude and frequency to adversely affect juvenile rearing and emigration (e.g., resulting temperatures >65°F), for a given month of this period over the 69-year period of record.
Annual early lifestage survival.	Decrease in annual or long-term average early lifestage survival, relative to the Baseline Condition, of sufficient magnitude to adversely affect initial year-class strength over the 72-year period of record.
Spring-run Chinook Salmon	
Monthly mean flow (cfs) below Keswick Dam and at Freeport for each month of the adult immigration and holding period (March through September).	Decrease in monthly mean flow, relative to the Baseline Condition, of sufficient magnitude and frequency to adversely affect adult immigration, for a given month of this period over the 72-year period of record.
Monthly mean water temperature (°F) at Bend Bridge, Jelly's Ferry, and Freeport for each month of the adult immigration and holding period (March through September).	Increase in monthly mean water temperature, relative to the Baseline Condition, of sufficient magnitude and frequency to adversely affect adult immigration, for a given month of this period over the 69-year period of record.
Monthly mean flows (cfs) below Keswick Dam and at Freeport for each month of the spawning, egg incubation and initial rearing period (August through January).	Decrease in monthly mean flow, relative to the Baseline Condition, of sufficient magnitude and frequency to adversely affect initial year-class strength, for a given month of this period over the 72-year period of record.

Table 9-4
Fish Resources and Aquatic Habitat Impact Indicators and Evaluation Criteria

Impact Indicators	Evaluation Criteria
Monthly mean water temperatures (°F) at Bend Bridge and Jelly's Ferry for each month of the spawning, egg incubation, and initial rearing period (August through January).	Increase in monthly mean water temperature, relative to the Baseline Condition, of sufficient magnitude and frequency to result in substantial egg and alevin loss (e.g., resulting temperatures >56°F), for a given month of this period over the 69-year period of record.
Monthly mean flow (cfs) below Keswick Dam and at Freeport for each month of the juvenile rearing and emigration period (December through April).	Decrease in monthly mean flow, relative to the Baseline Condition, of sufficient magnitude and frequency to adversely affect juvenile rearing and emigration, for a given month of this period over the 72-year period of record.
Monthly mean water temperature (°F) at Bend Bridge, Jelly's Ferry, and Freeport for each month of the juvenile rearing and emigration period (December through April).	Increase in monthly mean water temperature, relative to the Baseline Condition, of sufficient magnitude and frequency to adversely affect juvenile rearing and emigration (e.g., resulting temperatures >65°F), for a given month of this period over the 69-year period of record.
Annual early lifestage survival.	Decrease in annual or long-term average early lifestage survival, relative to the Baseline Condition, of sufficient magnitude to adversely affect initial year-class strength over the 72-year period of record.
Fall-run Chinook Salmon	
Monthly mean flow (cfs) below Keswick Dam and at Freeport for each month of the adult immigration period (September through November).	Decrease in monthly mean flow, relative to the Baseline Condition, of sufficient magnitude and frequency to adversely affect adult immigration, for a given month of this period over the 72-year period of record.
Monthly mean water temperature (°F) at Bend Bridge, Jelly's Ferry, and Freeport for each month of the adult immigration period (September through November).	Increase in monthly mean water temperature, relative to the Baseline Condition, of sufficient magnitude and frequency to adversely affect adult immigration, for a given month of this period over the 69-year period of record.
Monthly mean flows (cfs) below Keswick Dam and at Freeport for each month of the spawning, egg incubation, and initial rearing period (October through February).	Decrease in monthly mean flow, relative to the Baseline Condition, of sufficient magnitude and frequency to adversely affect initial year-class strength, for a given month of this period over the 72-year period of record.
Monthly mean water temperatures (°F) at Bend Bridge, Jelly's Ferry, and Freeport for each month of the spawning, egg incubation, and initial rearing period (October through February).	Increase in monthly mean water temperature, relative to the Baseline Condition, of sufficient magnitude and frequency to result in substantial egg and alevin loss (e.g., resulting temperatures >56°F), for a given month of this period over the 69-year period of record.
Monthly mean flow (cfs) below Keswick Dam and at Freeport for each month of the juvenile rearing and emigration period (February through June).	Decrease in monthly mean flow, relative to the Baseline Condition, of sufficient magnitude and frequency to adversely affect juvenile rearing and emigration, for a given month of this period over the 72-year period of record.
Monthly mean water temperature (°F) at Bend Bridge, Jelly's Ferry, and Freeport for each month of the juvenile rearing and emigration period (February through June).	Increase in monthly mean water temperature, relative to the Baseline Condition, of sufficient magnitude and frequency to adversely affect juvenile rearing and emigration (e.g., resulting temperatures >65°F), for a given month of this period over the 69-year period of record.
Annual early lifestage survival.	Decrease in annual or long-term average early lifestage survival, relative to the Baseline Condition, of sufficient magnitude to adversely affect initial year-class strength over the 72-year period of record.
Late-fall-run Chinook Salmon	
Monthly mean flow (cfs) below Keswick Dam and at Freeport for each month of the adult immigration and holding period (October through April).	Decrease in monthly mean flow, relative to the Baseline Condition, of sufficient magnitude and frequency to adversely affect adult immigration, for a given month of this period over the 72-year period of record.
Monthly mean water temperature (°F) at Bend Bridge, Jelly's Ferry, and Freeport for each month of the adult immigration and holding period (October through April).	Increase in monthly mean water temperature, relative to the Baseline Condition, of sufficient magnitude and frequency to adversely affect adult immigration, for a given month of this period over the 69-year period of record.
Monthly mean flows (cfs) below Keswick Dam and at Freeport for each month of the spawning, egg incubation, and initial rearing period (December through April).	Decrease in monthly mean flow, relative to the Baseline Condition, of sufficient magnitude and frequency to adversely affect initial year-class strength, for a given month of this period over the 72-year period of record.
Monthly mean water temperatures (°F) at Bend Bridge, Jelly's Ferry, and Freeport for each month of the spawning, egg incubation, and initial rearing period (December through April).	Increase in monthly mean water temperature, relative to the Baseline Condition, of sufficient magnitude and frequency to result in substantial egg and alevin loss (e.g., resulting temperatures >56°F), for a given month of this period over the 69-year period of record.

Table 9-4
Fish Resources and Aquatic Habitat Impact Indicators and Evaluation Criteria

Impact Indicators	Evaluation Criteria
Monthly mean flow (cfs) below Keswick Dam and at Freeport for each month of the juvenile rearing and emigration period (April through October).	Decrease in monthly mean flow, relative to the Baseline Condition, of sufficient magnitude and frequency to adversely affect juvenile rearing and emigration, for a given month of this period over the 72-year period of record.
Monthly mean water temperature (°F) at Bend Bridge, Jelly's Ferry, and Freeport for each month of the juvenile rearing and emigration period (April through October).	Increase in monthly mean water temperature, relative to the Baseline Condition, of sufficient magnitude and frequency to adversely affect juvenile rearing and emigration (e.g., resulting temperatures >65°F), for a given month of this period over the 69-year period of record.
Annual early lifestage survival.	Decrease in annual or long-term average early lifestage survival, relative to the Baseline Condition, of sufficient magnitude to adversely affect initial year-class strength over the 72-year period of record.
Steelhead	
Monthly mean flow (cfs) below Keswick Dam and at Freeport for each month of the adult immigration period (September through March).	Decrease in monthly mean flow, relative to the Baseline Condition, of sufficient magnitude and frequency to adversely affect adult immigration for a given month of this period over the 72-year period of record.
Monthly mean water temperature (°F) at Bend Bridge, Jelly's Ferry, and at Freeport for each month of the adult immigration period (September through March).	Increase in monthly mean water temperature, relative to the Baseline Condition, of sufficient magnitude and frequency to adversely affect adult immigration, for a given month of this period over the 69-year period of record.
Monthly mean flow (cfs) below Keswick Dam and at Freeport for each month of the spawning and egg incubation period (December through March),	Decrease in monthly mean flow, relative to the Baseline Condition, of sufficient magnitude and frequency to adversely affect initial year-class strength, for a given month of this period over the 72-year period of record.
Monthly mean water temperature (°F) at Bend Bridge, Jelly's Ferry, and at Freeport in the Sacramento River for each month of the spawning and egg incubation period (December through March),	Increase in monthly mean water temperature, relative to the Baseline Condition, of sufficient magnitude and frequency to result in substantial egg and alevin loss (e.g., resulting temperatures >56°F), for a given month of this period over the 69-year period of record.
Monthly mean flow (cfs) below Keswick Dam and at Freeport for each month of the juvenile over-summer rearing period not covered in the fall-run Chinook salmon juvenile rearing analysis (July through September).	Decrease in monthly mean flow, relative to the Baseline Condition, of sufficient magnitude and frequency to adversely affect initial year-class strength and juvenile rearing, for a given month of this period over the 72-year period of record.
Monthly mean water temperature (°F) at Bend Bridge, Jelly's Ferry, and Freeport for each month of the juvenile over-summer rearing period not covered in the fall-run Chinook salmon juvenile rearing analysis (July through September).	Increase in monthly mean water temperature, relative to the Baseline Condition, of sufficient magnitude and frequency to result in substantial adverse affects to juvenile rearing (e.g., resulting temperatures >65°F), for a given month of this period over the 69-year period of record.
Monthly mean flow (cfs) below Keswick Dam and at Freeport for each month of the juvenile fall/winter rearing period (October through January).	Decrease in monthly mean flow, relative to the Baseline Condition, of sufficient magnitude and frequency to adversely affect initial year-class strength and juvenile rearing for a given month of this period over the 72-year period of record.
Monthly mean water temperature (°F) at Bend Bridge, Jelly's Ferry, and Freeport for each month of the juvenile fall/winter rearing period (October through January).	Increase in monthly mean water temperature, relative to the Baseline Condition, of sufficient magnitude and frequency to result in substantial adverse affects to juvenile rearing for a given month of this period over the 69-year period of record.
Monthly mean flow (cfs) below Keswick Dam and at Freeport for each month of the juvenile rearing and emigration period (February through June).	Decrease in monthly mean flow, relative to the Baseline Condition, of sufficient magnitude and frequency to adversely affect juvenile emigration, for a given month of this period over the 72-year period of record.
Monthly water mean temperature (°F) at Bend Bridge, Jelly's Ferry, and Freeport for each month of the juvenile rearing and emigration period (February through June).	Increase in monthly mean water temperature, relative to the Baseline Condition, of sufficient magnitude and frequency to adversely affect juvenile emigration (e.g., resulting temperatures >65°F), for a given month of this period over the 69-year period of record.
Annual early lifestage survival, based on LSALMON2 output for late-fall run Chinook salmon.	Decrease in annual or long-term average early lifestage survival, relative to the Baseline Condition, of sufficient magnitude to adversely affect initial year-class strength over the 72-year period of record.
Sacramento Splittail	
Monthly mean flows (cfs) at Freeport and below Keswick during each month of the February through May spawning period.	Decrease in monthly mean flow, relative to the Baseline Condition, of sufficient magnitude and frequency to adversely affect potential splittail habitat availability, for each month of this period over the 72-year period of record.
Monthly mean water temperatures (°F) at Freeport, Bend Bridge, Jelly's Ferry, and the mouth during each month of the February through May spawning period.	Substantial increase in the frequency, relative to the Baseline Condition, in which monthly mean water temperatures exceed the reported upper temperature range for splittail spawning (68°F), for a given month of this period over the 69-year period of record.

Table 9-4
Fish Resources and Aquatic Habitat Impact Indicators and Evaluation Criteria

Impact Indicators	Evaluation Criteria
Striped Bass	
Monthly mean flows (cfs) at Freeport and below Keswick for each month of the May through June spawning and initial rearing period.	Decrease in monthly mean flow, relative to the Baseline Condition, of sufficient magnitude and frequency to adversely affect potential striped bass habitat availability, for each month of this period over the 72-year period of record.
Monthly mean water temperatures (°F) at Freeport, Bend Bridge, and Jelly's Ferry for each month of the May through June spawning and initial rearing period.	Substantial increase in the frequency, relative to the Baseline Condition, in which monthly mean water temperatures exceed the reported upper temperature range for striped bass spawning and initial rearing (59°F to 68°F), for a given month of this period over the 69-year period of record.
American Shad	
Monthly mean flows (cfs) at Freeport and Keswick for each month of the May through June spawning period.	Decrease in monthly mean flow, relative to the Baseline Condition, of sufficient magnitude and frequency to adversely affect potential American shad habitat availability and attraction, for each month of this period over the 72-year period of record.
Monthly mean water temperatures (°F) at Freeport, Bend Bridge, and Jelly's Ferry for each month of the May through June spawning period.	Substantial increase in frequency, relative to the Baseline Condition, in which monthly mean water temperatures exceed the reported upper temperature range for American shad spawning (60°F to 70°F), for a given month of the identified period over the 69-year period of record.
Butte Creek	
Spring-run Chinook Salmon	
Agricultural return flows downstream of the Western Canal (Butte Creek) Siphon during the adult immigration period (mid-February through July).	Decreases in flows, relative to the Baseline Condition, of sufficient frequency and magnitude to adversely affect adult immigration for a given month of this period.
Agricultural return flows downstream of the Western Canal (Butte Creek) Siphon during the juvenile emigration period (December through May).	Decreases in flows, relative to the Baseline Condition, of sufficient frequency and magnitude to adversely affect juvenile emigration for a given month of this period.
Fall-run Chinook Salmon	
Agricultural return flows downstream of the Western Canal (Butte Creek) Siphon during the adult immigration period (late-September through October).	Decreases in flows, relative to the Baseline Condition, of sufficient frequency and magnitude to adversely affect adult immigration for a given month of this period.
Agricultural return flows downstream of the Western Canal (Butte Creek) Siphon during the juvenile emigration period (December through June).	Decreases in flows, relative to the Baseline Condition, of sufficient frequency and magnitude to adversely affect juvenile emigration for a given month of this period.
Late-fall-run Chinook Salmon	
Agricultural return flows downstream of the Western Canal (Butte Creek) Siphon during the adult immigration period (late-December through February).	Decreases in flows, relative to the Baseline Condition, of sufficient frequency and magnitude to adversely affect adult immigration for a given month of this period.
Agricultural return flows downstream of the Western Canal (Butte Creek) Siphon during the juvenile emigration period (April through June).	Decreases in flows, relative to the Baseline Condition, of sufficient frequency and magnitude to adversely affect juvenile emigration for a given month of this period.
Steelhead	
Agricultural return flows downstream of the Western Canal (Butte Creek) Siphon during the adult immigration period (late-fall through winter).	Decreases in flows, relative to the Baseline Condition, of sufficient frequency and magnitude to adversely affect adult immigration for a given month of this period.
Agricultural return flows downstream of the Western Canal (Butte Creek) Siphon during the juvenile rearing period (year-round).	Decreases in flows, relative to the Baseline Condition, of sufficient frequency and magnitude to adversely affect juvenile rearing for a given month of this period.
Agricultural return flows downstream of the Western Canal (Butte Creek) Siphon during the juvenile emigration period (September through June).	Decreases in flows, relative to the Baseline Condition, of sufficient frequency and magnitude to adversely affect juvenile emigration for a given month of this period.
Sacramento Splittail	
Agricultural return flows downstream of the Western Canal (Butte Creek) Siphon during the spawning period (February through April).	Decreases in flows, relative to the Baseline Condition, of sufficient frequency and magnitude to adversely affect spawning habitat availability, for a given month of this period.
Lower Feather River	
Spring-run Chinook Salmon	
Monthly mean flow (cfs) at the mouth of the Feather River and below the Thermalito Afterbay Outlet, for each month of the adult immigration and holding period (March through August).	Decrease in monthly mean flow, relative to the Baseline Condition, of sufficient magnitude and frequency to adversely affect adult immigration for a given month of this period over the 72-year period of record.

Table 9-4
Fish Resources and Aquatic Habitat Impact Indicators and Evaluation Criteria

Impact Indicators	Evaluation Criteria
Monthly mean water temperature (°F) at the mouth of the Feather River, below the Thermalito Afterbay Outlet, and in the Low Flow Channel below the Fish Barrier Dam for each month of the adult immigration and holding period (March through August).	Increase in monthly mean water temperature, relative to the Baseline Condition, of sufficient magnitude and frequency to adversely affect adult immigration for a given month of this period over the 69-year period of record.
Monthly mean flows (cfs) below the Thermalito Afterbay Outlet for each month of the spawning and egg incubation period (August through November).	Decrease in monthly mean flow, relative to the Baseline Condition, of sufficient magnitude and frequency to adversely affect initial year-class strength, for a given month of this period over the 72-year period of record.
Monthly mean water temperatures (°F) below the Fish Barrier Dam and the Thermalito Afterbay Outlet for each month of the spawning and egg incubation period (August through November).	Increase in monthly mean water temperature, relative to the Baseline Condition, of sufficient magnitude and frequency to result in substantial egg and alevin loss (e.g., resulting temperatures >56°F), for a given month of this period over the 69-year period of record.
Monthly mean flow (cfs) below the Thermalito Afterbay Outlet and at the mouth of the Feather River for each month of the juvenile rearing and emigration period (November through June).	Decrease in monthly mean flow, relative to the Baseline Condition, of sufficient magnitude and frequency to adversely affect juvenile rearing and emigration, for a given month of this period over the 72-year period of record.
Monthly mean water temperature (°F) in the Low Flow Channel below the Fish Barrier Dam, below Thermalito Afterbay Outlet, and at the mouth of the Feather River for each month of the juvenile rearing and emigration period (November through June).	Increase in monthly mean water temperature, relative to the Baseline Condition, of sufficient magnitude and frequency to adversely affect juvenile rearing and emigration (e.g., resulting temperatures >65°F), for a given month of this period over the 69-year period of record.
Fall-run Chinook Salmon	
Monthly mean flow (cfs) at the mouth of the Feather River and below the Thermalito Afterbay Outlet for each month of the adult immigration period (September through November).	Decrease in monthly mean flow, relative to the Baseline Condition, of sufficient magnitude and frequency to adversely affect adult immigration, for a given month of this period over the 72-year period of record.
Monthly mean water temperature (°F) at the mouth of the Feather River and below the Thermalito Afterbay Outlet for each month of the adult immigration period (September through November).	Increase in monthly mean water temperature, relative to the Baseline Condition, of sufficient magnitude and frequency to adversely affect adult immigration, for a given month of this period over the 69-year period of record.
Monthly mean flows (cfs) below the Thermalito Afterbay Outlet for each month of the spawning/egg incubation and initial rearing period (October through February).	Decrease in monthly mean flow, relative to the Baseline Condition, of sufficient magnitude and frequency to adversely affect initial year-class strength, for a given month of this period over the 72-year period of record.
Monthly mean water temperatures (°F) below the Fish Barrier Dam and below the Thermalito Afterbay Outlet for each month of the spawning/egg incubation and initial rearing period (October through February).	Increase in monthly mean water temperature, relative to the Baseline Condition, of sufficient magnitude and frequency to result in substantial egg and alevin loss (e.g., resulting temperatures >56°F), for a given month of this period over the 69-year period of record.
Monthly mean flow (cfs) below the Thermalito Afterbay Outlet and at the mouth of the Feather River for each month of the juvenile rearing and emigration period (February through June).	Decrease in monthly mean flow, relative to the Baseline Condition, of sufficient magnitude and frequency to adversely affect juvenile rearing and emigration, for a given month of this period over the 72-year period of record.
Monthly mean water temperature (°F) below the Fish Barrier Dam, below the Thermalito Afterbay Outlet, and at the mouth of the Feather River for each month of the juvenile rearing and emigration period (February through June).	Increase in monthly mean water temperature, relative to the Baseline Condition, of sufficient magnitude and frequency to adversely affect juvenile rearing and emigration (e.g., resulting temperatures >65°F), for a given month of this period over the 69-year period of record.
Steelhead	
Monthly mean flow (cfs) below the Thermalito Afterbay Outlet and at the mouth of the Feather River for each month of the adult immigration period (September through January).	Decrease in monthly mean flow, relative to the Baseline Condition, of sufficient magnitude and frequency to adversely affect adult immigration, for a given month of this period over the 72-year period of record.
Monthly mean water temperature (°F) below the below the Thermalito Afterbay Outlet and at the mouth of the Feather River for each month of the adult immigration period (September through January).	Increase in monthly mean water temperature, relative to the Baseline Condition, of sufficient magnitude and frequency to adversely affect adult immigration, for a given month of this period over the 69-year period of record.
Monthly mean flow (cfs below Thermalito Afterbay Outlet for the spawning and egg incubation period (December through April).	Decrease in monthly mean flow, relative to the Baseline Condition, of sufficient magnitude and frequency to adversely affect initial year-class strength for a given month of this period over the 72-year period of record.
Monthly mean water temperature (°F) below the Fish Barrier Dam, and below Thermalito Afterbay for each month of the spawning and egg incubation period (December through April).	Increase in monthly mean water temperature, relative to the Baseline Condition, of sufficient magnitude and frequency to result in substantial egg and alevin loss (e.g., resulting temperatures >56°F), for a given month of this period over the 69-year period of record.

Table 9-4
Fish Resources and Aquatic Habitat Impact Indicators and Evaluation Criteria

Impact Indicators	Evaluation Criteria
Monthly mean flow (cfs) below Thermalito Afterbay Outlet and at the mouth of the Feather River for the juvenile over-summer rearing period (July through September).	Decrease in monthly mean flow, relative to the Baseline Condition, of sufficient magnitude and frequency to adversely affect juvenile rearing, for a given month of this period over the 72-year period of record.
Monthly mean water temperature (°F) below the Fish Barrier Dam, below Thermalito Afterbay, and at the mouth of the Feather River for each month of the juvenile over-summer rearing period (July through September).	Increase in monthly mean water temperature, relative to the Baseline Condition, of sufficient magnitude and frequency to result in substantial adverse affects to juvenile rearing (e.g., resulting temperatures >65°F), for a given month of this period over the 69-year period of record.
Monthly mean flow (cfs) below Thermalito Afterbay Outlet and at the mouth of the Feather River for the juvenile fall/winter rearing periods (October through January).	Decrease in monthly mean flow, relative to the Baseline Condition, of sufficient magnitude and frequency to adversely affect juvenile rearing for a given month of this period over the 72-year period of record.
Monthly mean water temperature (°F) below the Fish Barrier Dam, below Thermalito Afterbay, and at the mouth of the Feather River for each month of the juvenile fall/winter rearing period (October through January).	Increase in monthly mean water temperature, relative to the Baseline Condition, of sufficient magnitude and frequency to result in substantial adverse affects to juvenile rearing for a given month of this period over the 69-year period of record.
Monthly mean flow (cfs) below Thermalito Afterbay Outlet and at the mouth of the Feather River for each month of the juvenile rearing and emigration period (February through June).	Decrease in monthly mean flow, relative to the Baseline Condition, of sufficient magnitude and frequency, to adversely affect juvenile emigration, for a given month of this period over the 72-year period of record.
Monthly water mean temperature (°F) below the Fish Barrier Dam, below the Thermalito Afterbay Outlet, and at the mouth of the Feather River for each month of the juvenile rearing and emigration period (February through April).	Increase in monthly mean water temperature, relative to the Baseline Condition, of sufficient magnitude and frequency to adversely affect juvenile emigration (e.g., resulting temperatures >65°F), for a given month of this period over the 69-year period of record.
Striped Bass	
Monthly mean flows (cfs) at the mouth of the Feather River and below the Thermalito Afterbay Outlet for each month of the May through June spawning period.	Decrease in monthly mean flow, relative to the Baseline Condition, of sufficient magnitude and frequency to adversely affect potential striped bass habitat availability, for each month of this period over the 72-year period of record.
Monthly mean water temperatures (°F) at the mouth of the Feather River below Thermalito Afterbay and below the Fish Barrier Dam for each month of the May through June spawning period.	Substantial increase in the frequency, relative to the Baseline Condition, in which monthly mean water temperatures exceed the reported upper temperature range for striped bass spawning and initial rearing (59°F to 68°F), for a given month of this period over the 69-year period of record.
American Shad	
Monthly mean flows (cfs) at the mouth of the Feather River, below Thermalito Afterbay and below the Fish Barrier Dam for each month of the May through June spawning period.	Decrease in monthly mean flow, relative to the Baseline Condition, of sufficient magnitude and frequency to adversely affect potential American shad habitat availability or attraction, for each month of this period over the 72-year period of record.
Monthly mean water temperatures (°F) at the mouth of the Feather River, below Thermalito Afterbay and below the Fish Barrier Dam for each month of the May through June spawning period.	Substantial increase in the frequency, relative to the Baseline Condition, in which monthly mean water temperatures exceed the reported upper temperature range for American shad spawning (60°F to 70°F), for a given month of this period over the 69-year period of record.
Sacramento Splittail	
Monthly mean flows (cfs) at the mouth of the Feather River for each month of the February through May spawning period.	Decrease in monthly mean flow, relative to the Baseline Condition, of sufficient magnitude and frequency to adversely affect potential splittail habitat availability, for each month of this period over the 72-year period of record.
Monthly mean water temperatures (°F) at the mouth of the Feather River for each month of the February through May spawning period.	Substantial increase in the frequency, relative to the Baseline Condition, in which monthly mean water temperatures exceed the reported upper temperature range for splittail spawning (68°F), for a given month of this period over the 69-year period of record.
Yuba River	
Mean daily flows (cfs) occurring at the USGS gauge (at Marysville and Smartville) for each month of the year.	Increase in flows, relative to the basis of comparison, of sufficient magnitude and rapidity to attract non-indigenous salmonids into the lower Yuba River.
Mean daily water temperatures (°F) at the USGS gauge (at Marysville and Daguerre Point Dam) for each month of the year.	Decrease in water temperatures, relative to the basis of comparison, of sufficient magnitude and contrast to Feather River water temperatures to attract non-indigenous salmonids into the lower Yuba River.

Table 9-4
Fish Resources and Aquatic Habitat Impact Indicators and Evaluation Criteria

Impact Indicators	Evaluation Criteria
Middle Fork American River	
Monthly median flows (cfs) downstream of Ralston Afterbay.	Decrease in median river flows, relative to the Baseline Condition, of sufficient magnitude and frequency to adversely affect long-term population levels of recreationally important species.
Lake Natoma	
Monthly mean water temperatures (°F) of water released from Nimbus Dam for each month of the year.	Increase in monthly mean water temperature, relative to the Baseline Condition, of sufficient magnitude and frequency to adversely affect long-term population levels of coldwater fish, for a given month of the year over the 72-year period of record.
Nimbus Hatchery	
Monthly mean water temperatures (°F) of water released from Nimbus Dam for each month of the year.	Increase in monthly mean water temperature, relative to the Baseline Condition, of sufficient magnitude and frequency that would result in reduced hatchery production (using index temperatures of 60°F, 65°F, and 68°F), during any month of this period over the 69-year period of record.
Lower American River	
Fall-run Chinook Salmon	
Monthly mean flow (cfs) at the mouth of the American River for each month of the adult immigration period (September through December).	Decrease in monthly mean flow, relative to the Baseline Condition, of sufficient magnitude and frequency to adversely affect adult immigration, for a given month of this period over the 72-year period of record.
Monthly mean water temperature (°F) at the mouth of the American River and at Freeport on the Sacramento River for each month of the adult immigration period (September through December).	Increase in monthly mean water temperature, relative to the Baseline Condition, of sufficient magnitude and frequency to adversely affect adult immigration, for a given month of this period over the 69-year period of record.
Monthly mean flows (cfs) below Nimbus Dam and at Watt Avenue for each month of the spawning, egg incubation, and initial rearing period (October through February).	Decrease in monthly mean flow, relative to the Baseline Condition, of sufficient magnitude and frequency to adversely affect initial year-class strength, for a given month of this period over the 72-year period of record.
Monthly mean water temperatures (°F) below Nimbus Dam and at Watt Avenue for each month of the spawning, egg incubation, and initial rearing period (October through February).	Increase in monthly mean water temperature, relative to the Baseline Condition, of sufficient magnitude and frequency to result in substantial egg and alevin loss (e.g., resulting temperatures >56°F), for a given month of this period over the 69-year period of record.
Monthly mean flow (cfs) at Watt Avenue and the mouth of the American River for each month of the juvenile rearing and emigration period (February through June).	Decrease in monthly mean flow, relative to the Baseline Condition, of sufficient magnitude and frequency to adversely affect juvenile rearing and emigration, for a given month of this period over the 72-year period of record.
Monthly mean water temperature (°F) below Nimbus Dam, at Watt Avenue, at the mouth of the lower American River, and at Freeport for each month of the juvenile rearing and emigration period (February through June).	Increase in monthly mean water temperature, relative to the Baseline Condition, of sufficient magnitude and frequency to adversely affect juvenile rearing and emigration (e.g., resulting temperatures >65°F), for a given month of this period over the 69-year period of record.
Annual early lifestage survival.	Decrease in annual or long-term average early lifestage survival, relative to the Baseline Condition, of sufficient magnitude to adversely affect initial year-class strength over the 72-year period of record.
Steelhead	
Monthly mean flow (cfs) at the mouth of the American River for each month of the adult immigration period (December through March).	Decrease in monthly mean flow, relative to the Baseline Condition, of sufficient magnitude and frequency to adversely affect adult immigration, for a given month of this period over the 72-year period of record.
Monthly mean water temperature (°F) at the mouth of the American River and at Freeport on the Sacramento River for each month of the adult immigration period (December through March).	Increase in monthly mean water temperature, relative to the Baseline Condition, of sufficient magnitude and frequency to adversely affect adult immigration, for a given month of this period over the 69-year period of record.
Monthly mean flow (cfs) below Nimbus Dam and at Watt Avenue for each month of the spawning and egg incubation period (December through April).	Decrease in monthly mean flow, relative to the Baseline Condition, of sufficient magnitude and frequency to adversely affect initial year-class strength, for a given month of this period over the 72-year period of record.
Monthly mean water temperature (°F) below Nimbus Dam and at Watt Avenue for each month of the spawning and egg incubation period (December through April).	Increase in monthly mean water temperature, relative to the Baseline Condition, of sufficient magnitude and frequency to result in substantial egg and alevin loss (e.g., resulting temperatures >56°F), for a given month of this period over the 69-year period of record.
Monthly mean flow (cfs) at Watt Avenue for the juvenile over-summer rearing period (July through September)	Decrease in monthly mean flow, relative to the Baseline Condition, of sufficient magnitude and frequency to adversely affect juvenile rearing, for a given month of this period over the 72-year period of record.

Table 9-4 **Fish Resources and Aquatic Habitat Impact Indicators and Evaluation Criteria**	
Impact Indicators	***Evaluation Criteria***
Monthly mean water temperature (°F) below Nimbus Dam and at Watt Avenue for each month of the juvenile over-summer rearing period (July through September).	Increase in monthly mean water temperature, relative to the Baseline Condition, of sufficient magnitude and frequency to result in substantial adverse affects to juvenile rearing (e.g., resulting temperatures >65°F), for a given month of this period over the 69-year period of record.
Monthly mean flow (cfs) at Watt Avenue for the juvenile fall/winter rearing period (October through January)	Decrease in monthly mean flow, relative to the Baseline Condition, of sufficient magnitude and frequency to adversely affect juvenile rearing, for a given month of this period over the 72-year period of record.
Monthly mean water temperature (°F) below Nimbus Dam and at Watt Avenue for each month of the juvenile fall/winter rearing period (October through January).	Increase in monthly mean water temperature, relative to the Baseline Condition, of sufficient magnitude and frequency to result in substantial adverse affects to juvenile rearing for a given month of this period over the 69-year period of record.
Monthly mean flow (cfs) at Watt Avenue, the mouth of the American River and at Freeport for each month of the juvenile rearing and emigration period (February through June).	Decrease in monthly mean flow, relative to the Baseline Condition, of sufficient magnitude and frequency, to adversely affect juvenile emigration, for a given month of this period over the 72-year period of record.
Monthly water mean temperature (°F) at Watt Avenue, at the mouth of the American River, and at Freeport for each month of the juvenile rearing and emigration period (February through June).	Increase in monthly mean water temperature, relative to the Baseline Condition, of sufficient magnitude and frequency to adversely affect juvenile emigration (e.g., resulting temperatures >65°F), for a given month of this period over the 69-year period of record.
Sacramento Splittail	
Monthly mean acreage of flooded riparian habitat at Watt Avenue during each month of the February through May spawning period.	Decrease in monthly mean quantity of submerged vegetation, relative to the Baseline Condition, of sufficient magnitude and frequency to adversely affect potential splittail habitat availability, for each month of this period over the 72-year period of record.
Monthly mean water temperatures (°F) at Watt Avenue and the mouth of the American River during each month of the February through May spawning period.	Substantial increase in the frequency, relative to the Baseline Condition, in which monthly mean water temperatures exceed the reported upper temperature range for splittail spawning (68°F), for a given month of this period over the 69-year period of record.
American Shad	
Monthly mean flows (cfs) at the mouth of the Lower American River during each month of the May through June spawning period.	Substantial decrease in the frequency, relative to the Baseline Condition, in which monthly mean flows are above the CDFG recommended “attraction flow” of 3,000 cfs for American shad spawning migrations, during each month of this period over the 72-year period of record.
Monthly mean water temperatures (°F) below Nimbus Dam and the mouth of the lower American River during the May through June spawning period.	Substantial increase in frequency, relative to the Baseline Condition, in which monthly mean water temperatures exceed the reported upper temperature range for American shad spawning (60°F to 70°F), for a given month of this period over the 69-year period of record.
Striped Bass	
Monthly mean flows (cfs) at the mouth of the Lower American River during the May through June striped bass spawning period.	Decrease in monthly mean flow, relative to the Baseline Condition, of sufficient magnitude and frequency to adversely affect striped bass juvenile spawning during May and June over the 72-year period of record.
Monthly mean flows (cfs) at the mouth of the Lower American River during the May through June striped bass sport fishery.	Substantial decrease in the frequency, relative to the Baseline Condition, in which monthly mean flows are above the CDFG recommended “attraction flow” of 1,500 cfs for the striped bass sport fishery, for each month of this period over the 72-year period of record.
Monthly mean water temperatures (°F) below Nimbus Dam and at the mouth during the May through June spawning period.	Substantial increase in the frequency, relative to the Baseline Condition, in which monthly mean water temperatures exceed the reported upper temperature range for striped bass spawning (59°F to 68°F), for a given month of this period over the 69-year period of record.
Merced River	
Fall-run Chinook Salmon	
Monthly mean flow (cfs) below Crocker-Huffman Dam and at the mouth of the Merced River for each month of the adult immigration period (October through December).	Decrease in monthly mean flow (> 25%), relative to the Baseline Condition, of sufficient magnitude and frequency to adversely affect adult immigration, for a given month of this period over the 72-year period of record.

Table 9-4
Fish Resources and Aquatic Habitat Impact Indicators and Evaluation Criteria

Impact Indicators	***Evaluation Criteria***
Monthly mean flows (cfs) below Crocker-Huffman Dam and at the mouth of the Merced River for each month of the spawning, egg incubation, and initial rearing period (October through December).	Decrease in monthly mean flow (> 25%), relative to the Baseline Condition, of sufficient magnitude and frequency to adversely affect initial year-class strength, for a given month of this period over the 72-year period of record.
Monthly mean flow (cfs) below Crocker-Huffman Dam and at the mouth of the Merced River for each month of the juvenile rearing and emigration period (January through June).	Decrease in monthly mean flow (> 25%), relative to the Baseline Condition, of sufficient magnitude and frequency to adversely affect juvenile rearing and emigration, for a given month of this period over the 72-year period of record.
Striped Bass	
Monthly mean flows (cfs) below Crocker-Huffman Dam and at the mouth of the Merced River during the May through June striped bass spawning and rearing period.	Decrease in monthly mean flow (> 25%), relative to the Baseline Condition, of sufficient magnitude and frequency to adversely affect striped bass spawning and juvenile rearing for May and June over the 72-year period of record.
San Joaquin River	
Fall-run Chinook Salmon	
Monthly mean flow (cfs) below the confluence of the Merced River and at Vernalis for each month of the adult immigration period (October through December).	Decrease in monthly mean flow (> 25%), relative to the Baseline Condition, of sufficient magnitude and frequency to adversely affect adult immigration, for a given month of this period over the 72-year period of record.
Monthly mean flows (cfs) below the confluence of the Merced River and at Vernalis for each month of the spawning and egg incubation period (October through January).	Decrease in monthly mean flow (> 25%), relative to the Baseline Condition, of sufficient magnitude and frequency to adversely affect initial year-class strength, for a given month of this period over the 72-year period of record.
Monthly mean flow (cfs) below the confluence of the Merced River and at Vernalis for each month of the juvenile rearing and emigration period (January through June).	Decrease in monthly mean flow (> 25%), relative to the Baseline Condition, of sufficient magnitude and frequency to adversely affect juvenile rearing and emigration, for a given month of this period over the 72-year period of record.
Steelhead	
Monthly mean flow (cfs) below the confluence of the Merced River and at Vernalis for each month of the adult immigration period (November through January).	Decrease in monthly mean flow (> 25%), relative to the Baseline Condition, of sufficient magnitude and frequency to adversely affect adult immigration, for a given month of this period over the 72-year period of record.
Monthly mean flow (cfs) below the confluence of the Merced River and at Vernalis for each month of the spawning and egg incubation period (November through January).	Decrease in monthly mean flow (> 25%), relative to the Baseline Condition, of sufficient magnitude and frequency to adversely affect initial year-class strength, for a given month of this period over the 72-year period of record.
Monthly mean flow (cfs) below the confluence of the Merced River and at Vernalis during the juvenile over-summer rearing period (July through September).	Decrease in monthly mean flow (> 25%), relative to the Baseline Condition, of sufficient magnitude and frequency to adversely affect juvenile rearing, for a given month of this period over the 72-year period of record.
Monthly mean flow (cfs) below the confluence of the Merced River and at Vernalis during the juvenile fall/winter rearing period (October through December).	Decrease in monthly mean flow (> 25%), relative to the Baseline Condition, of sufficient magnitude and frequency to adversely affect juvenile rearing for a given month of this period over the 72-year period of record.
Monthly mean flow (cfs) below the confluence of the Merced River and at Vernalis for each month of the juvenile emigration period (November through May).	Decrease in monthly mean flow (> 25%), relative to the Baseline Condition, of sufficient magnitude and frequency to adversely affect juvenile emigration, for a given month of this period over the 72-year period of record.
Sacramento Splittail	
Monthly mean flow (cfs) below the confluence of the Merced River and at Vernalis for each month of the spawning period (February through May).	Decrease in monthly mean flow (> 25%), relative to the Baseline Condition, of sufficient magnitude and frequency to adversely affect initial year-class strength and juvenile rearing, for a given month of this period over the 72-year period of record.
Delta Smelt	
Monthly mean flow (cfs) at Vernalis for each month of the spawning period (January through June).	Decrease in monthly mean flow (> 25%), relative to the Baseline Condition, of sufficient magnitude and frequency to adversely affect initial year-class strength and juvenile rearing, for a given month of this period over the 72-year period of record
Striped Bass	
Monthly mean flows (cfs) below the confluence of the Merced River and at Vernalis during the May through June striped bass rearing period.	Decrease in monthly mean flow (> 25%), relative to the Baseline Condition, of sufficient magnitude and frequency to adversely affect striped bass juvenile rearing for May and June over the 72-year period of record.

Table 9-4 ***Fish Resources and Aquatic Habitat Impact Indicators and Evaluation Criteria***	
Impact Indicators	***Evaluation Criteria***
American Shad	
Monthly mean flows (cfs) below the confluence of the Merced River and at Vernalis for each month of the May through June spawning period.	Decrease in monthly mean flow (> 25%), relative to the Baseline Condition, of sufficient magnitude and frequency to adversely affect potential American shad habitat availability, for each month of this period over the 72-year period of record.
Sacramento-San Joaquin Delta	
Monthly mean Delta outflow (cfs) for all months of the year.	Decrease in monthly mean Delta outflow, relative to the Baseline Condition, of sufficient magnitude and frequency to adversely affect Delta fishery resources over the 15-year period of record.
Monthly mean location of X_2 for all months of the year.	Increase in upstream movement of the monthly mean position of X_2, relative to the Baseline Condition, of sufficient magnitude (1 km) and frequency to adversely affect Delta fish resources over the 15-year period of record.
Export/Inflow (E/I) ratio during the February through June period.	Increase in monthly mean Delta E/I ratio, relative to the Baseline Condition, of sufficient magnitude and frequency to adversely affect Delta fish resources over the 15-year period of record.
Reverse flows (QWEST) during the February through June period.	Increase in reverse flows, relative to the Baseline Condition, of sufficient frequency and magnitude to result in reduced or delayed downstream transport of planktonic eggs and larvae or adverse effects on juvenile salmonid emigration.
Change in annual CVP/SWP salvage estimates (change in number of individuals salvaged per year) for Chinook salmon, steelhead, delta smelt, and Sacramento splittail.	Increase in the annual number of each species captured at the CVP and SWP fish salvage facilities, relative to the Baseline Condition, over the 15-year period (1979 – 1993) included in these analyses.
Change in long-term average annual CVP/SWP salvage estimates (change in number of individuals salvaged) for striped bass.	Increase in the annual number of striped bass captured at the CVP and SWP fish salvage facilities, relative to the Baseline Condition, over the 15-year period (1979 – 1993) included in these analyses.
San Luis Reservoir, Anderson Reservoir, Castaic Lake, Lake Perris, Lake Mathews, and Diamond Valley Lake	
Warmwater and Coldwater Fisheries	
Annual operating procedures	Increase in reservoir drawdown, thereby reducing the availability of habitat for warmwater and coldwater fish species

9.2.3 ASIP Conservation Measures

Conservation measures included in the Action Specific Implementation Plan (ASIP) applicable to the EWA actions for each species that have been incorporated into the program description are described in this section. The MSCS also includes programmatic conservation measures for each species.

Conservation Measure Applicable to all Species

The EWA Project Agencies will coordinate EWA water acquisition and transfer actions with Federal (USFWS and NOAA Fisheries), State (DWR and CDFG), other CALFED agency, and regional programs (e.g., the San Francisco Bay Ecosystem Goals Project, the Anadromous Fish Restoration Program, the Senate Bill [SB] 1086 program, the U.S. Army Corps of Engineers' [USACE's] Sacramento and San Joaquin Basin Comprehensive Study, the Riparian Habitat Joint Venture, the Central Valley Project Improvement Act (CVPIA), the Central Valley Habitat Joint Venture, and the Grassland Bird Conservation Plan) that could affect management of evaluated species. Coordination will avoid conflicts among management objectives.

General Fish Species Conservation Measures

- The EWA agencies will avoid acquisition and transfer of water that would reduce flows essential to maintaining populations of native aquatic species in the source river.

- The EWA water acquisition and transfers will not increase exports during times of the year when anadromous and estuarine fish are most vulnerable to damage or loss at project facilities or when their habitat may be adversely affected.

- The EWA agencies will avoid acquisition and transfer of stored reservoir water quantities that would impair compliance with flow requirements and maintenance of suitable habitat conditions in the source river in subsequent years.

Delta Smelt (T-FESA; T-CESA)

- The EWA agencies will fully adhere to the terms and conditions in all applicable CESA and FESA biological opinions and permits for CVP and SWP operations.

- The Project Agencies will not initiate EWA water exports in July until EWA Management Agencies agree that delta smelt will not be harmed.

Salmonids – General Conservation Measures - Central Valley Fall-run/Late-fall-run Chinook Salmon (C-FESA; SSC-CDFG); Sacramento River Winter-run Chinook Salmon (E-FESA; E-CESA); Central Valley Spring-run Chinook Salmon (T-FESA; CT-CESA); Central Valley Steelhead (T-FESA)

- The EWA agencies will fully adhere to the terms and conditions in all applicable CESA and FESA biological opinions and permits for CVP and SWP operations.

- The EWA agencies will minimize flow fluctuations resulting from the release of EWA assets from project reservoirs to reduce or avoid stranding of juveniles.

Central Valley Fall/Late-Fall Run Chinook Salmon (C-FESA; SSC-CDFG)

- In May, the EWA agencies will evaluate Folsom Reservoir coldwater pool availability to benefit returning adult fall-run Chinook salmon prior to releasing EWA assets.

Central Valley Steelhead (T-FESA)

- In May, the EWA agencies will evaluate Folsom Reservoir coldwater pool availability to benefit over-summering juvenile steelhead prior to releasing EWA assets.

- The EWA agencies will consult with the Multi-agency Team regarding ramping considerations before and after EWA transfers to avoid non-volitional steelhead downstream movement.

9.2.4 Environmental Consequences/Environmental Impacts of the No Action/No Project Alternative

The CEQA basis for comparison is defined as the Affected Environment/Environmental Setting, as described in Section 9.1. It is anticipated that if the EWA were not implemented, actions to protect fisheries and benefit aquatic environments would continue under existing regulatory requirements, including other CALFED actions intended to protect and enhance fisheries resources. Compliance with existing Biological Opinions, which represent the regulatory baseline, would result in pumping curtailments, resulting in reduced deliveries to the Export Service Area, particularly in dry years. DWR and Reclamation would continue to attempt to re-operate the SWP and CVP, respectively, to avoid decreased deliveries to export users. These actions are described in Sections 2.3.1 and 2.3.2.

There would be no variation in CVP/SWP reservoir storage levels, river flows, or water temperatures under the No Action/No Project Alternative, as described for the Affected Environment/Environmental Setting. Therefore, there would be no impacts on fisheries and aquatic ecosystems associated with the No Action/No Project Alternative.

As described in Section 3.4, the CEQA basis for comparison is the Affected Environment. The NEPA basis for comparison is the Future Conditions Without the Project. As described in the above paragraphs, the Affected Environment and the Future Conditions Without the Project are the same; therefore, they are collectively referred to as the Baseline Condition in the following sections.

9.2.5 Environmental Consequences/Environmental Impacts of the Flexible Purchase Alternative

The analysis provides a program-specific evaluation of how the Flexible Purchase Alternative would affect the resources described in the Affected Environment/Environmental Setting. As described in Section 3.4, the basis of comparison is future conditions without the EWA Program (operating conditions of the CVP/SWP without the project). The No Action/No Project Alternative and Affected Environment/Existing Conditions are termed “Baseline Condition” as referred to through the analysis of EWA Program alternatives (the Flexible Purchase Alternative and Fixed Purchase Alternative). The analysis of the Flexible Purchase Alternative incorporates implementation of the variable operational assets described in Attachment 1, Modeling Description.

The impact indicators selected to evaluate the resource topics represent the potential impact issues. A discussion for each impact issue is presented for the alternative. The anticipated change that would occur under each scenario is compared against the significance criteria to ascertain whether the individual alternative would result in a “*beneficial*,” “*less-than-significant*,” or “*significant*” impact determination. In most instances, where a potential adverse impact may occur, environmental protection measures to reduce environmental impacts on a "less-than-significant" impact have been identified and incorporated. (See Chapter 2, Alternatives, Including the Proposed Action/Proposed Project.)

9.2.5.1 Upstream from the Delta Region

This section analyzes the potential impacts of the EWA Flexible Purchase Alternative on the aquatic communities and associated fish species located in the riverine and lacustrine environments upstream from the Delta. Fishery resources of primary management concern included in this analysis are those species that are:

Recreationally or commercially important:

- Fall-run and late-fall run Chinook salmon (*Oncorhynchus tshawytscha*)[9];
- American shad (*Alosa sapidissima*);
- Striped bass (*Morone saxatilis*); and
- Various reservoir fish species[10].

Federally- and State-listed (or proposed for listing) species that occur within the Upstream from the Delta Region:

- Winter-run Chinook salmon (*Oncorhynchus tshawytscha*);
- Spring-run Chinook salmon (*Oncorhynchus tshawytscha*);
- Steelhead (*Oncorhynchus mykiss*);
- Delta smelt (*Hypomesus transpacificus*); and
- Sacramento splittail (*Pogonichthys macrolepidotus*).

Special emphasis is placed on these species to facilitate compliance with applicable laws, particularly State and/or Federal ESA, and to be consistent with other State and Federal restoration/recovery plans and Federal biological opinions. This focus is consistent with: 1) CALFED's 2000 Ecosystem Restoration Program Plan (ERPP) and Multi-Species Conservation Strategy (MSCS); 2) the programmatic determinations for the CALFED program, which include CDFG's Natural Communities Conservation Planning Act (NCCPA) approval and the programmatic biological opinions (BOs) issued by NOAA Fisheries and USFWS; 3) USFWS's 1997 Draft Anadromous Fish Restoration Program (AFRP), which identifies specific actions to protect anadromous salmonids; 4) CDFG's 1996 Steelhead Restoration and Management Plan for

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9 Late-fall-run Chinook salmon is also a candidate for federal and State listing.

10 For a full listing of reservoir fish species evaluated, refer to Section 9.1, Affected Environment/Existing Conditions.

California, which identifies specific actions to protect steelhead; and 5) CDFG's Restoring Central Valley Streams, A Plan for Action (1993), which identifies specific actions in the Sacramento River system to protect salmonids. Improvement of habitat conditions for these species of priority management concern will likely maintain, protect, or enhance conditions for other fish resources, including native resident species.

Potential impacts on fisheries resources are organized by river basin, starting with the Sacramento River and moving south through the Central Valley to the Merced and San Joaquin rivers. Potential impacts on reservoir fisheries are presented in the river basin in which each reservoir occurs.

9.2.5.1.1 Sacramento River Area of Analysis

EWA acquisition of Sacramento River contractor water via groundwater substitution and crop idling would alter Sacramento River flows downstream from Lake Shasta during June. EWA acquisition of Sacramento River contractor water via groundwater substitution and crop idling would alter surface water elevations at Lake Shasta from June through September.

This section includes an analysis of the warmwater and coldwater fisheries resources for Lake Shasta on the Sacramento River, followed by analyses for fish species of the Sacramento River. For individual fish species, flow- and temperature-related impacts are discussed separately below by species and lifestage. Organizationally, flow- and temperature-related impacts on winter-run Chinook salmon are presented after the discussion of Lake Shasta fisheries resources, and are followed by flow- and temperature-related impacts on spring-run Chinook salmon. Then, fall-run Chinook salmon and steelhead are discussed together, followed by impact discussions for Sacramento splittail, American shad, and striped bass.

<u>Impacts on Lake Shasta Warmwater Fisheries</u>

Hydrologic conditions under the Flexible Purchase Alternative would result in a negligible decrease in long-term average end-of-month water surface elevation in Lake Shasta during the April through November period, when warmwater fish juvenile rearing occurs (Table 9-5). As shown in Table 9-5, the long-term average end-of-month elevation would not differ between Flexible Purchase Alternative and Baseline Condition in the April through July and September through November periods, and would be reduced by 1 foot in August under the Flexible Purchase Alternative, relative to the Baseline Condition. Monthly mean end-of-month water surface elevation in Lake Shasta would be essentially equivalent to or greater than the Baseline Condition for 543 of the 576 months included in the analysis. (See Appendix H pgs. 181-192.)

Table 9-5
Long-term Average Shasta Reservoir End of Month Elevation Under Baseline and Flexible Purchase Alternative Conditions

Month	Average Elevation[1] (feet msl)		
	Baseline	Flexible Purchase Alternative	Difference
Mar	1027	1027	0
Apr	1037	1037	0
May	1036	1036	0
Jun	1024	1024	0
Jul	1001	1001	0
Aug	984	983	-1
Sep	977	977	0
Oct	973	973	0
Nov	977	977	0
Dec	985	985	0

[1] Based on 72 years modeled.

Changes in water surface elevation in Lake Shasta during the April through November period would result in corresponding changes in the availability of reservoir littoral habitat containing submerged vegetation (willows and button brush). Such shallow, near shore waters containing physical structure are important to producing and maintaining strong year-classes of warmwater fish annually. As shown in Table 9-6, the difference in the long-term average amount of littoral habitat potentially available to warmwater fish for spawning and/or rearing in Lake Shasta during the April through November period under the Flexible Purchase Alternative would be identical to the amount available under the Baseline Condition. Further, the monthly mean amount of littoral habitat would not be reduced under the Flexible Purchase Alternative, relative to the Baseline Condition, in any of the 576 months simulated for the April through November period. (See Appendix H pgs. 277-288.) Consequently, seasonal changes in water surface elevation under the Flexible Purchase Alternative would not result in reductions in littoral habitat availability, relative to the Baseline Condition.

Table 9-6
Long-term Average Number of Acres of Lake Shasta Littoral Habitat Under Baseline and Flexible Purchase Alternative Conditions

Month	Average Amount Of Littoral Habitat[1] (Acres)		Difference	
	Baseline	Flexible Purchase Alternative	(Acres)	(%)[2]
Mar	3,257	3,257	0	0.0
Apr	4,218	4,218	0	0.0
May	4,145	4,145	0	0.0
Jun	3,179	3,179	0	0.0
Jul	1,719	1,719	0	0.0
Aug	813	813	0	0.0
Sep	435	435	0	0.0
Oct	216	216	0	0.0
Nov	268	268	0	0.0
Dec	539	539	0	0.0

[1] Based on 72 years modeled.
[2] Relative difference of the monthly long-term average.

In addition, the Flexible Purchase Alternative could alter the extent to which water surface elevations in Lake Shasta change during each month of the primary warmwater fish-spawning period (March through June). As discussed in Section 9.2.1.1, adverse effects on spawning from nest dewatering are assumed to have the potential to occur when reservoir elevation decreases by more than nine feet within a given month. Modeling results, shown in Table 9-7, indicate that there is no difference in the frequency with which potential nest dewatering events could occur in Lake Shasta under the Flexible Purchase Alternative, compared to the Baseline Condition, during the spawning period.

Table 9-7
Long-term Average Surface Elevation and Number of Years with Elevation Decrease Greater than 9 feet in Shasta Reservoir Under Baseline and Flexible Purchase Alternative Conditions

Month	Average Reservoir Surface Elevation[1] (feet msl)			No. Years[1] w/Monthly Elevation Decrease During Month > 9 ft	
	Baseline	Flexible Purchase Alternative	Difference	Baseline	Flexible Purchase Alternative
Mar	1027	1027	0	1	1
Apr	1037	1037	0	5	5
May	1036	1036	0	9	9
Jun	1024	1024	0	46	46

[1] Based on 72 years modeled.

In summary, the Flexible Purchase Alternative is not likely to result in changes in the availability of littoral habitat at Lake Shasta, and thus, would not likely beneficially or adversely affect warmwater fish rearing. The Flexible Purchase Alternative does not change the frequency of potential nest dewatering events in Lake Shasta, and thus, would not beneficially or adversely affect long-term warmwater fish nesting success. Therefore, under the Flexible Purchase Alternative, impacts on Lake Shasta warmwater fisheries would be less than significant, relative to the Baseline Condition.

Impacts on Lake Shasta Coldwater Fisheries

Long-term average end-of-month storage during the April through November period would not change in April, May, June, October, and November, and would be reduced by 19 TAF in July, 10 TAF in August and 1 TAF in September with implementation of the Flexible Purchase Alternative, relative to the Baseline Condition, as shown in Table 9-8. Lake Shasta long-term average end-of-month storage under the Flexible Purchase Alternative would be essentially equivalent to or greater than the Baseline Condition for 539 of the 576 months included in the analysis (April through November, when the reservoir stratifies). Anticipated reductions in reservoir storage would not be expected to adversely affect the reservoir's coldwater fisheries because: 1) coldwater habitat would remain available within the reservoir during all months of all years; 2) physical habitat availability is not believed to be among the primary factors limiting coldwater fish populations; and 3) anticipated seasonal reductions in storage would not be expected to adversely affect the primary prey species utilized by coldwater fish. Therefore, changes in Lake Shasta end-of-month storage under the Flexible Purchase Alternative represent a less-than-significant effect on coldwater fish resources, relative to the Baseline Condition.

Table 9-8
Long-term Average Shasta Reservoir End of Month Storage Under Baseline and Flexible Purchase Alternative Conditions

Month	Average Storage[1] (TAF)		Difference	
	Baseline	Flexible Purchase Alternative	(TAF)	(%)[2]
Apr	3793	3793	0	0.0
May	3780	3780	0	0.0
Jun	3495	3495	0	0.0
Jul	3018	2999	-19	-0.6
Aug	2655	2645	-10	-0.4
Sep	2511	2510	-1	0.0
Oct	2432	2432	0	0.0
Nov	2509	2509	0	0.0

[1] Based on 72 years modeled.
[2] Relative difference of the monthly long-term average.

Impacts on Winter-run Chinook Salmon in the Sacramento River

Flow-related Impacts on Winter-run Chinook Salmon Adult Immigration (December through July)

Table 9-9 shows that the long-term average flow in the Sacramento River below Keswick Dam differs by less than 0.9 percent under the Flexible Purchase Alternative, compared to the Baseline Condition, during all months of the adult immigration period (December through July). In fact, long-term average Sacramento River flow below Keswick Dam under the Flexible Purchase Alternative would not differ from flows under the existing condition from December through June, and July flows under the Flexible Purchase Alternative would be approximately 114 cfs greater than flows under the Baseline Condition. Further, in 576 out of the 576 months simulated in this period, monthly mean flows under the Flexible Purchase Alternative in the Sacramento River below Keswick Dam would be essentially equivalent to or greater than those under the Baseline Condition. (See Appendix H pgs. 351-358.)

Table 9-10 shows that long-term average flow in the Sacramento River at Freeport differs by less than 18 percent under the Flexible Purchase Alternative, compared to the Baseline Condition, during the December through July period. Flows simulated under the Flexible Purchase Alternative would not differ from flows under the Baseline Condition from December through March, and would be from approximately 350 to 3,142 cfs greater under the Flexible Purchase Alternative from April through July. Monthly mean flows in the Sacramento River at Freeport under the Flexible Purchase Alternative would be essentially equivalent to or greater than flows under the Baseline Condition in 576 out of the 576 months simulated for the December through July period. (See Appendix H pgs. 387-394.) The Flexible Purchase Alternative would not result in reductions in long-term average flows in any month of the adult winter-run Chinook salmon immigration period, relative to the Baseline Condition.

Table 9-9 Long-term Average Release From Keswick Dam Under Baseline and Flexible Purchase Alternative Conditions				
Month	**Monthly Mean Flow[1] (cfs)**		**Difference**	
	Baseline	**Flexible Purchase Alternative**	**(cfs)**	**(%)[2]**
Oct	5842	5842	0	0.0
Nov	4854	4854	0	0.0
Dec	6672	6672	0	0.0
Jan	7951	7951	0	0.0
Feb	10056	10056	0	0.0
Mar	8249	8249	0	0.0
Apr	7706	7706	0	0.0
May	8381	8381	0	0.0
Jun	10529	10529	0	0.0
Jul	13284	13398	114	0.9
Aug	10556	10498	-58	-0.5
Sep	7278	7222	-56	-0.8

[1] Based on 72 years modeled.
[2] Relative difference of the monthly long-term average.

The minimum flow objective for Keswick Dam releases stipulated in the NOAA Fisheries Biological Opinion (1993, as revised in 1995) for the protection of winter-run Chinook salmon rearing and downstream passage is 3,250 cfs between October 1 and March 31. The minimum flow objective is applicable from December through March of the adult immigration period. Modeling output shows that the Flexible Purchase Alternative would not result in additional reductions below 3,250 cfs, relative to the Baseline Condition, throughout the December through March period. (See Appendix H pgs. 351-354.)

Table 9-10 Long-term Average Flow at Freeport Under Baseline and Flexible Purchase Alternative Conditions				
Month	**Monthly Mean Flow[1] (cfs)**		**Difference**	
	Baseline	**Flexible Purchase Alternative**	**(cfs)**	**(%)[2]**
Oct	11956	12044	88	0.7
Nov	14769	14783	14	0.1
Dec	24922	24927	5	0.0
Jan	33069	33071	2	0.0
Feb	39225	39226	1	0.0
Mar	34296	34299	3	0.0
Apr	25184	25665	481	1.9
May	19724	20076	352	1.8
Jun	18183	18533	350	1.9
Jul	17777	20919	3142	17.7
Aug	13762	15929	2167	15.7
Sep	13729	14373	644	4.7

[1] Based on 72 years modeled.
[2] Relative difference of the monthly long-term average.

Temperature-related Impacts on Winter-run Chinook Salmon Adult Immigration (December through July)

Long-term average water temperature in the Sacramento River at Freeport would not differ by more than 0.1°F during any month of the December through July period, relative to the Baseline Condition. (See Table 9-11.) Similarly, long-term average water temperatures in the Sacramento River at Bend Bridge and Jelly's Ferry would not differ during any month of the December through July period, as shown in Tables 9-12 and 9-13.

Table 9-11
Long-term Average Water Temperature in the Sacramento River at Freeport Under Baseline and Flexible Purchase Alternative Conditions

Month	Water Temperature[1] (ºF)		
	Baseline	Flexible Purchase Alternative	Difference (ºF)
Oct	60.1	60.1	0.0
Nov	52.5	52.5	0.0
Dec	46.0	45.9	-0.1
Jan	44.8	44.8	0.0
Feb	49.3	49.3	0.0
Mar	53.9	53.9	0.0
Apr	59.5	59.6	0.1
May	64.9	65.0	0.1
Jun	69.0	69.1	0.1
Jul	71.6	71.6	0.0
Aug	71.6	71.5	-0.1
Sep	68.4	68.3	-0.1

[1] Based on 69 years modeled.

Table 9-12
Long-term Average Water Temperature in the Sacramento River at Bend Bridge Under Baseline and Flexible Purchase Alternative Conditions

Month	Water Temperature[1] (ºF)		
	Baseline	Flexible Purchase Alternative	Difference (ºF)
Oct	53.6	53.6	0.0
Nov	51.0	51.0	0.0
Dec	47.0	47.0	0.0
Jan	44.9	44.9	0.0
Feb	48.3	48.3	0.0
Mar	52.1	52.1	0.0
Apr	54.5	54.5	0.0
May	54.6	54.6	0.0
Jun	54.6	54.6	0.0
Jul	54.6	54.6	0.0
Aug	56.8	56.8	0.0
Sep	55.8	55.8	0.0

[1] Based on 69 years modeled.

Table 9-13
Long-term Average Water Temperature in the Sacramento River at Jelly's Ferry Under Baseline and Flexible Purchase Alternative Conditions

Month	Water Temperature[1] (ºF)		
	Baseline	Flexible Purchase Alternative	Difference (ºF)
Oct	53.4	53.4	0.0
Nov	51.0	51.0	0.0
Dec	47.1	47.1	0.0
Jan	45.0	45.0	0.0
Feb	48.3	48.3	0.0
Mar	52.1	52.1	0.0
Apr	54.3	54.3	0.0
May	54.2	54.2	0.0
Jun	54.1	54.1	0.0
Jul	54.1	54.1	0.0
Aug	56.3	56.3	0.0
Sep	55.3	55.4	0.1

[1] Based on 69 years modeled.

The NOAA Fisheries Biological Opinion (1993, as revised in 1995) for winter-run Chinook salmon provides temperature requirements for Bend Bridge and Jelly's Ferry in the Sacramento River from April through October. The temperature criteria are applicable from April through July of the adult winter-run Chinook salmon immigration period (the most rigorous are maximum temperatures of 56°F from April through September and 60°F during October at Bend Bridge). As described above, the long-term average water temperatures in the Sacramento River modeled for the Flexible Purchase Alternative would not differ from those under the Baseline Condition at Bend Bridge and at Jelly's Ferry during all months of the April through July period. Monthly mean water temperatures in the Sacramento River at Bend Bridge under the Flexible Purchase Alternative would remain essentially equivalent to those under the Baseline Condition in 276 out of the 276 months included in the analysis. (See Appendix H pgs. 475-478.) Similarly, water temperatures at Jelly's Ferry under the Flexible Purchase Alternative also would remain essentially equivalent to the Baseline Condition in 276 out of the 276 months included in the analysis. (See Appendix H pgs. 463-466.) Further, while water temperatures at Bend Bridge would exceed 56°F in 32 out of 276 months modeled for the April through July period under the Baseline Condition, the Flexible Purchase Alternative would not result in additional occurrences in which Sacramento River water temperatures would exceed 56°F. (See Appendix H pgs. 471-478.)

Flow-related Impacts on Adult Winter-run Chinook Salmon Spawning, Egg Incubation, and Initial Rearing (April through August)

The long-term average flow in the Sacramento River below Keswick Dam under the Flexible Purchase Alternative would be within 0.9 percent of the flow under the Baseline Condition during all months of the April through August period, as shown in Table 9-9. In 344 of the 360 months simulated during this period, flow in the Sacramento River below Keswick Dam would be either essentially equivalent to or greater than flows under the Baseline Condition. (See Appendix H pgs. 355-359.)

Figure 9-6 through Figure 9-10 shows exceedance curves for the Sacramento River below Keswick Dam for the April through August period. The basis for development of these exceedance curves was the 1922-1993 period of record. These curves demonstrate that flows under the Flexible Purchase Alternative during April through August would be nearly identical to those under the Baseline Condition. There would be slight increases in simulated flows under the Flexible Purchase Alternative in July, and slight reductions in simulated flows under the Flexible Purchase Alternative during August, relative to the Baseline Condition.

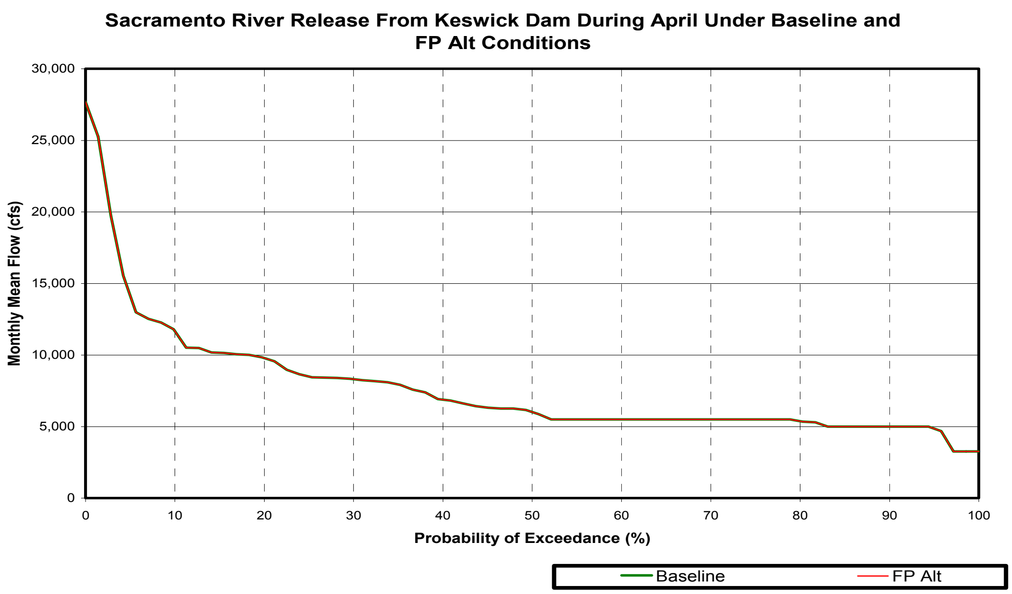

Figure 9-6
Sacramento River Release From Keswick Dam During April Under Baseline And Flexible Purchase Alternative Conditions

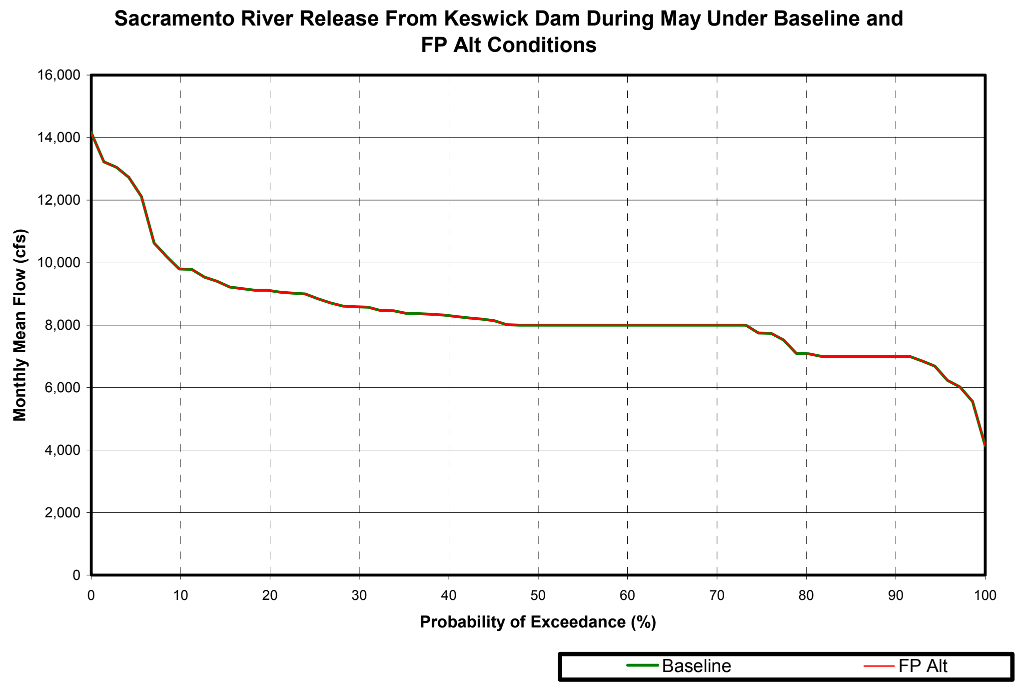

Figure 9-7
Sacramento River Release from Keswick Dam During May Under Baseline and Flexible Purchase Alternative Conditions

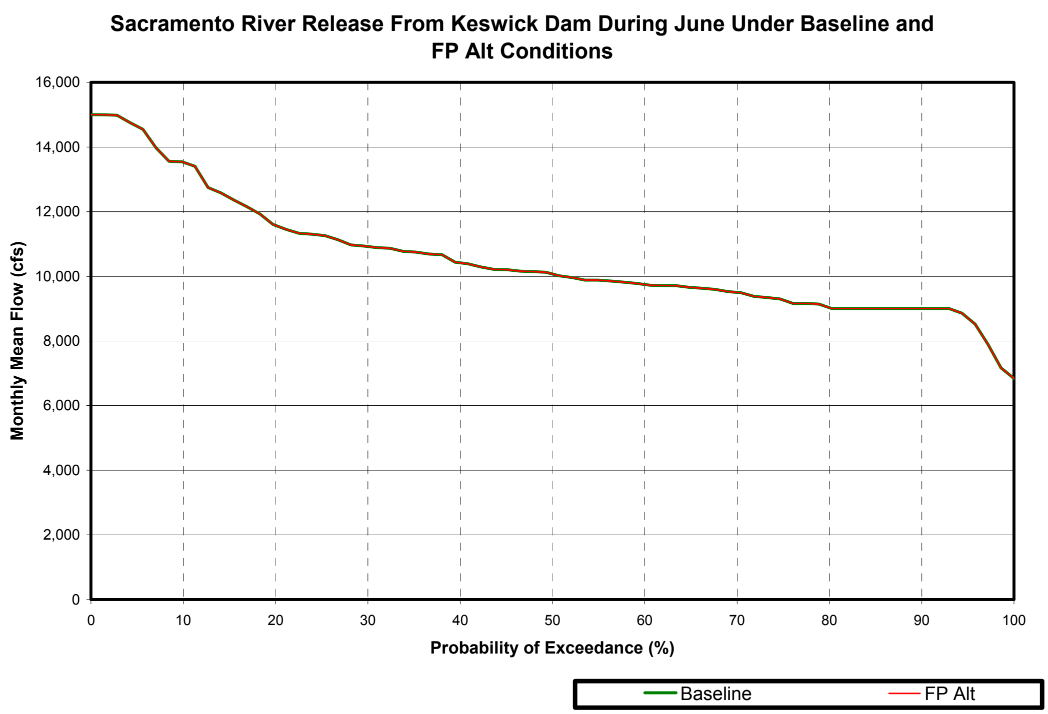

Figure 9-8
Sacramento River Release From Keswick Dam During June Under Baseline and Flexible Purchase Alternative Conditions

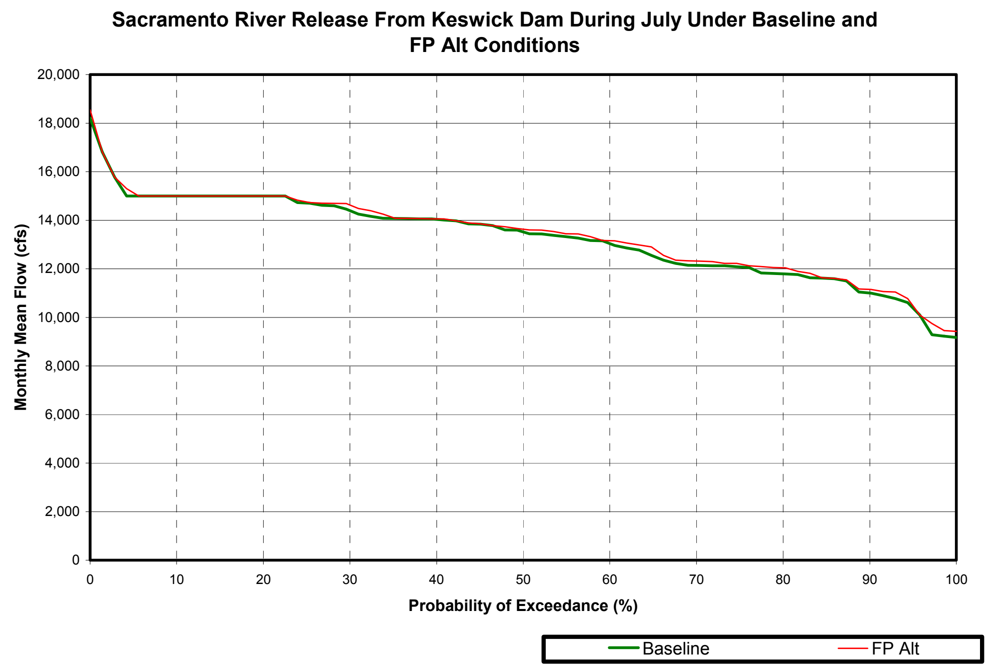

Figure 9-9
Sacramento River Release From Keswick Dam During July Under Baseline and Flexible Purchase Alternative Conditions

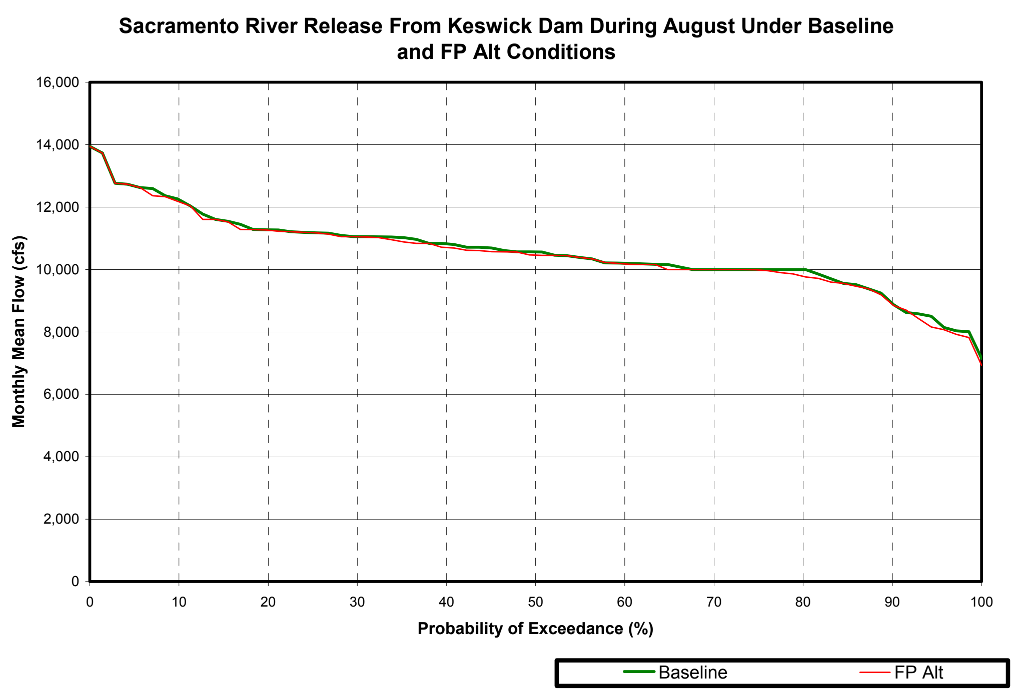

Figure 9-10
Sacramento River Release From Keswick Dam During August Under Baseline and Flexible Purchase Alternative Conditions

Temperature-related Impacts on Winter-run Chinook Salmon Spawning, Egg Incubation, and Initial Rearing (April through August)

Under the Flexible Purchase Alternative, the long-term average water temperatures would not differ from those under the Baseline Condition during the April through August period at Bend Bridge and at Jelly's Ferry, as shown in Tables 9-12 and 9-13. In fact, in 345 out of the 345 months included in the analysis, the water temperatures under the Flexible Purchase Alternative at these locations would be essentially equivalent to water temperatures under the Baseline Condition. (See Appendix H pgs. 463-467 and 475-479.)

Throughout the April through August period, Sacramento River water temperatures would not exceed NOAA Fisheries temperature criteria more frequently under the Flexible Purchase Alternative than under the Baseline Condition. Under the Flexible Purchase Alternative, there would not be any additional occurrences in which water temperatures at Bend Bridge in the Sacramento River under the Flexible Purchase Alternative would exceed 56°F, relative to the Baseline Condition. (See Appendix H pgs. 475-479.)

Table 9-14 shows the annual survival estimates for winter-run Chinook salmon in the Sacramento River for all 69 years modeled. The long-term average annual early lifestage survival for winter-run Chinook salmon in the Sacramento River would be 93.4 percent under the Baseline Condition and 93.4 percent under the Flexible Purchase Alternative. Substantial increases or decreases in survival would not occur in any individual year of the 69-year simulation. In five years under the Flexible Purchase Alternative, there would be slight reductions in annual early lifestage survival for winter-run Chinook salmon in the Sacramento River. However, the maximum relative reduction in annual early lifestage survival would be 0.1 percent, relative to the Baseline Condition. Potential reductions in annual early lifestage survival could have the greatest impact in years with low survival (dry or critically dry water years, including 1924, 1931, 1932, 1933, 1934, and 1977). However, implementation of the Flexible Purchase Alternative would not result in reductions in simulated annual early lifestage survival in those years, as shown in Table 9-14.

Table 9-14
Sacramento River Salmon Survival – Winter-run Chinook Salmon Under Baseline and Flexible Purchase Alternative Conditions

Water Year	Baseline Condition Survival (%)	Flexible Purchase Alternative Survival (%)	Absolute Difference (%)	Relative Difference (%)
1922	98.8	98.7	-0.1	-0.1
1923	95.8	95.8	0.0	0.0
1924	7.1	7.1	0.0	0.0
1925	98.3	98.3	0.0	0.0
1926	97.5	97.5	0.0	0.0
1927	99.2	99.2	0.0	0.0
1928	98.3	98.3	0.0	0.0
1929	99.1	99.1	0.0	0.0

Table 9-14
Sacramento River Salmon Survival – Winter-run Chinook Salmon Under Baseline and Flexible Purchase Alternative Conditions

Water Year	Baseline Condition Survival (%)	Flexible Purchase Alternative Survival (%)	Absolute Difference (%)	Relative Difference (%)
1930	96.8	96.8	0.0	0.0
1931	30.1	30.1	0.0	0.0
1932	67.6	67.6	0.0	0.0
1933	70.4	70.4	0.0	0.0
1934	29.0	29.0	0.0	0.0
1935	97.5	97.5	0.0	0.0
1936	95.4	95.4	0.0	0.0
1937	98.9	98.9	0.0	0.0
1938	98.2	98.2	0.0	0.0
1939	98.2	98.2	0.0	0.0
1940	98.6	98.6	0.0	0.0
1941	99.3	99.2	-0.1	-0.1
1942	98.9	98.9	0.0	0.0
1943	99.1	99.1	0.0	0.0
1944	98.5	98.5	0.0	0.0
1945	99.1	99.1	0.0	0.0
1946	99.3	99.3	0.0	0.0
1947	96.0	96.0	0.0	0.0
1948	98.7	98.7	0.0	0.0
1949	98.8	98.8	0.0	0.0
1950	98.8	98.8	0.0	0.0
1951	99.1	99.1	0.0	0.0
1952	99.1	99.1	0.0	0.0
1953	99.1	99.1	0.0	0.0
1954	99.5	99.5	0.0	0.0
1955	98.5	98.5	0.0	0.0
1956	98.6	98.6	0.0	0.0
1957	98.8	98.8	0.0	0.0
1958	98.7	98.7	0.0	0.0
1959	94.7	94.7	0.0	0.0
1960	97.9	97.9	0.0	0.0
1961	99.0	99.0	0.0	0.0
1962	98.6	98.6	0.0	0.0
1963	98.4	98.4	0.0	0.0
1964	99.2	99.2	0.0	0.0
1965	96.4	96.4	0.0	0.0
1966	99.2	99.2	0.0	0.0
1967	98.9	98.9	0.0	0.0
1968	98.9	98.9	0.0	0.0
1969	99.0	98.9	-0.1	-0.1
1970	98.6	98.6	0.0	0.0
1971	98.7	98.7	0.0	0.0
1972	99.4	99.4	0.0	0.0
1973	98.2	98.2	0.0	0.0
1974	98.2	98.1	-0.1	-0.1
1975	98.7	98.7	0.0	0.0
1976	98.1	98.1	0.0	0.0
1977	43.2	43.2	0.0	0.0
1978	96.5	96.5	0.0	0.0
1979	98.9	98.9	0.0	0.0
1980	99.4	99.4	0.0	0.0
1981	98.8	98.8	0.0	0.0

Table 9-14
Sacramento River Salmon Survival – Winter-run Chinook Salmon Under Baseline and Flexible Purchase Alternative Conditions

Water Year	Baseline Condition Survival (%)	Flexible Purchase Alternative Survival (%)	Absolute Difference (%)	Relative Difference (%)
1982	99.0	98.9	-0.1	-0.1
1983	99.5	99.5	0.0	0.0
1984	99.2	99.2	0.0	0.0
1985	99.1	99.1	0.0	0.0
1986	99.0	99.0	0.0	0.0
1987	99.2	99.2	0.0	0.0
1988	96.0	96.0	0.0	0.0
1989	99.0	99.0	0.0	0.0
1990	98.0	98.0	0.0	0.0
Mean:	93.4	93.4	0.0	0.0
Median:	98.7	98.7	0.0	0.0
Min:	7.1	7.1	-0.1	-0.1
Max:	99.5	99.5	0.0	0.0
Year Counts				
0.0 > X > = -1.0			5	5
-1.0 > X > = -2.0			0	0
-2.0 > X > = -4.0			0	0
-4.0 > X > = -6.0			0	0
X < -6.0			0	0
0.0 < X < = 1.0			0	0
1.0 < X < = 2.0			0	0
2.0 < X < = 4.0			0	0
4.0 < X < = 6.0			0	0
X > 6.0			0	0
No Difference (X = 0.0)			64	64

Flow-related Impacts on Juvenile Winter-run Chinook Salmon Rearing and Emigration (August through December)

Under the Flexible Purchase Alternative, the simulated long-term average flow below Keswick Dam would decrease, relative to the Baseline Condition, as shown in Table 9-9. Long-term average flows in the Sacramento River would decrease by up to 0.5 percent (58 cfs) in August, 0.2 percent (56 cfs) in September, and would increase by 0.9 percent (117 cfs) in July. In 356 out of the 360 months simulated for the Flexible Purchase Alternative, monthly mean flows in the Sacramento River below Keswick Dam would be essentially equivalent to those under the Baseline Condition. (See Appendix H pgs. 349-360.) In addition, flows would not be reduced below the 3,250 cfs flow criterion specified by the NOAA Fisheries winter-run Chinook salmon biological opinion more frequently under the Flexible Purchase Alternative compared to the Baseline Condition during the October through December period in which flow requirements must be maintained. (See Appendix H pgs. 349-360.) Long-term average flows in the Sacramento River at Freeport under the Flexible Purchase Alternative would be increased from August through October, and would not differ substantially during November and December, relative to flows under the Baseline Condition. (See Table 9-10.) In August and September, long-term average flows would increase by approximately 640 cfs to 2170 cfs (up to 15.7 percent). In 360 out of the 360 months modeled, monthly mean flows in the Sacramento River at Freeport under the Flexible Purchase Alternative would be essentially equivalent to or greater than flows simulated under the Baseline Condition. (See Appendix H pgs. 385-396.)

Temperature-related Impacts on Juvenile Winter-run Chinook Salmon Rearing and Emigration (August through December)

Long-term average water temperatures in the Sacramento River at Bend Bridge under the Flexible Purchase Alternative would not change during any month of the August through December period, relative to the Baseline Condition, as shown in Table 9-12. Monthly mean water temperatures at Bend Bridge in the Sacramento River would be essentially equivalent to those under the Baseline Condition in 343 months of the 345 months simulated for the August through December period. Further, monthly mean water temperatures under the Flexible Purchase Alternative would not exceed 65°F, the upper end of the suitable range of water temperatures for juvenile Chinook salmon, more frequently than under the Baseline Condition. (See Appendix H pgs. 469-480.) In fact, monthly mean water temperatures under the Baseline Condition and Flexible Purchase Alternative would remain below 65°F at this location for 339 of the 345 months included in the analysis.

Long-term average water temperatures in the Sacramento River at Jelly's Ferry under the Flexible Purchase Alternative would not change in August, October, November, and December, and would increase by 0.1°F in September, relative to the Baseline Condition, as shown in Table 9-13. Monthly mean water temperatures at Jelly's Ferry in the Sacramento River would be essentially equivalent to those under the Baseline Condition in 344 of the 345 months simulated for the August through December period. Further, monthly mean water temperatures under the Flexible Purchase Alternative would not exceed 65°F, the upper end of the suitable range of water temperatures for juvenile Chinook salmon, more frequently than under the Baseline Condition. In fact, monthly mean water temperatures under the Baseline Condition and Flexible Purchase Alternative would remain below 65°F at this location in 340 of the 345 months included in the analysis. (See Appendix H pgs. 457-468.)

NOAA Fisheries temperature criteria for winter-run Chinook salmon at Bend Bridge and Jelly's Ferry are applicable during August through October of the juvenile emigration period. Under the Flexible Purchase Alternative, there would not be any additional occurrences during August and September in which simulated monthly mean water temperatures in the Sacramento River at Bend Bridge would be above 56°F, relative to the Baseline Condition. (See Appendix H pgs. 479-480.) Similarly, at Jelly's Ferry in the Sacramento River, there would not be any additional occurrences during October when water temperatures would be greater than 60°F (the temperature criterion for Jelly's Ferry in October) during October, relative to the Baseline Condition. (See Appendix H pg. 457.)

Long-term average water temperatures in the Sacramento River at Freeport under the Flexible Purchase Alternative would not change during October and November, relative to the Baseline Condition, and would decrease 0.1°F during August, September, and December. (See Table 9-11.) Monthly mean water temperatures in the Sacramento River at Freeport would be essentially equivalent to or less than water temperatures under the Baseline Condition in 345 out of the 345 months modeled for the August through December period. (See Appendix H pgs. 481-492.) Further, water temperatures under the Flexible Purchase Alternative at this location would not exceed 65°F more frequently than under the Baseline Condition. (See Appendix H pgs. 481-492.)

Summary of Impacts on Sacramento River Winter-run Chinook Salmon

In summary, the increases in flow during the December through July period that would be expected to occur in the Sacramento River below Keswick Dam and at Freeport under the Flexible Purchase Alternative would not be of sufficient frequency or magnitude to beneficially or adversely affect attraction or passage of adult winter-run Chinook salmon immigrating into the Sacramento River. Changes in Sacramento River flows during the April through August period would not be of sufficient frequency or magnitude to beneficially or adversely affect spawning habitat availability and are not likely to beneficially or adversely impact long-term initial year-class strength. Although small flow reductions in the Sacramento River below Keswick Dam would occur in a few years during the August through December period, such changes would not be of sufficient frequency or magnitude to beneficially or adversely impact juvenile rearing and emigration.

Changes in Sacramento River water temperatures throughout the December through July period would not be of sufficient magnitude or frequency to beneficially or adversely affect adult immigration. Small temperature changes in the Sacramento River during the April through August period would not likely beneficially or adversely affect spawning, egg incubation, and initial rearing success. Changes in annual early lifestage survival would not be of sufficient magnitude to beneficially or adversely affect long-term initial year-class strength. Water temperature changes would not be of sufficient frequency or magnitude to beneficially or adversely affect juvenile rearing and emigration during the August through December period. Under the Flexible Purchase Alternative, there would be no additional occurrences, relative to the Baseline Condition, in which Sacramento River water temperatures would exceed the NOAA Fisheries Winter-run Chinook salmon BO temperature criterion.

The changes in flows and water temperatures in the Sacramento River that would occur under the Flexible Purchase Alternative, relative to the Baseline Condition, would not be of sufficient frequency or magnitude to beneficially or adversely affect winter-run Chinook salmon. Therefore, impacts on winter-run Chinook salmon in the Sacramento River with implementation of the Flexible Purchase Alternative would be less than significant, relative to the Baseline Condition.

Impacts on Spring-run Chinook Salmon in the Sacramento River

Flow-related Impacts on Adult Spring-run Chinook Salmon Immigration and Holding (March through September)

Table 9-9 shows that long-term average flows in the Sacramento River below Keswick Dam under the Flexible Purchase Alternative would be within 0.9 percent of flows under the Baseline Condition, during all months of the adult immigration period (March through September). In 468 out of the 504 months simulated during this period, monthly mean flows in the Sacramento River below Keswick Dam would be essentially equivalent to or greater than flows under the Baseline Condition . (See Appendix H pgs. 349-360.)

Long-term average flows in the Sacramento River at Freeport under the Flexible Purchase Alternative would not differ from flows under the Baseline Condition in March, and would increase by approximately 2 to 18 percent from April through September, relative to the Baseline Condition. (See Table 9-10.) Monthly mean flows in the Sacramento River at Freeport under the Flexible Purchase Alternative would be essentially equivalent to or greater than flows under the Baseline Condition in 504 out of the 504 months modeled for the March through September period. (See Appendix H pgs. 390-396.)

Temperature-related Impacts on Adult Spring-run Chinook Salmon Immigration and Holding (March through September)

Long-term average water temperatures in the Sacramento River at Bend Bridge under the Flexible Purchase Alternative would not differ from those under the Baseline Condition during the March through September period, as shown in Table 9-12. At Jelly's Ferry, long-term average water temperatures under the Flexible Purchase Alternative would not differ from the Baseline Condition from March through August, and would increase by 0.1°F during September. (See Table 9-13.) Monthly mean water temperatures at Bend Bridge and Jelly's Ferry would be essentially equivalent to those under the Baseline Condition in 481 and 482 months, respectively, of the 483 months simulated for the March through September period. (See Appendix H pgs. 474-480 and 462-468.)

Long-term average water temperatures during the March through September period in the Sacramento River at Freeport under the Flexible Purchase Alternative would not change in March and July, would increase by 0.1°F in April, May and June, and would decrease by 0.1°F in August and September. (See Table 9-11.) Further, monthly mean water temperatures in the Sacramento River at Freeport under the Flexible Purchase Alternative would be essentially equivalent to water temperatures under the Baseline Condition in all of the 483 months included in the analysis. (See Appendix H pgs. 486-492.)

Flow-related Impacts on Adult Spring-run Chinook Salmon Spawning, Egg Incubation, and Initial Rearing (August through January)

Long-term average flows in the Sacramento River below Keswick Dam under the Flexible Purchase Alternative would be within 0.8 percent of flows under the Baseline Condition during all months of the August through January period, as shown in Table 9-9. In 396 of the 432 months simulated during this period, Sacramento River flow below Keswick Dam would be essentially equivalent to flows under the Baseline Condition. (See Appendix H pgs. 349-360.)

Figures 9-10 through 9-15 show exceedance curves for the Sacramento River below Keswick Dam for the August through January period. The basis for development of these exceedance curves was the 1922-1993 period of record. These curves demonstrate that flows under the Flexible Purchase Alternative would be similar to those under the Baseline Condition at all flow ranges. The Flexible Purchase Alternative would result in only slight reductions in flows, relative to the Baseline Condition.

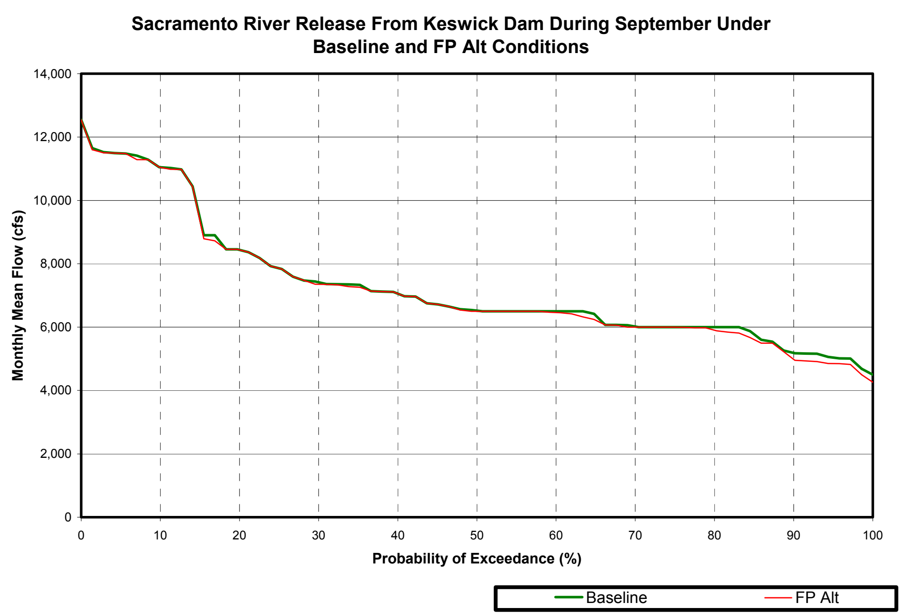

Figure 9-11
Sacramento River Release From Keswick Dam During September Under Baseline and Flexible Purchase Alternative Conditions

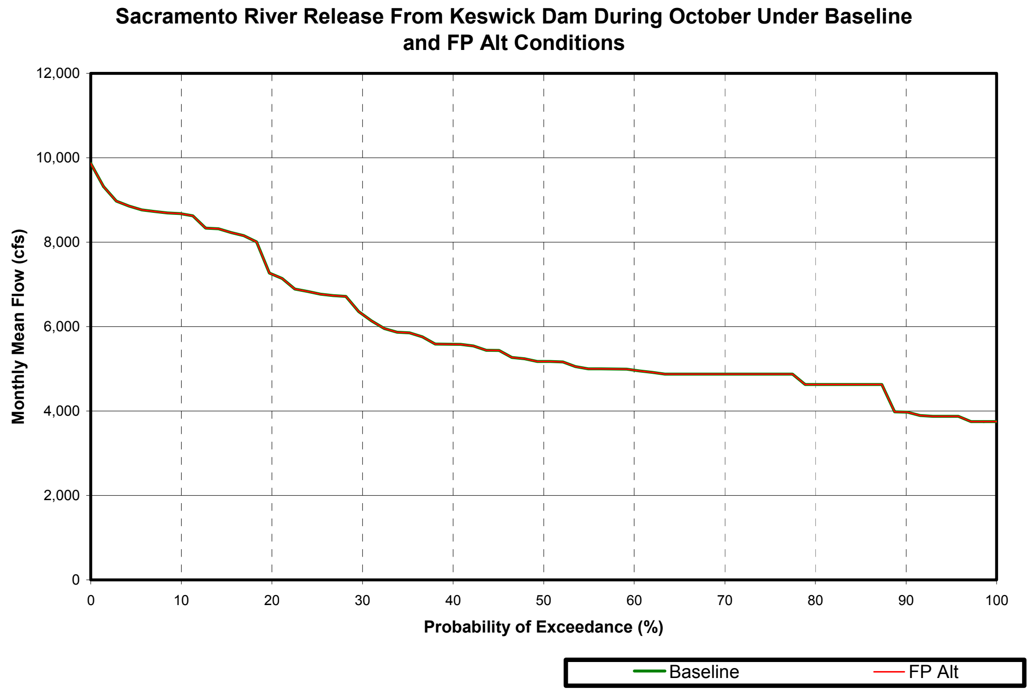

Figure 9-12
Sacramento River Release From Keswick Dam During October Under Baseline and Flexible Purchase Alternative Conditions

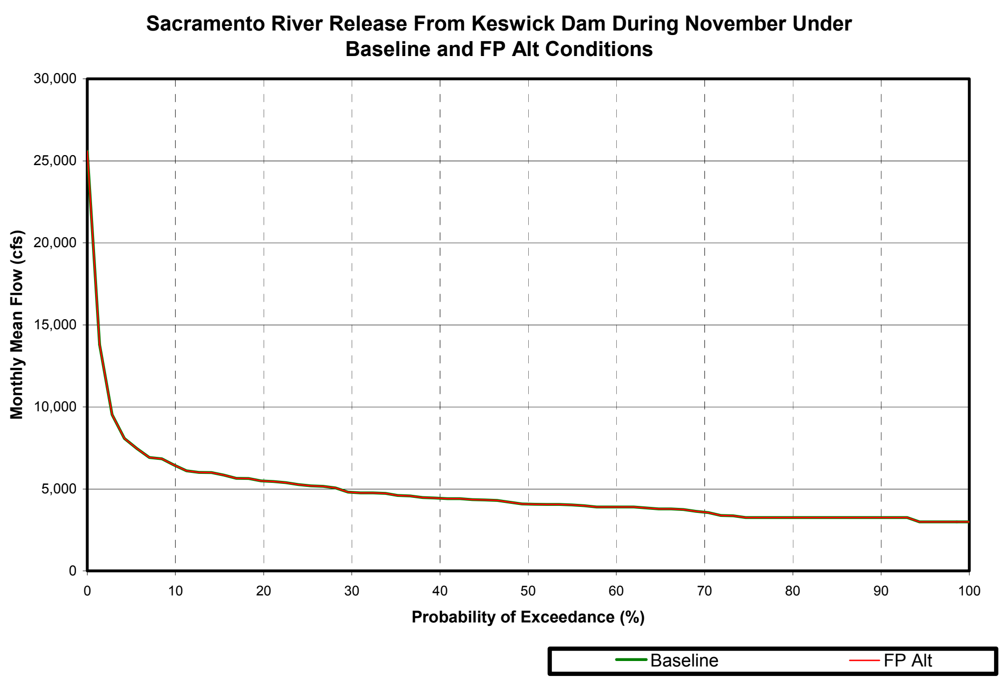

Figure 9-13
Sacramento River Release From Keswick Dam During November Under Baseline and Flexible Purchase Alternative Conditions

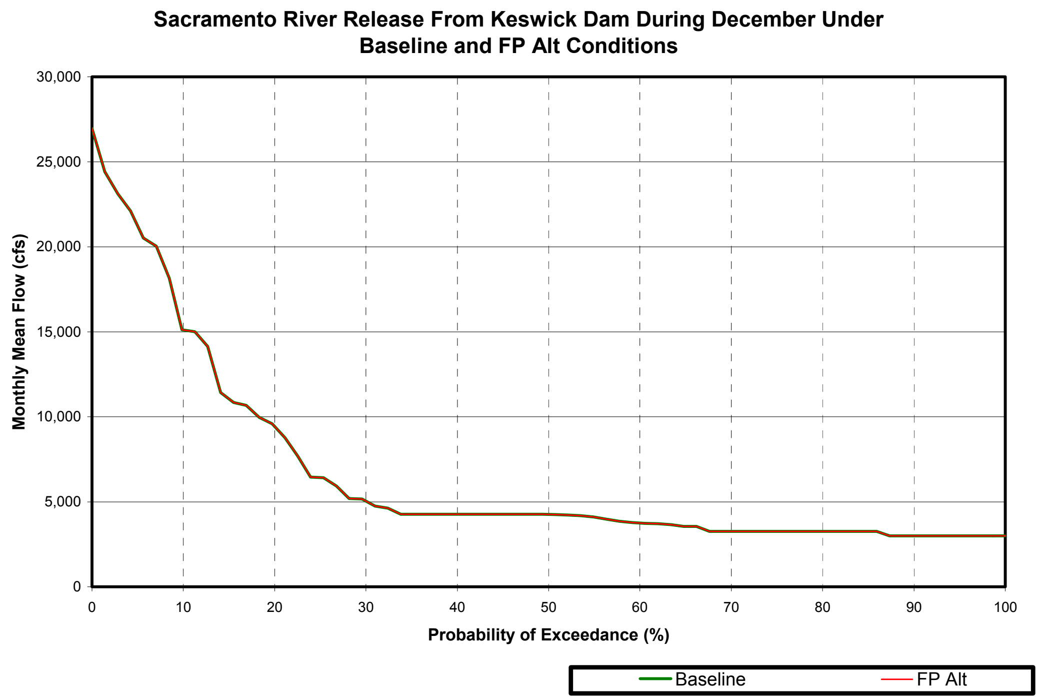

Figure 9-14
Sacramento River Release From Keswick Dam During December Under Baseline and Flexible Purchase Alternative Conditions

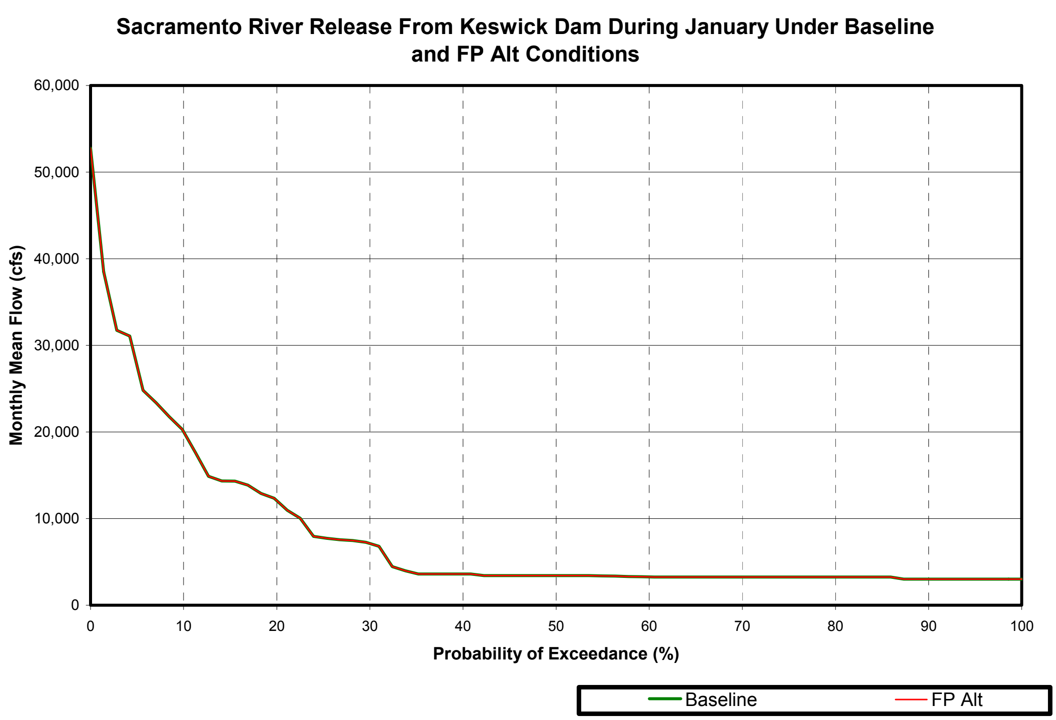

Figure 9-15
Sacramento River Release From Keswick Dam During January Under Baseline and Flexible Purchase Alternative Conditions

Temperature-related Impacts on Spring-run Chinook Salmon Spawning, Egg Incubation, and Initial Rearing (August through January)

Under the Flexible Purchase Alternative, long-term average water temperatures in the Sacramento River at Bend Bridge would not differ to those under the Baseline Condition in any month of the August through January period. (See Table 9-12.) In fact, in 412 of the 414 months included in the analysis, monthly mean water temperatures at Bend Bridge under the Flexible Purchase Alternative would be essentially equivalent to those under the Baseline Condition. (See Appendix H pgs. 457-468.) Further, there would not be any additional occurrences of water temperatures above 56°F under the Flexible Purchase Alternative, relative to the Baseline Condition, at Bend Bridge during the August through January period. (See Appendix H pgs. 457-468.)

Long-term average water temperatures under the Flexible Purchase Alternative at Jelly's Ferry in the Sacramento River would not change in August, October, November, December, and January, and would increase by 0.1°F in September, relative to the Baseline Condition. (See Table 9-13.) Monthly mean water temperatures at this location would be essentially equivalent to those under the Baseline Condition in 413 of the 414 months simulated for the August through January period. (See Appendix H pgs. 469-480.) In addition, implementation of the Flexible Purchase Alternative would not result in an increase in the frequency in which water temperatures would be above 65°F, relative to the Baseline Condition.

The long-term average annual early lifestage survival for spring-run Chinook salmon in the Sacramento River would be 87.5 percent under the Baseline Condition and 87.4 percent under the Flexible Purchase Alternative. Table 9-15 shows the annual survival estimates for spring-run Chinook salmon in the Sacramento River for the 69 years modeled. In 56 out of the 69 years modeled, there would be no difference in annual early lifestage survival of spring-run Chinook salmon between the Flexible Purchase Alternative and the Baseline Condition. In only 3 of 69 years, the relative decrease in survival would be greater than 0.1 percent. Such decreases in percent survival would range from 0.2 to 1.5 percent, relative to the Baseline Condition. Potential reductions in annual early lifestage survival could have the greatest impact in years with low survival (dry or critically dry water years, including 1924, 1931, 1932, 1933, 1934, and 1977). However, implementation of the Flexible Purchase Alternative would not result in reductions in simulated annual early lifestage survival in those years, as shown in Table 9-14.

Table 9-15
Sacramento River Salmon Survival – Spring-run Chinook Salmon Under Baseline and Flexible Purchase Alternative Conditions

Water Year	Baseline Condition Survival (%)	Flexible Purchase Alternative Survival (%)	Absolute Difference (%)	Relative Difference (%)
1922	97.0	97.0	0.0	0.0
1923	97.6	97.6	0.0	0.0
1924	5.3	5.3	0.0	0.0
1925	78.0	78.0	0.0	0.0
1926	73.9	73.9	0.0	0.0
1927	97.5	97.4	-0.1	-0.1
1928	96.8	96.8	0.0	0.0
1929	95.5	95.5	0.0	0.0
1930	97.1	97.1	0.0	0.0
1931	2.0	2.0	0.0	0.0
1932	0.4	0.4	0.0	0.0
1933	0.2	0.2	0.0	0.0
1934	1.9	1.9	0.0	0.0
1935	83.4	83.3	-0.1	-0.1
1936	92.5	91.1	-1.4	-1.5
1937	96.8	96.7	-0.1	-0.1
1938	96.6	96.6	0.0	0.0
1939	96.4	96.4	0.0	0.0
1940	97.3	97.3	0.0	0.0
1941	98.0	98.0	0.0	0.0
1942	97.4	97.4	0.0	0.0
1943	97.4	97.4	0.0	0.0
1944	95.6	95.4	-0.2	-0.2
1945	97.3	97.3	0.0	0.0
1946	98.4	98.4	0.0	0.0
1947	97.6	97.6	0.0	0.0
1948	96.4	96.3	-0.1	-0.1
1949	98.1	98.1	0.0	0.0
1950	97.2	97.2	0.0	0.0
1951	97.6	97.6	0.0	0.0
1952	97.2	97.1	-0.1	-0.1
1953	97.6	97.6	0.0	0.0
1954	97.6	97.6	0.0	0.0
1955	96.1	96.1	0.0	0.0
1956	96.9	96.9	0.0	0.0
1957	97.0	97.0	0.0	0.0
1958	96.6	96.5	-0.1	-0.1
1959	92.7	92.7	0.0	0.0
1960	95.9	95.9	0.0	0.0
1961	96.9	96.9	0.0	0.0
1962	96.2	96.2	0.0	0.0
1963	94.5	94.0	-0.5	-0.5
1964	96.4	96.4	0.0	0.0
1965	97.0	97.0	0.0	0.0
1966	97.1	97.1	0.0	0.0
1967	96.4	96.4	0.0	0.0
1968	96.4	96.4	0.0	0.0
1969	96.5	96.5	0.0	0.0

Table 9-15 Sacramento River Salmon Survival – Spring-run Chinook Salmon Under Baseline and Flexible Purchase Alternative Conditions				
Water Year	***Baseline Condition Survival (%)***	***Flexible Purchase Alternative Survival (%)***	***Absolute Difference (%)***	***Relative Difference (%)***
1970	96.5	96.5	0.0	0.0
1971	96.1	96.1	0.0	0.0
1972	97.0	97.0	0.0	0.0
1973	96.4	96.4	0.0	0.0
1974	96.1	96.0	-0.1	-0.1
1975	96.8	96.7	-0.1	-0.1
1976	92.3	92.3	0.0	0.0
1977	2.5	2.5	0.0	0.0
1978	96.3	96.2	-0.1	-0.1
1979	97.1	97.1	0.0	0.0
1980	97.5	97.5	0.0	0.0
1981	96.7	96.7	0.0	0.0
1982	97.0	96.9	-0.1	-0.1
1983	98.4	98.4	0.0	0.0
1984	97.0	97.0	0.0	0.0
1985	98.1	98.1	0.0	0.0
1986	97.6	97.6	0.0	0.0
1987	96.0	96.0	0.0	0.0
1988	92.7	92.7	0.0	0.0
1989	97.3	97.3	0.0	0.0
1990	88.8	88.8	0.0	0.0
Mean:	87.5	87.4	0.0	0.0
Median:	96.7	96.7	0.0	0.0
Min:	0.2	0.2	-1.4	-1.5
Max:	98.4	98.4	0.0	0.0
Year Counts				
0.0 > X > = -1.0			12	12
-1.0 > X > = -2.0			1	1
-2.0 > X > = -4.0			0	0
-4.0 > X > = -6.0			0	0
X < -6.0			0	0
0.0 < X < = 1.0			0	0
1.0 < X < = 2.0			0	0
2.0 < X < = 4.0			0	0
4.0 < X < = 6.0			0	0
X > 6.0			0	0
No Difference (X = 0.0)			56	56

Flow-related Impacts on Juvenile Spring-run Chinook Salmon Rearing and Emigration (December through April)

Under the Flexible Purchase Alternative, long-term average flows in the Sacramento River below Keswick Dam would not differ from flows modeled under the Baseline Condition during the December through April period. (See Table 9-9.) In 360 out of the 360 months simulated, monthly mean flows below Keswick Dam under the Flexible Purchase Alternative would be essentially equivalent to flows under the Baseline Condition. (See Appendix H pgs. 351-355.) Flow exceedance curves during the December through April period are shown for the Sacramento River below

Keswick Dam in Figure 9-16 through Figure 9-20. The basis for development of these exceedance curves was the 1922-1993 period of record. The flow exceedance curves indicate that flows below Keswick Dam under the Flexible Purchase Alternative would be nearly identical to flows under the Baseline Condition.

Long-term average flows in the Sacramento River at Freeport under the Flexible Purchase Alternative would be within approximately 2 percent of flows under the Baseline Condition throughout the December through April period. (See Table 9-10.) Monthly mean flows in the Sacramento River at Freeport under the Flexible Purchase Alternative would be essentially equivalent to or greater than flows under the Baseline Condition in 360 out of the 360 months modeled for the December through April period. (See Appendix H pgs. 387-391.)

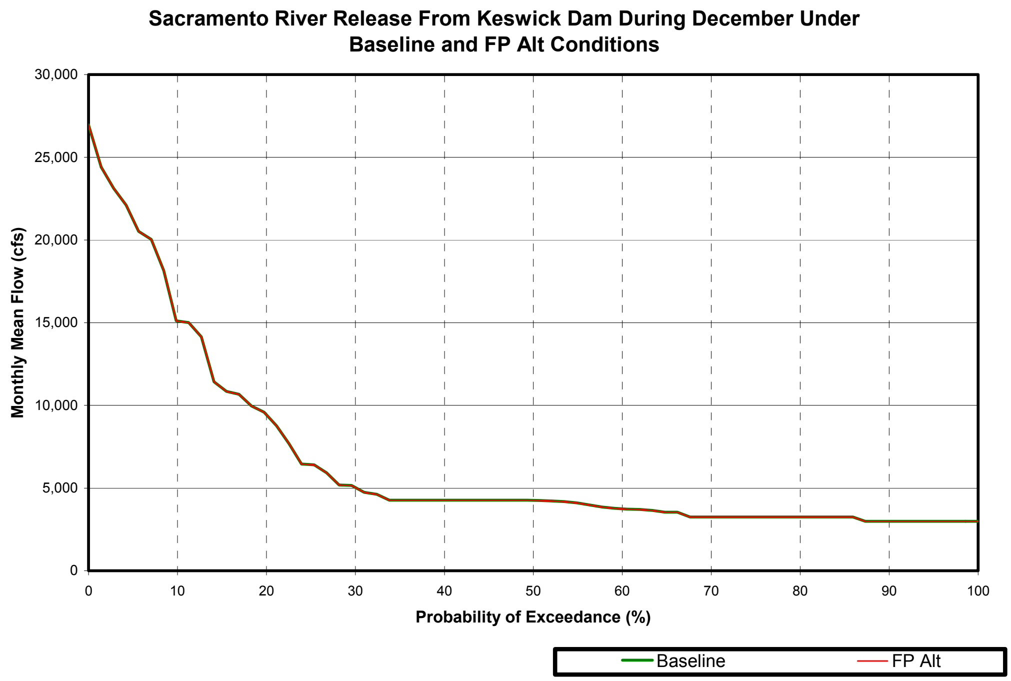

Figure 9-16
Sacramento River Release From Keswick Dam During December Under Baseline and Flexible Purchase Alternative Conditions

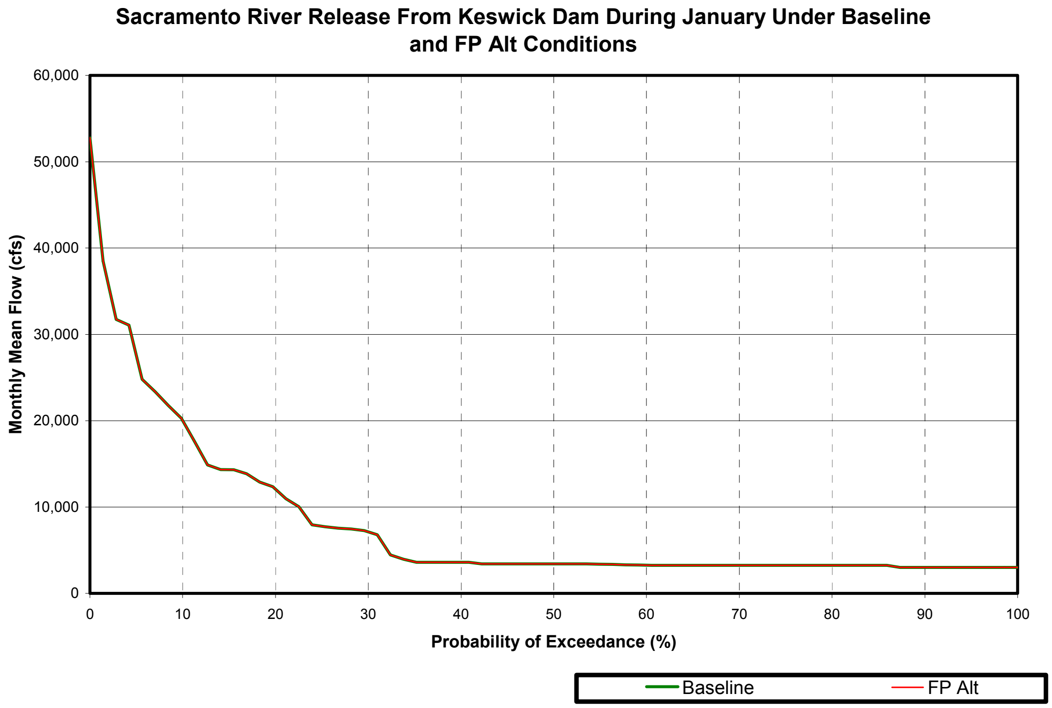

Figure 9-17
Sacramento River Release From Keswick Dam During January Under Baseline and Flexible Purchase Alternative Conditions

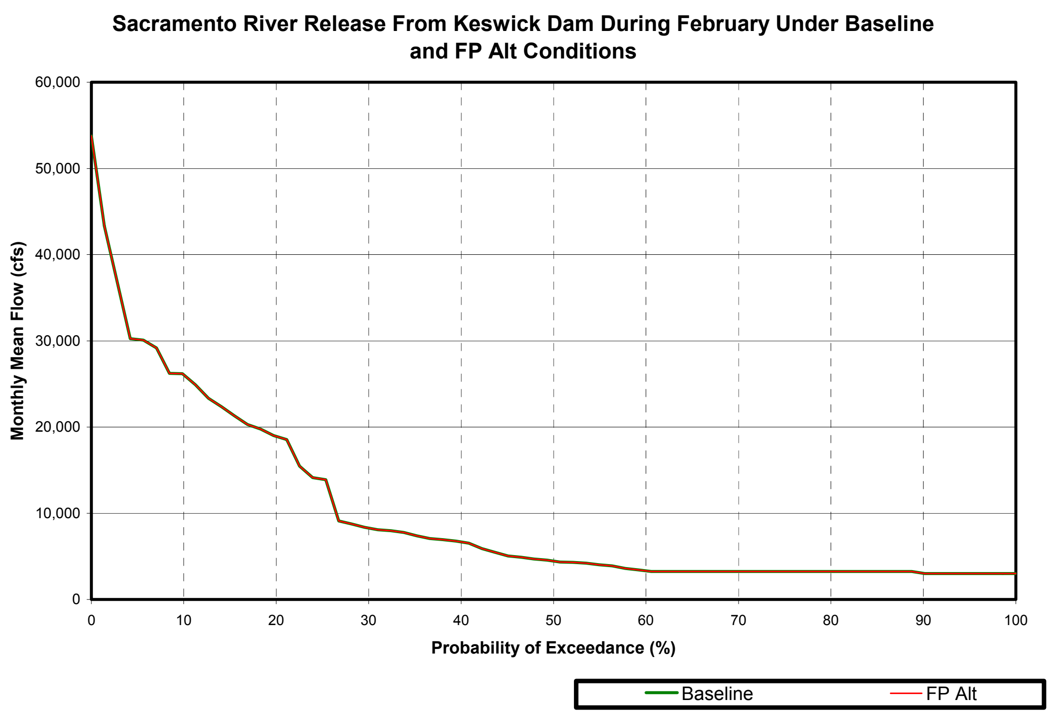

Figure 9-18
Sacramento River Release From Keswick Dam During February Under Baseline and Flexible Purchase Alternative Conditions

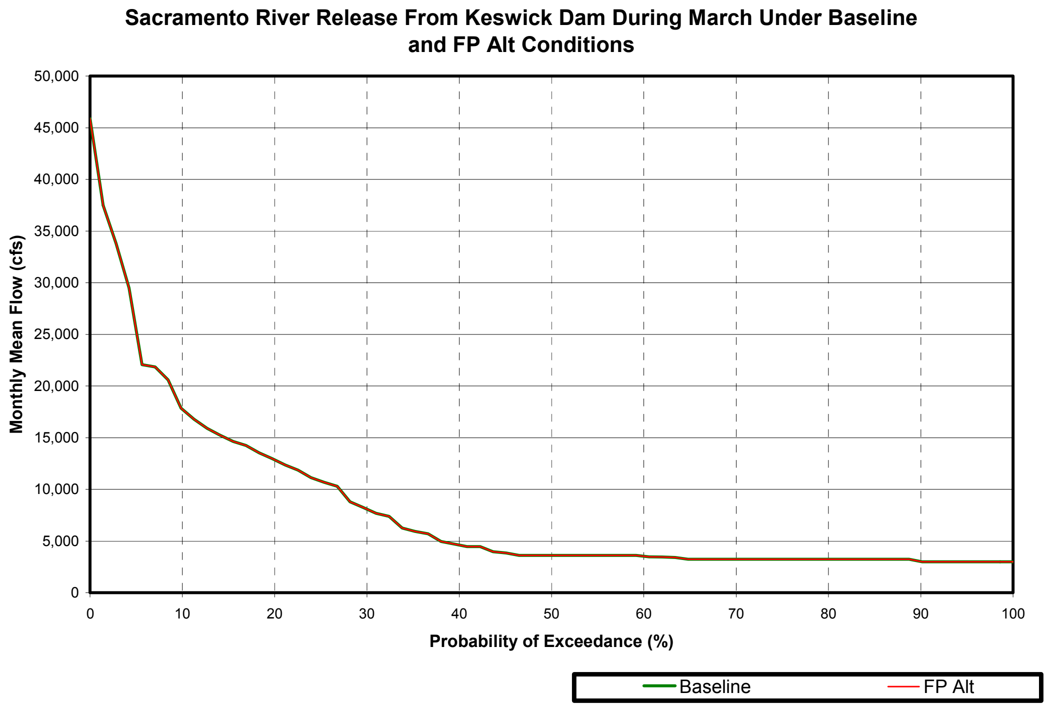

Figure 9-19
Sacramento River Release from Keswick Dam During March Under Baseline and Flexible Purchase Alternative Conditions

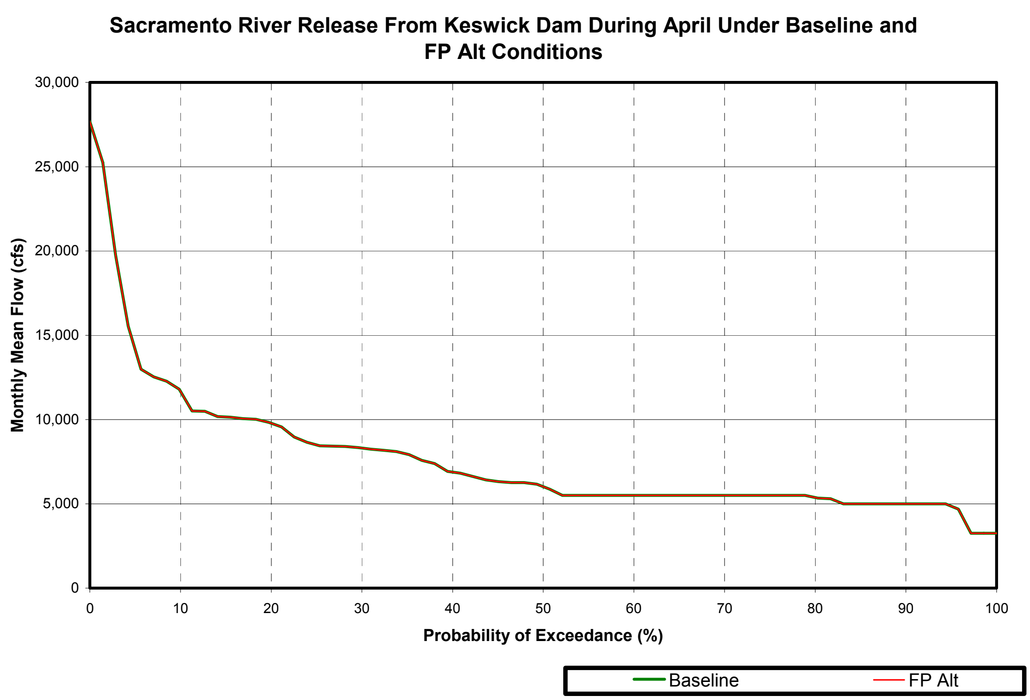

Figure 9-20
Sacramento River Release from Keswick Dam During April Under Baseline and Flexible Purchase Alternative Conditions

Overall, flows in the Sacramento River below Keswick Dam and at Freeport would not differ substantially under the Flexible Purchase Alternative, relative to the Baseline Condition.

Temperature-related Impacts on Juvenile Spring-run Chinook Salmon Rearing and Emigration (December through April)

Modeling associated with the Flexible Purchase Alternative indicates that long-term average water temperatures at Bend Bridge would not change during any month of the December through August period, compared to the Baseline Condition, as shown in Table 9-12. Further, monthly mean water temperatures in the Sacramento River at Bend Bridge under the Flexible Purchase Alternative would be essentially equivalent to those under the Baseline Condition in all of the 345 months simulated for the December through April period. (See Appendix H pgs. 471-475.) Further, the Flexible Purchase Alternative would not result in an increase in the frequency in which monthly mean water temperatures would exceed 65°F for each month of the December through April period. (See Appendix H pgs. 471-475.)

Long-term average water temperatures under the Flexible Purchase Alternative at Jelly's Ferry in the Sacramento River would not differ from those under the Baseline Condition throughout the December through April period, as shown in Table 9-13. Monthly mean water temperatures at this location under the Flexible Purchase Alternative would be essentially equivalent to those under the Baseline Condition in 345 out of the 345 months modeled for the December through April period. (See Appendix H pgs. 459-463.) Further, the Flexible Purchase Alternative would not result in an increase in the frequency in which monthly mean water temperatures would exceed 65°F at Jelly's Ferry in the Sacramento River, relative to the Baseline Condition, for a given month modeled throughout the juvenile rearing and emigration period. (See Appendix H pgs. 459-463.)

Similarly, long-term average water temperatures under the Flexible Purchase Alternative at Freeport in the Sacramento River would decrease by 0.1°F during December, would not change from January through March, and would increase by 0.1°F during April, relative to the Baseline Condition, as shown in Table 9-11. Monthly mean water temperatures at this location under the Flexible Purchase Alternative would be essentially equivalent to those under the Baseline Condition in 345 out of the 345 months modeled for the December through April period. (See Appendix H pgs. 483-487.) Further, the Flexible Purchase Alternative would not result in an increase in the frequency in which monthly mean water temperatures would exceed 65°F at Freeport in the Sacramento River, relative to the Baseline Condition, for a given month modeled throughout the juvenile rearing and emigration period. (See Appendix H pgs. 483-487.)

Overall, the Flexible Purchase Alternative would result in negligible changes in Sacramento River water temperatures at Bend Bridge, Jelly's Ferry, and Freeport throughout the December through April juvenile spring-run Chinook salmon rearing and emigration period. In addition, the frequency in which monthly mean water temperatures at Bend Bridge, Jelly's Ferry, or Freeport would exceed the upper end of the suitable range of water temperatures for juvenile Chinook salmon rearing would not increase under the Flexible Purchase Alternative.

Summary of Impacts on Spring-Run Chinook Salmon in the Sacramento River

In summary, the difference in Sacramento River flows below Keswick Dam and at Freeport during the March through September period that would occur under the Flexible Purchase Alternative would not be of sufficient frequency or magnitude to beneficially or adversely affect attraction, passage, and holding of adult spring-run Chinook salmon immigrating into the Sacramento River. Similarly, changes in flow in the Sacramento River under the Flexible Purchase Alternative would not be of sufficient frequency or magnitude to beneficially or adversely affect spawning, egg incubation, and initial rearing during the August through January period. Slight increases in flow that would occur under the Flexible Purchase Alternative would not be of sufficient frequency or magnitude to beneficially or adversely affect juvenile rearing and emigration during the December through April period.

Changes in Sacramento River water temperatures under the Flexible Purchase Alternative during the March through September period would not be of sufficient frequency or magnitude to beneficially or adversely affect adult spring-run Chinook salmon immigration and holding. Potential water temperature changes during the August through January period in the Sacramento River resulting from the implementation of the Flexible Purchase Alternative may affect, but are not likely to adversely affect, adult spring-run Chinook salmon spawning, egg incubation, and initial rearing. Changes in annual early lifestage survival under the Flexible Purchase Alternative would not be of sufficient magnitude to beneficially or adversely impact initial year-class strength of spring-run Chinook salmon in the Sacramento River. Changes in water temperatures under the Flexible Purchase Alternative would not be of sufficient frequency or magnitude to beneficially or adversely affect juvenile spring-run Chinook salmon rearing and emigration.

Overall, the changes in flows and water temperatures in the Sacramento River under the Flexible Purchase Alternative, relative to the baseline, would not be of sufficient frequency or magnitude to beneficially or adversely impact spring-run Chinook salmon. Therefore, impacts on spring-run Chinook salmon in the Sacramento River with implementation of the Flexible Purchase Alternative, relative to the Baseline Condition, would be less than significant.

<u>Impacts on Fall-run Chinook Salmon and Steelhead in the Sacramento River</u>

Flow-related Impacts on Adult Fall-run Chinook Salmon/Steelhead Immigration (September through November)

Table 9-9 shows that long-term average flows in the Sacramento River below Keswick Dam would differ by less than 0.8 percent (56 cfs) under the Flexible Purchase

Alternative, compared to the Baseline Condition, during all months of the adult immigration period (September through November). Under the Flexible Purchase Alternative, Sacramento River flows below Keswick Dam would be essentially equivalent to those under the Baseline Condition in 200 out of the 216 months simulated during this period. (See Appendix H pgs. 349-360.)

Long-term average flows under the Flexible Purchase Alternative in the Sacramento River at Freeport would be within one percent of flows under the Baseline Condition in October and November, and would increase by approximately 5 percent in September, relative to the Baseline Condition. (See Table 9-10.) Monthly mean flows under the Flexible Purchase Alternative would be essentially equivalent to or greater than flows under the Baseline Condition in 216 out of the 216 months modeled for the September through November period. (See Appendix H pgs. 385-396.)

Temperature-related Impacts on Adult Fall-run Chinook Salmon/Steelhead Immigration (September through November)

Long-term average water temperatures modeled for the Flexible Purchase Alternative would not differ from those under the Baseline Condition at Bend Bridge in the Sacramento River during all months of the September through November adult immigration period, as shown in Table 9-12. At Jelly's Ferry, long-term average water temperatures in the Sacramento River would not differ between the Flexible Purchase Alternative and Baseline Condition during October and November. (See Table 9-13.) In September, long-term average water temperatures at Jelly's Ferry would be 0.1°F greater under the Flexible Purchase Alternative than under the Baseline Condition. Moreover, under the Flexible Purchase Alternative, monthly mean water temperatures in the Sacramento River at Bend Bridge would remain essentially equivalent to those under the Baseline Condition in 205 out of the 207 months included in the analysis. (See Appendix H pgs. 469-480.) Monthly mean water temperatures at Jelly's Ferry under the Flexible Purchase Alternative would remain essentially equivalent to the Baseline Condition in 206 out of the 207 months included in the analysis. (Appendix H pgs. 457-468.)

Long-term average water temperatures under the Flexible Purchase Alternative at Freeport in the Sacramento River would be nearly identical to those under the Baseline Condition throughout the September through November period, as shown in Table 9-11. In fact, long-term average water temperatures under the Flexible Purchase Alternative at Freeport in the Sacramento River would decrease by 0.1°F in September, and would not change in October and November, relative to the Baseline Condition. Monthly mean water temperatures at this location under the Flexible Purchase Alternative would be essentially equivalent to those under the Baseline Condition in 207 out of the 207 months modeled for the September through November period. (See Appendix H pgs. 481-492.) Further, the Flexible Purchase Alternative would not result in an increase in the frequency in which monthly mean water temperatures would exceed 65°F at Freeport in the Sacramento River, relative to the Baseline Condition, for a given month simulated for the adult fall-run Chinook salmon and steelhead immigration period.

Flow-related Impacts on Adult Fall-run Chinook Salmon Spawning, Egg Incubation, and Initial Rearing (October through February)

Long-term average flows in the Sacramento River below Keswick Dam under the Flexible Purchase Alternative would not differ from flows under the Baseline Condition during all months of the October through February period, as shown in Table 9-9. Monthly mean flows under the Flexible Purchase Alternative would be essentially equivalent to flows under the Baseline Condition in 360 out of the 360 months simulated for the October through February period. (See Appendix H pgs. 349-353.)

Figure 9-12 through Figure 9-14, Figure 9-17, and Figure 9-21 show exceedance curves for the Sacramento River below Keswick Dam for the October through February period. The basis for development of these exceedance curves was the 1922-1993 period of record. These curves demonstrate that flows under the Flexible Purchase Alternative would be essentially identical to those under the Baseline Condition. Therefore, changes in flow that could potentially reduce the amount of available Chinook salmon spawning habitat would not be expected to occur under the Flexible Purchase Alternative, relative to the Baseline Condition.

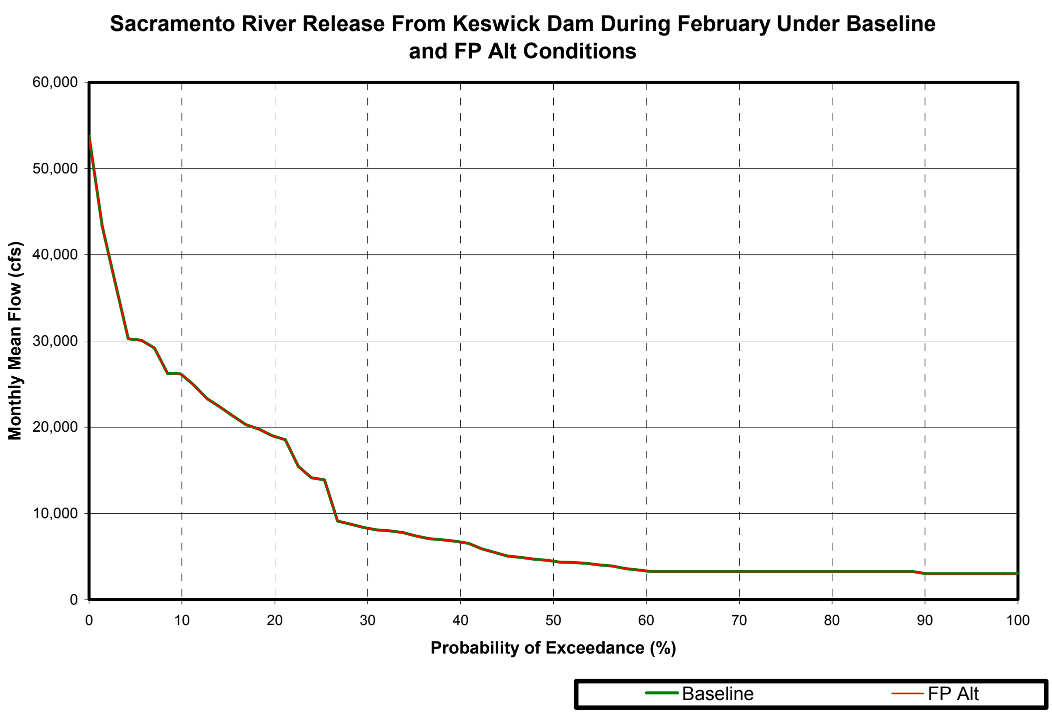

Figure 9-21
Sacramento River Release From Keswick Dam During February Under Baseline and Flexible Purchase Alternative Conditions

Temperature-related Impacts on Adult Fall-run Chinook Salmon Spawning, Egg Incubation, and Initial Rearing (October through February)

Under the Flexible Purchase Alternative, long-term average water temperatures would not differ from those modeled under the Baseline Condition during the October through February period at Bend Bridge and Jelly's Ferry, as shown in Tables 9-12 and 9-18. In fact, in 345 out of the 345 months included in the analysis, monthly mean water temperatures at these locations under the Flexible Purchase Alternative would be essentially equivalent to those under the Baseline Condition. (See Appendix H pgs. 457-461 and 469-473.) In addition, there would not be any additional occurrences in the Sacramento River at Bend Bridge or Jelly's Ferry of monthly mean water temperatures greater than 56°F, relative to the Baseline Condition, in any month simulated for the October through February period. (See Appendix H pgs. 457-461 and 469-473.) Further, water temperatures at Bend Bridge and Jelly's Ferry during December, January, and February would be below 56°F in all 69 years modeled under both the Flexible Purchase Alternative and Baseline Condition. (See Appendix H pgs. 457-461 and 469-473.)

The long-term average annual early lifestage survival for fall-run Chinook salmon in the Sacramento River would be 91.2 percent under the Baseline Condition and 91.1 percent under the Flexible Purchase Alternative. Table 9-16 shows the annual survival estimates for each year of the 69 years modeled. Under the Flexible Purchase Alternative, annual early lifestage survival would not change in 56 of the 69 years simulated, relative to the Baseline Condition. Reductions in annual early lifestage survival of 0.1 to 0.7 percent, relative to the Baseline Condition, would occur in 11 years of the 69-year simulation. In 8 of these years, reductions in survival would be 0.1 percent, relative to the Baseline Condition, and in 3 years, reductions in survival of 0.2 percent, 0.3 percent, and 0.7 percent would occur. In addition, increases in survival of 0.1 percent, relative to the Baseline Condition, would occur in 3 of the 69 years simulated. Potential reductions in annual early lifestage survival could have the greatest impact in years with low survival (dry or critically dry water years, including 1924, 1931, 1932, 1933, 1934, and 1977). However, implementation of the Flexible Purchase Alternative would not result in reductions in simulated annual early lifestage survival in those years, as shown in Table 9-14.

Table 9-16
Sacramento River Salmon Survival – Fall-run Chinook Salmon Under Baseline and Flexible Purchase Alternative Conditions

Water Year	Baseline Condition Survival (%)	Flexible Purchase Alternative Survival (%)	Absolute Difference (%)	Relative Difference (%)
1922	95.8	95.8	0.0	0.0
1923	92.9	92.9	0.0	0.0
1924	72.3	72.3	0.0	0.0
1925	78.6	78.6	0.0	0.0
1926	74.9	74.9	0.0	0.0
1927	96.3	96.2	-0.1	-0.1
1928	95.9	95.9	0.0	0.0
1929	83.1	83.1	0.0	0.0
1930	94.1	94.1	0.0	0.0

Table 9-16 Sacramento River Salmon Survival – Fall-run Chinook Salmon Under Baseline and Flexible Purchase Alternative Conditions				
Water Year	Baseline Condition Survival (%)	Flexible Purchase Alternative Survival (%)	Absolute Difference (%)	Relative Difference (%)
1931	66.7	66.7	0.0	0.0
1932	61.8	61.8	0.0	0.0
1933	59.9	59.9	0.0	0.0
1934	65.9	65.9	0.0	0.0
1935	80.0	79.9	-0.1	-0.1
1936	80.7	80.1	-0.6	-0.7
1937	96.4	96.4	0.0	0.0
1938	96.7	96.7	0.0	0.0
1939	88.8	88.8	0.0	0.0
1940	96.1	96.1	0.0	0.0
1941	98.4	98.4	0.0	0.0
1942	98.0	98.0	0.0	0.0
1943	95.5	95.5	0.0	0.0
1944	92.7	92.5	-0.2	-0.2
1945	94.8	94.8	0.0	0.0
1946	97.9	97.9	0.0	0.0
1947	93.6	93.6	0.0	0.0
1948	96.0	95.9	-0.1	-0.1
1949	97.8	97.8	0.0	0.0
1950	97.2	97.2	0.0	0.0
1951	97.0	97.0	0.0	0.0
1952	98.2	98.2	0.0	0.0
1953	98.1	98.1	0.0	0.0
1954	96.3	96.3	0.0	0.0
1955	93.5	93.5	0.0	0.0
1956	98.4	98.4	0.0	0.0
1957	95.2	95.3	0.1	0.1
1958	94.5	94.5	0.0	0.0
1959	80.0	80.0	0.0	0.0
1960	93.2	93.2	0.0	0.0
1961	94.2	94.2	0.0	0.0
1962	91.7	91.8	0.1	0.1
1963	93.4	93.1	-0.3	-0.3
1964	92.9	92.9	0.0	0.0
1965	95.1	95.1	0.0	0.0
1966	94.1	94.1	0.0	0.0
1967	95.8	95.8	0.0	0.0
1968	94.6	94.5	-0.1	-0.1
1969	97.5	97.5	0.0	0.0
1970	95.8	95.8	0.0	0.0
1971	97.6	97.6	0.0	0.0
1972	96.0	96.0	0.0	0.0
1973	96.7	96.7	0.0	0.0
1974	97.6	97.6	0.0	0.0
1975	96.7	96.7	0.0	0.0
1976	89.2	89.2	0.0	0.0
1977	66.8	66.8	0.0	0.0
1978	94.3	94.3	0.0	0.0
1979	95.1	95.1	0.0	0.0

Table 9-16
Sacramento River Salmon Survival – Fall-run Chinook Salmon Under Baseline and Flexible Purchase Alternative Conditions

Water Year	Baseline Condition Survival (%)	Flexible Purchase Alternative Survival (%)	Absolute Difference (%)	Relative Difference (%)
1980	96.2	96.2	0.0	0.0
1981	95.7	95.7	0.0	0.0
1982	97.4	97.3	-0.1	-0.1
1983	97.6	97.5	-0.1	-0.1
1984	96.1	96.0	-0.1	-0.1
1985	97.8	97.9	0.1	0.1
1986	96.9	96.8	-0.1	-0.1
1987	94.8	94.8	0.0	0.0
1988	83.0	83.0	0.0	0.0
1989	95.8	95.8	0.0	0.0
1990	81.0	81.0	0.0	0.0
Mean:	91.2	91.1	0.0	0.0
Median:	95.2	95.3	0.0	0.0
Min:	59.9	59.9	-0.6	-0.7
Max:	98.4	98.4	0.1	0.1
Year Counts				
0.0 > X >= -1.0			11	11
-1.0 > X >= -2.0			0	0
-2.0 > X >= -4.0			0	0
-4.0 > X >= -6.0			0	0
X < -6.0			0	0
0.0 < X <= 1.0			3	3
1.0 < X <= 2.0			0	0
2.0 < X <= 4.0			0	0
4.0 < X <= 6.0			0	0
X > 6.0			0	0
No Difference (X = 0.0)			55	55

Flow- and Temperature-related Impacts on Adult Steelhead Immigration, Spawning, and Egg Incubation (December through March)

Monthly mean flows below Keswick Dam and at Freeport in the Sacramento River under the Flexible Purchase Alternative would be essentially equivalent to flows under the Baseline Condition for 288 out of the 288 months simulated for the December through March period. (See Appendix H pgs. 351-354 and 387-390.) Additionally, monthly mean water temperatures under the Flexible Purchase Alternative at Bend Bridge and Jelly's Ferry would be essentially equivalent to water temperatures under the Baseline Condition for 276 of the 276 months included in the analysis. (See Appendix H pgs. 471-474 and 459-462.) Monthly mean water temperatures at Freeport under the Flexible Purchase Alternative would be essentially equivalent to water temperatures under the Baseline Condition in 276 out of the 276 months simulated during the December through March period. (See Appendix H pgs. 483-486.) Under the Flexible Purchase Alternative, the frequency in which water temperatures at Bend Bridge or Jelly's Ferry in the Sacramento River would exceed 56°F would not increase, relative to the Baseline Condition, throughout the December through March period. (See Appendix H pgs. 471-474 and 459-462.)

Steelhead survival cannot be estimated under the Flexible Purchase Alternative or Baseline Condition, because a steelhead mortality model has not been developed for the Sacramento River. However, as discussed in Section 9.2.1.2.1, output from the LSALMON 2 model for late-fall run Chinook salmon can be used as a conservative surrogate for steelhead survival estimates. For late-fall run Chinook salmon in the Sacramento River, the long-term average annual early lifestage survival would be 99.3 percent under both the Baseline Condition and Flexible Purchase Alternative. Table 9-17 shows the annual survival estimates for late-fall-run Chinook salmon in the Sacramento River for the 69 years modeled. Substantial increases or decreases in survival would not occur in any individual year of the 69-year simulation, relative to the Baseline Condition. In 67 out of the 69 years modeled, there would be no difference in annual early lifestage survival of late-fall-run Chinook salmon between the Flexible Purchase Alternative and the Baseline Condition. In the two years in which changes in annual early lifestage survival would occur, there would be one reduction in survival of 0.1 percent, as well as one increase in survival of 0.1 percent, relative to the Baseline Condition. Thus, decreases in late-fall run Chinook salmon survival under the Flexible Purchase Alternative would be negligible, relative to the Baseline Condition.

Table 9-17
Sacramento River Salmon Survival – Late-fall-run Chinook Salmon Under Baseline and Flexible Purchase Alternative Conditions

Water Year	*Baseline Condition Survival (%)*	*Flexible Purchase Alternative Survival (%)*	*Absolute Difference (%)*	*Relative Difference (%)*
1922	99.7	99.7	0.0	0.0
1923	99.0	99.0	0.0	0.0
1924	99.2	99.2	0.0	0.0
1925	99.1	99.1	0.0	0.0
1926	98.2	98.2	0.0	0.0
1927	99.9	99.9	0.0	0.0
1928	99.4	99.4	0.0	0.0
1929	97.4	97.4	0.0	0.0
1930	99.3	99.3	0.0	0.0
1931	98.6	98.6	0.0	0.0
1932	96.7	96.7	0.0	0.0
1933	96.9	96.9	0.0	0.0
1934	96.6	96.7	0.1	0.1
1935	98.3	98.3	0.0	0.0
1936	97.3	97.3	0.0	0.0
1937	99.7	99.7	0.0	0.0
1938	99.4	99.3	-0.1	-0.1
1939	98.5	98.5	0.0	0.0
1940	99.5	99.5	0.0	0.0
1941	99.9	99.9	0.0	0.0
1942	99.9	99.9	0.0	0.0
1943	99.7	99.7	0.0	0.0
1944	99.8	99.8	0.0	0.0
1945	99.8	99.8	0.0	0.0
1946	99.7	99.7	0.0	0.0
1947	99.2	99.2	0.0	0.0

Table 9-17
Sacramento River Salmon Survival – Late-fall-run Chinook Salmon Under Baseline and Flexible Purchase Alternative Conditions

Water Year	Baseline Condition Survival (%)	Flexible Purchase Alternative Survival (%)	Absolute Difference (%)	Relative Difference (%)
1948	99.9	99.9	0.0	0.0
1949	99.3	99.3	0.0	0.0
1950	99.6	99.6	0.0	0.0
1951	99.7	99.7	0.0	0.0
1952	99.9	99.9	0.0	0.0
1953	100.0	100.0	0.0	0.0
1954	99.9	99.9	0.0	0.0
1955	99.6	99.6	0.0	0.0
1956	99.8	99.8	0.0	0.0
1957	99.7	99.7	0.0	0.0
1958	97.3	97.3	0.0	0.0
1959	96.7	96.7	0.0	0.0
1960	99.8	99.8	0.0	0.0
1961	99.7	99.7	0.0	0.0
1962	99.5	99.5	0.0	0.0
1963	99.4	99.4	0.0	0.0
1964	99.9	99.9	0.0	0.0
1965	99.7	99.7	0.0	0.0
1966	99.5	99.5	0.0	0.0
1967	99.8	99.8	0.0	0.0
1968	99.7	99.7	0.0	0.0
1969	99.9	99.9	0.0	0.0
1970	99.6	99.6	0.0	0.0
1971	99.9	99.9	0.0	0.0
1972	99.8	99.8	0.0	0.0
1973	99.2	99.2	0.0	0.0
1974	99.7	99.7	0.0	0.0
1975	99.8	99.8	0.0	0.0
1976	98.9	98.9	0.0	0.0
1977	98.6	98.6	0.0	0.0
1978	99.7	99.7	0.0	0.0
1979	99.6	99.6	0.0	0.0
1980	99.9	99.9	0.0	0.0
1981	99.4	99.4	0.0	0.0
1982	99.5	99.5	0.0	0.0
1983	99.9	99.9	0.0	0.0
1984	99.7	99.7	0.0	0.0
1985	99.4	99.4	0.0	0.0
1986	99.8	99.8	0.0	0.0
1987	99.8	99.8	0.0	0.0
1988	99.2	99.2	0.0	0.0
1989	99.6	99.6	0.0	0.0
1990	98.9	98.9	0.0	0.0
Mean:	99.3	99.3	0.0	0.0
Median:	99.6	99.6	0.0	0.0
Min:	96.6	96.7	-0.1	-0.1
Max:	100.0	100.0	0.1	0.1
Year Counts				
0.0 > X >= -1.0			1	1
> X >= -2.0			0	0
> X >= -4.0			0	0

Table 9-17 Sacramento River Salmon Survival – Late-fall-run Chinook Salmon Under Baseline and Flexible Purchase Alternative Conditions				
Water Year	**Baseline Condition Survival (%)**	**Flexible Purchase Alternative Survival (%)**	**Absolute Difference (%)**	**Relative Difference (%)**
> X >= -6.0			0	0
X < -6.0			0	0
< X <= 1.0			1	1
< X <= 2.0			0	0
< X <= 4.0			0	0
< X <= 6.0			0	0
X > 6.0			0	0
No Difference (X = 0.0)			67	67

Overall, there would be no detectable change to monthly mean flows or water temperatures in the upper or lower Sacramento River under the Flexible Purchase Alternative, relative to the Baseline Condition.

Flow-related Impacts on Juvenile Fall-run Chinook Salmon and Steelhead Rearing and Emigration (February through June)

Under the Flexible Purchase Alternative, long-term average flows below Keswick Dam would not differ from flow under the Baseline Condition during the February through June period. (See Table 9-9.) In 360 out of the 360 months simulated, monthly mean flows below Keswick Dam under the Flexible Purchase Alternative would be essentially equivalent to flows under the Baseline Condition. (See Appendix H pgs. 353-357.) Flow exceedance curves for the Sacramento River below Keswick Dam during the February through June period are shown in Figures 9-18 through 9-20 and Figures 9-22 and 9-23. The basis for development of these exceedance curves was the 1922-1993 period of record. The flow exceedance curves indicate that flows in the Sacramento River below Keswick Dam under the Flexible Purchase Alternative would be nearly identical to flows under the Baseline Condition.

Long-term average flows under the Flexible Purchase Alternative in the Sacramento River at Freeport would be within 2 percent of flows under the Baseline Condition from February through June. (See Table 9-10.) Monthly mean flows under the Flexible Purchase Alternative would be essentially equivalent to or greater than flows under the Baseline Condition in 360 out of the 360 months modeled for the February through June period. (See Appendix H pgs. 389-393.) Exceedance curves for the Sacramento River flows at Freeport (Figure 9-24 through 9-28) indicate that flows under the Flexible Purchase Alternative would be nearly identical to slightly increased, relative to those under the Baseline Condition, throughout the February through June period. The basis for development of these exceedance curves was the 1922-1993 period of record.

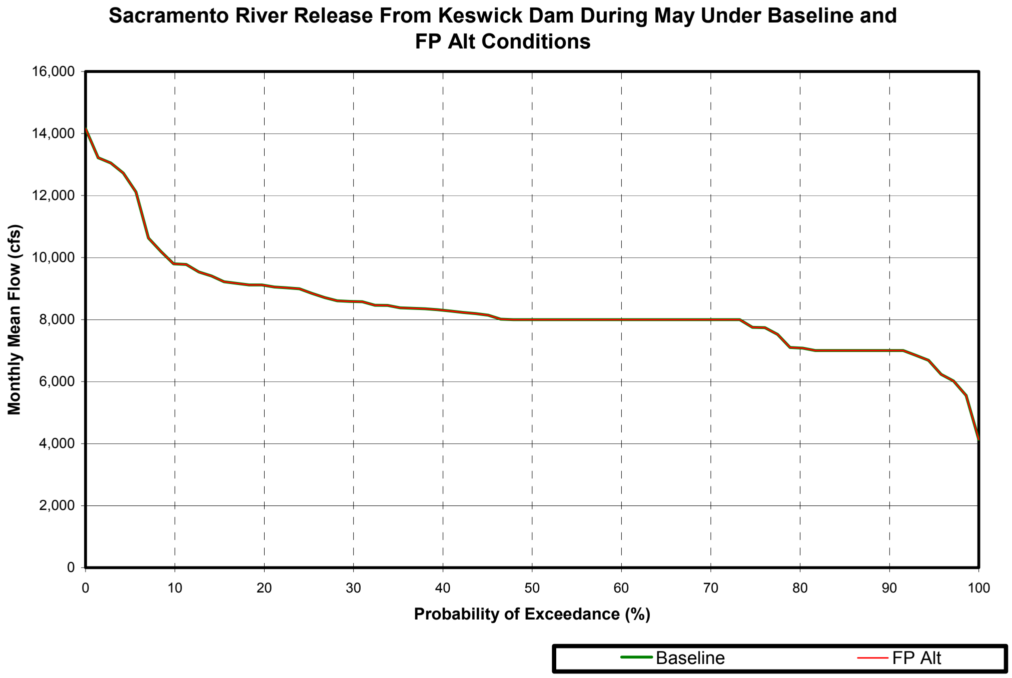

Figure 9-22
Sacramento River Release From Keswick Dam During May Under Baseline and Flexible Purchase Alternative Conditions

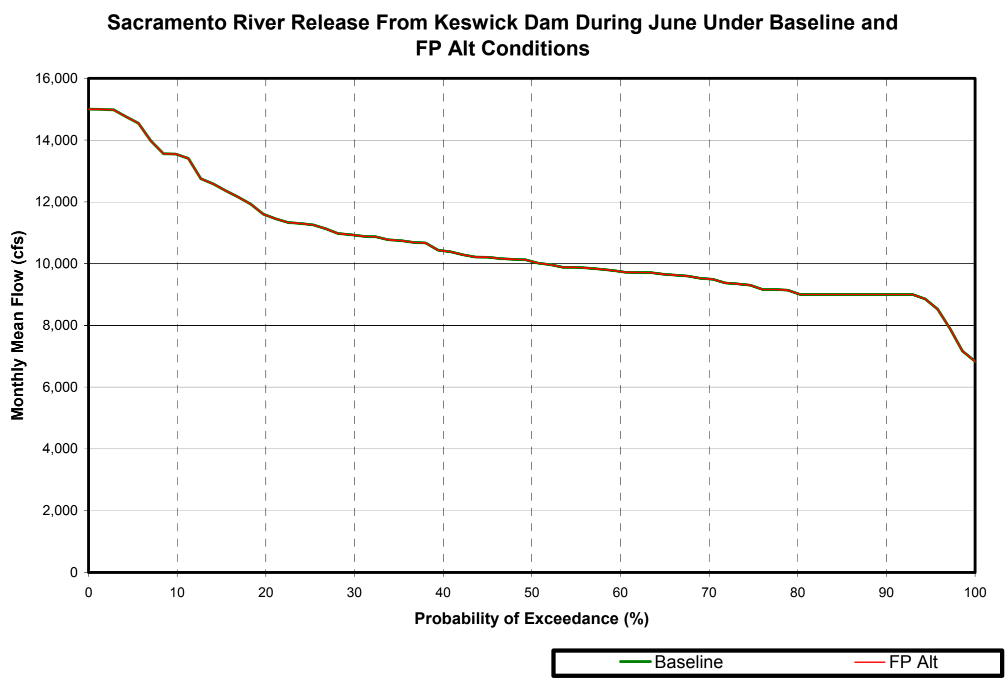

Figure 9-23
Sacramento River Release From Keswick Dam During June Under Baseline and Flexible Purchase Alternative Conditions

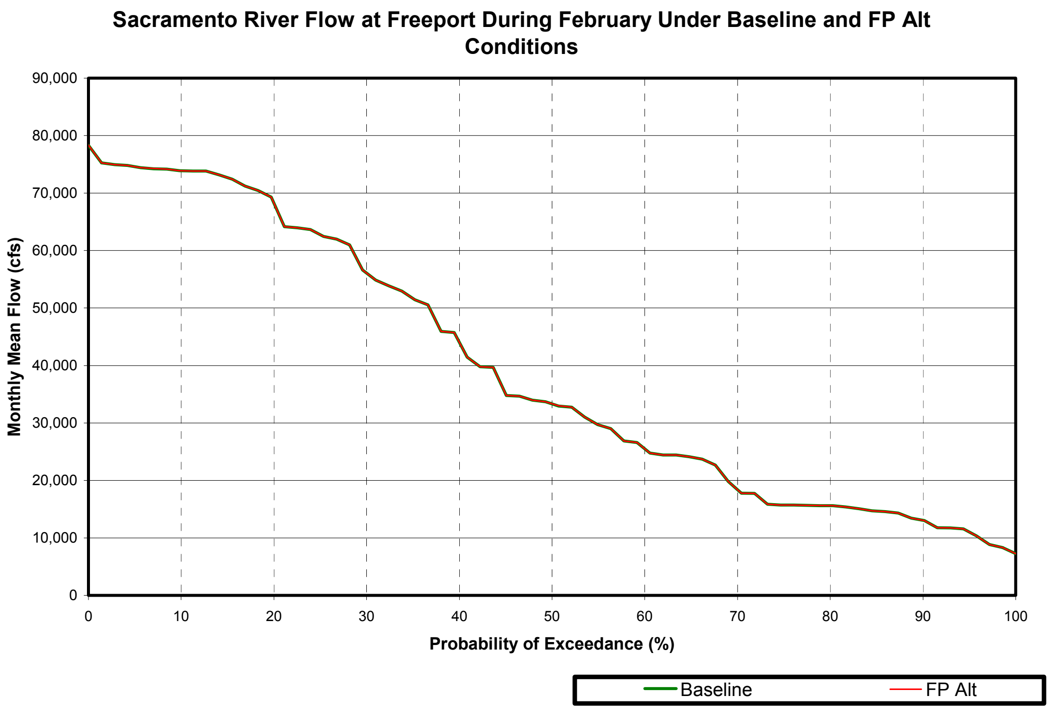

Figure 9-24
Sacramento River Flow at Freeport During February
Under Baseline and Flexible Purchase Alternative Conditions

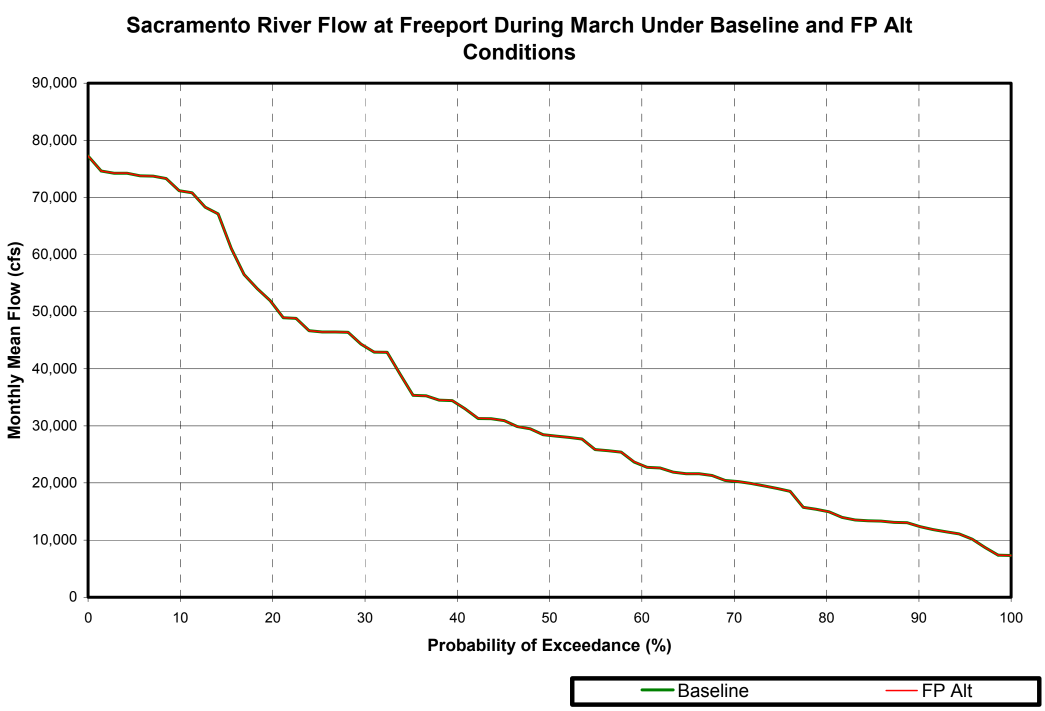

Figure 9-25
Sacramento River Flow at Freeport During March
Under Baseline and Flexible Purchase Alternative Conditions

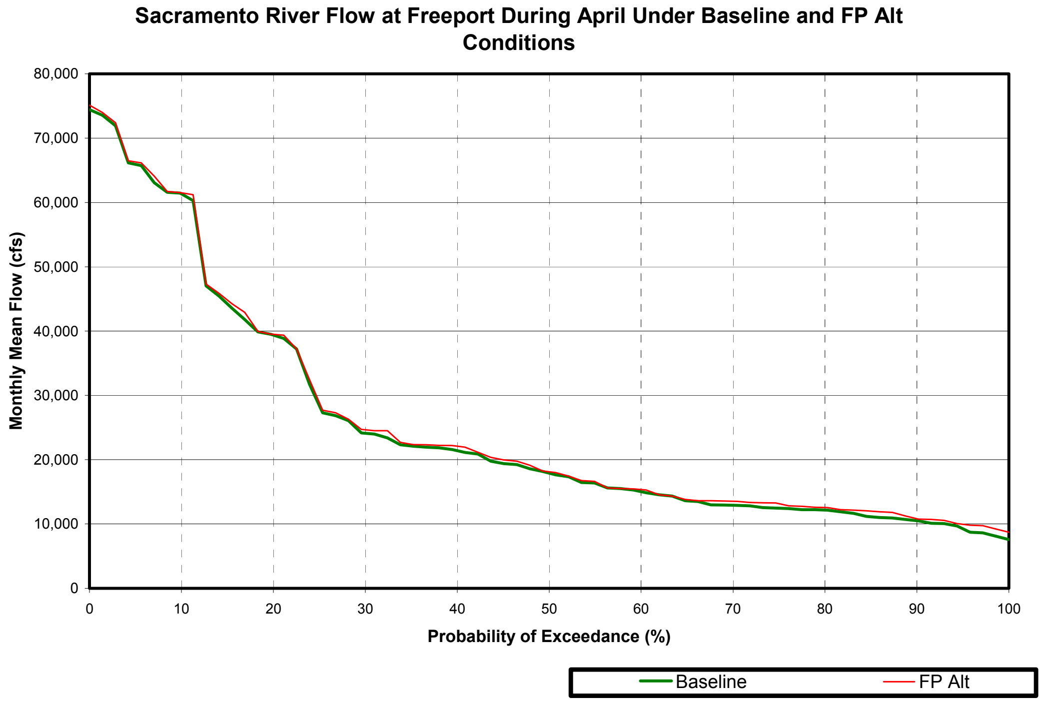

Figure 9-26
Sacramento River Flow at Freeport During April
Under Baseline and Flexible Purchase Alternative Conditions

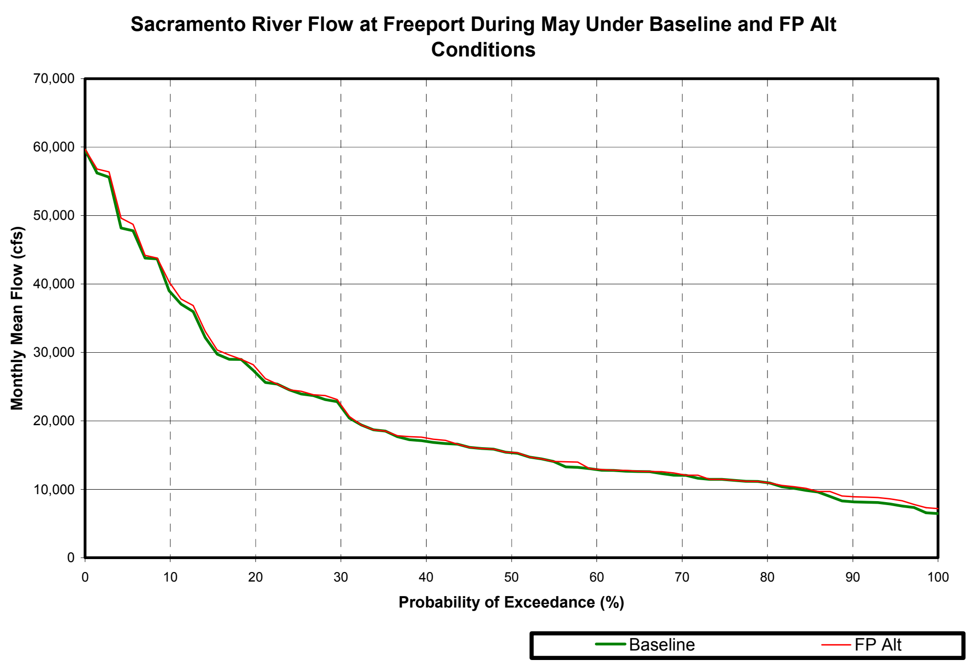

Figure 9-27
Sacramento River Flow at Freeport During May
Under Baseline and Flexible Purchase Alternative Conditions

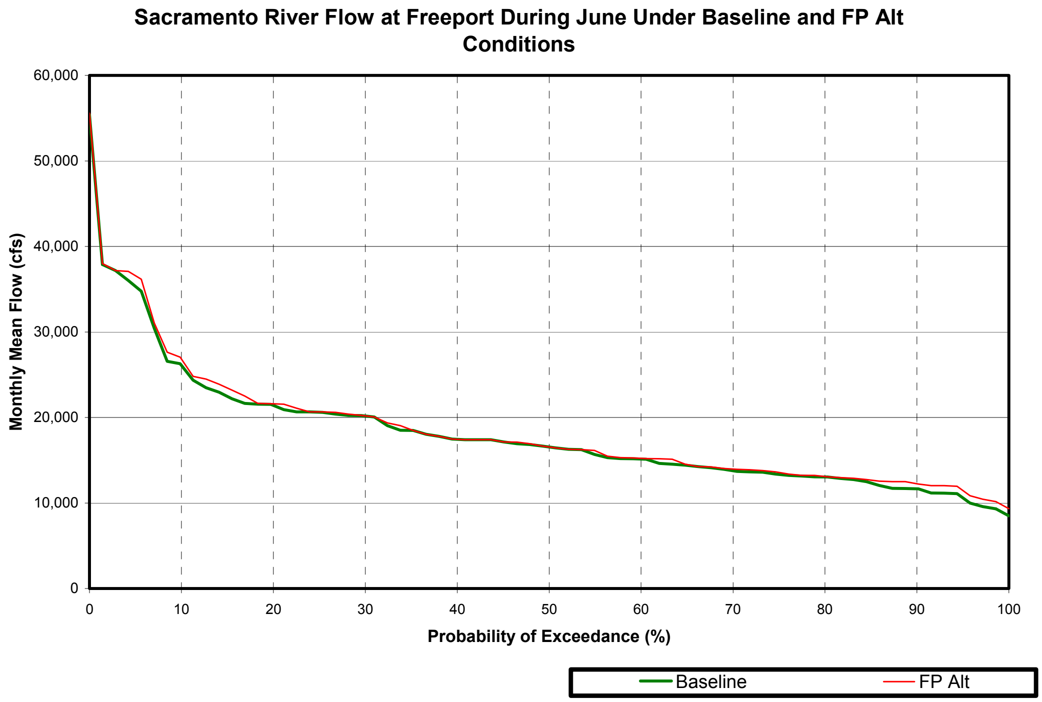

Figure 9-28
Sacramento River Flow at Freeport During June
Under Baseline and Flexible Purchase Alternative Conditions

Temperature-related Impacts on Juvenile Fall-run Chinook Salmon and Steelhead Rearing and Emigration (February through June)

Modeling associated with the Flexible Purchase Alternative indicates that simulated long-term average water temperatures at Bend Bridge would not change during any month of the February through June period, compared to the Baseline Condition, as shown in Table 9-12. Monthly mean water temperatures in the Sacramento River at Bend Bridge under the Flexible Purchase Alternative would not increase during any of the 345 months simulated for the February through June period. (See Appendix H pgs. 473-477.) Further, there would not be any additional occurrences under the Flexible Purchase Alternative in which water temperatures would be above 65°F at Bend Bridge, relative to the Baseline Condition. (Appendix H pgs. 473-477.)

Long-term average water temperatures under the Flexible Purchase Alternative at Jelly's Ferry in the Sacramento River would not differ from those under the Baseline Condition throughout the February through June period, as shown in Table 9-13. Monthly mean water temperatures at this location under the Flexible Purchase Alternative would be essentially equivalent to those under the Baseline Condition in 345 out of the 345 months modeled for the February through June period. (See Appendix H pgs. 461-465.) In addition, the Flexible Purchase Alternative would not result in an increase in the frequency in which monthly mean water temperatures would exceed 65°F at Jelly's Ferry in the Sacramento River, relative to the Baseline Condition, for a given month modeled throughout the juvenile rearing and emigration period. (See Appendix H pgs. 461-465.)

Long-term average water temperatures under the Flexible Purchase Alternative at Freeport in the Sacramento River would not change during February and March, and would increase by 0.1°F during April, May, and June, relative to the Baseline Condition. Monthly mean water temperatures at this location under the Flexible Purchase Alternative would be essentially equivalent to those under the Baseline Condition in 345 out of the 345 months modeled for the February through June period. (See Appendix H pgs. 485-489.) Further, the Flexible Purchase Alternative would not result in any measurable occurrences in which monthly mean water temperatures would exceed 65°F at Freeport in the Sacramento River, relative to the Baseline Condition, for all months simulated throughout the juvenile rearing and emigration period. (See Appendix H pgs. 485-489.)

Overall, changes in Sacramento River water temperatures at Bend Bridge, Jelly's Ferry, and Freeport under the Flexible Purchase Alternative throughout the February through June period would be negligible, relative to the Baseline Condition. There would be no increase in the frequency of water temperatures greater than 65°F at Bend Bridge, Jelly's Ferry, or Freeport.

Flow-related Impacts on Over-Summer Juvenile Steelhead Rearing (July through September)

Under the Flexible Purchase Alternative, long-term average flows in the Sacramento River below Keswick Dam would decrease by less than 0.2 percent for a given month of the July through September period, relative to the Baseline Condition. (See Table 9-9.) Monthly mean flows under the Flexible Purchase Alternative would be essentially equivalent to or greater than flows under the Baseline Condition in 212 out of the 216 months simulated. (See Appendix H pgs. 358-360.)

Long-term average flows under the Flexible Purchase Alternative in the Sacramento River at Freeport would increase by approximately 5 to 18 percent during the July through September period, relative to the Baseline Condition. (See Table 9-10.) Monthly mean flows under the Flexible Purchase Alternative would be essentially equivalent to or greater than flows under the Baseline Condition in 216 out of the 216 months modeled for the July through September period. (See Appendix H pgs. 394-396.) Freeport flows under the Flexible Purchase Alternative would be greater than flows under the Baseline Condition in nearly every month modeled for the July through September period.

Temperature-related Impacts on Over-summer Juvenile Steelhead Rearing (July through September)

Long-term average water temperatures under the Flexible Purchase Alternative at Bend Bridge, Jelly's Ferry, and Freeport would be within 0.1°F of long-term average water temperatures under the Baseline Condition during July, August, and

September. (Refer to Tables 9-12, 9-13, and 9-11, respectively.) Water temperatures at Bend Bridge would be essentially equivalent to those under the Baseline Condition in 205 out of the 207 months simulated for this three-month period. (See Appendix H pgs. 478-480.) At Jelly's Ferry, Sacramento River water temperatures under the Flexible Purchase Alternative would be essentially equivalent to those under the Baseline Condition in 206 of the 207 months simulated for the July through September period. (See Appendix H pgs. 466-468.) Monthly mean water temperatures at Freeport under the Flexible Purchase Alternative would be essentially equivalent to those under the Baseline Condition in 207 out of the 207 months included in the analysis. (See Appendix H pgs. 490-492.) Furthermore, the Flexible Purchase Alternative would not result in additional occurrences of water temperatures greater than 65°F during any month simulated for the July through September period at Bend Bridge, Jelly's Ferry, or Freeport in the Sacramento River, relative to the Baseline Condition. (See Appendix H pgs. 478-480, 466-468, and 490-492.) Overall, potential changes in water temperature that may occur under the Flexible Purchase Alternative would be negligible, relative to the Baseline Condition.

Flow-related Impacts on Fall/Winter Juvenile Steelhead Rearing (October through January)

Under the Flexible Purchase Alternative, long-term average flows in the Sacramento River below Keswick Dam would not decrease in any month of the October through January period, relative to the Baseline Condition. (See Table 9-9.) Monthly mean flows under the Flexible Purchase Alternative would be essentially equivalent to or greater than flows under the Baseline Condition in all of the 288 months simulated. (See Appendix H pgs. 349-352.)

Long-term average flows under the Flexible Purchase Alternative in the Sacramento River at Freeport would increase by no more than 0.7 percent during the October through January period, relative to the Baseline Condition. (See Table 9-10.) Monthly mean flows under the Flexible Purchase Alternative would be essentially equivalent to or greater than flows under the Baseline Condition in all of the 288 months modeled for the October through January period. (See Appendix H pgs. 385-388.)

Temperature-related Impacts on Fall/Winter Winter Juvenile Steelhead Rearing (October through January)

Long-term average water temperatures under the Flexible Purchase Alternative at Bend Bridge, Jelly's Ferry, and Freeport would be essentially equivalent during all months of the October through January period (Tables 9-12, 9-13, and 9-11, respectively), relative to the Baseline Condition. Water temperatures at Bend Bridge would be essentially equivalent to those under the Baseline Condition in all of the 276 months simulated for this four-month period. (See Appendix H pgs. 469-472.) At Jelly's Ferry, Sacramento River water temperatures under the Flexible Purchase Alternative would be essentially equivalent to those under the Baseline Condition in all of the 276 months simulated for the October through January period. (See

Appendix H pgs. 457-460.) Monthly mean water temperatures at Freeport under the Flexible Purchase Alternative would be essentially equivalent to those under the Baseline Condition in all of the 276 months included in the analysis. (See Appendix H pgs. 481-484.) Overall, potential changes in water temperature that may occur under the Flexible Purchase Alternative would be negligible, relative to the Baseline Condition.

Summary of Impacts on Fall-Run Chinook Salmon and Steelhead in the Sacramento River

In summary, potential changes in flow in the Sacramento River under the Flexible Purchase Alternative during the September through November period would not be of sufficient frequency or magnitude to beneficially or adversely affect adult fall-run Chinook salmon immigration. Similarly, changes in flows under the Flexible Purchase Alternative would not be of sufficient frequency or magnitude to beneficially or adversely impact fall-run Chinook salmon spawning, egg incubation, and initial rearing during the October through February period. Slight increases in flow that would occur under the Flexible Purchase Alternative would not be of sufficient frequency or magnitude to beneficially or adversely affect juvenile fall-run Chinook salmon rearing and emigration during the February through June period.

Changes in water temperature in the Sacramento River under the Flexible Purchase Alternative during the September through November period would not be of sufficient frequency or magnitude to beneficially or adversely affect adult fall-run Chinook salmon immigration. Changes in annual early lifestage survival under the Flexible Purchase Alternative would not be of sufficient magnitude to beneficially or adversely impact initial year-class strength. Changes in water temperature under the Flexible Purchase Alternative would not be of sufficient frequency or magnitude to beneficially or adversely impact spawning, egg incubation, and initial rearing during the October to February period. Changes in water temperature that would occur under the Flexible Purchase Alternative would not be of sufficient frequency or magnitude to beneficially or adversely affect juvenile fall-run Chinook salmon rearing and emigration during the February through June period.

Potential changes in flow in the Sacramento River under the Flexible Purchase Alternative during the September through November period would not be of sufficient frequency or magnitude to beneficially or adversely affect adult steelhead immigration. Flow related changes under the Flexible Purchase Alternative during the December through March period would not be of sufficient frequency or magnitude to beneficially or adversely impact adult steelhead immigration, spawning, and egg incubation. Slight increases in flow that would occur in the Sacramento River under the Flexible Purchase Alternative would not be of sufficient frequency or magnitude to beneficially or adversely affect juvenile steelhead rearing, including over-summer and fall/winter rearing, and emigration.

Changes in water temperature in the Sacramento River under the Flexible Purchase Alternative during the September through November period would not be of sufficient frequency or magnitude to beneficially or adversely affect adult steelhead immigration. Changes in annual early lifestage survival under the Flexible Purchase Alternative would not be of sufficient magnitude to beneficially or adversely impact initial year-class strength of steelhead in the Sacramento River. Water temperature related changes under the Flexible Purchase Alternative during the December through March period would not be of sufficient frequency or magnitude to beneficially or adversely impact adult steelhead immigration, spawning, and egg incubation. Negligible changes in water temperature that would occur in the Sacramento River under the Flexible Purchase Alternative would not be of sufficient frequency or magnitude to beneficially or adversely affect juvenile steelhead rearing, including over-summer and fall/winter rearing, and emigration.

Overall, the changes in flows and water temperatures in the Sacramento River under the Flexible Purchase Alternative would not be of sufficient frequency or magnitude to beneficially or adversely impacts on fall-run Chinook salmon. Therefore, impacts on fall-run Chinook salmon in the Sacramento River with implementation of the Flexible Purchase Alternative, relative to the Baseline Condition, would be less than significant.

Similarly, the changes in flows and water temperatures in the Sacramento River under the Flexible Purchase Alternative, relative to the Baseline Condition, would not be of sufficient frequency or magnitude to beneficially or adversely impact steelhead. Therefore, impacts on steelhead in the Sacramento River with implementation of the Flexible Purchase Alternative, relative to the Baseline Condition, would be less than significant.

<u>Impacts on Late-fall-run Chinook Salmon in the Sacramento River</u>

Flow-related Impacts on Adult Late-fall-run Chinook Salmon Immigration and Holding (October through April)

Table 9-9 shows that long-term average flows in the Sacramento River below Keswick Dam under the Flexible Purchase Alternative would not differ from flows under the Baseline Condition, during all months of the adult immigration period (October through April). In all 504 months simulated in this period, flows in the Sacramento River below Keswick Dam would be essentially equivalent to flows under the Baseline Condition. (See Appendix H pgs. 349-355.)

Long-term average flows in the Sacramento River at Freeport under the Flexible Purchase Alternative would not differ from flows under the Baseline Condition during December through March, and would increase by approximately 0.1 to 1.9 percent in April, October and November, relative to the Baseline Condition. (See Table 9-10.) Monthly mean flows in the Sacramento River at Freeport under the Flexible Purchase Alternative would be essentially equivalent to or greater than flows under the Baseline Condition in 504 out of the 504 months modeled for October through April. (See Appendix H pgs. 385-391.)

Temperature-related Impacts on Adult Late-fall-run Chinook Salmon Immigration and Holding (October through April)

Long-term average water temperatures in the Sacramento River modeled for the Flexible Purchase Alternative would not differ from those under the Baseline Condition at the Bend Bridge and Jelly's Ferry during all months of the October through April adult immigration period, as shown in Tables 9-12 and 9-13. Moreover, under the Flexible Purchase Alternative, water temperatures in the Sacramento River at Bend Bridge would remain essentially equivalent to those under the Baseline Condition in all of the 483 months included in the analysis. (See Appendix H pgs. 469-475.) Similarly, monthly mean water temperatures at Jelly's Ferry under the Flexible Purchase Alternative would remain essentially equivalent to those simulated under the Baseline Condition in all of the 483 months included in the analysis. (See Appendix H pgs. 457-463.)

October through April long-term average water temperatures in the Sacramento River at Freeport under the Flexible Purchase Alternative would be within 0.1°F of water temperatures under the Baseline Condition. (See Table 9-11.) In fact, long-term average water temperatures under the Flexible Purchase Alternative would not differ from those under the Baseline Condition in October, November, January, February, and March, and would decrease and increase by 0.1°F in December and April, respectively, relative to the Baseline Condition. Further, monthly mean water temperatures in the Sacramento River at Freeport under the Flexible Purchase Alternative would be essentially equivalent to water temperatures under the Baseline Condition in all of the 483 months modeled for the October through April period. (See Appendix H pgs. 486-492.)

Flow-related Impacts on Adult Late-fall-run Chinook Salmon Spawning, Egg Incubation, and Initial Rearing (December through April)

Long-term average flows in the Sacramento River below Keswick Dam under the Flexible Purchase Alternative would not differ from flows under the Baseline Condition during all months of the December through April period, as shown in Table 9-9. In all the 360 months simulated during this period, Sacramento River monthly mean flows below Keswick Dam would be essentially equivalent to flows under the Baseline Condition. (See Appendix H pgs. 351-355.)

Figure 9-14, Figure 9-15, and Figure 9-29 show exceedance curves for the Sacramento River below Keswick Dam for the December through April period. The basis for development of these exceedance curves was the 1922-1993 period of record. These curves demonstrate that flows under the Flexible Purchase Alternative would be similar to those under the Baseline Condition at all flow ranges. The Flexible Purchase Alternative would not be expected to result in reductions in flows during the December through April spawning period, relative to the Baseline Condition.

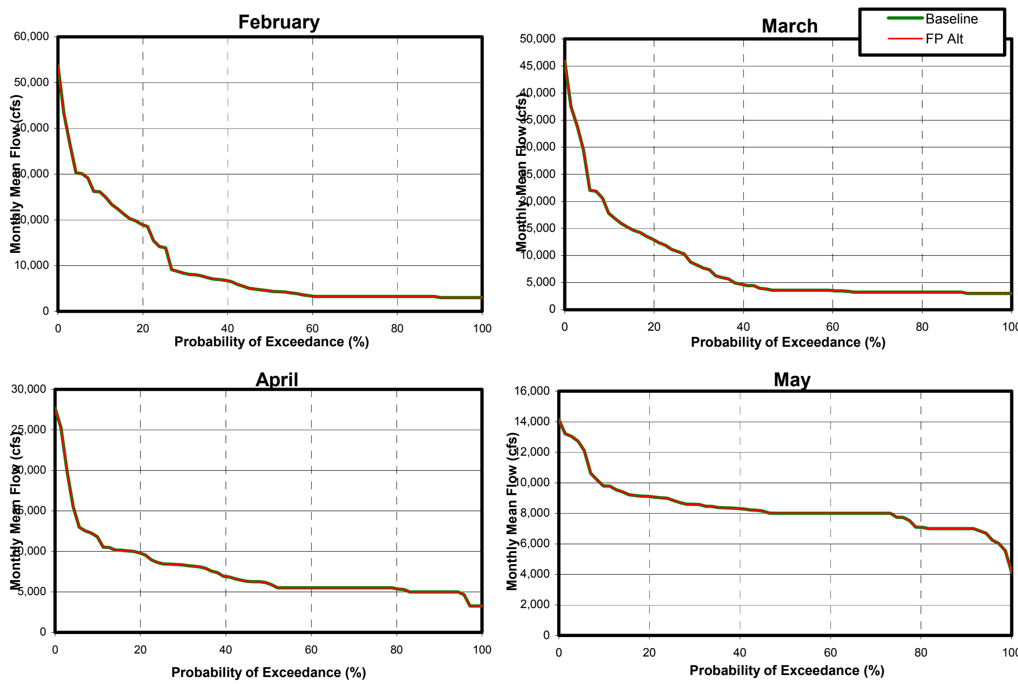

Figure 9-29
Sacramento River Release From Keswick Dam
Under Baseline and Flexible Purchase Alternative Conditions
February through May

Temperature-related Impacts on Adult Late-fall-run Chinook Salmon Spawning, Egg Incubation, and Initial Rearing (December through April)

Under the Flexible Purchase Alternative, long-term average water temperatures would not differ from those under the Baseline Condition during the December through April period at Bend Bridge and Jelly's Ferry, as shown in Tables 9-12 and Table 9-13. In fact, in all of the 345 months included in the analysis, monthly mean water temperatures at Bend Bridge and Jelly's Ferry, respectively, would be essentially equivalent to those under the Baseline Condition. (See Appendix H pgs. 471-475 and 459-463.) Further, there would not be any additional occurrences of water temperatures above 56°F under the Flexible Purchase Alternative, relative to the Baseline Condition, at either Bend Bridge or Jelly's Ferry. (See Appendix H pgs. 471-475 and 459-463.)

The long-term average annual early lifestage survival for late-fall-run Chinook salmon in the Sacramento River would be 99.3 percent under both the Baseline Condition and Flexible Purchase Alternative. Table 9-17 shows the annual survival estimates for late-fall-run Chinook salmon in the Sacramento River for the 69 years modeled. Substantial increases or decreases in survival would not occur in any individual year of the 69-year simulation, relative to the Baseline Condition. In 67 out of the 69 years modeled, there would be no difference in annual early lifestage survival of late-fall-run Chinook salmon between the Flexible Purchase Alternative and the Baseline

Condition. In the 2 years in which changes in survival would occur, there would be a relative decrease in survival of 0.1 percent and a relative increase in survival of 0.1 percent, relative to the Baseline Condition. Therefore, changes in annual early lifestage survival under the Flexible Purchase Alternative would not be of sufficient magnitude to result in adverse effects on initial year-class strength of late fall-run Chinook salmon in the Sacramento River.

Flow-related Impacts on Juvenile Late-fall-run Chinook Salmon Rearing and Emigration (April through October)

Under the Flexible Purchase Alternative, long-term average flows in the Sacramento River below Keswick Dam would not differ by greater than 0.9 percent or less than 0.8 percent from flows modeled under the Baseline Condition during the April through October period. (See Table 9-9.) In 468 out of the 504 months simulated, flows below Keswick Dam under the Flexible Purchase Alternative would be essentially equivalent to flows under the Baseline Condition. (See Appendix H pgs. 349, 355-360.) Flow exceedance curves during the April through October period are shown for the Sacramento River below Keswick Dam in Figure 9-29, Figure 9-30 and Figure 9-31. The basis for development of these exceedance curves was the 1922-1993 period of record. The flow exceedance curves indicate that flows below Keswick Dam under the Flexible Purchase Alternative would be nearly identical to flows under the Baseline Condition. Therefore, flows modeled under the Flexible Purchase Alternative would not be likely to result in adverse effects on long-term juvenile late-fall-run Chinook salmon rearing and emigration.

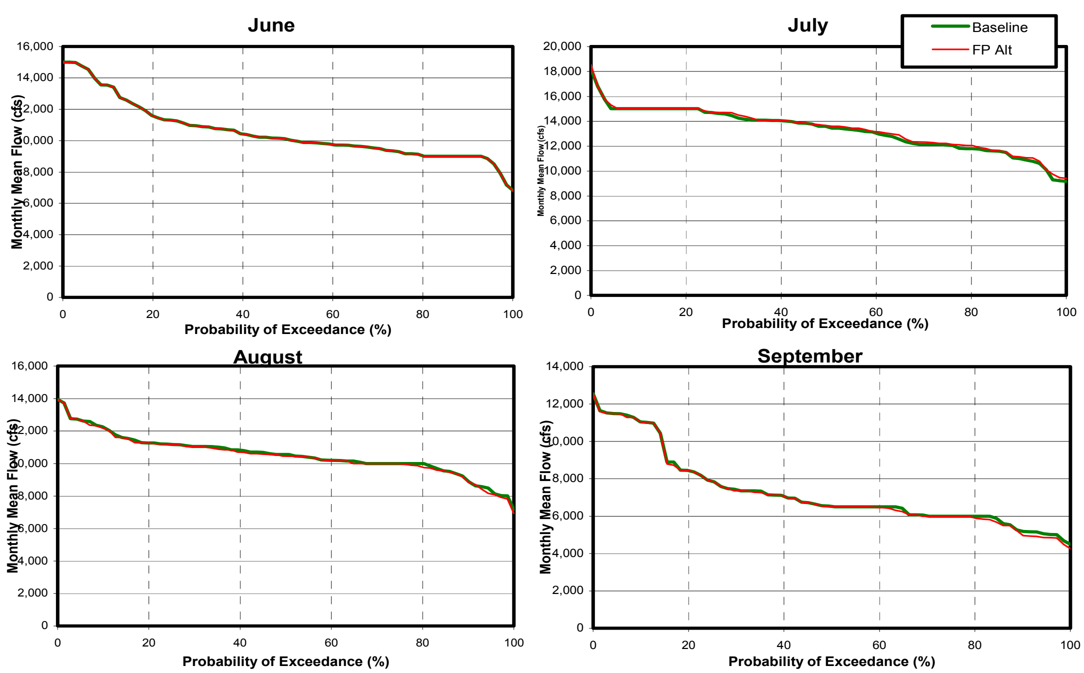

Figure 9-30
Sacramento River Release From Keswick Dam
Under Baseline and Flexible Purchase Alternative Conditions
June Through September

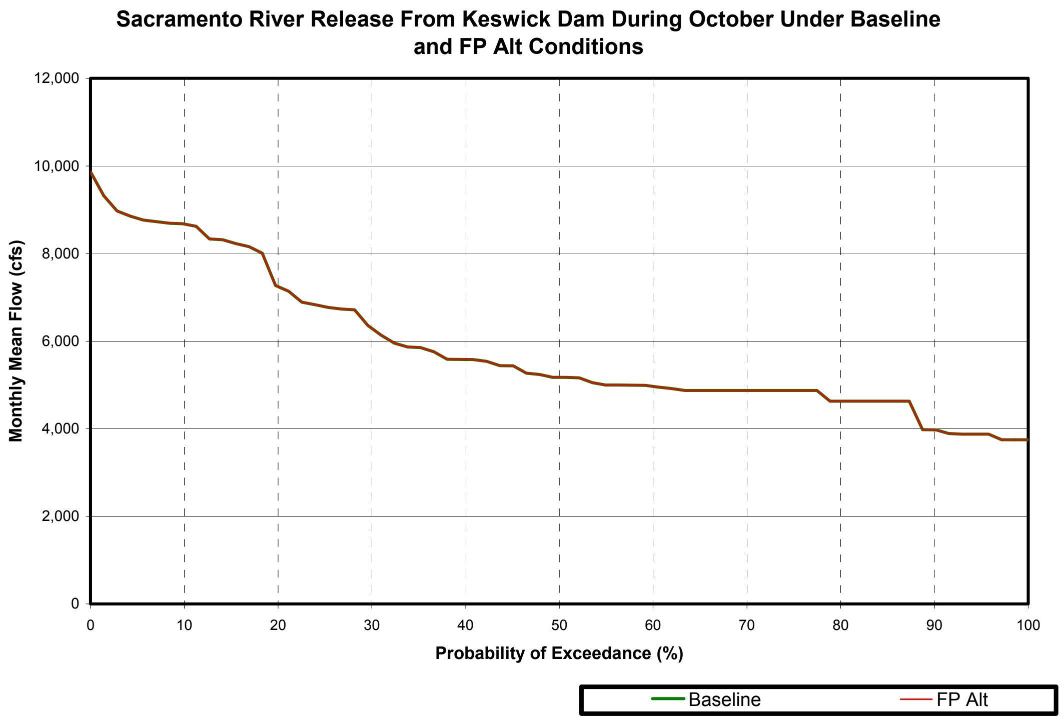

Figure 9-31
Sacramento River Release From Keswick Dam During October Under Baseline and Flexible Purchase Alternative Conditions

Long-term average flows in the Sacramento River at Freeport under the Flexible Purchase Alternative would increase by 17.7 percent in July, 15.7 percent in August, and 9.7 percent in September, relative to the Baseline Condition. During April through June and October, long-term average temperatures under the Flexible Purchase Alternative would not differ greater than 6.8 percent compared to the Baseline Condition. (Refer to Table 9-10.) Monthly mean flows in the Sacramento River at Freeport under the Flexible Purchase Alternative would be essentially equivalent to or greater than flows under the Baseline Condition in all of the 504 months modeled for the April through October period. (See Appendix H pgs. 385, 391-396.) Overall, flows in the Sacramento River below Keswick Dam and at Freeport would not differ substantially under the Flexible Purchase Alternative, relative to the Baseline Condition.

Temperature-related Impacts on Juvenile Late-fall-run Chinook Salmon Rearing and Emigration (April through October)

Modeling associated with the Flexible Purchase Alternative indicates that long-term average water temperatures at Bend Bridge would not change during any month of the April through October period, compared to the Baseline Condition, as shown in Table 9-12. Monthly mean water temperatures in the Sacramento River at Bend Bridge would be essentially equivalent to or less than those under to the Baseline

Condition in 481 of the 483 months of the April through October period. (See Appendix H pgs. 469, 475-480.) Further, the Flexible Purchase Alternative would not result in an increase in the frequency in which monthly mean water temperatures would exceed 65°F for each month of the April through October period. (See Appendix H pgs. 469, 475-480.)

Long-term average water temperatures under the Flexible Purchase Alternative at Jelly's Ferry in the Sacramento River would increase by 0.1°F in September and would not change during the remaining months of the April through October late fall-run Chinook salmon juvenile rearing and emigration period, as shown in Table 9-13. Monthly mean water temperatures at this location under the Flexible Purchase Alternative would be essentially equivalent to those under the Baseline Condition in 482 out of the 483 months modeled for the April through October period. (See Appendix H pgs. 457, 463-468.) Further, the Flexible Purchase Alternative would not result in an increase in the frequency in which monthly mean water temperatures would exceed 65°F at Jelly's Ferry in the Sacramento River, relative to the Baseline Condition, for a given month simulated for the juvenile rearing and emigration period. (See Appendix H pgs. 457, 463-468.)

Similarly, long-term average water temperatures under the Flexible Purchase Alternative at Freeport in the Sacramento River would increase by 0.1°F in April, May, and June, would decrease by 0.1°F in August and September, and would not change during November, as shown in Table 9-11. Monthly mean water temperatures at this location under the Flexible Purchase Alternative would be essentially equivalent to those under the Baseline Condition in all of the 483 months modeled for the April through October period. (See Appendix H pgs. 481, 487-492.) In addition, there would be no measurable increase in the frequency in which monthly mean water temperatures at Freeport would be above 65°F, relative to the Baseline Condition.

Overall, the Flexible Purchase Alternative would result in negligible changes in Sacramento River water temperatures at Bend Bridge, Jelly's Ferry, and Freeport throughout the April through October juvenile late-fall-run Chinook salmon rearing and emigration period.

Summary of Impacts on Late-fall-run Chinook Salmon in the Sacramento River

In summary, the difference in Sacramento River flows below Keswick Dam and at Freeport that would occur under the Flexible Purchase Alternative would not be of sufficient frequency or magnitude to beneficially or adversely affect attraction, passage, and holding of adult late-fall-run Chinook salmon immigrating into the Sacramento River during the October through April period. Similarly, changes in flow in the Sacramento River under the Flexible Purchase Alternative would not be of sufficient frequency or magnitude to beneficially or adversely impact spawning, egg incubation, and initial rearing during the December through April period. Changes in flow that would occur under the Flexible Purchase Alternative would not be of sufficient frequency or magnitude to beneficially or adversely affect juvenile late-fall-run Chinook salmon rearing and emigration during the April through October period.

Changes in Sacramento River water temperatures under the Flexible Purchase Alternative would not be of sufficient frequency or magnitude to beneficially or adversely affect adult late-fall-run Chinook salmon immigration and holding during the October through April period. Potential water temperature changes in the Sacramento River resulting from the implementation of the Flexible Purchase Alternative would not be of sufficient frequency or magnitude to beneficially or adversely impact spawning, egg incubation, and initial rearing during the December through April period. Changes in annual early lifestage survival under the Flexible Purchase Alternative would not be of sufficient magnitude to beneficially or adversely impact initial year-class strength of late-fall-run Chinook salmon in the Sacramento River. Changes in water temperatures under the Flexible Purchase Alternative would not be of sufficient frequency or magnitude to beneficially or adversely affect juvenile late-fall-run Chinook salmon rearing and emigration during the April through October period.

Overall, the changes in flows and water temperatures in the Sacramento River under the Flexible Purchase Alternative, relative to the Baseline Condition, would not be of sufficient frequency or magnitude to beneficially or adversely impact late-fall-run Chinook salmon. Therefore, impacts on late-fall-run Chinook salmon in the Sacramento River with implementation of the Flexible Purchase Alternative, relative to the Baseline Condition, would be less than significant.

Impacts on Splittail in the Sacramento River

Under the Flexible Purchase Alternative, long-term average flows at Freeport during the period of February through May would be within 2 percent of flows under the Baseline Condition, as shown in Table 9-10. In all of the 288 months simulated for this period, monthly mean flows would be essentially equivalent to or greater than flows under the Baseline Condition. (See Appendix H pgs. 389-392.) Below Keswick Dam, long-term average flows under the Flexible Purchase Alternative and the Baseline Condition would be identical throughout the February through May period, as shown in Table 9-9. Monthly mean flows below Keswick Dam under the Flexible Purchase Alternative would be essentially equivalent to those under the Baseline Condition in all of the 288 months simulated for the February through May period. (See Appendix H pgs. 353-356.) Therefore, flow changes under the Flexible Purchase Alternative would not be expected to reduce the availability of submerged habitat for splittail spawning, relative to the Baseline Condition.

During the February through May period, monthly mean water temperatures at Freeport would not rise above 68°F, the upper end of the reported preferred range for splittail spawning, more frequently as a result of the Flexible Purchase Alternative, relative to the Baseline Condition. (See Appendix H pgs. 485-488.) Similarly, monthly mean water temperatures at Jelly's Ferry in the Sacramento River would not rise above 68°F as a result of the Flexible Purchase Alternative. (See Appendix H pgs. 461-464.) Similarly, monthly mean water temperatures at Bend Bridge under the Flexible

Purchase Alternative would not rise above 68°F more frequently than under the Baseline Condition. (See Appendix F pgs. 473-476.)

Overall, potential flow and water temperature changes resulting from the implementation of the Flexible Purchase Alternative would not be of sufficient frequency or magnitude to beneficially or adversely impact splittail spawning. Therefore, impacts on splittail in the Sacramento River under the Flexible Purchase Alternative would be less than significant, relative to the Baseline Condition.

Impacts on American Shad in the Sacramento River

Table 9-10 shows that long-term average flows in the Sacramento River at Freeport would not differ from long-term average flows under the Baseline Condition in May and June. Similarly, monthly mean flows under the Flexible Purchase Alternative during May and June would be essentially equivalent to those under the Baseline Condition in all of the 144 months simulated for this period. (See Appendix H pgs. 392-393.) Thus, implementation of the Flexible Purchase Alternative would not be likely to result in reductions in flows at Freeport during May or June that could potentially reduce the number of adult shad attracted into the river.

The number of years that monthly mean water temperatures at Freeport in May and June would be within the reported preferred range for American shad spawning of 60°F to 70°F would not change measurably under the Flexible Purchase Alternative, relative to the Baseline Condition. (See Appendix H pgs. 488-489.) Therefore, the frequency with which suitable water temperatures for American shad spawning would occur would not decrease under the Flexible Purchase Alternative, relative to the Baseline Condition.

As shown in Table 9-9, long-term average flows below Keswick Dam in the Sacramento River would not differ from long-term average flows under the Baseline Condition in May and June. Similarly, monthly mean flows under the Flexible Purchase Alternative during May and June would be essentially equivalent to those under the Baseline Condition in all of the 144 months simulated for this period. (Refer to Appendix H pgs. 356-357.) Thus, implementation of the Flexible Purchase Alternative would not be likely to result in reductions in flows below Keswick Dam during May or June that could potentially reduce the number of adult shad attracted into the river.

Monthly mean water temperatures would be below the reported preferred range for American shad spawning of 60°F to 70°F under the Baseline Condition or Flexible Purchase Alternative in all of the 138 months simulated for the May through June period at both Bend Bridge and Jelly's Ferry. (Refer to Appendix H pgs. 464-465 and 476-477). Therefore, the Flexible Purchase Alternative would not result in a change in the frequency of upper Sacramento River water temperatures within the reported preferred range for American shad spawning.

Overall, changes in flows and water temperatures in the upper and lower Sacramento River under the Flexible Purchase Alternative would not be of sufficient frequency or magnitude to beneficially or adversely impact American shad attraction and spawning. Therefore, impacts on American shad in the Sacramento River under the Flexible Purchase Alternative would be less than significant, relative to the Baseline Condition.

Impacts on Striped Bass in the Sacramento River

Table 9-10 shows that long-term average flows in the Sacramento River at Freeport would not differ from long-term average flows under the Baseline Condition in May and June. Similarly, monthly mean flows under the Flexible Purchase Alternative during May and June would be essentially equivalent to those under the Baseline Condition in all of the 144 months simulated for this period [Appendix H pgs. 392-393]. Below Keswick Dam, long-term average flows in the upper Sacramento River under the Flexible Purchase Alternative would not differ from long-term average flows under the Baseline Condition during the May through June period, as shown in Table 9-9. Similarly, monthly mean flows under the Flexible Purchase Alternative during May and June would be essentially equivalent to those under the Baseline Condition in all of the 144 months simulated for this period. (Refer to Appendix H pgs. 356-357).

The frequency of monthly mean water temperatures in the Sacramento River at Freeport within the reported preferred range for striped bass spawning and initial rearing (59°F to 68°F) would not change measurably under the Flexible Purchase Alternative, relative to the Baseline Condition, during the May through June period [Appendix H pgs. 488-489]. At Bend Bridge and Jelly's Ferry, monthly mean water temperatures in the upper Sacramento River would be below 59°F in all of the 138 months simulated for the May through June period under the Baseline Condition and Flexible Purchase Alternative. (Refer to Appendix H. pgs. 464-465 and 476-477.) Therefore, the frequency in which suitable water temperature s would occur for striped bass spawning and initial rearing in Sacramento River would not change under the Flexible Purchase Alternative, relative to the Baseline Condition.

Overall, changes in flows and water temperatures in the upper and lower Sacramento River would not be of sufficient frequency or magnitude to beneficially or adversely impact striped bass spawning and initial rearing. Therefore, impacts on striped bass in the Sacramento River under the Flexible Purchase Alternative would be less than significant, relative to the Baseline Condition.

Butte Creek

Implementation of the Flexible Purchase Alternative has the potential to reduce agricultural return flows in Butte Creek, downstream of the Western Canal Siphon (Butte Creek Siphon), primarily from July through September.

Agricultural return flows are often characterized as warmer and of lower water quality than ambient stream receiving waters. If that is the case with agricultural return flows to Butte Creek, then a reduction in the volume of low quality water entering the river could potentially represent a beneficial effect to Chinook salmon, steelhead, and Sacramento splittail. However, the water quality in agricultural return flows may be suitable for the various lifestages of these species (refer to Section 9.1, Affected Environment/Existing Conditions), therefore flow reductions have been evaluated to determine potential effects.

<u>Impacts on Spring-run Chinook Salmon in Butte Creek</u>

Spring-run Chinook salmon adult holding, spawning, embryo incubation, fry emergence, and juvenile rearing in Butte Creek is reported to occur upstream of the Western Canal Siphon (CDFG 1998; Butte Creek Watershed Conservancy 2003). Therefore, reduced flows downstream of the Western Canal Siphon only have the potential to affect fish migrating through this area. Adult spring-run Chinook salmon upstream migration in Butte Creek reportedly extends from mid-February though July, with peak migration during May (CDFG 1998). Potential agricultural return flow reductions could be expected to occur at, or after, the end of the adult upstream migration period. In addition to upstream migrating adult spring-run Chinook salmon, juveniles migrating out of Butte Creek must pass through the area downstream of the Western Canal Siphon. However, the majority of juvenile spring-run Chinook salmon out-migration is reported to occur during December and January, with some emigration continuing through May (CDFG 1998). Some spring-run Chinook salmon in Butte Creek reportedly emigrate as yearlings from October to February, with peak yearling emigration occurring during November and December (CDFG 1998). Peak juvenile and yearling spring-run Chinook salmon outmigration periods do not coincide with potential agricultural return flow reductions. Although juvenile and yearling spring-run Chinook salmon outmigration may occur during the period of potentially reduced agricultural return flows (July through September), as shown in Table 9-1, implementation of conservation measures will avoid potential impacts related to flow reductions in Butte Creek.

In summary, potential reductions in agricultural return flow in Butte Creek under the Flexible Purchase Alternative would not occur during the appropriate time period to beneficially or adversely impact adult spring-run Chinook salmon immigration or juvenile spring-run Chinook salmon emigration. Overall, implementation of the Flexible Purchase Alternative represents a less-than-significant impact on spring-run Chinook salmon in Butte Creek.

<u>Impacts on Fall-run Chinook Salmon in Butte Creek</u>

Fall-run Chinook salmon adult spawning, embryo incubation, fry emergence, and juvenile rearing in Butte Creek is reported to occur upstream of the Western Canal Siphon (USFWS 2000; Butte Creek Watershed Conservancy 2003). Therefore, reduced flows downstream of the Western Canal Siphon, primarily from July through September, only have the potential to affect fish migrating through this area. Adult fall-run Chinook salmon upstream migration in Butte Creek reportedly extends from late-September through October (USFWS 2000; Butte Creek Watershed Conservancy 2003). Potential agricultural return flow reductions could be expected to occur before, or up to, the onset of adult fall-run Chinook salmon upstream immigration period. In addition to upstream migrating adult fall-run Chinook salmon, juveniles migrating out of Butte Creek must pass through the area downstream of the Western Canal Siphon. However, the majority of juvenile fall-run Chinook salmon out-migration is reported to occur during December through March (USFWS 2000; Butte Creek Watershed Conservancy 2003). Some fall-run Chinook salmon in Butte Creek reportedly emigrate from April to June (USFWS 2000; Butte Creek Watershed Conservancy 2003). The juvenile fall-run Chinook salmon out-migration periods do not coincide with the period of potential agricultural return flow reductions.

In summary, potential reductions in agricultural return flow in Butte Creek under the Flexible Purchase Alternative would not occur during the appropriate time period to beneficially or adversely impact adult fall-run Chinook salmon immigration or juvenile fall-run Chinook salmon emigration. Overall, implementation of the Flexible Purchase Alternative represents a less-than-significant impact on fall-run Chinook salmon in Butte Creek.

<u>Impacts on Late-fall-run Chinook Salmon in Butte Creek</u>

Late-fall-run Chinook salmon adult spawning, embryo incubation, fry emergence, and juvenile rearing in Butte Creek is reported to occur upstream of the Western Canal Siphon (USFWS 2000; Butte Creek Watershed Conservancy 2003). Therefore, reduced flows downstream of the Western Canal Siphon, primarily from July through September, only have the potential to affect fish migrating through this area. Adult late fall-run Chinook salmon upstream migration in Butte Creek reportedly extends from December through February (USFWS 2000; Butte Creek Watershed Conservancy 2003). Potential agricultural return flow reductions could be expected to occur before the onset of the adult late-fall-run Chinook salmon upstream migration period. In addition to upstream migrating adult late fall-run Chinook salmon, juveniles migrating out of Butte Creek must pass through the area downstream of the Western Canal Siphon. However, the majority of juvenile late fall-run Chinook salmon outmigration is reported to occur during April through June (USFWS 2000; Butte Creek Watershed Conservancy 2003). The juvenile late fall-run Chinook salmon outmigration period does not coincide with the period of potential agricultural return flow reductions.

In summary, potential reductions in agricultural return flow in Butte Creek under the Flexible Purchase Alternative would not occur during the appropriate time period to beneficially or adversely impact adult late-fall-run Chinook salmon immigration or juvenile late-fall-run Chinook salmon emigration. Overall, implementation of the Flexible Purchase Alternative represents a less-than-significant impact on late-fall-run Chinook salmon in Butte Creek.

Impacts on Steelhead in Butte Creek

Steelhead adult spawning, embryo incubation, and fry emergence is reported to occur in locations similar to spring-run Chinook salmon spawning in Butte Creek, which occur upstream of the Western Canal Siphon. In addition, steelhead spawning, embryo incubation, and fry emergence has been reported in Little Butte Creek (USFWS 2000; Butte Creek Watershed Conservancy 2003). Because steelhead spawning locations are similar to spring-run Chinook salmon spawning locations and because spring-run Chinook rearing is reported to occur in proximity to spawning (refer to Section 9.1, Affected Environment/Existing Conditions), it is likely that steelhead rearing also occurs in proximity to these spawning areas, all of which are upstream of the Western Canal Siphon. Therefore, reduced flows downstream of the Western Canal Siphon, primarily from July through September, only have the potential to affect fish migrating through this area, an would not affect steelhead rearing upstream of the siphon. Adult steelhead upstream migration in Butte Creek reportedly extends from late-fall though winter (USFWS 2000; Butte Creek Watershed Conservancy 2003). Potential agricultural return flow reductions could be expected to occur before the onset of the adult steelhead upstream migration period. In addition to upstream migrating adult steelhead, juveniles migrating out of Butte Creek must pass through the area downstream of the Western Canal Siphon. However, the majority of juvenile steelhead out-migration is reported to occur during March through June (USFWS 2000; Butte Creek Watershed Conservancy 2003). Some steelhead in Butte Creek reportedly emigrate as yearlings from September through March (USFWS 2000; Butte Creek Watershed Conservancy 2003). The juvenile and yearling steelhead out-migration periods do not coincide with the period of potential agricultural return flow reductions.

In summary, potential reductions in agricultural return flow in Butte Creek under the Flexible Purchase Alternative would not occur during the appropriate time period to beneficially or adversely impact adult steelhead immigration or juvenile steelhead emigration. Overall, implementation of the Flexible Purchase Alternative represents a less-than-significant impact on steelhead in Butte Creek.

Impacts on Sacramento Splittail in Butte Creek

During normal flow conditions, Butte Creek water is not diverted into the Sacramento River through the Butte Slough Outfall gates near Colusa and therefore flows through the Sutter Bypass, entering the Sacramento River via the Sacramento Slough southeast of the community of Knights Landing (Butte Creek Watershed Conservancy 2003). Within the Sutter Bypass, Butte Creek water flows through the East and West borrow pits, which are excavated channels on either side of the Sutter Bypass. It has been reported that flooded lands of the Sutter Bypass are an important spawning and nursery area for Sacramento splittail (USFWS 2000). Records indicate that most spawning takes place from February through April (USFWS 1995). Splittail have not been reported to spawn in these conveyance canals, but if they do, potential reductions in agricultural return flows could be expected to occur after the cessation of splittail spawning. Therefore, potential agricultural return flow reductions to Butte

Creek under the Flexible Purchase Alternative represent a less-than-significant impact on Sacramento splittail.

9.2.5.1.2 Feather River Area of Analysis

EWA acquisition of Oroville-Wyandotte ID stored reservoir water would alter surface water elevations in Sly Creek and Little Grass Valley reservoirs from November until refill. EWA acquisition of Oroville-Wyandotte ID stored reservoir water would alter surface water elevations in Lake Oroville from the November prior to the transfer until the following September. EWA acquisition of Feather River contractor water via groundwater substitution and crop idling would alter summer surface water elevations in Lake Oroville. EWA acquisition of Feather River contractor water via groundwater substitution and crop idling would alter Feather River flows below Lake Oroville, relative to the Baseline Condition.

The analysis of potential impacts on the fisheries resources in the Feather River Basin includes an assessment of the warmwater and coldwater fisheries of Little Grass Valley and Sly Creek reservoirs, Lake Oroville, and an assessment of fisheries resources of the lower Feather River below Lake Oroville. For lower Feather River fisheries resources, flow- and temperature-related impacts are discussed separately by species and lifestage. Organizationally, flow- and temperature-related impacts on fall-run Chinook salmon and steelhead are discussed together, followed by impact discussions for splittail, American shad, and striped bass.

<u>Impacts on Little Grass Valley and Sly Creek Reservoir Warmwater Fisheries</u>

Table 9-18 and Table 9-19 provide monthly median storage, elevation, and elevation changes for Little Grass Valley and Sly Creek reservoirs, respectively. Hydrologic conditions under the Flexible Purchase Alternative would result in reductions in the median water surface elevation of Little Grass Valley Reservoir of 2 feet in April and 6 feet in November, relative to the Baseline Condition, during the warmwater fish juvenile rearing period of April through November. At Sly Creek Reservoir, hydrologic conditions under the Flexible Purchase Alternative also would result in reductions in the median water surface elevation of 2 feet in April and 8 feet in November, relative to the Baseline Condition, during the April through November juvenile rearing period. Changes in water surface elevation of Little Grass Valley and Sly Creek reservoirs would result in corresponding changes in the availability of littoral habitat containing submerged vegetation. Such shallow, nearshore waters containing physical structure are important to producing and maintaining strong year-classes of warmwater fishes. Reductions in median end-of-month water surface elevation of Little Grass Valley and Sly Creek reservoirs under the Flexible Purchase Alternative would not be anticipated to result in substantial reductions in the amount of habitat potentially available to warmwater fishes for spawning and/or rearing, because large reductions in water surface elevation would occur outside of April and May, the primary months of the spawning and initial rearing period.

In addition, the Flexible Purchase Alternative could alter the rates by which water surface elevation in Little Grass Valley and Sly Creek reservoirs change, relative to the Baseline Condition. Table 9-18 and Table 9-19 indicate that the magnitude of monthly reservoir drawdown would not be greater under the Flexible Purchase Alternative than under the Baseline Condition during the warmwater fish-spawning period of March through June Reservoir. Further, it is anticipated that reductions in water surface elevation of greater than 9 feet msl per month during the warmwater fish-spawning period of March through June, which could potentially result in nest dewatering events, would not occur more frequently under the Flexible Purchase Alternative than under the Baseline Condition.

Table 9-18
Little Grass Valley Reservoir Monthly Median Storage, Elevation, and Elevation Change, Under Baseline and Flexible Purchase Alternative Conditions

	Storage				***Elevation***			***Elevation Change***		
Month	***Baseline (TAF)***	***FP Alt (TAF)***	***Diff (TAF)***	***Diff (%)***	***Baseline (ft msl)***	***FP Alt (ft msl)***	***Diff (ft msl)***	***Baseline (ft msl)***	***FP Alt (ft msl)***	***Diff (ft msl)***
Oct	52	52	0	0	5018	5018	0	-5	-5	0
Nov	50	44	-6	-12	5015	5010	-6	-2	-8	-6
Dec	50	38	-12	-24	5016	5004	-12	1	-6	-6
Jan	57	48	-10	-17	5022	5013	-9	6	9	3
Feb	63	55	-7	-11	5027	5021	-6	5	7	3
Mar	70	65	-5	-7	5033	5029	-4	6	8	2
Apr	76	73	-2	-3	5037	5035	-2	4	6	2
May	86	86	0	0	5044	5044	0	7	9	2
Jun	86	86	0	0	5044	5044	0	0	0	0
Jul	76	76	0	0	5037	5037	0	-7	-7	0
Aug	66	66	0	0	5029	5029	0	-8	-8	0
Sep	58	58	0	0	5023	5023	0	-6	-6	0

Based on median monthly storage and flow over the historical record from 1970 to 2001.
FP Alt = Flexible Purchase Alternative; Diff = Difference

Table 9-19
Sly Creek Reservoir Monthly Median Storage, Elevation, and Elevation Change Under Baseline and Flexible Purchase Alternative Conditions

	Storage				***Elevation***			***Elevation Change***		
Month	***Baseline (TAF)***	***FP Alt (TAF)***	***Diff (TAF)***	***Diff (%)***	***Baseline (ft msl)***	***FP Alt (ft msl)***	***Diff (ft msl)***	***Baseline (ft msl)***	***FP Alt (ft msl)***	***Diff (ft msl)***
Oct	22	22	0	0	3438	3438	0	-10	-10	0
Nov	21	18	-3	-12	3434	3425	-8	-4	-12	-8
Dec	19	14	-5	-27	3427	3410	-18	-7	-16	-9
Jan	27	23	-4	-15	3453	3441	-12	26	32	6
Feb	36	33	-3	-8	3476	3468	-8	23	27	4
Mar	48	46	-2	-4	3504	3500	-4	29	32	3
Apr	55	54	-1	-2	3521	3519	-2	17	19	2
May	62	62	0	0	3536	3536	0	15	17	2
Jun	58	58	0	0	3525	3525	0	-10	-10	0
Jul	48	48	0	0	3504	3504	0	-21	-21	0
Aug	33	33	0	0	3469	3469	0	-35	-35	0
Sep	25	25	0	0	3447	3447	0	-22	-22	0

Based on median monthly storage and flow over the historical record from 1970 to 2001.
FP Alt = Flexible Purchase Alternative; Diff = Difference

In summary, the Flexible Purchase Alternative is not likely to result in substantial changes in the availability of littoral habitat at Little Grass Valley or Sly Creek reservoirs, and thus, would not likely beneficially or adversely affect warmwater fish rearing. The Flexible Purchase Alternative does not increase the frequency of potential nest dewatering events in Little Grass Valley or Sly Creek reservoirs, and thus, would not adversely affect long-term warmwater fish nesting success.

Therefore, under the Flexible Purchase Alternative, impacts on Little Grass Valley and Sly Creek reservoirs warmwater fisheries would be less than significant, relative to the Baseline Condition.

<u>Impacts on Little Grass Valley and Sly Creek Reservoir Coldwater Fisheries</u>

Hydrologic conditions under the Flexible Purchase Alternative would result in a decrease in median storage of up to 6 TAF, or 12 percent, at Little Grass Valley Reservoir during the April through November period, relative to the Baseline Condition, as shown in Table 9-18. At Sly Creek Reservoir, hydrologic conditions under the Flexible Purchase Alternative would result in a decrease in median storage of up to 3 TAF, or 12 percent, during the April through November period, relative to the Baseline Condition. (See Table 9-19.) Anticipated reductions in reservoir storage would not be expected to adversely affect the reservoir's coldwater fisheries because: 1) coldwater habitat would remain available within the reservoir during all months of all years, 2) physical habitat availability is not believed to be among the primary factors limiting coldwater fish populations, and 3) anticipated seasonal reductions in storage would not be expected to adversely affect the primary prey species utilized by coldwater fish. Further, given the overall storage capacity of Little Grass Valley and Sly Creek reservoirs (94.7 TAF and 65.7 TAF, respectively), such changes in storage represent only a small proportion of each reservoir's total volume. Therefore, changes in end-of-month storage at Little Grass Valley and Sly Creek reservoirs under the Flexible Purchase Alternative represent a less-than-significant impact on coldwater fish resources.

<u>Impacts on Lake Oroville Warmwater Fisheries</u>

Hydrologic conditions under the Flexible Purchase Alternative would result in slight differences in the long-term average end-of-month water surface elevation of Lake Oroville during the warmwater juvenile fish-rearing period of April through November. As shown in Table 9-20, long-term average end-of-month water surface elevation under the Flexible Purchase Alternative would not change during April and September, would increase by 2 feet and 3 feet msl, respectively, during May and June, and would decrease by 4 feet and 3 feet msl, respectively, during July and August, relative to the Baseline Condition. Monthly mean end-of-month water surface elevation at Lake Oroville would be essentially equivalent to or greater than the Baseline Condition for 474 months of the 576 months included in the analysis. (See Appendix H pgs. 580-591.)

Changes in water surface elevation in Lake Oroville during the April through November period would result in corresponding changes in the availability of reservoir littoral habitat containing submerged vegetation (willows and button brush). Such shallow, nearshore waters containing physical structure are important to producing and maintaining strong year-classes of warmwater fish annually. The small and infrequent reduction in the water surface elevation that would occur under the Flexible Purchase Alternative would not be of sufficient magnitude to substantially reduce the amount of available littoral habitat and, thus, long-term average initial year-class strength of the warmwater fish populations.

Table 9-20
Long-term Average Oroville Reservoir End of Month Elevation Under Baseline and Flexible Purchase Alternative Conditions

Month	Average Elevation[1] (feet msl)		
	Baseline	Flexible Purchase Alternative	Difference
Mar	840	840	0
Apr	857	857	0
May	864	866	2
Jun	849	852	3
Jul	825	821	-4
Aug	794	791	-3
Sep	782	782	0
Oct	775	775	0
Nov	780	780	0
Dec	791	791	0

[1] Based on 72 years modeled.

In addition, the Flexible Purchase Alternative could alter the extent to which water surface elevations in Lake Oroville change during each month of the primary warmwater fish-spawning period (March through June). As discussed in Section 9.2.1.1.1, adverse effects on spawning from nest dewatering are assumed to have the potential to occur when reservoir elevation decreases by more than nine feet within a given month. Modeling results, shown in Table 9-21, indicate that the frequency with which potential nest dewatering events could occur in Lake Oroville would remain the same or be less under the Flexible Purchase Alternative, compared to the Baseline Condition, during any month of the March through June spawning period (two fewer occurrences in May and three fewer occurrences in June).

In summary, the Flexible Purchase Alternative is not likely to result in substantial changes in the availability of littoral habitat at Lake Oroville, and thus, would not likely beneficially or adversely affect warmwater fish rearing. The Flexible Purchase Alternative does not increase the frequency of potential nest dewatering events in Lake Oroville, and thus, would not adversely affect long-term warmwater fish nesting success. In fact, implementation of the Flexible Purchase Alternative would potentially beneficially affect warmwater fish spawning by reducing the number of potential nest dewatering events, relative to the baseline. Overall, under the Flexible Purchase Alternative, impacts on Lake Oroville warmwater fisheries would be less than significant, relative to the Baseline Condition.

Table 9-21 Long-term Average Surface Elevation and Number of Years with Elevation Decrease Greater than 9 feet in Oroville Reservoir Under Baseline and Flexible Purchase Alternative Conditions					
Month	**Average Reservoir Surface Elevation[1] (feet msl)**			**No. Years[1] w/Monthly Elevation Decrease During Month > 9 ft**	
	Baseline	**Flexible Purchase Alternative**	**Difference**	**Baseline**	**FP Alt**
Mar	840	840	0	2	2
Apr	857	857	0	3	3
May	864	866	2	9	7
Jun	849	852	3	50	47

[1] Based on 72 years modeled.

Impacts on Lake Oroville Coldwater Fisheries

Long-term average end-of-month storage under the Flexible Purchase Alternative would not change in April, September, October, and November, would increase by 17 TAF or 0.6 percent in May, 39 TAF or 1.4 percent in June, and would decrease 50 TAF or 2.0 percent in July, 26 TAF or 1.2 percent in August, and 2 TAF or 0.1 percent in September relative to the Baseline Condition, during the period when the reservoir thermally stratifies (April through November). (Refer to Table 9-22). Lake Oroville monthly mean end-of-month storage under the Flexible Purchase Alternative would be essentially equivalent to or greater than the Baseline Condition for 483 of the 576 months for November. (See Appendix H pgs. 121-122 and 127-132.) Anticipated reductions in reservoir storage that would occur under the Flexible Purchase Alternative would not be expected to adversely affect the reservoir's coldwater fisheries because: 1) coldwater habitat would remain available within the reservoir during all months of all years; 2) physical habitat availability is not believed to be among the primary factors limiting coldwater fish populations; and 3) anticipated seasonal reductions in storage would not be expected to adversely affect the primary prey species utilized by coldwater fish. Therefore, potential impacts on Lake Oroville coldwater fisheries under the Flexible Purchase Alternative would be less than significant, relative to the Baseline Condition.

Table 9-22 Long-term Average Oroville Reservoir End of Month Storage Under Baseline and Flexible Purchase Alternative Conditions				
Month	**Average Storage[1] (TAF)**		**Difference**	
	Baseline	**Flexible Purchase Alternative**	**(TAF)**	**(%)[2]**
Apr	2953	2953	0	0.0
May	3056	3073	17	0.6
Jun	2849	2888	39	1.4
Jul	2557	2507	-50	-2.0
Aug	2218	2192	-26	-1.2
Sep	2105	2103	-2	-0.1
Oct	2047	2047	0	0.0
Nov	2099	2099	0	0.0

[1] Based on 72 years modeled.
[2] Relative difference of the monthly long-term average.

Impacts on Spring-run Chinook Salmon in the Lower Feather River

Flow-related Impacts on Adult Spring-run Chinook Salmon Immigration and Holding (March through August)

Long-term average flows in the Feather River below the Thermalito Afterbay Outlet under the Flexible Purchase Alternative would not differ in March, and would be up to 29 percent greater than flows under the Baseline Condition during April through August, as shown in Table 9-23. Monthly mean flows below the Thermalito Afterbay Outlet under the Flexible Purchase Alternative would be essentially equivalent to or greater than flows under the Baseline Condition in 425 out of the 432 months included in the analysis for March through August. (See Appendix H pgs. 897-902.)

Table 9-23
Long-term Average Flow Below the Thermalito Afterbay Outlet Under Baseline and Flexible Purchase Alternative Conditions

Month	Monthly Mean Flow[1] (cfs)		Difference	
	Baseline	Flexible Purchase Alternative	(cfs)	(%)[2]
Oct	2441	2509	68	2.8
Nov	2301	2315	14	0.6
Dec	3984	3989	5	0.1
Jan	5005	5007	2	0.0
Feb	5930	5931	1	0.0
Mar	6144	6146	2	0.0
Apr	3416	3734	318	9.3
May	3826	3969	143	3.7
Jun	5084	5192	108	2.1
Jul	5896	7210	1314	22.3
Aug	4434	5737	1303	29.4
Sep	1600	1977	377	23.6

[1] Based on 72 years modeled.
[2] Relative difference of the monthly long-term average.

Long-term average flows at the mouth of the Feather River under the Flexible Purchase Alternative would not differ in March, and would be up to 35 percent greater than flows under the Baseline Condition during April through August, as shown in Table 9-24. Monthly mean flows at the mouth of the Feather River under the Flexible Purchase Alternative would be essentially equivalent to or greater than flows under the Baseline Condition in 430 out of the 432 months included in the analysis for March through August. (See Appendix H pgs. 873-878.)

Temperature-related Impacts on Adult Spring-run Chinook Salmon Immigration and Holding (March through August)

Long-term average water temperatures in the Feather River below the Fish Barrier Dam under the Flexible Purchase Alternative would not differ from those under the Baseline Condition during the March through August period, as shown in Table 9-25. Monthly mean water temperatures below the Fish Barrier Dam under the Flexible

Purchase Alternative would be essentially equivalent to those under the Baseline Condition in all of the 414 months included in the analysis. (See Appendix H pgs. 945-950.)

Table 9-24
Long-term Average Flow at the Feather River Mouth Under Baseline and Flexible Purchase Alternative Conditions

Month	Monthly Mean Flow[1] (cfs)		Difference	
	Baseline	Flexible Purchase Alternative	(cfs)	(%)[2]
Oct	3284	3352	68	2.1
Nov	3482	3496	14	0.4
Dec	6227	6232	5	0.1
Jan	11355	11357	2	0.0
Feb	13096	13097	1	0.0
Mar	13182	13184	2	0.0
Apr	9518	9836	318	3.3
May	7735	7877	142	1.8
Jun	7647	7755	108	1.4
Jul	6311	8497	2186	34.6
Aug	4881	6512	1631	33.4
Sep	3404	3852	498	13.2

[1] Based on 72 years modeled.
[2] Relative difference of the monthly long-term average.

Below the Thermalito Afterbay Outlet, long-term average water temperatures under the Flexible Purchase Alternative during the March through August period would be identical to those under the Baseline Condition, as shown in Table 9-26. Monthly mean water temperatures would remain essentially equivalent to those under the Baseline Condition in 413 of the 414 months simulated for the March through August adult spring-run Chinook salmon immigration and holding period. (See Appendix H pgs. 921-926.)

At the mouth of the Feather River, long-term average water temperatures under the Flexible Purchase Alternative would increase 0.1°F, 0.1°F, and 0.2°F during the months of April, May, and June, respectively, as shown in Table 9-27. By contrast, long-term average water temperatures would decrease 0.4°F and 0.5°F during August and September, respectively, with the implementation of the Flexible Purchase Alternative, and would not change during July. Monthly mean water temperatures at the mouth of the Feather River during the March through August period would remain essentially equivalent to or less than those under the Baseline Condition in 382 of the 414 months included in the analysis. (See Appendix H pgs. 933-938.) There would be 19 and 6 occurrences during May and June, respectively, in which water temperatures would increase by greater than 0.3°F, relative to the Baseline Condition. By contrast, during August and September, when long-term average water temperatures would be higher than those during May and June, numerous decreases in monthly mean water temperatures would occur. In August, there would be 30 months in which decreases in monthly mean water temperatures of greater than 0.3°F would occur, and in September, there would be 49 months with temperature decreases of greater than 0.3°F.

Table 9-25
Long-term Average Water Temperature in the Feather River Below the Fish Barrier Dam Under Baseline and Flexible Purchase Alternative Conditions

Month	Water Temperature[1] (ºF)		
	Baseline	Flexible Purchase Alternative	Difference (ºF)
Oct	54.0	54.0	0.0
Nov	52.4	52.4	0.0
Dec	48.0	48.0	0.0
Jan	46.0	46.0	0.0
Feb	47.1	47.1	0.0
Mar	49.0	49.0	0.0
Apr	51.0	51.0	0.0
May	55.3	55.3	0.0
Jun	57.4	57.4	0.0
Jul	61.6	61.6	0.0
Aug	60.8	60.8	0.0
Sep	56.5	56.5	0.0

[1] Based on 69 years modeled.

Table 9-26
Long-term Average Water Temperature in the Feather River Below the Thermalito Afterbay Outlet Under Baseline and Flexible Purchase Alternative Conditions

Month	Water Temperature[1] (ºF)		
	Baseline	Flexible Purchase Alternative	Difference (ºF)
Oct	59.6	59.6	0.0
Nov	53.0	53.0	0.0
Dec	46.4	46.4	0.0
Jan	45.3	45.3	0.0
Feb	49.0	49.0	0.0
Mar	52.7	52.7	0.0
Apr	57.0	57.0	0.0
May	62.4	62.4	0.0
Jun	66.2	66.2	0.0
Jul	70.1	70.1	0.0
Aug	69.2	69.2	0.0
Sep	64.7	64.7	0.0

[1] Based on 69 years modeled.

Table 9-27
Long-term Average Water Temperature at the Mouth of the Feather River Under Baseline and Flexible Purchase Alternative Conditions

Month	Water Temperature[1] (ºF)		
	Baseline	Flexible Purchase Alternative	Difference (ºF)
Oct	61.3	61.3	0.0
Nov	52.4	52.4	0.0
Dec	45.9	45.9	0.0
Jan	45.3	45.3	0.0
Feb	49.6	49.6	0.0
Mar	54.2	54.2	0.0
Apr	59.8	59.9	0.1
May	65.5	65.6	0.1
Jun	70.0	70.2	0.2
Jul	73.6	73.6	0.0
Aug	72.2	71.8	-0.4
Sep	69.7	69.2	-0.5

[1] Based on 69 years modeled.

Flow-Related Impacts on Adult Spring-run Chinook Salmon Spawning and Egg Incubation (August through November)

Long-term average flows in the Feather River below the Thermalito Afterbay Outlet under the Flexible Purchase Alternative would be up to 29 percent greater than flows under the Baseline Condition in August, September, and October, and would be essentially equivalent in November and December, as shown in Table 9-23. Monthly mean flows below the Thermalito Afterbay Outlet would be essentially equivalent to or greater than flows under the Baseline Condition in 288 of the 288 months included in the analysis. (See Appendix H pgs. 892, 902-903.)

Figures 9-32 through 9-35 show exceedance curves for below the Thermalito Afterbay Outlet in the lower Feather River for August through November. The basis for development of these exceedance curves was the 1922-1993 period of record. These curves demonstrate that flows under the Flexible Purchase Alternative would be equivalent to or greater than flows under the Baseline Condition.

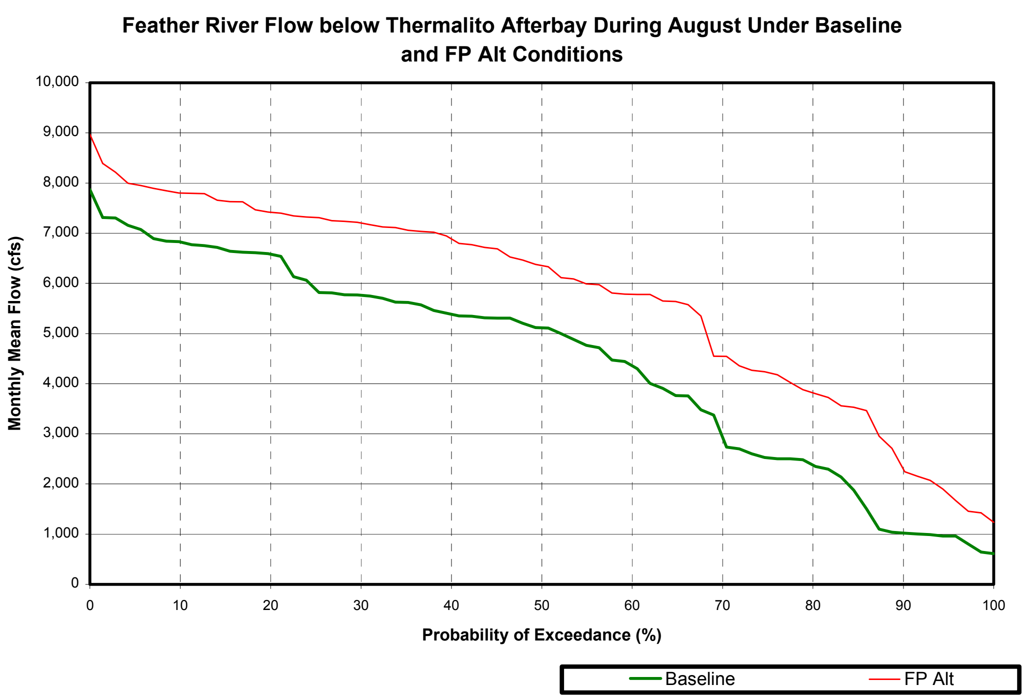

Figure 9-32
Feather River Flow Below Thermalito Afterbay During August Under Baseline and Flexible Purchase Alternative Conditions

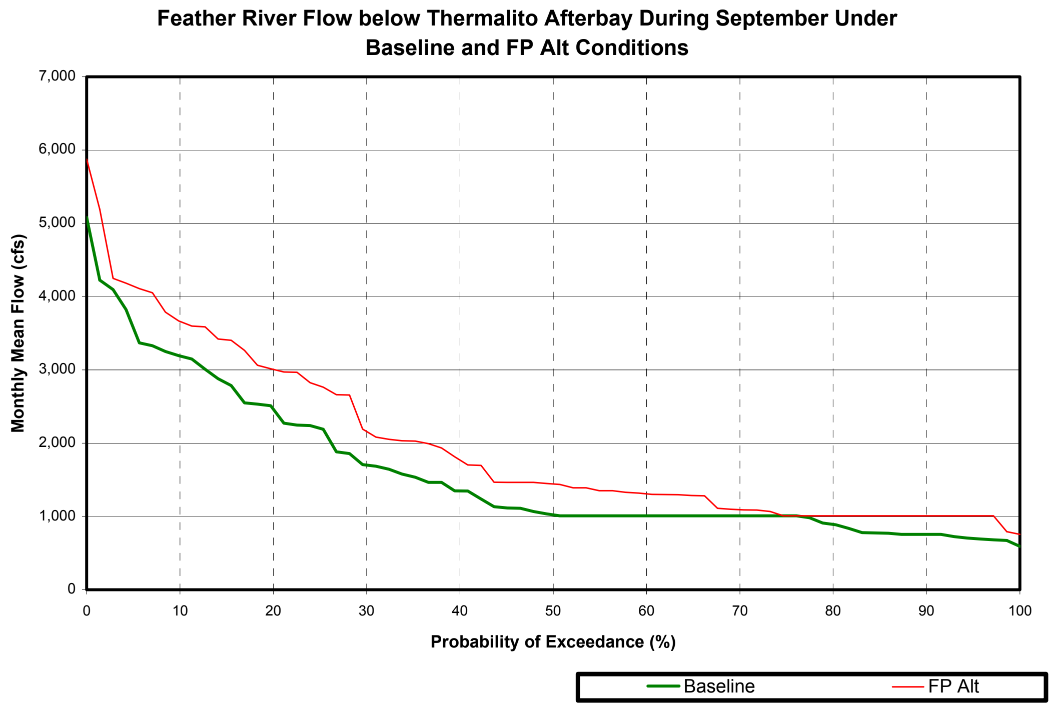

Figure 9-33
Feather River Flow Below Thermalito Afterbay During September Under Baseline and Flexible Purchase Alternative Conditions

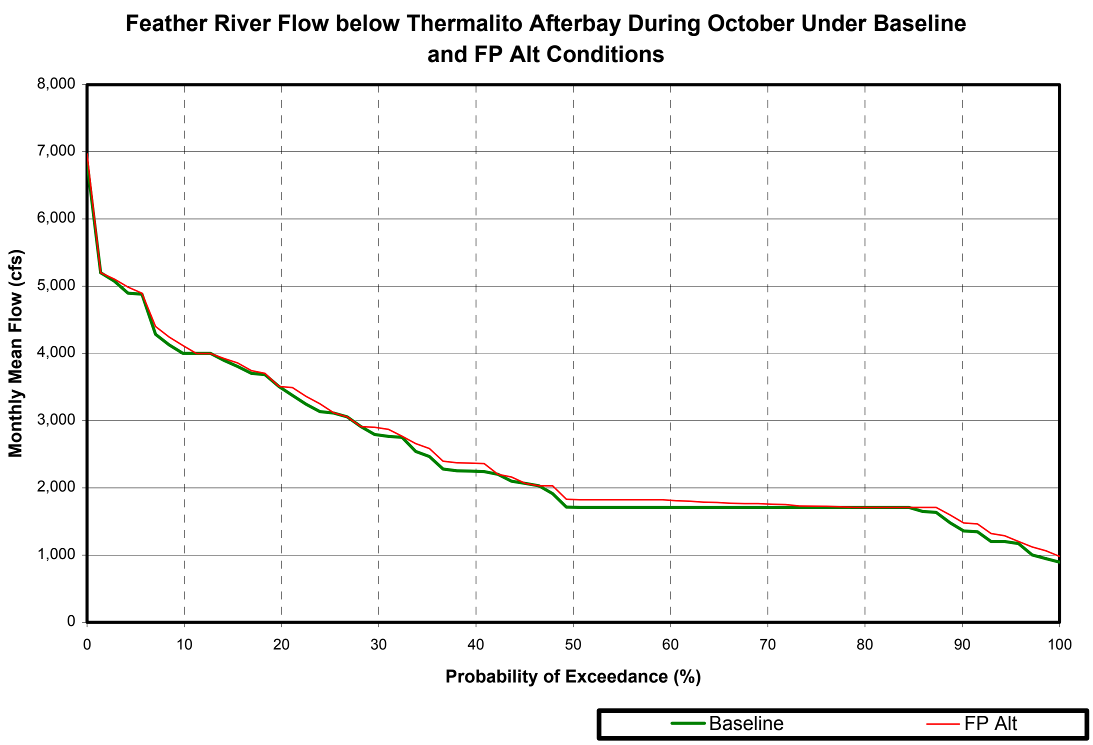

Figure 9-34
Feather River Flow Below Thermalito Afterbay During October Under Baseline and Flexible Purchase Alternative Conditions

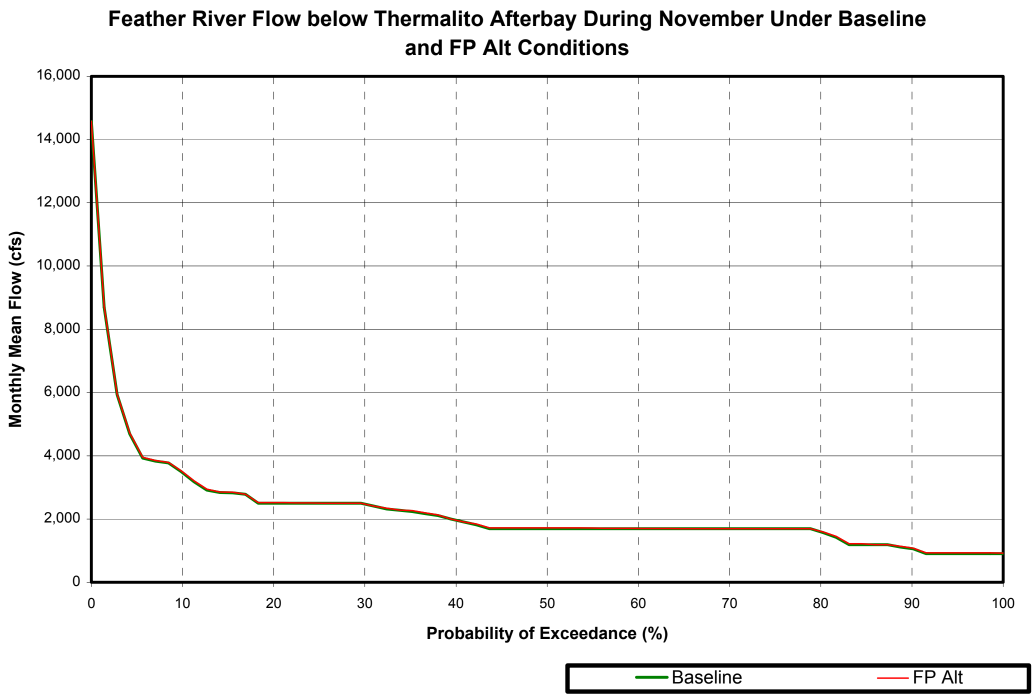

Figure 9-35
Feather River Flow Below Thermalito Afterbay During November Under Baseline and Flexible Purchase Alternative Conditions

These findings indicate that the Flexible Purchase Alternative could: 1) increase flows below Thermalito Afterbay for all flows relative to the Baseline Condition during August; 2) equal or increase flows below Thermalito Afterbay for all flows relative to the Baseline Condition during September; 3) equal or slightly increase flows below Thermalito Afterbay for all flows relative to the Baseline Condition during October; and 4) equal flows below Thermalito Afterbay for all flows relative to the Baseline Condition during November.

Temperature-related Impacts on Adult Spring-run Chinook Salmon Spawning and Egg Incubation (August through November)

Under the Flexible Purchase Alternative, long-term average water temperatures below the Fish Barrier Dam and below the Thermalito Afterbay Outlet would be identical to those under the Baseline Condition during the August through October period below the Fish Barrier Dam and below the Thermalito Afterbay Outlet, as shown in Table 9-25 and Table 9-26, respectively. In fact, in all of the 276 months included in the analysis, monthly mean water temperatures at these locations under the Flexible Purchase Alternative would be essentially equivalent to water temperatures under the Baseline Condition. (See Appendix H pgs. 916-927 and 940-951.) Further, there would not be any additional occurrences of water temperatures greater than 56°F under the Flexible Purchase Alternative, relative to the Baseline Condition, below the Fish Barrier Dam and below the Thermalito Afterbay Outlet.

Flow-related Impacts on Juvenile Spring-run Chinook Salmon Rearing and Emigration (November through June)

Long-term average flows in the Feather River below the Thermalito Afterbay Outlet under the Flexible Purchase Alternative would be up to 9 percent greater during the November through June juvenile spring-run Chinook salmon rearing and emigration period, relative to the Baseline Condition, as shown in Table 9-23. Monthly mean flows below the Thermalito Afterbay Outlet under the Flexible Purchase Alternative would be essentially equivalent to or greater than flows under the Baseline Condition in 576 of the 576 months included in the analysis for November through June. (Refer to Appendix H pgs. 893-900.)

Long-term average flows at the mouth of the Feather River under the Flexible Purchase Alternative would be up to three percent greater during the November through June juvenile spring-run Chinook salmon rearing and emigration period relative to the Baseline Condition. (Refer to Table 9-24.) Monthly mean flows at the mouth of the Feather River under the Flexible Purchase Alternative would be essentially equivalent to or greater than flows under the Baseline Condition in 576 of the 576 months included in the analysis for November through June. (Refer to Appendix H pgs. 869-876.)

Temperature-related Impacts on Juvenile Spring-run Chinook Salmon Rearing and Emigration (November through June)

Long-term average water temperatures under the Flexible Purchase Alternative below the Fish Barrier Dam would be identical to those under the Baseline Condition during the November through June period, as shown in Table 9-25. Monthly mean water temperatures at this location under the Flexible Purchase Alternative would be essentially equivalent to those under the Baseline Condition in all of the 552 months simulated for the November through June period. (See Appendix H pgs. 941-948.) Monthly mean water temperatures would not be greater than 65°F in any month simulated for the November through June period under both the Flexible Purchase Alternative and the Baseline Condition. (See Appendix H pgs. 941-948.) Therefore, implementation of the Flexible Purchase Alternative would not result in water temperatures above 65°F below the Fish Barrier Dam during the juvenile spring-run Chinook salmon rearing and emigration period.

Below the Thermalito Afterbay Outlet, long-term average water temperatures under the Flexible Purchase Alternative would be identical to those under the Baseline Condition throughout the November through June juvenile spring-run Chinook salmon rearing and emigration period, as shown in Table 9-26. Monthly mean water temperatures in the Feather River below the Thermalito Afterbay Outlet under the Flexible Purchase Alternative would be essentially equivalent to those under the Baseline Condition in all of the 552 months included in the analysis. (See Appendix H pgs. 917-924.) In addition, the Flexible Purchase Alternative would not result in an increase in the frequency in which monthly mean water temperatures below the Thermalito Afterbay Outlet would be greater than 65°F, relative to the Baseline Condition.

At the mouth of the Feather River, long-term average water temperatures under the Flexible Purchase Alternative would remain unchanged from November through March, and would increase by 0.1°F, 0.1°F, and 0.2°F during April, May, and June, respectively, as shown in Table 9-27. Monthly mean water temperatures in the Feather River at the mouth would be essentially equivalent to those under the Baseline Condition in 525 of the 552 months simulated for the November through June period. (See Appendix H pgs. 929-936.) However, there would only be one additional occurrence in which monthly mean water temperatures under the Flexible Purchase Alternative would be greater than 65°F, relative to the Baseline Condition.

Summary of Impacts on Spring-Run Chinook Salmon in the Feather River

In summary, the difference in flows below the Thermalito Afterbay Outlet and at the mouth of the Feather River that would occur under the Flexible Purchase Alternative would not be of sufficient frequency or magnitude to beneficially or adversely affect attraction, passage, and holding of adult spring-run Chinook salmon during the March through August period. Similarly, the difference in flows below the Thermalito Afterbay Outlet and at the mouth of the Feather River that would occur under the Flexible Purchase Alternative would not be of sufficient frequency or magnitude to beneficially or adversely affect spawning and egg incubation during the August through November period. Changes in flow that would occur under the Flexible Purchase Alternative would not be of sufficient frequency or magnitude to beneficially or adversely affect juvenile rearing and emigration during the November through June period.

Changes in Feather River water temperatures under the Flexible Purchase Alternative would not be of sufficient frequency or magnitude to beneficially or adversely affect adult spring-run Chinook salmon immigration and holding during the March through August period. Similarly, potential water temperature changes in the Feather River resulting from the implementation of the Flexible Purchase Alternative would not be of sufficient frequency or magnitude to beneficially or adversely impact spawning and egg incubation during the August through November period. Changes in water temperatures under the Flexible Purchase Alternative would not be of sufficient frequency or magnitude to beneficially or adversely affect juvenile rearing and emigration during the November through June period.

Overall, the changes in flows and water temperatures in the Feather River under the Flexible Purchase Alternative, relative to the Baseline Condition, would not be of sufficient frequency or magnitude to beneficially or adversely impact spring-run Chinook salmon. Therefore, impacts on spring-run Chinook salmon in the Feather

River with implementation of the Flexible Purchase Alternative would be less than significant, relative to the Baseline Condition.

Impacts on Fall-run Chinook Salmon and Steelhead in the Lower Feather River

Flow-related Impacts on Adult Fall-run Chinook Salmon/Steelhead Immigration (September through January)

Table 9-24 shows that long-term average flows at the mouth of the Feather River under the Flexible Purchase Alternative would be up to 13 percent greater during September through January relative to the Baseline Condition. Monthly mean flows at the mouth of the Feather River under the Flexible Purchase Alternative would be essentially equivalent to or greater than flows under the Baseline Condition in 360 of the 360 months included in the analysis for September through January. (See Appendix H pgs. 868-871, 879.)

Long-term average flows below the Thermalito Afterbay Outlet under the Flexible Purchase Alternative would be up to 24 percent greater during September through January relative to the Baseline Condition, as shown in Table 9-23. Monthly mean flows below the Thermalito Afterbay Outlet under the Flexible Purchase Alternative would be essentially equivalent to or greater than flows under the Baseline Condition in 360 of the 360 months included in the analysis for September through January. (See Appendix H pgs. 892-895, 903.)

Temperature-related Impacts on Adult Fall-run Chinook Salmon/Steelhead Immigration (September through January)

Under the Flexible Purchase Alternative, long-term average water temperatures at the mouth of the Feather River would decrease by 0.5°F in September, relative to the Baseline Condition, and would remain unchanged in the remaining months of the September through January period, as shown in Table 9-27. Moreover, under the Flexible Purchase Alternative, monthly mean water temperatures at the mouth of the Feather River would remain essentially equivalent to or less than those under the Baseline Condition in all of the 345 months included in the analysis. (See Appendix H pgs. 928-933, 939.)

Long-term average water temperatures below the Thermalito Afterbay Outlet under the Flexible Purchase Alternative would be identical those under the Baseline Condition during the September through January period, as shown in Table 9-26. Monthly mean water temperatures below the Thermalito Afterbay Outlet would remain essentially equivalent to those under the Baseline Condition in all of the 345 months simulated for the September through January period. (See Appendix H pgs. 916-919, 927.)

Flow-related Impacts on Adult Fall-run Chinook Salmon Spawning, Egg Incubation, and Initial Rearing (October through February)

Under the Flexible Purchase Alternative, long-term average flows in the Feather River below the Thermalito Afterbay Outlet would be 3 percent greater in October and essentially equivalent during November through February relative to the Baseline Condition, as shown in Table 9-23. Monthly mean flows under the Flexible Purchase Alternative would be essentially equivalent to or greater than flows under the Baseline Condition in 360 of the 360 months included in the analysis for October through February. (See Appendix H pgs. 892-896.)

Temperature-related Impacts on Adult Fall-run Chinook Salmon Spawning, Egg Incubation, and Initial Rearing (October through February)

Under the Flexible Purchase Alternative, long-term average water temperatures in the Feather River below the Fish Barrier Dam would not differ from those under the Baseline Condition during the October through February period, as shown in Table 9-25. In fact, in all of the 345 months included in the analysis, monthly mean water temperatures at this location under the Flexible Purchase Alternative would be essentially equivalent to water temperatures under the Flexible Purchase Alternative. (See Appendix H pgs. 940-944.) Moreover, implementation of the Flexible Purchase Alternative would not result in additional occurrences in which water temperatures during the October through February period would be above 56°F, relative to the Baseline Condition. (See Appendix H pgs. 940-944.)

Below the Thermalito Afterbay Outlet, long-term average water temperatures would not differ from those under the Baseline Condition during the October through February period, as shown in Table 9-26. Monthly mean water temperatures at this location under the Flexible Purchase Alternative would be essentially equivalent to those under the Baseline Condition in all of the 345 months included in the analysis. (See Appendix H pgs. 916-920.) In addition, there would not be any additional occurrences in which water temperatures would be greater than 56°F under the Flexible Purchase Alternative, relative to the Baseline Condition, during any month of the October through February period. (See Appendix H pgs. 916-920.)

Flow-related Impacts on Adult Steelhead Spawning and Egg Incubation (December through April)

Table 9-23 shows that long-term average flows in the Feather River below the Thermalito Afterbay Outlet under the Flexible Purchase Alternative would be up to 9 percent greater than flows under the Baseline Condition during the December through April adult steelhead spawning and egg incubation period. Further, monthly mean flows under the Flexible Purchase Alternative would be essentially equivalent to or greater than flows under the Baseline Condition in 360 of the 360 months included in the analysis for December through April. (See Appendix H pgs. 894-898.)

Temperature-related Impacts on Adult Steelhead Spawning and Egg Incubation (December through April)

Long-term average water temperatures below the Fish Barrier Dam under the Flexible Purchase Alternative would not differ from those under the Baseline Condition during the December through April period, as shown in Table 9-25. In addition, monthly mean water temperatures below the Fish Barrier Dam would be essentially equivalent to those under the Baseline Condition for all of the 345 months included in the analysis. (See Appendix H pgs. 942-946.) Moreover, implementation of the Flexible Purchase Alternative would not result in monthly mean water temperatures below the Fish Barrier Dam greater than 56°F, relative to the Baseline Condition, in any month simulated for the December through April period.

Below the Thermalito Afterbay Outlet, long-term average water temperatures under the Flexible Purchase Alternative throughout the December through April period would be identical to those under the Baseline Condition, as shown in Table 9-23. In addition, monthly mean water temperatures below the Thermalito Afterbay Outlet would be essentially equivalent to those under the Baseline Condition for all of the 345 months included in the analysis. (See Appendix H pgs. 918-922.) Further, there would be no additional occurrences in which water temperatures below Thermalito Afterbay would be greater than 56°F, relative to the Baseline Condition, for all of the 69 years modeled.

Flow-related Impacts on Juvenile Fall-run Chinook Salmon and Steelhead Rearing and Emigration (February through June)

Long-term average flows in the Feather River below the Thermalito Afterbay Outlet under the Flexible Purchase Alternative would be up to 9 percent or greater than flows under the Baseline Condition during February through June. (Refer to Table 9-23.) Monthly mean flows under the Flexible Purchase Alternative would be essentially equivalent to or greater than flows under the Baseline Condition included in the analysis for February through June. (See Appendix H pgs. 896-900.)

Flow exceedance curves for February through June in the Feather River below the Thermalito Afterbay are shown in Figures 9-36 through 9-40. The basis for development of these exceedance curves was the 1922-1993 period of record. These curves indicate that flows in the Feather River below the Thermalito Afterbay Outlet under the Flexible Purchase Alternative would be essentially equivalent o or slightly greater than flows under the Baseline Condition.

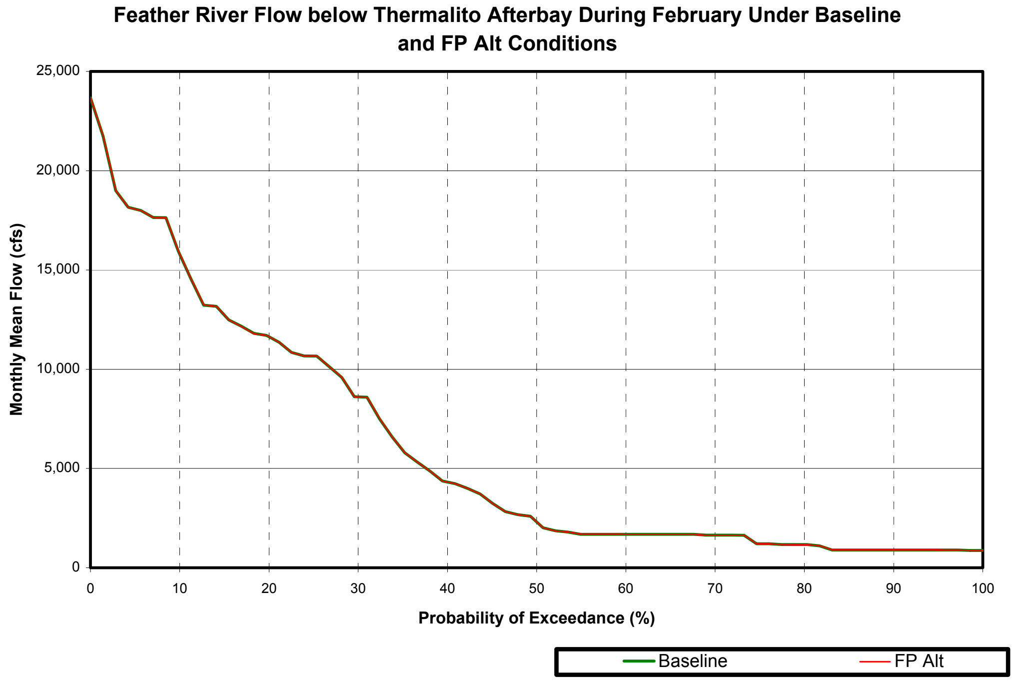

Figure 9-36
Feather River Flow Below Thermalito Afterbay During February Under Baseline and Flexible Purchase Alternative Conditions

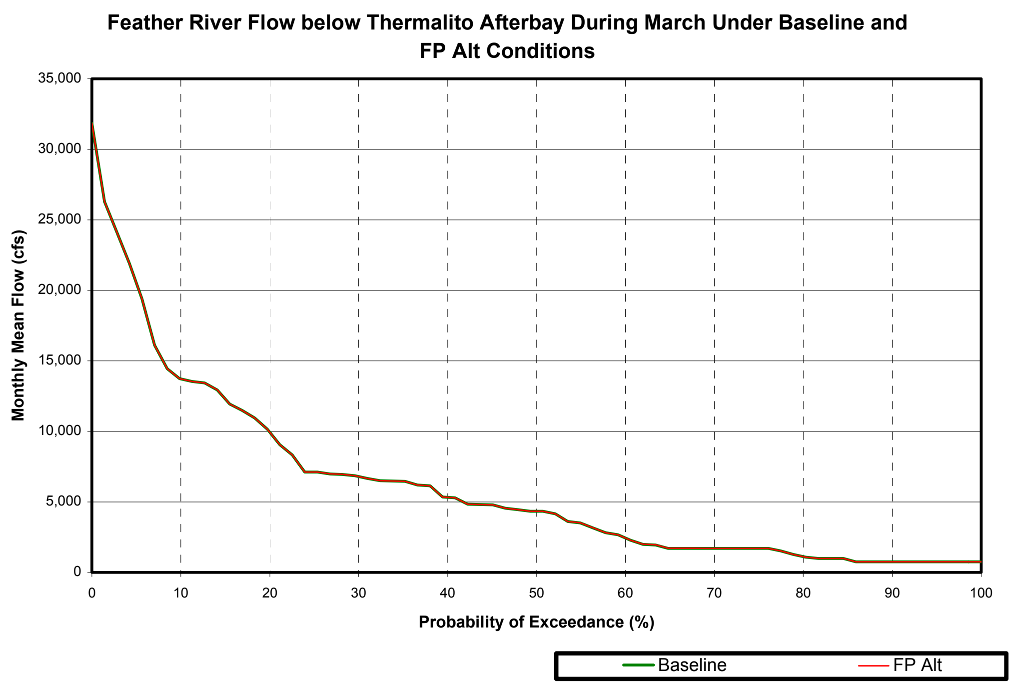

Figure 9-37
Feather River Flow Below Thermalito Afterbay During March Under Baseline and Flexible Purchase Alternative Conditions

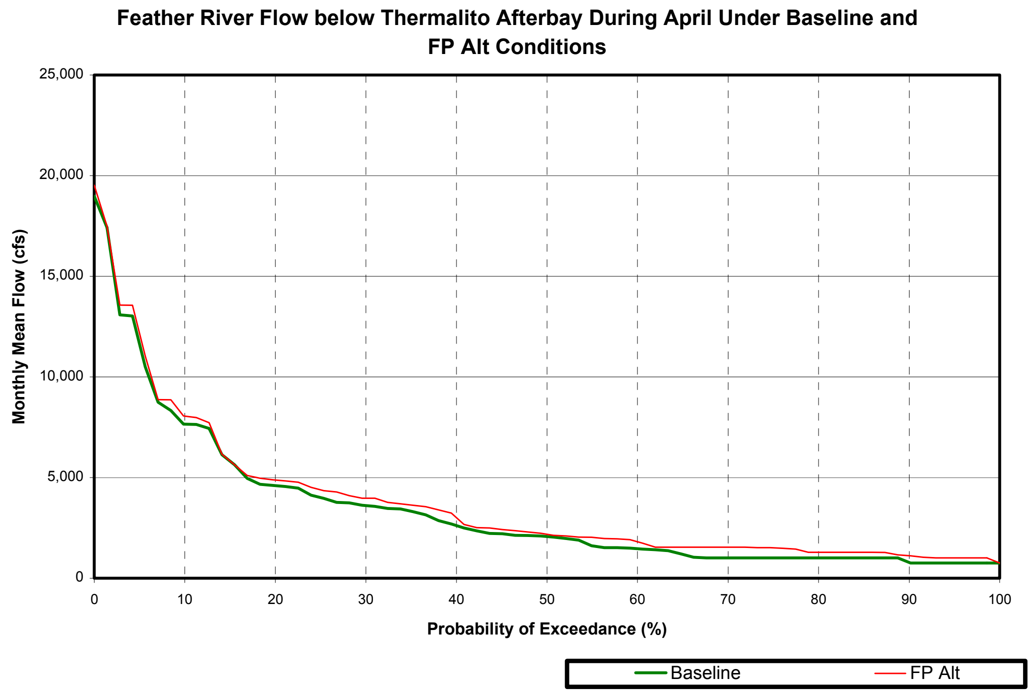

Figure 9-38
Feather River Flow Below Thermalito Afterbay During April Under Baseline and Flexible Purchase Alternative Conditions

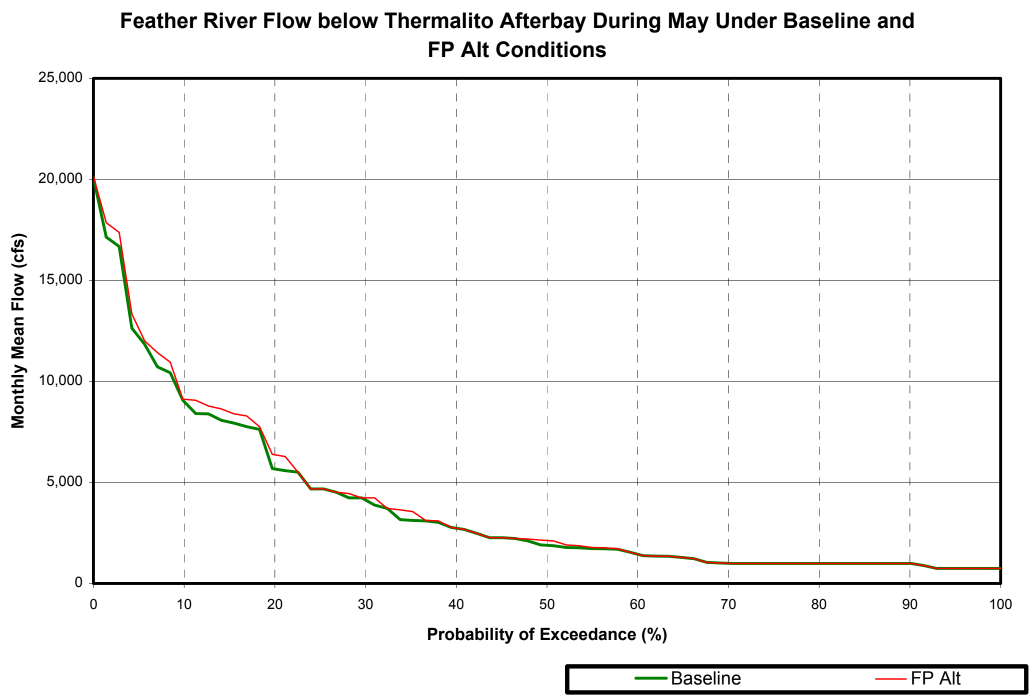

Figure 9-39
Feather River Flow Below Thermalito Afterbay During May Under Baseline and Flexible Purchase Alternative Conditions

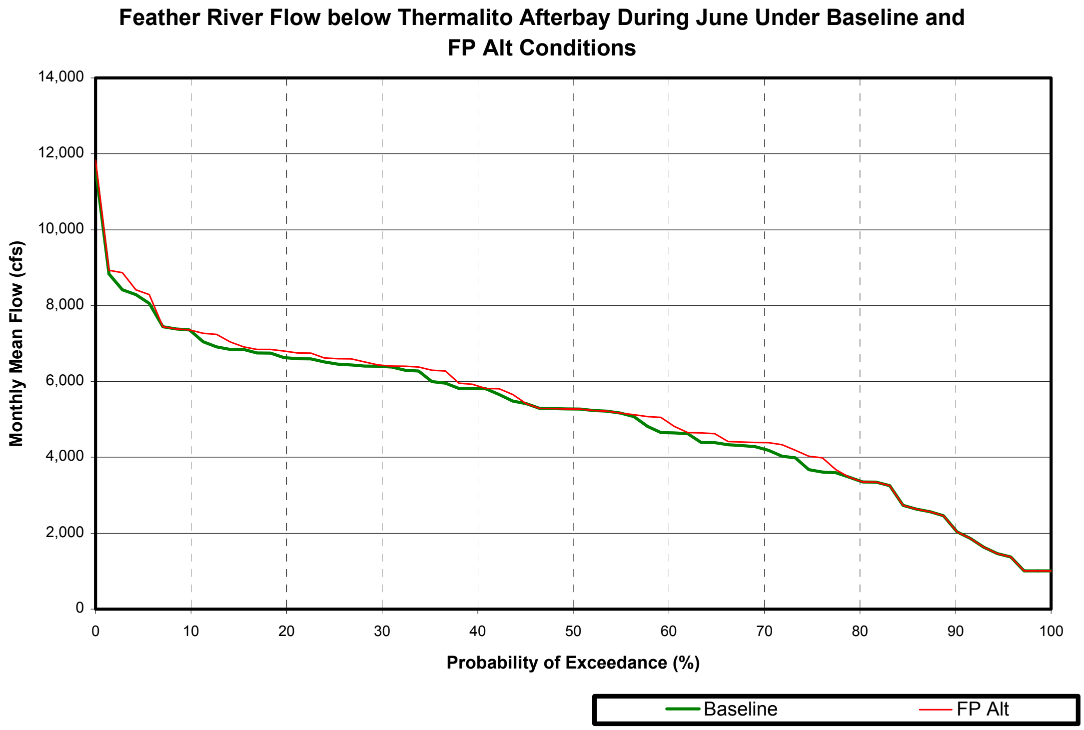

Figure 9-40
Feather River Flow Below Thermalito Afterbay During June Under Baseline and Flexible Purchase Alternative Conditions

Long-term average flows at the mouth of the Feather River under the Flexible Purchase Alternative would be up to 3 percent greater than flows under the Baseline Condition during February through June. (Refer to Table 9-24.) Further, monthly mean flows under the Flexible Purchase Alternative would be essentially equivalent to or greater than flows under the Baseline Condition in 360 of the 360 months included in the analysis for February through June. (Refer to Appendix H pgs. 872-876.)

Temperature-related Impacts on Juvenile Fall-run Chinook Salmon and Steelhead Rearing and Emigration (February through June)

Modeling associated with the Flexible Purchase Alternative indicates that the long-term average water temperatures in the lower Feather River below the Fish Barrier Dam would not differ during any month of the February through June period, relative to the Baseline Condition, as shown in Table 9-25. Monthly mean water temperatures in the Feather River below the Fish Barrier Dam would be essentially equivalent to those under the Baseline Condition in all of the 345 months simulated for the February through June period. (Refer to Appendix H pgs. 944-948.) In addition, monthly mean water temperatures under the Flexible Purchase Alternative and Baseline Condition would be below 65°F for each month simulated for the February through June period. Therefore, there would be no additional occurrences during February through June in which monthly mean water temperatures in the Feather River below the Fish Barrier

Dam under the Flexible Purchase Alternative would exceed 65°F, relative to the Baseline Condition.

NOAA Fisheries temperature criteria for daily water temperatures (less than 65°F) in the Low Flow Channel of the Feather River are applicable during June of the juvenile fall-run Chinook salmon and steelhead rearing and emigration period (NMFS 2001). As described in the Section 9.2.1.2.2 of the Assessment Methods, this analysis is based on monthly mean water temperatures due to modeling limitations. Therefore, this analysis evaluates the potential for monthly mean water temperatures to exceed NOAA Fisheries temperature criteria for the Feather River below the Fish Barrier Dam. As described above, the Flexible Purchase Alternative would not result in an increase in the frequency in which water temperatures would be above 65°F below the Fish Barrier Dam in the Low Flow Channel, relative to the Baseline Condition. Therefore, the Flexible Purchase Alternative would not exceed the NOAA Fisheries temperature criteria for the Feather River, relative to the Baseline Condition.

Below the Thermalito Afterbay Outlet, long-term average water temperatures under the Flexible Purchase Alternative would not differ from those under the Baseline Condition during any month of the February through June period, as shown in Table 9-26. Further, monthly mean water temperatures under the Flexible Purchase Alternative would be essentially equivalent to those under the Baseline Condition in all of the 345 months simulated for the February through June period and there would be no additional occurrences in which monthly mean water temperatures below the Thermalito Afterbay Outlet would be above 65°F, relative to the Baseline Condition.

Modeling associated with the Flexible Purchase Alternative indicates that long-term average water temperatures at the mouth of the Feather River would not change, relative to the Baseline Condition, during February and March, and would increase by up to 0.2°F during April, May, and June, as shown in Table 9-27. Monthly mean water temperatures under the Flexible Purchase Alternative would be essentially equivalent to those under the Baseline Condition in 318 of the 345 months included in the analysis. (See Appendix H pgs. 932-936.) However, the frequency in which monthly mean water temperatures at this location would exceed 65°F would increase by one measurable occurrence under the Flexible Purchase Alternative, relative to the Baseline Condition.

Overall, water temperatures under the Flexible Purchase Alternative in the Feather River below the Fish Barrier Dam and below the Thermalito Afterbay Outlet would be unchanged, relative to the Baseline Condition, and would change slightly during April, May and June at the Feather River mouth. However, implementation of the Flexible Purchase Alternative would not result in additional exceedances of NOAA Fisheries water temperature criteria for the Low Flow Channel in the lower Feather River.

Flow-related Impacts on Over-summer Juvenile Steelhead Rearing (July through September)

Long-term average flows in the Feather River below the Thermalito Afterbay Outlet under the Flexible Purchase Alternative would be between 22 percent and 29 percent greater than flows under the Baseline Condition during July through September. (See Table 9-23.) Monthly mean flows under the Flexible Purchase Alternative would be essentially equivalent to or greater than flows under the Baseline Condition in 209 of the 216 months included in the analysis. (See Appendix H pgs. 901-903.)

Long-term average flows at the mouth of the Feather River under the Flexible Purchase Alternative would be between 13 percent and 35 percent greater than flows under the Baseline Condition during July through September. (See Table 9-24.) Monthly mean flows would be essentially equivalent to or greater than flows under the Baseline Condition in 216 of the 216 months included in the analysis for July through September. (See Appendix H pgs. 877-879.)

Temperature-related Impacts on Over-summer Juvenile Steelhead Rearing (July through September)

Under the Flexible Purchase Alternative, long-term average water temperatures in the lower Feather River below the Fish Barrier Dam would not differ during any month of the July through September period, relative to the Baseline Condition, as shown in Table 9-25. Monthly mean water temperatures at this location under the Flexible Purchase Alternative would be essentially equivalent to those under the Baseline Condition in all of the 207 months simulated for the July through September period. (See Appendix H pgs. 949-951.) In addition, the Flexible Purchase Alternative would not result in additional occurrences during the July through September period in which monthly mean water temperatures in the Feather River below the Fish Barrier Dam would be above 65°F, relative to the Baseline Condition.

NOAA Fisheries temperature criteria for daily water temperatures (less than 65°F) in the Low Flow Channel of the Feather River are applicable during July through September of the over-summer juvenile steelhead-rearing period (NMFS 2001). As described in Section 9.2.1.2.2 of the Assessment Methods, this analysis is based on monthly mean water temperatures due to modeling limitations. Therefore, this analysis evaluates the potential for monthly mean water temperatures to exceed NOAA Fisheries temperature criteria for the Feather River below the Fish Barrier Dam. As described above, the Flexible Purchase Alternative would not result in an increase in the frequency in which water temperatures would be above 65°F below the Fish Barrier Dam throughout the July through September period, relative to the Baseline Condition. Therefore, the Flexible Purchase Alternative would not be expected to result in an increase in the frequency in which monthly mean water temperatures exceed the NOAA Fisheries temperature criteria for the Feather River, relative to the Baseline Condition.

Modeling associated with the Flexible Purchase Alternative indicates that long-term average water temperatures in the lower Feather River below the Thermalito Afterbay Outlet would not change during any month of the July through September period, relative to the Baseline Condition, as shown in Table 9-26. Monthly mean water temperatures at this location under the Flexible Purchase Alternative would be essentially equivalent to those under the Baseline Condition in all of the 207 months simulated for the July through September period. (See Appendix H pgs. 925-927.) Further, there would be no additional occurrences during the July through September period in which monthly mean water temperatures below the Thermalito Afterbay Outlet under the Flexible Purchase Alternative would be above 65°F, relative to the Baseline Condition.

At the mouth of the Feather River, implementation of the Flexible Purchase Alternative would result in no change in long-term average water temperatures in July, and reductions in long-term average water temperatures of 0.4°F and 0.5°F in August and September, respectively. (Refer to Table 9-27.) Monthly mean water temperatures under the Flexible Purchase Alternative at the mouth of the Feather River would be essentially equivalent to those under the Baseline Condition in 202 of the 207 months simulated for the July through September period. (See Appendix H pgs. 937-939.) Additionally, the Flexible Purchase Alternative would not result in an increase in the frequency of water temperatures above 65°F at the mouth of the Feather River, relative to the Baseline Condition.

Flow-related Impacts on Fall/Winter Juvenile Steelhead Rearing (October through January)

Long-term average flows in the Feather River below the Thermalito Afterbay Outlet under the Flexible Purchase Alternative would be no more than 2.8 percent greater than flows under the Baseline Condition during October through January. (Refer to Table 9-23.) Monthly mean flows under the Flexible Purchase Alternative would be essentially equivalent to or greater than flows under the Baseline Condition in all of the 288 months included in the analysis. (Refer to Appendix H pgs. 892-895.)

Long-term average flows at the mouth of the Feather River under the Flexible Purchase Alternative would be no more than 2.1 percent greater than flows under the Baseline Condition during October through January. (Refer to Table 9-24.) Monthly mean flows would be essentially equivalent to or greater than flows under the Baseline Condition in all of the 288 months included in the analysis for October through January. (Refer to Appendix H pgs. 868-871.)

Temperature-related Impacts on Fall/Winter Juvenile Steelhead Rearing (October through January)

Under the Flexible Purchase Alternative, long-term average water temperatures in the lower Feather River below the Fish Barrier Dam would not differ during any month of the October through January period, relative to the Baseline Condition, as shown in Table 9-25. Monthly mean water temperatures at this location under the Flexible Purchase Alternative would be essentially equivalent to those under the Baseline

Condition in all of the 276 months simulated for the October through January period. (Refer to Appendix H pgs. 940-943.)

Modeling associated with the Flexible Purchase Alternative indicates that long-term average water temperatures in the lower Feather River below the Thermalito Afterbay Outlet would not change during any month of the October through January period, relative to the Baseline Condition, as shown in Table 9-26. Monthly mean water temperatures at this location under the Flexible Purchase Alternative would be essentially equivalent to those under the Baseline Condition in all of the 276 months simulated for the October through January period. (Refer to Appendix H pgs. 916-919.)

At the mouth of the Feather River, implementation of the Flexible Purchase Alternative would result in no change in long-term average water temperatures in any month of the October through January period. (Refer to Table 9-27.) Monthly mean water temperatures under the Flexible Purchase Alternative at the mouth of the Feather River would be essentially equivalent to those under the Baseline Condition in all of the 276 months simulated for the October through January period. (Refer to Appendix H pgs. 928-931.)

Summary of Impacts on Fall-run Chinook Salmon and Steelhead in the Feather River

In summary, potential changes in flow in the Feather River under the Flexible Purchase Alternative during the September through January period would not be of sufficient frequency or magnitude to beneficially or adversely affect adult fall-run Chinook salmon immigration. Similarly, changes in flows under the Flexible Purchase Alternative would not be of sufficient frequency or magnitude to beneficially or adversely impact spawning, egg incubation, and initial rearing during the October through February period. Changes in flow that would occur under the Flexible Purchase Alternative would not be of sufficient frequency or magnitude to beneficially or adversely affect juvenile rearing and emigration during the February through June period.

Changes in water temperature in the Feather River under the Flexible Purchase Alternative during the September through January period would not be of sufficient frequency or magnitude to beneficially or adversely affect adult fall-run Chinook salmon immigration. Similarly, changes in water temperature under the Flexible Purchase Alternative would not be of sufficient frequency or magnitude to beneficially or adversely impact spawning, egg incubation, and initial rearing during the October through February period. Changes in water temperature that would occur under the Flexible Purchase Alternative would not be of sufficient frequency or magnitude to beneficially or adversely affect juvenile rearing and emigration during the February through June period.

Potential changes in flow in the Feather River under the Flexible Purchase Alternative during the September through January period would not be of sufficient frequency or magnitude to beneficially or adversely affect adult steelhead immigration. Flow related changes under the Flexible Purchase Alternative during the December through April period would not be of sufficient frequency or magnitude to beneficially or adversely impact adult steelhead spawning and egg incubation. Changes in flow that would occur in the Feather River under the Flexible Purchase Alternative would not be of sufficient frequency or magnitude to beneficially or adversely affect juvenile steelhead rearing, including over-summer and fall/winter rearing, and emigration during the February through June, July through September, and October through January periods.

Changes in water temperature in the Feather River under the Flexible Purchase Alternative during the September through January period would not be of sufficient frequency or magnitude to beneficially or adversely affect adult steelhead immigration. Water temperature changes under the Flexible Purchase Alternative during the December through March period would not be of sufficient frequency or magnitude to beneficially or adversely impact adult steelhead spawning and egg incubation. Changes in water temperature that would occur in the Feather River under the Flexible Purchase Alternative would not be of sufficient frequency or magnitude to beneficially or adversely affect juvenile steelhead rearing, including over-summer and fall/winter rearing and emigration during the February through June, July through September, and October through January periods.

Overall, the changes in flows and water temperatures in the Feather River under the Flexible Purchase Alternative, relative to the baseline, would not be of sufficient frequency or magnitude to beneficially or adversely impact fall-run Chinook salmon. Therefore, impacts on fall-run Chinook salmon in the Feather River with implementation of the Flexible Purchase Alternative, relative to the Baseline Condition, would be less than significant.

Similarly, the changes in flows and water temperatures in the Feather River under the Flexible Purchase Alternative, relative to the baseline, would not be of sufficient frequency or magnitude to beneficially or adversely impact steelhead. Therefore, impacts on steelhead in the Feather River with implementation of the Flexible Purchase Alternative, relative to the Baseline Condition, would be less than significant.

<u>Impacts on Splittail in the Feather River</u>

Splittail spawning occurs primarily at the mouth of the Feather River in areas of submerged vegetation. Long-term average flows at the mouth of the Feather River under the Flexible Purchase Alternative would be up to 3 percent greater than flows under the Baseline Condition during February through May, as shown in Table 9-24. Monthly mean flows at the mouth of the Feather River under the Flexible Purchase Alternative would be essentially equivalent to or greater than flows those under the Baseline Condition in 288 of the 288 months included in the analysis for February through May. (Refer to Appendix H pgs. 872-875.)

During the February through May period, long-term average water temperatures under the Flexible Purchase Alternative at the mouth of the Feather River would not change during February and March, and would increase by 0.1°F in both April and May, as shown in Table 9-27. Monthly mean water temperatures would exceed 68°F, the upper end of the reported preferred range for splittail spawning, in one additional month under the Flexible Purchase Alternative, relative to the Baseline Condition during the February through May period. (Refer to Appendix H pgs. 932-935.) Thus, there would be slight changes in water temperatures under the Flexible Purchase Alternative, relative to the Baseline Condition.

Overall, potential flow and water temperature changes in the Feather River resulting from the implementation of the Flexible Purchase Alternative would not be of sufficient frequency or magnitude to beneficially or adversely impact splittail spawning. Therefore, impacts on splittail in the Feather River under the Flexible Purchase Alternative would be less than significant, relative to the Baseline Condition.

Impacts on American Shad in the Feather River

Table 9-24 shows that long-term average flows at the mouth of the Feather River under the Flexible Purchase Alternative would be 1.8 percent greater during May and 1.4 percent greater during June, relative to the Baseline Condition. Monthly mean flows at the mouth of the Feather River under the Flexible Purchase Alternative would be essentially equivalent to or greater than flows under the Baseline Condition in 144 of the 144 months included in the analysis for the May through June spawning period. (Refer to Appendix H pgs. 875-876.)

Long-term average flows below the Thermalito Afterbay Outlet under the Flexible Purchase Alternative would be 3.7 percent greater during May and 2.1 percent greater during June relative tot he the Baseline Condition, as shown in Table 9-23. Monthly mean flows at this location under the Flexible Purchase Alternative would be essentially equivalent to or greater than flows under the Baseline Condition in 144 of the 144 months included in the analysis for May through June. (Refer to Appendix H pgs. 899-900.) The reported preferred range for American shad spawning is 60°F to 70°F. Implementation of the Flexible Purchase Alternative would not result in a change in the frequency of monthly mean water temperatures below the Fish Barrier Dam or below the Thermalito Afterbay Outlet within the reported preferred range for American shad spawning, relative to the Baseline Condition. (Refer to Appendix H pgs. 923-924 and 947-948.) At the mouth of the Feather River, there would be three fewer occurrences of water temperatures within the reported preferred range for American shad spawning under the Flexible Purchase Alternative, relative to the Baseline Condition. (Refer to Appendix H pgs. 935-936.) The frequency of monthly mean water temperatures within this range would remain unchanged under the Flexible Purchase Alternative below the Fish Barrier Dam and below the Thermalito Afterbay Outlet.

Overall, changes in flows and water temperatures in the Feather River under the Flexible Purchase Alternative would not be of sufficient frequency or magnitude to beneficially or adversely impact American shad attraction and spawning. Therefore, impacts on American shad in the Feather River with implementation of the Flexible Purchase Alternative would be less than significant, relative to the Baseline Condition.

<u>Impacts on Striped Bass in the Feather River</u>

Under the Flexible Purchase Alternative, long-term average flows at the mouth of the Feather River would be 1.8 percent greater during May and 1.4 percent greater during June, relative to the Baseline Condition, as shown in Table 9-24. Monthly mean flows at the mouth of the Feather River under the Flexible Purchase Alternative would be essentially equivalent to or greater than flows under the Baseline Condition in 144 of the 144 months included in the analysis for the May through June spawning period. (Refer to Appendix H pgs. 875-876.)

Table 9-23 shows that long-term average flows in the Feather River below the Thermalito Afterbay Outlet under the Flexible Purchase Alternative would be 3.7 percent greater during May and 2.1 percent greater during June. Monthly mean flows at this location under the Flexible Purchase Alternative would be essentially equivalent to or greater than flows under the Baseline Condition in 144 of the 144 months included in the analysis for May through June. (Refer to Appendix H pgs. 899-900.) Thus, reductions in flows would not occur under the Flexible Purchase Alternative.

The reported preferred range for striped bass spawning and initial rearing is 59°F to 68°F. Implementation of the Flexible Purchase Alternative would not result in a change in the frequency of monthly mean water temperatures within this range below the Fish Barrier Dam or below the Thermalito Afterbay Outlet. (Refer to Appendix H pgs. 923-924 and 947-948.) At the mouth of the Feather River, there would be one less occurrence of water temperatures within the reported preferred range for striped bass spawning under the Flexible Purchase Alternative, relative to the Baseline Condition (Refer to Appendix H pgs. 935-936.) The frequency of monthly mean water temperatures within this range would remain unchanged under the Flexible Purchase Alternative below the Fish Barrier Dam and below the Thermalito Afterbay Outlet. Overall, changes in flows and water temperatures in Feather River would not be of sufficient frequency or magnitude to beneficially or adversely impacts striped bass spawning and initial rearing. Therefore, impacts on striped bass in the Sacramento River with implementation of the Flexible Purchase Alternative would be less than significant, relative to the Baseline Condition.

9.2.5.1.3 Yuba River Area of Analysis

EWA acquisition of Yuba County WA water via groundwater substitution would alter Yuba River flows during April through June. EWA acquisition of Yuba County WA water via groundwater substitution and crop idling would alter water surface elevations in New Bullards Bar Reservoir during April through June, relative to the Baseline Condition. EWA *acquisition of Yuba County WA stored reservoir water would alter surface water elevations from July until refill at New Bullards Bar Reservoir.*

<u>Impacts on New Bullards Bar Reservoir Warmwater Fisheries</u>

Table 9-28 provides monthly median storage, elevation, and elevation changes for New Bullards Bar Reservoir. Hydrologic conditions under the Flexible Purchase Alternative could result in reductions of up to 27 feet msl in the median water surface elevation of New Bullards Bar Reservoir, relative to the Baseline Condition, during the April through November period, when warmwater fish rearing may be expected. Water surface elevation is typically correlated with the availability of littoral habitat (submerged vegetation) associated with the shoreline of reservoirs. Such shallow, nearshore waters containing physical structure are important to producing and maintaining strong year-classes of warmwater fishes.

Changes in water surface elevation of New Bullards Bar Reservoir would not result in corresponding changes in the availability of littoral habitat, as would be typical of several other reservoirs, for many reasons. New Bullards Bar Reservoir is a deep, steep-sloped reservoir created from the flooding of a tall, strongly sloped canyon. Because of its deep nature, the amount of littoral habitat typically available at New Bullards Bar Reservoir does not change substantially throughout the period of reservoir drawdown. Areas of potentially submerged littoral habitat important for escape cover for young-of-the-year warmwater fish rearing are typically exposed early in the period of reservoir drawdown (by summer). Consequently, littoral habitat is typically not available in summer, when escape cover would be utilized by rearing young-of-the-year warmwater fish species.

Table 9-28
New Bullards Bar Reservoir Monthly Median Storage, Elevation, and Elevation Change Under Baseline and Flexible Purchase Alternative Conditions

	Storage				***Elevation***			***Elevation Change***		
Month	***Base (TAF)***	***FP Alt (TAF)***	***Diff (TAF)***	***Diff (%)***	***Base (ft msl)***	***FP Alt (ft msl)***	***Diff (ft msl)***	***Base (ft msl)***	***FP Alt (ft msl)***	***Diff (ft msl)***
Oct	544	446	-98	-18	1838	1812	-27	-16	-19	-3
Nov	546	449	-98	-18	1839	1812	-26	1	1	0
Dec	532	442	-90	-17	1835	1810	-25	-4	-2	1
Jan	593	578	-15	-3	1850	1847	-3	15	36	22
Feb	649	649	0	0	1862	1862	0	12	15	3
Mar	735	735	0	0	1878	1878	0	16	16	0
Apr	774	788	14	2	1884	1886	2	6	9	2
May	879	908	28	3	1899	1902	3	15	16	1
Jun	917	960	43	5	1903	1908	5	5	6	1
Jul	825	820	-5	-1	1892	1891	-1	-12	-17	-5
Aug	713	660	-52	-7	1874	1864	-10	-18	-27	-9
Sep	614	514	-100	-16	1855	1831	-24	-19	-34	-14

Based on median monthly storage and flow over the historical record from 1970 to 2001.
FP Alt = Flexible Purchase Alternative
Diff = Difference

The Flexible Purchase Alternative could alter the rates by which water surface elevation in New Bullards Bar Reservoir change, relative to the Baseline Condition. As discussed in Section 9.2.1.1.1, adverse effects on warmwater fish spawning from nest dewatering are assumed to have the potential to occur when reservoir water surface elevation decreases by more than nine feet within a given month during the March-June warmwater fish-spawning period. Reductions in median water surface elevation between months at New Bullards Bar Reservoir, under the Flexible Purchase Alternative or the Baseline Condition, would not occur during the March through June spawning period, as shown in Table 9-28. Under the Flexible Purchase Alternative, the magnitude of monthly drawdown is not expected to exceed nine feet during the March through June spawning period.

In summary, because of New Bullards Bar Reservoir's unique bathymetric profile, reductions in surface water elevation resulting from implementing the Flexible Purchase Alternative is not likely to result in substantial changes in the availability of littoral habitat at New Bullards Bar Reservoirs. Thus, implementation of the Flexible Purchase Alternative would not likely adversely affect warmwater fish rearing in Bullards Bar Reservoir. The Flexible Purchase Alternative does not increase the frequency of potential nest dewatering events in New Bullards Bar Reservoir, and thus, would not adversely affect long-term warmwater fish nesting success. Therefore, under the Flexible Purchase Alternative, impacts on New Bullards Bar Reservoirs warmwater fisheries would be less than significant, relative to the Baseline Condition.

<u>Impacts on New Bullards Bar Reservoir Coldwater Fisheries</u>

Hydrologic conditions under the Flexible Purchase Alternative would result in a reduction in median storage of up to 100 TAF, or 16 percent, at New Bullards Bar Reservoir during the April through November period, relative to the Baseline Condition, as shown in Table 9-28. Changes in New Bullards Bar Reservoir storage under the Flexible Purchase Alternative would not be expected to result in significant impacts on coldwater fish resources, relative to the Baseline Condition, because New Bullards Bar Reservoir is a deep, steep-sloped reservoir with ample coldwater pool reserves. Throughout the period of operations of New Bullards Bar Reservoir (1969 – present), which encompasses the most extreme critically dry year on record, the coldwater pool in New Bullards Bar Reservoir has not been depleted. In fact, since 1993, coldwater pool availability in New Bullards Bar has been sufficient to accommodate year-round utilization of the lower river outlets at the direction provided by CDFG in order to provide the coldest water possible to the lower Yuba River. Therefore, anticipated reductions in reservoir storage would not be expected to adversely affect the reservoir's coldwater fisheries because: 1) coldwater habitat would remain available within the reservoir during all months of all years; 2) physical habitat availability is not believed to be among the primary factors limiting coldwater fish populations; and 3) anticipated seasonal reductions in storage would not be expected to adversely affect the primary prey species utilized by coldwater fish. Therefore, changes in end-of-month storage at New Bullards Bar Reservoir under the

Flexible Purchase Alternative represent a less-than-significant effect to coldwater fisheries, relative to the Baseline Condition.

<u>Impacts on Yuba River Fisheries Resources</u>

The analysis used to evaluate potential impacts of the EWA Program on the Yuba River Basin varies from that used for other river systems in the Area of analysis. Modeled streamflow data for the baseline and Flexible Purchase Alternative conditions, similar to that utilized in the analyses of EWA potential effects on other rivers, is not available for the Yuba River. The Yuba River HEC 5 operations model data consists only of input to flows at the confluence of the Yuba and Feather rivers. Thus, mean monthly flows for the Yuba River are not provided as part of the CALSIM II simulation outputs. Changes in flow due to Yuba River-specific EWA actions such as crop idling and ground water substitution were incorporated, when appropriate, to adjust the flows at the mouth of the Yuba River. Additionally, a water temperature model has not yet been developed for the Yuba River Basin; therefore, mean monthly water temperatures cannot be calculated and used as the basis for determining temperature-related impacts on fisheries resources within the Yuba River. However, water transfer issues and the health of aquatic resources in the Yuba River Basin have received a high level of scrutiny over the past few years. Information derived from recent monitoring has been used to analyze potential effects and describe ongoing efforts within the Yuba River Basin that are being employed to protect aquatic resources while also meeting other beneficial uses.

Recent historical flows in the Yuba River below Englebright Dam during June through October, the typical time period for water transfers, have ranged from approximately 600 to 2,500 cfs. Historical data suggests that, without EWA water transfer, flows below Englebright Reservoir range from approximately 1,000 to 1,800 cfs during June, July, and most of August. Streamflows range from approximately 500 to 900 cfs in late August and early September, and remain relatively constant at 600 to 900 cfs for October and November. At the onset of the wet season, unregulated winter storm and snowmelt flows primarily affect lower Yuba River hydrology. Without EWA water transfers, flows below Daguerre Point Dam range from approximately 245 to 800 cfs in June, and from 100 to 250 cfs during July, August, and September. Flows below Daguerre Point Dam in the first two weeks in October are approximately 320 to 400 cfs, and increase to 400 to 500 cfs for the last two weeks of October through the time period in the winter when runoff from winter storms significantly affects river flows.

Two transfer scenarios, referred to as the maximum transfer scenario and the minimum transfer scenario, are discussed for the Yuba River as part of potential EWA actions. Potential EWA operations may reflect the maximum or minimum transfer scenarios, or any gradient of water transfer between the two. Under all scenarios, the majority of the water transfer is expected to occur during July and August. In some years water transfer may begin as early as June depending on current instream conditions in the Yuba River, Delta conditions, and the SWP's ability to pump the water south of the Delta. Releases in September and October would be scheduled to provide fishery benefits in the lower Yuba River in addition to water delivery. Potential fisheries benefits of the water transfer may include: 1) increased spawning habitat availability for spring-run and fall-run Chinook salmon; 2) increased flows and possibly reduced water temperatures for juvenile steelhead rearing; and 3) minimal flow changes while transitioning to the fall instream flow spawning requirements.

Water transfers under all scenarios could affect Lake Oroville water levels. Lake Oroville water levels would be affected if DWR releases stored water to compensate for reduced flows to the Delta during the period when New Bullards Bar Reservoir is being refilled to account for the amount of evacuated storage resulting from the transfer. The need for increased releases from Lake Oroville resulting from reduced releases from New Bullards Bar Reservoir (reduced Yuba River outflow) would only occur under particular hydrologic conditions.

Under the maximum transfer scenario of the Flexible Purchase Alternative, the proposed transfer of 185 TAF to the EWA program is expected to take place mainly in July and August, with some water potentially released in June and between September 1 and October 31 to provide fishery benefits on the lower Yuba River, in addition to delivery of water. During late June, July, and August, streamflow would be relatively constant at up to 1,200 to 1,500 cfs above Yuba River instream flow and diversion delivery requirements.

Under the minimum transfer scenario of the Flexible Purchase Alternative, the expected amount of water to be transferred to EWA is 30 TAF. As with the maximum transfer, the delivery of this water would take place mainly in July and August, with some water released in June and between September 1 and October 31. During late June, July, and August, flow rates would be relatively constant at up to 500 cfs above Yuba River instream flow and diversion delivery requirements. Flow increases of 500 cfs would be realized only if the entire water transfer allotment were to be delivered in one month.

Recent Water Transfer History

The Yuba River is one of many Central Valley rivers that have been utilized in water transfer projects for a number of years. In 2001, the Yuba County WA and other local water agencies initiated water transfers from New Bullards Bar Reservoir through the Yuba River in order to satisfy a variety of downstream needs. The total water transfer consisted of approximately 172 TAF of water, including 114,052 AF utilized by DWR. The water transfers occurred approximately between July 1, 2001 and October 14, 2001. Over a few days in early July, flows were increased by about 1,200 cfs in the lower Yuba River and were generally sustained through late August when ramping down began.

Yuba River water transfers occurred again during 2002. Observations and discussions regarding flow and water temperature patterns and coincident fish behavior (e.g., juvenile steelhead downstream movement and adult Chinook salmon immigration) during the 2001 water transfers prompted Yuba County WA, NOAA Fisheries, USFWS, CDFG, and non-governmental organizations (NGO) representatives to collaboratively develop a rigorous monitoring and evaluation plan for the 2002 water transfers. Yuba County WA transferred a total of 162,050 acre-feet of water for downstream needs (157,050 AF allocated to DWR, and 5 TAF to the Contra Costa Water District) from about mid-June through mid-September 2002. The 2002 water transfers were characterized by the lack of a definitive ramping-up period. Instead, the relatively high flows that occurred during the spring were sustained until initiation of the water transfers. Relatively stable flows were maintained through mid-August, when a ramping down period began which extended to mid-September.

An evaluation of the numerous variables (e.g., ambient air temperature, cloud cover, diversion rates), which may have influenced instream water temperatures, has not yet been conducted, however, changes in Yuba River water temperatures were observed coincident with both the 2001 and 2002 water transfers. For example, in 2001, water temperatures at Highway 70 dropped from 73.4°F on July 3 to 62.6°F on July 8, subsequent to the commencement of the water transfer. Water temperatures at this site remained around 61°F until flows were reduced in late August, at which time the water temperatures increased coincident with flow reduction (CDFG unpublished data). A less dramatic change in water temperature was associated with the onset of the 2002 water transfer, compared to that in 2001, likely due to the higher sustained flow and the absence of a dramatic flow increase at the start of the transfer period.

Anadromous Salmonids in the Yuba River

The Yuba River provides habitat for three salmonid ESUs: Central Valley steelhead and Central Valley spring- and fall-run Chinook salmon. Since the timing of the life history events of each fish is different, at any given time water transfer operations could potentially affect different lifestages (e.g., adult immigration, spawning and incubation, and juvenile rearing and emigration) of the various salmonids and their habitat (e.g., spawning and rearing habitat). Both races of adult Chinook salmon immigrate to their spawning grounds in the Yuba River during the water transfer period. The immigration of adult steelhead in the lower Yuba River has been reported to occur from August through March, with peak immigration from October through February (CDFG 1991). Therefore, the adult immigration of Chinook salmon is more likely to be affected by Yuba County WA water transfers than is steelhead immigration. Juvenile fall-run Chinook salmon are believed to emigrate shortly after emergence (Moyle 2002) and thus are not likely to be subjected to water transfer river conditions. Juvenile steelhead often rear in the lower Yuba River for one year or more, and juvenile spring-run Chinook salmon also may exhibit some extended rearing in the river. Consequently, over-summering juvenile steelhead and some juvenile spring-run Chinook salmon may be subject to potential impacts associated with Yuba River water transfers.

The primary issues of concern regarding the water transfers are the potential associations between the water transfer and: 1) the downstream movement of juvenile salmonids; and 2) the attraction of non-native adult Chinook salmon into the Yuba River.

Evaluating the potential impacts associated with changes in flows during the summer months in the lower Yuba River must take into account: 1) that the Yuba County WA has embarked upon a cooperative process with the resource agencies in order to implement water transfers in the most fish-friendly manner possible; and 2) the development and implementation of monitoring and evaluation studies associated with the water transfers in order to more definitively evaluate potential impacts. For the past few years the public resource management agencies (CDFG, NOAA Fisheries, and USFWS) and non-governmental organizations such as the California Sportfishing Protection Alliance (CSPA) have discussed and collaborated on the water transfer timing, magnitude, and other resource management issues.

Potential Water Transfer-related Effects on Juvenile Salmonid Movement in the Yuba River

Juvenile Chinook salmon are not likely to be affected by Yuba County WA water transfers, as they usually spend very little time in their natal river before emigrating in large numbers as small fry during the winter (CDFG 2000). Most of the remaining juvenile Chinook salmon emigrate in the spring (April through June) as smolts. Recent CDFG unpublished catch data collected between November 24, 1999 and June 30, 2000, and between November 1, 2001 and March 31, 2002 by a rotary screw-trap (RST) in the lower Yuba River (located at Hallwood Blvd., approximately seven miles upstream from the Feather River) show that more than 97 percent of the juvenile Chinook salmon caught by the RST during the surveying season (November 1 through July 1) had been caught by April 1. Therefore, flow changes associated with Yuba County WA water transfers to the EWA are not expected to adversely affect juvenile Chinook salmon rearing.

Because juvenile steelhead rear in the Yuba River year-round, water transfers during the summer and early fall may potentially affect their behavior. Beginning approximately July 1, 2001, water transfers increased flows in the lower Yuba River over a few days by about 1,200 cfs. On July 8, 2001, a week subsequent to the start of the 2001 water transfers, the daily catch of the CDFG RST, located at Hallwood Blvd., increased from less than ten young-of-the-year (YOY) steelhead juveniles per day, to more than 450 YOY per day (CDFG, unpublished data). The next week, daily catches decreased to about 190 YOY per day. In the following weeks, while the transfers were continuing, daily catches decreased further, but still surpassed catches prior to the water transfers. For example, the average RST daily catch was 39 YOY per day for the period July 15 through August 31, while the average prior to the initiation of the water transfers (May 1 through June 30) was three YOY per day. Increased observations of juvenile steelhead at the RST during the water transfers suggest that a large, rapid increase in flow, similar to that which characterized the 2001 water transfer, may stimulate downstream movement of juvenile steelhead.

The relationship between a rapid increase in flow and a large influx in the number of juvenile steelhead captured at the trap may indicate the stimulation of downstream movement of juvenile steelhead, possibly over Daguerre Point Dam into the lower Yuba River, or indeed, into the lower Feather River, by the water transfer. Downstream movement may transport juvenile steelhead into less suitable habitat, particularly in the lower Feather River, where temperatures are much higher than those in the Yuba River. The potential movement of juvenile steelhead over Daguerre Point Dam restricts subsequent rearing to those areas downstream of Daguerre Point Dam because juvenile steelhead are not able to readily pass back upstream of Daguerre Point Dam. Conditions downstream of Daguerre Point Dam may or may not be suitable for juvenile steelhead rearing during the post-water transfer period, depending on several factors including post-transfer flow and air temperature.

Cooler water temperatures are likely associated with the relatively high flows of the water transfers, particularly between Daguerre Point Dam and the mouth of the Yuba River. The decreased water temperatures likely associated with these higher flows would potentially improve juvenile steelhead rearing habitat quality in the river downstream. However, when water transfers cease and flows are reduced to the early fall minimum flow requirements, a coincident increase in water temperature may expose juvenile steelhead that were transported downstream of Daguerre Point Dam to less suitable rearing conditions. Additional monitoring may help resolve the frequency and importance of this effect.

Yuba County WA, working together with the public trust resource management agencies, developed an instream flow release schedule associated with the 2002 water transfer that did not include a rapid increase in flow, or correspondingly rapid decrease in water temperature when the transfer began. Rather, the flows were held relatively constant in the late spring and then gradually increased up to the sustained summer flow. Preliminary RST information at the Hallwood Blvd. location in 2002 indicates that a large peak in downstream movement of juvenile steelhead observed in 2001 did not occur in 2002. Downstream movement of juvenile steelhead during the water transfers may be associated with the rate of flow increase from the water transfer, rather than the eventual maximum flow or a response to water temperature change. However, careful monitoring of the movements of juvenile steelhead under different environmental conditions (e.g., different water year types) with and without water transfers will be required to assess potential relationships between fish movement patterns and water transfers. Providing flow patterns similar to those in 2002 can likely minimize undesirable downstream movement of steelhead. Overall, the flow changes during Yuba County WA water transfers to the EWA are not expected to adversely affect juvenile Chinook salmon and steelhead rearing in the Yuba River.

Potential Water Transfer-related Effects on Attraction of Non-native Adult Chinook Salmon in the Yuba River

Chinook salmon straying is fairly common in Central Valley streams, and throughout the entire Chinook salmon distribution. However, introducing non-native Chinook salmon (especially of hatchery origin) at high rates may be detrimental to the overall well-being of self-sustaining natural Chinook salmon populations, such as those in the Yuba River.

Monitoring efforts in 2001 and 2002, water transfer years, confirmed a few Chinook salmon of hatchery origin ascended the fish ladders at Daguerre Point Dam in the lower Yuba River during both the water transfer and non-transfer periods. Chinook salmon of hatchery origin have also been observed ascending the Yuba River in non-transfer years (CDFG, unpublished data).

In 2001, the immigration of adult Chinook salmon was monitored at the fish ladders of Daguerre Point Dam from March 1 through July 31 (CDFG, unpublished data). During July, after the initiation of the 2001 water transfers, five out of the 11 salmon trapped at the ladders had clipped adipose fins, indicating hatchery origins for these fish. In the four months of trapping prior to the beginning of the 2001 water transfers, no adipose fin-clipped Chinook salmon were observed at the ladders. The observed fin-clipped Chinook salmon certainly came from other river basins, because there are no hatchery releases or tagging programs in the lower Yuba River. Conclusions based upon the above observations in the month of July during the 2001 water transfer season may not accurately characterize the overall effects of the 2001 water transfers on the attraction of non-native Chinook salmon in the Yuba River because: 1) the sample size is small; 2) the sampling period reflects only the first of the 3.5 month water transfer period; and 3) the sampling period reflects only the initial portion of the immigration period of Chinook salmon in the Yuba River, which likely peaks in September.

The annual adult salmon escapement survey in the Yuba River recovered a relatively high number of adipose fin-clipped Chinook salmon in 2001 compared to previous years (S. Theis 2002). However, this observation alone does not necessarily implicate the water transfer as the cause of the increased incidence of adipose fin-clipped Chinook salmon. The record high escapement of hatchery Chinook salmon in the Feather River in 2001 may explain the increased number of adipose fin-clipped Chinook salmon observed in the Yuba River (PFMC 2003).

A change in operation protocol avoided a rapid increase of flows, and corresponding decrease in water temperatures, during the 2002 water transfer. Also, a study specifically designed to address the concerns of increased straying due to water transfers was implemented during the 2002 water transfer. The results of the 2002 monitoring effort are described below.

In 2002, the immigration rates, calculated for fish passing Daguerre Point Dam, for unclipped and clipped adult Chinook salmon suggest that the relatively high water transfer flows or cool water temperatures did not attract non-native salmon immigrants. An increased immigration rate during the water transfer period, compared to the non-transfer period, would suggest that additional flows from the water transfer were attracting non-native fish into the Yuba River. The immigration rate for unclipped Chinook salmon during the post-water transfer period was five times higher than during the water transfer period itself (0.32683 and 1.63623 fish per hour, respectively). The immigration rate for adipose fin-clipped Chinook salmon during the post-water transfer period was 23 times higher than during the water transfer period itself (0.00627 and 0.1449 fish per hour, respectively). The much greater immigration rates, during both the water transfer and post-water transfer periods, for unclipped adult Chinook salmon relative to clipped adult salmon probably reflects the general lack of a significant hatchery influence on the lower Yuba River. Similarly, an increased immigration rate, during the post-water transfer period compared to water transfer period, for clipped adult salmon probably reflects the independency of water transfers and non-native adult salmon attraction. Although the exact time at which adult Chinook salmon entered the lower Yuba River is uncertain, the increase in the number of adult Chinook salmon passing Daguerre Point Dam in the latter part of the monitoring period most likely reflects the adult upstream migration lifestage periodicity expected for fall-run Chinook salmon.

Also, preliminary analyses of an extensive data set incorporating spawning stock escapement estimates and coded wire tag (CWT) recoveries incorporating recent years indicates that a low rate of straying occurs in the lower Yuba River (S. Cramer 2002).

Overall, the flow changes associated with Yuba County WA water transfers to the EWA are not expected to adversely affect adult salmonid immigration in the Yuba River. However, the potential interactions between run timing and the water transfers need to be evaluated with more years of adult Chinook salmon immigration data from water transfer and non-water transfer years, during various hydrologic and climatic conditions (SWRI and Jones & Stokes 2003) to provide more definitive results. The issue of salmon straying in Central Valley rivers is a topic of paramount importance and quantitative information is needed valley-wide, including the Yuba River.

Collaborative Monitoring Efforts in the Yuba River

It is anticipated that Yuba County WA will continue to work collaboratively and cooperatively with the resource agencies to implement appropriate monitoring and evaluation programs, on an annual basis, associated with water transfers. The results will be used to evaluate water transfers in the Yuba River and to develop and implement operational scenarios to avoid impacts on the salmonid populations within the Area of analysis. The study results also may be utilized in other investigations to help assess the impacts of water transfers on salmonids in California.

Summary of Water Transfer-related Impacts on Central Valley Spring- and Fall-run Chinook Salmon and Central Valley Steelhead in the Yuba River

Based on the above findings, potential flow and water temperature-related effects on anadromous salmonids in the lower Yuba River resulting from water transfers are expected to be less than significant. Flows are expected to increase and water temperatures are expected to decrease during water transfer years, relative to non-water transfer years; however, these changes are not expected to result in potentially adverse impacts on the various anadromous salmonid lifestages occurring coincident with the water transfer period (steelhead juvenile rearing and Chinook salmon upstream migration) in the Yuba River.

Management efforts in the Yuba River Basin are addressing the potential impacts of water transfers, particularly the downstream movement of juvenile steelhead and the attraction of non-indigenous fish. The magnitude of the flow increase resulting from the water transfer is not expected to result in an increase of downstream movement of juvenile steelhead. Preliminary data suggest that the magnitude and rate of change in flow, not the flow itself, may be associated with the potential downstream movement of juvenile steelhead in the lower Yuba River. Yuba County WA and the public trust resource management agencies are working together to avoid rapid increases in flow during water transfers, and to schedule gradual increases up to the sustained summer flows. Straying of non-natal fish into the lower Yuba River also has been recognized as a potential impact; however, this is a concern throughout the Central Valley and there is still a considerable amount of uncertainty as to the specific causes and factors that trigger fish to move into non-natal streams. Further efforts have been identified to expand CWT analyses in the Central Valley that may help better characterize the extent of adult salmon straying in the lower Yuba River.

The Yuba County WA and management agencies responsible for managing the Yuba River Basin are continuing to work towards understanding these processes. As part of these ongoing efforts, water transfer strategies have been carefully designed, implemented, and monitored to avoid adverse impacts on juvenile and adult anadromous salmonids. Based on preliminary data analyses and a continued commitment to the 2002 water transfer implementation strategy and to monitoring, Yuba County WA water transfers to EWA are expected to result in a less-than-significant impact on fishery resources within the Yuba River.

9.2.5.1.4 American River Area of Analysis

EWA acquisition of Placer County WA stored reservoir water would alter American River flows downstream of French Meadows Reservoir to Folsom Reservoir from June to October. EWA acquisition of Placer County WA stored reservoir water would alter American River flows downstream of French Meadows Reservoir to Folsom Reservoir during refill of Hell Hole and French Meadows reservoirs. EWA acquisition of Placer County WA stored reservoir water would alter surface water elevations from July until refill for French Meadows and Hell Hole reservoirs. EWA acquisition of Sacramento Groundwater Authority (SGA) water via groundwater purchase would alter summer surface water elevations at Folsom Reservoir. EWA acquisition of stored groundwater from SAG members, stored reservoir water, and water *obtained through Placer County WA crop idling and retained in Folsom would alter lower American River flows, relative to the Baseline Condition.*

The analysis of potential impacts on fisheries resources in the American River Basin includes an assessment of the warmwater and coldwater fisheries of French Meadows, Hell Hole, and Folsom reservoirs, and an assessment of fisheries resources of the Middle Fork of the American River below Ralston Afterbay and the lower American River below Folsom Dam to its confluence with the Sacramento River. For lower American River fisheries resources, flow- and temperature-related impacts are discussed separately by species and lifestage. Organizationally, flow- and temperature-related impacts on fall-run Chinook salmon and steelhead are discussed together, followed by impact discussions for splittail, American shad, and striped bass.

Impacts on French Meadows and Hell Hole Reservoir Warmwater Fisheries

Based on accounts from CDFG and Tahoe National Forest representatives, it is unlikely that there is a self-sustaining warmwater fishery in French Meadows or Hell Hole reservoirs. However, analyses were completed in the event that these reservoirs do support some minor component of a warmwater fishery. Table 9-29 and Table 9-30 provide monthly median storage, elevation, and elevation changes for French Meadows and Hell Hole reservoirs, respectively. Hydrologic conditions under the Flexible Purchase Alternative would result in reductions of 2 to 8 feet msl in the median water surface elevation of French Meadows Reservoir during the April through November period, when warmwater fish juvenile rearing would be expected. At Hell Hole Reservoir, hydrologic conditions under the Flexible Purchase Alternative would result in reductions of 5 to 15 ft msl in the median water surface elevation, relative to the Baseline Condition, during the April through November period.

Table 9-29
French Meadows Reservoir Monthly Median Storage, Elevation, and Elevation Change Under Baseline and EWA Conditions*

	Storage				Elevation			Elevation Change		
Month	Baseline (TAF)	EWA (TAF)	Diff (TAF)	Diff (%)	Baseline (ft msl)	EWA (ft msl)	Diff (ft msl)	Baseline (ft msl)	EWA (ft msl)	Diff (ft msl)
Oct	67	59	-8	-12	5205	5197	-8	-14	-15	-1
Nov	59	57	-3	-5	5197	5194	-3	-8	-3	5
Dec	56	53	-3	-5	5193	5189	-3	-4	-4	0
Jan	61	58	-2	-4	5198	5196	-3	6	6	1
Feb	61	61	0	0	5199	5199	0	1	4	3
Mar	75	75	0	0	5213	5213	0	14	14	0
Apr	93	93	0	0	5229	5229	0	16	16	0
May	116	116	0	0	5246	5246	0	17	17	0
Jun	129	129	0	0	5256	5256	0	10	10	0
Jul	113	111	-3	-2	5244	5242	-2	-12	-13	-2
Aug	100	94	-5	-5	5234	5230	-4	-10	-12	-2
Sep	82	74	-8	-9	5219	5212	-7	-14	-17	-3

* Based on median monthly storage and flow over the historical record from 1974 to 2001, with a maximum 20 TAF EWA Action on French Meadows and Hell Hole Reservoirs combined.
Diff = Difference

Table 9-30
Hell Hole Reservoir Monthly Median Storage, Elevation, and Elevation Change Under Baseline and EWA Conditions*

	Storage				Elevation			Elevation Change		
Month	Baseline (TAF)	EWA (TAF)	Diff (TAF)	Diff (%)	Baseline (ft msl)	EWA (ft msl)	Diff (ft msl)	Baseline (ft msl)	EWA (ft msl)	Diff (ft msl)
Oct	120	108	-12	-10	4555	4540	-15	0	0	0
Nov	110	106	-4	-4	4542	4536	-6	-13	-4	10
Dec	104	100	-4	-4	4534	4528	-6	-8	-8	0
Jan	102	98	-4	-4	4531	4525	-5	-3	-3	1
Feb	104	104	0	0	4533	4533	0	3	8	5
Mar	110	110	0	0	4542	4542	0	9	9	0
Apr	140	140	0	0	4578	4578	0	35	35	0
May	173	173	0	0	4616	4616	0	38	38	0
Jun	191	187	-4	-2	4637	4632	-5	21	16	-5
Jul	168	160	-8	-5	4610	4601	-9	-26	-31	-4
Aug	136	124	-12	-9	4573	4559	-14	-37	-42	-5
Sep	121	109	-12	-10	4555	4540	-15	-18	-19	-1

* Based on median monthly storage and flow over the historical record from 1974 to 2001, with a maximum 20 TAF EWA Action on French Meadows and Hell Hole Reservoirs combined.
Diff = Difference

Changes in water surface elevation of French Meadows and Hell Hole reservoirs would result in corresponding changes in the availability of littoral habitat containing submerged vegetation. Such shallow, nearshore waters containing physical structure are important to producing and maintaining strong year-classes of warmwater fishes. Reductions in median end-of-month water surface elevation of French Meadows and Hell Hole reservoirs under the Flexible Purchase Alternative would not be anticipated to result in substantial reductions in the amount of habitat potentially available to warmwater fishes for spawning and/or rearing, because reductions in water surface elevation would occur outside of April and May, the primary months of the spawning and rearing period at these high elevation facilities. Further, there are no fall-spawning fish species present in French Meadows or Hell Hole reservoirs that could be affected by reductions in water surface elevation that would occur later in the year under the Flexible Purchase Alternative.

In addition, the Flexible Purchase Alternative could alter the rates by which water surface elevation in French Meadows and Hell Hole reservoirs change, relative to the Baseline Condition. Reductions in median water surface elevation between months (the magnitude of monthly reservoir drawdown) throughout the March through June period at French Meadows and Hell Hole reservoirs (Tables 9-29 and 9-30, respectively), are not expected to occur under the Flexible Purchase Alternative or the Baseline Condition. Thus, it is anticipated that reductions in water surface elevation of greater than nine feet msl per month, which could potentially result in nest dewatering events, would not occur under the Flexible Purchase Alternative or the Baseline Condition. In summary, the Flexible Purchase Alternative is not likely to result in substantial changes in the availability of littoral habitat at French Meadows and Hell Hole reservoirs, and thus, would not likely beneficially or adversely affect warmwater fish rearing. The Flexible Purchase Alternative does not alter the frequency of potential nest dewatering events in French Meadows and Hell Hole reservoirs, relative to the Baseline Condition, and thus, would not beneficially or adversely affect long-term warmwater fish nesting success. Overall, implementation of the Flexible Purchase Alternative would result in a less-than-significant impact on French Meadows and Hell Hole reservoirs warmwater fisheries, relative to the Baseline Condition.

Impacts on French Meadows and Hell Hole Reservoir Coldwater Fisheries

Hydrologic conditions under the Flexible Purchase Alternative would result in a reduction in median storage of up to 8 TAF, or 12 percent, at French Meadows Reservoir during the April through November period, relative to the Baseline Condition, as shown in Table 9-29. At Hell Hole Reservoir, hydrologic conditions under the Flexible Purchase Alternative would result in a reduction in median storage of up to 12 TAF, or 10 percent, during the April through November period, relative to the Baseline Condition. (Refer to Table 9-30.) Anticipated reductions in reservoir storage would not be expected to adversely affect the reservoir's coldwater fisheries because: 1) coldwater habitat would remain available within the reservoir during all months of all years; 2) physical habitat availability is not believed to be among the primary factors limiting coldwater fish populations; and 3) anticipated seasonal reductions in storage would not be expected to adversely affect the primary prey species utilized by coldwater fish. Therefore, changes in end-of-month storage at French Meadows and Hell Hole reservoirs under the Flexible Purchase Alternative represent a less than significant impact on coldwater fish resources, relative to the Baseline Condition.

Middle Fork American River

Table 9-31 shows that median flow in the Middle Fork of the American River under the Flexible Purchase Alternative would not differ from median flow under the Baseline Condition during October, December, and March through June. Median flows in November, January, and February under the Flexible Purchase Alternative would be decreased, relative to the Baseline Condition, by 15 to 213 cfs (up to 44 percent), while flows during June through September would increase, relative to the Baseline Condition, by 44 to 107 cfs (10 to 17 percent). The minimum instream flow requirement in the Middle Fork of the American River is 75 cfs. This minimum instream flow requirement was established to protect aquatic resources of the Middle Fork of the American River. Although substantial decreases in flow could occur in late fall and winter under the Flexible Purchase Alternative, flows would remain above minimum instream flow requirements in each of the months in which flow reductions would occur under the Flexible Purchase Alternative. In fact, flows during these months under the Flexible Purchase Alternative would remain higher than the minimum instream flow requirement by approximately 200 cfs or more.

Table 9-31
Middle Fork American River Monthly Median Flows Under Baseline and Flexible Purchase Alternative Conditions

Month	Flow Below Ralston Afterbay			
	Baseline (cfs)	Flexible Purchase Alternative (cfs)	Diff (cfs)	Diff (%)
Oct	258	258	0	0
Nov	488	275	-213	-44
Dec	265	265	0	0
Jan	281	266	-15	-5
Feb	437	325	-112	-26
Mar	615	615	0	0
Apr	554	554	0	0
May	656	656	0	0
Jun	631	698	67	11
Jul	629	736	107	17
Aug	666	773	107	16
Sep	456	500	44	10

Based on median monthly storage and flow changes in French Meadows and Hell Hole Reservoirs over the historical record from 1974 to 2001, with a maximum 20 TAF EWA Action on French Meadows and Hell Hole Reservoirs combined.
Diff = Difference

Potential flow increases under the Flexible Purchase Alternative during summer months would not be expected to result in adverse effects on Middle Fork American River aquatic resources. PG&E operations of the Middle Fork Project under the Baseline Condition currently result in highly variable flows on a daily and weekly basis. The Middle Fork Project is operated to achieve stable power production during weekdays, while weekend flows are increased substantially to provide sufficient flows for recreational activities in the river. It is assumed that releases of EWA assets under the Flexible Purchase Alternative would be managed to maximize power generation and, therefore, would be released during the week. Thus, increases in releases from Middle Fork Project facilities increase flows during the week, thereby decreasing the difference between weekday and weekend flow conditions in the Middle Fork American River below Ralston Afterbay. Such changes in the flow regime would be likely to benefit the forage base of fish species in the Middle Fork American River. Aquatic invertebrates such as stoneflies, which may contribute to the forage base for fish, are more likely to successfully colonize and reproduce in an environment with more stable flow conditions.

Changes in Middle Fork American River flows under the Flexible Purchase Alternative would not result in adverse effects on resident fish species. Overall, habitat conditions would be expected to improve during summer months due to decreased variation in weekly flows, relative to the Baseline Condition, and reductions in flows that would occur in winter months would not be of sufficient frequency or magnitude to violate instream flow requirements and adversely affect aquatic resources. Therefore, impacts on Middle Fork American River fisheries resources would be less than significant, relative to the Baseline Condition.

Impacts on Folsom Reservoir Warmwater Fisheries

Hydrologic conditions under the Flexible Purchase Alternative would result in a slight reduction in the long-term average end-of-month water surface elevation in Folsom Reservoir during the April through November period, when warmwater juvenile fish rearing may be expected to occur. (Refer to Table 9-32.) As shown in Table 9-32, long-term average end-of-month water surface elevation under the Flexible Purchase Alternative would not change during the April through June and September through November periods, and would decrease by one foot msl in July and August, relative to the Baseline Condition. Monthly mean end-of-month water surface elevation at Folsom Reservoir under the Flexible Purchase Alternative would be essentially equivalent to the Baseline Condition for 575 months of the 576 months included in the analysis. (See Appendix H pgs. 198-204.) For the entire 72-year period of record, the largest single difference in end-of-month water surface elevation under the Flexible Purchase Alternative out of 576 months simulated for the April through November period would be a two-foot decrease, relative to the Baseline Condition. (See Appendix H pgs. 198-204.)

Table 9-32
Long-term Average Folsom Reservoir End of Month Elevation Under Baseline and Flexible Purchase Alternative Conditions

	Average Elevation[1] (feet msl)		
Month	Baseline	Flexible Purchase Alternative	Difference
Mar	425	425	0
Apr	438	438	0
May	449	449	0
Jun	444	444	0
Jul	428	427	-1
Aug	421	420	-1
Sep	411	411	0
Oct	409	409	0
Nov	407	407	0
Dec	408	408	0

[1] Based on 72 years modeled.

Changes in water surface elevation in Folsom Reservoir during the April through November period would result in corresponding changes in the availability of reservoir littoral habitat containing submerged vegetation (willows and button brush). Such shallow, near shore waters containing physical structure are important to producing and maintaining strong year-classes of warmwater fish annually. As shown in Table 9-33, the difference in the long-term average amount of littoral habitat potentially available to warmwater fish for spawning and/or rearing in Folsom Reservoir during the April through November period under the Flexible Purchase Alternative would not differ from the long-term average amount available under the Baseline Condition. Further, the monthly mean amount of littoral habitat would not be reduced under the Flexible Purchase Alternative, relative to the Baseline Condition, in any of the 576 months simulated for the April through November period. (See Appendix H pgs. 294-300.)

Table 9-33
Long-term Average Number of Acres of Folsom Reservoir Littoral Habitat Under Baseline and Flexible Purchase Alternative Conditions

Month	Average Amount Of Littoral Habitat[1] (Acres)		Difference	
	Baseline	Flexible Purchase Alternative	(Acres)	(%)[2]
Mar	1,253	1,253	0	0.0
Apr	2,207	2,207	0	0.0
May	2,713	2,713	0	0.0
Jun	2,420	2,420	0	0.0
Jul	1,573	1,573	0	0.0
Aug	1,285	1,285	0	0.0
Sep	780	780	0	0.0
Oct	604	604	0	0.0
Nov	444	444	0	0.0
Dec	436	436	0	0.0

[1] Based on 72 years modeled.
[2] Relative difference of the monthly long-term average.

In addition, the Flexible Purchase Alternative could alter the extent to which water surface elevations in Folsom Reservoir change during each month of the primary warmwater fish-spawning period of March through June. As discussed in Section 9.2.1.1.1, adverse effects on spawning from nest dewatering are assumed to have the potential to occur when reservoir elevation decreases by more than nine feet within a given month. Modeling results, shown in Table 9-34, indicate that the frequency with which potential nest dewatering events could occur in Folsom Reservoir would not increase under the Flexible Purchase Alternative, compared to the Baseline Condition, during any month of the March through June spawning period.

Table 9-34
Long-term Average Surface Elevation and Number of Years with Elevation Decrease Greater than 9 feet in Folsom Reservoir Under Baseline and Flexible Purchase Alternative Conditions

Month	Average Reservoir Surface Elevation[1] (feet msl)			No. Years[1] w/Monthly Elevation Decrease During Month > 9 ft	
	Baseline	Flexible Purchase Alternative	Difference	Baseline	Flexible Purchase Alternative
Mar	425	425	0	2	2
Apr	438	438	0	1	1
May	449	449	0	2	2
Jun	444	444	0	20	20

[1] Based on 72 years modeled.

In summary, the Flexible Purchase Alternative would not result in changes in the availability of littoral habitat at Folsom Reservoir, relative to the Baseline Condition, and thus, would not beneficially or adversely affect warmwater fish rearing. Implementation of the Flexible Purchase Alternative would not alter the frequency of potential nest dewatering events in Folsom Reservoir, relative to the Baseline Condition, and thus, would not beneficially or adversely affect long-term warmwater fish nesting success. Therefore, under the Flexible Purchase Alternative, impacts on

Folsom Reservoir warmwater fisheries would be less than significant, relative to the Baseline Condition.

Impacts on Folsom Reservoir Coldwater Fisheries

Long-term average end-of-month storage in Folsom Reservoir under the Flexible Purchase Alternative would be reduced by 4 TAF or 0.6 percent in July, and 3 TAF or 0.5 percent in August, and would not change during the remaining months of the April through November period, when the reservoir thermally stratifies, relative to the Baseline Condition. (Refer to Table 9-35.) For any given month, the largest difference between long-term average end-of-month storage under the Flexible Purchase Alternative would be a 6 AF decrease, relative to the Baseline Condition, a less than one percent difference. On a monthly mean basis, Folsom Reservoir end-of-month storage under the Flexible Purchase Alternative would be essentially equivalent to the Baseline Condition for 563 of the 576 months simulated for the April through November period. (See Appendix H pgs. 115-120 and 109-110.)

Table 9-35
Long-term Average Folsom Reservoir End of Month Storage Under Baseline and Flexible Purchase Alternative Conditions

Month	Average Storage[1] (TAF)		Difference	
	Baseline	Flexible Purchase Alternative	(TAF)	(%)[2]
Apr	703	703	0	0.0
May	815	815	0	0.0
Jun	769	769	0	0.0
Jul	626	622	-4	-0.6
Aug	568	565	-3	-0.5
Sep	488	488	0	0.0
Oct	469	469	0	0.0
Nov	451	451	0	0.0

[1] Based on 72 years modeled.
[2] Relative difference of the monthly long-term average.

The changes in Folsom Reservoir storage that would occur under the Flexible Purchase Alternative would result from the acquisition of Placer County WA stored reservoir water from Hell Hole and French Meadows reservoirs and the purchase of SGA groundwater via groundwater purchase. Such changes in reservoir storage are unlikely to result in either potentially beneficial or adverse effects on the coldwater pool volume, relative to the Baseline Condition, due to the timing of the transfer or storage of EWA assets to or within Folsom Reservoir. In late summer, the coldwater pool volume at Folsom Reservoir is typically substantially reduced, relative to the volume of coldwater available in spring months. The transfer of EWA assets in late summer would occur when water temperatures of transferred water would be too warm to sink into the hypolimnion, and would not result in the mixing of the warm and coldwater pools. The EWA agencies could schedule release of EWA assets stored in Folsom Reservoir into the lower American River in a fish-friendly manner consistent with flow and temperature objectives and Delta export capacity. Releases could occur later in the summer when water temperatures are higher and available flows are most in need of augmentation to benefit fish, and could occur as late as December. However, these releases would not occur in a manner that would adversely affect the Folsom Reservoir coldwater pool. In addition, the anticipated storage of EWA assets via groundwater purchase in Folsom Reservoir would constitute only a fraction of storage at Folsom Reservoir (approximately 2 percent). Thus, such storage of groundwater purchase assets would not substantially alter the coldwater pool volume in Folsom Reservoir, relative to the Baseline Condition.

Overall, minor changes in storage at Folsom Reservoir would not be expected to adversely affect habitat availability or the population levels of the primary prey species utilized by coldwater fish. Therefore, changes in Folsom Reservoir end-of-month storage under the Flexible Purchase Alternative represent a less-than-significant impact on coldwater fish resources, relative to the Baseline Condition.

Temperature-related Impacts on Lake Natoma and Nimbus Fish Hatchery

CVP operations of Folsom Dam and Reservoir under the Flexible Purchase Alternative would have little effect on water temperatures below Nimbus Dam during all months of the year, relative to the Baseline Condition. Table 9-36 shows that the long-term average temperature of water released from Nimbus Dam would increase by 0.1°F to 0.2°F during March, April, May, August, and September, would decrease by 0.1°F during January, and would not change during the remaining months of the year, relative to the Baseline Condition.

Table 9-36
Long-term Average Water Temperature in the American River Below Nimbus Dam Under Baseline and Flexible Purchase Alternative Conditions

Month	Water Temperature[1] (ºF)		
	Baseline	Flexible Purchase Alternative	Difference (ºF)
Oct	56.3	56.3	0.0
Nov	56.5	56.5	0.0
Dec	51.2	51.2	0.0
Jan	47.2	47.1	-0.1
Feb	47.8	47.8	0.0
Mar	50.3	50.4	0.1
Apr	53.7	53.8	0.1
May	56.5	56.6	0.1
Jun	59.6	59.6	0.0
Jul	64.3	64.3	0.0
Aug	64.5	64.6	0.1
Sep	65.9	66.1	0.2

[1] Based on 69 years modeled.

The May through September period has been identified as the portion of the year when hatching temperatures at the fish hatchery reach annual highs. In 331 out of the 345 months simulated for the May through September period, monthly mean water temperatures below Nimbus Dam under the Flexible Purchase Alternative would be essentially equivalent to or less than those under the Baseline Condition. (See Appendix H pgs. 416-420.) Further, implementation of the Flexible Purchase Alternative would not result in measurable increases in the frequency in which index water temperatures of 60°F, 65°F, and 68°F would be exceeded, relative to the Baseline Condition. (See Appendix H pgs. 416-420.) Therefore, implementation of the Flexible Purchase Alternative would have little, if any, effect on water temperatures in Lake Natoma or hatchery operations and resultant fish production. Consequently, impacts on coldwater fisheries at Lake Natoma and hatchery operations under the Flexible Purchase Alternative would be less than significant, relative to the Baseline Condition.

Impacts on Fall-run Chinook Salmon and Steelhead in the Lower American River

Flow-related Impacts on Adult Fall-run Chinook Salmon/Steelhead Immigration (September Through March)

Even at current minimum flow requirements (250 cfs under D-893), flow-related physical impediments to adult salmonid upstream passage are not known to occur. Therefore, flow-related impacts on adult Chinook salmon immigration primarily would be determined by flows at the mouth of the American River during the September through December period, when lower American River adult Chinook salmon immigrate through the Sacramento River and Delta in search of their natal stream to spawn. The same would be true for steelhead during the December through March period. Reduced flows at the mouth are of concern primarily because reduced flows could result in insufficient olfactory cues for immigrating adult salmonids, thereby making it more difficult for them to "home" to the lower American River. Large reductions in flow could result in higher rates of straying to other Central Valley rivers.

Table 9-37 shows that the long-term average flow at the mouth of the American River under the Flexible Purchase Alternative would increase by 0.3 percent in September and would not differ from the Baseline Condition from October through March. In all of the 504 months simulated in this period, monthly mean flows at the mouth of the American River under the Flexible Purchase Alternative would be essentially equivalent to or greater than those under the Baseline Condition. (See Appendix H pgs. 372, 361-366.)

Table 9-37
Long-term Average Flow at the Mouth of the American River Under Baseline and Flexible Purchase Alternative Conditions

Month	Monthly Mean Flow[1] (cfs)		Difference	
	Baseline	Flexible Purchase Alternative	(cfs)	(%)[2]
Oct	1557	1557	0	0.0
Nov	2426	2426	0	0.0
Dec	3441	3441	0	0.0
Jan	4077	4077	0	0.0
Feb	4949	4949	0	0.0
Mar	3902	3902	0	0.0
Apr	3518	3518	0	0.0
May	3632	3632	0	0.0
Jun	3936	3936	0	0.0
Jul	3851	3958	107	2.8
Aug	2253	2299	46	2.0
Sep	2707	2716	9	0.3

[1] Based on 72 years modeled.
[2] Relative difference of the monthly long-term average.

Temperature-related Impacts on Adult Fall-run Chinook Salmon/Steelhead Immigration (September Through March)

Reclamation's Lower American River Temperature Model does not account for the influence of Sacramento River water intrusion on water temperatures at the mouth. Therefore, the water temperature assessments for adult fall-run Chinook salmon and steelhead immigration are based on water temperatures modeled at the mouth of the lower American River and at Freeport in the Sacramento River. Long-term average water temperatures modeled for the Flexible Purchase Alternative would not increase or decrease by more than 0.1°F at the mouth of the American River and at Freeport in the Sacramento River, during the September through March adult immigration period, as shown in Tables 9-38 and 9-11. Monthly mean water temperatures at Freeport in the Sacramento River would be essentially equivalent to the Baseline Condition for all of the 483 months included in the analysis. (See Appendix H pgs. 492, 481-486.) At the mouth of the lower American River, monthly mean water temperatures under the Flexible Purchase Alternative would be essentially equivalent to those under the Baseline Condition for 477 of the 483 months simulated for the September through March period.)

Table 9-38 Long-term Average Water Temperature at the Mouth of the American River Under Baseline and Flexible Purchase Alternative Conditions			
Month	**Water Temperature[1] (ºF)**		
	Baseline	**Flexible Purchase Alternative**	**Difference (ºF)**
Oct	58.4	58.4	0.0
Nov	55.5	55.5	0.0
Dec	49.7	49.6	-0.1
Jan	46.5	46.5	0.0
Feb	48.5	48.5	0.0
Mar	51.7	51.8	0.1
Apr	55.8	55.9	0.1
May	59.7	59.8	0.1
Jun	63.2	63.3	0.1
Jul	67.2	67.2	0.0
Aug	68.1	68.1	0.0
Sep	67.3	67.3	0.0

[1] Based on 69 years modeled.

Flow-related Impacts on Adult Fall-run Chinook Salmon Spawning, Egg Incubation, and Initial Rearing (October through February)

All flow-related impact assessments for adult fall-run Chinook salmon spawning and egg incubation were based on flows below Nimbus Dam and at Watt Avenue, with a greater emphasis placed on flows below Nimbus Dam. Aerial redd surveys conducted by CDFG in recent years have shown that 98 percent of all adult fall-run Chinook salmon spawning occurs upstream of Watt Avenue, with 88 percent of spawning occurring upstream of RM 17 (located just upstream of Ancil Hoffman Park). Hence, the majority of spawning occurs in the approximate 6 miles below Nimbus Dam.

Long-term average flows below Nimbus Dam and at Watt Avenue under the Flexible Purchase Alternative from October through February would be identical to those under the Baseline Condition, as shown in Tables 9-39 and 9-40. In addition, in all of the 360 months simulated for the October through February period, monthly mean flows below Nimbus Dam and at Watt Avenue under the Flexible Purchase Alternative would be essentially equivalent to those under the Baseline Condition. (See Appendix H pgs. 313-317 and 325 -329.)

Table 9-39
Long-term Average Release From Nimbus Dam Under Baseline and Flexible Purchase Alternative Conditions

Month	***Monthly Mean Flow[1] (cfs)***		***Difference***	
	Baseline	***Flexible Purchase Alternative***	***(cfs)***	***(%)[2]***
Oct	1678	1678	0	0.0
Nov	2502	2502	0	0.0
Dec	3498	3498	0	0.0
Jan	4124	4124	0	0.0
Feb	4989	4989	0	0.0
Mar	3941	3941	0	0.0
Apr	3616	3616	0	0.0
May	3793	3793	0	0.0
Jun	4166	4166	0	0.0
Jul	4100	4208	108	2.6
Aug	2482	2528	46	1.9
Sep	2876	2885	9	0.3

[1] Based on 72 years modeled.
[2] Relative difference of the monthly long-term average.

Table 9-40
Long-term Average Flow at Watt Avenue Under Baseline and Flexible Purchase Alternative Conditions

Month	***Monthly Mean Flow[1] (cfs)***		***Difference***	
	Baseline	***Flexible Purchase Alternative***	***(cfs)***	***(%)[2]***
Oct	1507	1507	0	0.0
Nov	2385	2385	0	0.0
Dec	3402	3402	0	0.0
Jan	4038	4038	0	0.0
Feb	4906	4906	0	0.0
Mar	3861	3861	0	0.0
Apr	3428	3428	0	0.0
May	3531	3531	0	0.0
Jun	3814	3814	0	0.0
Jul	3729	3838	108	2.9
Aug	2148	2199	46	2.1
Sep	2633	2642	9	0.3

[1] Based on 72 years modeled.
[2] Relative difference of the monthly long-term average.

Figures 9-41 through 9-45 show exceedance curves for the American River release from Nimbus Dam for the October through February period. The basis for development of these exceedance curves was the 1922-1993 period of record. These curves demonstrate that flows under the Flexible Purchase Alternative would not differ from those under the Baseline Condition.

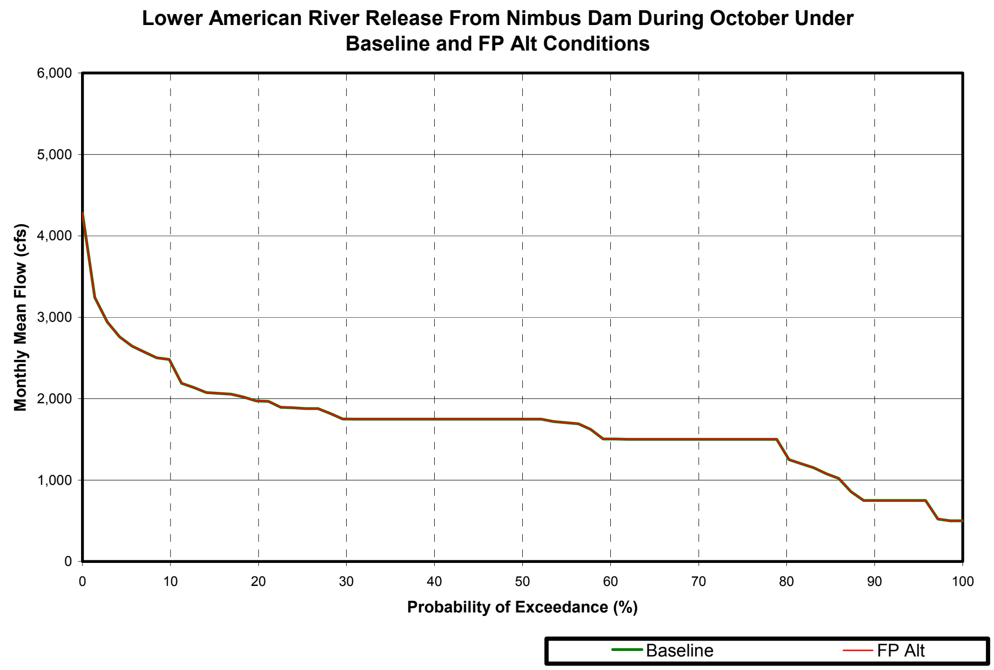

Figure 9-41
Lower American River Release From Nimbus Dam During October Under Baseline and Flexible Purchase Alternative Conditions

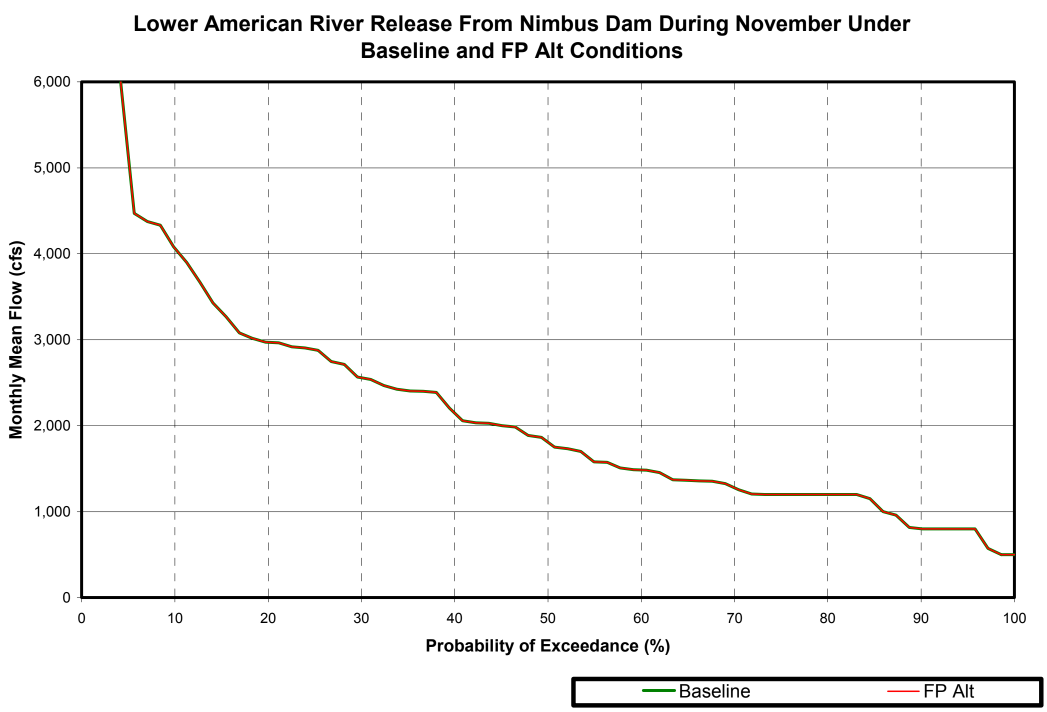

Figure 9-42
Lower American River Release From Nimbus Dam During November Under Baseline and Flexible Purchase Alternative Conditions

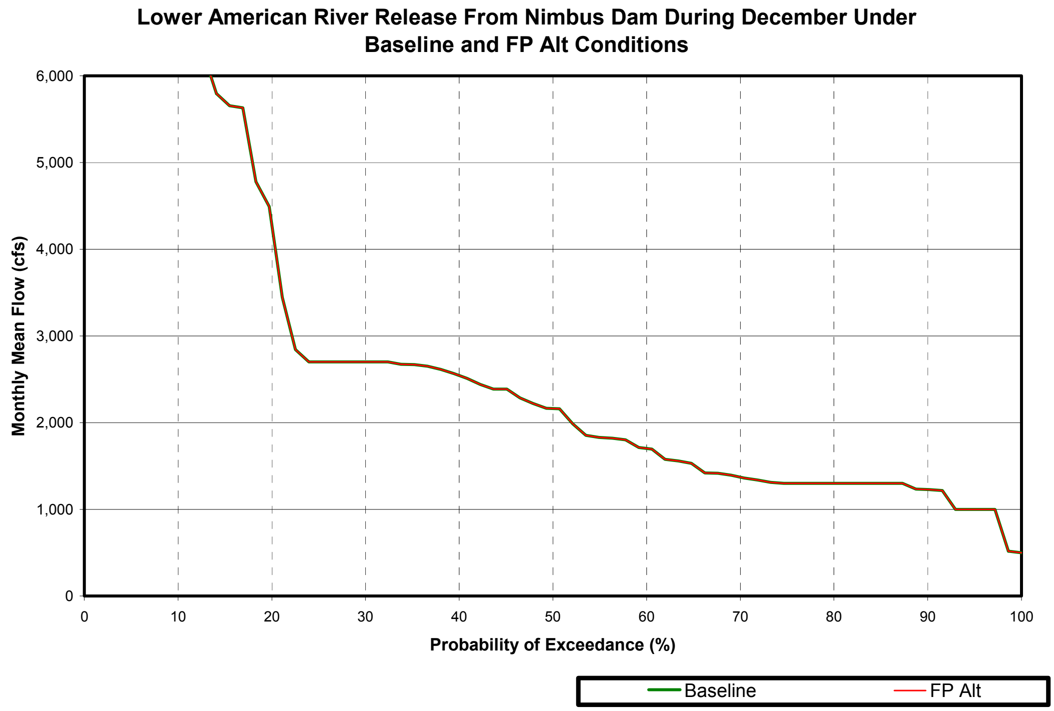

Figure 9-43
Lower American River Release From Nimbus Dam During December Under Baseline and Flexible Purchase Alternative Conditions

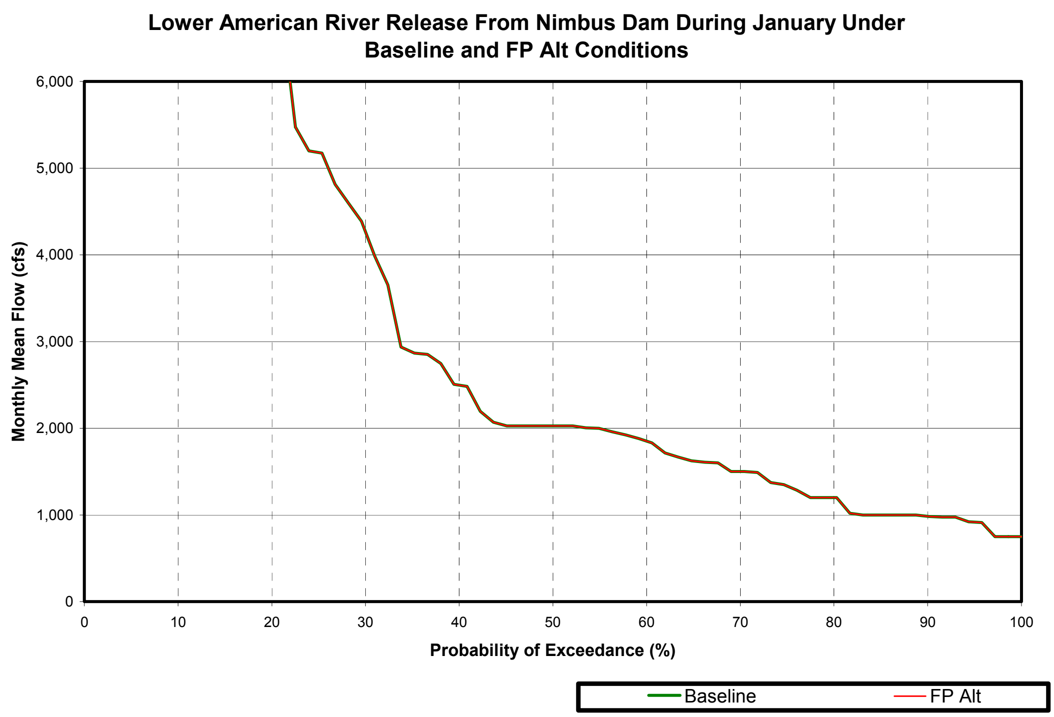

Figure 9-44
Lower American River Release From Nimbus Dam During January Under Baseline and Flexible Purchase Alternative Conditions

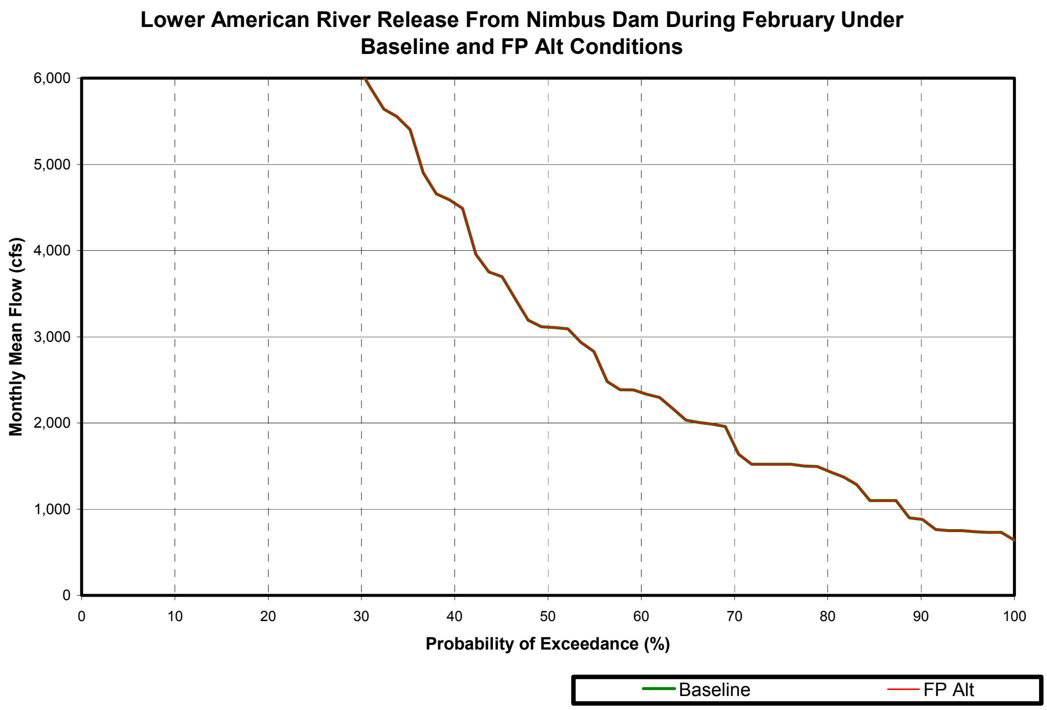

Figure 9-45
Lower American River Release From Nimbus Dam During February Under Baseline and Flexible Purchase Alternative Conditions

Reductions in flows below 2,000 cfs could reduce the amount of available Chinook salmon spawning habitat, which could result in increased redd superimposition during years when adult returns are high enough for spawning habitat to be limiting. However, these findings indicate that the Flexible Purchase Alternative would not result in flow changes when flows under the Baseline Condition would be below 2,000 cfs.

Temperature-related Impacts on Adult Fall-run Chinook Salmon Spawning, Egg Incubation, and Initial Rearing (October through February)

Under the Flexible Purchase Alternative, long-term average water temperatures below Nimbus Dam would decrease by 0.1°F in January, and would not change during October, November, December, and February, relative to the Baseline Condition, as shown in Table 9-41. In 336 out of the 345 months included in the analysis, water temperatures below Nimbus Dam under the Flexible Purchase Alternative during the October through February period would be essentially equivalent to or less than those under the Baseline Condition. (See Appendix H pgs. 409-413.) At Watt Avenue, long-term average water temperatures under the Flexible Purchase Alternative would not differ from those under the Baseline Condition during any month of the October through February period, as shown in Table 9-42. In 336 months out of the 345 months simulated for the October through February period, monthly mean water temperatures at Watt Avenue under the Flexible Purchase Alternative would be essentially equivalent to or less than those under the Baseline Condition. (See Appendix H pgs. 421-425.)

Table 9-41
Long-term Average Water Temperature in the American River below Nimbus Dam Under Baseline and Flexible Purchase Alternative Conditions

Month	Water Temperature¹ (ºF)		
	Baseline	Flexible Purchase Alternative	Difference (ºF)
Oct	56.3	56.3	0.0
Nov	56.5	56.5	0.0
Dec	51.2	51.2	0.0
Jan	47.2	47.1	-0.1
Feb	47.8	47.8	0.0
Mar	50.3	50.4	0.1
Apr	53.7	53.8	0.1
May	56.5	56.6	0.1
Jun	59.6	59.6	0.0
Jul	64.3	64.3	0.0
Aug	64.5	64.6	0.1
Sep	65.9	66.1	0.2

[1] Based on 69 years modeled.

Table 9-42
Long-term Average Water Temperature in the American River at Watt Avenue Under Baseline and Flexible Purchase Alternative Conditions

Month	Water Temperature¹ (ºF)		
	Baseline	Flexible Purchase Alternative	Difference (ºF)
Oct	57.7	57.7	0.0
Nov	55.8	55.8	0.0
Dec	50.2	50.2	0.0
Jan	46.7	46.7	0.0
Feb	48.2	48.2	0.0
Mar	51.2	51.3	0.1
Apr	55.1	55.2	0.1
May	58.7	58.7	0.0
Jun	62.0	62.0	0.0
Jul	66.2	66.2	0.0
Aug	66.9	66.9	0.0
Sep	66.8	66.8	0.0

[1] Based on 69 years modeled.

Water temperatures greater than 56°F may have the potential to adversely affect salmon spawning and egg incubation. Under the Flexible Purchase Alternative, there would be one additional occurrence in which monthly mean water temperatures would exceed 56°F below Nimbus Dam in October, relative to the Baseline Condition. (See Appendix H pgs. 409-413.) Similarly, at Watt Avenue, water temperatures under the Flexible Purchase Alternative would exceed 56°F in one additional month in October, relative to the Baseline Condition. (See Appendix H pgs. 421-425.)

The long-term average annual early lifestage survival for fall-run Chinook salmon in the American River would be 90.6 percent under the Baseline Condition and 90.5 percent under the Flexible Purchase Alternative, as shown in Table 9-43. Under the

Flexible Purchase Alternative, there would be no change in annual early lifestage survival in 20 of the 69 years simulated. In 10 of the 69 years modeled, there would be increases in annual early lifestage survival under the Flexible Purchase Alternative, and in 37 years, decreases would occur, relative to the Baseline Condition.

Table 9-43
Lower American River Salmon Survival – Fall-run Chinook Salmon Under Baseline and Flexible Purchase Alternative Conditions

Water Year	Baseline Condition Survival (%)	Flexible Purchase Alternative Survival (%)	Absolute Difference (%)	Relative Difference (%)
1922	92.5	92.2	-0.3	-0.3
1923	93.1	93.1	0.0	0.0
1924	89.7	89.7	0.0	0.0
1925	90.5	90.6	0.1	0.1
1926	90.2	90.1	-0.1	-0.1
1927	93.3	93.3	0.0	0.0
1928	92.7	92.6	-0.1	-0.1
1929	93.7	93.5	-0.2	-0.2
1930	92.9	92.8	-0.1	-0.1
1931	89.0	88.9	-0.1	-0.1
1932	83.3	83.3	0.0	0.0
1933	87.0	86.5	-0.5	-0.6
1934	86.3	86.2	-0.1	-0.1
1935	91.3	90.8	-0.5	-0.5
1936	86.0	85.8	-0.2	-0.2
1937	93.5	93.3	-0.2	-0.2
1938	91.8	91.8	0.0	0.0
1939	88.3	88.1	-0.2	-0.2
1940	86.8	86.8	0.0	0.0
1941	93.3	93.3	0.0	0.0
1942	92.9	92.9	0.0	0.0
1943	93.2	93.2	0.0	0.0
1944	93.0	92.7	-0.3	-0.3
1945	92.1	92.1	0.0	0.0
1946	93.0	93.2	0.2	0.2
1947	93.9	93.8	-0.1	-0.1
1948	93.0	93.5	0.5	0.5
1949	93.6	93.5	-0.1	-0.1
1950	88.3	88.3	0.0	0.0
1951	92.1	92.0	-0.1	-0.1
1952	92.5	92.1	-0.4	-0.4
1953	91.9	92.3	0.4	0.4
1954	93.0	93.0	0.0	0.0
1955	93.5	93.7	0.2	0.2
1956	91.9	91.5	-0.4	-0.4
1957	90.4	90.0	-0.4	-0.4
1958	82.9	82.8	-0.1	-0.1
1959	79.1	77.7	-1.4	-1.8
1960	92.3	92.0	-0.3	-0.3
1961	92.6	92.4	-0.2	-0.2
1962	90.4	90.4	0.0	0.0
1963	93.8	93.8	0.0	0.0
1964	93.6	93.5	-0.1	-0.1
1965	93.0	93.2	0.2	0.2
1966	90.2	89.6	-0.6	-0.7

Table 9-43
Lower American River Salmon Survival – Fall-run Chinook Salmon Under Baseline and Flexible Purchase Alternative Conditions

Water Year	Baseline Condition Survival (%)	Flexible Purchase Alternative Survival (%)	Absolute Difference (%)	Relative Difference (%)
1967	83.6	83.6	0.0	0.0
1968	91.7	91.3	-0.4	-0.4
1969	92.3	92.3	0.0	0.0
1970	93.2	92.8	-0.4	-0.4
1971	93.5	93.5	0.0	0.0
1972	93.0	93.0	0.0	0.0
1973	91.8	93.2	1.4	1.5
1974	92.7	92.6	-0.1	-0.1
1975	93.9	93.8	-0.1	-0.1
1976	87.7	87.5	-0.2	-0.2
1977	82.1	81.4	-0.7	-0.9
1978	89.4	89.6	0.2	0.2
1979	91.9	91.8	-0.1	-0.1
1980	92.1	92.1	0.0	0.0
1981	84.0	83.9	-0.10	-0.1
1982	93.1	93.1	0.0	0.0
1983	86.6	86.8	0.2	0.2
1984	90.1	89.4	-0.7	-0.8
1985	93.0	92.9	-0.1	-0.1
1986	90.7	90.7	0.0	0.0
1987	87.8	87.6	-0.2	-0.2
1988	85.9	86.0	0.1	0.1
1989	91.2	91.2	0.0	0.0
1990	91.2	90.7	-0.5	-0.5
Mean:	90.6	90.5	-0.1	-0.1
Median:	91.9	92.0	-0.1	-0.1
Min:	79.1	77.7	-1.4	-1.8
Max:	93.9	93.8	1.4	1.5
		Year Counts		
0.0 > X >= -1.0			36	36
-1.0 > X >= -2.0			1	1
-2.0 > X >= -4.0			0	0
-4.0 > X >= -6.0			0	0
X < -6.0			0	0
0.0 < X <= 1.0			9	9
1.0 < X <= 2.0			1	1
2.0 < X <= 4.0			0	0
4.0 < X <= 6.0			0	0
X > 6.0			0	0
No Difference (X = 0.0)			20	20

Flow-related Impacts on Adult Steelhead Spawning and Egg Incubation (December through April)

Long-term average flows below Nimbus Dam and at Watt Avenue under the Flexible Purchase Alternative would be identical to flows under the Baseline Condition during December through April, as shown in Table 9-39 and Table 9-40. Monthly mean flows under the Flexible Purchase Alternative below Nimbus Dam and at Watt Avenue would be essentially equivalent to those under the Baseline Condition for all of the 360 months included in the analysis. (See Appendix H pgs. 315-319 and 327-331.)

Temperature-related Impacts on Adult Steelhead Spawning and Egg Incubation (December through April)

Long-term average water temperatures under the Flexible Purchase Alternative below Nimbus Dam would not change during December and February, would decrease by 0.1°F in January, and would increase by 0.1°F in March and April, relative to the Baseline Condition. (Refer to Table 9-41.) Monthly mean water temperatures below Nimbus Dam under the Flexible Purchase Alternative would be essentially equivalent to those under the Baseline Condition for all of the 345 months included in the analysis [Appendix H pgs. 411-415]. Additionally, there would be no measurable increase in the frequency in which water temperatures under the Flexible Purchase Alternative at this location would exceed 56°F, relative to the Baseline Condition. (See Appendix H pgs. 411-415.)

Long term average water temperatures during the December through April period at Watt Avenue would not change from December through February, and would increase by 0.1°F during March and April, relative to the Baseline Condition, as shown in Table 9-42. Monthly mean water temperatures at Watt Avenue under the Flexible Purchase Alternative would be essentially equivalent to those under the Baseline Condition for all of the 345 months included in the analysis. (See Appendix H pgs. 423-427.) In addition, implementation of the Flexible Purchase Alternative would not result in a measurable increase in the frequency in which monthly mean water temperatures would exceed 56°F, relative to the Baseline Condition, throughout the December through April period. (See Appendix H pgs. 423–427.)

Flow-related Impacts on Juvenile Fall-run Chinook Salmon and Steelhead Rearing and Emigration (February through June)

The majority of juvenile salmonid rearing is believed to occur upstream of Watt Avenue, and depletions (primarily diversions) generally exceed tributary accretions to the river throughout the February through June period (generally resulting in lower flows at Watt Avenue than below Nimbus Dam). Therefore, all flow-related impact assessments for juvenile fall-run Chinook salmon and steelhead rearing are based on flows at Watt Avenue. Because juvenile emigration occurs at the mouth of the American River, flow-related impacts are also assessed at this location.

Under the Flexible Purchase Alternative, long-term average flows at Watt Avenue would not differ from flows under the Baseline Condition during the February through June period. (Refer to Table 9-40.) In all of the 360 months included in the analysis, monthly mean flows under the Flexible Purchase Alternative would be essentially equivalent to flows under the Baseline Condition. (Refer to Appendix H pgs. 329-333.) Flow exceedance curves for February through June at Watt Avenue are shown in Figures 9-46 through 9-50. The basis for development of these exceedance curves was the 1922-1993 period of record. These figures show that flows at Watt Avenue under the Flexible Purchase Alternative would be identical to those under the

Baseline Condition from February through June. Flows at Watt Avenue would not be expected to change under the Flexible Purchase Alternative. At the mouth of the American River, long-term average flows would not differ during the February through June period under the Flexible Purchase Alternative, relative to the Baseline Condition, as shown in Table 9-44. Under the Flexible Purchase Alternative, monthly mean flows at the mouth of the American River would be essentially equivalent to those under the Baseline Condition in all of the 360 months included in the analysis. (See Appendix H pgs. 365-369.)

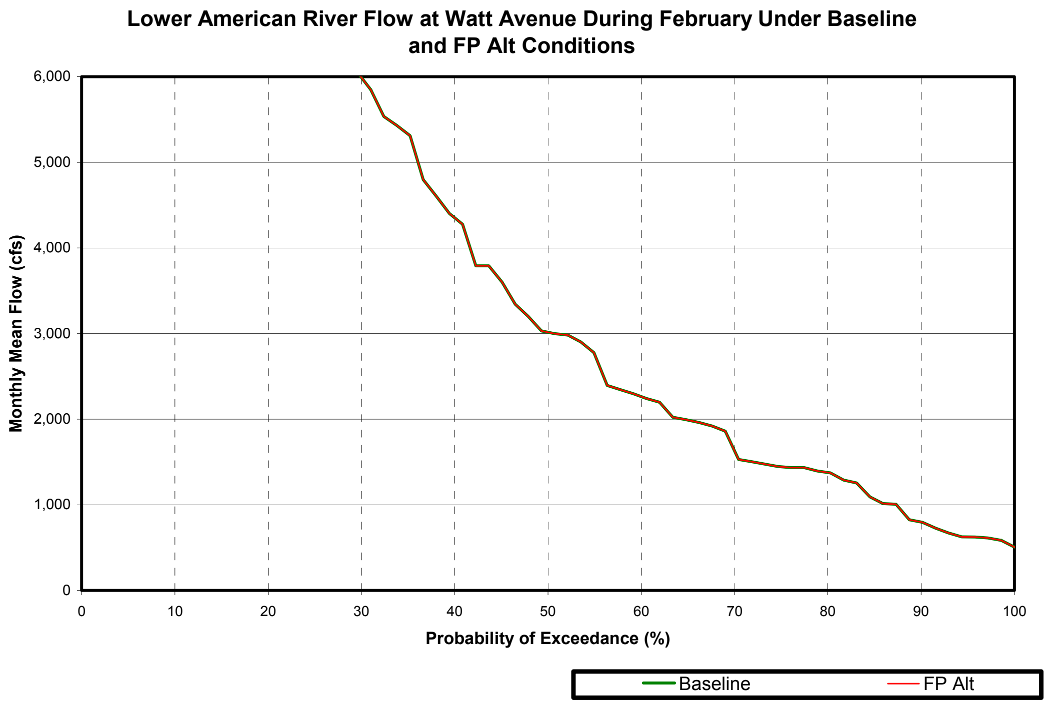

Figure 9-46
Lower American River Flow at Watt Avenue During February Under Baseline and Flexible Purchase Alternative Conditions

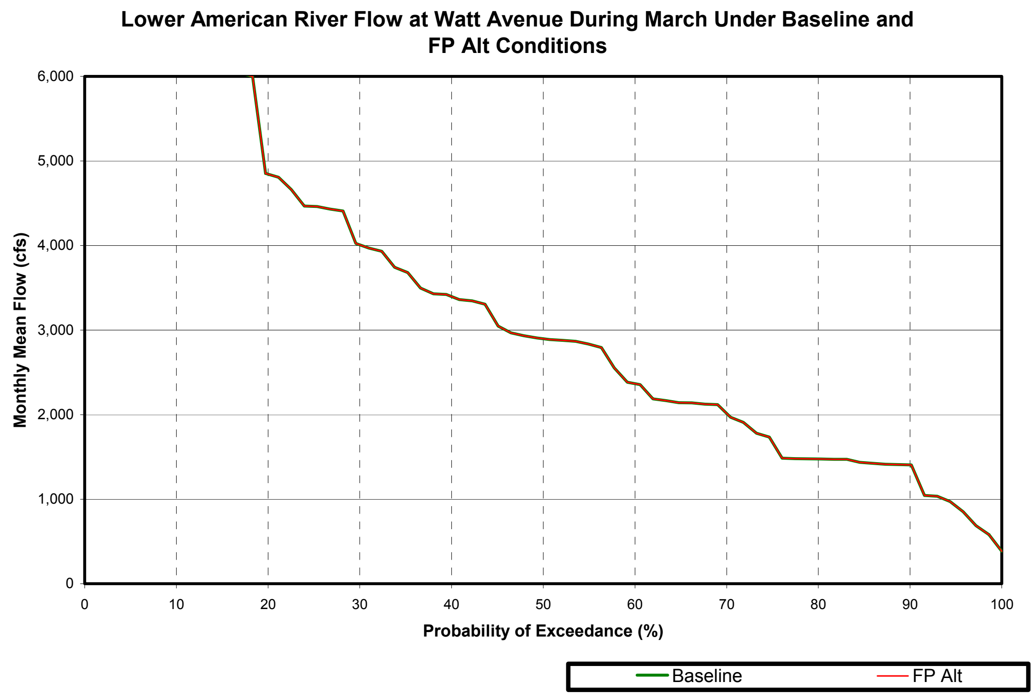

Figure 9-47
Lower American River Flow at Watt Avenue During March
Under Baseline and Flexible Purchase Alternative Conditions

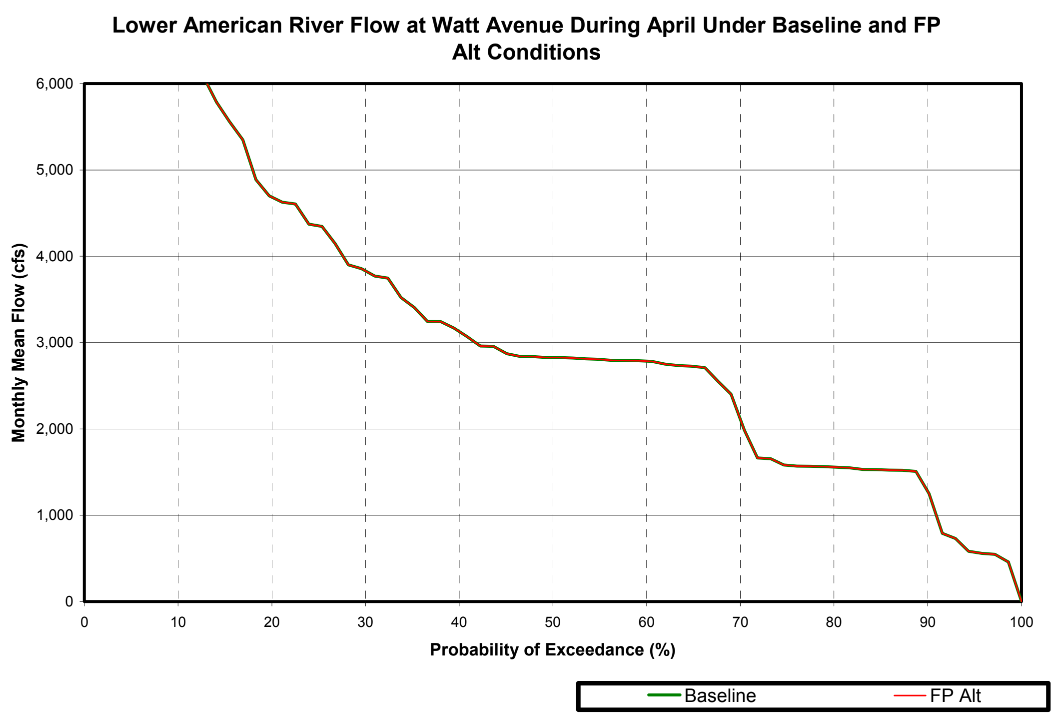

Figure 9-48
Lower American River Flow at Watt Avenue During April
Under Baseline and Flexible Purchase Alternative Conditions

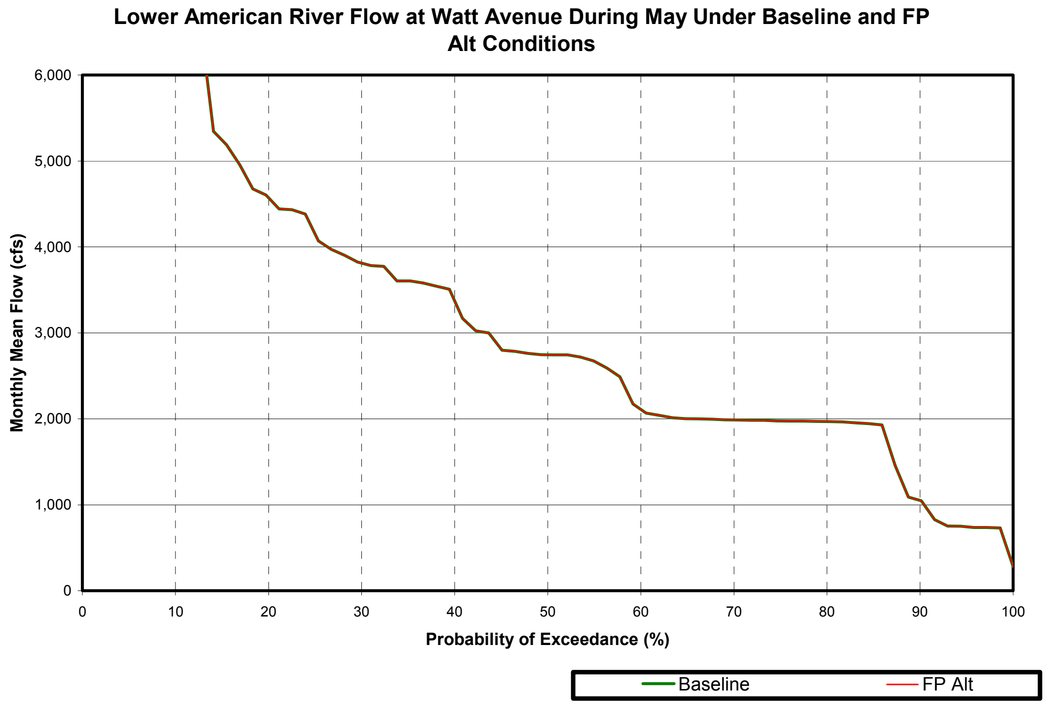

Figure 9-49
Lower American River Flow at Watt Avenue During May Under Baseline and Flexible Purchase Alternative Conditions

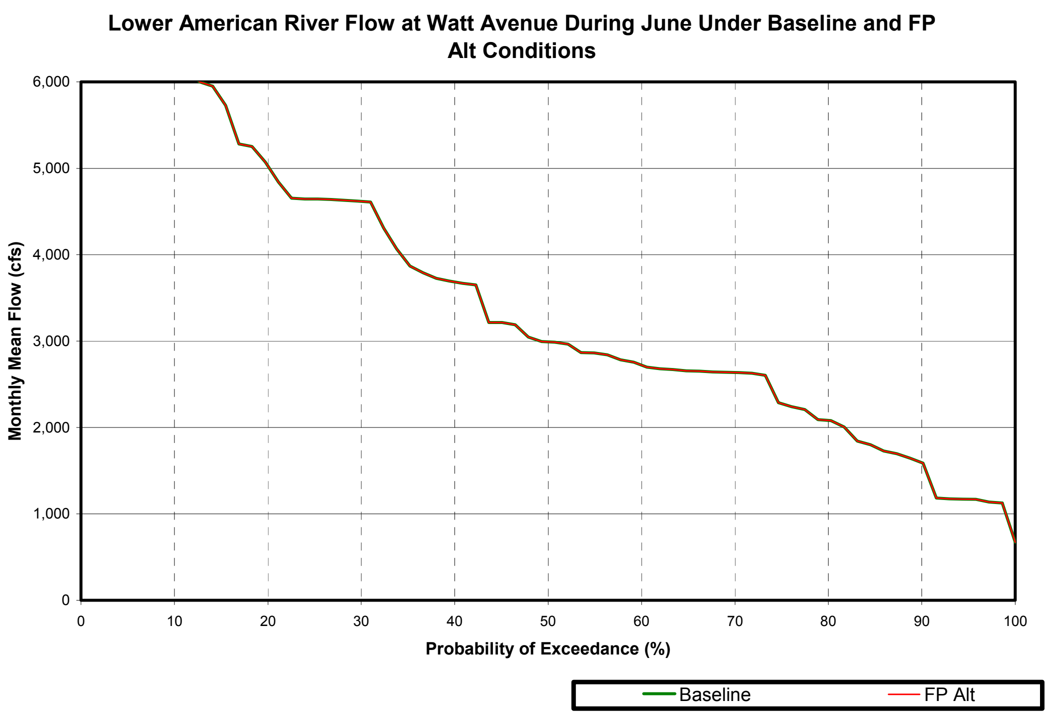

Figure 9-50
Lower American River Flow at Watt Avenue During June Under Baseline and Flexible Purchase Alternative Conditions

Table 9-44
Long-term Average Flow at the Mouth of the American River Under Baseline and Flexible Purchase Alternative Conditions

Month	Monthly Mean Flow[1] (cfs)		Difference	
	Baseline	Flexible Purchase Alternative	(cfs)	(%)[2]
Oct	1557	1557	0	0.0
Nov	2426	2426	0	0.0
Dec	3441	3441	0	0.0
Jan	4077	4077	0	0.0
Feb	4949	4949	0	0.0
Mar	3902	3902	0	0.0
Apr	3518	3518	0	0.0
May	3632	3632	0	0.0
Jun	3936	3936	0	0.0
Jul	3851	3958	107	2.8
Aug	2253	2299	46	2.0
Sep	2707	2716	9	0.3

[1] Based on 72 years modeled.
[2] Relative difference of the monthly long-term average.

Overall, flows in the lower American River at Watt Avenue and at the mouth would not differ substantially under the Flexible Purchase Alternative, relative to the Baseline Condition. Potential flow decreases would not be detected during the February through June period under the Flexible Purchase Alternative.

Temperature-related Impacts on Juvenile Fall-run Chinook Salmon and Steelhead Rearing and Emigration (February through June)

Water temperature modeling for juvenile fall-run Chinook salmon and steelhead rearing and emigration was simulated at four locations, in the lower American River below Nimbus Dam, at Watt Avenue, and at the mouth of the American River, as well as in the Sacramento River at Freeport. Modeling associated with the Flexible Purchase Alternative indicates that simulated long-term average water temperatures below Nimbus Dam would not change during February and June, and would increase by 0.1°F during March, April, and May, as shown in Table 9-41. Monthly mean water temperatures below Nimbus Dam under the Flexible Purchase Alternative would be essentially equivalent to or less than those under the Baseline Condition in 342 of the 345 months simulated for the February through June period. (Refer to Appendix H pgs. 473-477.) Further, there would not be any additional occurrences under the Flexible Purchase Alternative in which water temperatures would be above 65°F below Nimbus Dam, relative to the Baseline Condition. (Refer to Appendix H pgs. 473-477.)

Table 9-45
Long-term Average Water Temperature in the American River Below Nimbus Dam Under Baseline and Flexible Purchase Alternative Conditions

Month	Water Temperature[1] (ºF)		
	Baseline	Flexible Purchase Alternative	Difference (ºF)
Oct	56.3	56.3	0.0
Nov	56.5	56.5	0.0
Dec	51.2	51.2	0.0
Jan	47.2	47.1	-0.1
Feb	47.8	47.8	0.0
Mar	50.3	50.4	0.1
Apr	53.7	53.8	0.1
May	56.5	56.6	0.1
Jun	59.6	59.6	0.0
Jul	64.3	64.3	0.0
Aug	64.5	64.6	0.1
Sep	65.9	66.1	0.2

[1] Based on 69 years modeled.

Modeling associated with the Flexible Purchase Alternative indicates that long-term average water temperatures at Watt Avenue would not change during February, May, and June, and would increase by 0.1°F during March and April, relative to the Baseline Condition, as shown in Table 9-42. Monthly mean water temperatures at Watt Avenue under the Flexible Purchase Alternative would be essentially equivalent to those under the Baseline Condition in 274 months out of the 276 months included in the analysis. (See Appendix H pgs. 426– 429.) February and March water temperatures at Watt Avenue under the Flexible Purchase Alternative would remain below 65°F for all of the 69 years modeled. During April, May, and June, there would not be a measurable increase in the frequency in which monthly mean water temperatures under the Flexible Purchase Alternative would be above 65°F, relative to the Baseline Condition.

Long-term average water temperatures at the mouth of the American River during the February through June period under the Flexible Purchase Alternative would not change during February, and would increase 0.1°F during March through June, relative to the Baseline Condition. (Refer to Table 9-38.) Monthly mean water temperatures at the mouth of the American River under the Flexible Purchase Alternative would be essentially equivalent to or less than those under the Baseline Condition in 344 of the 345 months simulated for the February through June period. (Refer to Appendix H pgs. 437-441.) Monthly mean water temperatures at the mouth of the American River would be below 65°F in all 69 years modeled for the February through April period. During May and June, implementation of the Flexible Purchase Alternative would not result in an increase in the frequency of monthly mean water temperatures above 65°F, relative to the Baseline Condition. (Refer to Appendix H pgs. 437-441.)

Long-term average water temperatures under the Flexible Purchase Alternative in the Sacramento River at Freeport would be nearly identical to those under the Baseline Condition throughout the February through June period, as shown in Table 9-11. Long-term average water temperatures under the Flexible Purchase Alternative at Freeport would not change during February and March, and would increase by 0.1°F during April, May, and June. Monthly mean water temperatures at this location under the Flexible Purchase Alternative would be essentially equivalent to those under the Baseline Condition in all of the 345 months simulated for the February through June period. (Refer to Appendix H pgs. 485-489.) Further, the Flexible Purchase Alternative would not result in a measurable increase in the frequency in which monthly mean water temperatures would exceed 65°F at Freeport in the Sacramento River, relative to the Baseline Condition, for all months simulated for the juvenile fall-run Chinook salmon and steelhead rearing and emigration period. (Refer to Appendix H pgs. 485-489.)

Overall, implementation of the Flexible Purchase Alternative would result in negligible changes in lower American River water temperatures below Nimbus Dam, at Watt Avenue, and at the mouth of the American River, or in the Sacramento River at Freeport, throughout the February though June juvenile fall-run Chinook salmon and steelhead rearing and emigration period.

Flow-related Impacts on Juvenile Steelhead Rearing (July through September)

The majority of juvenile salmonid rearing is believed to occur upstream of Watt Avenue, and depletions generally exceed tributary accretions to the river throughout the February through June period (generally resulting in lower flows at Watt Avenue than below Nimbus Dam); therefore, all flow-related impact assessments for juvenile steelhead rearing are based on flows at Watt Avenue.

Under the Flexible Purchase Alternative, long-term average flows at Watt Avenue in the lower American River would increase by 2.9 percent, 2.1 percent, and 0.3 percent in July, August, and September, respectively, relative to the Baseline Condition. (Refer to Table 9-40.) In all of the 216 months simulated for the July through September period, monthly mean flows under the Flexible Purchase Alternative would be essentially equivalent to or greater than flows under the Baseline Condition. (Refer to Appendix H pgs. 334-336.) Figures 9-51 through 9-53 provide flow exceedance curves for the American River at Watt Avenue during July, August and September. The basis for development of these exceedance curves was the 1922-1993 period of record. These curves demonstrate that flows would slightly increase during July and August at nearly all flow levels simulated and generally remain the same during September at all flow levels simulated. Based on these findings, flow changes under the Flexible Purchase Alternative would not be expected to reduce juvenile steelhead rearing habitat. Further, steelhead populations in the lower American River are believed to be limited by instream water temperature conditions during the July through September period (discussed below), as opposed to flow conditions.

Temperature-related Impacts on Juvenile Steelhead Rearing (July through September)

Under the Flexible Purchase Alternative, long-term average water temperatures below Nimbus Dam would not differ in July and would increase by 0.1° and 0.2°F in August and September, respectively, relative to the Baseline Condition, as shown in Table 9-41. Long-term average water temperatures in the lower American River at Watt Avenue and at the mouth would not differ during July, August and September under the Flexible Purchase Alternative compared to the Baseline Condition. (Refer to Table 9-42 and Table 9-38.)

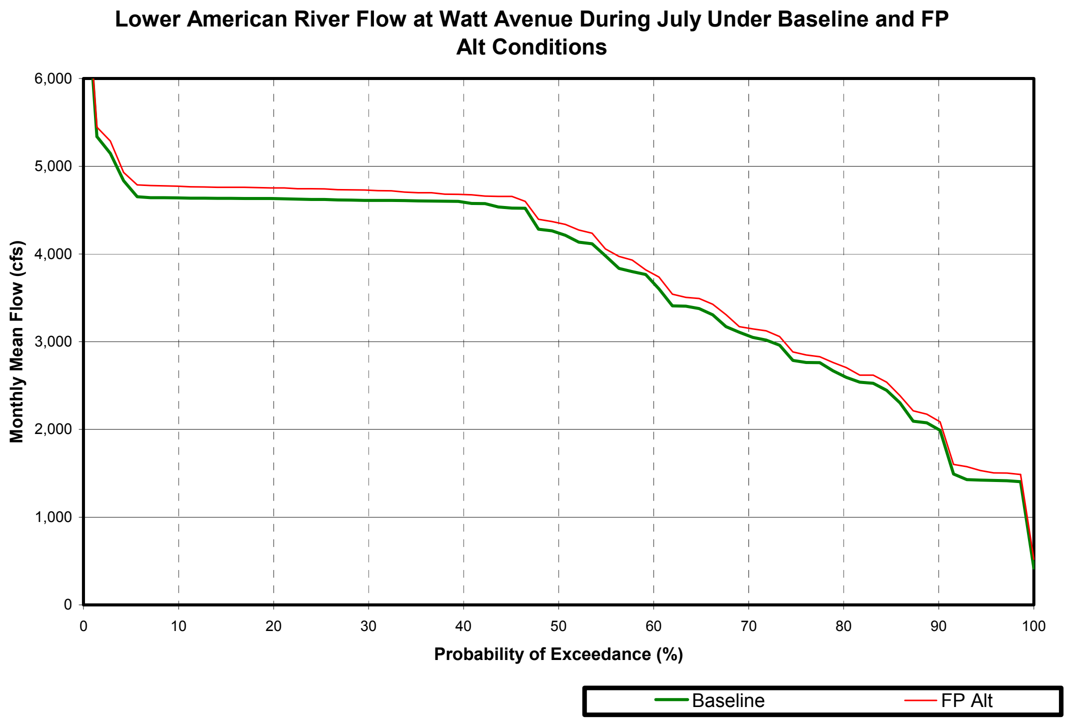

Figure 9-51
Lower American River Flow at Watt Avenue During July Under Baseline and Flexible Purchase Alternative Conditions

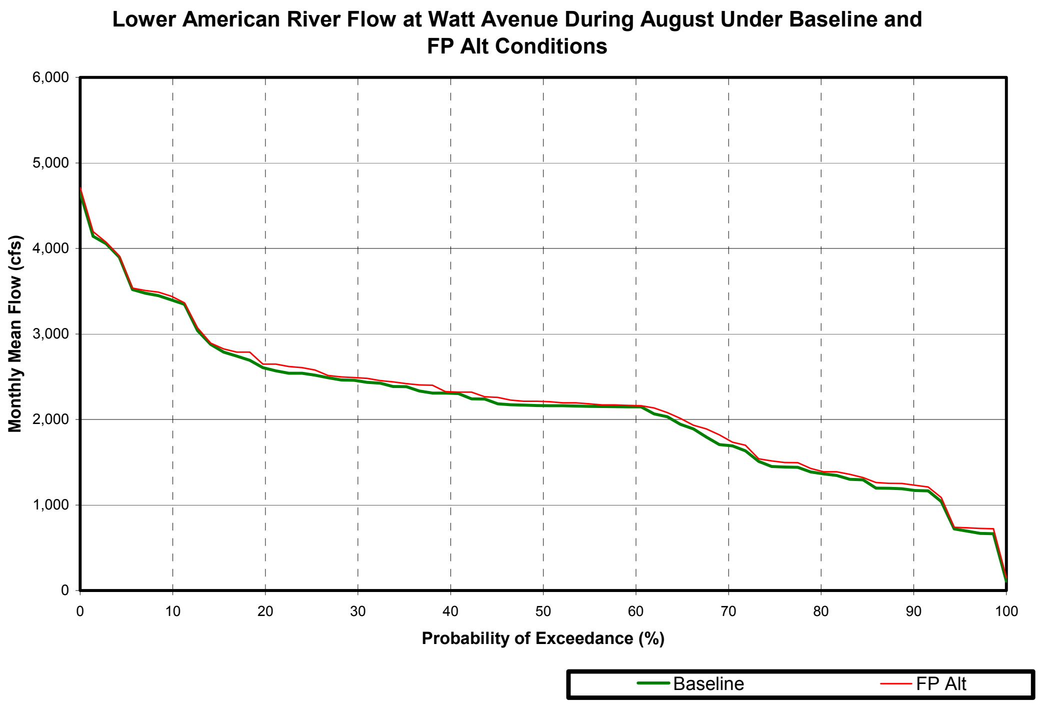

Figure 9-52
Lower American River Flow at Watt Avenue During August Under Baseline and Flexible Purchase Alternative Conditions

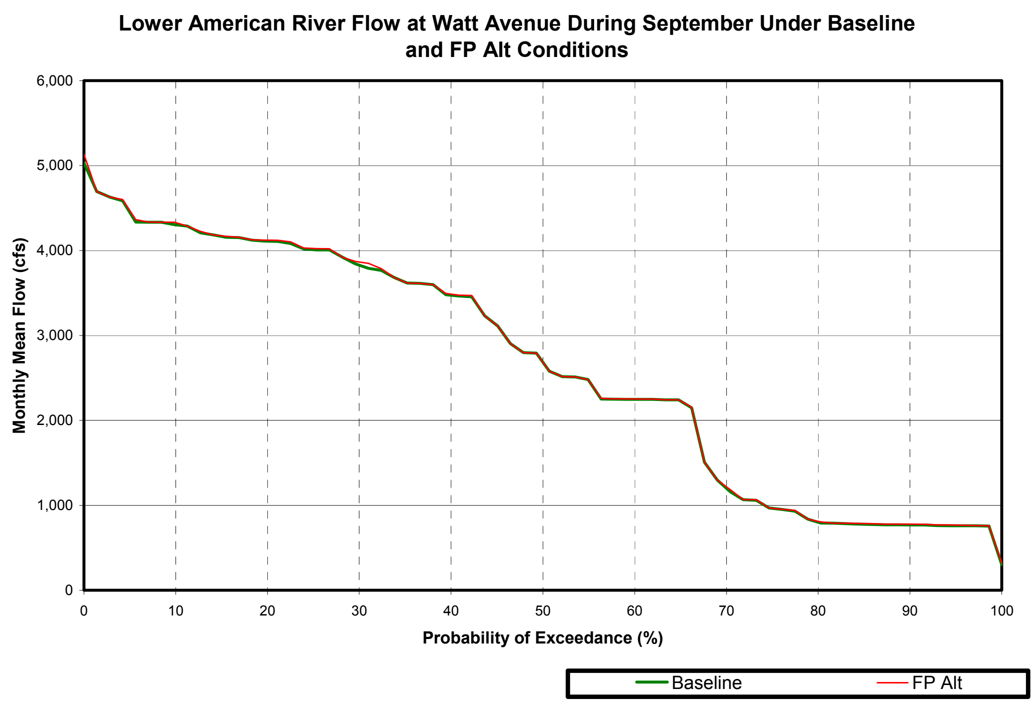

Figure 9-53
Lower American River Flow at Watt Avenue During September Under Baseline and Flexible Purchase Alternative Conditions

Monthly mean water temperatures below Nimbus Dam under the Flexible Purchase Alternative would be essentially equivalent to those under the Baseline Condition in 196 out of the 207 months simulated for this three-month period. (Refer to Appendix H pgs. 418-420.) Monthly mean water temperatures at Watt Avenue under the Flexible Purchase Alternative would be essentially equivalent to those under the Baseline Condition in 205 out of the 207 months simulated for this three-month period. (Refer to Appendix H pgs. 430–432.) In addition, monthly mean water temperatures at the mouth of the lower American River under the Flexible Purchase Alternative would be essentially equivalent to those under the Baseline Condition in 206 out of the 207 months simulated. (Refer to Appendix H pgs. 442–444.) At each of these locations, implementation of the Flexible Purchase Alternative would not result in a measurable increase in the frequency in which July through September monthly mean water temperatures would exceed 65°F relative to the Baseline Condition. (Refer to Appendix H pgs. 418-420, 430-432, and 442-444.) In summary, there would be little difference in water temperatures between the Flexible Purchase Alternative and the Baseline Condition during the over-summer juvenile steelhead rearing months of July through September.

Flow-related Impacts on Fall/Winter Juvenile Steelhead Rearing (October through January)

The majority of juvenile salmonid rearing is believed to occur upstream of Watt Avenue, and depletions generally exceed tributary accretions to the river throughout the February through June period (generally resulting in lower flows at Watt Avenue than below Nimbus Dam); therefore, all flow-related impact assessments for juvenile steelhead rearing are based on flows at Watt Avenue.

Under the Flexible Purchase Alternative, long-term average flows at Watt Avenue in the lower American River would not change during the October through January period, relative to the Baseline Condition. (Refer to Table 9-40.) In all of the 288 months simulated for the October through January period, monthly mean flows under the Flexible Purchase Alternative would be essentially equivalent to or greater than flows under the Baseline Condition. (Refer to Appendix H pgs. 325-328.)

Temperature-related Impacts on Fall/Winter Juvenile Steelhead Rearing (October through January)

Under the Flexible Purchase Alternative, long-term average water temperatures below Nimbus Dam would not differ October through December and would decrease by 0.1°F in January, relative to the Baseline Condition, as shown in Table 9-41. Long-term average water temperature in the lower American River at Watt Avenue would not change under the Flexible Purchase Alternative, relative to the Baseline Condition. (Refer to Table 9-42.) Long-term average water temperature in the lower American River at the mouth would not change under the Flexible Purchase Alternative during October, November, or January, and would decrease by 0.1°F in December, relative to the Baseline Condition. (Refer to Table 9-38.)

Monthly mean water temperatures below Nimbus Dam under the Flexible Purchase Alternative would be essentially equivalent to those under the Baseline Condition in 274 out of the 276 months simulated for the October through January period. (Refer to Appendix H pgs. 409-412.) Monthly mean water temperatures at Watt Avenue under the Flexible Purchase Alternative would be essentially equivalent to those under the Baseline Condition in 267 out of the 276 months simulated for this four-month period. (Refer to Appendix H pgs. 421-424.) In addition, monthly mean water temperatures at the mouth of the American River under the Flexible Purchase Alternative would be essentially equivalent to those under the Baseline Condition in 271 out of the 276 months simulated. (Refer to Appendix H pgs. 433-436.) In summary, there would be minimal differences in water temperatures between the Flexible Purchase Alternative and the Baseline Condition during the fall/winter juvenile steelhead rearing months of October through January.

Summary of Impacts on Fall-run Chinook Salmon and Steelhead in the Lower American River

In summary, potential changes in flow in the lower American River under the Flexible Purchase Alternative during the September through March period would not be of sufficient frequency or magnitude to beneficially or adversely effect adult fall-run Chinook salmon immigration or encourage straying into the lower American River. Similarly, slight fluctuations in flows under the Flexible Purchase Alternative during the October through February period would not be of sufficient frequency or magnitude to beneficially or adversely impact fall-run Chinook salmon spawning, egg incubation, and initial rearing in the lower American River. Changes in flow that would occur under the Flexible Purchase Alternative during the February through June period would not be of sufficient frequency or magnitude to beneficially or adversely effect juvenile fall-run Chinook salmon rearing and emigration.

Changes in water temperature in the lower American River under the Flexible Purchase Alternative during the September through March period would not be of sufficient frequency or magnitude to beneficially or adversely effect adult fall-run Chinook salmon immigration or encourage straying into the lower American River. Similarly, changes in water temperature under the Flexible Purchase Alternative during the October through February period would not be of sufficient frequency or magnitude to beneficially or adversely impact fall-run Chinook salmon spawning, egg incubation, and initial rearing. Although slight changes in water temperature would result in increases and decreases in annual early lifestage survival of fall-run Chinook salmon under the Flexible Purchase Alternative, these changes would not be of sufficient frequency or magnitude to beneficially or adversely impact long-term initial year class strength. Changes in water temperature that would occur under the Flexible Purchase Alternative during the February through June period would not be of sufficient frequency or magnitude to beneficially or adversely effect juvenile fall-run Chinook salmon rearing and emigration.

Potential changes in flow in the lower American River under the Flexible Purchase Alternative during the September through March period would not be of sufficient frequency or magnitude to beneficially or adversely effect adult steelhead immigration or encourage straying into the lower American River. Flow changes are not expected to occur under the Flexible Purchase Alternative during the December through April period, and thus, would not be of sufficient frequency or magnitude to beneficially or adversely impact adult steelhead spawning and egg incubation. Changes in flow that would occur in the lower American River under the Flexible Purchase Alternative during the February through June period would not be of sufficient frequency or magnitude to beneficially or adversely effect juvenile steelhead rearing and emigration. Slight changes in flow that would occur under the Flexible Purchase Alternative during the July through September and October through January periods would not be of sufficient frequency or magnitude to beneficially or adversely effect juvenile steelhead rearing.

Changes in water temperature in the lower American River under the Flexible Purchase Alternative during the September through March period would not be of sufficient frequency or magnitude to beneficially or adversely effect adult steelhead immigration or encourage straying into the lower American River. Small water temperature changes under the Flexible Purchase Alternative during the December through April period would not be of sufficient frequency or magnitude to beneficially or adversely impact adult steelhead spawning and egg incubation. Changes in water temperature that would occur in the lower American River under the Flexible Purchase Alternative during the February through June period would not be of sufficient frequency or magnitude to beneficially or adversely effect juvenile steelhead rearing and emigration. Slight changes in water temperature that would occur under the Flexible Purchase Alternative during the July through September and October through January periods would not be of sufficient frequency or magnitude to beneficially or adversely effect juvenile steelhead rearing.

Overall, the changes in flows and water temperatures in the lower American River under the Flexible Purchase Alternative would not be of sufficient frequency or magnitude to beneficially or adversely impact fall-run Chinook salmon. Therefore, impacts on fall-run Chinook salmon in the lower American River with implementation of the Flexible Purchase Alternative, relative to the Baseline Condition, would be less than significant.

Similarly, the changes in flows and water temperatures in the lower American River under the Flexible Purchase Alternative would not be of sufficient frequency or magnitude to beneficially or adversely impact steelhead. Therefore, impacts on steelhead in the lower American River with implementation of the Flexible Purchase Alternative, relative to the Baseline Condition, would be less than significant.

<u>Impacts on Splittail in the Lower American River</u>

Under the Flexible Purchase Alternative, long-term average flows at Watt Avenue during the February through May period would not differ from those under the

Baseline Condition, as shown in Table 9-40. In all of the 288 months simulated for this period, monthly mean flows under the Flexible Purchase Alternative would be essentially equivalent to those under the Baseline Condition. (Refer to Appendix H pgs. 329-332.)

Long-term average usable splittail habitat at Watt Avenue would not change during any month of the February through May period under the Flexible Purchase Alternative, relative to the Baseline Condition. In fact, as shown in Table 9-46, the monthly mean quantity of submerged vegetation available under the Flexible Purchase Alternative would not change during any month simulated for the February through May period, relative to the Baseline Condition. (Refer to Appendix H pgs. 558-561.)

Table 9-46
Long-term Average Usable Splittail Habitat at Watt Avenue Under Baseline and Flexible Purchase Alternative Conditions

Month	Usable Habitat[1] (Acres)		Difference		Years Unchanged[2]		Years Increased[2]		Years Decreased[2]	
	Baseline	FP Alt	(Acres)	(%)[3]	Number	Percent	Total	From Zero	Total	To Zero
Feb	3.5	3.5	0.0	0.0	0	0%	0	0	0	0
Mar	1.7	1.7	0.0	0.0	0	0%	0	0	0	0
Apr	0.9	0.9	0.0	0.0	0	0%	0	0	0	0
May	1.2	1.2	0.0	0.0	0	0%	0	0	0	0

[1] Usable habitat is submerged vegetation over 2.4 acres.
[2] Based on 72 years modeled.
[3] Relative difference of the monthly long-term average.
FP Alt = Flexible Purchase Alternative

Long-term average water temperatures in the lower American River at Watt Avenue under the Flexible Purchase Alternative during the February through May period would not change during February and May, and would increase by 0.1°F during March and April, relative to the Baseline Condition, as shown in Table 9-42. Monthly mean water temperatures at Watt Avenue under the Flexible Purchase Alternative would be essentially equivalent to those under the Baseline Condition in 274 of the 276 months simulated for the February through May period. (Refer to Appendix H pgs. 425-428.) In addition, monthly mean water temperatures would not rise above 68°F, the upper end of the reported preferred water temperature range for splittail spawning, more frequently under the Flexible Purchase Alternative than under the Baseline Condition. (Refer to Appendix H pgs. 425-428.)

At the mouth of the lower American River, long-term average water temperatures under the Flexible Purchase Alternative would not change during February, and would increase by 0.1°F during March, April, and May, relative to the Baseline Condition. (Refer to Table 9-38.) Monthly mean water temperatures at this location under the Flexible Purchase Alternative would be essentially equivalent to those under the Baseline Condition in 275 of the 276 months included in the analysis. (Refer to Appendix H pgs. 437-440.) Further, implementation of the Flexible Purchase

Alternative would not result in an increase in the frequency in which water temperatures would exceed 68°F, relative to the Baseline Condition. (Appendix H pgs. 437-440.)

Overall, potential flow and water temperature changes during the February through May period resulting from the implementation of the Flexible Purchase Alternative would not be of sufficient frequency or magnitude to beneficially or adversely effect splittail spawning. Therefore, impacts on splittail in the lower American River with implementation of the Flexible Purchase Alternative would be less than significant, relative to the Baseline Condition.

<u>Impacts on American Shad in the Lower American River</u>

Table 9-37 shows that long-term average flows at the mouth of the American River during May and June would not differ between the Flexible Purchase Alternative and the Baseline Condition. In addition, an analysis was performed to determine the probability that flows at the mouth of the American River during May and June under the Flexible Purchase Alternative would be above 3,000 cfs, the flow level defined by CDFG as sufficient to maintain the sport fishery for American shad. The model simulations for the Flexible Purchase Alternative indicate that there would be no difference in the frequency in which monthly mean flows at this location would be above 3,000 cfs during May and June, relative to the Baseline Condition. (See Appendix H pgs. 368 - 369.)

Further, monthly mean flows at the mouth of the American River during May and June under the Flexible Purchase Alternative would be essentially equivalent to those under the Baseline Condition in all of the 144 months included in the analysis. Therefore, potential flow-related impacts on American shad under the Flexible Purchase Alternative would be less-than-significant, relative to the Baseline Condition.

Long-term average water temperatures in the lower American River below Nimbus Dam under the Flexible Purchase Alternative would not change during May, and would increase by 0.1°F during June. (Refer to Table 9-41.) Monthly mean water temperatures at this location under the Flexible Purchase Alternative would be essentially equivalent to those under the Baseline Condition in 135 of the 138 months simulated for the May through June period. (Refer to Appendix H pgs. 416-417.) In addition, the frequency in which monthly mean water temperatures would be within the reported preferred range for American shad spawning (60°F to 70°F) would not decrease under the Flexible Purchase Alternative, relative to the Baseline Condition.

At the mouth of the American River, long-term average water temperatures under the Flexible Purchase Alternative during May and June would increase by 0.1°F, relative to the Baseline Condition. (Refer to Table 9-38.) Monthly mean water temperatures at this location under the Flexible Purchase Alternative would be essentially equivalent to those under the Baseline Condition in 137 of the 138 months simulated for the May through June period. (Refer to Appendix H pgs. 440-441.) Further, implementation of the Flexible Purchase Alternative would not result in a decrease in the frequency in which monthly mean water temperatures would be within the reported preferred range for American shad spawning.

Overall, negligible changes in flows and water temperatures in the lower American River under the Flexible Purchase Alternative during May and June would not be of sufficient frequency or magnitude to beneficially or adversely impact American shad attraction and spawning. Therefore, impacts on American shad in the lower American River with implementation of the Flexible Purchase Alternative would be less than significant, relative to the Baseline Condition.

<u>Impacts on Striped Bass in the Lower American River</u>

Long-term average flows at the mouth of the American River during May and June would not differ between the Flexible Purchase Alternative and the Baseline Condition, as shown in Table 9-37. In addition, an analysis was performed to determine the probability that flows at the mouth of the American River under the Flexible Purchase Alternative during May and June would be above 1,500 cfs, the flow level defined by CDFG as sufficient to maintain the sport fishery for striped bass. The model simulations for the Flexible Purchase Alternative indicate that there would be no difference in the frequency in which monthly mean flows at the mouth of the American River would be above 1,500 cfs during May and June relative to the Baseline Condition. Furthermore, monthly mean flows during May and June under the Flexible Purchase Alternative would be essentially equivalent to those under the Baseline Condition in all of the 144 months included in the analysis. (Refer to Appendix H pgs. 368 - 369.) Therefore, potential changes in flows under the Flexible Purchase Alternative would not be of sufficient magnitude or frequency to result in significant impacts on striped bass spawning.

Long-term average water temperatures in the lower American River below Nimbus Dam under the Flexible Purchase Alternative would not change during May, and would increase by 0.1°F during June. (Refer to Table 9-41.) Monthly mean water temperatures at this location under the Flexible Purchase Alternative would be essentially equivalent to those under the Baseline Condition in 135 of the 138 months simulated for the May through June period. (Refer to Appendix H pgs. 416-417.) In addition, the frequency in which monthly mean water temperatures would be within the reported preferred range for striped bass spawning (59°F to 68°F) would not decrease under the Flexible Purchase Alternative, relative to the Baseline Condition.

At the mouth of the American River, long-term average water temperatures under the Flexible Purchase Alternative during May and June would increase by 0.1°F, relative to the Baseline Condition. (Refer to Table 9-38.) Monthly mean water temperatures at this location under the Flexible Purchase Alternative would be essentially equivalent to those under the Baseline Condition in 137 of the 138 months simulated for the May through June period. (Refer to Appendix H pgs. 440-441.) Further, implementation of the Flexible Purchase Alternative would not result in a decrease in the frequency in which monthly mean water temperatures would be within the reported preferred range for striped bass spawning.

Overall, changes in flows and water temperatures in the lower American River would not be of sufficient frequency or magnitude to beneficially or adversely impact striped bass spawning and initial rearing. Therefore, impacts on striped bass in the lower American River with implementation of the Flexible Purchase Alternative would be less than significant, relative to the Baseline Condition.

9.2.5.1.5 San Joaquin River Area of Analysis

The Merced River

Various EWA acquisitions could potentially affect the hydrology of the Merced River and its associated reservoirs. EWA acquisition of MID water via groundwater substitution would alter Merced River flows. EWA acquisition of MID water via groundwater substitution would alter summer surface water elevations at Lake McClure.

Potential impacts on the fisheries resources in the Merced River Basin were analyzed by evaluating reservoir conditions at Lake McClure and instream flow conditions below Crocker-Huffman Dam and at the mouth of the Merced River. Crocker-Huffman Dam is the first in a series of dams that prevents anadromous and riverine fish from accessing the upper reaches of the Merced River. There are no listed fish species present above the Crocker-Huffman Dam. Flows at the mouth of the Merced River were assessed for the frequency and magnitude of changes that could affect fall-run Chinook salmon migration or habitat availability for striped bass. Following a discussion of potential impacts on reservoir fish species of Lake McClure, flow-related impacts on riverine fish species are discussed separately by species and lifestage, including fall-run Chinook salmon and striped bass.

Impacts on Lake McClure Warmwater Fisheries

Table 9-47 provides monthly median storage, water surface elevation, and elevation changes for Lake McClure. Hydrologic conditions under the Flexible Purchase Alternative would result in increases of up to 3 feet msl in the median water surface elevation of Lake McClure during the warmwater fish spawning and initial rearing period of April through November. Changes in water surface elevation of Lake McClure would result in corresponding changes in the availability of littoral habitat containing submerged vegetation. Such shallow, nearshore waters containing physical structure are important to producing and maintaining strong year-classes of warmwater fishes.

In addition, the Flexible Purchase Alternative could alter the rates by which water surface elevation in Lake McClure would change, relative to the Baseline Condition. Reductions in median elevation between months (the magnitude of monthly drawdown) at Lake McClure are not expected to occur under the Flexible Purchase Alternative during the March through June warmwater fish spawning period. (Refer to Table 9-47.) Thus, it is not anticipated that reductions in water surface elevation of greater than 9 ft per month would occur under the Flexible Purchase Alternative.

Table 9-47
McClure Reservoir Monthly Median Storage, Elevation, and Elevation Change Under Baseline and EWA Conditions

	Storage				Elevation			Elevation Change		
Month	Baseline (TAF)	EWA (TAF)	Diff (TAF)	Diff (%)	Baseline (ft msl)	EWA (ft msl)	Diff (ft msl)	Baseline (ft msl)	EWA (ft msl)	Diff (ft msl)
Oct	598	611	13	2	778	779	2	-2	-3	-1
Nov	590	590	0	0	777	777	0	-1	-3	-2
Dec	581	581	0	0	776	776	0	-1	-1	0
Jan	584	584	0	0	776	776	0	0	0	0
Feb	627	627	0	0	781	781	0	5	5	0
Mar	656	656	0	0	784	784	0	3	3	0
Apr	683	687	3	0	787	787	0	2	3	0
May	774	781	8	1	793	794	0	6	7	0
Jun	865	877	13	1	798	799	1	5	5	0
Jul	774	792	18	2	793	794	1	-5	-4	0
Aug	682	703	22	3	787	788	2	-7	-6	1
Sep	615	640	25	4	780	783	3	-7	-6	1

Diff = Difference

In summary, the Flexible Purchase Alternative may increase the availability of littoral habitat at Lake McClure during the warmwater fish-rearing period of April through November by increasing surface elevation, and thus, may beneficially affect warmwater fish rearing. The Flexible Purchase Alternative does not alter the frequency of potential nest dewatering events in Lake McClure, and thus, would not beneficially or adversely affect long-term warmwater fish nesting success. Overall, with implementation of the Flexible Purchase Alternative, impacts on Lake McClure warmwater fisheries would be less than significant, relative to the Baseline Condition.

Impacts on Lake McClure Coldwater Fisheries

Hydrologic conditions under the Flexible Purchase Alternative would result in an increase in median storage of 3 to 25 TAF, or up to 4 percent, at Lake McClure during the April through November period, relative to the Baseline Condition, as shown in Table 9-47. Anticipated increases in reservoir storage would not be of sufficient magnitude to substantially affect the coldwater pool volume at Lake McClure, because seasonal changes in reservoir storage that would occur under the Flexible Purchase Alternative would not be large in proportion to overall storage at Lake McClure (approximately 0.3 to 2.5 percent of total volume). Therefore, increases in reservoir storage under the Flexible Purchase Alternative would not substantially alter the coldwater pool volume at Lake McClure, and thus, impacts on coldwater fisheries would be considered less than significant, relative to the Baseline Condition.

Impacts on Fall-run Chinook Salmon in the Merced River

Flow-related Impacts on Adult Fall-run Chinook Salmon Immigration (October through December)

Table 9-48 shows that long-term average flows at the mouth of the Merced River under the Flexible Purchase Alternative would increase by 23.2 percent during October, 73.3 percent during November and would not change during December, relative to the Baseline Condition. In all of the 216 months included in the analysis, monthly mean flows at the mouth of the Merced River would be essentially equivalent to or greater than those under the Baseline Condition. (Refer to Appendix H pgs. 976-978.)

Table 9-48
Long-term Average Flow at the Mouth of the Merced River Under Baseline and Flexible Purchase Alternative Conditions

Month	Monthly Mean Flow[1] (cfs)		Difference	
	Baseline	Flexible Purchase Alternative	(cfs)	(%)[2]
Oct	881	1085	204	23.2
Nov	288	499	211	73.3
Dec	438	438	0	0.0
Jan	596	596	0	0.0
Feb	936	936	0	0.0
Mar	654	654	0	0.0
Apr	517	517	0	0.0
May	865	865	0	0.0
Jun	827	827	0	0.0
Jul	333	333	0	0.0
Aug	189	189	0	0.0
Sep	193	193	0	0.0

[1] Based on 72 years modeled.
[2] Relative difference of the monthly long-term average.

Table 9-49 shows that long-term average flows below Crocker-Huffman Dam under the Flexible Purchase Alternative would increase by 25.0 percent during October, 90.9 percent during November and would not change during December, relative to the Baseline Condition. Further, in all of the 216 months simulated for the October through December period, monthly mean flows below Crocker-Huffman Dam under the Flexible Purchase Alternative would be essentially equivalent to or greater than those under the Baseline Condition. (Refer to Appendix H pgs. 964-967.) Thus, decreases in monthly mean flows at both locations would not be expected to occur during any month of the October through December period under the Flexible Purchase Alternative.

Table 9-49
Long-term Average Flow in the Merced River Below Crocker-Huffman Dam Under Baseline and Flexible Purchase Alternative Conditions

Month	Monthly Mean Flow[1] (cfs)		Difference	
	Baseline	Flexible Purchase Alternative	(cfs)	(%)[2]
Oct	812	1015	203	25.0
Nov	231	441	210	90.9
Dec	353	353	0	0.0
Jan	493	493	0	0.0
Feb	784	784	0	0.0
Mar	500	500	0	0.0
Apr	501	501	0	0.0
May	894	894	0	0.0
Jun	881	881	0	0.0
Jul	329	329	0	0.0
Aug	159	159	0	0.0
Sep	178	178	0	0.0

[1] Based on 72 years modeled.
[2] Relative difference of the monthly long-term average.

Flow-related Impacts on Adult Fall-run Chinook Salmon Spawning, and Egg Incubation, and Initial Rearing (October through December)

Table 9-49 shows that long-term average flows under the Flexible Purchase Alternative below Crocker-Huffman Dam would increase by 25 percent during October and by approximately 91 percent during November, and would not change during December, relative to the Baseline Condition. In all of the 216 months simulated for the October through December period, monthly mean flows under the Flexible Purchase Alternative below Crocker-Huffman Dam would be essentially equivalent to or greater than those under the Baseline Condition. (Refer to Appendix H pgs. 964-966.)

Increases in flows and presumed increases in spawning habitat would occur under the Flexible Purchase Alternative during October and November, relative to the Baseline Condition. Under the Baseline Condition, long-term average flows would increase from November to December, whereas under the Flexible Purchase Alternative, long-term average flows would decrease from November to December, as shown in Tables 9-48 and 9-49.

Flow-related Impacts on Juvenile Fall-run Chinook Salmon Rearing and Emigration (January through June)

Under the Flexible Purchase Alternative, long-term average flows below Crocker-Huffman Dam would not change, relative to the Baseline Condition, during the January through June period, as shown in Table 9-49. Monthly mean flows at this location under the Flexible Purchase Alternative would be essentially equivalent to those under the Baseline Condition in all of the 432 months simulated for the January through June period. (Refer to Appendix H pgs. 967-972.) At the mouth of the Merced River, long-term average flows under the Flexible Purchase Alternative would not differ from flows under the Baseline Condition during the January through June period. (Refer to Table 9-48.) In all of the 432 months simulated, monthly mean flows under the Flexible Purchase Alternative would be essentially equivalent to those under the Baseline Condition. (Refer to Appendix H pgs. 979-984.)

Summary of Impacts on Fall-run Chinook Salmon in the Merced River

The increases in flows simulated under the Flexible Purchase Alternative during the fall-run Chinook salmon immigration period of October through December would generally be considered beneficial, yet with increases of such magnitude (73.3 percent and 90.0 percent), additional discussion is warranted. Increases in flows at the mouth of the Merced River and below Crocker-Huffman Dam would occur only during October and November. Under the Baseline Condition, monthly mean flows below Crocker Huffman Dam would be reduced by about 72 percent from October to November, when adults would have been attracted to the spawning grounds, and spawning would have generally already commenced. (Refer to Table 9-49.) The significant increases in flows with implementation of the Flexible Purchase Alternative would provide greater balance during the fall spawning period, providing higher, more stable flows. Therefore, relative to the Baseline Condition, the Flexible Purchase Alternative would be expected to result in a more beneficial flow regime for adult fall-run Chinook salmon immigration by decreasing the extent of the average monthly flow reduction that occurs between October and November. Moreover, higher flows in the fall stimulate upstream migration of fall-run Chinook salmon and conversely, low flows may inhibit or delay migration to spawning areas (USBR 2000). Additionally, fall flows provide access to the spawning gravels and may be important in attracting returning spawners to the San Joaquin River system. Causes of decline for Chinook salmon have been attributed to isolation from historical spawning areas, loss of habitat, and impaired conditions for smolt emigration, including decreasing flows and increasing water temperatures (Reclamation and SJRGA 1999). Higher flows during the fall would potentially alleviate some of these concerns. It has been stated that increases of flows greater than 10 percent would be considered beneficial (Reclamation and SJRGA 1999). Although increased flows and increased spawning habitat would be available during November under the Flexible Purchase Alternative, relative to the Baseline Condition, it should be pointed out that flows increase from November to December under the Baseline Condition and decrease from November to December under the Flexible Purchase Alternative. This change in flow pattern may raise the potential for redd dewatering. However, the more beneficial flow regime resulting in higher and more stable flows, increased spawning habitat, facilitation of upstream migration, and other beneficial effects associated with higher overall flows under the Flexible Purchase Alternative, would make the potential for redd dewatering comparatively minor. Therefore, potential flow-related impacts on adult fall-run Chinook salmon immigration with implementation of the Flexible Purchase Alternative are considered potentially beneficial.

The decrease in flows from November to December during the fall-run Chinook salmon spawning and egg incubation period under the Flexible Purchase Alternative could result in an increased likelihood of potential redd dewatering events. However, implementation of the Flexible Purchase Alternative would result in a more beneficial flow regime, relative to the Baseline Condition, including higher, more stable flows, increased availability of spawning habitat, the potential facilitation of upstream migration, and other potential beneficial effects associated with higher overall flows. Thus, flow changes that would occur with implementation of the Flexible Purchase Alternative may affect, but are unlikely to adversely affect, adult fall-run Chinook salmon spawning, egg incubation, and initial rearing.

Flows during the rearing and emigration period of January through June are not expected to change, and thus, would not be of sufficient frequency or magnitude to beneficially or adversely affect juvenile Chinook salmon.

Overall, the changes in flows in the Merced River under the Flexible Purchase Alternative, relative to the Baseline Condition, may be of sufficient frequency and magnitude to beneficially impact fall-run Chinook salmon. However, the overall beneficial impact cannot be quantified at this time. Impacts on Merced River fall-run

Chinook salmon with implementation of the Flexible Purchase Alternative, relative to the Baseline Condition, are anticipated to be less than significant.

<u>Impacts on Striped Bass in the Merced River</u>

Under the Flexible Purchase Alternative, long-term average flows below Crocker-Huffman Dam during the May through June striped bass spawning and initial rearing period would not change, relative to the Baseline Condition, as shown in Table 9-49. In all of the 144 months simulated for this period, monthly mean flows under the Flexible Purchase Alternative would be essentially equivalent to those under the Baseline Condition. (See Appendix H pgs. 971-972.) At the mouth of the Merced River, long-term average flows under the Flexible Purchase Alternative during the May through June spawning and initial rearing period would not differ, relative to flows under the Baseline Condition, as shown in Table 9-48. In all of the 144 months included in the analysis, monthly mean flows under the Flexible Purchase Alternative would be essentially equivalent to flows under the Baseline Condition. (See Appendix H pgs. 983-984.) Overall, changes in flows Merced River would not be of sufficient frequency or magnitude to beneficially or adversely impact striped bass spawning and initial rearing. Therefore, impacts on striped bass in the Merced River with implementation of the Flexible Purchase Alternative would be less than significant, relative to the Baseline Condition.

The San Joaquin River

EWA acquisition of MID water via groundwater substitution would alter San Joaquin River flows.

Potential impacts on the fisheries resources in the San Joaquin River were analyzed by evaluating instream flow conditions at Vernalis and at the confluence with the Merced River. Flow-related impacts are discussed separately by species and lifestage. Organizationally, potential flow-related impacts for most life stages of fall-run Chinook salmon and steelhead are discussed together. When combined, the time periods specified take into account the entire life stage of both fall-run Chinook salmon and steelhead. Therefore, some periods may be extended over those detailed in the methodology section. Potential flow related impacts are discussed individually for splittail, delta smelt, American shad, and striped bass.

<u>Impacts on Fall-run Chinook Salmon and Steelhead in the San Joaquin River</u>

Flow-related Impacts on Fall-run Chinook Salmon and Steelhead Adult Immigration (October through January)

The methodology states that adult fall-run Chinook salmon immigration occurs during October through December and adult steelhead immigration occurs from December through February. However, the analysis below considers the entire immigration period for both species. Long-term average flows in the San Joaquin

River below the confluence of the Merced River under the Flexible Purchase Alternative would increase by 14.6 percent and 28.8 percent in October and November, respectively, and would not change from December through January, as shown in Table 9-50. Throughout the October through January period, monthly mean flows under the Flexible Purchase Alternative in the San Joaquin River below the confluence of the Merced River would be essentially equivalent to those under the Baseline Condition in all of the 288 months included in the analysis, monthly mean flows at this location would be essentially equivalent to those under the Baseline Condition. (See Appendix H pgs. 988-991.)

Table 9-50
Long-term Average Flow in the San Joaquin River Below the Merced River Confluence Under Baseline and Flexible Purchase Alternative Conditions

	Monthly Mean Flow[1] (cfs)		Difference	
Month	**Baseline**	**Flexible Purchase Alternative**	**(cfs)**	**(%)[2]**
Oct	1391	1594	203	14.6
Nov	729	939	210	28.8
Dec	1138	1138	0	0.0
Jan	1648	1648	0	0.0
Feb	2381	2381	0	0.0
Mar	2066	2066	0	0.0
Apr	1739	1739	0	0.0
May	2236	2236	0	0.0
Jun	1997	1997	0	0.0
Jul	830	830	0	0.0
Aug	575	575	0	0.0
Sep	774	774	0	0.0

[1] Based on 72 years modeled.
Relative difference of the monthly long-term average.

Table 9-51 shows that long-term average flows under the Flexible Purchase Alternative in the San Joaquin River at Vernalis would increase by 6.7 percent and 10.6 percent in October and November, respectively, and would not change from December through January, relative to the Baseline Condition. Further, in all of the 288 months simulated for the October through January period, monthly mean flows at his location under the Flexible Purchase Alternative would be essentially equivalent to those under the Baseline Condition. (See Appendix H pgs. 73-76.)

Table 9-51
Long-term Average Delta Inflow from the San Joaquin River at Vernalis Under Baseline and Flexible Purchase Alternative Conditions

	Monthly Mean Flow[1] (cfs)		Difference	
Month	**Baseline**	**Flexible Purchase Alternative**	**(cfs)**	**(%)[2]**
Oct	3,016	3,219	203	6.7
Nov	1,980	2,190	210	10.6
Dec	3,038	3,038	0	0.0
Jan	4,505	4,505	0	0.0
Feb	6,392	6,392	0	0.0
Mar	6,361	6,361	0	0.0
Apr	6,127	6,127	0	0.0
May	5,482	5,482	0	0.0
Jun	4,219	4,219	0	0.0

Table 9-51
Long-term Average Delta Inflow from the San Joaquin River at Vernalis Under Baseline and Flexible Purchase Alternative Conditions

	Monthly Mean Flow[1] (cfs)		Difference	
Month	Baseline	Flexible Purchase Alternative	(cfs)	(%)[2]
Jul	2,314	2,314	0	0.0
Aug	1,696	1,696	0	0.0
Sep	1,909	1,909	0	0.0

[1] Based on 72 years modeled.
[2] Relative difference of the monthly long-term average.

Flow-related Impacts on Adult Fall-run Chinook Salmon and Steelhead Spawning and Egg Incubation (October through January)

As described in the above discussion of adult fall-run Chinook salmon and steelhead immigration, flows under the Flexible Purchase Alternative in the San Joaquin River below the confluence of the Merced River and at Vernalis would increase during October and November, and would not change from December through January, relative to the Baseline Condition.

Flow-related Impacts on Juvenile Fall-run Chinook Salmon Rearing and Emigration (January through June)

Under the Flexible Purchase Alternative, long-term average flows in the San Joaquin River below the confluence of the Merced River would not differ from those under the Baseline Condition during the January through June period. (See Table 9-50.) In all of the 432 months simulated for the January through June period, monthly mean flows under the Flexible Purchase Alternative would be essentially equivalent to those under the Baseline Condition. (Refer to Appendix H pgs. 991-996.) Flow exceedance curves for the January through June period are shown in Figures 9-54 through 9-56. The basis for development of these exceedance curves was the 1922-1993 period of record. The figures demonstrate that flows under the Flexible Purchase Alternative would be identical to those under the Baseline Condition in each month of the January through June period.

Long-term average flows in the San Joaquin River at Vernalis under the Flexible Purchase Alternative would be identical to those under the Baseline Condition for each month of the January through June period, as shown in Table 9-51. Monthly mean flows at Vernalis under the Flexible Purchase Alternative would be essentially equivalent to those under the Baseline Condition for all of the 432 months included in the analysis. (Refer to Appendix H pgs. 76-81.) Thus, implementation of the Flexible Purchase Alternative would not be expected to change flows, relative to the Baseline Condition, during any month of the January through June period.

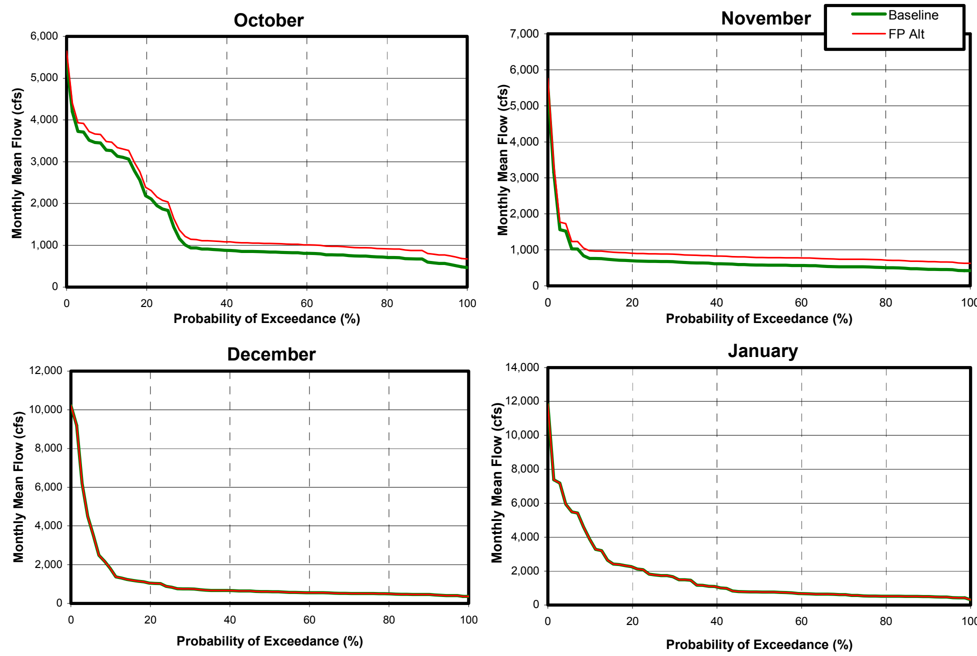

Figure 9-54
San Joaquin Flow Below Merced River
Under Baseline and Flexible Purchase Alternative Conditions

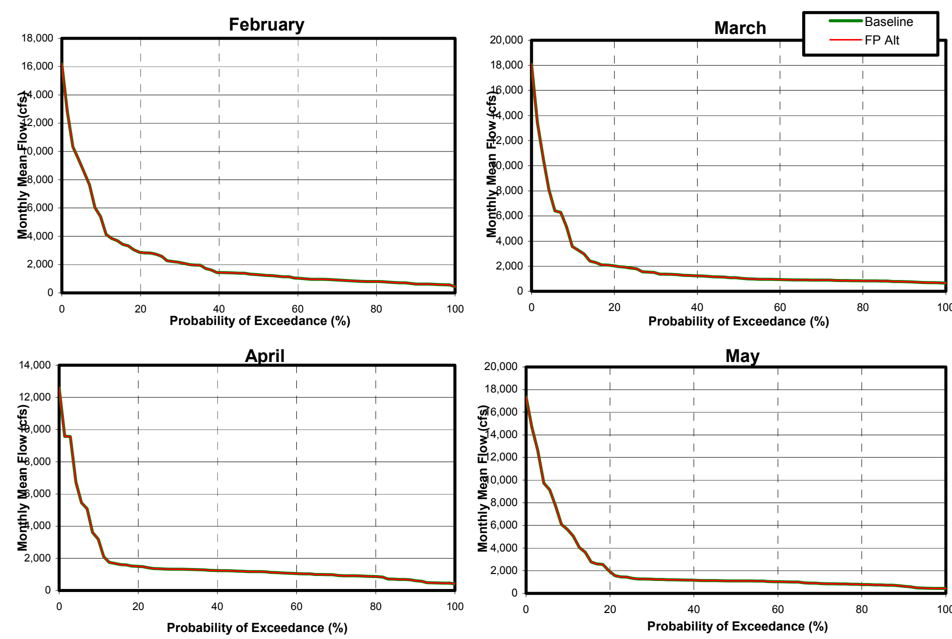

Figure 9-55
San Joaquin Flow Below Merced River
Under Baseline and Flexible Purchase Alternative Conditions

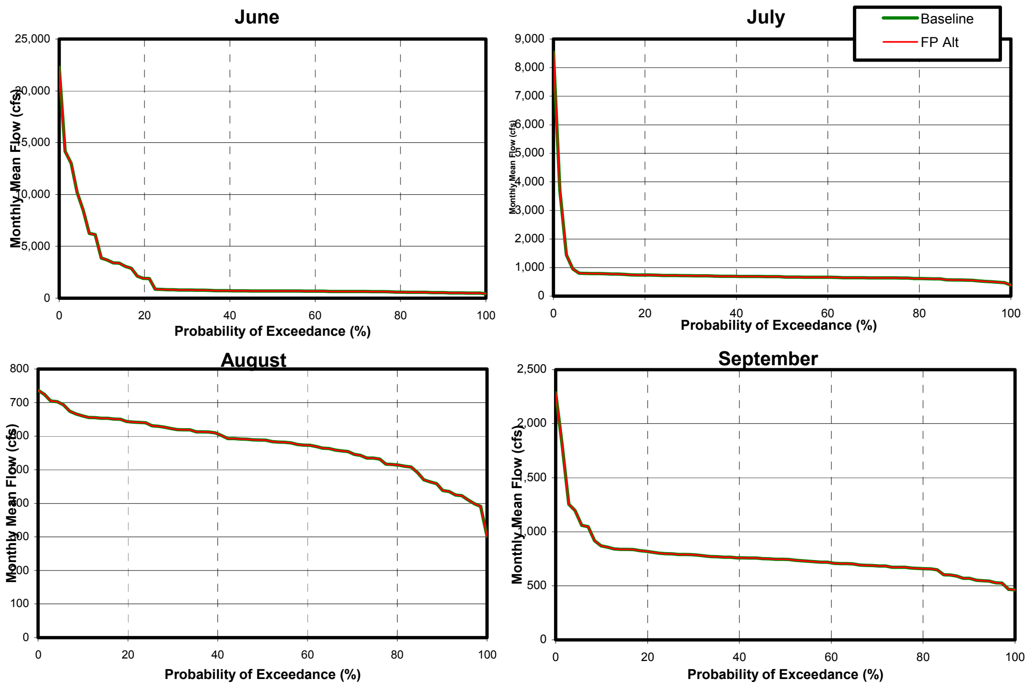

Figure 9-56
San Joaquin Flow Below Merced River
Under Baseline and Flexible Purchase Alternative Conditions

Flow-Related Impacts on Over-summer Juvenile Steelhead Rearing (July through September)

Under the Flexible Purchase Alternative, long-term average flows in the San Joaquin River below the confluence of the Merced River and at Vernalis would not decrease for a given month of the July through September period, relative to the Baseline Condition. (Refer to Table 9-50 and Table 9-51.) Further, in all of the 216 months simulated for the juvenile steelhead over-summer rearing period, monthly mean flows under the Flexible Purchase Alternative at both locations would be essentially equivalent to flows under the Baseline Condition. (Refer to Appendix H pgs. 997-999 and 82-84.) Overall, flows under the Flexible Purchase Alternative during the July through September period would not be expected to change, relative to the Baseline Condition.

Flow-related Impacts on Juvenile Steelhead Rearing (October Through December)

Under the Flexible Purchase Alternative, long-term average flows in the San Joaquin River below the confluence of the Merced River would increase by 14.6 percent in October, 28.8 percent in November, and not change in December, relative to the Baseline Condition. (Refer to Table 9-50.) Under the Flexible Purchase Alternative, long-term average flows in the San Joaquin River at Vernalis would increase 6.7 percent in October, 10.6 percent in November, and not change in December, relative to the Baseline Condition. (Refer to Table 9-51.) Further, in all of the 216 months simulated for the October through December juvenile steelhead rearing period, monthly mean flows under the Flexible Purchase Alternative at both locations would be essentially equivalent to or greater than flows under the Baseline Condition. (Refer to Appendix H pgs. 988-990 and 73-75.)

Flow-related Impacts on Juvenile Steelhead Emigration (November through May)

Juvenile steelhead emigration occurs from November through May (SJRGA 1999). As can be concluded from the discussion of potential flow-related impacts on adult fall-run Chinook salmon and steelhead immigration and juvenile fall-run Chinook salmon rearing and emigration, potential changes in flows at the confluence of the Merced River and at Vernalis under the Flexible Purchase Alternative during November through June would not be expected to adversely affect adult immigration or juvenile fall-run Chinook salmon rearing. As shown in Tables 9-50 and 9-51, there would be a 28.8 percent increase in flows in the San Joaquin River below the Merced River confluence, and a 10.6 percent increase of flows at Vernalis during November. Flows would not change at either location from December through May.

Summary of Impacts on Fall-run Chinook Salmon and Steelhead in the San Joaquin River

Under the Baseline Condition, mean monthly flows at the confluence of the Merced River would decrease by about 48 percent from October to November, when adult Chinook salmon would have been attracted to spawning grounds, and spawning would have generally already commenced. (Refer to Table 9-50.) The significant increases in flows under the Flexible Purchase Alternative would provide greater balance during the fall spawning period, providing higher, more stable flows. Therefore, relative to the Baseline Condition, the Flexible Purchase Alternative would be expected to result in a more beneficial flow regime for adult fall-run Chinook salmon immigration by decreasing the extent of the average monthly flow reduction between October and November. Moreover, higher flows in the fall stimulate upstream migration of fall-run Chinook salmon and conversely, low flows may inhibit or delay migration to spawning areas (USBR 2000). Additionally, fall flows provide access to the spawning gravels and may be important in attracting returning spawners to the San Joaquin River system. Causes of decline for Chinook salmon have been attributed to isolation from historical spawning areas, loss of habitat, and impaired conditions for smolt emigration, including decreasing flows and increasing water temperatures (Reclamation and SJRGA 1999). Higher flows during the fall would potentially alleviate some of these concerns and flow increases greater than 10 percent are considered beneficial (Reclamation and SJRGA 1999). Therefore, potential flow-related impacts on adult fall-run Chinook salmon immigration in the San Joaquin River under the Flexible Purchase Alternative are considered potentially beneficial.

As described above in the analysis of potential flow-related impacts on adult fall-run Chinook salmon and steelhead immigration, increases in flows and presumed increases in spawning habitat would occur under the Flexible Purchase Alternative during October and November, although the decrease in flows from November to December could result in an increased likelihood of potential redd dewatering events, because potentially more fish would have spawned. However, implementation of the

Flexible Purchase Alternative would result in a more beneficial flow regime, relative to the Baseline Condition, providing higher, more stable flows, increased availability of spawning habitat, the potential facilitation of upstream migration, and other potential beneficial effects associated with higher overall flows. Thus, flow changes that would occur under the Flexible Purchase Alternative may affect, but are unlikely to adversely affect, adult fall-run Chinook salmon and steelhead spawning and egg incubation.

Flows during the rearing and emigration period of January through June are not expected to change, and thus, would not be of sufficient frequency or magnitude to beneficially or adversely affect juvenile Chinook salmon or steelhead.

Flows are not expected to change during the juvenile steelhead over-summer-rearing period of July through September or during the juvenile steelhead emigration period of November through May, and thus, would not beneficially or adversely impact juvenile steelhead over-summer rearing or emigration.

The substantial increase in flow under the Flexible Purchase Alternative during the October through December juvenile steelhead rearing period could potentially benefit juvenile steelhead by increasing the amount of rearing habitat. An increase in flow would likely be beneficial only if rearing habitat during this time period were limiting in some manner. However, since data is not available supporting this clause, it is concluded that the increase in flows during the October through December juvenile steelhead rearing period would not beneficially or adversely affect juvenile rearing.

Overall, the changes in flows in the San Joaquin River under the Flexible Purchase Alternative, relative to the baseline, may be of sufficient frequency and magnitude to beneficially impact fall-run Chinook salmon and steelhead. However, the overall beneficial impact cannot be quantified at this time. Thus, impacts on San Joaquin River fall-run Chinook salmon and steelhead with implementation of the Flexible Purchase Alternative, relative to the Baseline Condition, would be less than significant.

<u>Impacts on Splittail in the San Joaquin River</u>

Under the Flexible Purchase Alternative, long-term average flows in the San Joaquin River below the confluence of the Merced River during the February through May spawning period would not differ from flows under the Baseline Condition, as shown in Table 9-50. In all of the 360 months simulated for this period, monthly mean flows under the Flexible Purchase Alternative would be essentially equivalent to flows under the Baseline Condition. (See Appendix H pgs. 992-995.) Similarly, at Vernalis, long-term average flows under the Flexible Purchase Alternative during the February through May spawning period would be identical to flows under the Baseline Condition, as shown in Table 9-58. Monthly mean flows under the Flexible Purchase Alternative at Vernalis would be essentially equivalent to those under the Baseline

Condition in all of the 360 months simulated for the February through May period. (See Appendix H pgs. 77-80.)

Overall, changes in flows in the San Joaquin River are not expected during the February through May spawning period, and thus, would not be of sufficient frequency or magnitude to beneficially or adversely impact splittail spawning. Therefore, impacts on splittail in the San Joaquin River with implementation of the Flexible Purchase Alternative would be less than significant, relative to the Baseline Condition.

Impacts on American Shad in the San Joaquin River

Under the Flexible Purchase Alternative, long-term average flows in the San Joaquin River below the confluence of the Merced River during the May through June spawning period would be identical to flows under the Baseline Condition. (Refer to Table 9-50.) In fact, in all of the 144 months included in the analysis, monthly mean flows would be essentially equivalent to those under the Baseline Condition. (Refer to Appendix H pgs. 995-996.) Under the Flexible Purchase Alternative, the long-term average flow at Vernalis during the May through June spawning period would not differ compared to flows under the Baseline Condition, as shown in Table 9-51. In all 144 months simulated for this period, flows would be essentially equivalent to flows under the Baseline Condition. (Refer to Appendix H pgs. 80-81.)

Overall, changes in flows in the San Joaquin River are not expected during the May and June spawning period, and thus, would not be of sufficient frequency or magnitude to beneficially or adversely impact American shad spawning. Therefore, impacts on American shad in the San Joaquin River with implementation of the Flexible Purchase Alternative would be less than significant, relative to the Baseline Condition.

Impacts on Striped Bass in the San Joaquin River

Under the Flexible Purchase Alternative, the long-term average flow at the confluence of the Merced River during the May through June rearing period would not differ compared to flows under the Baseline Condition, as shown in Table 9-50. In all 144 months simulated for this two-month period, flows would be essentially equivalent to flows under the Baseline Condition. (Refer to Appendix H pgs. 995-996.) Under the Flexible Purchase Alternative, the long-term average flow at Vernalis during the May through June period would not differ compared to flows under the Baseline Condition, as shown in Table 9-51. In all 144 months simulated for this period, flows would be essentially equivalent to flows under the Baseline Condition. (Refer to Appendix H pgs. 80-81.)

Overall, changes in flows in the San Joaquin River are not expected during the May and June spawning and initial rearing period, and thus, would not be of sufficient frequency or magnitude to beneficially or adversely impact striped bass spawning and initial rearing. Therefore, impacts on striped bass in the San Joaquin River with implementation of the Flexible Purchase Alternative would be less than significant, relative to the Baseline Condition.

Impacts on Delta Smelt in the San Joaquin River

Delta smelt are found in the San Joaquin River downstream of Vernalis. Long-term average flows at Vernalis would not differ during the January through June spawning period under the Flexible Purchase Alternative compared to the Baseline Condition, as shown in Table 9-50. Monthly mean flows at Vernalis during January through June under the Flexible Purchase Alternative would be essentially equivalent to the Baseline Condition for all 432 months included in the analysis. (Refer to Appendix H pgs. 76-81.)

Overall, changes in flows in the San Joaquin River are not expected during the January through June spawning period, and thus, would not be of sufficient frequency or magnitude to beneficially or adversely impact delta smelt spawning and initial rearing. Therefore, impacts on delta smelt in the San Joaquin River with implementation of the Flexible Purchase Alternative would be less than significant, relative to the Baseline Condition.

9.2.5.2 Sacramento-San Joaquin Delta Region

Delta outflow, X_2 location, E/I ratio, and frequency and magnitude of reverse flows (QWEST) have been identified as indicators of fishery habitat quality and availability within the Delta. Results of hydrologic modeling over a 15-year period of record were used to assess the potential effects of EWA operations on habitat conditions within the Delta supporting fish and macroinvertebrates. Comparative analyses of monthly hydrologic modeling results between the Baseline Condition and EWA operations were used to assess changes in potential habitat conditions based on: 1) Delta outflow; 2) X_2 location; 3) E/I ratio; and 4) the frequency and magnitude of reverse flow (QWEST).

Although habitat conditions within the Delta are important to fish and macroinvertebrates year-round, many of the species spawn and utilize the estuary as larval and juvenile rearing habitat and/or as a migratory corridor during the late winter and early spring. As a result, analysis of hydrologic modeling results as indicators of habitat conditions focused primarily on the seasonal period from February through June based on the life-cycle of many of the species inhabiting the system. Analyses also were conducted to identify and evaluate potential impacts on habitat conditions during all months.

In addition to the analysis of habitat conditions, results of hydrologic modeling were used to compare salvage at the SWP and CVP facilities for Chinook salmon, steelhead, striped bass, splittail, and delta smelt under the Baseline Condition and with EWA operation. Salvage estimates for delta smelt, Chinook salmon, steelhead, splittail, and striped bass were developed based upon historical salvage records, which exhibit variation due to interannual variability in the abundance and distribution of each species. Salvage modeling, described in Section 9.2.1.3, Estuarine Fish Species in the Delta, provides an indication of the relative effect of CVP and SWP pumping operations under the Flexible Purchase Alternative and Baseline Condition.

As part of the EWA Program described in Chapter 2, export pumping would be curtailed in July if the density data shows that fish species of concern are present at the SWP and CVP pumping facilities. The occurrence and density of fish species of concern would be determined from routine salvage monitoring. This practice would be effective in preventing potential salvage-related adverse effects at the CVP and SWP pumping facilities resulting from implementation of the Flexible Purchase Alternative. (Refer to Attachment 1, Modeling Description for additional discussion.)

An analysis of potential impacts related to implementation of the Flexible Purchase Alternative under the Maximum Water Purchase Scenario is presented first (Section 9.2.5.2.1), followed by an analysis of potential impacts related to implementation of the Flexible Purchase Alternative under the Typical Water Purchase Scenario (Section 9.2.5.2.2).

9.2.5.2.1. Maximum Water Purchase Scenario

Delta Outflow

Delta outflow provides an indicator of freshwater flow passing through the Delta and habitat conditions further downstream within San Pablo Bay and Central San Francisco Bay. Delta outflow affects salinity gradients within these downstream bays and the geographic distribution and abundance of various fish and macroinvertebrates (Baxter et al. 1999).

Reductions in long-term average Delta outflow under the Maximum Water Purchase Scenario would not occur with implementation of the Flexible Purchase Alternative, relative to the Baseline Condition, as shown in Table 9-52. Delta outflow during the period of February through June is believed to be of greatest concern for potential effects on spawning and rearing habitat and downstream transport flows for delta smelt, splittail, salmonids, striped bass, and other aquatic species in the Delta. Long-term average Delta outflow would increase by approximately 1.6 to 7.7 percent (ranging from 53.5 to 97.3 TAF per month) during the February through June period. Monthly mean flows under the Flexible Purchase Alternative would be essentially equivalent to or greater than flows under the Baseline Condition in all months included in the simulation. (Refer to Appendix H pgs. A1-A12.) Detectable decreases in Delta outflow would not occur with implementation of the Flexible Purchase Alternative under the Maximum Water Purchase Scenario, relative to the Baseline Condition, in any of the 75 months simulated for the February through June period. Therefore, the changes in Delta outflow resulting from implementation of the Flexible Purchase Alternative under the Maximum Water Purchase Scenario would result in beneficial impacts on fisheries resources in the Delta.

Table 9-52 Long-term Average Delta Outflow Under Baseline Condition and Flexible Purchase Alternative (Maximum Water Purchase Scenario) Conditions					
Month	Monthly Mean Flow[1] (cfs)		Difference		
	Baseline	Flexible Purchase Alternative	(cfs)	(%)[2]	TAF[2]
Oct	7,494	7,494	0	0	0
Nov	14,729	14,729	0	0	0
Dec	29,135	29,762	627	2.2	37.3
Jan	35,403	36,000	597	1.7	35.5
Feb	57,924	58,824	900	1.6	53.5
Mar	53,136	54,665	1,529	2.9	90.9
Apr	29,039	30,674	1,635	5.6	97.3
May	17,995	19,372	1,377	7.7	81.9
Jun	13,767	14,792	1,025	7.4	60.9
Jul	7,915	8,354	439	5.6	26.1
Aug	4,192	4,492	300	7.2	17.9
Sep	5,574	5,884	310	5.6	18.5

[1] Based on 1979-1993 period of record.
[2] Relative difference of the monthly long-term average.

X_2 Location

The location of the 2 ppt salinity near-bottom isohaline (X_2 location) has been identified as an indicator of estuarine habitat conditions within the Bay-Delta system. The location of X_2 within Suisun Bay during the February through June period is thought to be directly and/or indirectly related to the reproductive success and survival of the early lifestages for a number of estuarine species. Results of statistical regression analyses suggest that abundance of several estuarine species is greater during the spring when the X_2 location is within the western portion of Suisun Bay, with lower abundance correlated with those years when the X_2 location is farther to the east near the confluence between the Sacramento and San Joaquin rivers.

Under implementation of the Flexible Purchase Alternative under the Maximum Water Purchase Scenario, the long-term average position of X_2 would not shift upstream during any month, as shown in Table 9-53. In addition, the monthly mean position of X_2 would move downstream or would not shift, relative to the Baseline Condition, in all of the 75 months simulated with implementation of the Flexible Purchase Alternative under the Maximum Water Purchase Scenario for this period. (Refer to Appendix H pgs. A13-A24.) Therefore, changes in the location of X_2 resulting from implementation of the Flexible Purchase Alternative under the Maximum Water Purchase Scenario would result in beneficial impacts on fisheries resources in the Delta.

Table 9-53 Long-term Average Delta X_2 Position Under Baseline and Flexible Purchase Alternative (Maximum Water Purchase Scenario) Conditions			
Month	Monthly Mean Position[1] (km)		
	Baseline	Flexible Purchase Alternative	Difference
Oct	85.3	84.5	-0.8
Nov	83.6	83.4	-0.2
Dec	80.3	80.2	-0.1
Jan	76.9	76.6	-0.3

Table 9-53
Long-term Average Delta X_2 Position Under Baseline and Flexible Purchase Alternative (Maximum Water Purchase Scenario) Conditions

Month	Monthly Mean Position[1] (km)		
	Baseline	Flexible Purchase Alternative	Difference
Feb	71.7	71.3	-0.4
Mar	66.4	66.0	-0.4
Apr	64.5	63.8	-0.7
May	67.8	67.0	-0.8
Jun	72.0	70.9	-1.1
Jul	75.9	74.7	-1.2
Aug	79.5	78.6	-0.9
Sep	84.5	83.6	-0.9

[1] Kilometers from the Golden Gate Bridge.

Export/Inflow Ratio

Exports from the SWP and CVP result in direct effects, including salvage and entrainment losses, for many fish and macroinvertebrates. Export operations also are thought to indirectly affect survival; however, indirect effects have been difficult to quantify. The ratio between exports and Delta inflow (E/I ratio) has been identified as an indicator of the vulnerability of fish and macroinvertebrates to direct and indirect effects resulting from SWP and CVP operations. The E/I ratio limits are identified in the 1995 Water Quality Control Plan, with the greatest reductions in exports relative to inflows occurring during the biologically sensitive February through June period.

The long-term average E/I ratio with implementation of the Flexible Purchase Alternative under the Maximum Water Purchase Scenario would decrease during all months of the February through June period, relative to the Baseline Condition, as shown in Table 9-54. The long-term average E/I ratio would increase during July, August, and September with implementation of the Flexible Purchase Alternative under the Maximum Water Purchase Scenario. This increase would occur outside of the biologically sensitive February through June period. The monthly mean E/I ratio with implementation of the Flexible Purchase Alternative under the Maximum Water Purchase Scenario would be identical to or less than (a reduced proportion of exports, relative to inflow) the E/I ratio under the Baseline Condition in all of the 75 months simulated for the February through June period. (Refer to Appendix H pgs. A49-A60.) Such changes are not likely to adversely affect covered Delta fish species.

The model simulations conducted for the Flexible Purchase Alternative included conformance with export requirements set forth in the SWRCB Interim Water Quality Control Plan. Thus, the Delta E/I ratios under the Flexible Purchase Alternative and Baseline Condition would not exceed the maximum export ratio as set by the SWRCB Interim Water Quality Control Plan. (Refer to Appendix H pgs. A49-A60.) However, relaxation of the E/I ratio is considered an EWA asset. If the Management Agencies determine that the risk to fish is relatively low, then pumping above the applicable limit may be undertaken, with the additional water credited to the EWA. Such actions will not be taken if there is the potential to affect State or Federally protected species, and will only be taken under the unanimous direction of the Management Agencies. Therefore, the E/I ratios resulting from implementation of the Flexible Purchase

Alternative under the Maximum Water Purchase Scenario are not likely to adversely affect delta smelt, splittail, steelhead, fall-, late-fall-, winter-, or spring-run Chinook salmon in the Delta.

Table 9-54
Long-term Average Delta E/I Ratio Under Baseline and Flexible Purchase Alternative (Maximum Water Purchase Scenario) Conditions

Month	Monthly Mean Ratio[1] (%)		Difference	
	Baseline	Flexible Purchase Alternative	(%)	(%)[2]
Oct	49	49	0	0
Nov	39	39	0	0
Dec	37	34	-3	-8.1
Jan	36	34	-2	-5.6
Feb	23	20	-3	-13.0
Mar	21	17	-4	-19.0
Apr	18	12	-6	-33.3
May	20	13	-7	-35.0
Jun	27	22	-5	-18.5
Jul	32	36	+4	+12.5
Aug	51	55	+4	+7.8
Sep	57	60	+3	+5.3

[1] Based on 1979-1993 period of record.
[2] Relative difference of the monthly long-term average.

Reverse Flows (QWEST)

Reverse flows (also referred to as QWEST) have been identified as an indicator of the potential risk of adverse effects on planktonic fish eggs and larvae and the survival of downstream migrating juvenile Chinook salmon smolts. The potential for adverse effects associated with reverse flow is greatest during the late winter-spring period (February through June). Reverse flows occur primarily when freshwater inflow is low and export pumping is high, causing the lower San Joaquin River to change direction and flow upstream. Reversed flows are evaluated based on model simulations of the direction and magnitude of flows in the lower San Joaquin River in the vicinity of Jersey Point.

Under the Baseline Condition, reverse flows would occur in 25 months out of the 75 months simulated for the February through June period (33.3 percent of the time). Reverse flows would occur less frequently with implementation of the Flexible Purchase Alternative under the Maximum Water Purchase Scenario, in 13 of the 75 months simulated, or 17.3 percent of the time. (Refer to Appendix H pgs. A41-A45.) Table 9-55 illustrates that the frequency of reverse flows under the Flexible Purchase Alternative would be substantially reduced across all flow ranges during February through June, relative to the Baseline Condition. In most months in which reverse flows would occur under the Baseline Condition, flows would be positive or the magnitude of reverse flow substantially reduced under the Maximum Water Purchase Scenario. (Refer to Appendix H pgs. A41-A45.)

Table 9-55
Frequency[1] of Reverse Flows (QWEST) Over Varying Flow Ranges

Reverse Flow Range (cfs)	Baseline Condition	Flexible Purchase Alternative (Maximum Water Purchase Scenario)
February		
<0	6	5
<-100	4	3
<-250	0	0
<-500	0	0
<-1000	0	0
<-2000	0	0
March		
<0	6	1
<-100	3	0
<-250	0	0
<-500	0	0
<-1000	0	0
<-2000	0	0
April		
<0	2	1
<-100	0	0
<-250	0	0
<-500	0	0
<-1000	0	0
<-2000	0	0
May		
<0	5	2
<-100	0	0
<-250	0	0
<-500	0	0
<-1000	0	0
<-2000	0	0
June		
<0	6	4
<-100	3	1
<-250	1	1
<-500	0	0
<-1000	0	0
<-2000	0	0

[1] Based on the 1979-1993 period of record for each month.

Overall, implementation of the Flexible Purchase Alternative under the Maximum Water Purchase Scenario would provide a benefit to reverse flows, relative to the Baseline Condition, by decreasing the frequency of reverse flows and reducing the magnitude when reverse flows would still occur. Overall, such changes would be considered a benefit to juvenile salmonid emigration and the transport of planktonic eggs and larvae. Therefore, implementation of the Flexible Purchase Alternative may beneficially affect the survival of planktonic fish eggs and larvae and downstream migrating juvenile Chinook salmon smolts.

Salvage at the SWP and CVP Export Facilities

Salvage estimates for delta smelt, Chinook salmon, steelhead, and splittail, were developed based upon historical salvage records, which exhibit variation due to interannual variability in the abundance and distribution of each species. Salvage modeling, described in Section 9.2.1.3, Estuarine Fish Species in the Delta, provides an indication of the relative effect of CVP and SWP pumping operations with implementation of the Flexible Purchase Alternative and under the Baseline Condition. This section provides an analysis of potential salvage-related effects with implementation of the Flexible Purchase Alternative under the Maximum Water Purchase Scenario on delta smelt, Chinook salmon, steelhead, splittail, and striped bass.

Delta Smelt

Under the Flexible Purchase Alternative (Maximum Water Purchase Scenario), a net reduction in delta smelt salvage would occur over the 15-year period of record included in the analysis, relative to the Baseline Condition. Average annual salvage estimates with implementation of the Flexible Purchase Alternative under the Maximum Water Purchase Scenario decrease by 135,887 delta smelt relative to the Baseline Condition. (Refer to Table 9-56.)

Annual and monthly changes in delta smelt salvage estimates with implementation of the Flexible Purchase Alternative, relative to the Baseline Condition, over the 15-year period of record included in the analysis under the Maximum Water Purchase scenario are provided in Table 9-56. Annual salvage estimates decrease in every year by 293 to 66,002 delta smelt, relative to the Baseline Condition, except for one year (in 1991 there is an estimated increase of 398 delta smelt), as shown in Table 9-56. Monthly mean delta smelt salvage estimates under the Flexible Purchase Alternative would not change during October and November, relative to the Baseline Condition. From December through July, implementation of the Flexible Purchase Alternative under the Maximum Water Purchase Scenario would result in monthly mean reductions in salvage ranging from 2,358 to 61,929 delta smelt, relative to the Baseline Condition. During August and September, monthly mean salvage with implementation of the Flexible Purchase Alternative under the Maximum Water Purchase Scenario would increase by 4,763 and 1,117 delta smelt, respectively, relative to the Baseline Condition.

While annual salvage estimates exhibit a decrease in 14 of the 15 years simulated with implementation of the Flexible Purchase Alternative under the Maximum Water Purchase Scenario, there would be isolated occurrences of increases in delta smelt salvage in 34 of the 150 months simulated for the December through September period. However, such changes would not be of sufficient magnitude to result in increases in annual delta smelt salvage in 14 of the 15 years simulated.

As discussed in Chapter 2 and in Section 9.2.3, ASIP Conservation Measures, real-time operations would be implemented as needed to avoid pumping operations that would result in increased delta smelt salvage. Based on modeling output and the efficiency of real-time adjustment of operations (real-time implementation of the environmental measures outlined in Section 9.2.3, ASIP Conservation Measures) in response to abundance and distribution monitoring, implementation of the Flexible Purchase Alternative under the Maximum Water Purchase Scenario would result in overall beneficial impacts on delta smelt salvage, relative to the Baseline Condition.

Table 9-56
Change in Delta Smelt Salvage at the SWP and CVP Pumps Under the Maximum Water Purchase Scenario – Flexible Purchase Alternative vs. Baseline Condition

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1979				-125	-188	-337	-1,350	-3,121	-2,440	2,463	181	15	-4,902
1980	0	0	0	-188	-348	-408	-816	-238	-9,006	915	3,314	105	-6,668
1981	0	0	-416	0	-1,128	-6,552	-1,522	-37,501	-3,836	-15,305	235	24	-66,002
1982	0	0	-63	-781	-1,257	-634	-73	-218	-36	712	414	39	-1,897
1983	0	0	-161	-862	-254	-61	-10	-8	-2,932	852	0	245	-3,191
1984	0	0	0	0	-2	-186	-50	-5,046	-1,553	761	3	9	-6,065
1985	0	0	-340	0	-30	-57	-282	-456	-7,955	63	34	50	-8,973
1986	0	0	-20	-71	-356	-241	-128	-26	-39	112	166	0	-603
1987	0	0	-22	-5	-53	-357	-3,402	-3,886	-5,925	-892	75	150	-14,319
1988	0	0	-1,337	-862	-100	0	0	-4,816	0	418	0	0	-6,697
1989	0	0	0	-44	-6	-32	-40	-366	-581	-1,884	74	31	-2,848
1990	0	0	0	-27	-80	-56	0	0	-7,656	960	2	0	-6,857
1991	0	0	0	0	0	-213	-121	-857	0	880	261	448	398
1992	0	0	0	-10	-102	-164	-20	0	0	3	0	0	-293
1993	0	0	0	-89	-59	-49	0	-5,389	-1,681	293	5	0	-6,970
Total	0	0	-2,358	-3,063	-3,964	-9,347	-7,814	-61,929	-43,642	-9,651	4,763	1,117	-135,887

Chinook Salmon

With implementation of the Flexible Purchase Alternative under the Maximum Water Purchase Scenario, a net reduction in Chinook salmon salvage would occur over the 15-year period of record, relative to the Baseline Condition. Average annual salvage estimates under the Maximum Water Purchase Scenario would decrease by 1,123,826 Chinook salmon, relative to the Baseline Condition. (Refer to Table 9-57.)

Annual and monthly changes in Chinook salmon salvage estimates at the CVP and SWP pumps with implementation of the Flexible Purchase Alternative under the Maximum Water Purchase Scenario, relative to the Baseline Condition, are provided in Table 9-57. Annual salvage estimates decrease in every year by 2,529 to 320,526 Chinook salmon, relative to the Baseline Condition, as shown in Table 9-57. Monthly mean Chinook salmon salvage estimates under the Flexible Purchase Alternative would not change in October and November, relative to the Baseline Condition. From December through June, implementation of the Flexible Purchase Alternative would result in monthly mean decreases in salvage ranging from 7,383 to 444,219 Chinook salmon, relative to the Baseline Condition. During July, August, and September, monthly mean salvage estimates with implementation of the Flexible Purchase Alternative under the Maximum Water Purchase Scenario would increase by 2,742, 286, and 555 Chinook salmon, respectively, relative to the Baseline Condition.

Table 9-57
Change in Chinook Salmon Salvage at the SWP and CVP Pumps Under the Maximum Water Purchase Scenario – Flexible Purchase Alternative vs. Baseline Condition

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1979				-586	-197	-700	-55,499	-55,646	-1,570	1,450	75	28	-112,645
1980	0	0	-466	-238	-27	-20	-86,314	-54,922	-16,405	-567	10	519	-158,431
1981	0	0	-102	0	-156	-5,630	-24,295	-15,608	-64	0	14	0	-45,839
1982	0	0	-2,161	-1,300	-3,084	-3,354	-6,557	-71,783	-15,742	32	4	0	-103,945
1983	0	0	-15,916	-3,451	-3,350	-1,593	-6,707	-19,821	-37,634	284	0	0	-88,189
1984	0	0	0	0	-6	-1,290	-45,834	-46,789	-16,714	4	133	0	-110,496
1985	0	0	-1,625	0	-362	-829	-16,828	-48,989	-10,555	29	0	2	-79,156
1986	0	0	-399	-190	-93,319	-25,239	-57,136	-86,099	-59,386	1,244	0	0	-320,526
1987	0	0	-94	-27	-78	-4,394	-16,697	-11,139	-4,062	15	2	3	-36,471
1988	0	0	-4,804	-1,015	-913	0	-1,902	-14,700	0	248	21	2	-23,062
1989	0	0	0	-118	-9	-2,071	-770	-6,591	-148	0	6	0	-9,701
1990	0	0	-51	-298	-164	-744	0	0	-1,273	1	0	0	-2,529
1991	0	0	0	0	0	-1,355	-3,919	-7,895	0	0	0	0	-13,169
1992	0	0	0	-108	-1,814	-5,750	-2,877	0	0	0	0	0	-10,547
1993	0	0	0	-51	-67	-122	-4,429	-4,236	-238	2	21	0	-9,120
Total	0	0	-25,617	-7,383	-103,545	-53,091	-329,762	-444,219	-163,792	2,742	286	555	-1,123,826

While annual salvage estimates exhibit a decrease with implementation of the Flexible Purchase Alternative under the Maximum Water Purchase Scenario, there would be isolated occurrences of increases in SWP Chinook salmon salvage in 24 of the 150 months simulated for the December through September period. However, such changes would not be of sufficient magnitude to result in increases in annual salvage in any year simulated over the 15-year period of record included in the analysis. Thus, while there would be increases in Chinook salmon salvage with implementation of the Flexible Purchase Alternative under the Maximum Water Purchase Scenario in individual months of the simulation, annual salvage estimates for Chinook salmon would decrease, relative to the Baseline Condition. Therefore, implementation of the Flexible Purchase Alternative under the Maximum Water Purchase Scenario would result in overall beneficial impacts on Chinook salmon salvage, relative to the Baseline Condition.

Steelhead

A net reduction in steelhead salvage would occur with implementation of the Flexible Purchase Alternative under the Maximum Water Purchase Scenario, relative to the Baseline Condition, over the 15-year period of record included in the analysis. Average annual salvage estimates under the Maximum Water Purchase Scenario would be reduced by 28,928 steelhead, relative to the Baseline Condition. (Refer to Table 9-58.)

Annual and monthly changes in salvage estimates with implementation of the Flexible Purchase Alternative under the Maximum Water Purchase Scenario, relative to the Baseline Condition, are shown in Table 9-58. Annual salvage would decrease in every year by 293 to 4,085 steelhead, relative to the Baseline Condition, as shown in Table 9-58. Monthly mean steelhead salvage estimates with implementation of the Flexible Purchase Alternative under the Maximum Water Purchase Scenario would not change from August through November, relative to the Baseline Condition. From December through June, implementation of the Flexible Purchase Alternative would result in monthly mean reductions in salvage ranging from 428 to 12,182 steelhead, relative to the Baseline Condition. During July, monthly mean salvage estimates with implementation of the Flexible Purchase Alternative under the Maximum Water Purchase Scenario would increase by five steelhead, relative to the Baseline Condition. Therefore, implementation of the Flexible Purchase Alternative under the Maximum Water Purchase Scenario would result in overall beneficial impacts on steelhead salvage, relative to the Baseline Condition.

Table 9-58
Change in Steelhead Salvage at the SWP and CVP Pumps Under the Maximum Water Purchase Scenario – Flexible Purchase Alternative vs. Baseline Condition

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1979				-34	-93	-260	-1,425	-775	0	0	0	0	-2,588
1980	0	0	-2	-15	-48	-7	-738	-671	-55	0	0	0	-1,536
1981	0	0	-12	0	-132	-2,397	-1,452	-92	0	0	0	0	-4,085
1982	0	0	-32	-65	-130	-90	-1,790	-1,526	-373	0	0	0	-4,005
1983	0	0	-755	-40	-16	0	0	-75	0	0	0	0	-887
1984	0	0	0	0	0	-24	-261	-8	0	0	0	0	-293
1985	0	0	-2	0	-18	-145	-353	-163	0	0	0	0	-682
1986	0	0	0	-2	-144	-71	-423	-182	0	5	0	0	-815
1987	0	0	-138	-9	-12	-2,715	-546	-81	0	0	0	0	-3,500
1988	0	0	-83	-55	-189	0	-164	-170	0	0	0	0	-661
1989	0	0	0	-2	-42	-1,464	-34	-26	0	0	0	0	-1,568
1990	0	0	0	0	-383	-846	0	0	0	0	0	0	-1,230
1991	0	0	0	0	0	-1,988	-206	-31	0	0	0	0	-2,225
1992	0	0	0	-289	-1,016	-1,247	-39	0	0	0	0	0	-2,590
1993	0	0	0	-39	-588	-928	-395	-314	0	0	0	0	-2,264
Total	0	0	-1,024	-550	-2,810	-12,182	-7,826	-4,114	-428	5	0	0	-28,928

Splittail

With implementation of the Flexible Purchase Alternative under the Maximum Water Purchase Scenario, there would be a net reduction in splittail salvage, relative to the Baseline Condition, over the 15-year period of record included in the analysis. Average annual salvage estimates with implementation of the Flexible Purchase Alternative under the Maximum Water Purchase Scenario would decrease by 1,014,290 splittail, relative to the Baseline Condition. (Refer to Table 9-59.)

Annual and monthly change in splittail salvage estimates with implementation of the Flexible Purchase Alternative under the Maximum Water Purchase Scenario, relative to the Baseline Condition, over the 15-year period of record included in the analysis are provided in Table 9-59. Annual salvage estimates decrease in every year by 628 to 699,086 splittail, relative to the Baseline Condition, except for one year (in 1984 there is an estimated increase of 603 splittail), as shown in Table 9-59. Monthly mean splittail salvage estimates under the Flexible Purchase Alternative would not change in October and November, relative to the Baseline Condition. From December through June, implementation of the Flexible Purchase Alternative would result in monthly mean reductions in salvage ranging from 1,673 to 575,902 splittail, relative to the Baseline Condition. During July, August, and September, monthly mean salvage estimates with implementation of the Flexible Purchase Alternative under the Maximum Water Purchase Scenario would increase by 60,415, 34,596, and 2,996 splittail, respectively, relative to the Baseline Condition.

While annual salvage estimates exhibit a decrease in 14 of the 15 years simulated with implementation of the Flexible Purchase Alternative under the Maximum Water Purchase Scenario, there would be isolated occurrences of increases in splittail salvage in 35 of the 150 months simulated for the December through September period. However, such changes would not be of sufficient magnitude to result in increases in annual splittail salvage in 14 of the 15 years simulated.

Table 9-59
Change in Splittail Salvage at the SWP and CVP Pumps Under the Maximum Water Purchase Scenario – Flexible Purchase Alternative vs. Baseline Condition

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1979				-1	-38	-398	-1,479	-9,931	-10,819	2,979	778	71	-18,838
1980	0	0	-91	-1,613	-3,254	-69	-4,310	-23,974	-66,341	46	2,198	341	-97,068
1981	0	0	-20	0	-299	-1,819	-2,823	-29,018	0	0	16	0	-33,963
1982	0	0	-73	-1,241	-3,442	-1,371	-1,274	-9,822	-23,597	13,903	20,387	166	-6,365
1983	0	0	-737	-497	-3,791	-1,437	-515	-8,712	-59,762	9,261	4,804	194	-61,192
1984	0	0	0	0	-218	-1,114	-2,807	-2,315	-3,868	8,776	1,941	208	603
1985	0	0	-138	0	-371	-677	-1,662	-700	-14,563	383	78	20	-17,630
1986	0	0	0	-10	-356	-2,094	-16,567	-368,329	-339,879	22,726	3,675	1,748	-699,086
1987	0	0	-89	-74	-268	-2,357	-642	-373	-54,289	-436	96	106	-58,326
1988	0	0	-518	-2,602	-1,315	0	-259	-1,378	0	1,178	24	47	-4,824
1989	0	0	0	-32	-83	-1,351	-104	-2,308	-670	-994	455	79	-5,008
1990	0	0	-6	-132	-757	-1,192	0	0	0	1,459	0	0	-628
1991	0	0	0	0	0	-1,337	-648	-1,329	0	459	0	0	-2,855
1992	0	0	0	-35	-642	-839	-22	0	0	0	55	0	-1,482
1993	0	0	0	-1,439	-457	-448	-1,459	-2,489	-2,114	675	89	16	-7,627
Total	0	0	-1,673	-7,675	-15,292	-16,502	-34,572	-460,681	-575,902	60,415	34,596	2,996	-1,014,290

Although there would be increases in splittail salvage with implementation of the Flexible Purchase Alternative under the Maximum Water Purchase Scenario in one year and in individual months of the simulation, annual splittail salvage estimates would decrease in 14 of the 15 years simulated, relative to the Baseline Condition. Therefore, implementation of the Flexible Purchase Alternative under the Maximum Water Purchase Scenario would result in overall beneficial impacts on splittail salvage, relative to the Baseline Condition.

Striped Bass

With implementation of the Flexible Purchase Alternative under the Maximum Water Purchase Scenario, there would be a net reduction in striped bass salvage, relative to the Baseline Condition, over the 15-year period of record included in the analysis. Average annual salvage estimates with implementation of the Flexible Purchase Alternative under the Maximum Water Purchase Scenario would decrease by 8,935,211 striped bass, relative to the Baseline Condition. (Refer to Table 9-60.)

Table 9-60
Change in Striped Bass Salvage at the SWP and CVP Pumps Under the Maximum Water Purchase Scenario – Flexible Purchase Alternative vs. Baseline Condition

Year	*Oct*	*Nov*	*Dec*	*Jan*	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sep*	*Total*
1979				-8,826	-4,485	-4,242	-17,619	-22,746	-306,443	303,742	69,339	2,757	11,477
1980	0	0	-13,204	-1,264	-1,435	-201	-4,872	-391	-340,030	-377,333	217,262	40,460	-481,008
1981	0	0	-9,691	0	-2,538	-11,056	-5,455	-573,284	-398,328	-690,377	31,842	1,834	-1,657,052
1982	0	0	-8,090	-15,566	-12,801	-3,561	-8,536	-2,940	-26,663	230,894	139,488	18,278	310,503
1983	0	0	-51,197	-9,417	-7,039	-983	-749	-2,671	-13,244	10,617	15,353	2,781	-56,549
1984	0	0	0	0	-273	-321	-3,775	-9,699	-474,933	974,583	28,344	8,591	522,516
1985	0	0	-24,799	0	-1,420	-1,473	-1,692	-11,193	-2,069,967	72,709	8,370	1,442	-2,028,023
1986	0	0	-6,065	-4,968	-37,481	-5,607	-853	-23,360	-5,474,745	2,979,732	174,696	52,965	-2,345,686
1987	0	0	-6,524	-3,749	-3,043	-6,896	-2,338	-74,155	-2,352,908	-412,880	9,673	8,122	-2,844,697
1988	0	0	-39,350	-7,649	-14,796	0	-332	-223,777	0	588,763	52,364	8,873	364,096
1989	0	0	0	-2,615	-2,983	-3,636	-84	-334,230	-1,165,724	-671,695	12,286	2,032	-2,166,650
1990	0	0	-714	-7,899	-7,600	-7,801	0	0	-341,601	228,030	54,293	14,987	-68,306
1991	0	0	0	0	0	-8,009	-1,531	-40,828	0	948,362	80,261	15,094	993,350
1992	0	0	0	-2,969	-40,625	-17,025	-183	0	0	127,063	11,835	7,915	86,011
1993	0	0	0	-18,400	-6,587	-6,747	-577	-96	-994,599	1,351,688	93,979	6,148	424,808
Total	0	0	-159,633	-83,323	-143,105	-77,559	-48,595	-1,319,370	-13,959,185	5,663,898	999,384	192,277	-8,935,211

Annual and monthly change in striped bass salvage estimates with implementation of the Flexible Purchase Alternative under the Maximum Water Purchase Scenario, relative to the Baseline Condition, over the 15-year period of record included in the analysis are provided in Table 9-60. Annual salvage estimates decrease in 8 of the 15 years simulated by 56,594 to 2,844,697 striped bass, relative to the Baseline Condition, and increase by 11,477 to 993, 350 striped bass in 7 of the 15 years simulated, as shown in Table 9-60. Monthly mean striped bass salvage estimates under the Flexible Purchase Alternative would not change in October and November, relative to the Baseline Condition. From December through June, implementation of the Flexible Purchase Alternative would result in monthly mean reductions in salvage ranging from 48,595 to 13,959,185 striped bass, relative to the Baseline Condition. During July, August, and September, monthly mean salvage estimates with implementation of the Flexible Purchase Alternative under the Maximum Water Purchase Scenario would increase by 5,663,898, 999,384, and 192,277 striped bass, respectively, relative to the Baseline Condition.

Salvage losses of striped bass during the spring months are primarily small juvenile fish (young-of-the-year), while salvage of striped bass during the fall is primarily comprised of larger juveniles that have survived and grown throughout the summer and fall months. As a result of natural mortality, smaller juvenile striped bass salvage during the spring would have a lower probability (on an individual basis) of surviving to become reproductive adults compared to the expected survival rate of larger juveniles salvaged during the fall. The potential for adverse effects of salvage losses on the overall striped bass population are, therefore, a combination of both the number of fish salvaged and their probability of survival to become reproductive adults.

There would be frequent occurrences of measurable increases in striped bass salvage in 41 of the 150 months simulated during December through September, resulting in increases in long-term average annual salvage in 7 of the 15 years simulated. However, with implementation of the Flexible Purchase Alternative under the Maximum Water Purchase Scenario, there would be a net reduction in salvage of 8,935,211 striped bass, relative to the Baseline Condition. Therefore, potential salvage-related impacts on striped bass with implementation of the Flexible Purchase Alternative under the Maximum Water Purchase Scenario would be less than significant, relative to the Baseline Condition.

9.2.5.2.2 Typical Water Purchase Scenario

Delta Outflow

Reductions in long-term average Delta outflow under the Typical Water Purchase Scenario would not occur with implementation of the Flexible Purchase Alternative, relative to the Baseline Condition, as shown in Table 9-61. Delta outflow during the period of February through June is believed to be of greatest concern for potential effects on spawning and rearing habitat and downstream transport flows for delta smelt, splittail, salmonids, and other aquatic species in the Delta. Long-term average Delta outflow would increase by approximately 1.3 to 6.9 percent (ranging from 43.5 to 64.7 TAF per month) during the February through June period. Monthly mean flows with implementation of the Flexible Purchase Alternative under the Typical Water Purchase Scenario would be essentially equivalent to or greater than flows under the Baseline Condition in all months included in the simulation. (Refer to Appendix H pgs. B1-B12.) Detectable decreases in Delta outflow would not occur with implementation of the Flexible Purchase Alternative under the Typical Water Purchase Scenario, relative to the Baseline Condition, in any of the 75 months simulated for the February through June period. Therefore, changes in Delta outflow resulting from implementation of the Flexible Purchase Alternative under the Typical Water Purchase Scenario would result in beneficial impacts on fisheries resources in the Delta.

Table 9-61
Long-term Average Delta Outflow Under Baseline and Flexible Purchase Alternative (Typical Water Purchase Scenario) Conditions

Month	Monthly Mean Flow[1] (cfs)		Difference		
	Baseline	Flexible Purchase Alternative	(cfs)	(%)[2]	TAF[2]
Oct	7,494	7,494	0	0	0
Nov	14,729	14,729	0	0	0
Dec	29,135	29,669	534	1.8	31.8
Jan	35,403	35,805	401	1.1	23.9
Feb	57,924	58,656	732	1.3	43.5
Mar	53,136	54,123	987	1.9	58.7
Apr	29,039	30,111	1072	3.7	63.8
May	17,995	19,082	1087	6.0	64.7
Jun	13,767	14,718	950	6.9	56.5
Jul	7,915	8,280	365	4.6	21.7
Aug	4,192	4,476	284	6.8	16.9
Sep	5,574	5,867	293	5.3	17.4

[1] Based on the 1979-1993 period of record.
[2] Relative difference of the monthly long-term average.

X_2 Location

With implementation of the Flexible Purchase Alternative under the Typical Water Purchase Scenario, the long-term average position of X_2 would not shift upstream during any month of the February through June period, as shown in Table 9-62. In addition, the monthly mean position of X_2 would move downstream or would not shift, relative to the Baseline Condition, in all of the 75 months simulated with implementation of the Flexible Purchase Alternative under the Typical Water Purchase Scenario. (Refer to Appendix H pgs. B13-B24.) Therefore, changes in the location of X_2 resulting from implementation of the Flexible Purchase Alternative under the Typical Water Purchase Scenario would result in beneficial impacts on fisheries resources in the Delta.

Table 9-62
Long-term Average Delta X_2 Position Under Baseline and Flexible Purchase Alternative (Typical Water Purchase Scenario) Conditions

Month	Monthly Mean Position[1] (km)		
	Baseline	Flexible Purchase Alternative	Difference
Oct	85.3	84.5	-0.8
Nov	83.6	83.4	-0.2
Dec	80.3	80.3	0
Jan	76.9	76.6	-0.3
Feb	71.7	71.5	-0.2
Mar	66.4	66.1	-0.3
Apr	64.5	64.1	-0.4
May	67.8	67.3	-0.5
Jun	72.0	71.2	-0.8
Jul	75.9	74.8	-1.1
Aug	79.5	78.7	-0.8
Sep	84.5	83.7	-0.8

[1] Kilometers from the Golden Gate Bridge.

Export/Inflow Ratio

The long-term average E/I ratio with implementation of the Flexible Purchase Alternative under the Typical Water Purchase Scenario would decrease during all months of the February through June period, relative to the Baseline Condition, as shown in Table 9-63. The long-term average E/I ratio would increase during July, August, and September with implementation of the Flexible Purchase Alternative under the Typical Water Purchase Scenario. This increase would occur outside of the biologically sensitive February through June period. The monthly mean E/I ratio with implementation of the Flexible Purchase Alternative under the Typical Water Purchase Scenario would be identical to or less than (a reduced proportion of exports, relative to inflow) the E/I ratio under the Baseline Condition in all of the 75 months simulated for the February through June period. (Refer to Appendix H pgs. B49-B60.) Such changes are not likely to adversely affect covered Delta fish species.

Table 9-63
Long-term Average Delta E/I Ratio Under Baseline and Flexible Purchase Alternative (Typical Water Purchase Scenario) Conditions

Month	Monthly Mean Ratio[1] (%)		Difference	
	Baseline	Flexible Purchase Alternative	(%)	(%)[2]
Oct	49	49	0	0
Nov	39	39	0	0
Dec	37	35	-2	-5.4
Jan	36	35	-1	-2.8
Feb	23	21	-2	-8.7
Mar	21	19	-2	-9.5
Apr	18	14	-4	-22.2
May	20	14	-6	-30.0
Jun	27	22	-5	-18.5
Jul	32	36	+4	+12.5
Aug	51	55	+4	+7.8
Sep	57	60	+3	+5.3

[1] Based on the 1979-1993 period of record.
[2] Relative difference of the monthly long-term average.

The model simulations conducted for the Flexible Purchase Alternative included conformance with export requirements set forth in the SWRCB Interim Water Quality Control Plan. Thus, the Delta E/I ratios under the Flexible Purchase Alternative and Baseline Condition would not exceed the maximum export ratio as set by the SWRCB Interim Water Quality Control Plan. (Refer to Appendix H pgs. B49-B60.) However, relaxation of the E/I ratio is an EWA asset. If the Management Agencies determine that the risk to fish is relatively low, then pumping above the applicable limit may be undertaken, with the additional water credited to the EWA. Such actions will not be taken if there is the potential to affect State or Federally protected species, and will only be taken under the unanimous direction of the Management Agencies. Therefore, the E/I ratios resulting from implementation of the Flexible Purchase Alternative under the Typical Water Purchase Scenario are not likely to adversely affect delta smelt, splittail, striped bass, steelhead, fall-, late-fall-, winter-, or spring-run Chinook salmon in the Delta.

Reverse Flows (QWEST)

Under the Baseline Condition, reverse flows would occur in 25 months out of the 75 months simulated for the February through June period (33.3 percent of the time). Reverse flows would occur less frequently with implementation of the Flexible Purchase Alternative under the Typical Water Purchase Scenario, in 16 of the 75 months simulated, or 21.3 percent of the time. (Refer to Appendix H pgs. B41-B45.) Table 9-64 illustrates that the frequency of reverse flows from February through June under the Flexible Purchase Alternative would be unchanged or substantially reduced across all flow ranges, relative to the Baseline Condition. In most months in which reverse flows would occur under the Baseline Condition, flows would be positive or the magnitude of reverse flow substantially reduced under the Typical Water Purchase Scenario. (Refer to Appendix H pgs. B41-B45.)

Table 9-64
Frequency[1] of Reverse Flows (QWEST) Over Varying Flow Ranges

Reverse Flow Range (cfs)	Baseline Condition	Flexible Purchase Alternative (Typical Water Purchase Scenario)
February		
<0	6	6
<-100	4	3
<-250	0	0
<-500	0	0
<-1000	0	0
<-2000	0	0
March		
<0	6	3
<-100	3	1
<-250	0	0
<-500	0	0
<-1000	0	0
<-2000	0	0
April		
<0	2	1
<-100	0	0
<-250	0	0
<-500	0	0
<-1000	0	0
<-2000	0	0
May		
<0	5	2
<-100	0	0
<-250	0	0
<-500	0	0
<-1000	0	0
<-2000	0	0
June		
<0	6	4
<-100	3	1
<-250	1	1
<-500	0	0
<-1000	0	0
<-2000	0	0

[1] Based on the 1979-1993 period of record for each month.

Overall, implementation of the Flexible Purchase Alternative under the Typical Water Purchase Scenario would provide a benefit to reverse flows, relative to the Baseline Condition, by decreasing the frequency of reverse flows and reducing the magnitude when reverse flows would still occur. Overall, such changes would be considered a benefit to juvenile salmonid emigration and the transport of planktonic eggs and larvae. Therefore, implementation of the Flexible Purchase Alternative would beneficially affect the survival of planktonic fish eggs and larvae and downstream migrating juvenile Chinook salmon smolts.

Salvage at the SWP and CVP Export Facilities

Salvage estimates for delta smelt, Chinook salmon, steelhead, and splittail, were developed based upon historical salvage records, which exhibit variation due to interannual variability in the abundance and distribution of each species. Salvage modeling, described in Section 9.2.1.3, Estuarine Fish Species in the Delta, provides an indication of the relative effect of CVP and SWP pumping operations with implementation of the Flexible Purchase Alternative and under the Baseline Condition. This section provides an analysis of potential salvage-related effects with implementation of the Flexible Purchase Alternative under the Typical Water Purchase Scenario on delta smelt, Chinook salmon, steelhead, splittail, and striped bass.

Delta Smelt

Under the Flexible Purchase Alternative (Typical Water Purchase Scenario), a net reduction in delta smelt salvage would occur over the 15-year period of record included in the analysis, relative to the Baseline Condition. Average annual salvage estimates with implementation of the Flexible Purchase Alternative under the Typical Water Purchase Scenario decrease by 93,690 delta smelt relative to the Baseline Condition. (Refer to Table 9-65.)

Annual and monthly changes in delta smelt salvage estimates at the CVP and SWP pumps with implementation of the Flexible Purchase Alternative, relative to the Baseline Condition, over the 15-year period of record included in the analysis under the Typical Water Purchase scenario are provided in Table 9-65. Annual salvage estimates decrease in every year by 293 to 26,355 delta smelt, relative to the Baseline Condition, as shown in Table 9-65. Monthly mean delta smelt salvage estimates under the Flexible Purchase Alternative would not change during October and November, relative to the Baseline Condition. From December through July, implementation of the Flexible Purchase Alternative would result in monthly mean reductions in salvage ranging from 1,533 to 41,354 delta smelt, relative to the Baseline Condition. During August and September, monthly mean salvage under the Flexible Purchase Alternative would increase by 4,711 and 928 delta smelt, respectively, relative to the Baseline Condition.

While annual salvage estimates exhibit a decrease with implementation of the Flexible Purchase Alternative under the Typical Water Purchase Scenario, there would be isolated occurrences of increases in delta smelt salvage in 31 of the 150 months simulated for the December through September period. However, such changes would not be of sufficient magnitude to result in increases in annual delta smelt salvage for any of the 15 years simulated. In fact, annual delta smelt salvage would decrease, relative to the Baseline Condition in all 15 years simulated for the analysis.

As discussed in Chapter 2, Alternatives, Including the Proposed Action/Proposed Project, real-time operations would be implemented as needed to avoid pumping operations that would result in increased delta smelt salvage. Based on modeling output and the efficiency of real-time adjustment of operations (real-time implementation of environmental measures outlined in Section 9.2.3, ASIP Conservation Measures) in response to abundance and distribution monitoring, implementation of the Flexible Purchase Alternative under the Typical Water Purchase Scenario would result in overall beneficial impacts on delta smelt salvage, relative to the Baseline Condition.

Table 9-65
Change in Delta Smelt Salvage at the SWP and CVP Pumps Under the Typical Water Purchase Scenario – Flexible Purchase Alternative vs. Baseline Condition

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1979				-42	-125	-225	-442	-1,874	-2,440	2,463	181	15	-2,489
1980	0	0	0	-188	-348	-408	-498	-127	-6,754	-8,217	3,314	105	-13,121
1981	0	0	-416	0	-1,128	-1,966	-1,036	-13,130	-3,836	-5,102	235	24	-26,355
1982	0	0	-63	-781	-1,257	-634	-73	-218	-36	712	414	39	-1,897
1983	0	0	-161	-862	-254	-61	-10	-8	-2,199	852	0	245	-2,458
1984	0	0	0	0	-2	-186	-21	-2,895	-1,165	761	3	9	-3,496
1985	0	0	-170	0	-30	-29	-255	-906	-6,524	63	34	50	-7,765
1986	0	0	-20	-71	-356	-145	-128	-18	-19	91	104	0	-561
1987	0	0	-15	0	-35	-208	-1,301	-3,886	-5,925	-19	-21	132	-11,279
1988	0	0	-668	-287	-35	0	0	-4,816	-487	290	0	0	-6,004
1989	0	0	-21	-44	-6	-32	-40	-366	-581	441	74	31	-543
1990	0	0	0	-9	-27	-28	0	-28	-7,656	136	0	0	-7,612
1991	0	0	0	0	0	-106	-121	-531	-2,708	1,240	368	277	-1,582
1992	0	0	0	-10	-102	-164	-20	0	0	3	0	0	-293
1993	0	0	0	-60	-59	-33	0	-7,318	-1,022	250	5	0	-8,237
Total	0	0	-1,533	-2,352	-3,765	-4,223	-3,945	-36,121	-41,354	-6,036	4,711	928	-93,690

Chinook Salmon

With implementation of the Flexible Purchase Alternative under the Typical Water Purchase Scenario, a net reduction in Chinook salmon salvage would occur over the 15-year period of record, relative to the Baseline Condition. Average annual salvage estimates under the Typical Water Purchase Scenario would decrease by 895,433 Chinook salmon, relative to the Baseline Condition. (Refer to Table 9-66.)

Annual and monthly changes in Chinook salmon salvage estimates at the CVP and SWP pumps with implementation of the Flexible Purchase Alternative under the Typical Water Purchase Scenario, relative to the Baseline Condition, are provided in Table 9-66. Annual salvage would decrease in every year by 2,117 to 252,497 Chinook salmon, relative to the Baseline Condition, as shown in Table 9-66. Monthly mean Chinook salmon salvage estimates under the Flexible Purchase Alternative would not change in October and November, relative to the Baseline Condition. From December through June, implementation of the Flexible Purchase Alternative would result in monthly mean decreases in salvage ranging from 6,073 to 356,022 Chinook salmon, relative to the Baseline Condition. During July, August, and September, monthly mean salvage estimates with implementation of the Flexible Purchase Alternative under the Typical Water Purchase Scenario would increase by 2,181, 274, and 551 Chinook salmon, respectively, relative to the Baseline Condition.

While annual salvage estimates exhibit a decrease with implementation of the Flexible Purchase Alternative under the Typical Water Purchase Scenario, there would be isolated occurrences of increases in SWP Chinook salmon salvage in 20 of the 150 months simulated for the December through September period. However, such changes would not be of sufficient magnitude to result in increases in annual salvage in any year simulated over the 15-year period of record included in the analysis. Thus, while there would be increases in Chinook salmon salvage with implementation of the Flexible Purchase Alternative under the Typical Water Purchase Scenario in individual months of the simulation, annual salvage estimates for Chinook salmon would decrease, relative to the Baseline Condition. Therefore, implementation of the Flexible Purchase Alternative under the Typical Water Purchase Scenario would result in overall beneficial impacts on Chinook salmon salvage, relative to the Baseline Condition.

Table 9-66
Change in Chinook Salmon Salvage at the SWP and CVP Pumps Under the Typical Water Purchase Scenario – Flexible Purchase Alternative vs. Baseline Condition

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1979				-195	-131	-467	-31,668	-32,892	-1,570	1,450	75	28	-65,370
1980	0	0	-466	-238	-27	-20	-60,802	-35,637	-12,304	-567	10	519	-109,532
1981	0	0	-102	0	-156	-1,689	-21,608	-12,312	-64	0	14	0	-35,916
1982	0	0	-2,161	-1,300	-3,084	-3,354	-6,557	-71,783	-15,742	32	4	0	-103,945
1983	0	0	-15,916	-3,451	-3,350	-1,593	-6,707	-19,821	-28,226	284	0	0	-78,780
1984	0	0	0	0	-6	-1,290	-24,188	-29,496	-25,410	4	133	0	-80,252
1985	0	0	-812	0	-362	-415	-13,751	-56,365	-9,911	29	0	2	-81,584
1986	0	0	-399	-190	-93,319	-15,144	-57,136	-57,399	-29,693	784	0	0	-252,497
1987	0	0	-63	0	-52	-2,167	-13,631	-11,139	-4,062	-4	-1	-1	-31,120
1988	0	0	-2,402	-338	-320	0	-1,348	-14,700	-53	168	15	2	-18,978
1989	0	0	-52	-118	-9	-2,071	-770	-6,591	-148	0	6	0	-9,753
1990	0	0	-51	-99	-55	-372	0	-266	-1,273	0	0	0	-2,117
1991	0	0	0	0	0	-678	-3,919	-5,484	-500	0	0	0	-10,581
1992	0	0	0	-108	-1,814	-5,750	-2,877	0	0	0	0	0	-10,547
1993	0	0	0	-34	-67	-81	-1,957	-2,136	-205	2	18	0	-4,461
Total	0	0	-22,424	-6,073	-102,751	-35,090	-246,917	-356,022	-129,162	2,181	274	551	-895,433

Steelhead
A net reduction in steelhead salvage would occur with implementation of the Flexible Purchase Alternative under the Typical Water Purchase Scenario, relative to the Baseline Condition, over the 15-year period of record included in the analysis. Average annual salvage estimates under the Typical Water Purchase Scenario would be reduced by 20,386 steelhead, relative to the Baseline Condition. (Refer to Table 9-67.)

Annual and monthly changes in steelhead salvage estimates at the CVP and SWP pumps with implementation of the Flexible Purchase Alternative under the Typical Water Purchase Scenario, relative to the Baseline Condition, are shown in Table 9-67. Annual salvage would decrease in ever year by 180 to 4,005 steelhead, relative to the Baseline Condition, as shown in Table 9-67. Monthly mean steelhead salvage estimates with implementation of the Flexible Purchase Alternative under the Typical Water Purchase Scenario would not change from August through November, relative to the Baseline Condition. From December through June, implementation of the Flexible Purchase Alternative would result in monthly mean reductions in salvage ranging from 414 to 7,088 steelhead, relative to the Baseline Condition. During July, monthly mean salvage estimates with implementation of the Flexible Purchase Alternative under the Typical Water Purchase Scenario would increase by three steelhead, relative to the Baseline Condition. Therefore, implementation of the Flexible Purchase Alternative under the Typical Water Purchase Scenario would result in overall beneficial impacts on steelhead salvage, relative to the Baseline Condition.

Table 9-67
Change in Steelhead Salvage at the SWP and CVP Pumps Under the Typical Water Purchase Scenario – Flexible Purchase Alternative vs. Baseline Condition

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1979				-11	-62	-173	-707	-473	0	0	0	0	-1,428
1980	0	0	-2	-15	-48	-7	-507	-458	-41	0	0	0	-1,078
1981	0	0	-12	0	-132	-719	-1,016	-24	0	0	0	0	-1,903
1982	0	0	-32	-65	-130	-90	-1,790	-1,526	-373	0	0	0	-4,005
1983	0	0	-755	-40	-16	0	0	-75	0	0	0	0	-887
1984	0	0	0	0	0	-24	-151	-5	0	0	0	0	-180
1985	0	0	-1	0	-18	-73	-220	-221	0	0	0	0	-532
1986	0	0	0	-2	-144	-43	-423	-121	0	3	0	0	-728
1987	0	0	-92	0	-8	-1,213	-302	-81	0	0	0	0	-1,695
1988	0	0	-42	-18	-103	0	-78	-170	0	0	0	0	-411
1989	0	0	-5	-2	-42	-1,464	-34	-26	0	0	0	0	-1,573
1990	0	0	0	0	-128	-423	0	-3	0	0	0	0	-554
1991	0	0	0	0	0	-994	-206	-24	0	0	0	0	-1,224
1992	0	0	0	-289	-1,016	-1,247	-39	0	0	0	0	0	-2,590
1993	0	0	0	-26	-588	-618	-165	-200	0	0	0	0	-1,597
Total	0	0	-941	-468	-2,434	-7,088	-5,636	-3,407	-414	3	0	0	-20,386

Splittail

With implementation of the Flexible Purchase Alternative under the Typical Water Purchase Scenario, there would be a net reduction in splittail salvage, relative to the Baseline Condition, over the 15-year period of record included in the analysis. Average annual salvage estimates with implementation of the Flexible Purchase Alternative under the Typical Water Purchase Scenario would decrease by 656,597 splittail, relative to the Baseline Condition. (Refer to Table 9-68.)

Annual and monthly change in splittail salvage estimates with implementation of the Flexible Purchase Alternative under the Typical Water Purchase Scenario, relative to the Baseline Condition, over the 15-year period of record included in the analysis are provided in Table 9-68. Annual salvage would decrease in every year by 75 to 409,257 splittail, relative to the Baseline Condition, as shown in Table 9-68. Monthly mean splittail salvage estimates under the Flexible Purchase Alternative would not change in October and November, relative to the Baseline Condition. From December through June, implementation of the Flexible Purchase Alternative would result in monthly mean reductions in salvage ranging from 1,322 to 375,810 splittail, relative to the Baseline Condition. During July, August, and September, monthly mean salvage estimates with implementation of the Flexible Purchase Alternative under the Typical Water Purchase Scenario would increase by 47,272, 34,061, and 2,687 splittail, respectively, relative to the Baseline Condition.

While annual salvage estimates exhibit a decrease with implementation of the Flexible Purchase Alternative under the Typical Water Purchase Scenario for each year simulated over the 15-year period of record, there would be isolated occurrences of increases in splittail salvage in 36 of the 150 months simulated for the December through September period. However, such changes would not be of sufficient magnitude to result in increases in annual salvage in any year simulated under the Flexible Purchase Alternative. Thus, although there would be increases in splittail salvage with implementation of the Flexible Purchase Alternative under the Typical Water Purchase Scenario in individual months of the simulation, annual splittail salvage estimates would decrease, relative to the Baseline Condition. Therefore, implementation of the Flexible Purchase Alternative under the Typical Water Purchase Scenario would result in overall beneficial impacts on splittail salvage, relative to the Baseline Condition.

Table 9-68
Change in Splittail Salvage at the SWP and CVP Pumps Under the Typical Water Purchase Scenario – Flexible Purchase Alternative vs. Baseline Condition

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1979				0	-26	-266	-474	-4,595	-10,819	2,979	778	71	-12,351
1980	0	0	-91	-1,613	-3,254	-69	-2,861	-12,446	-49,756	-10,584	2,198	341	-78,134
1981	0	0	-20	0	-299	-546	-2,541	-8,210	0	0	16	0	-11,600
1982	0	0	-73	-1,241	-3,442	-1,371	-1,274	-9,822	-23,597	13,903	20,387	166	-6,365
1983	0	0	-737	-497	-3,791	-1,437	-515	-8,712	-44,822	9,261	4,804	194	-46,251
1984	0	0	0	0	-218	-1,114	-1,615	-1,609	-6,445	8,776	1,941	208	-75
1985	0	0	-69	0	-371	-339	-963	-1,602	-7,063	383	78	20	-9,925
1986	0	0	0	-10	-356	-1,256	-16,567	-245,553	-169,939	19,755	3,198	1,472	-409,257
1987	0	0	-60	0	-178	-1,208	-389	-373	-54,289	13	63	89	-56,332
1988	0	0	-259	-867	-666	0	-136	-1,378	-614	724	16	32	-3,147
1989	0	0	-7	-32	-83	-1,351	-104	-2,308	-670	205	455	79	-3,815
1990	0	0	-6	-44	-252	-596	0	-111	0	780	0	0	-230
1991	0	0	0	0	0	-668	-648	-825	-5,886	490	0	0	-7,539
1992	0	0	0	-35	-642	-839	-22	0	0	0	50	0	-1,487
1993	0	0	0	-959	-457	-298	-648	-6,489	-1,910	585	76	14	-10,088
Total	0	0	-1,322	-5,298	-14,036	-11,357	-28,759	-304,034	-375,810	47,272	34,061	2,687	-656,597

Striped Bass

With implementation of the Flexible Purchase Alternative under the Typical Water Purchase Scenario, there would be a net reduction in striped bass salvage, relative to the Baseline Condition, over the 15-year period of record included in the analysis. Average annual salvage estimates with implementation of the Flexible Purchase Alternative under the Typical Water Purchase Scenario would decrease by 7,087,274 striped bass, relative to the Baseline Condition. (Refer to Table 9-69.)

Annual and monthly change in striped bass salvage estimates with implementation of the Flexible Purchase Alternative under the Typical Water Purchase Scenario, relative to the Baseline Condition, over the 15-year period of record included in the analysis are provided in Table 9-69. Annual salvage estimates decrease in 9 of the 15 years simulated by 53,238 to 2,409,375 striped bass, relative to the Baseline Condition, and increase by 6,616 to 310,503 striped bass in 6 of the 15 years simulated, as shown in

Table 9-69. Monthly mean striped bass salvage estimates under the Flexible Purchase Alternative would not change in October and November, relative to the Baseline Condition. From December through June, implementation of the Flexible Purchase Alternative would result in monthly mean reductions in salvage ranging from 35,821 to 12,289,541 striped bass, relative to the Baseline Condition. During July, August, and September, monthly mean salvage estimates with implementation of the Flexible Purchase Alternative under the Typical Water Purchase Scenario would increase by 5,682,524, 891,257, and 164,809 striped bass, respectively, relative to the Baseline Condition.

Table 9-69
Change in Striped Bass Salvage at the SWP and CVP Pumps Under the Typical Water Purchase Scenario – Flexible Purchase Alternative vs. Baseline Condition

Year	*Oct*	*Nov*	*Dec*	*Jan*	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sep*	*Total*
1979				-2,942	-2,990	-2,828	-11,156	-13,337	-306,443	303,742	69,339	2,757	36,142
1980	0	0	-13,204	-1,264	-1,435	-201	-3,373	-152	-255,023	-798,525	217,262	40,460	-815,454
1981	0	0	-9,691	0	-2,538	-3,317	-4,312	-160,382	-398,328	-230,126	31,842	1,834	-775,017
1982	0	0	-8,090	-15,566	-12,801	-3,561	-8,536	-2,940	-26,663	230,894	139,488	18,278	310,503
1983	0	0	-51,197	-9,417	-7,039	-983	-749	-2,671	-9,933	10,617	15,353	2,781	-53,238
1984	0	0	0	0	-273	-321	-2,066	-7,543	-1,316,151	974,583	28,344	8,591	-314,837
1985	0	0	-12,399	0	-1,420	-737	-1,587	-93,218	-1,626,016	72,709	8,370	1,442	-1,652,857
1986	0	0	-6,065	-4,968	-37,481	-3,364	-853	-15,573	-2,737,372	2,620,207	148,024	44,061	6,616
1987	0	0	-4,349	0	-2,029	-4,167	-1,004	-74,155	-2,352,908	14,787	7,776	6,673	-2,409,375
1988	0	0	-19,675	-2,550	-4,727	0	-132	-223,777	-59,966	393,993	32,509	4,691	120,366
1989	0	0	-10,633	-2,615	-2,983	-3,636	-84	-334,230	-1,165,724	155,133	12,286	2,032	-1,350,455
1990	0	0	-714	-2,633	-2,533	-3,900	0	-16,422	-341,601	31,373	29,352	8,519	-298,560
1991	0	0	0	0	0	-4,004	-1,531	-24,981	-946,451	630,339	60,011	10,185	-276,432
1992	0	0	0	-2,969	-40,625	-17,025	-183	0	0	117,752	11,032	7,213	75,195
1993	0	0	0	-12,267	-6,587	-4,498	-254	-159,908	-746,963	1,155,044	80,270	5,294	310,131
Total	0	0	-136,017	-57,191	-125,460	-52,543	-35,821	-1,129,290	-12,289,541	5,682,524	891,257	164,809	-7,087,274

Salvage losses of striped bass during the spring months are primarily small juvenile fish (young-of-the-year), while salvage of striped bass during the fall is primarily comprised of larger juveniles that have survived and grown throughout the summer and fall months. As a result of natural mortality, smaller juvenile striped bass salvage during the spring would have a lower probability (on an individual basis) of surviving to become reproductive adults compared to the expected survival rate of larger juveniles salvaged during the fall. The potential for adverse effects of salvage losses on the overall striped bass population are, therefore, a combination of both the number of fish salvaged and their probability of survival to become reproductive adults.

There would be frequent occurrences of measurable increases in striped bass salvage in 43 of the 150 months simulated during December through September, resulting in increases in long-term average annual salvage in 6 of the 15 years simulated. However, with implementation of the Flexible Purchase Alternative under the Typical Water Purchase Scenario, there would be a net reduction in salvage of 7,087,274 striped bass, relative to the Baseline Condition. Therefore, potential salvage-related impacts on striped bass with implementation of the Flexible Purchase Alternative under the Typical Water Purchase Scenario would be less than significant, relative to the Baseline Condition.

As discussed in Chapter 2 and in Section 9.2.3, ASIP Conservation Measures, opportunities exist for reducing and/or avoiding adverse effects of salvage loss identified through these analyses. Results of real-time biological monitoring information (e.g., results of daily salvage, results of fishery monitoring performed elsewhere within the Delta, etc.) can be used, in combination with an adaptive management process, for allocating available EWA resources to reduce or avoid adverse impacts on Delta species. Modification of operations based on real-time biological data could result in impacts on water supply operations, unless mitigated through storage and/or other operational strategies.

9.2.5.3 Export Service Area

Within the Export Service Area, there are no Federally or State listed anadromous, estuarine, or riverine special-status species. The main channelized waterway in this area is the California Aqueduct, an artificial canal that is not managed for fishery resources. However, there are several non-project reservoirs within the Export Service Area that may be affected by EWA actions. This section provides an analysis of potential impacts on fisheries resources under the Flexible Purchase Alternative at San Luis Reservoir, Anderson Reservoir, Lake Perris, Castaic Lake, and Diamond Valley Lake.

9.2.5.3.1 Export Service Area Reservoirs

Borrowing EWA assets from San Luis Reservoir, Anderson Reservoir, Diamond Valley Lake, Castaic Lake, Lake Perris, and Lake Mathews via source shifting would not change the normal operating parameters of these reservoirs.

Generally, under the Flexible Purchase Alternative, if source shifting were implemented in surface water storage facilities, the participating reservoir levels would decrease prior to time under the Baseline Condition, and return to levels under the Baseline Condition later in the year, after EWA has paid water back to the Projects. The purpose of implementing source shifting is to protect the San Luis Reservoir from reaching its low-point earlier with EWA than it would have without the EWA Program. Under the Baseline Condition, water surface elevations in San Luis Reservoir would begin to decrease in mid-April and would continue to decrease until reservoir storage reached approximately 300 TAF, the level where water quality begins to create problems for contractors. Under the Flexible Purchase Alternative, EWA acquisitions would not reduce San Luis Reservoir levels below 300 TAF.

If projections show San Luis Reservoir storage levels would decrease to 300 TAF earlier in the year than normal, then the EWA agencies would implement source shifting agreements. Source shifting would decrease the water surface level, and therefore, decrease the amount of available spawning and rearing habitat for warm water fish and the amount of habitat available to coldwater fish. In some years, San Luis Reservoir storage would fall below 300 TAF without the EWA. In this situation, the EWA agencies would not be responsible for source shifting to return storage level to 300 TAF, but would only need to shift sources to bring the storage back up to the without-EWA levels. Therefore, implementation of the Flexible Purchase Alternative would not adversely affect the normal operating procedures of San Luis Reservoir. Consequently, impacts on warmwater and coldwater fisheries would be considered less than significant.

Santa Clara Valley Water District is considering two actions involving the EWA Program. The first action would be pre-delivery of project water using the District's Anderson Reservoir. Pre-delivery actions would occur in the fall when EWA assets would be in risk of spill from San Luis Reservoir. EWA water assets would be transferred to Anderson Reservoir using the Cross Valley Pipeline only if Anderson Reservoir had available capacity under Anderson Reservoir's flood control operation rules (Anderson Reservoir needs to maintain flood control runoff capacity December through March of each year). The Santa Clara Valley Water District may also use the EWA Program's ability to source shift assets based on conditions of San Luis Reservoir. If San Luis Reservoir were in risk of reaching low-point earlier than without EWA, the District would delay delivery of its project water supply later into the year to protect water quality of San Luis Reservoir. The District would only engage in source shifting if it could maintain its 20,000 acre-feet minimum storage amount and address in-stream flow requirements for Coyote Creek.

Metropolitan WD has access to water stored in Diamond Valley Lake, Castaic Lake, Lake Perris, and Lake Mathews, and may draw these reservoir levels down in the process of obtaining their entitlement water. However, before Metropolitan WD shifts operations, both the water supply and water quality of the potential source would be evaluated. If a particular reservoir would be altered beyond the confines of normal operating ranges as a result of withdrawing entitlement water, Metropolitan WD would choose another option for obtaining water. Overall, reductions that may take place within the terminal reservoirs, Castaic Lake, Lake Perris, Diamond Valley Lake, or Lake Mathews, would not likely be beyond normal operational parameters. Therefore, storage levels under the Flexible Purchase Alternative would not differ from the Baseline Condition. Consequently, inundated riparian habitat for warmwater fish species and available habitat for coldwater fish species would not be adversely affected.

When source shifting begins under the Flexible Purchase Alternative, water surface elevations in the reservoirs would decrease, as compared to the Baseline Condition. As the water is paid back, water levels would return to water surface elevations similar to those under the Baseline Condition. Source shifting does lower water levels temporarily, but only within existing operational parameters. The reservoirs in the Export Service Area would not be operated outside of their standard operational ranges. Implementation of the EWA program would not result in any potential impacts on littoral habitat or spawning grounds within these reservoirs that would be beyond the range of fluctuations that occur under the Baseline Condition. Therefore, EWA acquisition of borrowed assets from San Luis Reservoir, Anderson Reservoir, and Diamond Valley Lake, Castaic Lake, Lake Mathews, and Lake Perris within the Export Service Area would have a less than significant impact on warm water and coldwater fish species.

9.2.6 Environmental Consequences/Environmental Impacts of the Fixed Purchase Alternative

Extensive hydrologic modeling was performed for the Flexible Purchase Alternative to provide a quantitative basis from which to assess potential impacts of the Flexible Purchase Alternative on the fisheries and aquatic habitats within the EWA Area of analysis. As discussed in Section 3.3, Framework for Environmental Consequences/ Environmental Impact Analysis, the effects analysis for fisheries resources does not depend on the location of a particular seller, but on the total amount of EWA water to be transferred via a particular tributary and receiving water body. Therefore, fisheries effects were evaluated based on the largest amount of water that EWA agencies could manage for Delta fish actions (approximately 600 TAF), regardless of whether the specific water sellers could be identified at this time. The effects analysis with implementation of the Flexible Purchase Alternative represents a "worst case scenario" based on the maximum amount of water purchased by the EWA agencies. The impacts described in Section 9.2.5, Environmental Consequences/Environmental Impacts of the Flexible Purchase Alternative, represent the effects on fisheries and aquatic ecosystems for this maximum transfer amount. The analysis of the Fixed Purchase Alternative incorporates implementation of the variable operational assets described in Attachment 1, Modeling Description.

The Fixed Purchase Alternative would involve the same actions as the Flexible Purchase Alternative, but to a lesser degree. The Fixed Purchase Alternative specifies purchases of 35 TAF from the Upstream from the Delta Region, and 150 TAF from the Export Service Area, for a total purchase of 185 TAF. While the amounts in each region are fixed, the acquisition types and sources could vary. The EWA agencies would most likely seek stored reservoir water for the entire purchase, however the EWA agencies may also rotate acquisitions among diverse sources. The Fixed Purchase Alternative assumes that the EWA agencies would acquire 35 TAF from any mix of upstream from the Delta sources. However, the total acquisition amount allowed under the Fixed Purchase Alternative from the Upstream from the Delta Region (35 TAF) could also be purchased from a single source (Oroville-Wyandotte ID or Yuba County WA), potentially resulting in the same impacts as those associated with the Flexible Purchase Alternative.

Potential impacts associated with implementation of the Fixed Purchase Alternative were analyzed on a qualitative basis, in relation to the hydrologic modeling results for the maximum amount of water that could be purchased under the Flexible Purchase Alternative. Data generated as part of the Flexible Purchase Alternative analysis is also used to approximate the in-Delta fishery impacts that could occur under the Flexible Purchase Alternative.

9.2.6.1 Upstream from the Delta Region

9.2.6.1.1 Sacramento River Area of Analysis

EWA acquisition of Sacramento River contractor water via groundwater substitution and crop idling would alter Sacramento River flows downstream from Lake Shasta during June. EWA acquisition of Sacramento River contractor water via groundwater substitution and crop idling would alter surface water elevations at Lake Shasta from June through September.

Under the Flexible Purchase Alternative, changes in Shasta Reservoir storage and water surface elevations are not anticipated to reduce the availability of littoral habitat for warmwater fish, increase the potential for nest dewatering events for warmwater fish, reduce the volume of the coldwater pool, or affect the primary prey species of coldwater fish. No significant impacts on reservoir fish species under the Flexible Purchase Alternative were identified. Impacts considered less than significant under the Flexible Purchase Alternative also would be considered less than significant for a lesser or identical transfer amount (the Fixed Purchase Alternative). Therefore impacts on warmwater and coldwater fish species within Shasta Reservoir with implementation of the Fixed Purchase Alternative are anticipated to be less than significant.

Under the Flexible Purchase Alternative, changes in Sacramento River flows and water temperatures would not be of sufficient frequency or magnitude to beneficially or adversely affect attraction or adult immigration of anadromous species, spawning habitat availability, egg incubation, initial rearing success, long-term initial year-class strength, or juvenile rearing and emigration of Chinook salmon, Central Valley steelhead, Sacramento splittail, striped bass, or American shad, as applicable. In addition, under the Flexible Purchase Alternative, there would be no additional occurrences, relative to the Baseline Condition, in which Sacramento River water temperatures would exceed the NOAA Fisheries Winter-run Chinook salmon BO temperature criterion.

No significant impacts on the fish species of primary management concern under the Flexible Purchase Alternative were identified within the Sacramento River. Impacts considered less than significant under the Flexible Purchase Alternative would also be considered less than significant for a lesser or identical transfer amount (the Fixed Purchase Alternative). Therefore impacts on fish species of primary management concern within the Sacramento River with implementation of the Fixed Purchase Alternative are anticipated to be less than significant.

Implementation of the Flexible Purchase Alternative has the potential to reduce agricultural return flows in Butte Creek, downstream of the Western Canal Siphon (Butte Creek Siphon), primarily from July through September.

Under the Flexible Purchase Alternative, potentially reduced agricultural return flows downstream of the Western Canal Siphon would not occur during the appropriate time period to beneficially or adversely affect anadromous salmonid adult immigration and juvenile emigration, and splittail spawning.

No significant impacts on the fish species of primary management concern under the Flexible Purchase Alternative were identified within Butte Creek. Impacts considered less than significant under the Flexible Purchase Alternative would also be considered less than significant for a lesser or identical transfer amount (the Fixed Purchase Alternative). Therefore impacts on fish species of primary management concern within Butte Creek with implementation of the Fixed Purchase Alternative are anticipated to be less than significant.

9.2.6.1.2 Feather River Area of Analysis

EWA acquisition of Oroville-Wyandotte ID stored reservoir water would alter surface water elevations in Sly Creek and Little Grass Valley reservoirs from November until refill. EWA acquisition of Oroville-Wyandotte ID stored reservoir water would alter surface water elevations in Lake Oroville from the November prior to the transfer until the following September. EWA acquisition of Feather River contractor water via groundwater substitution and crop idling would alter summer surface water elevations in Lake Oroville. EWA acquisition of Feather River contractor water via groundwater substitution and crop idling would alter Feather River flows below Lake Oroville, relative to the Baseline Condition.

Under the Flexible Purchase Alternative, changes in Project and non-Project reservoir storage and water surface elevations are not anticipated to reduce the availability of littoral habitat for warmwater fish, increase the potential for nest dewatering events for warmwater fish, reduce the volume of the coldwater pool, or affect the primary prey species of coldwater fish. No significant impacts on reservoir fish species under the Flexible Purchase Alternative were identified. Impacts considered less than significant under the Flexible Purchase Alternative also would be considered less than significant for a lesser or identical transfer amount (the Fixed Purchase Alternative). Therefore impacts on warmwater and coldwater fish species within Sly Creek and Little Grass Valley reservoirs and Lake Oroville with implementation of the Fixed Purchase Alternative are anticipated to be less than significant.

Under the Flexible Purchase Alternative, changes in Feather River flows and water temperatures would not be of sufficient frequency or magnitude to beneficially or adversely affect attraction or adult immigration of anadromous species, spawning habitat availability, egg incubation, initial rearing success, or juvenile rearing and emigration of Chinook salmon, Central Valley steelhead, Sacramento splittail, striped bass, or American shad, as applicable. In addition, under the Flexible Purchase Alternative, there would be no additional occurrences, relative to the Baseline Condition, in which Feather River water temperatures would exceed the NOAA Fisheries temperature criteria for spring-run Chinook salmon and steelhead.

No significant impacts on the fish species of primary management concern under the Flexible Purchase Alternative were identified with the Feather River Area of analysis. Impacts considered less than significant under the Flexible Purchase Alternative would also be considered less than significant for a lesser or identical transfer amount (the Fixed Purchase Alternative). Therefore impacts on fish species of primary management concern within the Feather River Area of analysis with implementation of the Fixed Purchase Alternative are anticipated to be less than significant.

9.2.6.1.3 Yuba River Area of Analysis

EWA acquisition of Yuba County WA water via groundwater substitution would alter Yuba River flows during April through June. EWA acquisition of Yuba County WA water via groundwater substitution and crop idling would alter water surface elevations in New Bullards Bar Reservoir during April through June, relative to the Baseline Condition. EWA acquisition of Yuba County WA stored reservoir water would alter surface water elevations from July until refill at New Bullards Bar Reservoir.

Under the Flexible Purchase Alternative, changes in New Bullards Bar Reservoir storage and water surface elevations are not anticipated to reduce the availability of littoral habitat for warmwater fish, increase the potential for nest dewatering events for warmwater fish, reduce the volume of the coldwater pool, or affect the primary prey species of coldwater fish. No significant impacts on reservoir fish species under the Flexible Purchase Alternative were identified. Impacts considered less than significant under the Flexible Purchase Alternative also would be considered less than significant for a lesser or identical transfer amount (the Fixed Purchase Alternative). Therefore impacts on warmwater and coldwater fish species in New Bullards Bar Reservoir with implementation of the Fixed Purchase Alternative are anticipated to be less than significant.

Changes in Yuba River water temperature and flows are expected under the Flexible Purchase Alternative, relative to the Baseline Condition. The potential for these changes to beneficially or adversely impact anadromous salmonid adult immigration and juvenile emigration is still in question. It is expected that the changes in water temperature and flow within the Yuba River with implementation of the Flexible Purchase Alternative would be less than significant. The Yuba County WA and management agencies responsible for managing the Yuba River Basin are continuing to work towards understanding the processes that could affect fish resources within the Yuba River. As part of these ongoing efforts, water transfer strategies have been carefully designed, implemented, and monitored to avoid adverse impacts on juvenile and adult anadromous salmonids.

No significant impacts on the fish species of primary management concern under the Flexible Purchase Alternative were identified within the Yuba River Area of analysis. Impacts considered less than significant under the Flexible Purchase Alternative would also be considered less than significant for a lesser or identical transfer amount (the Fixed Purchase Alternative). Therefore impacts on fish species of primary management concern within the Yuba River Area of analysis with implementation of the Fixed Purchase Alternative are anticipated to be less than significant.

9.2.6.1.4 American River Area of Analysis

EWA acquisition of Placer County WA stored reservoir water would alter American River flows downstream of French Meadows Reservoir to Folsom Reservoir from June to October. EWA acquisition of Placer County WA stored reservoir water would alter American River *flows downstream of French Meadows and Hell Hole reservoirs to Folsom Reservoir during refill of Hell Hole and French Meadows reservoirs. EWA acquisition of Placer County WA stored reservoir water would alter surface water elevations from July until refill for French Meadows and Hell Hole reservoirs. EWA acquisition of Sacramento Groundwater Authority (SGA) water via groundwater purchase would alter summer surface water elevations at Folsom Reservoir. EWA acquisition of stored groundwater from SGA members, stored reservoir water, and water obtained through Placer County WA crop idling and retained in Folsom would alter lower American River flows, relative to the Baseline Condition*.

Under the Flexible Purchase Alternative, changes in Project and non-Project reservoir storage and water surface elevations are not anticipated to reduce the availability of littoral habitat for warmwater fish, increase the potential for nest dewatering events for warmwater fish, reduce the volume of the coldwater pool, or affect the primary prey species of coldwater fish. No significant impacts on reservoir fish species under the Flexible Purchase Alternative were identified. Impacts considered less than significant under the Flexible Purchase Alternative also would be considered less than significant for a lesser or identical transfer amount (the Fixed Purchase Alternative). Therefore impacts on warmwater and coldwater fish species within French Meadows, Hell Hole, and Folsom reservoirs with implementation of the Fixed Purchase Alternative are anticipated to be less than significant.

Under the Flexible Purchase Alternative, changes in lower American River flows and water temperatures would not be of sufficient frequency or magnitude to beneficially or adversely affect attraction or adult immigration of anadromous species, spawning habitat availability, egg incubation, initial rearing success, long-term initial year-class strength, or juvenile rearing and emigration of Chinook salmon, Central Valley steelhead, Sacramento splittail, striped bass, or American shad, as applicable. In addition, implementation of the Flexible Purchase Alternative would not result in a measurable increase in the frequency in which monthly mean water temperatures would exceed 65°F during the anadromous salmonid rearing period. Further, under the Flexible Purchase Alternative, there would be one additional occurrence below Nimbus Dam and one additional occurrence at Watt Avenue in which monthly mean water temperatures would exceed 56°F in October, relative to the Baseline Condition, during the anadromous salmonid spawning and egg incubation period.

Changes in Middle Fork American River flows under the Flexible Purchase Alternative would not result in adverse effects on resident fish species. Overall, habitat conditions would be expected to improve during summer months due to decreased variation in weekly flows, relative to the Baseline Condition, and reductions in flows that would occur in winter months would not be of sufficient frequency or magnitude to violate instream flow requirements and adversely affect aquatic resources. Therefore, impacts on Middle Fork American River fisheries resources would be less than significant, relative to the Baseline Condition.

No significant impacts on the fish species of primary management concern under the Flexible Purchase Alternative were identified within the American River Area of analysis. Impacts considered less than significant under the Flexible Purchase Alternative would also be considered less than significant for a lesser or identical transfer amount (the Fixed Purchase Alternative). Therefore impacts on fish species of primary management concern within the American River Area of analysis with implementation of the Fixed Purchase Alternative are anticipated to be less than significant.

9.2.6.1.5 San Joaquin River Area of Analysis

Various EWA acquisitions could potentially affect the hydrology of the Merced River and its associated reservoirs. EWA acquisition of MID water via groundwater substitution would alter Merced River flows. EWA acquisition of MID water via groundwater substitution would alter summer surface water elevations at Lake McClure.

Under the Flexible Purchase Alternative, changes in Lake McClure storage and water surface elevations are not anticipated to reduce the availability of littoral habitat for warmwater fish, increase the potential for nest dewatering events for warmwater fish, reduce the volume of the coldwater pool, or affect the primary prey species of coldwater fish. No significant impacts on reservoir fish species under the Flexible Purchase Alternative were identified. Impacts considered less than significant under the Flexible Purchase Alternative also would be considered less than significant for a lesser or identical transfer amount (the Fixed Purchase Alternative). Therefore impacts on warmwater and coldwater fish species in Lake McClure with implementation of the Fixed Purchase Alternative are anticipated to be less than significant.

Under the Flexible Purchase Alternative, changes in Merced River flows and would not be of sufficient frequency or magnitude to beneficially or adversely affect attraction or adult immigration of anadromous species, spawning habitat availability, egg incubation, initial rearing success, or juvenile rearing and emigration of Chinook salmon and striped bass, as applicable. No significant impacts on the fish species of primary management concern under the Flexible Purchase Alternative were identified within the Merced River. Impacts considered less than significant under the Flexible Purchase Alternative would also be considered less than significant for a lesser or identical transfer amount (the Fixed Purchase Alternative). Therefore impacts on fish species of primary management concern within the Merced River with implementation of the Fixed Purchase Alternative are anticipated to be less than significant.

EWA acquisition of MID water via groundwater substitution would alter San Joaquin River flows.

Under the Flexible Purchase Alternative, changes in San Joaquin River flows would not be of sufficient frequency or magnitude to beneficially or adversely affect attraction or adult immigration of anadromous species, spawning habitat availability, egg incubation, initial rearing success, or juvenile rearing and emigration of Chinook salmon, Central Valley steelhead, Sacramento splittail, striped bass, American shad, or delta smelt, as applicable.

No significant impacts on the fish species of primary management concern under the Flexible Purchase Alternative were identified within the San Joaquin River. Impacts considered less than significant under the Flexible Purchase Alternative would also be considered less than significant for a lesser or identical transfer amount (the Fixed Purchase Alternative). Therefore impacts on fish species of primary management concern within the San Joaquin River with implementation of the Fixed Purchase Alternative are anticipated to be less than significant.

9.2.6.2 Sacramento-San Joaquin Delta Region

Various EWA Actions could potentially affect habitat conditions (Delta outflow, the position of X_2, the export/inflow ratio, and the frequency and magnitude of reverse flows) within the Delta during the December through June period, as well as fish salvage at the CVP and SWP pumping plants.

Under the Flexible Purchase Alternative, the evaluation of potential impacts on Delta fisheries involves two study scenarios, including: 1) the Maximum Water Purchase Scenario; and 2) the Typical Water Purchase Scenario. Although the Maximum Water Purchase Scenario represents potential worst-case effects on fish resources upstream from the Delta, the Typical Water Purchase Scenario was developed to analyze a more likely representation of potential worst-case effects within the Delta. Attachment 1, Modeling Description, provides a more detailed discussion of the two scenarios, the modeling process, and in-Delta fishery benefits provided by the EWA Program.

With implementation of the Flexible Purchase Alternative under both the Maximum and Typical Water Purchase Scenarios, long-term average Delta outflow would increase, relative to the Baseline Condition, and monthly mean flows would be essentially equivalent to or greater than flows under the Baseline Condition. The monthly mean position of X_2 would move downstream or would not shift, relative to the Baseline Condition, under both the Maximum Water Purchase and Typical Water Purchase Scenarios. The monthly mean E/I ratio would be identical to or less than (a reduced proportion of exports, relative to inflow) the E/I ratio under the Baseline Condition in all of the months simulated for the February through June period, under both the Maximum Water Purchase and Typical Water Purchase Scenarios. Implementation of the Flexible Purchase Alternative under both the Maximum Water Purchase Scenario and Typical Water Purchase Scenario would provide a benefit to reverse flows, relative to the Baseline Condition, by decreasing the frequency of reverse flows and reducing the magnitude when reverse flows would still occur. Overall, such changes would be considered a benefit to juvenile salmonid emigration and the transport of planktonic eggs and larvae. Therefore, the habitat conditions resulting from implementation of the Flexible Purchase Alternative under both the

Maximum Water Purchase Scenario and Typical Water Purchase Scenario would result in beneficial impacts on fisheries resources in the Delta.

Annual salvage estimates for delta smelt, Chinook salmon, steelhead, and splittail exhibit a decrease in all 15 years simulated under the Typical Water Purchase Scenario, relative to the Baseline Condition. Under the Maximum Water Purchase Scenario, average annual Chinook salmon and steelhead salvage estimates would decrease in all 15 years simulated, and delta smelt and splittail salvage estimates would decrease in 14 out of the 15 years simulated. Striped bass salvage estimates would decrease in 8 of the 15 years simulated under the Maximum Water Purchase Scenario, and would decrease in 9 of the 15 years simulated under the Typical Water Purchase Scenario. Although there would be increases in salvage with implementation of the Flexible Purchase Alternative under both the Maximum Water Purchase and Typical Water Purchase Scenarios in individual months and in some years, annual salvage estimates for delta smelt, Chinook salmon, steelhead, splittail, and striped bass would decrease, relative to the Baseline Condition. Therefore, implementation of the Flexible Purchase Alternative under the Typical Water Purchase Scenario would result in overall beneficial impacts on Delta fisheries related to salvage at the SWP/CVP export facilities, relative to the Baseline Condition.

Total fish actions under the Fixed Purchase Alternative would be less than under the Flexible Purchase Alternative (for both the Maximum Water Purchase and Typical Water Purchase Scenarios), therefore benefits to fish from December through June would be less under the Fixed Purchase Alternative than the Flexible Purchase Alternative. Because the Fixed Purchase Alternative limits upstream from the Delta transfers to 35 TAF, export of this relatively small volume of water would likely result in fewer adverse impacts from water transfers during July through September than those occurring with implementation of the Flexible Purchase Alternative. Therefore, the qualitative conclusion is that the Fixed Purchase Alternative would provide fewer environmental benefits than the benefits resulting from implementation of the Flexible Purchase Alternative.

However, given that the majority of benefits provided by the EWA Program occur within the Delta due to export reductions to benefit fish, the process described below was used in an effort to reasonably approximate salvage-related impacts within the Delta with implementation of the Fixed Purchase Alternative.

It was estimated in the CALFED ROD that the average annual variable operational asset would be 70 TAF. (See CALFED Bay-Delta Program Record of Decision page 58.) For this analysis it is assumed that the available Fixed Purchase Alternative annual assets will total 255 TAF (185 + 70 = 255 TAF). Using the results from the Typical Water Purchase Scenario, the EWA benefits, measured in reduced fish salvaged at the CVP and SWP pumping plants during the December through June period, for the Fixed Water Purchase Alternative were calculated by multiplying the annual benefits during the December through June period under the Typical Water Purchase Scenario by 255 TAF and dividing it by the assets available or used in that year under the Typical Water Purchase Scenario. (See second column in Tables 9-70 through 9-74 below.) This calculation does not allow the ratio to exceed 1.0. The increase in fish salvage due to increased export of EWA water purchased from the Upstream from the Delta Region during the July through September period for the Fixed Water Purchase Alternative was calculated in a similar manner, using a ratio of 35 TAF divided by the amount of water exported under the Typical Water Purchase Scenario during that period. (See third column in Tables 9-70 through 9-74 below.) The results of the analysis using the above process to calculate the overall, net changes in fish salvage under the Fixed Water Purchase Alternative are shown in Tables 9-70 through 9-74.

The second column of Tables 9-70 through 9-74 shows the decrease in the number of fish salvaged under the Typical Water Purchase Scenario during December though June due to the reduction of available assets with implementation of the Fixed Purchase Alternative. The third column shows the decrease in the number of fish salvaged under the Typical Water Purchase Scenario during the July through the September period. The fourth column is the total of the first two columns. The fifth column is the total reduction in salvage calculated for the Typical Water Purchase Scenario. (See Section 9.2.4.2.2, Typical Water Purchase Scenario.) The sixth column is the reduction in fish salvage for the Fixed Water Purchase Alternative calculated by subtracting column four from column five.

Table 9-70
Chinook Salmon Salvage – Fixed Purchase Alternative

Year	*Dec-Jun*	*Jul-Sep*	*Net Change*	*Typical Water Purchase Scenario Annual Total*	*Fixed Purchase Alternative Annual Total*
1979	10,040	-1,305	8,735	-65,370	-56,635
1980	39,620	-445	39,175	-109,532	-70,357
1981	5,390	-10	5,380	-35,916	-30,536
1982	0	0	0	-103,945	-103,945
1983	0	0	0	-78,780	-78,780
1984	28,940	-115	28,825	-80,252	-51,427
1985	12,240	-15	12,225	-81,584	-69,359
1986	91,180	-715	90,465	-252,497	-162,032
1987	4,665	0	4,665	-31,120	-26,455
1988	0	-160	-160	-18,978	-19,138
1989	0	-5	-5	-9,753	-9,758
1990	0	0	0	-2,117	-2,117
1991	0	0	0	-10,581	-10,581
1992	0	0	0	-10,547	-10,547
1993	1,615	-15	1,600	-4,461	-2,861
Total	193,690	-2,785	190,905	-895,433	-704,528

Table 9-71 Splittail Salvage – Fixed Purchase Alternative					
Year	**Dec-Jun**	**Jul-Sep**	**Net Change**	**Typical Water Purchase Scenario Annual Total**	**Fixed Purchase Alternative Annual Total**
1979	2,425	-3,215	-790	-12,351	-13,141
1980	29,040	-2,185	26,855	-78,134	-51,279
1981	1,740	-10	1,730	-11,600	-9,870
1982	0	0	0	-6,365	-6,365
1983	0	0	0	-46,251	-46,251
1984	3,960	-9,285	-5,325	-75	-5,400
1985	1,560	-255	1,305	-9,925	-8,620
1986	156,125	-22,225	133,900	-409,257	-275,357
1987	8,475	-145	8,330	-56,332	-48,002
1988	0	-665	-665	-3,147	-3,812
1989	0	-525	-525	-3,815	-4,340
1990	0	-645	-645	-230	-875
1991	0	-470	-470	-7,539	-8,009
1992	0	-45	-45	-1,487	-1,532
1993	3,840	-580	3,260	-10,088	-6,828
Total	207,165	-40,250	166,915	-656,596	-489,681

Table 9-72 Delta Smelt Salvage – Fixed Purchase Alternative					
Year	**Dec-Jun**	**Jul-Sep**	**Net Change**	**Typical Water Purchase Scenario Annual Total**	**Fixed Purchase Alternative Annual Total**
1979	770	-2,235	-1,465	-2,489	-3,954
1980	5,995	-2,940	3,055	-13,121	-10,066
1981	3,990	-180	3,810	-26,355	-22,545
1982	0	0	0	-1,897	-1,897
1983	0	0	0	-2,458	-2,458
1984	1,535	-910	625	-3,496	-2,871
1985	1,185	-80	1,105	-7,765	-6,660
1986	270	-180	90	-561	-471
1987	1,705	-80	1,625	-11,279	-9,654
1988	0	-250	-250	-6,004	-6,254
1989	0	-390	-390	-543	-933
1990	0	-115	-115	-7,612	-7,727
1991	0	-1,810	-1,810	-1,582	-3,392
1992	0	0	0	-293	-293
1993	3,055	-220	2,835	-8,237	-5,402
Total	18,505	-9,390	9,115	-93,692	-84,577

Table 9-73 **Steelhead Salvage – Fixed Purchase Alternative**					
Year	***Dec-Jun***	***Jul-Sep***	***Net Change***	***Typical Water Purchase Scenario Annual Total***	***Fixed Purchase Alternative Annual Total***
1979	215	0	215	-1,428	-1,213
1980	390	0	390	-1,078	-688
1981	285	0	285	-1,903	-1,618
1982	0	0	0	-4,005	-4,005
1983	0	0	0	-887	-887
1984	65	0	65	-180	-115
1985	80	0	80	-532	-452
1986	265	0	265	-728	-463
1987	255	0	255	-1,695	-1,440
1988	0	0	0	-411	-411
1989	0	0	0	-1,573	-1,573
1990	0	0	0	-554	-554
1991	0	0	0	-1,224	-1,224
1992	0	0	0	-2,590	-2,590
1993	575	0	575	-1,597	-1,022
Total	2,130	0	2,130	-20,386	-18,255

Table 9-74 **Striped Bass Salvage – Fixed Purchase Alternative**					
Year	***Dec-Jun***	***Jul-Sep***	***Net Change***	***Typical Water Purchase Scenario Annual Total***	***Fixed Purchase Alternative Annual Total***
1979	50,955	-323,220	-272,265	36,142	-236,123
1980	386,345	-221,640	164,705	-815,454	-650,749
1981	121,305	-23,575	97,730	-775,017	-677,287
1982	0	0	0	-310,503	-310,503
1983	0	0	0	-53,238	-53,238
1984	477,485	-859,790	-382,305	-314,837	-697,142
1985	260,305	-43,735	216,570	-1,652,857	-1,436,287
1986	1,010,045	-255,920	754,125	6,616	760,741
1987	365,790	-25,725	340,065	-2,409,375	-2,069,310
1988	0	-370,825	-370,825	120,366	-250,459
1989	0	-120,310	-120,310	-1,350,455	-1,470,765
1990	0	-57,470	-57,470	-298,560	-356,030
1991	0	-67,250	-67,250	-276,432	-343,682
1992	0	-116,955	-116,955	75,195	-41,760
1993	334,970	-1,066,920	-731,950	310,131	-421,819
Total	3,007,200	-3,553,335	-546,135	-7,087,274	-7,633,409

The results of this analysis verify the above-stated qualitative conclusion, which indicates that the beneficial impacts resulting from implementation of the Fixed Purchase Alternative would be less than the benefits provided under the Typical Water Purchase Scenario. For each fish species analyzed, implementation of the Fixed Purchase Alternative would result in net salvage-related benefits in every year of the study period. For striped bass, these are some years when implementation of the

Fixed Purchase Alternative would not result in beneficial effects, however, the overall net reduction in fish salvage for the entire study period would be 7,633,409 striped bass. Therefore, implementation of the Fixed Purchase Alternative would result in less-than-significant impacts on fisheries and aquatic resources within the Sacramento-San Joaquin Delta Region.

9.2.6.3 Export Service Area

Borrowing EWA assets from San Luis Reservoir, Anderson Reservoir, Diamond Valley Lake, Castaic Lake, Lake Mathews, and Lake Perris via source shifting would not change the normal operating parameters of these reservoirs.

Under the Flexible Purchase Alternative, EWA acquisition of borrowed assets from San Luis Reservoir, Anderson Reservoir, and Diamond Valley Lake, Castaic Lake, Lake Mathews, and Lake Perris within the Export Service Area would have a less than significant impact on warmwater and coldwater fish species. (Refer to Section 9.2.5.3.1, Export Service Area Reservoirs.) Impacts considered less than significant under the Flexible Purchase Alternative would also be considered less than significant for a lesser or identical transfer amount (the Fixed Purchase Alternative). Therefore impacts on warmwater and coldwater fish species within the Export Service Area with implementation of the Fixed Purchase Alternative are anticipated to be less than significant.

9.2.7 Comparative Analysis of Alternatives

The Fixed Purchase Alternative would be limited to a maximum upstream from the Delta acquisition of 35 TAF, compared to the maximum 600 TAF of water that could be purchased under the Flexible Purchase Alternative. In addition, the Fixed Purchase Alternative limits export service area transfers to 150 TAF, whereas the Flexible Purchase Alternative does not specify transfer limits from the Upstream from the Delta Region or the Export Service Area. As discussed in Section 9.2.6, the impacts described in Section 9.2.5, Environmental Consequences/Environmental Impacts of the Flexible Purchase Alternative, represent the effects on fisheries and aquatic ecosystems for a maximum transfer amount (Maximum Water Purchase Scenario) within the Upstream from the Delta Region and Export Service Area, and for both the Maximum Water Purchase Scenario and Typical Water Purchase Scenario within the Delta Region. Impacts considered less than significant under the Flexible Purchase Alternative also would be considered less than significant for a lesser or identical transfer amount (the Fixed Purchase Alternative).

EWA agencies would prefer to purchase water from upstream sources because the water is generally less expensive. The amount that could be purchased would be limited by the excess capacity of the Delta export pumps to move the water to export areas south of the Delta. During wet years, excess pump capacity may be limited to as little as 50 to 60 TAF of EWA asset water because the pumps primarily would be used to export State and Federal Project water to Export Service Area users. During dry years, when there would be less Project water available for pumping (and therefore the pumps would have greater available capacity), the EWA Project Agencies could acquire up to 600 TAF of water from sources upstream from the Delta. Potential impacts on the Delta with the Flexible Purchase Alternative would vary depending on the water-year type, with more potential impacts occurring during wet years when more water is moved through the Delta.

EWA asset acquisition in the Export Service Area under the Flexible Purchase Alternative would be dependent on the water year type north of the Delta. Export pump capacity during wet years would limit the ability of the EWA Project Agencies to move assets through the Delta, requiring reliance on greater purchase amounts from Export Service Area sources. During wet years, acquisitions within the Export Service Area could involve up to 600 TAF of assets. The EWA agencies would acquire assets from stored groundwater and idled cropland sources. The EWA agencies would acquire less water from the Export Service Area during dry years, when most of the assets needed could be moved through the Delta. Moving stored groundwater into the California Aqueduct, therefore, would be less of a concern during dry years.

Table 9-75 summarizes and compares the potential impacts and level of significance relative to fisheries and aquatic ecosystems with implementation of the EWA program under both the Flexible Purchase Alternative and Fixed Purchase Alternative.

9.2.8 Mitigation Measures

The ASIP conservation measures presented in Section 9.2.3 have been developed to reduce effects on fisheries and aquatic resources to less than significant levels. No adverse effects on fisheries and aquatic resources are anticipated with implementation of the Flexible Purchase Alternative or Fixed Purchase Alternative for any of the acquisition types associated with the EWA Program. Consequently, no mitigation measures are proposed for fisheries and aquatic resources.

9.2.9 Potentially Significant Unavoidable Impacts

Within the EWA Action Area, no potentially significant impacts on fisheries and aquatic resources with implementation of the Flexible Purchase Alternative or Fixed Purchase Alternative were identified. Therefore, there are no potentially significant unavoidable impacts on fisheries and aquatic resources associated with implementation of the EWA Program.

9.2.10 Cumulative Effects

The analysis of potential cumulative impacts on fisheries and aquatic resources within the EWA Area of analysis is based on a discussion of potential impacts resulting from the comparative analysis of the Flexible Purchase Alternative and the cumulative condition. CALSIM II hydrologic modeling output (see Attachment 1, Modeling Description) for reservoir storage volumes, water surface elevations, and river flows were used as a baseline for the comparative analysis, which is discussed in detail in Section 9.2.5, Environmental Consequences/Environmental Impacts of the Flexible Purchase Alternative. The analysis includes an assessment of potential impacts on reservoir, riverine, and Delta fish species using the relative change in flows, reservoir

Table 9-75
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Summary and Comparison of Flexible Purchase Alternative and Fixed Purchase Alternative Impacts

Region	Area of Analysis	Asset Acquisition Type	Result	Potentially Affected Resource	Potential Effects	Flexible Alternative Change from Baseline	Fixed Alternative Change from Baseline	Significance of Flexible Purchase Alternative	Significance of Fixed Purchase Alternative
Upstream from the Delta Region	Sacramento River	Groundwater Substitution and Crop Idling	Seasonal changes in the timing of releases from Lake Shasta.	Shasta Reservoir warmwater fisheries	Reduction in the acreage of littoral habitat available for spawning and rearing; increase in the frequency of potential nest dewatering events.	Reductions in reservoir water surface elevation would not be of sufficient frequency or magnitude to result in substantial decreases in the availability of littoral habitat or substantial increases in the frequency of potential nest dewatering events.	Reductions in reservoir water surface elevation would not be of sufficient frequency or magnitude to result in substantial decreases in the availability of littoral habitat or substantial increases in the frequency of potential nest dewatering events.	Less-than-significant impact	Less-than-significant impact
				Shasta Reservoir coldwater fisheries	Reduction in coldwater habitat availability.	Reductions in reservoir storage would not be of sufficient frequency or magnitude to result in substantial changes in coldwater habitat availability.	Reductions in reservoir storage would not be of sufficient frequency or magnitude to result in substantial changes in coldwater habitat availability.	Less-than-significant impact	Less-than-significant impact
			Altered flows in the Sacramento River.	Sacramento River winter-run, spring-run, fall-run, and late fall-run Chinook salmon and steelhead	Decreases in flow or increases in water temperatures below and above, respectively, thresholds suitable for adult immigration, spawning, egg incubation, initial rearing, juvenile rearing, and juvenile emigration.	Changes in flows and water temperatures would not be of sufficient frequency or magnitude to adversely or beneficially affect winter-run, spring-run, fall-run, or late-fall-run Chinook salmon or steelhead adult immigration, spawning, egg incubation, and initial rearing, or juvenile rearing and emigration.	Changes in flows and water temperatures would not be of sufficient frequency or magnitude to adversely or beneficially affect winter-run, spring-run, fall-run, or late-fall-run Chinook salmon or steelhead adult immigration, spawning, egg incubation, and initial rearing, or juvenile rearing and emigration.	Less-than-significant impact	Less-than-significant impact

Table 9-75
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Summary and Comparison of Flexible Purchase Alternative and Fixed Purchase Alternative Impacts

Region	Area of Analysis	Asset Acquisition Type	Result	Potentially Affected Resource	Potential Effects	Flexible Alternative Change from Baseline	Fixed Alternative Change from Baseline	Significance of Flexible Purchase Alternative	Significance of Fixed Purchase Alternative
Upstream from the Delta Region (cont)	Sacramento River (cont)	Groundwater Substitution and Crop Idling (cont)	Altered flows in the Sacramento River (cont)	Sacramento River splittail	Decreases in flow or increases in water temperatures below and above, respectively, thresholds suitable for spawning.	Decreases in flows would not occur during the splittail spawning period, and increases in flows would not be of sufficient frequency or magnitude to beneficially or adversely affect the availability of splittail spawning habitat. There would be no substantial change in the frequency in which water temperatures would be within the reported preferred range for splittail spawning.	Decreases in flows would not occur during the splittail spawning period, and increases in flows would not be of sufficient frequency or magnitude to beneficially or adversely affect the availability of splittail spawning habitat. There would be no substantial change in the frequency in which water temperatures would be within the reported preferred range for splittail spawning.	Less-than-significant impact	Less-than-significant impact
				Sacramento River American shad	Decreases in flow or increases in water temperatures below and above, respectively, thresholds suitable for spawning.	Decreases in flows would not occur during the American shad spawning period of May through June; there would be no substantial change in the frequency in which Sacramento River water temperatures would be within the reported preferred range for American shad spawning.	Decreases in flows would not occur during the American shad spawning period of May through June; there would be no substantial change in the frequency in which Sacramento River water temperatures would be within the reported preferred range for American shad spawning.	Less-than-significant impact	Less-than-significant impact
				Sacramento River striped bass	Decreases in flow or increases in water temperatures below and above, respectively, thresholds suitable for spawning.	Decreases in flows would not occur during the striped bass spawning period of May through June; there would be no substantial change in the frequency in which Sacramento River water temperatures would be within the reported preferred range for striped bass spawning.	Decreases in flows would not occur during the striped bass spawning period of May through June; there would be no substantial change in the frequency in which Sacramento River water temperatures would be within the reported preferred range for striped bass spawning.	Less-than-significant impact	Less-than-significant impact

Table 9-75
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Summary and Comparison of Flexible Purchase Alternative and Fixed Purchase Alternative Impacts

Region	Area of Analysis	Asset Acquisition Type	Result	Potentially Affected Resource	Potential Effects	Flexible Alternative Change from Baseline	Fixed Alternative Change from Baseline	Significance of Flexible Purchase Alternative	Significance of Fixed Purchase Alternative
Upstream from the Delta Region (cont)	Sacramento River (cont)	Groundwater Substitution and Crop Idling (cont)	Decreased agricultural return flows in Butte Creek from July through September.	Butte Creek spring-run, fall-run, and late-fall-run Chinook salmon and steelhead	Reduction in adult holding and spawning or juvenile rearing habitat; decreases in flows during adult immigration or juvenile emigration for spring-run, fall-run, or late-fall-run Chinook salmon or steelhead.	Decreases in agricultural return flows to Butte Creek would occur downstream of holding, spawning, and rearing habitat for spring-run, fall-run, or late-fall-run Chinook salmon and steelhead (below the Western Canal Siphon); decreases in agricultural return flows would occur outside of the migration periods when adult or juvenile spring-run, fall-run, or late-fall-run Chinook salmon and steelhead would be present.	Decreases in agricultural return flows to Butte Creek would occur downstream of holding, spawning, and rearing habitat for spring-run, fall-run, or late-fall-run Chinook salmon and steelhead (below the Western Canal Siphon); decreases in agricultural return flows would occur outside of the migration periods when adult or juvenile spring-run, fall-run, or late-fall-run Chinook salmon and steelhead would be present.	Less-than-significant impact	Less-than-significant impact
				Butte Creek Sacramento splittail	Reduction in spawning habitat in the Sutter Bypass conveyance canals, if present.	Reductions in agricultural return flows would be expected to occur after the cessation of splittail spawning.	Reductions in agricultural return flows would be expected to occur after the cessation of splittail spawning.	Less-than-significant impact	Less-than-significant impact
	Feather River	Stored Reservoir Water Purchase	Additional water releases from Little Grass Valley and Sly Creek reservoirs.	Little Grass Valley and Sly Creek reservoirs warmwater fisheries	Reduction in the acreage of littoral habitat available for spawning and rearing; increase in the frequency of potential nest dewatering events.	Reductions in reservoir water surface elevation would not be of sufficient frequency or magnitude to result in substantial decreases in the availability of littoral habitat or substantial increases in the frequency of potential nest dewatering events.	Reductions in reservoir water surface elevation would not be of sufficient frequency or magnitude to result in substantial decreases in the availability of littoral habitat or substantial increases in the frequency of potential nest dewatering events.	Less-than-significant impact	Less-than-significant impact
				Little Grass Valley and Sly Creek reservoirs coldwater fisheries	Reduction in coldwater habitat availability.	Reductions in reservoir storage would not be of sufficient frequency or magnitude to result in substantial changes in coldwater habitat availability.	Reductions in reservoir storage would not be of sufficient frequency or magnitude to result in substantial changes in coldwater habitat availability.	Less-than-significant impact	Less-than-significant impact

Table 9-75
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Summary and Comparison of Flexible Purchase Alternative and Fixed Purchase Alternative Impacts

Region	Area of Analysis	Asset Acquisition Type	Result	Potentially Affected Resource	Potential Effects	Flexible Alternative Change from Baseline	Fixed Alternative Change from Baseline	Significance of Flexible Purchase Alternative	Significance of Fixed Purchase Alternative
Upstream from the Delta Region (cont)	Feather River (cont)	Groundwater Substitution, Crop Idling, and Stored Reservoir Water Purchase	Seasonal changes in the timing of releases and additional water releases from Oroville Reservoir.	Oroville Reservoir warmwater fisheries	Reduction in the acreage of littoral habitat available for spawning and rearing; increase in the frequency of potential nest dewatering events.	Reductions in reservoir water surface elevation would not be of sufficient frequency or magnitude to result in substantial decreases in the availability of littoral habitat or substantial increases in the frequency of potential nest dewatering events.	Reductions in reservoir water surface elevation would not be of sufficient frequency or magnitude to result in substantial decreases in the availability of littoral habitat or substantial increases in the frequency of potential nest dewatering events.	Less-than-significant impact	Less-than-significant impact
				Oroville Reservoir coldwater fisheries	Reduction in coldwater habitat availability.	Reductions in reservoir storage would not be of sufficient frequency or magnitude to result in substantial changes in coldwater habitat availability.	Reductions in reservoir storage would not be of sufficient frequency or magnitude to result in substantial changes in coldwater habitat availability.	Less-than-significant impact	Less-than-significant impact
			Altered flows in the lower Feather River.	Lower Feather River spring-run and fall-run Chinook salmon and steelhead	Decreases in flow or increases in water temperatures below and above, respectively, thresholds suitable for adult immigration, spawning, egg incubation, initial rearing, juvenile rearing, and juvenile emigration.	Changes in flows and water temperatures would not be of sufficient frequency or magnitude to adversely or beneficially affect spring-run or fall-run Chinook salmon or steelhead adult immigration, spawning, egg incubation, and initial rearing, or juvenile rearing and emigration.	Changes in flows and water temperatures would not be of sufficient frequency or magnitude to adversely or beneficially affect spring-run or fall-run Chinook salmon or steelhead adult immigration, spawning, egg incubation, and initial rearing, or juvenile rearing and emigration.	Less-than-significant impact	Less-than-significant impact

Table 9-75
Fisheries and Aquatic Ecosystems
Summary and Comparison of Flexible Purchase Alternative and Fixed Purchase Alternative Impacts

Region	Area of Analysis	Asset Acquisition Type	Result	Potentially Affected Resource	Potential Effects	Flexible Alternative Change from Baseline	Fixed Alternative Change from Baseline	Significance of Flexible Purchase Alternative	Significance of Fixed Purchase Alternative
Upstream from the Delta Region (cont)	Feather River (cont)	Groundwater Substitution, Crop Idling, and Stored Reservoir Water Purchase (cont)	Altered flows in the lower Feather River (cont).	Lower Feather River splittail	Decreases in flow or increases in water temperatures below and above, respectively, thresholds suitable for spawning.	Decreases or increases in flows and water temperatures would not be of sufficient frequency or magnitude to beneficially or adversely affect the availability of splittail spawning habitat or the frequency of water temperatures within the reported preferred range for splittail spawning.	Decreases or increases in flows and water temperatures would not be of sufficient frequency or magnitude to beneficially or adversely affect the availability of splittail spawning habitat or the frequency of water temperatures within the reported preferred range for splittail spawning.	Less-than-significant impact	Less-than-significant impact
				Lower Feather River American shad	Decreases in flow or increases in water temperatures below and above, respectively, thresholds suitable for spawning.	Decreases in flows would not occur during the American shad spawning period; increases in flows would not be of sufficient frequency or magnitude to beneficially affect the number of spawning American shad attracted into the lower Feather River; there would be no substantial change in the frequency of Sacramento River water temperatures within the reported preferred range for American shad spawning.	Decreases in flows would not occur during the American shad spawning period; increases in flows would not be of sufficient frequency or magnitude to beneficially affect the number of spawning American shad attracted into the lower Feather River; there would be no substantial change in the frequency of Sacramento River water temperatures within the reported preferred range for American shad spawning.	Less-than-significant impact	Less-than-significant impact

Table 9-75
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Summary and Comparison of Flexible Purchase Alternative and Fixed Purchase Alternative Impacts

Region	Area of Analysis	Asset Acquisition Type	Result	Potentially Affected Resource	Potential Effects	Flexible Alternative Change from Baseline	Fixed Alternative Change from Baseline	Significance of Flexible Purchase Alternative	Significance of Fixed Purchase Alternative
Upstream from the Delta Region (cont)	Feather River (cont)	Groundwater Substitution, Crop Idling, and Stored Reservoir Water Purchase (cont)	Altered flows in the lower Feather River (cont).	Lower Feather River striped bass	Decreases in flow or increases in water temperatures below and above, respectively, thresholds suitable for spawning.	Decreases in flows would not occur during the striped bass spawning period; increases in flows would not be of sufficient frequency or magnitude to beneficially affect striped bass spawning habitat; there would be no substantial change in the frequency of water temperatures within the reported preferred range for striped bass spawning.	Decreases in flows would not occur during the striped bass spawning period; increases in flows would not be of sufficient frequency or magnitude to beneficially affect striped bass spawning habitat; there would be no substantial change in the frequency of water temperatures within the reported preferred range for striped bass spawning.	Less-than-significant impact	Less-than-significant impact
	Yuba River	Stored Reservoir Water Purchase, Groundwater Substitution	Seasonal changes in releases and additional releases from New Bullards Bar Reservoir.	New Bullards Bar reservoir warmwater fisheries	Reduction in the acreage of littoral habitat available for spawning and rearing; increase in the frequency of potential nest dewatering events.	Reductions in reservoir water surface elevation would not be of sufficient frequency or magnitude to result in substantial decreases in the availability of littoral habitat or substantial increases in the frequency of potential nest dewatering events.	Reductions in reservoir water surface elevation would not be of sufficient frequency or magnitude to result in substantial decreases in the availability of littoral habitat or substantial increases in the frequency of potential nest dewatering events.	Less-than-significant impact	Less-than-significant impact
				New Bullards Bar coldwater fisheries	Reduction in coldwater habitat availability.	Reductions in reservoir storage would not be of sufficient frequency or magnitude to result in substantial changes in coldwater habitat availability.	Reductions in reservoir storage would not be of sufficient frequency or magnitude to result in substantial changes in coldwater habitat availability.	Less-than-significant impact	Less-than-significant impact

Table 9-75
Fisheries and Aquatic Ecosystems
Summary and Comparison of Flexible Purchase Alternative and Fixed Purchase Alternative Impacts

Region	Area of Analysis	Asset Acquisition Type	Result	Potentially Affected Resource	Potential Effects	Flexible Alternative Change from Baseline	Fixed Alternative Change from Baseline	Significance of Flexible Purchase Alternative	Significance of Fixed Purchase Alternative
Upstream from the Delta Region (cont)	Yuba River (cont)	Stored Reservoir Water Purchase, Groundwater Substitution (cont)	Increased Yuba River flows from July through September.	Yuba River spring-run and fall-run Chinook salmon and steelhead.	Increases in flow resulting in the non-volitional movement of juvenile steelhead and decreases in water temperatures resulting in the attraction of non-indigenous salmonids into the lower Yuba River.	Rate of flow increase would not be of sufficient frequency or magnitude to result in the attraction of non-indigenous salmonids into the lower Yuba River or the non-volitional movement of juvenile steelhead downstream of suitable rearing areas.	Rate of flow increase would not be of sufficient frequency or magnitude to result in the attraction of non-indigenous salmonids into the lower Yuba River or the non-volitional movement of juvenile steelhead downstream of suitable rearing areas.	Less-than-significant impact	Less-than-significant impact
	American River	Stored Reservoir Water Purchase, Stored Groundwater Purchase	Additional water releases from French Meadows and Hell Hole reservoirs.	French Meadows and Hell Hole reservoirs warmwater fisheries	Reduction in the acreage of littoral habitat available for spawning and rearing; increase in the frequency of potential nest dewatering events.	Reductions in reservoir water surface elevation would not be of sufficient frequency or magnitude to result in substantial decreases in the availability of littoral habitat or substantial increases in the frequency of potential nest dewatering events.	Reductions in reservoir water surface elevation would not be of sufficient frequency or magnitude to result in substantial decreases in the availability of littoral habitat or substantial increases in the frequency of potential nest dewatering events.	Less-than-significant impact	Less-than-significant impact
				French Meadows and Hell Hole reservoirs coldwater fisheries	Reduction in coldwater habitat availability.	Reductions in reservoir storage would not be of sufficient frequency or magnitude to result in substantial changes in coldwater habitat availability.	Reductions in reservoir storage would not be of sufficient frequency or magnitude to result in substantial changes in coldwater habitat availability.	Less-than-significant impact	Less-than-significant impact

Table 9-75
Fisheries and Aquatic Ecosystems
Summary and Comparison of Flexible Purchase Alternative and Fixed Purchase Alternative Impacts

Region	Area of Analysis	Asset Acquisition Type	Result	Potentially Affected Resource	Potential Effects	Flexible Alternative Change from Baseline	Fixed Alternative Change from Baseline	Significance of Flexible Purchase Alternative	Significance of Fixed Purchase Alternative
Upstream from the Delta Region (cont)	American River (cont)	Stored Reservoir Water Purchase, Stored Groundwater Purchase (cont)	Altered flows in the Middle Fork American River.	Middle Fork American River recreational fisheries	Decreases in flow.	Decreases in flow would not be of sufficient frequency or magnitude to result in violation of minimum instream flow requirements; increases and decreases in flows would not be of sufficient frequency or magnitude to adversely or beneficially affect aquatic insects, which serve as a forage base for recreational fish species in the Middle Fork American River.	Decreases in flow would not be of sufficient frequency or magnitude to result in violation of minimum instream flow requirements; increases and decreases in flows would not be of sufficient frequency or magnitude to adversely or beneficially affect aquatic insects, which serve as a forage base for recreational fish species in the Middle Fork American River.	Less-than-significant impact	Less-than-significant impact
			Seasonal changes in the timing of releases and additional water releases from Folsom Reservoir.	Folsom Reservoir warmwater fisheries	Reduction in the acreage of littoral habitat available for spawning and rearing; increase in the frequency of potential nest dewatering events.	Reductions in reservoir water surface elevation would not be of sufficient frequency or magnitude to result in substantial decreases in the availability of littoral habitat or substantial increases in the frequency of potential nest dewatering events.	Reductions in reservoir water surface elevation would not be of sufficient frequency or magnitude to result in substantial decreases in the availability of littoral habitat or substantial increases in the frequency of potential nest dewatering events.	Less-than-significant impact	Less-than-significant impact
				Folsom Reservoir coldwater fisheries	Reduction in coldwater habitat availability.	Reductions in reservoir storage would not be of sufficient frequency or magnitude to result in substantial changes in coldwater habitat availability.	Reductions in reservoir storage would not be of sufficient frequency or magnitude to result in substantial changes in coldwater habitat availability.	Less-than-significant impact	Less-than-significant impact

Table 9-75
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Summary and Comparison of Flexible Purchase Alternative and Fixed Purchase Alternative Impacts

Region	*Area of Analysis*	*Asset Acquisition Type*	*Result*	*Potentially Affected Resource*	*Potential Effects*	*Flexible Alternative Change from Baseline*	*Fixed Alternative Change from Baseline*	*Significance of Flexible Purchase Alternative*	*Significance of Fixed Purchase Alternative*
Upstream from the Delta Region (cont)	American River (cont)	Stored Reservoir Water Purchase, Stored Groundwater Purchase (cont)	Altered flows in the lower American River.	Lake Natoma coldwater fisheries	Increases in water temperatures.	Changes in releases from Nimbus Dam would not be of sufficient frequency or magnitude to result in water temperature increases of sufficient frequency or magnitude to adversely impact reservoir coldwater fisheries.	Changes in releases from Nimbus Dam would not be of sufficient frequency or magnitude to result in water temperature increases of sufficient frequency or magnitude to adversely impact reservoir coldwater fisheries.	Less-than-significant impact	Less-than-significant impact
				Nimbus Hatchery	Increases in water temperatures.	Changes in releases from Nimbus Dam would not be of sufficient frequency or magnitude to result in water temperature increases that would adversely impact hatchery operations.	Changes in releases from Nimbus Dam would not be of sufficient frequency or magnitude to result in water temperature increases that would adversely impact hatchery operations.	Less-than-significant impact	Less-than-significant impact
				Lower American River fall-run Chinook salmon and steelhead	Decreases in flow or increases in water temperatures below and above, respectively, thresholds suitable for adult immigration, spawning, egg incubation, initial rearing, juvenile rearing, and juvenile emigration.	Changes in flows and water temperatures would not be of sufficient frequency or magnitude to adversely or beneficially affect fall-run Chinook salmon or steelhead adult immigration, spawning, egg incubation, and initial rearing, or juvenile rearing and emigration.	Changes in flows and water temperatures would not be of sufficient frequency or magnitude to adversely or beneficially affect fall-run Chinook salmon or steelhead adult immigration, spawning, egg incubation, and initial rearing, or juvenile rearing and emigration.	Less-than-significant impact	Less-than-significant impact

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Region	Area of Analysis	Asset Acquisition Type	Result	Potentially Affected Resource	Potential Effects	Flexible Alternative Change from Baseline	Fixed Alternative Change from Baseline	Significance of Flexible Purchase Alternative	Significance of Fixed Purchase Alternative
Upstream from the Delta Region (cont)	American River (cont)	Stored Reservoir Water Purchase, Stored Groundwater Purchase (cont)	Altered flows in the lower American River (cont).	Lower American River splittail	Decreases in the availability of splittail spawning habitat or increases in water temperatures below and above, respectively, thresholds suitable for spawning.	There would be no reduction in the availability of submerged vegetation utilized for splittail spawning habitat; there would be no substantial change in frequency of water temperatures within the reported preferred range for splittail spawning.	There would be no reduction in the availability of submerged vegetation utilized for splittail spawning habitat; there would be no substantial change in frequency of water temperatures within the reported preferred range for splittail spawning.	Less-than-significant impact	Less-than-significant impact
				Lower American River American shad	Decreases in flow or increases in water temperatures below and above, respectively, thresholds suitable for spawning.	There would be no decreases in flows during the May through June American shad spawning period, and no change in the frequency of flows above recommended levels to maintain the American shad sport fishery; there would be no decrease in the frequency of water temperatures within the reported preferred range for American shad spawning.	There would be no decreases in flows during the May through June American shad spawning period, and no change in the frequency of flows above recommended levels to maintain the American shad sport fishery; there would be no decrease in the frequency of water temperatures within the reported preferred range for American shad spawning.	Less-than-significant impact	Less-than-significant impact
			Altered flows in the lower American River (cont)	Lower American River striped bass	Decreases in flow or increases in water temperatures below and above, respectively, thresholds suitable for spawning.	There would be no decreases in flows during the May through June striped bass spawning period, and no change in the frequency of flows above recommended levels to maintain the sport fishery for striped bass; there would be no decrease in the frequency of water temperatures within the reported preferred range for striped bass spawning.	There would be no decreases in flows during the May through June striped bass spawning period, and no change in the frequency of flows above recommended levels to maintain the sport fishery for striped bass; there would be no decrease in the frequency of water temperatures within the reported preferred range for striped bass spawning.	Less-than-significant impact	Less-than-significant impact

Table 9-75
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Summary and Comparison of Flexible Purchase Alternative and Fixed Purchase Alternative Impacts

Region	Area of Analysis	Asset Acquisition Type	Result	Potentially Affected Resource	Potential Effects	Flexible Alternative Change from Baseline	Fixed Alternative Change from Baseline	Significance of Flexible Purchase Alternative	Significance of Fixed Purchase Alternative
Upstream from the Delta Region (cont)	Merced and San Joaquin Rivers	Stored Groundwater Purchase	Seasonal changes in the timing of releases from Lake McClure.	Lake McClure warmwater fisheries	Reduction in the acreage of littoral habitat available for spawning and rearing; increase in the frequency of potential nest dewatering events.	There would be no reductions in reservoir water surface elevation; increases in reservoir water surface elevation would not be of sufficient frequency or magnitude to result in substantial changes in the availability of littoral habitat; changes in the rate of drawdown would not be likely to result in a change in the frequency of potential nest dewatering events.	There would be no reductions in reservoir water surface elevation; increases in reservoir water surface elevation would not be of sufficient frequency or magnitude to result in substantial changes in the availability of littoral habitat; changes in the rate of drawdown would not be likely to result in a change in the frequency of potential nest dewatering events.	Less-than-significant impact	Less-than-significant impact
				Lake McClure coldwater fisheries	Reduction in coldwater habitat availability.	There would be no reduction in reservoir storage, and therefore, no reduction in coldwater habitat availability.	There would be no reduction in reservoir storage, and therefore, no reduction in coldwater habitat availability.	Less-than-significant impact	Less-than-significant impact
			Altered flows in the Merced River.	Merced River fall-run Chinook salmon	Decreases in flow of sufficient frequency or magnitude to result in adverse effects on adult immigration, spawning, egg incubation, initial rearing, juvenile rearing, and juvenile emigration.	Flows would not decrease during any month of the year; increases in flows may represent a beneficial effect to adult fall-run Chinook salmon immigration, and would not be of sufficient frequency or magnitude to result in adverse or beneficial effects on adult fall-run Chinook salmon spawning, egg incubation, and initial rearing; there would be no change in flows during the juvenile fall-run Chinook salmon rearing and emigration period.	Flows would not decrease during any month of the year; increases in flows may represent a beneficial effect to adult fall-run Chinook salmon immigration, and would not be of sufficient frequency or magnitude to result in adverse or beneficial effects on adult fall-run Chinook salmon spawning, egg incubation, and initial rearing; there would be no change in flows during the juvenile fall-run Chinook salmon rearing and emigration period.	Less-than-significant impact	Less-than-significant impact

Table 9-75
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Summary and Comparison of Flexible Purchase Alternative and Fixed Purchase Alternative Impacts

Region	Area of Analysis	Asset Acquisition Type	Result	Potentially Affected Resource	Potential Effects	Flexible Alternative Change from Baseline	Fixed Alternative Change from Baseline	Significance of Flexible Purchase Alternative	Significance of Fixed Purchase Alternative
Upstream from the Delta Region (cont)	Merced and San Joaquin Rivers (cont)	Stored Groundwater Purchase (cont)	Altered flows in the Merced River (cont)	Merced River striped bass	Changes in flow affecting spawning.	No changes in flow would occur during the striped bass spawning period of May through June.	No changes in flow would occur during the striped bass spawning period of May through June.	Less-than-significant impact	Less-than-significant impact
			Altered flows in the San Joaquin River	San Joaquin River fall-run Chinook salmon and steelhead	Decreases in flow of sufficient frequency or magnitude to result in adverse effects on adult immigration, spawning, egg incubation, initial rearing, juvenile rearing, and juvenile emigration.	Flows would not decrease during any month of the year; increases in flows may represent a beneficial effect to adult fall-run Chinook salmon and steelhead immigration, and would not be of sufficient frequency or magnitude to adversely or beneficially affect adult fall-run Chinook salmon or steelhead spawning, egg incubation, and initial rearing; there would be no change in flows during the juvenile fall-run Chinook salmon rearing and emigration or juvenile steelhead over-summer and fall/winter rearing periods.	Flows would not decrease during any month of the year; increases in flows may represent a beneficial effect to adult fall-run Chinook salmon and steelhead immigration, and would not be of sufficient frequency or magnitude to adversely or beneficially affect adult fall-run Chinook salmon or steelhead spawning, egg incubation, and initial rearing; there would be no change in flows during the juvenile fall-run Chinook salmon rearing and emigration or juvenile steelhead over-summer and fall/winter rearing periods.	Less-than-significant impact	Less-than-significant impact
				San Joaquin River Sacramento splittail	Changes in flow affecting the availability of spawning habitat.	No changes in flow would occur during the splittail spawning period of February through May.	No changes in flow would occur during the splittail spawning period of February through May.	Less-than-significant impact	Less-than-significant impact
				San Joaquin River delta smelt	Changes in flow affecting spawning.	No changes in flow would occur during the delta smelt spawning period of January through June.	No changes in flow would occur during the delta smelt spawning period of January through June.	Less-than-significant impact	Less-than-significant impact

Table 9-75
Fisheries and Aquatic Ecosystems
Summary and Comparison of Flexible Purchase Alternative and Fixed Purchase Alternative Impacts

Region	Area of Analysis	Asset Acquisition Type	Result	Potentially Affected Resource	Potential Effects	Flexible Alternative Change from Baseline	Fixed Alternative Change from Baseline	Significance of Flexible Purchase Alternative	Significance of Fixed Purchase Alternative
Upstream from the Delta Region (cont)	Merced and San Joaquin Rivers (cont)	Stored Groundwater Purchase (cont)	Altered flows in the San Joaquin River (cont).	San Joaquin River striped bass	Changes in flow affecting spawning.	No changes in flow would occur during the striped bass spawning period of May through June.	No changes in flow would occur during the striped bass spawning period of May through June.	Less-than-significant impact	Less-than-significant impact
				San Joaquin River American shad	Changes in flow affecting spawning.	No changes in flow would occur during the American shad spawning period of May through June.	No changes in flow would occur during the American shad spawning period of May through June.	Less-than-significant impact	Less-than-significant impact
Sacramento-San Joaquin Delta Region	Sacramento-San Joaquin Delta	Crop Idling, Groundwater Substitution, Stored Groundwater Purchase, Stored Reservoir Water Purchase	Increased salvage at the CVP and SWP salvage facilities.	Chinook salmon	Increases in the annual number of Chinook salmon captured at the CVP and SWP fish salvage facilities.	Annual Chinook salmon salvage would decrease; long-term average annual Chinook salmon salvage would decrease; there would be isolated monthly increases in salvage, which would not be of sufficient frequency or magnitude to result in annual increases in salvage in any year.	Annual Chinook salmon salvage would decrease; there would be isolated monthly increases in salvage, which would not be of sufficient frequency or magnitude to result in annual increases in salvage in any year.	Beneficial impact	Beneficial impact
				Steelhead	Increases in the annual number of steelhead captured at the CVP and SWP fish salvage facilities.	Annual steelhead salvage would decrease in 15 of 15 years simulated; long-term average annual steelhead salvage would decrease; there would be isolated monthly increases in salvage, which would not be of sufficient frequency or magnitude to result in annual increases in salvage in any year.	Annual steelhead salvage would decrease; there would be isolated monthly increase in salvage, which would not be of sufficient frequency or magnitude to result in annual increases in salvage in any year.	Beneficial impact	Beneficial impact

Table 9-75
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Summary and Comparison of Flexible Purchase Alternative and Fixed Purchase Alternative Impacts

Region	Area of Analysis	Asset Acquisition Type	Result	Potentially Affected Resource	Potential Effects	Flexible Alternative Change from Baseline	Fixed Alternative Change from Baseline	Significance of Flexible Purchase Alternative	Significance of Fixed Purchase Alternative
Sacramento-San Joaquin Delta Region (cont)	Sacramento-San Joaquin Delta (cont)	Crop Idling, Groundwater Substitution, Stored Groundwater Purchase, Stored Reservoir Water Purchase (cont)	Increased salvage at the CVP and SWP salvage facilities (cont)	Delta smelt	Increases in the annual number of delta smelt captured at the CVP and SWP fish salvage facilities.	Annual delta smelt salvage would decrease in 15 of 15 years simulated; long-term average annual delta smelt salvage would decrease; isolated monthly increases in salvage would be avoided through the real-time implementation of avoidance measures to reduce pumping.	Annual delta smelt salvage would decrease; isolated monthly increases in salvage would be avoided through the real-time implementation of avoidance measures to reduce pumping.	Beneficial impact	Beneficial impact
				Sacramento splittail	Increases in the annual number of splittail captured at the CVP and SWP fish salvage facilities.	Annual splittail salvage would decrease in 14 of 15 years simulated; long-term average annual splittail salvage would decrease; there would be isolated monthly increases in salvage, which would not be of sufficient frequency or magnitude to result in overall annual increases in salvage in more than one year.	Annual splittail salvage would decrease; there would be isolated monthly increases in salvage, which would not be of sufficient frequency or magnitude to result in annual increases in salvage in any year.	Beneficial impact	Beneficial impact
				Striped bass	Increases in the long-term average annual number of striped bass captured at the CVP and SWP fish salvage facilities.	Monthly and annual increases in striped bass salvage would occur, however long-term average annual striped bass salvage would decrease.	Monthly and annual increases in striped bass salvage may occur, however long-term average annual striped bass salvage would decrease.	Less-than-significant impact	Less-than-significant impact

Table 9-75
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Summary and Comparison of Flexible Purchase Alternative and Fixed Purchase Alternative Impacts

Region	Area of Analysis	Asset Acquisition Type	Result	Potentially Affected Resource	Potential Effects	Flexible Alternative Change from Baseline	Fixed Alternative Change from Baseline	Significance of Flexible Purchase Alternative	Significance of Fixed Purchase Alternative
Sacramento-San Joaquin Delta Region (cont)	Sacramento-San Joaquin Delta (cont)	Crop Idling, Groundwater Substitution, Stored Groundwater Purchase, Stored Reservoir Water Purchase (cont)	Seasonal changes in the timing of Delta inflow.	Delta aquatic habitats	Decreases in Delta outflow during the February through June period.	Decreases in Delta outflow would not occur during the February through June period believed to be important for rearing and transport of juvenile fish species in the Delta.	Decreases in Delta outflow would not occur during the February through June period believed to be important for rearing and transport of juvenile fish species in the Delta.	Beneficial impact	Potentially beneficial impact
					Changes in position of X2 during the February through June period.	The position of X2 would move downstream or would not shift during the February through June period.	The position of X2 would move downstream or would not shift during the February through June period.	Beneficial impact	Potentially beneficial impact
					Changes in Delta Export/Inflow (E/I) ratio during the February through June period.	Current E/I standards would not be exceeded; use of the relaxation of E/I only would occur if the Management Agencies determine that the risk to sensitive species would be low.	Current E/I standards would not be exceeded; use of the relaxation of E/I only would occur if the Management Agencies determine that the risk to sensitive species would be low.	Beneficial impact	Potentially beneficial impact
					Changes in the frequency and magnitude of reverse flows (QWEST) during the February through June period.	There would be reductions in the frequency and magnitude of reverse flows across all flow ranges, resulting in a potentially beneficial effect to survival of planktonic fish eggs and larvae and downstream migrating juvenile Chinook salmon smolts.	There would be reductions in the frequency and magnitude of reverse flows across all flow ranges, resulting in a potentially beneficial effect to survival of planktonic fish eggs and larvae and downstream migrating juvenile Chinook salmon smolts.	Beneficial impact.	Potentially beneficial impact.

Table 9-75
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Summary and Comparison of Flexible Purchase Alternative and Fixed Purchase Alternative Impacts

Region	Area of Analysis	Asset Acquisition Type	Result	Potentially Affected Resource	Potential Effects	Flexible Alternative Change from Baseline	Fixed Alternative Change from Baseline	Significance of Flexible Purchase Alternative	Significance of Fixed Purchase Alternative
Export Service Area	Export Service Area Reservoirs	Source Shifting/All Acquisition Types	Seasonal changes in reservoir water surface elevations.	San Luis and Anderson reservoirs warmwater fisheries	Reduction in the acreage of littoral habitat available for spawning and rearing; increase in the frequency of potential nest dewatering events.	Reductions in reservoir water surface elevation would not be of sufficient frequency or magnitude to result in substantial decreases in the availability of littoral habitat or substantial increases in the frequency of potential nest dewatering events.	Reductions in reservoir water surface elevation would not be of sufficient frequency or magnitude to result in substantial decreases in the availability of littoral habitat or substantial increases in the frequency of potential nest dewatering events.	Less-than-significant impact	Less-than-significant impact
				Castaic Lake and Lake Perris warmwater fisheries	Reduction in the acreage of littoral habitat available for spawning and rearing; increase in the frequency of potential nest dewatering events.	Reductions in reservoir water surface elevation would not be of sufficient frequency or magnitude to result in substantial decreases in the availability of littoral habitat or substantial increases in the frequency of potential nest dewatering events.	Reductions in reservoir water surface elevation would not be of sufficient frequency or magnitude to result in substantial decreases in the availability of littoral habitat or substantial increases in the frequency of potential nest dewatering events.	Less-than-significant impact	Less-than-significant impact

storage and water surface elevation, water temperatures, and various Delta parameters as impact indicators. The following sections discuss the manner in which these indicators may or may not be affected under the cumulative condition.

Within the Upstream from the Delta Region, all five programs (Sacramento Valley Water Management Agreement, Dry Year Purchase Program, Drought Risk Reduction Investment Program (DRRIP), CVPIA Water Acquisition Program, and Environmental Water Program) have the potential to acquire water from the same potential water sources as the EWA. The analysis performed for the Flexible Purchase Alternative was designed to maximize the utilization of available export capacity of Delta facilities, which is the limiting constraint on transfers for these programs. As a result, implementation of one or more of these programs in conjunction with the EWA will alter the beneficiary of the transferred water, but the total supply of water from upstream sources would not be any greater than that analyzed for the Flexible Purchase Alternative. Because transfers under other programs are managed during the same time periods evaluated for the management of EWA assets, these increases or decreases in flows would not be expected to change, relative to levels identified under the Flexible Purchase Alternative.

Water surface elevation and end-of-month storage levels would not be reduced further than those analyzed for the Flexible Purchase Alternative. Thus, reservoir operations under the EWA cumulative condition would not be expected to differ substantially from the conditions described in Section 9.2.5, Environmental Consequences/Environmental Impacts of the Flexible Purchase Alternative, and, therefore, cumulative impacts on reservoir warmwater and coldwater fisheries would be less than significant. Similarly, changes in flows and water temperatures in rivers potentially affected by the EWA cumulative condition also would be similar to those analyzed for the Flexible Purchase Alternative and, therefore, represent less-than-significant cumulative impacts on riverine fishes and their habitats.

In the Delta, potential impacts of the Flexible Purchase Alternative were determined by conducting an analysis based on the maximum utilization of available export capacity of Delta facilities (Maximum Water Purchase Scenario), which is the limiting constraint on transfers for the five programs discussed above, including the EWA Program. Consequently, implementation of one or more of these programs in conjunction with the EWA would not result in additional water conveyed through the CVP and SWP pumping facilities. As described in Chapter 2, water transfers occurring through the Delta under the EWA Program would facilitate associated export reductions to benefit in-Delta aquatic resources. More benefits to fish would be derived from reducing exports from the Delta at key times for fish (EWA actions) than adverse impacts caused by a similar amount of increased export pumping to move the acquired water when fish are not as abundant. Most fish benefits (decreased fish salvage and improved in-Delta aquatic habitat conditions) are provided by the cumulative condition when the Delta pumping capacity for the transfers is utilized by the EWA Program. When some of the transferred water is for a consumptive user within the Export Service Area instead of as part of the EWA Program, there would be no export reductions with that water to benefit fish. A reduction in the volume of water transferred by the EWA Program under the EWA cumulative condition (as would occur under the Typical Water Purchase Scenario) would result in correspondingly fewer overall benefits to in-Delta aquatic habitat and fish salvage than those provided by the EWA cumulative condition under the Maximum Water Purchase Scenario.

The DRIPP, CVPIA Water Acquisition Program, and the EWA Program would operate in the Export Service Area under the EWA cumulative condition. Stored reservoir water is not available for purchase from San Luis, Anderson, Castaic, Perris, Mathews, and Diamond Valley reservoirs in the Export Service Area. In addition, source shifting would only occur under the EWA Program. Source shifting is not likely to occur in dry or below normal years since capacity is not limiting. Sources shifting would occur in wet or above normal years when capacity is limiting. (See Chapter 2, Alternatives, Including the Proposed Action/Proposed Project.)

Source shifting would not be expected to result in reservoir water surface elevations in San Luis, Anderson, Castaic, Perris, Mathews, and Diamond Valley reservoirs lower than those reached under the Baseline Condition. Thus, there would be no reduction in the quantity of littoral habitat available for warmwater fish spawning, and no increase in the frequency of potential nest dewatering events, relative to those levels analyzed under the Flexible Purchase Alternative. Therefore, potential cumulative impacts resulting from implementation of the Flexible Purchase Alternative in the Export Service Area would be less than significant.

As discussed in Section 9.2.6, Environmental Consequences/Environmental Impacts of the Fixed Purchase Alternative, the Fixed Purchase Alternative would involve the same actions as the Flexible Purchase Alternative, but to a lesser degree. Potential cumulative impacts on fisheries and aquatic resources resulting from implementation of the Flexible Purchase Alternative would be less than significant. Therefore potential cumulative impacts on fisheries and aquatic resources resulting from implementation of a lesser transfer amount (the Fixed Purchase Alternative) would also be less than significant.

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