Chapter 11 Fisheries and Aquatic Ecosystems

11.1 Affected Environment

This section describes the affected environment related to fisheries and aquatic ecosystems for the dam and reservoir modifications proposed under SLWRI action alternatives. For a more in-depth description of the affected environment, see the *Fisheries and Aquatic Ecosystems Technical Report*.

11.1.1 Aquatic Habitat

Shasta Lake and Vicinity

Water resources development, including the construction of dams and diversions, has affected the hydrology, geomorphology, and ecology of the watershed. Before the construction of Shasta Dam, the Sacramento River typically experienced large fluctuations in flow driven by winter storms, with late-summer flows averaging 3,000 cubic feet per second (cfs) or less. These fluctuations and periodic flows moved large amounts of sediment and gravel out of the mountainous tributaries and down the Sacramento River. The completion of Shasta Dam in 1945 resulted in general dampening of historic high and low flows, reducing the timing, magnitude, and duration of winter floods while maintaining higher summer flows between 7,000 and 13,000 cfs. The annual volume of flow in the Sacramento River continues to vary significantly from year to year. However, average monthly flows following the construction of Shasta Dam no longer exhibit pronounced seasonal winter highs and summer lows. This is primarily because of winter flood control operations that have reduced peak flood flows, and summer releases made for water supply purposes.

The current composition and distribution of fish species inhabiting the study area reflect habitat conditions, the historic fishery, the operational effects of Shasta Dam, effects of dams on several of the upstream tributaries, and the introduction of nonnative species.

The distribution and productivity of organisms and aquatic habitats of Shasta Lake are greatly affected by the reservoir’s dynamic seasonal surface elevation fluctuations and thermal stratification. The reservoir’s flood control, water storage, and water delivery operations typically result in declining water elevations during the summer through the fall months, rising or stable elevations during the winter months, and rising elevations during the spring months and sometimes into the early-summer months, while storing precipitation and snowmelt runoff. During summer months, the relatively warm surface layer within the lake favors warm-water fishes such as bass and catfish. Deeper layers are cooler and are suitable for cold-water species. Shasta Lake is classified as a cool-water, mesotrophic, monomictic reservoir because it is moderately productive and has one period of mixing each year, although it never completely turns over (Bartholow et al. 2001). Shasta Lake tributary fish species comprise several native and nonnative species and have been managed to favor naturally produced ("wild") and stocked (hatchery-cultured) native and nonnative trout species (Rode 1989, Moyle 2002, Rode and Dean 2004). Major assemblages of non-fish aquatic animal species include benthic macroinvertebrates and zooplankton communities. Climate conditions and reservoir storage volume are the two most influential factors affecting cold-water habitat and primary productivity in Shasta Lake (Bartholow et al. 2001). Cold-water habitat provided by Shasta Lake is a function of the total storage and associated surface area provided by Shasta Lake. This relationship is influenced by variation in the water surface elevation (WSEL) throughout the year. Variation in WSEL is a function of water demand, water quality requirements, and inflow, and WSEL can change based on the water year type.[1] Typically, primary production in reservoirs is associated with storage volumes when all other factors are held constant (Stables et al. 1990). Increased storage and the corresponding increase in surface area results in a greater total biomass and a greater abundance of plankton and fish, because available habitat area is increased.

Upper Sacramento River (Shasta Dam to Red Bluff)

The reach of the Sacramento River between Shasta Dam and Red Bluff has cool water temperatures because releases from Shasta and Keswick dams are regulated, and because the channel is stable and largely confined, with little meander. Riffle habitat with gravel substrates and deep pool habitats are more abundant than in reaches downstream, although they are still insufficient to support healthy salmonid populations. Immediately below Keswick Dam, the river is deeply incised in bedrock, with very limited riparian vegetation and limited functioning riparian ecosystems. Water temperatures are generally cool even in late summer because of the regulated dam releases. The reaches of the Sacramento River immediately downstream from Shasta Dam support populations of resident rainbow trout and other resident fish while the reach immediately downstream from Keswick Dam supports an abundant resident rainbow trout population, other resident fish, and provides holding habitat, spawning habitat, and juvenile rearing habitat for Chinook salmon and steelhead.

Near Redding, the river flows into the valley and the floodplain broadens. Historically, this area appears to have had wide expanses of riparian forests, but

[1] Throughout this document, water year types are defined according to the Sacramento Valley Index Water Year Hydrologic Classification unless specified otherwise.

much of the river's riparian zone is currently subject to urban encroachment and noxious-weed problems. This encroachment becomes quite extensive in the Anderson/Redding area, with homes placed directly within or adjacent to the riparian zone.

Despite net losses of gravel since construction of Shasta Dam, substrates in much of this reach contain gravel needed for spawning by salmonids. This gravel is derived mostly from the Central Valley Project Improvement Act (CVPIA) gravel augmentation program. This reach provides much of the remaining spawning and rearing habitat of several listed anadromous salmonids (i.e., species that spawn in freshwater after migrating as adults from marine habitat). The Livingston Stone Hatchery, located immediately downstream from Shasta Dam produces winter-run Chinook salmon while the Coleman National Fish Hatchery, located on Battle Creek at tributary to the Sacramento River downstream from Keswick Dam, produces both Chinook salmon and steelhead. The reach of the Sacramento River downstream from Keswick Dam provides spawning and juvenile rearing habitat for winter-run, spring-run, fall-run, and late fall-run Chinook salmon and Central Valley steelhead. For this reason, the Sacramento River between Shasta Dam and Red Bluff is one of the most sensitive and important stream reaches in California.

Three water control structures – Keswick Dam, the Anderson-Cottonwood Irrigation District Dam, and Red Bluff Pumping Plant (RBPP) – are located along the Sacramento River in this reach. Currently, revisions have been or are being made at RBPP to improve fish, including construction of a state-of-the-art positive barrier fish screen that will allow the Red Bluff Diversion Dam gates to remain open most of the year to facilitate upstream and downstream passage by adult and juvenile Chinook salmon, steelhead, sturgeon, and other fish. A temperature control structure has been installed at Shasta Dam to improve cold-water pool management for salmonids spawning and rearing in the main stem river downstream from Keswick Dam. Instream flow regulation to meet habitat requirements and seasonal water temperatures for salmonids and other fish, flood control, and water supply deliveries are controlled primarily through managed releases of water from Shasta Dam that subsequently pass downstream through Keswick Dam into the main stem Sacramento River.

The main tributaries to the Sacramento River between Shasta Dam and Red Bluff are Battle, Bear, Clear, Cow, and Cottonwood creeks. The primary land uses along the Sacramento River between Shasta Dam and RBPP are urban, residential, and agricultural.

Lower Sacramento River and Delta

The roughly 300 miles of the Sacramento River can be subdivided into distinct reaches. The reaches in the lower Sacramento River and Delta area are discussed separately because of differences in morphology, water temperature, and aquatic habitat functions.

Sacramento River from Red Bluff to Colusa In this reach, the Sacramento River functions as a large alluvial river with active meander migration through the valley floor. The river is classified as a meandering river, where relatively stable, straight sections alternate with more sinuous, dynamic sections (Resources Agency 2003). The active channel is fairly wide in some stretches and the river splits into multiple braided channels at many different locations, creating gravel islands, often with riparian vegetation. Historic bends in the river are visible throughout this reach and appear as scars of the historic channel locations; the riparian corridor and oxbow lakes are still present in many locations. The channel remains active and has the potential to migrate during times of high water. Point bars, islands, high and low terraces, instream woody cover, growth of early successional riparian plants, and other evidence of river meander and erosion are common in this reach. The channel has varying widths, and aquatic habitats consist of shallow riffles, deep runs, deep pools at meander bends, glides, and willow vegetated floodplain areas that become inundated during high flows.

Sacramento River from Colusa to the Delta The general character of the Sacramento River changes drastically downstream from Colusa from a dynamic and active meandering channel to a confined, narrow channel restricted from migration. Setback levees exist along portions of the river upstream from Colusa; however, the levees become much narrower along the river's edge as the river continues south to the Delta. Agricultural lands are located directly adjacent to the levees, which have cut the river off from most of its riparian corridor, especially on the east side of the river. Between Colusa and the Delta, Sacramento River levees are mostly lined with riprap, allowing the river no erodible substrate. Because the river is confined by levees, the trapezoidal channel width is fairly uniform (typically around 500 and 600 feet wide) and river bends are static. Depth profiles and substrate composition are fairly uniform throughout the reach, so aquatic habitats are fairly homogenous. Several major flood control bypass facilities, including the Sutter and Yolo.

Several major flood control bypass facilities, including the Sutter and Yolo bypasses, are managed to provide flood protection for local municipalities and agricultural areas, and also provide important seasonal floodplain habitat that support juvenile salmonid rearing, habitat for Sacramento splittail spawning and larval rearing, and food production that passes downstream into the Sacramento River and Delta. Multiple water diversion structures move floodwaters into floodplain bypass areas during high-flow events. A large number of screened and unscreened agricultural irrigation diversions occur within the reach.

Tributaries to the Lower Sacramento River The lower reaches of primary tributaries to the lower Sacramento River are characterized here because of the potential for project effects on flows and associated flow-related effects on fish species of management concern. These potential flow changes, however, are minimized by upstream CVP and SWP reservoir operations and flow increases from tributary inflows and return flows from diversions and flood bypasses.

Lower Feather River Aquatic habitats found in the lower Feather River vary as the river flows from its release at the DWR Oroville Dam facilities down to the confluence with the Sacramento River at Verona. Included in the Oroville facilities are a low-flow channel and a high-flow channel. Under the Federal Energy Regulatory Commission license, DWR maintains an approximate 8-mile low-flow channel at 700 to 800 cfs. The low-flow channel at the upper extent of the lower Feather River contains mainly riffles and runs, which provide spawning habitat for the majority of Chinook salmon and steelhead. Also present in the low-flow channel is a series of remnant gravel pit pools/ponds that connect to the main channel.

This stretch of the Feather River is mostly confined by levees as it flows through the city of Oroville. Instream flows and water temperature management in the low-flow section of the river are managed by releases from Oroville Dam in compliance with the Federal Energy Regulatory Commission (Project 2100) requirements, and NMFS biological opinion (BO), and other regulatory requirements. From the downstream end of the low-flow channel, the river is fairly active and meanders its way south to Marysville. However, the high flow channel is bordered by active farmland, which confines the river to an incised channel in certain stretches. Some areas of adjacent farmlands have been restored to floodplain habitat with the construction of setback levee. The high flow channel that extends downstream to the Sacramento River also provides habitat for a variety of resident and migratory fish, as well as a migratory corridor, on the lower Feather River. The Feather River also supports wetland habitat for resident fish and wildlife. The Feather River Fish Hatchery, located immediately downstream from Oroville Dam, produces fall-run and spring-run Chinook salmon and steelhead.

Lower American River Flows in the lower American River (below Folsom and Nimbus dams) provide habitat for anadromous and resident fish species. The lower American River supports spawning and juvenile rearing by fall-run Chinook salmon and steelhead (although oversummering water temperatures limit juvenile steelhead rearing habitat) as well as a variety of resident fish and migratory fish, including American shad. The river is fairly low gradient and is composed of riffle, run, glide, and pool habitats. Folsom and Nimbus Dams, as well as a number of impoundments located further upstream in the watershed have reduced gravel inputs to the system, but the lower American River contains large gravel bars and forks in many locations, leaving gravel/cobble islands within the channel. Instream flows in the lower American River are managed by Reclamation through operations of Folsom and Nimbus Dams to provide instream flows for fishery habitat, maintenance of stream temperatures, flood control, and downstream water supplies and water quality management in the Delta.

Hatcheries located on the lower American River produce fall-run Chinook salmon, steelhead, and resident trout. Most of the lower American River is surrounded by the American River Parkway, preserving the surrounding riparian zone. The river channel does not migrate to a large degree because the geologic composition has allowed the river to incise deep into sediments, leaving tall cliffs and bluffs adjacent to the river.

Sacramento River Floodplain Bypasses There are three major floodplain bypasses – the Butte Basin, Sutter Bypass, and Yolo Bypass – along the main stem Sacramento River. These bypasses operate with a total of 10 overflow structures (6 weirs, 3 flood relief structures, and an emergency overflow roadway) primarily to provide flood control and secondarily to provide access to broad, inundated floodplain habitat for salmon rearing and splittail spawning during wet years. In high-flow periods, the stage of the Sacramento River is elevated and water flows over the weirs into the bypasses. Although the bypasses serve as important seasonal habitat for juvenile salmonid rearing and splittail spawning, an alternative migration pathway, and for the production and transport of organic matter downstream into the river and Delta, the bypasses are primarily operated and managed for flood control during the winter and for agricultural production during the spring and summer.

Unlike other Sacramento River and Delta habitats, floodplains and floodplain bypasses are dewatered seasonally as high flows recede between late spring and autumn. This prevents introduced fish species from establishing year-round dominance except in perennial water sources (Sommer et al. 2003). Moreover, many of the native fish, such as Sacramento splittail, are adapted to spawn and rear in winter and early spring (Moyle 2002) during the winter flood pulse. Introduced fish typically spawn between late spring and summer, when most of the floodplain is not available to them.

Butte Basin The Butte Basin lies east of the Sacramento River and extends from the Butte Slough outfall gates near Meridian to Big Chico Creek near Chico Landing. Flood flows are diverted out of the Sacramento River into the Butte Basin and Sutter Bypass via several designated overflow areas (i.e., low points along the east side of the river) that allow high flood flows to exit the Sacramento River channel.

Sutter Bypass The Sutter Bypass is a narrow floodwater bypass that conveys Sacramento River flood flows from the Butte Basin and the Tisdale Weir. The bypass area is an expansive land area in Sutter County used mainly for agriculture. In times of high water (when the stage exceeds 45.5 feet), Sacramento River water enters the bypass through the Butte Slough outfall and the Tisdale Weir and inundates the bypass with as much as 12 feet of water. The Sutter Bypass, in turn, conveys flows to the lower Sacramento River region at the Fremont Weir near the confluence with the Feather River and into the Sacramento River and the Yolo Bypass (USACE and The Reclamation Board 2002).

Yolo Bypass The Yolo Bypass is an approximately 59,000-acre land area that conveys Sacramento River floodwaters around Sacramento during times of high runoff. Sacramento River flow is diverted into the bypass when the river stage exceeds 33.5 feet (corresponding to 56,000 cfs at Verona). Diversion of most floodwaters from the Sacramento River, Sutter Bypass, and Feather River into the Yolo Bypass from Fremont Weir controls Sacramento River flood stages at Verona. During large flood events, up to 80 percent of Sacramento River flows are diverted into the bypass. The Yolo Bypass subsequently drains back into the Sacramento River in the vicinity of Cache Slough, which is located just upstream from Rio Vista. Cache Slough and the adjacent Sacramento Deep Water Ship Channel have recently been found to provide habitat year-round for delta smelt as well as other fish. Efforts are currently underway to enhance aquatic habitat for juvenile salmonids, delta smelt, and other fish in the Yolo Bypass/Cache Slough complex.

Sacramento Deep Water Ship Channel The Sacramento Deep Water Ship Channel is a tidally influenced canal that is about 30 feet deep, 200 feet wide, and 43 miles long. It flows from the Port of Sacramento into the Sacramento River, which flows into San Francisco Bay. The channel was completed in 1969 and is primarily used to transport agricultural products. Due to manipulations to the channel, such as dredging, it tends to have low dissolved oxygen (DO) concentrations. Delta smelt (*Hypomesus transpacificus*) spawn in and around the Sacramento Deep Water Ship Channel, and juvenile delta smelt are found in the channel (Baxter 2010).

Lower San Joaquin and Stanislaus Rivers The lower San Joaquin River is characterized by a relatively wide (approximately 300-foot) channel with little canopy or overhead vegetation and minimal bank cover. Aquatic habitat in the San Joaquin River is characterized primarily by slow-moving glides and pools, is depositional in nature, and has limited water clarity and habitat diversity. The Stanislaus River provides habitat for fall-run Chinook salmon spawning and juvenile rearing as well as a small population of resident trout and steelhead. Instream flows on the river are managed by Reclamation through releases from New Melones Reservoir for fishery habitat, water temperature management, flood control, and water supplies. Many of the fish species using the lower San Joaquin River use this lower segment of the river to some degree, even if only as a migratory pathway to and from upstream spawning and rearing areas. The lower river also is used by certain fish species (e.g., delta smelt) that make little to no use of areas in the upper segment of the river (see the Delta discussion below).

Aquatic habitats in the lower Stanislaus River vary longitudinally and provide fish spawning, rearing, and/or migratory habitat for a diverse assemblage of common Central Valley native and nonnative fish species. Aquatic habitats include riffles, runs, pools, and glides. Floodplain and associated riparian habitat also varies with the development of levees and encroachment of agriculture and urban uses. There is no fish hatchery located on the Stanislaus River although salmonids produced in hatcheries on other rivers (e.g., Merced River Fish Hatchery) have periodically been released into the Stanislaus River.

Water temperature and flows in both the lower San Joaquin and Stanislaus river systems are highly altered and are managed for flood control and water supply purposes.

Sacramento-San Joaquin Delta The Delta and Suisun Bay, on the western edge of the Delta, are located at the confluence of the Sacramento and San Joaquin rivers and may be considered to represent the most important, complex, and controversial geographic area for both anadromous and resident fisheries production and distribution of California water resources for numerous beneficial uses. The Delta's channels are used to transport water from upstream reservoirs to the south Delta, where Federal and State export facilities (Jones Pumping Plant and Harvey O. Banks Delta Pumping Plant, respectively) pump water into CVP and SWP canals, respectively.

Environmental conditions in the Delta depend primarily on the physical structure of Delta channels, inflow volume and source, Delta Cross Channel (DCC) operations, Delta exports and diversions, and tides. The CVP affects Delta conditions primarily through control of upstream storage and diversions, Delta exports and diversions, and DCC operations. These factors also determine outflow and the location of the low salinity zone (LSZ), which is an area of high organic carbon that is critically important to a number of fish and invertebrate species, as well as to the overall ecology of the Delta and Suisun Bay. The location of the LSZ in the estuary is typically denoted as the distance in kilometers upstream from the Golden Gate Bridge where the 2-practical-salinity-unit bottom salinity isohaline is located which is commonly referred to as the X2 location. The location of X2 is downstream in the Suisun Bay area (e.g., adjacent to Chipps or Roe Islands) when Delta outflow is relatively high and further upstream in the lower Sacramento and San Joaquin Rivers (e.g., Collinsville) when Delta outflow is reduced (Kimmerer 2004, Cloern and Jassby 2012). The location of X2 during the late winter and spring is managed in accordance with provisions of SWRCB Water Rights Decision 1641 (D-1641). In addition to these physical factors, environmental conditions such as water temperature, predation, food production and availability, competition with introduced exotic fish and invertebrate species, and pollutant concentrations all contribute to interactive, cumulative conditions that have substantial effects on Delta fish populations.

Water development has changed the volume and timing of freshwater flows through the San Francisco Bay/Sacramento-San Joaquin River Delta (Bay-Delta). Over the past several decades, the volume of the Bay-Delta's freshwater supply and Delta outflow from the estuary has been reduced by upstream diversions, in-Delta use, and Delta exports. As a result, the proportion of Delta outflow depleted by upstream and Delta diversions has grown substantially (Kimmerer 2004).

Water development has also altered the seasonal timing of flows passing into and through the Bay-Delta. Flows have decreased in April, May, and June and have increased slightly during the summer and fall (SWRCB 2012). Seasonal flows influence the transport of eggs and young organisms (e.g., zooplankton, fish eggs, larvae) through the Delta and into San Francisco Bay. Flows during the late winter and spring (e.g., February to 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, Rosenfield 2010, Rosenfield and Baxter 2007, MacNally et al. 2010, Thomson et al. 2010).

An estimated 25 percent of all warm-water and anadromous sport fishing and 80 percent of California's commercial fishery depend on species that live in or migrate through the Delta. The Delta serves as a migration path for all Central Valley anadromous species returning to their natal rivers to spawn. Adult Chinook salmon move through the Delta during most months of the year. Salmon and steelhead juveniles depend on the Delta as transient rearing habitat during migration through the system to the ocean and could remain for several months, feeding in marshes, tidal flats, and sloughs. In addition, Delta outflow has been correlated to changes in the abundance and distribution of fish, such as green sturgeon and longfin smelt, and invertebrates in the bay through changes to salinity, currents, nutrient levels, and pollutant concentrations (Thomson et al. 2010, Mac Nally et al. 2010, Kimmerer 2002, Rosenfield and Baxter 2007, Rosenfield 2010). Delta smelt is a key species driving many of the ongoing water management decisions in the Delta (USFWS 2008).

Trinity River Sacramento River flow is augmented in average water years by the transfer of up to 1 million acre-feet of Trinity River water through Clear Creek and Spring Creek tunnels to Keswick Reservoir (Reclamation 2004). Flows in the Trinity River (below Lewiston Dam) are generally cold, providing habitat for anadromous and resident fish species. Aquatic habitats in the river consist of riffle, run, glide, and pool habitats. Fish habitat values have increased in quantity and quality through restoration activities that have taken place over the last several years. Implementation of the Trinity River Restoration Program is expected to further increase the value of the habitat below Lewiston Dam over the next 10 to 15 years (NMFS 2000).

CVP/SWP Service Areas

The CVP/SWP service areas contain primarily highly altered aquatic habitat types, including reservoirs, canals, ditches, and other manmade water conveyance structures/facilities. Agricultural land and urban development are the dominate land uses within these service areas. As a result of all these factors, the aquatic communities that occupy the habitats are highly adapted to these disturbed environments and are dominated by nonnative species.

11.1.2 Fish Species

Special-status aquatic species within the primary and extended study areas are listed in Table 11-1. These include animals that are legally protected or are otherwise considered sensitive by Federal, State, or local resource conservation agencies and organizations, and fish species of primary management concern (recreationally and/or commercially important species). The *Fisheries and Aquatic Ecosystems Technical Report* describes life histories and environmental/habitat requirements of special-status species, and information on seasonal timing of important life stages. The following text describes the fishes in the primary and extended areas that include special-status fish as well as other important species.

Table 11-1. Special-Status Aquatic Species Potentially Occurring in the Primary and Extended Study Areas

Species	Status[1]				Habitat	Potential to Occur in the Primary and Extended Study Areas
	USFWS/ NMFS	CDFW	USFS	MSCS Goals		
Central Valley steelhead *Oncorhynchus mykiss*	T			R	Requires cold, freshwater streams with suitable gravel for spawning; rears in seasonally inundated floodplains, rivers, tributaries, and Delta.	Occurs in the primary and extended study areas in the Sacramento River, tributaries, and Delta.
Central California Coast steelhead *Oncorhynchus mykiss*	T				Requires cold, freshwater streams with suitable gravel for spawning; rears in seasonally inundated floodplains, rivers, tributaries, and Delta.	Occurs in the extended study area in the lower Delta, Suisun Bay, and San Francisco Bay.
Sacramento winter-run Chinook salmon *Oncorhynchus tshawytscha*	E	E		R	Requires cold, freshwater streams with suitable gravel for spawning; rears in seasonally inundated floodplains, rivers, tributaries, and Delta.	Occurs in the primary and extended study areas in the Sacramento River, tributaries, and Delta.
Central Valley spring-run Chinook salmon *Oncorhynchus tshawytscha*	T	T		R	Requires cold, freshwater streams with suitable gravel for spawning; rears in seasonally inundated floodplains, rivers, tributaries, and Delta.	Occurs in the primary and extended study areas in the Sacramento River, tributaries, and Delta.

Table 11-1. Special-Status Aquatic Species Potentially Occurring in the Primary and Extended Study Areas (contd.)

Species	Status[1]				Habitat	Potential to Occur in the Primary and Extended Study Areas
	USFWS/ NMFS	CDFW	USFS	MSCS Goals		
Central Valley fall/late fall-run Chinook salmon *Oncorhynchus tshawytscha*		SSC	S	R	Requires cold, freshwater streams with suitable gravel for spawning; rears in seasonally inundated floodplains, rivers, tributaries, and Delta.	Occurs in the primary and extended study areas in the Sacramento River, tributaries, and Delta.
Southern Oregon Northern California Coasts Coho salmon *Oncorhynchus kisutch*	T	T			Requires cold, freshwater streams with suitable gravel for spawning; rears in inundated floodplains, edgewater, off-channel habitat, rivers, tributaries, and estuaries.	Occurs in the extended study area in the Trinity River.
Klamath Mountain Province steelhead *Oncorhynchus mykiss*			S		Requires cold, freshwater streams with suitable gravel for spawning; rears in seasonally inundated floodplains, rivers, tributaries, and Delta	Occurs in the extended study area in the Trinity River.
Southern DPS of the North American Green sturgeon *Acipenser medirostris*	T			R	Requires cold, freshwater streams with suitable gravel for spawning; rears in seasonally inundated floodplains, rivers, tributaries, and Delta.	Occurs in the primary and extended study areas in the Sacramento River, tributaries, and Delta.
Delta smelt *Hypomesus transpacificus*	T	E		R	Spawns in tidally influenced freshwater wetlands and seasonally submerged uplands; rears in tidal marsh and Delta.	Occurs in the extended study area in the Delta.

Table 11-1. Special-Status Aquatic Species Potentially Occurring in the Primary and Extended Study Areas (contd.)

Species	Status[1]				Habitat	Potential to Occur in the Primary and Extended Study Areas
	USFWS/ NMFS	CDFW	USFS	MSCS Goals		
Longfin smelt *Spirinchus thaleichthys*	P	T		R	Primary habitat is the open water of estuaries, both in seawater and freshwater areas, typically in the middle or deeper areas of the water column; spawn in estuaries in fresh or slightly brackish water over sandy or gravel substrates.	Occurs in the extended study area in the Delta.
Sacramento splittail *Pogonichthys macrolepidotus*	DT	SSC		R	Spawning and juvenile rearing occur from winter to early summer in shallow weedy areas inundated during seasonal flooding in the lower reaches and flood bypasses of the Sacramento River, including the Yolo Bypass.	Occurs in the primary and extended study areas in the Delta and Sacramento River and tributaries.
Hardhead *Mylopharodon conocephalus*		SSC	S	m	Spawning occurs in pools and side pools of rivers and creeks; juveniles rear in pools of rivers and creeks, and shallow to deeper water of lakes and reservoirs.	Occurs in the primary and extended study areas in freshwater portions of Sacramento River and tributaries.
San Joaquin roach *Lavinia symmetricus* sp.		SSC			Spawning occurs in pools and side pools of small rivers and creeks; juveniles rear in pools of small rivers and creeks.	Occurs in the extended study area in the San Joaquin River and tributaries and Delta.
Rough sculpin *Cottus asperrimus*		FP			Prefers sand or gravel substrate in cool streams or reservoirs. Spawns in streams.	Potentially occurs in the Shasta Lake and vicinity portion of the primary study area in the Pit River and tributaries upstream from Shasta Lake.

Table 11-1. Special-Status Aquatic Species Potentially Occurring in the Primary and Extended Study Areas (contd.)

Species	Status[1]				Habitat	Potential to Occur in the Primary and Extended Study Areas
	USFWS/ NMFS	CDFW	USFS	MSCS Goals		
Rainbow trout *Oncorhynchus mykiss*					Requires cold, freshwater streams with suitable gravel for spawning; rears in seasonally inundated floodplains, rivers, and tributaries.	Occurs in Shasta Lake, Keswick Reservoir, tributaries, and lakes.
Redband trout *Oncorhynchus mykiss stonei*			S		Requires cold, freshwater streams with suitable gravel for spawning; rears in seasonally inundated floodplains, rivers, and tributaries.	Occurs upstream from McCloud Dam.
Bull trout *Salvelinus confluentus*	T	E			Requires cold, freshwater streams with suitable gravel for spawning; rears in seasonally inundated floodplains, rivers, and tributaries.	Previously found in the McCloud River. Now considered extirpated from California.
California floater *Anodonta californiensis*			S		Potentially occurs in shallow areas of clean, clear ponds, lakes and rivers with sandy and silty substrate.	Potentially occurs in Shasta Lake, Keswick Reservoir, and tributaries.
Nugget pebblesnail *Fluminicola seminalis*			M		Potentially occurs in mixed conifer and conifer/woodland habitats (seeps, springs, and/or riverine habitats).	Potentially occurs in the Shasta Lake and vicinity portion of the primary study area in large creeks and rivers tributary to Shasta Lake.
Potem pebblesnail *Fluminicola* sp. 14			M		Potentially occurs in mixed conifer and conifer/woodland habitats (seeps, springs, and/or riverine habitats)	Potentially occurs in the Shasta Lake and vicinity portion of the primary study area in tributaries to Shasta Lake.
Flat-top pebblesnail *Fluminicola* sp. 15			M		Potentially occurs in mixed conifer and conifer/woodland habitats (seeps, springs, and/or riverine habitats).	Potentially occurs in the Shasta Lake and vicinity portion of the primary study area in tributaries to Shasta Lake.

Table 11-1. Special-Status Aquatic Species Potentially Occurring in the Primary and Extended Study Areas (contd.)

Species	Status[1]				Habitat	Potential to Occur in the Primary and Extended Study Areas
	USFWS/ NMFS	CDFW	USFS	MSCS Goals		
Shasta pebblesnail *Fluminicola* sp. 16			M		Potentially occurs in mixed conifer and conifer/woodland habitats (seeps, springs, and/or riverine habitats).	Potentially occurs in the Shasta Lake and vicinity portion of the primary study area in spring complexes associated with the Sacramento River upstream from Shasta Lake.
Disjunct pebblesnail *Fluminicola* sp. 17			M		Potentially occurs in mixed conifer and conifer/woodland habitats (seeps, springs, and/or riverine habitats).	Potentially occurs in the Shasta Lake and vicinity portion of the primary study area in spring complexes associated with the Sacramento River upstream from Shasta Lake.
Globular pebblesnail *Fluminicola* sp. 18			M		Potentially occurs in mixed conifer and conifer/woodland habitats (seeps, springs, and/or riverine habitats).	Potentially occurs in the Shasta Lake and vicinity portion of the primary study area in tributaries to Shasta Lake.
Cinnamon juga *Juga* (*Orebasis*) sp. 3			M		Potentially occurs in mixed conifer and conifer/woodland habitats (seeps, springs, and/or riverine habitats).	Potentially occurs in the Shasta Lake and vicinity portion of the primary study area in spring complexes associated with the Sacramento River upstream from Shasta Lake.
Canary duskysnail *Lyogyrus* sp. 3			M		Potentially occurs in mixed conifer and conifer/woodland habitats (seeps, springs, and/or riverine habitats).	Potentially occurs in the Shasta Lake and vicinity portion of the primary study area in spring complexes associated with the Pit River upstream from Shasta Lake.
Knobby rams-horn *Vorticefex* sp. 1			M		Potentially occurs in mixed conifer and conifer/woodland habitats (seeps, springs, and/or riverine habitats).	Potentially occurs in the Shasta Lake and vicinity portion of the primary study area in spring complexes associated with the Pit River upstream from Shasta Lake.

Table 11-1. Special-Status Aquatic Species Potentially Occurring in the Primary and Extended Study Areas (contd.)

Sources: Vogel and Marine 1991; Moyle 2002; Wang 1986; NMFS 2005

Notes:
[1] Legal Status Definitions
Federal Listing Categories (USFWS and NMFS)
- DT Recently delisted from threatened status
- E Endangered (legally protected)
- T Threatened (legally protected)
- P Proposed for Federal Listing

State Listing Categories (CDFW)
- E Endangered (legally protected)
- SSC Species of Special Concern
- T Threatened (legally protected)
- FP Fully Protected

U.S. Forest Service (USFS)
- M Survey and Manage

S Sensitive

Multi-Species Conservation Strategy Goals
- R Recovery. Recover species' populations within the MSCS focus area to levels that ensure the species' long-term survival in nature.

m Maintain. Ensure that any adverse effects on the species that could be associated with implementation of CALFED actions will be fully offset through implementation of actions beneficial to the species (CALFED 2000a).

Key:
Delta = Sacramento-San Joaquin Delta
CDFW = California Department of Fish and Wildlife
DPS = Distinct Population Segment
MSCS = CALFED Bay-Delta Program's Multi-Species Conservation Strategy
NMFS = National Marine Fisheries Service
USFS = U.S. Forest Service
USFWS = U.S. Fish and Wildlife Service

Shasta Lake and Vicinity

Shasta Lake fish species include native and nonnative species, which are dominated by mostly introduced warm-water and cold-water species (Weidlein 1971) (Table 11-2). Major assemblages of non-fish aquatic animal species include benthic macroinvertebrates and zooplankton communities.

Table 11-2. Fish Species Known to Occur in the Primary Study Area

Common Name	Scientific Name	Distribution Within the Primary Study Area		
		Shasta Lake Tributaries	Shasta Lake/ Keswick Reservoir	Sacramento River – Keswick Dam to RBPP
Chinook salmon	*Oncorhynchus tshawytscha*		X	
winter-run				X
spring-run				X
fall-run				X
late fall-run				X
Rainbow trout	*Oncorhynchus mykiss*	X	X	X
Steelhead trout	*Oncorhynchus mykiss*			X
Brown trout	*Salmo trutta*	X	X	X
Green sturgeon	*Acipenser medirostris*			X
White sturgeon	*Acipenser transmontanus*	X	X	X
Pacific lamprey	*Lampetra tridentata*			X
Western brook lamprey	*Lampetra richardsoni*			X
Sacramento sucker	*Catostomus occidentalis*	X	X	X
Sacramento pikeminnow	*Ptychocheilus grandis*	X	X	X
Sacramento splittail	*Pogonichthys macrolepidotus*			X

Table 11-2. Fish Species Known to Occur in the Primary Study Area (contd.)

Common Name	Scientific Name	Distribution Within the Primary Study Area		
		Shasta Lake Tributaries	Shasta Lake/ Keswick Reservoir	Sacramento River – Keswick Dam to RBPP
Hardhead	*Mylopharodon conocephalus*	X	X	X
Sacramento blackfish	*Orthodon microlepidotus*	X	X	
California roach	*Hesperolecus symmetricus*	X		X
Speckled dace	*Rhinichthys osculus*	X	X	
Golden shiner	*Notemigonus crysoleucas*	X	X	X
Carp	*Cyprinus carpio*	X	X	X
Channel catfish	*Ictalurus punctatus*	X	X	X
White catfish	*Ameiurus catus*		X	X
Brown bullhead	*Ameiurus nebulosus*		X	X
Black bullhead	*Ameiurus melas*		X	X
Riffle sculpin	*Cottus gulosus*	X	X	
Prickly sculpin	*Cottus asper*			X
Rough sculpin	*Cottus asperrimus*	X		
Pit sculpin	*Cottus pitensus*	X		
Bigeye marbled sculpin	*Cottus klamathensis macrops*	X		
Largemouth bass	*Micropterus salmoides*		X	X
Smallmouth bass	*Micropterus dolomieui*	X	X	X
Spotted bass	*Micropterus punctulatus*	X	X	X
Black crappie	*Pomoxis nigromaculatus*		X	X
White crappie	*Pomoxis annulauris*		X	X
Bluegill sunfish	*Lepomis macrochirus*		X	X
Green sunfish	*Lepomis cyanellus*	X	X	X
Threadfin shad	*Dorosoma petenense*		X	
Tule perch	*Hysterocarpus traski*	X	X	X
Tui chub	*Siphateles bicolor*	X	X	

Sources: Moyle 2002; Reclamation 2004
Key:
RBPP = Red Bluff Pumping Plant

Cold-Water Species Shasta Lake and its tributaries provide very productive habitats for cold-water fish species, which typically prefer or require temperatures cooler than 70 degrees Fahrenheit (°F). During the cooler months, cold-water species such as rainbow trout, brown trout, and landlocked Chinook salmon may be found rearing throughout the lake; however, these species do not spawn in the lake, preferring to spawn in tributary streams, however, few Chinook salmon stocked in Shasta Lake have ever been observed to spawn in the reservoir tributaries (J. Zustak, USFS, pers. comm., 2009). During the summer months, these cold-water species may be found rearing in association with the cold, deep hypolimnion and metalimnion layers within the reservoir, although the fish may make frequent forays into the epilimnion to feed on small prey fish and return to cooler depths to digest their prey (Finnell and Reed 1969, Koski and Johnson 2002, Moyle 2002, Quinn 2005).

Native species such as white sturgeon, hardhead, riffle sculpin, Sacramento sucker, and Sacramento pikeminnow tend to reside in cooler water strata in the reservoir and in and near tributary inflows (Moyle 2002). Trout may also congregate near the mouths of the reservoir's tributaries, including the upper Sacramento River, McCloud River, Pit River, and Squaw Creek, at various times of the year seeking thermal refuge, foraging, and spawning, when conditions are favorable for these species.

Hatchery- and pen-reared trout and salmon are stocked in Shasta Lake several times each year to support the sport fishery. About 60,000 pounds of juvenile rainbow trout and about 50,000 subcatchable Chinook salmon are planted annually (S. Baumgartner, CDFW, pers. comm., 2008).

Climate conditions and reservoir storage volume are the two most influential factors affecting cold-water habitat and primary productivity in Shasta Lake (Bartholow et al. 2001). Cold-water habitat provided by Shasta Lake is a function of the total storage and associated surface area provided by Shasta Lake. This relationship is influenced by variation in the WSEL throughout the year. Variation in WSEL is a function of water demand and downstream instream flow releases, water quality requirements, and inflow. WSEL can change within and among years based on hydrology within the watershed, based on the water year type. Typically, primary production in reservoirs is associated with storage volumes when all other factors are held constant (Stables et al. 1990). Increased storage and the corresponding increases in surface area and aquatic habitat results in a greater total biomass and a greater abundance of plankton and fish, because available aquatic habitat area is increased.

Warm-Water Species The warm-water fish habitats of Shasta Lake occupy two ecological zones: the littoral (shoreline/rocky/vegetated) and the pelagic (open water) zones. The littoral zone lies along the reservoir shoreline down to the maximum depth of light penetration on the reservoir bottom, and supports populations of spotted bass, smallmouth bass, largemouth bass, black crappie, bluegill, channel catfish, and other warm-water species.

The upper, surface layer of the pelagic zone is the principal plankton-producing region of the reservoir. Plankton comprises the base of the food web for most of the reservoir's fish populations. Operation of the Shasta Dam temperature control device (TCD), which helps conserve the reservoir's cold-water pool by accessing warmer water for storage releases in the winter, spring, and early summer, may reduce zooplankton biomass in the epilimnion. However, operations of the TCD may result in some increased plankton production at deeper levels as a result of a slight warming of the hypolimnetic layers within the reservoir during the fall months (Bartholow et al. 2001).

Warm-water species, such as largemouth bass, smallmouth bass, spotted bass, and other sunfishes, were introduced into Shasta Lake and have become well established with naturally sustaining populations. Spotted bass are currently the dominant warm-water species in Shasta Lake (S. Baumgartner, CDFW, pers. comm., 2006). These warm-water fishes feed primarily on invertebrates while young and become predaceous on other fishes, including engaging in some cannibalism, as they grow. In Shasta Lake, threadfin shad, crayfish, and other invertebrates are most abundant in the diets of these fish (Saito et al. 2001). Spawning activity usually begins during late March or April when temperatures rise to around 60°F. Males generally build the nests in sand, fine gravel, rubble, or debris-covered bottoms at depths between 1 and 20 feet, which varies by species. Spotted bass and catfishes typically spawn at greater depths than the other warm-water species in Shasta Lake. Eggs generally hatch in 3 to 5 days at the predominant springtime water temperatures in Shasta Lake, and males guard the eggs and larvae for up to 4 weeks (Moyle 2002). Fry and juveniles disperse into shallow water and prefer areas with vegetation and large rubble as protective cover from predators (Moyle 2002, Ratcliff 2006).

The primary factors affecting warm-water fish abundance and production in Shasta Lake include seasonal reservoir fluctuations, availability of high-quality littoral habitat, and annual climate variations (Ratcliff 2006). The effect of sport fishery harvests on Shasta Lake fish populations is not well understood, although it is generally thought that overfishing of naturally reproducing populations by sport fisheries seldom limits fish abundance (Moyle 2002).

Reservoir level fluctuations, associated shoreline erosion, and suppression of shoreline and emergent vegetation are thought to generally be the most significant factors affecting warm-water fish production in reservoirs, including Shasta Lake (Moyle 2002, Ratcliff 2006). Water level variations influence physical, chemical, and biological processes, which in turn affect fish populations. Reservoir drawdowns reduce water depths and influence thermal stratification and the resulting temperature, DO, and water chemistry profiles.

The typical seasonality of reservoir fluctuations on Shasta Lake can affect year-to-year reproductive success of littoral-spawning fishes, especially the black bass species, by influencing nesting behavior (e.g., abandonment of nests) and dewatering of nests containing eggs in years when reservoir levels decline during the spring and early summer months. Under these same conditions, juveniles may be forced to move to areas with less protection from predation or lower food production. In years when the reservoir rises rapidly and/or extensively during the spring and early summer months, submergence of active bass nests by more than 15 to 20 feet often results in high egg mortality (Stuber, Gebhart, and Maughan 1982, Moyle 2002).

Shoreline and littoral vegetation are important warm-water fish habitat components for sustainable fishery production (Ratcliff 2006). Structural diversity (e.g., submerged trees, brush, rock, boulders, and rubble) provides shelter and feeding areas for fish. During construction of the reservoir, many trees and brush fields were cleared prior to inundation. Portions of the Pit River and Squaw Creek arms were not cleared, as evidenced by the large number of inundated trees observable in certain areas. Clearing efforts reduced the potential structural diversity of the inundated habitat. Vegetative clearing in many reservoirs has resulted in rocks, boulders, and man-made features (e.g., bridge pilings, riprap, marinas) being the only structural habitat features available, especially for bass and other warm-water fishes.

Annual reservoir fluctuations create highly variable conditions for establishment and maintenance of shoreline and littoral-zone vegetation and aquatic invertebrate communities that subsequently impose limitations on warm-water fish production. Exposed shoreline reservoir areas generally require 3 to 4 years to reestablish terrestrial vegetation. The absence of established, rooted aquatic vegetation is a common aquatic habitat factor that limits populations and fishery production for many fish species in reservoirs (Ploskey 1986, Moyle 2002).

The Shasta-Trinity National Forest (STNF), in cooperation with other Federal and State agencies and local nongovernmental organizations, has implemented a habitat improvement program at Shasta Lake. The objective of this program is to increase cover for warm-water fish. As the fishery management agency for Shasta Lake, CDFW prepared a Draft Management Plan for Shasta Lake in 1991. This plan, which has not been finalized, acknowledges the benefit to warm-water fish of structural enhancement projects.

STNF, CDFW, and nongovernmental organizations have used a variety of materials and techniques to construct structural enhancements (e.g., willow planting, brush structures) to provide warm-water fish habitat within the drawdown zone of Shasta Lake. The materials and techniques have varied because of differences in funding, available materials, site conditions (reservoir levels), longevity, and desired outcome.

According to STNF aquatic biologists, brush structures constructed from whiteleaf manzanita (*Arctostaphylos manzanita)* have been the STNF's preferred means of structural enhancement since about 1990. These structures have been constructed in areas where manzanita is available near the shoreline, typically in a manner that provides varying degree of structural habitat as water levels change over time. The biologists have indicated that these structures have typically resulted in a threefold to tenfold increase in the abundance of warm-water fish in the treated areas (Ratcliff 2006; J. Zustak, USFS, pers. comm., 2007).

Tributary Species The lower reaches of the tributaries draining to the reservoir provide spawning habitat for adfluvial fishes (i.e., fish that spawn in streams, but rear and grow to maturity in lakes) residing in Shasta Lake, as well as stream-resident fishes, with rainbow trout the principal game species. Accessible and suitable cold-water fish spawning habitat, including appropriate seasonal flows, depths, and gravel substrates was observed in 7 percent of intermittent and in over 90 percent of perennial tributaries to Shasta Lake surveyed in 2011 and 2012 (see *Fisheries and Aquatic Ecosystems Technical*

Report for details). Most native fish species found in Shasta Lake may also inhabit the lower reaches of the tributaries. Several tributaries to Shasta Lake (e.g., Squaw Creek,[2] Little Backbone Creek) have been subjected to discharge from abandoned upslope copper mines. The Shasta Lake West Watershed analysis (Bachmann 2000) suggests that these creeks are “biologically dead” as a result of acid mine discharge from these mines. This watershed analysis also stated that “fish kills” have occurred in Shasta Lake in the vicinity of such tributaries during high runoff conditions.

The four main tributaries to Shasta Lake, which include the Sacramento River, McCloud River, Squaw Creek, and Pit River, are renowned for their high-quality recreational trout fisheries. Each of these streams drains considerable watershed areas comprising mixed conifer forests in the reaches above Shasta Lake. With the exception of the Pit River, which has a series of hydroelectric project dams that begin immediately upstream from Shasta Lake, each of these tributaries has more than 30 miles of high-quality, fish-bearing riverine habitat between the Shasta Lake and upstream dams on the Sacramento and McCloud rivers and steep headwater reaches on Squaw Creek.

For the most part, land use along the main Shasta Lake tributaries upstream from the reservoir is a mix of Federal and privately managed forest and timberlands and except for sparse residential development, several small municipalities, and the hydropower projects on the Pit, McCloud, and Sacramento rivers much of the area is lightly developed. The Sacramento River above Shasta Lake is paralleled by a major interstate highway and railroad transportation corridor. In July 1991, a railroad accident spilled 19,000 gallons of the fumigant pesticide metam sodium into the Sacramento River near the town of Dunsmuir, approximately 35 stream miles upstream from Shasta Lake. Metam sodium is highly toxic and killed aquatic and riparian vegetation, aquatic macroinvertebrates, and fish and amphibians along the entire length of the river to Shasta Lake, where a massive chemical containment and neutralization effort was mounted. Ecological recovery efforts were implemented shortly after this spill incident and populations of fish, aquatic macroinvertebrates, and the vegetation adjacent to the stream have attained levels that appear to be in a natural dynamic equilibrium consistent with full recovery, although some amphibian and mollusk population remained depressed at least 15 years later (Cantara Trustee Council 2007).

There are about 2,903 miles of ephemeral, intermittent, and perennial stream channels that contribute to the main Shasta Lake tributaries within the study area. Most of these sub-tributaries are relatively short and steep and may be classified as confined, headwater channels that contribute water, sediment, and organic and inorganic material to Shasta Lake. Most (64 percent) of these stream channels are intermittent and have a slope greater than 10 percent. About

[2] This refers to a stream draining the terrain and entering Shasta Lake northwest of Shasta Dam, a historic mining district; not to be confused with the Squaw Creek drainage forming the “Squaw Creek Arm” of the lake.

14 percent of the stream channels are perennial, with slopes of less than 7 percent. In the Pacific coast and Cascade ranges, stream channels with gradients up to about 4 percent to 7 percent and possessing sufficient flows typically exhibit a good potential to support habitation by fish and other aquatic organisms; although, steeper slopes do not necessarily, in and of themselves, preclude habitation by fish, particularly trout, sculpins, and dace (Naiman 1998; Reeves, Bisson, and Dambacher 1998). About 79 percent of the tributaries with good fish-bearing potential in the study area occur within the Sacramento, Squaw, and Pit Arms (see Chapter 4, "Geology, Geomorphology, Minerals, and Soils," for more detail).

Most of the lower gradient, potentially fish-bearing reaches of tributary streams to Shasta Lake are near their confluence with the reservoir. The gradient of most of these tributaries rapidly increases upstream from the shoreline, and natural barriers to fish migration are common. These barriers are most often created by cascades, waterfalls, and steep reaches of stream channel (i.e., greater than 7-percent slope) that are more than one-quarter mile in length. Stream channel data generated from field inventories and analysis using Reclamation's geographic information system Digital Elevation Model indicate that most barriers to fish migration on the perennial tributaries occur near the reservoir (see Chapter 4, "Geology, Geomorphology, Minerals, and Soils," for more detail).

Upper Sacramento River (Shasta Dam to Red Bluff)

Keswick Reservoir USFWS conducts a propagation and captive broodstock program for endangered winter-run Chinook salmon at the Livingston Stone National Fish Hatchery, located at the base of Shasta Dam on the Sacramento River upstream from Keswick Reservoir. The program consists of collecting adult winter-run Chinook salmon from the mainstem Sacramento River, holding and spawning the adults, rearing the juveniles in the hatchery environment, and then releasing them back into the mainstem Sacramento River downstream from Keswick Dam. The overriding goal of the program is to supplement the endangered population and provide an insurance policy against extinction. The propagation program (initiated in 1989), and the captive broodstock program (initiated in 1991) are recognized in both of NMFS's Draft Recovery Plans (1993, 2009) for this endangered species. Water is supplied to the hatchery from Shasta Dam.

Keswick Reservoir is operated by Reclamation as a reregulating facility. Water levels in Keswick Reservoir are subject to operational changes at Whiskeytown and Shasta lakes. The reservoir provides habitat for a variety of aquatic organisms, including native and nonnative fish. Table 11-2 includes the fish species known to occur in Keswick Reservoir. In addition to water released from Shasta Dam and Whiskeytown Lake, this reservoir is the recipient of surface flows and sediment from Spring Creek, as well as groundwater, emanating from the Iron Mountain Mine. Additional information on the relationship between Spring Creek and Keswick Reservoir is provided in Chapter 9, "Hazards and Hazardous Materials."

Keswick Dam to Red Bluff The upper Sacramento River (Keswick Dam to Red Bluff) provides vital fish spawning, rearing, and/or migratory habitat for a diverse assemblage of native and nonnative species (Table 11-2).

Native species present in this reach of the river can be separated into anadromous and resident species. Native anadromous species include four runs of Chinook salmon, steelhead, green and white sturgeon (*Acipenser medirostris* and *A. transmontanus*), and Pacific lamprey (*Lampetra tridentata*). Native resident species include Sacramento pikeminnow (*Ptychocheilus grandis*), Sacramento splittail, Sacramento sucker (*Catostomus occidentalis*), hardhead (*Mylopharodon conocephalus*), California roach (*Lavinia symmetricus*), and rainbow trout (*O. mykiss*).

Nonnative resident species present in the upper Sacramento River include largemouth bass (*Micropterus salmoides*), smallmouth bass (*M. dolomieu*), white and black crappie (*Pomoxis annularis* and *P. nigromaculatus*), channel catfish (*Ictalurus punctatus*), white catfish (*Ameiurus catus*), black bullhead (*A. melas*), brown bullhead (*A. nebulosus*), bluegill (*Lepomis macrochirus*), green sunfish (*L. cyanellus*), and golden shiner (*Notemigonus crysaleucas*).

See Table 11-1 for a list of special-status species with the potential to occur in the upper Sacramento River.

Lower Sacramento River and Delta Like habitats in the primary study area, habitats in the extended study area provide vital fish spawning, rearing, and/or migratory habitat for a diverse assemblage of native and nonnative species. Many of those species are the same as those found in the primary study area, including Chinook salmon, steelhead, and sturgeon (see the *Fisheries and Aquatic Ecosystems Technical Report*).

Trinity River The Trinity River provides habitat for Southern Oregon/Northern California Coast Coho salmon (*Oncorhynchus kisutch*), Southern Oregon/Northern California Coast Chinook salmon, Klamath Mountains Province steelhead, green sturgeon, white sturgeon, Pacific lamprey, resident rainbow trout, speckled dace, three-spine stickleback, Klamath small scale sucker (*Catostomus rimiculus*), prickly sculpin, riffle sculpin (*Cottus gulosus*), brook trout (*Salvelinus fontinalis*), brown trout (*Salmo trutta*), American shad, brown bullhead, golden shiner, and green sunfish. Coho salmon and Klamath Mountains Province steelhead are included in this discussion because they are special-status species, while CVP and SWP operations in response to changes at Shasta Dam have the potential to affect Trinity River flows.

See Table 11-1 for a list of special-status species with the potential to occur in the Trinity River.

CVP/SWP Service Areas

See Table 11-1 for a list of special-status species with the potential to occur in the CVP/SWP Service Areas.

11.1.3 Aquatic Macroinvertebrates

The constant flow of water in river systems provides an energetically convenient and economical way for aquatic macroinvertebrates to disperse to new habitats; this movement downstream is known as drift. Some invertebrates passively enter the drift (e.g., benthic organisms may be entrained in the water column when a large current sweeps through), and others exhibit active drift behavior (individuals actively enter the water column by voluntary actions) (Waters 1965, 1972; Müller 1974; Wiley and Kohler 1984). Macroinvertebrates drift to colonize new habitats (for dispersal of various life stages or to find suitable resources), or leave unsuitable habitats (in response to habitat quality or predation pressure). Drift is one of the most important downstream dispersal mechanisms for macroinvertebrates. Macroinvertebrates drift more commonly in the evening, usually at dusk (Waters 1972, Müller 1974, Wiley and Kohler 1984, Smock 1996).

Drifting invertebrates are the primary source of prey for juvenile fish, including salmonids (Chapman and Bjornn 1969). Juvenile Chinook salmon will often seek refuge in slow-velocity habitats where they can rest and drifting invertebrates will tend to be deposited.

Shasta Lake and Vicinity

Aquatic macroinvertebrates provide an important food base for many fish and wildlife species. In general, published information on the taxonomy, distribution, and abundance of macroinvertebrates in the Sacramento River drainage is limited. In Shasta Lake, seasonal fluctuations in phytoplankton biomass regulate the abundance of the zooplankton, which form the base of the food chain for the lake's fisheries. Typically, the spring phytoplankton bloom peaks in late-March and April at the on-set of thermal stratification, when nutrients are abundant in surface waters and available to the algae, and again in the fall coincident with the breakdown of the thermocline and mixing of the water column (Lieberman and Horn 1998). The zooplankton community of Shasta Lake is dominated by cladoceran and copepod species, with lower abundance of several rotifer species. Cladocera are most abundant during algae blooms and their abundance wanes, with a corresponding increase in copepod abundance, during the mid-summer (Lieberman and Horn 1998).

A number of different aquatic mollusks (e.g., snails, limpets, mussels, and clams) are known to inhabit the principal tributaries and general vicinity of Shasta Lake, including several species of management importance (Frest and

Johannes 1995, 1999; Howard 2010). Several species of hydrobiid "spring snails" are known to inhabit the upper reaches of the Sacramento and McCloud rivers upstream from Shasta Lake (Frest and Johannes 1995, 1999) in spring complexes and associated headwater areas. These snails require clear, cold-water streams with cobbly gravel beds and tend to be associated with submergent vegetation; however, none of these species has been reported in the reaches of tributaries near Shasta Lake. A number of these spring snails and other stream-dwelling snails are ecologically important and used by the Forest Service for their survey and manage program (see Table 11-1).

The Forest Service sensitive freshwater mussel, the California floater (*Adonota californiensis*), is also known historically to have occurred in Shasta Lake tributaries near the head of the lake (Howard 2010; J. Zustak, USFS, personal communication). However, recent surveys of historically occupied sites around Shasta Lake failed to find this species (Howard 2010). This species has experienced significant population declines throughout its range, primarily because of hydromodification of its habitat (Howard 2010). Its preferred habitat is unpolluted, slow-moving rivers and large streams, with beds composed of balanced mixtures of gravel, sand, and silt; however, California floaters are sometimes found in lake shore areas with stable water levels and suitable water currents and substrates (Pennak 1989). Other freshwater mollusks commonly observed in the tributaries of Shasta Lake include another freshwater mussel of the genus *Gonidea* and freshwater limpets of the genus *Lanx* (Howard 2010). The western pearlshell (*Margaritifera falcata*) is also historically known from the McCloud River, but its close dependence on migratory salmonids for its life cycle has undoubtedly resulted in a decline in its abundance since construction of Shasta Dam blocked anadromous fish migrations (Howard 2010).

Invasive Species

New Zealand Mudsnail The New Zealand mudsnail (*Potamopyrgus antipodarum*), known to have been introduced to North America since about 1987 (Bowler 1991), was identified in Shasta Lake at the Bridge Bay Marina on September 10, 2007 (Benson and Kipp 2011). New Zealand mudsnail have also been found lower in the Central Valley, including Sacramento River near Red Bluff, and the American, Mokelumne and Calaveras rivers (Benson and Kipp 2011). This invasive aquatic mollusk is known from a number of other locations within California and can reach densities of over 500,000 snails per square meter. Densities can fluctuate seasonally, with lowest densities coinciding with the freezing winter months (Proctor et al. 2007). New Zealand mudsnails are highly effective competitors and predators of many native North American benthic macroinvertebrates, including other mollusks, crustaceans, and important aquatic insects. Predators of the New Zealand mudsnail include rainbow trout, brown trout, sculpins, and mountain whitefish (Proctor, Kerans, and Clancey 2007). Unfortunately, snails are capable of passing through the digestive system of fish alive and intact (Bondesen and Kaiser 1949; Haynes et al. 1985).

Possible pathways of introduction into Shasta Lake include contaminated recreational watercraft and trailers and recreational water users (Proctor, Kerans, and Clancey 2007). Introduced snails may also be transported in the feathers and mud adhering to waterbirds and wildlife as they move from one waterbody to another. Other vectors known to spread the snails, such as contaminated livestock, commercial ships, and dredging/mining equipment, are less likely in the case of Shasta Lake's recent invasion given the lack of commercial activities on the lake. If the particular clone detected in Shasta Lake is tolerant of the local conditions, a rapid colonization of the lake and its tributaries could occur through a variety of vectors.

The potential involvement of recreational watercraft and trailers and recreational water users in the translocation of New Zealand mudsnails between State waters is of immediate concern. Enlargement of Shasta Lake could provide a larger perimeter of shoreline accessibility for the snail, but not necessarily increase preferred lake habitats. In lakes in North America, New Zealand mudsnails do not commonly occupy shoreline habitats. Highest densities of New Zealand mudsnails occur at depths of between 20 and 25 meters (m) in Lake Ontario (Proctor, Kerans, and Clancey 2007).

Quagga and Zebra Mussel   Quagga mussels (*Dressenia bugensis*) and zebra mussels (*Dressenia polymorpha*), are invasive European aquatic mollusks introduced to North America in ship ballast water and first discovered in Lake Erie in 1989 (Spidle, Marsden, and May 1994), have not been found in Shasta Lake, to date, but were discovered in California at Lake Havasu in 2007 (Cohen 2007). The CDFW has begun monitoring at Lake Shasta for adult mussels and veligers (S. Baumgartner, CDFW, pers. comm., 2008). Possible pathways of introduction into Shasta Lake include contaminated recreational watercraft and trailers and recreational water users. The potential involvement of recreational watercraft and trailers and recreational water users in the translocation of dressenid mussels between State waters is of immediate concern. Enlargement of Shasta Lake could provide a greater area of deepwater and littoral habitat available for occupation by quagga and zebra mussels.

In a 2007 report produced for CDFW, Cohen (2007) described the temperature, calcium, pH, DO, and salinity tolerances of quagga mussels in an effort to assess the vulnerability of various California waters to invasion by quagga mussels and zebra mussels. Cohen identified calcium thresholds as the most important environmental factor influencing distribution of zebra mussels in North America and applied similar thresholds for quagga mussels. In an investigation of the upper Sacramento River region, including Whiskeytown Reservoir and the watersheds above Shasta Dam, Cohen found that the McCloud River above Shasta Reservoir and the Pit River near Canby have the proper range of salinity, DO, temperature and calcium (at less than or equal to 12 milligrams per liter to be of low and moderate suitability to invasion by quagga mussels.

Upper Sacramento River (Shasta Dam to Red Bluff)

A large-scale monitoring effort on the Sacramento River from Keswick Dam to Verona, coordinated by DWR in 2001, found that benthic macroinvertebrate diversity and richness decreased as the river moved downstream. Oligochaetes, chironomids, and mollusks became more prominent in this reach than in the reach from Keswick Dam to Red Bluff (Sacramento River Watershed Program 2002).

Petrusso and Hayes (2001) examined the diurnal feeding habits of juvenile Chinook salmon in the Sacramento River between RM 193 and RM 275 (downstream and upstream from Red Bluff, respectively) in relation to drifting invertebrates. Chironomids and baetids dominated both the drift and stomach contents. Diets of 153 juvenile salmonids were examined; more than 63 percent of the diet was made up of chironomids of all life stages. Baetids composed 14 percent of the total diet. It was concluded that based on measurements of mean stomach fullness and availability of drifting organisms, there was reasonable feeding opportunity during the sampling period in spring 1996. Mean drift densities ranged from 211 to 2,100 organisms per 100 cubic meters, with an overall mean of 617 organisms per 100 cubic meters (Petrusso and Hayes 2001). Daily mean drift density appeared to show no spatial patterns across the several sites sampled.

Lower Sacramento River and Delta

Aquatic macroinvertebrates provide an important food base for many fish and wildlife species. In general, published information on the taxonomy, distribution, and abundance of macroinvertebrates in the Sacramento River and Delta are limited.

Current macroinvertebrate monitoring efforts on the Sacramento River have focused on large-basin scale patterns, and survey sites on the mainstem have been at various locations along the study reach. As part of the Sacramento River Watershed Program, CDFW collected snag samples at two sites, one site near Colusa and one site near Hamilton City. Dominant taxa found in the fall of 1999 at the Hamilton City site included Orthocladiinae, Naididae, Ephemeroptera (*Baetis* and *Acentrella* sp.), and Trichoptera (*Hydropsyche* sp.) (Sacramento River Watershed Program 2002). Schaffter, Jones, and Karlton (1983) found no substantial difference in abundance of drifting invertebrates near riprapped and natural habitats on the Sacramento River. More than 50 percent of the drift was composed of chironomids, baetids, and aphids. Analysis of fish diets found the same 3 families in 72 percent of the guts sampled.

As mentioned above under “Upper Sacramento River (Shasta Dam to Red Bluff),” a large-scale monitoring effort by DWR on the river from Keswick Dam to Verona found that benthic macroinvertebrate diversity and richness decreased as the river moved downstream. Oligochaetes, chironomids, and mollusks became more prominent in this reach than in the reach from Keswick Dam to Red Bluff (Sacramento River Watershed Program 2002).

Also, as described previously, Petrusso and Hayes (2001) examined the diurnal feeding habits of juvenile Chinook salmon in the river between River Mile (RM) 193 and RM 275 (downstream and upstream from Red Bluff, respectively) in relation to drifting invertebrates. Petrusso and Hayes found that chironomids and baetids dominated both the drift and stomach contents; they concluded that there was reasonable feeding opportunity during the sampling period and that daily mean drift density appeared to show no spatial patterns.

The lower rivers and Delta support a diverse assemblage of zooplankton and macroninvertebrates. Many of these invertebrates are native to the Bay-Delta while many have been introduced into the estuary through ship ballast water discharges, oyster planting, and other processes. Many of the fish species forage on small zooplankton (e.g., copepods) during their early lifestages or throughout their life, while larger macroinvertebrates such as amphipods, shrimp, and crabs provide a forage source for many of the other fish species. Sturgeon and many of the flatfish, for example, forage extensively on shrimp (e.g., Cangon) while other fish such as largemouth bass forage extensively on crawfish. The macroinvertebrate communities are affected by changes in salinity gradients and other habitat factors as well as by filter feeding by other introduced nonnative species such as the Asian overbite clam that has extensively colonized areas of the estuary such as Suisun Bay.

Macroinvertebrate monitoring in the Delta has been focused on impacts to food web dynamics as a result of increases in phosphorous and nitrogen, and on loss of macroinvertebrate species diversity due to nonnative species introductions. The macroinvertebrate communities of the Delta are characterized by low diversity and are dominated by a minimal number of species (less than 10) (Nichols 1980). This is in part because of the predominately soft, silty substrate found throughout the Delta, and an ever-changing fresh and salt water (brackish) water mix (Nichols 1980).

11.2 Regulatory Framework

Several Federal, State, and local agencies have regulatory authority or responsibility over activities that affect aquatic and fisheries resources. These regulatory authorities are described in the following sections.

11.2.1 Federal

Federal Endangered Species Act

Pursuant to the Federal Endangered Species Act (ESA), USFWS and NMFS have authority over projects that may result in take of a Federally listed species. Under the ESA, the definition of “take” is to “harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct.” Under Federal regulation, “take” is further defined to include habitat modification or degradation where it would be expected to result in death or injury to listed fish and wildlife by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering. If the project may affect a Federally listed species, either an incidental take permit, under Section 10(a) of the ESA through a Habitat Conservation Plan (HCP), or a Federal interagency consultation, under Section 7 of the ESA, is required. USFWS has regulatory jurisdiction over freshwater and estuarine fishes (such as delta smelt), while NMFS has jurisdiction over anadromous and marine species (such as Chinook salmon, steelhead, and green sturgeon).

Protection of these listed species is typically addressed through issuance of BOs and incidental take authorization by USFWS and NMFS, as well as designation of critical habitat. BOs have been issued for delta smelt by USFWS (2008) and for winter-run and spring-run Chinook salmon, Central Valley steelhead, and green sturgeon by NMFS (2009a). These recent BOs have been challenged in Federal court and remanded to the agencies for revisions. USFWS and NMFS have requested extensions on the deadlines for completing the revisions to the BOs required by the Federal court rulings.

NMFS Recovery Plan

Under Section 4(f) of the ESA, both NMFS and USFWS are required to publish a recovery plan for each species it lists as threatened or endangered. These plans must have objective and measureable criteria that would help the species be removed from the ESA list, a description of site-specific management actions necessary for the species recovery, and estimates of time and cost to carry out the recommended recovery measures.

In 2009, NMFS published the *Public Draft Recovery Plan for Evolutionarily Significant Units of Sacramento River Winter-Run Chinook Salmon and Central Valley Spring-Run Chinook Salmon and Distinct Population Segments of Central Valley Steelhead* (NMFS 2009b). In this Draft Recovery Plan, NMFS indicates that the recovery of winter-run Chinook salmon is affected by the Shasta cold-water pool by stating:

> *"Although the status of the Sacramento River winter-run Chinook salmon population numbers has shown improvement over the last six years, there is still only one naturally-spawned component of the ESU, and this single population depends on coldwater releases from Shasta Dam on the Sacramento River. Lindley et al. (2007) considers the Sacramento River winter-run Chinook salmon population at a moderate risk of extinction primarily due to the risks associated with only one existing population. The viability of an ESU that is represented by a single population is vulnerable to changes in the environment through a lack of spatial geographic diversity and genetic diversity that result from having only one population. A single catastrophe with effects persisting for four or more years could*

> *extirpate the entire Sacramento River winter-run Chinook salmon ESU (Lindley et al. 2007). Such potential catastrophes include volcanic eruption of Mt. Lassen, prolonged drought which depletes the coldwater pool in Shasta Reservoir or some related failure to manage coldwater storage, a spill of toxic materials with effects that persist for four or more years, or a disease outbreak. Moreover, an ESU that is represented by a single population is vulnerable to the limitation in life history and genetic diversity that would otherwise increase the ability of individuals in the population to withstand environmental variation."*

While the action plans surrounding this issue of cold-water pool are focused primarily on reintroduction into the upper watershed (upstream from Shasta Dam), these actions for upstream reintroduction may not be achievable. Improving the cold-water pool could reduce impacts to the species recovery if the reintroduction process is not successful. Additionally, NMFS includes management actions to improve gravel augmentation programs in the upper Sacramento River. A final recovery plan is expected to be completed by NMFS in 2013.

Sustainable Fisheries Act (Essential Fish Habitat)

In response to growing concern about the status of United States fisheries, Congress passed the Sustainable Fisheries Act of 1996 (Public Law 104-297) to amend the Magnuson-Stevens Fishery Conservation and Management Act (Public Law 94-265), the primary law governing marine fisheries management in the Federal waters of the United States. Under the Sustainable Fisheries Act, consultation is required by NMFS on any activity that might adversely affect essential fish habitat. Essential fish habitat includes those habitats that fish rely on throughout their life cycles. It encompasses habitats necessary to allow sufficient production of commercially valuable aquatic species to support a long-term sustainable fishery and contribute to a healthy ecosystem. Fish species managed under Essential Fish Habitat by NMFS within the Bay-Delta include Pacific salmon, starry flounder, and English sole.

Fish and Wildlife Coordination Act

The Fish and Wildlife Coordination Act requires Federal agencies to consult with USFWS, NMFS, and State fish and wildlife resource agencies before undertaking or approving projects that control or modify surface water. The recommendations made by these agencies must be fully considered in project plans by Federal agencies.

Clean Water Act, Section 404

Section 404 of the Clean Water Act (CWA) requires project proponents to obtain a permit from USACE before performing any activity that involves any discharge of dredged or fill material into "waters of the United States," including wetlands. Waters of the United States include navigable waters of the

United States, interstate waters, all other waters where the use or degradation or destruction of the waters could affect interstate or foreign commerce, tributaries to any of these waters, and wetlands that meet any of these criteria or that are adjacent to any of these waters or their tributaries. Many surface waters and wetlands in California, including those in the primary and extended study area, meet the criteria for waters of the United States.

Clean Water Act, Section 402

CWA Section 402 regulates construction-related stormwater discharges to surface waters through the National Pollutant Discharge Elimination System (NPDES) program, which is administered by the U.S. Environmental Protection Agency. In California, the State Water Resources Control Board (SWRCB) is authorized by the U.S. Environmental Protection Agency (EPA) to oversee the National Pollutant Discharge Elimination System program through the regional water quality control boards (RWQCB), in this case, the Central Valley RWQCB (CVRWQCB).

Clean Water Act, Section 401

CWA Section 401(a)(1) specifies that any applicant for a Federal license or permit to conduct any activity that may result in any discharge into navigable waters will provide the Federal licensing or permitting agency with a certification that any such discharge will not violate State water quality standards. The RWQCBs administer the Section 401 program with the intent of prescribing measures for projects that are necessary to avoid, minimize, and mitigate adverse impacts on water quality and ecosystems.

Central Valley Project Improvement Act

Reclamation's evolving mission was written into law on October 30, 1992, with the passage by Congress and signing by President George H.W. Bush, of Public Law 102-575, the Reclamation Projects Authorization and Adjustment Act of 1992. Included in the law was Title 34, the CVPIA. The CVPIA amended previous authorizations of the CVP to include fish and wildlife protection, restoration, and mitigation as project purposes having equal priority with irrigation and domestic water supply uses, and fish and wildlife enhancement having equal priority with power generation. The following are among the changes mandated by the CVPIA:

- Dedicating 800,000 acre-feet annually to fish, wildlife, and habitat restoration
- Authorizing water transfers outside the CVP service area
- Implementing the Anadromous Fish Restoration Program (AFRP)
- Creating a restoration fund financed by water and power users
- Providing for the Shasta temperature control device

- Implementing fish passage measures at RBPP
- Planning to increase the CVP yield
- Mandating firm water supplies for Central Valley wildlife refuges
- Meeting the Federal trust responsibility to protect fishery resources on the Trinity River

The CVPIA is being implemented on a broad front. The Final Programmatic Environmental Impact Statement for the CVPIA analyzes projected conditions in 2022, 30 years from the CVPIA's adoption in 1992. The Final Programmatic Environmental Impact Statement was released in October 1999, and the CVPIA Record of Decision (ROD) was signed on January 9, 2001.

Operations of the CVP reflect provisions of the CVPIA, particularly Sections 3406(b)(1), (b)(2), and (b)(3). The U.S. Department of the Interior's Decision on Implementation of Section 3406(b)(2) of the CVPIA, October 5, 1999, provides the basis for implementing upstream and Delta actions with CVP delivery capability. The AFRP assumes that Sacramento River water will be acquired under Section 3406(b)(2).

CALFED Ecosystem Restoration Program

USFWS and NMFS implement CALFED Bay-Delta Program's (CALFED) Ecosystem Restoration Program (ERP) with guidance from the Delta Stewardship Council and the Delta Plan, and in coordination with the Sacramento–San Joaquin Delta Conservancy. The ERP works to improve the ecological health of the Bay-Delta watershed by restoring and protecting habitats, ecosystem functions, and native species. Since the program's inception, ERP agencies have identified more than 600 programmatic actions and 119 milestones throughout the Bay-Delta watershed. The program includes all projects authorized, funded, and permitted (even if not constructed) to date, particularly in the Delta, that aim to do any of the following:

- Recover at-risk native species dependent on the Delta, Suisun Bay, and San Francisco Bay
- Minimize the downward population trends of native species that are not listed
- Protect and restore functional habitat types in the Bay-Delta estuary and its watershed for ecological and public values
- Prevent the establishment of additional nonnative invasive species and reduce the negative ecological and economic impacts of established nonnative species in the Bay-Delta estuary

- Improve and/or maintain water and sediment quality conditions that fully support healthy and diverse aquatic ecosystems in the Bay-Delta estuary and watershed

Bay Delta Conservation Plan Recently the state and federal water agencies have initiated a process to develop of HCP for the Bay-Delta estuary. The draft plan includes over 20 conservation measures designed to improve habitat conditions (e.g., restoration of 65,000 acres of wetland habitat, etc.) and water supply reliability (e.g., construction of three new north Delta water intake structures with a combined diversion capacity of 9,000 cfs in association with two underground tunnels to transfer the water from the north Delta to the south Delta export facilities). The plan is in the development stage with draft sections scheduled for release to the public for review and comment in 2013. If adopted the plan would provide funding for implementation of conservation measures and incidental take of ESA listed species over a 50 year period.

Operating Agreements and Constraints

Coordinated Operations Agreement With the goal of using coordinated management of surplus flows in the Delta to improve Delta export and conveyance capability, the Coordinated Operations Agreement (COA) received Congressional approval in 1986 and became Public Law 99-546. The COA, as modified by interim agreements, coordinates operations between the CVP and SWP and provides for the equitable sharing of surplus water supply. The COA requires that the CVP and SWP operate in conjunction to meet State objectives for water quality in the Bay-Delta estuary, except as specified. Under this agreement the CVP and SWP can each contract for the purchase of surplus water supplies from the other, potentially increasing the efficiency of water operations.

The COA specifies two basic conditions for operational purposes: balanced conditions and excess conditions. Balanced water conditions occur when releases from upstream reservoirs plus unregulated flow equal the water supply needed to meet Sacramento Valley in-basin uses plus exports. During balanced water conditions, storage releases required to meet the Sacramento in-basin uses are made 75 percent from the CVP and 25 percent from the SWP. If unstored water is available during balanced conditions, this water is allocated 55 percent to the CVP and 45 percent to the SWP. Excess water conditions occur when Delta inflows (combined releases from upstream reservoirs and unregulated flow) are greater than needed to meet in-basin uses plus export. Under this condition, flow through the Delta is adequate to meet all needs and no coordinated operation between the CVP and SWP is required.

Since 1986, the COA principles have been modified to reflect changes in regulatory standards, facilities, and operating conditions. At its inception, the COA water quality standards were those of the 1978 Water Quality Control Plan; these were subsequently modified in the 1991 Water Quality Control Plan. The adoption of the 1995 Bay-Delta Plan by the SWRCB superseded those requirements. Evolution of the Clean Water Act over time has also impacted the implementation of the COA.

Biological Opinions BOs are prepared through formal consultation under Section 7 of the ESA (described above) by either NMFS or USFWS in response to a Federal action affecting a listed species. On February 12, 1993, NMFS issued a long-term BO regarding the operational impacts of the CVP on winter-run Chinook salmon (NMFS 1993). Based on Reclamation's *Long-Term Central Valley Project Operations Criteria and Plan* and biological assessment of impacts, the BO concluded that the proposed long-term operations of the CVP and SWP would likely jeopardize the continued existence of winter-run Chinook salmon, and identified "Reasonable and Prudent Alternatives" (RPA) to avoid jeopardy. The RPAs consisted of 13 separate actions that changed the pattern of storage and withdrawal at Shasta, Trinity, and Whiskeytown Reservoirs for the purpose of improving water temperature control and protecting Sacramento River winter-run Chinook salmon (NMFS 1993). Since that time, many of the original RPA actions have been amended or incorporated into the 1995 Water Quality Control Plan Decision 1641. Therefore, these components of the RPA have become part of the baseline conditions.

Actions that have not changed in later BOs include:

- Water year forecasting based on a 90-percent probability of exceedence
- Maintaining a minimum 3,250 cfs flow below Keswick Dam from October 1 through March 30
- Implementing ramp-down rates for Shasta Dam releases from July 1 through March 31
- Locating temperature compliance points based on annual plans
- Monitoring of winter-run Chinook salmon juveniles in the Delta
- Monitoring entrainment loss of winter-run Chinook salmon juveniles at Rock Slough Pumping Plant
- Monitoring of incidental take at the CVP and SWP Delta pumping facilities

With the signing of the Principles for Agreement for the Bay-Delta Framework process which established CALFED, USFWS agreed to initiate immediate reconsultation on the BO it had issued on February 4, 1994, which addressed the effects of the combined operations of the CVP and SWP on delta smelt for the period of February 15, 1994, through February 15, 1995. In that opinion, USFWS had concluded that the proposed operations of the CVP and SWP would result in jeopardy; therefore, RPAs were included in the BO, which consisted of specific operational criteria that the CVP and SWP would implement.

On March 6, 1995, USFWS issued a revised BO for delta smelt. This opinion states that the proposed long-term combined CVP and SWP operations, as modified by the BO for winter-run Chinook salmon, the Principles for Agreement, and the Bay-Delta Plan (draft at the time), are not likely to jeopardize the continued existence of the threatened delta smelt or adversely modify its critical habitat. The BO identifies water quality standards and operational constraints that would provide benefits to delta smelt.

On October 22, 2004, NMFS issued a BO regarding effects of the Long-Term Operations Criteria and Plan (OCAP) for the CVP in coordination with the SWP on Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, Central Valley steelhead, Southern Oregon Northern California Coastal Coho salmon, and Central California Coast steelhead and their designated critical habitat. The 2004 BO superseded the 1993 BO issued by NMFS.

The 2004 and 2005 BOs issued by both NMFS and USFWS were subsequently sued. In response to further litigation, the 2004 and 2005 BOs were remanded to USFWS and NMFS for revision, but were not vacated. USFWS and NMFS released revised BOs in 2008 and 2009, respectively.

Actions were brought challenging the NMFS and USFWS BOs (2008 and 2009) under ESA and the Administrative Procedure Act (APA), concerning the effects of the CVP and SWP on endangered fish species. The cases arose out of continuing efforts to protect several species listed under ESA. Plaintiffs moved for summary judgment on their claims that the NMFS and USFWS BO addressing the impacts of the coordinated operations of the CVP and SWP and its RPA violates the ESA and APA and were arbitrary, capricious, and unlawful.

The 2009 NMFS BO included RPAs to improve conditions for anadromous fish in the Sacramento River basin. These RPAs included revised water operations, habitat restoration and enhancement actions, and fish passage actions. Water operations defined in RPAs were included in the modeling evaluations for both existing and future conditions, and therefore were included in cumulative effects analyses. However, the following restoration and enhancement actions and fish passage actions for the Sacramento River and its tributaries were not included in existing or future conditions operations modeling. The actions related to the 2009 NMFS BO were identified as present or reasonably foreseeable actions.

In September 2011, the court remanded the 2009 BO to NMFS, in a mixed ruling, finding in favor of the Federal government on some counts, and in favor of water contractor plaintiffs on other counts. On December 12, 2011, the court ordered NMFS to submit a revised draft BO to Reclamation on October 1, 2014, and submit a final BO on February 1, 2016. Reclamation must issue final NEPA documentation by February 1, 2016 and a ROD by April 29, 2016.

On December 27, 2010, the Court entered an "Amended Order on Cross-Motions for Summary Judgment" (Doc. 761). The Amended Order remanded the BO to the USFWS without vacatur for further consideration. This amended order remains in effect except as modified by:

- The parties seek to settle and compromise issues relating to the interim operation of the CVP and the SWP related to effects to delta smelt through June 30, 2011; and
- USFWS intends that its determinations regarding, and the CVP and SWP compliance with, the Old and Middle River flow criteria identified in the stipulation will provide equivalent protection for delta smelt through June 30, 2011, as the protection set forth in the BO.

A time extension was requested for the BOs.

Real-Time Decision-Making to Assist Fishery Management

Reclamation and DWR work closely with USFWS, NMFS, CDFW, and other agencies to coordinate the operation of the CVP and SWP with fishery needs. This coordination is facilitated through several forums, as discussed below.

CALFED Water Operations Management Team The Water Operations Management Team (WOMT) was established to facilitate decision making at the appropriate levels and provide timely support of decisions. This team, which first met in 1999, consists of management-level participants from Reclamation, DWR, USFWS, NMFS, and CDFW. The WOMT meets frequently to provide oversight and decision making that must routinely occur within the CALFED Ops Group process. The WOMT relies heavily on other teams and work groups for recommendations on fishery actions. It also utilizes the CALFED Ops Group (see below) to communicate with stakeholders about its decisions. Although the goal of the WOMT is to achieve consensus on decisions, the agencies retain their authorized roles and responsibilities.

Delta Operations for Salmonids and Sturgeon Group The Delta Operations for Salmonids and Sturgeon (DOSS) was established from Action IV.5 in the NMFS BO. The responsibilities of DOSS are to provide advice to the WOMT and NMFS on measures to reduce adverse effects from Delta operations of the CVP and the SWP to salmonids and green sturgeon. DOSS coordinates the work of other technical teams to provide expertise on issues pertinent to Delta water quality, hydrology, and environmental parameters. The 2009 NMFS BO states the DOSS will:

1. Provide recommendations for real-time management of operations to WOMT and NMFS, consistent with implementation procedures provided in this RPA;

2. Review annually project operations in the Delta and the collected data from the different ongoing monitoring programs;

3. Track the implementation of Actions IV.1 through IV.4;

4. Evaluate the effectiveness of Actions IV.1 through IV.4 in reducing mortality or impairment of essential behaviors of listed species in the Delta;

5. Oversee implementation of the acoustic tag experiment for San Joaquin fish provided for in Action IV.2.2;

6. Coordinate with the Smelt Working Group to maximize benefits to all listed species; and

7. Coordinate with the other technical teams identified in this RPA to ensure consistent implementation of the RPA.

CALFED Ops Group The CALFED Ops Group consists of participants from Reclamation, DWR, USFWS, NMFS, CDFW, SWRCB, and EPA. The CALFED Ops Group generally meets 11 times a year in a public setting to discuss CVP and SWP operations, CVPIA implementation, and coordination with efforts to protect endangered species. The CALFED Ops Group held its first public meeting in January 1995, and during the next 6 years the group developed and refined its process. The CALFED Ops Group is recognized within SWRCB D-1641 and elsewhere as a forum where agencies can consult and achieve consensus on coordinating CVP and SWP operations with endangered species, water quality, and CVPIA requirements. Decisions made by the CALFED Ops Group have been incorporated into the Delta standards to protect beneficial uses of water (e.g., export/inflow ratios and some closures of DCC gates).

Several teams were established as part of the Ops Group. These teams are described below.

Operations and Fishery Forum The stakeholder-driven Operations and Fishery Forum disseminates information about recommendations and decisions regarding CVP and SWP operations. Forum members are considered the contact people for their respective agencies or interest groups when the CALFED Ops Group needs to provide information about take of listed species or address other topics or urgent issues. Alternatively, the CALFED Ops Group may direct the Operations and Fishery Forum to recommend operational responses to issues of concern raised by member agencies.

Data Assessment Team The Data Assessment Team consists of technical staff members from the agencies and stakeholders. The team meets frequently during the fall, winter, and spring to review and interpret data relating to fish movement, location, and behavior. Based on its assessments and information about CVP and SWP operations, the Data Assessment Team recommends potential changes in operations to protect fish.

B2 Interagency Team The B2 Interagency Team was established in 1999 and consists of technical staff members from the agencies. The team meets weekly to discuss implementation of Section 3406(b)(2) of the CVPIA, which defines the dedication of CVP water supply for environmental purposes. It communicates with the WOMT to ensure coordination with the other operational programs or resource-related aspects of project operations.

Fisheries Technical Teams Several fisheries-specific teams have been established to provide guidance on resource management issues. These teams are described below.

Interagency Fish Passage Steering Committee The Interagency Fish Passage Steering Committee (IFPSC) was established in 2010 because of the NMFS 2009 BO, and consists of members from Reclamation, NMFS, USFWS, CDFW, DWR, RWQCB, USFS, and academia. The IFPSC's role is to provide insight and technical, management, and policy direction for a Fish Passage Program to evaluate the potential reintroduction of listed fish species upstream from Shasta, Folsom, and New Melones dams. The IFPSC provides a stabilizing influence so organizational concepts and directions are established and maintained with a visionary view, and provides insight on long-term strategies in support of implementation of the fish passage RPA.

The Sacramento River Temperature Task Group The Sacramento River Temperature Task Group (SRTTG) is a multiagency group formed pursuant to SWRCB Water Right Orders 90-5 and 91-1 to help improve and stabilize the Chinook salmon population in the Sacramento River. Reclamation develops temperature operation plans each year for the Shasta and Trinity divisions of the CVP. These plans consider impacts of CVP operations on winter-run and other races of Chinook salmon. The SRTTG meets in the spring to discuss biological and operational information, objectives, and alternative operations plans for temperature control, then recommends an operations plan for temperature control. Reclamation then submits a report to the SWRCB, generally on or before June 1 each year.

After the operations plan is implemented, the SRTTG may perform additional studies and hold meetings to revise the plan based on updated biological data, reservoir temperature profiles, and operations data. Updated plans may be needed for summer operations to protect winter-run Chinook salmon, or in fall for the fall-run spawning season. If any changes are made to the plan, Reclamation submits a supplemental report to the SWRCB.

Delta Smelt Working Group The Delta Smelt Working Group was established in 1995 to resolve biological and technical issues regarding delta smelt and to develop recommendations for consideration by USFWS. The working group generally acts when Reclamation and DWR seek consultation with USFWS on delta smelt or when unusual salvage of delta smelt occurs. It also has assisted in developing strategies to improve habitat conditions for delta smelt.

The Delta Smelt Working Group employs a delta smelt decision tree when forming recommendations to send to the WOMT. The working group does not decide what actions will be taken and does not supplant the Data Assessment Team, but merely provides additional advice to the WOMT. The group may propose operations modifications that it believes will protect delta smelt, either by reducing take at the export facilities or by preserving smelt habitat. The decision tree is adapted by the working group as new knowledge becomes available.

American River Operations Work Group In 1996, Reclamation established an operational working group for the lower American River, known as the American River Operations Work Group. Although open to anyone, the working group's meetings generally include representatives from several agencies and organizations with ongoing concerns about management of the lower American River: Reclamation, USFWS, NMFS, CDFW, the Sacramento Area Flood Control Agency, the Water Forum, the City of Sacramento, Sacramento County, the Western Area Power Administration, and the Save the American River Association. The American River Operations Work Group convenes at least monthly to provide fishery updates and reports to enable Reclamation to better manage Folsom Reservoir for fish resources in the lower American River.

National Forest Management Act

The National Forest Management Act requires the USFS to prepare the STNF Land and Resources Management Plan (LRMP) that provides the direction to manage the goods and services that are associated with National Forest System lands managed by the STNF. In addition to the requirement for LRMPs, National Forest Management Act also has a specific requirement to "provide for a diversity of plant and animal communities" (16 U.S Code 1604(g)(3)(B)) as part of their multiple use mandate. The USFS must maintain "viable populations of existing native and desired nonnative species in the planning area" (36 Code of Federal Regulations 219.19).

U.S. Forest Service Sensitive Species

The Sensitive Species program is designed to meet the National Forest Management Act requirement to demonstrate the USFS's commitment to maintaining biodiversity on National Forest System lands. The program is a proactive approach to conserving species to prevent a trend toward listing under the ESA, and to ensure the continued existence of viable, well-distributed populations. A "Sensitive Species" is any species of plant or animal that has been recognized by the Regional Forester to need special management in order to prevent it from becoming threatened or endangered.

Shasta-Trinity National Forest Land and Resource Management Plan

The STNF, LRMP adopted what is commonly referred to as the Northwest Forest Plan, a plan for the management of habitat for late-successional and old-growth forest-related species within the range of the northern spotted owl. The LRMP encompasses all the goals, standards and guidelines established in the 1994 ROD for the Northwest Forest Plan, as a well as establishing Forest goals, standards, and guidelines designed to guide the management of the STNF. As adopted in 1995, this LRMP incorporates the following goals, standards, and guidelines related to aquatic and fisheries resource issues associated with the project site, which were excerpted from the STNF LRMP (USFS 2003).

Biological Diversity

Goals (LRMP, p. 4-4)

- Integrate multiple resource management on a landscape level to provide and maintain diversity and quality of habitats that support viable populations of plants, fish, and wildlife.

Threatened, Endangered, and Sensitive Species (Plants and Animals)

Goals (LRMP, p. 4-5)

- Monitor and protect habitat for Federally listed threatened and endangered and candidate species. Assist in recovery efforts for threatened and endangered species. Cooperate with the State to meet objectives for state listed species.

- Manage habitat for sensitive plants and animals in a manner that will prevent any species from becoming a candidate for threatened and endangered status.

Wildlife

Goals (LRMP, p. 4-6)

- Meet habitat or population objectives established for management indicators.

- Cooperate with Federal, State, and local agencies to maintain or improve wildlife habitat.

- Maintain natural wildlife species diversity by continuing to provide special habitat elements within Forest ecosystems.

Standards and Guidelines (LRMP, pp. 4-29 through 4-30)

- Consider transplants, introductions, or reintroductions of wildlife species only after ecosystem analysis and coordination with other agencies and the public.

- Develop interpretation/view sites for wildlife viewing, photography, and study. Provide pamphlets, slide shows, and other educational material that enhance the watchable wildlife and other interpretive programs.

- Maintain and/or enhance habitat for Federally listed threatened and endangered or USFS sensitive species consistent with individual species recovery plans.

U.S. Forest Service Survey and Manage Species

In 1994, the U.S. Bureau of Land Management and USFS adopted standards and guidelines, The Northwest Forest Plan was designed to address human and environmental needs served by the Federal forests of the western part of the Pacific Northwest and Northern California. The development of the Northwest Forest Plan was triggered in the early 1990s by the listing of the northern spotted owl and marbled murrelet as threatened under the ESA.

To mitigate potential impacts to plant and wildlife species that have the potential to occur within the range of the northern spotted owl, surveys are required for species thought to be rare or whose status is unknown due to a lack of information. These species became known as the Survey and Manage species. The Northwest Forest Plan has gone through several revisions since its implementation in 1994, including the elimination of the Survey and Manage Mitigation Measure Standards and Guidelines in 2004. However, these guidelines were re-instated in January 2006 as the result of a court order.

Management Guide for the Shasta and Trinity Units of the Whiskeytown-Shasta-Trinity National Recreation Area

The Management Guide for the Shasta and Trinity Units of the Whiskeytown-Shasta-Trinity National Recreation Area contains management strategies intended to achieve or maintain a desired condition. These strategies take into account opportunities, management recommendations for specific projects, and mitigation measures needed to achieve specific goals. The following strategies related to biological resource issues associated with the project were excerpted from the Management Guide (USFS 2003).

Wildlife (Management Guide, pp. IV-19 through IV-20)

- Management activities will assure population viability for all native and non-native desirable species. Management to insure viability will occur within occupied habitat for bald eagle, peregrine falcon, northern spotted owl, northern goshawk, willow flycatcher, northwestern pond turtle, Pacific fisher, Shasta salamander, and candidate species in accordance with species and/or territory management plans, Forest Orders, and appropriate laws and policy.

- Surveys will continue within potential suitable habitats to determine occupancy status for threatened, endangered, sensitive, and candidate species.
- Cooperation will continue with CDFW and the USFWS regarding habitat management of wildlife species inhabiting the National Recreation Area. Consultation with USFWS will continue regarding habitat management for threatened and endangered species.

11.2.2 State

California Endangered Species Act

Pursuant to the California Endangered Species Act (CESA), a permit from CDFW is required for projects that could result in take of a State-listed threatened or endangered species. Under CESA, "take" is defined as an activity that would directly or indirectly kill an individual of a species, but the definition does not include "harming" or "harassing," as the ESA does. As a result, the threshold for take under CESA is higher than under the ESA (e.g., habitat modification is not necessarily considered take under CESA; proposed activities must meet a no-net-loss standard for CESA listed species). Authorization for take of State-listed species can be obtained through a California Fish and Game Code, Section 2080.1, Consistency Determination or Section 2081 Incidental Take Permit.

"Fully Protected" Fish Species

California law (Fish and Game Code, Section 5515) also identifies 10 "fully protected fish" that cannot lawfully be "taken," even with an incidental take permit. None of these species are present in the primary study area.

California Fish and Game Code Section 1602 – Streambed Alteration

All diversions, obstructions, or changes to the natural flow or bed, channel, or bank of any river, stream, or lake in California that supports wildlife resources are subject to regulation by CDFW under Section 1602 of the California Fish and Game Code. Under Section 1602, it is unlawful for any person, governmental agency, or public utility to do the following without first notifying CDFW: substantially divert or obstruct the natural flow of, or substantially change or use any material from the bed, channel, or bank of any river, stream, or lake, or deposit or dispose of debris, waste, or other material containing crumbled, flaked, or ground pavement where it may pass into any river, stream, or lake. A stream is defined as a body of water that flows at least periodically or intermittently through a bed or channel that has banks and supports fish or other aquatic life. This definition includes watercourses with a surface or subsurface flow that supports or has supported riparian vegetation. CDFW's jurisdiction within altered or artificial waterways is based on the value of those waterways to fish and wildlife. A CDFW streambed alteration agreement must be obtained for any project that would result in an impact on a river, stream, or lake.

California Public Resources Code, Sections 5093.50-5093.70

The California Public Resources Code (PRC) Sections 5093.50 – 5093.70 were established through 1972 enactment of the Wild and Scenic Rivers Act, which was subsequently amended on several occasions. The essential policy of the State in regard to the matters addressed by the PRC is expressed in Section 5093.50:

> *5093.50 It is the policy of the State of California that certain rivers which possess extraordinary scenic, recreational, fishery, or wildlife values will be preserved in their free-flowing state, together with their immediate environments, for the benefit and enjoyment of the people of the state. The Legislature declares that such use of these rivers is the highest and most beneficial use and is a reasonable and beneficial use of water within the meaning of Section 2 of Article X of the California Constitution.*

The PRC identifies, classifies, and provides protection for specific rivers or river segments, as approved by the Legislature (much of the text of the PRC is devoted to detailed descriptions of river segment locations). Rivers or river segments that are specifically identified and classified in the PRC comprise the State Wild and Scenic Rivers System. As described in Section 5093.50 of the PRC, rivers or river segments included in the State Wild and Scenic Rivers System must possess "extraordinary scenic, recreational, fishery, or wildlife values"; however, the PRC does not define these "extraordinary values."

Various amendments to the California Wild and Scenic Rivers Act have been passed, modifying the PRC. Rivers or river segments are added to (or, as in a few past cases, removed from) the System by Legislative action. In 1986, Assembly Bill 3101 (Statutes of 1986, Chapter 894) established a study process to help determine eligibility for potential additions to the State Wild and Scenic Rivers System (Section 5093.547 and Section 5093.548). In 1982, the original mandate in the PRC requiring management plans for designated rivers was eliminated; however, the California Resources Agency is required to coordinate activities affecting the State Wild and Scenic Rivers System with other Federal, State, and local agencies (Section 5093.69).

The PRC has also been modified to protect river segments without formally identifying them as part of the State Wild and Scenic Rivers System. Such protective language for the McCloud River was added to the PRC in Section 5093.542, emphasizing protection of the wild trout fishery in the McCloud River.

California Wild Trout Program

The California Wild Trout Program was established by the California Fish and Game Commission in 1971 to protect and enhance high-quality fisheries sustained by wild strains of trout. The primary purpose of the wild trout program is to identify, enhance, and perpetuate natural and attractive trout fisheries where wild strains of trout are given major emphasis, in contrast to the majority of the State's accessible waters that are managed by planting domesticated catchable-sized trout on a "put and take" basis (Rode 1989; Rode and Dean 2004). The Commission adopted a wild trout policy that provides for the designation of "aesthetically pleasing and environmentally productive" streams and lakes to be managed exclusively for wild trout, where the trout populations are managed with appropriate regulations to be "largely unaffected by the angling process."

All designated waters must meet the following policy criteria (Rode 1989, Rode and Dean 2004):

- Be open to public angling
- Be of sufficient size to accommodate a significant number of anglers without overcrowding
- Be able to support, with appropriate angling regulations, wild trout populations of sufficient magnitude to provide satisfactory trout catches in terms of number or size of fish

Designated wild trout waters are required to have a management plan and must be subject to angling restrictions that "emphasize unique values and diversity of opportunity in the geographic area" (Rode 1989, Rode and Dean 2004). Wild trout waters are required to be managed in accordance with the following stipulations:

- Domestic strains of catchable-sized trout will not be planted in designated wild trout waters.
- Hatchery-produced trout of suitable wild and semiwild strains may be planted in designated waters, but only if necessary to supplement natural trout reproduction.
- Habitat protection is of utmost importance for maintenance of wild trout populations. All necessary actions, consistent with State law, will be taken to prevent adverse impacts by land or water development projects affecting designated wild trout waters.

The California Fish and Game Commission in 1976 designated a 10.5-mile river segment immediately below McCloud Dam for special management and habitat protection under the Commission's wild trout program (Rode 1988).

11.2.3 Regional and Local

County and City Policies and Ordinances

Shasta, Tehama, Glenn, Sutter, Sacramento, and Yolo counties and the cities of Redding, Colusa, and Sacramento have established codes and policies that address protection of natural resources, including fisheries, sensitive species, and aquatic resources, and are applicable to the project.

Shasta County's general plan emphasizes that the maintenance and enhancement of quality fish and wildlife habitat is critical to the recreation and tourism industry, and acknowledges that any adverse and prolonged decline of these resources could result in negative impacts on an otherwise vibrant industry. The general plan identifies efforts to protect and restore these habitats to sustain the long-term viability of the tourism and recreation industry (Shasta County 2004).

The City of Redding's general plan strives to strike a balance between development and conservation by implementing several measures such as creek-corridor protection and habitat protection (City of Redding 2000).

Tehama County's general plan update provides an overarching guide to future development and establishes goals, policies, and implementation measures designed to address potential changes in county land use and development.

Glenn County's general plan provides a comprehensive plan for growth and development in Glenn County through 2027. This plan recognizes that public lands purchased for wildlife preservation generate economic activity as scientists and members of the public come to view and study remnant ecosystems (Glenn County 1993).

The City of Colusa's general plan seeks to promote its natural resources through increased awareness and improved public access (City of Colusa 2007).

Sutter County's general plan contains policies that generally address preservation of aquatic resources.

Sacramento County's general plan contains policies that promote protection of marsh and riparian areas, including specification of setbacks and "no net loss" of riparian woodland or marsh acreage (Sacramento County 1993).

Yolo County's general plan aims to provide an active and productive buffer of farmland and open space separating the San Francisco Bay Area from Sacramento, and integrating green spaces into its communities.

11.2.4 Federal, State, and Local Programs and Projects

Watershed Conservancies

Several watershed conservancy groups exist within the study area. These include but may not be limited to the Butte Creek, Mill Creek, Deer Creek, and Cottonwood Creek watershed conservancies. Watershed conservancies tend to focus on developing and implementing conservation efforts on watershed lands.

California Bay-Delta Authority

The California Bay-Delta Authority (CBDA) was established as a State agency in 2003 to oversee implementation of CALFED for the 25 Federal and State agencies working cooperatively to improve the quality and reliability of California's water supplies while restoring the Bay-Delta ecosystem. The July 2000 CALFED *Final Programmatic EIS/EIR* (CALFED 2000b) identified and analyzed a range of alternatives to address these needs and included a Multi-Species Conservation Strategy (MSCS) to provide a framework for compliance with ESA, CESA, and Natural Community Conservation Planning Act. The August 2000 CALFED ROD identified 12 action plans, including Ecosystem Restoration, Watersheds, and Water Supply Reliability, among others (CALFED 2000c). The CALFED Ecosystem Restoration Program has provided a funding source for projects that include those involving acquisition of lands within the Sacramento River Conservation Area (SRCA), initial baseline monitoring and preliminary restoration planning, and preparation of long-term habitat restoration management and monitoring plans. In 2009, the California Legislature passed sweeping water reform legislation, including the establishment of the Delta Stewardship Council (DSC). The DSC was transferred all the responsibilities, programs, staff and most of the funding from the CBDA, and the CBDA was dissolved. The DSC was also given additional mandates, including the development of a Delta Plan to guide activities and programs of State and local programs in the legal Delta through a consistency determination process. The Delta Plan is currently undergoing the final public review.

Cantara Trustee Council

The Cantara Trustee Council administers a grant program that has provided funding for numerous environmental restoration projects in the primary study area, including programs in the Fall River watershed, Sulphur Creek, the upper Sacramento River, Middle Creek, lower Clear Creek, Battle Creek, Salt Creek, and Olney Creek. The Cantara Trustee Council is a potential local sponsor for future restoration actions in the primary study area. The Cantara Trustee Council includes representatives from CDFW, USFWS, the CVRWQCB, California Sportfishing Protection Alliance, and Shasta Cascade Wonderland Association.

Resource Conservation Districts

There are numerous resource conservation districts (RCD) within the study area. Once known as soil conservation districts, RCDs were established under

California law with a primary purpose to implement local conservation measures. Although RCDs are locally governed agencies with locally appointed, independent boards of directors, they often have close ties to county agencies and the U.S. Natural Resources Conservation Service. RCDs are empowered to conserve resources within their districts by implementing projects on public and private lands and to educate landowners and the public about resource conservation. They are often involved in the formation and coordination of watershed working groups and other conservation alliances. Districts in the vicinity of Shasta Lake and the upper Sacramento River include the Western Shasta County RCD and the Tehama County RCD. To the east are the Fall River and Pit River RCDs, and to the west and north are the Trinity County and Shasta Valley RCDs.

Riparian Habitat Joint Venture

The Riparian Habitat Joint Venture (RHJV) was initiated in 1994 and includes signatories from 18 Federal, State, and private agencies. The RHJV promotes conservation and the restoration of riparian habitat to support native bird population through three goals:

- Promote an understanding of the issues affecting riparian habitat through data collection and analysis.
- Double riparian habitat in California by funding and promoting on-the-ground conservation projects.
- Guide land managers and organizations to prioritize conservation actions.

RHJV conservation and action plans are documented in the *Riparian Bird Conservation Plan* (RHJV 2004). The conservation plan targets 14 “indicator” species of riparian-associated birds and provides recommendations for habitat protection, restoration, management, monitoring, and policy. The report notes habitat loss and degradation as one of the most important factors causing the decline of riparian birds in California. The RHJV has participated in monitoring efforts within the Sacramento National Wildlife Refuge Complex and other conservation areas. The RHJV’s conservation plan identifies lower Clear Creek as a prime breeding area for yellow warblers and song sparrows, advocating a continuous riparian corridor along lower Clear Creek. Other recommendations of the conservation plan apply to the North Delta Offstream Storage Investigation study area.

Sacramento River Advisory Council

In 1986, the California Legislature passed Senate Bill 1086, which called for a management plan for the Sacramento River and its tributaries to protect, restore, and enhance fisheries and riparian habitat in an area stretching from the confluence of the Sacramento River with the Feather River and continuing northward to Keswick Dam. The law established an advisory council that included representatives of Federal and State agencies, county supervisors, and representatives of landowners, water contractors, commercial and sport fisheries, and general wildlife and conservation interests. Responsibilities of the advisory council included development of the *Sacramento River Conservation Area Forum Handbook* to guide management of riparian habitat and agricultural uses along the river (Resources Agency 2003). This action also resulted in formation in May 2000 of the SRCA Forum, a nonprofit public-benefit corporation with a board of directors that includes private landowners and public-interest representatives from a seven-county area, an appointee of the California Resources Agency, and ex-officio members from six Federal and State resource agencies. The work of the organization is generally focused on planning actions and river management within the SRCA planning area.

Sacramento River Conservation Area Program

Senate Bill 1086 called for a management plan for the Sacramento River and its tributaries to protect, restore, and enhance both fisheries and riparian habitat. The SRCA Program has an overall goal of preserving remaining riparian habitat and reestablishing a continuous riparian ecosystem along the Sacramento River between Redding and Chico, and reestablishing riparian vegetation along the river from Chico to Verona. The program is to be accomplished through an incentive-based, voluntary river management plan. The *Upper Sacramento River Fisheries and Riparian Habitat Management Plan* (Resources Agency 1989) identifies specific actions to help restore the Sacramento River fishery and riparian habitat between the Feather River and Keswick Dam. The *Sacramento River Conservation Area Forum Handbook* (Resources Agency 2003) is a guide to implementing the program. The Keswick Dam–Red Bluff portion of the conservation area includes areas within the 100-year floodplain, existing riparian bottomlands, and areas of contiguous valley oak woodland, totaling approximately 22,000 acres. The 1989 fisheries restoration plan recommended several actions specific to the study area:

- Fish passage improvements at the Red Bluff Diversion Dam (final EIS/EIR released May 2008)
- Modification of the Spring Creek Tunnel intake for temperature control (completed)
- Spawning gravel replacement program (ongoing)
- Development of side-channel spawning areas, such as those at Turtle Bay in Redding (ongoing)
- Structural modifications to the Anderson-Cottonwood Irrigation District Dam to eliminate short-term flow fluctuations (completed)
- Maintaining instream flows through coordinated operation of water facilities (ongoing)

- Improvements at the Coleman National Fish Hatchery (partially complete)
- Measures to reduce acute toxicity caused by acid mine drainage and heavy metals (ongoing)
- Various fisheries improvements on Clear Creek (partially complete)
- Flow increases, fish screens, and revised gravel removal practices on Battle Creek (began 2006)
- Control of gravel mining, improvement of spawning areas, improvement of land management practices in the watershed, and protection and restoration of riparian vegetation along Cottonwood Creek

The Nature Conservancy

The Nature Conservancy (TNC) is a private nonprofit organization involved in environmental restoration and conservation throughout the United States and the world. TNC approaches environmental restoration primarily by strategically acquiring land from willing sellers and obtaining conservation easements. Some of the lands are retained by TNC for active restoration, research, or monitoring activities, while others are turned over to government agencies such as USFWS or CDFW for long-term management. Lower in the Sacramento River basin, TNC has been instrumental in acquiring and restoring lands in the Sacramento River National Wildlife Refuge and managing several properties along the Sacramento River. It also has pursued conservation easements on various properties at tributary confluences, including Cottonwood and Battle creeks.

11.3 Environmental Consequences and Mitigation Measures

11.3.1 Methods and Assumptions

The following sections describe the methods, processes, procedures, and/or assumptions used to formulate and conduct the environmental impact analysis.

This analysis of impacts on fisheries and aquatic ecosystems resulting from implementation of the project alternatives under consideration is based on extensive review of existing documentation that addresses aquatic habitats and fishery resources in the primary and extended study areas, and on water resources modeling analysis.

Summary of Water Resources Modeling

Extensive modeling of hydrologic conditions, water temperature, and salmon production and mortality was performed to provide a quantitative basis from which to assess potential operational effects of the project alternatives on fisheries resources and aquatic habitats within the primary and extended study areas. Model selection and use for each of the variables were as follows:

- **Hydrologic modeling** – CalSim-II (primary and extended study areas)
- **Water temperature modeling** – Sacramento River water temperature model (primary study area)
- **Salmon production and mortality** – SALMOD, Version 3.8 (SALMOD) (primary study area)

Modeling output provided monthly values for each year of the 82-year period of record modeled for river flows, reservoir storage and elevation. These monthly values are then converted to daily values for use in water temperature modeling, which gives 6-hour interval river water temperatures. , The period of record is based on records from 1921 through 2003. Outputs on river flow and water temperature were put into weekly form for use in SALMOD to characterize flow- and water temperature–induced production and mortality of salmon under each simulated condition.

The models used in the fisheries analyses (i.e., CalSim-II, Sacramento River water temperature model, and SALMOD) are tools that have been developed for comparative planning purposes, rather than to predict actual river conditions at specific locations and times. The 82-year period of record for CalSim-II and water temperature modeling provides an index of the kinds of changes that would be expected to occur with implementation of a specified set of operational conditions. Output on reservoir storage, river flows, water temperature, and salmon survival for the period modeled should not be interpreted or used as definitive absolutes depicting actual river conditions that would occur in the future. Rather, output for the project alternatives was compared to that for the simulation of the Existing Condition (2005) and No-Action Alternative (future 2030) to determine the following:

- Whether reservoir storage or river flows and water temperatures would be expected to change with implementation of the SLWRI alternatives
- The months in which changes to reservoir storage and river flow and water temperatures could occur
- The relative 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 fisheries resources and aquatic habitats within the region

The models used, though mathematically precise, should be viewed as having reasonable detection limits. Establishing reasonable detection limits is useful when interpreting modeling output for an impact assessment; establishing such limits prevents the user from making inferences beyond the capabilities of the models and beyond the ability to actually measure changes.

The Modeling Appendix provides a more detailed discussion of the modeling process and its application to the project analysis. The appendix describes (1) the primary assumptions and model inputs used to represent hydrologic, regulatory, structural, and operational conditions; and (2) the simulations performed from which effects were estimated. SALMOD is discussed in more detail below.

Modeling Uncertainties and Real-Time Decision-Making As described in Section 11.2 , a process exists to make decisions about CVP and SWP operations in real time. This process allows for fishery management that involves flexible decision-making and adjustments for uncertainties as the outcomes of management actions and other events become better understood.

The modeling simulations conducted to support the analysis of the project alternatives are based on operational assumptions that are generally accepted. However, they do not always capture operational changes that may be associated with the human element of real-time decision-making. Therefore, there may be isolated inaccuracies regarding human decisions made in real time to ensure operational compliance with existing objectives, standards, and/or agreements.

For example, both the NMFS BO for the CVP/SWP Long-Term OCAP and various SWRCB orders require that CVP and SWP operations for the Sacramento River meet specific water temperature criteria. In 1997, construction was completed on the TCD at Shasta Dam. The TCD was designed to selectively withdraw water from elevations within Shasta Lake to better manage water temperatures in the upper river, while allowing power generation. The SRTTG is an interagency team that identifies water management alternatives and TCD operations in real time, interprets the availability of cold-water resources in Shasta Lake, and designs an annual/seasonal river temperature compliance strategy, as outlined in SWRCB Water Right Order 90-5 and multiple BOs.

Reservoir Fisheries Analysis

Monthly values for WSEL, surface area, and cold-water storage in Shasta Lake were calculated for 1922 to 2003 using data outputs from CalSim-II. Values were produced for five alternative dam raise scenarios (project alternatives) using a 2005 water supply demand, and a projected 2030 water supply demand for a total of 10 scenarios. Each year of the hydrologic record was categorized as one of five water year categories (wet, above-normal, below-normal, dry, critical) based on the Sacramento River Inflow Index. Model outputs for the last day of each month from February to July (e.g., February 29, March 31) were used for analysis of potential changes in surface area and WSEL. End-of-month values for April, June, August, and October were used to analyze the potential changes in Shasta Lake's cold-water storage. Potential impacts of the enlargement of Shasta Dam and Shasta Lake on the fisheries resources of Shasta Lake were investigated using several habitat-based metrics that are associated with factors known to limit or otherwise regulate warm-water and cold-water reservoir fish populations. The following metrics were computed and used:

- **Surface Area –** Surface area is the metric used to investigate changes in the amount of available littoral (i.e., shoreline) and limnetic (i.e., open water) habitat, which could impact warm-water and cold-water fisheries, under each of the project alternatives. Variations in surface area influence biological productivity (including fish production) because the upper, lighted layer of the pelagic zone is the principal plankton-producing region of the reservoir. Reservoir enlargement may initially produce a "trophic upsurge" phenomenon that occurs in response to terrestrial habitat inundation, nutrient loading, and increases in labile detritus (Kimmel and Groeger 1986). The initial trophic enrichment will decline and stabilize over time as the reservoir ecosystem approaches its natural trophic equilibrium (Kimmel and Groeger 1986). Trophic depression is a response to decreased nutrient loading and decreased labile detritus. Fisheries production experiences a depression in response to the same factors as well as decreases in available terrestrial organic detritus and loss of cover as inundated vegetation deteriorates (Stables et al. 1990).

- **Cold-Water Storage to Surface Area Ratio –** Cold-water storage to surface area ratio (a dimensionless value) is a useful metric for assessing the potential impact of project alternatives on Shasta Lake's cold-water fishery. Because this ratio relates cold-water volume to the surface area of the reservoir, the metric is sensitive to disproportionate changes in surface area without concomitant changes in the cold-water pool. Stables et al. (1990) suggest that an increase in pelagic and littoral trout habitat accompanied by lake enlargement should lead to higher total fish yield. While increases in water surface area, such as those that might result from reservoir enlargement, can stimulate primary and secondary productivity (Jones and Stokes Associates 1988), access to cold-water refuge can be a limiting factor for cold-water fish production. Therefore, increases in reservoir surface area without proportional increases in cold-water storage are likely to result in little change in cold-water fish production. Conversely, a proportional increase in the cold-water storage to surface area ratio should result in increased cold-water fish productivity.

- **WSEL –**WSEL is a metric that is useful in analyzing the impact of project alternatives on the Shasta Lake warm-water fishery. The timing and duration of WSEL fluctuation can have a great impact on the reproductive success of nearshore spawning fishes (Ploskey 1986). Stable or increasing WSEL during spring months (March through June) can contribute to increased reproductive success, young-of-the-year production, and juvenile growth rate of several warm-water species, including the black basses (Lee 1999, Ploskey 1986). Inundation of shoreline vegetation and structural habitat enhancement features installed around the reservoir also leads to increased structural diversity and availability of spawning substrate and cover for juvenile fishes (Miranda, Shelton, and Bryce 1984, Ratcliff 2006). Conversely, reduced or variable WSEL due to reservoir drawdown during spring spawning months can cause reduced spawning success for warm-water fishes through nest dewatering, egg desiccation, and physical disruption of spawning or nest guarding activities (Lee 1999, Ploskey 1986). Loss of access to inundated shoreline vegetation and habitat enhancement structures during reservoir drawdown in the summer increases predation mortality of juvenile bass and other sport fish (Lee 1999, Ploskey 1986, Ratliff 2006).

WSEL values were obtained from CalSim-II outputs, as described above, and were graphed for each comparison set. Monthly change in surface elevation (monthly change in elevation) was calculated by subtracting the previous month's surface elevation from each month. For example, change in elevation for March was calculated by subtracting the February 29 WSEL from the March 31 WSEL. The relative difference in monthly change in elevation from the basis-of-comparison and the relative percent difference in monthly change in elevation were graphed for each comparison set, with the basis-of-comparison as the Existing Condition in sets one and three, and the No-Action Alternative in set two. The relative difference and relative percent difference in monthly change in elevation between CP3 and CP4 were also graphed for comparison sets one and three.

Surface area values obtained from CalSim-II outputs were graphed for each comparison set. Relative differences in monthly surface area values from the basis-of-comparison were graphed for each comparison set, as described for WSEL.

Cold-Water Storage Values obtained from CalSim-II outputs were divided by surface area outputs to generate monthly cold-water storage to surface area ratios. The cold-water storage to surface area ratios were graphed for comparison set two only. The relative difference and relative percent difference in monthly cold-water storage to surface area ratio from the basis-of-comparison were also calculated and graphed for comparison set two only.

For each metric, CalSim-II projections for monthly change under the Existing Condition were graphed against the No-Action Alternative.

Additionally, graphs were prepared depicting the expected ratio of monthly cold-water storage to surface area, monthly surface area, and expected monthly changes in elevation under 2005 and 2030 water demands (separately) for all water year types for CP1, CP2, CP3, and CP4 for the Shasta Lake and vicinity portion of the primary study area. For example, in the discussion of potential impacts associated with implementation of CP1 is a graph comparing monthly surface area under CP1 with a 2005 water supply demand to monthly surface area under the Existing Condition, and a separate graph making this comparison for CP1 with a 2030 water supply demand versus the No-Action Alternative.

Values for the three habitat metrics were compared in graphical form to address the following issues:

- How reservoir cold-water storage, WSEL, or the cold-water storage to surface area ratio would be expected to change with implementation of the project alternatives
- Months or seasons when potential changes in the habitat metrics could occur
- Relative magnitude of change that could occur during specific months of particular water year types, and the potential impacts these changes could have on fisheries resources, aquatic resources, and habitats within the reservoir

All analyses were based on CalSim-II model outputs. CalSim-II is California's primary water operations planning model, used by both Reclamation and DWR. While model sensitivity and accuracy calibrations are still being developed for CalSim-II, the model's widespread use for water planning and management operations in Central California makes it useful and its projections easily comparable between projects. However, model outputs should be used as tools for interpretation of anticipated impacts rather than actual projections (Close et al. 2003).

Tributaries to Shasta Lake

The primary study area is composed of Shasta Dam and Shasta Lake, the lower reaches of the tributaries draining into Shasta Lake, and the Sacramento River downstream to Keswick Dam. Thirteen representative tributary streams to Shasta Reservoir were selected for focused examination as part of this assessment, including the five primary tributaries: Sacramento River, McCloud River, Pit River, Squaw Creek, and Big Backbone Creek.

Considerations for reservoir and tributary fisheries include the following:

- Connectivity to tributary spawning/refuge habitat.
- Potential connectivity to nonfish-bearing streams.
- Potential impacts to special-status species or their habitat from inundation of stream habitat (e.g., through increased

turbidity/erosion/sedimentation that may affect connectivity or create a barrier).

Chinook Salmon Between Keswick Dam and Red Bluff Pumping Plant

SALMOD is a computer model that simulates the dynamics of freshwater salmonid populations, but for the SLWRI, SALMOD simulates population dynamics for all four runs of Chinook salmon between Keswick Dam and RBPP. SALMOD was applied to this project because the model had been previously used on the upper Sacramento River (from Keswick Dam to Battle Creek), and has been updated using model parameters and techniques developed for use on the Klamath River and from Sacramento River-specific Chinook salmon information obtained from USFWS and CDFW fisheries biologists (Bartholow 2003; Modeling Appendix, Chapter 5). Also, resource agency personnel were presented with the capabilities of the model by John Bartholow (formerly with the U.S. Geological Survey) under contract by Reclamation, and agreed that using SALMOD was the appropriate means of evaluating potential conditions. John Bartholow and John Heasley (contractor to U.S. Geological Survey) were instrumental in extending SALMOD to assess fish production and mortality between Keswick Dam and the RBPP. They also assisted in preparation of the SALMOD description included in the Modeling Appendix, Chapter 5, which contains a detailed discussion of the SALMOD model.

Comprehensive Plans Evaluated SALMOD used weekly streamflow and water temperature to evaluate six different scenarios: the Existing Condition, No-Action Alternative, CP1, CP2, CP3, and CP4. The Existing Condition is based on a 2005 level of development. The No-Action Alternative represents the Future Conditions (2030) without completion of a project to address the objectives of the SLWRI. CP1 is based on a 6.5-foot dam raise; CP2 is based on a 12.5-foot dam raise; and CP3 is based on an 18-foot dam raise. CP4 was developed based on an 18.5-foot dam raise with operations modified to create a more “fish-friendly” environment, with one-third of the reservoir storage dedicated to fish, to either improve flows or water temperatures.

Additional scenarios were evaluated, but not pursued further, due to inconsistencies or lack of achievement of the primary goals of the project.

In the original presentation (August 16, 2005) of the SALMOD model to resource agency personnel, interest was expressed in setting the number of spawning adults at the AFRP production goal for the Sacramento River upstream from the RBPP. The AFRP defined natural production to be that portion of Chinook salmon not produced in hatcheries, and defined total production to be the sum of harvest and escapement. The production goals include adult fish removed from the system due to both sport and commercial fishing in both freshwater and marine environments. Therefore, SALMOD was run using the appropriate number of spawners (Table 11-3).

SALMOD was also conducted using a spawning population based on the 1999 to 20 average adult return provided by CDFW (2012), which documents spawning escapement estimates for each year in the Central Valley. Using this average was expected to result in a more realistic effect of the project operations on salmon under the Existing Condition, and on the premise that the AFRP goals should take the populations closer to a state of carrying capacity. Thus, if a population is already at or nearing carrying capacity, increases in the populations are unlikely. The starting year for calculating the average number of spawners was in 1999 because the effects of the TCD began in 1999, and ended in 20, which was the extent of collected and processed data.

Populations of 500 or more spawning Chinook salmon are considered necessary for accurate results using SALMOD because it is a deterministic model that relies on the “law of large numbers.” When populations are “low” (an arbitrary term), mean responses are quickly affected by environmental stochasticity and individual variability, which are factors SALMOD was not designed to address. Therefore, because the 1999 to 2011 average for spring-run Chinook salmon was 132 adult spawners, the criterion of 500 or more fish was not met. However, because of concerns expressed by CDFW and USFWS, the spawning population was left at 132 fish for purposes of the model.

Table 11-3. Number of Spawning Fish Incorporated into SALMOD Model

Reach	Fall-Run	Late Fall-Run	Winter-Run	Spring-Run
California Department of Fish and Game (Grand Tab, 1999 through 2011 average)				
Keswick to ACID	4,624	3,487	2,592	6
ACID to Highway 44 Bridge	2,784	1,546	1,271	25
Highway 44 Bridge to Airport Road Bridge	4,984	2,304	2,195	42
Airport Road Bridge to Balls Ferry Bridge	8,620	1,849	118	23
Balls Ferry Bridge to Battle Creek	5,792	566	6	14
Battle Creek to Jellys Ferry Bridge	8,441	212	6	20
Jellys Ferry Bridge to Bend Bridge	6,106	101	12	2
Bend Bridge to RBPP Inundation Zone	3,502	51	0	0
Total Adult Spawners	**47,754**	**10,116**	**6,200**	**132**
Potential Eggs	**107,754,831**	**24,255,323**	**8,928,222**	**317,169**

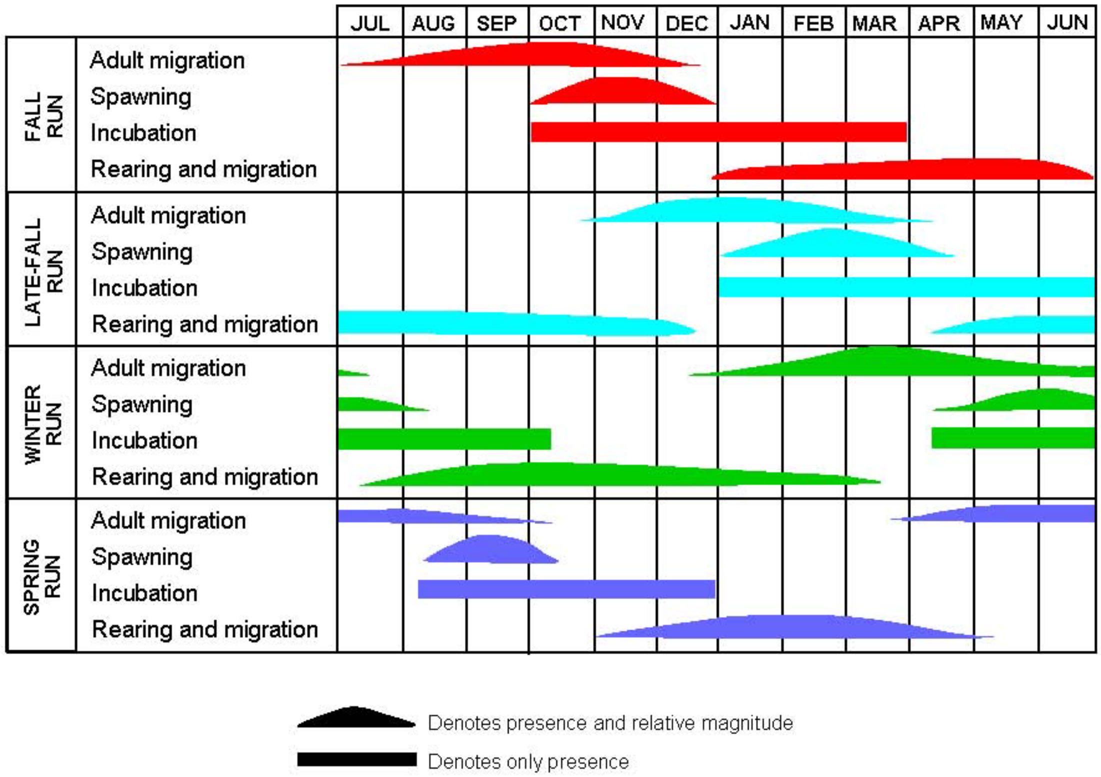
Table 11-3. Number of Spawning Fish Incorporated into SALMOD Model (contd.)

Reach	Fall-Run	Late Fall-Run	Winter-Run	Spring-Run
U.S. Fish and Wildlife Service (AFRP goals)				
Keswick to ACID	10,218	9,761	19,320	1,003
ACID to Highway 44 Bridge	6,174	4,328	9,455	4,235
Highway 44 Bridge to Airport Road Bridge	10,925	6,447	16,358	7,021
Airport Road Bridge to Balls Ferry Bridge	19,022	6,169	886	3,901
Balls Ferry Bridge to Battle Creek	12,731	1,591	66	2,340
Battle Creek to Jellys Ferry Bridge	18,629	597	26	3,343
Jellys Ferry Bridge to Bend Bridge	13,427	278	106	334
Bend Bridge to RBPP Inundation Zone	7,705	146	0	0
Total Adult Spawners	**98,830**	**28,318**	**46,218**	**22,178**
Potential Eggs	**237,200,000**	**67,960,000**	**66,552,000**	**53,220,000**

Note:
Spawners include males and females.
Key:
ACID = Anderson-Cottonwood Irrigation District
AFRP = Anadromous Fish Restoration Program
RBPP = Red Bluff Pumping Plant

SALMOD Output SALMOD produces many forms of output files, but two basic output files – production and mortality (both weekly and annual) – were used in this assessment. Production derived with SALMOD is the number of immature smolts that survive to pass the RBPP. Two types of mortality were calculated – those caused by the operations (triggered by changes in flow and water temperature) and those that are nonoperations-related (mortalities caused by factors that would still occur without the project in effect, such as disease, predation, and entrainment). Mortality was calculated for each life stage, from migrating/holding adult to the emigrating juvenile.

SALMOD evaluated five separate life stages of Chinook salmon – adult, egg, fry, presmolt, and immature smolt. Figure 11-1 shows the timing for each life stage. Mortality of adults in SALMOD was calculated during the adult migration and spawning time periods. Mortality of eggs (both eggs and in-gravel alevins) was calculated during the adult migration, spawning, and incubation stages, while fry, presmolts, and immature smolts were calculated during the rearing and migration time period.



Source: Vogel and Marine 1991

Figure 11-1. Approximate Timing of the Four Runs of Chinook Salmon in the Sacramento River

Production SALMOD defines production as follows:

Production = (Potential eggs + entrants) – (prespawn egg mortality + other mortality + residuals)

Where:

- Production is the number of young fish surviving to migrate downstream from the RBPP
- Potential eggs are the number of eggs that could be spawned, providing there is no prespawn mortality of either adult females or eggs *in vivo*
- Entrants are the number of young fish entering the project reach (Keswick Dam to RBPP) from the tributaries
- Mortality is the number of eggs and/or fish that die before leaving the project reach
- Residuals are the number of young fish under 60 mm that, after 52 weeks, have not left the project reach

Mortality The mortality process computed all mortality not explicitly included with one of the other processes. This includes mortality from unsuitable water temperature, population density, superimposition, and eggs while *in vivo* and incubating. In addition, a base mortality for all causes not related to any other process (e.g., entrainment, predation) was also computed.

Categories of mortality calculated in SALMOD include the following and are further described in Chapter 5 of the Modeling Appendix:

- **Flow- and Water Temperature-Related Mortality**
  - **Habitat –** Operations-related mortality resulting from forced movement of fry, presmolts, or immature smolts due to habitat constraints.
  - **Temperature –** Operations-related mortality to adults, eggs, fry, presmolts, and/or immature smolts caused by unsuitable water temperatures.
  - **Lost Egg –** Number of eggs lost due to the lack of spawning habitat (a single adult Chinook salmon female cannot spawn because all redds are guarded). It was assumed that these eggs are shed, but as they are alive when leaving the female spawners, they were tallied in the mass balance table. The lack of spawning habitat could be due to lack of spawning gravel, or lower flows precluding access to suitable spawning habitat.
  - ***In Vivo* –** Number of eggs lost because of operations-related water temperature mortality within the female either prior to spawning, or prespawning, thermal mortality in which exposure kills the egg or malformed young fish after spawning.
  - **Incubation –** Number of eggs lost if redds (or portions of redds) are affected by changing egg incubation habitat through the duration of the incubation season due to flushing flows scouring out the redds (occurs at a minimum of 60,000 cfs) or redd dewatering from a drop in streamflows resulting from operations-related actions.
  - **Superimposition –** Number of eggs lost due to new spawning on top of a currently incubating redd resulting from operations-related activities.
- **Nonoperations Mortality**
  - **Base –** An accounting of mortality of adults, eggs, fry, presmolts, and immature smolts for everything other than what is in the model,

or background mortality (mortality that would occur regardless of the project operations) from factors, such as predation and disease.

- **Seasonal –** Extra outmigration mortality of presmolts or immature smolts, including diversion-related mortality.

Analysis To evaluate the effects of the project, productions and mortalities were calculated and the differences between the project alternatives and the No-Action Alternative and the Existing Condition were then compared. Most of the years for each run showed minimal differences from the No-Action Alternative, creating an overall average production approaching zero. Each model has its own inherent level of error. In addition, flow data derived from CalSim-II had to be disaggregated from monthly data to weekly, resulting in potential additional error. Because water year type affects Chinook salmon populations, separate production trends based on water year type were evaluated for each run.

Starting populations used in SALMOD were derived from an average population for the years 1999 through 2011, based on the CDFW Grandtab table (2011), which lists population estimates on a yearly basis. The AFRP populations were based on the goals identified for the Sacramento River for each run of Chinook salmon.

SALMOD computes mortality by lifestage from various sources, including water temperature and habitat availability. For this evaluation, the lifestage-specific mortalities were converted to smolt equivalent mortality by using annual survival rates for the lifestages later than those at which the mortality occurred. This was an attempt to provide information on the relative effect of water temperature versus habitat availability (as affected by flow volume) on juvenile production. Smolt equivalents were calculated as follows:

Prespawn/Egg Mortality to Immature Smolt Equivalent Prespawn/ Egg Mortality

$$Immature\ Smolt\ Equivalent\ Mortality_i = Mortality_i \times \%\ Survival_{Eggs\ to\ Fry} \times \%\ Survival_{Fry\ to\ Presmolt} \times \%\ Survival_{Preolt\ to\ Immature\ Smolt}$$

Where:

$$i = Prespawn\ Base, Prespawn\ Temperature, Incubation, Superimposition, Eggs\text{-}Base, or\ Eggs\text{-}Temperature\ Mortality$$

Fry Mortality to Immature Smolt Equivalent Fry Mortality

$$Immature\ Smolt\ Equivalent\ Mortality_i = Mortality_i \times \%\ Survival_{Fry\ to\ Presmolt} \times \%\ Survival_{Presmolt\ to\ Immature\ Smolt}$$

Where: *i = Base, Temperature, or Habitat Mortality*

Presmolt Mortality to Immature Smolt Presmolt Mortality

$$Immature\ Smolt\ Equivalent\ Mortality_i = Mortality_i \times \%\ Survival_{Pre-Smolt\ to\ Immature\ Smolt}$$

Where: *i = Base, Temperature, Habitat, or Seasonal Mortality*

Although water year classifications are somewhat arbitrary, and the biological year for each run of Chinook salmon encompasses portions of two separate water years, mortalities caused by operations were separated by water year types to identify trends, such as changes in mortality in critical water years due to unsuitable water temperatures. Once the years were separated by water year type, the mortality categories were ranked to determine which mortality category under each alternative was the primary factor affecting production for each run.

The SLWRI has the greatest variations in project operations from the Existing Condition, No-Action Alternative, and the Comprehensive Plans during critical and dry water years (for further detail, refer to the *Hydrology, Hydraulics and Water Management Technical Report*). Besides providing a more reliable water source for delivery, CP1 through CP5 are able to provide more suitable flows and water temperatures during critical and dry water years. This is shown in increased production and/or decreased operations-related mortalities. Because CP5 is operated the same as CP3, all results for CP5 are synonymous with CP3 and are not listed in the table of results.

Riverine Fisheries

Riverine fish, including steelhead and green sturgeon, were evaluated based on differences between monthly mean flows at various modeling locations on the lower Sacramento River and tributaries under each Comprehensive Plan and the monthly mean flows simulated for Existing Conditions and No-Action Alternative conditions. Modeling for the lower American River occurred at Verona and Freeport; for the lower Feather River, modeling occurred below Thermalito Afterbay; and American River modeling occurred near the H Street Bridge in Sacramento. Modeling also occurred on the Trinity River. Additionally, flow changes were used to evaluate the potential change in ecologically important geomorphic processes such as channel forming and maintenance, meander migration, and the creation of seasonally inundated floodplains.

Delta Fisheries

Delta Outflow Water development has changed the volume and timing of freshwater flows through the Bay-Delta. Over the past several decades, the volume of the Bay-Delta's freshwater supply has been reduced by upstream diversions, in-Delta use, and Delta exports. As a result, the proportion of Delta outflow depleted by upstream and Delta diversions has grown substantially. In wet years, diversions reduce outflow by 10 percent to 30 percent. In dry years, diversions may reduce outflow by more than 50 percent.

Water development has also altered the seasonal timing of flows passing into and through the Bay-Delta. Flows have decreased in April, May, and June and have increased slightly during the summer and fall (SWRCB 2012). Seasonal flows influence the transport of eggs and young organisms (e.g., zooplankton, fish eggs, larvae) through the Delta and into San Francisco Bay. Flows during the months of February through 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, Rosenfield 2010, Rosenfield and Baxter 2007).

For purposes of evaluating the potential effect of changes in outflow on fish habitat within the Bay-Delta, and considering the accuracy and inherent noise within the hydrologic model, it was assumed that changes in the average monthly flows that were less than 5 percent (plus or minus) relative to the basis-of-comparison would not be expected to result in a significant (detectable) effect on habitat quality or availability. It would also not be expected to result in a significant effect on the transport mechanisms provided by Delta outflow, on resident or migratory fish or the zooplankton and phytoplankton on which they rely for a food resource.

Delta Inflow Changes in upstream reservoir storage have the potential to affect Delta inflow (water entering the Delta). Delta inflow may affect hydrologic conditions within Delta channels, hydraulic residence times, salinity gradients, and the transport and movement of various life stages of fish, invertebrates, phytoplankton, and nutrients into and through the Delta. Delta inflow serves as a surrogate metric for a variety of habitat conditions within the Delta that directly or indirectly affect fish and other aquatic resources.

The comparison includes the estimated average monthly inflow under the basis-of-comparison conditions (Existing Condition and No-Active Alternative), the average monthly flow under each of the project alternatives evaluated, and the percentage change between base flows and operations. For purposes of evaluating the potential effect of changes in Delta inflow on fish habitat within the Bay-Delta, and considering the accuracy and inherent noise within the hydrologic model, it was assumed that changes in the average monthly flows that were less than 5 percent (plus or minus) relative to the basis-of-comparison would not be expected to result in a significant (detectable) effect on habitat quality or availability, or the transport mechanisms provided by Delta inflow, on resident or migratory fish or the zooplankton and phytoplankton that they rely on for a food resource.

Sacramento River Inflow Flow within the Sacramento River has been identified as an important factor affecting the survival of emigrating juvenile Chinook salmon, important to the downstream transport of planktonic fish eggs and larvae such as delta smelt and longfin smelt, striped bass, and shad, and important for seasonal floodplain inundation that has been identified as important habitat for successful spawning and larval rearing by species such as Sacramento splittail and as seasonal foraging habitat for juvenile Chinook salmon and steelhead. Sacramento River flows are also important in the transport of organic material and nutrients from the upper regions of the watershed downstream into the Delta. A reduction in Sacramento River flow as a result of SLWRI alternative operations, depending on the season and magnitude of change, could adversely affect habitat conditions for both resident and migratory fish species. An increase in river flow is generally considered to be beneficial for aquatic resources within the normal range of typical project operations and flood control. Very large changes in river flow could also affect sediment erosion, scour, deposition, suspended and bedload transport, and other geomorphic processes within the river and watershed.

For purposes of evaluating the potential effect of changes in Sacramento River inflow on fish habitat within the Bay-Delta, and considering the accuracy and inherent noise within the hydrologic model, it was assumed that changes in the average monthly flows less than 5 percent (plus or minus) relative to the basis-of-comparison would not be expected to result in a significant (detectable) effect on habitat quality or availability, or the transport mechanisms provided by Sacramento River inflow, on resident or migratory fish or the zooplankton and phytoplankton that they rely on for a food resource.

San Joaquin River Flow at Vernalis Flow within the San Joaquin River has been identified as an important factor affecting the survival of juvenile Chinook salmon migrating downstream from the tributaries through the mainstem San Joaquin River and Delta, important to the downstream transport of planktonic fish eggs and larvae such as striped bass, and important for seasonal floodplain inundation that is considered to be important habitat for successful spawning and larval rearing by species such as Sacramento splittail and as seasonal foraging habitat for juvenile Chinook salmon. San Joaquin River flows are also important in the transport of organic material and nutrients from the upper regions of the watershed downstream into the Delta. A reduction in San Joaquin River flow as a result of SLWRI alternative operations, depending on the season and magnitude of change, could adversely affect habitat conditions for both resident and migratory fish species. An increase in river flow is generally considered to be beneficial for aquatic resources within the normal range of typical project operations and flood control. Very large changes in river flow could also affect sediment erosion, scour, deposition, suspended and bedload transport, and other geomorphic processes within the river and watershed.

For purposes of evaluating the potential effect of changes in San Joaquin River flow at Vernalis on fish habitat within the Bay-Delta, and considering the accuracy and inherent noise within the hydrologic model, less than a 5-percent change (plus or minus) relative to the basis-of-comparison, would not be expected to result in a significant (detectable) effect on habitat quality or availability, or the transport mechanisms provided by San Joaquin River flow at Vernalis, on resident or migratory fish or the zooplankton and phytoplankton that they rely on for a food resource.

Low Salinity Zone and X2 In many segments of the Bay-Delta, but particularly in Suisun Bay and the Delta, salinity is controlled by the balance of saltwater intrusion from San Francisco Bay and freshwater flow from the tributaries to the Delta. By altering the timing and volume of flows, water development has affected salinity patterns in the Delta and in parts of San Francisco Bay (Kimmerer 2002, Kimmerer 2004, SWRCB 2012). Under natural conditions, the Carquinez Strait/Suisun Bay region marked the approximate boundary between saltwater and freshwater in the Bay-Delta 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 freshwater 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 (SWRCB 2012).

Salinity is an important habitat factor in the Bay-Delta (Baxter et al. 1999). All estuarine species are assumed to 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 Bay-Delta 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 (Unger 1994, Kimmerer 2002).

The transition area between saline waters within the Bay and freshwater within the rivers, frequently referred to as the LSZ, is located within Suisun Bay and the western Delta. The LSZ has also been associated with the region of the Bay-Delta characterized by higher levels of particulates, higher abundances of several types of organisms, and a turbidity maximum. It is commonly associated with the position of the 2 parts per thousand salinity isohaline (X2), but actually occurs over a broader range of salinities (Kimmerer 1992, Kimmerer 2004).

Originally, the primary mechanism responsible for this region 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 LSZ in all years, nor is it always associated with X2 (Burau et al. 1998). Lateral circulation within the Bay-Delta or chemical flocculation may play a role in the formation of turbidity maximum within the estuary.

As a consequence of higher levels of particulates, the LSZ 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, introduced species have cropped much of the primary production in the Bay-Delta and there has been virtually no enhancement of phytoplankton production or biomass in the LSZ (CUWA 1994, Lund et al. 2012).

This region continues to have relatively high levels of invertebrates and larval fish, even though the base of the food chain may not have been enhanced in the LSZ during the past decade. 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 region, but recent evidence suggests that vertical migration does not provide a complete explanation (Kimmerer et al. 2002).

Although evidence indicates that X2 and the LSZ are not as closely related as previously believed (Burau et al. 1998), X2 continues to be used as an index of the location of the LSZ and area/or of increased biological productivity. Historically, X2 has varied between San Pablo Bay (River Kilometer 50) during high Delta outflow and Rio Vista (River Kilometer 100) during low Delta outflow. In recent years, it has typically been located between approximately Honker Bay and Sherman Island (River Kilometer 70 to 85). X2 is controlled directly by the volume of Delta outflow, although changes in X2 lag behind changes in outflow. Minor modifications in outflow do not greatly alter X2.

Operations of upstream storage reservoirs have the potential to affect the location of X2 as a result of changes in freshwater flows from the upstream tributaries through the Delta. For purposes of evaluating changes in habitat quantity and quality for estuarine species, a significance criterion of an upstream change in X2 location within 1 kilometer (km) of the basis-of-comparison condition was considered to be less than significant. The criterion was applied to a comparison of hydrologic model results for basis-of-comparison conditions and project alternatives, by month and water year, for the months from February through May and September through November.

Old and Middle River Reverse Flows Reverse flows occur when Delta exports and agricultural demands exceed San Joaquin River inflow plus

Sacramento River inflow through the DCC, Georgiana Slough, and Threemile Slough. The capacities of the DCC, Georgiana Slough, and Threemile Slough are fixed; therefore, 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 CVP and SWP pumps. The reverse flow condition within the lower San Joaquin River is typically referred to as Qwest. As second reverse flow condition occurs within Old and Middle rivers as the rate of water diverted at the CVP and SWP export facilities exceeds tidal and downstream flows within the central region of the Delta.

Reverse flows in Old and Middle rivers, resulting from low San Joaquin River inflows and increased exports to the CVP and SWP, have been identified as a potential cause of increased delta smelt and salmonid mortality at the CVP and SWP fish facilities within recent years (Simi and Ruhl 2005, USFWS 2008, NMFS 2009a, Wanger 2007 Case 1:05-cv-01207-OWW-NEW). Results of analyses of the relationship between the magnitude of reverse flows in Old and Middle rivers and salvage of adult delta smelt in the late winter shows a substantial increase in salvage as reverse flows exceed approximately -5,000 cfs. Concerns regarding reverse flows in Old and Middle rivers have also focused on planktonic egg and larval stages of delta and longfin smelt, striped bass, splittail, and on Chinook salmon smolts, and while these species do not spawn to a significant extent in the south Delta, eggs and larvae may be transported into the area by reverse flows in Old and Middle rivers. As discussed previously, these early life stages are generally entrained, since they are too small to be effectively screened from export waters.

Old and Middle river reverse flows have been calculated for project alternatives that equate San Joaquin River flow at Vernalis and exports to Old and Middle river flows. Summaries of Old and Middle river reverse flows are included for the Existing Condition, No-Action and action alternatives, by month and water year type. The most biologically sensitive period when the potential effects of reverse flows could affect delta smelt, Chinook salmon, and many other species extends from the late winter through early summer. For purposes of these analyses, a comparison of reverse flows within Old and Middle rivers under the basis-of-comparison and proposed alternative project operations was prepared for the seasonal period extending from January through June. Per the RPAs in the USFWS 2008 and NMFS 2009 BOs, any reduction in Old and Middle River reverse flows (i.e., flows that are more negative) that result in flows greater than (i.e., flows that are more negative) -5,000 cfs are considered to be a significant impact. Additionally, a 5 percent reduction in Old and Middle River flows making them more negative is also considered a significant impact.

CVP and SWP Export Operations Increased exports could increase the risk of entrainment and salvage of resident and migratory fish present in the south Delta, which may include delta smelt, longfin smelt, juvenile Chinook salmon, steelhead, striped bass, and other species of fish as well as macroinvertebrates and nutrients. Increased exports during drier water years in the summer could result in an increased risk of entrainment and salvage for juvenile delta smelt and salmon (April to June) and resident warm-water fish such as striped bass, threadfin shad, catfish, and others during the warmer summer months (July through August). Increased exports could also increase the entrainment and removal of phytoplankton, zooplankton, macroinvertebrates, organic material, and nutrients from the Delta.

Estimated Fish Entrainment/Losses Changes in the volume of water exported at the CVP and SWP facilities is assumed to result in a direct proportional increase or decrease in the risk of fish being entrained and salvaged at the facilities. Using information from the hydrodynamic operations model, in combination with information on the densities of various fish species observed at the salvage facilities, an index in the form of a change in the numbers of a fish species theoretically affected by a change in export operations can be developed. Fish lost to entrainment/salvage at the CVP and SWP were estimated based on monthly estimated combined exports. The project alternatives were modeled in CalSim and assume, for each alternative, that the project would be implemented under the Existing Condition, and under the Future Condition. Both the Existing Condition, or “existing base” conditions, and future base conditions, or “future No-Action Alternative” conditions – which assumes no project was implemented, were assessed.

Data sources used to calculate fish losses at the CVP and SWP consisted of 1995 through 2005 monthly average density data, collected by DWR (2006) at the Skinner Fish Facility and by Reclamation at the Jones Fish Facility located at each export facility, respectively. These density data were calculated for delta smelt, longfin smelt, Chinook salmon, steelhead, striped bass, and splittail. Green sturgeon were considered for this analysis; however, they are seldom collected at the fish facilities, and thus, have not been modeled in the entrainment loss estimates. Fish density data was combined with CalSim results export flows modeled.

From CalSim modeling results, average monthly exports, and average exports each year from 1922 to 2003 in cfs were converted to acre-feet per each month (January through December), and were then multiplied by monthly average densities (number of fish per acre-foot), for each of the selected fish species. Average monthly fish losses calculated for each year were then averaged by water year type (e.g., wet, above-normal, normal, below-normal, dry, and critical) for each month, as well as an average across all years (all water year types), for each month. Fish losses, for each species, were totaled across months to show the total fish loss index for a given species for an average year (all water year types), wet, above-normal, normal, below-normal, dry, and critical years.

Fish losses resulting from entrainment were calculated two ways, which both produced identical entrainment indices to represent the change in entrainment based on changes in CVP and SWP exports as a result of the SLWRI alternatives:

- Fish losses were estimated by calculating losses under the base conditions, and then by calculating losses under the project alternative, from CalSim modeling. The total number of fish lost under the base case was subtracted from the number lost under the project alternative, indicating whether a net benefit (negative number) or a net loss (positive number) would result from the project alternatives.

- Fish losses were estimated by calculating losses directly from the "Alt minus Base" modeling results in CalSim.

The general calculation of the change in entrainment/salvage risk is shown below:

A = Density of fish per acre-foot for a given fish species (e.g., delta smelt, longfin smelt, salmon, striped bass, steelhead, splittail)

B = Monthly export rate (cfs), by year

C = [B x 1.983 x (number of days/month)] = average monthly exports (for CVP+SWP) for a given year, 1922 to 2003, in acre-feet

D = [A] [C] = Average monthly fish loss, per species, in a given year

D_A = $\sum (C_{1922,} C_{1923} \ldots C_{2003})$ = Average monthly fish losses at the CVP + SWP

D_W = $\sum$ (*wet water years*) = Fish losses, by month, at the CVP + SWP, based on wet water years, 1922 to 2003

D_{AN} = $\sum$ (*above-normal water years*) = Fish losses, by month, at the CVP + SWP, based on above-normal water years, 1922 to 2003

D_N = $\sum$ (*normal water years*) = Fish losses, by month, at the CVP + SWP, based on normal water years, 1922 to 2003

D_{BN} = $\sum$ (*below-normal water years*)) = Fish losses, by month, at the CVP + SWP, based on below-normal water years, 1922 to 2003

D_D = $\sum$ (*dry water years*) = Fish losses, by month, at the CVP + SWP, based on dry water years, 1922 to 2003

D_C = $\sum$ (*critical water years*) = Fish losses, by month, at the CVP + SWP, based on critical water years, 1922 to 2003

E_A = ($D_{A\text{-}JANUARY}$ + $D_{A\text{-}FEBRUARY}$...+ $D_{A\text{-}DECEMBER}$) = Total yearly average fish losses, based on monthly average 1922 to 2003 fish losses

E_W = ($D_{W\text{-}JANUARY}$ + $D_{W\text{-}FEBRUARY}$...+ $D_{W\text{-}DECEMBER}$) = Total yearly fish losses in a wet year, based on monthly average 1922 to 2003 fish losses

E_{AN} = ($D_{AN\text{-}JANUARY}$ + $D_{AN\text{-}FEBRUARY}$...+ $D_{AN\text{-}DECEMBER}$) = Total yearly fish losses in an above-normal year, based on monthly average 1922 to 2003 fish losses

E_N = ($D_{N\text{-}JANUARY}$ + $D_{N\text{-}FEBRUARY}$...+ $D_{N\text{-}DECEMBER}$) = Total yearly fish losses in a normal year, based on monthly average 1922 to 2003 fish losses

E_{BN} = ($D_{BN\text{-}JANUARY}$ + $D_{BN\text{-}FEBRUARY}$...+ $D_{BN\text{-}DECEMBER}$) = Total yearly fish losses in a below-normal year, based on monthly average 1922 to 2003 fish losses

E_D = ($D_{D\text{-}JANUARY}$ + $D_{D\text{-}FEBRUARY}$...+ $D_{D\text{-}DECEMBER}$) = Total yearly fish losses in a dry year, based on monthly average 1922 to 2003 fish losses

E_C = ($D_{C\text{-}JANUARY}$ + $D_{C\text{-}FEBRUARY}$...+ $D_{C\text{-}DECEMBER}$) = Total yearly fish losses in a critical year, based on monthly average 1922 to 2003 fish losses

Impact Mechanisms

The project could potentially affect fisheries and aquatic ecosystems through the following impact mechanisms:

- Construction-related impacts:
  - Temporary construction-related loss or degradation of aquatic habitat
- Operations-related impacts, including the following:
  - Flow- and/or water temperature–related impacts on species of primary management concern
  - Geomorphic impacts resulting from reduced frequency, duration, and/or magnitude of ecologically important intermediate and peak flows

- Delta flow-related effects, including the following:
  - Delta outflow and inflow related effects on species of primary management concern
  - Effects related to changes in Sacramento River inflow to the Delta
  - San Joaquin River flow-related effects
  - Effects on species of primary management concern resulting from changes in the location of the LSZ and X2
  - Effects resulting from reverse flows in Old and Middle rivers
  - Effects of changes in CVP and SWP exports to fish entrainment and salvage

The analysis assessed potential effects on fish species of primary management concern and important aquatic ecological processes from construction activities and/or operations occurring in the primary study area or the extended study area. Species of primary management concern are special-status, ecologically important, and recreationally or commercially important fish species. For the upper Sacramento River (Shasta Dam to Red Bluff) portion of the primary study area, fish species of primary management concern consist of the following:

- Four runs of Chinook salmon (winter-, spring-, fall-, and late fall–run)
- Steelhead
- Green sturgeon
- Sacramento splittail
- American shad
- Striped bass

For the lower Sacramento River to the Delta portion of the extended study area, fish species of primary management concern include the same fish identified above, as well as delta smelt and longfin smelt, and exclude American shad.

For the Trinity River portion of the extended study area, fish species of primary management concern consist of the following:

- Chinook salmon
- Steelhead

- Coho salmon
- Green sturgeon
- White sturgeon

The analysis of potential impacts on primary fish species of management concern considered species' life history stages (adult migration, spawning, egg incubation, and juvenile rearing and emigration) and biological requirements. For all fish species of primary management concern in the Sacramento River, evaluation of potential impacts on individual life stages was based on life history descriptions provided in the *Fisheries and Aquatic Ecosystems Technical Report*.

Increased water supplies or increased supply reliability also could reduce a limitation on population growth, changes in local land use, or on other activities that could affect aquatic habitats and fishery resources in the primary and extended study areas, resulting in potentially significant impacts. The impacts of this growth would be analyzed in general plan EIRs and in project-level CEQA compliance documents for the local jurisdictions in which the growth would occur. Mitigation of these impacts would be the responsibility of these local jurisdictions, and not of Reclamation. The expected increase in water yield relative to the entire CVP and SWP service areas would be small, however. Assuming that this new yield could be provided to any number of geographic areas within the CVP and SWP service areas, the project's impact on growth that could affect aquatic habitats would be minor.

Similarly, projects potentially affecting most aquatic habitats and listed species would require permits from CDFW, USACE, USFWS, and NMFS. It is anticipated that effects on aquatic habitats and listed species would be avoided, minimized, and/or mitigated during those agency consultations.

The extent, location, and timing of induced growth are currently highly uncertain; the effects of this growth would be analyzed and mitigated during future land use planning and environmental review for specific projects. Therefore, growth-inducing effects on aquatic habitats and fisheries resources are not discussed further in this chapter.

11.3.2 Criteria for Determining Significance of Effects

An environmental document prepared to comply with NEPA must consider the context and intensity of the environmental effects that would be caused by, or result from, the proposed action. Under NEPA, the significance of an effect is used solely to determine whether an Environmental Impact Statement must be prepared. An environmental document prepared to comply with CEQA must identify the potentially significant environmental effects of a proposed project. A "[s]ignificant effect of the environment" means a substantial, or potentially substantial, adverse change in any of the physical conditions within the area affected by the project (State CEQA Guidelines, Section 15382). CEQA also requires that the environmental document propose feasible measures to avoid or substantially reduce significant environmental effects (State CEQA Guidelines, Section 15126.4(a)).

Significance criteria (sometimes called "thresholds of significance") used in this analysis are based on the checklist presented in Appendix G of the State CEQA Guidelines; factual or scientific information and data; and regulatory standards of Federal, State, and local agencies. These thresholds also encompass the factors taken into account under NEPA to determine the significance of an action in terms of the context and the intensity of its effects.

For the assessment of impacts on fisheries and aquatic ecosystems, habitat indicators for project operations such as water temperature, flows, and important ecological processes have been used to evaluate whether the project alternatives would have an adverse effect on the species and/or species' habitat. For example, exceedence of monthly mean water temperatures identified by NMFS for certain species (e.g., 56ºF at Bend Bridge from April 15 through September 30 for winter-run Chinook salmon) is one such impact on a habitat indicator. Reduction of reservoir WSELs can reduce the availability of nearshore littoral habitat used by warm-water fish for spawning and rearing, thereby reducing spawning and rearing success and subsequent year class strength; therefore, reservoir WSEL is another habitat indicator used. 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) have also been used as habitat impact indicators for species of primary management concern.

The following significance criteria were developed based on guidance provided by the State CEQA Guidelines, and consider the context and intensity of the environmental effects as required under NEPA. Impacts of an alternative on fisheries and aquatic ecosystems would be significant if project implementation would do any of the following:

- Have a substantial adverse effect, either directly or through habitat modifications, on any species identified as a candidate, sensitive, or special-status species in local or regional plans, policies, or regulations or by CDFW, USFWS, or NMFS.

- Conflict with the provisions of an adopted habitat conservation plan, natural community conservation plan, or other approved local, regional, or State habitat conservation plan or policies or ordinances protecting biological resources.

- Interfere substantially with the movement of any native resident or migratory fish species or with established habitat, or impede the use of native fish nursery/rearing sites.

- Conflict with a local policy or ordinance that protects aquatic and fishery resources.

- Substantially reduce the habitat of a fish species, cause a fish species to drop below self-sustaining levels, threaten to eliminate a fish or macroinvertebrate community, or substantially reduce the number or restrict the range of an endangered, rare, or threatened fish species.

Significance statements are relative to both the Existing Condition (2005) and Future Conditions (2030), unless stated otherwise.

11.3.3 Direct and Indirect Effects

This section identifies how aquatic habitats and fish communities could be affected by the project. The project could affect fisheries and aquatic ecosystems through the following:

- Causing construction-related loss or degradation of aquatic habitat in the vicinity of and downstream from Shasta Dam.

- Altering flow regimes and water temperatures downstream from Shasta Dam and downstream from other reservoirs with altered releases.

- Causing a reduction in ecologically important geomorphic processes resulting from reduced frequency and magnitude of intermediate to high flows.

By altering reservoir storage and releases, the project would change flow regimes in downstream waterways. In turn, these alterations to the flow regime could affect fishery resources and important ecological processes on which the fish community depends, particularly their instream and seasonal floodplain habitats along waterways immediately downstream from reservoirs.

No-Action Alternative

Under the No-Action Alternative, the Federal Government would take reasonably foreseeable actions, including actions with current authorization, secured funding for design and construction, and environmental permitting and compliance activities that are substantially complete. However, the Federal Government would not take additional actions toward implementing a plan to raise Shasta Dam to help increase anadromous fish survival in the upper Sacramento River, nor help address the growing water reliability issues in California. Shasta Dam would not be modified, and the CVP would continue operating similar to the Existing Condition. Changes in regulatory conditions and water supply demands would result in differences in flows on the Sacramento River and at the Delta between existing and future conditions. Possible changes include the following:

- Firm Level 2 Federal refuge deliveries
- SWP deliveries based on full Table A amounts
- Full implementation of the Grassland Bypass Project
- Implementation of salinity management actions similar to the Vernalis Adaptive Management Plan
- Implementation of the South Bay Aqueduct Improvement and Enlargement Project
- Increased San Joaquin River diversions for water users in the Stockton metropolitan area associated with the Delta Water Supply Project
- Increased Sacramento River diversions by Freeport Regional Water Project agencies
- San Joaquin River Restoration Program Full Restoration Flows

This alternative is used as a basis of comparison for future condition comparisons.

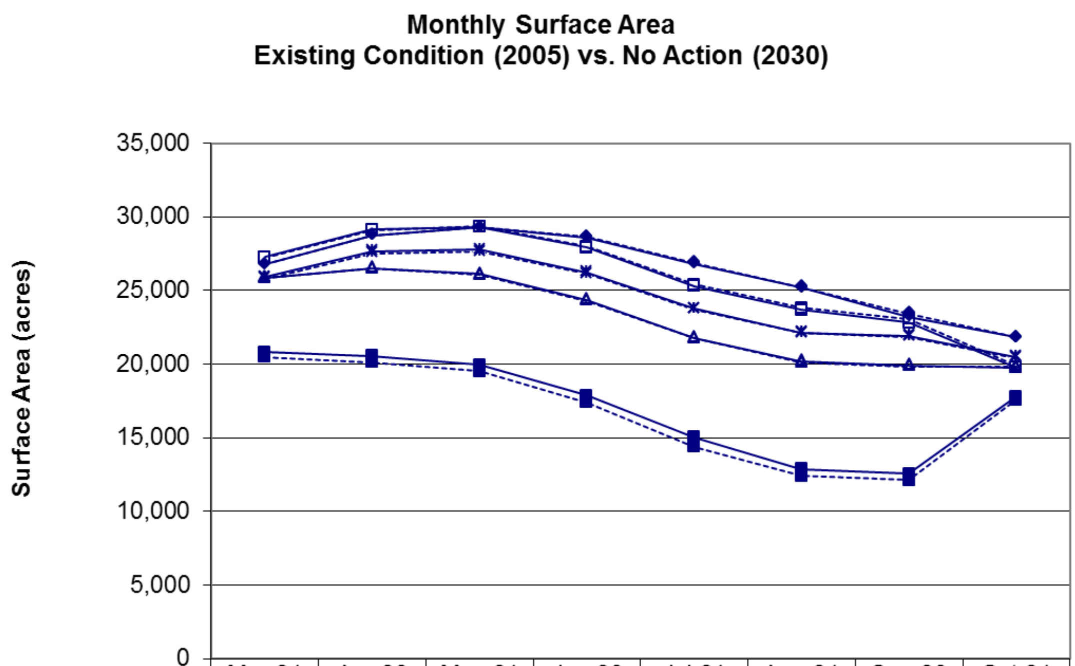
Shasta Lake and Vicinity

Impact Aqua-1 (No-Action): Effects on Nearshore, Warm-Water Habitat in Shasta Lake from Project Operations Under the No-Action Alternative, dam enlargement activities would not be implemented. Seasonal fluctuations in the surface area and WSEL of Shasta Lake could be affected, however, by changing water supply demand and regulatory conditions, which could in turn affect the amount of nearshore, warm-water habitat in Shasta Lake. This impact would be less than significant.

Under the No-Action Alternative with a 2030 water supply demand, the mean surface area of Shasta Lake in all months and all water year types, except critical years, would be slightly less than under the Existing Condition. The greatest potential decreases would be experienced from September through November in above-normal water years (Figure 11-2). Fluctuations in WSELs are similar for the No-Action Alternative and the Existing Condition and differ by no more than ± 1-foot in any month under all hydrologic conditions (Figure 11-3). Therefore, this impact would be less than significant. Mitigation is not required for the No-Action Alternative.

Seasonal fluctuations in the surface area and WSEL of Shasta Lake could be affected by changing water supply demand and regulatory conditions. Such fluctuations could have an adverse effect on the quality and quantity of nearshore, warm-water habitat in the lake. Therefore, this impact would be potentially significant. Mitigation is not required for the No-Action Alternative.

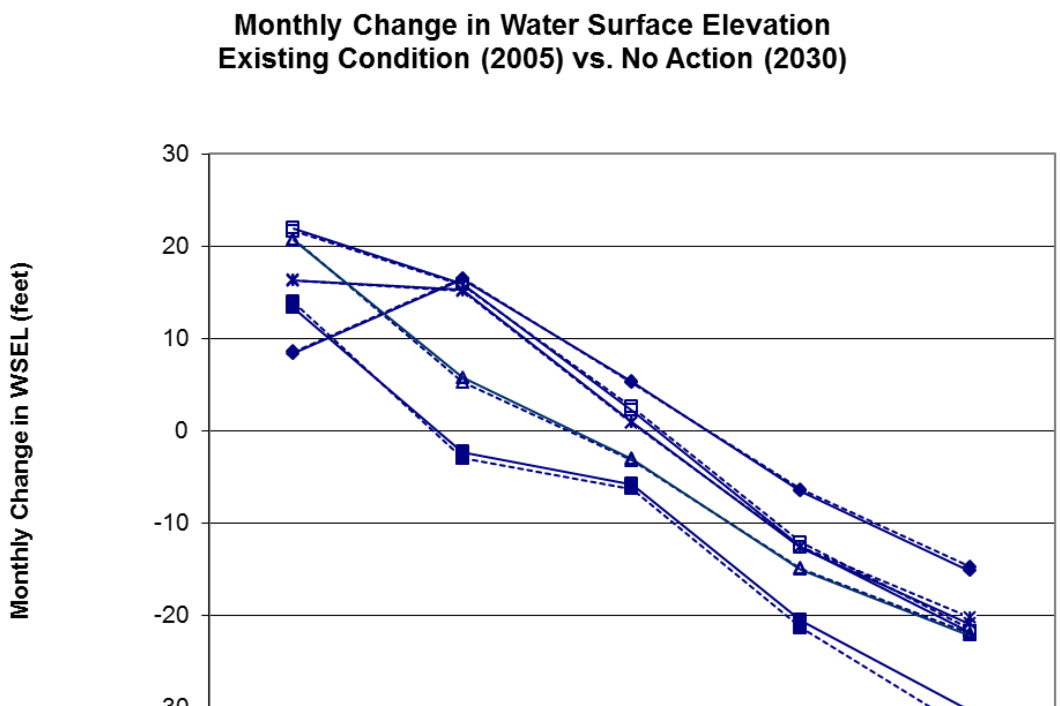
Impact Aqua-2 (No-Action): Effects on Nearshore, Warm-Water Habitat in Shasta Lake from Project Construction Under the No-Action Alternative, dam enlargement activities would not be implemented, and no new facilities would be constructed within the vicinity of Shasta Lake. There would be no impact. Mitigation is not required for the No-Action Alternative.



	Mar 31	Apr 30	May 31	Jun 30	Jul 31	Aug 31	Sep 30	Oct 31
EC W	26,790	28,748	29,277	28,624	26,872	25,226	23,413	21,827
EC AN	27,245	29,082	29,336	27,992	25,400	23,826	23,061	19,906
EC BN	25,807	27,534	27,621	26,104	23,714	22,114	21,837	20,425
EC D	25,850	26,467	26,058	24,300	21,754	20,093	19,840	19,828
EC C	20,467	20,142	19,500	17,381	14,400	12,418	12,111	17,572
NA W	26,775	28,735	29,273	28,604	26,797	25,183	23,205	21,808
NA AN	27,258	29,117	29,325	27,921	25,294	23,687	22,800	19,759
NA BN	25,918	27,662	27,770	26,239	23,764	22,137	21,923	20,469
NA D	25,843	26,514	26,134	24,346	21,780	20,209	19,910	19,728
NA C	20,801	20,548	19,942	17,866	15,026	12,873	12,556	17,800

Key:
AN = above-normal water
BN= below-normal water years
C = critical water years
CP = Comprehensive Plan
D = dry water years
EC = Existing Condition
NA = No-Action
W = wet water years

Figure 11-2. Average Monthly Surface Area (in acres) for Each Water Year Type Within the Shasta Lake Vicinity of the Primary Study Area, the Existing Condition Versus No-Action Alternative



	Mar 31	Apr 30	May 31	Jun 30	Jul 31
EC W	9	16	5	-6	-15
EC AN	22	16	3	-12	-21
EC BN	16	15	1	-13	-20
EC D	21	5	-3	-15	-22
EC C	14	-3	-6	-21	-32
NA W	8	16	5	-7	-15
NA AN	22	16	2	-13	-22
NA BN	16	15	1	-13	-21
NA D	21	6	-3	-15	-22
NA C	13	-2	-6	-21	-30

Key:
AN = above-normal water
BN= below-normal water years
C = critical water years
CP = Comprehensive Plan
D = dry water years
EC = Existing Condition
NA = No-Action
W = wet water years
WSEL = water surface elevation

Figure 11-3. Average Monthly Change in WSEL (in feet) for Each Water Year Type Within the Shasta Lake Vicinity of the Primary Study Area, the Existing Condition Versus No-Action Alternative

Impact Aqua-3 (No-Action): Effects on Cold-Water Habitat in Shasta Lake

Under the No-Action Alternative, dam enlargement activities would not be implemented. Under this alternative, seasonal fluctuations in the ratio of the volume of cold-water storage in Shasta Lake to the surface area of the lake could be affected by changing water supply demand and regulatory conditions, which could affect the amount of cold-water habitat, including habitat for cold-water fishes, such as resident trout and stocked salmon. This impact would be potentially significant. Mitigation is not required for the No-Action Alternative.

Impact Aqua-4 (No-Action): Effects on Special-Status Aquatic Mollusks Under the No-Action Alternative, dam enlargement activities would not be implemented. Seasonal fluctuations in the surface area and WSEL of Shasta Lake in response to water demand and regulatory conditions could affect special-status aquatic mollusks that may occupy habitat in or near Shasta Lake and its tributaries. These impacts would continue to occur under this alternative. This impact would be less than significant.

One special-status mollusk, the California floater, occurs in Shasta Lake, and nine other special-status mollusks could occupy seeps, springs, or tributaries surrounding the reservoir. However, evidence from field surveys of the lower reaches of representative tributaries to the lake did not detect any special-status mollusks.

Except for the California floater, the probability of occurrence of other special-status mollusks in Shasta Lake and the lower reaches of its tributaries is low. The California floater is a bivalve that resides in soft sediment on stream and lake beds and, therefore, could be adversely affected by seasonal fluctuations in the WSEL of the lake that currently exists. This impact would be less than significant. Mitigation is not required for the No-Action Alternative.

Impact Aqua-5 (No-Action): Effects on Special-Status Fish Species Under the No-Action Alternative, dam enlargement activities would not be implemented. However, one fish species occurring within the primary study area and designated as sensitive by USFS could be affected by seasonal fluctuations in the surface area and WSEL of Shasta Lake in response to changing water demand and regulatory conditions; however, this impact would be less than significant.

The hardhead minnow is designated as sensitive by USFS and is known to occur in Shasta Lake. Two other USFS sensitive species, rough sculpin (in the Pit River) and redband trout (in the upper McCloud River), are known to occur upstream from Shasta Lake, but their presence have not been documented in Shasta Lake or in their respective tributaries within the primary study area. The analysis of the No-Action Alternative therefore excludes consideration of these two special-status species.

Fluctuations in the surface area and WSEL of Shasta Lake under the No-Action Alternative could interfere with the connectivity to riverine habitat preferred by hardhead in tributaries that drain into Shasta Lake. However, access to riverine habitat among all the main tributaries to the reservoir would not likely become any more limiting than under current conditions. Therefore, this impact would be less than significant. Mitigation is not required for the No-Action Alternative.

Impact Aqua-6 (No-Action): Creation or Removal of Barriers to Fish Between Tributaries and Shasta Lake Under the No-Action Alternative, dam enlargement activities would not be implemented, and tributaries to Shasta Lake would continue to respond to fluctuations in reservoir levels. New barriers would not be created or removed that could impede or facilitate the movement of native and nonnative fish species between Shasta Lake and its tributaries. There would be no impact. Mitigation is not required for the No-Action Alternative.

Impact Aqua-7 (No-Action): Effects on Spawning and Rearing Habitat of Adfluvial Salmonids in Low-Gradient Tributaries to Shasta Lake Under the No-Action Alternative, dam enlargement activities would not be implemented, and there would be no change to spawning and rearing habitat for adfluvial salmonids in low-gradient tributaries to Shasta Lake. There would be no impact. Mitigation is not required for the No-Action Alternative.

Impact Aqua-8 (No-Action): Effects on Aquatic Connectivity in Non-Fish-Bearing Tributaries to Shasta Lake Under the No-Action Alternative, dam enlargement activities would not be implemented. Therefore, aquatic connectivity in non-fish-bearing streams would not be affected. There would be no impact. Mitigation is not required for the No-Action Alternative.

Impact Aqua-9 (No-Action): Effects on Water Quality at Livingston Stone Hatchery Under the No-Action Alternative, dam enlargement activities would not be implemented. Therefore, there would be no changes to the water system that supplies high-quality water to the Livingston Stone Hatchery. There would be no impact. Mitigation is not required for the No-Action Alternative.

Upper Sacramento River (Shasta Dam to Red Bluff)

Impact Aqua-10 (No-Action): Loss or Degradation of Aquatic Habitat in the Upper Sacramento River During Construction Activities Under the No-Action Alternative, there would be no construction-related loss or degradation of aquatic habitat. No project-generated variation in the storage levels of CVP and SWP reservoirs along the upper Sacramento River or tributaries would occur. If none of the project alternatives were implemented, actions to protect fisheries and aquatic resources would likely continue under existing regulatory requirements. Such actions would include other restoration/management actions intended to protect and enhance fisheries resources. Therefore, no impact would occur. Mitigation is not required for the No-Action Alternative.

Impact Aqua-11 (No-Action): Release and Exposure of Contaminants in the Upper Sacramento River During Construction Activities Under the No-Action

Alternative, no project construction–related contaminant exposure in the upper Sacramento River or tributaries would occur. If none of the project alternatives were implemented, actions to protect fisheries and aquatic resources would likely continue under existing regulatory requirements. Such actions would include other restoration/management actions intended to protect and enhance fisheries resources. Therefore, no impact would occur. Mitigation is not required for the No-Action Alternative.

Impact Aqua-12 (No-Action): Changes in Flow and Water Temperature in the Upper Sacramento River Resulting from Project Operation – Chinook Salmon Flow releases would continue to be operated in compliance with existing BOs and regulatory and contractual requirements, which represent the regulatory baseline. However, it is anticipated that climate change would result in an increase in water temperatures in the upper Sacramento River (NMFS 2009a and b), which could make it more difficult, especially in critical water years, to meet the water temperature requirements needs for all runs of Chinook salmon, particularly winter-run and spring-run Chinook salmon. As a result, the impact to Chinook salmon in the upper Sacramento River would be potentially significant. Mitigation is not required for the No-Action Alternative.

Impact Aqua-13 (No-Action): Changes in Flow and Water Temperature in the Upper Sacramento River Resulting from Project Operation – Steelhead, Green Sturgeon, Sacramento Splittail, American Shad, and Striped Bass Flow releases would continue to be operated in compliance with existing BOs and other regulatory and contractual requirements, which represent the regulatory baseline. However, climate change would likely result in an increase in water temperatures (NMFS 2009a and b). This could make it much more difficult, especially in critical water years, to meet the water temperature requirements for steelhead, green sturgeon, Sacramento splittail, American shad, and striped bass. As a result, this impact would be potentially significant. Mitigation is not required for the No-Action Alternative.

Impact Aqua-14 (No-Action): Reduction in Ecologically Important Geomorphic Processes in the Upper Sacramento River Resulting from Reduced Frequency and Magnitude of Intermediate to High Flows Under the No-Action Alternative, no change to the ongoing geomorphic processes in the upper Sacramento River would occur. No impact would occur. Mitigation is not required for the No-Action Alternative.

Lower Sacramento River, Tributaries, Delta and Trinity River Under the No-Action Alternative, no project-related alteration of CVP and SWP reservoir storage levels, river flows, or water temperatures would occur in the lower Sacramento River, tributaries, and Delta. If none of the project alternatives were implemented, actions to protect fisheries and benefit aquatic environments would likely continue under existing regulatory requirements. Such actions would include other restoration/management actions intended to protect and enhance fisheries resources. Compliance with existing BOs would result in continued pumping curtailments, particularly in dry years. Reclamation and DWR would continue to attempt to reoperate the CVP and SWP, respectively, to avoid decreased deliveries to export users. Therefore, no change in impacts on fisheries and aquatic ecosystems in the lower Sacramento River, tributaries, and Delta would occur under the No-Action Alternative.

Under the No-Action Alternative, no project-related alteration of CVP and SWP reservoir storage levels, river flows, or water temperatures would occur in the Trinity River. Therefore, no change in impacts on aquatic resources in the Trinity River would occur under the No-Action Alternative.

CVP/SWP Service Areas Under the No-Action Alternative, there would be no project-related change in CVP and SWP operations or deliveries to the CVP and SWP service areas. It is anticipated that if the project alternatives were not implemented, actions to protect fisheries and benefit aquatic environments would continue under existing regulatory requirements, including other restoration/management actions and existing BOs intended to protect and enhance fisheries resources.

CP1 – 6.5-Foot Dam Raise, Anadromous Fish Survival and Water Supply Reliability

CP1 focuses on increasing water supply reliability and increasing anadromous fish survival. This plan primarily consists of raising Shasta Dam by 6.5 feet, which, in combination with spillway modifications, would increase the height of the reservoir's full pool by 8.5 feet and enlarge the total storage capacity in the reservoir by 256,000 acre-feet. The existing TCD would also be extended to achieve efficient use of the expanded cold-water pool. Shasta Dam operational guidelines would continue essentially unchanged, except during dry years and critical years, when 70 thousand acre-feet (TAF) and 35 TAF, respectively, of the increased storage capacity in Shasta Reservoir would be reserved to specifically focus on increasing municipal and industrial (M&I) deliveries. CP1 would help reduce future water shortages through increasing drought year and average year water supply reliability for agricultural and M&I deliveries. In addition, the increased depth and volume of the cold-water pool in Shasta Reservoir would contribute to improving seasonal water temperatures for anadromous fish in the upper Sacramento River.

Shasta Lake and Vicinity

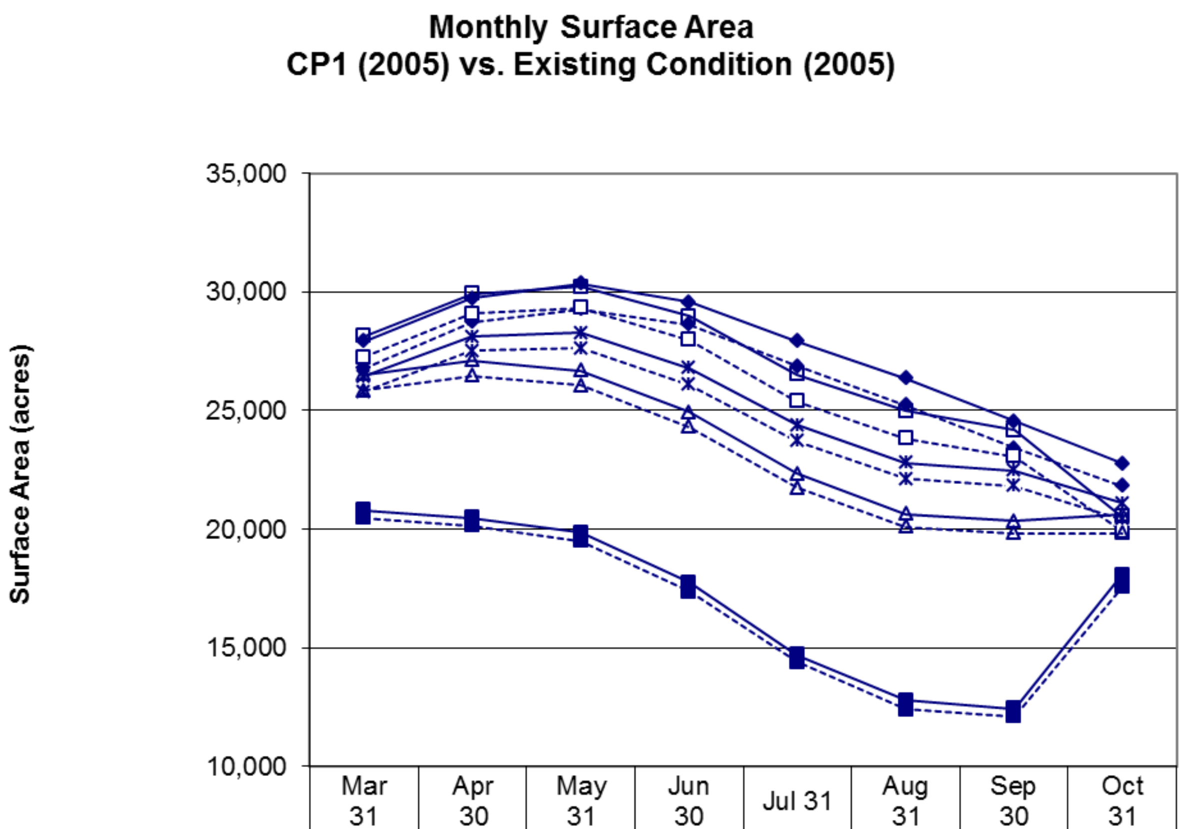
Impact Aqua-1 (CP1): Effects on Nearshore, Warm-Water Habitat in Shasta Lake from Project Operations Under CP1, project operations would contribute to an increase in the surface area and WSEL of Shasta Lake, which would in turn increase the area and productivity of nearshore, warm-water habitat. Project operations would also result in reduced monthly fluctuations in the WSEL, which would contribute to increased reproductive success, young-of-the-year production, and the juvenile growth rate of warm-water fish species. The increase in the WSEL will influence riparian vegetation, including willow species planted to enhance lacustrine habitat, likely resulting in some amount of willow mortality. The increase in the WSEL will also influence the effectiveness of the brush structures that have been installed by the STNF at various locations within the current drawdown zone of Shasta Lake. While the value of these structural improvements will be influenced by an overall increase in the maximum WSEL, these structures will continue to function to varying degrees under the operational conditions established for CP1. These impacts to structural habitat improvements are expected to be localized and will vary as the brush structures age and riparian vegetation readjusts to a new average reservoir pool elevation. The retention of vegetation along more than 40 percent of the increased shoreline area that would be subject to inundation as a result of CP1 is expected to offset reductions in effective structural habitat improvements for a period of time. The benefits of inundated vegetation will decrease over time (e.g., 10-20 years) as the vegetation decays and the shoreline erosion processes expand into the new drawdown zone. This impact would be less than significant.

Biological productivity is greatest in the upper, lighted layer of the reservoir, where most plankton production occurs. An increase in the surface area of the reservoir could affect warm-water habitat by increasing the area of littoral (nearshore) habitat, which could result in increased biological productivity. Increased inundation of terrestrial habitat, leading to increased nutrient loading from vegetative debris along the shore for some period of time, could increase plankton production, causing an upsurge in nutritional sources for warm-water species (Kimmel and Groeger 1986).

CalSim-II modeling indicated that the surface area of Shasta Lake would be larger under CP1 with a 2005 water supply demand than under the Existing Condition for all five water year types (Figure 11-4). The Shasta Lake surface area would be larger under CP1 with a 2030 water supply demand than under the No-Action Alternative in all five water years (Figure 11-5).

An increase in the WSEL could benefit fish by increasing the amount and quality of available warm-water habitat in Shasta Lake. According to Ozen and Noble (2002), inundation of a reservoir creates an area that is sparsely populated by fish (i.e., decreases fish density per unit of habitat); the low population numbers stimulate the natural reproductive and growth processes of the fish. The newly inundated vegetation creates temporary cover for shoreline-dwelling fishes. As the vegetation decomposes, it releases nutrients for phytoplankton and periphyton, which are in turn consumed by the fish.

According to CalSim-II modeling, the Shasta Lake WSEL would be higher under CP1 with a 2005 water supply demand than under the Existing Condition for all five water year types. The Shasta Lake WSEL would also be higher under CP1 with a 2030 water supply demand than under the No-Action Alternative in all five water years.



	Mar 31	Apr 30	May 31	Jun 30	Jul 31	Aug 31	Sep 30	Oct 31
EC W	26,790	28,748	29,277	28,624	26,872	25,226	23,413	21,827
EC AN	27,245	29,082	29,336	27,992	25,400	23,826	23,061	19,906
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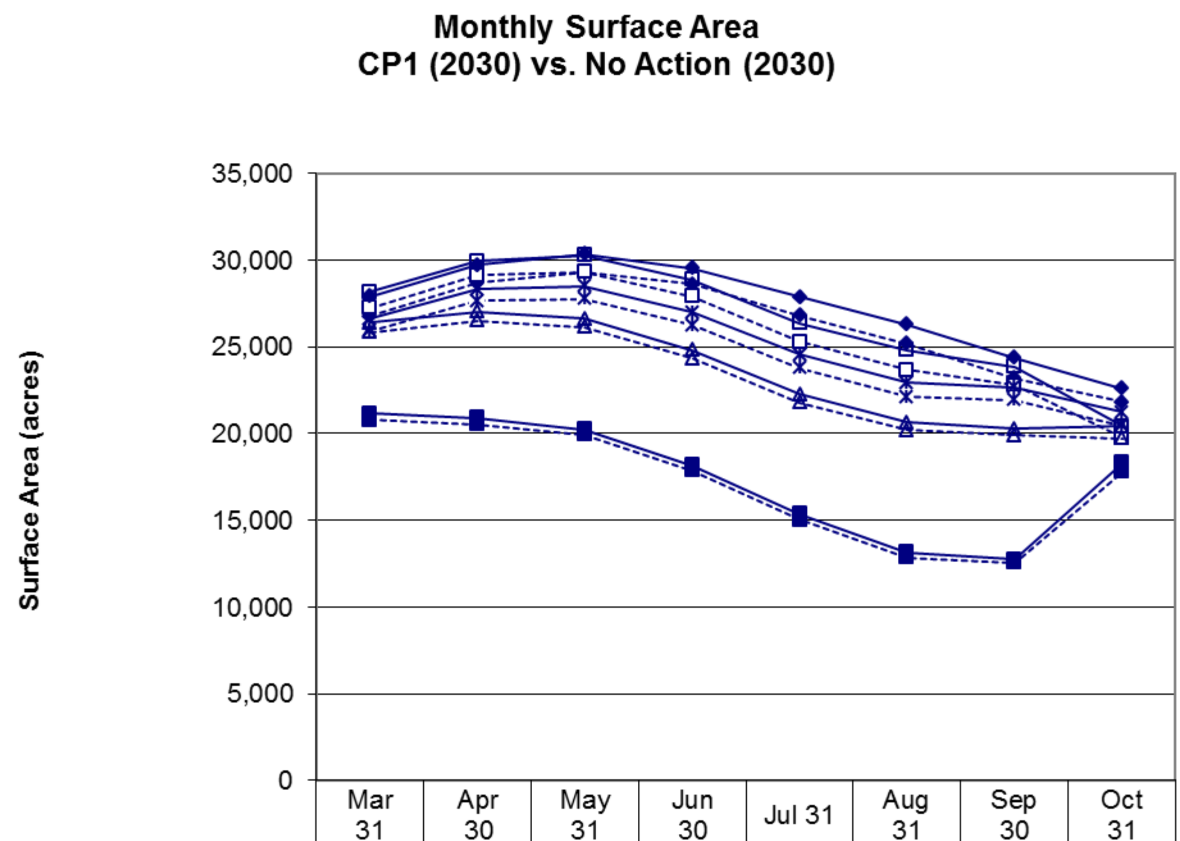
EC D	25,850	26,467	26,058	24,300	21,754	20,093	19,840	19,828
EC C	20,467	20,142	19,500	17,381	14,400	12,418	12,111	17,572
CP1 2005 W	27,923	29,734	30,345	29,575	27,935	26,353	24,562	22,784
CP1 2005 AN	28,141	29,920	30,228	28,974	26,520	24,980	24,184	20,527
CP1 2005 BN	26,431	28,118	28,273	26,798	24,404	22,790	22,475	21,099
CP1 2005 D	26,520	27,106	26,682	24,934	22,347	20,633	20,348	20,615
CP1 2005 C	20,806	20,488	19,848	17,746	14,716	12,787	12,428	18,087

Key:
AN = above-normal water
BN= below-normal water years
C = critical water years
CP = Comprehensive Plan
D = dry water years
EC = Existing Condition
W = wet water years

Figure 11-4. Average Monthly Surface Area for Each Water Year Type Within the Shasta Lake Vicinity of the Primary Study Area, CP1 Versus the Existing Condition



	Mar 31	Apr 30	May 31	Jun 30	Jul 31	Aug 31	Sep 30	Oct 31
NA W	26,775	28,735	29,273	28,604	26,797	25,183	23,205	21,808
NA AN	27,258	29,117	29,325	27,921	25,294	23,687	22,800	19,759
NA BN	25,918	27,662	27,770	26,239	23,764	22,137	21,923	20,469
NA D	25,843	26,514	26,134	24,346	21,780	20,209	19,910	19,728
NA C	20,801	20,548	19,942	17,866	15,026	12,873	12,556	17,800
CP1 2030 W	27,913	29,722	30,342	29,548	27,861	26,284	24,361	22,615
CP1 2030 AN	28,164	29,959	30,258	28,879	26,366	24,810	23,840	20,432
CP1 2030 BN	26,626	28,325	28,490	26,992	24,551	22,929	22,688	21,244
CP1 2030 D	26,417	27,031	26,615	24,808	22,278	20,626	20,266	20,430
CP1 2030 C	21,154	20,891	20,244	18,157	15,377	13,136	12,759	18,334

Key:
AN = above-normal water
BN= below-normal water years
C = critical water years
CP = Comprehensive Plan
D = dry water years
NA = No-Action
W = wet water years

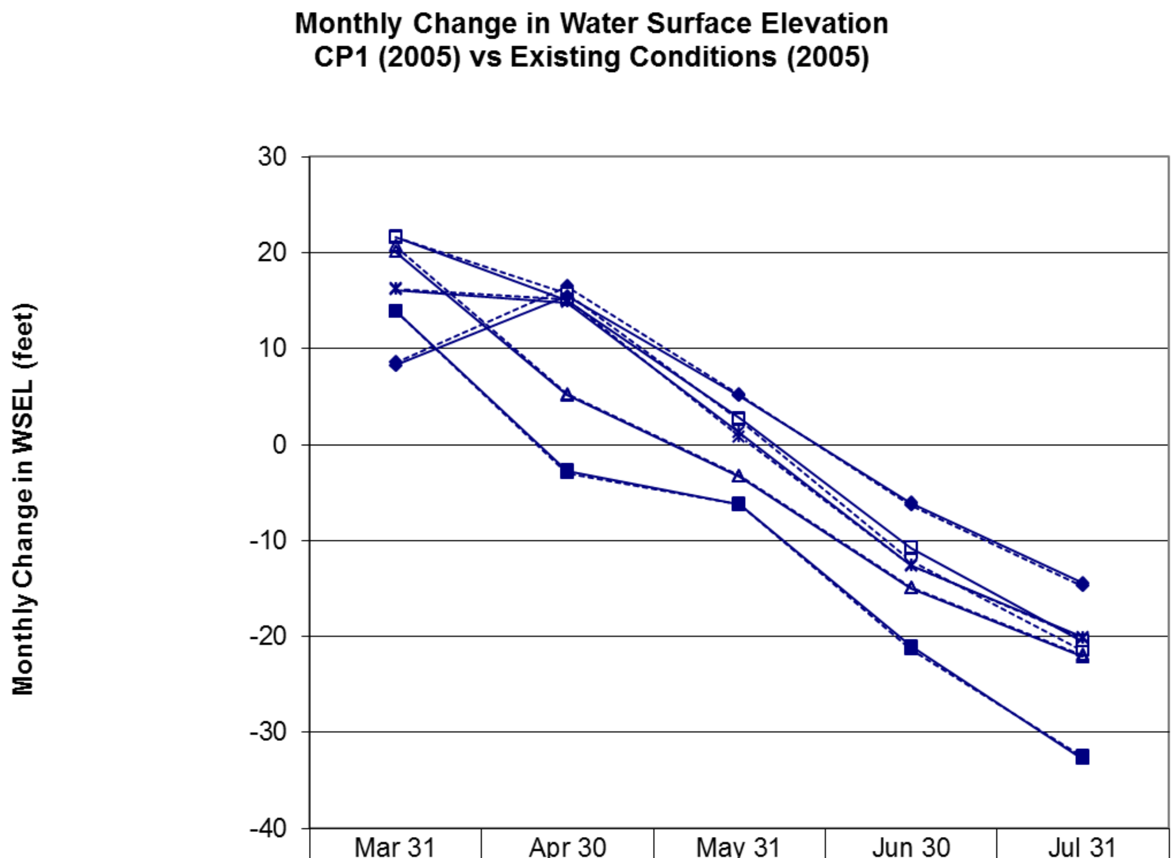
Figure 11-5. Average Monthly Surface Area for Each Water Year Type Within the Shasta Lake Vicinity of the Primary Study Area, CP1 (2030) Versus No-Action Alternative

Rapid rates of increase in WSEL during the critical spring nesting period can lead to such adverse effects as decreased spawning success through nest abandonment or decreased egg survival (Mitchell 1982). Jones & Stokes (1998) reported that mortality approaches 10 percent for eggs in nests submerged under more than 15 feet of water during periods of rapid increase in reservoir elevations.

Rapidly decreasing WSELs can also have an adverse effect on aquatic organisms. According to Lee (1999), the maximum rate of drawdown that would allow a nesting success rate of 10 percent varied between species, with receding water level rates of less than 0.07, less than 0.03, and less than 0.02 feet per day for largemouth, smallmouth, and spotted bass nests, respectively. Lee found that daily drawdown rates of 0.36, 0.36, and 0.72 feet per day for largemouth, smallmouth, and spotted bass, respectively, resulted in 20-percent nest survival. Under CP1, none of the changes in monthly WSEL fluctuation were substantially different from the Existing Condition.

Monthly WSEL fluctuations were compared with projections for water supply demand. For CP1 with a 2005 water supply demand, 24 percent of monthly changes in projected WSELs (i.e., 6 of the 25 total projections made for the 5 months from March through July for all five water year types) showed decreased monthly WSEL fluctuations relative to the Existing Condition and 4 percent showed a slight increase in monthly WSEL fluctuations (Figure 11-6). For CP1 with a projected 2030 water supply demand, 36 percent of monthly changes in projected WSELs showed decreased WSEL fluctuations relative to the No-Action Alternative and 4 percent showed a slight increase in monthly WSEL fluctuations (Figure 11-7).

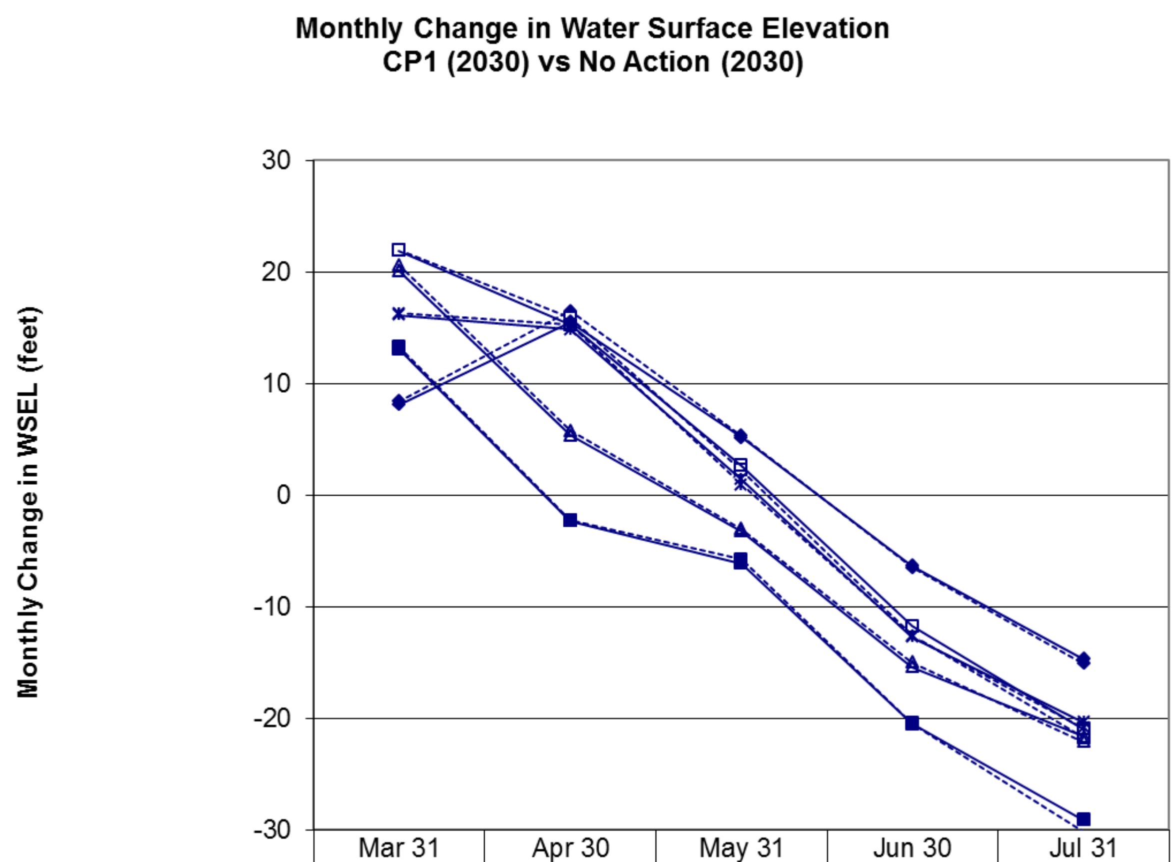
Increases in the overall surface area and WSEL under CP1 would increase the area of available warm-water habitat and stimulate biological productivity, including fish production, of the entire lake, although the value of structural and vegetative improvements that currently provide effective structural habitat at specific locations will be decreased to some extent. Overall, CP1 would result in reductions in the magnitude of monthly WSEL fluctuations and would contribute to increased reproductive success, young-of-the-year production, and juvenile growth rate of warm-water species, and provide for an increase in structural habitat (inundated vegetation) for some period of time. Therefore, this impact would be less than significant. Mitigation for this impact is not needed, and thus not proposed.



	Mar 31	Apr 30	May 31	Jun 30	Jul 31
EC W	9	16	5	-6	-15
EC AN	22	16	3	-12	-21
EC BN	16	15	1	-13	-20
EC D	21	5	-3	-15	-22
EC C	14	-3	-6	-21	-32
CP1 2005 W	8	15	5	-6	-14
CP1 2005 AN	22	15	3	-11	-21
CP1 2005 BN	16	15	1	-13	-20
CP1 2005 D	20	5	-3	-15	-22
CP1 2005 C	14	-3	-6	-21	-33

Key:
AN = above-normal water
BN = below-normal water years
C = critical water years
CP = Comprehensive Plan
D = dry water years
EC = Existing Condition
W = wet water years
WSEL = water surface elevation

Figure 11-6. Average Monthly Change in WSEL for Each Water Year Type Within the Shasta Lake Vicinity of the Primary Study Area, CP1 Versus the Existing Condition



	Mar 31	Apr 30	May 31	Jun 30	Jul 31
NA W	8	16	5	-7	-15
NA AN	22	16	2	-13	-22
NA BN	16	15	1	-13	-21
NA D	21	6	-3	-15	-22
NA C	13	-2	-6	-21	-30
CP1 2030 W	8	15	5	-6	-15
CP1 2030 AN	22	15	3	-12	-21
CP1 2030 BN	16	15	1	-13	-20
CP1 2030 D	20	5	-3	-15	-22
CP1 2030 C	13	-2	-6	-21	-29

Key:
AN = above-normal water
BN= below-normal water years
C = critical water years
CP = Comprehensive Plan
D = dry water years
NA = No-Action
W = wet water years
WSEL = water surface elevation

Figure 11-7. Average Monthly Change in WSEL for Each Water Year Type Within the Shasta Lake Vicinity of the Primary Study Area, CP1 Versus No-Action Alternative

Impact Aqua-2 (CP1): Effects on Nearshore, Warm-Water Habitat in Shasta Lake from Project Construction Localized increases in soil erosion and resulting runoff sedimentation, and turbidity resulting from project construction in the vicinity of Shasta Dam and at utility, road, and other facility relocation areas could affect nearshore warm-water habitat. However, the environmental commitments for all action alternatives include the development and implementation of a Construction Management Plan, Erosion and Sediment Control Plan, Stormwater Pollution Prevention Plan, and Revegetation Plan as well as water quality and fisheries conservation measures and compliance with all required permit terms and conditions. These environmental commitments would result in less-than-significant impacts. Mitigation for this impact is not needed, and thus not proposed.

Impact Aqua-3 (CP1): Effects on Cold-Water Habitat in Shasta Lake Under CP1, operations-related changes in the ratio of the volume of cold-water storage to surface area would increase the availability of suitable habitat for cold-water fish in Shasta Lake, including rainbow trout. This impact would be beneficial.

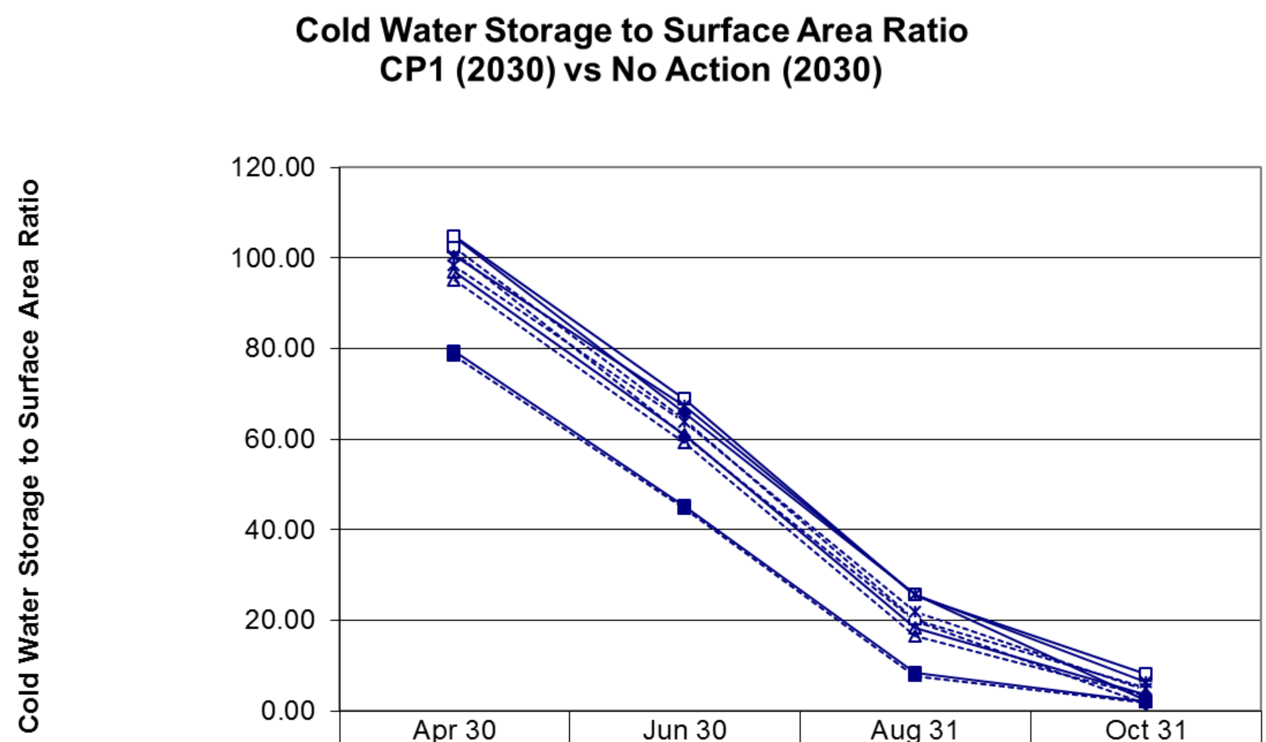
Access to cold-water refuge can be a limiting factor for the production of cold-water fish, even when the benefits of increased surface area are present. Increases in the surface area of a reservoir without proportional increases in the volume of cold-water storage result in little change to cold-water fisheries production (Jones & Stokes Associates 1988).

CalSim-II modeling showed that under CP1 with a 2030 water supply demand[3], the ratio of the volume of cold-water storage to surface area was slightly higher than under the No-Action Alternative in all water years and during all months modeled. The greatest projected increases over the No-Action Alternative occurred between June 30 and August 31, which is a critical rearing and oversummering period for cold-water fishes in reservoirs; the increases were highest in wet water years (Figure 11-8).

CP1 would increase the availability of suitable habitat for cold-water fish in Shasta Lake. Therefore, this impact would be beneficial. Mitigation for this impact is not needed, and thus not proposed.

Impact Aqua-4 (CP1): Effects on Special-Status Aquatic Mollusks Under CP1, habitat for special-status mollusks may become inundated. Seasonal fluctuations in the surface area and WSEL of Shasta Lake could also adversely affect special-status aquatic mollusks that may occupy habitat in or near Shasta Lake and its tributaries. This impact would be potentially significant.

[3] Only the 2030 water demand scenario is shown for this reservoir fishery metric because it illustrates the worst case benefit to cold-water fisheries of the water demand scenarios analyzed.



	Apr 30	Jun 30	Aug 31	Oct 31
NA W	101.33	60.49	19.89	1.43
NA AN	102.30	64.04	20.12	5.09
NA BN	98.27	63.71	21.84	4.64
NA D	95.13	59.14	16.50	3.38
NA C	78.43	44.58	7.66	1.82
CP1 2030 W	104.60	65.65	25.58	2.32
CP1 2030 AN	104.79	68.73	25.54	8.10
CP1 2030 BN	100.42	67.24	25.68	6.26
CP1 2030 D	96.84	60.84	18.29	3.64
CP1 2030 C	79.30	45.13	8.32	1.96

Key:
AN = above-normal water
BN= below-normal water years
C = critical water years
CP = Comprehensive Plan
D = dry water years
NA = No-Action
W = wet water years

Figure 11-8. Average Monthly Cold-water Storage to Surface Area Ratio for Each Water Year Type Within the Shasta Lake Vicinity of the Primary Study Area, CP1 Versus No-Action Alternative

One special-status mollusk, the California floater, occurs in Shasta Lake, and nine other special-status mollusks could occupy affected seeps, springs, or tributaries. However, evidence from field surveys of the lower reaches of representative tributaries to the lake did not detect any special-status mollusks. Tributary investigations are ongoing and will provide additional information for inclusion in the Final EIS. Except for the California floater, the probability of occurrence of other special-status mollusks in Shasta Lake and the lower reaches of its tributaries is low. If they do occur in these habitats, they could be adversely affected by increased WSEL and seasonal fluctuations in the surface area under CP1. Therefore, this impact would be potentially significant. Mitigation for this impact is proposed in Section 11.3.4.

Impact Aqua-5 (CP1): Effects on Special-Status Fish Species The expansion of the surface area of Shasta Lake and the inundation of additional tributary habitat under CP1 could affect one species designated as sensitive by USFS, the hardhead. This impact would be less than significant.

The hardhead minnow is designated as sensitive by USFS and is known to occur in Shasta Lake. Two other USFS sensitive species, rough sculpin (in the Pit River) and redband trout (in the upper McCloud River), are known to occur upstream from Shasta Lake, but their presence have not been documented in Shasta Lake or in their respective tributaries within the primary study area. The analysis of the CP1 therefore excludes consideration of these special-status species.

Expansion of the surface area of Shasta Lake could be modestly beneficial to hardhead because it could expand the amount of habitat available to this species in the lake, although the abundance of warm-water predators, primarily sunfishes and basses, in the lake already likely limits the hardhead population there (Moyle 2002; J. Zustak, USFS, personal communication). Hardhead prefer low gradient stream habitat, which can be created by the backwater effect of the reservoir within the transition reaches of the main tributaries at their confluence; however, this would not be expected to be much greater than under existing conditions, since reservoir enlargement would simply move the transition reaches farther upstream in the tributaries. Tributary investigations, including an analysis of barriers are ongoing and will provide additional information for inclusion in the Final EIS. Although there is some evidence that a physical barrier at the upper end of the Squaw Creek Arm may be modified by an increase in WSEL (J. Zustak, USFS, pers. comm., 2009), there is no evidence that other barriers exist in a form that would impact this species or its habitat. Recent fish surveys in the Sacramento and McCloud rivers have not found hardhead to inhabit them in the vicinity of Shasta Lake (Nevares and Liebig 2007, Weaver and Mehalik 2008), suggesting that this species may not occur in these tributaries or is very uncommon. Pending new information, this impact would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

Impact Aqua-6 (CP1): Creation or Removal of Barriers to Fish Between Tributaries and Shasta Lake Under CP1, project implementation would result in the periodic inundation of steep and low-gradient tributaries to Shasta Lake up to approximately the 1,080-foot contour, the maximum inundation level under this alternative. Tributary investigations are ongoing and will provide additional information for inclusion in the Final EIS. However, based on digital topographic data and stream channel data generated from the limited available field inventories, about 21 percent of intermittent and 4 percent of perennial tributaries contain substantial barriers between the 1,070-foot and 1,080-foot contours that would be inundated under this alternative; although none of streams with barriers was found to be inhabited by special-status fish in upstream reaches. The access of warm-water fish species from the lake into some tributaries would be extended by inundation of passage barriers under CP1, with a potential to alter existing resident fish communities. However, except for the main river tributaries (i.e., Sacramento, Pit, and McCloud rivers), few of the lake's other accessible tributaries have been found to be colonized by warm-water fish above the varial zone and any further access is expected to be limited primarily to the newly inundated reaches of some streams. This impact would be less than significant.

Most (82 percent) of the intermittent tributaries are too steep (i.e., greater than 7 percent) up to the 1,080-foot contour to be passable by fish; the intermittent and perennial tributaries that are low-gradient and do not contain barriers up to the 1,080-foot contour and thus allow fish passage remain low-gradient well upstream from the 1,080-foot contour. Therefore, this impact would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

Impact Aqua-7 (CP1): Effects on Spawning and Rearing Habitat of Adfluvial Salmonids in Low-Gradient Tributaries to Shasta Lake CP1 would result in additional periodic inundation of riverine habitat potentially suitable for spawning and rearing habitat for adfluvial salmonids (trout and land-locked salmon that spawn in streams and rear in lakes) in tributaries to Shasta Lake. In addition to modification of the flow regimes of these affected reaches, changes in the WSEL as a result of CP1 will affect the character and location of substrate (e.g., spawning gravel) at some locations, thereby influencing the suitability and availability of spawning and rearing habitat for adfluvial salmonids. Tributary investigations are ongoing and will provide additional information for inclusion in the Final EIS. All of the perennial streams and only 7 percent of intermittent streams surveyed contained suitable salmonid spawning habitat between the 1,070-foot and 1,080-foot contours. Only 5.4 miles of low-gradient reaches that could potentially provide some spawning and rearing habitat for adfluvial salmonids (estimated as 23,000 square feet for all tributaries) would be affected by CP1, which is only about 1.4 percent of the low-gradient habitat upstream from Shasta Lake. Although a small proportion of total stream mileage would be impacted by CP1, most of the suitable spawning habitat between the 1,070-foot and 1,090-foot contours was estimated to occur in this reach. This impact would be significant.

CP1 would inundate perennial stream reaches with gradients of less than 7 percent that could provide suitable spawning and rearing habitat for adfluvial salmonids. Chapter 4, "Geology, Geomorphology, Minerals, and Soils," discusses the periodic inundation of low-gradient stream reaches. The lengths of low-gradient tributaries to each arm of Shasta Lake and estimated suitable spawning habitat areas that would be periodically affected are as follows:

- Sacramento Arm – 2.2 miles (7,040 square feet, excludes mainstem river)
- McCloud Arm – 1.1 miles (9,768 square feet)
- Pit Arm – 1.0 mile (355 square feet, excludes mainstem river)
- Big Backbone Arm – 0.5 miles (106 square feet)
- Squaw Arm – 0.6 miles (1,300 square feet)

Although only about 1.4 percent of the low-gradient habitat upstream from Shasta Lake would be periodically inundated, a significant portion of the suitable cold-water fish spawning area below the1,090-foot contour occurs from 1,070-foot to 1,080-foot elevation. Therefore, this impact would be significant. Mitigation for this impact is proposed in Section 11.3.4.

Impact Aqua-8 (CP1): Effects on Aquatic Connectivity in Non-Fish-Bearing Tributaries to Shasta Lake CP1 would result in periodic inundation of varying amounts of non-fish-bearing tributaries to Shasta Lake. About 12.6 miles of non-fish-bearing tributary habitat would be affected by CP1, which is a length of only about 0.4 percent of non-fish-bearing tributary upstream from Shasta Lake. Tributary investigations are ongoing and will provide additional information and analysis for inclusion in the Final EIS. Examination of initial field surveys suggest that few, if any of the non-fish bearing streams contain special-status invertebrate or vertebrate species that would be affected by increased connectivity to Shasta Lake. This impact would be less than significant.

As described in Chapter 4, "Geology, Geomorphology, Minerals, and Soils," CP1 would inundate tributary segments with channel slopes in excess of 7 percent. Although these segments do not typically support salmonid populations, they do provide riparian and aquatic habitat for a variety of organisms and serve as corridors that connect habitat types. The lengths of non-fish-bearing tributaries for each arm of Shasta Lake that would be periodically inundated are as follows:

- Sacramento Arm – 2.9 miles
- McCloud Arm – 2.1 miles
- Pit Arm – 1.8 miles

- Big Backbone Arm – 1.3 miles
- Squaw Arm – 0.9 miles
- Main Body – 3.6 miles

Although12.6 miles of non-fish-bearing tributary habitat would be periodically inundated under CP1, this amounts to only about 0.4 percent of the habitat upstream from Shasta Lake and no special-status aquatic vertebrate and invertebrate species have been detected in these reaches. Therefore, this impact would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

Upper Sacramento River (Shasta Dam to Red Bluff)

Impact Aqua-10 (CP1): Loss or Degradation of Aquatic Habitat in the Upper Sacramento River During Construction Activities Temporary construction-related increases in sediments and turbidity levels would adversely affect aquatic habitats and fish populations immediately downstream in the upper Sacramento River. However, environmental commitments would be in place to reduce the effects. This impact would be less than significant.

Increasing the height of Shasta Dam, constructing haul roads, using staging areas, and placing excavated material could disturb sediments and soils within and adjacent to waterways. Any construction-related erosion or disturbance of sediments and soils would temporarily increase downstream turbidity and sedimentation throughout the primary study area if soils were transported in river flows, stormwater runoff, or reservoir water. Such sedimentation and increased turbidity, or other contamination, would be most pronounced in the segment of river from Shasta Dam to Keswick Dam because of the backwater effect that Keswick Reservoir has on flow conditions in the Sacramento River. It is also important to note that Keswick Dam acts as a barrier to upstream fish migration; therefore, all anadromous fish species are downstream from this facility. (See Chapter 7, “Water Quality,” for additional discussion of this issue.)

The abundance, distribution, and survival of fish populations have been linked to levels of turbidity and silt deposition. Prolonged exposure to high levels of suspended sediment would create a loss of visual capability in fish in aquatic habitats within the study area, leading to reduced feeding and growth rates. Such exposure would also result in a thickening of the gills, potentially causing the loss of respiratory function; in clogging and abrasion of gills; and in increased stress levels, which in turn could reduce tolerance to disease and toxicants (Waters 1995, Clark and Wilber 2000, Newcombe and Jensen 1996, Wilber and Clark 2001). Turbidity also could result in increased water temperature and decreased DO levels, especially in low-velocity pools, which can cause stressed respiration.

High levels of suspended sediments could also cause redistribution and movement of fish populations in the upper Sacramento River, and could diminish the character and quality of the physical habitat important to fish survival. Deposited sediments can reduce water depths in stream pools and can contribute to a reduction in carrying capacity for juvenile and adult fish (Waters 1995). Increased sediment loading downstream from construction areas would degrade food-producing habitat, by interfering with photosynthesis of aquatic flora, and could displace aquatic fauna.

Many fish, including salmonids, are sight feeders; turbid waters reduce the ability of these fish to locate and feed on prey. Some fish, particularly juveniles, likely would become disoriented and leave the areas where their main food sources are located, ultimately reducing growth rates.

Prey of fish populations, such as macroinvertebrates, could be adversely affected by declines in habitat quality (water quality and substrate conditions) caused by increased turbidity, decreased DO content, an increased level of pollutants (Coull and Chandler 1992), and (although unlikely) an extreme change in pH or water temperatures (Rundle and Hildrew 1990). Decreases in the diversity and abundance of smaller organisms living on or in the sediments have been associated with smaller sediment grain sizes (Coull 1988) and associated DO decreases in those sediments (Boulton et al. 1991).

Avoidance of adverse habitat conditions by fish is the most common result of increases in turbidity and sedimentation. Fish will not occupy areas unsuitable for survival unless they have no other option. Some fish, such as bluegill and bass species, will not spawn in excessively turbid water (Bell 1990), and salmonids require gravels that are relatively clean and free of excess amounts of fine sediments. Therefore, increased turbidity attributed to construction activities could preclude fish from occupying habitat required for specific life stages. In some locations, few opportunities for escape from turbid waters may be available, particularly during low-flow conditions.

Construction-related sedimentation and increased turbidity or other contamination could temporarily degrade water quality and reduce or adversely affect fish habitat and fish populations in localized areas. However, the environmental commitments for all action alternatives include the development and implementation of best management practices (BMP), including a Construction Management Plan, Erosion and Sediment Control Plan, Storm Water Pollution Prevention Plan (SWPPP), and revegetation plan. Water quality and fisheries conservation measures would also be implemented and project activities would be in compliance with all required permit terms and conditions. With implementation of these environmental commitments, this impact would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

Impact Aqua-11 (CP1): Release and Exposure of Contaminants in the Upper Sacramento River During Construction Activities Construction-related activities could result in the release and exposure of contaminants. Such exposure could adversely affect aquatic habitats, the aquatic food web, and fish populations, including special-status species, downstream in the primary study area. However, environmental commitments would be in place to reduce the effects. Therefore, this impact would be less than significant.

Contaminants such as fuels, oils, other petroleum products, cement, and various chemicals used during construction could be introduced into the water system directly through accidental spills or incrementally through surface runoff from haul routes and construction sites. In sufficient concentrations, contaminants would be toxic to fish and prey organisms (e.g., benthic macroinvertebrates) occupying habitats in the study area. They also may alter oxygen diffusion rates and cause acute and chronic toxicity to aquatic organisms, thereby reducing growth and survival and/or leading to mortality.

A potential release of hazardous materials into the upper Sacramento River could reduce aquatic habitats and fish populations if proper procedures were not implemented to contain the discharge. However, the environmental commitments for all action alternatives include the development and implementation of a Construction Management Plan, Emergency Response Plan, Erosion and Sediment Control Plan, SWPPP, and revegetation plan. They also include implementation of water quality and fisheries conservation measures and compliance with all required permit terms and conditions. With implementation of these environmental commitments, this impact would be less than significant. Mitigation for this impact is not needed, and thus is not proposed.

Impact Aqua-12 (CP1): Changes in Flow and Water Temperature in the Upper Sacramento River Resulting from Project Operation – Chinook Salmon CP1 operation would result in generally improved flow and water temperature conditions in the upper Sacramento River for Chinook salmon relative to both the No-Action Alternative and the Existing Condition, but not all runs show a significant (greater than 5 percent) increase in production. This impact would be less than significant.

Winter-Run Chinook Salmon

<u>Production</u>

CP1 would have a less-than-significant (less than 5 percent) average decrease in winter-run Chinook salmon production relative to the Existing Condition and the No-Action Alternative. The maximum increase in simulated production relative to the No-Action Alternative for CP1 was nearly 23 percent (critical water year). The largest decrease in production relative to the No-Action Alternative was less than 5 percent (Table 11-4, Figure 11-9, and Attachment 3 of the Modeling Appendix). The largest increase in production relative to the

Existing Condition for CP1 was 54 percent, while the largest decrease was -27 percent (Table 11-4 and Attachment 4 of the Modeling Appendix).

Figure 11-9 shows the change in production relative to the No-Action Alternative for all water years and all comprehensive plans. Separating production by water year type to focus on critical water years (when water storage is more reliable) showed an average 0.6-percent increase over the No-Action Alternative, but 2 out of 10 critical water years resulted in a significant (greater than 5 percent) increase in winter-run production relative to the No-Action Alternative, ranging from 0.1 percent to almost 23 percent (Table 11-4).

Table 11-4. Change in Production by Water Year Type Under CP1 for Winter-Run Chinook Salmon

Year Type	No. of Years	Average Production	Change in Production from Baseline	Average Change in Production	Maximum Increase in Production	Number of Months with Significant Increase	Maximum Decrease in Production	Number of Months with Significant Decrease
Future Condition (2030)								
All	81	3,792,084	-9,031	-0.2	22.7	2	-4.9	0
Critical	13	3,397,023	19,067	0.6	22.7	2	-4.8	0
Dry	17	3,973,270	940	0.0	3.3	0	-3.9	0
Below Normal	14	3,943,663	5,104	0.1	2.0	0	-2.0	0
Above Normal	11	3,837,410	-21,520	-0.6	0.9	0	-1.4	0
Wet	26	3,770,350	-31,928	-0.8	2.2	0	-4.9	0
Existing Condition (2005)								
All	81	3,770,537	-10,710	-0.3	54.0	2	-27.3	2
Critical	13	3,225,352	14,413	0.4	54.0	2	-27.3	1
Dry	17	3,975,760	-8,101	-0.2	4.0	0	-1.9	0
Below Normal	14	3,946,894	6,745	0.2	3.0	0	-1.4	0
Above Normal	11	3,839,788	-12,894	-0.3	3.4	0	-3.9	0
Wet	26	3,784,684	-33,452	-0.9	2.2	0	-5.3	1

Note:
Production is the number of immature smolts surviving to pass the Red Bluff Pumping Plant

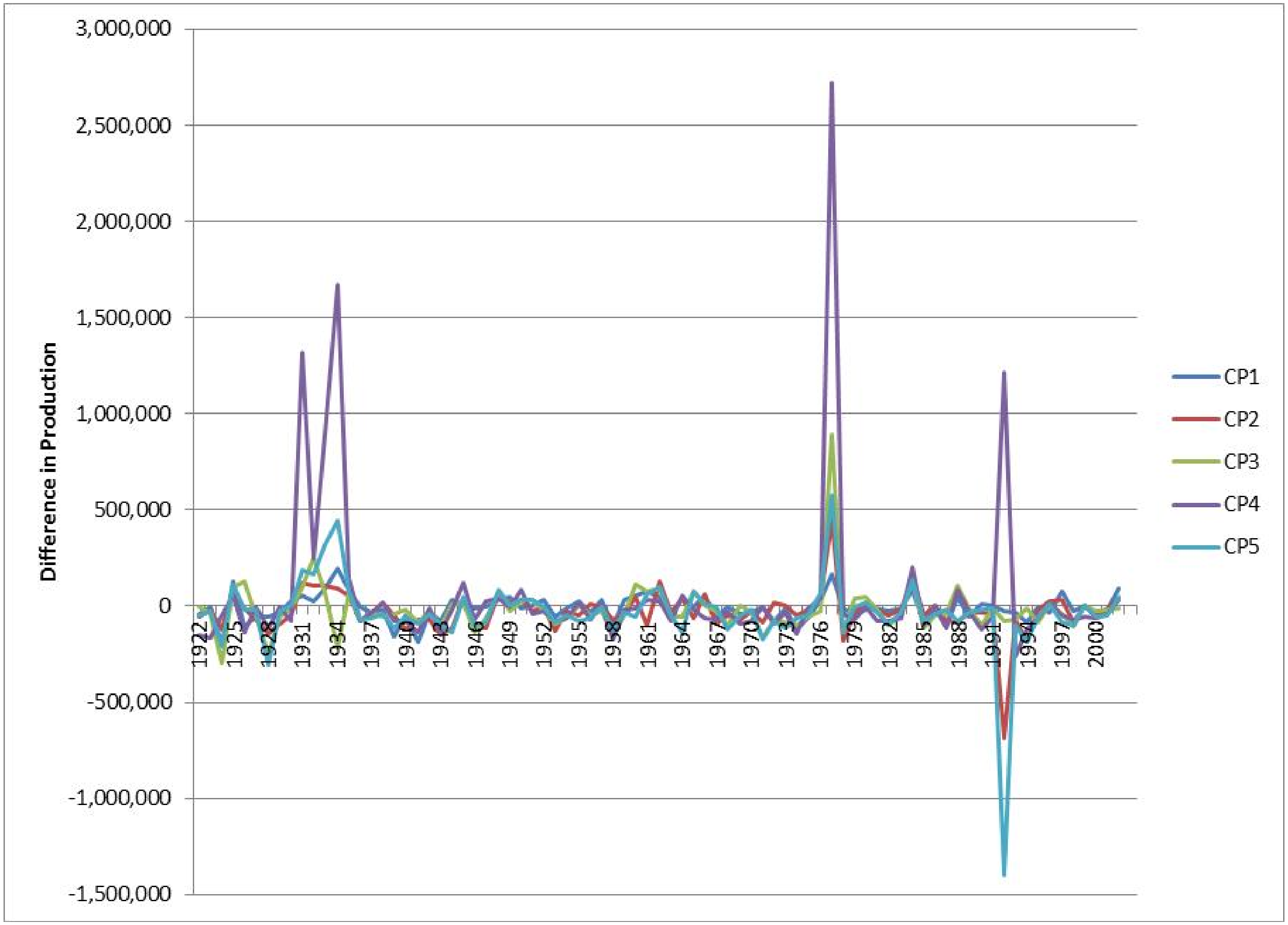


Figure 11-9. Change in Production of Winter-Run Chinook Salmon Compared to the No-Action Alternative

CP1 production under 2005 conditions was similar to the Existing Condition. The maximum increase in production was 54 percent for CP1, and the largest decrease in production was less than 5 percent for CP1 (Table 11-4 and Attachment 4 of the Modeling Appendix). Under CP1, 2 out of 10 critical water years resulted in a significant increase in winter-run production relative to the Existing Condition with a maximum of 54 percent; however, water year 1992 resulted in a -27-percent decrease in production. In all other water years, there was an insignificant change in production except for wet water year 1928, which decreased production by -5.3 percent.

Mortality

Mortality was separated by flow- and water temperature-related mortality to assess the level of impacts on winter-run Chinook salmon caused by the actions of the project (Attachments 3 and 4 of the Modeling Appendix). Nonoperations-related mortality are the base and seasonal mortality that would occur even without the effects of Shasta operations (such as disease, predation, and entrainment). Flow- and water temperature-related mortality is that caused by altering flow and water temperatures. In all cases, most mortality is caused by nonoperations-related factors (e.g., disease, predation, entrainment)−around 86 percent of the total mortality.

Mortality is presented in two manners–total mortality and smolt equivalent mortality (Attachments 3 and 4 of the Modeling Appendix). The greatest average mortality to winter-run Chinook salmon under CP1 in all water year types based on smolt equivalents would occur to the fry life stage, followed by eggs, then presmolts, and lastly to immature smolts. Table 11-5 displays the overall mortalities for each Comprehensive Plan that were caused by changes in operations (i.e., water temperature and flow) (Attachments 3 and 4 of the Modeling Appendix).

Years with the highest simulated flow- and water temperature-related mortality were the same for the No-Action Alternative, the Existing Condition, and CP1. Each of these years was a critical water year, and was preceded by either a critical (1976, 1991), or dry (1930, 1932). Years in which the project had the greatest effect, both as an increase and decrease in production were the years in which the lowest production occurs (Attachments 3 and 4 of the Modeling Appendix).

Table 11-5. Average Annual Winter-Run Chinook Salmon Smolt Equivalent Mortality Under Each Base Condition and the Difference in Mortality Under Each Comprehensive Plan Caused by Changes in Flow and Water Temperature

Plan	Egg Count Based on Smolt Equivalent[1, 2]	Difference in Mortality Factor from Baseline Condition										Total Difference	Percent Mortality[2]
		Pre-spawn	Incu-bation	Super-Imposition	Eggs Temp	Fry Temp	Fry Habitat	Pre-smolt Temp	Pre-smolt Habitat	Immature Smolt Temp	Immature Smolt Habitat		
Future Condition (2030)													
No-Action Alternative	7,534,801	8	71,606	2,777	36,693	11,848	360,066	13,991	2,750	0	302	500,040	6.6
CP1	7,519,462	0	-3,684	-133	-147	1,306	5,518	524	-229	0	-10	3,143	6.7
CP2	7,489,492	-1	-4,661	-68	2,453	783	12,023	-1,355	-382	0	-29	8,763	6.8
CP3	7,500,867	-1	-4,102	-256	-1,547	958	4,333	-519	-410	0	-55	-1,600	6.6
CP4	7,617,894	0	593	-175	-23,972	-8,403	9,078	-9,165	162	0	-95	-31,976	6.1
CP5	7,474,687	-1	-7,323	267	2,012	554	11,862	-1,311	-304	0	-13	5,743	6.8
Existing Condition (2005)													
Existing Condition	7,496,582	8	73,885	2,127	43,031	12,704	347,547	13,581	2,560	0	282	495,724	6.6
CP1	7,474,164	0	-3,725	20	-2,847	-1,404	9,423	-1,568	41	0	9	-52	6.6
CP2	7,486,271	0	-3,597	-97	-9,890	-2,013	20,242	-3,413	-142	0	-26	1,063	6.6
CP3	7,508,897	-1	-1,823	-69	-4,143	535	8,189	-2,577	-135	0	-9	-31	6.6
CP4	7,626,344	0	708	119	-28,096	-9,099	14,407	-9,017	26	1	4	-30,948	6.1
CP5	7,467,882	0	-6,156	135	-4,983	-1,490	14,976	-2,994	-234	0	-25	-771	6.6

Note:

[1] The potential number of smolt equivalent is based on the spawning population of 6,200 adults, using the formula:
Immature Smolt Equivalent Mortality = Mortality * % Survival $_{(eggs\ to\ fry)}$ * % Survival $_{(fry\ to\ presmolts)}$ * % Survival $_{(presmolts\ to\ immature\ smolts)}$

[2] Values in these two columns do not constitute a difference from the baseline condition.

Because winter-run Chinook salmon would have an insignificant change (1 percent or less) in flow- and water temperature-related mortality under CP1, and an insignificant change in production (less than 5 percent overall), a less-than-significant impact to winter-run Chinook salmon would occur from actions taken in CP1. Mitigation for this impact is not needed, and thus not proposed.

Spring-Run Chinook Salmon

Production

Spring-run Chinook salmon production for the 81-year period does not change significantly between CP1 and the No-Action Alternative and the Existing Condition (Attachments 6 and 7 of the Modeling Appendix). The maximum increase in production relative to the No-Action Alternative was around 71 percent for CP1, while the largest decrease in production relative to the No-Action Alternative was -66 percent, both in critical water years (Table 11-6, Figure 11-10, and Attachment 6 of the Modeling Appendix). The maximum increase in production relative to the Existing Condition was 256 percent for CP1, while the largest decrease in production relative to the Existing Condition was -41 percent, also both in critical water years (Table 11-6, Figure 11-10, and Attachment 7 of the Modeling Appendix).

Figure 11-10 shows the change in production relative to the No-Action Alternative for all water years and all Comprehensive Plans. Separating production by water year type to focus on critical years in which production was the lowest under the No-Action Alternative typically had the largest increase under CP1 conditions, except for 1977 and 1992, which had 12 percent and 52 percent reductions, respectively (Attachment 6 of the Modeling Appendix).

Compared to the No-Action Alternative, six critical, one dry, and one below-normal water years had significant increases in production, while three critical water years have a significant decrease in production (Table 11-5 and Attachment 6 of the Modeling Appendix). Compared to the Existing Condition, nine critical and two dry water years had significant increases in production, while one critical water years resulted in significant decreases in production (Table 11-6 and Attachment 7 of the Modeling Appendix).

Table 11-6. Change in Production Under CP1 for Spring-Run Chinook Salmon

	Number of Years	Average Production	Change in Production from Baseline	Average Change in Production	Maximum Increase in Production	Number of Months with Significant Increase	Maximum Decrease in Production	Number of Months with Significant Decrease
Future Condition (2030)								
All	81	165,227	1,172	0.7	70.6	8	-66.3	3
Critical	13	88,867	7,677	9.5	70.6	6	-66.3	3
Dry	17	170,150	698	0.4	7.2	1	-2.1	0
Below Normal	14	178,425	1,245	0.7	19.8	1	-4.3	0
Above Normal	11	183,396	-370	-0.2	3.3	0	-2.5	0
Wet	26	185,393	-1,158	-0.6	1.1	0	-2.2	0
Existing Condition (2005)								
All	81	164,198	990	0.6	256	11	-41.3	1
Critical	13	83,012	8,950	12.1	256	9	-41.3	1
Dry	17	170,380	1,519	0.9	16.5	2	-1.0	0
Below Normal	14	177,394	-636	-0.4	1.7	0	-2.1	0
Above Normal	11	182,943	-1,170	-0.6	2.2	0	-2.3	0
Wet	26	185,666	-1,563	-0.8	1.7	0	-3.1	0

Note:

Production is the number of immature smolts surviving to pass the Red Bluff Pumping Plant

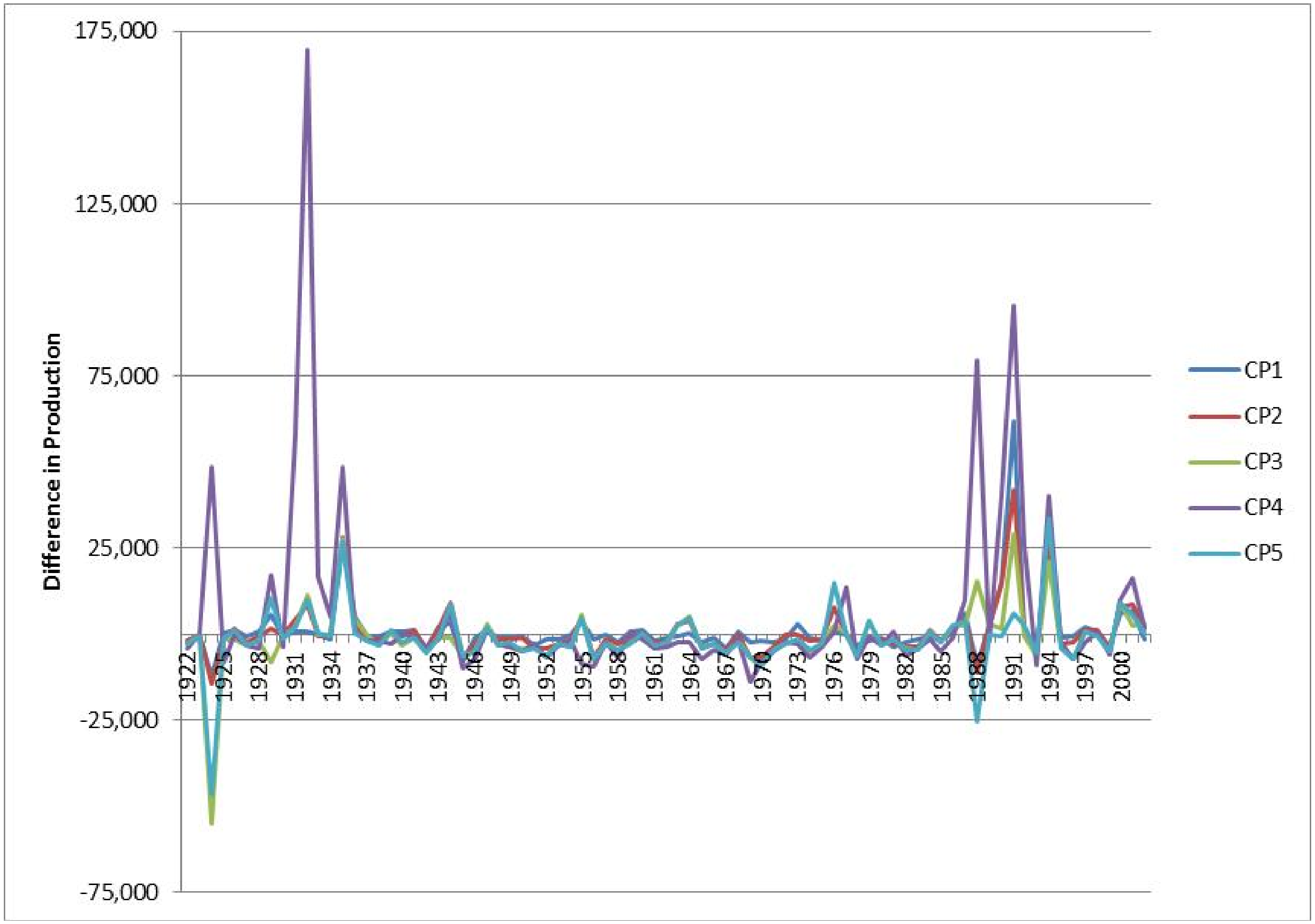


Figure 11-10. Change in Production of Spring-Run Chinook Salmon Compared to the No-Action Alternative

Mortality

Mortality was separated by flow- and water temperature-related mortality to assess the level of impacts on spring-run Chinook salmon caused by the actions of the project (Attachments 6 and 7). In all cases, most mortality is caused by nonoperations-related factors (e.g., disease, predation, entrainment) −around 83 percent of the total mortality.

Mortality is presented in two manners–total mortality and smolt equivalent mortality (Attachments 6 and 7 of the Modeling Appendix). Under both the 2030 and 2005 conditions, the greatest mortality to spring-run occurred to eggs, with minimal mortality to the other life stages. Table 11-7 displays the smolt-equivalent mortalities for each Comprehensive Plan that are caused by flow- and water-related factors (also see Attachments 6 and 7 of the Modeling Appendix). In both 2030 and 2005 conditions, only eggs and fry would be affected by operation of the Comprehensive Plans (Table 11-7 and Attachments 6 and 7 of the Modeling Appendix). In all but wet water years, mortality to eggs due to unsuitable water temperatures would be the primary cause of operations-related mortalities (Attachments 6 and 7 of the Modeling Appendix).

Years with the highest flow- and water temperature-related mortality were the same for all the Comprehensive Plans. Except in 1932 (a dry water year), each of these years was a critical water year type and was preceded by either a below, dry, or (predominantly) critical water year. However, years with the lowest mortality varied between all but critical water year types (Attachments 6 and 7 of the Modeling Appendix).

Spring-run Chinook salmon would have, overall, an insignificant change flow- and water temperature-related mortality, and an insignificant increase in production for all 82 years. However, spring-run Chinook salmon would have a significant increase in production in critical water years. Therefore, spring-run Chinook salmon would benefit from actions taken in CP1. Mitigation for this impact is not needed, and thus not proposed.

Table 11-7. Average Annual Spring-Run Chinook Salmon Smolt Equivalent Mortality Under Each Base Condition and the Difference in Mortality Under Each Comprehensive Plan Caused by Changes in Flow and Water Temperature

Plan	Egg Count Based on Smolt Equivalent[1, 2]	Difference in Mortality Factor from Baseline Condition										Total	Percent Mortality[2]
		Pre-spawn	Incu-bation	Super-Impo-sition	Eggs Temp	Fry Temp	Fry Habitat	Pre-smolt Temp	Pre-smolt Habitat	Immature Smolt Temp	Immature Smolt Habitat		
Future Condition (2030)													
No-Action Alternative	302,510	106	1,328	0	6,189	0	29	0	0	0	0	7,653	2.5
CP1	304,299	-7	82	0	-1,382	0	1	0	0	0	0	-1,306	2.1
CP2	303,633	-3	-35	0	-1,467	0	-2	0	0	0	0	-1,507	2.0
CP3	301,437	-8	17	0	-1,170	0	-5	0	0	0	0	-1,166	2.2
CP4	313,315	-23	415	0	-2,829	0	-3	0	0	0	0	-2,440	1.7
CP5	300,918	10	-16	0	-1,654	0	-3	0	0	0	0	-1,664	2.0
Existing Condition (2005)													
Existing Condition	300,637	126	1,124	0	6,155	0	27	0	0	0	0	7,432	2.5
CP1	302,611	-4	-40	0	-861	0	3	0	0	0	0	-902	2.2
CP2	304,787	-14	44	0	-1,548	0	2	0	0	0	0	-1,517	1.9
CP3	303,602	1	128	0	-1,308	0	-3	0	0	0	0	-1,181	2.1
CP4	313,736	-45	305	0	-2,754	0	5	0	0	0	0	-2,489	1.6
CP5	302,329	-1	67	0	-1,718	0	-2	0	0	0	0	-1,654	1.9

Note:
[1] The potential number of smolt equivalent is based on the spawning population of 132 adults, using the formula:
Immature Smolt Equivalent Mortality = Mortality * % Survival $_{(eggs\ to\ fry)}$ * % Survival $_{(fry\ to\ presmolts)}$ * % Survival $_{(presmolts\ to\ immature\ smolts)}$
[2] Values in these two columns do not constitute a difference from the baseline condition.

Fall-Run Chinook Salmon

Production

The overall average fall-run Chinook salmon production for the 81-year period was similar for CP1 relative to the No-Action Alternative and the Existing Condition (Attachments 9 and 10 of the Modeling Appendix). The maximum increase in production relative to the No-Action Alternative was 17 percent for CP1. The largest decrease in production relative to the No-Action Alternative was 51 percent for CP1 (Table 11-8 and Attachment 9 of the Modeling Appendix). The maximum increase in production relative to the Existing Condition was 80 percent for CP1. The largest decrease in production relative to the Existing Condition was 13 percent for CP1 (Table 11-8 and Attachment 10 of the Modeling Appendix).

Figure 11-11 shows the annual change in production relative to the No-Action Alternative for all Comprehensive Plans.

Under CP1, three critical water years, two dry water years, and one below-normal water year resulted in increases in production relative to the No-Action Alternative greater than 5 percent. Only critical water year resulted in a significant decrease (more than 5 percent) in production relative to the No-Action (Attachment 9 of the Modeling Appendix).

Under CP1, one critical and one dry water year resulted in significant increases in production relative to the Existing Condition greater than 5 percent. Critical water years 1977 and 1992 and wet water years 1929 and 1992 resulted in significant decreases in production relative to the Existing Condition greater than 5 percent.

Table 11-8. Change in Production Under CP1 for Fall-Run Chinook Salmon

Year Type	Number of Years	Average Production	Change in Production from Baseline	Average Change in Production	Maximum Increase in Production	Number of Months with Significant Increase	Maximum Decrease in Production	Number of Months with Significant Decrease
Future Condition (2030)								
All	81	29,597,665	79,258	0.3	17.2	6	-51.3	1
Critical	13	26,551,960	107,131	-0.8	14.6	3	-51.3	1
Dry	17	29,819,701	279,541	1.5	12.7	2	-3.3	0
Below Normal	14	31,090,422	-7,489	0.6	17.2	1	-4.6	0
Above Normal	11	31,088,575	55,565	0.4	4.1	0	-2.3	0
Wet	26	29,540,778	-8,898	-0.1	4.8	0	-4.3	0
Existing Condition (2005)								
All	81	29,743,213	314,871	1.1	61.1	8	-4.5	0
Critical	13	27,135,675	959,539	3.7	61.1	3	-3.6	0
Dry	17	29,933,697	473,296	1.6	12.1	3	-2.4	0
Below Normal	14	31,504,560	486,298	1.6	24.3	2	-3.6	0
Above Normal	11	30,856,686	-13,710	0.0	2.5	0	-1.9	0
Wet	26	29,502,932	-64,339	-0.2	3.8	0	-4.5	0

Note:

Production is the number of immature smolts surviving to pass the Red Bluff Pumping Plant

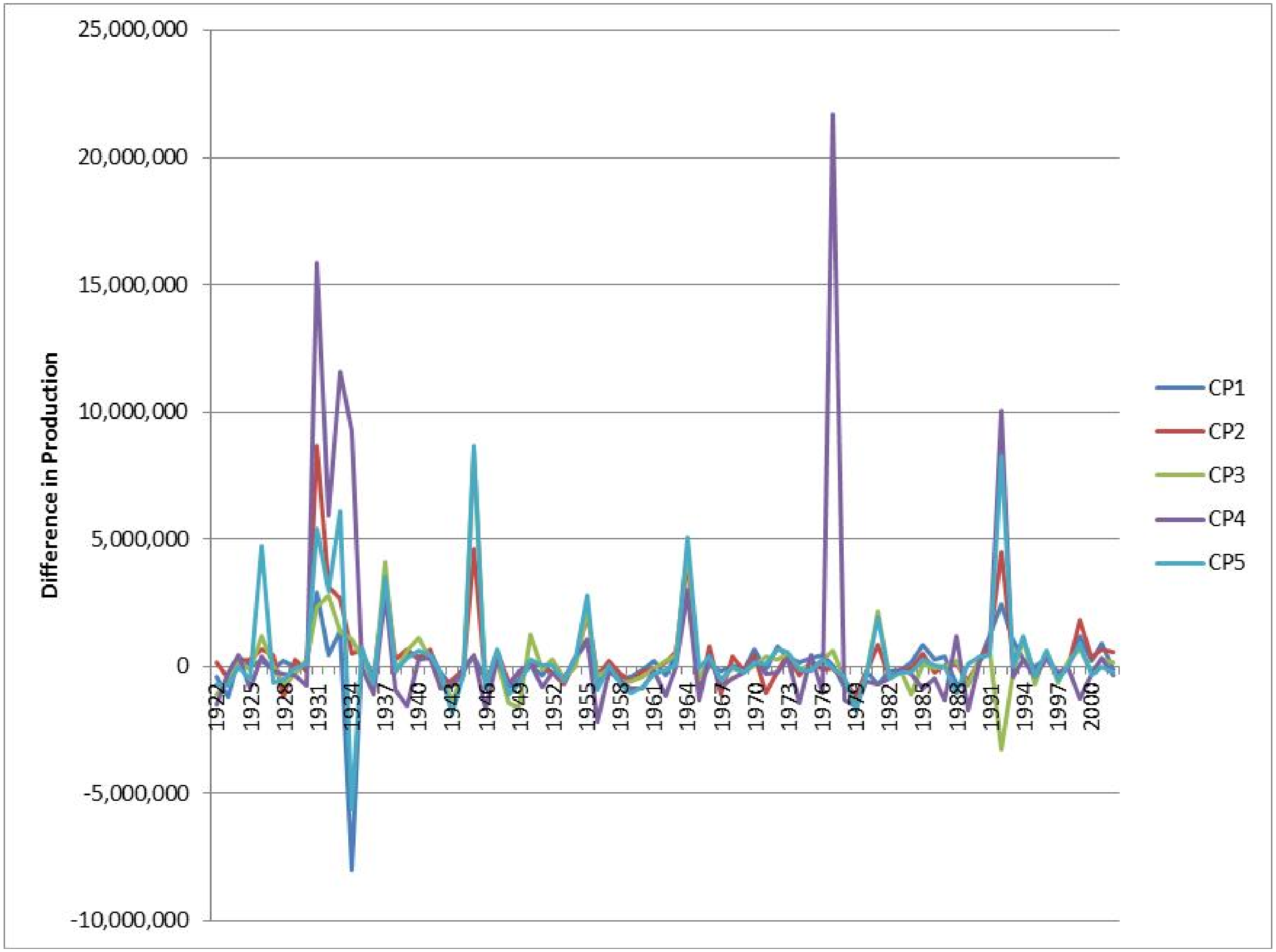


Figure 11-11. Change in Production of Fall-Run Chinook Salmon Compared to the No-Action Alternative

Mortality

Mortality was separated by flow- and water temperature-related mortality to assess the level of impacts on fall-run Chinook salmon caused by the actions of the project (Attachments 9 and 10). In all cases, most mortality is caused by nonoperations-related factors (e.g., disease, predation, entrainment)−around 64 percent of the total mortality.

Mortality is presented in two manners–total mortality and smolt equivalent mortality (Attachments 9 and 10 of the Modeling Appendix). Under both 2030 and 2005 conditions, the greatest mortality based on the smolt equivalents to fall-run Chinook salmon under CP1 occurred to fry, followed by eggs, prespawn adults, presmolts, and lastly to immature smolts. Flow-related effects triggered a higher percentage of the operations-related mortality (Table 11-9). In all water year types, the greatest portion of mortality under CP1 occurred to fry caused by forced movement to downstream habitats. Other non-flow- and water temperature-related conditions were the primary causes of mortality for all life stages except fry (Attachments 9 and 10 in the Modeling Appendix).

Most differences in production and mortality are insignificant for fall-run Chinook salmon. Therefore, there would be a less-than-significant impact to fall-run Chinook salmon. Mitigation for this impact is not needed, and thus not proposed.

Table 11-9. Average Annual Fall-Run Chinook Salmon Smolt Equivalent Mortality Under Each Base Condition and the Difference in Mortality Under Each Comprehensive Plan Caused by Changes in Flow and Water Temperature

Plan	Egg Count Based on Smolt Equivalent[1,2]	Difference in Mortality Factor from Baseline Condition										Total	Percent Mortality[2]
		Pre-spawn	Incu-bation	Super-Impo-sition	Eggs Temp	Fry Temp	Fry Habitat	Pre-smolt Temp	Pre-smolt Habitat	Immature Smolt Temp	Immature Smolt Habitat		
Future Condition (2030)													
No-Action Alternative	53,997,584	532,611	698,320	1,098,998	130,219	1,098	7,297,067	6,839	191,817	3,554	15,051	9,975,575	18.5
CP1	54,020,735	-82,771	-7,088	-29,273	-14,950	-77	60,531	-594	-7,185	-283	-1,168	-82,858	18.3
CP2	54,623,098	-66,868	-13,920	-9,913	4,390	95	83,271	657	-19,704	-416	-1,198	-23,605	18.2
CP3	54,307,062	-10,196	-18,624	-44,357	-16,910	188	91,866	52	-16,532	-585	-2,444	-17,543	18.3
CP4	55,174,850	-196,088	1,013	-35,321	-29,663	-46	417,965	284	8,577	-867	-595	165,258	18.4
CP5	54,516,383	-148,596	-19,715	-22,701	24,634	193	87,028	1,389	-14,705	-248	-1,230	-93,952	18.1
Existing Condition (2005)													
Existing Condition	53,773,316	508,244	691,873	1,107,388	119,149	1,144	7,272,250	6,199	192,979	3,408	14,665	9,917,299	18.4
CP1	54,339,007	-2,695	-6,984	-8,457	7,564	-90	55,007	1,207	-4,141	414	805	42,629	18.3
CP2	54,186,119	-203,671	-12,659	-8,650	15,915	-78	74,966	860	-8,525	-310	-1,349	-143,502	18.0
CP3	54,439,932	-40,503	-12,017	-35,451	3,131	-93	76,845	260	-9,640	-691	-1,242	-19,400	18.2
CP4	55,250,903	-212,958	1,638	-15,390	-11,051	-77	317,170	1,956	5,951	-371	2,284	89,152	18.1
CP5	54,821,535	15,805	-17,399	-40,060	42,336	-66	82,328	2,931	-4,389	77	-1,594	79,967	18.2

Note:

[1] The potential number of smolt equivalent is based on the spawning population of 47,754 adults, using the formula:
Immature Smolt Equivalent Mortality = Mortality * % Survival $_{\text{(eggs to fry)}}$ * % Survival $_{\text{(fry to presmolts)}}$ * % Survival $_{\text{(presmolts to immature smolts)}}$

[2] Values in these two columns do not constitute a difference from the baseline condition.

Late Fall-Run Chinook Salmon

<u>Production</u>

Overall average late fall-run Chinook salmon production for the 80-year period was similar for CP1 relative to the No-Action Alternative. The maximum increase in production relative to the No-Action Alternative was almost 9 percent for CP1, while the largest decrease in production relative to the No-Action Alternative was less than 5 percent for CP1 (Table 11-10 and Attachment 12 of the Modeling Appendix).

Overall average late fall-run Chinook salmon production for the 80-year period was similar for CP1 relative to Existing Conditions. There were two critical water years with a significant increase (greater than 5 percent) in production, and no years with significant decreases in production relative to Existing Conditions (Table 11-10 and Attachment 13 of the Modeling Appendix).

Figure 11-12 and Table 11-10 display the annual differences in production for late fall-run Chinook salmon for all Comprehensive Plans.

Table 11-10. Change in Production Under CP1 for Late Fall-Run Chinook Salmon

Year Type	Number of Years	Average Production	Change in Production from Baseline	Average Change in Production	Maximum Increase in Production	Number of Months with Significant Increase	Maximum Decrease in Production	Number of Months with Significant Decrease
Future Condition (2030)								
All	80	7,570,927	-14,507	-0.1	8.8	1	-3.8	0
Critical	13	7,038,385	-25,783	-0.4	3.6	0	-3.7	0
Dry	16	7,394,185	39,817	0.5	8.8	1	-1.7	0
Below Normal	14	7,598,833	-13,785	-0.2	2.6	0	-2.5	0
Above Normal	11	7,543,667	-42,417	-0.6	3.1	0	-2.6	0
Wet	26	7,442,276	-17,388	-0.2	3.6	0	-3.8	0
Existing Condition (2005)								
All	80	7,425,077	38,516	0.5	9.4	2	-4.0	0
Critical	13	7,029,066	65,770	0.9	5.3	1	-2.5	0
Dry	16	7,443,310	83,042	1.1	9.4	1	-2.7	0
Below Normal	14	7,642,832	31,738	0.4	4.6	0	-2.9	0
Above Normal	11	7,578,729	19,056	0.3	1.5	0	-0.6	0
Wet	26	7,429,604	9,372	0.1	3.8	0	-4.0	0

Note:
Production is the number of immature smolts surviving to pass the Red Bluff Pumping Plant

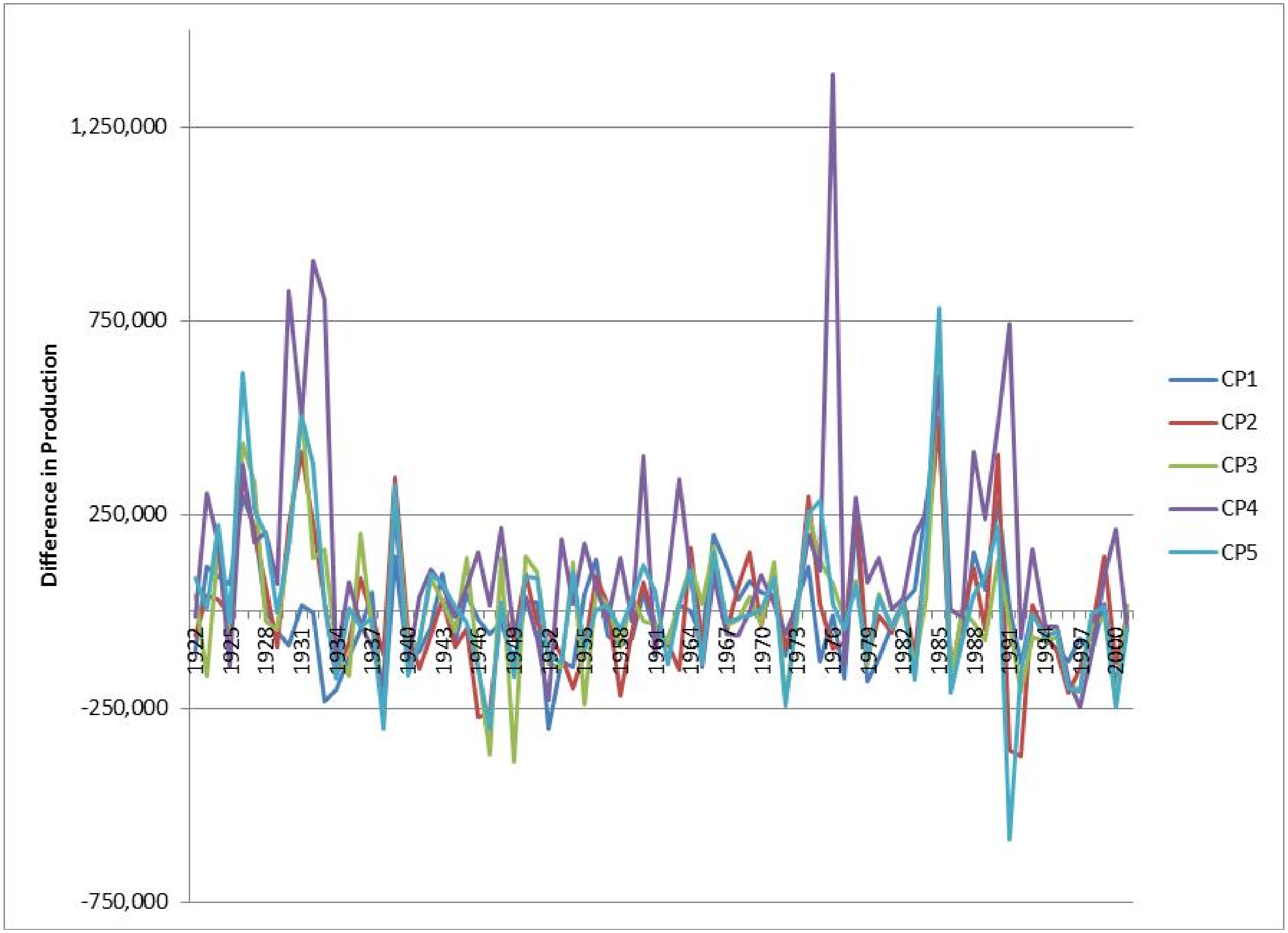


Figure 11-12. Change in Production of Late Fall-Run Chinook Salmon Compared to the No-Action Alternative

Mortality

Mortality was separated by flow- and water temperature-related mortality to assess the level of impacts on late fall-run Chinook salmon caused by the actions of the project (Attachments 12 and 13). In all cases, most mortality is caused by nonoperations-related factors (e.g., disease, predation, entrainment)−around 78 percent of the total mortality.

Mortality is presented in two manners–total mortality and smolt equivalent mortality (Attachments 12 and 13 of the Modeling Appendix). Under both 2030 and 2005 conditions, the largest mortality to late fall-run Chinook salmon under CP1 occurred to fry, followed by eggs, presmolts, immature smolts, and prespawn adults. Table 11-10 displays the overall mortalities for each Comprehensive Plan that are caused by changes in water temperature and flow (see also Attachments 12 and 13 of the Modeling Appendix).

When comparing mortality for flow- and water temperature-related activities only, fry are most affected, followed by eggs, presmolts, and immature smolts. Most mortality occurred as a result of flow conditions rather than water temperature (Table 11-11).

Years with the highest mortality under CP1 occurred in all water year types under both 2030 and 2005 conditions. Three years were preceded by a wet water year, one was preceded by an above-normal water year, and one was preceded by a dry water year (see also Attachments 12 and 13 of the Modeling Appendix).

Because late fall-run Chinook salmon have an insignificant change in mortality and production, late fall-run Chinook salmon would have a less-than-significant impact from actions taken in CP1. Mitigation for this impact is not needed, and thus not proposed.

Table 11-11. Average Annual Late Fall-Run Chinook Salmon Smolt Equivalent Mortality Under Each Base Condition and the Difference in Mortality Under Each Comprehensive Plan Caused by Changes in Flow and Water Temperature

Plan	Egg Count Based on Smolt Equivalent [1,2]	Difference in Mortality Factor from Baseline Condition										Total	Percent Change in Mortality [2]
		Pre-spawn	Incu-bation	Super-Imposition	Eggs Temp	Fry Temp	Fry Habitat	Pre-smolt Temp	Pre-smolt Habitat	Immature Smolt Temp	Immature Smolt Habitat		
Future Condition (2030)													
No-Action Alternative	16,705,033	1,170	146,002	235,542	10,735	852	1,632,849	50,469	13,329	37,065	1,856	2,129,869	12.7
CP1	16,684,898	-21	-4,429	-12,051	12	61	20,781	238	183	-1,486	19	3,307	12.8
CP2	16,688,408	0	-6,900	-20,579	10	156	27,936	-929	416	-5,594	-32	-5,516	12.7
CP3	16,696,739	4	-6,567	-23,126	-29	-135	20,686	-3,672	-900	-3,504	-69	-17,313	12.7
CP4	16,887,581	5	-4,024	-11,189	451	-786	19,411	-42,164	1,781	-21,871	414	-57,973	12.3
CP5	16,707,840	6	-7,853	-23,366	108	24	17,066	-1,902	-605	-4,430	-61	-21,013	12.6
Existing Condition (2005)													
Existing Condition	16,655,609	1,011	148,473	231,022	10,803	1,229	1,636,762	59,662	12,623	39,091	1,894	2,142,570	12.9
CP1	16,707,969	13	-4,413	-9,236	71	257	1,318	-4,919	673	-3,955	8	-20,182	12.7
CP2	16,732,145	16	-6,844	-17,080	-224	-232	12,851	-13,110	1,348	-7,682	21	-30,936	12.6
CP3	16,692,227	7	-6,965	-19,779	21	-500	24,395	-13,715	1,582	-9,119	-13	-24,085	12.7
CP4	16,880,481	30	-3,769	-9,321	113	-1,164	24,171	-51,236	1,578	-24,854	371	-64,080	12.3
CP5	16,711,829	10	-7,693	-19,827	63	40	14,417	-13,649	-469	-10,417	-17	-37,541	12.6

Note:
[1] The potential number of smolt equivalent is based on the spawning population of 10,116 adults, using the formula:
Immature Smolt Equivalent Mortality = Mortality * % Survival $_{\text{(eggs to fry)}}$ * % Survival $_{\text{(fry to presmolts)}}$ * % Survival $_{\text{(presmolts to immature smolts)}}$
[2] Values in these two columns do not constitute a difference from the baseline condition.

Impact Aqua-13 (CP1): Changes in Flow and Water Temperatures in the Upper Sacramento River Resulting from Project Operation – Steelhead, Green Sturgeon, Sacramento Splittail, American Shad, and Striped Bass Project operation generally would result in slightly improved flow and water temperature conditions in the upper Sacramento River for steelhead, green sturgeon, Sacramento splittail, American shad, and striped bass. This impact would be less than significant.

Flow-Related Effects Under CP1, monthly mean flows at all modeling locations along the upper Sacramento River (below Shasta Dam, below Keswick Dam, above Bend Bridge, and above RBPP) would be essentially equivalent to (less than 2-percent difference from) flows under the Existing Condition and No-Action Alternative simulated for all months. (See the Modeling Appendix for complete modeling results.)

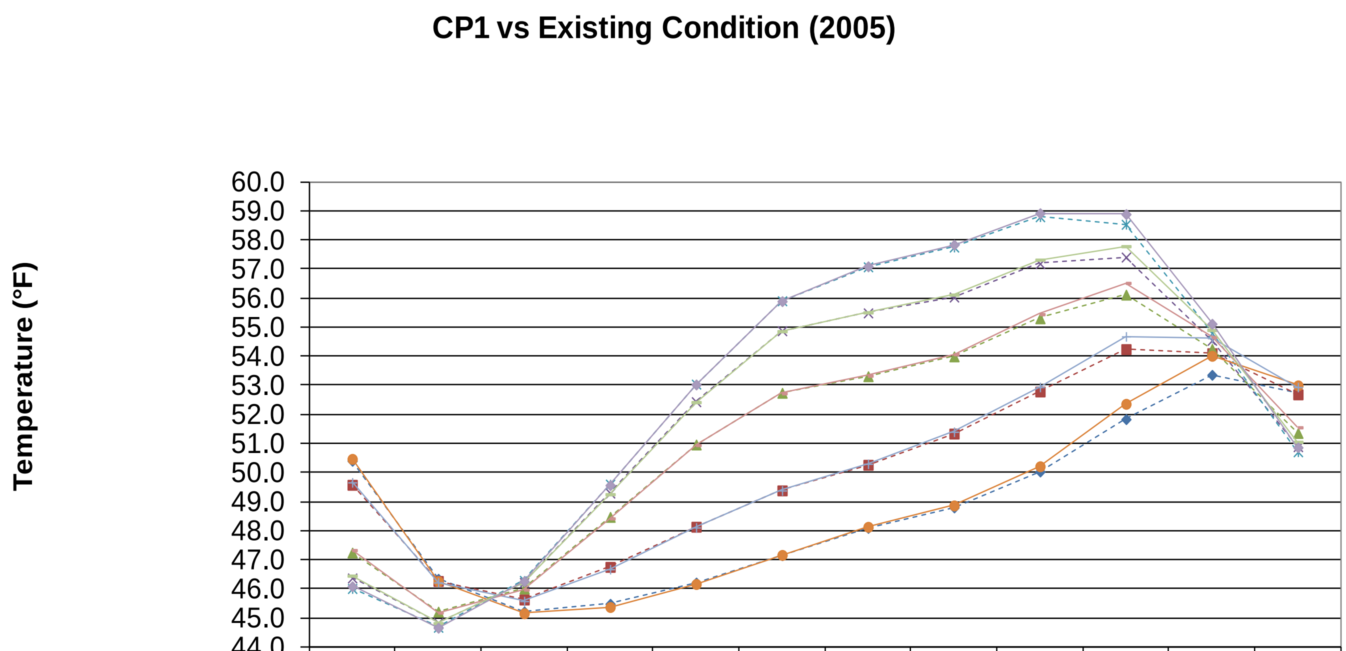
Potential flow-related effects of CP1 on fish species of management concern in the upper Sacramento River would be minimal. During most years, releases from Shasta Lake would be unchanged. During average and wet years, river flows would decrease slightly from December through February in some years because of the use of increased capacity within Shasta Lake, usually after an extended dry period. Also, flows (and stages) would increase slightly from June through October in most years. Although small, increased flow would be most pronounced during dry periods as a result of increased releases from Shasta Dam for water supply reliability purposes. However, few to no changes would occur in water flows during dry years in winter and spring.

The average changes in monthly mean flow would be reductions or increases of several percent, although the changes in monthly mean flow would be greater in some years. Nonetheless, differences generally would be small (less than 2 percent). Potential changes in flows and stages would diminish downstream from RBPP because of increased effects from tributary inflows, diversions, and flood bypasses.

Changes in monthly mean flows under CP1 relative to the Existing Condition and No-Action Alternative would have no discernible effects on steelhead, green sturgeon, Sacramento splittail, American shad, or striped bass in the upper Sacramento River. Functional flows for migration, attraction, spawning, egg incubation, and rearing/emigration for these species would be unchanged. Therefore, flow-related impacts on these species would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

Water Temperature–Related Effects Under CP1, monthly mean water temperatures at all modeling locations along the upper Sacramento River (below Shasta Dam, below Keswick Dam, Balls Ferry, above Bend Bridge, and above RBPP) would be the same as, or fractionally less than, water temperatures under the Existing Condition and No-Action Alternative conditions simulated for all months (Figures 11-13 and 11-14). (See the Modeling Appendix for complete modeling results.)

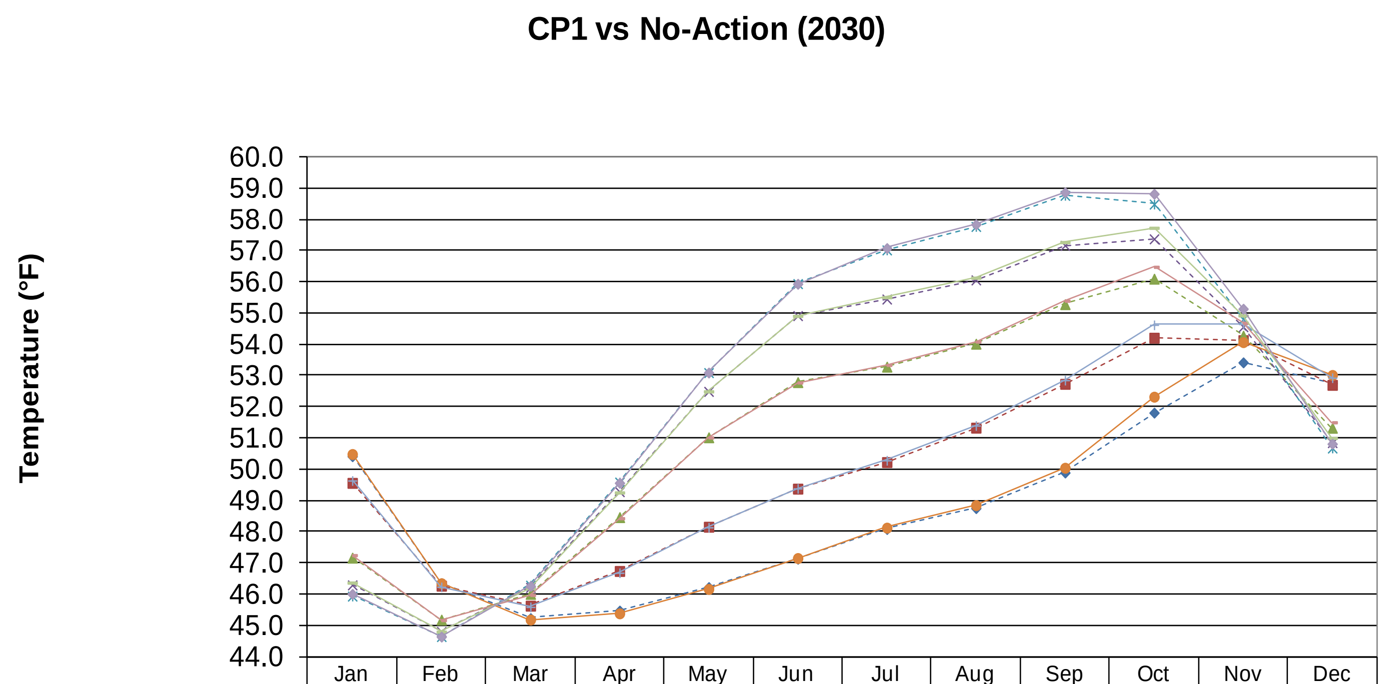
As discussed above, the modeling simulations may not fully account for real-time management of the cold-water pool and TCD (through the SRTTG) to achieve maximum cold-water benefits. Therefore, the modeled changes in water temperature (i.e., small benefits) are likely conservative and understated to some degree. Potential water temperature–related effects of CP1 on fish species of management concern in the upper Sacramento River would be minimal.



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
CP1 Below Shasta	50.4	46.3	45.2	45.5	46.2	47.2	48.1	48.8	50.0	51.8	53.4	52.7
CP1 Below Keswick	49.6	46.3	45.6	46.8	48.1	49.4	50.3	51.3	52.8	54.2	54.1	52.7
CP1 Balls Ferry	47.2	45.2	46.0	48.5	51.0	52.7	53.3	54.0	55.3	56.1	54.3	51.4
CP1 Bend Bridge	46.4	44.8	46.2	49.3	52.4	54.9	55.5	56.0	57.2	57.4	54.5	50.9
CP1 RBPP	46.0	44.7	46.3	49.6	53.0	55.9	57.1	57.8	58.8	58.5	54.8	50.7
EC Below Shasta	50.5	46.3	45.2	45.4	46.2	47.2	48.1	48.9	50.2	52.4	54.0	53.0
EC Below Keswick	49.7	46.2	45.6	46.7	48.1	49.4	50.3	51.4	52.9	54.7	54.6	52.9
EC Balls Ferry	47.3	45.2	46.0	48.4	50.9	52.7	53.3	54.1	55.4	56.5	54.7	51.6
EC Bend Bridge	46.5	44.8	46.2	49.3	52.4	54.9	55.5	56.1	57.3	57.8	54.9	51.1
EC RBPP	46.1	44.7	46.3	49.6	53.0	55.9	57.1	57.8	58.9	58.9	55.1	50.9

Key: EC = Existing Condition
CP = Comprehensive Plan RBPP = Red Bluff Pumping Plant

Figure 11-13. Changes in Mean Monthly Water Temperature at Modeled Locations in the Sacramento River Within the Primary Study Area (CP1 Versus Existing Condition)



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
CP1 Below Shasta	50.4	46.3	45.2	45.5	46.2	47.1	48.1	48.8	49.9	51.8	53.4	52.8
CP1 Below Keswick	49.6	46.3	45.6	46.7	48.2	49.4	50.2	51.3	52.7	54.2	54.1	52.7
CP1 Balls Ferry	47.2	45.2	46.0	48.5	51.0	52.8	53.3	54.0	55.3	56.1	54.3	51.3
CP1 Bend Bridge	46.3	44.8	46.2	49.3	52.5	54.9	55.4	56.1	57.2	57.4	54.6	50.9
CP1 RBPP	45.9	44.6	46.3	49.6	53.1	55.9	57.0	57.8	58.8	58.5	54.8	50.7
NA Below Shasta	50.5	46.3	45.2	45.4	46.2	47.2	48.1	48.9	50.0	52.3	54.1	53.0
NA Below Keswick	49.6	46.2	45.6	46.7	48.1	49.4	50.3	51.4	52.9	54.6	54.6	52.9
NA Balls Ferry	47.3	45.2	46.0	48.4	51.0	52.8	53.3	54.1	55.4	56.5	54.7	51.5
NA Bend Bridge	46.4	44.8	46.2	49.3	52.5	54.9	55.5	56.1	57.3	57.7	54.9	51.0
NA RBPP	46.0	44.6	46.3	49.6	53.1	55.9	57.1	57.8	58.9	58.8	55.1	50.8

Key: NA = No-Action Alternative
CP = Comprehensive Plan RBPP = Red Bluff Pumping Plant

Figure 11-14. Changes in Mean Monthly Water Temperature at Modeled Locations in the Sacramento River Within the Primary Study Area (CP1 Versus No-Action Alternative)

The slightly cooler monthly mean water temperatures under CP1 relative to the Existing Condition and the No-Action Alternative would have very small effects on steelhead, green sturgeon, Sacramento splittail, American shad, and striped bass in the upper Sacramento River. Mean monthly water temperatures would not rise above important thermal tolerances for the species life stages relevant to the upper Sacramento River. Therefore, water temperature–related impacts on these fish species would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

Impact Aqua-14 (CP1): Reduction in Ecologically Important Geomorphic Processes in the Upper Sacramento River Resulting from Reduced Frequency and Magnitude of Intermediate to High Flows Project operations could cause a reduction in the magnitude, duration, and frequency of intermediate to large flows both in the upper Sacramento River and in the lowermost (confluence) areas of tributaries. Such flows are necessary for channel formation and maintenance, meander migration, and the creation of seasonally inundated floodplains. These geomorphic processes are ecologically important because they are needed to maintain important aquatic habitat functions and values for fish and macroinvertebrate communities. This impact would be potentially significant.

Sediment transport, deposition, and scour regulate the formation of key habitat features such as point bars, gravel deposits, and shaded riverine aquatic (SRA) habitat. These processes are regulated by the magnitude, duration, and frequency of flows. Relatively large floods provide the energy required to mobilize sediment from the riverbed, produce meander migration, and create seasonally inundated floodplains. Project operations could cause a reduction in the intermediate to large flows necessary for channel formation and maintenance, meander migration, and the creation of seasonally inundated floodplains.

Channel Forming and Maintenance In undisturbed alluvial rivers, channels and bedforms develop in response to flow and sediment loading conditions that may vary by orders of magnitude within a few hours. In many cases, the frequency distribution of flow and sediment supply are such that rivers convey the greatest fraction of their sediment load at an intermediate dominant discharge, which is often close to the bankfull flow (Leopold, Wolman, and Miller 1964). Although the recurrence interval of bankfull flow varies from river to river, it is often close to 1.5 to 2 years (Leopold, Wolman, and Miller 1964). This provides a rational basis for assuming that coarse sediment is routed as bedload during the 1.5-year flood (i.e., Q1.5). Flow regulation of the Sacramento River has reduced the river's Q1.5 by 30 percent from 86,000 cfs to 61,000 cfs (Kondolf et al. 2000).

Bankfull flow may provide a good first approximation for assessing the threshold for bed mobilization; however, it does not necessarily indicate the flow levels required to maintain the health of habitats in the alluvial system. For example, it has been estimated that a naturally occurring flood with a 5- to 10-year recurrence interval may often be required for maintenance of a mobile alternating bar-pool sequence (Trush, McBain, and Leopold 2000), which is an ecologically desired condition. In the regulated flow regime of the Sacramento River, the 10-year flood has been reduced by 38 percent from 218,000 cfs to 134,000 cfs (Kondolf et al. 2000).

At many locations between Keswick Dam and RBPP, the channel is characterized by bedrock control of its base level and its banks. This implies that, compared to alluvial reaches downstream, the channel in this area has been less able to adjust hydraulic geometry (channel width and depth) in response to dam-related changes in flow. Thus, it is possible that the channel is not in balance with the current flow regime, so that typical recurrence intervals of mobilization and bedform alteration are much longer than they were before the dams reduced the magnitude of the 1.5-year and 10-year floods (i.e., Q1.5 and Q10). This implies that the bed and point bars may have become static in the postdam era, and that only remnants of gravel from once-abundant spawning habitat in this reach remain.

The flow required for mobilization and scour of a channel bed depends in part on the grain-size distribution of the bed sediment. On the Sacramento River, the grain-size distributions of deposits between Keswick Dam and Cottonwood Creek may have increased since construction of Shasta Dam because of winnowing associated with dam-related reductions in sediment supply (Stillwater Sciences 2006). This would tend to increase the threshold for mobilization and scour of the channel bed, even as the frequency of high flows was reduced by operations of Shasta Dam. The hypothesized coarsening of the bed would thus tend to make mobilization of sediment and bedforms even less likely under the regulated flow regime in the upper Sacramento River.

Changes (reductions) in intermediate to large flows in the Sacramento River also have the potential to affect the lower reaches (confluence areas) of tributaries by reducing the mainstem river’s backwater effect on the lower reaches of the tributaries. A decrease in the frequency, duration, and intensity of intermediate to large flows on the Sacramento River, and an associated decrease in the stage elevation of the river surface, could increase the amount of downcutting in the lower reaches of the tributaries. Downcutting of the lower tributaries could result in bank erosion, channel widening, and disconnection of the channel from its floodplain, which in turn could affect riparian recruitment and succession processes.

Meander Migration Suitable spawning habitat on the mainstem Sacramento River currently extends from Keswick Dam to Princeton. Since 1945, Shasta (and later Keswick) Dam has altered mainstem flow and sediment supply, and has thus affected the quantity and grain-size distributions of gravel in the channel bed. This in turn has affected the extent and quality of salmonid spawning habitat. The expected evolution of spawning gravel in the Sacramento

River can be summarized in the following three working hypotheses (Stillwater Sciences 2006):

1. Bed coarsening in the upper Sacramento River has occurred and is continuing. As a result, spawning habitat has been progressively reduced in the reach between Keswick Dam and Anderson Bridge, despite the effects of recent gravel augmentation.

2. Bed coarsening has progressed downstream since 1980 and has now reduced the area of spawning habitat between Anderson Bridge and Cottonwood Creek.

3. The concentration of fine sediment below the surface has appeared to remain suitably low between Keswick Dam and Cottonwood Creek. It may have become higher in downstream reaches, however, because of a combination of factors: dam-related reductions in large flows, high sediment supply from Cottonwood Creek, and local hydraulic conditions (i.e., a break in slope) that promote local deposition. Thus, successful spawning of Chinook salmon in reaches below Cottonwood Creek may have been compromised.

The success of anadromous salmonids depends strongly on gravel dynamics in the mainstem river. However, other fish species of primary management concern rely much more heavily on the dynamics of meander migration, which affects the quality and availability of near- and off-channel habitat such as SRA.

SRA habitat is defined as the nearshore aquatic habitat occurring at the interface between a river and adjacent woody riparian habitat. SRA habitat is composed of vegetation and instream tree and shrub debris that provides important fish habitat. The principal attributes of this cover type are (1) an adjacent bank composed of natural, eroding substrates supporting riparian vegetation that either overhang or protrude into the water; and (2) water that contains variable amounts of woody debris, such as leaves, logs, branches, and roots, and has variable depths, velocities, and currents.

Riparian habitat provides structure (through SRA habitat) and food for fish species. Shade decreases water temperatures, while low overhanging branches can provide sources of food by attracting terrestrial insects. As riparian areas mature and banks erode, the vegetation sloughs off into the rivers, creating structurally complex habitat consisting of instream woody material that furnishes refugia from predators, alters water velocities, and provides habitat for aquatic invertebrates. For these reasons, many fish species are attracted to SRA habitat.

On the upper Sacramento River, actively migrating reaches alternate with stable reaches, which migrate slowly or not at all because they are confined by erosion-resistant geologic deposits or revetment placed to protect adjacent land uses. Meander migration and bank erosion occur by progressive channel migration and episodic meander-bend cutoff. Over decadal timescales, cutoffs generally affect less than 10 percent of the actively migrating length of the Sacramento River. Even so, cutoffs can account for well over 20 percent of the integrated lateral channel change, because they affect relatively large areas when they do occur (Stillwater Sciences 2006).

Chute cutoff and progressive migration interact to produce a characteristic pattern of planform development over time. Individual bends evolve greater sinuosity and curvature via progressive channel migration. Cutoffs reduce sinuosity when it exceeds a local threshold for the initiation of cutoff processes. This should produce measurable changes in local geomorphology over time. Averaged over larger timescales, however, changes in morphology in one reach should be balanced by changes in morphology in others. Thus, in the absence of human modifications, the overall pattern of planform geometry for migrating portions of rivers should approach a state of dynamic equilibrium. Recent studies indicate that the sinuosity of cutoff bends on the Sacramento River is decreasing over time (Stillwater Sciences 2006). This suggests that the Sacramento River is not in a state of dynamic equilibrium. The fact that cutoff migration has increased in frequency and is increasingly dominated by partial cutoffs (which affect smaller areas than complete cutoffs) provides further evidence that nonequilibrium conditions may prevail.

Process-based interpretations suggest that potential project-related changes in flow (i.e., reductions in peak flow and overbank discharge) could tend to reduce the frequency of these important geomorphic processes. This would generally be accompanied by a reduction in average sinuosity; however, observations from the Sacramento River indicate that the overall number of channel cutoffs has nevertheless increased in recent times. This supports the hypothesis that the erodibility of banks and floodplains has increased (thus enhancing the likelihood of cutoff) because of the effects of agricultural clearing of riparian forests on floodplains (Micheli, Kirchner, and Larsen 2004).

Floodplain Inundation Inundation of floodplains reduces the magnitude (i.e., peak volume) of flood flows and promotes exchange of nutrients, organisms, sediment, and energy between the terrestrial and aquatic systems. Flood pulses contribute to high rates of primary productivity in functioning floodplain systems (Junk, Bayley, and Sparks 1989). On the Sacramento River, floodplains provide important winter and spring spawning and rearing habitats for native fish, such as Sacramento splittail and Chinook salmon (Moyle et al. 2004, Sommer et al. 2001).

Typically, the floodplain immediately adjacent to the river is maintained at an elevation equal to the bankfull stage of the channel, such that discharge magnitudes greater than the bankfull flow inundate the adjacent floodplains (Leopold, Wolman, and Miller 1964). Because bankfull flow typically has a recurrence interval of 1.5 to 2 years (Q1.5–2) on alluvial rivers, flow magnitudes greater than the 1.5-year (Q1.5) flow event are often assumed to initiate floodplain inundation.

These effects would likely occur throughout the upper Sacramento River portion of the primary study area. Reductions in the magnitude of high flows would likely be sufficient to reduce ecologically important processes along the upper Sacramento River. Therefore, this impact would be potentially significant. Mitigation for this impact is proposed in Section 11.3.4.

Lower Sacramento River and Tributaries, Delta, and Trinity River

Impact Aqua-15 (CP1): Changes in Flow and Water Temperatures in the Lower Sacramento River and Tributaries and Trinity River Resulting from Project Operation – Fish Species of Primary Management Concern Project operation would result in no discernible change in monthly mean flows or water temperature conditions in the lower Sacramento River. However, predicted changes in flows in the Feather, American, and Trinity rivers could result in adverse effects on Chinook salmon, steelhead, Coho salmon, green sturgeon, Sacramento splittail, American shad, and striped bass. This impact would be potentially significant.

As described below, monthly mean flows at various modeling locations on the lower Sacramento River and tributaries under CP1 were compared with monthly mean flows simulated for the Existing Condition and No-Action Alternative conditions. Modeling for the lower American River occurred at Verona and Freeport; for the lower Feather River, modeling occurred below Thermalito Afterbay, and American River modeling occurred near the H Street Bridge in Sacramento. Modeling also occurred on the Trinity River. See the Modeling Appendix for complete CalSim-II modeling results.

Lower Sacramento River Under CP1, monthly mean flows at the lower Sacramento River modeling locations would be comparable to flows under the Existing Condition and No-Action Alternative conditions simulated for all months. Differences in modeled monthly mean flow were generally small (less than 2 percent) and within the existing range of variability. Potential changes in flows would diminish rapidly downstream from RBPP because of increased effects from tributary inflows, diversions, and flood bypasses. Thus, potential flow-related effects of CP1 on fish species of management concern in the lower Sacramento River would be minimal.

Mean monthly mean flows at all modeling locations on the lower Feather River and American River under CP1 would be essentially equivalent to (less than 2-percent difference from) flows under the Existing Condition and No-Action Alternative conditions simulated for all months. Potential changes in flows are diminished in these areas because of operation of upstream CVP and SWP reservoirs (i.e., Lake Oroville and Folsom Lake) and increasing effects from tributary inflows, diversions, and flood bypasses. Potential flow-related effects of CP1 on fish species of management concern in the Feather River and

American River would be minimal and within the existing range of variability. Potential changes in water temperatures in the lower Sacramento River caused by small changes in releases would diminish rapidly downstream because of the increasing effects of inflows, atmospheric influences, and groundwater. Therefore, flow- and water temperature–related impacts on fish species in the lower Sacramento River would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

The effects of altered flow regimes resulting from implementation of CP1 are unlikely to extend into the lower Sacramento River downstream from Verona and into the Delta because the Central Valley's reservoirs and diversions are managed as a single integrated system (consisting of the CVP and SWP). The guidelines for this management, described in the CVP/SWP OCAP, have been designed to maintain standards for flow to the lower Sacramento River and Delta. CVP and SWP operations must be consistent with the OCAP to allow ESA coverage by the OCAP permits and BOs. Thus, implementation of CP1 would likely not alter flow to the Delta or water temperatures in the lower Sacramento River and its primary tributaries to a sufficient degree to affect Chinook salmon, steelhead, green sturgeon, Sacramento splittail, American shad, or striped bass relative to the Existing Condition and No-Action Alternative. Functional flows for fish migration, attraction, spawning, egg incubation, and rearing/emigration for all these fish species would be unchanged. Therefore, flow- and water temperature–related effects on these fish species in the lower Sacramento River and tributaries would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

Lower Feather River and American River Under CP1, monthly mean flows at modeling locations on the lower Feather River and American River would be essentially equivalent to (less than 2-percent difference from) flows under the Existing Condition and No-Action Alternative conditions simulated for most months. However, simulations for several months within the modeling record show substantial changes to flows in tributaries. Potential changes in flows in these areas could be reduced by real-time operations to meet existing rules and operation of upstream CVP and SWP reservoirs (Lake Oroville and Folsom Lake). Nevertheless, based on predicted changes in flow and associated flow-habitat relationships (including water temperature) for fish, potential flow-related impacts on species of management concern in the American and Feather rivers would be potentially significant. Mitigation for this impact is proposed in Section 11.3.4.

Trinity River As with the lower Feather River and American River, monthly mean flows at all modeling locations within the Trinity River under CP1 would be essentially equivalent to (less than 2-percent difference from) flows under the Existing Condition and No-Action Alternative simulated for most months. Based on predicted changes in flow and associated flow-habitat relationships for fish, potential flow-related impacts on species of management concern in the

Trinity River would be potentially significant. Mitigation for this impact is proposed in Section 11.3.4.

Impact Aqua-16 (CP1): Reduction in Ecologically Important Geomorphic Processes in the Lower Sacramento River Resulting from Reduced Frequency and Magnitude of Intermediate to High Flows Project operation could cause a reduction in intermediate to large flows both in the lower Sacramento River and in the lowermost (confluence) areas of its tributaries. Such flows are necessary for channel forming and maintenance, meander migration, and the creation of seasonally inundated floodplains. These geomorphic processes are ecologically important because they are needed to maintain important aquatic habitat functions and values for fish and macroinvertebrate communities. This impact would be potentially significant.

As discussed under Impact Aqua-14 (CP1), sediment transport, deposition, and scour regulate the formation of key habitat features such as point bars, gravel deposits, and SRA habitat. These processes are regulated by the magnitude, duration, and frequency of flows. Relatively large flows provide the energy required to mobilize sediment from the riverbed, produce meander migration, and create seasonally inundated floodplains. Project operations could cause a reduction in the intermediate to large flows necessary for channel forming and maintenance, meander migration, and the creation of seasonally inundated floodplains (including floodplain bypasses) along the lower Sacramento River.

There is substantially less bedrock control between RBPP and Colusa than along the upper Sacramento River. Consequently, sediment transport and meander migration processes are more pronounced in this more alluvial reach. This is supported by widespread evidence of frequent lateral migration in the upper reaches of the lower Sacramento River (between RBPP and Colusa) (e.g., Micheli, Kirchner, and Larsen 2004). This implies that these reaches of the Sacramento River experience much more frequent bed and bar mobilization than the upper Sacramento River.

As discussed under Impact Aqua-14 (CP1), changes (reductions) in intermediate to large flows in the Sacramento River have the potential to affect the lower reaches (confluence areas) of tributaries by reducing the mainstem river’s backwater effect on the lower reaches of the tributaries. A decrease in the frequency, duration, and intensity of intermediate to large flows on the Sacramento River, and an associated decrease in the stage elevation of the river surface, could increase the amount of downcutting in the lower reaches of the tributaries. Downcutting of the lower tributaries could result in bank erosion, channel widening, and disconnection of the channel from its floodplain, which in turn could affect riparian recruitment and succession processes.

Reaches of the Sacramento River differ in the extent of floodplain inundation. Most of the upper Sacramento River between Keswick Dam and RBPP is also bounded by high banks and terraces, limiting the opportunity for floodplain inundation in this reach. Also along the upper reaches of the lower Sacramento River, between Chico Landing and Colusa, the river is bounded by levees that provide flood protection for cities and agricultural areas. However, the levees of this reach of the Sacramento River are mostly set back from the mainstem channel, so that substantial flooding can occur within the river corridor. In the lower Sacramento River between RBPP and Chico Landing, the mainstem channel is flanked by broad floodplains. Evidence of ongoing sediment deposition of these areas testifies to continued inundation in floodplains in this reach (Buer 1994).

An important attribute of the middle and lower reaches of the Sacramento River is the presence of floodplain bypasses (e.g., Butte Basin, Sutter Bypass, and Yolo Bypass). In winter and spring, agricultural fields and wetland habitats throughout the floodplain bypasses often flood during high flows and are used by Sacramento splittail for spawning and rearing, and by Chinook salmon and steelhead for rearing (Sommer et al. 2001, 2003). Numerous studies have shown that shallow water and dense vegetation in these areas provide highly productive rearing areas for numerous species, including Chinook salmon and splittail. Seasonally flooded habitat provides rearing habitat for Chinook salmon and spawning, rearing, and foraging habitat for splittail (Sommer et al. 1997, 2001, 2002; Baxter et al. 1996; USACE 1999). Floodplain habitat offers protection from large piscivorous fish such as striped bass. The temporary nature of the flooded habitat and the protection offered by shallow water and dense vegetative cover serve to exclude predatory fish.

The productivity of floodplains is generally related to the frequency, timing, water depths, velocities, vegetation, water quality, and duration of inundation relative to the life history and habitat requirements of fish species. Physical conditions (e.g., type and extent of vegetation, soil conditions, and drainage patterns) may also contribute to habitat quality. Flooded vegetation provides an abundant source of food, consisting of detrital material, insect larvae, crustaceans, and other invertebrates. Juvenile Chinook salmon and splittail apparently forage among a variety of vegetation types, such as trees, brush, and herbaceous vegetation; however, but the relative importance of these vegetation types, alone or in combination, is unknown.

Juvenile Chinook salmon that rear in seasonally flooded habitat have higher survival and growth rates than juveniles that remain in the main river channel to rear (USACE 1999, Sommer et al. 2001). The increased growth rate may be related to the higher water temperatures in the shallow water in this habitat. It also may be related to the higher associated rate of production of invertebrates, which are a substantial source of food for rearing juveniles, and of the grasses that support the invertebrates. Increases in the area available to juveniles could also reduce competition for food and space, and could reduce the likelihood of encounters with predators (Sommer et al. 2001). In addition, juvenile Chinook salmon that grow faster are likely to migrate downstream sooner, which helps to reduce the risks of predation and competition in freshwater systems.

In summary, implementation of CP1 could cause a further reduction in the magnitude, duration, and frequency of intermediate to large flows relative to the Existing Condition and No-Action Alternative. Overall, the project would increase the existing, ongoing effects on geomorphic processes resulting from operation of Shasta Dam that are necessary for channel forming and maintenance, meander migration, the creation of seasonally inundated floodplains, and the inundation of floodplain bypasses. These effects would likely occur along the upper reaches of the lower Sacramento River. Reductions in the magnitude of high flows would likely be sufficient to reduce ecologically important processes along the upper Sacramento River and its floodplain bypasses. This impact would be potentially significant. Mitigation for this impact is proposed in Section 11.3.4.

Impact Aqua-17 (CP1): Effects to Delta Fisheries Resulting from Changes to Delta Outflow Based on the results of hydrologic modeling comparing Delta outflow under the No-Action Alternative, Existing Condition, and CP1, CP1 would result in changes to average monthly Delta outflow of less than 5 percent in all year types (with the exception of November of above-normal water years under 2005 conditions). Delta outflow serves as a surrogate metric for a variety of habitat conditions within the Delta that directly, or indirectly, affects fish and other aquatic resources.

This impact on Delta fisheries and hydrologic transport processed within the Bay-Delta would be less than significant.

Results of the comparison of Delta outflows are summarized by month and water year type in Table 11-12. Delta outflow serves as a surrogate metric for a variety of habitat conditions within the Delta that directly, or indirectly, affects fish and other aquatic resources.

The comparison includes the estimated average monthly outflow under the Existing Condition, No-Action Alternative, and CP1, and the percentage change between base flows and CP1 operations. Results of the analysis (Table 11-12) show that Delta outflows would be slightly lower under many of the CP1 operations, and slightly higher than basis-of-comparison conditions depending on month and water year type. However, only one of the simulated changes was greater than 5 percent (November of above-normal water years under 2005 conditions). Based on results of this analysis, CP1 would result in a less-than-significant impact on Delta fisheries as a consequence of changes in Delta outflow. Mitigation for this impact is not needed, and thus not proposed.

Table 11-12. Delta Outflow Under the Existing Condition, No-Action Alternative, and CP1

		Existing Condition	CP1 (2005)		No-Action Alternative	CP1 (2030)	
Month	**Water Year**	**Flow (cfs)**	**Flow (cfs)**	**Percent Change**	**Flow (cfs)**	**Flow (cfs)**	**Percent Change**
January	Average	42,078	42,002	0	42,169	41,971	0
	W	84,136	83,964	0	84,037	83,638	0
	AN	47,221	47,120	0	46,984	46,914	0
	BN	21,610	21,622	0	21,990	22,023	0
	D	14,166	14,038	-1	14,452	14,302	-1
	C	11,560	11,687	1	11,757	11,525	-2
February	Average	51,618	51,526	0	51,430	51,274	0
	W	95,261	95,104	0	94,634	94,399	0
	AN	60,080	59,779	-1	60,278	59,738	-1
	BN	35,892	35,976	0	35,665	35,755	0
	D	20,978	20,924	0	20,946	20,869	0
	C	12,902	12,898	0	13,088	13,081	0
March	Average	42,722	42,651	0	42,585	42,582	0
	W	78,448	78,500	0	78,376	78,430	0
	AN	53,486	53,121	-1	53,139	53,014	0
	BN	23,102	22,906	-1	22,980	22,892	0
	D	19,763	19,848	0	19,559	19,621	0
	C	11,881	11,747	-1	11,893	11,892	0
April	Average	30,227	30,236	0	30,743	30,757	0
	W	54,640	54,650	0	55,460	55,459	0
	AN	32,141	32,127	0	32,971	32,976	0
	BN	21,773	21,820	0	22,511	22,523	0
	D	14,347	14,343	0	14,538	14,559	0
	C	9,100	9,108	0	8,873	8,918	0
May	Average	22,619	22,567	0	22,249	22,196	0
	W	41,184	41,165	0	40,543	40,522	0
	AN	24,296	24,201	0	24,454	24,229	-1
	BN	16,346	16,144	-1	15,989	15,809	-1
	D	10,554	10,580	0	10,116	10,170	1
	C	6,132	6,110	0	5,910	5,947	1
June	Average	12,829	12,776	0	12,660	12,620	0
	W	23,473	23,473	0	23,015	23,016	0
	AN	12,080	11,746	-3	11,799	11,635	-1
	BN	7,995	8,019	0	7,991	7,920	-1
	D	6,691	6,656	-1	6,764	6,743	0
	C	5,361	5,361	0	5,378	5,376	0

1 **Table 11-12. Delta Outflow Under the Existing Condition, No-Action Alternative,**
2 **and CP1 (contd.)**

		Existing Condition	CP1 (2005)		No-Action Alternative	CP1 (2030)	
Month	**Water Year**	**Flow (cfs)**	**Flow (cfs)**	**Percent Change**	**Flow (cfs)**	**Flow (cfs)**	**Percent Change**
July	Average	7,864	7,864	0	7,864	7,869	0
	W	11,230	11,237	0	11,181	11,185	0
	AN	9,562	9,530	0	9,407	9,400	0
	BN	7,117	7,118	0	7,225	7,274	1
	D	5,005	5,006	0	5,052	5,042	0
	C	4,034	4,050	0	4,098	4,088	0
August	Average	4,322	4,337	0	4,335	4,349	0
	W	5,302	5,319	0	5,097	5,093	0
	AN	4,000	4,000	0	4,000	4,000	0
	BN	4,000	4,000	0	4,002	4,000	0
	D	3,906	3,896	0	4,142	4,189	1
	C	3,520	3,604	2	3,699	3,736	1
September	Average	9,841	9,840	0	9,844	9,858	0
	W	19,695	19,670	0	19,702	19,707	0
	AN	11,784	11,771	0	11,849	11,836	0
	BN	3,876	3,886	0	3,913	3,926	0
	D	3,508	3,516	0	3,442	3,496	2
	C	3,008	3,040	1	3,005	3,005	0
October	Average	6,067	6,063	0	6,000	6,003	0
	W	7,926	7,894	0	7,633	7,596	0
	AN	5,309	5,360	1	5,476	5,550	1
	BN	5,479	5,514	1	5,502	5,504	0
	D	5,228	5,234	0	5,236	5,238	0
	C	4,741	4,684	-1	4,714	4,732	0
November	Average	11,706	11,549	-1	11,675	11,525	-1
	W	17,717	17,621	-1	17,715	17,484	-1
	AN	12,667	11,852	-6	12,491	12,084	-3
	BN	8,543	8,513	0	8,686	8,579	-1
	D	8,482	8,468	0	8,414	8,414	0
	C	6,250	6,256	0	6,150	6,156	0

3

Table 11-12. Delta Outflow Under the Existing Condition, No-Action Alternative, and CP1 (contd.)

		Existing Condition	CP1 (2005)		No-Action Alternative	CP1 (2030)	
Month	**Water Year**	**Flow (cfs)**	**Flow (cfs)**	**Percent Change**	**Flow (cfs)**	**Flow (cfs)**	**Percent Change**
December	Average	21,755	21,601	-1	21,745	21,592	-1
	W	44,974	44,556	-1	44,661	44,182	-1
	AN	18,581	18,667	0	18,562	18,513	0
	BN	12,219	12,135	-1	12,326	12,402	1
	D	8,531	8,453	-1	8,803	8,710	-1
	C	5,580	5,567	0	5,677	5,774	2

Note:
A negative percentage change reflects a reduction in Delta outflow
Key:
AN = above-normal
BN = below-normal
C = critical
cfs = cubic feet per second
CP = Comprehensive Plan
D = dry
W = wet

Impact Aqua-18 (CP1): Effects to Delta Fisheries Resulting from Changes to Delta Inflow Based on the results of hydrologic modeling comparing Delta inflow under CP 2 to the Existing Condition and No-Action Alternative, CP1 would result in changes to average monthly Delta inflow of less than 5 percent in all year types. This impact on Delta fisheries and hydrologic transport processes within the Bay-Delta would be less than significant.

Changes in upstream reservoir storage have the potential to affect Delta inflow. Delta inflow may affect hydrologic conditions within Delta channels, hydraulic residence times, salinity gradients, and the transport and movement of various life stages of fish, invertebrates, phytoplankton, and nutrients into and through the Delta. Delta inflow serves as a surrogate metric for a variety of habitat conditions within the Delta that directly, or indirectly, affects fish and other aquatic resources.

Results of the comparison of Delta inflows between the Existing Condition, No-Action Alternative, and CP1 are summarized by month and water year type in Table 11-13. The comparison includes the estimated average monthly inflow under the 2005 and 2030 conditions, the average monthly Delta inflow under CP1, and the percent change in flows between the Existing Condition or No-Action Alternative and CP1. Delta inflows would be slightly lower under many of the CP1 operations and slightly higher than basis-of-comparison conditions, depending on month and water year type. The difference in simulated average monthly Delta inflow between CP1 and the Existing Condition and the No-Action Alternative did not exceed 5 percent. Based on the results of this analysis, CP1 would have a less-than-significant effect on Delta fisheries and hydrologic transport processes within the Bay-Delta as a consequence of changes in Delta inflow. Mitigation for this impact is not needed, and thus not proposed.

Table 11-13. Delta Inflow Under the Existing Condition, No-Action Alternative, and CP1

		Existing Condition	CP1 (2005)		No-Action Alternative	CP1 (2030)	
Month	**Water Year**	**Flow (cfs)**	**Flow (cfs)**	**Percent Change**	**Flow (cfs)**	**Flow (cfs)**	**Percent Change**
January	Average	47,426	47,352	0	47,457	47,275	0
	W	89,431	89,259	0	89,328	88,930	0
	AN	51,611	51,501	0	51,267	51,100	0
	BN	27,269	27,281	0	27,576	27,609	0
	D	20,125	20,017	-1	20,371	20,221	-1
	C	16,699	16,820	1	16,749	16,724	0
February	Average	57,835	57,703	0	57,623	57,478	0
	W	103,140	102,976	0	102,606	102,393	0
	AN	65,379	64,882	-1	65,574	65,008	-1
	BN	41,782	41,832	0	41,374	41,419	0
	D	26,530	26,459	0	26,431	26,356	0
	C	17,818	17,813	0	17,958	18,054	1
March	Average	49,829	49,786	0	49,713	49,699	0
	W	87,688	87,728	0	87,703	87,782	0
	AN	61,498	61,359	0	61,339	61,232	0
	BN	30,569	30,372	-1	30,415	30,326	0
	D	24,943	24,943	0	24,640	24,610	0
	C	15,933	15,923	0	15,896	15,891	0
April	Average	33,962	33,971	0	34,783	34,798	0
	W	58,684	58,694	0	60,017	60,020	0
	AN	35,588	35,575	0	36,738	36,745	0
	BN	25,351	25,398	0	26,403	26,414	0
	D	17,962	17,959	0	18,315	18,336	0
	C	12,817	12,822	0	12,635	12,679	0
May	Average	27,383	27,332	0	27,091	27,044	0
	W	46,973	46,955	0	46,494	46,473	0
	AN	28,466	28,372	0	28,711	28,490	-1
	BN	20,747	20,542	-1	20,427	20,247	-1
	D	14,882	14,908	0	14,534	14,591	0
	C	10,347	10,333	0	10,038	10,109	1
June	Average	22,171	22,116	0	22,090	22,068	0
	W	35,459	35,459	0	35,172	35,172	0
	AN	23,124	22,791	-1	22,776	22,612	-1
	BN	16,884	16,897	0	16,941	16,987	0
	D	14,095	14,059	0	14,337	14,312	0
	C	10,710	10,711	0	10,694	10,694	0

Table 11-13. Delta Inflow Under the Existing Condition, No-Action Alternative, and CP1 (contd.)

		Existing Condition	CP1 (2005)		No-Action Alternative	CP1 (2030)	
Month	**Water Year**	**Flow (cfs)**	**Flow (cfs)**	**Percent Change**	**Flow (cfs)**	**Flow (cfs)**	**Percent Change**
July	Average	23,099	23,111	0	22,839	22,876	0
	W	27,442	27,449	0	27,496	27,500	0
	AN	25,169	25,089	0	25,065	25,044	0
	BN	23,282	23,306	0	23,362	23,347	0
	D	20,937	20,980	0	20,082	20,160	0
	C	14,647	14,706	0	14,048	14,215	1
August	Average	17,147	17,180	0	17,026	17,068	0
	W	20,235	20,257	0	20,154	20,150	0
	AN	18,784	18,760	0	18,927	18,935	0
	BN	18,274	18,272	0	18,297	18,231	0
	D	15,066	15,274	1	14,371	14,580	1
	C	10,626	10,517	-1	10,850	10,897	0
September	Average	20,946	21,049	0	21,145	21,292	1
	W	31,918	31,920	0	32,428	32,431	0
	AN	23,912	23,930	0	24,747	24,856	0
	BN	16,518	16,546	0	16,563	16,569	0
	D	14,440	14,703	2	14,233	14,683	3
	C	9,130	9,386	3	8,809	9,013	2
October	Average	14,407	14,445	0	14,175	14,236	0
	W	17,072	17,016	0	16,558	16,596	0
	AN	13,176	13,364	1	13,223	13,359	1
	BN	14,044	14,180	1	14,159	14,139	0
	D	13,133	13,243	1	12,846	12,987	1
	C	12,196	12,070	-1	11,976	11,983	0
November	Average	19,512	19,531	0	19,463	19,442	0
	W	26,429	26,521	0	26,536	26,397	0
	AN	20,269	19,726	-3	20,052	19,854	-2
	BN	16,984	17,051	0	16,980	16,884	-1
	D	15,771	15,942	1	15,705	15,909	1
	C	12,330	12,467	1	12,081	12,244	-1

Table 11-13. Delta Inflow Under the Existing Condition, No-Action Alternative, and CP1 (contd.)

		Existing Condition	CP1 (2005)		No-Action Alternative	CP1 (2030)	
Month	**Water Year**	**Flow (cfs)**	**Flow (cfs)**	**Percent Change**	**Flow (cfs)**	**Flow (cfs)**	**Percent Change**
December	Average	30,984	30,833	0	30,988	30,838	0
	W	53,758	53,345	-1	53,516	53,042	-1
	AN	28,431	28,505	0	28,223	28,197	0
	BN	21,958	21,855	0	22,143	22,223	0
	D	18,560	18,501	0	18,837	18,743	-1
	C	13,363	13,358	0	13,484	13,565	1

Note:
A negative percentage change reflects a reduction in Delta inflow
Key:
AN = above-normal
BN = below-normal
C = critical
cfs = cubic feet per second
CP = Comprehensive Plan
D = dry
W = wet

Impact Aqua-19 (CP1): Effects to Delta Fisheries Resulting from Changes in Sacramento River Inflow CP1 operation would result in a variable response in Sacramento River inflow, resulting in both increases and decreases in river flow above basis-of-comparison conditions depending on month and water year. Decreases in Sacramento River inflow would not equal or exceed 5 percent. This impact would be less than significant.

Flow within the Sacramento River has been identified as an important factor affecting the survival of emigrating juvenile Chinook salmon; important to the downstream transport of planktonic fish eggs and larvae such as delta and longfin smelt, striped bass and shad; and important for seasonal floodplain inundation that has been identified as important habitat for successful spawning and larval rearing by species such as Sacramento splittail and as seasonal foraging habitat for juvenile Chinook salmon and steelhead. Sacramento River flows are also important in the transport of organic material and nutrients from the upper regions of the watershed downstream into the Delta. Sacramento River inflow serves as a surrogate metric for a variety of habitat conditions within the Delta that directly, or indirectly, affects fish and other aquatic resources. A reduction in Sacramento River flow as a result of CP1, depending on the season and magnitude of change, could adversely affect habitat conditions for both resident and migratory fish species. An increase in river flow is generally considered to be beneficial for aquatic resources within the normal range of typical project operations and flood control. Very large changes in river flow could also affect sediment erosion, scour, deposition, suspended and bedload transport, and other geomorphic processes within the river and watershed.

Results of hydrologic modeling, by month and year type, for the Existing Condition, No-Action Alternative, and CP1 for Sacramento River inflow are presented in Table 11-14. Results of these analyses show a variable response in Sacramento River inflow with CP1 operations resulting in both increases and decreases in river inflow above the Existing Condition and the No-Action Alternative, depending on month and water year type. Under CP1, Sacramento River flow would not decrease by 5 percent or more. Based on these results the impact of CP1 on fish habitat and transport mechanisms within the lower Sacramento River and Delta would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

Table 11-14. Sacramento River Inflow Under the Existing Condition, No-Action Alternative, and CP1

		Existing Condition	CP1 (2005)		No-Action Alternative	CP1 (2030)	
Month	**Water Year**	**Flow (cfs)**	**Flow (cfs)**	**Percent Change**	**Flow (cfs)**	**Flow (cfs)**	**Percent Change**
January	Average	31,139	31,144	0	31,167	31,136	0
	W	50,173	50,145	0	50,164	50,098	0
	AN	38,122	38,073	0	38,006	37,960	0
	BN	22,370	22,461	0	22,540	22,654	1
	D	16,980	16,924	0	17,109	17,025	0
	C	14,384	14,505	1	14,322	14,291	0
February	Average	36,608	36,567	0	36,618	36,586	0
	W	56,740	56,763	0	56,637	56,661	0
	AN	44,453	44,104	-1	44,672	44,295	-1
	BN	30,911	31,023	0	30,780	30,909	0
	D	21,249	21,178	0	21,237	21,144	0
	C	14,830	14,824	0	15,075	15,168	1
March	Average	32,396	32,367	0	32,352	32,343	0
	W	49,248	49,287	0	49,403	49,461	0
	AN	44,060	44,017	0	43,972	43,939	0
	BN	23,188	22,992	-1	23,068	22,978	0
	D	20,390	20,389	0	20,138	20,107	0
	C	12,971	12,961	0	12,942	12,938	0
April	Average	23,232	23,241	0	23,206	23,222	0
	W	37,918	37,929	0	38,019	38,024	0
	AN	26,053	26,041	0	26,039	26,048	0
	BN	17,518	17,565	0	17,439	17,450	0
	D	13,205	13,202	0	13,164	13,185	0
	C	10,295	10,300	0	10,067	10,111	0

Table 11-14. Sacramento River Inflow Under the Existing Condition, No-Action Alternative, and CP1 (contd.)

		Existing Condition	CP1 (2005)		No-Action Alternative	CP1 (2030)	
Month	**Water Year**	**Flow (cfs)**	**Flow (cfs)**	**Percent Change**	**Flow (cfs)**	**Flow (cfs)**	**Percent Change**
May	Average	19,417	19,369	0	19,114	19,069	0
	W	32,095	32,084	0	31,800	31,785	0
	AN	21,204	21,110	0	21,080	20,859	-1
	BN	14,530	14,326	-1	14,144	13,965	-1
	D	11,226	11,252	0	10,836	10,893	1
	C	8,148	8,134	0	7,874	7,945	1
June	Average	16,508	16,454	0	16,511	16,488	0
	W	24,092	24,092	0	23,905	23,902	0
	AN	16,598	16,264	-2	16,533	16,369	-1
	BN	13,792	13,805	0	13,822	13,868	0
	D	12,283	12,247	0	12,569	12,544	0
	C	9,492	9,493	0	9,516	9,516	0
July	Average	19,518	19,531	0	19,266	19,303	0
	W	20,071	20,077	0	20,058	20,062	0
	AN	22,070	21,990	0	21,976	21,954	0
	BN	21,232	21,256	0	21,374	21,359	0
	D	19,577	19,620	0	18,788	18,866	0
	C	13,683	13,741	0	13,100	13,267	1
August	Average	14,710	14,743	0	14,596	14,637	0
	W	16,285	16,306	0	16,189	16,185	0
	AN	16,418	16,393	0	16,561	16,569	0
	BN	16,112	16,110	0	16,170	16,104	0
	D	13,632	13,841	2	12,968	13,177	2
	C	9,570	9,461	-1	9,785	9,831	0
September	Average	18,211	18,313	1	18,417	18,563	1
	W	27,839	27,841	0	28,337	28,340	0
	AN	21,244	21,261	0	22,088	22,197	0
	BN	14,088	14,116	0	14,147	14,152	0
	D	12,522	12,779	2	12,341	12,792	4
	C	7,664	7,920	3	7,347	7,550	3
October	Average	11,309	11,389	1	11,117	11,184	1
	W	13,419	13,493	1	13,040	13,099	0
	AN	10,499	10,687	2	10,571	10,707	1
	BN	11,053	11,188	1	11,195	11,174	0
	D	10,150	10,260	1	9,830	9,972	1
	C	9,587	9,461	-1	9,333	9,340	0

Table 11-14. Sacramento River Inflow Under the Existing Condition, No-Action Alternative, and CP1 (contd.)

		Existing Condition	CP1 (2005)		No-Action Alternative	CP1 (2030)	
Month	**Water Year**	**Flow (cfs)**	**Flow (cfs)**	**Percent Change**	**Flow (cfs)**	**Flow (cfs)**	**Percent Change**
November	Average	15,640	15,677	0	15,605	15,629	0
	W	20,726	20,866	1	20,832	20,821	0
	AN	16,893	16,375	-3	16,666	16,506	-1
	BN	13,755	13,819	0	13,793	13,695	-1
	D	12,720	12,890	1	12,723	12,926	2
	C	9,948	10,086	1	9,653	9,815	2
December	Average	23,248	23,182	0	23,229	23,174	0
	W	37,645	37,420	-1	37,434	37,236	-1
	AN	22,604	22,694	0	22,461	22,468	0
	BN	16,930	16,961	0	17,103	17,193	1
	D	15,760	15,701	0	15,934	15,839	-1
	C	11,303	11,299	0	11,310	11,390	1

Note:
A negative percentage change reflects a reduction in Sacramento River inflow
Key:
AN = above-normal
BN = below-normal
C = critical
cfs = cubic feet per second
CP = Comprehensive Plan
D = dry
W = wet

Impact Aqua-20 (CP1): Effects to Delta Fisheries Resulting from Changes in San Joaquin River Flow at Vernalis CP1 operation would result in no discernible change in San Joaquin River flows at Vernalis, and, therefore, no effect on Delta fisheries or transport mechanisms within the lower San Joaquin River and Delta from CP1 relative to No-Action Alternative and the Existing Condition. There would be no impact.

Flow within the San Joaquin River has been identified as an important factor affecting the survival of juvenile Chinook salmon migrating downstream from the tributaries through the mainstem San Joaquin River and Delta; important to the downstream transport of planktonic fish eggs and larvae such as striped bass; and important for seasonal floodplain inundation that is considered to be important habitat for successful spawning and larval rearing by species such as Sacramento splittail and as seasonal foraging habitat for juvenile Chinook salmon. San Joaquin River flows are also important in the transport of organic material and nutrients from the upper regions of the watershed downstream into the Delta. San Joaquin River inflow serves as a surrogate metric for a variety of habitat conditions within the Delta that directly, or indirectly, affects fish and other aquatic resources. A reduction in San Joaquin River flow as a result of

CP1 operations, depending on the season and magnitude of change, could adversely affect habitat conditions for both resident and migratory fish species. An increase in river flow is generally considered to be beneficial for aquatic resources within the normal range of typical project operations and flood control. Very large changes in river flow could also affect sediment erosion, scour, deposition, suspended and bedload transport, and other geomorphic processes within the river and watershed.

Results of hydrologic modeling, by month and year type, for the Existing Condition, No-Action Alternative, and CP1 for San Joaquin River flow are summarized in Table 11-15. Results of these analyses show that CP1 would have no effect on seasonal San Joaquin River flows compared with the Existing Condition and No-Action Alternative. Based on these results CP1 would have no impact on Delta fisheries or transport mechanisms within the lower San Joaquin River and Delta under CP1. Mitigation for this impact is not needed, and thus not proposed.

Table 11-15. San Joaquin River Flow at Vernalis

		Existing Condition	CP1 (2005)		No-Action Alternative	CP1 (2030)	
Month	**Water Year**	**Flow (cfs)**	**Flow (cfs)**	**Percent Change**	**Flow (cfs)**	**Flow (cfs)**	**Percent Change**
January	Average	4,770	4,770	0	4,764	4,764	0
	W	9,273	9,273	0	9,097	9,097	0
	AN	4,223	4,223	0	4,259	4,259	0
	BN	2,986	2,986	0	3,081	3,081	0
	D	2,084	2,084	0	2,160	2,160	0
	C	1,673	1,673	0	1,746	1,746	0
February	Average	6,265	6,265	0	6,143	6,143	0
	W	11,036	11,036	0	10,845	10,845	0
	AN	6,047	6,047	0	6,179	6,179	0
	BN	5,767	5,767	0	5,565	5,565	0
	D	2,642	2,642	0	2,528	2,528	0
	C	2,161	2,161	0	2,014	2,014	0
March	Average	7,133	7,133	0	7,003	7,003	0
	W	13,443	13,443	0	13,170	13,170	0
	AN	6,788	6,788	0	6,674	6,673	0
	BN	5,322	5,322	0	5,293	5,293	0
	D	2,963	2,963	0	2,895	2,895	0
	C	2,176	2,176	0	2,129	2,129	0
April	Average	6,720	6,720	0	7,533	7,533	0
	W	11,420	11,420	0	12,614	12,614	0
	AN	6,671	6,671	0	7,799	7,798	0
	BN	5,852	5,852	0	6,910	6,910	0
	D	3,726	3,726	0	4,112	4,112	0
	C	2,087	2,087	0	2,118	2,118	0

Table 11-15. San Joaquin River Flow at Vernalis (contd.)

		Existing Condition	CP1 (2005)		No-Action Alternative	CP1 (2030)	
Month	**Water Year**	**Flow (cfs)**	**Flow (cfs)**	**Percent Change**	**Flow (cfs)**	**Flow (cfs)**	**Percent Change**
May	Average	6,204	6,204	0	6,234	6,234	0
	W	11,268	11,268	0	11,135	11,135	0
	AN	5,611	5,611	0	5,987	5,987	0
	BN	5,010	5,010	0	5,108	5,108	0
	D	3,070	3,070	0	3,111	3,111	0
	C	1,920	1,920	0	1,862	1,862	0
June	Average	4,739	4,739	0	4,671	4,671	0
	W	9,451	9,451	0	9,390	9,390	0
	AN	5,608	5,609	0	5,326	5,326	0
	BN	2,424	2,424	0	2,471	2,470	0
	D	1,598	1,598	0	1,554	1,554	0
	C	1,076	1,076	0	1,035	1,035	0
July	Average	3,202	3,202	0	3,208	3,208	0
	W	6,556	6,556	0	6,660	6,660	0
	AN	2,783	2,784	0	2,767	2,768	0
	BN	1,775	1,775	0	1,733	1,733	0
	D	1,282	1,282	0	1,216	1,216	0
	C	898	898	0	880	880	0
August	Average	2,029	2,029	0	2,040	2,041	0
	W	3,099	3,099	0	3,158	3,159	0
	AN	2,020	2,020	0	2,014	2,015	0
	BN	1,828	1,828	0	1,817	1,816	0
	D	1,342	1,342	0	1,315	1,315	0
	C	984	984	0	993	993	0
September	Average	2,331	2,331	0	2,340	2,340	0
	W	3,274	3,274	0	3,317	3,317	0
	AN	2,328	2,328	0	2,312	2,312	0
	BN	2,109	2,109	0	2,119	2,119	0
	D	1,795	1,795	0	1,774	1,775	0
	C	1,358	1,358	0	1,355	1,355	0
October	Average	2,757	2,757	0	2,753	2,753	0
	W	3,112	3,112	0	3,107	3,107	0
	AN	2,446	2,446	0	2,424	2,424	0
	BN	2,749	2,749	0	2,718	2,718	0
	D	2,686	2,686	0	2,710	2,710	0
	C	2,416	2,416	0	2,423	2,423	0

Table 11-15. San Joaquin River Flow at Vernalis (contd.)

		Existing Condition	CP1 (2005)		No-Action Alternative	CP1 (2030)	
Month	**Water Year**	**Flow (cfs)**	**Flow (cfs)**	**Percent Change**	**Flow (cfs)**	**Flow (cfs)**	**Percent Change**
November	Average	2,633	2,633	0	2,603	2,603	0
	W	3,372	3,372	0	3,340	3,340	0
	AN	2,213	2,213	0	2,176	2,176	0
	BN	2,412	2,412	0	2,360	2,360	0
	D	2,388	2,388	0	2,355	2,355	0
	C	2,075	2,075	0	2,088	2,088	0
December	Average	3,199	3,199	0	3,263	3,263	0
	W	5,081	5,081	0	5,178	5,178	0
	AN	2,916	2,916	0	2,899	2,899	0
	BN	2,705	2,705	0	2,753	2,753	0
	D	2,047	2,047	0	2,123	2,123	0
	C	1,710	1,710	0	1,785	1,785	0

Note:
A negative percentage change reflects a reduction in San Joaquin River flow
Key:
AN = above-normal
BN = below-normal
C = critical
cfs = cubic feet per second
CP = Comprehensive Plan
D = dry
W = wet

Impact Aqua-21 (CP1): Reduction in Low-Salinity Habitat Conditions Resulting from an Upstream Shift in X2 Location CP1 operation would result in a less than 0.5 km movement upstream or downstream from the X2 location from its location during February through May or September through November under the Existing Condition or No-Action Alternative, and thus cause minimal reduction in low-salinity habitats. This impact would be less than significant.

Operations of upstream storage reservoirs have the potential to affect the location of X2 as a result of changes in freshwater flows from the upstream tributaries through the Delta. X2 serves as a surrogate metric for a variety of habitat conditions within the Delta that directly, or indirectly, affects fish and other aquatic resources. For purposes of evaluating changes in habitat quantity and quality for estuarine species, a significance criterion of an upstream change in X2 location less than 1 km of the location under either the Existing Condition or the No-Action Alternative was considered to be less than significant. The criterion was applied to a comparison of hydrologic model results for basis-of-comparison conditions and CP1, by month and water year, for February through May and September through November.

Results of the comparison of X2 position under the Existing Condition, No-Action Alternative, and CP1 are summarized in Table 11-16. The results showed that changes in X2 location under CP1 as compared with the Existing Condition would be less than 1 km (all were less than 0.5 km) with both variable upstream and downstream movement of the X2 location, depending on month and water year. Changes in X2 location between the No-Action Alternative and CP1 assuming future operating conditions would also be small (less than 0.2 km). These results are consistent with model results for Delta outflow that showed a less-than-significant change in flows under CP1. Based on these results, CP1 would have a less-than-significant impact on low-salinity habitat conditions within the Bay-Delta. Mitigation for this impact is not needed, and thus not proposed.

Table 11-16. X2 Under the Existing Condition, No-Action Alternative, and CP1

		Existing Condition	CP1 (2005)		No-Action Alternative	CP1 (2030)	
Month	**Water Year**	**Location (km)**	**Location (km)**	**Difference (km)**	**Location (km)**	**Location (km)**	**Difference (km)**
January	Average	67.5	67.5	0.0	67.3	67.3	0.0
	W	53.6	53.6	0.0	53.7	53.7	0.0
	AN	61.7	61.7	0.0	61.6	61.6	0.0
	BN	72.1	72.0	-0.1	71.7	71.6	-0.1
	D	77.9	78.0	0.1	77.4	77.6	0.1
	C	82.2	82.0	-0.1	81.9	82.1	0.2
February	Average	60.9	60.9	0.0	60.8	60.9	0.0
	W	50.4	50.4	0.0	50.4	50.4	0.0
	AN	54.8	54.8	0.0	54.6	54.6	0.1
	BN	61.0	60.9	0.0	60.9	60.9	0.0
	D	70.1	70.1	0.0	69.9	70.0	0.0
	C	76.2	76.2	0.0	75.9	76.1	0.2
March	Average	60.9	60.9	0.0	60.9	60.9	0.0
	W	52.1	52.1	0.0	52.1	52.1	0.0
	AN	53.6	53.7	0.0	53.7	53.7	0.0
	BN	63.3	63.4	0.1	63.3	63.4	0.0
	D	67.1	67.0	-0.1	67.2	67.1	0.0
	C	75.2	75.3	0.1	75.1	75.1	0.1
April	Average	63.5	63.5	0.0	63.4	63.4	0.0
	W	54.5	54.5	0.0	54.3	54.3	0.0
	AN	58.6	58.6	0.0	58.4	58.4	0.0
	BN	64.5	64.5	0.0	64.1	64.1	0.0
	D	69.9	69.9	0.0	69.9	69.8	-0.1
	C	77.5	77.5	0.0	77.6	77.6	0.0

Table 11-16. X2 Under the Existing Condition, No-Action Alternative, and CP1 (contd.)

		Existing Condition	CP1 (2005)		No-Action Alternative	CP1 (2030)	
Month	**Water Year**	**Location (km)**	**Location (km)**	**Difference (km)**	**Location (km)**	**Location (km)**	**Difference (km)**
May	Average	67.5	67.5	0.0	67.7	67.7	0.0
	W	57.6	57.6	0.0	57.7	57.7	0.0
	AN	62.7	62.7	0.0	62.6	62.6	0.1
	BN	68.3	68.4	0.1	68.3	68.4	0.1
	D	74.4	74.4	0.0	74.8	74.7	-0.1
	C	82.5	82.5	0.0	82.9	82.8	-0.1
June	Average	74.5	74.6	0.0	74.7	74.7	0.0
	W	65.0	65.0	0.0	65.2	65.2	0.0
	AN	72.6	72.8	0.2	72.7	72.8	0.1
	BN	76.6	76.6	0.0	76.7	76.8	0.1
	D	80.4	80.5	0.0	80.7	80.7	0.0
	C	85.9	85.9	0.0	86.0	86.0	0.0
July	Average	80.5	80.5	0.0	80.5	80.5	0.0
	W	74.4	74.4	0.0	74.5	74.5	0.0
	AN	78.1	78.2	0.1	78.4	78.4	0.1
	BN	81.7	81.7	0.0	81.6	81.6	0.0
	D	84.8	84.9	0.0	84.8	84.8	0.0
	C	88.1	88.1	0.0	88.0	88.0	0.0
August	Average	85.6	85.6	0.0	85.6	85.5	0.0
	W	82.7	82.6	0.0	82.8	82.8	0.0
	AN	83.7	83.8	0.0	83.9	83.9	0.0
	BN	85.6	85.6	0.0	85.5	85.4	0.0
	D	87.8	87.8	0.0	87.5	87.5	0.0
	C	90.4	90.3	-0.1	90.2	90.2	0.0
September	Average	83.7	83.7	0.0	83.7	83.6	0.0
	W	73.4	73.4	0.0	73.5	73.5	0.0
	AN	81.4	81.4	0.0	81.4	81.4	0.0
	BN	88.8	88.8	0.0	88.8	88.8	0.0
	D	90.2	90.2	0.0	90.0	89.9	-0.1
	C	92.5	92.4	-0.1	92.3	92.3	0.0
October	Average	83.9	83.9	0.0	83.9	83.9	0.0
	W	73.6	73.6	0.0	73.7	73.7	0.0
	AN	79.8	79.8	0.0	79.8	79.8	0.0
	BN	88.9	88.9	0.0	88.9	88.9	0.0
	D	91.4	91.4	0.0	91.3	91.2	-0.1
	C	93.3	93.2	-0.1	93.1	93.0	-0.1

Table 11-16. X2 Under the Existing Condition, No-Action Alternative, and CP1 (contd.)

		Existing Condition	CP1 (2005)		No-Action Alternative	CP1 (2030)	
Month	**Water Year**	**Location (km)**	**Location (km)**	**Difference (km)**	**Location (km)**	**Location (km)**	**Difference (km)**
November	Average	82.2	82.3	0.1	82.2	82.3	0.1
	W	73.1	73.1	0.0	73.2	73.2	0.0
	AN	78.4	78.4	0.0	78.4	78.5	0.1
	BN	84.8	85.3	0.5	84.8	85.2	0.4
	D	88.9	89.0	0.0	88.8	88.9	0.1
	C	92.6	92.7	0.0	92.8	92.6	-0.1
December	Average	76.1	76.2	0.1	76.0	76.0	0.0
	W	62.9	63.0	0.1	63.0	63.1	0.1
	AN	76.4	76.7	0.3	76.4	76.6	0.2
	BN	81.4	81.3	0.0	81.1	81.1	0.0
	D	82.8	82.9	0.1	82.6	82.7	0.1
	C	87.9	87.9	0.0	87.8	87.7	-0.1

Key:
AN = above-normal
BN = below-normal
C = critical
CP = Comprehensive Plan
D = dry
km = kilometer
W = wet

Impact Aqua-22 (CP1): Increase in Mortality of Species of Primary Management Concern as a Result of Increased Reverse Flows in Old and Middle Rivers CP1 operation would result in minimal changes to reverse flows in Old and Middle rivers. The increases in reverse flows under CP1 do not exceed -5,000 cfs; thus, the increases in reverse flows are not expected to contribute to an increase in the vulnerability of delta smelt, longfin smelt, Chinook salmon, juvenile striped bass, or threadfin shad—but summer Old and Middle river flows could contribute to an increase in vulnerability of other resident warm-water fish to increased salvage and potential losses. This impact would be less than significant.

Results of the analysis show two occurrences relative to the Existing Condition, and one compared with the No-Action Alternative when reverse flows within Old and Middle rivers would increase by more than 5 percent; however, neither change resulted in a flow greater (more negative) than -5,000 cfs. Two of these events occurred in critical water years, which would be expected as a result of greater export operations under CP1. During January, operations under CP1 would result in an increase in reverse flow of 5 percent during critical years under future conditions (Table 11-17). Based on results of the delta smelt analysis of the relationship between reverse flows and delta smelt salvage, the increase from approximately 3,900 cfs in January under the basis-of-comparison in a critical water year to approximately 4,100 cfs under CP1would not be expected to result in a significant increase in adverse impacts to delta smelt or longfin smelt.

Table 11-17. Old and Middle River Reverse Flows for the Existing Condition, No-Action Alternative, and CP1

		Existing Condition	CP1 (2005)		No-Action Alternative	CP1 (2030)	
Month	Water Year	Flow (cfs)	Flow (cfs)	Percent Change	Flow (cfs)	Flow (cfs)	Percent Change
January	Average	-3,542	-3,544	0	-3,553	-3,568	0
	W	-2,034	-2,034	0	-2,151	-2,151	0
	AN	-3,654	-3,645	0	-3,574	-3,488	-2
	BN	-4,240	-4,240	0	-4,240	-4,240	0
	D	-4,773	-4,791	0	-4,772	-4,772	0
	C	-4,033	-4,029	0	-3,940	-4,131	5
February	Average	-3,293	-3,255	-1	-3,358	-3,367	0
	W	-2,745	-2,738	0	-2,950	-2,970	1
	AN	-3,248	-3,061	-6	-3,165	-3,139	-1
	BN	-3,335	-3,303	-1	-3,291	-3,250	-1
	D	-4,016	-4,001	0	-4,045	-4,044	0
	C	-3,391	-3,393	0	-3,482	-3,573	3
March	Average	-2,784	-2,810	1	-2,877	-2,867	0
	W	-1,792	-1,780	-1	-2,023	-2,046	1
	AN	-4,021	-4,227	5	-4,260	-4,272	0
	BN	-4,005	-4,001	0	-3,982	-3,983	0
	D	-2,951	-2,873	-3	-2,918	-2,834	-3
	C	-2,023	-2,138	6	-1,994	-1,991	0
April	Average	955	955	0	1,060	1,059	0
	W	2,706	2,706	0	2,798	2,793	0
	AN	1,087	1,087	0	1,314	1,314	0
	BN	697	697	0	898	898	0
	D	-244	-244	0	-207	-205	-1
	C	-874	-874	0	-872	-872	0
May	Average	491	490	0	416	412	-1
	W	2,077	2,077	0	1,781	1,781	0
	AN	562	562	0	646	646	0
	BN	277	277	0	270	270	0
	D	-674	-674	0	-696	-696	0
	C	-1,018	-1,026	1	-936	-966	3
June	Average	-3,654	-3,652	0	-3,718	-3,736	0
	W	-4,226	-4,226	0	-4,354	-4,354	0
	AN	-4,825	-4,825	0	-4,818	-4,818	0
	BN	-4,137	-4,126	0	-4,119	-4,227	3
	D	-3,079	-3,079	0	-3,205	-3,204	0
	C	-1,542	-1,542	0	-1,542	-1,542	0

Table 11-17. Old and Middle River Reverse Flows for the Existing Condition, No-Action Alternative, and CP1

		Existing Condition	CP1 (2005)		No-Action Alternative	CP1 (2030)	
Month	**Water Year**	**Flow (cfs)**	**Flow (cfs)**	**Percent Change**	**Flow (cfs)**	**Flow (cfs)**	**Percent Change**
July	Average	-9,502	-9,514	0	-9,292	-9,325	0
	W	-8,948	-8,947	0	-8,905	-8,904	0
	AN	-9,993	-9,949	0	-9,929	-9,916	0
	BN	-10,886	-10,907	0	-10,903	-10,859	0
	D	-10,998	-11,038	0	-10,419	-10,504	1
	C	-6,355	-6,397	1	-5,928	-6,089	3

Note:
A positive percentage change reflects more negative reverse flows under CP5 when compared to the Existing Condition or the No-Action Alternative.

Key:
AN = above-normal
BN = below-normal
C = critical
cfs = cubic feet per second
CP = Comprehensive Plan
D = dry
W = wet

Juvenile Chinook salmon and steelhead are migrating through the Delta during January, and an increase in average monthly reverse flows of around 200 cfs would be expected to increase the potential risk of increased mortality to these species. However, given the tidal volumes and hydrodynamics of the Old and Middle river region, it is not expected that the change in reverse flows in January in a critical year would result in a detectable change in fish survival. The majority of juvenile Chinook salmon emigrating from the San Joaquin River typically migrate downstream later in dry years and would not be expected to occur in high numbers within Old and Middle rivers in January.

The increase in reverse flows estimated to occur under CP1 in critical and above-normal water years in March would exceed 5 percent, but would not increase the flows beyond -5,000 cfs. The potential change in Old and Middle river flows of approximately 100 to 200 cfs may result in a small increase in vulnerability of fish, particularly delta smelt and longfin smelt, to CVP and SWP salvage, resulting in a potentially significant impact. The increased reverse flows would not result in a significant increase in risk of mortality for Chinook salmon. The potential change in Old and Middle river flows would result in a less-than-significant impact to juvenile striped bass, threadfin shad, and other resident warm-water fish inhabiting the south Delta, due mainly to larger resident populations of these species.

The potential increase in losses during January and March is considered to be less than significant for Chinook salmon, steelhead, delta smelt, longfin smelt, and Chinook salmon, but potentially significant for other resident warm-water fish. Mitigation for this impact is not proposed because operations will be guided by RPAs established by NMFS and USFWS BOs to reduce any impacts to listed fish species.

Impact Aqua-23 (CP1): Increase in the Risk of Entrainment or Salvage of Species of Primary Management Concern at CVP and SWP Export Facilities Due to Changes in CVP and SWP Exports CP1 operations may result in an increase in CVP and SWP exports, which is assumed to result in a direct proportional increase in the risk of fish being entrained and salvaged at the facilities. Future operations of the SWP and CVP export facilities would continue to be managed and regulated in accordance with incidental take limits established for each of the protected fish by USFWS, NMFS, and CDFW. The resulting impact to Chinook salmon, steelhead, longfin smelt, striped bass, and splittail would be less than significant; the resulting impact to delta smelt would be potentially significant. Overall, this impact would be potentially significant.

Results of entrainment loss modeling at the CVP and SWP export facilities are presented in Table 11-18 for CP1. The initial modeling was conducted using average fish densities developed from past fish salvage monitoring at the SWP and CVP export facilities. Average monthly water exports were used in the analysis based on hydrologic simulation modeling. The indices of the potential risk of entrainment for some species, such as Chinook salmon, were not estimated separately for each species (e.g., winter-run Chinook salmon) in these analyses. These indices were calculated for wet, above-normal, below-normal, dry, and critical water year types, and for an average across all years (no water year type specified). The total numbers of fish lost annually, by species, are presented in Attachment 1 of the *Fisheries and Aquatic Ecosystems Technical Report*. The difference between the nonoperations-related and operations-related fish mortality is represented as the entrainment index, shown in Table 11-18, to represent the effect of project operations on each fish species for the CVP and SWP.

Table 11-18. Indices of Entrainment at the CVP and SWP facilities Under the Existing Condition, No-Action Alternative, and CP1

Species	Water Year	CP1 Minus Existing Condition	Percent Change	CP1 Minus No-Action Alternative	Percent Change
Delta Smelt	Average	6	0.0	111	0.3
	W	-6	-0.0	7	0.0
	AN	-16	-0.0	-29	-0.1
	BN	-33	-0.1	273	0.8
	D	1	0.0	1	0.0
	C	105	0.4	452	2.0
Chinook Salmon	Average	-8	-0.0	88	0.2
	W	-23	-0.0	66	0.1
	AN	-8	-0.0	-92	-0.2
	BN	-59	-0.1	83	0.2
	D	-88	-0.2	-98	-0.2
	C	206	0.6	597	1.8
Longfin Smelt	Average	3	0.0	14	0.2
	W	-1	-0.0	2	0.0
	AN	2	0.0	-1	-0.0
	BN	0	-0.0	3	0.1
	D	-1	-0.0	-2	-0.0
	C	22	0.4	93	1.8
Steelhead	Average	-4	-0.1	4	0.1
	W	-4	-0.1	10	0.2
	AN	-10	-0.2	-18	-0.4
	BN	-9	-0.2	-10	-0.2
	D	-15	-0.4	-16	-0.4
	C	22	0.8	57	2.1
Striped Bass	Average	2533	0.2	5,666	0.4
	W	1518	0.1	1,399	0.1
	AN	837	0.1	1,533	0.1
	BN	1092	0.1	8,237	0.6
	D	6826	0.6	8,789	0.8
	C	1671	0.3	11,359	1.9
Splittail	Average	503	0.2	967	0.4
	W	-6	-0.0	11	0.0
	AN	-380	-0.1	-110	-0.0
	BN	-182	-0.1	3,141	1.2
	D	435	0.2	796	0.4
	C	451	0.4	1,835	1.9

Note:
Negative percentage change reflects a reduction in entrainment risk while a positive percentage change reflects an increase in entrainment risk.

Key:
AN = above-normal
BN = below-normal
C = critical
CP = Comprehensive Plan
CVP = Central Valley Project
D = dry
SWP = State Water Project
W = wet

The greatest change in the risk of entrainment at the CVP and SWP export facilities would be expected to occur in dry and critical water year types when export rates would increase, especially during February and summer months. Entrainment indices under CP1 operations indicate a relatively minor increase, on average, in salvage for most species (e.g., delta smelt, steelhead, Chinook salmon, and longfin smelt). Although the risk of entrainment showed both increases and decreases depending on species and water year type, the general trend was a small incremental increase in the risk of entrainment/salvage losses at the CVP and SWP export facilities when compared to the Existing Condition. Species with relatively lower abundance at the CVP and SWP, such as longfin smelt, during months of the highest exports, would be less affected by CP1 operations, with entrainment indices typically representing a net benefit as a result of CP1 relative to the Existing Condition. Species with relatively higher abundance at the CVP and SWP fish facilities, such as splittail and striped bass, would experience increased risk of mortality due to higher exports during June and July, as these species are generally collected at their highest abundances during these months. Under CP1, the risk of entrainment of juvenile Chinook salmon, whose occurrence at the facilities is highest during February through May, would increase as a result of generally higher project export rates during these months when compared to the Existing Condition.

Results of the entrainment risk calculations for delta smelt showed a change of less than 1 percent from the Existing Condition in all water year types and up to a 2-percent increase during critical water years (Table 11-18). The risk of increased losses of delta smelt would be greatest in critical years with a net reduction in losses under CP1 relative to the No-Action Alternative. Although the incremental change in the risk of delta smelt losses resulting from CVP and SWP export operations would be small, the delta smelt population abundance is currently at such critically low levels that even a small increase in the risk of losses is considered to be potentially significant. The increase in risk would also contribute to cumulative factors affecting the survival of delta smelt.

The estimated change in the risk of losses for Chinook salmon under CP1 follows a similar pattern to that described for delta smelt (Table 11-18). Overall, CP1 would result in a small increase in the risk of losses relative to both the Existing Condition and No-Action Alternative. Given the numbers of juvenile Chinook salmon produced each year in the Central Valley, the relatively small incremental increase in the risk of entrainment/salvage at the CVP and SWP export facilities is considered to be a less-than-significant direct impact but would contribute incrementally to the overall cumulative factors affecting juvenile Chinook salmon survival within the Delta and population dynamics of the stocks.

The estimated change in the risk of longfin smelt entrainment/salvage under CP1 compared with the Existing Condition and No-Action Alternative include small positive and negative changes (less than 2 percent), depending on water year type (Table 11-18). Given the greater abundance of longfin smelt, when compared to delta smelt, their 2-year life history, and geographic distribution within the estuary, these small changes in the risk of entrainment are considered to be less than significant.

The estimated change in the risk to steelhead of entrainment/salvage at the CVP and SWP export facilities under CP1 are summarized in Table 11-18. The increase in risk of steelhead losses in wet years (as compared with the No-Action Alternative) and critical water years (as compared with the Existing Condition) would be less than significant based on the abundance of Sacramento and San Joaquin river juvenile steelhead migrating through the Delta, but would contribute directly to cumulative factors affecting the survival and population dynamics of Central Valley steelhead. The predicted increase in potential entrainment risk for steelhead under critical water years represents an initial estimate of the change (percentage) between the CP1 and the Existing Condition and No-Action Alternatives and does not allow the predicted losses to be evaluated at the population level (see Attachment 1 of the *Fisheries and Aquatic Ecosystems Technical Report)*.

The change in risk to juvenile striped bass for entrainment/salvage at the CVP and SWP export facilities are summarized in Table 11-18. The changes in risk in all water year types of less than 2 percent would be less than significant to striped bass but would contribute to the cumulative factors affecting striped bass survival and population dynamics in the Delta. The increased losses, particularly in drier water years when juvenile striped bass production is lower, would contribute to the cumulative effects of factors affecting juvenile striped bass survival in the Delta.

Results of the risk estimates for juvenile splittail losses relative to the Existing Condition and No-Action Alternative show a pattern similar to other species (Table 11-18). The increased risk index of less than 2 percent was considered to be a less-than-significant impact. The simulated loss index increased during dry and critical water years. Higher risk of entrainment/salvage losses in drier water years has a potentially greater effect on abundance of juvenile splittail since reproductive success and overall juvenile abundance is typically lower in the Delta in dry years. The increased risk of losses in drier years would not be potentially significant, but the increased losses would contribute to cumulative factors affecting survival of juvenile splittail within the Delta.

Impact Aqua-23 (CP1) is considered to be less than significant for all species except delta smelt which could experience potentially significant effects. Mitigation for this impact is not proposed because operations will be guided by RPAs established by NMFS and USFWS BOs to reduce any impacts to listed fish species.

CVP/SWP Service Areas

Impact Aqua-24 (CP1): Impacts on Aquatic Habitats and Fish Populations in the CVP and SWP Service Areas Resulting from Modifications to Existing Flow

Regimes CP1 implementation could result in modified flow regimes that would reduce the frequency and magnitude of high winter flows along the Sacramento River; however, hydrologic effects in tributaries and reservoirs with CVP and SWP dams are expected to be less than impacts on the lower Sacramento River. Changes in hydrology could affect aquatic habitats that provide habitat for the fish communities. However, these changes are unlikely to result in substantial effects on the distribution or abundance of these species in the CVP and SWP service areas. Therefore, this impact would be less than significant.

CP1 implementation could result in modified flow regimes that would reduce the frequency and magnitude of high winter flows along the Sacramento River; however, the hydrologic effects in tributaries (e.g., San Joaquin River, canals) and reservoirs (e.g., New Melones and San Luis) with CVP and SWP dams are expected to be less than impacts on the lower Sacramento River. The change in hydrology and reservoir levels could affect aquatic habitats for local resident fish communities, but these changes are unlikely to result in substantial effects on the distribution or abundance of these species in the CVP and SWP service areas. The effects from CP1 on CVP and SWP reservoir elevations, filling, spilling, and planned releases, and the resulting flows downstream from those reservoirs, would be small and well within the range of variability that commonly occurs in these reservoirs and downstream. Therefore, this impact would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

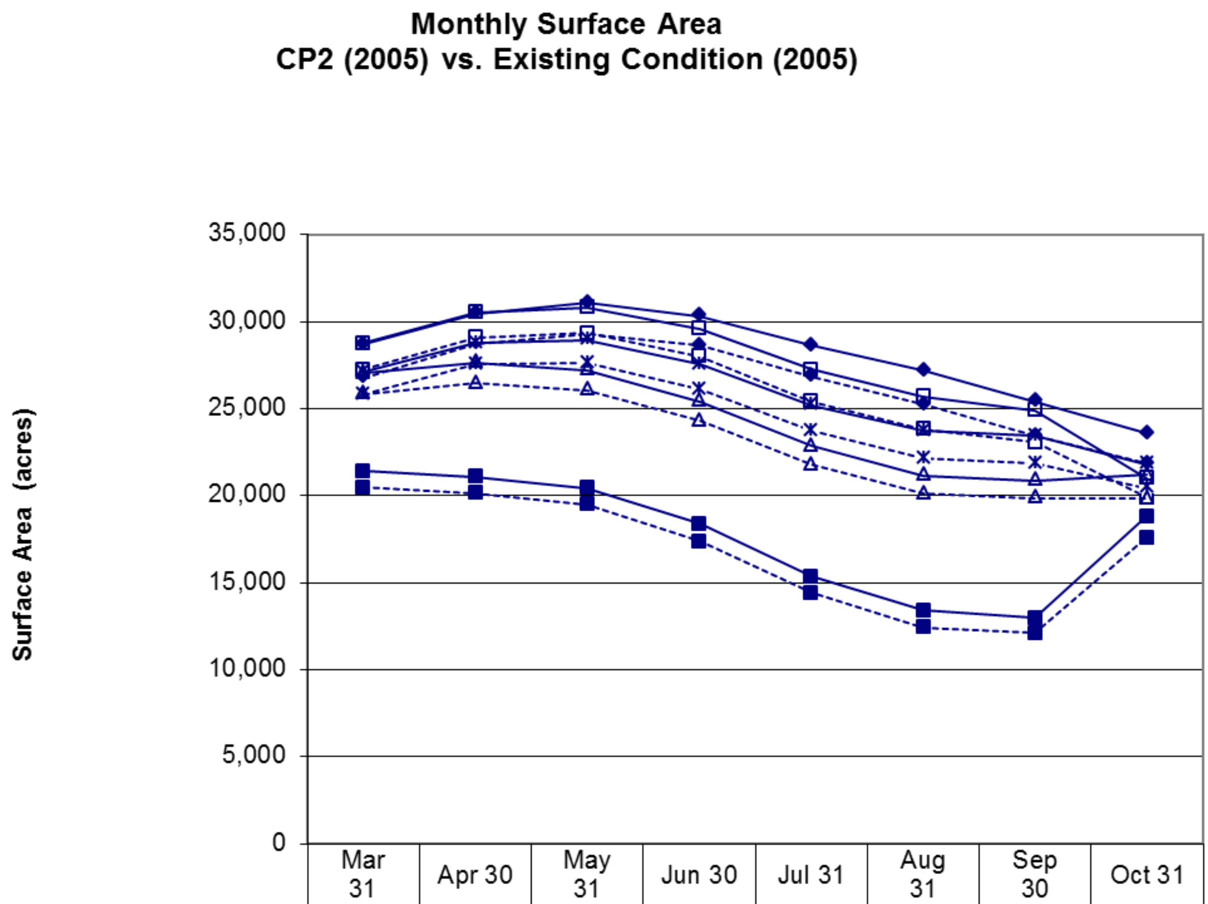
CP2 – 12.5-Foot Dam Raise, Anadromous Fish Survival and Water Supply Reliability

As with CP1, CP2 focuses on increasing water supply reliability and increasing anadromous fish survival. CP2 primarily consists of raising Shasta Dam by 12.5 feet, which, in combination with spillway modifications, would increase the height of the reservoir’s full pool by 14.5 feet and enlarge the total storage capacity in the reservoir by 443,000 acre-feet. The existing TCD would also be extended to achieve efficient use of the expanded cold-water pool. Shasta Dam operational guidelines would continue essentially unchanged, except during dry years and critical years, when 120 TAF and 60 TAF, respectively, of the increased storage capacity in Shasta Reservoir reserved to specifically focus on increasing M&I deliveries. CP2 would help reduce future water shortages through increasing drought year and average year water supply reliability for agricultural and M&I deliveries. In addition, the increased depth and volume of the cold-water pool in Shasta Reservoir would contribute to improving seasonal water temperatures for anadromous fish in the upper Sacramento River.

Shasta Lake and Vicinity

Impact Aqua-1 (CP2): Effects on Nearshore, Warm-Water Habitat in Shasta Lake from Project Operations Under CP2, project operations would contribute to an increase in the surface area and WSEL of Shasta Lake, which would in turn increase the area and productivity of nearshore, warm-water habitat. CP2 operations would also result in reduced monthly fluctuations in WSEL, which would contribute to increased reproductive success, young-of-the-year production, and the juvenile growth rate of warm-water fish species. Similar to CP1, the value of existing structural habitat improvements (e.g., brush piles, willow plantings) would be diminished; however, the existing habitat-enhancement features would become functional during reservoir drawdowns later in the season and during normal and drier years. Additionally, large areas of the shoreline would not be cleared, and the vegetation along these sections would be inundated periodically. In the short term, this newly inundated vegetation will initially increase warm-water fish habitat, with decay expected to occur over several decades. This impact would be less than significant.

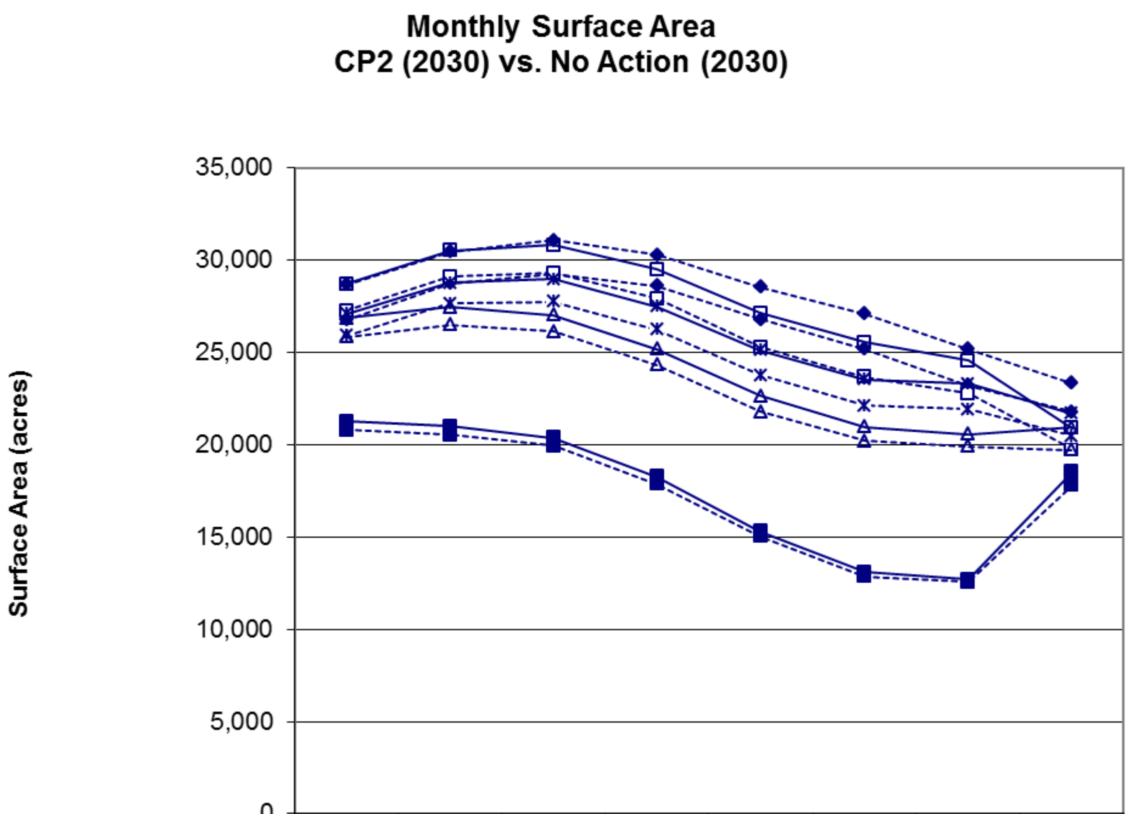
This impact would be similar to Impact Aqua-1 (CP1), but the surface area would be larger under the 12.5-foot dam raise than under the 6.5-foot dam raise. CalSim-II modeling shows that the surface area of Shasta Lake would be larger under the CP2 than the Existing Condition or No-Action Alternative in all five water year types (Figures 11-15 and 11-16).



	Mar 31	Apr 30	May 31	Jun 30	Jul 31	Aug 31	Sep 30	Oct 31
EC W	26,790	28,748	29,277	28,624	26,872	25,226	23,413	21,827
EC AN	27,245	29,082	29,336	27,992	25,400	23,826	23,061	19,906
EC BN	25,807	27,534	27,621	26,104	23,714	22,114	21,837	20,425
EC D	25,850	26,467	26,058	24,300	21,754	20,093	19,840	19,828
EC C	20,467	20,142	19,500	17,381	14,400	12,418	12,111	17,572
CP2 2005 W	28,683	30,458	31,083	30,334	28,625	27,177	25,409	23,590
CP2 2005 AN	28,750	30,541	30,832	29,595	27,244	25,710	24,895	21,007
CP2 2005 BN	27,113	28,780	28,964	27,542	25,197	23,700	23,425	21,813
CP2 2005 D	27,028	27,636	27,226	25,428	22,865	21,169	20,879	21,210
CP2 2005 C	21,404	21,076	20,452	18,375	15,342	13,395	12,971	18,813

Key:
AN = above-normal water
BN= below-normal water years
C = critical water years
CP = Comprehensive Plan
D = dry water years
EC = Existing Condition
W = wet water years

Figure 11-15. Average Monthly Surface Area for Each Water Year Type Within the Shasta Lake Vicinity of the Primary Study Area, CP2 Versus the Existing Condition



	Mar 31	Apr 30	May 31	Jun 30	Jul 31	Aug 31	Sep 30	Oct 31
NA W	26,775	28,735	29,273	28,604	26,797	25,183	23,205	21,808
NA AN	27,258	29,117	29,325	27,921	25,294	23,687	22,800	19,759
NA BN	25,918	27,662	27,770	26,239	23,764	22,137	21,923	20,469
NA D	25,843	26,514	26,134	24,346	21,780	20,209	19,910	19,728
NA C	20,801	20,548	19,942	17,866	15,026	12,873	12,556	17,800
CP2 2030 W	28,670	30,446	31,078	30,287	28,541	27,085	25,189	23,343
CP2 2030 AN	28,727	30,540	30,824	29,523	27,130	25,553	24,563	20,891
CP2 2030 BN	27,085	28,777	28,968	27,497	25,110	23,530	23,305	21,689
CP2 2030 D	26,863	27,455	27,043	25,202	22,650	20,971	20,561	20,933
CP2 2030 C	21,267	21,006	20,364	18,273	15,299	13,085	12,712	18,527

Key:
AN = above-normal water
BN= below-normal water years
C = critical water years
CP = Comprehensive Plan
D = dry water years
NA = No-Action
W = wet water years

Figure 11-16. Average Monthly Surface Area for Each Water Year Type Within the Shasta Lake Vicinity of the Primary Study Area, CP2 Versus No-Action

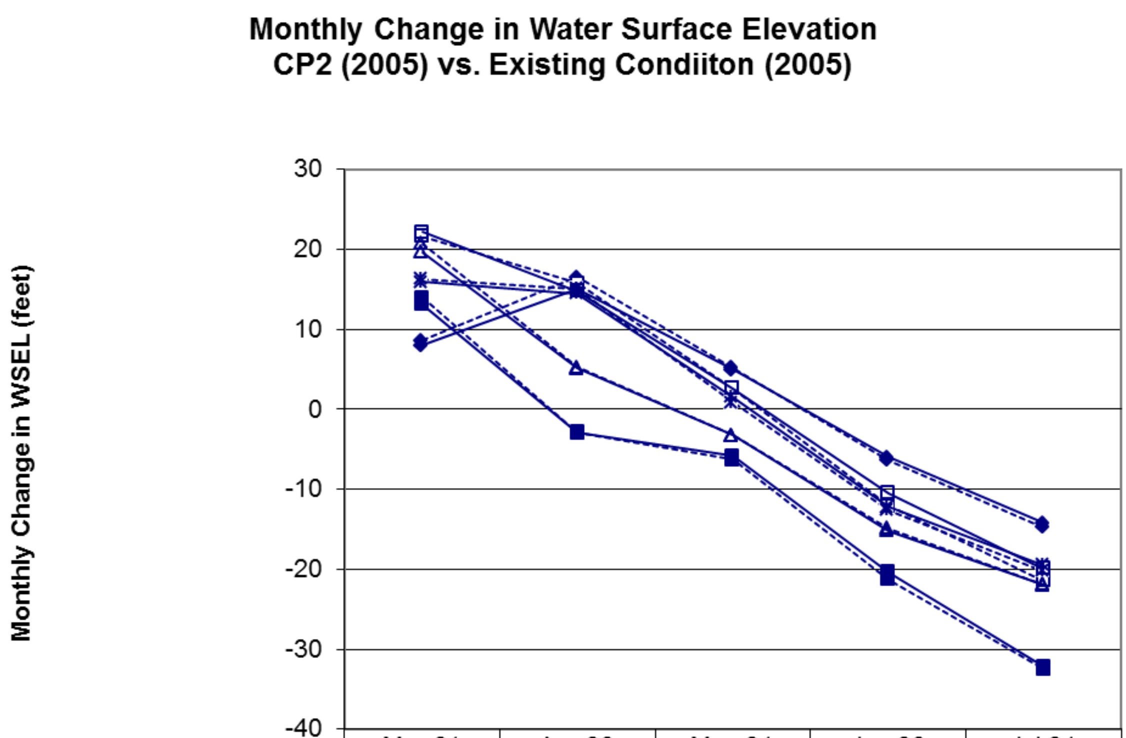
Monthly WSEL fluctuations were compared with projections for water supply demand. For CP2, with a 2005 water supply demand, 44 percent of monthly changes in projected WSEL (i.e., 11 of the 25 total projections made for the 5 months from March through July for all five water year types) showed decreased monthly WSEL fluctuations relative to the Existing Condition and 4 percent showed increased monthly WSEL fluctuations (Figure 11-17). For CP2, with a projected 2030 water supply demand, 36 percent of monthly changes in projected WSEL showed decreased WSEL fluctuations relative to the No-Action Alternative and 16 percent showed increased monthly WSEL fluctuations (Figure 11-18). Under CP2, none of the changes in monthly WSEL fluctuation is different enough from the Existing Condition to warrant the investigation of daily WSEL fluctuation.

Increases in the overall surface area and WSEL under CP2 would increase the area of available warm-water habitat and stimulate biological productivity, including fish production, of the entire lake for a period of time, possibly for several decades. Furthermore, reductions in the magnitude of monthly WSEL fluctuations could contribute to increased reproductive success, young-of-the-year production, and juvenile growth rate of warm-water fish species. Therefore, this impact would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

Impact Aqua-2 (CP2): Effects on Nearshore, Warm-Water Habitat in Shasta Lake from Project Construction Localized increases in soil erosion and resulting runoff sedimentation, and turbidity resulting from project construction in the vicinity of Shasta Dam and at utility, road, and other facility relocation areas could affect nearshore warm-water habitat. This impact would be similar to Impact Aqua-2 (CP1). However, CP2 would have a larger project footprint and would take longer to implement. However, the environmental commitments for all action would result in less-than-significant impacts. Mitigation for this impact is not needed, and thus not proposed.

Impact Aqua-3 (CP2): Effects on Cold-Water Habitat in Shasta Lake Under CP2, operations-related changes in the ratio of the volume of cold-water storage to surface area would increase the availability of suitable habitat for cold-water fish in Shasta Lake, including rainbow trout. This impact would be beneficial.

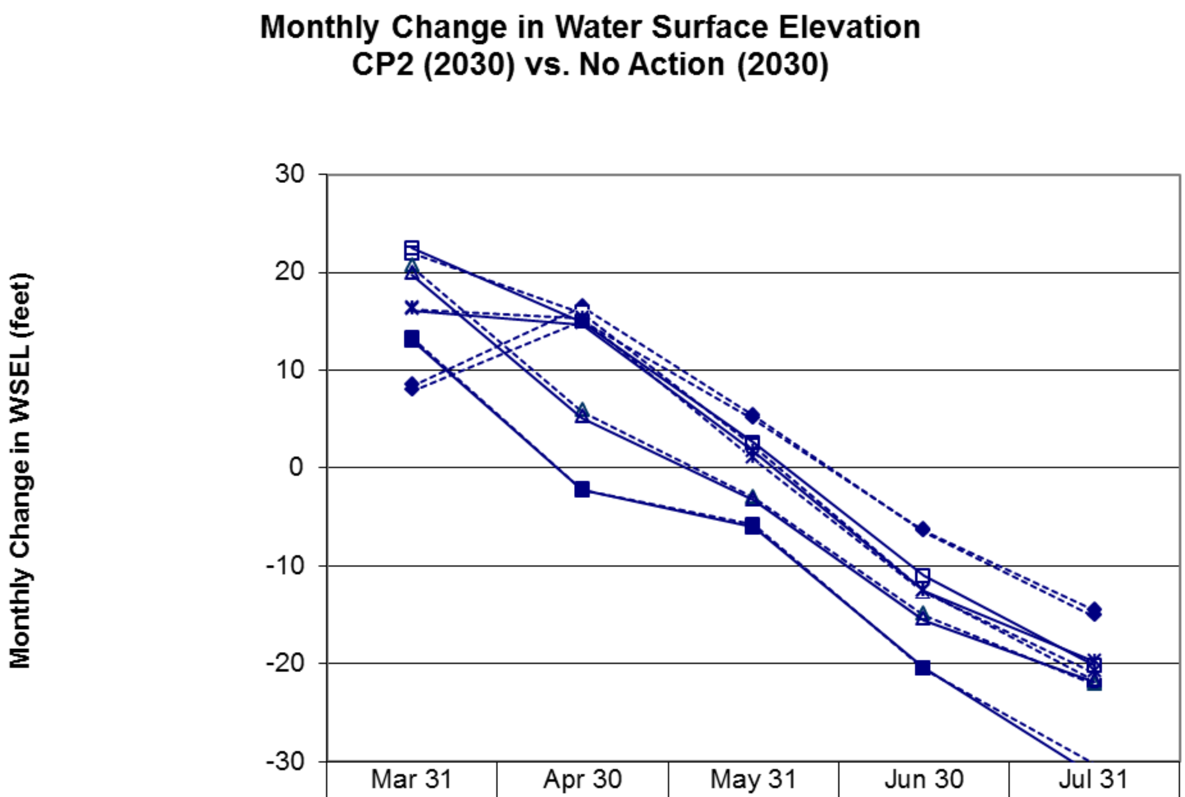
This impact would be similar to Impact Aqua-3 (CP1). However, it would be of greater magnitude owing to a greater increase in the ratio of the volume of cold-water storage in the lake to the surface area of the lake. CalSim-II modeling shows that under CP2 with a 2030 water supply demand, the ratio of cold-water storage to surface area is higher than under the No-Action Alternative in all water years and during all months modeled. The greatest projected increases over the No-Action Alternative occur between June 30 and August 31, which is a critical rearing and oversummering period for cold-water fishes in reservoirs, and the increases are greatest in wet and above-normal water years (Figure 11-19).



	Mar 31	Apr 30	May 31	Jun 30	Jul 31
EC W	9	16	5	-6	-15
EC AN	22	16	3	-12	-21
EC BN	16	15	1	-13	-20
EC D	21	5	-3	-15	-22
EC C	14	-3	-6	-21	-32
CP2 (2005) W	8	15	5	-6	-14
CP2 (2005) AN	22	15	3	-10	-20
CP2 (2005) BN	16	15	2	-12	-19
CP2 (2005) D	20	5	-3	-15	-22
CP2 (2005) C	13	-3	-6	-20	-32

Key:
AN = above-normal water
BN= below-normal water years
C = critical water years
CP = Comprehensive Plan
D = dry water years
NA = No-Action
W = wet water years

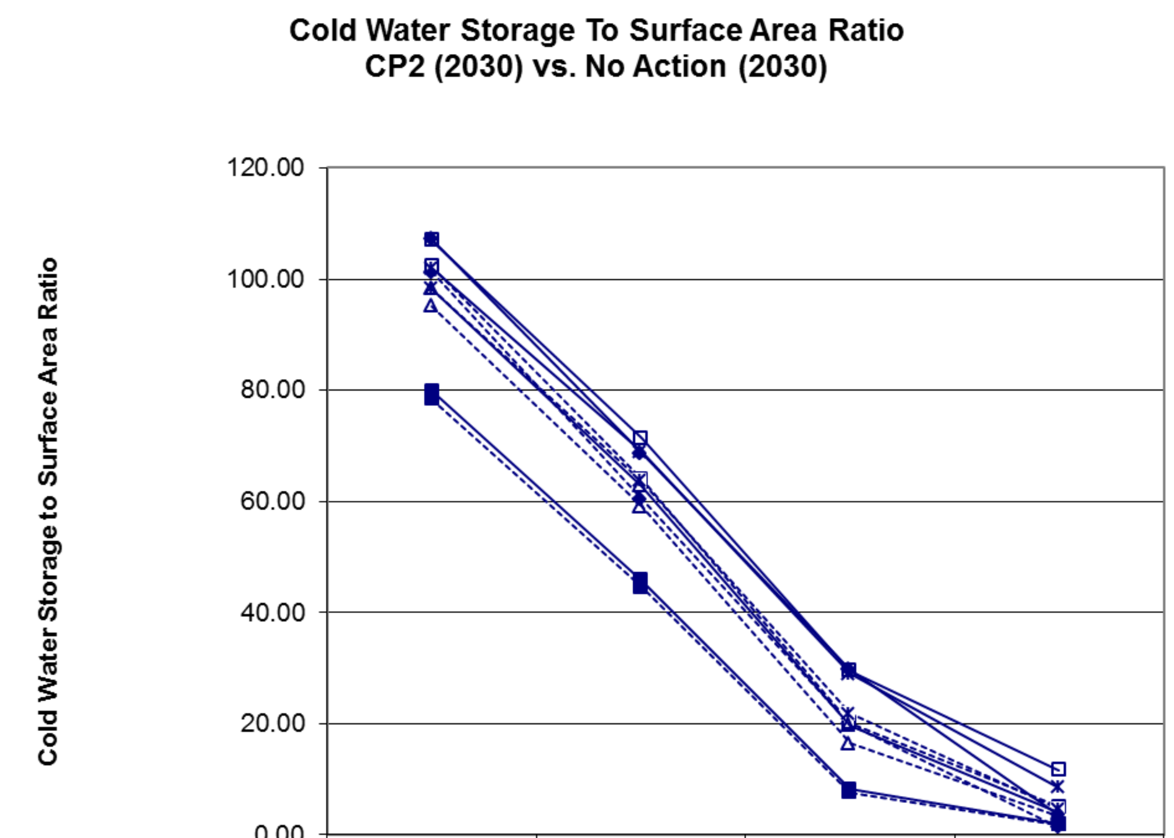
Figure 11-17. Average Monthly Change in WSEL for Each Water Year Type Within the Shasta Lake Vicinity of the Primary Study Area, CP2 Compared with the Existing Condition



	Mar 31	Apr 30	May 31	Jun 30	Jul 31
NA W	8	16	5	-7	-15
NA AN	22	16	2	-13	-22
NA BN	16	15	1	-13	-21
NA D	21	6	-3	-15	-22
NA C	13	-2	-6	-21	-30
CP2 (2030) W	8	15	5	-6	-15
CP2 (2030) AN	22	15	3	-11	-20
CP2 (2030) BN	16	15	2	-13	-20
CP2 (2030) D	20	5	-3	-16	-22
CP2 (2030) C	13	-2	-6	-20	-31

Key:
AN = above-normal water
BN= below-normal water years
C = critical water years
CP = Comprehensive Plan
D = dry water years
NA = No-Action
W = wet water years

Figure 11-18. Average Monthly Change in WSEL for Each Water Year Type Within the Shasta Lake Vicinity of the Primary Study Area, CP2 Compared with No-Action



	Apr 30	Jun 30	Aug 31	Oct 31
NA W	101.33	60.49	19.89	1.43
NA AN	102.30	64.04	20.12	5.09
NA BN	98.27	63.71	21.84	4.64
NA D	95.13	59.14	16.50	3.38
NA C	78.43	44.58	7.66	1.82
CP2 2030 W	107.24	68.75	29.70	3.60
CP2 2030 AN	106.94	71.41	29.47	11.66
CP2 2030 BN	102.01	68.96	28.99	8.58
CP2 2030 D	98.28	62.83	19.64	3.90
CP2 2030 C	79.90	45.87	8.14	1.89

Key:
AN = above-normal water
BN= below-normal water years
C = critical water years
CP = Comprehensive Plan
D = dry water years
NA = No-Action
W = wet water years

Figure 11-19. Average Monthly Cold-water Storage to Surface Area Ratio for Each Water Year Type Within the Shasta Lake Vicinity of the Primary Study Area, CP2 Compared with the Existing Condition

CP2 would increase the availability of suitable habitat for cold-water fish in Shasta Lake, particularly in dry to wetter water year, with a slight improvement in critical years. Therefore, this impact would be beneficial. Mitigation for this impact is not needed, and thus not proposed.

Impact Aqua-4 (CP2): Effects on Special-Status Aquatic Mollusks Under CP2, habitat for special-status mollusks could become inundated. Seasonal fluctuations in the surface area and WSEL of Shasta Lake could also adversely affect special-status aquatic mollusks that may occupy habitat in or near Shasta Lake and its tributaries. Investigations are ongoing but initial evidence from field surveys of the lower reaches of representative tributaries to the lake suggests that the probability of occurrence of special-status mollusks in in these reaches is low. These studies will provide additional information and analysis for inclusion in the Final EIS. However, because the California floater, a special-status mollusk species, is known from Shasta Lake, this impact would be potentially significant. Mitigation for this impact is proposed in Section 11.3.4.

Impact Aqua-5 (CP2): Effects on Special-Status Fish Species The expansion of the surface area of Shasta Lake and the inundation of additional tributary habitat under CP2 could affect one species designated as sensitive by USFS, the hardhead. However, available data suggest that hardhead do not currently occur or are very uncommon in the primary tributaries to Shasta Lake, other than the Pit River above the Pit 7 afterbay. Tributary investigations are ongoing and will provide additional information and analysis for inclusion in the Final EIS. This impact is considered to be less than significant. Mitigation for this impact is not needed, and thus not proposed.

Impact Aqua-6 (CP2): Creation or Removal of Barriers to Fish Between Tributaries and Shasta Lake Under CP2, project implementation would result in the periodic inundation of steep and low-gradient tributaries to Shasta Lake up to the 1,084-foot contour, the maximum inundation level under this alternative. Tributary investigations are ongoing and will provide additional information and analysis for inclusion in the Final EIS. However, based on digital topographic data and stream channel data generated from field inventories, about 21 percent of intermittent and 4 percent of perennial tributaries contain substantial barriers between the 1,070-foot and 1,084-foot contours that would be inundated under this alternative; although none of the streams with barriers was found to be inhabited by special-status fish in upstream reaches. This impact would be less than significant.

This impact would be similar to Impact Aqua-6 (CP1). However, the maximum inundation level would be higher under CP2. Most (82 percent) of the tributaries are too steep (i.e., greater than 7 percent) up to the 1,084-foot contour to be passable by fish; the tributaries that are low-gradient up to the 1,084-foot contour, and thus allow fish passage remain low-gradient well upstream from this contour; an exception to this pattern is Squaw Creek, which has a 12- to15-

foot-tall passage barrier from about 1,070 feet msl to 1,083 feet msl. The access of warm-water fish species from the lake into some tributaries would be extended by periodic inundation of this and smaller passage impediments in other streams under CP2, with a potential to alter existing resident fish communities. However, except for the main river tributaries (i.e., Sacramento, Pit, and McCloud rivers), few of the lake's other accessible tributaries have been found to be colonized by warm-water fish above the varial zone and any further access is expected to be limited primarily to the newly inundated reaches of some streams. Therefore, this impact would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

Impact Aqua-7 (CP2): Effects on Spawning and Rearing Habitat of Adfluvial Salmonids in Low-Gradient Tributaries to Shasta Lake CP2 would result in additional periodic inundation of potential spawning and rearing habitat for adfluvial salmonids in low-gradient tributaries. Tributary investigations are ongoing and will provide additional information and analysis for inclusion in the Final EIS. A total of 7.4 miles of low-gradient reaches that could provide some spawning and rearing habitat for adfluvial salmonids (estimated as 31,000 square feet for all tributaries) would be affected by CP2, which is only about 1.8 percent of the low-gradient habitat upstream from Shasta Lake. This impact would be significant.

As described in Chapter 4, "Geology, Geomorphology, Minerals, and Soils," CP2 would inundate perennial reaches with gradients of less than 7 percent that could provide potentially suitable spawning and rearing habitat for adfluvial salmonids. The lengths of low-gradient tributaries to each arm of Shasta Lake and estimated suitable spawning areas that would be periodically inundated are as follows:

- Sacramento Arm – 3.1 miles (16,430 Square feet, excludes mainstem river)
- McCloud Arm – 1.4 miles (9,990 square feet)
- Pit Arm – 1.4 miles (523 square feet, excludes mainstem river)
- Big Backbone Arm – 0.6 miles (144 square feet)
- Squaw Arm – 0.9 miles (1,300 square feet)

This impact would be similar to Impact Aqua-7 (CP1). However, it would periodically inundate an additional 8,000 square feet of suitable spawning habitat in low-gradient reaches to Shasta Lake. Therefore, this impact would be potentially significant. Mitigation for this impact is proposed in Section 11.3.4.

Impact Aqua-8 (CP2): Effects on Aquatic Connectivity in Non-Fish-Bearing Tributaries to Shasta Lake CP2 would result in periodic inundation of the lower reaches of high-gradient, non-fish-bearing tributaries to Shasta Lake. About 17.3 miles of non-fish-bearing tributary habitat would be affected by CP2, which is only about 0.7 percent of this habitat upstream from Shasta Lake. Tributary investigations are ongoing and will provide additional information and analysis for inclusion in the Final EIS. Examination of initial field surveys suggest that few, if any of the non-fish bearing streams contain special-status invertebrate or vertebrate species that would be affected by increased connectivity to Shasta Lake. This impact would be less than significant.

As described in Chapter 4, CP2 would inundate tributary segments with channel slopes in excess of 7 percent. Although these segments do not typically support salmonid populations, they do provide riparian and aquatic habitat for a variety of organisms and serve as corridors that connect habitat types. The lengths of non-fish-bearing tributaries for each arm of Shasta Lake that would be periodically inundated are as follows:

- Sacramento Arm – 3.9 miles
- McCloud Arm – 2.8 miles
- Pit Arm – 2.5 miles
- Big Backbone Arm – 1.8 miles
- Squaw Arm – 1.3 miles
- Main Body – 5.0 miles

This impact would be similar to Impact Aqua-8 (CP1). However, it would periodically inundate a larger amount of habitat in low-gradient reaches to Shasta Lake, but the total amount inundated would be only 0.7 percent of the low-gradient habitat upstream from the lake and no special-status aquatic vertebrate and invertebrate species have been detected in these reaches. Therefore, this impact would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

Impact Aqua-9 (CP2): Effects on Water Quality at Livingston Stone Hatchery Reclamation provides the water supply to the Livingston Stone Hatchery from a pipeline emanating from Shasta Dam. This supply would not be interrupted by any activity associated with CP2. There would be no impact.

This impact is the same as Impact Aqua-9 (CP1) and there would be no impact. Mitigation for this impact is not needed, and thus not proposed.

Upper Sacramento River (Shasta Dam to Red Bluff)
Impact Aqua-10 (CP2): Loss or Degradation of Aquatic Habitat in the Upper Sacramento River During Construction Activities Temporary construction-related increases in sediments and turbidity levels would adversely affect

aquatic habitats and fish populations immediately downstream in the upper Sacramento River. However, environmental commitments would be in place to reduce the effects. This impact would be less than significant.

This impact would be similar to Impact Aqua-10 (CP1). The impact could be greater under CP2 than under CP1 because of the increased activity associated with a 12.5-foot raise compared to a 6.5-foot raise. However, as under CP1, environmental commitments for all actions would be in place to reduce the effects. Therefore, this impact would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

Impact Aqua-11 (CP2): Release and Exposure of Contaminants in the Upper Sacramento River During Construction Activities Construction-related activities could result in the release and exposure of contaminants. Such exposure could adversely affect aquatic habitats, the aquatic food web, and fish populations, including special-status species, downstream in the primary study area. However, environmental commitments would be in place to reduce the effects. Therefore, this impact would be less than significant.

This impact would be similar to Impact Aqua-11 (CP1). The impact could be greater under CP2 than under CP1 because of the increased activity associated with a 12.5-foot raise compared to a 6.5-foot raise. A potential release of hazardous materials into the upper Sacramento River could cause a reduction in aquatic habitats and fish populations if proper procedures were not implemented to contain the discharge. However, as under CP1, environmental commitments for all actions would be in place to reduce the effects. Therefore, this impact would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

Impact Aqua-12 (CP2): Changes in Flow and Water Temperature in the Upper Sacramento River Resulting from Project Operation – Chinook Salmon CP2 operation under CP2 would generally result in improved flow and water temperature conditions in the upper Sacramento River for Chinook salmon, but not all runs have an increase in production. This impact would be beneficial.

Winter-Run Chinook Salmon

<u>Production</u>

The overall average winter-run production for the 81-year period was similar for CP2 relative to the No-Action Alternative and the Existing Condition (Attachments 3 and 4 of the Modeling Appendix). The maximum increase in production relative to the No-Action Alternative was 61 percent in a critical water year for CP2, while the largest decrease in production relative to the No-Action Alternative was around 24 percent, also in a critical water year (Table 11-19 and Attachment 3 of the Modeling Appendix). The maximum increase in production relative to the Existing Condition was 54 percent for CP2, while the largest decrease in production relative to the Existing Condition was around 27 percent under CP2 (Table 11-19 and Attachment 4 of the Modeling Appendix).

Figure 11-9 shows the change in production relative to the No-Action Alternative for all water years and all Comprehensive Plans.

Under CP2, only two critical water years had significant increases (greater than 5 percent) in production relative to the No-Action Alternative for winter-run Chinook salmon. No other water year type had a significant increase in production. One critical water year had a significant decrease in production.

Under CP2, four critical, one dry water, and one below-normal water years had significant increases in production relative to the Existing Condition for winter-run Chinook salmon. Three years (one each in critical, dry and above-normal water year types) had significant decreases in production greater than 5 percent.

Table 11-19. Change in Production Under CP2 for Winter-Run Chinook Salmon

Year Type	Number of Years	Average Production	Change in Production from Baseline	Average Change in Production	Maximum Increase in Production	Number of Months with Significant Increase	Maximum Decrease in Production	Number of Months with Significant Decrease
Future Condition (2030)								
All	81	3,772,931	-28,184	-0.7	61.1	2	-23.8	1
Critical	13	3,343,654	-34,302	-1.0	61.1	2	-23.8	1
Dry	17	3,953,711	-18,620	-0.5	2.9	0	-2.9	0
Below Normal	14	3,941,590	3,032	0.1	3.6	0	-2.6	0
Above Normal	11	3,799,691	-59,239	-1.5	0.5	0	-4.7	0
Wet	26	3,767,230	-35,048	-0.9	4.4	0	-3.9	0
Existing Condition (2005)								
All	81	3,776,950	-4,297	-0.1	44.5	6	-5.8	3
Critical	13	3,357,691	146,752	4.6	44.5	4	-5.6	1
Dry	17	3,965,107	-18,754	-0.5	15.2	1	-5.0	1
Below Normal	14	3,941,118	968	0.0	5.2	1	-4.4	0
Above Normal	11	3,782,121	-70,562	-1.8	2.3	0	-5.8	1
Wet	26	3,772,968	-45,168	-1.2	1.5	0	-4.4	0

Note:

Production is the number of immature smolts surviving to pass the Red Bluff Pumping Plant

Mortality

Mortality was separated by flow- and water temperature-related mortality to assess the level of impacts on winter-run Chinook salmon caused by the actions of the project (Attachments 3 and 4). Nonoperations-related mortality are the base and seasonal mortality that would occur even without the effects of Shasta operations (such as disease, predation, and entrainment). Flow- and water temperature-related mortality is that caused by altering flow and water temperatures. In all cases, most mortality is caused by nonoperations-related factors (e.g., disease, predation, entrainment)‒around 86 percent of the total mortality.

Mortality is presented in two manners–total mortality and smolt equivalent mortality (Attachments 3 and 4 of the Modeling Appendix). The greatest average mortality to winter-run Chinook salmon under CP1 in all water year types based on smolt equivalents would occur to the fry life stage, followed by eggs, then presmolts, and lastly immature smolts. Table 11-5 displays the overall mortalities for each Comprehensive Plan that were caused by changes in water temperature and flow) (Attachments 3 and 4 of the Modeling Appendix).

Years with the highest flow- and water temperature-related mortality were the same for the No-Action Alternative, the Existing Condition, and CP2. Each of these years was a critical water year, and was preceded by either a critical (1933, 1976, 1991), or dry (1930, 1932) water year type. Years with the lowest mortality varied between all water year types. Years in which the project has the greatest effect on winter-run were also years in which the lowest production occurred (Attachments 3 and 4).

Although winter-run Chinook salmon have, under both 2030 and 2005 conditions, an insignificant change in productivity, there is a decrease in project-related mortality under 2005 conditions (4.4 percent) and an increase in project-related mortality under 2030 conditions (0.9 percent). Additionally, there would not be a significant improvement in production during critical water years. Therefore, the actions taken in CP2 would result in less-than-significant impacts to winter-run Chinook salmon under both 2030 and 2005 conditions. Mitigation for this impact is not needed, and thus not proposed.

Spring-Run Chinook Salmon

Production

The overall 81-year average production for spring-run Chinook salmon under CP2 is insignificantly higher relative to the No-Action Alternative and insignificantly lower than the Existing Condition (Attachments 6 and 7 of the Modeling Appendix). The maximum increase in production relative to the No-Action Alternative was 97 percent in a critical water year for CP2, while the largest decrease in production relative to the No-Action Alternative was -19 percent, also in a critical water year (Table 11-20 and Attachment 6 of the Modeling Appendix). The maximum increase in production relative to the Existing Condition was 375 percent for CP2 and the largest decrease in production was less than -5 percent under CP2 in 1977 (Table 11-20 and Attachment 7 of the Modeling Appendix). Figure 11-10 shows the change in production relative to the No-Action Alternative for all water years and all Comprehensive Plans.

Under CP2, five critical, two dry, and one below-normal water years had significant increases in production relative to the No-Action Alternative. Production significantly decreased in five critical water years (between -11 and -17 percent). No other water year type had a significant decrease in production.

Under CP2, nine critical, two dry, and one below-normal water years had significant increases in production relative to the Existing Condition. No water years had significant decrease in production relative to the Existing Condition.

Table 11-20. Change in Production Under CP2 for Spring-Run Chinook Salmon

Year Type	Number of Years	Average Production	Change in Production from Baseline	Average Change in Production	Maximum Increase in Production	Number of Months with Significant Increase	Maximum Decrease in Production	Number of Months with Significant Decrease
Future Condition (2030)								
All	81	164,655	601	0.4	97.4	8	-17.4	5
Critical	13	87,341	6,152	7.6	97.4	5	-17.4	5
Dry	17	171,229	1,777	1.0	96.7	2	-1.7	0
Below Normal	14	177,935	754	0.4	21.1	1	-3.8	0
Above Normal	11	182,449	-1,317	-0.7	4.2	0	-2.9	0
Wet	26	184,335	-2,215	-1.2	1.6	0	-3.9	0
Existing Condition (2005)								
All	81	165,357	2,149	1.3	375	12	-4.2	0
Critical	13	89,925	15,863	21.4	151	9	-4.2	0
Dry	17	171,694	2,833	1.7	375	2	-2.4	0
Below Normal	14	178,901	872	0.5	29.6	1	-2.5	0
Above Normal	11	182,404	-1,709	-0.9	3.3	0	-2.8	0
Wet	26	184,305	-2,925	-1.6	1.9	0	-4.2	0

Note:
Production is the number of immature smolts surviving to pass the Red Bluff Pumping Plant

Mortality

Mortality was separated by flow- and water temperature-related mortality to assess the level of impacts on spring-run Chinook salmon caused by the actions of the project (Attachments 6 and 7 of the Modeling Appendix). In all cases, most mortality is caused by nonoperations-related factors (e.g., disease, predation, entrainment)−around 83 percent of the total mortality.

Mortality is presented in two manners–total mortality and smolt equivalent mortality (Attachments 6 and 7 of the Modeling Appendix). Under both 2030 and 2005 conditions, the greatest mortality to spring-run Chinook salmon under CP2 (as with CP1) in all water year types based on smolt equivalents would occur to eggs, with minimal mortality to the other life stages. Table 11-7 displays the smolt-equivalent mortalities for each Comprehensive Plan that are caused by flow- and water-related factors (also see Attachments 6 and 7 of the Modeling Appendix).

Years with the highest flow- and water temperature-related mortality were the same for the No-Action Alternative, the Existing Condition, and CP2. Except for 1932 (a dry water year), each of these years was a critical water year type and was preceded by either a below, dry, or (predominantly) a critical water year. However, years with the lowest mortality varied between all water year types (Attachments 6 and 7 of the Modeling Appendix).

Under both 2030 and 2005 conditions, spring-run Chinook salmon would experience a significant reduction in flow- and water temperature-related mortality, but an insignificant increase in overall production. However, spring-run would experience a significant increase in production overall for critical water years, especially in years in which the spring-run Chinook salmon could be extirpated from the Sacramento River due to such a low number of fish surviving to pass RBPP. Therefore, spring-run Chinook salmon would benefit from actions taken in CP2. Mitigation for this impact is not needed, and thus not proposed.

Fall-Run Chinook Salmon

Production

Overall average fall-run Chinook salmon production for the simulation period was slightly higher for CP2 than for either the No-Action Alternative or Existing Condition (Attachments 9 and 10 of the Modeling Appendix). The maximum increase in production relative to the No-Action Alternative was 44 percent for CP2 in a critical water year, while the largest decrease in production relative to the No-Action Alternative was -6 percent, also in a critical water year (Table 11-21 and Attachment 9 of the Modeling Appendix). The maximum increase in production relative to the Existing Condition was 47 percent for CP2, and the largest decrease in production was around -6 percent under CP2 (Table 11-21 and Attachment 10 of the Modeling Appendix). Figure 11-11 shows the annual change in production relative to the No-Action Alternative for all Comprehensive Plans.

Table 11-21. Change in Production Under CP2 for Fall-Run Chinook Salmon

Year Type	Number of Years	Average Production	Change in Production from Baseline	Average Change in Production	Maximum Increase in Production	Number of Months with Significant Increase	Maximum Decrease in Production	Number of Months with Significant Decrease
No-Action Alternative (2030)								
All	81	29,926,852	408,446	2.1	44.0	10	-6.0	1
Critical	13	27,955,633	1,510,805	7.0	44.0	4	-1.4	0
Dry	17	30,244,797	704,637	3.4	18.4	3	-1.7	0
Below Normal	14	31,488,759	390,848	2.4	22.1	2	-4.4	0
Above Normal	11	31,022,573	-10,437	0.4	4.9	0	-3.4	0
Wet	26	29,399,974	-149,702	-0.6	7.2	1	-6.0	1
Existing Condition (2005)								
All	81	29,770,129	341,787	1.2	47.4	10	26.8	3
Critical	13	27,223,572	1,047,436	5.5	47.4	3	-26.8	1
Dry	17	30,168,009	707,608	3.2	27.5	5	-2.9	0
Below Normal	14	31,401,051	382,789	2.4	36.4	2	-6.0	1
Above Normal	11	30,916,415	46,018	0.4	2.7	0	-2.8	0
Wet	26	29,420,098	-147,172	-0.6	4.3	0	-6.4	1

Note:
Production is the number of immature smolts surviving to pass the Red Bluff Pumping Plant

Except for 1977, in critical, dry, and below-normal water years, when production was lowest over the simulation period, the increase in production resulting from operations-related activities was greatest. In wet water years, however, the lowest production years typically had a slight decrease in production under CP2 conditions relative to the No-Action Alternative.

Under CP2, four critical, three dry, two below-normal, and one wet water year had significant increases in production relative to the No-Action Alternative. Only one year (1969) out of the 81 simulated years had a significant decrease in production (Table 11-21).

Under CP2, three critical, five dry, and two below-normal water years had significant increases in production relative to the Existing Condition. One critical (1977), one below-normal (1979), and one wet (1969) water years resulted in significantly decreased production relative to the Existing Condition (Table 11-21).

<u>Mortality</u>
Mortality was separated by flow- and water temperature-related mortality to assess the level of impacts on fall-run Chinook salmon caused by the actions of the project (Attachments 9 and 10). In all cases, most mortality is caused by nonoperations-related factors (e.g., disease, predation, entrainment)−around 65 percent of the total mortality.

Under both 2030 and 2005 conditions, the greatest mortality to fall-run Chinook salmon under CP2 (as with CP1) in all water year types based on smolt equivalents would occur to fry, then to eggs, prespawn adults, presmolts and then immature smolts. Table 11-9 displays the overall mortalities for each alternative that would be caused by flow and water temperature changes (Attachments 9 and 10 of the Modeling Appendix). Mortalities caused by operations-related activities would be lower for CP2 than for the No-Action Alternative (Table 11-9).

There was no real trend with respect to water year type with the greatest mortality.

Fall-run Chinook salmon have an insignificant increase in production and an insignificant reduction in project-related mortality, but would have a significant increase in production overall during critical water years. However, the fall-run Chinook salmon would benefit from actions taken in CP2. Mitigation for this impact is not needed, and thus not proposed.

Late Fall-Run Chinook Salmon

<u>Production</u>
Overall average late fall-run Chinook salmon production for the 80-year period was similar (less than 5 percent change) for CP2 relative to the No-Action Alternative and the Existing Condition (Attachments 12 and 13 of the Modeling

Appendix). The maximum increase in production relative to the No-Action Alternative was almost 9 percent for CP2 in a dry water year, while the greatest decrease in production relative to the No-Action Alternative was -5 percent in a critical water year (Table 11-22 and Attachment 12 of the Modeling Appendix).

The maximum increase in production relative to the Existing Condition was 12 percent for CP2 in 1985. The largest decrease in production relative to the Existing Condition was less than almost -7 percent under CP2 (Table 11-22 and Attachment 13 of the Modeling Appendix). Figure 11-12 shows the change in production relative to the No-Action Alternative for all water years and all Comprehensive Plans.

Under CP2, production significantly (greater than 5 percent) increased for two critical and two dry water years, while two critical water years had significant decreases in production relative to the No-Action Alternative.

Table 11-22. Change in Production Under CP2 for Late Fall-Run Chinook Salmon

Year Type	Number of Years	Average Production	Change in Production from Baseline	Average Change in Production	Maximum Increase in Production	Number of Months with Significant Increase	Maximum Decrease in Production	Number of Months with Significant Decrease
Future Condition (2030)								
All	80	7,592,973	-35,743	0.0	8.7	4	-5.1	2
Critical	13	7,044,042	-20,127	-0.3	5.9	2	-5.1	2
Dry	16	7,429,076	74,707	1.0	8.7	2	-3.2	0
Below Normal	14	7,588,598	-24,020	-0.3	1.6	0	-3.4	0
Above Normal	11	7,574,775	-11,309	-0.1	3.6	0	-2.6	0
Wet	26	7,436,378	-23,286	-0.3	4.3	0	-2.9	0
Existing Condition (2005)								
All	80	7,445,153	58,592	0.8	12.3	4	-6.6	1
Critical	13	7,058,132	94,836	1.4	8.6	1	-2.2	0
Dry	16	7,498,737	138,469	1.9	12.3	3	-3.5	0
Below Normal	14	7,657,874	46,780	0.6	3.2	0	-2.3	0
Above Normal	11	7,616,470	56,796	0.8	2.6	0	-2.3	0
Wet	26	7,418,665	-1,566	0.0	3.5	0	-6.6	1

Note:

Production is the number of immature smolts surviving to pass the Red Bluff Pumping Plant

Under CP2 compared with the Existing Condition, one critical and three dry water years had significant increases in production. One wet water year had a significant (greater than 5 percent) decreases in production.

Mortality

Mortality was separated by flow- and water temperature-related mortality to assess the level of impacts on late fall-run Chinook salmon caused by the actions of the project (Attachments 12 and 13). In all cases, most mortality is caused by nonoperations-related factors (e.g., disease, predation, entrainment)−around 78 percent of the total mortality.

Under both 2030 and 2005 conditions, the greatest mortality to late fall-run Chinook salmon under CP2 (as with CP1) in all water year types based on smolt equivalents would occur to fry, then eggs, presmolts, immature smolts, and lastly to prespawn adults. Table 11-11 displays overall mortalities for each Comprehensive Plan that would be caused by changes in flow and water temperature (see also Attachments 12 and 13 of the Modeling Appendix).

Years with the highest operations-related mortality would be the same for CP2, the No-Action Alternative, and Existing Condition. All water year types were covered. Three years were preceded by a wet water year, and one preceded by an above-normal water year (Attachments 12 and 13 of the Modeling Appendix).

Because late fall-run Chinook salmon would have, overall, an insignificant change in mortality and production (including in critical water years), late fall-run Chinook salmon would have a less-than-significant impact from actions taken in CP2. Mitigation for this impact is not needed, and thus not proposed.

Impact Aqua-13 (CP2): Changes in Flow and Water Temperatures in the Upper Sacramento River Resulting from Project Operation – Steelhead, Green Sturgeon, Sacramento Splittail, American Shad, and Striped Bass Project operation generally would result in slightly improved flow and water temperature conditions in the upper Sacramento River for steelhead, green sturgeon, Sacramento splittail, American shad, and striped bass. This impact would be less than significant.

This impact would be similar to Impact Aqua-13 (CP1). The impact could be greater under CP2 than under CP1 because the increased reservoir capacity associated with a 12.5-foot raise compared to a 6.5-foot raise would allow storage of additional water volume (and flows) behind the raised dam.

Flow-Related Effects As under CP1, monthly mean flows at all modeling locations along the upper Sacramento River (below Shasta Dam, below Keswick Dam, above Bend Bridge, and above RBPP) under CP2 would generally be equivalent to (less than 2-percent difference from, with more increases than decreases) flows under the Existing Condition and No-Action

Alternative simulated for all months. (See the Modeling Appendix for complete modeling results.)

Potential flow-related effects of CP2 on fish species of management concern in the upper Sacramento River would be minimal. Potential changes in flows and stages would diminish rapidly downstream from RBPP because of increased effects from tributary inflows, diversions, and flood bypasses.

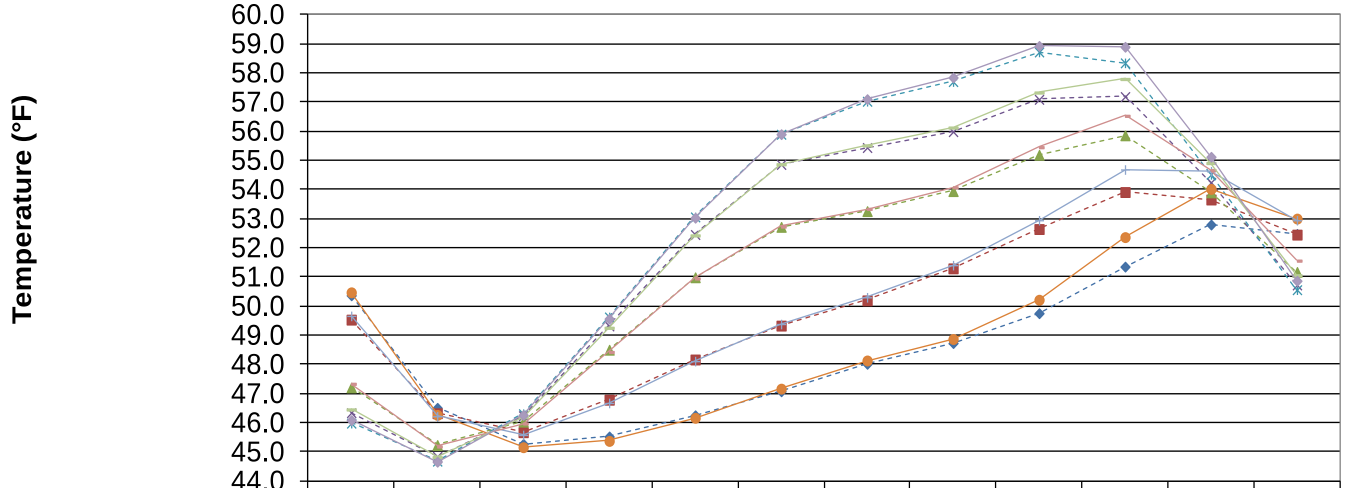
Changes in monthly mean flows under CP2 relative to the Existing Condition and No-Action Alternative would have no discernible effects on steelhead, green sturgeon, Sacramento splittail, American shad, or striped bass in the upper Sacramento River. Functional flows for migration, attraction, spawning, egg incubation, and rearing/emigration for these species would be unchanged. Therefore, flow-related impacts on these fish species would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

Water Temperature–Related Effects As under CP1, monthly mean water temperatures at all modeling locations along the upper Sacramento River (below Shasta Dam, below Keswick Dam, Balls Ferry, above Bend Bridge, and above RBPP) under CP2 would be the same as, or fractionally less than, water temperatures under the Existing Condition and No-Action Alternative simulated for all months (Figures 11-20 and 11-21). (See the Modeling Appendix for complete modeling results.)

As discussed above, the modeling simulations may not fully account for real-time management of the cold-water pool and TCD (through the SRTTG) to achieve maximum cold-water benefits. Therefore, the modeled changes in water temperature (i.e., small benefits) are likely conservative and understated to some varying degree. Potential water temperature-related effects of CP2 on fish species of management concern in the upper Sacramento River would be minimal. During most years, releases from Shasta Lake would be unchanged.

The slightly cooler monthly mean water temperatures under CP2 relative to the Existing Condition and the No-Action Alternative would have very small effects on steelhead, green sturgeon, Sacramento splittail, American shad, or striped bass in the upper Sacramento River. Monthly mean water temperatures would not rise above important thermal tolerances for the species life stages relevant to the upper Sacramento River. Therefore, water temperature–related impacts on these fish species would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

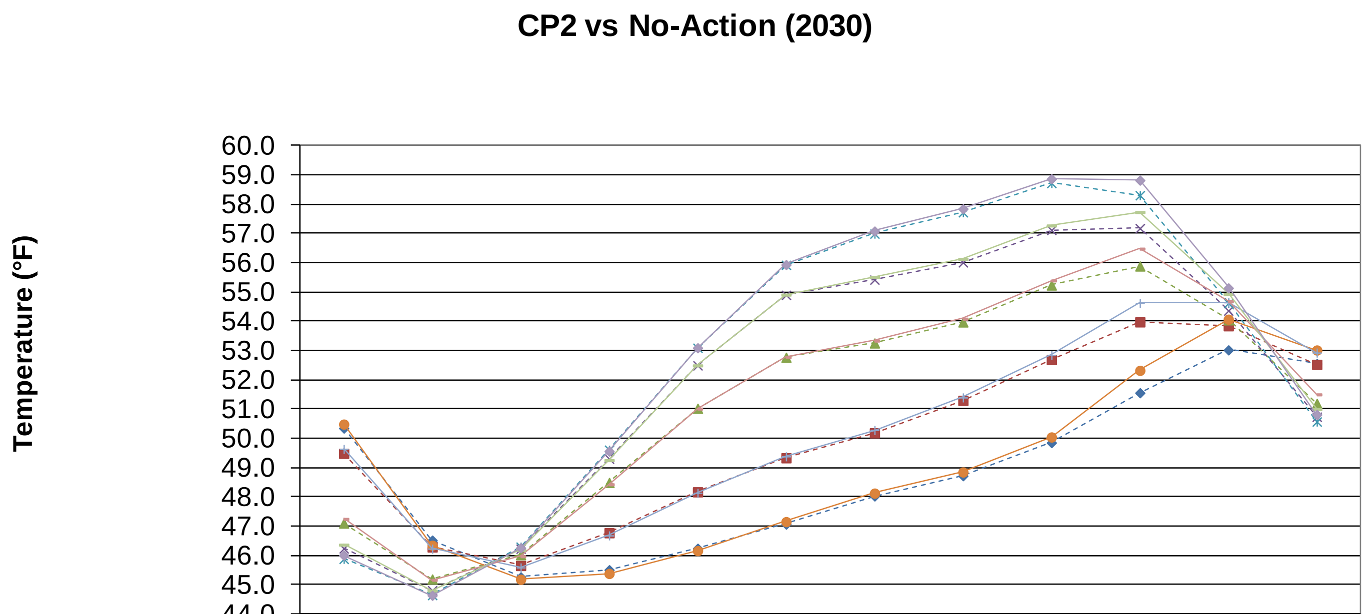
CP2 vs Existing Condition (2005)



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
CP2 Below Shasta	50.4	46.5	45.3	45.5	46.3	47.1	48.0	48.7	49.8	51.4	52.8	52.5
CP2 Below Keswick	49.5	46.3	45.7	46.8	48.2	49.3	50.2	51.3	52.6	53.9	53.7	52.5
CP2 Balls Ferry	47.2	45.2	46.0	48.5	51.0	52.7	53.3	53.9	55.2	55.9	53.9	51.2
CP2 Bend Bridge	46.3	44.8	46.2	49.3	52.5	54.9	55.4	56.0	57.1	57.2	54.2	50.7
CP2 RBPP	46.0	44.7	46.3	49.6	53.1	55.9	57.0	57.7	58.7	58.3	54.5	50.6
EC Below Shasta	50.5	46.3	45.2	45.4	46.2	47.2	48.1	48.9	50.2	52.4	54.0	53.0
EC Below Keswick	49.7	46.2	45.6	46.7	48.1	49.4	50.3	51.4	52.9	54.7	54.6	52.9
EC Balls Ferry	47.3	45.2	46.0	48.4	50.9	52.7	53.3	54.1	55.4	56.5	54.7	51.6
EC Bend Bridge	46.5	44.8	46.2	49.3	52.4	54.9	55.5	56.1	57.3	57.8	54.9	51.1
EC RBPP	46.1	44.7	46.3	49.6	53.0	55.9	57.1	57.8	58.9	58.9	55.1	50.9

Key:
EC = Existing Condition
CP = Comprehensive Plan
RBPP = Red Bluff Pumping Plant

Figure 11-20. Changes in Mean Monthly Water Temperature at Modeled Locations in the Sacramento River Within the Primary Study Area (CP2 Versus the Existing Condition)



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
CP2 Below Shasta	50.4	46.5	45.3	45.5	46.2	47.1	48.0	48.7	49.9	51.6	53.0	52.6
CP2 Below Keswick	49.5	46.3	45.7	46.8	48.2	49.3	50.2	51.3	52.7	54.0	53.8	52.5
CP2 Balls Ferry	47.1	45.2	46.0	48.5	51.0	52.8	53.3	54.0	55.2	55.9	54.0	51.2
CP2 Bend Bridge	46.2	44.8	46.2	49.3	52.5	54.9	55.4	56.0	57.1	57.2	54.4	50.7
CP2 RBPP	45.9	44.7	46.3	49.6	53.1	55.9	57.0	57.7	58.7	58.3	54.6	50.6
NA Below Shasta	50.5	46.3	45.2	45.4	46.2	47.2	48.1	48.9	50.0	52.3	54.1	53.0
NA Below Keswick	49.6	46.2	45.6	46.7	48.1	49.4	50.3	51.4	52.9	54.6	54.6	52.9
NA Balls Ferry	47.3	45.2	46.0	48.4	51.0	52.8	53.3	54.1	55.4	56.5	54.7	51.5
NA Bend Bridge	46.4	44.8	46.2	49.3	52.5	54.9	55.5	56.1	57.3	57.7	54.9	51.0
NA RBPP	46.0	44.6	46.3	49.6	53.1	55.9	57.1	57.8	58.9	58.8	55.1	50.8

Key: NA = No-Action Alternative
CP = Comprehensive Plan RBPP = Red Bluff Pumping Plant

Figure 11-21. Changes in Mean Monthly Water Temperature at Modeled Locations in the Sacramento River Within the Primary Study Area (CP2 Versus No-Action Alternative)

Impact Aqua-14 (CP2): Reduction in Ecologically Important Geomorphic Processes in the Upper Sacramento River Resulting from Reduced Frequency and Magnitude of Intermediate to High Flows Project operations could cause a reduction in the magnitude, duration, and frequency of intermediate to large flows both in the upper Sacramento River and in the lowermost (confluence) areas of tributaries. Such flows are necessary for channel forming and maintenance, meander migration, and creation of seasonally inundated floodplains. These geomorphic processes are ecologically important because they are needed to maintain important aquatic habitat functions and values for fish and macroinvertebrate communities. This impact would be potentially significant.

This impact would be similar to Impact Aqua-14 (CP1). The impact could be greater under CP2 than under CP1 because the increased reservoir capacity associated with a 12.5-foot raise compared to a 6.5-foot raise would allow for storage of additional water volume (and flows) behind the raised dam.

Sediment transport, deposition, and scour regulate the formation of key habitat features such as point bars, gravel deposits, and SRA habitat. Intermediate to high flows and the associated stage elevation of the river surface also provide a backwater effect on the lowermost segment of tributaries, reducing the potential for downcutting. These processes are regulated by the magnitude and frequency of flow. Relatively large floods provide the energy required to mobilize sediment from the riverbed, produce meander migration, increase stage elevation, and create seasonally inundated floodplains. Operations under CP2 could result in a reduction in the intermediate to large flows necessary for channel forming and maintenance, meander migration, and creation of seasonally inundated floodplains.

Implementation of CP2 would cause a further reduction in the magnitude, duration, and frequency of intermediate to large flows, relative to the Existing Condition and No-Action Alternative. Overall, the project would increase the existing, ongoing effects on geomorphic processes resulting from the operation of Shasta Dam that are necessary for channel forming and maintenance, meander migration, and creation of seasonally inundated floodplains. These effects would likely occur throughout the upper Sacramento River portion of the primary study area.

Reductions in the magnitude of high flows would likely be sufficient to reduce ecologically important processes along the upper Sacramento River. This impact would be potentially significant. Mitigation for this impact is proposed in Section 11.3.4.

Lower Sacramento River and Delta

Impact Aqua-15 (CP2): Changes in Flow and Water Temperatures in the Lower Sacramento River and Tributaries and Trinity River Resulting from Project Operation – Fish Species of Primary Management Concern Project operation would result in no discernible change in monthly mean flows or water temperature conditions in the lower Sacramento River. However, predicted changes in flows in the Feather, American, and Trinity rivers could result in adverse effects on Chinook salmon, steelhead, Coho salmon, green sturgeon, Sacramento splittail, American shad, and striped bass. This impact would be potentially significant.

This impact would be similar to Impact Aqua-15 (CP1). The impact could be greater under CP2 than under CP1 because the increased reservoir capacity associated with a 12.5-foot raise compared to a 6.5-foot raise would allow for storage of additional water volume (and increased cold-water pool) behind the raised dam.

As described below, mean monthly flows at various modeling locations on the lower Sacramento River and tributaries under CP2 were compared with mean monthly flows simulated for the Existing Condition and No-Action Alternative conditions. See the Modeling Appendix for complete CalSim-II modeling results.

Lower Sacramento River As under CP1, monthly mean flows at the lower Sacramento River modeling locations under CP2 would be comparable to flows under the Existing Condition and No-Action Alternative conditions simulated for all months. Differences in monthly mean flow were generally small (less than 2 percent) and within the existing range of variability. Potential changes in flows would diminish rapidly downstream from RBPP because of increased effects from tributary inflows, diversions, and flood bypasses. Similarly, potential changes in water temperatures in the lower Sacramento River caused by small changes in releases would diminish rapidly downstream because of the increasing effects of inflows, atmospheric influences, and groundwater. Therefore, flow- and temperature-related impacts of CP2 on fish species in the lower Sacramento River would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

Also, as under CP1, the effects of altered flow regimes resulting from implementation of CP2 are unlikely to extend into the lower Sacramento River downstream from Verona and into the Delta because the Central Valley's reservoirs and diversions are managed as a single integrated system (consisting of the SWP and the CVP). The guidelines for this management, described in the CVP/SWP OCAP, have been designed to maintain standards for flow to the lower Sacramento River and Delta. CVP and SWP operations must be consistent with the OCAP and SWRCB D-1641 to allow ESA coverage by the OCAP permits and BOs. Thus, implementation of CP2 would not likely alter flow to the Delta or water temperatures in the lower Sacramento River and its primary tributaries to a sufficient degree to affect Chinook salmon, steelhead, green sturgeon, Sacramento splittail, American shad, or striped bass relative to the Existing Condition and No-Action Alternative. Functional flows for fish migration, attraction, spawning, egg incubation, and rearing/emigration for all these fish species would be unchanged. Therefore, flow- and water temperature–related effects on these fish species would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

Lower Feather River, American River, and Trinity River Also, as under CP1, monthly mean flows at modeling locations on the lower Feather River, the American River, and the Trinity River under CP2 would generally be equivalent to (less than 2-percent difference from) flows under the Existing Condition and No-Action Alternative simulated for most months. However, simulations for several months within the modeling record show substantial changes to flows in tributaries. Potential changes in flows could be reduced by real-time operations to meet existing rules and because of operation of upstream reservoirs (Lake Oroville, Folsom Lake, and Trinity Lake) and increasing effects from tributary inflows, diversions, and flood bypasses. Potential changes in water temperatures in the Feather River and American River caused by altered releases from reservoirs could diminish downstream because of the increasing effect of inflows, and atmospheric and groundwater influences. Nevertheless, based on predicted changes in flow and associated flow-habitat relationships, potential flow-related impacts on species of management concern in the American, Feather, and Trinity rivers could occur. This impact would be potentially significant. Mitigation for this impact is proposed in Section 11.3.4.

Impact Aqua-16 (CP2): Reduction in Ecologically Important Geomorphic Processes in the Lower Sacramento River Resulting from Reduced Frequency and Magnitude of Intermediate to High Flows Project operation could cause a reduction in intermediate to large flows both in the lower Sacramento River and in the lowermost (confluence) areas of tributaries. Such flows are necessary for channel forming and maintenance, meander migration, and the creation of seasonally inundated floodplains. These geomorphic processes are ecologically important because they are needed to maintain important aquatic habitat functions and values for fish and macroinvertebrate communities. This impact would be potentially significant.

This impact would be similar to Impact Aqua-16 (CP1). The impact could be greater under CP2 than under CP1 because the increased reservoir capacity associated with a 12.5-foot raise compared to a 6.5-foot raise would allow for storage of additional water volume (and flows) behind the raised dam.

Sediment transport, deposition, and scour regulate the formation of key habitat features such as point bars, gravel deposits, and SRA habitat. Intermediate to high flows and the associated stage elevation of the river surface also provide a backwater effect on the lowermost segment of tributaries, which reduces the potential for downcutting. These processes are regulated by the magnitude and frequency of flows. Relatively large floods provide the energy required to mobilize sediment from the riverbed, produce meander migration, increase stage elevation, create seasonally inundated floodplains, and inundate floodplain bypasses. Operations under CP2 could result in reduced intermediate to large flows that are necessary for channel forming and maintenance, meander migration, and the creation of seasonally inundated floodplains.

Implementation of CP2 would cause a further reduction in the magnitude, duration, and frequency of intermediate to large flows, relative to the Existing Condition and No-Action Alternative. Overall, the project would increase the existing, ongoing impacts on geomorphic processes resulting from operation of Shasta Dam that are necessary for channel forming and maintenance, meander migration, the creation of seasonally inundated floodplains, and the inundation of floodplain bypasses. These effects would likely occur along the upper reaches of the lower Sacramento River.

Reductions in the magnitude of high flows would likely be sufficient to reduce ecologically important processes along the upper Sacramento River and its floodplain bypasses. This impact would be potentially significant. Mitigation for this impact is proposed in Section 11.3.4.

Impact Aqua-17 (CP2): Effects to Delta Fisheries Resulting from Changes to Delta Outflow Based on results of hydrologic modeling comparing Delta outflow under the No-Action Alternative, Existing Condition, and CP2, CP2 would result in changes to average monthly Delta outflow of less than 5 percent in all year types (with the exception of December of critical years under 2005 conditions). This impact on Delta fisheries and hydrologic transport processes within the Bay-Delta would be less than significant.

Results of the comparison of Delta outflows between CP2 and the Existing Condition and No-Action Alternative are summarized by month and water year type in Table 11-23. Delta outflow would increase by greater than 5 percent under CP2 only in December of critical water years. Based on the results of this analysis, CP2 would have a less-than-significant effect on Delta fisheries and hydrologic transport processes within the Bay-Delta. Mitigation for this impact is not needed, and thus not proposed.

Table 11-23. Delta Outflow Under the Existing Condition, No-Action Alternative, and CP2

		Existing Condition	CP2 (2005)		No-Action Alternative	CP2 (2030)	
Month	**Water Year**	**Flow (cfs)**	**Flow (cfs)**	**Percent Change**	**Flow (cfs)**	**Flow (cfs)**	**Percent Change**
January	Average	42,078	41,860	-1	42,169	41,892	-1
	W	84,136	83,807	0	84,037	83,397	-1
	AN	47,221	47,015	0	46,984	46,937	0
	BN	21,610	21,643	0	21,990	22,017	0
	D	14,166	13,955	-1	14,452	14,174	-2
	C	11,560	11,263	-3	11,757	11,682	-1

Table 11-23. Delta Outflow Under the Existing Condition, No-Action Alternative, and CP2 (contd.)

		Existing Condition	CP2 (2005)		No-Action Alternative	CP2 (2030)	
Month	**Water Year**	**Flow (cfs)**	**Flow (cfs)**	**Percent Change**	**Flow (cfs)**	**Flow (cfs)**	**Percent Change**
February	Average	51,618	51,459	0	51,430	51,194	0
	W	95,261	94,989	0	94,634	94,259	0
	AN	60,080	59,683	-1	60,278	59,494	-1
	BN	35,892	35,856	0	35,665	35,782	0
	D	20,978	20,902	0	20,946	20,812	-1
	C	12,902	12,954	0	13,088	13,142	0
March	Average	42,722	42,580	0	42,585	42,530	0
	W	78,448	78,493	0	78,376	78,446	0
	AN	53,486	52,768	-1	53,139	52,656	-1
	BN	23,102	22,799	-1	22,980	22,825	-1
	D	19,763	19,860	0	19,559	19,648	0
	C	11,881	11,740	-1	11,893	11,899	0
April	Average	30,227	30,239	0	30,743	30,782	0
	W	54,640	54,645	0	55,460	55,478	0
	AN	32,141	32,130	0	32,971	32,977	0
	BN	21,773	21,868	0	22,511	22,538	0
	D	14,347	14,317	0	14,538	14,621	1
	C	9,100	9,119	0	8,873	8,942	1
May	Average	22,619	22,539	0	22,249	22,170	0
	W	41,184	41,155	0	40,543	40,532	0
	AN	24,296	24,237	0	24,454	24,215	-1
	BN	16,346	15,984	-2	15,989	15,645	-2
	D	10,554	10,553	0	10,116	10,189	1
	C	6,132	6,134	0	5,910	5,927	0
June	Average	12,829	12,759	-1	12,660	12,595	-1
	W	23,473	23,471	0	23,015	23,027	0
	AN	12,080	11,650	-4	11,799	11,446	-3
	BN	7,995	7,992	0	7,991	7,939	-1
	D	6,691	6,666	0	6,764	6,727	-1
	C	5,361	5,361	0	5,378	5,376	0
July	Average	7,864	7,869	0	7,864	7,861	0
	W	11,230	11,243	0	11,181	11,177	0
	AN	9,562	9,538	0	9,407	9,386	0
	BN	7,117	7,124	0	7,225	7,259	0
	D	5,005	5,006	0	5,052	5,030	0
	C	4,034	4,053	0	4,098	4,097	0

Table 11-23. Delta Outflow Under the Existing Condition, No-Action Alternative, and CP2 (contd.)

		Existing Condition	CP2 (2005)		No-Action Alternative	CP2 (2030)	
Month	**Water Year**	**Flow (cfs)**	**Flow (cfs)**	**Percent Change**	**Flow (cfs)**	**Flow (cfs)**	**Percent Change**
August	Average	4,322	4,343	0	4,335	4,357	1
	W	5,302	5,313	0	5,097	5,091	0
	AN	4,000	4,000	0	4,000	4,000	0
	BN	4,000	4,000	0	4,002	4,000	0
	D	3,906	3,895	0	4,142	4,198	1
	C	3,520	3,655	4	3,699	3,782	2
September	Average	9,841	9,845	0	9,844	9,882	0
	W	19,695	19,670	0	19,702	19,713	0
	AN	11,784	11,771	0	11,849	11,836	0
	BN	3,876	3,878	0	3,913	3,932	0
	D	3,508	3,554	1	3,442	3,591	4
	C	3,008	3,033	1	3,005	3,008	0
October	Average	6,067	6,081	0	6,000	6,000	0
	W	7,926	7,872	-1	7,633	7,550	-1
	AN	5,309	5,334	0	5,476	5,546	1
	BN	5,479	5,551	1	5,502	5,510	0
	D	5,228	5,250	0	5,236	5,243	0
	C	4,741	4,815	2	4,714	4,804	2
November	Average	11,706	11,549	-1	11,675	11,500	-1
	W	17,717	17,588	-1	17,715	17,488	-1
	AN	12,667	11,996	-5	12,491	11,965	-4
	BN	8,543	8,501	0	8,686	8,586	-1
	D	8,482	8,483	0	8,414	8,375	0
	C	6,250	6,173	-1	6,150	6,150	0
December	Average	21,755	21,621	-1	21,745	21,471	-1
	W	44,974	44,605	-1	44,661	43,902	-2
	AN	18,581	18,426	-1	18,562	18,375	-1
	BN	12,219	12,041	-1	12,326	12,246	-1
	D	8,531	8,494	0	8,803	8,678	-1
	C	5,580	5,882	5	5,677	5,920	4

Note: A negative percentage change reflects a reduction in Delta outflow
Key:
AN = above-normal
BN = below-normal
C = critical
cfs = cubic feet per second
CP = Comprehensive Plan
D = dry
W = wet

Impact Aqua-18 (CP2): Effects to Delta Fisheries Resulting from Changes to Delta Inflow Based on the results of hydrologic modeling comparing Delta inflow under CP2 to the Existing Condition and No-Action Alternative, CP2 would not decrease average monthly Delta inflow by 5 percent or more in any year type. This impact on Delta fisheries and hydrologic transport processes within the Bay-Delta would be less than significant.

Results of the comparison of Delta inflows between the No-Action Alternative, Existing Condition, and CP2 are summarized by month and water year type in Table 11-24. Under CP2, Delta inflow would not decrease by more than 5 percent during any month compared to either the Existing Condition or the No-Action Alternative. Based on the results of this comparison, CP2 would have a less-than-significant effect on Delta fisheries and hydrologic transport processes within the Bay-Delta as a consequence of changes in Delta inflow. Mitigation for this impact is not needed, and thus not proposed.

Table 11-24. Delta Inflow Under the Existing Condition, No-Action Alternative, and CP2

		Existing Condition	CP2 (2005)		No-Action Alternative	CP2 (2030)	
Month	**Water Year**	**Flow (cfs)**	**Flow (cfs)**	**Percent Change**	**Flow (cfs)**	**Flow (cfs)**	**Percent Change**
January	Average	47,426	47,218	0	47,457	47,194	-1
	W	89,431	89,103	0	89,328	88,690	-1
	AN	51,611	51,349	-1	51,267	51,113	0
	BN	27,269	27,305	0	27,576	27,603	0
	D	20,125	19,959	-1	20,371	20,094	-1
	C	16,699	16,457	-1	16,749	16,872	1
February	Average	57,835	57,676	0	57,623	57,385	0
	W	103,140	102,862	0	102,606	102,252	0
	AN	65,379	64,734	-1	65,574	64,768	-1
	BN	41,782	41,822	0	41,374	41,385	0
	D	26,530	26,473	0	26,431	26,332	0
	C	17,818	18,017	1	17,958	18,035	0
March	Average	49,829	49,721	0	49,713	49,647	0
	W	87,688	87,726	0	87,703	87,793	0
	AN	61,498	61,010	-1	61,339	60,883	-1
	BN	30,569	30,281	-1	30,415	30,256	-1
	D	24,943	24,955	0	24,640	24,639	0
	C	15,933	15,916	0	15,896	15,895	0
April	Average	33,962	33,976	0	34,783	34,823	0
	W	58,684	58,688	0	60,017	60,025	0
	AN	35,588	35,578	0	36,738	36,745	0
	BN	25,351	25,447	0	26,403	26,429	0
	D	17,962	17,939	0	18,315	18,411	1
	C	12,817	12,837	0	12,635	12,707	1

Table 11-24. Delta Inflow Under the Existing Condition, No-Action Alternative, and CP2 (contd)

		Existing Condition	CP2 (2005)		No-Action Alternative	CP2 (2030)	
Month	Water Year	Flow (cfs)	Flow (cfs)	Percent Change	Flow (cfs)	Flow (cfs)	Percent Change
May	Average	27,383	27,305	0	27,091	27,021	0
	W	46,973	46,945	0	46,494	46,482	0
	AN	28,466	28,407	0	28,711	28,475	-1
	BN	20,747	20,382	-2	20,427	20,083	-2
	D	14,882	14,881	0	14,534	14,609	1
	C	10,347	10,360	0	10,038	10,110	1
June	Average	22,171	22,118	0	22,090	22,042	0
	W	35,459	35,457	0	35,172	35,190	0
	AN	23,124	22,687	-2	22,776	22,423	-2
	BN	16,884	16,985	1	16,941	17,008	0
	D	14,095	14,067	0	14,337	14,278	0
	C	10,710	10,713	0	10,694	10,695	0
July	Average	23,099	23,131	0	22,839	22,906	0
	W	27,442	27,453	0	27,496	27,491	0
	AN	25,169	25,083	0	25,065	25,033	0
	BN	23,282	23,292	0	23,362	23,288	0
	D	20,937	20,930	0	20,082	20,300	1
	C	14,647	14,929	2	14,048	14,311	2
August	Average	17,147	17,158	0	17,026	17,094	0
	W	20,235	20,253	0	20,154	20,148	0
	AN	18,784	18,762	0	18,927	18,941	0
	BN	18,274	18,171	-1	18,297	18,232	0
	D	15,066	15,288	1	14,371	14,688	2
	C	10,626	10,472	-1	10,850	10,913	1
September	Average	20,946	21,074	1	21,145	21,396	1
	W	31,918	31,921	0	32,428	32,422	0
	AN	23,912	23,931	0	24,747	24,859	0
	BN	16,518	16,518	0	16,563	16,592	0
	D	14,440	14,839	3	14,233	15,081	6
	C	9,130	9,383	3	8,809	9,118	4
October	Average	14,407	14,455	0	14,175	14,260	1
	W	17,072	16,986	-1	16,558	16,547	0
	AN	13,176	13,416	2	13,223	13,412	1
	BN	14,044	14,203	1	14,159	14,175	0
	D	13,133	13,270	1	12,846	13,115	2
	C	12,196	12,079	-1	11,976	11,968	0

Table 11-24. Delta Inflow Under the Existing Condition, No-Action Alternative, and CP2 (contd.)

		Existing Condition	CP2 (2005)		No-Action Alternative	CP2 (2030)	
Month	**Water Year**	**Flow (cfs)**	**Flow (cfs)**	**Percent Change**	**Flow (cfs)**	**Flow (cfs)**	**Percent Change**
November	Average	19,512	19,583	0	19,463	19,510	0
	W	26,429	26,528	0	26,536	26,428	0
	AN	20,269	19,859	-2	20,052	19,788	-2
	BN	16,984	17,053	0	16,980	16,986	0
	D	15,771	16,039	2	15,705	16,074	2
	C	12,330	12,530	2	12,081	12,339	0
December	Average	30,984	30,850	0	30,988	30,692	-1
	W	53,758	53,401	-1	53,516	52,765	-1
	AN	28,431	28,303	0	28,223	28,079	-1
	BN	21,958	21,784	-1	22,143	22,046	0
	D	18,560	18,520	0	18,837	18,696	-1
	C	13,363	13,607	2	13,484	13,560	1

Note: A negative percentage change reflects a reduction in Delta inflow

Key:
AN = above-normal
BN = below-normal
C = critical
cfs = cubic feet per second
CP = Comprehensive Plan
D = dry
W = wet

Impact Aqua-19 (CP2): Effects to Delta Fisheries Resulting from Changes in Sacramento River Inflow CP2 operation would result in a variable response in Sacramento River inflow, resulting in both increases and decreases in river flow above basis-of-comparison conditions depending on month and water year type. Decreases in Sacramento River inflow would not equal or exceed 5 percent. This impact would be less than significant.

Results of hydrologic modeling, by month and water year type, for the Existing Condition, No-Action Alternative, and CP2 for Sacramento River inflow are presented in Table 11-25. Results of these analyses show a variable response in Sacramento River inflow with CP2 operations resulting in both increases and decreases in river inflow above the Existing Condition and the No-Action Alternative, depending on month and water year type. Under CP2, Sacramento River inflow would not decrease by 5 percent or more. Based on these results the impact of CP2 on fish habitat and transport mechanisms within the lower Sacramento River and Delta would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

Table 11-25. Sacramento River Inflow Under the Existing Condition, No-Action Alternative, and CP2

		Existing Condition	CP2 (2005)		No-Action Alternative	CP2 (2030)	
Month	**Water Year**	**Flow (cfs)**	**Flow (cfs)**	**Percent Change**	**Flow (cfs)**	**Flow (cfs)**	**Percent Change**
January	Average	31,139	31,061	0	31,167	31,107	0
	W	50,173	50,083	0	50,164	49,991	0
	AN	38,122	38,034	0	38,006	37,988	0
	BN	22,370	22,485	1	22,540	22,649	0
	D	16,980	16,886	-1	17,109	16,929	-1
	C	14,384	14,145	-2	14,322	14,442	1
February	Average	36,608	36,596	0	36,618	36,563	0
	W	56,740	56,796	0	56,637	56,659	0
	AN	44,453	44,029	-1	44,672	44,176	-1
	BN	30,911	31,054	0	30,780	30,923	0
	D	21,249	21,192	0	21,237	21,120	-1
	C	14,830	15,028	1	15,075	15,152	1
March	Average	32,396	32,332	0	32,352	32,319	0
	W	49,248	49,293	0	49,403	49,461	0
	AN	44,060	43,860	0	43,972	43,783	0
	BN	23,188	22,900	-1	23,068	22,928	-1
	D	20,390	20,400	0	20,138	20,135	0
	C	12,971	12,954	0	12,942	12,941	0
April	Average	23,232	23,246	0	23,206	23,247	0
	W	37,918	37,923	0	38,019	38,030	0
	AN	26,053	26,044	0	26,039	26,049	0
	BN	17,518	17,613	1	17,439	17,465	0
	D	13,205	13,182	0	13,164	13,261	1
	C	10,295	10,314	0	10,067	10,140	1
May	Average	19,417	19,341	0	19,114	19,046	0
	W	32,095	32,075	0	31,800	31,795	0
	AN	21,204	21,145	0	21,080	20,843	-1
	BN	14,530	14,166	-3	14,144	13,801	-2
	D	11,226	11,225	0	10,836	10,911	1
	C	8,148	8,161	0	7,874	7,946	1
June	Average	16,508	16,455	0	16,511	16,462	0
	W	24,092	24,089	0	23,905	23,920	0
	AN	16,598	16,160	-3	16,533	16,179	-2
	BN	13,792	13,894	1	13,822	13,889	0
	D	12,283	12,256	0	12,569	12,509	0
	C	9,492	9,494	0	9,516	9,517	0
July	Average	19,518	19,551	0	19,266	19,333	0
	W	20,071	20,081	0	20,058	20,052	0
	AN	22,070	21,983	0	21,976	21,942	0
	BN	21,232	21,242	0	21,374	21,301	0
	D	19,577	19,571	0	18,788	19,006	1
	C	13,683	13,964	2	13,100	13,363	2
August	Average	14,710	14,721	0	14,596	14,663	0
	W	16,285	16,303	0	16,189	16,182	0
	AN	16,418	16,396	0	16,561	16,574	0
	BN	16,112	16,010	-1	16,170	16,106	0
	D	13,632	13,855	2	12,968	13,284	2
	C	9,570	9,416	-2	9,785	9,847	1

Table 11-25. Sacramento River Inflow Under the Existing Condition, No-Action Alternative, and CP2 (contd.)

		Existing Condition	CP2 (2005)		No-Action Alternative	CP2 (2030)	
Month	**Water Year**	**Flow (cfs)**	**Flow (cfs)**	**Percent Change**	**Flow (cfs)**	**Flow (cfs)**	**Percent Change**
September	Average	18,211	18,338	1	18,417	18,667	1
	W	27,839	27,841	0	28,337	28,331	0
	AN	21,244	21,262	0	22,088	22,200	1
	BN	14,088	14,088	0	14,147	14,175	0
	D	12,522	12,915	3	12,341	13,189	7
	C	7,664	7,917	3	7,347	7,655	4
October	Average	11,309	11,401	1	11,117	11,210	1
	W	13,419	13,472	0	13,040	13,056	0
	AN	10,499	10,738	2	10,571	10,760	2
	BN	11,053	11,211	1	11,195	11,211	0
	D	10,150	10,287	1	9,830	10,100	3
	C	9,587	9,471	-1	9,333	9,325	0
November	Average	15,640	15,735	1	15,605	15,699	1
	W	20,726	20,893	1	20,832	20,854	0
	AN	16,893	16,497	-2	16,666	16,449	-1
	BN	13,755	13,823	0	13,793	13,798	0
	D	12,720	12,988	2	12,723	13,091	3
	C	9,948	10,149	2	9,653	9,911	3
December	Average	23,248	23,227	0	23,229	23,124	0
	W	37,645	37,487	0	37,434	37,188	-1
	AN	22,604	22,586	0	22,461	22,378	0
	BN	16,930	16,956	0	17,103	17,134	0
	D	15,760	15,720	0	15,934	15,793	-1
	C	11,303	11,547	2	11,310	11,386	1

Note: A negative percentage change reflects a reduction in Sacramento River inflow
Key:
AN = above-normal
BN = below-normal
C = critical
cfs = cubic feet per second
CP = Comprehensive Plan
D = dry
W = wet

Impact Aqua-20 (CP2): Effects to Delta Fisheries Resulting from Changes in San Joaquin River Flow at Vernalis CP2 operation would result in no discernible change in San Joaquin River flows at Vernalis, and therefore no impact to Delta fisheries or transport mechanisms within the lower San Joaquin River and Delta would occur under CP2 relative to the No-Action Alternative or Existing Condition. There would be no impact.

Results of hydrologic modeling, by month and water year type, for the Existing Condition, No-Action Alternative, and CP2 for San Joaquin River flow are summarized in Table 11-26. Results of these analyses show that the proposed CP2 would have no effect on seasonal San Joaquin River flows compared with the Existing Condition and No-Action Alternative. Based on these results CP2 would have no impact on Delta fisheries or transport mechanisms within the lower San Joaquin River and Delta. Mitigation for this impact is not needed, and thus not proposed.

Table 11-26. San Joaquin River Flow at Vernalis Under the Existing Condition and CP2

		Existing Condition	CP2 (2005)		No-Action Alternative	CP2 (2030)	
Month	**Water Year**	**Flow (cfs)**	**Flow (cfs)**	**Percent Change**	**Flow (cfs)**	**Flow (cfs)**	**Percent Change**
January	Average	4,770	4,770	0	4,764	4,764	0
	W	9,273	9,273	0	9,097	9,097	0
	AN	4,223	4,223	0	4,259	4,259	0
	BN	2,986	2,986	0	3,081	3,081	0
	D	2,084	2,084	0	2,160	2,160	0
	C	1,673	1,673	0	1,746	1,746	0
February	Average	6,265	6,265	0	6,143	6,143	0
	W	11,036	11,036	0	10,845	10,845	0
	AN	6,047	6,047	0	6,179	6,179	0
	BN	5,767	5,767	0	5,565	5,565	0
	D	2,642	2,642	0	2,528	2,528	0
	C	2,161	2,161	0	2,014	2,014	0
March	Average	7,133	7,133	0	7,003	7,003	0
	W	13,443	13,443	0	13,170	13,170	0
	AN	6,788	6,788	0	6,674	6,673	0
	BN	5,322	5,322	0	5,293	5,293	0
	D	2,963	2,963	0	2,895	2,895	0
	C	2,176	2,176	0	2,129	2,129	0
April	Average	6,720	6,720	0	7,533	7,533	0
	W	11,420	11,420	0	12,614	12,614	0
	AN	6,671	6,671	0	7,799	7,798	0
	BN	5,852	5,852	0	6,910	6,910	0
	D	3,726	3,726	0	4,112	4,112	0
	C	2,087	2,087	0	2,118	2,118	0
May	Average	6,204	6,204	0	6,234	6,234	0
	W	11,268	11,268	0	11,135	11,135	0
	AN	5,611	5,611	0	5,987	5,987	0
	BN	5,010	5,010	0	5,108	5,108	0
	D	3,070	3,070	0	3,111	3,111	0
	C	1,920	1,920	0	1,862	1,862	0
June	Average	4,739	4,739	0	4,671	4,671	0
	W	9,451	9,451	0	9,390	9,390	0
	AN	5,608	5,609	0	5,326	5,326	0
	BN	2,424	2,424	0	2,471	2,470	0
	D	1,598	1,598	0	1,554	1,554	0
	C	1,076	1,076	0	1,035	1,035	0

Table 11-26. San Joaquin River Flow at Vernalis Under the Existing Condition and CP2 (contd.)

		Existing Condition	CP2 (2005)		No-Action Alternative	CP2 (2030)	
Month	Water Year	Flow (cfs)	Flow (cfs)	Percent Change	Flow (cfs)	Flow (cfs)	Percent Change
July	Average	3,202	3,202	0	3,208	3,208	0
	W	6,556	6,556	0	6,660	6,660	0
	AN	2,783	2,784	0	2,767	2,768	0
	BN	1,775	1,775	0	1,733	1,733	0
	D	1,282	1,282	0	1,216	1,216	0
	C	898	898	0	880	880	0
August	Average	2,029	2,029	0	2,040	2,041	0
	W	3,099	3,099	0	3,158	3,159	0
	AN	2,020	2,020	0	2,014	2,015	0
	BN	1,828	1,828	0	1,817	1,816	0
	D	1,342	1,342	0	1,315	1,315	0
	C	984	984	0	993	993	0
September	Average	2,331	2,331	0	2,340	2,340	0
	W	3,274	3,274	0	3,317	3,317	0
	AN	2,328	2,328	0	2,312	2,312	0
	BN	2,109	2,109	0	2,119	2,119	0
	D	1,795	1,795	0	1,774	1,775	0
	C	1,358	1,358	0	1,355	1,355	0
October	Average	2,757	2,757	0	2,753	2,753	0
	W	3,112	3,112	0	3,107	3,107	0
	AN	2,446	2,446	0	2,424	2,424	0
	BN	2,749	2,749	0	2,718	2,718	0
	D	2,686	2,686	0	2,710	2,710	0
	C	2,416	2,416	0	2,423	2,423	0
November	Average	2,633	2,633	0	2,603	2,603	0
	W	3,372	3,372	0	3,340	3,340	0
	AN	2,213	2,213	0	2,176	2,176	0
	BN	2,412	2,412	0	2,360	2,360	0
	D	2,388	2,388	0	2,355	2,355	0
	C	2,075	2,075	0	2,088	2,088	0

Table 11-26. San Joaquin River Flow at Vernalis Under the Existing Condition and CP2 (contd.)

		Existing Condition	CP2 (2005)		No-Action Alternative	CP2 (2030)	
Month	Water Year	Flow (cfs)	Flow (cfs)	Percent Change	Flow (cfs)	Flow (cfs)	Percent Change
December	Average	3,199	3,199	0	3,263	3,263	0
	W	5,081	5,081	0	5,178	5,178	0
	AN	2,916	2,916	0	2,899	2,899	0
	BN	2,705	2,705	0	2,753	2,753	0
	D	2,047	2,047	0	2,123	2,123	0
	C	1,710	1,710	0	1,785	1,785	0

Note:
A negative percentage change reflects a reduction in San Joaquin River flow.

Key:
AN = above-normal
BN = below-normal
C = critical
cfs = cubic feet per second
CP = Comprehensive Plan
D = dry
W = wet

Impact Aqua-21 (CP2): Reduction in Low-Salinity Habitat Conditions Resulting from an Upstream Shift in X2 Location CP2 operation would result in less than 0.5 km movement upstream or downstream from the X2 location from its location during February through May or September through November under the Existing Condition or No-Action Alternative, and thus cause minimal reduction in low-salinity habitats. This impact would be less than significant.

Results of the comparison of X2 position under the Existing Condition, No-Action Alternative, and CP2 are summarized in Table 11-27. The results showed that changes in X2 location under CP2 as compared with the Existing Condition during February through May and September through November would be less than 1 km (all were less than 0.3 km) with both variable upstream and downstream movement of the X2 location, depending on month and water year type. Changes in X2 location between the No-Action Alternative and CP2 assuming future operating conditions would also be small (less than 0.4 km). These results are consistent with model results for Delta outflow that showed a less-than-significant change in flows. Based on these results, CP2 would have a less-than-significant impact on low-salinity habitat conditions within the Bay-Delta. Mitigation for this impact is not needed, and thus not proposed.

Table 11-27. X2 Under the Existing Condition, No-Action Alternative, and CP2

		Existing Condition	CP2 (2005)		No-Action Alternative	CP2 (2030)	
Month	**Water Year**	**Location (km)**	**Location (km)**	**Difference (km)**	**Location (km)**	**Location (km)**	**Difference (km)**
January	Average	67.5	67.5	0.0	67.3	67.3	0.0
	W	53.6	53.7	0.0	53.7	53.7	0.1
	AN	61.7	61.7	0.0	61.6	61.5	0.0
	BN	72.1	72.0	-0.1	71.7	71.6	-0.1
	D	77.9	78.0	0.1	77.4	77.6	0.2
	C	82.2	82.2	0.0	81.9	81.8	-0.1
February	Average	60.9	60.9	0.0	60.8	60.9	0.0
	W	50.4	50.4	0.0	50.4	50.4	0.0
	AN	54.8	54.8	0.0	54.6	54.6	0.1
	BN	61.0	60.9	0.0	60.9	60.9	0.0
	D	70.1	70.1	0.0	69.9	70.0	0.0
	C	76.2	76.2	0.0	75.9	76.1	0.2
March	Average	60.9	60.9	0.0	60.9	60.9	0.0
	W	52.1	52.1	0.0	52.1	52.1	0.0
	AN	53.6	53.7	0.0	53.7	53.7	0.0
	BN	63.3	63.4	0.1	63.3	63.4	0.0
	D	67.1	67.0	-0.1	67.2	67.1	0.0
	C	75.2	75.3	0.1	75.1	75.1	0.1
April	Average	63.5	63.5	0.0	63.4	63.4	0.0
	W	54.5	54.5	0.0	54.3	54.3	0.0
	AN	58.6	58.6	0.0	58.4	58.4	0.0
	BN	64.5	64.5	0.0	64.1	64.1	0.0
	D	69.9	69.9	0.0	69.9	69.8	-0.1
	C	77.5	77.5	0.0	77.6	77.6	0.0
May	Average	67.5	67.5	0.0	67.7	67.7	0.0
	W	57.6	57.6	0.0	57.7	57.7	0.0
	AN	62.7	62.7	0.0	62.6	62.6	0.1
	BN	68.3	68.4	0.1	68.3	68.4	0.1
	D	74.4	74.4	0.0	74.8	74.7	-0.1
	C	82.5	82.5	0.0	82.9	82.8	-0.1
June	Average	74.5	74.6	0.0	74.7	74.7	0.0
	W	65.0	65.0	0.0	65.2	65.2	0.0
	AN	72.6	72.8	0.2	72.7	72.8	0.1
	BN	76.6	76.6	0.0	76.7	76.8	0.1
	D	80.4	80.5	0.0	80.7	80.7	0.0
	C	85.9	85.9	0.0	86.0	86.0	0.0

Table 11-27. X2 Under the Existing Condition, No-Action Alternative, and CP2 (contd.)

		Existing Condition	CP2 (2005)		No-Action Alternative	CP2 (2030)	
Month	**Water Year**	**Location (km)**	**Location (km)**	**Difference (km)**	**Location (km)**	**Location (km)**	**Difference (km)**
July	Average	80.5	80.5	0.0	80.5	80.5	0.0
	W	74.4	74.4	0.0	74.5	74.5	0.0
	AN	78.1	78.2	0.1	78.4	78.4	0.1
	BN	81.7	81.7	0.0	81.6	81.6	0.0
	D	84.8	84.9	0.0	84.8	84.8	0.0
	C	88.1	88.1	0.0	88.0	88.0	0.0
August	Average	85.6	85.6	0.0	85.6	85.5	0.0
	W	82.7	82.6	0.0	82.8	82.8	0.0
	AN	83.7	83.8	0.0	83.9	83.9	0.0
	BN	85.6	85.6	0.0	85.5	85.4	0.0
	D	87.8	87.8	0.0	87.5	87.5	0.0
	C	90.4	90.3	-0.1	90.2	90.2	0.0
September	Average	83.7	83.7	0.0	83.7	83.6	0.0
	W	73.4	73.4	0.0	73.5	73.5	0.0
	AN	81.4	81.4	0.0	81.4	81.4	0.0
	BN	88.8	88.8	0.0	88.8	88.8	0.0
	D	90.2	90.2	0.0	90.0	89.9	-0.1
	C	92.5	92.4	-0.1	92.3	92.3	0.0
October	Average	83.9	83.9	0.0	83.9	83.9	0.0
	W	73.6	73.6	0.0	73.7	73.7	0.0
	AN	79.8	79.8	0.0	79.8	79.8	0.0
	BN	88.9	88.9	0.0	88.9	88.9	0.0
	D	91.4	91.4	0.0	91.3	91.2	-0.1
	C	93.3	93.2	-0.1	93.1	93.0	-0.1
November	Average	82.2	82.3	0.1	82.2	82.3	0.1
	W	73.1	73.1	0.0	73.2	73.2	0.0
	AN	78.4	78.4	0.0	78.4	78.5	0.1
	BN	84.8	85.3	0.5	84.8	85.2	0.4
	D	88.9	89.0	0.0	88.8	88.9	0.1
	C	92.6	92.7	0.0	92.8	92.6	-0.1

Table 11-27. X2 Under the Existing Condition, No-Action Alternative, and CP2 (contd.)

		Existing Condition	CP2 (2005)		No-Action Alternative	CP2 (2030)	
Month	**Water Year**	**Location (km)**	**Location (km)**	**Difference (km)**	**Location (km)**	**Location (km)**	**Difference (km)**
December	Average	76.1	76.2	0.1	76.0	76.0	0.0
	W	62.9	63.0	0.1	63.0	63.1	0.1
	AN	76.4	76.7	0.3	76.4	76.6	0.2
	BN	81.4	81.3	0.0	81.1	81.1	0.0
	D	82.8	82.9	0.1	82.6	82.7	0.1
	C	87.9	87.9	0.0	87.8	87.7	-0.1

Key:
AN = above-normal
BN = below-normal
C = critical
CP = Comprehensive Plan
D = dry
km = kilometer
W = wet

Impact Aqua-22 (CP2): Increase in Mortality of Species of Primary Management Concern as a Result of Increased Reverse Flows in the Old and Middle Rivers CP2 operation would result in minimal changes to reverse flows in Old and Middle rivers. The increases in reverse flows under CP2 would not be expected to contribute to an increase in the vulnerability of Chinook salmon, delta smelt, longfin smelt striped bass, threadfin shad, and other resident warm-water fish to increased salvage and potential losses because the flows do not exceed (become more negative) -5,000 cfs. This impact would be less than significant.

Results of the analysis showed two occurrences relative to the Existing Condition when reverse flows within Old and Middle rivers would increase by more than 5 percent. Based on results of the delta smelt analysis of the relationship between reverse flows and delta smelt salvage in March, the increased reverse flows from approximately -4,000 cfs to -4,200 cfs in above-normal water years, and around -2,000 to -2,100 in critical water years would not be expected to result in a significant increase in adverse effects to delta smelt (Table 11-28). Additionally, given the tidal volumes and hydrodynamics of the Old and Middle river region, it is not expected that the change in reverse flows in March would result in detectable changes in fish survival, including for Chinook salmon, striped bass, and other anadromous and resident warm-water fishes.

Table 11-28. Old and Middle River Reverse Flows for the Existing Condition, No-Action Alternative, and CP1

		Existing Condition	CP2 (2005)		No-Action Alternative	CP2 (2030)	
Month	**Water Year**	**Flow (cfs)**	**Flow (cfs)**	**Percent Change**	**Flow (cfs)**	**Flow (cfs)**	**Percent Change**
January	Average	-3,542	-3,550	0	-3,553	-3,566	0
	W	-2,034	-2,034	0	-2,151	-2,151	0
	AN	-3,654	-3,598	-2	-3,574	-3,479	-3
	BN	-4,240	-4,240	0	-4,240	-4,240	0
	D	-4,773	-4,813	1	-4,772	-4,771	0
	C	-4,033	-4,086	1	-3,940	-4,122	5
February	Average	-3,293	-3,289	0	-3,358	-3,351	0
	W	-2,745	-2,735	0	-2,950	-2,970	1
	AN	-3,248	-3,011	-7	-3,165	-3,142	-1
	BN	-3,335	-3,401	2	-3,291	-3,195	-3
	D	-4,016	-4,028	0	-4,045	-4,065	0
	C	-3,391	-3,527	4	-3,482	-3,497	0
March	Average	-2,784	-2,814	1	-2,877	-2,867	0
	W	-1,792	-1,786	0	-2,023	-2,044	1
	AN	-4,021	-4,230	5	-4,260	-4,282	1
	BN	-4,005	-4,015	0	-3,982	-3,979	0
	D	-2,951	-2,873	-3	-2,918	-2,834	-3
	C	-2,023	-2,136	6	-1,994	-1,985	0
April	Average	955	954	0	1,060	1,061	0
	W	2,706	2,706	0	2,798	2,806	0
	AN	1,087	1,087	0	1,314	1,314	0
	BN	697	697	0	898	898	0
	D	-244	-247	1	-207	-214	4
	C	-874	-874	0	-872	-872	0
May	Average	491	490	0	416	409	-2
	W	2,077	2,077	0	1,781	1,781	0
	AN	562	562	0	646	646	0
	BN	277	277	0	270	270	0
	D	-674	-674	0	-696	-696	0
	C	-1,018	-1,028	1	-936	-984	5
June	Average	-3,654	-3,669	0	-3,718	-3,734	0
	W	-4,226	-4,226	0	-4,354	-4,360	0
	AN	-4,825	-4,819	0	-4,818	-4,818	0
	BN	-4,137	-4,233	2	-4,119	-4,227	3
	D	-3,079	-3,079	0	-3,205	-3,184	-1
	C	-1,542	-1,542	0	-1,542	-1,542	0

Table 11-28. Old and Middle River Reverse Flows for the Existing Condition, No-Action Alternative, and CP1 (contd.)

		Existing Condition	CP1 (2005)		No-Action Alternative	CP1 (2030)	
Month	Water Year	Flow (cfs)	Flow (cfs)	Percent Change	Flow (cfs)	Flow (cfs)	Percent Change
July	Average	-9,502	-9,526	0	-9,292	-9,361	1
	W	-8,948	-8,946	0	-8,905	-8,903	0
	AN	-9,993	-9,935	-1	-9,929	-9,918	0
	BN	-10,886	-10,888	0	-10,903	-10,826	-1
	D	-10,998	-10,992	0	-10,419	-10,638	2
	C	-6,355	-6,588	4	-5,928	-6,168	4

Note:
A positive percentage change reflects more negative reverse flows under CP5 when compared to the Existing Condition or the No-Action Alternative.
Key:
AN = above-normal
BN = below-normal
C = critical
cfs = cubic feet per second
CP = Comprehensive Plan
D = dry
W = wet

Juvenile Chinook salmon and steelhead migrate through the Delta during January, and an increase in average monthly reverse flows of 100 to 200 cfs would be expected to increase the potential risk of increased mortality to these species. However, given the tidal volumes and hydrodynamics of the Old and Middle river region, it is not expected that the change in reverse flows in January in a critical year would result in a detectable change in fish survival. The majority of juvenile Chinook salmon emigrating from the San Joaquin River typically migrate downstream later in dry years and would not be expected to occur in high numbers within Old and Middle rivers in January. Delta smelt would not be significantly affected by the slight increase in reverse flows in January because their presence in the region is minimal during this time. Longfin smelt larvae, however, are present in January, particularly in critical years, however, reverse flows do not exceed (become more negative) -5,000 cfs, and therefore, do not constitute a significant impact to longfin smelt.

Under 2030 conditions, the increase in reverse flows estimated to occur under CP2 in critical water years in May would be 5 percent, but the flows are less than 1,000 cfs. The increased reverse flows in May of critical water years occurred at a time of the year when water temperatures in the Delta were elevated and juvenile Chinook salmon or steelhead could occur in the area in high numbers. However, changes to reverse flows in March and May would not exceed the -5,000 cfs criteria established by the USFWS and NMFS BOs, and would result in less-than-significant impacts to Chinook salmon and steelhead.

Juvenile delta smelt may occur in the area in May; however a change in Old and Middle rivers flow of approximately 100 to 200 cfs may result in a small increase in their vulnerability to CVP and SWP salvage, but this increase is expected to be less than significant. As water temperatures increase in the Delta during May, the majority of delta smelt move towards Suisun Bay where temperatures are more suitable. The increase in reverse flows in May of a critical year would be expected to contribute to a small increase in the vulnerability of juvenile striped bass, threadfin shad, and other resident warm-water fish to increased salvage and potential losses as a result of increased reverse flows. The increased reverse flows in low-flow years would be expected to result in a low, but potentially significant, increase in mortality for resident warm-water fish inhabiting the south Delta under CP2.

The potential increase in losses relative to the Existing Conditions during March and No-Action Alternative during January and May is considered to be less than significant. Mitigation for this impact is not proposed because operations will be guided by RPAs established by NMFS and USFWS BOs to reduce any impacts to listed fish species.

Impact Aqua-23 (CP2): Increase in the Risk of Entrainment or Salvage of Species of Primary Management Concern at CVP and SWP Export Facilities Due to Changes in CVP and SWP Exports CP2 operations may result in an increase in CVP and SWP exports, which is assumed to result in a direct proportional increase in the risk of fish being entrained and salvaged at the facilities. Future operations of the SWP and CVP export facilities would continue to be managed and regulated in accordance with incidental take limits established for each of the protected fish by USFWS, NMFS, and CDFW. The resulting impact to Chinook salmon, steelhead, and longfin smelt would be less than significant; the resulting impact to delta smelt, striped bass, and splittail would be potentially significant. Overall, this impact would be potentially significant.

Results of entrainment loss modeling at the CVP and SWP export facilities are presented in Table 11-29 for CP2. The estimated index of total numbers of fish lost annually, by species, are presented in Attachment 1 of the *Fisheries and Aquatic Ecosystems Technical Report.* The difference between fish losses under CP2 relative to the No-Action Alternative and the Existing Condition is represented as the entrainment index, shown in Table 11-29, to represent the effect of project operations on each fish species at the CVP and SWP facilities.

Table 11-29. Indices of Entrainment at the CVP and SWP Facilities Under the Existing Condition, No-Action Alternative, and CP2

Species	Water Year	CP2 Minus Existing Condition	Percent Change	CP2 Minus No-Action Alternative	Percent Change
Delta Smelt	Average	68	0.2	138	0.3
	W	-7	-0.0	21	0.0
	AN	-58	-0.1	-28	-0.1
	BN	273	0.8	255	0.7
	D	0	0.0	-19	-0.1
	C	219	0.9	656	2.9
Salmon	Average	77	0.1	83	0.2
	W	-20	-0.0	34	0.0
	AN	-118	-0.2	-84	-0.2
	BN	223	0.5	6	0.0
	D	-24	-0.1	-62	-0.1
	C	464	1.3	665	2.0
Longfin Smelt	Average	5	0.1	22	0.3
	W	-1	-0.0	-4	-0.0
	AN	1	0.0	0	-0.0
	BN	3	0.1	3	0.1
	D	1	0.0	2	0.0
	C	32	0.6	149	2.9
Steelhead	Average	7	0.2	-1	-0.0
	W	-3	-0.1	9	0.2
	AN	-30	-0.7	-17	-0.4
	BN	21	0.5	-25	-0.6
	D	-4	-0.1	-9	-0.3
	C	68	2.4	35	1.3
Striped Bass	Average	5,229	0.4	8,231	0.6
	W	1,762	0.1	2,140	0.1
	AN	-322	-0.0	2,527	0.2
	BN	10,781	0.8	7,230	0.5
	D	5,807	0.5	17,295	1.6
	C	10,946	1.8	14,704	2.5
Splittail	Average	766	0.3	1,247	0.5
	W	-33	-0.0	187	0.0
	AN	-737	-0.2	-88	-0.0
	BN	3,196	1.2	2,823	1.1
	D	13	0.0	1,479	0.7
	C	2,294	2.2	2,694	2.8

Note:
Negative percentage change reflects a reduction in entrainment risk while a positive percentage change reflects an increase in entrainment risk.
Key:
AN = above-normal
BN = below-normal
C = critical
CP = Comprehensive Plan
D = dry
W = wet

Results of the entrainment risk calculations for delta smelt showed a change of less than 1 percent from the Existing Condition in all water years (Table 11-29). The greatest increase in risk (0.9 percent) was estimated for CP2 in a critical year. The entrainment risk for delta smelt relative to the No-Action Alternative would increase in critical years by almost 3 percent (Table 11-29). Although the incremental change in the risk of delta smelt losses resulting from CVP and SWP export operations would be small, the delta smelt population abundance is currently at such critically low levels that even a small increase in the risk of losses is considered to be potentially significant. The increase in risk would also contribute to cumulative factors affecting the survival of delta smelt.

The estimated change in the risk of losses for Chinook salmon under CP2 follows a similar pattern to that described for delta smelt (Table 11-29). Overall, CP2 would result in a small increase in the risk of losses relative to both the Existing Condition and No-Action Alternative. The change in risk under CP2 would not exceed 2 percent in any year type as compared with the Existing Condition and the No-Action Alternative, and is considered to be less than significant. Given the numbers of juvenile Sacramento and San Joaquin river Chinook salmon produced each year in the Central Valley, the relatively small incremental increase in the risk of entrainment/salvage at the CVP and SWP export facilities is considered to be a less-than-significant direct impact but would contribute incrementally to the overall cumulative factors affecting juvenile Chinook salmon survival within the Delta and population dynamics of the stocks.

The estimated change in the risk of longfin smelt entrainment/salvage under CP2 compared with the Existing Condition and No-Action Alternative includes small positive and negative changes depending on water year type (Table 11-29). The increased risk of losses in drier years was considered to be potentially significant. These small changes in the risk of entrainment are considered to be less than significant in most water years, but potentially significant in critically dry years when juvenile longfin smelt production is typically low. The increased losses would also contribute to cumulative factors affecting survival of juvenile longfin smelt within the Delta.

The estimated change in the risk to steelhead of entrainment/salvage at the CVP and SWP export facilities under CP2 are summarized in Table 11-29. The small positive and negative changes in risk under most year types are considered to be less than significant. The increase in risk of steelhead losses in below-normal and critical water years (as compared with the Existing Condition) and in wet water years (as compared with the No-Action Alternative) is considered to be less than significant based on the abundance of juvenile Sacramento and San Joaquin river steelhead migrating through the Delta, but would contribute directly to cumulative factors affecting the survival and population dynamics of Central Valley steelhead. The increased risk of losses in drier years was considered to be potentially significant. The predicted increase in potential entrainment risk for steelhead under wet, below-normal, and critical water years represents an initial estimate of the change (percentage) between CP2 and the Existing Condition and the No-Action Alternative, and does not allow the predicted losses to be evaluated at the population level (see Attachment 1 of the *Fisheries and Aquatic Ecosystems Technical Report)*. The increased losses would also contribute to cumulative factors affecting survival of juvenile steelhead within the Delta.

The change in risk to juvenile striped bass for entrainment/salvage at the CVP and SWP export facilities is summarized in Table 11-29. The change in risk in all water years is considered to be less than significant for striped bass, but would contribute to the cumulative factors affecting striped bass survival and population dynamics in the Delta. The losses of juvenile striped bass increased substantially under dry and critical year conditions, which would be expected with an increase in exports during the summer months. The increased losses, particularly in drier water years when juvenile striped bass production is lower, would be expected to contribute to the cumulative effects of factors affecting juvenile striped bass survival in the Delta.

Results of the risk estimates for juvenile splittail losses show a pattern similar to other species (Table 11-29). The risk index would increase by less than 3 percent under CP2 compared to the Existing Condition or the No-Action Alternative. Higher risk of entrainment/salvage losses in drier water years has a potentially greater effect on abundance of juvenile splittail since reproductive success and overall juvenile abundance is typically lower within the Delta in dry years. The increased risk of losses in drier years was considered to be potentially significant. The increased losses would also contribute to cumulative factors affecting survival of juvenile splittail within the Delta.

Impact Aqua-23 (CP2) is considered to be less than significant for Chinook salmon, but potentially significant for delta smelt, steelhead, longfin smelt, striped bass, and splittail. Mitigation for this impact is not proposed because operations will be guided by RPAs established by NMFS and USFWS BOs to reduce any impacts to listed fish species, and will thus benefit non-listed fishes as well.

CVP/SWP Service Areas

Impact Aqua-24 (CP2): Impacts on Aquatic Habitats and Fish Populations in the CVP and SWP Service Areas Resulting from Modifications to Existing Flow Regimes CP2 implementation could result in modified flow regimes that would reduce the frequency and magnitude of high winter flows along the Sacramento River; however, the hydrologic effects in tributaries and reservoirs (e.g., New Melones and San Luis) with CVP and SWP dams are expected to be less than impacts on the lower Sacramento River. The change in hydrology could affect aquatic habitats for the local resident fish community. These changes are unlikely to result in substantial effects on the distribution or abundance of these species in the CVP and SWP service areas. Therefore, this impact would be less than significant.

This impact would be similar to Impact Aqua-24 (CP1). The impact could be greater because the increased reservoir capacity associated with a 12.5-foot raise compared to a 6.5-foot raise would allow for additional water volume (and flows) to be stored behind the raised dam. However, these changes are unlikely to result in substantial effects on the distribution or abundance of fish populations in the CVP and SWP service areas. The effects from CP2 on CVP and SWP reservoir elevations, filling, spilling, and planned releases, and the resulting flows downstream from those reservoirs would be small and well within range of variability that commonly occurs in these reservoirs and downstream, as described for Impact Aqua-24 (CP1). Therefore, this impact would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

CP3 – 18.5-Foot Dam Raise, Agricultural Water Supply Reliability and Anadromous Fish Survival

CP3 focuses on increasing agricultural water supply reliability while also increasing anadromous fish survival. This plan primarily consists of raising Shasta Dam by 18.5 feet, which, in combination with spillway modifications, would increase the height of the reservoir's full pool by 20.5 feet and enlarge the total storage capacity in the reservoir by 634,000 acre-feet. The existing TCD would also be extended to achieve efficient use of the expanded cold-water pool. Because CP3 focuses on increasing agricultural water supply reliability, none of the increased storage capacity in Shasta Reservoir would be reserved for increasing M&I deliveries. Operations for water supply, hydropower, and environmental and other regulatory requirements would be similar to existing operations, with the additional storage retained for water supply reliability and to expand the cold-water pool for downstream anadromous fisheries.

Simulations of CP3 did not involve any changes to the modeling logic for deliveries or flow requirements; all rules for water operations were updated to include the new storage, but were not otherwise changed.

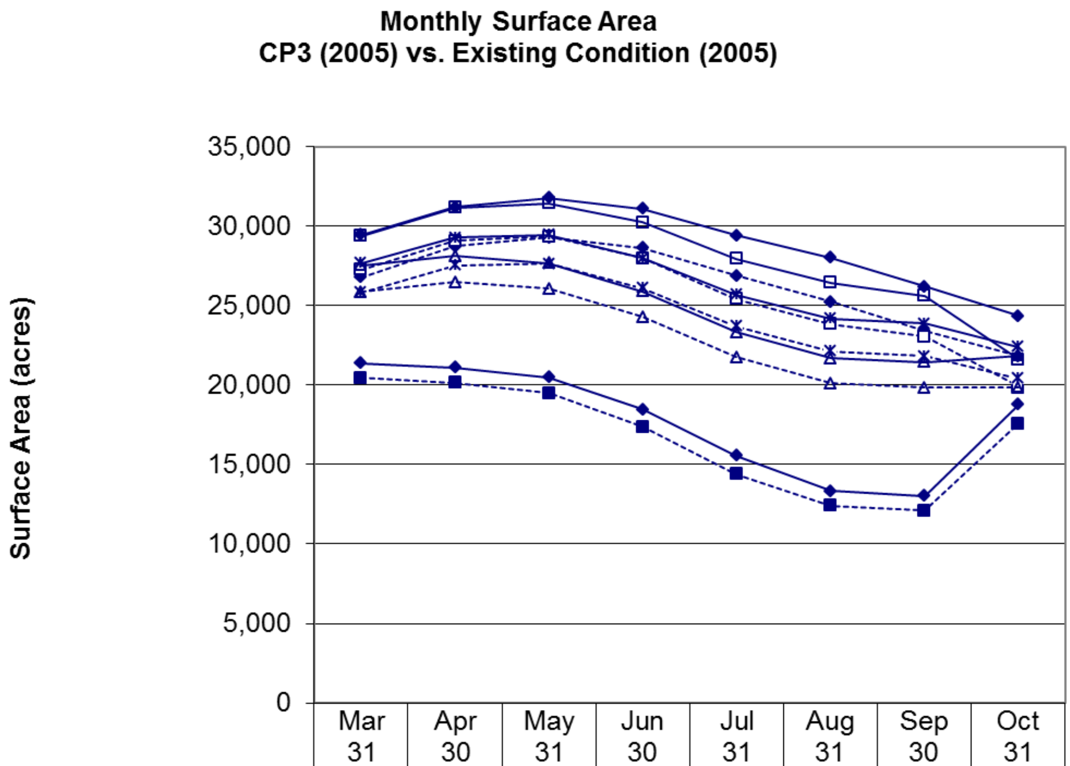
Shasta Lake and Vicinity

Impact Aqua-1 (CP3): Effects on Nearshore, Warm-Water Habitat in Shasta Lake from Project Operations Under CP3, project operations would contribute to an increase in the surface area and WSEL of Shasta Lake, which would in turn increase the area and productivity of nearshore, warm-water habitat. CP3 operations would also result in reduced monthly fluctuations in WSEL, which would contribute to increased reproductive success, young-of-the-year production, and the juvenile growth rate of warm-water fish species. Similar to CP-1, the value of existing structural habitat improvements would be diminished by deeper and longer periods of inundation to varying degrees; however, the existing habitat enhancement features would become functional during reservoir drawdowns later in the season and during below-normal and drier years, when the reservoir does not refill. Additionally, large areas of the shoreline would not be cleared, and the vegetation along these sections would be inundated periodically. In the short term, this newly inundated vegetation will initially increase warm-water fish habitat, with decay expected to occur over several decades. This impact would be less than significant.

This impact would be similar to Impacts Aqua-1 (CP1 and CP2), but the surface area would be larger under the 18.5-foot dam raise than under the 6.5-foot and 12.5-foot dam raises. CalSim-II modeling shows that the surface area of Shasta Lake would be larger under CP3 for both a 2005 and a 2030 water supply demand than under the Existing Condition or the No-Action Alternative in all five water year types (Figures 11-22 and 11-23).

Monthly WSEL fluctuations were compared with projections for water supply demand. For CP3, with a 2005 water supply demand, 52 percent of monthly changes in projected WSELs (i.e., 13 of the 25 total projections made for the 5 months from March through July for all five water year types) showed decreased monthly WSEL fluctuations relative to the Existing Condition and 4 percent showed increased monthly WSEL fluctuations (Figure 11-24). For CP3, with a projected 2030 water supply demand, 52 percent of monthly changes in projected WSELs showed decreased WSEL fluctuations relative to the No-Action Alternative and 4 percent showed increased monthly WSEL fluctuations (Figure 11-25). Under CP3, none of the changes in monthly WSEL fluctuation are different enough from the Existing Condition to warrant the investigation of daily WSEL fluctuation.

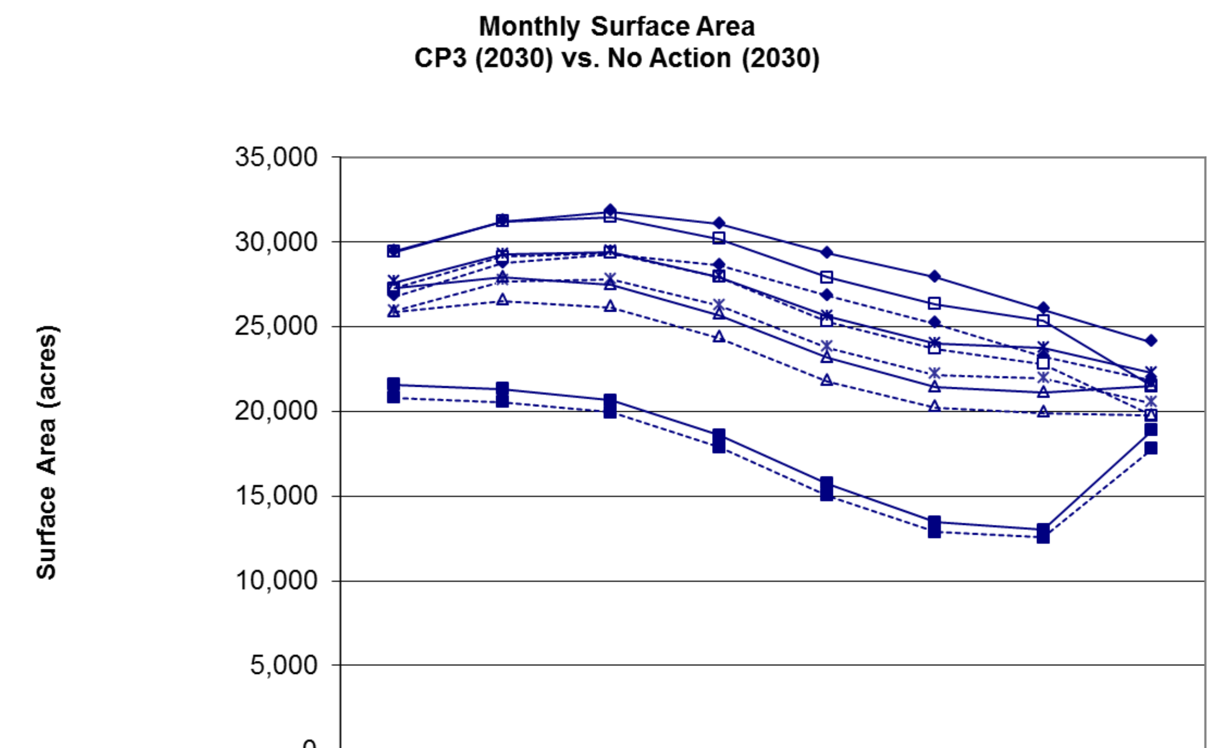
Increases in the overall surface area and WSEL under CP3 would increase the area of available warm-water habitat and stimulate biological productivity, including fish production, of the entire lake for a period of time, possibly for several decades. Furthermore, reductions in the magnitude of monthly WSEL fluctuations could contribute to increased reproductive success, young-of-the-year production, and juvenile growth rate of warm-water fish species. Therefore, this impact would be less than significant. Mitigation for this impact is not needed, and thus not proposed.



	Mar 31	Apr 30	May 31	Jun 30	Jul 31	Aug 31	Sep 30	Oct 31
EC W	26,790	28,748	29,277	28,624	26,872	25,226	23,413	21,827
EC AN	27,245	29,082	29,336	27,992	25,400	23,826	23,061	19,906
EC BN	25,807	27,534	27,621	26,104	23,714	22,114	21,837	20,425
EC D	25,850	26,467	26,058	24,300	21,754	20,093	19,840	19,828
EC C	20,467	20,142	19,500	17,381	14,400	12,418	12,111	17,572
CP3 2005 W	29,448	31,208	31,794	31,080	29,401	28,015	26,214	24,345
CP3 2005 AN	29,386	31,151	31,444	30,225	27,957	26,440	25,635	21,622
CP3 2005 BN	27,659	29,270	29,441	27,996	25,675	24,184	23,889	22,404
CP3 2005 D	27,536	28,121	27,669	25,892	23,340	21,666	21,430	21,859
CP3 2005 C	21,390	21,110	20,501	18,455	15,567	13,341	13,013	18,761

Key:
AN = above-normal water
BN= below-normal water years
C = critical water years
CP = Comprehensive Plan
EC = Existing Condition
D = dry water years
W = wet water years

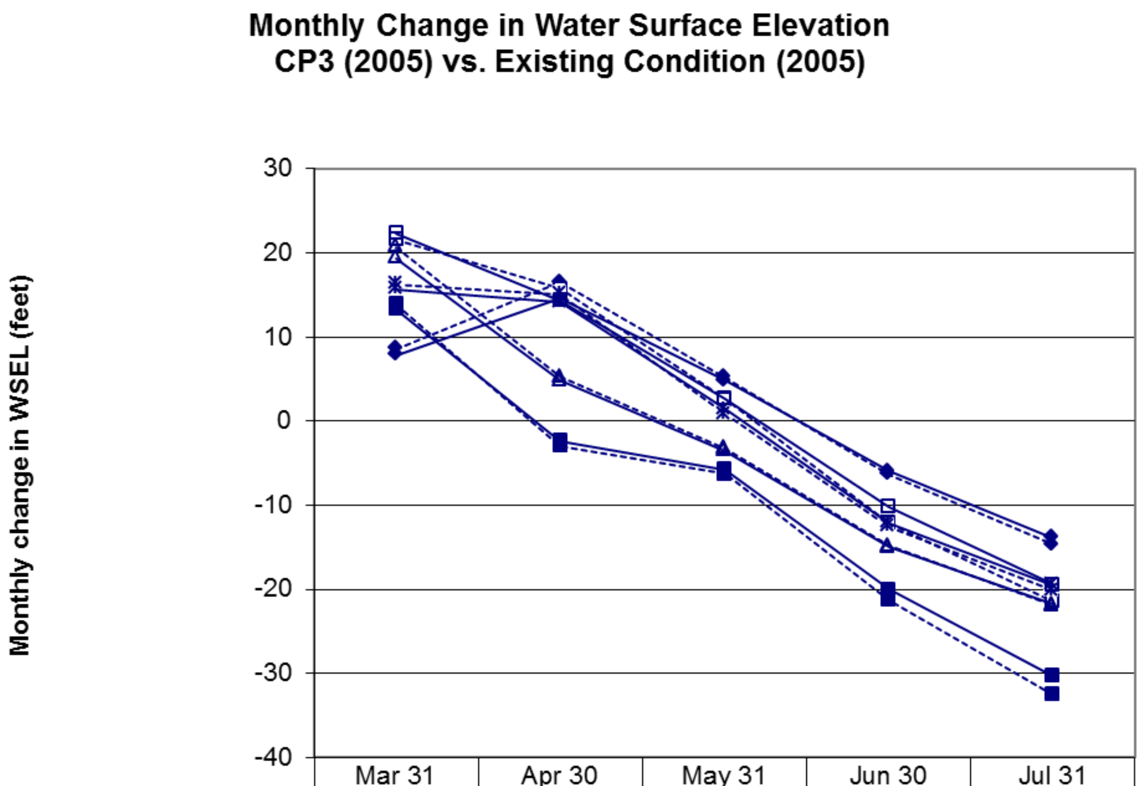
Figure 11-22. Average Monthly Surface Area for Each Water Year Type Within the Shasta Lake Vicinity of the Primary Study Area, CP3 Versus the Existing Condition



	Mar 31	Apr 30	May 31	Jun 30	Jul 31	Aug 31	Sep 30	Oct 31
NA W	26,775	28,735	29,273	28,604	26,797	25,183	23,205	21,808
NA AN	27,258	29,117	29,325	27,921	25,294	23,687	22,800	19,759
NA BN	25,918	27,662	27,770	26,239	23,764	22,137	21,923	20,469
NA D	25,843	26,514	26,134	24,346	21,780	20,209	19,910	19,728
NA C	20,801	20,548	19,942	17,866	15,026	12,873	12,556	17,800
CP3 2030 W	29,435	31,196	31,789	31,038	29,303	27,905	25,998	24,089
CP3 2030 AN	29,416	31,202	31,473	30,163	27,881	26,335	25,322	21,473
CP3 2030 BN	27,596	29,232	29,397	27,935	25,584	23,992	23,732	22,261
CP3 2030 D	27,290	27,887	27,450	25,672	23,146	21,416	21,087	21,492
CP3 2030 C	21,574	21,303	20,651	18,580	15,745	13,443	12,996	18,870

Key:
AN = above-normal water
BN= below-normal water years
C = critical water years
CP = Comprehensive Plan
D = dry water years
NA = No-Action
W = wet water years

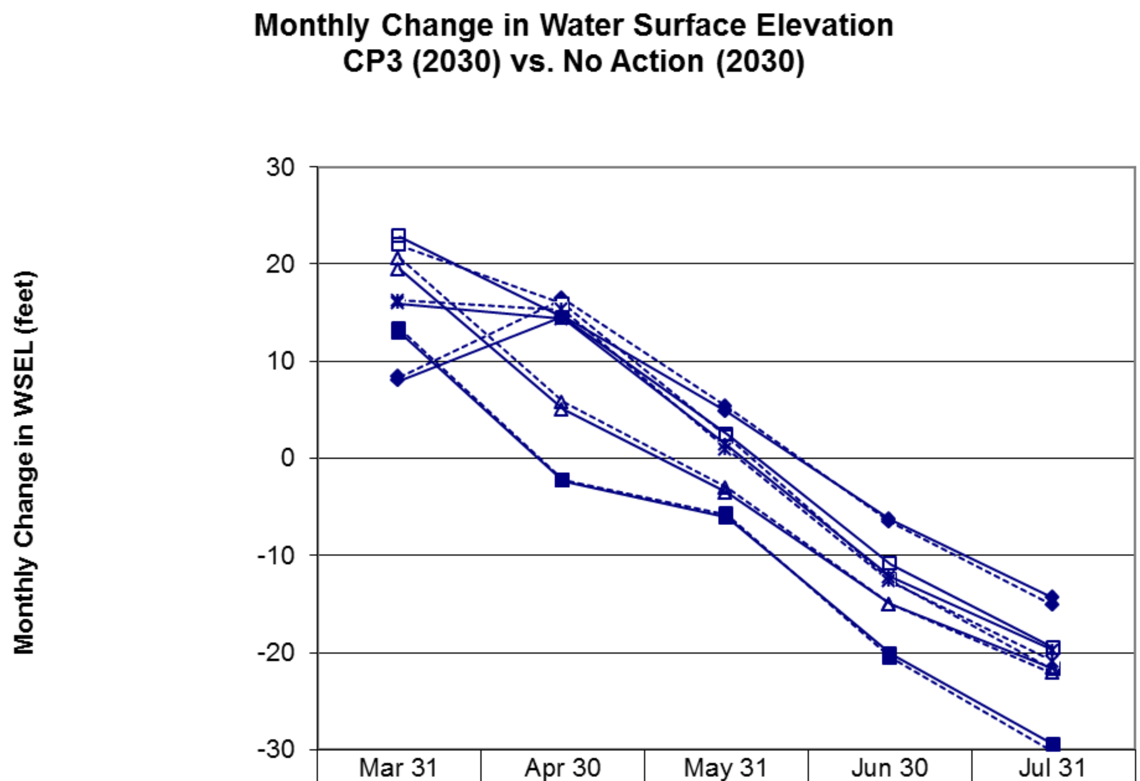
Figure 11-23. Average Monthly Surface Area for Each Water Year Type Within the Shasta Lake Vicinity of the Primary Study Area, CP3 Versus No-Action Alternative



	Mar 31	Apr 30	May 31	Jun 30	Jul 31
EC W	9	16	5	-6	-15
EC AN	22	16	3	-12	-21
EC BN	16	15	1	-13	-20
EC D	21	5	-3	-15	-22
EC C	14	-3	-6	-21	-32
CP3 (2005) W	8	15	5	-6	-14
CP3 (2005) AN	22	14	3	-10	-19
CP3 (2005) BN	16	14	1	-12	-20
CP3 (2005) D	19	5	-4	-15	-22
CP3 (2005) C	13	-2	-6	-20	-30

Key:
AN = above-normal water
BN= below-normal water years
C = critical water years
CP = Comprehensive Plan
D = dry water years
EC = Existing Condition
W = wet water years

Figure 11-24. Average Monthly Change in WSEL for Each Water Year Type Within the Shasta Lake Vicinity of the Primary Study Area, CP3 Versus the Existing Condition



	Mar 31	Apr 30	May 31	Jun 30	Jul 31
NA W	8	16	5	-7	-15
NA AN	22	16	2	-13	-22
NA BN	16	15	1	-13	-21
NA D	21	6	-3	-15	-22
NA C	13	-2	-6	-21	-30
CP3 (2030) W	8	15	5	-6	-14
CP3 (2030) AN	23	15	2	-11	-20
CP3 (2030) BN	16	14	1	-12	-20
CP3 (2030) D	19	5	-4	-15	-22
CP3 (2030) C	13	-2	-6	-20	-29

Key:
AN = above-normal water
BN = below-normal water years
C = critical water years
CP = Comprehensive Plan
D = dry water years
NA = No-Action
W = wet water years

Figure 11-25. Average Monthly Change in WSEL for Each Water Year Type Within the Shasta Lake Vicinity of the Primary Study Area, CP3 Versus No-Action Alternative

Impact Aqua-2 (CP3): Effects on Nearshore, Warm-Water Habitat in Shasta Lake from Project Construction Localized increases in soil erosion and resulting runoff sedimentation, and turbidity resulting from project construction in the vicinity of Shasta Dam and at utility, road, and other facility relocation areas could affect nearshore warm-water habitat. However, the environmental commitments for all action alternatives would result in less-than-significant impacts. Mitigation for this impact is not needed, and thus not proposed.

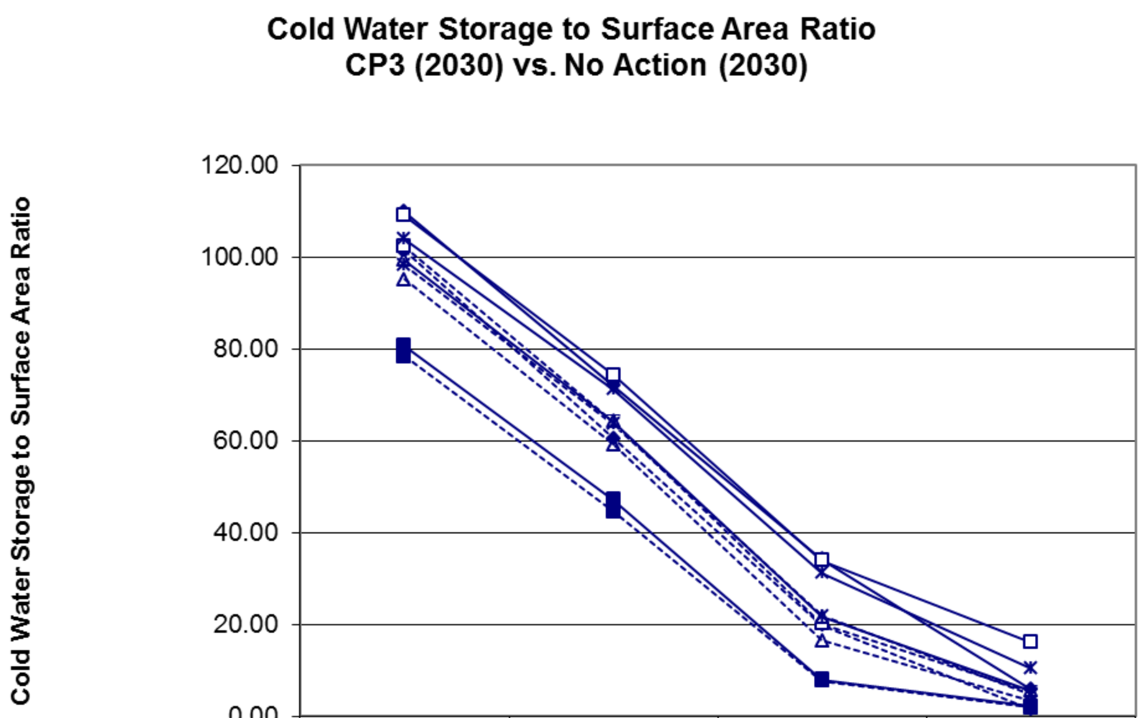
Impact Aqua-3 (CP3): Effects on Cold-Water Habitat in Shasta Lake Operations-related changes in the ratio of the volume of cold-water storage to surface area would increase the availability of suitable habitat for cold-water fish in Shasta Lake, including rainbow trout. This impact would be beneficial.

This impact would be similar to Impacts Aqua-3 (CP1 and CP2). However, it would be of greater magnitude owing to a greater increase in the ratio of the volume of cold-water storage in the lake to the surface area of the lake. CalSim-II modeling shows that under CP3 with a 2030 water supply demand, the ratio of cold-water storage to surface area is higher than under the No-Action Alternative in all water years and during all months modeled. The greatest projected increases over the No-Action Alternative occurred between June 30 and August 31, which is a critical rearing and oversummering period for cold-water fishes in reservoirs, and are greatest in wet, above-normal, and below-normal water years (Figure 11-26).

CP3 would increase the availability of suitable habitat for cold-water fish in Shasta Lake. Therefore, this impact would be beneficial. Mitigation for this impact is not needed, and thus not proposed.

Impact Aqua-4 (CP3): Effects on Special-Status Aquatic Mollusks Under CP3, habitat for special-status mollusks could be inundated. Seasonal fluctuations in the surface area and WSEL of Shasta Lake could also adversely affect special-status aquatic mollusks that could occupy habitat in or near Shasta Lake and its tributaries. Investigations are ongoing but initial evidence from field surveys of the lower reaches of representative tributaries to the lake suggests that the probability of occurrence of special-status mollusks in these reaches is low. However, because the California floater, a special-status mollusk species, is known from Shasta Lake, this impact would be potentially significant.

This impact would be similar to Impacts Aqua-4 (CP1 and CP2). However, a larger area would be inundated under CP3, which could result in an increase in impacts to these species and their habitat. Seasonal fluctuations in the surface area and WSEL of Shasta Lake could adversely affect special-status mollusks that may occupy habitat in or near Shasta Lake and its tributaries. Tributary investigations are ongoing and will provide additional information and analysis for inclusion in the Final EIS. Therefore, this impact would be potentially significant. Mitigation for this impact is proposed in Section 11.3.4.



	Apr 30	Jun 30	Aug 31	Oct 31
NA W	101.33	60.49	19.89	1.43
NA AN	102.30	64.04	20.12	5.09
NA BN	98.27	63.71	21.84	4.64
NA D	95.13	59.14	16.50	3.38
NA C	78.43	44.58	7.66	1.82
CP3 2030 W	109.95	72.07	34.15	5.76
CP3 2030 AN	109.16	74.33	33.92	16.04
CP3 2030 BN	104.02	71.30	31.23	10.44
CP3 2030 D	99.41	64.23	21.58	5.57
CP3 2030 C	80.70	47.15	7.90	2.07

Key:
AN = above-normal water
BN= below-normal water years
C = critical water years
CP = Comprehensive Plan
D = dry water years
NA = No-Action
W = wet water years

Figure 11-26. Average Monthly Cold-water Storage to Surface Area Ratio for Each Water Year Type Within the Shasta Lake Vicinity of the Primary Study Area, CP3 Versus No-Action Alternative

Impact Aqua-5 (CP3): Effects on Special-Status Fish Species The expansion of the surface area of Shasta Lake and the inundation of additional tributary habitat under CP3 could affect one species designated as sensitive by USFS, the hardhead. This impact would be less than significant.

This impact would be similar to Impacts Aqua-5 (CP1 and CP2), but its magnitude would be greater owing to an increase in surface area and WSEL and expansion of the area subject to inundation. However, available data suggest that hardhead do not currently occur or are very uncommon in the primary tributaries to Shasta Lake, other than the Pit River above the Pit 7 afterbay. Tributary investigations are ongoing and will provide additional information and analysis for inclusion in the Final EIS. Therefore, this impact is considered to be less than significant. Mitigation for this impact is not needed, and thus not proposed.

Impact Aqua-6 (CP3): Creation or Removal of Barriers to Fish Between Tributaries and Shasta Lake Under CP3, project implementation would result in the periodic inundation of steep and low-gradient tributaries to Shasta Lake up to the 1,090-foot contour, the maximum inundation level under this alternative. Tributary investigations are ongoing and will provide additional information and analysis for inclusion in the Final EIS. However, based on digital topographic data and stream channel data generated from field inventories, about 63 percent of the intermittent and 48 percent of perennial tributaries surveyed contain substantial barriers between the 1,070-foot and 1,090-foot contours that would be inundated under this alternative; although none of the streams with barriers was found to be inhabited by special-status fish in upstream reaches. This impact would be less than significant.

This impact would be similar to Impacts Aqua-6 (CP1 and CP2). However, the maximum inundation level would be higher under this alternative. Most (82 percent) of the tributaries are too steep (i.e., greater than 7 percent) up to the 1,090-foot contour to be passable by fish; the tributaries that are low-gradient up to the 1,090-foot contour, and thus, allow fish passage remain low-gradient well upstream from this contour; an exception to this pattern is Squaw Creek, which has a 12- to15-foot-tall passage barrier, the top of which is at about 1,083 feet msl. The access of warm-water fish species from the lake into some tributaries, including Squaw Creek, would be extended by periodic inundation of this and smaller passage impediments on other streams under CP3, with a potential to alter existing resident fish communities. However, except for the main river tributaries (i.e., Sacramento, Pit, and McCloud rivers), few of the lake's other accessible tributaries have been found to be colonized by warm-water fish above the varial zone and any further access is expected to be limited primarily to the newly inundated reaches of some streams. Therefore, this impact is considered to be less than significant. Mitigation for this impact is not needed, and thus not proposed.

Impact Aqua-7 (CP3): Effects on Spawning and Rearing Habitat of Adfluvial Salmonids in Low-Gradient Tributaries to Shasta Lake CP3 would result in additional periodic inundation of potentially suitable spawning and rearing habitat for adfluvial salmonids in the tributaries of the Sacramento River, McCloud River, Pit River, Big Backbone Creek, and Squaw Creek upstream from Shasta Lake. Eleven miles of low-gradient reaches that could potentially provide some spawning and rearing habitat for adfluvial salmonids (estimated as 40,103 square feet for all tributaries) would be affected by CP3, which is only about 2.8 percent of the low-gradient habitat upstream from Shasta Lake. Tributary investigations are ongoing and will provide additional information and analysis for inclusion in the Final EIS. This impact would be significant.

As described in Chapter 4, “Geology, Geomorphology, Minerals, and Soils,”CP3 would inundate perennial reaches with gradients of less than 7 percent that could provide spawning and rearing habitat for adfluvial salmonids. The lengths of low-gradient tributaries to each arm and estimated suitable spawning areas that would be periodically inundated are as follows:

- Sacramento Arm – 4.0 miles (19,852 square feet, excludes mainstem river)
- McCloud Arm – 2.7 miles (13,601 square feet)
- Pit Arm – 1.9 miles (615 square feet, excludes mainstem river)
- Big Backbone Arm – 1.1 miles (175 square feet)
- Squaw Arm – 1.3 miles (1,300 square feet)

This impact would be similar to Impacts Aqua-7 (CP1 and CP2). However, it would periodically inundate an additional 9,000 square feet of suitable spawning habitat in low-gradient reaches to Shasta Lake. Therefore, this impact would be potentially significant. Mitigation for this impact is proposed in Section 11.3.4.

Impact Aqua-8 (CP3): Effects on Aquatic Connectivity in Non-Fish-Bearing Tributaries to Shasta Lake CP3 would result in periodic inundation of the lower reaches of high-gradient, non-fish-bearing tributaries to Shasta Lake. Twenty-four miles of non-fish-bearing tributary habitat would be affected by CP3, which is only about 1 percent of the total length of non-fish-bearing tributaries upstream from Shasta Lake. Tributary investigations are ongoing and will provide additional information and analysis for inclusion in the Final EIS. Examination of initial field surveys suggest that few, if any of the non-fish bearing streams contain special-status invertebrate or vertebrate species that would be affected by increased connectivity to Shasta Lake. This impact would be less than significant.

As described in Chapter 4, "Geology, Geomorphology, Minerals, and Soils," CP3 would inundate tributary segments with channel slopes in excess of 7 percent. Although these segments do not typically support salmonid populations, they do provide riparian and aquatic habitat for a variety of organisms and serve as corridors that connect habitat types. The lengths of non-fish-bearing tributaries for each arm of Shasta Lake that would be periodically inundated are as follows:

- Sacramento Arm – 5.5 miles
- McCloud Arm – 4.1 miles
- Pit Arm – 3.5 miles
- Big Backbone Arm – 2.7 miles
- Squaw Arm – 1.9 miles
- Main Body – 6.3 miles

This impact would be similar to Impacts Aqua-8 (CP1 and CP2). However, it would periodically inundate a larger amount of habitat in high-gradient reaches to Shasta Lake, but the total amount inundated would be only 1 percent of the non-fish-bearing tributaries upstream from the lake and no special-status aquatic vertebrate and invertebrate species have been detected in these reaches. Therefore, this impact would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

Impact Aqua-9 (CP3): Effects on Water Quality at Livingston Stone Hatchery
Reclamation provides the water supply to the Livingston Stone Hatchery from a pipeline emanating from Shasta Dam. This supply would not be interrupted by any activity associated with CP3. There would be no impact.

This impact is the same as Impact Aqua-9 (CP1), and there would be no impact. Mitigation for this impact is not needed, and thus not proposed.

Upper Sacramento River (Shasta Dam to Red Bluff)
Impact Aqua-10 (CP3): Loss or Degradation of Aquatic Habitat in the Upper Sacramento River during Construction Activities Temporary construction-related increases in sediments and turbidity levels would adversely affect aquatic habitats and fish populations immediately downstream in the upper Sacramento River. However, environmental commitments would be in place to reduce the effects. This impact would be less than significant.

This impact would be similar to Impact Aqua-10 (CP1). The impact could be greater under CP3 than under CP1 because of the increased activity associated with an 18.5-foot dam raise compared to a 6.5-foot dam raise. However, as under CP1, environmental commitments for all actions would be in place to reduce the effects. Therefore, this impact would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

Impact Aqua-11 (CP3): Release and Exposure of Contaminants in the Upper Sacramento River During Construction Activities Construction-related activities could result in the release and exposure of contaminants. Such exposure could adversely affect aquatic habitats, the aquatic food web, and fish populations, including special-status species, downstream in the primary study area. However, environmental commitments would be in place to reduce the effects. Therefore, this impact would be less than significant.

This impact would be similar to Impact Aqua-11 (CP1). The impact could be greater under CP3 than under CP1 because of the increased activity associated with an 18.5-foot raise compared to a 6.5-foot raise. However, as under CP1, environmental commitments for all actions would be in place to reduce the effects. Therefore, this impact would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

Impact Aqua-12 (CP3): Changes in Flow and Water Temperature in the Upper Sacramento River Resulting from Project Operation – Chinook Salmon CP3 operation would result in improved overall flow and water temperature conditions in the upper Sacramento River for fish species of management concern. This impact would be beneficial.

Winter-Run Chinook Salmon

<u>Production</u>

Overall average winter-run production for the 82-year period would be similar (less than 5 percent change) for CP3 relative to the No-Action Alternative and the Existing Condition (Attachments 3 and 4 of the Modeling Appendix). The maximum increase in production relative to the No-Action Alternative was 121 percent for CP3, and the largest decrease in production relative to the No-Action Alternative was -14 percent (Table 11-30 and Attachment 3 of the Modeling Appendix). The maximum increase in production relative to the Existing Condition was 191 percent for CP3, and the largest decrease in production relative to the Existing Condition was -7 percent (Table 11-30 and Attachment 4 of the Modeling Appendix). Figure 11-9 shows the change in production relative to the No-Action Alternative for all water years and all Comprehensive Plans.

Under CP3, two critical and one dry water year had significant increases in production compared to the No-Action Alternative, while two critical and one above-normal water years had a significantly decreased production.

Table 11-30. Change in Production Under CP3 for Winter-Run Chinook Salmon

Year Type	Number of Years	Average Production	Change in Production from Baseline	Average Change in Production	Maximum Increase in Production	Number of Months with Significant Increase	Maximum Decrease in Production	Number of Months with Significant Decrease
Future Condition (2030)								
All	81	3,784,037	-17,078	-0.4	121.0	2	-14.1	3
Critical	13	3,405,883	27,928	0.8	121.0	1	-14.1	2
Dry	17	3,989,211	16,880	0.4	6.9	1	-2.8	0
Below Normal	14	3,925,807	-12,751	-0.3	3.6	0	-3.6	0
Above Normal	11	3,804,872	-54,058	-1.4	1.2	0	-6.0	1
Wet	26	3,753,808	-48,470	-1.3	3.9	0	-4.3	0
Existing Condition (2005)								
All	81	3,788,864	7,618	0.2	191.4	6	-7.0	3
Critical	13	3,444,999	234,060	7.3	191.4	5	-4.1	0
Dry	17	3,980,152	-3,710	-0.1	14.3	1	-3.5	0
Below Normal	14	3,924,037	-16,112	-0.4	3.8	0	-3.3	0
Above Normal	11	3,795,459	-57,223	-1.5	0.7	0	-7.0	1
Wet	26	3,760,148	-57,987	-1.5	2.0	0	-6.4	2

Note:

Production is the number of immature smolts surviving to pass the Red Bluff Pumping Plant

Under CP3, five out of 13 critical and one out of 17 dry water years had significant increases in production, compared to the Existing Condition. One above-normal (out of 11 years) and one wet (out of 26 years) water year had significant decreases in production.

Mortality

Mortality was separated by flow- and water temperature-related mortality to assess the level of impacts on winter-run Chinook salmon caused by the actions of the project (Attachments 3 and 4 of the Modeling Appendix). Nonoperations-related mortality is the base and seasonal mortality that would occur even without the effects of Shasta operations (such as disease, predation, and entrainment). Flow- and water temperature-related mortality is that caused by altering flow and water temperatures. In all cases, most mortality is caused by nonoperations-related factors (e.g., disease, predation, entrainment) −around 87 percent of the total mortality.

Mortality is presented in two manners–total mortality and smolt equivalent mortality (Attachments 3 and 4 of the Modeling Appendix). Under both 2030 and 2005 conditions, the greatest mortality to winter-run Chinook salmon under CP3 (as with CP1 and CP2) in all water year types, based on smolt equivalents, would occur to fry, then eggs, presmolts, immature smolts, and prespawn adults. Table 11-5 displays the overall mortalities for each Comprehensive Plan that would be caused by changes in water temperature and flow (see also Attachments 3 and 4 of the Modeling Appendix).

Years with the highest mortality were the same for the No-Action Alternative and CP3. Each of these years was a critical water year, and was preceded by either a critical (1933, 1976, 1991) or dry (1930 and 1932) water year type (Attachments 3 and 4).

Winter-run Chinook salmon would have, overall, an insignificant change in project-related mortality relative to No-Action Alternative, but significant compared with the Existing Condition. They would also have an insignificant change in production (including in critical water years), winter-run Chinook salmon would have a less-than-significant impact from actions taken in CP3. Mitigation for this impact is not needed, and thus not proposed.

Spring-Run Chinook Salmon

Production

Overall average spring-run Chinook salmon production for the 81-year period remained relatively similar (less than 5 percent change) to the No-Action Alternative and Existing Condition. The maximum increase in production relative to the No-Action Alternative was 123 percent for CP3 in a dry water year, while the largest decrease in production was almost 44 percent in a critical water year (Table 11-31 and Attachment 6 of the Modeling Appendix). The maximum increase in production relative to the Existing Condition was 602 percent for CP3. The largest decrease in production relative to the Existing

Condition was 9 percent for CP3 (Table 11-31 and Attachment 7 of the Modeling Appendix). Figure 11-10 shows the change in production relative to the No-Action Alternative for all water years and all Comprehensive Plans.

Under CP3, five critical, one dry, and one below-normal water years had significant increases in production compared to the No-Action Alternative, while two critical water years had significant decreases in production (Attachment 6 of the Modeling Appendix).

Under CP3, eight critical, one dry, and one below-normal water years had significant increases in production compared to the Existing Condition. Only one critical water year had a significant decrease in production (Attachment 7 of the Modeling Appendix).

Table 11-31. Change in Production Under CP3 for Spring-Run Chinook Salmon

Year Type	Number of Years	Average Production	Change in Production from Baseline	Average Change in Production	Maximum Increase in Production	Number of Months with Significant Increase	Maximum Decrease in Production	Number of Months with Significant Decrease
Future Condition (2030)								
All	81	163,036	-1,019	-0.6	123	7	-43.8	3
Critical	13	82,081	892	1.1	86.1	5	-43.8	2
Dry	17	170,498	1,046	0.6	123	1	-2.2	0
Below Normal	14	177,547	366	0.2	20.7	1	-3.4	0
Above Normal	11	181,387	-2,378	-1.3	4.9	0	-3.5	0
Wet	26	183,056	-3,495	-1.9	1.5	0	-5.1	1
Existing Condition (2005)								
All	81	164,298	1,090	0.7	602	10	-8.7	2
Critical	13	89,222	15,160	20.5	602	8	-8.7	1
Dry	17	169,946	1,084	0.6	243	1	-2.8	0
Below Normal	14	178,606	577	0.3	30.4	1	-3.6	0
Above Normal	11	181,593	-2,520	-1.4	3.0	0	-3.1	0
Wet	26	182,953	-4,277	-2.3	2.3	0	-5.1	1

Note:
Production is the number of immature smolts surviving to pass the Red Bluff Pumping Plant

Mortality

Mortality was separated by flow- and water temperature-related mortality to assess the level of impacts on spring-run Chinook salmon caused by the actions of the project (Attachments 6 and 7). In all cases, most mortality is caused by nonoperations-related factors (e.g., disease, predation, entrainment)−about 83 percent of the total mortality.

Mortality is presented in two manners–total mortality and smolt equivalent mortality (Attachments 6 and 7 of the Modeling Appendix). Under both 2030 and 2005 conditions, the greatest mortality to spring-run Chinook salmon under CP3 (as with CP1 and CP2) in all water year types based on smolt equivalents, would occur to the eggs, then fry, followed by presmolts and lastly immature smolts. Nonoperational conditions would be the primary causes of mortality for all life stages under all Comprehensive Plans. Table 11-7 displays the smolt-equivalent mortalities for each Comprehensive Plan changes in water temperature and flow (Attachments 6 and 7 of the Modeling Appendix).

Years with the highest operations-related mortality were the same CP3, No-Action Alternative and the Existing Condition. These were each preceded by a critical or dry water year. However, years with the lowest mortality varied between all water year types (Attachments 6 and 7).

Because spring-run Chinook salmon have, overall, a significant reduction in project-related mortality under both 2030 and 2005 conditions, but insignificant increase in overall production. However, spring-run Chinook salmon would have a significant increase in production during critical water years–those years in which they are at greatest risk. Therefore, spring-run Chinook salmon would benefit from actions taken in CP3. Mitigation for this impact is not needed, and thus not proposed.

Fall-Run Chinook Salmon

Production

Overall average fall-run Chinook salmon production for the 81-year period was similar between CP3 and the No-Action Alternative and the Existing Condition (Attachments 9 and 10 of the Modeling Appendix). The maximum increase in production relative to the No-Action Alternative was 41 percent (below-normal water year) for CP3, while the largest decrease in production relative to the No-Action Alternative was around -14 percent (in a critical water year) (Table 11-32 and Attachment 9 of the Modeling Appendix). The maximum increase in production relative to the Existing Condition was just around 144 percent for CP3 in a critical water year, and the largest decrease in production relative to the Existing Condition was –less than 7 percent in a wet water year (Table 11-32 and Attachment 10 of the Modeling Appendix). Figure 11-11 shows the change in production relative to the No-Action Alternative for all water years and all Comprehensive Plans.

Table 11-32. Change in Production Under CP3 for Fall-Run Chinook Salmon

Year Type	Number of Years	Average Production	Change in Production from Baseline	Average Change in Production	Maximum Increase in Production	Number of Months with Significant Increase	Maximum Decrease in Production	Number of Months with Significant Decrease
Future Conditions (2030)								
All	81	29,737,538	219,131	0.7	40.9	12	-13.8	3
Critical	13	26,803,488	358,660	3.1	17.1	5	-13.8	1
Dry	17	30,186,998	646,837	3.5	19.8	5	-4.7	0
Below Normal	14	31,748,386	650,475	3.8	40.9	2	-5.9	1
Above Normal	11	30,879,929	-153,081	-0.1	4.9	0	-2.9	0
Wet	26	29,344,601	-205,074	-0.8	4.7	0	-6.4	1
Existing Condition (2005)								
All	81	29,905,352	477,011	1.6	144	13	-6.8	3
Critical	13	27,963,775	1,787,639	18.6	144	6	-1.6	0
Dry	17	30,111,299	650,898	3.3	25.3	4	-3.6	0
Below Normal	14	31,784,514	766,252	4.3	59.4	2	-6.7	1
Above Normal	11	30,762,948	-107,448	0.0	3.6	0	-3.3	0
Wet	26	29,366,799	-200,472	-0.8	5.9	1	-6.8	2

Note:
Production is the number of immature smolts surviving to pass the Red Bluff Pumping Plant

In critical, dry, and below-normal water years, when production was lowest over the simulation period, the increase in production resulting from operations-related activities was greatest. In above-normal and wet water years, however, the lowest production years typically had a slight decrease in production under CP1 conditions relative to the No-Action Alternative (Attachments 9 and 10 of the Modeling Appendix).

Under CP3, five critical, five dry, and two below-normal water years had significant increases in production relative to the No-Action Alternative. Significant decreases in production occurred in one critical, one below-normal, and one wet water year (Attachment 9 of the Modeling Appendix).

Under CP3, six critical, four dry, two below-normal, and one wet water year had significant increases in production relative to the Existing Condition. Significant reductions in production occurred in one below-normal, and two wet water years (Attachment 10 of the Modeling Appendix).

Mortality

Mortality was separated by flow- and water temperature-related mortality to assess the level of impacts on fall-run Chinook salmon caused by the actions of the project (Attachments 9 and 10). In all cases, most mortality is caused by nonoperations-related factors (e.g., disease, predation, entrainment)−around 65 percent of the total mortality.

Mortality is presented in two manners–total mortality and smolt equivalent mortality (Attachments 9 and 10 of the Modeling Appendix). Under both 2030 and 2005 conditions, the greatest mortality based on the smolt equivalents to fall-run Chinook salmon under CP3 (as with CP1 and CP2) occurs to fry, followed by egg, prespawn adults, presmolts, and lastly to immature smolts. Table 11-9 displays the overall mortalities for each Comprehensive Plan that were caused by changes in water temperature and flow (see also Attachments 9 and 10 of the Modeling Appendix).

There was no real trend with respect to years with the greatest mortality. Years with the lowest production were in all water years except above-normal water years, and were preceded by all water year types.

Fall-run Chinook salmon have a significant reduction in project-related mortality under CP3 but an insignificant increase in average production. However, fall-run Chinook salmon would benefit from actions taken in CP3, experiencing a significant increase in 15 percent of the years. Mitigation for this impact is not needed, and thus not proposed.

Late Fall-Run Chinook Salmon

Production

Overall average late fall-run Chinook salmon production for the 80-year period was similar to CP3 and the No-Action Alternative and the Existing Condition

(Attachments 12 and 13 of the Modeling Appendix). The maximum increase in production relative to the No-Action Alternative was 12 percent in a dry water year for CP3, while the largest decrease in production relative to the No-Action Alternative was less than 5 percent for CP3 (Table 11-33 and Attachment 12 of the Modeling Appendix). The maximum increase in production relative to the Existing Condition was almost 13 percent for CP3 (in a dry water year), while the largest decrease in production relative to the Existing Condition was less than -5 percent (Table 11-33 and Attachment 13 of the Modeling Appendix). Figure 11-12 shows the change in production relative to the No-Action Alternative for all water years and all Comprehensive Plans.

Under CP3, one critical and two dry water years had significant increases in production compared to the No-Action Alternative, and there were no significant decreases in production.

Table 11-33. Change in Production Under CP3 for Late Fall-Run Chinook Salmon

Year Type	Number of Years	Average Production	Change in Production from Baseline	Average Change in Production	Maximum Increase in Production	Number of Months with Significant Increase	Maximum Decrease in Production	Number of Months with Significant Decrease
Future Condition (2030)								
All	80	7,596,054	-20,961	0.1	12.1	3	-4.9	0
Critical	13	7,107,373	43,205	0.6	7.5	1	-2.9	0
Dry	16	7,390,273	35,904	0.5	12.1	2	-4.9	0
Below Normal	14	7,599,738	-12,880	-0.2	2.4	0	-3.2	0
Above Normal	11	7,583,369	-2,715	0.0	1.7	0	-3.0	0
Wet	26	7,443,783	-15,881	-0.2	4.4	0	-3.9	0
Existing Condition (2005)								
All	80	7,422,929	36,368	0.5	12.9	5	-4.7	0
Critical	13	7,054,205	90,909	1.3	12.2	2	-3.4	0
Dry	16	7,398,822	38,554	0.5	12.9	3	-4.7	0
Below Normal	14	7,632,250	21,156	0.3	3.3	0	-2.6	0
Above Normal	11	7,593,708	34,035	0.5	2.6	0	-1.2	0
Wet	26	7,437,163	16,932	0.2	3.5	0	-4.0	0

Note:

Production is the number of immature smolts surviving to pass the Red Bluff Pumping Plant

Under CP3, two critical and three dry water years had significant increases in production compared to the Existing Condition, and there were no significant decreases in production.

Mortality

Mortality was separated by flow- and water temperature-related mortality to assess the level of impacts on late fall-run Chinook salmon caused by the actions of the project (Attachments 12 and 13). In all cases, most mortality is caused by nonoperations-related factors (e.g., disease, predation, entrainment)−around 78 percent of the total mortality.

Mortality is presented in two manners–total mortality and smolt equivalent mortality (Attachments 12 and 13 of the Modeling Appendix). Under both 2030 and 2005 conditions, the greatest mortality to late fall-run under CP3 (as with CP1 and CP2) in all water year types based on smolt equivalents, would occur to fry, then eggs, presmolts, immature smolts, and lastly to prespawn adults. Table 11-11 displays the overall mortalities for each Comprehensive Plan that were caused by changes in water temperature and flow) (Attachments 12 and 13 of the Modeling Appendix).

Years with the highest mortality were the same for CP3, the No-Action Alternative and Existing Conditions. All water year types were covered. Two years were preceded by a wet water year, one preceded by an above-normal water year, and two by a below-normal water year (Attachments 12 and 13 of the Modeling Appendix).

Late fall-run Chinook salmon would have an insignificant reduction in project-related mortality and production. Therefore, there would be a less-than-significant impact to late fall-run Chinook salmon from actions taken in CP3. Mitigation for this impact is not needed, and thus not proposed.

Impact Aqua-13 (CP3): Changes in Flow and Water Temperatures in the Upper Sacramento River Resulting from Project Operation – Steelhead, Green Sturgeon, Sacramento Splittail, American Shad, and Striped Bass CP3 operation generally would result in slightly improved flow and water temperature conditions in the upper Sacramento River for steelhead, green sturgeon, Sacramento splittail, American shad, and striped bass. This impact would be less than significant.

This impact would be similar to Impact Aqua-13 (CP1). The impact could be greater under CP3 than under CP1 because of the increased reservoir capacity associated with an 18.5-foot raise compared to a 6.5-foot raise.

Flow-Related Effects As under CP1, monthly mean flows at all modeling locations along the upper Sacramento River (below Shasta Dam, below Keswick Dam, above Bend Bridge, and above RBPP) under CP3 would generally be equivalent to (less than 5-percent difference from) flows under the

Existing Condition and No-Action Alternative conditions simulated for all months. (See the Modeling Appendix for complete modeling results.)

Potential flow-related effects of CP3 on fish species of management concern in the upper Sacramento River would be minimal. Potential changes in flows and stages would diminish rapidly downstream from RBPP because of increased effects from tributary inflows, diversions, and flood bypasses.

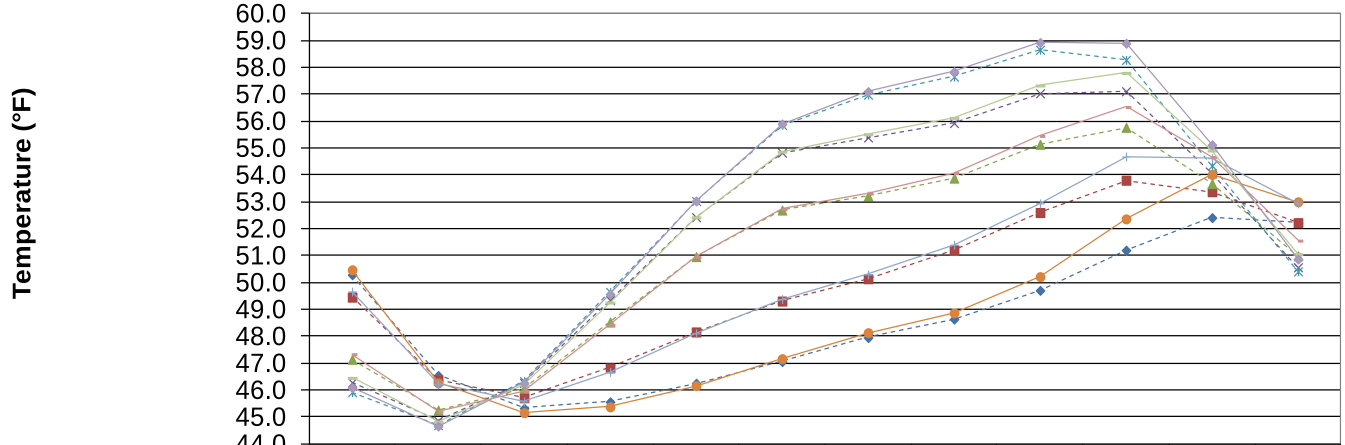
Changes in monthly mean flows under CP3 relative to the Existing Condition and No-Action Alternative would have no discernible effects on steelhead, green sturgeon, Sacramento splittail, American shad, or striped bass in the upper Sacramento River. Functional flows for migration, attraction, spawning, egg incubation, and rearing/emigration for these species would be unchanged. Flow-related effects on these fish species would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

Water Temperature–Related Effects As under CP1, monthly mean water temperatures at all modeling locations along the upper Sacramento River (below Shasta Dam, below Keswick Dam, Balls Ferry, above Bend Bridge, and above RBPP) under CP3 would be the same as, or fractionally lower than, water temperatures under the Existing Condition and No-Action Alternative simulated for all months (Figures 11-27 and 11-28). (See the Modeling Appendix for complete modeling results.)

As discussed above, the modeling simulations may not fully account for real time management of the cold-water pool and TCD (through the SRTTG) to achieve maximum cold-water benefits. Therefore, the modeled changes in water temperature (i.e., small benefits) are likely conservative and understated to some degree. Potential water temperature–related effects of CP3 on fish species of management concern in the upper Sacramento River would be minimal. During most years, annual releases from Shasta Dam would be unchanged. Potential changes in flows and stages would diminish downstream from RBPP because of the increasing effect from tributary inflows, diversions, and flood bypasses.

The slightly cooler monthly mean water temperatures under CP3 relative to the Existing Condition and the No-Action Alternative would have very small effects on steelhead, green sturgeon, Sacramento splittail, American shad, or striped bass in the upper Sacramento River. Monthly mean water temperatures would not rise above important thermal tolerances for the species life stages relevant to the upper Sacramento River. Therefore, water temperature–related effects on these fish species would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

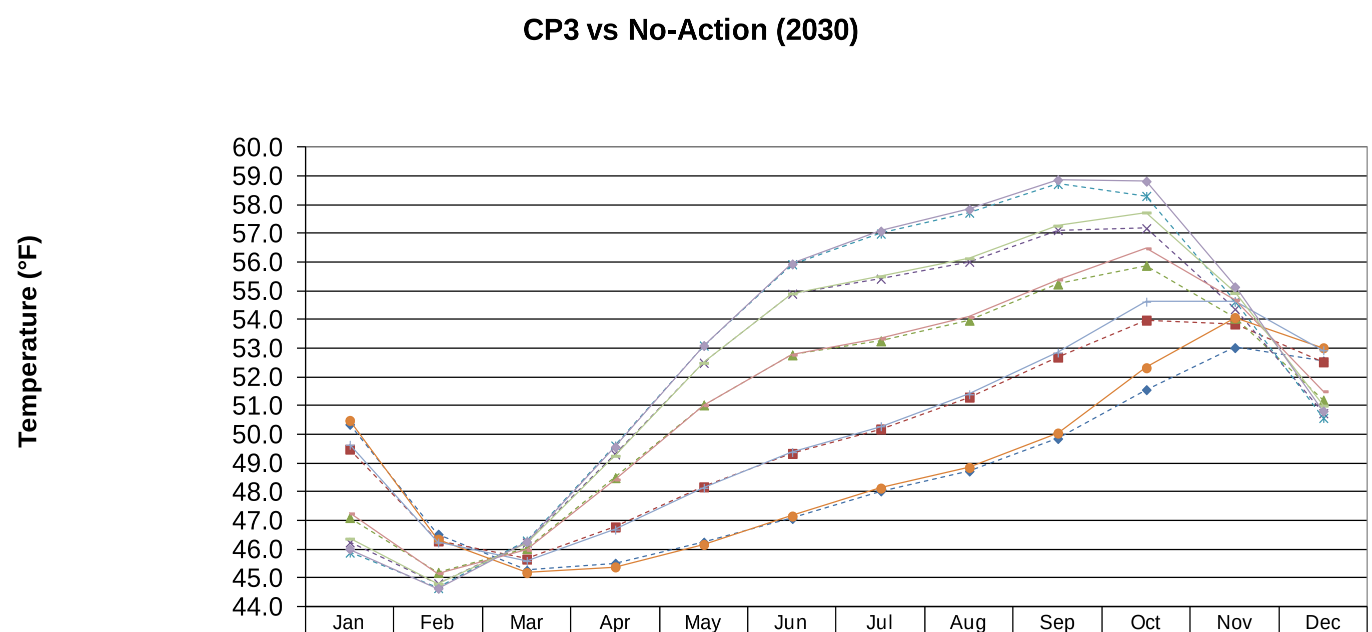
CP3 vs Existing Condition (2005)



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
CP3 Below Shasta	50.3	46.5	45.3	45.6	46.3	47.1	48.0	48.6	49.7	51.2	52.4	52.2
CP3 Below Keswick	49.5	46.4	45.7	46.8	48.2	49.3	50.1	51.2	52.6	53.8	53.4	52.2
CP3 Balls Ferry	47.1	45.3	46.1	48.5	51.0	52.7	53.2	53.9	55.1	55.8	53.7	51.0
CP3 Bend Bridge	46.3	44.9	46.3	49.3	52.4	54.8	55.4	55.9	57.0	57.1	54.1	50.6
CP3 RBPP	45.9	44.7	46.3	49.6	53.0	55.9	57.0	57.7	58.7	58.3	54.3	50.4
EC Below Shasta	50.5	46.3	45.2	45.4	46.2	47.2	48.1	48.9	50.2	52.4	54.0	53.0
EC Below Keswick	49.7	46.2	45.6	46.7	48.1	49.4	50.3	51.4	52.9	54.7	54.6	52.9
EC Balls Ferry	47.3	45.2	46.0	48.4	50.9	52.7	53.3	54.1	55.4	56.5	54.7	51.6
EC Bend Bridge	46.5	44.8	46.2	49.3	52.4	54.9	55.5	56.1	57.3	57.8	54.9	51.1
EC RBPP	46.1	44.7	46.3	49.6	53.0	55.9	57.1	57.8	58.9	58.9	55.1	50.9

Key:
CP = Comprehensive Plan
EC = Existing Condition
RBPP = Red Bluff Pumping Plant

Figure 11-27. Changes in Mean Monthly Water Temperature at Modeled Locations in the Sacramento River Within the Primary Study Area (CP3 Versus Existing Condition)



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
CP3 Below Shasta	50.4	46.5	45.3	45.5	46.2	47.1	48.0	48.7	49.9	51.6	53.0	52.6
CP3 Below Keswick	49.5	46.3	45.7	46.8	48.2	49.3	50.2	51.3	52.7	54.0	53.8	52.5
CP3 Balls Ferry	47.1	45.2	46.0	48.5	51.0	52.8	53.3	54.0	55.2	55.9	54.0	51.2
CP3 Bend Bridge	46.2	44.8	46.2	49.3	52.5	54.9	55.4	56.0	57.1	57.2	54.4	50.7
CP3 RBPP	45.9	44.7	46.3	49.6	53.1	55.9	57.0	57.7	58.7	58.3	54.6	50.6
NA Below Shasta	50.5	46.3	45.2	45.4	46.2	47.2	48.1	48.9	50.0	52.3	54.1	53.0
NA Below Keswick	49.6	46.2	45.6	46.7	48.1	49.4	50.3	51.4	52.9	54.6	54.6	52.9
NA Balls Ferry	47.3	45.2	46.0	48.4	51.0	52.8	53.3	54.1	55.4	56.5	54.7	51.5
NA Bend Bridge	46.4	44.8	46.2	49.3	52.5	54.9	55.5	56.1	57.3	57.7	54.9	51.0
NA RBPP	46.0	44.6	46.3	49.6	53.1	55.9	57.1	57.8	58.9	58.8	55.1	50.8

Key: NA = No-Action
CP = Comprehensive Plan RBPP = Red Bluff Pumping Plant

Figure 11-28. Changes in Mean Monthly Water Temperature at Modeled Locations in the Sacramento River Within the Primary Study Area (CP3 Versus No-Action Alternative)

Impact Aqua-14 (CP3): Reduction in Ecologically Important Geomorphic Processes in the Upper Sacramento River Resulting from Reduced Frequency and Magnitude of Intermediate to High Flows Project operations could cause a reduction in the magnitude, duration, and frequency of intermediate to large flows both in the upper Sacramento River and in the lowermost (confluence) areas of tributaries. Such flows are necessary for channel forming and maintenance, meander migration, and the creation of seasonally inundated floodplains. These geomorphic processes are ecologically important because they are needed to maintain important aquatic habitat functions and values for fish and macroinvertebrate communities. This impact would be potentially significant.

This impact would be similar to Impact Aqua-14 (CP1). The impact could be greater under CP3 than under CP1 because the increased reservoir capacity associated with an 18.5-foot raise compared to a 6.5-foot raise would allow for storage of additional water volume (and flows) behind the raised dam.

Sediment transport, deposition, and scour regulate the formation of key habitat features such as point bars, gravel deposits, and SRA habitat. Intermediate to high flows and the associated stage elevation of the river surface also provide a backwater effect on the lowermost segment of tributaries, reducing the potential for downcutting. These processes are regulated by the magnitude and frequency of flow. Relatively large flows provide the energy required to mobilize sediment from the riverbed, produce meander migration, increase stage elevation, and create seasonally inundated floodplains. Operations under CP3 could result in a reduction in the intermediate to large flows necessary for channel forming and maintenance, meander migration, and the creation of seasonally inundated floodplains.

Implementation of CP3 would cause a further reduction in the magnitude, duration, and frequency of intermediate to large flows, relative to the Existing Condition and No-Action Alternative. Overall, the project would increase the existing, ongoing effects on geomorphic processes resulting from operation of Shasta Dam that are necessary for channel forming and maintenance, meander migration, and the creation of seasonally inundated floodplains. These effects would likely occur throughout the upper Sacramento River portion of the primary study area.

Reductions in the magnitude of high flows would likely be sufficient to reduce ecologically important processes along the upper Sacramento River, downstream from Shasta Dam, throughout the primary study area. This impact would be potentially significant. Mitigation for this impact is proposed in Section 11.3.4.

Lower Sacramento River and Delta

Impact Aqua-15 (CP3): Changes in Flow and Water Temperatures in the Lower Sacramento River and Tributaries and Trinity River Resulting from Project

Operation – Fish Species of Primary Management Concern Project operation would result in no discernible change in monthly mean flows or water temperature conditions in the lower Sacramento River. However, predicted changes in flows in the Feather, American, and Trinity rivers could result in adverse effects on Chinook salmon, steelhead, Coho salmon, green sturgeon, Sacramento splittail, American shad, and striped bass. This impact would be potentially significant.

This impact would be similar to Impact Aqua-15 (CP1). The impact could be greater under CP3 than under CP1 because the increased reservoir capacity associated with an 18.5-foot raise compared to a 6.5-foot raise would allow for storage of additional water volume (and increased cold-water pool) behind the raised dam.

As described below, mean monthly flows at various modeling locations on the lower Sacramento River and tributaries under CP3 were compared with mean monthly flows simulated for Existing Conditions and No-Action Alternative conditions. See the Modeling Appendix for complete CalSim-II modeling results.

Lower Sacramento River As under CP1, monthly mean flows at the lower Sacramento River modeling locations under CP3 would be comparable to flows under the Existing Condition and No-Action Alternative conditions simulated for all months. Differences in monthly mean flow were generally small (less than 2 percent) and within the existing range of variability. Potential changes in flows diminished rapidly downstream from RBPP because of the increasing effect from tributary inflows, diversions, and flood bypasses. Similarly, potential changes in water temperatures in the lower Sacramento River caused by small changes in releases would diminish rapidly downstream because of the increasing effect of inflows, atmospheric influences, and groundwater. Therefore, flow- and temperature-related impacts on fish species in the lower Sacramento River would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

Also, as under CP1, the effects of altered flow regimes resulting from implementation of CP3 are unlikely to extend into the lower Sacramento River and Delta because the Central Valley's reservoirs and diversions are managed as a single integrated system (consisting of the SWP and the CVP). The guidelines for this management, which are described in the CVP/SWP OCAP, have been designed to maintain standards for flow to the lower Sacramento River and Delta. CVP and SWP operations must be consistent with the OCAP and SWRCB D-1641 to allow ESA coverage by OCAP permits and BOs. Thus, implementation of CP3 would not likely alter flow to the Delta or water temperatures in the lower Sacramento River and its primary tributaries to a sufficient degree to affect Chinook salmon, steelhead, green sturgeon, Sacramento splittail, American shad, or striped bass relative to the Existing Condition and No-Action Alternative. Functional flows for fish migration, attraction, spawning, egg incubation, and rearing/emigration for all these fish species would be unchanged. Therefore, flow- and water temperature–related effects on these fish species would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

Lower Feather River, American River, and Trinity River Also, as under CP1, monthly mean flows at modeling locations on the lower Feather River, the American River, and the Trinity River under CP3 would generally be equivalent to (less than 2-percent difference from) flows under the Existing Condition and No-Action Alternative simulated for most months. However, simulations for several months within the modeling record showed substantial changes to flows in tributaries. Potential changes in flows could be reduced by real-time operations to meet existing rules and because of operation of upstream reservoirs (Lake Oroville, Folsom Lake, and Trinity Lake) and increasing effects from tributary inflows, diversions, and flood bypasses. Potential changes in water temperatures in the Feather River and American River caused by altered releases from reservoirs could diminish downstream because of the increasing effect of inflows, and atmospheric and groundwater influences. Nevertheless, based on predicted changes in flow and associated flow-habitat relationships, potential flow-related impacts on species of management concern in the American, Feather, and Trinity rivers could occur. This impact would be potentially significant. Mitigation for this impact is proposed in Section 11.3.4.

Impact Aqua-16 (CP3): Reduction in Ecologically Important Geomorphic Processes in the Lower Sacramento River Resulting from Reduced Frequency and Magnitude of Intermediate to High Flows Project operation could cause a reduction in intermediate to large flows both in the lower Sacramento River and in the lowermost (confluence) areas of tributaries. Such flows are necessary for channel forming and maintenance, meander migration, and the creation of seasonally inundated floodplains. These geomorphic processes are ecologically important because they are needed to maintain important aquatic habitat functions and values for fish and macroinvertebrate communities. This impact would be potentially significant.

This impact would be similar to Impact Aqua-16 (CP1). The impact could be greater under CP3 than under CP1 because the increased reservoir capacity associated with an 18.5-foot raise compared to a 6.5-foot raise would allow for storage of additional water volume (and flows) behind the raised dam.

Sediment transport, deposition, and scour regulate the formation of key habitat features such as point bars, gravel deposits, and SRA habitat. Intermediate to high flows and the associated stage elevation of the river surface also provide a backwater effect on the lowermost segment of tributaries, which reduces the potential for downcutting. These processes are regulated by the magnitude and frequency of flows. Relatively large floods provide the energy required to mobilize sediment from the riverbed, produce meander migration, increase stage elevation, create seasonally inundated floodplains, and inundate floodplain bypasses. Operations under CP3 could result in reduced intermediate to large flows that are necessary for channel forming and maintenance, meander migration, and creation of seasonally inundated floodplains.

Implementation of CP3 would cause a further reduction in the magnitude, duration, and frequency of intermediate to large flows relative to the Existing Condition and No-Action Alternative. Overall, the project would increase the existing, ongoing impacts on geomorphic processes resulting from the operation of Shasta Dam that are necessary for channel forming and maintenance, meander migration, the creation of seasonally inundated floodplains, and the inundation of floodplain bypasses. These effects would likely occur along upper reaches of the lower Sacramento River (mostly upstream from RBPP).

Reductions in the magnitude of high flows would likely be sufficient to reduce ecologically important processes along the upper Sacramento River and its floodplain bypasses. This impact would be potentially significant. Mitigation for this impact is proposed in Section 11.3.4.

Impact Aqua-17 (CP3): Effects to Delta Fisheries Resulting from Changes to Delta Outflow Based on the results of hydrologic modeling comparing Delta outflow under the No-Action Alternative, Existing Condition, and CP3, CP3 would result in changes to average monthly Delta outflow of less than 5 percent in all year types (with the exception of November of above-normal water years under 2005 conditions). This impact on Delta fisheries and hydrologic transport processes within the Bay-Delta would be less than significant.

Results of the comparison of Delta outflows under CP3 compared with the Existing Condition and No-Action Alternative are summarized by month and water year type in Table 11-34. Only in November of above-normal water years (compared to the Existing Condition) and in December of Critical years (compared to the No-Action Alternative) would changes in Delta outflow exceed 5 percent. Based on the results of this comparison, CP3 would have a less-than-significant impact on Delta fisheries and hydrologic transport processes within the Bay-Delta as a consequence of changes in Delta outflow under existing conditions. Mitigation for this impact is not needed, and thus not proposed.

Table 11-34. Delta Outflow Under Existing Conditions, No-Action Alternative, and CP3

		Existing Condition	CP3 (2005)		No-Action Alternative	CP3 (2030)	
Month	**Water Year**	**Flow (cfs)**	**Flow (cfs)**	**Percent Change**	**Flow (cfs)**	**Flow (cfs)**	**Percent Change**
January	Average	42,078	41,783	-1	42,169	41,769	-1
	W	84,136	83,571	-1	84,037	83,211	-1
	AN	47,221	46,936	-1	46,984	46,680	-1
	BN	21,610	21,584	0	21,990	22,027	0
	D	14,166	13,973	-1	14,452	14,168	-2
	C	11,560	11,366	-2	11,757	11,501	-2
February	Average	51,618	51,432	0	51,430	51,126	-1
	W	95,261	94,991	0	94,634	94,196	0
	AN	60,080	59,591	-1	60,278	59,405	-1
	BN	35,892	35,791	0	35,665	35,669	0
	D	20,978	20,909	0	20,946	20,775	-1
	C	12,902	12,924	0	13,088	13,089	0
March	Average	42,722	42,577	0	42,585	42,428	0
	W	78,448	78,457	0	78,376	78,402	0
	AN	53,486	52,493	-2	53,139	52,224	-2
	BN	23,102	22,943	-1	22,980	22,668	-1
	D	19,763	19,864	1	19,559	19,656	0
	C	11,881	11,892	0	11,893	11,900	0
April	Average	30,227	30,300	0	30,743	30,826	0
	W	54,640	54,671	0	55,460	55,482	0
	AN	32,141	32,225	0	32,971	33,053	0
	BN	21,773	21,952	1	22,511	22,645	1
	D	14,347	14,430	1	14,538	14,665	1
	C	9,100	9,115	0	8,873	8,961	1
May	Average	22,619	22,552	0	22,249	22,209	0
	W	41,184	41,155	0	40,543	40,526	0
	AN	24,296	24,171	-1	24,454	24,255	-1
	BN	16,346	15,983	-2	15,989	15,703	-2
	D	10,554	10,655	1	10,116	10,268	2
	C	6,132	6,134	0	5,910	5,975	1
June	Average	12,829	12,779	0	12,660	12,582	-1
	W	23,473	23,473	0	23,015	23,028	0
	AN	12,080	11,666	-3	11,799	11,431	-3
	BN	7,995	8,004	0	7,991	7,865	-2
	D	6,691	6,734	1	6,764	6,737	0
	C	5,361	5,363	0	5,378	5,372	0
July	Average	7,864	7,877	0	7,864	7,863	0
	W	11,230	11,270	0	11,181	11,190	0
	AN	9,562	9,525	0	9,407	9,381	0
	BN	7,117	7,130	0	7,225	7,244	0
	D	5,005	5,005	0	5,052	5,016	-1
	C	4,034	4,054	1	4,098	4,126	1
August	Average	4,322	4,316	0	4,335	4,329	0
	W	5,302	5,307	0	5,097	5,088	0
	AN	4,000	4,000	0	4,000	4,000	0
	BN	4,000	4,000	0	4,002	4,002	0
	D	3,906	3,878	-1	4,142	4,171	1
	C	3,520	3,509	0	3,699	3,631	-2

Table 11-34. Delta Outflow Under Existing Conditions, No-Action Alternative, and CP3 (contd.)

		Existing Condition	CP3 (Existing Condition)		No-Action Alternative	CP3 (Future Condition)	
Month	**Water Year**	**Base Flow (cfs)**	**Flow (cfs)**	**Percent Change**	**Base Flow (cfs)**	**Flow (cfs)**	**Percent Change**
September	Average	9,841	9,836	0	9,844	9,864	0
	W	19,695	19,687	0	19,702	19,712	0
	AN	11,784	11,771	0	11,849	11,836	0
	BN	3,876	3,885	0	3,913	3,945	1
	D	3,508	3,484	-1	3,442	3,491	1
	C	3,008	3,027	1	3,005	3,020	1
October	Average	6,067	6,056	0	6,000	5,981	0
	W	7,926	7,866	-1	7,633	7,539	-1
	AN	5,309	5,368	1	5,476	5,593	2
	BN	5,479	5,502	0	5,502	5,469	-1
	D	5,228	5,247	0	5,236	5,235	0
	C	4,741	4,682	-1	4,714	4,711	0
November	Average	11,706	11,541	-1	11,675	11,484	-2
	W	17,717	17,637	0	17,715	17,534	-1
	AN	12,667	11,728	-7	12,491	11,755	-6
	BN	8,543	8,527	0	8,686	8,591	-1
	D	8,482	8,479	0	8,414	8,384	0
	C	6,250	6,256	0	6,150	6,131	0
December	Average	21,755	21,427	-2	21,745	21,386	-2
	W	44,974	44,189	-2	44,661	43,587	-2
	AN	18,581	18,521	0	18,562	18,180	-2
	BN	12,219	11,752	-4	12,326	12,070	-2
	D	8,531	8,477	-1	8,803	8,933	1
	C	5,580	5,730	-3	5,677	6,040	6

Note:
A negative percentage change reflects a reduction in Delta outflow
Key:
AN = above-normal
BN = below-normal
C = critical
CP = Comprehensive Plan
cfs = cubic feet per second
D = dry
W = wet

Impact Aqua-18 (CP3): Effects to Delta Fisheries Resulting from Changes to Delta Inflow Based on the results of hydrologic modeling comparing Delta inflow under CP3 to the Existing Condition and No-Action Alternative, CP3 would not decrease average monthly Delta inflow by 5 percent or more in any year type. This impact on Delta fisheries and hydrologic transport processes within the Bay-Delta would be less than significant.

Results of the comparison of Delta inflows between the Existing Condition, No-Action Alternative, and CP3 are summarized by month and water year type in Table 11-35. Under CP3, Delta inflow would not decrease by more than 5 percent during any month compared to either the Existing Condition or the No-Action Alternative. Based on the results of this comparison, CP3 would have a less-than-significant effect on Delta fisheries and hydrologic transport processes within the Bay-Delta as a consequence of changes in Delta inflow. Mitigation for this impact is not needed, and thus not proposed.

Table 11-35. Delta Inflow Under Existing Conditions, No-Action Alternative, and CP3

		Existing Condition	CP3 (2005)		No-Action Alternative	CP3 (2030)	
Month		**Flow (cfs)**	**Flow (cfs)**	**Percent Change**	**Flow (cfs)**	**Flow (cfs)**	**Percent Change**
January	Average	47,426	47,165	-1	47,457	47,099	-1
	W	89,431	88,863	-1	89,328	88,512	-1
	AN	51,611	51,258	-1	51,267	51,016	0
	BN	27,269	27,243	0	27,576	27,612	0
	D	20,125	19,963	-1	20,371	20,093	-1
	C	16,699	16,774	0	16,749	16,701	0
February	Average	57,835	57,646	0	57,623	57,342	0
	W	103,140	102,862	0	102,606	102,190	0
	AN	65,379	64,639	-1	65,574	64,664	-1
	BN	41,782	41,823	0	41,374	41,367	0
	D	26,530	26,484	0	26,431	26,290	-1
	C	17,818	17,886	0	17,958	18,065	1
March	Average	49,829	49,701	0	49,713	49,536	0
	W	87,688	87,695	0	87,703	87,713	0
	AN	61,498	60,733	-1	61,339	60,449	-1
	BN	30,569	30,414	-1	30,415	30,086	-1
	D	24,943	24,957	0	24,640	24,645	0
	C	15,933	15,964	0	15,896	15,936	0
April	Average	33,962	34,036	0	34,783	34,868	0
	W	58,684	58,715	0	60,017	60,029	0
	AN	35,588	35,673	0	36,738	36,823	0
	BN	25,351	25,531	1	26,403	26,537	1
	D	17,962	18,048	0	18,315	18,463	1
	C	12,817	12,832	0	12,635	12,726	1
May	Average	27,383	27,315	0	27,091	27,039	0
	W	46,973	46,945	0	46,494	46,477	0
	AN	28,466	28,341	0	28,711	28,514	-1
	BN	20,747	20,384	-2	20,427	20,140	-2
	D	14,882	14,983	1	14,534	14,686	1
	C	10,347	10,341	0	10,038	10,027	0
June	Average	22,171	22,139	0	22,090	22,029	0
	W	35,459	35,459	0	35,172	35,190	0
	AN	23,124	22,703	-2	22,776	22,408	-2
	BN	16,884	17,003	1	16,941	16,932	0
	D	14,095	14,134	0	14,337	14,294	0
	C	10,710	10,710	0	10,694	10,686	0
July	Average	23,099	23,110	0	22,839	22,894	0
	W	27,442	27,477	0	27,496	27,501	0
	AN	25,169	25,070	0	25,065	25,015	0
	BN	23,282	23,400	1	23,362	23,371	0
	D	20,937	20,904	0	20,082	20,195	1
	C	14,647	14,661	0	14,048	14,283	2

Table 11-35. Delta Inflow Under Existing Conditions, No-Action Alternative, and CP3 (contd.)

		Existing Condition	CP3 (2005)		No-Action Alternative	CP3 (2030)	
Month		**Flow (cfs)**	**Flow (cfs)**	**Percent Change**	**Flow (cfs)**	**Flow (cfs)**	**Percent Change**
August	Average	17,147	17,132	0	17,026	17,122	1
	W	20,235	20,248	0	20,154	20,146	0
	AN	18,784	18,759	0	18,927	18,941	0
	BN	18,274	18,212	0	18,297	18,332	0
	D	15,066	15,066	0	14,371	14,680	2
	C	10,626	10,593	0	10,850	11,000	1
September	Average	20,946	20,993	0	21,145	21,272	1
	W	31,918	32,081	1	32,428	32,495	0
	AN	23,912	23,913	0	24,747	24,917	1
	BN	16,518	16,542	0	16,563	16,650	1
	D	14,440	14,329	-1	14,233	14,437	1
	C	9,130	9,237	1	8,809	8,957	2
October	Average	14,407	14,469	0	14,175	14,268	1
	W	17,072	17,057	0	16,558	16,562	0
	AN	13,176	13,412	2	13,223	13,433	2
	BN	14,044	14,065	0	14,159	14,188	0
	D	13,133	13,241	1	12,846	13,100	2
	C	12,196	12,234	0	11,976	11,977	0
November	Average	19,512	19,550	0	19,463	19,534	0
	W	26,429	26,571	1	26,536	26,504	0
	AN	20,269	19,609	-3	20,052	19,676	-3
	BN	16,984	17,037	0	16,980	16,947	0
	D	15,771	16,027	2	15,705	16,163	2
	C	12,330	12,494	1	12,081	12,364	0
December	Average	30,984	30,666	-1	30,988	30,568	-1
	W	53,758	52,982	-1	53,516	52,445	-2
	AN	28,431	28,381	0	28,223	27,886	-1
	BN	21,958	21,520	-2	22,143	21,965	-1
	D	18,560	18,516	0	18,837	18,715	-1
	C	13,363	13,498	1	13,484	13,666	1

Note:
A negative percentage change reflects a reduction in Delta inflow
Key:
AN = above-normal
BN = below-normal
C = critical
cfs = cubic feet per second
CP = Comprehensive Plan
D = dry
W = wet

Impact Aqua-19 (CP3): Effects to Delta Fisheries Resulting from Changes in Sacramento River Inflow CP3 operation would result in a variable response in Sacramento River inflow, resulting in both increases and decreases in river flow above basis-of-comparison conditions depending on month and water year type. Decreases in Sacramento River inflow would not equal or exceed 5 percent. This impact would be less than significant.

Results of hydrologic modeling, by month and year type, for the Existing Condition, No-Action Alternative, and CP3 for Sacramento River inflow are presented in Table 11-36. Results of these analyses show a variable response in Sacramento River inflow with CP3 operations resulting in both increases and decreases in river inflow above the Existing Condition and the No-Action Alternative, depending on month and water year. Under CP3, Sacramento River inflow would not decrease by 5 percent or more. Based on these results, the impact of CP3 on fish habitat and transport mechanisms within the lower Sacramento River and Delta would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

Table 11-36. Sacramento River Inflow Under Existing Conditions, No-Action Alternative, and CP3

		Existing Condition	CP3 (2005)		No-Action Alternative	CP3 (2030)	
Month	**Water Year**	**Flow (cfs)**	**Flow (cfs)**	**Percent Change**	**Flow (cfs)**	**Flow (cfs)**	**Percent Change**
January	Average	31,139	31,068	0	31,167	31,061	0
	W	50,173	50,005	0	50,164	49,930	0
	AN	38,122	38,012	0	38,006	37,955	0
	BN	22,370	22,422	0	22,540	22,658	1
	D	16,980	16,885	-1	17,109	16,936	-1
	C	14,384	14,459	1	14,322	14,274	0
February	Average	36,608	36,578	0	36,618	36,535	0
	W	56,740	56,783	0	56,637	56,660	0
	AN	44,453	43,988	-1	44,672	44,089	-1
	BN	30,911	31,056	0	30,780	30,838	0
	D	21,249	21,203	0	21,237	21,095	-1
	C	14,830	14,897	0	15,075	15,179	1
March	Average	32,396	32,342	0	32,352	32,262	0
	W	49,248	49,279	0	49,403	49,448	0
	AN	44,060	43,726	-1	43,972	43,573	-1
	BN	23,188	23,053	-1	23,068	22,758	-1
	D	20,390	20,405	0	20,138	20,143	0
	C	12,971	13,002	0	12,942	12,982	0
April	Average	23,232	23,280	0	23,206	23,292	0
	W	37,918	37,951	0	38,019	38,035	0
	AN	26,053	25,963	0	26,039	26,128	0
	BN	17,518	17,697	1	17,439	17,573	1
	D	13,205	13,290	1	13,164	13,313	1
	C	10,295	10,309	0	10,067	10,158	1

Table 11-36. Sacramento River Inflow Under Existing Conditions, No-Action Alternative, and CP3 (contd.)

		Existing Condition	CP3 (2005)		No-Action Alternative	CP3 (2030)	
Month	**Water Year**	**Flow (cfs)**	**Flow (cfs)**	**Percent Change**	**Flow (cfs)**	**Flow (cfs)**	**Percent Change**
May	Average	19,417	19,352	0	19,114	19,064	0
	W	32,095	32,075	0	31,800	31,790	0
	AN	21,204	21,080	-1	21,080	20,882	-1
	BN	14,530	14,168	-2	14,144	13,858	-2
	D	11,226	11,327	1	10,836	10,987	1
	C	8,148	8,142	0	7,874	7,863	0
June	Average	16,508	16,475	0	16,511	16,449	0
	W	24,092	24,092	0	23,905	23,920	0
	AN	16,598	16,176	-3	16,533	16,165	-2
	BN	13,792	13,911	1	13,822	13,812	0
	D	12,283	12,323	0	12,569	12,525	0
	C	9,492	9,491	0	9,516	9,507	0
July	Average	19,518	19,529	0	19,266	19,320	0
	W	20,071	20,104	0	20,058	20,063	0
	AN	22,070	21,970	0	21,976	21,924	0
	BN	21,232	21,349	1	21,374	21,383	0
	D	19,577	19,544	0	18,788	18,900	1
	C	13,683	13,695	0	13,100	13,334	2
August	Average	14,710	14,695	0	14,596	14,690	1
	W	16,285	16,297	0	16,189	16,180	0
	AN	16,418	16,393	0	16,561	16,575	0
	BN	16,112	16,050	0	16,170	16,205	0
	D	13,632	13,632	0	12,968	13,276	2
	C	9,570	9,536	0	9,785	9,933	2
September	Average	18,211	18,257	0	18,417	18,544	1
	W	27,839	28,002	1	28,337	28,403	0
	AN	21,244	21,244	0	22,088	22,257	1
	BN	14,088	14,112	0	14,147	14,233	1
	D	12,522	12,404	-1	12,341	12,545	2
	C	7,664	7,771	1	7,347	7,494	2
October	Average	11,309	11,416	1	11,117	11,219	1
	W	13,419	13,543	1	13,040	13,070	0
	AN	10,499	10,734	2	10,571	10,781	2
	BN	11,053	11,074	0	11,195	11,228	0
	D	10,150	10,258	1	9,830	10,085	3
	C	9,587	9,626	0	9,333	9,334	0

Table 11-36. Sacramento River Inflow Under Existing Conditions, No-Action Alternative, and CP3 (contd.)

		Existing Condition	CP3 (2005)		No-Action Alternative	CP3 (2030)	
Month	Water Year	Flow (cfs)	Flow (cfs)	Percent Change	Flow (cfs)	Flow (cfs)	Percent Change
November	Average	15,640	15,703	0	15,605	15,724	1
	W	20,726	20,936	1	20,832	20,929	0
	AN	16,893	16,259	-4	16,666	16,344	-2
	BN	13,755	13,809	0	13,793	13,759	0
	D	12,720	12,975	2	12,723	13,181	4
	C	9,948	10,113	2	9,653	9,935	3
December	Average	23,248	23,156	0	23,229	23,096	-1
	W	37,645	37,341	-1	37,434	37,045	-1
	AN	22,604	22,634	0	22,461	22,287	-1
	BN	16,930	16,871	0	17,103	17,196	1
	D	15,760	15,716	0	15,934	15,811	-1
	C	11,303	11,439	1	11,310	11,492	-2

Note:
A negative percentage change reflects a reduction in Sacramento River inflow
Key:
AN = above-normal
BN = below-normal
C = critical
cfs = cubic feet per second
CP = Comprehensive Plan
D = dry
W = wet

Impact Aqua-20 (CP3): Effects to Delta Fisheries Resulting from Changes in San Joaquin River Flow at Vernalis CP3 operation would result in no discernible change in San Joaquin River flows at Vernalis, and therefore no effects on fish habitat or transport mechanisms within the lower San Joaquin River and Delta compared with the Existing Condition and No-Action Alternative. There would be no impact.

Results of hydrologic modeling, by month and water year type, for the Existing Condition, No-Action Alternative, and CP3 for San Joaquin River flow are summarized in Table 11-37. Results of these analyses show that CP3 would have no effect on seasonal San Joaquin River flows compared with the Existing Condition and No-Action Alternative. Based on these results CP3 would have no impact on Delta fisheries or transport mechanisms within the lower San Joaquin River and Delta. Mitigation for this impact is not needed, and thus not proposed.

Table 11-37. San Joaquin River Flow at Vernalis Under Existing Conditions, and CP3

		Existing Condition	CP3 (2005)		No-Action Alternative	CP3 (2030)	
Month	**Water Year**	**Flow (cfs)**	**Flow (cfs)**	**Percent Change**	**Flow (cfs)**	**Flow (cfs)**	**Percent Change**
January	Average	4,770	4,770	0	4,764	4,764	0
	W	9,273	9,273	0	9,097	9,097	0
	AN	4,223	4,223	0	4,259	4,259	0
	BN	2,986	2,986	0	3,081	3,081	0
	D	2,084	2,084	0	2,160	2,160	0
	C	1,673	1,673	0	1,746	1,746	0
February	Average	6,265	6,265	0	6,143	6,143	0
	W	11,036	11,036	0	10,845	10,845	0
	AN	6,047	6,047	0	6,179	6,179	0
	BN	5,767	5,767	0	5,565	5,565	0
	D	2,642	2,642	0	2,528	2,528	0
	C	2,161	2,161	0	2,014	2,014	0
March	Average	7,133	7,133	0	7,003	7,003	0
	W	13,443	13,443	0	13,170	13,170	0
	AN	6,788	6,788	0	6,674	6,673	0
	BN	5,322	5,322	0	5,293	5,293	0
	D	2,963	2,963	0	2,895	2,895	0
	C	2,176	2,176	0	2,129	2,129	0
April	Average	6,720	6,720	0	7,533	7,533	0
	W	11,420	11,420	0	12,614	12,614	0
	AN	6,671	6,671	0	7,799	7,798	0
	BN	5,852	5,852	0	6,910	6,910	0
	D	3,726	3,726	0	4,112	4,112	0
	C	2,087	2,087	0	2,118	2,118	0
May	Average	6,204	6,204	0	6,234	6,234	0
	W	11,268	11,268	0	11,135	11,135	0
	AN	5,611	5,611	0	5,987	5,987	0
	BN	5,010	5,010	0	5,108	5,108	0
	D	3,070	3,070	0	3,111	3,111	0
	C	1,920	1,920	0	1,862	1,862	0
June	Average	4,739	4,739	0	4,671	4,671	0
	W	9,451	9,451	0	9,390	9,390	0
	AN	5,608	5,609	0	5,326	5,326	0
	BN	2,424	2,424	0	2,471	2,470	0
	D	1,598	1,598	0	1,554	1,554	0
	C	1,076	1,076	0	1,035	1,035	0
July	Average	3,202	3,202	0	3,208	3,208	0
	W	6,556	6,556	0	6,660	6,660	0
	AN	2,783	2,784	0	2,767	2,768	0
	BN	1,775	1,775	0	1,733	1,733	0
	D	1,282	1,282	0	1,216	1,216	0
	C	898	898	0	880	880	0

Table 11-37. San Joaquin River Flow at Vernalis Under Existing Conditions, and CP3 (contd.)

		Existing Condition	CP3 (2005)		No-Action Alternative	CP3 (2030)	
Month	Water Year	Flow (cfs)	Flow (cfs)	Percent Change	Flow (cfs)	Flow (cfs)	Percent Change
August	Average	2,029	2,029	0	2,040	2,041	0
	W	3,099	3,099	0	3,158	3,159	0
	AN	2,020	2,020	0	2,014	2,015	0
	BN	1,828	1,828	0	1,817	1,816	0
	D	1,342	1,342	0	1,315	1,315	0
	C	984	984	0	993	993	0
September	Average	2,331	2,331	0	2,340	2,340	0
	W	3,274	3,274	0	3,317	3,317	0
	AN	2,328	2,328	0	2,312	2,312	0
	BN	2,109	2,109	0	2,119	2,119	0
	D	1,795	1,795	0	1,774	1,775	0
	C	1,358	1,358	0	1,355	1,355	0
October	Average	2,757	2,757	0	2,753	2,753	0
	W	3,112	3,112	0	3,107	3,107	0
	AN	2,446	2,446	0	2,424	2,424	0
	BN	2,749	2,749	0	2,718	2,718	0
	D	2,686	2,686	0	2,710	2,710	0
	C	2,416	2,416	0	2,423	2,423	0
November	Average	2,633	2,633	0	2,603	2,603	0
	W	3,372	3,372	0	3,340	3,340	0
	AN	2,213	2,213	0	2,176	2,176	0
	BN	2,412	2,412	0	2,360	2,360	0
	D	2,388	2,388	0	2,355	2,355	0
	C	2,075	2,075	0	2,088	2,088	0
December	Average	3,199	3,199	0	3,263	3,263	0
	W	5,081	5,081	0	5,178	5,178	0
	AN	2,916	2,916	0	2,899	2,899	0
	BN	2,705	2,705	0	2,753	2,753	0
	D	2,047	2,047	0	2,123	2,123	0
	C	1,710	1,710	0	1,785	1,785	0

Note:
A negative percentage change reflects a reduction in San Joaquin River flow
Key:
AN = above-normal
BN = below-normal
C = critical
cfs = cubic feet per second
CP = Comprehensive Plan
D = dry
W = wet

Impact Aqua-21 (CP3): Reduction in Low-Salinity Habitat Conditions Resulting from an Upstream Shift in X2 Location CP3 operation would result in less than 0.5 km movement upstream or downstream from the X2 location from its location under the Existing Condition or No-Action Alternative during February through May and September through November, and thus cause minimal reduction in low-salinity habitats. This impact would be less than significant.

The 1 km X2 criterion was applied to a comparison of hydrologic model results for the Existing Condition, No-Action Alternative, and CP3, by month and water year type, for the months from February through May and September through November. Results of the comparisons are summarized in Table 11-38. These results showed that changes in X2 location under CP3 were less than 1 km (all were less than 0.2 km) with both variable upstream and downstream movement of the X2 location depending on month and water year type. These results are consistent with model results for Delta outflow that showed a less-than-significant change in flows. Based on these results, CP3 would have a less-than-significant impact on low-salinity habitat conditions within the Bay-Delta. Mitigation for this impact is not needed, and thus not proposed.

Table 11-38. Difference in X2 Under Existing Conditions, No-Action Alternative, and CP3

		Existing Condition	CP3 (2005)		No-Action Alternative	CP3 (2030)	
Month	**Water Year**	**Location (km)**	**Location (km)**	**Difference (km)**	**Location (km)**	**Location (km)**	**Differe (km**
January	Average	67.5	67.5	0.0	67.3	67.2	0.0
	W	53.6	53.7	0.1	53.7	53.7	0.1
	AN	61.7	61.7	0.0	61.6	61.6	0.0
	BN	72.1	72.0	-0.1	71.7	71.6	-0.1
	D	77.9	78.0	0.1	77.4	77.4	-0.1
	C	82.2	82.2	0.1	81.9	81.9	0.0
February	Average	60.9	61.0	0.0	60.8	60.9	0.0
	W	50.4	50.4	0.0	50.4	50.4	0.0
	AN	54.8	54.8	0.0	54.6	54.6	0.1
	BN	61.0	61.0	0.0	60.9	60.9	0.0
	D	70.1	70.1	0.0	69.9	69.9	0.0
	C	76.2	76.3	0.1	75.9	76.1	0.2
March	Average	60.9	60.9	0.0	60.9	61.0	0.0
	W	52.1	52.1	0.0	52.1	52.1	0.0
	AN	53.6	53.7	0.1	53.7	53.7	0.1
	BN	63.3	63.3	0.1	63.3	63.5	0.2
	D	67.1	67.0	-0.1	67.2	67.1	0.0
	C	75.2	75.2	0.0	75.1	75.1	0.1

Table 11-38. Difference in X2 Under Existing Conditions, No-Action Alternative, and CP3 (contd.)

		Existing Condition	CP3 (2005)		No-Action Alternative	CP3 (2030)	
Month	Water Year	Location (km)	Location (km)	Difference (km)	Location (km)	Location (km)	Differe (km
April	Average	63.5	63.5	0.0	63.4	63.3	0.0
	W	54.5	54.5	0.0	54.3	54.3	0.0
	AN	58.6	58.6	0.0	58.4	58.4	0.0
	BN	64.5	64.4	-0.1	64.1	64.1	0.0
	D	69.9	69.8	-0.1	69.9	69.7	-0.1
	C	77.5	77.5	0.0	77.6	77.6	0.0
May	Average	67.5	67.5	0.0	67.7	67.6	-0.1
	W	57.6	57.6	0.0	57.7	57.7	0.0
	AN	62.7	62.7	0.0	62.6	62.6	0.0
	BN	68.3	68.3	0.1	68.3	68.4	0.0
	D	74.4	74.2	-0.2	74.8	74.6	-0.2
	C	82.5	82.5	0.0	82.9	82.7	-0.1
June	Average	74.5	74.5	0.0	74.7	74.7	0.0
	W	65.0	65.0	0.0	65.2	65.2	0.0
	AN	72.6	72.8	0.2	72.7	72.9	0.2
	BN	76.6	76.6	0.0	76.7	76.8	0.1
	D	80.4	80.3	-0.1	80.7	80.6	-0.1
	C	85.9	85.9	0.0	86.0	86.0	-0.1
July	Average	80.5	80.5	0.0	80.5	80.5	0.0
	W	74.4	74.4	0.0	74.5	74.5	0.0
	AN	78.1	78.3	0.2	78.4	78.5	0.2
	BN	81.7	81.7	0.0	81.6	81.7	0.0
	D	84.8	84.8	-0.1	84.8	84.8	0.0
	C	88.1	88.1	0.0	88.0	88.0	0.0
August	Average	85.6	85.6	0.0	85.6	85.5	0.0
	W	82.7	82.6	0.0	82.8	82.8	0.0
	AN	83.7	83.8	0.0	83.9	83.9	0.0
	BN	85.6	85.5	0.0	85.5	85.4	0.0
	D	87.8	87.8	0.0	87.5	87.5	0.0
	C	90.4	90.4	0.0	90.2	90.3	0.0
September	Average	83.7	83.7	0.0	83.7	83.6	0.0
	W	73.4	73.4	0.0	73.5	73.5	0.0
	AN	81.4	81.4	0.0	81.4	81.4	0.0
	BN	88.8	88.8	0.0	88.8	88.8	0.0
	D	90.2	90.2	0.0	90.0	90.0	-0.1
	C	92.5	92.5	0.0	92.3	92.3	0.0

Table 11-38. Difference in X2 Under Existing Conditions, No-Action Alternative, and CP3 (contd.)

		Existing Condition	CP3 (2005)		No-Action Alternative	CP3 (2030)	
Month	**Water Year**	**Location (km)**	**Location (km)**	**Difference (km)**	**Location (km)**	**Location (km)**	**Differe (km**
October	Average	83.9	83.9	0.0	83.9	83.9	0.0
	W	73.6	73.5	0.0	73.7	73.7	0.0
	AN	79.8	79.8	0.0	79.8	79.8	0.0
	BN	88.9	88.9	0.0	88.9	88.9	0.0
	D	91.4	91.4	0.0	91.3	91.3	0.0
	C	93.3	93.2	0.0	93.1	93.0	-0.1
November	Average	82.2	82.3	0.1	82.2	82.3	0.1
	W	73.1	73.1	0.0	73.2	73.2	0.0
	AN	78.4	78.4	0.0	78.4	78.5	0.1
	BN	84.8	85.4	0.6	84.8	85.3	0.6
	D	88.9	88.9	0.0	88.8	88.9	0.1
	C	92.6	92.7	0.0	92.8	92.7	-0.1
December	Average	76.1	76.2	0.1	76.0	76.0	0.0
	W	62.9	63.1	0.1	63.0	63.2	0.1
	AN	76.4	76.8	0.4	76.4	76.8	0.4
	BN	81.4	81.4	0.0	81.1	81.1	0.0
	D	82.8	82.9	0.1	82.6	82.4	-0.1
	C	87.9	87.7	-0.2	87.8	87.5	-0.4

Key:
AN = above-normal
BN = below-normal
C = critical
CP = Comprehensive Plan
D = dry
km = kilometer
W = wet

Impact Aqua-22 (CP3): Increase in Mortality of Species of Primary Management Concern as a Result of Increased Reverse Flows in Old and Middle Rivers CP3 operation would result in minimal changes to reverse flows in Old and Middle rivers during January, March and April; however, flows do not exceed (become more negative) -5,000 cfs. Because the flows do not exceed -5,000 cfs, the increases in reverse flows are not expected to contribute to an increase in the vulnerability of delta smelt, longfin smelt, Chinook salmon, juvenile striped bass, or threadfin shad, but summer Old and Middle river flows could contribute to an increase in vulnerability of other resident warm-water fish to increased salvage and potential losses. This impact would be less than significant.

Results of the analysis showed several occurrences when reverse flows within Old and Middle rivers would be higher than under the Existing Condition or No-Action Alternative by more than 5 percent. These events would occur in critical, dry, and above-normal water years, which would be expected as a result of greater export operations under CP3.

During January (Table 11-39), operations under CP3 would result in an increase in reverse flow of greater than 5 percent during critical years compared with both Existing Conditions and the No-Action Alternative. Based on results of the delta smelt analysis of the relationship between reverse flows and delta smelt salvage, the increase of approximately 200 cfs in a critical water year would not be expected to result in a significant increase in adverse effects to delta smelt because their presence in the region is minimal during this time. Longfin smelt, however, are likely in the area during dry water years, but the flows do not exceed -5,000 cfs, so longfin smelt are not expected to experience significant impacts.

Table 11-39. Old and Middle River Reverse Flows Under Existing Conditions, No-Action Alternative, and CP3

		Existing Condition	CP3 (2005)		No-Action Alternative	CP3 (2030)	
Month	**Water Year**	**Flow (cfs)**	**Flow (cfs)**	**Percent Change**	**Flow (cfs)**	**Flow (cfs)**	**Percent Change**
January	Average	-3,542	-3,575	1	-3,553	-3,592	1
	W	-2,034	-2,034	0	-2,151	-2,161	0
	AN	-3,654	-3,592	-2	-3,574	-3,626	1
	BN	-4,240	-4,240	0	-4,240	-4,240	0
	D	-4,773	-4,802	1	-4,772	-4,777	0
	C	-4,033	-4,282	6	-3,940	-4,129	5
February	Average	-3,293	-3,287	0	-3,358	-3,375	1
	W	-2,745	-2,734	0	-2,950	-2,972	1
	AN	-3,248	-3,012	-7	-3,165	-3,129	-1
	BN	-3,335	-3,464	4	-3,291	-3,279	0
	D	-4,016	-4,033	0	-4,045	-4,063	0
	C	-3,391	-3,433	1	-3,482	-3,576	3
March	Average	-2,784	-2,799	1	-2,877	-2,860	-1
	W	-1,792	-1,789	0	-2,023	-2,010	-1
	AN	-4,021	-4,230	5	-4,260	-4,282	1
	BN	-4,005	-4,008	0	-3,982	-3,972	0
	D	-2,951	-2,872	-3	-2,918	-2,834	-3
	C	-2,023	-2,038	1	-1,994	-2,022	1
April	Average	955	955	0	1,060	1,059	0
	W	2,706	2,706	0	2,798	2,806	0
	AN	1,087	1,087	0	1,314	1,314	0
	BN	697	697	0	898	898	0
	D	-244	-242	-1	-207	-220	6
	C	-874	-874	0	-872	-872	0

Table 11-39. Old and Middle River Reverse Flows Under Existing Conditions, No-Action Alternative, and CP3 (contd.)

		Existing Condition	CP3 (2005)		No-Action Alternative	CP3 (2030)	
Month	Water Year	Flow (cfs)	Flow (cfs)	Percent Change	Flow (cfs)	Flow (cfs)	Percent Change
May	Average	491	492	0	416	426	2
	W	2,077	2,076	0	1,781	1,781	0
	AN	562	562	0	646	646	0
	BN	277	277	0	270	271	0
	D	-674	-674	0	-696	-695	0
	C	-1,018	-1,012	-1	-936	-867	-7
June	Average	-3,654	-3,669	0	-3,718	-3,735	0
	W	-4,226	-4,226	0	-4,354	-4,359	0
	AN	-4,825	-4,819	0	-4,818	-4,818	0
	BN	-4,137	-4,233	2	-4,119	-4,227	3
	D	-3,079	-3,079	0	-3,205	-3,191	0
	C	-1,542	-1,542	0	-1,542	-1,542	0
July	Average	-9,502	-9,500	0	-9,292	-9,330	0
	W	-8,948	-8,942	0	-8,905	-8,901	0
	AN	-9,993	-9,935	-1	-9,929	-9,906	0
	BN	-10,886	-10,982	1	-10,903	-10,908	0
	D	-10,998	-10,969	0	-10,419	-10,480	1
	C	-6,355	-6,343	0	-5,928	-6,121	3

Note:
A positive percentage change reflects more negative reverse flows under CP5 when compared to the Existing Condition or the No-Action Alternative.
Key:
AN = above-normal
BN = below-normal
C = critical
cfs = cubic feet per second
CP = Comprehensive Plan
D = dry
W = wet

Juvenile Chinook salmon and steelhead are migrating through the Delta during January, and an increase in average monthly reverse flows of around 200 cfs would be expected to increase the potential risk of increased mortality to these species. However, given the tidal volumes and hydrodynamics of the Old and Middle rivers region, it is not expected that the change in reverse flows in January in a critical year would result in a detectable change in fish survival. The majority of juvenile Chinook salmon emigrating from the San Joaquin River typically migrate downstream later in dry years and would not be expected to occur in high numbers within Old and Middle rivers in January.

The increase in reverse flows estimated to occur under CP3 in above-normal water years in March (under 2005 conditions) and in dry water years in April (under 2030 conditions) would exceed 5 percent. Juvenile and larval delta smelt occur in the area in March and April. A change in Old and Middle river flows of approximately 100 to 200 cfs does not increase the flows to beyond -5,000 cfs.

The potential increase in losses during January, March and April under CP3 is considered to be less than significant. Mitigation for this impact is not proposed because operations will be guided by RPAs established by NMFS and USFWS BOs to reduce any impacts to listed fish species, which would thus reduce impacts to non-listed species as well.

Impact Aqua-23 (CP3): Increase in the Risk of Entrainment or Salvage of Species of Primary Management Concern at CVP and SWP Export Facilities Due to Changes in CVP and SWP Exports CP3 operations may result in an increase in CVP and SWP exports, which is assumed to result in a direct proportional increase in the risk of fish being entrained and salvaged at the facilities. Future operations of the SWP and CVP export facilities would continue to be managed and regulated in accordance with incidental take limits established for each of the protected fish by USFWS, NMFS, and CDFW. The resulting impact to Chinook salmon would be less than significant; the resulting impact to delta smelt, longfin smelt, steelhead, striped bass, and splittail would be potentially significant. Overall, this impact would be potentially significant.

Results of entrainment loss modeling at the CVP and SWP export facilities are presented in Table 11-40 for CP3. The total numbers of fish lost annually, by species, are presented in Attachment 1 of the *Fisheries and Aquatic Ecosystems Technical Report.* The difference between the nonoperations-related and operations-related fish mortality is represented as the entrainment index, shown in Table 11-40, to represent the effect of project operations on each fish species at the CVP and SWP facilities.

Table 11-40. Indices of Entrainment at the CVP and SWP Facilities Comparing Existing Conditions, No-Action Alternative, and CP3

Species	Water Year	CP3 minus Existing Condition	Percent Change	CP3 Minus Future Condition	Percent Change
Delta Smelt	Average	42	0.1	-49	-0.1
	W	-4	-0.0	20	0.0
	AN	-60	-0.1	12	0.0
	BN	305	0.9	292	0.8
	D	-6	-0.0	-43	-0.1
	C	10	0.0	-665	-2.9
Chinook Salmon	Average	53	0.1	-37	-0.1
	W	-16	-0.0	8	0.0
	AN	-123	-0.2	33	0.1
	BN	302	0.6	116	0.2
	D	-47	-0.1	-52	-0.1
	C	235	0.7	-360	-1.1
Longfin Smelt	Average	-2	-0.0	-29	-0.4
	W	0	-0.0	-4	-0.0
	AN	1	0.0	1	0.0
	BN	3	0.1	4	0.1
	D	-2	-0.0	5	0.1
	C	-17	-0.3	-202	-4.0

Table 11-40. Indices of Entrainment at the CVP and SWP Facilities Comparing Existing Conditions, No-Action Alternative, and CP3 (contd.)

Species	Water Year	CP3 minus Existing Condition	Percent Change	CP3 Minus Future Condition	Percent Change
Steelhead	Average	7	0.2	8	0.2
	W	-3	-0.1	4	0.1
	AN	-31	-0.7	4	0.1
	BN	36	0.9	-3	-0.1
	D	-5	-0.2	-10	-0.3
	C	55	2.0	57	2.1
Striped Bass	Average	3,981	0.3	7,305	0.6
	W	2,316	0.1	2,465	0.1
	AN	-513	-0.0	3,333	0.2
	BN	15,204	1.1	12,919	1.0
	D	1,563	0.1	8,672	0.8
	C	2,616	0.4	13,162	2.2
Splittail	Average	507	0.2	886	0.3
	W	-36	-0.0	158	0.0
	AN	-738	-0.2	-171	-0.1
	BN	4,107	1.6	3,650	1.4
	D	-283	-0.1	164	0.1
	C	-83	-0.1	1,378	1.4

Note: A negative percentage change reflects a reduction in entrainment risk while a positive percentage change reflects an increase in entrainment risk.

Key:
AN = above-normal
BN = below-normal
C = critical
cfs = cubic feet per second
CP = Comprehensive Plan
D = dry
W = wet

Results of entrainment risk calculations for delta smelt showed a change of less than 1 percent in wet, above-normal, and below-normal water years and an increase in risk of less than 3 percent during critical water years under CP3 relative to the Existing Condition (Table 11-40). The risk of increased losses of delta smelt under CP3 compared to the No-Action Alternative (Table 11-40) would be greatest in the below-normal water years. Although the incremental change in the risk of delta smelt losses resulting from CVP and SWP export operations is small, delta smelt population abundance is currently at such critically low levels that even a small increase in the risk of losses is considered to be potentially significant. The increase in risk is also expected to contribute to cumulative factors affecting the survival of delta smelt.

The estimated change in the risk of losses for Chinook salmon increases during below-normal and critical water years under 2005 conditions, and above-normal and below-normal water years under 2030 conditions (Table 11-40). Given the numbers of juvenile Sacramento River Chinook salmon produced each year in the Central Valley, the relatively small incremental increase in the risk of entrainment/salvage at the CVP and SWP export facilities would be a less-than-significant direct impact but would contribute incrementally to the overall cumulative factors affecting juvenile Chinook salmon survival within the Delta, and population dynamics of the stocks.

The estimated change in the risk of longfin smelt entrainment/salvage under CP3 compared to the Existing Condition and the No-Action Alternative shows small positive and negative changes depending on water year type and alternative (Table 11-40). These small changes in the risk of entrainment are considered to be less than significant.

The estimated change in the risk to steelhead of entrainment/salvage at the CVP and SWP export facilities are summarized in Table 11-40. The small positive and negative changes in risk under wet, above-normal, below-normal, and dry water years are considered to be less than significant. The increase (approximately 2 percent) in risk of steelhead losses in critical water years are considered to be potentially significant based on the apparently low abundance of juvenile Sacramento and San Joaquin river steelhead migrating through the Delta, but would contribute directly to cumulative factors affecting the survival and population dynamics of Central Valley steelhead. The predicted increase in potential entrainment risk for steelhead under critical water years represents an initial estimate of the change (percentage) between CP3 and Existing Conditions and the No-Action Alternative, and does not allow the predicted losses to be evaluated at the population level (see Attachment 1 of the *Fisheries and Aquatic Ecosystems Technical Report)*.

The change in risk to juvenile striped bass for entrainment/salvage at the CVP and SWP export facilities are summarized in Table 11-40. The change in risk in wet, above-normal, and below-normal water years are considered to be less than significant based on the abundance of striped bass, but would contribute to the cumulative factors affecting striped bass survival and population dynamics in the Delta. The losses of juvenile striped bass increased substantially under dry and critical water years, which would be expected with an increase in exports during the summer months and is considered to be potentially significant. The increased losses under CP3, particularly in drier water years when juvenile striped bass production is lower, would be expected to contribute to the cumulative effects of factors affecting juvenile striped bass survival in the Delta.

The increased risk index for splittail was less than 1 percent under both the Existing Condition and No-Action Alternative, and was considered to be less than significant. The loss index increased during dry and critical water years, with the greatest increase for CP3. Higher risk of entrainment/salvage losses in drier water years has a potentially greater effect of abundance of juvenile splittail since reproductive success and overall juvenile abundance is typically lower within the Delta in dry years. The increased risk of losses in drier years was considered to be potentially significant. The increased losses would also contribute to cumulative factors affecting survival of juvenile splittail within the Delta.

Impact Aqua-23 (CP3) is considered to be less than significant for Chinook salmon, and longfin smelt, but potentially significant for delta smelt, steelhead, striped bass, and splittail. Mitigation for this impact is not proposed because operations will be guided by RPAs established by NMFS and USFWS BOs to reduce any impacts to listed fish species, and thus, reduce impacts to non-listed fishes as well.

CVP/SWP Service Areas

Impact Aqua-24 (CP3): Impacts on Aquatic Habitats and Fish Populations in the CVP and SWP Service Areas Resulting from Modifications to Existing Flow Regimes Project implementation would result in modified flow regimes that would reduce the frequency and magnitude of high winter flows along the Sacramento River; however, the hydrologic effects in tributaries and reservoirs (e.g., New Melones and San Luis) with CVP and SWP dams are expected to be less than impacts on the lower Sacramento River. The change in hydrology could affect aquatic habitats that provide habitat for the fish community. These changes are unlikely to result in substantial effects on the distribution or abundance of these species in the CVP and SWP service areas. Therefore, this impact would be less than significant.

This impact would be similar to Impact Aqua-24 (CP1). The impact could be greater because the increased reservoir capacity associated with an 18.5-foot raise compared to a 6.5-foot raise would allow for additional water volume (and flows) to be stored behind the raised dam. However, these changes are unlikely to result in substantial effects on the distribution or abundance of these species in the CVP and SWP service areas. The effects from CP3 on CVP and SWP reservoir elevations, filling, spilling, and planned releases, and resulting flows downstream from those reservoirs, would be small and well within the range of variability that commonly occurs in these reservoirs and downstream. Therefore, this impact would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

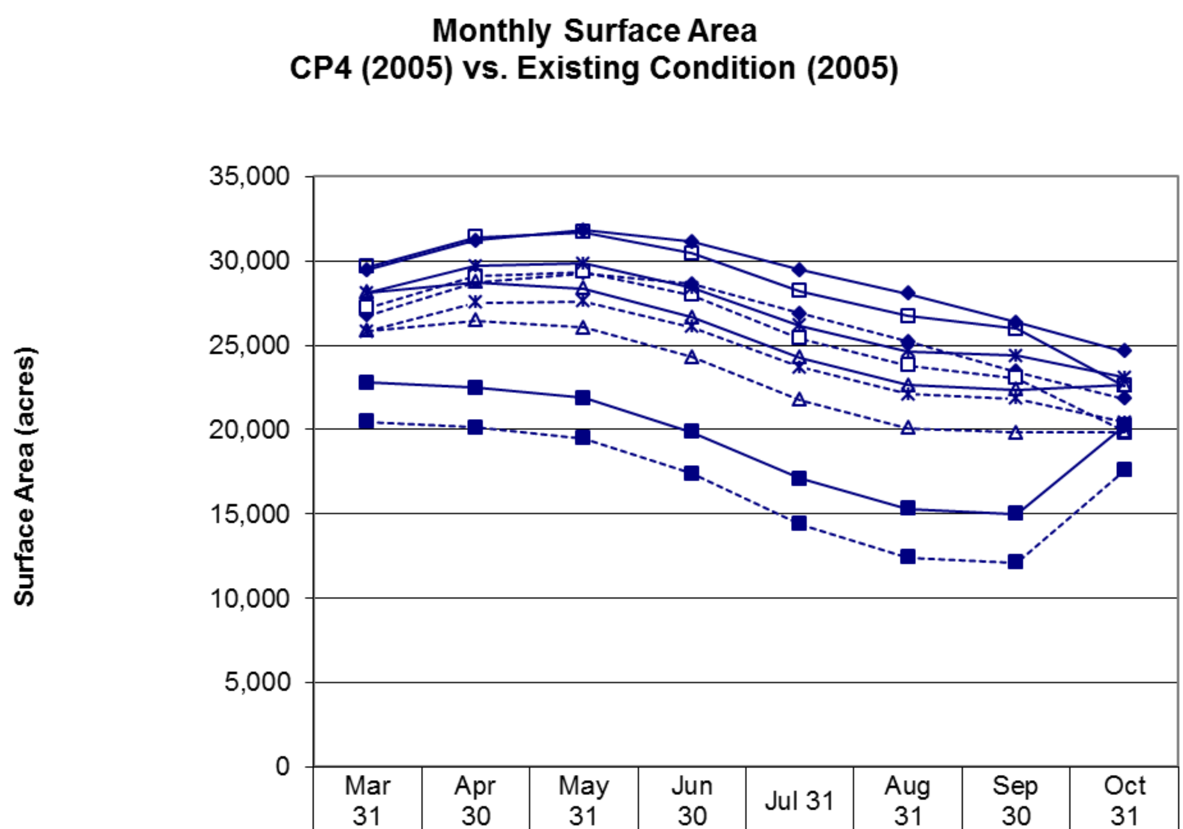
CP4 – 18.5-Foot Dam Raise, Anadromous Fish Focus with Water Supply Reliability

CP4 focuses on increasing anadromous fish survival while also increasing water supply reliability. By raising Shasta Dam 18.5 feet, in combination with spillway modifications, CP4 would increase the height of the reservoir full pool by 20.5 feet and enlarge the total storage capacity in the reservoir by 634,000 acre-feet. The existing TCD would also be extended to achieve efficient use of the expanded cold-water pool. The additional storage created by the 18.5-foot dam raise would be used to improve the ability to meet temperature objectives and habitat requirements for anadromous fish during drought years and increase water supply reliability. Of the increased reservoir storage space, about 378,000 acre-feet would be dedicated to increasing the supply of cold water for anadromous fish survival purposes. Operations for the remaining portion of increased storage (approximately 256,000 acre-feet) would be the same as in CP1, with 70 TAF and 35 TAF reserved to specifically focus on increasing M&I deliveries during dry and critical years, respectively. CP4 also includes augmenting spawning gravel and restoring riparian, floodplain, and side channel habitat in the upper Sacramento River.

Shasta Lake and Vicinity

Impact Aqua-1 (CP4): Effects on Nearshore, Warm-Water Habitat in Shasta Lake from Project Operations Under CP4, project operations would contribute to an increase in the surface area and WSEL of Shasta Lake, which would in turn increase the area and productivity of nearshore, warm-water habitat. CP4 operations would also result in reduced monthly fluctuations in WSEL, which would contribute to increased reproductive success, young-of-the-year production, and the juvenile growth rate of warm-water fish species. Similar to CP3, the value of existing structural habitat improvements would be diminished to varying degrees; however, the existing habitat enhancement features would become functional during reservoir drawdowns later in the season and during below-normal and drier years, when the reservoir does not refill. Additionally, large areas of the shoreline would not be cleared, and the vegetation along these sections will be inundated periodically. In the short term, this newly inundated vegetation will initially increase warm-water fish habitat, with decay expected to occur over several decades. This impact would be less than significant.

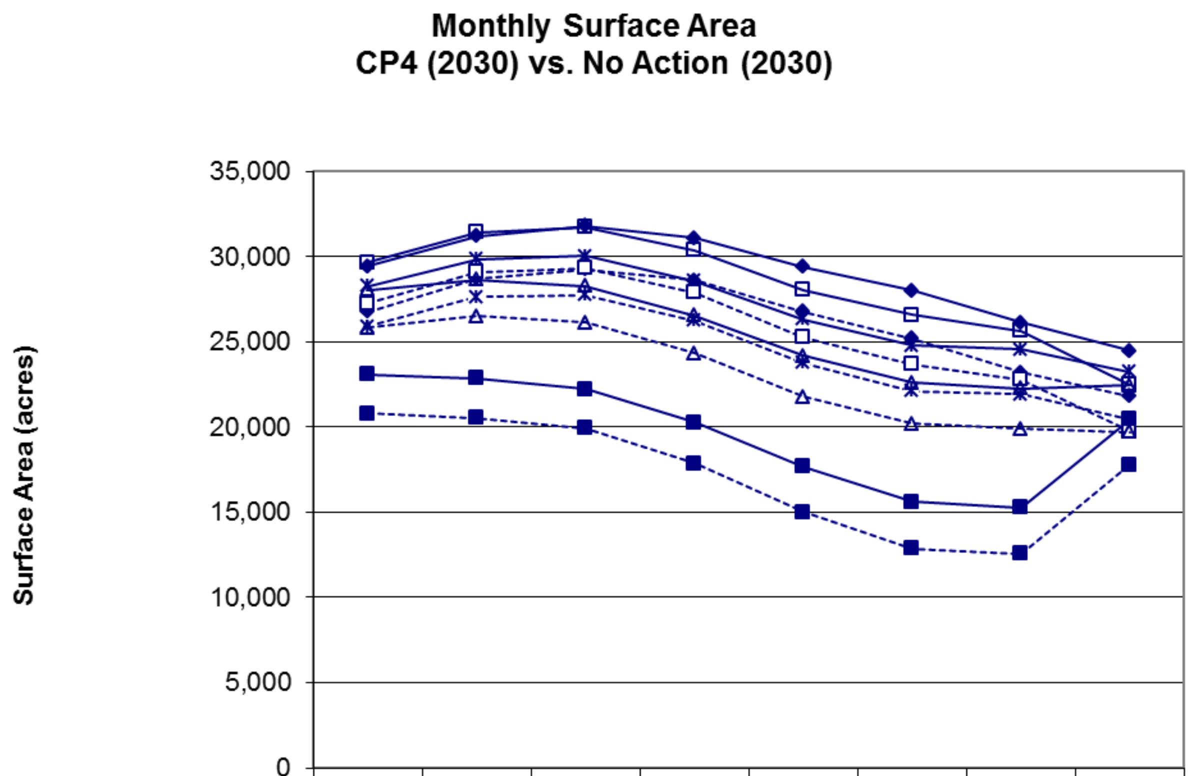
This impact would be similar to Impacts Aqua-1 (CP1, CP2, and CP3), but the surface area would be larger under the 18.5-foot dam raise than under CP1 and CP2. CalSim-II modeling shows that the surface area of Shasta Lake would be larger under CP4 for both a 2005 and 2030 water supply demand than under the Existing Condition or the No-Action Alternative in all five water year types (Figures 11-29 and 11-30).



	Mar 31	Apr 30	May 31	Jun 30	Jul 31	Aug 31	Sep 30	Oct 31
EC W	26,790	28,748	29,277	28,624	26,872	25,226	23,413	21,827
EC AN	27,245	29,082	29,336	27,992	25,400	23,826	23,061	19,906
EC BN	25,807	27,534	27,621	26,104	23,714	22,114	21,837	20,425
EC D	25,850	26,467	26,058	24,300	21,754	20,093	19,840	19,828
EC C	20,467	20,142	19,500	17,381	14,400	12,418	12,111	17,572
CP4 2005 W	29,449	31,220	31,811	31,125	29,463	28,073	26,342	24,655
CP4 2005 AN	29,658	31,393	31,719	30,465	28,195	26,742	25,983	22,590
CP4 2005 BN	28,094	29,692	29,832	28,406	26,179	24,663	24,362	23,088
CP4 2005 D	28,155	28,742	28,351	26,665	24,248	22,630	22,360	22,625
CP4 2005 C	22,780	22,473	21,856	19,871	17,077	15,320	14,997	20,243

Key:
AN = above-normal water
BN= below-normal water years
C = critical water years
CP = Comprehensive Plan
D = dry water years
EC = Existing Condition
W = wet water years

Figure 11-29. Average Monthly Surface Area for Each Water Year Type Within the Shasta Lake Vicinity of the Primary Study Area, CP4 Versus Existing Condition (2005)



	Mar 31	Apr 30	May 31	Jun 30	Jul 31	Aug 31	Sep 30	Oct 31
NA W	26,775	28,735	29,273	28,604	26,797	25,183	23,205	21,808
NA AN	27,258	29,117	29,325	27,921	25,294	23,687	22,800	19,759
NA BN	25,918	27,662	27,770	26,239	23,764	22,137	21,923	20,469
NA D	25,843	26,514	26,134	24,346	21,780	20,209	19,910	19,728
NA C	20,801	20,548	19,942	17,866	15,026	12,873	12,556	17,800
CP4 2030 W	29,436	31,209	31,806	31,089	29,398	28,006	26,152	24,495
CP4 2030 AN	29,677	31,437	31,740	30,369	28,051	26,579	25,658	22,492
CP4 2030 BN	28,276	29,878	30,048	28,591	26,320	24,798	24,567	23,228
CP4 2030 D	28,045	28,663	28,287	26,552	24,182	22,623	22,283	22,451
CP4 2030 C	23,112	22,855	22,235	20,262	17,674	15,624	15,282	20,472

Key:
AN = above-normal water
BN= below-normal water years
C = critical water years
CP = Comprehensive Plan
D = dry water years
EC = Existing Condition
W = wet water years

Figure 11-30. Average Monthly Surface Area for Each Water Year Type Within the Shasta Lake Vicinity of the Primary Study Area, CP4 Versus No-Action Alternative

Monthly WSEL fluctuations were compared to projections for water supply demand. For CP4, with a 2005 water supply demand, 68 percent of monthly changes in projected WSELs (i.e., 17 of the 25 total projections made for the 5 months from March through July for all five water year types) showed decreased monthly WSEL fluctuations relative to the Existing Condition and none showed an increased monthly WSEL fluctuation (Figure 11-31). For CP4, with a projected 2030 water supply demand, 76 percent of monthly changes in projected WSELs showed decreased WSEL fluctuations relative to the No-Action Alternative and none showed an increased monthly WSEL fluctuation (Figure 11-32). Under CP4, none of the changes in monthly WSEL fluctuation are different enough from the Existing Condition to warrant the investigation of daily WSEL fluctuation.

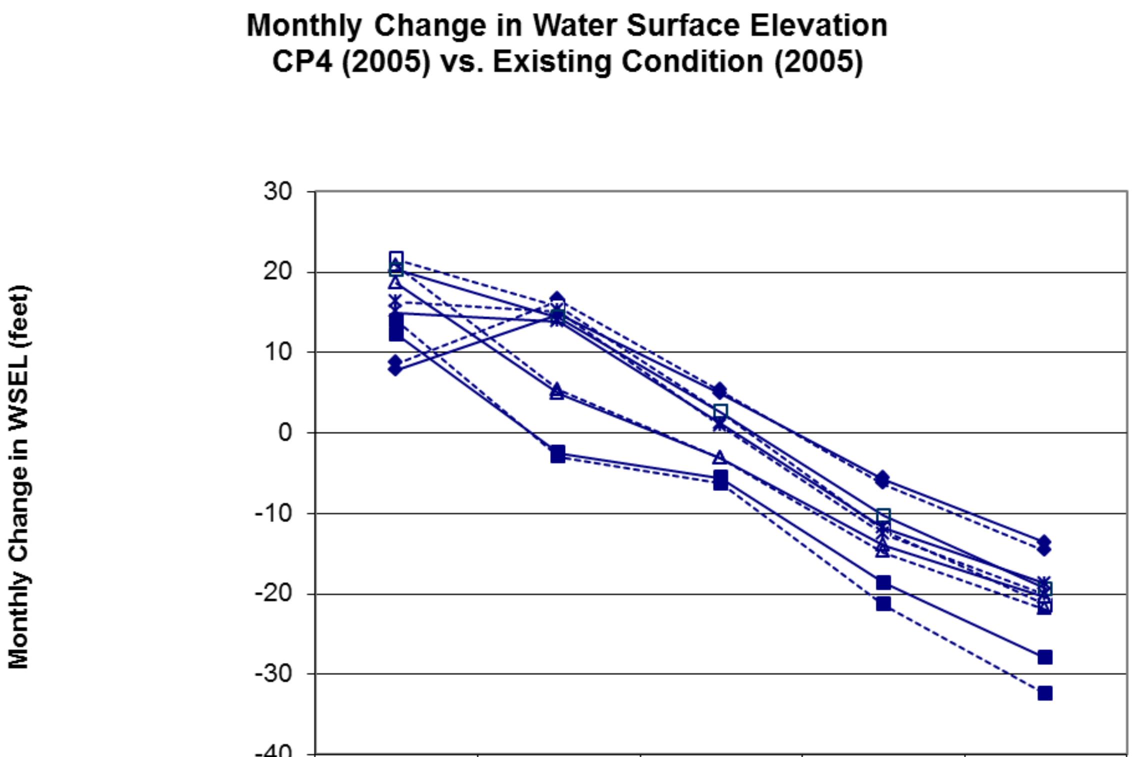
Increases in the overall surface area and WSEL under CP4 would increase the area of available warm-water habitat and stimulate biological productivity, including fish production, of the entire lake for a period of time, possibly for several decades. Furthermore, reductions in the magnitude of monthly WSEL fluctuations could contribute to increased reproductive success, young-of-the-year production, and juvenile growth rate of warm-water fish species. Therefore, this impact would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

Impact Aqua-2 (CP4): Effects on Nearshore, Warm-Water Habitat in Shasta Lake from Project Construction This impact would be similar to Impact Aqua-2 (CP3). This impact would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

Impact Aqua-3 (CP4): Effects on Cold-Water Habitat in Shasta Lake Operations-related changes in the ratio of cold-water storage to surface area would affect the availability of suitable cold-water habitat in Shasta Lake, including rainbow trout. This impact would be beneficial.

This impact would be similar to Impacts Aqua-3 (CP1, CP2, and CP3) but would be of greater benefit to the reservoir cold-water fishery than Aqua-1 (CP3) owing to its focus on increasing the volume of cold water available to the TCD to benefit anadromous fish downstream from Shasta Dam.

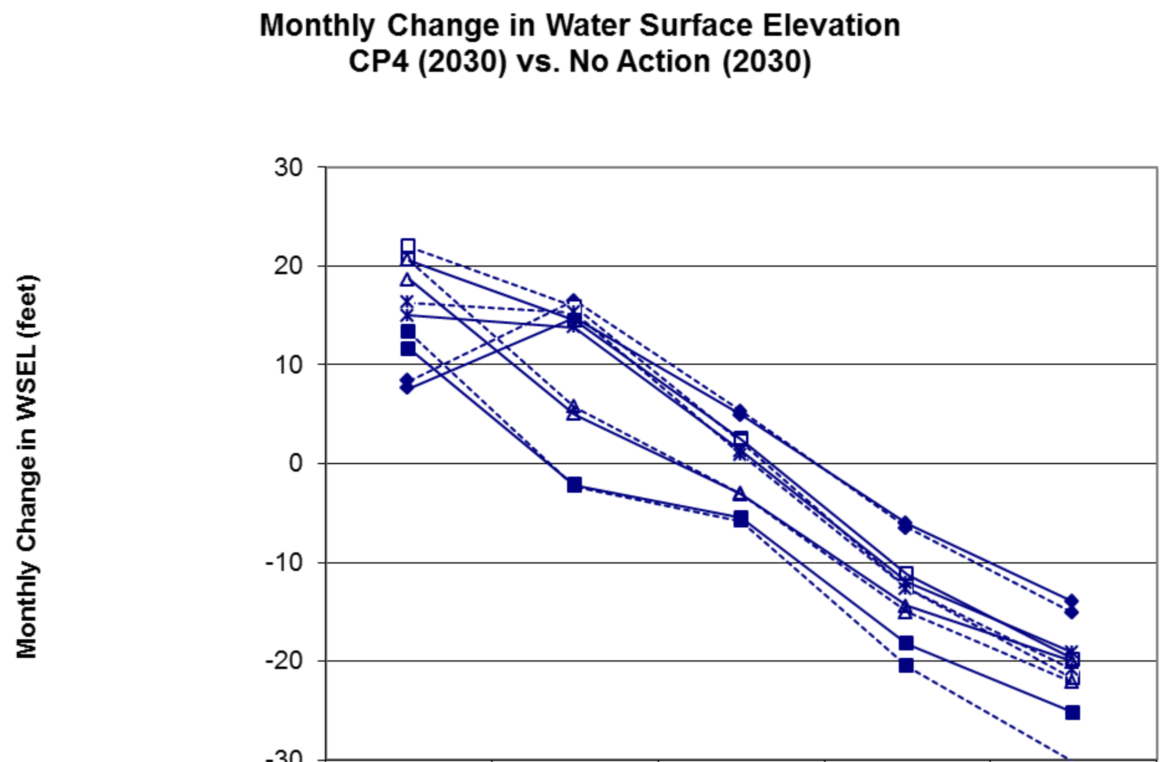
CalSim-II modeling shows that under CP4, with a 2030 water supply demand, the ratio of cold-water storage to surface area is higher than under the No-Action Alternative in all water years and during all months modeled. The greatest projected increases over the No-Action Alternative occurred between June 30 and August 31, which is a critical rearing and oversummering period for cold-water fishes in reservoirs (Figure 11-33). Therefore, this impact would be beneficial. Mitigation for this impact is not needed, and thus not proposed.



	Mar 31	Apr 30	May 31	Jun 30	Jul 31
EC W	9	16	5	-6	-15
EC AN	22	16	3	-12	-21
EC BN	16	15	1	-13	-20
EC D	21	5	-3	-15	-22
EC C	14	-3	-6	-21	-32
CP4 (2005) W	8	15	5	-6	-14
CP4 (2005) AN	20	14	3	-10	-19
CP4 (2004) BN	15	14	1	-12	-19
CP4 (2005) D	19	5	-3	-14	-21
CP4 (2005) C	12	-3	-6	-19	-28

Key:
AN = above-normal water
BN= below-normal water years
C = critical water years
CP = Comprehensive Plan
D = dry water years
EC = Existing Condition
W = wet water years

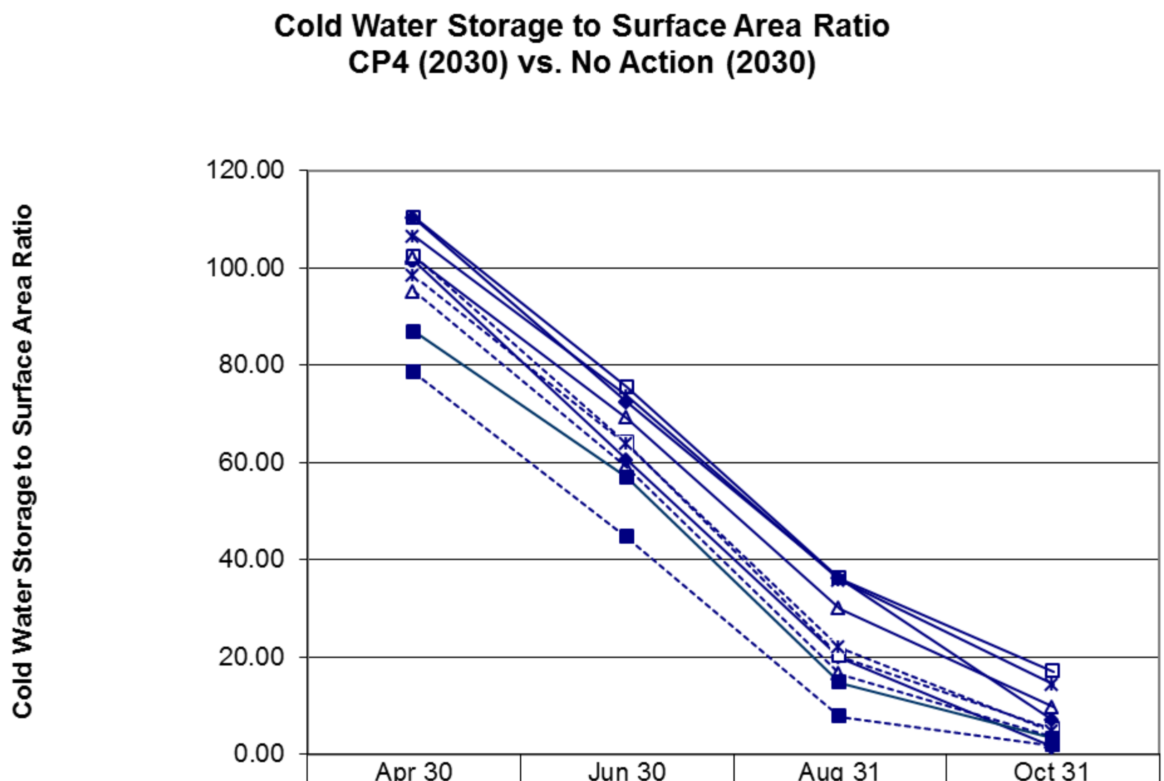
Figure 11-31. Average Monthly Change in WSEL for Each Water Year Type Within the Shasta Lake Vicinity of the Primary Study Area, CP4 Versus Existing Condition (2005)



	Mar 31	Apr 30	May 31	Jun 30	Jul 31
NA W	8	16	5	-7	-15
NA AN	22	16	2	-13	-22
NA BN	16	15	1	-13	-21
NA D	21	6	-3	-15	-22
NA C	13	-2	-6	-21	-30
CP4 (2030) W	8	15	5	-6	-14
CP4 (2030) AN	21	14	2	-11	-20
CP4 (2030) BN	15	14	1	-12	-19
CP4 (2030) D	19	5	-3	-14	-20
CP4 (2030) C	12	-2	-6	-18	-25

Key:
AN = above-normal water
BN= below-normal water years
C = critical water years
CP = Comprehensive Plan
D = dry water years
NA = No-Action
W = wet water years

Figure 11-32. Average Monthly Change in WSEL for Each Water Year Type Within the Shasta Lake Vicinity of the Primary Study Area, CP4 Versus No-Action Alternative



	Apr 30	Jun 30	Aug 31	Oct 31
NA W	101.33	60.49	19.89	1.43
NA AN	102.30	64.04	20.12	5.09
NA BN	98.27	63.71	21.84	4.64
NA D	95.13	59.14	16.50	3.38
NA C	78.43	44.58	7.66	1.82
CP4 2030 W	110.16	72.43	36.06	6.87
CP4 2030 AN	110.27	75.42	36.12	17.05
CP4 2030 BN	106.38	73.71	35.68	14.32
CP4 2030 D	102.04	69.13	29.86	9.68
CP4 2030 C	86.77	56.88	14.72	3.13

Key:
AN = above-normal water
BN= below-normal water years
C = critical water years
CP = Comprehensive Plan
D = dry water years
NA = No-Action
W = wet water years

Figure 11-33. Average Monthly Cold-water Storage to Surface Area Ratio for Each Water Year Type Within the Shasta Lake Vicinity of the Primary Study Area, CP4 Versus the No-Action Alternative

Impact Aqua-4 (CP4): Effects on Special-Status Aquatic Mollusks Under CP4, habitat for special-status mollusks could be inundated. Seasonal fluctuations in the surface area and WSEL of Shasta Lake could also adversely affect special-status aquatic mollusks that could occupy habitat in or near Shasta Lake and its tributaries. Tributary investigations are ongoing and will provide additional information and analysis for inclusion in the Final EIS. Initial evidence from field surveys of lower reaches of representative tributaries to the lake suggests that the probability of occurrence of special-status mollusks in these reaches is low. However, because the California floater, a special-status mollusk, is known from Shasta Lake, this impact would be potentially significant. Mitigation for this impact is proposed in Section 11.3.4.

Impact Aqua-5 (CP4): Effects on Special-Status Fish Species The expansion of the surface area of Shasta Lake and the inundation of additional tributary habitat under CP4 would be similar to CP3 and could affect one species designated as sensitive by the USFS, the hardhead. Tributary investigations are ongoing and will provide additional information and analysis for inclusion in the Final EIS; however, available evidence from recent fish surveys suggests that hardhead do not currently inhabit or are very uncommon in the lower reaches of the principal tributaries, except the Pit River above the Pit 7 afterbay. This impact would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

Impact Aqua-6 (CP4): Creation or Removal of Barriers to Fish Between Tributaries and Shasta Lake Under CP4, project implementation would result in the periodic inundation of steep and low-gradient tributaries to Shasta Lake up to the 1,090-foot contour, the maximum inundation level under this alternative. Similar to CP3, initial analysis indicates that about 63 percent of the intermittent and 48 percent of perennial tributaries surveyed contain substantial barriers between the 1,070-foot and 1,090-foot contours that would be inundated under this alternative; however, none of the streams with barriers was found to be inhabited by special-status fish in the upstream reaches. Additionally, except in the Sacramento and McCloud rivers, colonization of inundated streams appears to be limited to the reservoir varial zone. Tributary investigations are ongoing and will provide additional information and analysis for inclusion in the Final EIS. This impact is considered to be less than significant. Mitigation for this impact is not needed, and thus not proposed.

Impact Aqua-7 (CP4): Effects on Spawning and Rearing Habitat of Adfluvial Salmonids in Low-Gradient Tributaries to Shasta Lake Similar to that described for CP3, CP4 would result in additional periodic inundation of potentially suitable spawning and rearing habitat for adfluvial salmonids in the tributaries of the Sacramento River, McCloud River, Pit River, Big Backbone Creek, and Squaw Creek upstream from Shasta Lake. A total of 11 miles of low-gradient reaches that could potentially provide some spawning and rearing habitat for adfluvial salmonids (estimated as 40,103 square feet for all tributaries) would be affected by CP4, which is only about 2.8 percent of the low-gradient habitat upstream from Shasta Lake. Tributary investigations are ongoing and will provide additional information and analysis for inclusion in the Final EIS. This impact would be potentially significant. Mitigation for this impact is proposed in Section 11.3.4.

Impact Aqua-8 (CP4): Effects on Aquatic Connectivity in Non-Fish-Bearing Tributaries to Shasta Lake Similar to CP3, CP4 would result in periodic inundation of the lower reaches of high-gradient, non-fish-bearing tributaries to Shasta Lake. About 24 miles of non-fish-bearing tributary habitat would be affected by CP4, which is only about 1 percent of the lengths of non-fish-bearing tributaries upstream from Shasta Lake. Tributary investigations are ongoing and will provide additional information and analysis for inclusion in the Final EIS. Examination of initial field surveys suggest that few, if any, of the non-fish bearing streams contain special-status aquatic invertebrate or vertebrate species that would be affected by increased connectivity to Shasta Lake. This impact would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

Impact Aqua-9 (CP4): Effects on Water Quality at Livingston Stone Hatchery Reclamation provides the water supply to the Livingston Stone Hatchery from a pipeline emanating from Shasta Dam. This supply would not be interrupted by any activity associated with CP4. There would be no impact. Mitigation for this impact is not needed, and thus not proposed.

Upper Sacramento River (Shasta Dam to Red Bluff)

Impact Aqua-10 (CP4): Loss or Degradation of Aquatic Habitat in the Upper Sacramento River During Construction Activities Temporary construction-related increases in sediments and turbidity levels would adversely affect aquatic habitats and fish populations immediately downstream in the upper Sacramento River. However, environmental commitments would be in place to reduce the effects. This impact would be less than significant.

This impact would be similar to Impact Aqua-10 (CP1). The impact could be greater under CP4 than under CP1 because of the increased activity associated with an 18.5-foot dam raise compared to a 6.5-foot dam raise. Also, CP4 includes implementation of a 10-year gravel augmentation program as an additional environmental commitment. Placing gravel along the Sacramento River channel and bank annually would release an additional source of fine sediment and expose it to the river and aquatic communities. However, the gravel augmentation activities would occur only during previously specified in-water work windows, which would minimize the potential for impacts associated with this activity.

CP4 also includes restoration of riparian, floodplain, and side-channel habitat in the upper Sacramento River at up to six potential restoration sites. Riparian, floodplain, and side-channel restoration at these sites could result in additional disturbed surfaces, but most of this construction is expected to occur away from the wetted channel, and all disturbed areas would be revegetated.

As under CP4, environmental commitments for all actions would be in place to reduce effects. Therefore, this impact would be less than significant. Mitigation for this impact is not needed, and thus is not proposed.

Impact Aqua-11 (CP4): Release and Exposure of Contaminants in the Upper Sacramento River During Construction Activities Construction-related activities could result in the release and exposure of contaminants. Such exposure could adversely affect aquatic habitats, the aquatic food web, and fish populations, including special-status species, downstream in the primary study area. However, environmental commitments would be in place to reduce the effects. Therefore, this impact would be less than significant.

This impact would be similar to Impact Aqua-11 (CP1). The impact could be greater under CP4 than under CP1 because of the increased activity associated with an 18.5-foot raise compared to a 6.5-foot raise. Additionally, as discussed above, CP4 includes implementation of a 10-year gravel augmentation program and restoration of riparian, floodplain, and side-channel habitat as additional environmental commitments. Both of these construction activities could cause additional sources of equipment-related contaminants to be released and exposed to the river and aquatic communities. However, implementation of additional environmental commitments that call for in-water work windows and specific BMPs would minimize and/or avoid the potential for impacts associated with this activity. As under CP1, environmental commitments for all actions would be in place to reduce effects. Therefore, this impact would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

Impact Aqua-12 (CP4): Changes in Flow and Water Temperature in the Upper Sacramento River Resulting from Project Operation – Chinook Salmon CP4 operation would result in generally improved flow and water temperature conditions in the upper Sacramento River for fish species of management concern. Additionally, the restoration actions proposed under CP4 would provide benefits to Chinook salmon. This impact would be beneficial.

Winter-Run Chinook Salmon

Production

Overall average winter-run production for the 81-year period would be greater under CP4 conditions relative to the No-Action Alternative and Existing Condition (Attachments 3 and 4 of the Modeling Appendix). The maximum increase in simulated production relative to the No-Action Alternative was 369 percent (critical water year), while the largest decrease in production under CP4 relative to the No-Action Alternative was less than -7 percent (above-normal water year) (Table 11-41 and Attachment 3 of the Modeling Appendix). The maximum increase in production relative to the Existing Condition was around 392 percent in 1934 (critical water year) for CP4, while the largest decrease in production relative to the Existing Condition was less than -5 percent CP4 (Table 11-41 and Attachment 4 of the Modeling Appendix). Figure 11-9 shows the change in production relative to the No-Action Alternative for all water years and all Comprehensive Plans.

Under CP4, five critical, one dry, and one wet water year had significant increases in production compared to the No-Action Alternative, while one above-normal water year had a significant decrease in production compared with the No-Action Alternative.

Table 11-41. Change in Production Under CP4 for Winter-Run Chinook Salmon

Year Type	Number of Years	Average Production	Change in Production from Baseline	Average Change in Production	Maximum Increase in Production	Number of Months with Significant Increase	Maximum Decrease in Production	Number of Months with Significant Decrease
Future Condition (2030)								
All	81	3,863,877	62,762	1.7	369	7	-6.7	1
Critical	13	3,958,608	580,652	17.2	369	5	-3.0	0
Dry	17	3,961,832	-10,499	-0.3	6.6	1	-3.3	0
Below Normal	14	3,924,052	-14,506	-0.4	3.6	0	-3.9	0
Above Normal	11	3,782,793	-76,137	-2.0	0.3	0	-6.7	1
Wet	26	3,754,368	-47,911	-1.3	5.7	1	-4.3	0
Existing Condition (2005)								
All	81	3,868,418	87,171	2.3	392	7	-4.7	0
Critical	13	3,934,478	723,539	22.5	392	6	-1.9	0
Dry	17	3,979,718	-4,144	-0.1	16.0	1	-4.3	0
Below Normal	14	3,908,625	-31,525	-0.8	4.6	0	-4.7	0
Above Normal	11	3,808,985	-43,697	-1.1	3.8	0	-3.7	0
Wet	26	3,766,110	-52,025	-1.4	1.0	0	-4.3	0

Note:

Production is the number of immature smolts surviving to pass the Red Bluff Pumping Plant

Under CP4, six critical and one dry water years had significant increases in production compared to the Existing Condition, while no water years had a significant decrease in production.

Mortality

Mortality was separated by flow- and water temperature-related mortality to assess the level of impacts on winter-run Chinook salmon caused by the actions of the project (Attachments 3 and 4 of the Modeling Appendix). Nonoperations-related mortality are the base and seasonal mortality that would occur even without the effects of Shasta operations (such as disease, predation, and entrainment). Flow- and water temperature-related mortality is that caused by altering flow and water temperatures. In all cases, most mortality is caused by nonoperations-related factors (e.g., disease, predation, entrainment)‒around 89 percent of the total mortality.

Mortality is presented in two manners–total mortality and smolt equivalent mortality (Attachments 3 and 4 of the Modeling Appendix). The greatest average mortality to winter-run Chinook salmon under CP1 in all water year types based on smolt equivalents would occur to the fry life stage, followed by eggs, then presmolts, and lastly to immature smolts. Table 11-5 displays the overall mortalities for each Comprehensive Plan that were caused by changes in operations (i.e., water temperature and flow) (Attachments 3 and 4 of the Modeling Appendix).

Under CP4, years with the highest mortality were different between CP4, No-Action Alternative and Existing Conditions and included critical, dry and wet water year types. These years with highest mortality were preceded by three critical, and three dry water years. Years with the lowest mortality varied between all water year types (Attachments 3 and 4).

Winter-run Chinook salmon would have, overall, a significant reduction in project-related mortality (19-percent reduction for 2030 conditions, and 23-percent reduction under 2005 conditions). Winter-run Chinook salmon would have an overall insignificant increase in production, but a significant increase in production during critical water years–those years in which they are at greatest risk. Therefore, winter-run Chinook salmon would benefit from water temperature and flow conditions under in CP4. Additionally, winter-run Chinook salmon will likely benefit from the downstream restoration program, although this was not modeled with SALMOD. Mitigation for this impact is not needed, and thus not proposed.

Spring-Run Chinook Salmon

Production

Overall average spring-run Chinook salmon production increased for the 82-year period under CP4 compared to the No-Action Alternative and the Existing Condition (Attachments 6 and 7 of the Modeling Appendix). The maximum increase in simulated production relative to the No-Action Alternative was

6,006 percent for CP4. The largest decrease in production relative to the No-Action Alternative was -8 percent for CP4 (Table 11-42 and Attachment 6 of the Modeling Appendix). The maximum increase in production relative to the Existing Condition was 5,516 percent for CP4. The largest decrease in production relative to the Existing Condition was just -8.5 percent for CP4 (Table 11-42 and Attachment 7 of the Modeling Appendix). Figure 11-10 shows the change in production relative to the No-Action Alternative for all water years and all Comprehensive Plans.

Under CP4, 12 critical, two dry, one below-normal, and one above-normal water years had significant increases in production compared to the No-Action Alternative. One each dry, below-normal and wet water years had significant decreases in production (Attachment 6 of the Modeling Appendix).

Table 11-42. Change in Production Under CP4 for Spring-Run Chinook Salmon

Year Type	Number of Years	Average Production	Change in Production from Baseline	Average Change in Production	Maximum Increase in Production	Number of Months with Significant Increase	Maximum Decrease in Production	Number of Months with Significant Decrease
Future Condition (2030)								
All	81	169,926	5,871	3.6	6006	15	-8.1	3
Critical	13	116,448	35,259	43.4	6006	12	0.4	0
Dry	17	178,300	8,848	5.2	1844	2	-5.2	1
Below Normal	14	178,039	859	0.5	36.3	1	-5.3	1
Above Normal	11	181,294	-2,472	-1.3	5.5	1	-4.6	0
Wet	26	182,011	-4,539	-2.4	0.5	0	-8.1	1
Existing Condition (2005)								
All	81	170,326	7,119	4.3	5517	15	-8.5	2
Critical	13	116,199	42,136	56.9	5517	12	4.9	0
Dry	17	179,369	10,508	6.2	2485	1	-4.9	0
Below Normal	14	179,032	1,002	0.6	34.4	1	-3.9	0
Above Normal	11	180,906	-3,208	-1.7	3.3	0	-4.7	0
Wet	26	182,157	-5,072	-2.7	0.5	0	-8.5	2

Note:
Production is the number of immature smolts surviving to pass the Red Bluff Pumping Plant

Under CP4, 12 critical, one dry, and one below-normal water years had significant increases in production compared to the Existing Condition. Two wet water years had significant decreases in production (Attachment 6 of the Modeling Appendix).

<u>Mortality</u>

Mortality was separated by flow- and water temperature-related mortality to assess the level of impacts on spring-run Chinook salmon caused by the actions of the project (Attachments 6 and 7). In all cases, most mortality is caused by nonoperations-related factors (e.g., disease, predation, entrainment)−around 89 percent of the total mortality.

Mortality is presented in two manners–total mortality and smolt equivalent mortality (Attachments 6 and 7 of the Modeling Appendix). Under both the 2030 and 2005 conditions, the greatest mortality to spring-run Chinook salmon under CP4 (as with CP1 through CP3) in all water year types based on smolt equivalents, occurred to eggs, with minimal mortality to the other life stages. Table 11-7 displays the smolt-equivalent mortalities for each Comprehensive Plan that are caused by flow- and water-related factors (also see Attachments 6 and 7 of the Modeling Appendix).

Years with the highest operations-related mortality were different for CP4 compared with No-Action Alternative and Existing Conditions with fewer years with high mortality. All years with the highest mortality were preceded by either a critical or dry water year. Years with the lowest mortality varied between all water year types (Attachments 6 and 7 of the Modeling Appendix).

Spring-run Chinook salmon would have significantly reduced flow- and water temperature-related mortality under CP4, but an insignificant increase in overall production. However, they would experience a significant increase in production during almost all critical water years. Therefore, spring-run Chinook salmon would benefit from actions taken in CP4. Additionally, spring-run Chinook salmon will benefit from the downstream restoration program, although this was not modeled with SALMOD. Mitigation for this impact is not needed, and thus not proposed.

Fall-Run Chinook Salmon

<u>Production</u>

Overall average fall-run Chinook salmon production under CP4 increased for the 81-year period compared with the No-Action Alternative and Existing Condition (Attachments 9 and 10 of the Modeling Appendix). The maximum increase in simulated production relative to the No-Action Alternative was 617 percent (in a critical water year, while the largest decrease in production relative to the No-Action Alternative was -6.5 percent (in a wet water year) for CP4 (Table 11-43 and Attachment 9 of the Modeling Appendix). The maximum increase in production relative to the Existing Condition was 656 percent in 1934 (a critical water year). The largest decrease in production relative to the

Existing Condition was -6.7 percent (in a wet water year) for CP4 (Table 11-43 and Attachment 10 of the Modeling Appendix). Figure 11-11 shows the change in production relative to the No-Action Alternative for all water years and all Comprehensive Plans.

Under CP4, five critical, three dry, and one above-normal water years had a significant increases in production relative to the No-Action Alternative. Significant reductions in production occurred in two dry, one below-normal, and three wet water years (Attachment 9 of the Modeling Appendix).

Table 11-43. Change in Production Under CP4 for Fall-Run Chinook Salmon

Year Type	Number of Years	Average Production	Change in Production from Baseline	Average Change in Production	Maximum Increase in Production	Number of Months with Significant Increase	Maximum Decrease in Production	Number of Months with Significant Decrease
No-Action Alternative								
All	81	30,134,465	616,059	2.1	617	9	-6.5	6
Critical	13	31,842,200	5,397,372	66.0	617	5	-3.0	0
Dry	17	29,597,381	57,220	0.7	20.2	3	-5.7	2
Below Normal	14	30,794,778	-303,133	-0.4	15.8	1	-5.9	1
Above Normal	11	30,633,357	-399,653	-0.9	3.6	0	-4.1	0
Wet	26	29,065,145	-484,530	-1.7	2.5	0	-6.5	3
Existing Conditions								
All	81	30,309,575	881,234	3.0	656	10	-6.7	4
Critical	13	32,618,696	6,442,560	83.5	656	5	-0.3	0
Dry	17	29,773,255	312,854	1.6	35.8	3	-5.4	1
Below Normal	14	30,960,930	-57,332	0.8	25.2	2	-5.1	1
Above Normal	11	30,419,848	-450,549	-1.1	1.9	0	-4.0	0
Wet	26	29,108,303	-458,967	-1.6	4.4	0	-6.7	2

Note:

Production is the number of immature smolts surviving to pass the Red Bluff Pumping Plant

Under CP4, five critical, three dry, and two below-normal water years had significant increases in production relative to the Existing Condition. One dry, one below-normal, and two wet water years resulted in significant decreases in production relative to the Existing Condition.

<u>Mortality</u>
Mortality was separated by flow- and water temperature-related mortality to assess the level of impacts on fall-run Chinook salmon caused by the actions of the project (Attachments 9 and 10). In all cases, most mortality is caused by nonoperations-related factors (e.g., disease, predation, entrainment)‒around 66 percent of the total mortality.

Mortality is presented in two manners–total mortality and smolt equivalent mortality (Attachments 9 and 10 of the Modeling Appendix). Under both 2030 and 2005 conditions, the greatest mortality based on the smolt equivalents to fall-run Chinook salmon under CP4 (as with CP1 through CP3) in all water year types based on smolt equivalents occurred to fry, followed by eggs, prespawn adults, presmolts, and lastly to immature smolts. Flow-related effects triggered a higher percentage of the operations-related mortality (Table 11-9). In all water year types, the greatest portion of mortality under CP1 occurred to fry caused by forced movement to downstream habitats. Other non-flow- and water temperature-related conditions were the primary causes of mortality for all life stages except fry (Attachments 9 and 10 in the Modeling Appendix).

There was no real trend with respect to years with the greatest mortality.

Fall-run Chinook salmon would have significantly reduced project-related mortality, but an insignificant increase in overall production However, fall-run Chinook salmon would experience an overall increase in production during 38 percent of the critical water years. Therefore, fall-run Chinook salmon would benefit from actions taken in CP4. Additionally, fall-run Chinook salmon will benefit from the downstream restoration program, although this was not modeled with SALMOD. Mitigation for this impact is not needed, and thus not proposed.

Late Fall-Run Chinook Salmon

<u>Production</u>
Overall average late fall-run Chinook salmon production for the 80-year period under CP4 conditions was slightly greater than the No-Action Alternative and the Existing Condition (Attachments 12 and 13 of the Modeling Appendix). The maximum increase in production relative to the No-Action Alternative was 23 percent, and the maximum increase in production relative to Existing Conditions was 27 percent both in critical water years (Table 11-44 and Attachments 12 and 13 of the Modeling Appendix). There were no years under either 2030 or 2005 conditions with decreases in production greater than 5 percent. Figure 11-12 shows the change in production relative to the No-Action Alternative for all water years and all Comprehensive Plans.

Under CP4, six critical and five dry water years had significant increases in production compared to the No-Action Alternative. Under CP4, four critical, three dry, one below-normal, and two wet water years had significant increases in production compared to the Existing Condition.

Table 11-44. Change in Production Under CP4 for Late Fall-Run Chinook Salmon

Year Type	Number of Years	Average Production	Change in Production from Baseline	Average Change in Production	Maximum Increase in Production	Number of Months with Significant Increase	Maximum Decrease in Production	Number of Months with Significant Decrease
Future Condition (2030)								
All	80	7,726,290	69,818	1.7	23.0	11	-4.7	0
Critical	13	7,382,128	317,959	4.5	23.0	6	-1.8	0
Dry	16	7,577,473	223,104	3.0	13.5	5	-1.7	0
Below Normal	14	7,671,893	59,275	0.8	3.8	0	-1.4	0
Above Normal	11	7,658,120	72,036	0.9	3.8	0	-1.7	0
Wet	26	7,494,413	34,749	0.5	4.4	0	-4.7	0
Existing Condition (2005)								
All	80	7,539,887	153,326	2.1	27.0	10	-3.5	0
Critical	13	7,333,049	369,753	5.3	27.0	4	-2.6	0
Dry	16	7,587,721	227,453	3.1	15.4	3	-3.3	0
Below Normal	14	7,652,128	41,034	0.5	5.9	1	-3.5	0
Above Normal	11	7,649,290	89,617	1.2	4.6	0	-1.4	0
Wet	26	7,507,147	86,915	1.2	6.4	2	-2.1	0

Note:
Production is the number of immature smolts surviving to pass the Red Bluff Pumping Plant

<u>Mortality</u>

Mortality was separated by flow- and water temperature-related mortality to assess the level of impacts on late fall-run Chinook salmon caused by the actions of the project (Attachments 12 and 13). In all cases, most mortality is caused by nonoperations-related factors (e.g., disease, predation, entrainment)−around 79 percent of the total mortality.

Mortality is presented in two manners–total mortality and smolt equivalent mortality (Attachments 12 and 13 of the Modeling Appendix). Under both 2030 and 2005 conditions, the largest mortality to late fall-run Chinook salmon under CP4 (as with CP1 through CP3) in all water year types based on smolt equivalents, occurred to the egg life stage, followed by fry, then presmolts, and lastly to immature smolts. Most mortality occurred as a result of flow conditions rather than water temperature (Table 11-11).

Years with the highest mortality were the same for CP4 and the No-Action Alternative and the Existing Condition, and occurred in all water year types. Four of these years were preceded by a wet water year, and the rest were each preceded by an above-normal, below-normal or dry water year (Attachments 12 and 13 of the Modeling Appendix).

Late fall-run Chinook salmon would have an insignificant change in project-related mortality and production under CP4, including during critical water years. Therefore, CP4 would result in a less-than-significant impact to late fall-run Chinook salmon from actions taken in CP4. Additionally, late fall-run Chinook salmon would benefit from the downstream restoration program, although this was not modeled with SALMOD. Mitigation for this impact is not needed, and thus not proposed.

Impact Aqua-13 (CP4): Changes in Flow and Water Temperature in the Upper Sacramento River Resulting from Project Operation – Steelhead, Green Sturgeon, Sacramento Splittail, American Shad, and Striped Bass CP4 operations generally would result in slightly improved flow and water temperature conditions in the upper Sacramento River for steelhead, green sturgeon, Sacramento splittail, American shad, and striped bass. Overall, potential flow changes resulting from the implementation of CP4 would not be of sufficient frequency or magnitude to beneficially or adversely affect these species. However, potential water temperature changes (reductions) resulting from the implementation of CP4 would result in beneficial effects on steelhead, green sturgeon, Sacramento splittail, American shad, and striped bass in the river, especially during critical water years. Flow- and water temperature–related effects on these fish species would be less than significant (flow) and beneficial (water temperature) relative to the Existing Condition and No-Action Alternative. The benefits of the water temperature decrease outweigh the minimal effects of flow changes. Therefore, this impact would be beneficial.

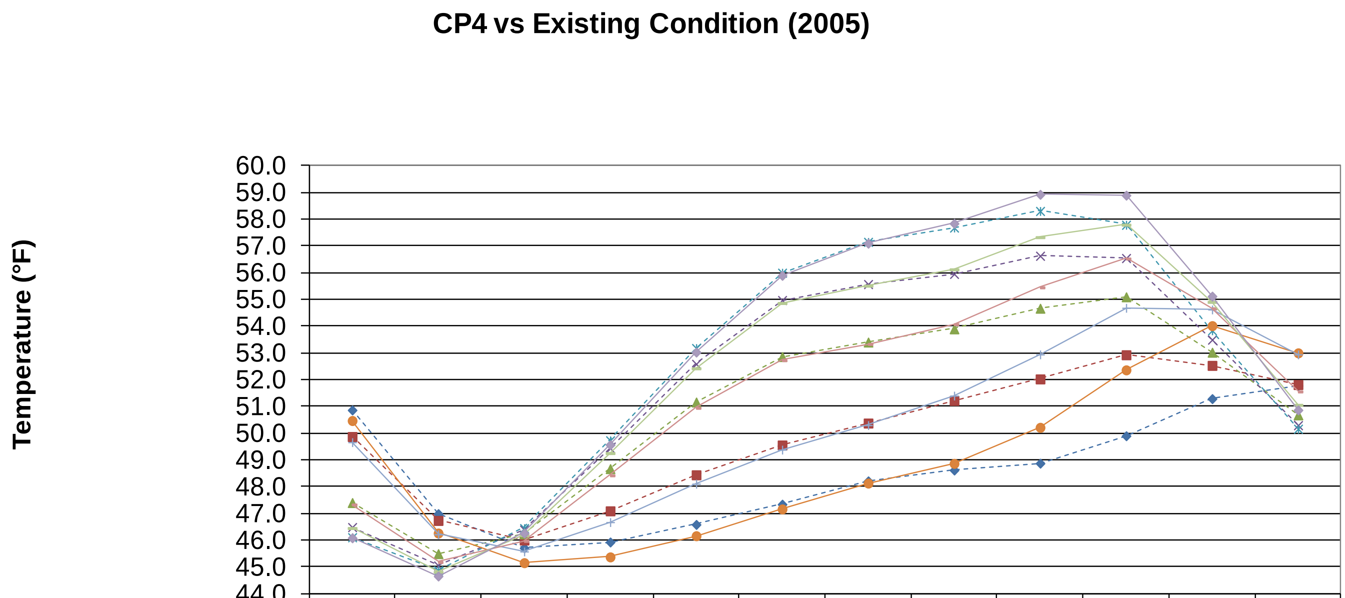
This impact would be similar to Impact Aqua-13 (CP1). However, during certain years, the impact could be greater (beneficial) under CP4 than under CP1 because of the increased reservoir capacity associated with an 18.5-foot raise compared to a 6.5-foot raise, and because of the additional volume of cold water that would be available for anadromous fish.

Flow-Related Effects As under CP1, monthly mean flows at all modeling locations along the upper Sacramento River (below Shasta Dam, below Keswick Dam, above Bend Bridge, and above RBPP) under CP4 would be similar to (generally less than 4-percent difference from) flows under the Existing Condition and No-Action Alternative simulated for all months. (See the Modeling Appendix for complete modeling results.)

Potential flow-related effects of CP4 on fish species of management concern in the upper Sacramento River would be minimal. Potential changes in flows and stages would diminish rapidly downstream from RBPP because of increased effects from tributary inflows, diversions, and flood bypasses.

Changes in monthly mean flows under CP4 relative to the Existing Condition and No-Action Alternative would have no discernible effects on steelhead, green sturgeon, Sacramento splittail, American shad, or striped bass in the upper Sacramento River. Functional flows for migration, attraction, spawning, egg incubation, and rearing/emigration for these species would be unchanged. Therefore, flow-related effects on these fish species would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

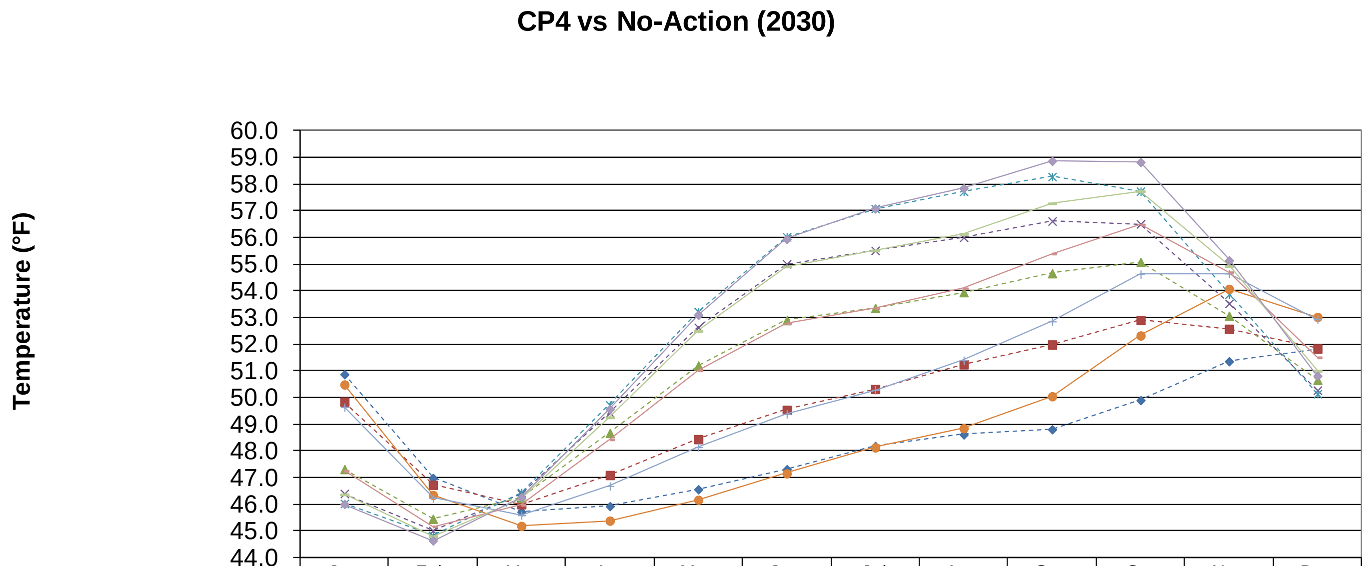
Water Temperature–Related Effects As under CP1, monthly mean water temperatures at all modeling locations along the upper Sacramento River (below Shasta Dam, below Keswick Dam, Balls Ferry, above Bend Bridge, and above RBPP) under CP4 would be slightly less than water temperatures under the Existing Condition and No-Action Alternative conditions simulated for all months (Figures 11-34 and 11-35). (See the Modeling Appendix for complete modeling results.)



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
CP4 Below Shasta	50.9	47.0	45.7	45.9	46.6	47.3	48.2	48.6	48.9	49.9	51.3	51.8
CP4 Below Keswick	49.9	46.7	46.0	47.1	48.4	49.6	50.4	51.2	52.0	52.9	52.5	51.8
CP4 Balls Ferry	47.4	45.5	46.2	48.7	51.2	52.9	53.4	53.9	54.7	55.1	53.0	50.7
CP4 Bend Bridge	46.5	45.1	46.4	49.4	52.6	55.0	55.6	56.0	56.6	56.5	53.5	50.3
CP4 RBPP	46.1	44.9	46.4	49.7	53.2	56.0	57.1	57.7	58.3	57.8	53.8	50.2
EC Below Shasta	50.5	46.3	45.2	45.4	46.2	47.2	48.1	48.9	50.2	52.4	54.0	53.0
EC Below Keswick	49.7	46.2	45.6	46.7	48.1	49.4	50.3	51.4	52.9	54.7	54.6	52.9
EC Balls Ferry	47.3	45.2	46.0	48.4	50.9	52.7	53.3	54.1	55.4	56.5	54.7	51.6
EC Bend Bridge	46.5	44.8	46.2	49.3	52.4	54.9	55.5	56.1	57.3	57.8	54.9	51.1
EC RBPP	46.1	44.7	46.3	49.6	53.0	55.9	57.1	57.8	58.9	58.9	55.1	50.9

Key:
CP = Comprehensive Plan
EC = Existing Condition
RBPP = Red Bluff Pumping Plant

Figure 11-34. Changes in Mean Monthly Water Temperature at Modeled Locations in the Sacramento River Within the Primary Study Area (CP4 Versus Existing Condition)



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
CP4 Below Shasta	50.9	47.0	45.7	45.9	46.6	47.3	48.2	48.6	48.8	49.9	51.4	51.8
CP4 Below Keswick	49.8	46.7	46.0	47.1	48.4	49.5	50.3	51.2	52.0	52.9	52.6	51.8
CP4 Balls Ferry	47.3	45.5	46.2	48.7	51.2	52.9	53.4	53.9	54.7	55.1	53.1	50.7
CP4 Bend Bridge	46.4	45.0	46.4	49.4	52.6	55.0	55.5	56.0	56.6	56.5	53.5	50.3
CP4 RBPP	46.0	44.8	46.4	49.7	53.2	56.0	57.1	57.7	58.3	57.7	53.9	50.1
NA Below Shasta	50.5	46.3	45.2	45.4	46.2	47.2	48.1	48.9	50.0	52.3	54.1	53.0
NA Below Keswick	49.6	46.2	45.6	46.7	48.1	49.4	50.3	51.4	52.9	54.6	54.6	52.9
NA Balls Ferry	47.3	45.2	46.0	48.4	51.0	52.8	53.3	54.1	55.4	56.5	54.7	51.5
NA Bend Bridge	46.4	44.8	46.2	49.3	52.5	54.9	55.5	56.1	57.3	57.7	54.9	51.0
NA RBPP	46.0	44.6	46.3	49.6	53.1	55.9	57.1	57.8	58.9	58.8	55.1	50.8

Key:
CP = Comprehensive Plan
NA = No-Action
RBPP = Red Bluff Pumping Plant

Figure 11-35. Changes in Mean Monthly Water Temperature at Modeled Locations in the Sacramento River Within the Primary Study Area (CP4 Versus No-Action Alternative)

As discussed above, the modeling simulations may not fully account for real-time management of the cold-water pool and TCD (through the SRTTG) to achieve maximum cold-water benefits. Therefore, the modeled changes in water temperature (i.e., small benefits) are likely conservative and understated to some varying degree. Potential changes in flows and stages would diminish rapidly downstream from RBPP because of the increasing effect of tributary inflows, diversions, and flood bypasses.

The cooler monthly mean water temperatures under CP4 relative to the Existing Condition and the No-Action Alternative would have effects on steelhead, green sturgeon, Sacramento splittail, American shad, or striped bass in the upper Sacramento River. Monthly mean water temperatures would not rise above important thermal tolerances for the species life stages relevant to the upper Sacramento River, and would actually create more suitable conditions. Therefore, water temperature–related impacts on these fish species would be beneficial. Mitigation for this impact is not needed, and thus not proposed.

Impact Aqua-14 (CP4): Reduction in Ecologically Important Geomorphic Processes in the Upper Sacramento River Resulting from Reduced Frequency and Magnitude of Intermediate to High Flows Project operations could cause a reduction in the magnitude, duration, or frequency of intermediate to large flows both in the upper Sacramento River and in the lowermost (confluence) areas of tributaries. Such flows are necessary for channel forming and maintenance, meander migration, and the creation of seasonally inundated floodplains. These geomorphic processes are ecologically important because they are needed to maintain important aquatic habitat functions and values for fish and macroinvertebrate communities. This impact would be potentially significant.

This impact would be similar to Impact Aqua-14 (CP1). The impact could be greater under CP4 than under CP1 because the increased reservoir capacity associated with an 18.5-foot raise compared to a 6.5-foot raise would allow for storage of additional water volume (and flows) behind the raised dam.

Sediment transport, deposition, and scour regulate the formation of key habitat features such as point bars, gravel deposits, and SRA habitat. Intermediate to high flows and the associated stage elevation of the river surface also provide a backwater effect on the lowermost segment of tributaries, reducing the potential for downcutting. These processes are regulated by the magnitude and frequency of flow. Relatively large floods provide the energy required to mobilize sediment from the riverbed, produce meander migration, increase stage elevation, and create seasonally inundated floodplains. Operations under CP4 could result in a reduction in the intermediate to large flows necessary for channel forming and maintenance, meander migration, and creation of seasonally inundated floodplains.

Implementation of CP4 would cause a further reduction in the magnitude, duration, and frequency of intermediate to large flows, relative to the Existing Condition and No-Action Alternative. Overall, the project would increase the existing, ongoing effects on geomorphic processes resulting from the operation of Shasta Dam that are necessary for channel forming and maintenance, meander migration, and the creation of seasonally inundated floodplains. These effects would likely occur throughout the upper Sacramento River portion of the primary study area.

As discussed above, CP4 also includes a 10-year gravel augmentation program and the restoration of riparian, floodplain, and side-channel habitat at up to six potential restoration sites as additional environmental commitments. Placing gravel along the Sacramento River channel and bank annually and restoring riparian, floodplain, and side-channel habitat at up to six sites would result in benefits to ecological processes (e.g., sediment transport and deposition, floodplain inundation) that would partially offset the effects described above. Nevertheless, reductions in the magnitude of high flows would likely be sufficient to reduce ecologically important processes along the upper Sacramento River. This impact would be potentially significant. Mitigation for this impact is proposed in Section 11.3.4.

Lower Sacramento River and Delta

Impact Aqua-15 (CP4): Changes in Flow and Water Temperatures in the Lower Sacramento River and Tributaries and Trinity River Resulting from Project Operation – Fish Species of Primary Management Concern Project operation would result in no discernible change in monthly mean flows or water temperature conditions in the lower Sacramento River. However, predicted changes in flows in the Feather, American, and Trinity rivers could result in adverse effects on Chinook salmon, steelhead, Coho salmon, green sturgeon, Sacramento splittail, American shad, and striped bass. This impact would be potentially significant.

This impact would be similar to Impact Aqua-15 (CP1). The impact could be greater under CP4 than under CP1 because the increased reservoir capacity associated with an 18.5-foot raise compared to a 6.5-foot raise would allow for storage of additional water volume (and increased cold-water pool) behind the raised dam.

As described below, mean monthly flows at various modeling locations on the lower Sacramento River and tributaries under CP4 were compared with mean monthly flows simulated for Existing Conditions and No-Action Alternative conditions. See the Modeling Appendix for complete CalSim-II modeling results.

Lower Sacramento River As under CP1, monthly mean flows at the lower Sacramento River modeling locations under CP4 would be essentially equivalent to flows under the Existing Condition and No-Action Alternative simulated for all months. Differences in monthly mean flow were generally small (less than 2 percent) and within the existing range of variability. Potential changes in flows would diminish rapidly downstream from RBPP because of the increasing effect from tributary inflows, diversions, and flood bypasses. Similarly, potential changes in water temperatures in the lower Sacramento River caused by small changes in releases would diminish rapidly downstream because of the increasing effects of inflows, atmospheric influences, and groundwater. Therefore, flow- and temperature-related impacts on fish species in the lower Sacramento River would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

As under CP1, the effects of altered flow regimes resulting from implementation of CP4 are unlikely to extend into the lower Sacramento River and Delta because the Central Valley's reservoirs and diversions are managed as a single integrated system (consisting of the SWP and the CVP). The guidelines for this management, described in the CVP/SWP OCAP, have been designed to maintain standards for flow to the lower Sacramento River and Delta. CVP and SWP operations must be consistent with the OCAP and SWRCB D-1641 to allow ESA coverage by the OCAP permits and BOs. Thus, implementation of CP4 would not likely alter flow to the Delta or water temperatures in the lower Sacramento River and primary tributaries within the extended study area to a sufficient degree to cause discernible effects on Chinook salmon, steelhead, green sturgeon, Sacramento splittail, American shad, or striped bass relative to the Existing Condition and No-Action Alternative. Functional flows for fish migration, attraction, spawning, egg incubation, and rearing/emigration for all these fish species would be unchanged. Therefore, flow- and water temperature–related effects on these fish species would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

Lower Feather River, American River, and Trinity River Also, as under CP1, monthly mean flows at all modeling locations on the lower Feather River, the American River, and the Trinity River under CP4 would be essentially equivalent to (less than 2-percent difference from) flows under the Existing Condition and No-Action Alternative simulated for most months. However, simulations for several months within the modeling record show substantial changes to flows in tributaries. Potential changes in flows could be reduced by real-time operations to meet existing rules and because of operation of upstream reservoirs (Lake Oroville, Folsom Lake, and Trinity Lake) and increasing effects from tributary inflows, diversions, and flood bypasses. Potential changes in water temperatures in the Feather and American rivers caused by altered releases from reservoirs could diminish downstream because of the increasing effect of inflows, and atmospheric and groundwater influences. Nevertheless, based on predicted changes in flow and associated flow-habitat relationships, potential flow-related impacts on species of management concern in the American, Feather, and Trinity rivers could occur. This impact would be potentially significant. Mitigation for this impact is proposed in Section 11.3.4.

Impact Aqua-16 (CP4): Reduction in Ecologically Important Geomorphic Processes in the Lower Sacramento River Resulting from Reduced Frequency and Magnitude of Intermediate to High Flows Project operation could cause a reduction in intermediate to large flows both in the lower Sacramento River and in the lowermost (confluence) areas of tributaries. Such flows are necessary for channel forming and maintenance, meander migration, and the creation of seasonally inundated floodplains. These geomorphic processes are ecologically important because they are needed to maintain important aquatic habitat functions and values for fish and macroinvertebrate communities. This impact would be potentially significant.

This impact would be similar to Impact Aqua-16 (CP1). The impact could be greater under CP4 than under CP1 because the increased reservoir capacity associated with an 18.5-foot raise compared to a 6.5-foot raise would allow for storage of additional water volume (and flows) behind the raised dam.

Sediment transport, deposition, and scour regulate the formation of key habitat features such as point bars, gravel deposits, and SRA habitat. Intermediate to high flows and the associated stage elevation of the river surface also provide a backwater effect on the lowermost segment of tributaries, which reduces the potential for downcutting. These processes are regulated by the magnitude and frequency of flows. Relatively large floods provide the energy required to mobilize sediment from the bed, produce meander migration, increase stage elevation, create seasonally inundated floodplains, and inundate floodplain bypasses. Operations under CP4 could result in reduced intermediate to large flows that are necessary for channel forming and maintenance, meander migration, and the creation of seasonally inundated floodplains.

Implementation of CP4 would cause a further reduction in the magnitude, duration, and frequency of intermediate to large flows, relative to the Existing Condition and No-Action Alternative. Overall, the project would increase the existing, ongoing impacts on geomorphic processes resulting from the operation of Shasta Dam that are necessary for channel forming and maintenance, meander migration, the creation of seasonally inundated floodplains, and the inundation of floodplain bypasses. These effects would likely occur along the upper reaches of the lower Sacramento River.

Reductions in the magnitude of high flows would likely be sufficient to reduce ecologically important processes along the upper Sacramento River and its floodplain bypasses. This impact would be potentially significant. Mitigation for this impact is proposed in Section 11.3.4.

Impact Aqua-17 (CP4): Effects to Delta Fisheries Resulting from Changes to Delta Outflow Delta outflow conditions under CP4 would be the same as those under CP1, and would result in changes to average monthly Delta outflow of less than 5 percent in all water year types (with the exception of December of critical years under 2005 conditions). This impact on Delta fisheries and hydrologic transport processes within the Bay-Delta would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

Impact Aqua-18 (CP4): Effects to Delta Fisheries Resulting from Changes to Delta Inflow Delta inflow conditions under CP4 would be the same as those under CP1, and would not decrease average monthly Delta inflow by 5 percent or more in any year type, as shown on Table 11-24. This impact on Delta fisheries and hydrologic transport processes within the Bay-Delta would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

Impact Aqua-19 (CP4): Effects to Delta Fisheries Resulting from Changes in Sacramento River Inflow CP4 operations would be the same as those under CP1 and would result in a variable response in Sacramento River flow, in turn, resulting in both increases and decreases in river flow above the Existing Condition and No-Action Alternative depending on month and water year type. Decreases in Sacramento River inflow would not equal or exceed 5 percent. This impact would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

Impact Aqua-20 (CP4): Effects to Delta Fisheries Resulting from Changes in San Joaquin River Flow at Vernalis CP4 operation would be the same as under CP1 and would result in no discernible change in San Joaquin River flows at Vernalis. Therefore, CP4 would have no effect on Delta fisheries or transport mechanisms within the lower San Joaquin River and Delta relative to either the No-Action Alternative of Existing Condition. There would be no impact. Mitigation for this impact is not needed, and thus not proposed.

Impact Aqua-21 (CP4): Reduction in Low-Salinity Habitat Conditions Resulting from an Upstream Shift in X2 Location CP4 operations would be the same as CP1 operations, and would result in a less than 0.5 km movement upstream or downstream from the X2 location from its location under the Existing Condition or No-Action Alternative, and thus cause minimal reduction in low-salinity habitats. This impact would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

Impact Aqua-22 (CP4): Increase in Mortality of Species of Primary Management Concern as a Result of Increased Reverse Flows in Old and Middle Rivers CP4 operations would be the same as CP1 operations, and would result in minimal changes to reverse flows in Old and Middle rivers. The increases in reverse flows would be expected to contribute to a small increase in the vulnerability of Chinook salmon, delta smelt, striped bass, threadfin shad, and other resident warm-water fish to increased salvage and potential losses. This impact would be less than significant for striped bass, threadfin shad, and other resident warm-water fish, and potentially significant for delta smelt and Chinook salmon. Overall, this impact would be potentially significant. Mitigation for this impact is not proposed because operations will be guided by

RPAs established by NMFS and USFWS BOs to reduce any impacts to listed fish species, thus reducing effects to non-listed fish species as well.

Impact Aqua-23 (CP4): Increase in the Risk of Entrainment or Salvage of Species of Primary Management Concern at CVP and SWP Export Facilities Due to Changes in CVP and SWP Exports CP4 operations would be the same as CP1 operations, and may result in an increase of CVP and SWP exports, which is assumed to result in a direct proportional increase or decrease in the risk of fish being entrained and salvaged at the facilities. The resulting impact to Chinook salmon, steelhead, longfin smelt, striped bass, and splittail would be less than significant; the resulting impact to delta smelt would be potentially significant. Overall, this impact would be potentially significant. Mitigation for this impact is not proposed because operations will be guided by RPAs established by NMFS and USFWS BOs to reduce any impacts to listed fish species.

CVP/SWP Service Areas

Impact Aqua-24 (CP4): Impacts on Aquatic Habitats and Fish Populations in the CVP and SWP Service Areas Resulting from Modifications to Existing Flow Regimes CP4 implementation could result in modified flow regimes that would reduce the frequency and magnitude of high winter flows along the Sacramento River; however, the hydrologic effects in tributaries and reservoirs (e.g., New Melones and San Luis) with CVP and SWP dams are expected to be less than impacts on the lower Sacramento River. The change in hydrology could affect aquatic habitats that provide habitat for the fish community. These changes are unlikely to result in substantial effects on the distribution or abundance of these species in the CVP and SWP service areas. Therefore, this impact would be less than significant.

This impact would be similar to Impact Aqua-33 (CP1). The impact could be greater because the increased reservoir capacity associated with an 18.5-foot raise compared to a 6.5-foot raise would allow additional water volume (and flows) to be stored behind the raised dam. However, these changes are unlikely to result in substantial effects on the distribution or abundance of these species in the CVP and SWP service areas. The effects from CP4 on CVP and SWP reservoir elevations, filling, spilling, and planned releases, and resulting downstream flows, would be small and well within the range of variability that commonly occurs in these reservoirs and downstream flows. Therefore, this impact would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

CP5 – 18.5-Foot Dam Raise, Combination Plan

CP5 primarily focuses on increasing water supply reliability, anadromous fish survival, Shasta Lake area environmental resources, and recreation opportunities. By raising Shasta Dam 18.5 feet, in combination with spillway modifications, CP5 would increase the height of the reservoir full pool by 20.5 feet and enlarge the total storage capacity in the reservoir by 634,000 acre-feet.

The existing TCD would be extended to achieve efficient use of the expanded cold-water pool. Shasta Dam operational guidelines would continue essentially unchanged, except during dry years and critical years, when 150 TAF and 75 TAF, respectively, of the increased storage capacity in Shasta Reservoir would be reserved to specifically focus on increasing M&I deliveries. CP5 also includes constructing additional fish habitat in and along the shoreline of Shasta Lake and along the lower reaches of its tributaries; augmenting spawning gravel and restoring riparian, floodplain, and side channel habitat in the upper Sacramento River; and increasing recreation opportunities at Shasta Lake.

CP5 would help reduce future water shortages through increasing drought year and average year water supply reliability for agricultural and M&I deliveries. In addition, the increased depth and volume of the cold-water pool in Shasta Reservoir would contribute to improving seasonal water temperatures for anadromous fish in the upper Sacramento River.

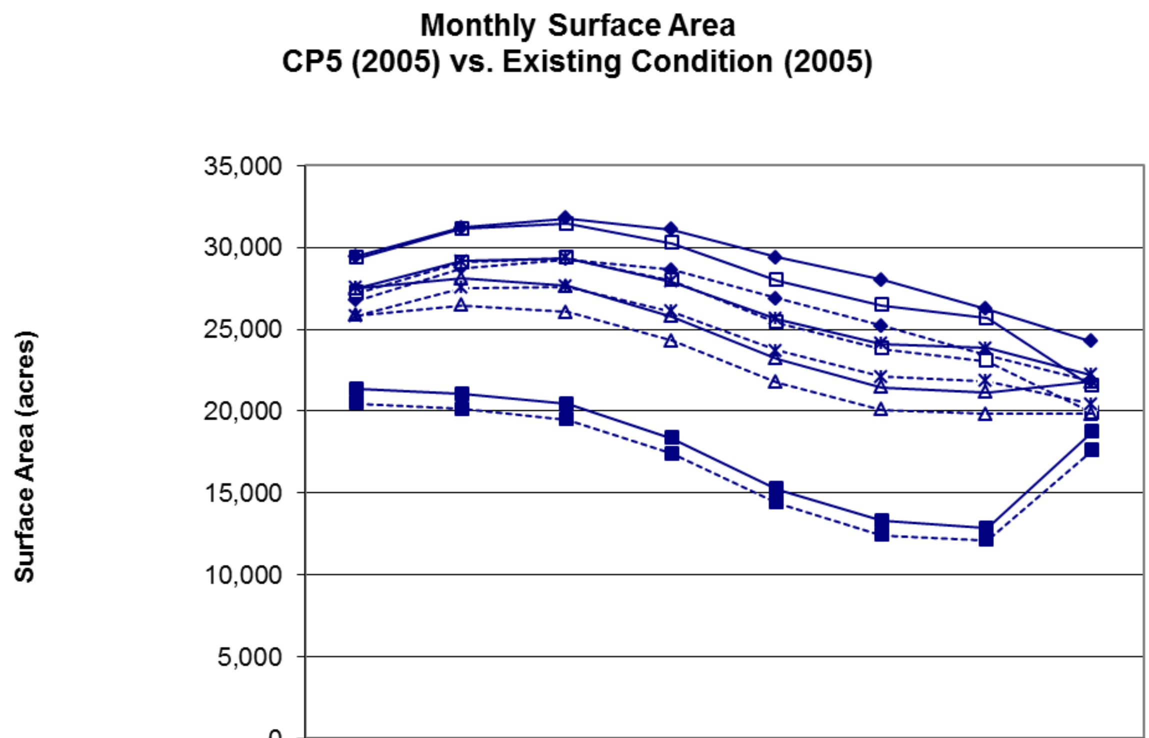
Shasta Lake and Vicinity

Impact Aqua-1 (CP5): Effects on Nearshore, Warm-Water Habitat in Shasta Lake from Project Operations Under CP5, this impact would be similar to CP3, with a slightly less of an increase in warm-water fish habitat than CP3 from because of differences in operations but inclusion of nearshore fish habitat enhancement would result in a similar or greater increase than CP3. Warm-water fish habitat would be increased compared to the Existing Condition and the No-Action Alternative as measured by increased lake surface area and reductions in lake level fluctuations (Figures 11-36 through 11-39). Its impact would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

Impact Aqua-2 (CP5): Effects on Nearshore, Warm-Water Habitat in Shasta Lake from Project Construction This impact would be similar to Impact Aqua-2 (CP3). This impact would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

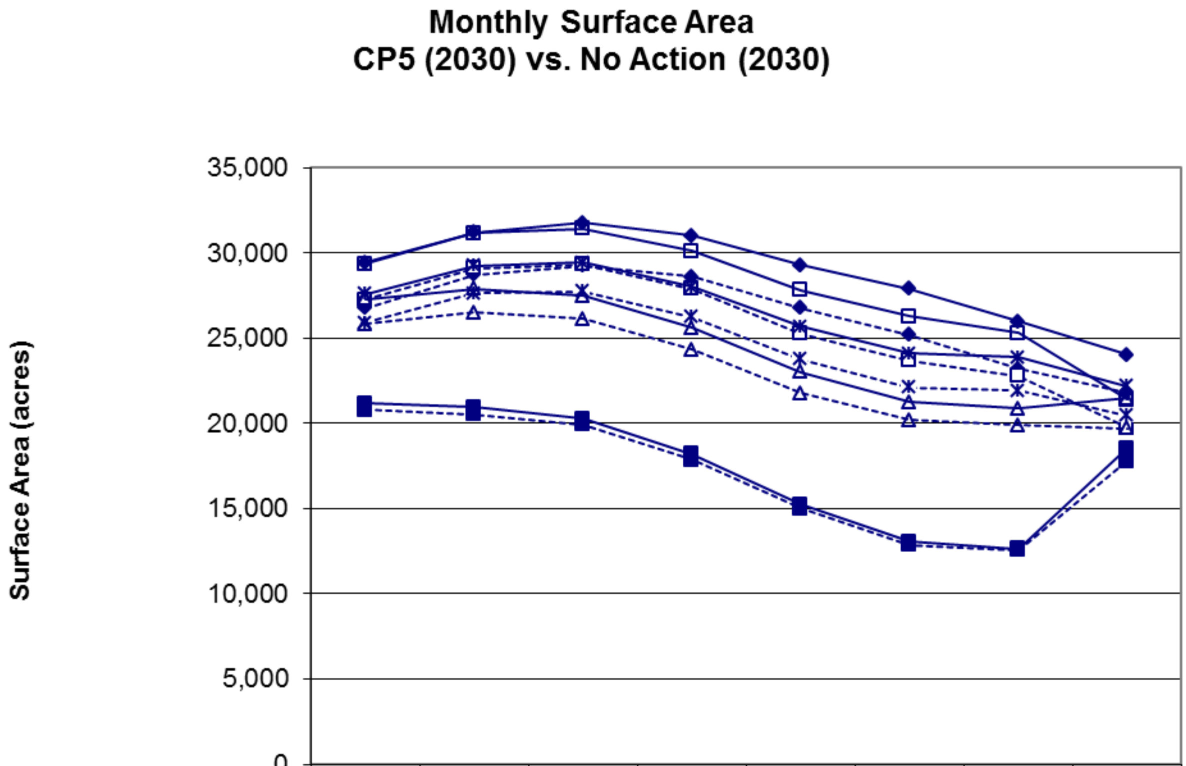
Impact Aqua-3 (CP5): Effects on Cold-Water Habitat in Shasta Lake Under CP5, operations-related changes in the ratio of the volume of cold-water storage to surface area would increase the availability of suitable habitat for cold-water fish in Shasta Lake, including rainbow trout (Figure 11-40). This impact would be beneficial.

This impact would be beneficial, but slightly than that provided under CP3. Mitigation for this impact is not needed, and thus not proposed.



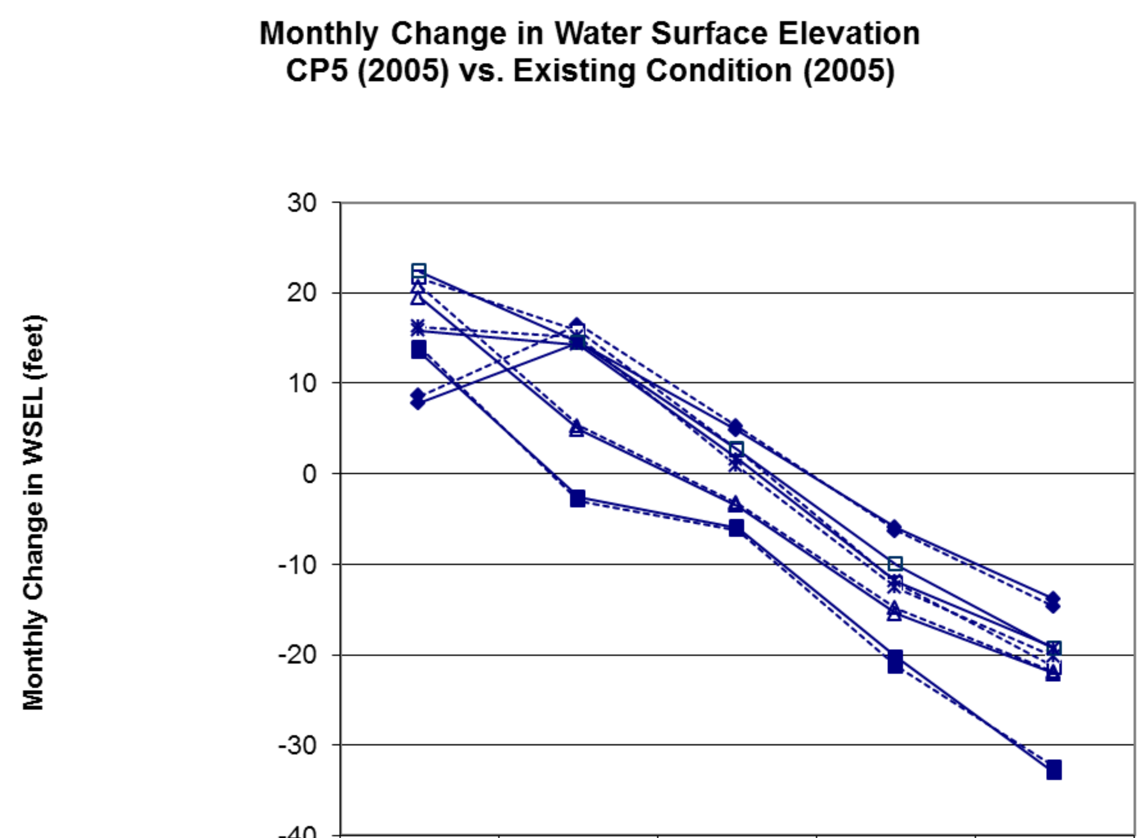
	Mar 31	Apr 30	May 31	Jun 30	Jul 31	Aug 31	Sep 30	Oct 31
EC W	26,790	28,748	29,277	28,624	26,872	25,226	23,413	21,827
EC AN	27,245	29,082	29,336	27,992	25,400	23,826	23,061	19,906
EC BN	25,807	27,534	27,621	26,104	23,714	22,114	21,837	20,425
EC D	25,850	26,467	26,058	24,300	21,754	20,093	19,840	19,828
EC C	20,467	20,142	19,500	17,381	14,400	12,418	12,111	17,572
CP5 2005 W	29,448	31,208	31,794	31,081	29,404	28,018	26,222	24,264
CP5 2005 AN	29,371	31,154	31,450	30,246	27,971	26,468	25,652	21,521
CP5 2005 BN	27,525	29,160	29,355	27,921	25,627	24,124	23,836	22,213
CP5 2005 D	27,499	28,088	27,639	25,800	23,210	21,473	21,142	21,790
CP5 2005 C	21,359	21,047	20,422	18,355	15,245	13,295	12,828	18,737

Figure 11-36. Average Monthly Surface Area for Each Water Year Type Within the Shasta Lake Vicinity of the Primary Study Area, CP5 Versus Existing Condition



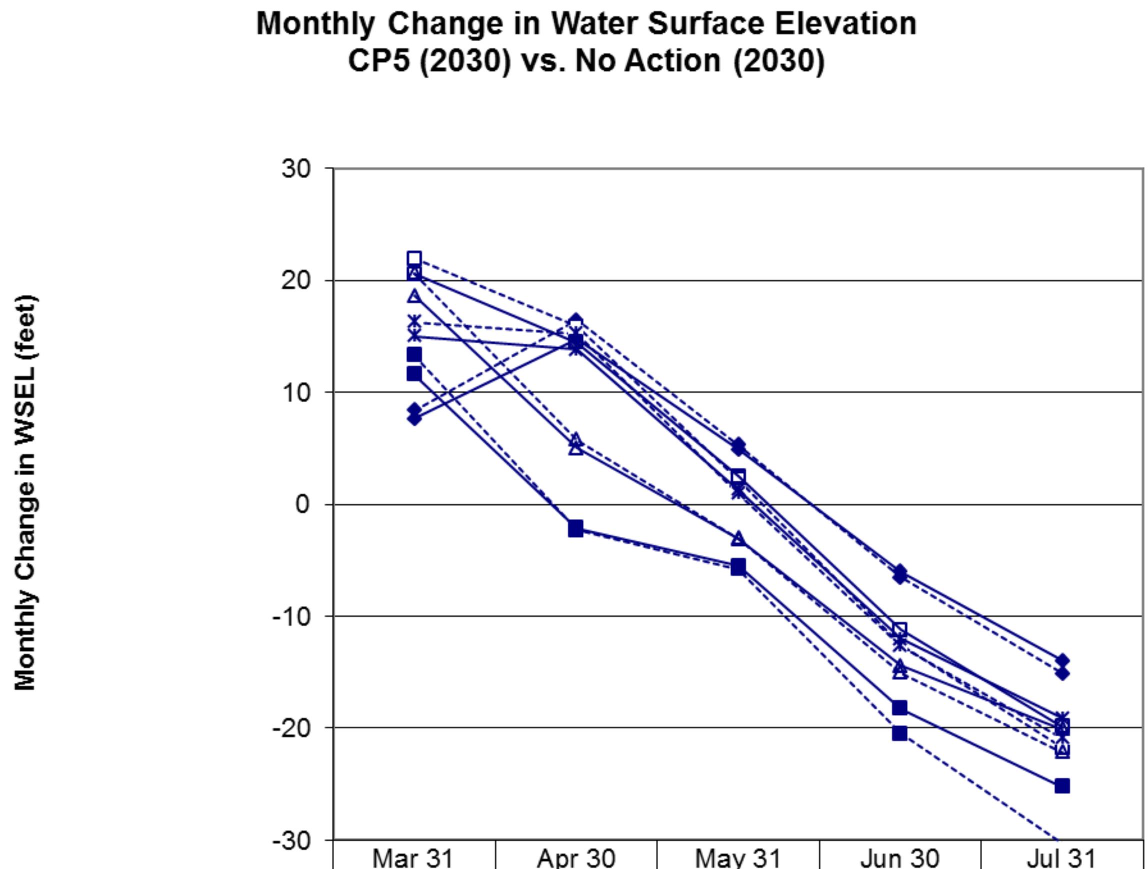
	Mar 31	Apr 30	May 31	Jun 30	Jul 31	Aug 31	Sep 30	Oct 31
NA W	26,775	28,735	29,273	28,604	26,797	25,183	23,205	21,808
NA AN	27,258	29,117	29,325	27,921	25,294	23,687	22,800	19,759
NA BN	25,918	27,662	27,770	26,239	23,764	22,137	21,923	20,469
NA D	25,843	26,514	26,134	24,346	21,780	20,209	19,910	19,728
NA C	20,801	20,548	19,942	17,866	15,026	12,873	12,556	17,800
CP5 2030 W	29,435	31,196	31,789	31,040	29,305	27,909	26,001	24,052
CP5 2030 AN	29,355	31,158	31,429	30,120	27,832	26,297	25,298	21,414
CP5 2030 BN	27,600	29,249	29,439	28,012	25,678	24,121	23,875	22,176
CP5 2030 D	27,316	27,918	27,481	25,609	23,020	21,267	20,867	21,475
CP5 2030 C	21,189	20,934	20,294	18,198	15,233	13,069	12,642	18,553

Figure 11-37. Average Monthly Surface Area for Each Water Year Type Within the Shasta Lake Vicinity of the Primary Study Area, CP5 Versus the No-Action Alternative



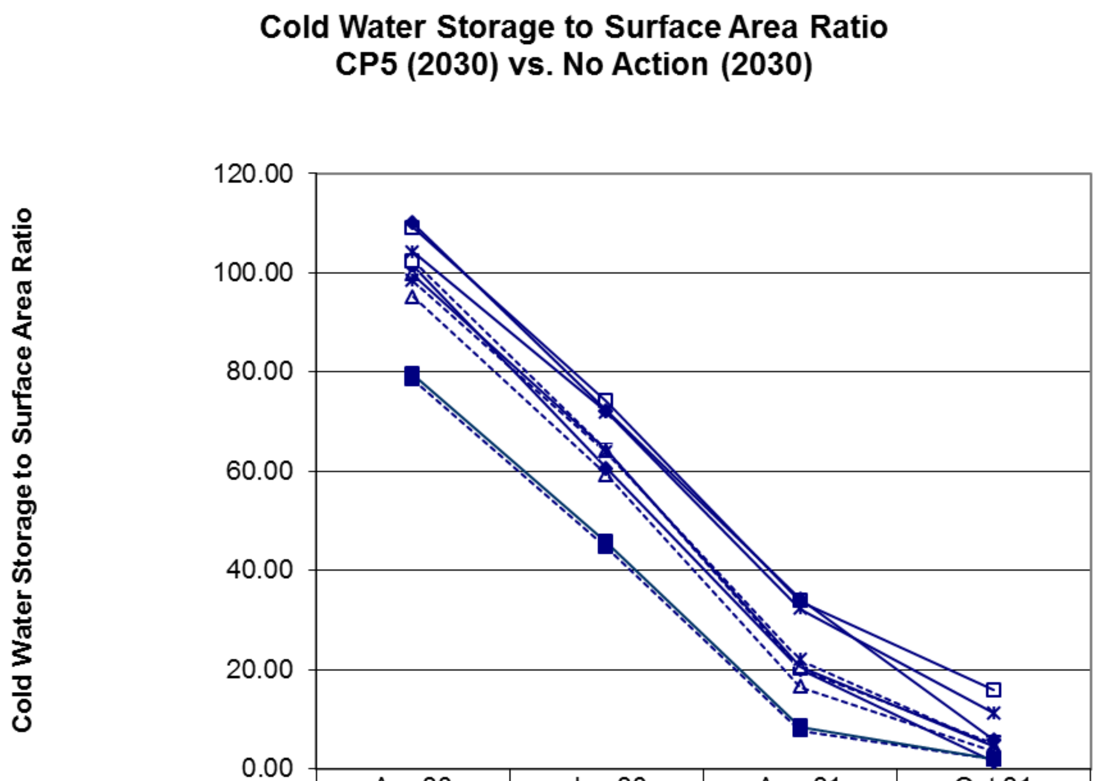
	Mar 31	Apr 30	May 31	Jun 30	Jul 31
EC W	9	16	5	-6	-15
EC AN	22	16	3	-12	-21
EC BN	16	15	1	-13	-20
EC D	21	5	-3	-15	-22
EC C	14	-3	-6	-21	-32
CP5 (2005) W	8	15	5	-6	-14
CP5 (2005) AN	22	15	3	-10	-19
CP5 (2004) BN	16	14	2	-12	-19
CP5 (2005) D	19	5	-4	-15	-22
CP5 (2005) C	13	-3	-6	-20	-33

Figure 11-38. Average Monthly Change in WSEL for Each Water Year Type Within the Shasta Lake Vicinity of the Primary Study Area, CP5 Versus the Existing Condition



	Mar 31	Apr 30	May 31	Jun 30	Jul 31
NA W	8	16	5	-7	-15
NA AN	22	16	2	-13	-22
NA BN	16	15	1	-13	-21
NA D	21	6	-3	-15	-22
NA C	13	-2	-6	-21	-30
CP4 (2030) W	8	15	5	-6	-14
CP4 (2030) AN	21	14	2	-11	-20
CP4 (2030) BN	15	14	1	-12	-19
CP4 (2030) D	19	5	-3	-14	-20
CP4 (2030) C	12	-2	-6	-18	-25

Figure 11-39. Average Monthly Change in WSEL for Each Water Year Type Within the Shasta Lake Vicinity of the Primary Study Area, CP5 Versus the No-Action Alternative



	Apr 30	Jun 30	Aug 31	Oct 31
NA W	101.33	60.49	19.89	1.43
NA AN	102.30	64.04	20.12	5.09
NA BN	98.27	63.71	21.84	4.64
NA D	95.13	59.14	16.50	3.38
NA C	78.43	44.58	7.66	1.82
CP5 2030 W	109.95	72.09	34.16	5.78
CP5 2030 AN	109.05	74.02	33.71	15.89
CP5 2030 BN	104.10	71.89	32.26	11.23
CP5 2030 D	99.54	64.08	20.51	4.45
CP5 2030 C	79.50	45.61	8.44	1.91

Figure 11-40. Average Monthly Cold-water Storage to Surface Area Ratio for Each Water Year Type Within the Shasta Lake Vicinity of the Primary Study Area, CP5 Versus the No-Action Alternative

Impact Aqua-4 (CP5): Effects on Special-Status Aquatic Mollusks Under CP5, habitat for special-status mollusks could be inundated. Seasonal fluctuations in the surface area and WSEL of Shasta Lake could also adversely affect special-status aquatic mollusks that could occupy habitat in or near Shasta Lake and its tributaries. Tributary investigations are ongoing and will provide additional information and analysis for inclusion in the Final EIS. Available reports for recent surveys of historic monitoring sites and initial evidence from surveys of lower reaches of representative tributaries to the lake suggest that the probability of occurrence of special-status mollusks is low. However, because the California floater, a special-status mollusk, is known from Shasta Lake, This impact would be potentially significant.

This impact would be similar to Impact Aqua-4 (CP3) and would be potentially significant. Mitigation for this impact is proposed in Section 11.3.4.

Impact Aqua-5 (CP5): Effects on Special-Status Fish Species Similar to CP3 and CP4, the expansion of the surface area of Shasta Lake and the inundation of additional tributary habitat under CP5 could affect one species designated as sensitive by the USFS, the hardhead. Tributary investigations are ongoing and will provide additional information and analysis for inclusion in the Final EIS. This impact is considered to be less than significant.

This impact would be similar to Impact Aqua-5 (CP3) and would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

Impact Aqua-6 (CP5): Creation or Removal of Barriers to Fish Between Tributaries and Shasta Lake Under CP5, project implementation would result in the periodic inundation of steep and low-gradient tributaries to Shasta Lake up to the 1,090-foot contour, the maximum inundation level under this alternative. Similar to CP3, initial analysis indicates that about 63 percent of the intermittent and 48 percent of perennial tributaries surveyed contain substantial barriers between the 1,070-foot and 1,090-foot contours that would be inundated under this alternative; however, none of the streams with barriers was found to be inhabited by special-status fish in upstream reaches. Additionally, except in the Sacramento and McCloud rivers, colonization of inundated streams appears to be limited to the reservoir varial zone. Tributary investigations are ongoing and will provide additional information and analysis for inclusion in the Final EIS. This impact is considered to be less than significant.

This impact would be similar to Impact Aqua-6 (CP3) and would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

Impact Aqua-7 (CP5): Effects on Spawning and Rearing Habitat of Adfluvial Salmonids in Low-Gradient Tributaries to Shasta Lake CP5 would result in additional periodic inundation of potentially suitable spawning and rearing habitat for adfluvial salmonids in low-gradient tributaries to Shasta Lake. Tributary investigations are ongoing and will provide additional information and analysis for inclusion in the Final EIS. A total of 11 miles of low-gradient reaches that could potentially provide some spawning and rearing habitat for adfluvial salmonids (estimated as 40,103 square feet for all tributaries) would be affected by CP5, which is only about 2.8 percent of the low-gradient habitat upstream from Shasta Lake. CP5 includes construction of nearshore fish habitat enhancement and spawning gravel augmentation around Shasta Lake, which would reduce this impact. Therefore, this impact would be less than significant.

This impact would differ from that of CP3 and CP4 and would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

Impact Aqua-8 (CP5): Effects on Aquatic Connectivity in Non-Fish-Bearing Tributaries to Shasta Lake CP5 would result in periodic inundation of the lower reaches of high-gradient, non-fish-bearing tributaries to Shasta Lake. About 24 miles of non-fish-bearing tributary habitat would be affected by CP5, which is only about 1 percent of the total length of non-fish-bearing tributaries upstream from Shasta Lake. Tributary investigations are ongoing and will provide additional information and analysis for inclusion in the Final EIS. Examination of initial field surveys suggest that few, if any, of the non-fish bearing streams contain special-status invertebrate or vertebrate species that would be affected by increased connectivity to Shasta Lake. This impact would be less than significant.

This impact would be similar to Impact Aqua-8 (CP3) and would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

Impact Aqua-9 (CP5): Effects on Water Quality at Livingston Stone Hatchery Reclamation provides the water supply to the Livingston Stone Hatchery from a pipeline emanating from Shasta Dam. This supply would not be interrupted by any activity associated with CP5. There would be no impact.

This impact would be similar to Impact Aqua-9 (CP1), and there would be no impact. Mitigation for this impact is not needed, and thus not proposed.

Upper Sacramento River (Shasta Dam to Red Bluff)

Impact Aqua-10 (CP5): Loss or Degradation of Aquatic Habitat in the Upper Sacramento River During Construction Activities Temporary construction-related increases in sediments and turbidity levels would adversely affect aquatic habitats and fish populations immediately downstream in the upper Sacramento River. However, environmental commitments would be in place to reduce the effects. This impact would be less than significant.

This impact would be similar to Impact Aqua-10 (CP1). The impact could be greater under CP5 than under CP1 because of the increased activity associated with an 18.5-foot dam raise compared to a 6.5-foot dam raise.

Like CP4, CP5 includes a 10-year gravel augmentation program as an additional environmental commitment. Placing gravel along the Sacramento River channel and bank annually would release an additional source of fine sediment and expose it to the river and aquatic communities. However, the gravel augmentation activities would occur only during previously specified in-water work windows, which would minimize the potential for impacts associated with this activity.

Also, like CP4, CP5 includes restoration of riparian, floodplain, and side-channel habitat in the upper Sacramento River at up to six potential restoration sites. Riparian, floodplain, and side-channel restoration at these sites could result in additional disturbed surfaces, but most of this construction is expected to occur away from the wetted channel, and all disturbed areas would be revegetated.

As under CP1 and CP4, environmental commitments for all actions would be in place to reduce effects. Therefore, this impact would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

Impact Aqua-11 (CP5): Release and Exposure of Contaminants in the Upper Sacramento River During Construction Activities Construction-related activities could result in the release and exposure of contaminants. Such exposure could adversely affect aquatic habitats, the aquatic food web, and fish populations, including special-status species, downstream in the primary study area. However, environmental commitments would be in place to reduce the effects. Therefore, this impact would be less than significant.

This impact would be similar to Impact Aqua-11 (CP1). The impact could be greater under CP5 than under CP1 because of the increased activity associated with an 18.5-foot raise compared to a 6.5-foot raise. Like CP4, CP5 includes implementation of a gravel augmentation program and restoration of riparian, floodplain, and side-channel habitat at up to six potential restoration sites. Both of these construction activities could cause additional sources of equipment-related contaminants to be released and exposed to the river and aquatic communities. However, environmental commitments for all actions would be in place to reduce effects. Therefore, this impact would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

Impact Aqua-12 (CP5): Changes in Flow and Water Temperature in the Upper Sacramento River Resulting from Project Operation – Chinook Salmon Project operation under CP5 would generally result in improved flow and water temperature conditions in the upper Sacramento River for Chinook salmon, but not all runs have an increase in production. Additionally, restoration actions that are proposed under CP5 would benefit Chinook salmon. This impact would be beneficial.

Winter-Run Chinook Salmon

<u>Production</u>

The overall average winter-run production for the 1-year period was similar for CP5 relative to the No-Action Alternative and the Existing Condition (Attachments 3 and 4 of the Modeling Appendix). The maximum increase in production relative to the No-Action Alternative was 78 percent for CP5 (critical water year), while the largest decrease in production relative to the No-Action Alternative was around 49 percent (also a critical water year) (Table 11-45 and Attachment 3 of the Modeling Appendix). The maximum increase in production relative to the Existing Condition was 144 percent (critical water year) for CP5, while the largest decrease in production relative to the Existing Condition was around 26 percent (critical water year) (Table 11-45 and Attachment 4 of the Modeling Appendix). Figure 11-9 shows the change in production relative to the No-Action Alternative for all water years and all Comprehensive Plans.

Under CP5, four critical water years had significant increases in production relative to the No-Action Alternative for winter-run Chinook salmon. No other water year type had a significant increase in production. Two critical and one above-normal water year had a significant decrease in production.

Under CP5, four critical, one dry, and one below-normal water years had significant increases in production relative to the Existing Condition, while four years (one each in critical, dry, above-normal and wet water year types) had significant decreases in production greater than 5 percent.

Table 11-45. Change in Production Under CP5 for Winter-Run Chinook Salmon

Year Type	Number of Years	Average Production	Change in Production from Baseline	Average Change in Production	Maximum Increase in Production	Number of Months with Significant Increase	Maximum Decrease in Production	Number of Months with Significant Decrease
Future Condition (2030)								
All	81	3,765,847	-35,268	-0.9	77.8	6	-48.7	3
Critical	13	3,348,152	-29,804	-0.9	77.8	4	-48.7	2
Dry	17	3,950,128	-22,202	-0.6	4.5	0	-3.5	0
Below Normal	14	3,929,045	-9,514	-0.2	3.6	0	-3.1	0
Above Normal	11	3,784,945	-73,985	-1.9	0.8	0	-7.4	1
Wet	26	3,758,247	-44,032	-1.2	0.1	0	-4.5	0
Existing Condition (2005)								
All	81	3,767,299	-13,948	-0.4	144	6	-26.3	4
Critical	13	3,312,821	101,881	3.2	144	4	-26.3	1
Dry	17	3,971,126	-12,736	-0.3	10.9	1	-6.6	1
Below Normal	14	3,940,814	665	0.0	5.1	1	-3.2	0
Above Normal	11	3,788,962	-63,720	-1.7	0.3	0	-5.5	1
Wet	26	3,758,670	-59,466	-1.6	1.7	0	-5.4	1

Note:

Production is the number of immature smolts surviving to pass the Red Bluff Pumping Plant

<u>Mortality</u>

Mortality was separated by flow- and water temperature-related mortality to assess the level of impacts on winter-run Chinook salmon caused by the actions of the project (Attachments 3 and 4 of the Modeling Appendix). Nonoperations-related mortality are the base and seasonal mortality that would occur even without the effects of Shasta operations (such as disease, predation, and entrainment). Flow- and water temperature-related mortality is that caused by altering flow and water temperatures. In all cases, most mortality is caused by nonoperations-related factors (e.g., disease, predation, entrainment)−around 86 percent of the total mortality.

Mortality is presented in two manners–total mortality and smolt equivalent mortality (Attachments 3 and 4 of the Modeling Appendix). The greatest average mortality to winter-run Chinook salmon under CP5 (as with CP1 through CP4) in all water year types based on smolt equivalents would occur to the fry life stage, followed by eggs, then presmolts, and lastly to immature smolts. Table 11-5 displays the overall mortalities for each Comprehensive Plan that were caused by changes in operations (i.e., water temperature and flow) (Attachments 3 and 4 of the Modeling Appendix).

Years with the highest mortality were the same for the No-Action Alternative and the Existing Condition and CP5. Each of these years was a critical water year, and was preceded by either a critical (1933, 1976, 1991), or dry (1930, 1932) water year type. Years with the lowest mortality varied between all water year types. Years in which the project has the greatest effect on winter-run were also years in which the lowest production occurred (Attachments 3 and 4).

Winter-run Chinook salmon have a less-than-significant change to production and project-related mortality under CP5. Therefore, the actions taken in CP5 would result in less-than-significant impacts to winter-run Chinook salmon under both 2030 and 2005 conditions. Winter-run Chinook salmon will, however, benefit from the downstream restoration efforts, although this was not modeled with SALMOD. Mitigation for this impact is not needed, and thus not proposed.

Spring-Run Chinook Salmon

<u>Production</u>

Overall average spring-run Chinook salmon simulated production for CP5 is slightly higher relative to the No-Action Alternative and slightly lower than Existing Condition (Attachments 6 and 7 of the Modeling Appendix). The maximum increase in production relative to the No-Action Alternative was 143 percent for CP5 (critical water year), and the largest decrease in production relative to the No-Action Alternative was -37 percent (also a critical water year) (Table 11-46 and Attachment 6 of the Modeling Appendix). The maximum increase in production relative to the Existing Condition was 712 percent for CP5 and largest decrease in production was less than -27 percent (both in critical water years) (Table 11-46 and Attachment 7 of the Modeling Appendix).

Figure 11-10 shows the change in production relative to the No-Action Alternative for all water years and all Comprehensive Plans.

Under CP5, seven critical, two dry and one below-normal water years had significant increases in production relative to the No-Action Alternative. Production significantly decreased in four critical water years and one wet year.

Under CP5, 10 critical, 2 dry, and 1 below-normal water years had significant increases in production relative to the Existing Condition, and two critical and one wet water years had significant decreases in production relative to Existing Conditions.

Table 11-46. Change in Production Under CP5 for Spring-Run Chinook Salmon

Year Type	Number of Years	Average Production	Change in Production from Baseline	Average Change in Production	Maximum Increase in Production	Number of Months with Significant Increase	Maximum Decrease in Production	Number of Months with Significant Decrease
Future Condition (2030)								
All	81	162,956	-1,098	-0.7	143	10	-37.3	5
Critical	13	81,451	262	0.3	143	7	-37.3	4
Dry	17	171,004	1,552	0.9	110	2	-1.8	0
Below Normal	14	176,922	0	0.0	20	1	-3.4	0
Above Normal	11	181,549	-2,217	-1.2	4.9	0	-3.3	0
Wet	26	183,061	-3,490	-1.9	1.5	0	-5.0	1
Existing Condition (2005)								
All	81	163,801	593	0.4	712	13	-26.7	3
Critical	13	86,086	12,024	16.2	712	10	-26.7	2
Dry	17	170,788	1,927	1.1	155	2	-1.7	0
Below Normal	14	177,764	-266	-0.1	21.9	1	-3.4	0
Above Normal	11	181,446	-2,667	-1.4	2.9	0	-3.4	0
Wet	26	182,939	-4,290	-2.3	2.1	0	-5.1	1

Note:
Production is the number of immature smolts surviving to pass the Red Bluff Pumping Plant

Mortality

Mortality was separated by flow- and water temperature-related mortality to assess the level of impacts on spring-run Chinook salmon caused by the actions of the project (Attachments 6 and 7). In all cases, most mortality is caused by nonoperations-related factors (e.g., disease, predation, entrainment) −around 83 percent of the total mortality.

Mortality is presented in two manners–total mortality and smolt equivalent mortality (Attachments 6 and 7 of the Modeling Appendix). Under both the 2030 and 2005 conditions, the greatest mortality to spring-run under CP5 (as with CP1 through CP4) in all water year types based on smolt equivalents, occurred to eggs, with minimal mortality to the other life stages. Table 11-7 displays the smolt-equivalent mortalities for each Comprehensive Plan that are caused by flow- and water-related factors (also see Attachments 6 and 7 of the Modeling Appendix).

Years with the highest operations-related mortality were the same for the No-Action Alternative, Existing Conditions, and CP5. Except for 1932 (a dry water year), each of these years was a critical water year type and was preceded by either a below, dry, or (predominantly) a critical water year. However, years with the lowest mortality varied between all water year types (Attachments 6 and 7 of the Modeling Appendix).

Under both 2030 and 2005 conditions, spring-run Chinook salmon would experience a significant reduction in project-related mortality and significant increase in production during critical water years. Therefore, spring-run Chinook salmon would benefit from actions taken in CP5. Additionally, spring-run Chinook salmon will benefit from the downstream restoration efforts, although this was not modeled with SALMOD. Mitigation for this impact is not needed, and thus not proposed.

Fall-Run Chinook Salmon

Production

Overall average fall-run Chinook salmon simulated production for the simulation period was slightly higher for CP5 than for either the No-Action Alternative or Existing Condition (Attachments 9 and 10 of the Modeling Appendix). The maximum increase in production relative to the No-Action Alternative was almost 42 percent (in a below-normal water year) for CP5, and the largest decrease in was 36 percent (critical water year) (Table 11-47 and Attachment 9 of the Modeling Appendix). The maximum increase in production relative to the Existing Condition was around 162 percent(critical water year) , and the largest decrease in production was 6.5 percent (wet water year) (Table 11-47 and Attachment 10 of the Modeling Appendix). Figure 11-11 shows the change in production relative to the No-Action Alternative for all water years and all Comprehensive Plans.

Table 11-47. Change in Production Under CP5 for Fall-Run Chinook Salmon

Year Type	Number of Years	Average Production	Change in Production from Baseline	Average Change in Production	Maximum Increase in Production	Number of Months with Significant Increase	Maximum Decrease in Production	Number of Months with Significant Decrease
No-Action Alternative								
All	81	29,917,761	399,355	1.4	41.7	13	-36.0	4
Critical	13	27,603,770	1,158,942	4.6	34.9	4	-36.0	1
Dry	17	30,477,780	937,620	4.8	25.0	5	-2.4	0
Below Normal	14	31,664,669	566,758	3.4	41.7	2	-6.3	1
Above Normal	11	30,957,316	-75,694	0.2	5.8	1	-1.8	0
Wet	26	29,328,136	-221,539	-0.8	5.0	1	-6.6	2
Existing Conditions								
All	81	30,073,307	644,966	2.2	162	13	-6.5	2
Critical	13	28,683,817	2,507,681	28.8	162	5	-1.5	0
Dry	17	30,474,368	1,013,967	4.8	24.4	5	-4.1	0
Below Normal	14	31,576,655	558,393	3.5	53.2	2	-5.8	1
Above Normal	11	30,739,508	-130,889	0.0	3.0	0	-3.0	0
Wet	26	29,414,471	-152,799	-0.7	5.3	1	-6.5	1

Note:
Production is the number of immature smolts surviving to pass the Red Bluff Pumping Plant

Under CP5, four critical, five dry, two below-normal, one above-normal, and one wet water year had significant increases in production relative to the No-Action Alternative. Significant decreases in production occurred in one critical, one below-normal, and two wet water years.

Compared with Existing Conditions, five critical, five dry, two below-normal, and one wet water year had significant increases in production. One below-normal and one wet water year resulted in significantly decreased production relative to the Existing Condition.

Mortality

Mortality was separated by flow- and water temperature-related mortality to assess the level of impacts on fall-run Chinook salmon caused by the actions of the project (Attachments 9 and 10). In all cases, most mortality is caused by nonoperations-related factors (e.g., disease, predation, entrainment)‒around 65 percent of the total mortality.

Mortality is presented in two manners–total mortality and smolt equivalent mortality (Attachments 9 and 10 of the Modeling Appendix). Under both 2030 and 2005 conditions, the greatest mortality based on the smolt equivalents to fall-run Chinook salmon under CP5 (as with CP1 through CP4) in all water year types based on smolt equivalents occurred to fry, followed by eggs, prespawn adults, presmolts, and lastly immature smolts. Flow-related effects triggered a higher percentage of the operations-related mortality (Table 11-9). In all water year types, the greatest portion of mortality under CP1 occurred to fry caused by forced movement to downstream habitats. Other non-flow- and water temperature-related conditions were the primary causes of mortality for all life stages except fry (Attachments 9 and 10 in the Modeling Appendix).

There was no real trend with respect to years with the greatest mortality. Years with the lowest production were in all water years except above-normal water years, and were preceded by all water year types.

Because fall-run Chinook salmon would have a significant reduction in mortality, but an insignificant change in average production, fall-run Chinook salmon would experience a less-than-significant impact from actions taken in CP5. Additionally, fall-run Chinook salmon would benefit from the downstream restoration efforts, although this was not modeled with SALMOD. Mitigation for this impact is not needed, and thus not proposed.

Late Fall-Run Chinook Salmon

Production

Overall average late fall-run Chinook salmon simulated production for the 80-year period was similar to CP5 and the No-Action Alternative and the Existing Condition (Attachments 12 and 13 of the Modeling Appendix). The maximum increase in production relative to the No-Action Alternative was around 14 percent for CP5, while the largest decrease in production relative to the No-

Action Alternative was just over 8 percent for CP5 (Table 11-48 and Attachment 12 of the Modeling Appendix). The maximum increase in production relative to the Existing Condition was 15 percent for CP5, while the largest decrease in production relative to the Existing Condition was less than 5 percent for CP5 (Table 11-48 and Attachment 13 of the Modeling Appendix). Figure 11-12 shows the change in production relative to the No-Action Alternative for all water years and all Comprehensive Plans.

Under CP5, one critical and three dry water years had significant increases in production compared to the No-Action Alternative. One critical water year had a significant decrease in production.

Under CP5, three critical and two dry water years had greater significant increases in production compared to the Existing Condition. There were no water years in which there was a significant decrease in production.

Table 11-48. Change in Production Under CP5 for Late Fall-Run Chinook Salmon

Year Type	Number of Years	Average Production	Change in Production from Baseline	Average Change in Production	Maximum Increase in Production	Number of Months with Significant Increase	Maximum Decrease in Production	Number of Months with Significant Decrease
Future Condition (2030)								
All	80	7,613,166	4,814	0.2	13.8	4	-8.4	1
Critical	13	7,060,574	-3,595	-0.1	7.2	1	-8.4	1
Dry	16	7,474,409	120,040	1.6	13.8	3	-3.7	0
Below Normal	14	7,580,922	-31,696	-0.4	2.0	0	-3.2	0
Above Normal	11	7,601,343	15,259	0.2	2.5	0	-3.2	0
Wet	26	7,443,786	-15,878	-0.2	3.6	0	-3.9	0
Existing Condition (2005)								
All	80	7,439,596	53,035	0.7	15.4	7	-4.0	0
Critical	13	7,016,840	53,544	0.8	10.9	3	-2.0	0
Dry	16	7,506,162	145,894	2.0	15.4	4	-3.8	0
Below Normal	14	7,608,790	-2,304	0.0	2.9	0	-2.1	0
Above Normal	11	7,600,738	41,065	0.5	2.2	0	-1.0	0
Wet	26	7,450,731	30,499	0.4	4.8	0	-4.0	0

Note:

Production is the number of immature smolts surviving to pass the Red Bluff Pumping Plant

Mortality

Mortality was separated by flow- and water temperature-related mortality to assess the level of impacts on late fall-run Chinook salmon caused by the actions of the project (Attachments 12 and 13). In all cases, most mortality is caused by nonoperations-related factors (e.g., disease, predation, entrainment)−around 78 percent of the total mortality.

Mortality is presented in two manners–total mortality and smolt equivalent mortality (Attachments 12 and 13 of the Modeling Appendix). Under both 2030 and 2005 conditions, the largest mortality to late fall-run Chinook salmon under CP1 (as with CP1 and CP2) in all water year types based on smolt equivalents, occurred to the egg life stage, followed by fry, then presmolts, and lastly to immature smolts.

Years with the highest mortality were the same for CP5 and the No-Action Alternative and the Existing Condition, and occurred in all water year types. Four of these years were preceded by a wet water year, and the rest were each preceded by an above-normal, a below-normal, or a dry water year (Attachments 12 and 13 of the Modeling Appendix).

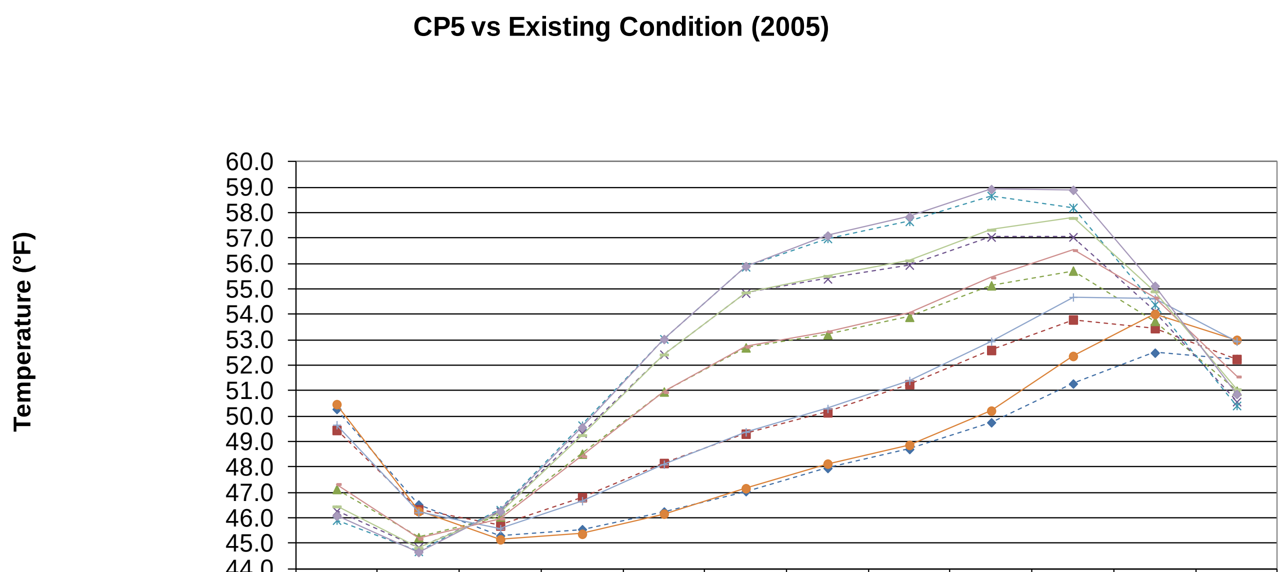
Because late fall-run Chinook salmon would have under CP5 an insignificant change in project-related mortality and production, late fall-run Chinook salmon have a less-than-significant impact from actions taken in CP5. Additionally, late fall-run Chinook salmon will benefit from the downstream restoration efforts, although this was not modeled with SALMOD. Mitigation for this impact is not needed, and thus not proposed.

Impact Aqua-13 (CP5): Changes in Flow and Water Temperature in the Upper Sacramento River Resulting from Project Operation – Steelhead, Green Sturgeon, Sacramento Splittail, American Shad, and Striped Bass CP5 operations generally would result in slightly improved flow and water temperature conditions in the upper Sacramento River for steelhead, green sturgeon, Sacramento splittail, American shad, and striped bass. This impact would be less than significant.

This impact would be the same as Impact Aqua-13 (CP3). As under CP3, monthly mean flows at all modeling locations along the upper Sacramento River under CP5 would generally be equivalent to (less than 5-percent difference from) flows under the Existing Condition and No-Action Alternative conditions simulated for all months. Changes in monthly mean flows under CP5 would have no discernible effects on steelhead, green sturgeon, Sacramento splittail, American shad, or striped bass in the upper Sacramento River. Functional flows for migration, attraction, spawning, egg incubation, and rearing/emigration for these species would be unchanged.

Also, as under CP3, monthly mean water temperatures at all modeling locations along the upper Sacramento River under CP5 would be the same as or fractionally lower than those under the Existing Condition and No-Action Alternative simulated for all months (Figures 11-41 and 11-42). The slightly cooler monthly mean water temperatures under CP5 relative to the Existing Condition and the No-Action Alternative would have very small effects on steelhead, green sturgeon, Sacramento splittail, American shad, or striped bass. Monthly mean water temperatures would not rise above important thermal tolerances for the species life stages relevant to the upper Sacramento River.

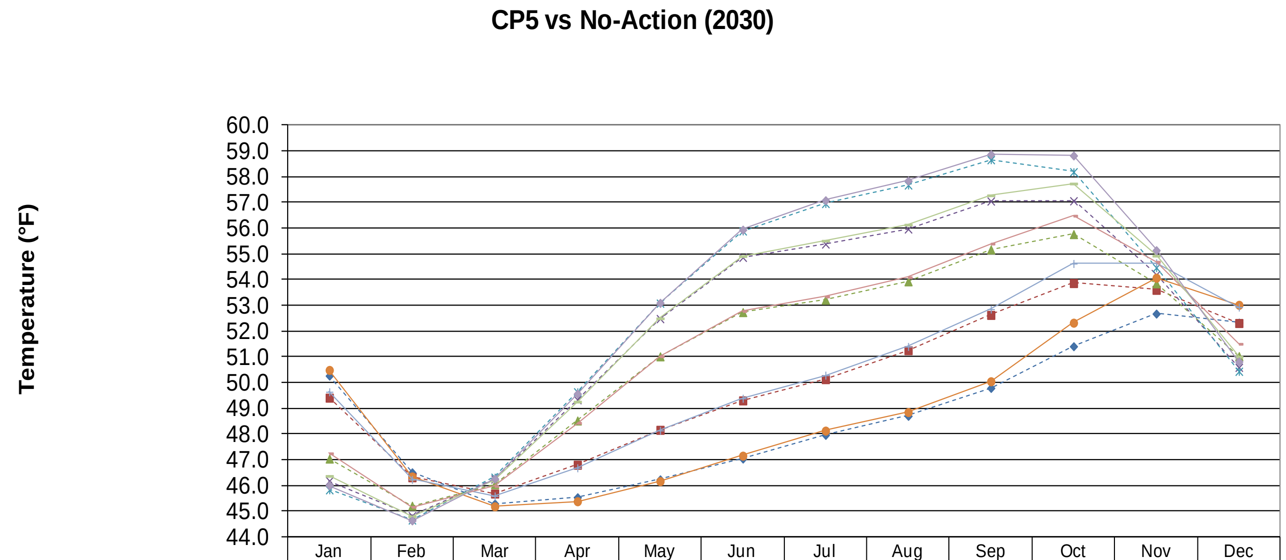
Therefore, with respect to both flow- and water temperature–related effects on fish species, this impact would be less than significant. Mitigation for this impact is not needed, and thus not proposed.



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
CP5 Below Shasta	50.3	46.5	45.3	45.6	46.3	47.1	48.0	48.7	49.8	51.3	52.5	52.2
CP5 Below Keswick	49.5	46.3	45.7	46.8	48.2	49.3	50.1	51.3	52.6	53.8	53.5	52.2
CP5 Balls Ferry	47.1	45.2	46.1	48.5	51.0	52.7	53.2	53.9	55.1	55.7	53.7	51.0
CP5 Bend Bridge	46.3	44.9	46.3	49.3	52.4	54.8	55.4	55.9	57.0	57.0	54.1	50.6
CP5 RBPP	45.9	44.7	46.3	49.6	53.0	55.9	57.0	57.7	58.7	58.2	54.4	50.4
EC Below Shasta	50.5	46.3	45.2	45.4	46.2	47.2	48.1	48.9	50.2	52.4	54.0	53.0
EC Below Keswick	49.7	46.2	45.6	46.7	48.1	49.4	50.3	51.4	52.9	54.7	54.6	52.9
EC Balls Ferry	47.3	45.2	46.0	48.4	50.9	52.7	53.3	54.1	55.4	56.5	54.7	51.6
EC Bend Bridge	46.5	44.8	46.2	49.3	52.4	54.9	55.5	56.1	57.3	57.8	54.9	51.1
EC RBPP	46.1	44.7	46.3	49.6	53.0	55.9	57.1	57.8	58.9	58.9	55.1	50.9

Key:
CP = Comprehensive Plan
EC = Existing Condition
RBPP = Red Bluff Pumping Plant

Figure 11-41. Changes in Mean Monthly Water Temperature at Modeled Locations in the Sacramento River Within the Primary Study Area (CP5 Versus Existing Condition)



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
CP5 Below Shasta	50.3	46.5	45.3	45.5	46.2	47.0	48.0	48.7	49.8	51.4	52.7	52.3
CP5 Below Keswick	49.4	46.3	45.7	46.8	48.2	49.3	50.1	51.3	52.6	53.9	53.6	52.3
CP5 Balls Ferry	47.0	45.2	46.0	48.5	51.0	52.7	53.2	53.9	55.2	55.8	53.9	51.0
CP5 Bend Bridge	46.2	44.8	46.3	49.3	52.5	54.9	55.4	56.0	57.1	57.1	54.2	50.6
CP5 RBPP	45.8	44.7	46.3	49.6	53.1	55.9	57.0	57.7	58.7	58.2	54.5	50.4
NA Below Shasta	50.5	46.3	45.2	45.4	46.2	47.2	48.1	48.9	50.0	52.3	54.1	53.0
NA Below Keswick	49.6	46.2	45.6	46.7	48.1	49.4	50.3	51.4	52.9	54.6	54.6	52.9
NA Balls Ferry	47.3	45.2	46.0	48.4	51.0	52.8	53.3	54.1	55.4	56.5	54.7	51.5
NA Bend Bridge	46.4	44.8	46.2	49.3	52.5	54.9	55.5	56.1	57.3	57.7	54.9	51.0
NA RBPP	46.0	44.6	46.3	49.6	53.1	55.9	57.1	57.8	58.9	58.8	55.1	50.8

Key: NA = No-Action
CP = Comprehensive Plan RBPP = Red Bluff Pumping Plant

Figure 11-42. Changes in Mean Monthly Water Temperature at Modeled Locations in the Sacramento River Within the Primary Study Area (CP5 Versus No-Action Alternative)

Impact Aqua-14 (CP5): Reduction in Ecologically Important Geomorphic Processes in the Upper Sacramento River Resulting from Reduced Frequency and Magnitude of Intermediate to High Flows Project operations could cause a reduction in the magnitude, duration, and frequency of intermediate to large flows both in the upper Sacramento River and in the lowermost (confluence) areas of tributaries. Such flows are necessary for channel forming and maintenance, meander migration, and the creation of seasonally inundated floodplains. These geomorphic processes are ecologically important because they are needed to maintain important aquatic habitat functions and values for fish and macroinvertebrate communities. This impact would be potentially significant.

This impact would be similar to Impact Aqua-14 (CP1). The impact could be greater under CP5 than under CP1 because the increased reservoir capacity associated with an 18.5-foot raise compared to a 6.5-foot raise would allow for storage of additional water volume (and flows) behind the raised dam.

Sediment transport, deposition, and scour regulate the formation of key habitat features such as point bars, gravel deposits, and SRA habitat. Intermediate to high flows and the associated stage elevation of the river surface also provide a backwater effect on the lowermost segment of tributaries, reducing the potential for downcutting. These processes are regulated by the magnitude and frequency of flow. Relatively large floods provide the energy required to mobilize sediment from the riverbed, produce meander migration, increase stage elevation, and create seasonally inundated floodplains. Operations under CP5 could result in a reduction in the intermediate to large flows necessary for channel forming and maintenance, meander migration, and the creation of seasonally inundated floodplains.

Implementation of CP5 would cause a further reduction in the magnitude, duration, and frequency of intermediate to large flows, relative to the Existing Condition and No-Action Alternative. Overall, the project would increase the existing, ongoing effects on geomorphic processes resulting from operation of Shasta Dam that are necessary for channel forming and maintenance, meander migration, and the creation of seasonally inundated floodplains. These effects would likely occur throughout the upper Sacramento River portion of the primary study area.

As discussed above, CP5 also includes a 10-year gravel augmentation program and the restoration of riparian, floodplain, and side-channel habitat at up to six potential restoration sites as additional environmental commitments. Placing gravel along the Sacramento River channel and bank annually and restoring riparian, floodplain, and side-channel habitat at up to six sites would result in benefits to ecological processes (e.g., sediment transport and deposition, floodplain inundation) that would partially offset the effects described above. Nevertheless, reductions in the magnitude of high flows would likely be sufficient to reduce ecologically important processes along the upper Sacramento River. This impact would be potentially significant. Mitigation for this impact is proposed in Section 11.3.4.

Lower Sacramento River and Tributaries, Delta, and Trinity River

Impact Aqua-15 (CP5): Changes in Flow and Water Temperatures in the Lower Sacramento River and Tributaries and Trinity River Resulting from Project Operation – Fish Species of Primary Management Concern Project operation would result in no discernible change in monthly mean flows or water temperature conditions in the lower Sacramento River. However, predicted changes in flow in the Feather, American, and Trinity rivers could result in adverse effects on Chinook salmon, steelhead, Coho salmon, green sturgeon, Sacramento splittail, American shad, and striped bass. This impact would be potentially significant.

This impact would be similar to Impact Aqua-15 (CP1). The impact could be greater under CP5 than under CP1 because the increased reservoir capacity associated with an 18.5-foot raise compared to a 6.5-foot raise would allow for storage of additional water volume (and increased cold-water pool) behind the raised dam.

As described below, mean monthly flows at various modeling locations on the lower Sacramento River and tributaries under CP5 were compared with mean monthly flows simulated for Existing Conditions and No-Action Alternative conditions. See the Modeling Appendix for complete CalSim-II modeling results.

Lower Sacramento River As under CP3, monthly mean flows at the lower Sacramento River modeling locations under CP5 would be essentially equivalent to flows under the Existing Condition and No-Action Alternative conditions simulated for all months. Differences in monthly mean flow were generally small (less than 2 percent) and within the existing range of variability. Potential changes in flows would diminish rapidly downstream from RBPP because of the increasing effects of tributary inflows, diversions, and flood bypasses. Potential flow-related effects of CP5 on fish species of management concern in the lower Sacramento River would be minimal. Potential changes in water temperatures in the lower Sacramento River caused by small changes in releases would diminish rapidly downstream because of the increasing effects of inflows, atmospheric influences, and groundwater. Therefore, flow- and temperature-related impacts on fish species in the lower Sacramento River would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

Lower Feather River, American River, and Trinity River Also, as under CP3, monthly mean flows at all modeling locations on the lower Feather River, the American River, and the Trinity River under CP5 would be essentially equivalent to (less than 2-percent difference from) flows under the Existing Condition and No-Action Alternative simulated for most months. However, simulations for several months within the modeling record show substantial changes to flows in tributaries. Potential changes in flows could be reduced by real-time operations to meet existing rules, and because of operation of upstream reservoirs (Lake Oroville, Folsom Lake, and Trinity Lake) and increasing effects from tributary inflows, diversions, and flood bypasses. Based on predicted changes in flow and associated flow-habitat relationships, potential flow-related impacts on species of management concern in the American, Feather, and Trinity rivers could occur. This impact would be potentially significant. Mitigation for this impact is proposed in Section 11.3.4.

Impact Aqua-16 (CP5): Reduction in Ecologically Important Geomorphic Processes in the Lower Sacramento River Resulting from Reduced Frequency and Magnitude of Intermediate to High Flows Project operation could cause a reduction in intermediate to large flows both in the lower Sacramento River and in the lowermost (confluence) areas of tributaries. Such flows are necessary for channel forming and maintenance, meander migration, and the creation of seasonally inundated floodplains. These geomorphic processes are ecologically important because they are needed to maintain important aquatic habitat functions and values for fish and macroinvertebrate communities. This impact would be potentially significant.

This impact would be similar to Impact Aqua-16 (CP1). The impact could be greater under CP5 than under CP1 because the increased reservoir capacity associated with an 18.5-foot raise compared to a 6.5-foot raise would allow for storage of additional water volume (and flows) behind the raised dam.

Sediment transport, deposition, and scour regulate the formation of key habitat features such as point bars, gravel deposits, and SRA habitat. Intermediate to high flows and the associated stage elevation of the river surface also provide a backwater effect on the lowermost segment of tributaries, which reduces the potential for downcutting. These processes are regulated by the magnitude and frequency of flows. Relatively large floods provide the energy required to mobilize sediment from the bed, produce meander migration, increase stage elevation, create seasonally inundated floodplains, and inundate floodplain bypasses. Operations under CP5 could result in reduced intermediate to large flows that are necessary for channel forming and maintenance, meander migration, and the creation of seasonally inundated floodplains.

Implementation of CP5 would cause a further reduction in the magnitude, duration, and frequency of intermediate to large flows relative to the Existing Condition and No-Action Alternative. Overall, the project would increase the existing, ongoing impacts on geomorphic processes resulting from operation of Shasta Dam that are necessary for channel forming and maintenance, meander migration, the creation of seasonally inundated floodplains, and the inundation of floodplain bypasses. These effects would likely occur along the upper reaches of the lower Sacramento River.

Reductions in the magnitude of high flows would likely be sufficient to reduce ecologically important processes along the upper Sacramento River and its floodplain bypasses. This impact would be potentially significant. Mitigation for this impact is proposed in Section 11.3.4.

Impact Aqua-17 (CP5): Effects to Delta Fisheries Resulting from Changes to Delta Outflow Based on the results of hydrologic modeling comparing Delta outflow under the No-Action Alternative, Existing Condition, and CP5, CP5 would result in changes to average monthly Delta outflow of less than 5 percent in all water year types (with the exception of September in dry years, November in above-normal years, and December of critical years). This impact on Delta fisheries and hydrologic transport processes within the Bay-Delta would be less than significant.

Results of the comparison of Delta outflows under CP5 compared with the Existing Condition and No-Action Alternative are summarized by month and water year type in Table 11-49. Under 2030 conditions, Delta outflows would change by greater than 5 percent only in November of above-normal water years. Under 2005 conditions, Delta outflows would decrease by more than 5 percent in November of above-normal water years, but would not result in an overall significant impact to Delta fisheries. Under 2030 conditions, Delta outflows would increase by 5 percent in September and December, but decrease by over 5 percent in November of above-normal water years. An increase in Delta outflow during critical water years would not result in significant impacts to Delta fisheries, particularly at flows between 3,500 and 6,000, while a decrease in Delta outflow by around 700 cfs when outflows are higher in November would also not result in significant impacts to Delta fisheries. Based on the results of this comparison, it was concluded that CP5 would have a less-than-significant impact on Delta fisheries and hydrologic transport processed within the Bay-Delta as a consequence of changes in Delta outflow under existing conditions. Mitigation for this impact is not needed, and thus not proposed.

Table 11-49. Delta Outflow Under Existing Conditions, No-Action Alternative, and CP5

		Existing Condition	CP5 (2005)		No-Action Alternative	CP5 (2030)	
Month	Water Year	Flow (cfs)	Flow (cfs)	Percent Change	Flow (cfs)	Flow (cfs)	Percent Change
January	Average	42,078	41,817	-1	42,169	41,806	-1
	W	84,136	83,584	-1	84,037	83,176	-1
	AN	47,221	46,892	-1	46,984	46,828	0
	BN	21,610	21,578	0	21,990	22,012	0
	D	14,166	13,956	-1	14,452	14,174	-2
	C	11,560	11,649	1	11,757	11,691	-1
February	Average	51,618	51,340	-1	51,430	51,033	-1
	W	95,261	94,826	0	94,634	94,068	-1
	AN	60,080	59,474	-1	60,278	59,353	-2
	BN	35,892	35,776	0	35,665	35,522	0
	D	20,978	20,804	-1	20,946	20,694	-1
	C	12,902	12,945	0	13,088	13,076	0
March	Average	42,722	42,532	0	42,585	42,469	0
	W	78,448	78,481	0	78,376	78,447	0
	AN	53,486	52,431	-2	53,139	52,313	-2
	BN	23,102	22,800	-1	22,980	22,746	-1
	D	19,763	19,873	1	19,559	19,659	1
	C	11,881	11,750	-1	11,893	11,895	0
April	Average	30,227	30,282	0	30,743	30,794	0
	W	54,640	54,674	0	55,460	55,472	0
	AN	32,141	32,147	0	32,971	32,976	0
	BN	21,773	21,903	1	22,511	22,598	0
	D	14,347	14,429	1	14,538	14,665	1
	C	9,100	9,121	0	8,873	8,897	0
May	Average	22,619	22,547	0	22,249	22,179	0
	W	41,184	41,151	0	40,543	40,526	0
	AN	24,296	24,183	0	24,454	24,242	-1
	BN	16,346	15,948	-2	15,989	15,625	-2
	D	10,554	10,660	1	10,116	10,265	1
	C	6,132	6,132	0	5,910	5,882	0

Table 11-49. Delta Outflow Under Existing Conditions, No-Action Alternative, and CP5 (contd.)

		Existing Condition	CP5 (2005)		No-Action Alternative	CP5 (2030)	
Month	Water Year	Flow (cfs)	Flow (cfs)	Percent Change	Flow (cfs)	Flow (cfs)	Percent Change
June	Average	12,829	12,756	-1	12,660	12,550	-1
	W	23,473	23,471	0	23,015	23,027	0
	AN	12,080	11,625	-4	11,799	11,433	-3
	BN	7,995	7,977	0	7,991	7,727	-3
	D	6,691	6,681	0	6,764	6,697	-1
	C	5,361	5,360	0	5,378	5,376	0
July	Average	7,864	7,864	0	7,864	7,855	0
	W	11,230	11,223	0	11,181	11,144	0
	AN	9,562	9,519	0	9,407	9,384	0
	BN	7,117	7,131	0	7,225	7,275	1
	D	5,005	5,006	0	5,052	5,019	-1
	C	4,034	4,074	1	4,098	4,130	1
August	Average	4,322	4,335	0	4,335	4,355	0
	W	5,302	5,274	-1	5,097	5,060	-1
	AN	4,000	4,000	0	4,000	4,000	0
	BN	4,000	4,000	0	4,002	4,008	0
	D	3,906	3,903	0	4,142	4,203	1
	C	3,520	3,676	4	3,699	3,811	3
September	Average	9,841	9,866	0	9,844	9,898	1
	W	19,695	19,717	0	19,702	19,736	0
	AN	11,784	11,771	0	11,849	11,836	0
	BN	3,876	3,862	0	3,913	3,950	1
	D	3,508	3,576	2	3,442	3,600	5
	C	3,008	3,061	2	3,005	3,029	1
October	Average	6,067	6,072	0	6,000	6,003	0
	W	7,926	7,870	-1	7,633	7,558	-1
	AN	5,309	5,293	0	5,476	5,536	1
	BN	5,479	5,559	1	5,502	5,546	1
	D	5,228	5,264	1	5,236	5,253	0
	C	4,741	4,765	1	4,714	4,757	1
November	Average	11,706	11,531	-1	11,675	11,466	-2
	W	17,717	17,590	-1	17,715	17,494	-1
	AN	12,667	11,767	-7	12,491	11,755	-6
	BN	8,543	8,509	0	8,686	8,557	-1
	D	8,482	8,481	0	8,414	8,386	0
	C	6,250	6,266	0	6,150	6,132	0

Table 11-49. Delta Outflow Under Existing Conditions, No-Action Alternative, and CP5 (contd.)

		Existing Condition	CP5 (2005)		No-Action Alternative	CP5 (2030)	
Month	**Water Year**	**Flow (cfs)**	**Flow (cfs)**	**Percent Change**	**Flow (cfs)**	**Flow (cfs)**	**Percent Change**
December	Average	21,755	21,437	-1	21,745	21,324	-2
	W	44,974	44,310	-1	44,661	43,598	-2
	AN	18,581	18,300	-2	18,562	18,271	-2
	BN	12,219	11,850	-3	12,326	12,008	-3
	D	8,531	8,517	0	8,803	8,678	-1
	C	5,580	5,578	0	5,677	5,954	5

Note:
A negative percentage change reflects a reduction in Delta outflow
Key:
AN = above-normal
BN = below-normal
C = critical
CP = Comprehensive Plan
cfs = cubic feet per second
D = dry
W = wet

Impact Aqua-18 (CP5): Effects to Delta Fisheries Resulting from Changes to Delta Inflow Based on the results of hydrologic modeling comparing Delta inflow under CP5 to the Existing Condition and No-Action Alternative, CP5 would not decrease average monthly Delta inflow by 5 percent or more in any year type (except in September of dry and critical years). This impact on Delta fisheries and hydrologic transport processes within the Bay-Delta would be less than significant.

Results of the comparison of Delta inflows are summarized by month and water year type in Table 11-50. Delta inflows were observed to be slightly lower under many of the CP5 operations and slightly higher than either the Existing Condition or the No-Action Alternative depending on month and water year type. Average monthly Delta inflow would increase by more than 5 percent during September of critical years compared to the Existing Condition, and during September of dry and critical years compared to the No-Action Alternative. Average monthly Delta inflow would not decrease by more than 5 percent in any water year type. Based on the results of this comparison, it was concluded that CP5 would have a less-than-significant effect on Delta fisheries and hydrologic transport processes within the Bay-Delta as a consequence of changes in Delta inflow. Mitigation for this impact is not needed, and thus not proposed.

Table 11-50. Delta Inflow Under Existing Conditions, No-Action Alternative, and CP5

		Existing Condition	CP5 (2005)		No-Action Alternative	CP5 (2030)	
Month		**Flow (cfs)**	**Flow (cfs)**	**Percent Change**	**Flow (cfs)**	**Flow (cfs)**	**Percent Change**
January	Average	47,426	47,149	-1	47,457	47,115	-1
	W	89,431	88,880	-1	89,328	88,469	-1
	AN	51,611	51,213	-1	51,267	51,053	0
	BN	27,269	27,240	0	27,576	27,598	0
	D	20,125	19,962	-1	20,371	20,094	-1
	C	16,699	16,677	0	16,749	16,882	1
February	Average	57,835	57,570	0	57,623	57,250	-1
	W	103,140	102,698	0	102,606	102,066	-1
	AN	65,379	64,552	-1	65,574	64,598	-1
	BN	41,782	41,781	0	41,374	41,253	0
	D	26,530	26,384	-1	26,431	26,214	-1
	C	17,818	18,008	1	17,958	18,014	0
March	Average	49,829	49,675	0	49,713	49,588	0
	W	87,688	87,738	0	87,703	87,801	0
	AN	61,498	60,673	-1	61,339	60,540	-1
	BN	30,569	30,264	-1	30,415	30,183	-1
	D	24,943	24,967	0	24,640	24,654	0
	C	15,933	15,916	0	15,896	15,884	0
April	Average	33,962	34,019	0	34,783	34,833	0
	W	58,684	58,717	0	60,017	60,019	0
	AN	35,588	35,595	0	36,738	36,744	0
	BN	25,351	25,482	1	26,403	26,490	0
	D	17,962	18,057	1	18,315	18,448	1
	C	12,817	12,838	0	12,635	12,663	0
May	Average	27,383	27,312	0	27,091	27,029	0
	W	46,973	46,941	0	46,494	46,476	0
	AN	28,466	28,354	0	28,711	28,502	-1
	BN	20,747	20,349	-2	20,427	20,062	-2
	D	14,882	14,988	1	14,534	14,686	1
	C	10,347	10,351	0	10,038	10,065	0
June	Average	22,171	22,115	0	22,090	22,001	0
	W	35,459	35,457	0	35,172	35,190	0
	AN	23,124	22,662	-2	22,776	22,410	-2
	BN	16,884	16,971	1	16,941	16,796	-1
	D	14,095	14,082	0	14,337	14,262	-1
	C	10,710	10,711	0	10,694	10,696	0
July	Average	23,099	23,160	0	22,839	22,959	1
	W	27,442	27,430	0	27,496	27,455	0
	AN	25,169	25,065	0	25,065	25,018	0
	BN	23,282	23,351	0	23,362	23,338	0
	D	20,937	20,983	0	20,082	20,408	2
	C	14,647	15,042	3	14,048	14,544	4

Table 11-50. Delta Inflow Under Existing Conditions, No-Action Alternative, and CP5 (contd.)

		Existing Condition	CP5 (2005)		No-Action Alternative	CP5 (2030)	
Month	**Flow (cfs)**	**Flow (cfs)**	**Flow (cfs)**	**Percent Change**	**Flow (cfs)**	**Flow (cfs)**	**Percent Change**
August	Average	17,147	17,154	0	17,026	17,128	1
	W	20,235	20,217	0	20,154	20,118	0
	AN	18,784	18,754	0	18,927	18,941	0
	BN	18,274	18,202	0	18,297	18,231	0
	D	15,066	15,348	2	14,371	14,976	4
	C	10,626	10,404	-2	10,850	10,782	-1
September	Average	20,946	21,184	1	21,145	21,461	1
	W	31,918	32,076	0	32,428	32,518	0
	AN	23,912	23,902	0	24,747	24,877	1
	BN	16,518	16,468	0	16,563	16,652	1
	D	14,440	14,960	4	14,233	15,039	6
	C	9,130	9,707	6	8,809	9,332	6
October	Average	14,407	14,469	0	14,175	14,278	1
	W	17,072	17,019	0	16,558	16,569	0
	AN	13,176	13,391	2	13,223	13,442	2
	BN	14,044	14,251	1	14,159	14,201	0
	D	13,133	13,264	1	12,846	13,135	2
	C	12,196	12,085	-1	11,976	11,956	0
November	Average	19,512	19,554	0	19,463	19,503	0
	W	26,429	26,491	0	26,536	26,433	0
	AN	20,269	19,631	-3	20,052	19,651	-3
	BN	16,984	17,064	0	16,980	16,972	0
	D	15,771	16,056	2	15,705	16,116	2
	C	12,330	12,595	2	12,081	12,372	0
December	Average	30,984	30,673	-1	30,988	30,568	-1
	W	53,758	53,109	-1	53,516	52,482	-2
	AN	28,431	28,177	-1	28,223	27,981	-1
	BN	21,958	21,606	-2	22,143	21,842	-1
	D	18,560	18,550	0	18,837	18,696	-1
	C	13,363	13,322	0	13,484	13,666	1

Note:
A negative percentage change reflects a reduction in Delta inflow

Key:
AN = above-normal
BN = below-normal
C = critical
cfs = cubic feet per second
CP = Comprehensive Plan
D = dry
W = wet

Impact Aqua-19 (CP5): Effects to Delta Fisheries Resulting from Changes in Sacramento River Inflow Project operation would result in a variable response in Sacramento River inflow, resulting in both increases and decreases in river flow above basis-of-comparison conditions depending on month and water year type. Decreases in Sacramento River inflow would not equal or exceed 5 percent. This impact would be less than significant.

Results of hydrologic modeling, by month and year type, for the Existing Condition, No-Action Alternative, and CP5 for Sacramento River inflow, are presented in Table 11-51. Results of these analyses show a variable response in Sacramento River inflow with CP5 operations resulting in both increases and decreases in river inflow above the Existing Condition and the No-Action Alternative, depending on month and water year. Under CP5, Sacramento River inflow would not decrease by 5 percent or more. Based on these results, the impact of CP5 on fish habitat and transport mechanisms within the lower Sacramento River and Delta would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

Table 11-51. Sacramento River Inflow Under Existing Conditions, No-Action Alternative, and CP5

		Existing Condition	CP5 (2005)		No-Action Alternative	CP5 (2030)	
Month	**Water Year**	**Flow (cfs)**	**Flow (cfs)**	**Percent Change**	**Flow (cfs)**	**Flow (cfs)**	**Percent Change**
January	Average	31,139	31,046	0	31,167	31,076	0
	W	50,173	50,011	0	50,164	49,899	-1
	AN	38,122	37,945	0	38,006	37,975	0
	BN	22,370	22,420	0	22,540	22,643	0
	D	16,980	16,884	-1	17,109	16,929	-1
	C	14,384	14,362	0	14,322	14,455	1
February	Average	36,608	36,559	0	36,618	36,490	0
	W	56,740	56,751	0	56,637	56,637	0
	AN	44,453	43,913	-1	44,672	44,028	-1
	BN	30,911	31,090	1	30,780	30,832	0
	D	21,249	21,103	-1	21,237	21,002	-1
	C	14,830	15,020	1	15,075	15,129	0
March	Average	32,396	32,301	0	32,352	32,284	0
	W	49,248	49,293	0	49,403	49,459	0
	AN	44,060	43,672	-1	43,972	43,624	-1
	BN	23,188	22,866	-1	23,068	22,855	-1
	D	20,390	20,414	0	20,138	20,151	0
	C	12,971	12,954	0	12,942	12,930	0
April	Average	23,232	23,290	0	23,206	23,257	0
	W	37,918	37,953	0	38,019	38,025	0
	AN	26,053	26,062	0	26,039	26,048	0
	BN	17,518	17,648	1	17,439	17,526	0
	D	13,205	13,300	1	13,164	13,297	1
	C	10,295	10,316	0	10,067	10,095	0
May	Average	19,417	19,349	0	19,114	19,054	0
	W	32,095	32,071	0	31,800	31,789	0
	AN	21,204	21,092	-1	21,080	20,871	-1
	BN	14,530	14,133	-3	14,144	13,780	-3
	D	11,226	11,332	1	10,836	10,987	1
	C	8,148	8,152	0	7,874	7,901	0

Table 11-51. Sacramento River Inflow Under Existing Conditions, No-Action Alternative, and CP5 (contd.)

		Existing Condition	CP5 (2005)		No-Action Alternative	CP5 (2030)	
Month	**Water Year**	**Flow (cfs)**	**Flow (cfs)**	**Percent Change**	**Flow (cfs)**	**Flow (cfs)**	**Percent Change**
June	Average	16,508	16,452	0	16,511	16,420	-1
	W	24,092	24,090	0	23,905	23,920	0
	AN	16,598	16,136	-3	16,533	16,166	-2
	BN	13,792	13,879	1	13,822	13,677	-1
	D	12,283	12,271	0	12,569	12,493	-1
	C	9,492	9,493	0	9,516	9,517	0
July	Average	19,518	19,579	0	19,266	19,386	1
	W	20,071	20,058	0	20,058	20,016	0
	AN	22,070	21,966	0	21,976	21,927	0
	BN	21,232	21,301	0	21,374	21,350	0
	D	19,577	19,623	0	18,788	19,113	2
	C	13,683	14,077	3	13,100	13,596	4
August	Average	14,710	14,717	0	14,596	14,697	1
	W	16,285	16,266	0	16,189	16,152	0
	AN	16,418	16,388	0	16,561	16,575	0
	BN	16,112	16,040	0	16,170	16,105	0
	D	13,632	13,915	2	12,968	13,572	5
	C	9,570	9,348	-2	9,785	9,716	-1
September	Average	18,211	18,449	1	18,417	18,733	2
	W	27,839	27,997	1	28,337	28,426	0
	AN	21,244	21,234	0	22,088	22,218	1
	BN	14,088	14,038	0	14,147	14,236	1
	D	12,522	13,036	4	12,341	13,147	7
	C	7,664	8,241	8	7,347	7,869	7
October	Average	11,309	11,416	1	11,117	11,230	1
	W	13,419	13,506	1	13,040	13,080	0
	AN	10,499	10,714	2	10,571	10,790	2
	BN	11,053	11,259	2	11,195	11,242	0
	D	10,150	10,281	1	9,830	10,120	3
	C	9,587	9,477	-1	9,333	9,313	0
November	Average	15,640	15,710	0	15,605	15,694	1
	W	20,726	20,867	1	20,832	20,860	0
	AN	16,893	16,281	-4	16,666	16,319	-2
	BN	13,755	13,833	1	13,793	13,784	0
	D	12,720	13,004	2	12,723	13,134	3
	C	9,948	10,214	3	9,653	9,944	3

Table 11-51. Sacramento River Inflow Under Existing Conditions, No-Action Alternative, and CP5 (contd.)

		Existing Condition	CP5 (2005)		No-Action Alternative	CP5 (2030)	
Month	Water Year	Flow (cfs)	Flow (cfs)	Percent Change	Flow (cfs)	Flow (cfs)	Percent Change
December	Average	23,248	23,143	0	23,229	23,090	-1
	W	37,645	37,387	-1	37,434	37,102	-1
	AN	22,604	22,532	0	22,461	22,282	-1
	BN	16,930	16,902	0	17,103	17,083	0
	D	15,760	15,750	0	15,934	15,792	-1
	C	11,303	11,262	0	11,310	11,492	2

Note: A negative percentage change reflects a reduction in Sacramento River inflow

Key:
AN = above-normal
BN = below-normal
C = critical
cfs = cubic feet per second
CP = Comprehensive Plan
D = dry
W = wet

Impact Aqua-20 (CP5): Effects to Delta Fisheries Resulting from Changes in San Joaquin River Flow at Vernalis CP5 operation would result in no discernible change in San Joaquin River flows at Vernalis, and therefore no effects on fish habitat or transport mechanisms within the lower San Joaquin River and Delta compared with the Existing Condition and No-Action Alternative. There would be no impact.

Results of hydrologic modeling, by month and water year type, for the Existing Condition, No-Action Alternative, and CP5 for San Joaquin River flow are summarized in Table 11-52. Results of these analyses show that CP5 would have no effect on seasonal San Joaquin River flows compared with the Existing Condition and No-Action Alternative. Based on these results CP5 would have no impact on Delta fisheries or transport mechanisms within the lower San Joaquin River and Delta. Mitigation for this impact is not needed, and thus not proposed.

Table 11-52. San Joaquin River Flow at Vernalis Under Existing Conditions, and CP5

		Existing Condition	CP5 (2005)		No-Action Alternative	CP5 (2030)	
Month	Water Year	Flow (cfs)	Flow (cfs)	Percent Change	Flow (cfs)	Flow (cfs)	Percent Change
January	Average	4,770	4,770	0	4,764	4,764	0
	W	9,273	9,273	0	9,097	9,097	0
	AN	4,223	4,223	0	4,259	4,259	0
	BN	2,986	2,986	0	3,081	3,081	0
	D	2,084	2,084	0	2,160	2,160	0
	C	1,673	1,673	0	1,746	1,746	0

Table 11-52. San Joaquin River Flow at Vernalis Under Existing Conditions, and CP5 (contd.)

		Existing Condition	CP5 (2005)		No-Action Alternative	CP5 (2030)	
Month	**Water Year**	**Flow (cfs)**	**Flow (cfs)**	**Percent Change**	**Flow (cfs)**	**Flow (cfs)**	**Percent Change**
February	Average	6,265	6,265	0	6,143	6,143	0
	W	11,036	11,036	0	10,845	10,845	0
	AN	6,047	6,047	0	6,179	6,179	0
	BN	5,767	5,767	0	5,565	5,565	0
	D	2,642	2,642	0	2,528	2,528	0
	C	2,161	2,161	0	2,014	2,014	0
March	Average	7,133	7,133	0	7,003	7,003	0
	W	13,443	13,443	0	13,170	13,170	0
	AN	6,788	6,788	0	6,674	6,673	0
	BN	5,322	5,322	0	5,293	5,293	0
	D	2,963	2,963	0	2,895	2,895	0
	C	2,176	2,176	0	2,129	2,129	0
April	Average	6,720	6,720	0	7,533	7,533	0
	W	11,420	11,420	0	12,614	12,614	0
	AN	6,671	6,671	0	7,799	7,798	0
	BN	5,852	5,852	0	6,910	6,910	0
	D	3,726	3,726	0	4,112	4,112	0
	C	2,087	2,087	0	2,118	2,118	0
May	Average	6,204	6,204	0	6,234	6,234	0
	W	11,268	11,268	0	11,135	11,135	0
	AN	5,611	5,611	0	5,987	5,987	0
	BN	5,010	5,010	0	5,108	5,108	0
	D	3,070	3,070	0	3,111	3,111	0
	C	1,920	1,920	0	1,862	1,862	0
June	Average	4,739	4,739	0	4,671	4,671	0
	W	9,451	9,451	0	9,390	9,390	0
	AN	5,608	5,609	0	5,326	5,326	0
	BN	2,424	2,424	0	2,471	2,470	0
	D	1,598	1,598	0	1,554	1,554	0
	C	1,076	1,076	0	1,035	1,035	0
July	Average	3,202	3,202	0	3,208	3,208	0
	W	6,556	6,556	0	6,660	6,660	0
	AN	2,783	2,784	0	2,767	2,768	0
	BN	1,775	1,775	0	1,733	1,733	0
	D	1,282	1,282	0	1,216	1,216	0
	C	898	898	0	880	880	0

Table 11-52. San Joaquin River Flow at Vernalis Under Existing Conditions, and CP5 (contd.)

		Existing Condition	CP5 (2005)		No-Action Alternative	CP5 (2030)	
Month	**Water Year**	**Flow (cfs)**	**Flow (cfs)**	**Percent Change**	**Flow (cfs)**	**Flow (cfs)**	**Percent Change**
August	Average	2,029	2,029	0	2,040	2,041	0
	W	3,099	3,099	0	3,158	3,159	0
	AN	2,020	2,020	0	2,014	2,015	0
	BN	1,828	1,828	0	1,817	1,816	0
	D	1,342	1,342	0	1,315	1,315	0
	C	984	984	0	993	993	0
September	Average	2,331	2,331	0	2,340	2,340	0
	W	3,274	3,274	0	3,317	3,317	0
	AN	2,328	2,328	0	2,312	2,312	0
	BN	2,109	2,109	0	2,119	2,119	0
	D	1,795	1,795	0	1,774	1,775	0
	C	1,358	1,358	0	1,355	1,355	0
October	Average	2,757	2,757	0	2,753	2,753	0
	W	3,112	3,112	0	3,107	3,107	0
	AN	2,446	2,446	0	2,424	2,424	0
	BN	2,749	2,749	0	2,718	2,718	0
	D	2,686	2,686	0	2,710	2,710	0
	C	2,416	2,416	0	2,423	2,423	0
November	Average	2,633	2,633	0	2,603	2,603	0
	W	3,372	3,372	0	3,340	3,340	0
	AN	2,213	2,213	0	2,176	2,176	0
	BN	2,412	2,412	0	2,360	2,360	0
	D	2,388	2,388	0	2,355	2,355	0
	C	2,075	2,075	0	2,088	2,088	0
December	Average	3,199	3,199	0	3,263	3,263	0
	W	5,081	5,081	0	5,178	5,178	0
	AN	2,916	2,916	0	2,899	2,899	0
	BN	2,705	2,705	0	2,753	2,753	0
	D	2,047	2,047	0	2,123	2,123	0
	C	1,710	1,710	0	1,785	1,785	0

Note:
A negative percentage change reflects a reduction in San Joaquin River inflow
Key:
AN = above-normal
BN = below-normal
C = critical
cfs = cubic feet per second
CP = Comprehensive Plan
D = dry
W = wet

Impact Aqua-21 (CP5): Reduction in Low-Salinity Habitat Conditions Resulting from an Upstream Shift in X2 Location CP5 operation would result in less than 0.5 km movement upstream or downstream from the X2 location from its location under the Existing Condition or No-Action Alternative during February through May and September through November, and thus cause minimal reduction in low-salinity habitats. This impact would be less than significant.

The 1 km X2 criterion was applied to a comparison of hydrologic model results for the Existing Condition, No-Action Alternative, and CP5, by month and water year type, for the months from February through May and September through November. Results of the comparisons are summarized in Table 11-53. These results showed that changes in X2 location under CP5 were less than 1 km (all were less than 0.4 km) with both variable upstream and downstream movement of the X2 location depending on month and water year type. These results are consistent with model results for Delta outflow that showed a less-than-significant change in flows. Based on these results, CP5 would have a less-than-significant impact on low-salinity habitat conditions within the Bay-Delta. Mitigation for this impact is not needed, and thus not proposed.

Table 11-53. Difference in X2 Under Existing Conditions, No-Action Alternative, and CP5

		Existing Condition	CP5 (2005)		No-Action Alternative	CP5 (2030)	
Month	**Water Year**	**Location (km)**	**Location (km)**	**Difference (km)**	**Location (km)**	**Location (km)**	**Difference (km)**
January	Average	67.5	67.5	0.0	67.3	67.3	0.0
	W	53.6	53.7	0.1	53.7	53.8	0.1
	AN	61.7	61.7	0.0	61.6	61.5	0.0
	BN	72.1	72.0	-0.1	71.7	71.6	-0.1
	D	77.9	78.0	0.1	77.4	77.6	0.2
	C	82.2	82.1	-0.1	81.9	81.8	-0.2
February	Average	60.9	61.0	0.0	60.8	60.9	0.1
	W	50.4	50.4	0.0	50.4	50.4	0.0
	AN	54.8	54.8	0.0	54.6	54.6	0.1
	BN	61.0	61.0	0.0	60.9	60.9	0.0
	D	70.1	70.2	0.1	69.9	70.0	0.1
	C	76.2	76.2	0.0	75.9	75.9	0.0
March	Average	60.9	61.0	0.0	60.9	60.9	0.0
	W	52.1	52.1	0.0	52.1	52.1	0.0
	AN	53.6	53.8	0.1	53.7	53.7	0.0
	BN	63.3	63.4	0.2	63.3	63.5	0.1
	D	67.1	67.0	-0.1	67.2	67.1	0.0
	C	75.2	75.3	0.1	75.1	75.1	0.0
April	Average	63.5	63.5	0.0	63.4	63.4	0.0
	W	54.5	54.5	0.0	54.3	54.3	0.0
	AN	58.6	58.6	0.0	58.4	58.4	0.0
	BN	64.5	64.5	0.0	64.1	64.1	0.0
	D	69.9	69.8	-0.1	69.9	69.7	-0.1
	C	77.5	77.4	0.0	77.6	77.7	0.0

Table 11-53. Difference in X2 Under Existing Conditions, No-Action Alternative, and CP5 (contd.)

		Existing Condition	CP5 (2005)		No-Action Alternative	CP5 (2030)	
Month	**Water Year**	**Location (km)**	**Location (km)**	**Difference (km)**	**Location (km)**	**Location (km)**	**Difference (km)**
May	Average	67.5	67.5	0.0	67.7	67.6	0.0
	W	57.6	57.6	0.0	57.7	57.7	0.0
	AN	62.7	62.7	0.0	62.6	62.6	0.0
	BN	68.3	68.4	0.1	68.3	68.4	0.1
	D	74.4	74.2	-0.2	74.8	74.6	-0.2
	C	82.5	82.5	0.0	82.9	82.9	0.0
June	Average	74.5	74.6	0.0	74.7	74.8	0.1
	W	65.0	65.0	0.0	65.2	65.2	0.0
	AN	72.6	72.8	0.2	72.7	72.9	0.2
	BN	76.6	76.6	0.0	76.7	76.9	0.3
	D	80.4	80.4	-0.1	80.7	80.6	-0.1
	C	85.9	85.8	0.0	86.0	86.1	0.0
July	Average	80.5	80.5	0.0	80.5	80.6	0.0
	W	74.4	74.4	0.0	74.5	74.5	0.0
	AN	78.1	78.3	0.2	78.4	78.5	0.1
	BN	81.7	81.7	0.0	81.6	81.7	0.1
	D	84.8	84.8	0.0	84.8	84.8	0.1
	C	88.1	88.0	0.0	88.0	88.0	0.0
August	Average	85.6	85.5	0.0	85.6	85.5	0.0
	W	82.7	82.7	0.0	82.8	82.9	0.0
	AN	83.7	83.8	0.0	83.9	83.9	0.0
	BN	85.6	85.5	0.0	85.5	85.4	-0.1
	D	87.8	87.8	0.0	87.5	87.5	0.0
	C	90.4	90.2	-0.2	90.2	90.1	-0.1
September	Average	83.7	83.6	0.0	83.7	83.6	-0.1
	W	73.4	73.4	0.0	73.5	73.5	0.0
	AN	81.4	81.4	0.0	81.4	81.4	0.0
	BN	88.8	88.9	0.0	88.8	88.7	0.0
	D	90.2	90.1	-0.1	90.0	89.8	-0.2
	C	92.5	92.3	-0.2	92.3	92.2	-0.1
October	Average	83.9	83.8	-0.1	83.9	83.8	-0.1
	W	73.6	73.5	0.0	73.7	73.7	0.0
	AN	79.8	79.8	0.0	79.8	79.9	0.0
	BN	88.9	88.9	0.0	88.9	88.9	0.0
	D	91.4	91.3	-0.2	91.3	91.2	-0.1
	C	93.3	93.1	-0.2	93.1	92.7	-0.4

Table 11-53. Difference in X2 Under Existing Conditions, No-Action Alternative, and CP5 (contd.)

		Existing Condition	CP5 (2005)		No-Action Alternative	CP5 (2030)	
Month	**Water Year**	**Location (km)**	**Location (km)**	**Difference (km)**	**Location (km)**	**Location (km)**	**Difference (km)**
November	Average	82.2	82.3	0.1	82.2	82.3	0.1
	W	73.1	73.1	0.0	73.2	73.2	0.0
	AN	78.4	78.4	0.0	78.4	78.5	0.1
	BN	84.8	85.3	0.6	84.8	85.4	0.6
	D	88.9	88.9	-0.1	88.8	88.9	0.1
	C	92.6	92.6	-0.1	92.8	92.5	-0.2
December	Average	76.1	76.2	0.1	76.0	76.1	0.1
	W	62.9	63.0	0.1	63.0	63.2	0.2
	AN	76.4	76.9	0.4	76.4	76.8	0.4
	BN	81.4	81.4	0.0	81.1	81.2	0.0
	D	82.8	82.8	0.0	82.6	82.7	0.1
	C	87.9	87.8	0.0	87.8	87.5	-0.3

Key:
AN = above-normal
BN = below-normal
C = critical
CP = Comprehensive Plan
D = dry
km = kilometer
W = wet

Impact Aqua-22 (CP5): Increase in Mortality of Species of Primary Management Concern as a Result of Increased Reverse Flows in Old and Middle Rivers CP5 operation would result in minimal increases in reverse flows in Old and Middle rivers during January, March and April; however, flows do not exceed (become more negative) -5,000 cfs. Because the flows do not exceed -5,000 cfs, the increases in reverse flows are not expected to contribute to an increase in the vulnerability of delta smelt, longfin smelt, Chinook salmon, juvenile striped bass, or threadfin shad, but summer Old and Middle river flows could contribute to an increase in vulnerability of other resident warm-water fish to increased salvage and potential losses. This impact would be less than significant.

Results of the analysis showed several occurrences when reverse flows within Old and Middle rivers would be higher than either 2005 or 2030 conditions by more than 5 percent. These events would mainly occur in critical water years, which would be expected as a result of greater export operations under CP5. An increase in average monthly reverse flows of 5 percent also would occur in March of above-normal years.

During January (Table 11-54), operations under CP5 resulted in an increase in reverse flow of 5 percent during critical years compared with the No-Action Alternative. Based on results of the delta smelt analysis of the relationship between reverse flows and delta smelt salvage, the increase of approximately 200 cfs in a critical water year would not be expected to result in a significant increase in adverse effects to delta smelt or longfin smelt.

Table 11-54. Old and Middle River Reverse Flows Under Existing Conditions, No-Action Alternative, and CP5

		Existing Condition	CP5 (2005)		No-Action Alternative	CP5 (2030)	
Month	Water Year	Flow (cfs)	Flow (cfs)	Percent Change	Flow (cfs)	Flow (cfs)	Percent Change
January	Average	-3,542	-3,526	0	-3,553	-3,572	1
	W	-2,034	-2,034	0	-2,151	-2,151	0
	AN	-3,654	-3,586	-2	-3,574	-3,523	-1
	BN	-4,240	-4,240	0	-4,240	-4,240	0
	D	-4,773	-4,814	1	-4,772	-4,771	0
	C	-4,033	-3,936	-2	-3,940	-4,123	5
February	Average	-3,293	-3,300	0	-3,358	-3,374	0
	W	-2,745	-2,735	0	-2,950	-2,973	1
	AN	-3,248	-3,035	-7	-3,165	-3,114	-2
	BN	-3,335	-3,437	3	-3,291	-3,312	1
	D	-4,016	-4,036	0	-4,045	-4,065	0
	C	-3,391	-3,528	4	-3,482	-3,542	2
March	Average	-2,784	-2,817	1	-2,877	-2,869	0
	W	-1,792	-1,808	1	-2,023	-2,048	1
	AN	-4,021	-4,230	5	-4,260	-4,281	1
	BN	-4,005	-4,002	0	-3,982	-3,985	0
	D	-2,951	-2,872	-3	-2,918	-2,838	-3
	C	-2,023	-2,125	5	-1,994	-1,979	-1
April	Average	955	954	0	1,060	1,063	0
	W	2,706	2,706	0	2,798	2,806	0
	AN	1,087	1,087	0	1,314	1,314	0
	BN	697	697	0	898	898	0
	D	-244	-249	2	-207	-206	0
	C	-874	-874	0	-872	-872	0
May	Average	491	491	0	416	409	-2
	W	2,077	2,077	0	1,781	1,781	0
	AN	562	562	0	646	646	0
	BN	277	277	0	270	270	0
	D	-674	-674	0	-696	-695	0
	C	-1,018	-1,022	0	-936	-984	5

Table 11-54. Old and Middle River Reverse Flows Under Existing Conditions, No-Action Alternative, and CP5 (contd.)

		Existing Condition	CP5 (2005)		No-Action Alternative	CP5 (2030)	
Month	Water Year	Flow (cfs)	Flow (cfs)	Percent Change	Flow (cfs)	Flow (cfs)	Percent Change
June	Average	-3,654	-3,669	0	-3,718	-3,737	0
	W	-4,226	-4,226	0	-4,354	-4,359	0
	AN	-4,825	-4,819	0	-4,818	-4,818	0
	BN	-4,137	-4,233	2	-4,119	-4,227	3
	D	-3,079	-3,079	0	-3,205	-3,198	0
	C	-1,542	-1,542	0	-1,542	-1,542	0
July	Average	-9,502	-9,559	1	-9,292	-9,402	1
	W	-8,948	-8,943	0	-8,905	-8,901	0
	AN	-9,993	-9,936	-1	-9,929	-9,906	0
	BN	-10,886	-10,937	0	-10,903	-10,853	0
	D	-10,998	-11,051	0	-10,419	-10,692	3
	C	-6,355	-6,672	5	-5,928	-6,354	7

Note:
A positive percentage change reflects more negative reverse flows under CP5 when compared to the Existing Condition or the No-Action Alternative.
Key:
AN = above-normal
BN = below-normal
C = critical
cfs = cubic feet per second
CP = Comprehensive Plan
D = dry
W = wet

Juvenile Chinook salmon and steelhead are migrating through the Delta during January, and an increase in average monthly reverse flows of around 200 cfs would be expected to increase the potential risk of increased mortality to these species. However, given the tidal volumes and hydrodynamics of the Old and Middle rivers region, it is not expected that the change in reverse flows in January in a critical year would result in a detectable change in fish survival. The majority of juvenile Chinook salmon emigrating from the San Joaquin River typically migrate downstream later in dry years and would not be expected to occur in high numbers within Old and Middle rivers in January.

The increase in average monthly reverse flows estimated to occur under CP5 in critical and above-normal water years in March (under 2005 conditions), in critical years in May (under 2030 conditions), and in critical years in July (under both 2005 and 2030 conditions) would exceed 5 percent. This increase could negatively affect resident warm water fish species.

Juvenile and larval delta smelt occur in the area in March through May, and juvenile and larval longfin smelt are present in March. A change in Old and Middle river flows of approximately 100 to 200 cfs may result in an increase in their vulnerability to CVP and SWP salvage, but this increase is expected to be less than significant. The increased reverse flows in May of critical water years would occur at a time of year when water temperatures in the Delta are typically increasing and juvenile Chinook salmon or steelhead may be more abundant in the area. However, changes to reverse flows in March and May would not exceed the -5,000 cfs criteria established by the USFWS and NMFS BOs, and would result in less-than-significant impacts to Chinook salmon and steelhead.

The increased average monthly reverse flows in July of critical years would occur at a time of year when water temperatures in the Delta are elevated and juvenile Chinook salmon or steelhead would not be expected to be present in the area. Longfin smelt would not be expected in the area, and low numbers of juvenile delta smelt may occur in the area in July. However, as water temperatures increase in the Delta during June and July, the majority of delta smelt are located farther downstream in Suisun Bay where temperatures are more suitable. Therefore, changes in reverse flows in July would result in less-than-significant impacts to Chinook salmon, steelhead delta smelt and longfin smelt.

The increase in reverse flows estimated from the modeling in July of a critical water year would be expected to contribute to a small increase in the vulnerability of juvenile striped bass, threadfin shad, and other resident warm-water fish to increased salvage and potential losses as a result of increased reverse flows. The increased reverse flows in low-flow years would be expected to result in a small but less-than-significant increase in mortality for resident warm-water fish inhabiting the south Delta.

The potential increase in losses during January, March and May under CP5 is considered to be less than significant for Chinook salmon, steelhead, delta smelt and longfin smelt. Mitigation for this impact is not proposed because operations will be guided by RPAs established by NMFS and USFWS BOs to reduce any impacts to listed fish species, and thus reduce effects to non-listed fish species as well.

Impact Aqua-23 (CP5): Increase in the Risk of Entrainment or Salvage of Species of Primary Management Concern at CVP and SWP Export Facilities Due to Changes in CVP and SWP Exports CP5 operations may result in an increase in CVP and SWP exports, which is assumed to result in a direct proportional increase in the risk of fish being entrained and salvaged at the facilities. Future operations of the SWP and CVP export facilities would continue to be managed and regulated in accordance with incidental take limits established for each of the protected fish by USFWS, NMFS, and CDFW. The resulting impact to Chinook salmon and steelhead would be less than significant; the resulting impact to delta smelt, longfin smelt striped bass, and splittail would be potentially significant. Overall, this impact would be potentially significant.

Results of the entrainment loss modeling at the CVP and SWP export facilities are presented in Table 11-55 for CP5. The estimated index of total numbers of fish lost annually, by species, are presented in Attachment 1 of the *Fisheries and Aquatic Ecosystems Technical Report.* The difference between the nonoperations related and operations related fish mortality is represented as the entrainment index, shown in Table 11-55, to represent the effect of project operations on each selected fish species at the CVP and SWP facilities.

Table 11-55. Entrainment at the CVP and SWP Facilities Comparing Existing Conditions, No-Action Alternative, and CP5

Species	Water Year	CP5 minus Existing Condition	Percent Change	CP5 Minus Future Condition	Percent Change
Delta Smelt	Average	60	0.1	162	0.4
	W	-4	-0.0	22	0.0
	AN	-56	-0.1	-22	-0.1
	BN	289	0.8	286	0.8
	D	15	0.0	30	0.1
	C	114	0.5	707	3.1
Chinook Salmon	Average	67	0.1	124	0.2
	W	4	0.0	42	0.1
	AN	-96	-0.2	-79	-0.2
	BN	257	0.6	169	0.4
	D	-8	-0.0	-59	-0.1
	C	255	0.7	728	2.2
Longfin Smelt	Average	2	0.0	21	0.3
	W	-1	-0.0	-4	-0.0
	AN	2	0.0	0	-0.0
	BN	3	0.1	3	0.1
	D	2	0.0	0	-0.0
	C	11	0.2	149	3.0
Steelhead	Average	7	0.2	7	0.2
	W	1	0.0	10	0.2
	AN	-26	-0.6	-17	-0.4
	BN	28	0.7	7	0.2
	D	-2	-0.1	-8	-0.2
	C	41	1.5	47	1.7
Striped Bass	Average	7,044	0.5	11,575	0.9
	W	1,854	0.1	2,393	0.1
	AN	-214	-0.0	2,958	0.2
	BN	13,841	1.0	9,181	0.7
	D	9,518	0.9	24,383	2.2
	C	13,907	2.2	23,669	4.0

Table 11-55. Entrainment at the CVP and SWP Facilities Comparing Existing Conditions, No-Action Alternative, and CP5 (contd.)

Species	Water Year	CP5 minus Existing Condition	Percent Change	CP5 Minus Future Condition	Percent Change
Splittail	Average	1,075	0.4	1,753	0.7
	W	-31	-0.0	171	0.0
	AN	-727	-0.2	-195	-0.1
	BN	3,671	1.4	3,108	1.2
	D	588	0.3	2,498	1.2
	C	2,976	2.9	4,432	4.6

Note:
Negative percentage change reflects a reduction in entrainment risk while a positive percentage change reflects an increase in entrainment risk.
Key:
AN = above-normal
BN = below-normal
C = critical
cfs = cubic feet per second
CP = Comprehensive Plan
D = dry
W = wet

Results of the entrainment risk calculations for delta smelt showed a change of less than 1 percent in wet, above-normal, and below-normal water years and an increase in risk of less than 3 percent during critical water years under CP5 relative to the Existing Condition (Table 11-55). The risk of increased losses of delta smelt under CP5 compared to the No-Action Alternative (Table 11-55) would be greatest in the below-normal water years. Although the incremental change in the risk of delta smelt losses resulting from CVP and SWP export operations is small, delta smelt population abundance is currently at such critically low levels that even a small increase in the risk of losses is considered to be potentially significant. The increase in risk would also contribute to cumulative factors affecting the survival of delta smelt.

The estimated change in the risk of losses for salmon increases during below-normal and critical water years under 2005 conditions, and above-normal and below-normal water years under 2030 conditions (Table 11-55). Given the numbers of juvenile Chinook salmon produced each year in the Central Valley, the relatively small incremental increase in the risk of entrainment/salvage at the CVP and SWP export facilities would be a less-than-significant direct impact but would contribute incrementally to the overall cumulative factors affecting juvenile Chinook salmon survival within the Delta, and population dynamics of the stocks.

The change in the risk of longfin smelt entrainment/salvage under CP5 compared to the No-Action Alternative and to the Existing Condition shows small positive and negative changes depending on water year type and alternative (Table 11-55). These small changes in the risk of entrainment would be less than significant in most water years. The estimated 3 percent increase in entrainment risk in critically dry years is potentially significant given the trend of low longfin smelt juvenile production in dry years.

The change in the risk to steelhead of entrainment/salvage at the CVP and SWP export facilities are summarized in Table 11-55. The small positive and negative changes in risk under wet, above-normal, below-normal, and dry water years are considered to be less than significant. The increase in risk of steelhead losses in critical water years are considered to be less than significant (less than 2 percent), but would contribute directly to cumulative factors affecting the survival and population dynamics of Central Valley steelhead. The predicted increase in potential entrainment risk for steelhead under critical water years represents an initial estimate of the change (percentage) between CP5 and Existing Conditions and the No-Action Alternative, and does not allow the predicted losses to be evaluated at the population level (see Attachment 1 of the *Fisheries and Aquatic Ecosystems Technical Report)*.

The estimated changes in risk to juvenile striped bass from entrainment/salvage at the CVP and SWP export facilities are summarized in Table 11-55. The change in risk in wet, above-normal, and below-normal water years are considered to be less than significant for striped bass, but would contribute to the cumulative factors affecting striped bass survival and population dynamics in the Delta. The losses of juvenile striped bass increased substantially under dry and critical water years, which would be expected with an increase in exports during the summer months and is considered to be a potentially significant impact. The increased losses under CP5, particularly in drier water years when juvenile striped bass production is lower, would be expected to contribute to the cumulative effects of factors affecting juvenile striped bass survival in the Delta.

The overall average increased risk index for splittail was less than 1 percent under both 2005 and 2030 conditions, and was considered to be less than significant. The loss index is, however, higher during dry and critical water years. Higher risk of entrainment/salvage losses in drier water years has a potentially greater effect of abundance of juvenile splittail since reproductive success and overall juvenile abundance is typically lower within the Delta in dry years. The increased risk of losses in drier years was considered to be potentially significant. The increased losses would also contribute to cumulative factors affecting survival of juvenile splittail within the Delta.

Impact Aqua-23 (CP5) is considered to be less than significant for Chinook salmon and steelhead, but potentially significant for delta smelt, longfin smelt, striped bass, and splittail. Mitigation for this impact is not proposed because operations will be guided by RPAs established by NMFS and USFWS BOs to reduce any impacts to listed fish species, thus reducing the impacts to non-listed fish species.

CVP/SWP Service Areas

Impact Aqua-24 (CP5): Impacts on Aquatic Habitats and Fish Populations in the CVP and SWP Service Areas Resulting from Modifications to Existing Flow Regimes Project implementation could result in modified flow regimes that would reduce the frequency and magnitude of high winter flows along the Sacramento River; however, the hydrologic effects in tributaries and reservoirs (e.g., New Melones and San Luis) from CVP and SWP dams are expected to be less than impacts on the lower Sacramento River. The change in hydrology could affect aquatic habitats that provide habitat for the fish community. These changes are unlikely to result in substantial effects on the distribution or abundance of these species in the CVP and SWP service areas. Therefore, this impact would be less than significant.

This impact would be similar to Impact Aqua-24 (CP1). The impact could be greater because the increased reservoir capacity associated with an 18.5-foot raise compared to a 6.5-foot raise would allow additional water volume (and flows) to be stored behind the raised dam. However, these changes are unlikely to result in substantial effects on the distribution or abundance of these species in the CVP and SWP service areas. The effects from CP4 on CVP and SWP reservoir elevations, filling, spilling, and planned releases, and the resulting downstream flows, would be small and well within the range of variability that commonly occurs in these reservoirs and downstream flows. Therefore, this impact would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

11.3.4 Mitigation Measures

Table 11-56 presents a summary of mitigation measures for fisheries and aquatic ecosystems.

No-Action Alternative

No mitigation measures are required for this alternative.

Table 11-56. Summary of Mitigation Measures for Fisheries and Aquatic Ecosystems

Impact		No-Action Alternative	CP1	CP2	CP3	CP4	CP5
Impact Aqua-1: Effects on Nearshore, Warm-Water Habitat in Shasta Lake from Project Operations	LOS before Mitigation	LTS	LTS	LTS	LTS	LTS	LTS
	Mitigation Measure	None required.	None needed; thus, none proposed.				
	LOS after Mitigation	LTS	LTS	LTS	LTS	LTS	LTS
Impact Aqua-2: Effects on Nearshore, Warm-Water Habitat in Shasta Lake from Project Construction	LOS before Mitigation	NI	LTS	LTS	LTS	LTS	LTS
	Mitigation Measure	None required.	None needed; thus, none proposed.				
	LOS after Mitigation	NI	LTS	LTS	LTS	LTS	LTS
Impact Aqua-3: Effects on Cold-Water Habitat in Shasta Lake	LOS before Mitigation	PS	B	B	B	B	B
	Mitigation Measure	None required.	None needed; thus, none proposed.				
	LOS after Mitigation	PS	B	B	B	B	B

Table 11-56. Summary of Mitigation Measures for Fisheries and Aquatic Ecosystems (contd.)

Impact		No-Action Alternative	CP1	CP2	CP3	CP4	CP5
Impact Aqua-4: Effects on Special-Status Aquatic Mollusks	LOS before Mitigation	LTS	PS	PS	PS	PS	PS
	Mitigation Measure	None required.	Mitigation Measure Aqua-4: Implement Mitigation Measure Geo-2: Replace Lost Ecological Functions of Aquatic Habitats by Restoring Existing Degraded Aquatic Habitats in the Vicinity of the Impact.				
	LOS after Mitigation	LTS	LTS	LTS	LTS	LTS	LTS
Impact Aqua-5: Effects on Special-Status Fish Species	LOS before Mitigation	LTS	LTS	LTS	LTS	LTS	LTS
	Mitigation Measure	None required.	None needed; thus, none proposed.				
	LOS after Mitigation	LTS	LTS	LTS	LTS	LTS	LTS
Impact Aqua-6: Creation or Removal of Barriers to Fish Between Tributaries and Shasta Lake	LOS before Mitigation	NI	LTS	LTS	LTS	LTS	LTS
	Mitigation Measure	None required.	None needed; thus, none proposed.				
	LOS after Mitigation	NI	LTS	LTS	LTS	LTS	LTS
Impact Aqua-7: Effects on Spawning and Rearing Habitat of Adfluvial Salmonids in Low-Gradient Tributaries to Shasta Lake	LOS before Mitigation	NI	S	S	S	PS	LTS
	Mitigation Measure	None required.	Mitigation Measure Aqua-7: Implement Mitigation Measure Geo-2: Replace Lost Ecological Functions of Aquatic Habitats by Restoring Existing Degraded Aquatic Habitats in the Vicinity of the Impact.				None required.
	LOS after Mitigation	NI	LTS	LTS	LTS	LTS	LTS

Table 11-56. Summary of Mitigation Measures for Fisheries and Aquatic Ecosystems (contd.)

Impact		No-Action Alternative	CP1	CP2	CP3	CP4	CP5
Impact Aqua-8: Effects on Aquatic Connectivity in Non-Fish-Bearing Tributaries to Shasta Lake	LOS before Mitigation	NI	LTS	LTS	LTS	LTS	LTS
	Mitigation Measure	None required.	None needed; thus, none proposed.				
	LOS after Mitigation	NI	LTS	LTS	LTS	LTS	LTS
Impact Aqua-9: Effects on Water Quality at Livingston Stone Hatchery	LOS before Mitigation	NI	NI	NI	NI	NI	NI
	Mitigation Measure	None required.	None needed; thus, none proposed.				
	LOS after Mitigation	NI	NI	NI	NI	NI	NI
Impact Aqua-10: Loss or Degradation of Aquatic Habitat in the Upper Sacramento River During Construction Activities	LOS before Mitigation	NI	LTS	LTS	LTS	LTS	LTS
	Mitigation Measure	None required.	None needed; thus, none proposed.				
	LOS after Mitigation	NI	LTS	LTS	LTS	LTS	LTS
Impact Aqua-11: Release and Exposure of Contaminants in the Upper Sacramento River During Construction Activities	LOS before Mitigation	NI	LTS	LTS	LTS	LTS	LTS
	Mitigation Measure	None required.	None needed; thus, none proposed.				
	LOS after Mitigation	NI	LTS	LTS	LTS	LTS	LTS

Table 11-56. Summary of Mitigation Measures for Fisheries and Aquatic Ecosystems (contd.)

Impact		No-Action Alternative	CP1	CP2	CP3	CP4	CP5
Impact Aqua-12: Changes in Flow and Water Temperature in the Upper Sacramento River Resulting from Project Operation – Chinook Salmon	LOS before Mitigation	PS	LTS	B	B	B	B
	Mitigation Measure	None required.	None needed; thus, none proposed.				
	LOS after Mitigation	PS	LTS	B	B	B	B
Impact Aqua-13: Changes in Flow and Water Temperature in the Upper Sacramento River Resulting from Project Operation – Steelhead, Green Sturgeon, Sacramento Splittail, American Shad, and Striped Bass	LOS before Mitigation	PS	LTS	LTS	LTS	B	LTS
	Mitigation Measure	None required.	None needed; thus, none proposed.				
	LOS after Mitigation	PS	LTS	LTS	LTS	B	LTS
Impact Aqua-14: Reduction in Ecologically Important Geomorphic Processes in the Upper Sacramento River Resulting from Reduced Frequency and Magnitude of Intermediate to High Flows	LOS before Mitigation	NI	PS	PS	PS	PS	PS
	Mitigation Measure	None required.	Mitigation Measure Aqua-14: Implement Mitigation Measure Bot-7: Develop and Implement a Riverine Ecosystem Mitigation and Adaptive Management Plan to Avoid and Compensate for the Impact of Altered Flow Regimes on Riparian and Wetland Communities.				
	LOS after Mitigation	NI	LTS	LTS	LTS	LTS	LTS

Table 11-56. Summary of Mitigation Measures for Fisheries and Aquatic Ecosystems (contd.)

Impact		No-Action Alternative	CP1	CP2	CP3	CP4	CP5
Impact Aqua-15: Changes in Flow and Water Temperatures in the Lower Sacramento River and Tributaries and Trinity River Resulting from Project Operation – Fish Species of Primary Management Concern	LOS before Mitigation	NI	PS	PS	PS	PS	PS
	Mitigation Measure	None required.	Mitigation Measure Aqua-15: Maintain Flows in the Feather River, American River, and Trinity River Consistent with Existing Regulatory and Operational Requirements and Agreements.				
	LOS after Mitigation	NI	LTS	LTS	LTS	LTS	LTS
Impact Aqua-16: Reduction in Ecologically Important Geomorphic Processes in the Lower Sacramento River Resulting from Reduced Frequency and Magnitude of Intermediate to High Flows	LOS before Mitigation	NI	PS	PS	PS	PS	PS
	Mitigation Measure	None required.	Mitigation Measure Aqua-16: Implement Mitigation Measure Bot-7: Develop and Implement a Riverine Ecosystem Mitigation and Adaptive Management Plan to Avoid and Compensate for the Impact of Altered Flow Regimes on Riparian and Wetland Communities.				
	LOS after Mitigation	NI	LTS	LTS	LTS	LTS	LTS
Impact Aqua-17: Effects to Delta Fisheries Resulting from Changes to Delta Outflow	LOS before Mitigation	NI	LTS	LTS	LTS	LTS	LTS
	Mitigation Measure	None required.	None needed; thus, none proposed.				
	LOS after Mitigation	NI	LTS	LTS	LTS	LTS	LTS

Table 11-56. Summary of Mitigation Measures for Fisheries and Aquatic Ecosystems (contd.)

Impact		No-Action Alternative	CP1	CP2	CP3	CP4	CP5
Impact Aqua-18: Effects to Delta Fisheries Resulting from Changes to Delta Inflow	LOS before Mitigation	NI	LTS	LTS	LTS	LTS	LTS
	Mitigation Measure	None required.	None needed; thus, none proposed.				
	LOS after Mitigation	NI	LTS	LTS	LTS	LTS	LTS
Impact Aqua-19: Effects to Delta Fisheries Resulting from Changes in Sacramento River Inflow	LOS before Mitigation	NI	LTS	LTS	LTS	LTS	LTS
	Mitigation Measure	None required.	None needed; thus, none proposed.				
	LOS after Mitigation	NI	LTS	LTS	LTS	LTS	LTS
Impact Aqua-20: Effects to Delta Fisheries Resulting from Changes in San Joaquin River Flow at Vernalis	LOS before Mitigation	NI	NI	NI	NI	NI	NI
	Mitigation Measure	None required.	None needed; thus, none proposed.				
	LOS after Mitigation	NI	NI	NI	NI	NI	NI
Impact Aqua-21: Reduction in Low-Salinity Habitat Conditions Resulting from an Upstream Shift in X2 Location	LOS before Mitigation	NI	LTS	LTS	LTS	LTS	LTS
	Mitigation Measure	None required.	None needed; thus, none proposed.				
	LOS after Mitigation	NI	LTS	LTS	LTS	LTS	LTS

Table 11-56. Summary of Mitigation Measures for Fisheries and Aquatic Ecosystems (contd.)

Impact		No-Action Alternative	CP1	CP2	CP3	CP4	CP5
Impact Aqua-22: Increase in Mortality of Species of Primary Management Concern as a Result of Increased Reverse Flows in Old and Middle Rivers	LOS before Mitigation	NI	LTS	LTS	LTS	LTS	LTS
	Mitigation Measure	None required.	None needed; thus, none proposed.				
	LOS after Mitigation	NI	LTS	LTS	LTS	LTS	LTS
Impact Aqua-23: Increase in the Risk of Entrainment or Salvage of Species of Primary Management Concern at CVP and SWP Export Facilities Due to Changes in CVP and SWP Exports	LOS before Mitigation	NI	PS	PS	PS	PS	PS
	Mitigation Measure	None required.	None proposed because operations will be guided by RPAs established by NMFS and USFWS BOs to reduce any impacts to listed fish species, and thus reduce impacts to non-listed fish species				
	LOS after Mitigation	NI	LTS	LTS	LTS	LTS	LTS
Impact Aqua-24: Impacts on Aquatic Habitats and Fish Populations in the CVP and SWP Service Areas Resulting from Modifications to Existing Flow Regimes	LOS before Mitigation	NI	LTS	LTS	LTS	LTS	LTS
	Mitigation Measure	None required.	None needed; thus, none proposed.				
	LOS after Mitigation	NI	LTS	LTS	LTS	LTS	LTS

Key:
B = beneficial
LOS = level of significance
LTS = less than significant
NI = No Impact
PS = potentially significant
S = significant
BO = Biological Opinion
NMFS = National Marine Fisheries Service
RPA = Reasonable and Prudent Alternative
USFWS = U.S. Fish and Wildlife Service

CP1 – 6.5-Foot Dam Raise, Anadromous Fish Survival and Water Supply Reliability

No mitigation is required for Impacts Aqua-1 (CP1) through Aqua-3 (CP1), Impacts Aqua-5 (CP1) and Aqua-6 (CP1), Impacts Aqua-8 (CP1) through Aqua-13 (CP1), or Impacts Aqua-17 through Aqua-21 (CP1). No mitigation is proposed for Impact Aqua-22 (CP1) or Impact Aqua-23 (CP1) because operations will be guided by RPAs established by NMFS and USFWS BOs, which should reduce impacts to listed and non-listed fish species. Mitigation measures are provided below for other impacts of CP1 on fisheries and aquatic ecosystems.

Mitigation Measure Aqua-4 (CP1): Implement Mitigation Measure Geo-2 (CP1): Replace Lost Ecological Functions of Aquatic Habitats by Restoring Existing Degraded Aquatic Habits in the Vicinity of the Impact This mitigation measure is the same as Mitigation Measure Geo-2 (CP1) described in Chapter 4, "Geology, Geomorphology, Minerals, and Soils." The loss of riparian habitat provided by springs, seeps and streams will be mitigated by compensating for the impact by replacing or providing substitute resources or environments. Compensation will be accomplished by restoring and enhancing the aquatic functions of existing, degraded aquatic habitats in or near the study sub-area. Examples of techniques that may be used include channel and bank stabilization, channel redirection, channel reconstruction, culvert replacement and elimination of barriers to fish passage, and enhancement of habitat physical structure (e.g., placement of woody debris, rocks). The nature and extent of the restoration and enhancement activities will be based on an assessment of the ecological functions that are lost as a consequence of implementing this alternative. Implementation of this mitigation measure would reduce Impact Aqua-4 (CP1) to a less-than-significant level.

Mitigation Measure Aqua-7 (CP1): Implement Mitigation Measure Geo-2 (CP1): Replace Lost Ecological Functions of Aquatic Habitats by Restoring Existing Degraded Aquatic Habits in the Vicinity of the Impact This mitigation measure is the same as Mitigation Measure Geo-2 (CP1) described in Chapter 4, "Geology, Geomorphology, Minerals, and Soils." The loss of riparian habitat provided by springs, seeps and streams will be mitigated by compensating for the impact by replacing or providing substitute resources or environments. Compensation will be accomplished by restoring and enhancing the aquatic functions of existing, degraded aquatic habitats in or near the study sub-area. Examples of techniques that may be used include channel and bank stabilization, channel redirection, channel reconstruction, culvert replacement and elimination of barriers to fish passage, and enhancement of habitat physical structure (e.g., placement of woody debris, rocks). The nature and extent of the restoration and enhancement activities will be based on an assessment of the ecological functions that are lost as a consequence of implementing this alternative. Implementation of this mitigation measure would reduce Impact Aqua-7 (CP1) to a less-than-significant level.

Mitigation Measure Aqua-14 (CP1): Implement Mitigation Measure Bot-7 (CP1): Develop and Implement a Riverine Ecosystem Mitigation and Adaptive Management Plan to Avoid and Compensate for the Impact of Altered Flow Regimes on Riparian and Wetland Communities This measure is identical to Mitigation Measure Bot-7 (CP1), described in Chapter 12, "Botanical Resources and Wetlands." Implementation of this mitigation measure would reduce Impact Aqua-14 (CP1) to a less-than-significant level.

Mitigation Measure Aqua-15 (CP1): Maintain Flows in the Feather River, American River, and Trinity River Consistent with Existing Regulatory and Operational Requirements and Agreements Flows in the Feather, American, and Trinity rivers will be maintained pursuant to existing operational agreements, BOs, criteria, and standards that are protective of fisheries resources. Implementation of this measure would reduce Impact Aqua-15 (CP1) to a less-than-significant level.

Mitigation Measure Aqua-16 (CP1): Implement Mitigation Measure Bot-7(CP1): Develop and Implement a Riverine Ecosystem Mitigation and Adaptive Management Plan to Avoid and Compensate for the Impact of Altered Flow Regimes on Riparian and Wetland Communities This measure is identical to Mitigation Measure Bot-7 (CP1), described in Chapter 12, "Botanical Resources and Wetlands." Implementation of this mitigation measure would reduce Impact Aqua-16 (CP1) to a less-than-significant level.

CP2 – 12.5-Foot Dam Raise, Anadromous Fish Survival and Water Supply Reliability

No mitigation is required for Impacts Aqua-1 (CP2) through Aqua-3 (CP2), Impacts Aqua-5 (CP2) and Aqua-6 (CP2), Impacts Aqua-8 (CP2) through Aqua-13 (CP2), or Impacts Aqua-17 (CP2) through Aqua-21 (CP2). No mitigation is proposed for Impact Aqua-22 (CP2) or Impact Aqua-23 (CP2) because operations will be guided by RPAs established by NMFS and USFWS BOs, which should reduce impacts to listed and non-listed fish species. Mitigation measures are provided below for other impacts of CP2 on fisheries and aquatic ecosystems.

Mitigation Measure Aqua-4 (CP2): Implement Mitigation Measure Geo-2 (CP2): Replace Lost Ecological Functions of Aquatic Habitats by Restoring Existing Degraded Aquatic Habitats in the Vicinity of the Impact This mitigation measure is the same as Mitigation Measure Geo-2 (CP2) described in Chapter 4, "Geology, Geomorphology, Minerals, and Soils." The loss of riparian habitat provided by springs, seeps and streams will be mitigated by compensating for the impact by replacing or providing substitute resources or environments. Compensation will be accomplished by restoring and enhancing the aquatic functions of existing, degraded aquatic habitats in or near the study sub-area. Examples of techniques that may be used include channel and bank stabilization, channel redirection, channel reconstruction, culvert replacement and elimination of barriers to fish passage, and enhancement of habitat physical structure (e.g., placement of woody debris, rocks). The nature and extent of the restoration and enhancement activities will be based on an assessment of the ecological functions that are lost as a consequence of implementing this alternative. Implementation of this mitigation measure would reduce Impact Aqua-4 (CP2) to a less-than-significant level.

Mitigation Measure Aqua-7 (CP2): Implement Mitigation Measure Geo-2 (CP2): Replace Lost Ecological Functions of Aquatic Habitats by Restoring Existing Degraded Aquatic Habitats in the Vicinity of the Impact This mitigation measure is the same as Mitigation Measure Geo-2 (CP2) described in Chapter 4, "Geology, Geomorphology, Minerals, and Soils." The loss of riparian habitat provided by springs, seeps and streams will be mitigated by compensating for the impact by replacing or providing substitute resources or environments. Compensation will be accomplished by restoring and enhancing the aquatic functions of existing, degraded aquatic habitats in or near the study sub-area. Examples of techniques that may be used include channel and bank stabilization, channel redirection, channel reconstruction, culvert replacement and elimination of barriers to fish passage, and enhancement of habitat physical structure (e.g., placement of woody debris, rocks). The nature and extent of the restoration and enhancement activities will be based on an assessment of the ecological functions that are lost as a consequence of implementing this alternative. Implementation of this mitigation measure would reduce Impact Aqua-7 (CP2) to a less-than-significant level.

Mitigation Measure Aqua-14 (CP2): Implement Mitigation Measure Bot-7(CP2): Develop and Implement a Riverine Ecosystem Mitigation and Adaptive Management Plan to Avoid and Compensate for the Impact of Altered Flow Regimes on Riparian and Wetland Communities This measure is identical to Mitigation Measure Bot-7 (CP2), described in Chapter 12, "Botanical Resources and Wetlands." Implementation of this mitigation measure would reduce Impact Aqua-14 (CP2) to a less-than-significant level.

Mitigation Measure Aqua-15 (CP2): Maintain Flows in the Feather River, American River, and Trinity River Consistent with Existing Regulatory and Operational Requirements and Agreements Flows in the Feather, American, and Trinity rivers will be maintained pursuant to existing operational agreements, BOs, criteria, and standards that are protective of fisheries resources. Implementation of this measure would reduce Impact Aqua-15 (CP2) to a less-than-significant level.

Mitigation Measure Aqua-16 (CP2): Implement Mitigation Measure Bot-7(CP2): Develop and Implement a Riverine Ecosystem Mitigation and Adaptive Management Plan to Avoid and Compensate for the Impact of Altered Flow Regimes on Riparian and Wetland Communities This measure is identical to Mitigation Measure Bot-7 (CP2), described in Chapter 12, "Botanical Resources and Wetlands." The riverine ecosystem mitigation and adaptive management plan will include mitigation measures from Shasta Dam downstream to Colusa (RM 144). The plan will be developed and implemented before project construction, and will be consistent with and will support implementation of the Senate Bill 1086 program. The plan will also be developed in coordination with USFWS, NMFS, CDFW, and the Sacramento River Conservation Area Forum. One of the goals of the plan will be to ensure that project implementation results in no net reduction in the amount (i.e., frequency and magnitude) of overbank inundation; this includes inundation of floodplains and bypasses. Therefore, implementation of this mitigation measure would reduce Impact Aqua-16 (CP2) to a less-than-significant level.

CP3 – 18.5-Foot Dam Raise, Agricultural Water Supply Reliability and Anadromous Fish Survival

No mitigation is required for Impacts Aqua-1 (CP3) through Aqua-3 (CP3), Impacts Aqua-5 (CP3) and Aqua-6 (CP3), Impacts Aqua-8 (CP3) through Aqua-13 (CP3), or Impacts Aqua-17 (CP3) through Aqua-21 (CP3). No mitigation is proposed for Impact Aqua-22 (CP3) or Impact Aqua-23 (CP3) because operations will be guided by RPAs established by NMFS and USFWS BOs, which should reduce impacts to listed and non-listed fish species. Mitigation measures are provided below for other impacts of CP3 on fisheries and aquatic ecosystems.

Mitigation Measure Aqua-4 (CP3): Implement Mitigation Measure Geo-2 (CP3): Replace Lost Ecological Functions of Aquatic Habitats by Restoring Existing Degraded Aquatic Habitats in the Vicinity of the Impact This mitigation measure is the same as Mitigation Measure Geo-2 (CP3) described in Chapter 4, “Geology, Geomorphology, Minerals, and Soils.” The loss of riparian habitat provided by springs, seeps and streams will be mitigated by compensating for the impact by replacing or providing substitute resources or environments. Compensation will be accomplished by restoring and enhancing the aquatic functions of existing, degraded aquatic habitats in or near the study sub-area. Examples of techniques that may be used include channel and bank stabilization, channel redirection, channel reconstruction, culvert replacement and elimination of barriers to fish passage, and enhancement of habitat physical structure (e.g., placement of woody debris, rocks). The nature and extent of the restoration and enhancement activities will be based on an assessment of the ecological functions that are lost as a consequence of implementing this alternative. Implementation of this mitigation measure would reduce Impact Aqua-4 (CP3) to a less-than-significant level.

Mitigation Measure Aqua-7 (CP3): Implement Mitigation Measure Geo-2 (CP3): Replace Lost Ecological Functions of Aquatic Habitats by Restoring Existing Degraded Aquatic Habitats in the Vicinity of the Impact This mitigation measure is the same as Mitigation Measure Geo-2 (CP3) described in Chapter 4, “Geology, Geomorphology, Minerals, and Soils.” The loss of riparian habitat provided by springs, seeps and streams will be mitigated by compensating for the impact by replacing or providing substitute resources or environments. Compensation will be accomplished by restoring and enhancing the aquatic functions of existing, degraded aquatic habitats in or near the study sub-area. Examples of techniques that may be used include channel and bank stabilization, channel redirection, channel reconstruction, culvert replacement and elimination of barriers to fish passage, and enhancement of habitat physical structure (e.g., placement of woody debris, rocks). The nature and extent of the restoration and enhancement activities will be based on an assessment of the ecological functions that are lost as a consequence of implementing this alternative. Implementation of this mitigation measure would reduce Impact Aqua-7 (CP3) to a less-than-significant level.

Mitigation Measure Aqua-14 (CP3): Implement Mitigation Measure Bot-7 (CP3): Develop and Implement a Riverine Ecosystem Mitigation and Adaptive Management Plan to Avoid and Compensate for the Impact of Altered Flow Regimes on Riparian and Wetland Communities This measure is identical to Mitigation Measure Bot-7 (CP3), described in Chapter 12, "Botanical Resources and Wetlands." Implementation of this mitigation measure would reduce Impact Aqua-14 (CP3) to a less-than-significant level.

Mitigation Measure Aqua-15 (CP3): Maintain Flows in the Feather River, American River, and Trinity River Consistent with Existing Regulatory and Operational Requirements and Agreements Flows in the Feather, American, and Trinity rivers will be maintained pursuant to existing operational agreements, BOs, criteria, and standards that are protective of fisheries resources. Implementation of this measure would reduce Impact Aqua-15 (CP3) to a less-than-significant level.

Mitigation Measure Aqua-16 (CP3): Implement Mitigation Measure Bot-7 (CP3): Develop and Implement a Riverine Ecosystem Mitigation and Adaptive Management Plan to Avoid and Compensate for the Impact of Altered Flow Regimes on Riparian and Wetland Communities This measure is identical to Mitigation Measure Bot-7 (CP3), described in Chapter 12, "Botanical Resources and Wetlands." Implementation of this measure would reduce Impact Aqua-16 (CP3) to a less-than-significant level.

CP4 – 18.5-Foot Dam Raise, Anadromous Fish Focus with Water Supply Reliability

No mitigation is required for Impacts Aqua-1 (CP4) through Aqua-3 (CP4), Impacts Aqua-5 (CP4) and Aqua-6 (CP4), Impacts Aqua-8 (CP4) through Aqua-13 (CP4), or Impacts Aqua-17 (CP4) through Aqua-21 (CP4). No mitigation is proposed for Impact Aqua-22 (CP4) or Impact Aqua-23 (CP4) because operations will be guided by RPAs established by NMFS and USFWS BOs, which should reduce impacts to listed and non-listed fish species. Mitigation measures are provided below for other impacts of CP4 on fisheries and aquatic ecosystems.

Mitigation Measure Aqua-4 (CP4): Implement Mitigation Measure Geo-2 (CP4): Replace Lost Ecological Functions of Aquatic Habitats by Restoring

Existing Degraded Aquatic Habitats in the Vicinity of the Impact This mitigation measure is the same as Mitigation Measure Geo-2 (CP3) described in Chapter 4, "Geology, Geomorphology, Minerals, and Soils." The loss of riparian habitat provided by springs, seeps and streams will be mitigated by compensating for the impact by replacing or providing substitute resources or environments. Compensation will be accomplished by restoring and enhancing the aquatic functions of existing, degraded aquatic habitats in or near the study sub-area. Examples of techniques that may be used include channel and bank stabilization, channel redirection, channel reconstruction, culvert replacement and elimination of barriers to fish passage, and enhancement of habitat physical structure (e.g., placement of woody debris, rocks). The nature and extent of the restoration and enhancement activities will be based on an assessment of the ecological functions that are lost as a consequence of implementing this alternative. Implementation of this mitigation measure would reduce Impact Aqua-4 (CP4) to a less-than-significant level.

Mitigation Measure Aqua-7 (CP4): Implement Mitigation Measure Geo-2 (CP4): Replace Lost Ecological Functions of Aquatic Habitats by Restoring Existing Degraded Aquatic Habitats in the Vicinity of the Impact This mitigation measure is the same as Mitigation Measure Geo-2 (CP3) described in Chapter 4, "Geology, Geomorphology, Minerals, and Soils." The loss of riparian habitat provided by springs, seeps and streams will be mitigated by compensating for the impact by replacing or providing substitute resources or environments. Compensation will be accomplished by restoring and enhancing the aquatic functions of existing, degraded aquatic habitats in or near the study sub-area. Examples of techniques that may be used include channel and bank stabilization, channel redirection, channel reconstruction, culvert replacement and elimination of barriers to fish passage, and enhancement of habitat physical structure (e.g., placement of woody debris, rocks). The nature and extent of the restoration and enhancement activities will be based on an assessment of the ecological functions that are lost as a consequence of implementing this alternative. Implementation of this mitigation measure would reduce Impact Aqua-7 (CP4) to a less-than-significant level.

Mitigation Measure Aqua-14 (CP4): Implement Mitigation Measure Bot-7 (CP1): Develop and Implement a Riverine Ecosystem Mitigation and Adaptive Management Plan to Avoid and Compensate for the Impact of Altered Flow Regimes on Riparian and Wetland Communities This measure is identical to Mitigation Measure Bot-7 (CP4), described in Chapter 12, "Botanical Resources and Wetlands." Implementation of this mitigation measure would reduce Impact Aqua-14 (CP4) to a less-than-significant level.

Mitigation Measure Aqua-15 (CP4): Maintain Flows in the Feather River, American River, and Trinity River Consistent with Existing Regulatory and Operational Requirements and Agreements Flows in the Feather, American, and Trinity rivers will be maintained pursuant to existing operational agreements, BOs, criteria, and standards that are protective of fisheries resources. Implementation of this measure would reduce Impact Aqua-15 (CP4) to a less-than-significant level.

Mitigation Measure Aqua-16 (CP4): Implement Mitigation Measure Bot-7 (CP1): Develop and Implement a Riverine Ecosystem Mitigation and Adaptive Management Plan to Avoid and Compensate for the Impact of Altered Flow Regimes on Riparian and Wetland Communities This measure is identical to Mitigation Measure Bot-7 (CP1), described in Chapter 12, "Botanical Resources and Wetlands." Implementation of this measure would reduce Impact Aqua-16 (CP4) to a less-than-significant level.

CP5 – 18.5-Foot Dam Raise, Combination Plan

No mitigation is required for Impacts Aqua-1 (CP5) through Aqua-3 (CP5), Impacts Aqua-5 (CP5) through Aqua-13 (CP5), or Impacts Aqua-17 (CP5) through Aqua-21 (CP5). No mitigation is proposed for Impact Aqua-22 (CP5) or Impact Aqua-23 (CP5) because operations will be guided by RPAs established by NMFS and USFWS BOs, which should reduce impacts to listed and non-listed fish species. Mitigation measures are provided below for the other impacts of CP5 on fisheries and aquatic ecosystems.

Mitigation Measure Aqua-4 (CP5): Implement Mitigation Measure Geo-2 (CP5): Replace Lost Ecological Functions of Aquatic Habitats by Restoring Existing Degraded Aquatic Habitats in the Vicinity of the Impact This mitigation measure is the same as Mitigation Measure Geo-2 (CP3) described in Chapter 4, "Geology, Geomorphology, Minerals, and Soils." The loss of riparian habitat provided by springs, seeps and streams will be mitigated by compensating for the impact by replacing or providing substitute resources or environments. Compensation will be accomplished by restoring and enhancing the aquatic functions of existing, degraded aquatic habitats in or near the study sub-area. Examples of techniques that may be used include channel and bank stabilization, channel redirection, channel reconstruction, culvert replacement and elimination of barriers to fish passage, and enhancement of habitat physical structure (e.g., placement of woody debris, rocks). The nature and extent of the restoration and enhancement activities will be based on an assessment of the ecological functions that are lost as a consequence of implementing this alternative. Implementation of this mitigation measure would reduce Impact Aqua-4 (CP5) to a less-than-significant level.

Mitigation Measure Aqua-14 (CP5): Implement Mitigation Measure Bot-7 (CP3): Develop and Implement a Riverine Ecosystem Mitigation and Adaptive Management Plan to Avoid and Compensate for the Impact of Altered Flow Regimes on Riparian and Wetland Communities This measure is identical to Mitigation Measure Bot-7 (CP3), described in Chapter 12, "Botanical Resources and Wetlands." Implementation of this mitigation measure would reduce Impact Aqua-14 (CP5) to a less-than-significant level.

Mitigation Measure Aqua-15 (CP5): Maintain Flows in the Feather River, American River, and Trinity River Consistent with Existing Regulatory and Operational Requirements and Agreements Flows in the Feather, American, and Trinity rivers will be maintained pursuant to existing operational agreements, BOs, criteria, and standards that are protective of fisheries resources. Implementation of this measure would reduce Impact Aqua-15 (CP5) to a less-than-significant level.

Mitigation Measure Aqua-16 (CP5): Implement Mitigation Measure Bot-7 (CP3): Implement Mitigation Measure Bot-7: Develop and Implement a Riverine Ecosystem Mitigation and Adaptive Management Plan to Avoid and Compensate for the Impact of Altered Flow Regimes on Riparian and Wetland Communities This measure is identical to Mitigation Measure Bot-7 (CP3), described in Chapter 12, "Botanical Resources and Wetlands." Implementation of this measure would reduce Impact Aqua-16 (CP5) to a less-than-significant level.

11.3.5 Cumulative Effects

Chapter 3, "Considerations for Describing the Affected Environment and Environmental Consequences," discusses overall cumulative impacts of the project alternatives and the No-Action Alternative, including the relationship to CALFED Programmatic Cumulative Impacts Analysis, qualitative and quantitative assessment, past and future actions in the study area, and significance criteria.

As described in Section 11.1, "Affected Environment," aquatic habitats within the primary and extended study areas historically contained large populations of anadromous and other native fish species. Water supply projects, urban development, pollution, and flood control modifications have resulted in altered and degraded habitat conditions and reduced this historical fishery throughout the primary and extended study areas. The combined effects of past and present projects have resulted in a significant adverse cumulative impact on fisheries and aquatic ecosystems of the Sacramento River and its watershed.

Many of the reasonably foreseeable future projects identified in Chapter 3 (see Table 3-1) would involve changes to SWP and CVP water operations downstream from Shasta Dam and changes to operations of hydroelectric projects upstream from Shasta Dam that would in turn be anticipated to affect fisheries and aquatic ecosystems. While some of these changes could result in beneficial effects compared to current conditions, aquatic habitat and fisheries resources would remain limited the affected ecosystem of aquatic habitat and fisheries resources would remain limited due to continuing effects from blockage of upstream fish habitat, blockage of spawning gravels, mortality due to water diversions, habitat alterations caused by large-scale modifications to hydrology (hydromodification), and high water temperatures due to lack of riparian vegetation and hydromodification.

The effects of climate change during this century on operations at Shasta Lake and downstream and upstream from the dam, could result in changes to water temperature, flow, and ultimately, fish populations under the No-Action Alternative. As described in the Climate Change Projection Appendix, climate change could result in increased inflows to Shasta Lake and higher reservoir releases in the future due to an increase in winter and early spring inflow into the lake from high-intensity storm events. The change in reservoir releases could be necessary to manage flood events resulting from these potentially larger storms. Climate change could also result in reduced-end-of September carryover storage volumes, resulting in lower lake levels for a portion of the year, and a smaller cold-water pool resulting in warmer water temperature and reduced water quality within Shasta Reservoir. Most importantly, it is expected that climate change will result in increased water temperatures downstream from Shasta Dam, particularly in summer months, and more frequent wet and drought (particularly extended drought) years. The increased water temperatures, and greater inter-annual precipitation variability will compound the threats to fish (especially anadromous fish) in the Sacramento River. Winter-run Chinook salmon are particularly vulnerable to climate warming, prolonged droughts, and other catastrophic environmental events because they have only one remaining population that spawns during the summer months, when water temperature increases are expected to be the largest (NMFS 2009a and b). Additionally, ocean productivity is expected to decline from altered upwelling cycles. This could reduce the available food resources for ocean-rearing salmonids and sturgeon, impacting fish survival.

Climate change is also expected to result in sea-level rise during this century, which will have effects on Delta salinity levels due to greater tidal excursion. This in turn will affect the location of X2 (2 parts per thousand salinity concentration) position from February through June, moving X2 upstream, which will have adverse effects to native species in the Delta under the No-Action Alternative.

The following analysis evaluates the potential cumulative impacts on fisheries and aquatic ecosystems when considering the project alternatives in combination with other past, present, and reasonably foreseeable future projects.

CP1– 6.5-Foot Dam Raise, Anadromous Fish Survival and Water Supply Reliability

As described in Section 11.3.3, without mitigation, CP1 could cause potentially significant effects on vegetation and habitats and special-status species in the primary and extended study areas. These effects would be caused by the loss or degradation of aquatic habitats in the primary study area, or by alteration of the flow regime of the upper Sacramento River and associated geomorphic processes in the primary and extended study areas.

Given the scale and duration of the project construction activities associated with CP1, the contribution of CP1 to construction-related cumulative impacts on fisheries and aquatic ecosystems would be cumulatively considerable. CP1 would be undertaken in accordance with a project-specific SWPPP as reviewed and approved by the CVRWQCB. The SWPPP would require implementation of extensive BMPs during project construction, as well as postconstruction site restoration and stabilization to control erosion and sedimentation and to prevent the discharge of pollutants into the Sacramento River and other waterways. Implementation of these measures would reduce the project's contribution to cumulative construction-related impacts to a less-than-significant level.

Given major past alterations to the Sacramento River's aquatic ecosystem and associated aquatic habitats, the contributing adverse effects from CP1 would be cumulatively considerable; specifically, (1) additional inundation of potential riverine habitat for special-status mollusk species above Shasta Lake, (2) additional inundation of cold-water riverine spawning and rearing habitat above Shasta Lake, and (3) reduction of the magnitude and frequency of flows for ecologically important geomorphic processes in the upper and lower Sacramento River below Shasta Dam. With implementation of Mitigation Measure Aqua-4 (CP1) (focused on Shasta Lake and vicinity) and Mitigation Measures Aqua-14 (CP1) through Aqua-16 (CP1) (focused on the Sacramento River downstream from Shasta Lake), adverse effects from CP1 would be reduced and would no longer result in a cumulatively considerable incremental contribution to significant cumulative effects on these resources.

As stated previously, effects of climate change on operations of Shasta Lake could include increased inflows and releases at certain times of the year, and decreased inflows at other times. The additional storage associated with CP1 would potentially reduce these effects and allow Shasta Lake to capture some of the increased runoff in the winter and early spring for release in late spring and summer. More importantly, an increased cold-water pool volume will allow Shasta Lake to be managed to provide cooler water releases downstream during critical life stages, particularly for Chinook spawning. Additionally, habitat for both warm- and cold-water reservoir fisheries would be increased with an enlarged reservoir area. Under CP1, potential impacts to Sacramento River fish downstream from Shasta Dam would be beneficial.

Modeling conducted for the Climate Change Appendix was inconclusive about the effects of this alternative on Delta salinity. If exports are increased under this alternative, it could have an adverse effect on the location of X2, when considered along with other potential projects. However, if the location of X2 remains a water quality and regulatory requirement, then additional exports would not occur when X2 compliance would be violated. Therefore, no cumulative impact on X2 will occur under this alternative.

CP2 – 12.5-Foot Dam Raise, Anadromous Fish Survival and Water Supply Reliability

The cumulative effects of CP2 on special-status mollusks above Shasta Dam, cold-water fish spawning and rearing habitat above Shasta Dam, and ecologically important geomorphic processes below Shasta Dam would be associated with mechanisms similar to those of CP1. However, the magnitude of these impacts would be greater, in many cases, because of the greater inundation area and greater effects increased storage volume on the timing, magnitude, and duration of flows downstream than would occur under CP1.

Given the scale and duration of the project construction activities associated with CP2, the contribution of CP2 to construction-related cumulative impacts on fisheries and aquatic ecosystems would be cumulatively considerable; specifically, (1) additional inundation of potential riverine habitat for special-status mollusk species above Shasta Dam, (2) additional inundation of cold-water riverine fish spawning and rearing habitat above Shasta Dam, and (3) reduction of the magnitude and frequency of flows for ecologically important geomorphic processes in the upper and lower Sacramento River below Shasta Dam. CP2 would be undertaken in accordance with a project-specific SWPPP as reviewed and approved by the CVRWQCB. The SWPPP would require implementation of extensive BMPs during project construction, as well as post construction site restoration and stabilization to control erosion and sedimentation and to prevent the discharge of pollutants into the Sacramento River and other waterways. Implementation of these measures would reduce the project's contribution to cumulative construction-related impacts to a less-than-significant level.

Given major past alterations to the Sacramento River's aquatic ecosystem and associated aquatic habitats, the contributing adverse effects from CP2 would be cumulatively considerable. With implementation of Mitigation Measure Aqua-4 (CP2) (focused on Shasta Lake and vicinity) and Mitigation Measures Aqua-14 (CP2) through Aqua-16 (CP2) (focused on the Sacramento River downstream from Shasta Lake), adverse effects from CP2 would be reduced and would no longer result in a cumulatively considerable incremental contribution to significant cumulative effects on these resources.

As stated previously, effects of climate change on operations of Shasta Lake could include increased inflows and releases at certain times of the year, and decreased inflows at other times. The additional storage associated with CP2 would potentially reduce these effects and allow Shasta Lake to capture some of the increased runoff in the winter and early spring for release in late spring and summer. More importantly, an increased cold-water pool volume will allow Shasta Lake to be managed to provide cooler water releases downstream during critical life stages, particularly for Chinook spawning. Additionally, habitat for both warm- and cold-water reservoir fisheries would be increased with an enlarged reservoir area. Under CP2, potential impacts to Sacramento River fish below Shasta Dam would be beneficial.

Modeling conducted for the Climate Change Appendix was inconclusive about the effects of this alternative on Delta salinity. If exports are increased under this alternative, it could have an adverse effect on the location of X2, when considered along with other potential projects. However, if the location of X2 remains a water quality and regulatory requirement, then additional exports would not occur when X2 compliance would be violated. Therefore, no cumulative impact on X2 will occur under this alternative.

CP3 – 18.5-Foot Dam Raise, Agricultural Water Supply Reliability and Anadromous Fish Survival

The cumulative effects of CP3 on special-status mollusks above Shasta Dam, cold-water fish spawning and rearing habitat above Shasta Dam, and ecologically important geomorphic processes below Shasta Dam would be associated with mechanisms similar to those of CP1 and CP2. However, the magnitude of these impacts would be greater, in many cases, because of the greater inundation area and greater effects increased storage volume on the timing, magnitude, and duration of flows downstream than would occur under CP1 and CP2.

Given the scale and duration of the project construction activities associated with CP3, the contribution of CP3 to construction-related cumulative impacts on fisheries and aquatic ecosystems would be cumulatively considerable: specifically, (1) additional inundation of potential riverine habitat for special-status mollusk species above Shasta Dam, (2) additional inundation of cold-water riverine fish spawning and rearing habitat above Shasta Dam, and (3) reduction of the magnitude and frequency of flows for ecologically important geomorphic processes in the upper and lower Sacramento River below Shasta Dam. CP3 would be undertaken in accordance with a project-specific SWPPP as reviewed and approved by the CVRWQCB. The SWPPP would require implementation of extensive BMPs during project construction, as well as postconstruction site restoration and stabilization to control erosion and sedimentation and to prevent the discharge of pollutants into the Sacramento River and other waterways. Implementation of these measures would reduce the project's contribution to cumulative construction-related impacts to a less-than-significant level.

Given major past alterations to the Sacramento River aquatic ecosystem and associated aquatic habitats, the contributing adverse effects from CP3 would be cumulatively considerable. With implementation of Mitigation Measure Aqua-4 (CP3) (focused on Shasta Lake and vicinity) and Mitigation Measures Aqua-14 (CP3) through Aqua-16 (CP3) (focused on the Sacramento River downstream from Shasta Lake), adverse effects from CP3 would be reduced and would no longer result in a cumulatively considerable incremental contribution to significant cumulative effects on these resources.

As stated previously, effects of climate change on operations of Shasta Lake could include increased inflows and releases at certain times of the year, and decreased inflows at other times. The additional storage associated with CP3 would potentially reduce these effects and allow Shasta Lake to capture some of the increased runoff in the winter and early spring for release in late spring and summer. More importantly, an increased cold-water pool volume will allow Shasta Lake to be managed to provide cooler water releases downstream during critical life stages, particularly for Chinook salmon. Additionally, habitat for both warm- and cold-water reservoir fisheries would be increased with an enlarged reservoir area. Under CP3, potential impacts to Sacramento River fish below Shasta Dam would be beneficial.

Modeling conducted for the Climate Change Appendix was inconclusive about the effects of this alternative on Delta salinity. If exports are increased under this alternative, it could have an adverse effect on the location of X2, when considered along with other potential projects. However, if the location of X2 remains a water quality and regulatory requirement, then additional exports would not occur when X2 compliance would be violated. Therefore, no cumulative impact on X2 will occur under this alternative.

CP4 – 18.5-Foot Dam Raise, Anadromous Fish Focus with Water Supply Reliability

The cumulative effects of CP4 on special-status mollusks above Shasta Dam, cold-water fish spawning and rearing habitat above Shasta Dam, and ecologically important geomorphic processes below Shasta Dam would be associated with mechanisms similar to those of CP1, CP2, and CP3. However, the magnitude of these impacts would be greater, in many cases, because of the greater inundation area and greater effects increased storage volume on the timing, magnitude, and duration of flows downstream than would occur under CP1 and CP2, but similar to CP3. Some of these impacts would be partially offset with the implementation of the gravel augmentation program, floodplain and riparian restoration at six potential sites along the upper Sacramento River, and cold-water supply for anadromous fish management.

Given the scale and duration of the project construction activities associated with CP4, the contribution of CP4 to construction-related cumulative impacts on fisheries and aquatic ecosystems would be cumulatively considerable. CP4 would be undertaken in accordance with a project-specific SWPPP as reviewed and approved by the CVRWQCB. The SWPPP would require implementation of extensive BMPs during project construction, as well as postconstruction site restoration and stabilization to control erosion and sedimentation and to prevent the discharge of pollutants into the Sacramento River and other waterways. Implementation of these measures would reduce the project’s contribution to cumulative construction-related impacts to a less-than-significant level.

Given major past alterations to the Sacramento River’s aquatic ecosystem and associated aquatic habitats, the contributing adverse effects from CP4 would be cumulatively considerable; specifically, (1) additional inundation of potential riverine habitat for special-status mollusk species above Shasta Dam, (2) additional inundation of cold-water riverine fish spawning and rearing habitat above Shasta Dam, and (3) reduction of the magnitude and frequency of flows for ecologically important geomorphic processes in the upper and lower

Sacramento River below Shasta Dam. With implementation of Mitigation Measure Aqua-4 (CP4) (focused on Shasta Lake and vicinity) and Mitigation Measures Aqua-14 (CP4) through Aqua-16 (CP4) (focused on the Sacramento River downstream from Shasta Lake), adverse effects from CP4 would be further reduced, in combination with the downstream geomorphic restoration program elements, and would no longer result in a cumulatively considerable incremental contribution to significant cumulative effects on these resources.

As stated previously, effects of climate change on operations of Shasta Lake could include increased inflows and releases at certain times of the year, and decreased inflows at other times. The additional storage associated with CP4 would potentially reduce these effects and allow Shasta Lake to capture some of the increased runoff in the winter and early spring for release in late spring and summer. More importantly, an increased cold-water pool volume will allow Shasta Lake to be managed to provide cooler water releases downstream during critical life stages, particularly for Chinook salmon. Additionally, habitat for both warm- and cold-water reservoir fisheries would be increased with an enlarged reservoir area. Under CP4, potential impacts to Sacramento River fish below Shasta Dam would be beneficial.

Modeling conducted for the Climate Change Appendix was inconclusive about the effects of this alternative on Delta salinity. If exports are increased under this alternative, it could have an adverse effect on the location of X2, when considered along with other potential projects. However, if the location of X2 remains a water quality and regulatory requirement, then additional exports would not occur when X2 compliance would be violated. Therefore, no cumulative impact on X2 will occur under this alternative.

CP5 – 18.5-Foot Dam Raise, Combination Plan

The cumulative effects of CP5 on special-status mollusks above Shasta Dam, cold-water fish spawning and rearing habitat above Shasta Dam, and ecologically important geomorphic processes below Shasta Dam would be associated with mechanisms similar to those of CP1, CP2, CP3, and CP4. However, the magnitude of these impacts would be greater, in many cases, because of the greater inundation area and greater effects increased storage volume on the timing, magnitude, and duration of flows downstream than would occur under CP1 and CP2, but similar to CP 3 and CP4. Some of these impacts would be partially offset with the implementation of the gravel augmentation program, and floodplain and riparian restoration at six potential sites along the upper Sacramento River.

Given the scale and duration of the project construction activities associated with CP5, the contribution of CP5 to construction-related cumulative impacts on fisheries and aquatic ecosystems would be cumulatively considerable. CP5 would be undertaken in accordance with a project-specific SWPPP as reviewed and approved by the CVRWQCB. The SWPPP would require implementation of extensive BMPs during project construction, as well as postconstruction site restoration and stabilization to control erosion and sedimentation and to prevent the discharge of pollutants into the Sacramento River and other waterways. Implementation of these measures would reduce the project's contribution to cumulative construction-related impacts to a less-than-significant level.

Given major past alterations to the Sacramento River's aquatic ecosystem and associated aquatic habitats, the contributing adverse effects from CP5 would be cumulatively considerable; specifically, (1) additional inundation of potential riverine habitat for special-status mollusk species above Shasta Dam, (2) additional inundation of cold-water riverine fish spawning and rearing habitat above Shasta Dam, and (3) reduction of the magnitude and frequency of flows for ecologically important geomorphic processes in the upper and lower Sacramento River below Shasta Dam. With implementation of Mitigation Measure Aqua-4 (CP5) (focused on Shasta Lake and vicinity) and Mitigation Measures Aqua-14 (CP5) through Aqua-16 (CP5) (focused on the Sacramento River downstream from Shasta Lake), adverse effects from CP5 would be reduced, in combination with the downstream geomorphic restoration program elements, and would no longer result in a cumulatively considerable incremental contribution to significant cumulative effects on these resources.

As stated previously, effects of climate change on operations of Shasta Lake could include increased inflows and releases at certain times of the year, and decreased inflows at other times. The additional storage associated with CP5 would potentially reduce these effects and allow Shasta Lake to capture some of the increased runoff in the winter and early spring for release in late spring and summer. More importantly, an increased cold-water pool volume will allow Shasta Lake to be managed to provide cooler water releases downstream during critical life stages, particularly for Chinook salmon. Additionally, habitat for both warm- and cold-water reservoir fisheries would be increased with an enlarged reservoir area. Under CP5, potential impacts to Sacramento River fish below Shasta Dam would be beneficial.

Modeling conducted to evaluate project effects on Delta salinity for the Climate Change Appendix was focused on CP 5. Under this alternative Delta outflows are reduced by 15 to 100 TAF/year compared to the Baseline due to greater diversions. The changes are largest with the drier climate scenarios. If exports are increased under this alternative, it could have an adverse effect on the location of X2, when considered along with other potential projects. However, if the location of X2 remains a water quality and regulatory requirement, then additional exports would not occur when X2 compliance would be violated. Therefore, no cumulative impact on X2 will occur under this alternative.

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