4.1 Fish

This section presents information on fishes and other aquatic resources that occur or have the potential to occur within the geographical area encompassed by the Restoration Project and in the connected upper Sacramento River (i.e., Keswick Dam to Red Bluff). The recognition of the decline in salmon and steelhead populations in the Sacramento Valley and its tributaries has led to several legislative mandates to restore the fishery. The most relevant state planning process that initiated restoration on Battle Creek was the California Resources Agency's Upper Sacramento River Fisheries and Riparian Management Plan (1989), which involved public agencies, local government/communities, and stakeholders. Much of this state plan was later embodied in the CVPIA, which also includes the AFRP. The Restoration Project is part of a larger basinwide effort described in the CALFED Program Ecosystem Restoration Program Plan (ERPP) (CALFED 2000b). A focus of the ERPP is salmon and steelhead populations, the primary focus for the habitat improvements proposed for the Restoration Project.

Detailed biological data provided the background for this section (DFG 1966; Thomas R. Payne and Associates 1994, 1998a, 1998b, 1998c, 1998d; and Kier Associates 1999a). Information on the occurrence and life history of special-status fish in the Restoration Project area and the upper Sacramento River basin was obtained from the ERPP, Volumes I and II (CALFED 2000a, 2000b). The habitat analyses conducted by Thomas R. Payne and Associates (1998a) considered three resident fish. Flow/habitat relationships were developed for rainbow trout in the entire creek and for smallmouth bass in the mainstem.

Affected Environment

Regional Setting

The Restoration Project is located in the Battle Creek watershed in the Cascade Range Foothill physiographic region (Hickman 1993). The Cascade region's geology is derived from the volcanic formations created by Mount Lassen and its predecessor volcanoes. The volcanic formations produce a type of hydrology that is unusual for the Central Valley, characterized by abundant cold, spring-fed flows and relatively high dry-season base flows. The climate of Battle Creek is Mediterranean in the low-elevation, Sacramento Valley portions of the Restoration Project. Summers are hot and dry, with most of the precipitation falling as rain during the late fall, winter, and early spring months.

Restoration of Battle Creek will restore coldwater anadromous fish habitat unique to the Cascade region in Northern California. The construction of Shasta and Keswick Dams in the 1940s permanently blocked the access of chinook salmon and steelhead to 187 miles of unique Cascade region spawning and rearing habitat (Skinner 1958). Battle Creek (a tributary to the upper Sacramento River located approximately 28 river miles below Keswick Dam) has been identified as one of the only watersheds of significant size remaining in the Cascade region that has habitat types similar to the habitat types in which the now scarce salmon runs evolved (USFWS 1995b). Prior to the hydroelectric development in Battle Creek watershed more than a century ago, prime habitat for chinook salmon and steelhead extended from the confluence with the Sacramento River upstream to natural barrier waterfalls. The Restoration Project is designed to restore and reopen these habitats in the watershed. Although the Restoration Project will likely benefit all runs of salmon and steelhead, species that are specifically dependent on the Cascade region's unique habitat features, such as the winter-run chinook salmon, are a priority target species for the Restoration Project.

Species Occurrence and Status

Seventeen resident and anadromous fish species are known to occur in Battle Creek (Table 4.1-1).

Table 4.1-1. Fish Species in Battle Creek

Species	Scientific Name
Chinook salmon—N	(*Oncorhynchus tshawytscha*)
Steelhead trout—N	(*Oncorhynchus mykiss*)
Pacific lamprey—N	(*Lampetra tridentata*)
River lamprey—N	(*Lampetra ayresi*)
Rainbow trout—N	(*Oncorhynchus mykiss*)
Sacramento pikeminnow—N	(*Ptychocheilus grandis*)
Sacramento sucker—N	(*Catostomus occidentalis*)
California roach—N	(*Hesperoleucus symmetricus*)
Riffle sculpin—N	(*Cottus gulosus*)
Speckled dace—N	(*Rhinichthys osculus*)
Hardhead—N	(*Mylopharodon conocephalus*)
Three-spine stickleback—N	(*Gasterosteus aculeatus*)
Tule perch—N	(*Hysterocarpus traski*)
Brown trout—I	(*Salmo trutta*)
Smallmouth bass—I	(*Micropterus dolomieui*)
Green sunfish—I	(*Lepomis cyanellus*)
Golden shiner—I	(*Notemigonus crysoleucas*)

Species	Scientific Name
Notes :	
N = Native	
I = Nonnative	
Sources: Kier Associates 1999a, Thomas R. Payne and Associates 1998c, Moyle 2002	

Chinook salmon from the upper Sacramento River are important components of the commercial and sport fish along the Pacific Coast and an important sport fish in the Sacramento–San Joaquin River Delta (Delta) and Sacramento River. Steelhead are an important sport fish in the Sacramento River and its tributaries. Chinook salmon and steelhead are anadromous, spending the majority of their lives in the Pacific Ocean and migrating to freshwater rivers and streams to spawn. Prior to migration to the Pacific Ocean, juvenile fish rear in stream habitat anywhere from several weeks to several months. Steelhead remain in fresh water longer than chinook salmon. Pacific lamprey are similarly anadromous, but reside for several years in freshwater habitat.

The distribution and abundance of resident fish in Battle Creek were examined in detail in 1989 (Thomas R. Payne and Associates 1998c). Unlike anadromous species, the resident species in Battle Creek spend their entire lives in fresh water. Resident species include natives as well as nonnative. The assemblage of resident native fish that evolved in streams like Battle Creek transitions from warmwater species that occupy warmer, low-velocity reaches of the lower to mid-elevations to coldwater species that use colder, higher-velocity reaches of the mid- to high elevations (Moyle and Cech 1988). Warmwater species such as bass, sunfish, and native cyprinids (minnows) typically prefer slow-moving, low-velocity stream reaches in the low elevations of Battle Creek. Recreationally important coldwater resident species, such as brown and rainbow trout, generally prefer colder water and higher velocity than warmwater fish; however, their occurrences overlap to varying degrees. The upper portions of Battle Creek and the Hydroelectric Project's canal system are both acknowledged to support a sport fishery for rainbow and brown trout (Kier Associates 1999a).

Special-Status Fish Species

Special-status fish species present in the Sacramento River and its tributaries include chinook salmon and steelhead (Table 4.1-2). These species receive additional protection from the CESA and ESA based on scientific findings for their particular Evolutionarily Significant Units (ESUs).

Table 4.1-2. Special-Status Fish Species in Battle Creek

Species	Evolutionarily Significant Unit (ESU)	State Listing	Critical Habitat Designation	Federal Listing
Chinook salmon	Sacramento River winter-run	Endangered	Yes	Endangered
Chinook salmon	Central Valley spring-run	Threatened	Under development	Threatened
Chinook salmon	Central Valley fall-/late fall–run	None	Not applicable	Candidate/not warranted
Steelhead	Central Valley	None	Under development	Threatened
River lamprey	N/A	Species of Concern	Not applicable	Species of Concern

Winter-Run Chinook Salmon

Abundance of returning adult winter-run chinook salmon in the Sacramento River declined from approximately 120,000 adults in the late 1960s to a few hundred in the early 1990s. Since the early 1990s, winter-run chinook salmon abundance appears to be increasing (USFWS 2001a). Between 1987 and 1999, an average of 1,273 spawners returned each year to this basin. Juvenile production indices for naturally spawning winter chinook salmon averaged more than 1.9 million from 1995 through 1999, ranging between 384,146 and 4,628,597 annually (USFWS 2001a). Since the late 1990s, winter-run chinook salmon populations have increased. The likely explanation for these trends is a combination of factors, including improved freshwater and marine habitat conditions, changes in hatchery production, restricted commercial harvest, and changes to the operations of water development facilities in the Sacramento River, its tributaries, and its estuary.

Winter-run chinook salmon are unique to the Central Valley (Healey 1991). They originally occurred in the Sacramento River upstream of Shasta Dam and in Battle Creek (Yoshiyama et al. 1998). Currently, winter-run chinook salmon spawn and rear primarily in the Sacramento River. Historical reports of naturally produced winter-run chinook salmon in Battle Creek include observations of juvenile outmigrants in the early 1900s (Rutter 1902, 1903), runs in the late 1940s and early 1950s (USFWS 1987), uncounted runs in the late 1950s and early 1960s, and 24 adults observed in the South Fork of Battle Creek in 1965 (DFG 1965).

Monitoring conducted during a part of the migration period for winter-run and spring-run chinook salmon estimated that 0 to 4 of the observed adults were late fall–run chinook salmon, 0 to a few were winter-run, and approximately 100 were spring-run(USFWS 2002c). These observations were made after the hatchery program for winter-run chinook salmon was moved from Coleman National Fish Hatchery on Battle Creek to Livingston Stone National Fish Hatchery on the Sacramento River. Juvenile downstream migrant trap data indicated winter-run and spring-run juveniles were produced in Battle Creek (CAMP 2001). The number of winter-run chinook salmon in Battle Creek is unknown, but if they do occur, they are scarce.

The Sacramento River winter-run chinook salmon was state-listed as endangered on September 22, 1989 (CNDDB 2001) and federally listed as endangered on January 4, 1994 (59 FR 440). Designated critical habitat includes the Sacramento River from Keswick Dam downstream to the Sacramento–San Joaquin Estuary (58 FR 33212; June 16, 1993). Battle Creek is not included as critical habitat for winter-run chinook salmon; however, Battle Creek is the only stream in the Central Valley in which the recovery plan recommended an effort be made to establish a self-sustaining population of this ESU (NOAA Fisheries 1997b).

Spring-Run Chinook Salmon

Sacramento River spring-run chinook salmon population sizes have varied significantly since the 1950s, declining to less than 1,000 adults since 1991. Counts for this run at Red Bluff Diversion Dam, however, are not particularly reliable (DFG 1999). Estimated spawner escapement for the Sacramento River basin averaged 11,155 between 1987 and 1999 (USFWS 2001a). Yearly estimates range from 3,000 to more than 31,000 adults within this period.

Beginning with a short period in the 1940s, only sporadic counts of spring-run chinook salmon are available for Battle Creek. During this period, incomplete counts of 1,000 or more fish indicated that a relatively large population was present in Battle Creek (DFG 1998). Population estimates from recent years indicate a remnant of the original population, perhaps ranging between 50 and 100 (USFWS 2001a).

The Central Valley spring-run chinook salmon was state-listed as threatened on February 5, 1999 (CNDDB 2001) and federally listed as threatened on September 16, 1999 (64 FR 50394). NOAA Fisheries has withdrawn the critical habitat designation for spring-run chinook salmon.

USFWS administered a monitoring program for adult chinook salmon, rainbow trout, and steelhead in Battle Creek from March through October 2001 (USFWS 2002c). A total of seven reaches were sampled on a monthly basis: four reaches on mainstem Battle Creek; two reaches on North Fork Battle Creek (from the confluence to Eagle Canyon Diversion Dam); and one reach on the South Fork (from the confluence to Coleman Dam). From July through September, approximately 68 % of the chinook salmon observed in holding locations were observed in the South Fork reach. No chinook salmon were observed holding in the North Fork, and the remaining 32% were observed holding in the mainstem of Battle Creek (USFWS 2002c). It is not possible to determine whether the spring-run chinook salmon observed in the South Fork were natal to the South Fork or were falsely attracted to the South Fork during power system outages, when large amounts of predominantly North Fork power water were discharged to the lower South Fork for substantial periods of time while North Fork flow was low. USFWS monitoring revealed that 75% of chinook redds in their analysis area were located in the North and South Forks of Battle Creek (USFWS 2002c). The majority of the redds in the South Fork were located close to the Coleman Diversion Dam, where the fish ladder is impassable (USFWS 2002c). Redds were observed in the North Fork between Wildcat and Eagle Canyon Diversion Dams (near River Mile [RM] 3).

Fall-/Late Fall–Run Chinook Salmon

Fall-run chinook salmon constitute the largest population of spawning chinook salmon in both the Sacramento River and Battle Creek. Most fish in Battle Creek are thought to be derived from production at the Coleman National Fish Hatchery (USFWS 2001a). In the Sacramento River, abundance of adult fall-run chinook salmon has varied from approximately 50,000 to more than 100,000 adults; abundance in Battle Creek fluctuated from less than 10,000 to more than 100,000.

Late fall–run chinook salmon compose the second largest population of chinook salmon in the upper Sacramento River and Battle Creek. Run size estimates for late fall–run chinook salmon in the Sacramento River have steadily declined from approximately 35,000 adults in the late 1960s to approximately 7,000 to 10,000 adults in the early 1990s. Return of late fall–run chinook salmon to Coleman National Fish Hatchery increased from 323 to 7,075 over the period from 1995 to 1999. The majority of the Battle Creek population of this run is thought to be derived from Coleman National Fish Hatchery Production (USFWS 2001a).

Following a status review of the Central Valley fall-/late fall–run chinook salmon ESU, NOAA Fisheries determined that listing this ESU as threatened or endangered was not warranted. The ESU is designated as a candidate for listing under the ESA because of concerns over specific risk factors (NOAA Fisheries 1999). Long-term population trends appear generally stable or increasing; however, it is unclear whether natural populations are self-sustaining because hatchery and natural fall chinook salmon are not distinguishable and not all hatchery chinook salmon are marked (64 FR 50394; September 16, 1999).

Steelhead

Populations of steelhead in the Sacramento River basin have declined precipitously in the last 40 years. From 1953 through 1958 the population passing Red Bluff Diversion Dam averaged approximately 20,000 adults (Hallock et al. 1961). In recent years, based on comparison with adults returning to the Coleman National Fish Hatchery, most of the adults counted at Red Bluff Diversion Dam originated from the hatchery.

All naturally spawned adult steelhead are allowed to pass the barrier at Coleman National Fish Hatchery and migrate into the Battle Creek watershed. The returning adults during the winter of 2001–2002, however, represented the first year in which all returning hatchery steelhead had been marked to distinguish them from naturally occurring steelhead. Although estimates are generally unavailable, the size of naturally spawned steelhead populations in Battle Creek is fewer than 100–300 adults returning in a given year USFWS 2002c)

Central Valley steelhead was federally listed as threatened on May 19, 1998 (63 FR 13347); the steelhead is not state-listed. The final rule designating federal critical habitat for this species has been withdrawn.

Other Aquatic Organisms

In addition to fish, the aquatic community in Battle Creek includes many other organisms. The shallow, fast-flowing areas of the stream provide habitat for algae, crustaceans, and aquatic insects that make up part of the food web for fish in Battle Creek. Aquatic insects serve as a major food supply for resident fish and juvenile anadromous fish. Upon emergence from Battle Creek as adults, the aquatic insects contribute to the food supply of wildlife (e.g., flycatchers, bats, etc.).

Battle Creek and its tributaries also support amphibians. The early life stages of the amphibians spend their entire time in the water. Amphibians are discussed in more detail in Section 4.2.

The riparian communities in the Restoration Project area provide important habitat for stream-dependent wildlife. Terrestrial insects that inhabit riparian habitat contribute to the food supply for fish and amphibians. Shade provided by tall trees and shrubs reduces solar heating of the stream. Trees that fall into the stream, along with the roots that help hold the bank together, provide cover for fish. Leaves that accumulate on the streambanks and in the stream provide shelter as well as nutrients and food for aquatic and terrestrial species. Riparian communities and other stream-dependent species are discussed in more detail in Section 4.2.

Selected Species Life Histories

Chinook Salmon

The upper Sacramento River and its tributaries, including Battle Creek, provide essential habitat for adult holding, spawning, egg incubation, and juvenile rearing (Figure 4.1-1). Chinook salmon spend the largest proportion of their lives in the Pacific Ocean (generally 3 years, but ranging from 1 to 5 years). While reaching sexual maturity, adults migrate to the Sacramento River and its tributaries. Chinook salmon home to the stream where they hatched, although some adults stray and spawn in streams other than their streams of origin. Spawning requires cool water temperature, access to holding and resting pools, clean gravel for building nests, or redds, where eggs are deposited and fertilized, and suitable water velocity and depth.

As indicated previously, four runs of chinook salmon occur in the upper Sacramento River and Battle Creek: fall, late fall, winter, and spring. Identification of the runs is based on the time of year the adults leave the Pacific

Ocean and enter fresh water. Fall- and late fall–run chinook salmon spawn upon arrival at spawning grounds. One or more life stages of chinook salmon are found in the upper Sacramento River throughout the year. Limited studies indicate that chinook salmon in Battle Creek exhibit a life history pattern similar to that derived from the studies made at Red Bluff Diversion Dam (CAMP 2001). The actual timing of runs throughout the upper Sacramento River and its tributaries varies slightly from year to year as a function of weather, streamflow, and water temperature (Vogel and Marine 1991).

Spring-run chinook salmon migrate upstream in the spring and over-summer or hold in cool river and stream reaches where cover is provided by deep water or boulders. Adults spawn in August through October (Figure 4.1-1). The species is dependent on cold reservoir releases and cold spring-fed or high-elevation streams for holding and spawning habitat.

Winter-run chinook salmon migrate upstream in winter and hold in cool reaches during the spring and early summer (Figure 4.1-1). Adults spawn in the summer and are dependent on cool reservoir releases or streams dominated by cold spring water.

Steelhead

Steelhead occur in the upper Sacramento River and its tributaries, which provide the main habitat for holding, spawning, egg incubation, and fry and juvenile rearing. The number of steelhead that actually spawn in the Sacramento River is small. Spawning occurs primarily in cool reaches of tributaries.

The majority of adult steelhead migrate into the upper Sacramento River from July through March and spawn in the upper Sacramento River and its tributaries, such as Battle Creek, from December through April and possibly May in most years (Hallock et al. 1961, DFG 1996a, Kier Associates 1999a) (Figure 4.1-1). Steelhead home to the stream where they were hatched; although a portion of the population can be expected to stray and spawn in other streams.

Unlike chinook salmon, steelhead typically rear in the upper Sacramento River watershed for at least 2 years before migrating to the Pacific Ocean. Also unlike chinook salmon, steelhead may spawn more than once, returning to the Pacific Ocean between spawning runs. The proportion of the population that spawns more than once is small.

Other Anadromous Species

Pacific lamprey adults migrate to Battle Creek and the upper Sacramento River from July to October (Thomas R. Payne and Associates 1998c and as documented by U.S. Fish and Wildlife Service monitoring programs). Lampreys are eel-like in appearance. In the ocean, adults are parasitic, feeding off larger fish species including salmonids. Adults excavate a nest in gravel substrate where fertilized eggs are deposited. Following incubation, larval lamprey distribute in slow water where abundant organic material provides a source of food and cover. After 5 to 7 years of freshwater residence, lamprey begin their migration to the Pacific Ocean and, as they transform into the adult stage, develop a sucker-like mouth with numerous rasping teeth that are used to bore into the sides of host fish (Hart 1988).

Resident Species

Central Valley rivers include many other native and nonnative species (Table 4.1-1). In general, native species, such as Sacramento pikeminnow, hardhead, Sacramento sucker, and California roach, spawn early in the spring. Most native fishes do not guard the eggs or young. Native fishes are adapted to rear in areas that provide abundant cover and abundant prey (Moyle 2002).

With some exceptions, nonnative species, such as green sunfish and smallmouth bass, spawn later in the spring and in the summer. Nonnative species are more successful in disturbed environments than native species. In general, they are adapted to warm, slow-moving and nutrient-rich waters (Moyle 2002). An exception is the nonnative brown trout that spawns in the fall and has habitat requirements similar to rainbow trout, the nonanadromous form of steelhead.

Factors Affecting Abundance

Information relating abundance with environmental conditions is most available for chinook salmon and steelhead; therefore, the following section focuses on factors that have affected the abundance of chinook salmon and steelhead, especially within the Battle Creek Watershed. Although not specifically referenced, many of the factors discussed for chinook salmon and steelhead also have affected the abundance of other species, including resident fish species.

The decline of salmon and steelhead in the Sacramento River and its tributaries is attributed to a number of factors that have acted upon the populations in a cumulative fashion over decades. These factors include reduced key habitat quantity, reduced migration habitat, warm water temperature, increased contaminants, entrainment in diversions, increased predation, reduced food, hatchery effects, and harvest.

Key Habitat Quantity

The primary factor affecting spawning and rearing habitat area in Battle Creek is streamflow. Habitat quality is also significantly affected by temperature as influenced by diversion of cold spring water accretions away from adjacent stream sections and reduced flows in the stream below dams. Diversion for power generation have substantially reduced streamflow in all the reaches of Battle Creek downstream of Keswick Diversion Dam and South Diversion Dam. Although minimum flows are maintained, reduced streamflow has substantially reduced spawning and rearing habitat area available to chinook salmon, steelhead, and other fish species.

Limited information is available for flow-habitat relationships on Soap, Ripley, and Baldwin Creeks. However, the FERC license–required minimum flow of 0 cfs would not provide sufficient water to sustain fish. Occurrence of fish in the reaches below the existing diversion dams is limited under the No Action Alternative.

Spawning habitat area may limit the production of juveniles and subsequent adult abundance of some species. Spawning habitat area for fall-/late fall–run chinook salmon, which compose more than 90% of the chinook salmon returning to the Central Valley streams, has been identified as limiting their population abundance. Spawning habitat area has not been identified as a limiting factor for the less-abundant winter-run and spring-run chinook salmon (NOAA Fisheries 1997b; USFWS 1996), although habitat may be limiting in some streams (e.g., Battle Creek), especially during years of high adult abundance.

Spawning habitat area is defined by a number of factors, such as gravel size and quality and water depth and velocity. Although maximum usable gravel size depends on fish size, a number of studies have determined that chinook salmon require gravel ranging from approximately 0.3 cm (0.1 inch) to 15 cm (5.9 inches) in diameter (Raleigh et al. 1986). Steelhead prefer substrate no larger than 10 cm (3.9 inches) (Reiser and Bjornn 1979). Salmonids spawn in water depths that range from a few inches to several feet. A minimum depth of 0.8 foot for chinook salmon and steelhead spawning has been widely used in the literature and is within the range observed in some Central Valley rivers (DFG 1991). Velocity that supports spawning ranges from 0.8 foot per second to 3.8 feet per second (USFWS 1994).

Rearing habitat area may limit the production of juveniles and subsequent adult abundance of some species. Rearing habitat for salmonids is defined by environmental conditions such as water temperature, dissolved oxygen, turbidity, substrate, water velocity, water depth, and cover (Jackson 1992; Reiser and Bjornn 1979; Healey 1993).

Rearing area varies with flow. High flow increases the area available to juvenile chinook salmon because they extensively use submerged terrestrial vegetation on the channel edge and the floodplain. Deeper inundation provides more overhead cover and protection from avian and terrestrial predators than shallow water (Everest and Chapman 1972). In broad, low-gradient rivers, change in flow can greatly increase or decrease the lateral area available to juvenile chinook salmon, particularly in riffles and shallow glides (Jackson 1992).

Battle Creek is a high-gradient, headwater stream with an elevation change in excess of 5,000 ft over 50 miles. The creek flows through remote, deep-shaded canyons and riparian corridors with little development near its banks. Battle Creek flow consists of rainfall and snowmelt from the western slope of the Cascade Mountain Range, complemented by the year-round flow of natural springs.

Substrate size ranges from sand to boulder with predominantly gravel and cobble throughout the system. The total estimated area of spawning gravel is 57,000 square feet in the mainstem above Coleman Powerhouse; 81,000 square feet in the North Fork up to the barrier waterfall; and 28,000 in the South Fork up to Panther Creek (Thomas R. Payne and Associates 1994). Concentration and types of gravel deposits are directly correlated to stream gradient. Mobility studies imply that gravel in Battle Creek moves with enough frequency to keep it clean of fine sediment and loose enough to support spawning.

The Battle Creek channel is characterized by alternating pools and riffles. The channel form, along with boulders, ledges, and turbulence, provides key elements of rearing habitat for fish species.

Water Temperature

Fish species have different responses to water temperature conditions depending on their physiological adaptations. Salmonids in general have evolved under conditions in which water temperatures are fairly cool. In addition to species-specific thresholds, different life stages have different water temperature requirements. Eggs and larval fish are the most sensitive to changes in water temperature.

Unsuitable water temperatures for adult salmonids such as chinook salmon and steelhead during upstream migration lead to delayed migration and potential lower reproduction. Elevated summer water temperature in holding areas of Battle Creek causes mortality of spring-run chinook salmon (USFWS 1996). Warm water temperature and low dissolved oxygen also result in an increase of egg and fry mortality. USFWS (1996) cited elevated water temperatures as limiting factors for fall- and late fall–run chinook salmon in Battle Creek.

Juvenile salmonid survival, growth, and vulnerability to disease are affected by water temperature. In addition, water temperature affects prey species abundance and predator occurrence and activity. Juvenile salmonids alter their behavior depending on water temperature, including movement to take advantage of local water temperature refugia (e.g., movement into stratified pools, shaded habitat, and subsurface flow) and to improve feeding efficiency (e.g., movement into riffles).

Water temperature in Central Valley rivers frequently exceeds the tolerance of chinook salmon and steelhead life stages. Based on a literature review, conditions supporting adult chinook salmon migration are reported to deteriorate as temperature warms between 54ºF and 70ºF (Hallock 1970 as cited in McCullough 1999). For chinook salmon eggs and larvae, survival during incubation is assumed to decline with warming temperature between 54ºF and 63ºF (Myrick and Cech 2001; Seymour 1956). For juvenile chinook salmon, survival is assumed to decline as temperature warms from 64ºF to 75ºF (Myrick and Cech 2001; Rich 1997). Relative to rearing, chinook salmon require cooler temperatures to complete the parr-smolt transformation and to maximize their saltwater survival. Successful smolt transformation is assumed to deteriorate at temperatures ranging from 63ºF to 73ºF (Marine 1997; Baker et al. 1995).

For steelhead, successful adult migration and holding are assumed to deteriorate as water temperature warms between 52ºF and 70ºF. Adult steelhead appear to be much more sensitive to thermal extremes than are juveniles (McCullough 1999). Conditions supporting steelhead spawning and incubation are assumed to deteriorate as temperature warms between 52ºF and 59ºF (Myrick and Cech 2001). Juvenile rearing success is assumed to deteriorate at water temperatures ranging from 63ºF to 77ºF (Raleigh et al. 1984; Myrick and Cech 2001). Relative to rearing, smolt transformation requires cooler temperatures, and successful transformation occurs at temperatures ranging from 42.8ºF to 50ºF. Juvenile steelhead have, however, been captured at Chipps Island in June and July at water temperatures exceeding 68ºF (Nobriega and Cadrett 2001). Juvenile chinook salmon have also been observed to migrate at water temperatures warmer than expected based on laboratory experimental results (Baker et al. 1995).

Warm water temperature can limit the amount of habitat available and cause mortality of chinook salmon, steelhead, and other fish species in the Battle Creek system. Water temperature is determined primarily by weather, channel form and dimension, shade, and flow. Diversion of flow, including spring water accretions, from Battle Creek substantially warms water temperature, especially from March through October. Flow diversion and subsequent warming substantially reduce the habitat area that can support migration, holding, spawning, and rearing of chinook salmon and steelhead in Battle Creek (Kier Associates 1999a). Transbasin water diversions from the North Fork of Battle Creek to the South Fork tend to warm North Fork Battle Creek and cool South Fork Battle Creek. Additional information on water temperature is provided in Section 4.4, “Water Quality.”

Migration Habitat

Migration habitat is the specific conditions that support migration of individuals to habitat required for activities essential to survival, growth, and reproduction. Migration habitat is supported by streamflows that provide suitable water velocities and depths.

Absolute barriers mark the terminus of the Restoration Project on North Fork and South Fork Battle Creek at all times. In the steep, high-elevation stream reaches there are natural features in the channel such as boulders and logs that can impede passage depending on vertical drop, flow depth, and flow velocity. Seven diversion dams block passage of chinook salmon, steelhead, and other fish species; a fish barrier at Coleman National Fish Hatchery blocks passage six months of the year.

Passage conditions that support migration of chinook salmon, steelhead, and other fish species in Battle Creek also have been affected by the reduction in streamflow attributable to diversions for power production. Streamflow affects passage conditions, both flows within the range that can be controlled by the Hydroelectric Project and the high, uncontrolled flows that spill. Natural events, such as floods, can alter physical characteristics of the channel, including depth of pools from which the fish jump, height that must be jumped, water velocity, slope of the streambed, and the length of the slope, all factors affecting passage. An on-site survey identified transitory barriers in 18 locations on North Fork Battle Creek and five locations on South Fork Battle Creek (Table 4.1-3). Passage of all or some adult chinook salmon and steelhead could be impaired under streamflow conditions in the range controlled by the hydroelectric diversions. Based on the conditions observed at the time of the survey, a general estimate was made of the streamflow allowing passage through the entire reach for all adult salmon and steelhead. On North Fork Battle Creek, obstacles required greater amounts of streamflow for unimpaired passage than on South Fork Battle Creek. In one extreme case on North Fork Battle Creek (river mile 5.14), an especially steep transitory barrier was modified by DFG in 1997 (Warner pers. comm.) to provide numerous ascent routes at more gradual slopes (Kier Associates 1999a).

The North Battle Creek Feeder, Eagle Canyon, Wildcat, Coleman, Inskip, and South Diversion Dams potentially block approximately 55 miles of upstream habitat. The fish ladders at Eagle Canyon, Wildcat, and Coleman Diversion Dams are considered ineffective under most flow conditions (DWR 1997 and 1998). The fish ladder effective flow range for each diversion dam is between 2 and 7 cfs. The ladder at the South Diversion Dam has an effective flow range between 3 and 35 cfs. The ladders proved impossible to maintain during high flows. During average or wet water years, fish ladders at North Battle Creek Feeder, Eagle Canyon, Wildcat, Inskip, and Coleman Diversion Dams could be ineffective for 3 to 8 months because flow exceeds the maximum effective capacity of the ladders by a factor of 10 or more. Fish ladders at Eagle Canyon and Coleman Diversion Dams were intentionally closed to fish passage under the 1998 Interim Agreement.

In addition to the barriers discussed above, Coleman National Fish Hatchery operates a barrier weir along with a fish ladder 5.5 miles upstream of Battle Creek's confluence with the Sacramento River (USFWS 2001a). When the fish ladder is closed, the barrier weir extends across the full width of Battle Creek and obstructs passage of adult steelhead and chinook salmon to Battle Creek above the hatchery. The barrier is not completely effective and some adult chinook salmon and steelhead pass the barrier, especially at flow in excess of 350 cfs. The number of adult chinook salmon passing over the barrier weir has been substantial (several thousand fish). The barrier weir is being redesigned to improve the ability to block upstream migration under all flow conditions. A fish ladder at the barrier weir is operated to manage and monitor passage of adult chinook salmon into Battle Creek upstream of the weir. The objectives of management currently are to:

- minimize the potential for hybridization between co-occurring, naturally-reproducing runs of chinook salmon in Battle Creek upstream of the barrier weir;
- minimize the risk of infectious hematopoietic necrosis (IHN) virus being shed into the Coleman National Fish Hatchery water supply; and
- monitor passage of salmonids.

Contaminants

In the Sacramento River, industrial and municipal discharge and agricultural runoff introduce contaminants. Organophosphate insecticides, such as carbofuran, chlorpyrifos, and diazinon, are present throughout the Central Valley and are dispersed in agricultural and urban runoff. Contaminants enter rivers in winter runoff and enter the estuary in concentrations that can be toxic to invertebrates (CALFED 2000a). Because they accumulate in living organisms, they may become toxic to fish species, especially those life stages that remain in the system year-round and spend considerable time during the early stages of development, such as chinook salmon and steelhead.

Water samples were collected at eight sites in the Battle Creek watershed and analyzed for metal, total suspended solids (TSS), and oil and grease. The results revealed that each of these parameters was within the EPA's recommended levels for aquatic life. Contaminant levels in Battle Creek are relatively low and adverse effects are not currently documented.

Entrainment

All fish species are entrained to varying degrees by diversions throughout the Sacramento River system. Fish entrainment and subsequent mortality are a function of the size of the diversion, the location of the diversion, the behavior of the fish, and other factors, such as fish screens, presence of predatory species, and water temperature. Low approach velocities and fish screens are assumed to minimize stress and protect fish from entrainment.

Given that most of the flow is diverted from Battle Creek for power production and that fish screens are absent from all of the diversions, most downstream migrant fish, including steelhead and chinook salmon, would be entrained. Survival of passage through the power turbines would likely be minimal and entrained fish would be lost from the population. Diversion volume is discussed in detail in Section 4.3, "Hydrology."

Predation and Pathogens

Native and nonnative species may cause substantial predation mortality on salmonids and other species. Nonnative fish predators in Battle Creek include brown trout, smallmouth bass, green sunfish, and other species (Table 4.1-1). Although the contribution to mortality is uncertain, predation mortality may reduce survival of juvenile chinook salmon and steelhead and other species, especially where the stream or river channel has been altered from natural conditions (DWR 1995). The existing diversion dams in the Restoration Project area may create environmental conditions that increase the probability that predator species will capture juvenile chinook salmon, steelhead, and other species during downstream movement. Water turbulence in the vicinity of the dams and other structures may disorient migrating juvenile chinook salmon and steelhead, increasing their vulnerability to predators. In addition, changes in flow velocity and depth affect the quality of habitat and potentially increase vulnerability of fish species to predation by other fish species and by birds and mammals.

Steelhead and chinook salmon that are present in Battle Creek carry pathogens, including IHN. Currently the potential for occurrence of fish pathogens associated with anadromous fishes is likely low because the abundance of chinook salmon and steelhead is relatively low. Rainbow trout (i.e., the resident form of steelhead) are susceptible to pathogens carried by stocked trout, chinook salmon, and steelhead. Rainbow trout are relatively abundant in the reaches of Battle Creek upstream of the diversion dams and in the canals conveying flow diverted from Battle Creek. Existing flows and fish ladder design and operation, including the operation of the fish barrier at Coleman National Fish Hatchery, control the migration and abundance of anadromous fish in Battle Creek and in reaches upstream of the diversion dams. Although data on the incidence of pathogens in wild populations of rainbow trout are not available, the low abundance of chinook salmon and steelhead in upstream reaches may minimize the incidence of pathogens upstream of diversion dams and in the canals conveying diversions.

Aquaculture facilities amplify pathogens and stress fish because of confined conditions, combining to create a higher level of disease in aquaculture settings than in wild populations in a stream. Rainbow trout (or other salmonid species) raised in the aquaculture facilities at Mount Lassen Trout Farms (MLTF) are potentially exposed to pathogens carried by chinook salmon and steelhead that spawn and rear upstream of the diversions for Eagle and Inskip Canals. The canal water seeps into the spring-fed water supplies servicing MLTF Jeffcoat and Willows Springs facilities, potentially carrying pathogens. The possibility of pathogens entering the aquaculture facilities increases with increasing abundance of chinook salmon and steelhead within the stream reaches upstream of the canal diversions.

Food

Food availability and type affect survival of fish species. Flow affects stream surface area and production of food. A primary factor affecting food production in Battle Creek is streamflow. Diversion for power generation has substantially reduced streamflow in all the reaches of Battle Creek downstream of Keswick Diversion Dam and South Diversion Dam. Although minimum flows are maintained, reduced streamflow has substantially reduced stream area. In addition, diversions entrain food organisms, exporting nutrients from segments of Battle Creek.

The density of adult salmon carcasses has been shown to increase nutrient input to stream systems and contribute to increased growth rates of juvenile salmonids (Wipfli et al. 2002). The historical reduction of chinook salmon populations also may have reduced food availability and productivity of Battle Creek.

Hatchery

The primary objective of the Coleman National Fish Hatchery is to serve as mitigation for the habitat lost when the upper Sacramento River and its tributaries were blocked by the construction of Shasta Dam in the 1940s. Coleman National Fish Hatchery propagates three salmonid stocks: fall-run chinook salmon, late fall–run chinook salmon, and steelhead trout (USFWS 2001a). The fall- and late fall–run chinook salmon and steelhead hatchery programs are considered to be integrated with naturally spawning fall chinook salmon in the upper Sacramento River and Battle Creek (USFWS 2001a). Risks that hatchery operations and augmentation may pose to natural populations of steelhead and chinook salmon include: introduction, spread, or amplification of fish pathogens; deleterious genetic effects of hatchery fish on natural stocks; impedance of migrating fish at the hatchery barrier weir and water intake structures; and exceeding the carrying capacity of riverine, estuarine, and marine habitat.

Harvest

Sport and commercial fishing affects the abundance of adult chinook salmon and steelhead (sport fishing only) returning to the Sacramento River system, including Battle Creek. Ocean survival may be reduced by 35%–85% (Pacific Fishery Management Council 2001). Ocean and river regulations have been implemented to minimize effects of sport and commercial fishing, especially on winter-run chinook salmon and steelhead. Sport fishing in Battle Creek may have local effects on anadromous and resident fish species that are currently unknown; however, Battle Creek is closed to the legal harvest of naturally produced anadromous fish.

Regulatory Setting

The regulations, laws, permits, and policies relevant to aquatic biological resources in stream reaches influenced by the operation of the Hydroelectric Project diversions and canals include:

- Federal Power Act;
- Fish and Wildlife Coordination Act (16 USC 661-667e);
- ESA administered by NOAA Fisheries for anadromous fish and USFWS for nonanadromous species (16 USC 1531 *et seq*);
- California Fish and Game Code, in particular sections relating to dams and diversions (Section 5900 *et seq*.), streambeds (1600 *et seq.*), and CESA administered by DFG (Sections 2080 and 2081 *et seq*) and sport fishing regulations;
- Magnuson-Stevens Fishery Conservation and Management Act, as amended by the Sustainable Fisheries Act of 1996 (Public Law 104-267);
- Clean Water Act Section 401 (clean water certification) and 402 (NPDES permitting) administered by SWRCB and the RWQCB through the Regional Water Quality Control Board, Central Valley Region (CVRWQCB) Basin Plan
- Clean Water Act Section 404 administered by the Corps for dredge-and-fill activities; and
- California Water Code Section 1707 regarding dedication of water to instream environmental purposes administered by SWRCB.

Environmental Consequences

This section identifies and describes potential beneficial and adverse effects on fish species that could result from implementation of the Restoration Project. The analysis is based on the best available information relevant to the proposed changes in the operation of the Hydroelectric Project and modification of its facilities. Feasible mitigation measures are provided for each significant adverse impact to reduce it to a less-than-significant level. Monitoring is also identified for mitigation measures as appropriate.

Assessment species are selected based on listing under the ESA, listing in environmental management plans (e.g., local environmental plans and state resource agency plans), and ecological, economic, or social importance. Information relating changes in environmental conditions to effects on species survival and abundance is most available for chinook salmon and steelhead. Therefore the following assessment provides the greatest detail for factors that may affect chinook salmon and steelhead within the Battle Creek watershed. In addition, the Restoration Project focuses on reestablishing and enhancing the production of winter- and spring-run chinook salmon and steelhead that use habitat in the project area for adult migration, adult holding, spawning, egg incubation, juvenile rearing, and juvenile migration. There is a recognized need to stabilize and increase the populations of these three species in the upper Sacramento River basin, including Battle Creek. When appropriate, discussions include a qualitative and general assessment of the effects on other fish species, including resident fish species.

Summary

The flow and channel dimensions of Battle Creek were modified in the late nineteenth century by development of hydroelectric facilities that included construction of multiple dams and diversions (Reynolds et al. 1980). The primary purpose of the Restoration Project is to reestablish steelhead and winter- and spring-run chinook salmon populations in Battle Creek. Consequently, most of the project impacts on fish and fish habitat are beneficial. The Five Dam Removal, No Dam Removal, Six Dam Removal, and Three Dam Removal Alternatives would restore habitat that could serve to reestablish steelhead and chinook salmon populations, substantially increasing the population abundance of steelhead and winter- and spring-run chinook salmon relative to the No Action Alternative.

Significant adverse impacts on fish and fish habitat in Battle Creek may occur during construction of project elements, including the removal of dams under the Five Dam Removal, Six Dam Removal, and Three Dam Removal Alternatives. The following significant adverse impacts could occur:

- short-term mortality and lowered growth rates and reproductive success of fish and other aquatic species in Battle Creek as a result of accidental spill of petroleum products and other construction-related materials;
- short-term mortality of fish eggs and larvae and reduced reproductive success of fish and other aquatic species as a result of increased fine sediment to Battle Creek from construction activities; and
- short-term mortality of fish eggs and larvae and reduced reproductive success of fish and other aquatic species as a result of removing Eagle Canyon, South, and Coleman Diversion Dams, which would temporarily release stored fine sediment to the stream channel

The adverse impacts would be reduced to less-than-significant levels through development and implementation of toxic materials control and spill response plans, a vegetation protection plan, erosion and sediment control plans, and worker environmental education programs. Work in and near the stream channel, including removal of dams, would be conducted during the dry season to minimize the mobilization of fine sediment (i.e., July–October).

Beneficial impacts would occur through substantially increasing the population abundance of steelhead, spring-run chinook salmon, winter-run chinook salmon, and other species that historically were part of the aquatic community in Battle Creek. There are different levels of performance and certainty for the beneficial impacts derived from each of the four action alternatives, but in general the different levels include:

- increased capacity for spawning and rearing habitat for steelhead and chinook salmon as a result of increased minimum instream flows for various reaches and tributaries;
- increased production of fry and juvenile life stages for steelhead and chinook salmon as a result of cooler water temperatures for various reaches and tributaries;
- increased survival of juvenile fish as a result of decreased flow fluctuations associated with power system operations, resulting from installation of tailrace connectors and flow ramping operations;
- increased survival of adults and increased spawning success as a result of higher instream flows that would improve conditions that facilitate passage of chinook salmon and steelhead over natural barriers;
- increased survival of adults and increased spawning success as a result of removing diversion dams, depending on the alternative, and constructing more effective fish ladders on remaining dams to facilitate passage of chinook salmon and steelhead;
- increased spawning success and fry production as a result of ceasing discharge of North Fork Battle Creek water to South Fork Battle Creek (resulting in reduced straying caused by abnormal olfactory cues and cooler temperatures of mixed water) to facilitate the return of adult chinook salmon and steelhead to natal spawning habitat in North Fork Battle Creek (depending on alternative);
- increased survival of juvenile steelhead and chinook salmon during downstream movement and migration as a result of eliminating some diversions and constructing fish screens on the remaining diversions on Battle Creek; and
- increased food production for fish as a result of increased minimum instream flows.

Detailed analysis and results are presented in the following sections.

Methods

Existing literature and discussions with fish biologists knowledgeable about the project area provided information used to evaluate the environmental consequences of the Proposed Action on fishes and their habitats.

The assessment addresses construction-related impacts and long-term impacts. Construction-related impacts are those effects that occur during or shortly after construction activities, including potential spill of contaminants and input of fine sediment, direct injury to individual organisms, temporary impedance of movement (i.e., migration habitat), and temporary disturbance of the channel bottom and bank. Construction-related impacts are generally of relatively short duration and affect a restricted area, although effects may continue over many years and extend into downstream areas. Long-term impacts include changes to key habitat quantity (as estimated by the Instream Flow Incremental Methodology [IFIM]), this includes a habitat quality component), migration habitat, water temperature, entrainment in diversions, predation, and food. Long-term impacts are associated with permanent and ongoing (e.g., hydropower operations) changes in environmental conditions. The project is not expected to substantially influence existing and ongoing harvest and hatchery effects, factors that currently affect the abundance of steelhead and chinook salmon that was discussed in the affected environment section.

A variety of predictive models on physical and biological parameters have been linked together to provide a relative assessment of fish production indices for each alternative. Many of the inputs to the models require assumptions based on observations taken at many times and places. These observations are broadly simplified in models to examine conditions and fish survival and productivity indices. If the assumptions and inputs to the models are sufficiently representative of actual conditions, and the model is applied equally to all alternatives, the model output is usable for discerning differences among alternatives to meet the needs for NEPA and CEQA. It should be noted that the models contain varying degrees of accuracy and should not be construed as predictive. A key premise of this impact assessment is that the tools applied support the comparison of alternatives based on the available physical and biological information. The water temperature survival indices, flow-habitat relationships, and other elements should not be considered as specific management recommendations or targets for the management of flow, water temperature, or other environmental conditions in Battle Creek or elsewhere in Central Valley rivers.

Key Habitat Quantity

Methods for evaluating key habitat quantity rely on minimum flow requirements for each of the alternatives (for details, see Section 4.3, "Hydrology"). Streamflow directly influences the availability and function of important habitat elements, including water velocity, depth, wetted area, and cover. Flow-habitat relationships for Battle Creek are based on the IFIM and Physical Habitat Simulation (PHABSIM) system (Milhous et al. 1984, Thomas R. Payne and Associates 1998a). Flow-habitat relationships are applied to minimum flow requirements for each alternative to estimate available spawning and rearing habitat area for chinook salmon and steelhead (Appendix F).

The estimated spawning habitat area is used to calculate a fry capacity index—the potential capacity to produce chinook salmon fry and steelhead fry. Fry are young fish that have recently emerged from a redd (a nest constructed by the female fish). The calculation takes into consideration redd size, the number of eggs produced by each female, and an estimated base survival rate.

The estimated rearing habitat area is used to calculate a juvenile capacity index—the potential capacity to produce juvenile chinook salmon and steelhead. Juveniles are young fish that have finished rearing in Battle Creek and are ready to begin downstream migration. The calculation takes into consideration the habitat need of an individual fish. The potential production of juvenile fish cannot exceed the potential number of fry produced (i.e., fry capacity index) or the juvenile capacity index.

Water Temperature

As water temperature increases toward the extremes of the tolerance range of a fish, biological responses, such as impaired growth and risk of disease and predation, are more likely to occur (Myrick and Cech 2001; Sullivan et al. 2000). Acceptable water temperatures identified in the available literature for chinook salmon and steelhead life stages fall within a relatively broad range (See the discussion above, Factors That Affect Abundance of Fish Species—Water Temperature). Conclusive studies of the thermal requirements completed for chinook salmon and steelhead in Central Valley streams are limited (Myrick and Cech 2001), but for the purposes of this impact assessment, survival indices are based on experimental tolerance studies reported in the literature.

Monthly average water temperature was simulated for the minimum flow requirements in each reach of Battle Creek for each alternative (for details, see Section 4.4, “Water Quality”). Temperature survival suitability indices were calculated for chinook salmon and steelhead life stages, including incubation and rearing (Appendix F). The survival indices applied in this assessment support the comparison of alternatives and should not be considered specific management recommendations or targets for water temperature management in Central Valley rivers.

The water temperature assessment builds on the assessment of Key Habitat Quantity discussed above. Temperature-survival relationships are applied to simulated water temperature for each alternative to estimate survival through incubation and rearing. The potential effects of water temperature are presented as production indices for fry and juveniles (Appendix F).

Migration Habitat

Migration habitat includes the specific conditions that support migration of individuals to spawning and rearing habitat, in particular the upstream migration of adult chinook salmon and steelhead. Methods for evaluation of migration habitat are qualitative. Minimum required flows under each alternative are used to assess the potential for impedance of migration. Delay and multiple attempts at passing the dams or natural barriers may reduce the survival of adults because of injury and exhaustion. After failed attempts at passing a dam, adults may spawn downstream of the dams where survival of eggs may be reduced by warmer water temperature.

The effective flow range for fish ladders is used to determine the potential for passage impedance at all dams (Table 4.1-4). For natural barriers (Table 4.1-3), Thomas R. Payne and Associates (1998b) determined flows that would allow fish passage at all low-flow barriers. Flow less than the minimum passage flow are assumed to impede upstream migration. Although the minimum passage flows are based on field observation of potential barriers (Thomas R. Payne and Associates 1998b), the actual impedance of migration is uncertain, and adult steelhead and chinook salmon undoubtedly would pass many of the barriers at lower flows or take advantage of peaks in runoff.

In addition to flow barriers, mixing of North Fork Battle Creek flow with South Fork Battle Creek flow potentially results in false attraction of adult chinook salmon and steelhead from their natal reaches in North Fork Battle Creek. Water temperature in North Fork Battle Creek is cooler than temperature in South Fork Battle Creek. Water temperatures required for spawning and rearing of steelhead and chinook salmon are more likely to be adverse in South Fork Battle Creek, especially from April through October. Reproductive failure of adults that stray to South Fork Battle Creek may reduce the overall year class production for Battle Creek as a whole, depending on the level of habitat saturation in North Fork Battle Creek.

The mechanisms that allow salmonids to home properly generally stem from their ability to recognize the olfactory characteristics of their home stream (Hasler and Scholz 1983). Juvenile salmonids remember, or “imprint on,” the smell of organic compounds that are uniquely characteristic of a given stream or stream reach. When returning to fresh water to spawn, adult salmonids use these odors to locate and return to the stream reach where they were hatched and reared. Homing may be influenced by such factors as flow, water temperature, presence of other salmon, and habitat quality (Pascual and Quinn 1994; Quinn 1984, 1997). For instance, the homing precision of salmon increases with the relative magnitude of streamflow present in the home stream (Hindar 1992).

Evaluation of the potential for false attraction is qualitative. The proportion of the flow in South Fork Battle Creek that comprises flow discharged from North Fork Battle Creek is assumed to indicate the potential for false attraction. False attraction is assumed to increase at higher proportions of North Fork Battle Creek flow.

Entrainment in Diversions

Diversions entrain fish encountering the intake. Fish diverted into the hydropower canals are assumed to suffer total mortality and not contribute to annual production for the species populations in the stream. For reaches upstream of a diversion point, the proportion of production entrained is assumed equal to the proportion of streamflow diverted. Simulated flows and diversions under each alternative (for details, see Section 4.3, "Hydrology") are used to assess the potential entrainment. Fish screens that function at design and performance criteria are expected to avoid most losses of juvenile chinook salmon and steelhead attributable to entrainment and impingement.

Predation, Pathogens, and Food

Analysis of potential effects on predation and pathogens is qualitative. Dams and the associated fish ladders and other facilities are assumed to increase predation above natural levels, potentially increasing the abundance of predators and disorienting prey. Increased abundance of chinook salmon and steelhead is assumed to increase the occurrence of salmonid pathogens in Battle Creek.

Analysis of food effects is similarly qualitative. Prey abundance affects growth rate and the survival of individual fish. Prey abundance may increase with increased stream surface area. The minimum required flows under each alternative (for details, see Section 4.3, "Hydrology") are used to estimate stream surface area and assess relative differences in prey-species production.

Impact Significance Criteria

Impacts are considered significant when project actions potentially reduce the abundance and distribution of the assessed fish species (CEQA State Guidelines Section 15065 and Appendix G). Impacts may occur through:

- change in conditions affecting the movement of any resident or migratory fish species and other aquatic species,
- long- or short-term change in habitat quality or quantity,
- effects on rare or endangered species or habitat of the species, and
- effects on fish communities or species protected by applicable environmental plans and goals.

Significant impacts occur when changes in environmental conditions change the abundance, geographic range, or seasonal timing of any species life stage.

Impact Assessment

Table 4.1-5 summarizes the facility and instream flow modifications proposed for the No Action, Five Dam Removal, No Dam Removal, Six Dam Removal, and Three Dam Removal Alternatives. Impacts associated with each alternative are described in the following sections.

Table 4.1-5. Summary of Facility and Instream Flow Modifications for the No Action and the Proposed Salmon and Steelhead Restoration Alternatives

	Alternative				
Component	NA	5D[1]	ND	6D	3D
Remove Eagle Canyon Diversion Dam and appurtenant facilities				T	T
Remove Wildcat Diversion Dam and appurtenant facilities		T		T	T
Remove South Diversion Dam and appurtenant facilities		T		T	
Remove Soap Creek Diversion Dam and appurtenant facilities		T		T	
Increase releases at all Battle Creek dams not removed to levels per MOU		T		T	
Increase releases at all Battle Creek dams not removed to levels per AFRP			T		T
Remove Lower Ripley Creek Diversion Dam and facilities		T		T	
Remove Coleman Diversion Dam and appurtenant facilities		T		T	T
Provide water below dam sites on Soap and Lower Ripley Creeks		T			
Reoperate and gage Asbury Dam		T		T	T
Provide water below Asbury Diversion Dam		T		T	T
Redirect cold water from spring complexes from canals to adjacent creek reaches		T		T	T[2]
Maintain and replace, as needed all fish ladders on dams	T	T	T	T	T
Construct North Battle Creek Feeder Diversion Dam fish screen and fish ladder		T	T	T	T
Construct Eagle Canyon Diversion Dam fish screen and fish ladder		T	T		
Construct Wildcat Diversion Dam fish screen and fish ladder			T		
Construct South Diversion Dam fish screen and fish ladder			T		T
Construct Inskip Diversion Dam fish screen and fish ladder		T	T	T	T
Construct Coleman Diversion Dam fish screen and fish ladder			T		
Screen and ladder designs meet failsafe definition in MOU		T	T	T	T
Construct tailrace connector between South Powerhouse and Inskip Canal		T		T	
Construct channel to separate South Powerhouse tailrace waters from the stream					T
Construct tailrace connector between Inskip Powerhouse and Coleman Canal		T		T	T
Construct Inskip Powerhouse bypass facility		T		T	
Provide ramping rate during operations reducing flows below dams		T	T	T	T

Component	Alternative				
	NA	5D[1]	ND	6D	3D

Notes:
[1] The Five Dam Removal Alternative is the Proposed Action as developed in the MOU.
[2] Includes only springs at Eagle Canyon.
NA = No Action Alternative
5D = Five Dam Removal Alternative
ND = No Dam Removal Alternative
6D = Six Dam Removal Alternative
3D = Three Dam Removal Alternative.

No Action Alternative

Under the No Action Alternative, the facilities and operations (Table 4.1-5) are assumed to abide by the conditions of the current FERC license. As part of the FERC license, fish ladders would be maintained and operated in accordance with all applicable and relevant regulations, and the existing minimum flows would continue to be provided.

The No Action Alternative does not meet the underlying purpose of and need for the Restoration Project. Without the Restoration Project, it is expected that Battle Creek would continue to support relatively low numbers of anadromous salmonids as observed in the past. The steelhead and chinook salmon produced in Battle Creek would not be expected to contribute to the population and recovery goals for the upper Sacramento River basin as a whole.

Construction-Related Effects

Construction of new facilities and removal of existing facilities are not proposed under the No Action Alternative, and fish species would not be affected.

Long-Term and Ongoing Effects

Long-term and ongoing effects fall into five categories: key habitat quantity, water temperature, migration habitat, entrainment in diversions, and predation, pathogens, and food.

Key Habitat Quantity and Predicted Fish Capacity Indices. Based on flow-habitat relationships, the minimum flow required under the No Action Alternative (i.e., FERC license-required minimum flows) potentially supports spawning habitat area with a capacity index of approximately 760,000 fry, depending on the species (see the Methods section for more information on the model output for fry capacity indices and its limitations). Figures 4.1-2 through 4.1-5 show the capacity indices for each reach of North Fork and South Fork Battle Creek under all alternatives. Habitat areas used to calculate capacity are discussed in Appendix F

Minimum flow requirements under the No Action Alternative support rearing habitat with a capacity index of approximately 360,000 juveniles, depending on the species, as shown on Figures 4.1-6 through 4.1-9. The capacity index for fry exceeds the capacity index for juveniles, indicating that surplus fry could be produced in years when the abundance of adults is sufficient to use all available spawning habitat. A surplus of fry, however, assumes that other environmental conditions would not substantially reduce fry production (i.e., see the assessment of water temperature effects described below).

The number of fry and juveniles indicated in Figures 4.1-2 through 4.1-9 reflects the assumption that adult steelhead can access all reaches and that chinook salmon can access all reaches except Keswick. An assessment of access to the reaches is provided in a following section (Migration Habitat). Late fall–run chinook salmon may be limited primarily to reaches downstream of Wildcat and Coleman Diversion Dams; therefore, the capacity indices may be overestimated. Including the capacity represented by the mainstem, Coleman, and Wildcat reaches might be a better estimate of expected capacity indices. Although some fall-run chinook salmon spawn in Battle Creek upstream of Coleman National Fish Hatchery, capacity indices are not simulated because current management objectives include blocking fall-run chinook salmon at the hatchery weir. Capacity indices of fall-run chinook salmon would likely be similar in magnitude and pattern to the indices represented by late fall–run chinook salmon (Figures 4.1-6 and 4.1-9).

Limited information is available for flow-habitat relationships on Soap, Ripley, and Baldwin Creeks. However, the FERC license–required minimum flow of 0 cfs would not provide sufficient water to support fish. Occurrence of fish in the reaches below the diversion dams on these streams is limited under the No Action Alternative.

Water Temperature. The water temperature assessment uses the capacity to produce fry and juvenile life stages identified in the assessment of key habitat quantity (see above). The potential effects of water temperature under the No Action Alternative are presented for fry and juveniles for the minimum flow requirements under each alternative (Figures 4.1-2 through 4.1-5 and Figures 4.1-6 through 4.1-9). Water temperatures that potentially occur in Battle Creek reduce the capacity indices of fry and juveniles.

Estimated survival for steelhead fry is relatively high, as indicated by 78% survival attributable to water temperature conditions during the incubation period (Table 4.1-6). Water temperature effects on spring- and winter-run chinook salmon are substantially more severe, with as little as 20% survival for spring-run fry and 5% survival for winter-run fry. The increased severity is attributable to the timing of spawning for spring- and winter-run chinook salmon that coincides with warmer water temperatures.

Estimated survival for juvenile steelhead is lower than the survival estimated for fry because juvenile steelhead rear through the warm summer months (Table 4.1-6). Approximately 44% of the steelhead fry production are estimated to survive as a result of water temperature conditions during the juvenile rearing period. Water temperature effects on juvenile spring-run chinook salmon are less than effects described for juvenile steelhead because rearing occurs in cooler months.

Expected survival attributable to water temperature effects could be substantially less than indicated. Two factors could result in warmer water temperatures and lower survival of fry and juveniles.

- Digger Creek inflow may have biased the water temperature data used for calibration of the water temperature model. The model may predict cooler water temperature and higher survival than would actually occur, resulting in overstatement of fry and juvenile production indices. This is especially true for the No Action Alternative because low minimum flow requirements could result in greater warming between North Battle Creek Feeder and Eagle Canyon Diversion Dams.
- Cool water temperatures below Inskip and Coleman Diversion Dams are dependent on discharge of cool North Fork Battle Creek water into warmer South Fork Battle Creek flow. Failure of the canal and powerhouse facilities could interrupt the discharge of North Fork Battle Creek water and result in warming of Inskip and Coleman reaches. Warmer water temperatures would reduce survival and result in lower fry and juvenile production indices for steelhead and chinook salmon.

Migration Habitat. The minimum flows required (i.e., existing FERC license flows) below the diversion dams in the steeper elevation reaches of the North Fork and South Fork Battle Creek result in conditions that impede passage of adult chinook salmon and steelhead. Passage over dams and natural barriers, as identified previously (Tables 4.1-3 and 4.1-4), is facilitated by flow in excess of the minimum effective flow and, for dams, less than the maximum effective flow. Barriers may impede passage of adult steelhead and chinook salmon under the No Action Alternative (Table 4.1-7). Impeded passage may result in lower survival of adults, minimal use of upstream spawning habitat, and spawning in locations supporting lower egg survival. Impeded passage occurs relatively far downstream under the No Action Alternative, indicating the potential of limited habitat access.

Although fish ladders on existing diversion dams would be maintained and replaced as needed under the No Action Alternative, the effective flow range for existing fish ladders at all dams except South Diversion Dam is between 2 and 7 cfs (Table 4.1-4). The ladder at South Diversion Dam has an effective flow range between 3 and 35 cfs. Flow less than 3 cfs and in excess of 35 cfs is assumed to impede passage. Fish ladders potentially impede passage of adult steelhead and chinook salmon at higher flows. The existing fish ladders are also susceptible to obstruction by debris and can be maintained only during low streamflows. Debris and maintenance issues may further impede passage of fish.

Under the No Action Alternative, flow diverted from North Fork Battle Creek is discharged into South Fork Battle Creek at South and Inskip Powerhouses. North Fork Battle Creek discharge mixes with the South Fork Battle Creek flow, resulting in a relatively high proportion of North Fork Battle Creek flow continuing downstream in the South Fork channel (Table 4.1-8). The presence of significant North Fork Battle Creek water in South Fork Battle Creek potentially increases the false attraction of North Fork chinook salmon and steelhead. Environmental conditions in South Fork Battle Creek (e.g., water temperature) support lower production of chinook salmon and steelhead than environmental conditions in North Fork Battle Creek. False attraction could result in lower overall production. The potential for increased false attraction is currently unknown, given that adults returning to their natal reach may be able to distinguish the correct pathway.

In addition to false attraction, the discharge of cool water at Inskip and Coleman Diversion Dams may cause winter- and spring-run chinook salmon to break off their upstream migration. The gradient of warm to cool water temperatures from downstream to upstream may be a primary cue for migration to natal spawning areas. Winter- and spring-run chinook salmon may not move to cool reaches upstream of South Diversion Dam and may hold and spawn downstream of Coleman and Inskip Diversion Dams. Failure of the canal and powerhouse facilities could interrupt the discharge of North Fork Battle Creek water and result in warming of Inskip and Coleman reaches. Warmer water temperatures could substantially reduce adult and egg survival, resulting in lower fry production.

Entrainment in Diversions. Diversions occur at North Battle Creek Feeder, Eagle Canyon, Wildcat, South, Inskip, and Coleman Diversion Dams. The proportion of flow diverted under the No Action Alternative is as high as 97% in some months (Table 4.1-9). The diversion fraction depends on the monthly flow and the monthly diversion (Section 4.3, "Hydrology"). The modeling has shown results for five levels of monthly flows, corresponding to each 20% increment of possible future flows during each month. These values are shown in Appendix L. The diversion flow was divided by the sum of the diversion flow and the flow released below the diversion dam to calculate the percentage of flow diverted at the dam (Table 4.1-9). Diversions entrain fish encountering the intake. Fish diverted into the hydropower canals are assumed to suffer total mortality and not contribute to annual production for the species populations in the stream. Under the No Action Alternative, most of the production of steelhead and chinook salmon would be lost to entrainment in diversions, especially during dryer years.

Predation, Pathogens, and Food. The existing dams and the associated fish ladders and other facilities are assumed to maintain predation above levels that would occur in the absence of dams. Juveniles passing over the dams are potentially disoriented by turbulent flow conditions. In addition, the dams may stop the upstream migration of predatory species, such as pikeminnow. Concentration of pikeminnow below the diversion dams coincident with the downstream migration of juvenile salmonids could increase predation losses. The potential effect on steelhead, chinook salmon, and other species, however, is unknown.

Prey abundance affects growth rate and the survival of individual fish. Prey abundance may be dependent on stream surface area and the associated primary productivity. The summer stream area under the No Action Alternative is approximately 109 acres (Table 4.1-10).

Five Dam Removal Alternative (Proposed Action)

The Five Dam Removal Alternative proposes to reoperate and modify the hydropower facilities on North Fork and South Fork Battle Creek and three of its minor tributaries: Soap, Ripley, and Baldwin Creeks (Table 4.1-5). Reoperation would increase and stabilize streamflow for the purpose of significantly increasing cold water and stream area and providing a reliable migratory pathway over obstacles in the project area.

The Five Dam Removal Alternative proposes to modify the facilities at remaining diversion dams to substantially improve the reliability and effectiveness of upstream and downstream fish passage (Table 4.1-5). New fish screens and fish ladders that meet NOAA Fisheries and DFG criteria would be constructed at three diversion dams (North Battle Creek Feeder, Eagle Canyon, and Inskip Diversion Dams). Five diversion dams would be removed (Wildcat, South, Coleman, Soap Creek Feeder, and Lower Ripley Creek Feeder Diversion Dams). Connectors are proposed that prevent the discharge of North Fork Battle Creek water to South Fork Battle Creek and the mixing of flow sources. Higher minimum flow requirements (i.e., MOU minimum flow requirements) would increase instream flows, subsequently cooling water temperature, increasing stream area, and providing reliable passage conditions for adult salmonids in downstream reaches. In addition, the MOU minimum flow requirements support future adaptive management that may incorporate new information related to flows needed to facilitate passage, increase habitat area, and improve water temperature conditions.

Construction-Related Effects

Short-term construction-related effects fall into four categories: key habitat quantity, migration habitat, contaminants, and direct injury.

Impact 4.1-1 Significant—Mortality and lowered growth rates and reproductive success of fish and other aquatic species in Battle Creek from an accidental spill of petroleum products and other construction-related materials (contaminants). Construction activities associated with removing the five dams would include dismantling and removing Wildcat, South, Coleman, Soap Creek Feeder, and Lower Ripley Creek Feeder Diversion Dams and their appurtenant facilities. Heavy equipment would be used in the channel to remove the concrete structure, gravel, rock, and other materials from the dam footprint. Construction of the fish screens and ladders would involve blasting and dismantling the existing structures and constructing new facilities. Construction of the Inskip Powerhouse bypass facility and the tailrace connectors at South and Inskip Powerhouses would include the use of heavy equipment. The use of heavy equipment in and near the stream channel would increase the potential for an accidental spill of petroleum products, concrete wash, and other construction-related materials into the channel.

Depending on the volume of petroleum products and other construction-related contaminants entering the stream, growth, reproduction, and survival could be adversely affected. The impact of contaminant spill is significant because the abundance of steelhead, spring-run chinook salmon, and other fish and aquatic life could be substantially reduced. Effects on population abundance and aquatic species diversity could be short term or could continue over several years. Implementing the following mitigation measures would reduce the impact to less-than-significant levels.

Mitigation Measures for Impact 4.1-1. Significant impacts attributable to accidental spill of petroleum products will be reduced to less-than-significant levels by requiring contractors to develop and implement toxic materials control and spill response plans. Toxic materials control and spill response plans will regulate the use of hazardous materials, such as petroleum-based products used as fuel and lubricants for equipment and other potentially toxic materials associated with project construction. Reclamation would implement a construction-area fish management program to emphasize the importance of protecting chinook salmon and steelhead trout and their habitat.

Impact 4.1-2 Significant—Mortality of fish eggs and larvae and reduced reproductive success of fish and other aquatic species because of increased sedimentation to North Fork and South Fork Battle Creek as a result of construction activities (contaminants). Construction activities would mobilize fine sediments through direct disturbance and increased erosion. Input of fine sediment to the stream could infiltrate gravel substrates and adversely affect the quality of spawning habitat for steelhead and chinook salmon. The occurrence of fine sediment in spawning gravel in excess of 30% substantially increases the mortality of eggs and larvae of chinook salmon and steelhead (Reiser and Bjornn 1979). Deposition of fine sediment on occupied redds would fill interstitial spaces between gravel and cobble substrates, inhibiting the flow of oxygen-rich water to the embryos and impeding the ability of larval fish to exit the redd after hatching. The impact of fine sediment is significant because the abundance of steelhead and spring-run chinook salmon could be substantially reduced. Effects on population abundance and aquatic species diversity could be short term or could continue over several years, depending on the extent and duration of fine sediment input and on flow conditions that mobilize and transport fine sediment through the stream ecosystem. Infiltration of fine sediment into gravel would also adversely affect habitat for other aquatic species, such as aquatic insects that live in gravel and that provide food for fish. Implementing the following mitigation measures would reduce this impact to a less-than-significant level.

Mitigation Measures for Impact 4.1-2. Significant impacts attributable to mobilization of fine sediments would be reduced to less-than-significant levels by requiring contractors to develop a vegetation protection plan (Section 4.2, “Botanical, Wetland, and Wildlife Resources”) and erosion and sediment control plans (Section 4.7, “Geology and Soils”). Contractors will be required to develop and implement a vegetation protection plan to protect vegetation during construction. Contractors will also be required to develop and implement an erosion and sediment control plan to minimize the potential for sediment input to the aquatic system. The plans will include Best Management Practices (BMPs) to control sediment discharge during construction of roads and excavation and other activities in the stream channel during installation of fish screens and fish ladders and during dam removal. A worker environmental education program will be implemented by Reclamation to emphasize the importance of protecting chinook salmon and steelhead trout and their habitat from construction-related impacts.

Impact 4.1-3 Significant—Mortality of fish eggs and larvae and reduced reproductive success of fish and other aquatic species as a result of removing South, Coleman, and Eagle Canyon Diversion Dams, which would release currently stored fine sediment to the stream channel (contaminants). The removal of South, Coleman, and Eagle Canyon Diversion Dams would release sediment currently stored behind the dams. The volume and type of sediment stored behind the dams varies, with 30,000 yd^3 at South Diversion Dam and 28,000 yd^3 at Coleman Diversion Dam. Eagle Canyon Diversion Dam is relatively small and would not release substantial sediment. Removal of the dams potentially increases the input of fine sediment to the stream channel. The input of fine sediment would increase turbidity and sedimentation of gravel substrates. Increased turbidity could adversely affect feeding efficiency of juvenile steelhead and chinook salmon and other species dependent on sight in locating prey. The impact of increased turbidity would be relatively minor because the effect would be temporary. Sedimentation of gravel, however, would be a significant impact.

This impact is similar to that described above for Impact 4.1-2. Implementing the following mitigation measure would reduce this impact to a less-than-significant level.

Mitigation Measures for Impact 4.1-3. Reclamation will remove diversion dams during low-flow conditions (July–October) to minimize the downstream transport of fine sediment. Fine sediment would subsequently be mobilized and transported by higher flows during winter storms, minimizing deposition in gravel substrates and potential adverse effects on egg and larvae of chinook salmon and steelhead and other aquatic organisms dependent on clean gravel.

Impact 4.1-4 Less than significant—Disturbed steelhead and chinook salmon habitat in the stream channel as a result of construction activities (key habitat quantity). Construction activities associated with removing the five dams would include dismantling and removing Wildcat, South, Coleman, Soap Creek Feeder, and Lower Ripley Creek Feeder Diversion Dams and their appurtenant facilities. Construction of the tailrace connectors between South Powerhouse and Inskip Canal and between Inskip Powerhouse and Coleman Canal would also include work in the stream channel. Heavy equipment would be used in the stream channel to remove the concrete structure, gravel, rock, and other materials from the dam footprint or to prepare the site for construction of facilities. To a lesser degree, construction of fish screens and fish ladders at North Battle Creek Feeder, Eagle Canyon, and Inskip Diversion Dams would also disturb the channel bottom and bank.

The disturbance of the channel bottom and bank would alter the channel dimensions and form and the existing substrate. The changes in the channel may adversely affect conditions supporting spawning and rearing habitat (i.e., removal of gravel or changes in depth and velocity). This impact is considered less than significant because the affected spawning and rearing habitat area is small relative to total spawning and rearing habitat in Battle Creek; existing channel structure and substrate at these locations do not currently provide spawning and rearing habitat; and some of the affected areas would provide spawning and rearing habitat after construction is complete. No mitigation is required.

Impact 4.1-5 Less than significant—Disrupted movement and migration of fish species as a result of dewatering portions of the stream channel and temporarily removing fish ladders during construction (migration habitat). Construction activities within the stream channel may include placement of cofferdams to isolate constructed elements from the streamflow and temporary removal of existing fish ladders. Depth and velocity conditions that support movement and migration of fish species may be interrupted temporarily. This impact is considered less than significant because upstream passage of anadromous salmonids is currently blocked at Eagle Canyon and Coleman Diversion Dams. Although in-channel work will also occur at Wildcat Diversion Dam, which is downstream of Eagle Canyon Diversion Dam, removal of the existing dam is not expected to affect a substantial proportion of the migration period. This impact is considered less than significant. No mitigation is required.

Impact 4.1-6 Less than significant—Compromised feeding efficiency of sight-feeding fish from erosion and the input of fine sediment as a result of construction and demolition activities (contaminants). Vegetation would be removed and the soil would be graded in order to construct staging areas and new roads and expand existing roads in the project area. Construction and demolition activities adjacent to or in the flowing waters of Battle Creek and its tributaries would disturb soils and the streambed, potentially leading to erosion and input of fine sediment. The input of fine sediment would increase turbidity and sedimentation of gravel substrates. Increased turbidity could adversely affect feeding efficiency of juvenile steelhead and chinook salmon and other species dependent on sight to locate prey. The impact of increased turbidity is considered less than significant because the effect would be temporary. No mitigation is required.

Impact 4.1-7 Less than significant—Vulnerability of all life stages of fish to injury or mortality from percussion-related energy shock waves, operation of equipment, and becoming trapped in isolated pockets of water during construction activities (direct injury). Removal of the five diversion dams; construction of the Inskip Powerhouse bypass facility; construction of the tailrace connectors between South Powerhouse and Inskip Canal, and between Inskip Powerhouse and Coleman

Canal; and the construction of the fish screens and fish ladders at Eagle Canyon and Inskip Diversion Dams could physically injure and kill eggs, larvae, and juvenile fish. During incubation salmonid embryos are immobile and sensitive to percussion-related energy shock waves. During construction of fish facilities and demolition of dams, equipment may be operated in the streambed, potentially crushing incubating eggs, larvae, and juvenile fish that may be present.

The construction of access roads, trenches, and foundations for fish facilities and demolition of water management facilities may all require blasting of the bedrock common throughout the project area. Percussion-related shock waves created during these construction and deconstruction activities could cause mortality to chinook salmon and steelhead trout eggs incubating in the gravel. Juvenile fish may also be affected.

Cofferdams would be installed to divert flow and isolate the in-channel construction area from the main streamflow. Placement of cofferdams in the stream channel could trap salmonids and other fish species. Fish that become trapped in isolated pockets of water could be killed during desiccation of the construction area and construction activities.

Field surveys in the project area have revealed that chinook salmon and steelhead spawning and rearing habitat exists immediately below each diversion dam where construction activities are anticipated to occur. This impact is considered less than significant because the affected spawning and rearing habitat area is small relative to total spawning and rearing habitat in Battle Creek, construction will occur over a relatively short period of time, and measures will be implemented to exclude spawning within the construction foot print (see the general environmental protection measures listed in the introduction to this chapter, Section 4.0). In addition, salmon and steelhead access is currently being temporarily confined to the Restoration Project area downstream of Coleman and Eagle Canyon Diversion Dams (NOAA Fisheries, DFG, USFWS pers. comm.). No mitigation is required.

Long-Term and Ongoing Effects

Long-term and ongoing effects fall into five categories: key habitat quantity; water temperature; migration habitat; entrainment in diversions; and predation, pathogens, and food.

Impact 4.1-8 Less than significant—Reduced habitat and range of some resident warmwater species because of cooler water temperatures (water temperature). Cooler water temperatures, especially in the mainstem of Battle Creek, would reduce the linear extent of habitat area available to warmwater fish species currently found in Battle Creek (e.g., smallmouth bass, green sunfish, and Sacramento pikeminnow). The range of some resident warmwater species will be reduced. The impact is considered less than significant because the affected warmwater species are relatively abundant and found throughout the Central Valley; habitat area and quality may increase for all species in response to increased flow and increased productivity; and reestablishment of higher flows is consistent with restoration of conditions that existed prior to construction and operation of the Hydroelectric Project on Battle Creek. No mitigation is required.

Impact 4.1-9 Less than significant—Decreased rainbow trout abundance in canals as a result of eliminating some diversions and constructing effective fish screens at three dams (migration habitat). The extensive canal system for the hydropower facilities, including Cross Country Canal, South Canal, Union Canal, Inskip Canal, Eagle Canyon Canal, and Coleman Canal, supports juvenile and adult rainbow trout and other species (DFG 1966). Spawning habitat for rainbow trout within the canals is limited. The abundance of rainbow trout in the canals is dependent on entrainment of juvenile and adult rainbow trout from Battle Creek. Entrainment would continue to maintain rainbow trout abundance in the canals under the No Action Alternative but would not continue under the Five Dam Removal Alternative. The cessation of diversion at South, Coleman, and Wildcat Diversion Dams and the construction of effective fish screens at Inskip, North Battle Creek Feeder, and Eagle Canyon Diversion Dams (Table 4.1-5) would stop entrainment of rainbow trout. Rainbow trout abundance would likely be substantially less under the Five Dam Removal Alternative than under the No Action Alternative.

The adverse impact of reduced rainbow trout abundance in the canals is considered less than significant because the populations in the canals are not self-sustaining, and draining of the canals for maintenance periodically eliminates most of the rainbow trout from the canals. Most fish stranded in drained canals are rescued and released to Battle Creek. No mitigation is required. The substantial benefit of dam removal and fish screens to production of juvenile chinook salmon and steelhead (i.e., the anadromous form of rainbow trout) in Battle Creek is discussed in detail in the following section.

Impact 4.1-10 Less than significant—Increased exposure of rainbow trout to pathogens because of the increase of chinook salmon and steelhead in Battle Creek (predation, pathogens, and food). As indicated above, the Five Dam Removal Alternative would substantially increase the abundance of chinook salmon and steelhead in Battle Creek. The number of adult steelhead and chinook salmon spawning in Battle Creek may increase to several thousand adults, at least several times the abundance expected under the No Action Alternative. Increased abundance of chinook salmon and steelhead and occurrence upstream of Eagle Canyon, North Battle Creek Feeder, and Inskip Diversion Dams potentially increases the occurrence of pathogens in those reaches and in the water diverted from South Fork and North Fork Battle Creek. Rainbow trout populations in Battle Creek and the canals conveying Battle Creek diversions will have increased exposure to the pathogens, and the occurrence of pathogens in rainbow trout would potentially increase. Rainbow trout populations coexist with anadromous fish populations in the Sacramento River and other Central Valley Rivers. Therefore, the potential effects of increased occurrence of pathogens on rainbow trout in Battle Creek and the canals would likely be less than significant. No mitigation is required. Within aquaculture facilities, however, effects of pathogens may be amplified because of confined conditions. Effects of pathogens on rainbow trout raised by fish farms is discussed in Chapter 4.16 under Socioeconomics.

Impact 4.1-11 Beneficial—Substantially increased capacity indices for spawning and rearing of steelhead and chinook salmon resulting from increased minimum instream flows (key habitat quantity). The Five Dam Removal Alternative would increase the minimum instream flows in multiple reaches of Battle Creek (i.e., MOU minimum flow requirements). The increased flow would increase spawning and rearing habitat area, potentially increasing the capacity to produce additional fry and juvenile salmonids relative to the No Action Alternative. In addition, the MOU minimum flow requirements support future adaptive management of flow targets that may incorporate new information on flow-habitat relationships.

The increased spawning and rearing habitat area would be expected to increase the abundance of steelhead and spring-, winter-, and late fall–run chinook salmon through increased capacity for fry and juvenile life stages. Based on flow-habitat relationships, the flow under the Five Dam Removal Alternative potentially supports spawning habitat area with capacity index of 6.1 million fry, depending on the species (Figures 4.1-2 through 4.1-5). The fry production indices for all species under the Five Dam Removal Alternative are several times greater than indices for the No Action Alternative.

Similarly, flows under the Five Dam Removal Alternative support rearing habitat with a capacity index greater than 1.5 million juveniles, depending on the species (Figures 4.1-6 through 4.1-9). The juvenile capacity indices for the Five Dam Removal Alternative are, for most species, several times greater than indices for the No Action Alternative.

The increase in capacity indices is substantial relative to capacity indices under the No Action Alternative. Habitat capacity for fry exceeds the habitat capacity for juveniles, indicating that surplus fry could be produced in years when the abundance of adults is sufficient to use all available spawning habitat. A surplus of fry, however, assumes that other environmental conditions would not substantially reduce the production indices (i.e., see the assessment of water temperature effects described below).

Limited information is available for flow-habitat relationships on Soap, Ripley, and Baldwin Creeks. The removal of dams on Soap and Ripley Creeks and the substantial increase in minimum flow (i.e., greater than zero), would provide habitat that would support additional steelhead and possibly chinook salmon, contributing to the beneficial impact identified above. Although the contribution cannot be quantified, the increased flow would provide spawning and rearing habitat for salmonids that does not exist under the No Action Alternative, especially for steelhead (DFG file correspondence by Terry Healy, 1998, Redding, CA).

Soap Creek has a series of large cold springs that support a stable cold year-round flow. A self-sustaining rainbow trout population has been documented in a tributary to Soap Creek above the dam (DFG file correspondence by Douglas Parkinson, 1984, Redding, CA). In addition to habitat upstream of the Soap Creek Feeder Diversion Dam, approximately ¾ mile of habitat will become accessible to steelhead from the confluence of Battle Creek to the existing dam.

A small spring maintains a flow of approximately 3 cfs upstream of the dam on Ripley Creek. Within the upper Sacramento River basin, rainbow trout are known to use small tributaries like Ripley Creek in the wet season for spawning and rearing before the stream warms in the summer months. During the wet season, flow would provide habitat for spawning and rearing. With removal of the dam on Ripley Creek, more than a mile of stream would be accessible.

Baldwin Creek extends ¾ mile from Battle Creek to Asbury Dam. Flow released from Asbury Dam is contributed by Darrah Creek, a major cold spring–fed tributary. Flow below Asbury Dam in Baldwin Creek would provide rearing habitat for salmonids during the summer and during the wet season when spawning occurs.

Reestablishing higher streamflow under the Five Dam Removal Alternative benefits other species, including resident fish, aquatic invertebrates, amphibians and stream-dependent wildlife. Greater stream area potentially provides greater habitat area for other fish and other aquatic species. This impact is considered beneficial. No mitigation is required.

Impact 4.1-12 Beneficial—Substantially increased production indices for fry and juvenile life stages for steelhead and chinook salmon as a result of cooler water temperatures (water temperature). The water temperature assessment uses the capacity indices for fry and juvenile life stages identified in the assessment of key habitat quantity above. Increased flows (i.e., MOU minimum flow requirements) and subsequent cooler water temperature associated with the Five Dam Removal Alternative during the late spring, summer, and early fall months could substantially increase salmonid survival relative to survival under the No Action Alternative. Soap Creek inflow would also increase under the Five Dam Removal Alternative. The flow originates from cold springs and could further increase water temperature benefits in the South Fork of Battle Creek. Any additional benefit from Soap Creek inflow cannot be calculated from the available information. In addition, the MOU minimum flow requirements support future adaptive management of water temperature that may incorporate new information on water temperature needs during incubation and rearing life stages.

The increased production indices for fry and juvenile life stages under the Proposed Action would be expected to increase the abundance of steelhead and spring-, winter-, and late fall–run chinook salmon. The potential increase in production indices for fry and juvenile steelhead and chinook salmon in response to cooler water temperature under the Five Dam Removal Alternative would be substantial (Figures 4.1-2 through 4.1-5 and Figures 4.1-6 through 4.1-9, respectively).

The expected increase in survival of steelhead fry is substantial compared to the No Action Alternative (i.e., greater than 10 %) (Table 4.1-6). Juvenile steelhead survival is expected to increase by 30% relative to the No Action Alternative. Water temperature effects on spring- and winter-run chinook salmon also would be substantially beneficial. Survival of spring-run fry would increase by 8%, and juvenile survival by 40%. Survival of winter-run fry would increase by 7%, and juvenile survival by 2%. Late fall–run survival is less affected by water temperature than the other chinook salmon runs because spawning occurs in the winter. Winter- and spring-run chinook salmon would receive the most temperature benefits from increased flows and cool water accretions because spawning occurs during warmer months. This impact is considered beneficial. No mitigation is required.

Impact 4.1-13 Beneficial—Increased survival of adults and increased spawning success because higher instream flows would improve conditions that facilitate passage of chinook salmon and steelhead over natural barriers (migration habitat). The Five Dam Removal Alternative would increase the minimum flows (i.e., MOU minimum flow requirements) in multiple reaches of Battle Creek relative to the No Action Alternative (i.e., FERC minimum flow requirements). The increased minimum flow would improve passage conditions over natural barriers, facilitating upstream habitat use and increasing survival and spawning success of adult chinook salmon and steelhead. In addition, the MOU minimum flow requirements support future adaptive management of passage conditions that may incorporate new information on flow-passage relationships.

The maintenance of higher flows would improve passage conditions, substantially increasing unimpeded access to upstream spawning habitat (Table 4.1-7). Although the precise benefit of higher flows may not be illustrated by the required minimum flow, survival of adult chinook salmon and steelhead would increase because of reduced potential for injury and exhaustion related to multiple attempts at passing partial barriers. Improved passage would also facilitate distribution of adults to available upstream spawning habitat that could increase survival of eggs and production of fry.

Impact 4.1-14 Beneficial—Increased survival of adults and increased spawning success because removal of five dams and the construction of more reliable effective fish ladders would facilitate passage of chinook salmon and steelhead (migration habitat). Removal of Wildcat, Coleman, Soap Creek Feeder, Lower Ripley Creek Feeder, and South Diversion Dams under the Five Dam Removal Alternative and construction of improved fish ladders on North Battle Creek Feeder, Eagle Canyon, and Inskip Diversion Dams would provide significantly greater upstream passage efficiency relative to passage conditions provided in the No Action Alternative. The removal of dams and construction of ladders would substantially increase unimpeded access to upstream spawning habitat. Survival of adult chinook salmon and steelhead would increase because of reduced potential for injury and exhaustion related to multiple attempts at passing the dams. Improved passage would also facilitate distribution of adults to available upstream spawning habitat that could increase survival of eggs and production indices for fry.

The removal of dams and construction of more effective fish ladders under the Five Dam Removal Alternative would improve passage conditions for adult chinook salmon and steelhead. The proposed ladder capacity would be at least 10 times the capacity of existing ladders (Table 4.1-4). The ladders would be designed to convey 110% of the streamflow at average spill conditions for each diversion dam and facilitate adult passage under nearly all flow conditions. Where necessary, additional flow would be directed to facilitate attraction of adult salmonids into the ladder, minimizing delay associated with flow spilling over the dam. The new fish ladders would be designed to automatically clear debris and include safe maintenance access under all streamflow conditions. Detailed monitoring and operation and maintenance plans for the proposed ladders under the Five Dam Removal Alternative are included in this document for review (Appendix D). This impact is considered beneficial. No mitigation is required.

Impact 4.1-15 Beneficial—Potentially increased spawning success and fry production because eliminating the discharge of North Fork Battle Creek water to South Fork Battle Creek would facilitate the return of adult chinook salmon and steelhead to natal spawning habitat in South Fork and North Fork Battle Creek (migration habitat). Ceasing the discharge of North Fork Battle Creek water to South Fork Battle Creek would minimize the potential for increased false attraction to South Fork Battle Creek that exists under the No Action Alternative. The effect on population abundance is unknown, however, because the potential level of false attraction is uncertain given that adult chinook salmon and steelhead may be able to distinguish the correct pathway. Although the stream of origin is unknown, false attraction of winter-run chinook salmon to the South Fork is supported by observation of spawning below Coleman Diversion Dam (DFG 1966). Incubation of winter-run chinook salmon eggs is not supported by the warm summer water temperatures in this reach. Environmental conditions in South Fork Battle Creek (e.g., water temperature) support lower production indices for chinook salmon and steelhead than environmental conditions in North Fork Battle Creek. False attraction could result in lower overall production for the Battle Creek watershed.

With cessation of the discharge of North Fork Battle Creek water into the South Fork Battle Creek at Inskip and Coleman Diversion Dams, the gradient of warm to cool water temperatures from downstream to upstream would be restored. The restoration of the gradient may help ensure movement of adult winter- and spring-run chinook salmon to cool reaches upstream of South Diversion Dam. Flow and water temperature fluctuations that may occur during powerhouse outages would be minimized, and warming of Inskip and Coleman reaches would no longer occur. Successful adult holding and egg survival may be more consistently supported upstream of South Diversion Dam.

Under the Five Dam Removal Alternative, tailrace connectors would be constructed between South Powerhouse and Inskip Canal and between Inskip Powerhouse and Coleman Canal. Water delivered to South and Inskip Powerhouses originates from three locations in the North Fork Battle Creek watershed (i.e., Volta 2 Powerhouse, North Battle Creek Feeder Diversion Dam, and Eagle Canyon Diversion Dam). Flow diverted from North Battle Creek Feeder Diversion Dam would no longer be discharged into South Fork Battle Creek at South and Inskip Powerhouses. The absence of significant North Fork Battle Creek water in South Fork Battle Creek would facilitate return of adult chinook salmon and steelhead to natal spawning habitat in South Fork and North Fork Battle Creek. This impact on fish is considered beneficial. No mitigation is required.

Under the No Action Alternative, powerhouse outages result in canal flow spilling down natural pathways to enter South Fork Battle Creek near the existing powerhouses. The outage and subsequent canal spill cause short-term disruptions of flow to short segments of stream channel between the existing powerhouses and the canal intakes. In addition, the overland flow may warm the water temperature, depending on the weather during the outage.

Under the Five Dam Removal Alternative, tailrace connectors constructed between South Powerhouse and Inskip Canal and between Inskip Powerhouse and Coleman Canal and the Inskip bypass facility (i.e., designed to return bypass flow to the Coleman Canal), would minimize flow and water temperature fluctuations that may occur during powerhouse outages. The connectors and the bypass facility during would provide benefits during outages. The level of benefit would depend on the extent of stream affected by the outages and the frequency and duration of the outages. Historical outages have varied in frequency and duration (Table 4.1-11). The connectors would reduce the influence of outages on fish habitat in the South Fork. In addition, ramping rates would be implemented to gradually reduce high flows resulting from outages as the power plants and canals come back on line (Chapter 2). The ramping rates are designed to minimize stranding losses as flows are returned to normal following outages.

The removal of dams under the Five Dam Removal Alternative would also minimize adverse effects of powerhouse or canal outages that result in flow temporarily spilling down the South and North Forks of Battle Creek downstream of existing diversion dams (i.e., South Diversion Dam, Coleman Diversion Dam, and Wildcat Diversion Dam). The outages and subsequent canal spill cause short-term disruptions of flow in downstream reaches. When the canal and powerhouse come back on line, the drop in flow may result in desiccation of redds and stranding of juvenile and adult fish. The removal of dams would minimize flow fluctuations that may occur during canal outages. The level of benefit would depend on the extent of stream affected by the outages and the frequency and duration of the outages.

Under the Five Dam Removal Alternative, planned maintenance would be scheduled during the period of February 1 through April 30, as specified in the

MOU and AMP. Historical outages have varied in timing, frequency and duration (Table 4.1-11). The removal of dams, construction of connectors and the bypass, and subsequent minimization (i.e., ramping rates) and avoidance of flow fluctuation attributable to spill would avoid short-term fluctuation in habitat availability and the potential for stranding losses. This impact on fish is considered beneficial. No mitigation is required.

Impact 4.1-16 Beneficial—Substantially increased survival of juvenile steelhead and chinook salmon during downstream movement and migration as a result of eliminating some diversions and constructing fish screens at the remaining diversions from North Fork and South Fork Battle Creek (entrainment). Under the Five Dam Removal Alternative, diversions would no longer occur at South, Coleman, and Wildcat Diversion Dams (Table 4.1-5). Fish screens would be constructed on all remaining diversions at Inskip, North Battle Creek Feeder, and Eagle Canyon Diversion Dams from North Fork and South Fork Battle Creek. The removal of diversions and the new "failsafe" fish screens would minimize entrainment losses of juvenile chinook salmon and steelhead. The addition of tailrace connectors would also be a reliable way to avoid loss attributable to entrainment and impingement while reliably conveying the large quantities of power system water.

The No Action Alternative has very high diversion fractions at each of the six North Fork and South Fork diversion dams within the salmon and steelhead restoration area (Table 4.1-9). Under the No Action Alternative, diversions occur at North Battle Creek Feeder, Eagle Canyon, Wildcat, South, Inskip, and Coleman Diversion Dams. The proportion of flow diverted under the No Action Alternative is as high as 97% (Table 4.1-9). The diversion fractions will decrease dramatically under the Five Dam Removal Alternative because the MOU minimum flow requirements below each of the diversion dams are substantially greater than the FERC minimum flow requirements under the No Action Alternative. For those dams that are removed, the diversion fraction becomes zero.

Diversions would be screened using designs that meet or exceed criteria established by NOAA Fisheries and DFG. Proposed fish screens would include features that continuously monitor screen performance and, in the case of a malfunction, would automatically stop the diversion. Detailed monitoring and operation and maintenance plans have been developed for the proposed fish screens and bypass facilities (Appendix D).

Under the Five Dam Removal Alternative, entrainment losses would be reduced and the increased survival of the juvenile life stages would be expected to increase the abundance of steelhead and chinook salmon. Removal of diversions at South, Coleman, and Wildcat Diversion Dams would eliminate entrainment of juvenile chinook salmon, juvenile steelhead, and other fish species produced in the upstream segments of North Fork and South Fork Battle Creek. Effective fish screens at North Battle Creek Feeder, Eagle Canyon, and Inskip Diversion Dams would be expected to virtually eliminate entrainment-related mortality of fish moving downstream past the diversion intakes. This impact on fish is considered substantially beneficial. No mitigation is required.

Impact 4.1-17 Beneficial—Reduction of predation-related mortality as a result of removing dams and improving fish ladders (predation, pathogens, and food). The dams and associated fish ladders that would be present under the No Action Alternative are assumed to maintain predation above levels that would occur in the absence of dams. The existing dams may stop the upstream migration of predatory species, such as pikeminnow; juveniles passing over the dams, likely disoriented by turbulent flow conditions, are vulnerable to predation. Concentration of pikeminnow below the diversion dams coincident with the downstream migration of juvenile salmonids could increase predation losses.

Removal of Wildcat, South, Soap Creek, Lower Ripley Creek, and Coleman Diversion Dams under the Five Dam Removal Alternative would remove any potential effects of the existing dams on predation. The improved fish ladders at North Battle Creek Feeder, Eagle Canyon, and Inskip Diversion Dams would minimize disorientation of juveniles and improve conditions for downstream movement of chinook salmon and steelhead. The vulnerability to predation would be reduced. This impact is considered beneficial. No mitigation is required.

Although predation-related mortality may be reduced by removal of dams and fish ladder improvements, the benefit to fish species is unknown and may be minor given the area of stream affected. Fish species that prey on juvenile chinook salmon and steelhead would continue to occur throughout Battle Creek, especially in the mainstem where warmer water temperatures support known predators, including smallmouth bass, green sunfish, and Sacramento pikeminnow. Most salmonid predators occur below the Proposed Project area, and those populations may be reduced only if there is an increase in coldwater habitat below the restoration project.

Impact 4.1-18 Beneficial—Substantially increased production of food for fish resulting from increased minimum instream flows (predation, pathogens, and food). Prey abundance affects growth rate and the survival of individual fish. The quantity of habitat available for the production of periphyton and aquatic macroinvertebrates is at least partially dependent on the stream surface area. Periphyton is a key component of the aquatic food web and aquatic macroinvertebrates are a primary food for fish, especially juvenile chinook salmon and steelhead. Prey abundance may increase in response to increased stream surface area and subsequent increase in primary productivity. Minimum instream flows would increase under the Five Dam Removal Alternative (see Section 4.3, “Hydrology”), potentially increasing the abundance of food for fish.

Under the No Action Alternative, the summer stream surface area is approximately 175 acres (Table 4.1-10). In response to increased minimum instream flow requirements, the summer stream surface area would increase by approximately 66 acres (60%) under the Five Dam Removal Alternative. The increase in surface area may increase food availability for fish species, including juvenile chinook salmon and steelhead. This benefit is partially captured under key habitat quantity (described above), reflecting the effects of increased minimum flow requirements on habitat area and potential production of chinook salmon and steelhead.

Although the additional stream surface area provided by increased minimum flows in Soap, Ripley, and Baldwin Creeks is not simulated, the additional surface area in those streams would also increase production of food for fish in the Battle Creek watershed. The stream surface area in Soap, Lower Ripley, and Baldwin Creeks would increase dramatically compared to the surface area at a minimum instream flow of 0 cfs under the No Action Alternative. This impact on fish is considered beneficial. No mitigation is required.

No Dam Removal Alternative

The No Dam Removal Alternative would provide new fish screens and fish ladders at North Battle Creek Feeder, Eagle Canyon, Wildcat, South, Inskip, and Coleman Diversion Dams (Table 4.1-5). Fish screens would meet NOAA Fisheries and DFG criteria. The diversions, canals, and spring-water collection systems would remain at the same locations as under the No Action Alternative. The minimum flow requirements (i.e., AFRP minimum flow requirements) below the diversion dams would be higher than the instream flows for the No Action Alternative (i.e., FERC minimum flow requirements), but generally less than under the Five Dam Removal Alternative (i.e., MOU minimum flow requirements) (Section 4.3, "Hydrology"). Additional activities that would occur between dam sites or at off-site locations where disturbance is needed to facilitate construction includes: water conveyance upgrades, staging areas, road improvements, and other ground disturbing activities to support the construction of fish screens, fish ladders, and streamflow gages.

Construction-Related Effects

Short-term construction-related effects fall into four categories: key habitat quantity, migration habitat, contaminants, and direct injury. The impacts and mitigation measures are nearly the same as those described under the Five Dam Removal Alternative.

Impact 4.1-19 Significant—Mortality and lowered growth rates and reproductive success of fish and other aquatic species in Battle Creek from an accidental spill of petroleum products and other construction-related materials (contaminants). Impact 4.1-19 is the same as Impact 4.1-1 described above under the Five Dam Removal Alternative. Implementing the Mitigation Measure for Impact 4.1-1 would reduce this impact to a less-than-significant level.

Impact 4.1-20 Significant—Mortality of fish eggs and larvae and reduced reproductive success of fish and other aquatic species

because of increased sedimentation to North Fork and South Fork Battle Creek as a result of construction activities (contaminants). Impact 4.1-20 is the same as Impact 4.1-2 described above under the Five Dam Removal Alternative. Implementing the Mitigation Measure for Impact 4.1-2 would reduce this impact to a less-than-significant level.

Impact 4.1-21 Less than significant—Disturbed steelhead and chinook salmon habitat in the stream channel as a result of construction activities (key habitat quantity). Construction of fish screens and fish ladders at North Battle Creek Feeder, Eagle Canyon, Wildcat, South, Inskip, and Coleman Diversion Dams would disturb the channel bottom and bank. The disturbance of the channel bottom and bank would alter the channel dimensions and form and the existing substrate. The changes in the channel may adversely affect conditions supporting spawning and rearing habitat (i.e., removal of gravel or changes in depth and velocity). This impact is considered less than significant because the affected spawning and rearing habitat area is small relative to total spawning and rearing habitat in Battle Creek and existing channel structure and substrate at these locations do not currently provide spawning and rearing habitat. No mitigation is required.

Impact 4.1-22 Less than significant—Disrupted movement and migration of fish species as a result of dewatering portions of the stream channel and temporarily removing fish ladders during construction (migration habitat). Construction activities within the stream channel may include placement of cofferdams to isolate constructed elements from the streamflow and temporary removal of existing fish ladders. This impact is similar but less than the impact described under the Five Dam Removal Alternative under Impact 4.1-5. No mitigation is required.

Impact 4.1-23 Less than significant—Compromised feeding efficiency of sight-feeding fish from erosion and the input of fine sediment as a result of construction and demolition activities (contaminants). This impact is similar to Impact 4.1-6 described under the Five Dam Removal Alternative. No mitigation is required.

Impact 4.1-24 Less than significant—Vulnerability of all life stages of fish to injury or mortality from percussion-related energy shock waves, operation of equipment, and becoming trapped in isolated pockets of water during construction activities (direct injury). This impact is similar but less (i.e., no dams would be removed) than Impact 4.1-7 described under the Five Dam Removal Alternative. No mitigation is required.

Long-Term and Ongoing Effects

Long-term and ongoing effects fall into five categories: key habitat quantity, water temperature, migration habitat, entrainment in diversions, and predation, pathogens, and food.

Impact 4.1-25 Less than significant—Reduced habitat and range of some resident warmwater species because of cooler water

temperatures (water temperature). Cooler water temperatures, especially in the mainstem of Battle Creek, would reduce the linear extent of habitat area available to warmwater fish species currently found in Battle Creek (e.g., smallmouth bass, green sunfish, and Sacramento pikeminnow). The range of some resident warmwater species will be reduced. The impact is considered less than significant because all species are relatively abundant and found throughout the Central Valley; habitat area and quality may increase for all species in response to increased flow and increased productivity; and reestablishment of higher flows is consistent with restoration of conditions that existed prior to construction and operation of the Hydroelectric Project on Battle Creek. No mitigation is required.

Impact 4.1-26 Less than significant—Decreased rainbow trout abundance in canals as a result of eliminating some diversions and constructing effective fish screens at three dams (migration habitat). The extensive canal system for the Hydroelectric Project facilities, including Cross Country Canal, South Canal, Union Canal, Inskip Canal, Eagle Canyon Canal, and Coleman Canal, supports juvenile and adult rainbow trout and other species (DFG 1966). Spawning habitat for rainbow trout within the canals is limited. The abundance of rainbow trout in the canals is dependent on entrainment of juvenile and adult rainbow trout from Battle Creek. The construction of effective fish screens at North Battle Creek Feeder, Eagle Canyon Wildcat, South, Inskip, and Coleman Diversion Dams (Table 4.1-5) would stop entrainment of rainbow trout. Rainbow trout abundance would likely be substantially less under the No Dam Removal Alternative than would exist under the No Action Alternative. As described under the Five Dam Removal Alternative, the adverse impact of reduced rainbow trout abundance in the canals is considered less than significant.

Impact 4.1-27 Less than significant—Increased exposure of rainbow trout to pathogens because of the increase of chinook salmon and steelhead in Battle Creek (predation, pathogens, and food). As described under the Five Dam Removal Alternative, Impact 4.1-10, the No Dam Removal Alternative would substantially increase the abundance of chinook salmon and steelhead in Battle Creek and potentially increase the occurrence of pathogens in those reaches and in the water diverted from South Fork and North Fork Battle Creek. The potential effects of increased occurrence of pathogens on rainbow trout would likely be less than significant. No mitigation is required.

Impact 4.1-28 Beneficial—Substantially increased capacity indices for spawning and rearing of steelhead and chinook salmon resulting from increased minimum instream flows (key habitat quantity). The No Dam Removal Alternative would increase the minimum instream flow requirements in multiple reaches of Battle Creek (Section 4.3, "Hydrology"). The increased flow would increase spawning and rearing habitat area, potentially increasing the capacity indices for fry and juvenile salmonids relative to the No Action Alternative.

This beneficial impact is the same as Impact 4.1-11 described above under the Five Dam Removal Alternative. The increased capacity indices for spawning and rearing would be expected to increase the abundance of steelhead and chinook salmon through increased production of fry and juvenile life stages (Figures 4.1-2 through 4.1-5 and Figures 4.1-6 through 4.1-9).

The No Dam Removal alternative would not include the removal of dams on Soap and Ripley Creeks and would not include increases in minimum flow on Soap, Ripley, or Baldwin Creeks. Key habitat quantity in Soap, Ripley, and Baldwin Creeks would be the same as described under the No Action Alternative. The benefits described under the Five Dam Removal Alternative would not be realized under the No Dam Removal Alternative.

Reestablishing higher minimum flow requirements under the No Dam Removal Alternative would benefit other species, including resident fish, aquatic invertebrates, amphibians and stream-dependent wildlife. Greater stream area potentially provides greater habitat area for other fish and aquatic species.

Impact 4.1-29 Beneficial—Substantially increased production indices for fry and juvenile life stages for steelhead and chinook salmon as a result of cooler water temperatures (water temperature). The water temperature assessment uses the capacity indices for fry and juvenile life stages identified in the assessment of key habitat quantity described above. Increased flows and subsequent cooler water temperature associated with the No Dam Removal Alternative during the late spring, summer, and early fall months would substantially increase salmonid survival relative to survival under the No Action Alternative.

This beneficial impact is similar to Impact 4.1-12 described above under the Five Dam Removal Alternative. The increased production indices for fry and juvenile life stages would be expected to increase the abundance of steelhead and chinook salmon. The potential increase in production indices for fry and juvenile steelhead and chinook salmon in response to cooler water temperature under the No Dam Removal Alternative would be substantial (Figures 4.1-2 through 4.1-5 and Figures 4.1-6 through 4.1-9).

Relative to the Five Dam Removal Alternative, water temperature in South Fork Battle Creek would be cooler under the No Dam Removal Alternative, resulting in generally higher estimated survival, depending on species and life stage (Table 4.1-6). Relative to the No Action Alternative, the expected increase in survival attributable to cooler water temperature is substantial (Table 4.1-6). The tailrace connectors between South Powerhouse and Inskip Canal and between Inskip Powerhouse and Coleman Canal constructed under the Five Dam Removal Alternative would not be constructed for this alternative. Therefore, flow diverted from North Fork Battle Creek under the No Dam Removal Alternative would be discharged into South Fork Battle Creek at South and Inskip Powerhouses. The North Fork Battle Creek water would mix with South Fork Battle Creek flow and cool the water temperature, providing cooler water temperatures downstream of Inskip and Coleman Diversion Dams.

The apparent benefit of cooler water temperature in South Fork Battle Creek may be misleading. Cool water temperatures below Inskip and Coleman Diversion Dams are dependent on discharge of cool North Fork Battle Creek water into warmer South Fork Battle Creek flow. Failure of the canal and powerhouse facilities could interrupt the discharge of North Fork Battle Creek water and result in warming of Inskip and Coleman reaches. Warmer water temperatures would reduce survival and result in lower fry and juvenile production indices for steelhead and chinook salmon. The resulting production indices, depending on the distribution of spawning in response to North Fork Battle Creek discharge, could be equal to or less than the production indices under the Five Dam Removal Alternative. Interrupted discharge and subsequent effects on adult, egg, and juvenile survival may be relatively infrequent based on historical outages (Table 4.1-11). Production indices for steelhead and chinook salmon could be reduced periodically, resulting in lower production indices than identified in Figures 4.1-2 through 4.1-9. In addition, higher inflow from Soap Creek provides potential cooling benefits under the Five Dam Removal Alternative. The No Dam Removal Alternative would not include increased flow from Soap Creek, and potential cool water benefits would not occur.

Impact 4.1-30 Beneficial—Increased survival of adults and increased spawning success because higher instream flows would improve conditions that facilitate passage of chinook salmon and steelhead over natural barriers (migration habitat). The No Dam Removal Alternative would increase the required minimum flows (i.e., AFRP minimum flow requirements) in multiple reaches of Battle Creek (Section 4.3, "Hydrology"). The increased flow would improve passage conditions over natural barriers, facilitating upstream habitat use and increasing survival and spawning success of adult chinook salmon and steelhead.

The construction of more effective fish ladders under the No Dam Removal Alternative would improve passage conditions for adult chinook salmon and steelhead. The proposed ladder capacity would be at least 10 times the capacity of existing ladders. The ladders would be designed to convey 110% of the streamflow at average spill conditions for each diversion dam and facilitate adult passage under nearly all flow conditions. Where necessary, additional flow would be directed to facilitate attraction of adult salmonids into the ladder, minimizing delay associated with flow spilling over the dam. The new fish ladders would be designed to automatically clear debris and include safe maintenance access under all streamflow conditions. Detailed monitoring and operation and maintenance plans for the proposed ladders under the No Dam Removal Alternative are included in this document for review (Appendix D).

This beneficial impact is similar to Impact 4.1-13 described above under the Five Dam Removal Alternative. The higher minimum flow requirements would improve passage conditions, substantially increasing unimpeded access to upstream spawning habitat (Table 4.1-7). However, the minimum flow requirements would be lower than minimum flow requirements under the Five Dam Removal Alternative. The lower flow requirements may not provide the same level of adult passage that would be realized under the Five Dam Removal Alternative (Table 4.1-7).

Impact 4.1-31 Beneficial—The construction of more effective fish ladders on North Battle Creek Feeder, Eagle Canyon, Wildcat, South, Inskip, and Coleman Diversion Dams would facilitate passage of chinook salmon and steelhead, which would increase survival of adults and increase spawning success (migration habitat). Construction of improved fish ladders would provide significantly greater upstream passage efficiency relative to passage conditions provided in the No Action Alternative. Improved passage would increase survival of adults and facilitate distribution of adults to available upstream spawning habitat that could increase survival of eggs and production of fry. The additional survival of adult chinook salmon and steelhead that might be realized with dam removal (i.e., additional survival of adult chinook salmon and steelhead described under the Five Dam Removal Alternative) would not occur under the No Dam Removal Alternative.

As under the No Action Alternative, water delivered to South and Inskip Powerhouses originates from three locations in the North Fork Battle Creek watershed (i.e., Volta 2 Powerhouse, North Battle Creek Feeder Dam, and Eagle Canyon Diversion Dam). Flow diverted from North Fork Battle Creek is discharged into South Fork Battle Creek at South and Inskip Powerhouses. Although the proportion of South Fork Battle Creek flow composed of North Fork Battle Creek water under the No Dam Removal Alternative is slightly lower than the proportion of North Fork Battle Creek water under the No Action Alternative (Table 4.1-8), the presence of significant North Fork water in South Fork Battle Creek may continue to cause false attraction of adult chinook salmon and steelhead to South Fork Battle Creek.

Based on the assessment of water temperature effects described above, environmental conditions in South Fork Battle Creek would support greater production of chinook salmon and steelhead than environmental conditions under the No Action Alternative. False attraction, therefore, may not be as detrimental to production as indicated for the No Action Alternative. False attraction in response to flow conditions under the No Dam Removal Alternative is not expected to adversely affect production of steelhead and chinook salmon relative to the No Action Alternative, but the benefit described under the Five Dam Removal Alternative would not be realized under the No Dam Removal Alternative.

In addition to false attraction, the discharge of cool water at Inskip and Coleman Diversion Dams may cause winter- and spring-run chinook salmon to break off their upstream migration (i.e., similar to conditions described under the No Action Alternative). The gradient of warm to cool water temperatures from downstream to upstream may be a primary cue for migration to natal spawning areas. Winter- and spring-run chinook salmon may not move to cool reaches upstream of South Diversion Dam and may hold and spawn downstream of Coleman and Inskip Diversion Dams. Failure of the canal and powerhouse facilities could interrupt the discharge of North Fork Battle Creek water and result in warming of Inskip and Coleman reaches. Although interrupted discharge and subsequent warmer water temperatures could substantially reduce adult and egg survival, the occurrence may be relatively infrequent based on historical outages (Table 4.1-11). Production indices for steelhead and chinook salmon could be reduced periodically, resulting in lower production indices than identified in Figures 4.1-2 through 4.1-9.

Impact 4.1-32 Beneficial—Constructing fish screens at the remaining diversions from North Fork and South Fork Battle Creek would substantially increase the survival of juvenile steelhead and chinook salmon during downstream movement and migration (entrainment). Under the No Dam Removal Alternative, fish screens would be constructed on all diversions at North Battle Creek Feeder, Eagle Canyon, Wildcat, South, Inskip, and Coleman Diversion Dams. The new "failsafe" fish screens would minimize entrainment losses of juvenile chinook salmon and steelhead. Diversions would be screened as described under the Five Dam Removal Alternative. Although the benefit of fish screens would be substantial, diversion-related effects on survival (e.g., exposure to predation) would occur. The full benefits of dam removal that would occur at Wildcat, South, and Coleman Diversion Dams under the Five Dam Removal alternative would not be realized under the No Dam Removal Alternative.

Under the No Action Alternative, diversions occur at North Battle Creek Feeder, Eagle Canyon, Wildcat, South, Inskip, and Coleman Diversion Dams. The proportion of flow diverted under the No Action Alternative is as high as 97% (Table 4.1-9). The higher minimum flow requirement under the No Dam Removal Alternative (i.e., AFRP minimum flow requirement), would reduce the proportion of flow diverted. Effective fish screens would be expected to virtually eliminate entrainment-related mortality of fish moving downstream past the diversion intakes. Without the fish screens, substantial entrainment would continue to occur at the hydropower diversions (Table 4.1-9). Under the No Dam Removal Alternative, entrainment losses would be reduced and the increased survival of the juvenile life stages would be expected to increase the abundance of steelhead and chinook salmon.

Impact 4.1-33 Beneficial—Reduction of predation-related mortality as a result of improving fish ladders (predation, pathogens, and food). The dams and associated fish ladders that would be present under the No Action Alternative are assumed to maintain predation above levels that would occur in the absence of dams (i.e., that would occur at South, Coleman, and Wildcat under the Five Dam Removal Alternative). Juveniles passing over the dams are potentially disoriented by turbulent flow conditions. In addition, the dams may stop the upstream migration of predatory species, such as pikeminnow. Concentration of pikeminnow below the diversion dams coincident with the downstream migration of juvenile salmonids could increase predation losses.

The continued presence of dams under the No Dam Removal Alternative would continue to create the potential for predation losses. The improved fish ladders at all dams, however, would reduce disorientation of juveniles, improving conditions for downstream movement of juvenile chinook salmon and steelhead. The improved passage could reduce vulnerability to predation.

Although predation-related mortality may be reduced by fish ladder improvements, the benefit to fish species is unknown and may be minor given the area of stream affected. Fish species that prey on juvenile chinook salmon and steelhead would continue to occur throughout Battle Creek, especially in the mainstem where warmer water temperatures support known predators, including smallmouth bass, green sunfish, and Sacramento pikeminnow.

Impact 4.1-34 Beneficial—Substantially increased production of food for fish resulting from increased minimum instream flows (predation, pathogens, and food). This beneficial impact is the same as Impact 4.1-18 described above under the Five Dam Removal Alternative. In response to increased minimum flow requirements, the summer stream surface area would increase by approximately 59 acres (54%) under the No Dam Removal Alternative (Table 4.1-10). The increase in surface area may increase food availability for fish species, including juvenile chinook salmon and steelhead. The benefits identified for Soap, Ripley, and Baldwin Creeks under the Five Dam Removal Alternative would not occur under the No Dam Removal Alternative.

Six Dam Removal Alternative

The Six Dam Removal Alternative proposes to reoperate and modify hydropower facilities on North Fork and South Fork Battle Creek and three minor tributaries, Soap, Ripley, and Baldwin Creeks (Table 4.1-5). Diversion dams would be removed at Eagle Canyon, Wildcat, South, Soap Creek Feeder, Lower Ripley Creek Feeder, and Coleman Diversion Dams, and flow would no longer be diverted at those locations. Fish screens and new fish ladders would be constructed at North Battle Creek Feeder and Inskip Diversion Dams and would meet NOAA Fisheries and DFG criteria. Other physical changes to the Hydroelectric Project hydropower facilities include construction of tailrace connectors and flow bypass facilities. Higher minimum flow requirements (i.e., MOU minimum flow requirements) would increase instream flow, subsequently cooling water temperature, increasing stream area, and providing reliable passage conditions for adult salmonids in downstream reaches.

Construction-Related Effects

Short-term construction-related effects fall into four categories: key habitat quantity, migration habitat, contaminants, and direct injury. The impacts and mitigation measures are nearly the same as those described under the Five Dam Removal Alternative.

Impact 4.1-35 Significant—Mortality and lowered growth rates and reproductive success of fish and other aquatic species in Battle Creek from an accidental spill of petroleum products and other construction-related materials (contaminants). Impact 4.1-35 is the same as Impact 4.1-1 described above under the Five Dam Removal Alternative. Implementing the Mitigation Measure for Impact 4.1-1 would reduce this impact to a less-than-significant level.

Impact 4.1-36 Significant—Mortality of fish eggs and larvae and reduced reproductive success of fish and other aquatic species because of increased sedimentation to North Fork and South Fork Battle Creek as a result of construction activities (contaminants). Impact 4.1-36 is the same as Impact 4.1-2 described above under the Five Dam Removal Alternative. Implementing the Mitigation Measure for Impact 4.1-2 would reduce this impact to a less-than-significant level.

Impact 4.1-37 Significant—Mortality of fish eggs and larvae and reduced reproductive success of fish and other aquatic species as a result of removing South, Coleman, and Eagle Canyon Diversion Dams, which would release currently stored fine sediment to the stream channel (contaminants). Impact 4.1-37 is the same as Impact 4.1-3 described above under the Five Dam Removal Alternative. Implementing the Mitigation Measure for Impact 4.1-3 would reduce this impact to a less-than-significant level.

Impact 4.1-38 Less than significant—Disturbed steelhead and chinook salmon habitat in the stream channel as a result of construction activities (key habitat quantity). Construction activities associated with removing the six dams would include dismantling and removing Eagle, Wildcat, South, Coleman, Soap Creek Feeder, and Lower Ripley Creek Feeder Diversion Dams and their appurtenant facilities. Impact 4.1-38 is the same as Impact 4.1-4 described above under the Five Dam Removal Alternative. The changes in the channel may adversely affect conditions supporting spawning and rearing habitat (i.e., removal of gravel or changes in depth and velocity). This impact is considered less than significant because the affected spawning and rearing habitat area is small relative to total spawning and rearing habitat in Battle Creek; existing channel structure and substrate at these locations do not currently provide spawning and rearing habitat; and some of the affected areas would provide spawning and rearing habitat after construction is complete. No mitigation is required.

Impact 4.1-39 Less than significant—Disrupted movement and migration of fish species as a result of dewatering portions of the stream channel and temporarily removing fish ladders during construction (migration habitat). Impact 4.1-39 is the same as Impact 4.1-5 described above under the Five Dam Removal Alternative. This impact is considered less than significant. No mitigation is required.

Impact 4.1-40 Less than significant—Compromised feeding efficiency of sight-feeding fish from erosion and the input of fine sediment as a result of construction and demolition activities (contaminants). Impact 4.1-40 is the same as Impact 4.1-6 described above under the Five Dam Removal Alternative. The input of fine sediment would increase turbidity and sedimentation of gravel substrates. The impact of increased turbidity is considered less than significant because the effect would be temporary. No mitigation is required.

Impact 4.1-41 Less than significant—Vulnerability of all life stages of fish to injury or mortality from percussion-related energy shock waves, operation of equipment, and becoming trapped in isolated pockets of water during construction activities (direct injury). Removal of the six diversion dams; construction of the Inskip Powerhouse bypass facility; construction of the tailrace connectors between South Powerhouse and Inskip Canal, and between Inskip Powerhouse and Coleman Canal; and the construction of the fish screens and fish ladders could physically injure and kill eggs, larvae, and juvenile fish. Impact 4.1-41 is the same as Impact 4.1-7 described above under the Five Dam Removal Alternative. This impact is considered less than significant because the affected spawning and rearing habitat area is small relative to total spawning and rearing habitat in Battle Creek; construction will occur over a relatively short period of time; and measures will be implemented to exclude spawning within the construction foot print (see the general environmental protection measures listed in the introduction to this chapter, Section 4.0). No mitigation is required.

Long-Term and Ongoing Effects

Long-term and ongoing effects fall into five categories: key habitat quantity, water temperature, migration habitat, entrainment in diversions, and predation, pathogens, and food.

Impact 4.1-42 Less than significant—Reduced habitat and range of some resident warmwater species because of cooler water temperatures (water temperature). Impact 4.1-42 is the same as Impact 4.1-8 described above under the Five Dam Removal Alternative. The impact is considered less than significant because the affected warmwater species are relatively abundant and found throughout the Central Valley; habitat area and quality may increase for all species in response to increased flow and increased productivity; and reestablishment of higher flows is consistent with restoration of conditions that existed prior to construction and operation of the Hydroelectric Project on Battle Creek. No mitigation is required.

Impact 4.1-43 Less than significant—Decreased rainbow trout abundance in canals as a result of eliminating some diversions and constructing effective fish screens at three dams (migration habitat). Impact 4.1-43 is the same as Impact 4.1-9 described above under the Five Dam Removal Alternative. The adverse impact of reduced rainbow trout abundance in the canals is considered less than significant because the populations in the canals are not self-sustaining and draining of the canals for maintenance periodically eliminates most of the rainbow trout from the canals. No mitigation is required.

Impact 4.1-44 Less than significant—Increased exposure of rainbow trout to pathogens because of the increase of chinook salmon and steelhead in Battle Creek (predation, pathogens, and food). The potential increased occurrence of pathogens associated with increased abundance of chinook salmon and steelhead would be similar to that described under the Five Dam Removal Alternative, and the impact would be less than significant. The removal of the diversion at Eagle Canyon Diversion Dam could reduce the potential transfer of fish pathogens to the Coleman Canal relative to the Five Dam Removal Alternative. No mitigation is required.

Impact 4.1-45 Beneficial—Substantially increased capacity indices for spawning and rearing of steelhead and chinook salmon resulting from increased minimum instream flows (key habitat quantity). The Six Dam Removal Alternative would increase the minimum flow requirements in multiple reaches of Battle Creek (Section 4.3, “Hydrology”). The higher flow requirements and increased flow would increase spawning and rearing habitat area, potentially increasing the capacity indices for fry and juvenile salmonids relative to the No Action Alternative.

This beneficial impact is the same as Impact 4.1-11 described above under the Five Dam Removal Alternative. The increased capacity of spawning and rearing habitat would be expected to increase the abundance of steelhead and chinook salmon through increased production of fry and juvenile life stages (Figures 4.1-2 through 4.1-5 and Figures 4.1-6 through 4.1-9, respectively).

Impact 4.1-46 Beneficial—Substantially increased production indices for fry and juvenile life stages for steelhead and chinook salmon as a result of cooler water temperatures (water temperature). The water temperature assessment uses the capacity indices for fry and juvenile life stages identified in the assessment of key habitat quantity described above. Increased flows and subsequent cooler water temperature associated with the Six Dam Removal Alternative during the late spring, summer, and early fall months substantially increase salmonid survival relative to survival under the No Action Alternative.

This beneficial impact is the same as Impact 4.1-12 described above under the Five Dam Removal Alternative. The increased production indices for fry and juvenile life stages would be expected to increase the abundance of steelhead and chinook salmon (Figures 4.1-2 through 4.1-5 and Figures 4.1-6 through 4.1-9). Relative to the No Action Alternative, the expected increase in survival attributable to cooler water temperature is substantial (Table 4.1-6).

Impact 4.1-47 Beneficial—Increased survival of adults and increased spawning success because higher instream flows would improve conditions that facilitate passage of chinook salmon and steelhead over natural barriers (migration habitat). The Six Dam

Removal Alternative would increase the minimum flows in multiple reaches of Battle Creek (Section 4.3, "Hydrology"). The increased flow would improve passage conditions over natural barriers, facilitating upstream habitat use and increasing survival and spawning success of adult chinook salmon and steelhead.

This beneficial impact is the same as Impact 4.1-13 described above under the Five Dam Removal Alternative. The maintenance of higher flows would improve passage conditions, substantially increasing unimpeded access to upstream spawning habitat (Table 4.1-7).

Impact 4.1-48 Beneficial—Increased survival of adults and increased spawning success because removal of dams and the construction of more effective fish ladders would facilitate passage of chinook salmon and steelhead (migration habitat). The removal of dams and construction of more effective fish ladders under the Six Dam Removal Alternative would improve passage conditions for adult chinook salmon and steelhead. This beneficial impact is the same as Impact 4.1-14 described above under the Five Dam Removal Alternative, with the additional benefit of removing Eagle Canyon Diversion Dam. The removal of dams and construction of ladders would substantially improve fish passage under nearly all flow conditions.

Impact 4.1-49 Beneficial—Potentially increased spawning success and fry production because eliminating the discharge of North Fork Battle Creek water to South Fork Battle Creek would facilitate the return of adult chinook salmon and steelhead to natal spawning habitat in South Fork and North Fork Battle Creek (migration habitat). Under the Six Dam Removal Alternative, tailrace connectors would be constructed between South Powerhouse and Inskip Canal and between Inskip Powerhouse and Coleman Canal. The absence of significant North Fork Battle Creek water in South Fork Battle Creek would facilitate return of adult chinook salmon and steelhead to natal spawning habitat in North Fork Battle Creek. This beneficial impact is the same as Impact 4.1-15 described above under the Five Dam Removal Alternative.

Impact 4.1-50 Beneficial—Substantially increased survival of juvenile steelhead and chinook salmon during downstream movement and migration as a result of ceasing diversions and constructing fish screens at the remaining diversions from North Fork and South Fork Battle Creek (entrainment). Under the Six Dam Removal Alternative, diversions would no longer occur at Eagle Canyon, Wildcat, South, and Coleman Diversion Dams (Table 4.1-9). Fish screens would be constructed on all remaining diversions at North Battle Creek Feeder and Inskip Diversion Dams. The fish screens would be designed as described under the Five Dam Removal Alternative. This beneficial impact is the same as Impact 4.1-16 described above under the Five Dam Removal Alternative. Without the fish screens, substantial entrainment would continue to occur at the hydropower diversions (Table 4.1-9).

Impact 4.1-51 Beneficial—Substantially increased production of food for fish resulting from increased minimum instream flows (predation, pathogens, and food). Minimum instream flows would increase under the Six Dam Removal Alternative, potentially increasing the abundance of food for fish. This beneficial impact is the same as Impact 4.1-18 described above under the Five Dam Removal Alternative. In response to increased minimum flow requirements, the summer stream surface area would increase by approximately 66 acres (61%) under the Six Dam Removal Alternative (Table 4.1-10). The increase in surface area may increase food availability for fish species, including juvenile chinook salmon and steelhead.

Impact 4.1-52 Beneficial—Reduction of predation-related mortality as a result of removing dams and improving fish ladders (predation, pathogens, and food). Impact 4.1-52 is nearly the same as Impact 4.1-17 under the Five Dam Removal Alternative with an additional potential benefit associated with the removal of Eagle Canyon Diversion Dam.

Three Dam Removal Alternative

The Three Dam Removal Alternative proposes to reoperate and modify Hydroelectric Project hydropower facilities on North Fork and South Fork Battle Creek (Table 4.1-5). Diversion dams would be removed at Eagle Canyon, Wildcat, and Coleman Diversion Dams, and flow would no longer be diverted at those locations. Fish screens and new fish ladders would be constructed at North Battle Creek Feeder, South, and Inskip Diversion Dams and would meet NOAA Fisheries and DFG criteria. Other physical changes to the hydropower facilities include construction of tailrace connectors at South and Inskip Powerhouses. Higher minimum flow requirements (i.e., AFRP minimum flow requirements) would increase instream flows, subsequently cooling water temperature, increasing stream area, and providing reliable passage conditions for adult salmonids in downstream reaches.

Construction-Related Effects

Short-term construction-related effects fall into four categories: key habitat quantity, migration habitat, contaminants, and direct injury. The impacts and mitigation measures are the same as those described under the Five Dam Removal Alternative.

Impact 4.1-53 Significant—Mortality and lowered growth rates and reproductive success of fish and other aquatic species in Battle Creek from an accidental spill of petroleum products and other construction-related materials (contaminants). Impact 4.1-53 is the same as Impact 4.1-1 described above under the Five Dam Removal Alternative. Implementing the Mitigation Measure for Impact 4.1-1 would reduce this impact to a less-than-significant level.

Impact 4.1-54 Significant—Mortality of fish eggs and larvae and reduced reproductive success of fish and other aquatic species

because of increased sedimentation to North Fork and South Fork Battle Creek as a result of construction activities (contaminants). Impact 4.1-54 is the same as Impact 4.1-2 described above under the Five Dam Removal Alternative. Implementing the Mitigation Measure for Impact 4.1-2 would reduce this impact to a less-than-significant level.

Impact 4.1-55 Significant—Mortality of fish eggs and larvae and reduced reproductive success of fish and other aquatic species as a result of removing South, Coleman, and Eagle Canyon Diversion Dams, which would release currently stored fine sediment to the stream channel (contaminants). Impact 4.1-55 is the same as Impact 4.1-3 described above under the Five Dam Removal Alternative. Implementing the Mitigation Measure for Impact 4.1-3 would reduce this impact to a less-than-significant level.

Impact 4.1-56 Less than significant—Disturbed steelhead and chinook salmon habitat in the stream channel as a result of construction activities (key habitat quantity). Impact 4.1-56 is the same as Impact 4.1-4 described above under the Five Dam Removal Alternative. Construction activities associated with removing the 3 dams would include dismantling and removing Eagle, Wildcat, and Coleman Diversion Dams and their appurtenant facilities. Construction of the tailrace connectors between South Powerhouse and Inskip Canal and between Inskip Powerhouse and Coleman Canal would also include work in the stream channel. The disturbance of the channel bottom and bank would alter the channel dimensions and form and the existing substrate. This impact is considered less than significant. No mitigation is required.

Impact 4.1-57 Less than significant—Disrupted movement and migration of fish species as a result of dewatering portions of the stream channel and temporarily removing fish ladders during construction (migration habitat). Impact 4.1-57 is the same as Impact 4.1-5 described above under the Five Dam Removal Alternative. This impact is considered less than significant because upstream passage of anadromous salmonids is currently blocked at Eagle Canyon and Coleman Diversion Dams. No mitigation is required.

Impact 4.1-58 Less than significant—Compromised feeding efficiency of sight-feeding fish from erosion and the input of fine sediment as a result of construction and demolition activities (contaminants). Impact 4.1-58 is the same as Impact 4.1-6 described above under the Five Dam Removal Alternative. The input of fine sediment would increase turbidity. The impact of increased turbidity is considered less than significant because the effect would be temporary. No mitigation is required.

Impact 4.1-59 Less than significant—Vulnerability of all life stages of fish to injury or mortality from percussion-related energy shock waves, operation of equipment, and becoming trapped in isolated pockets of water during construction activities (direct injury). Impact

4.1-59 is the same as Impact 4.1-7 described above under the Five Dam Removal Alternative. Removal of the three diversion dams; construction of the Inskip Powerhouse bypass facility; construction of the tailrace connectors between South Powerhouse and Inskip Canal, and between Inskip Powerhouse and Coleman Canal; and the construction of the fish screens and fish ladders at Eagle Canyon and Inskip Diversion Dams could physically injure and kill eggs, larvae, and juvenile fish. This impact is considered less than significant because the affected spawning and rearing habitat area is small relative to total spawning and rearing habitat in Battle Creek; construction will occur over a relatively short period of time; and measures will be implemented to exclude spawning within the construction foot print (see the general environmental protection measures listed in the introduction to this chapter, Section 4.0). No mitigation is required.

Long-Term and Ongoing Effects

Long-term and ongoing effects fall into five categories: key habitat quantity, water temperature, migration habitat, entrainment in diversions, and predation, pathogens, and food.

Impact 4.1-60 Less than significant—Reduced habitat and range of some resident warmwater species because of cooler water temperatures (water temperature). Impact 4.1-60 is the same as Impact 4.1-8 described above under the Five Dam Removal Alternative. The impact is considered less than significant. No mitigation is required.

Impact 4.1-61 Less than significant—Decreased rainbow trout abundance in canals as a result of eliminating some diversions and constructing effective fish screens at three dams (migration habitat). Impact 4.1-61 is the same as Impact 4.1-9 described above under the Five Dam Removal Alternative. The adverse impact of reduced rainbow trout abundance in the canals is considered less than significant because the populations in the canals are not self-sustaining and draining of the canals for maintenance periodically eliminates most of the rainbow trout from the canals. No mitigation is required.

Impact 4.1-62 Less than significant—Increased exposure of rainbow trout to pathogens because of the increase of chinook salmon and steelhead in Battle Creek (predation, pathogens, and food). The potential increased occurrence of pathogens associated with increased abundance of chinook salmon and steelhead would be similar to that described under the Five Dam Removal Alternative (i.e., Impact 4.1-10), and the impact would be less than significant. The removal of the diversion at Eagle Canyon Diversion Dam could reduce the potential transfer of fish pathogens to the Coleman Canal relative to the Five Dam Removal Alternative. Additional transfer of fish pathogens to the canals, however, could occur through the diversion at South Diversion Dam.

Impact 4.1-63 Beneficial—Substantially increased capacity indices for spawning and rearing of steelhead and chinook salmon resulting from increased minimum instream flows (key habitat quantity). The Three Dam Removal Alternative would increase the minimum instream flow requirements (i.e., AFRP minimum flow requirements) in multiple reaches of Battle Creek (Section 4.3, “Hydrology”). The increased flow would increase spawning and rearing habitat area, increasing the capacity indices for fry and juvenile salmonids relative to the No Action Alternative.

This beneficial impact is similar to Impact 4.1-11 described above under the Five Dam Removal Alternative. The increased capacity of spawning and rearing habitat would be expected to increase the abundance of steelhead and chinook salmon through increased capacity indices for fry and juvenile life stages (Figures 4.1-2 through 4.1-5 and Figures 4.1-6 through 4.1-9, respectively). The lower minimum flow requirements under the Three Dam Removal Alternative may result in slightly less capacity for some life stages than capacity indicated under the Five Dam Removal Alternative. In addition, the lower minimum flow requirements would be less supportive of future adaptive management of flow targets that may incorporate new information on flow-habitat relationships. The Three Dam Removal alternative would also not include the removal of dams on Soap and Ripley Creeks and would not include increases in minimum flow on Soap and Ripley Creeks. The benefits described under the Five Dam Removal Alternative related to Soap and Ripley Creeks would not be realized under the Three Dam Removal Alternative. Key habitat quantity in Soap and Ripley Creeks would be the same as described under the No Action Alternative. Increased flow in Baldwin Creek would provide the benefits described under the Five Dam Removal Alternative.

Impact 4.1-64 Beneficial—Substantially increased production indices for fry and juvenile life stages for steelhead and chinook salmon as a result of cooler water temperatures (water temperature). The water temperature assessment uses the capacity indices for fry and juvenile life stages identified in the assessment of key habitat quantity described above. Increased flows and subsequent cooler water temperature associated with the Three Dam Removal Alternative during the late spring, summer, and early fall months would substantially increase salmonid survival relative to survival under the No Action Alternative.

This beneficial impact is similar to Impact 4.1-12 described above under the Five Dam Removal Alternative. The increased production indices for fry and juvenile life stages would be expected to increase the abundance of steelhead and chinook salmon (Figures 4.1-2 through 4.1-5 and Figures 4.1-6 through 4.1-9, respectively). Relative to the Five Dam Removal Alternative, the benefits of cool water temperature are slightly less under the Three Dam Removal Alternative (Table 4.1-6). Relative to the No Action Alternative, the expected increase in survival attributable to cooler water temperature is substantial.

As under the Five Dam Removal Alternative, the tailrace connectors constructed between South Powerhouse and Inskip Canal would minimize flow and water temperature fluctuations that may occur during South Powerhouse outages. As under the No Action Alternative, Inskip Powerhouse outages under the Three Dam Removal Alternative would result in canal flow spilling down natural pathways to enter South Fork Battle Creek near the Inskip Powerhouse. The outage and subsequent canal spill would cause short-term disruptions of flow to the short segment of stream channel between the existing powerhouses and the canal intake. In addition, the overland flow may warm the water temperature, depending on the weather during the outage. Based on the historical frequency of outages at Inskip Powerhouse (Table 4.1-11), however, the input of North Fork Battle Creek water would likely be infrequent and have minimal effect on water temperature.

The removal of South Diversion Dam under the Five Dam Removal Alternative would minimize adverse effects of powerhouse outages that result in flow temporarily spilling down the South Fork Battle Creek. South Diversion Dam would not be removed under the Three Dam Removal Alternative, and outage and subsequent canal spill could cause short-term disruptions of flow in downstream reaches. When the canal and powerhouse come back on line, the drop in flow may result in desiccation of redds and stranding of juvenile and adult fish. The level of effect would be less detrimental than effects under the No Action Alternative. The difference in benefit from the Five Dam Removal Alternative would depend on the extent of stream affected by the outages and the frequency and duration of the outages. Historical outages have varied in frequency and duration (Table 4.1-11). The removal of Eagle Canyon Diversion Dam under the Three Dam Removal Alternative would avoid flow fluctuation attributable to spill in North Fork Battle Creek and subsequent effects on habitat availability and the potential for stranding losses. The potential benefit relative to the Five Dam Removal Alternative, however, is unknown, partially because removal of Eagle Canyon Diversion Dam also reduces the potential to manage North Fork Battle Creek flow to derive cool water benefits from Eagle Canyon spring inflow.

Impact 4.1-65 Beneficial—Increased survival of adults and increased spawning success because higher instream flows would improve conditions that facilitate passage of chinook salmon and steelhead over natural barriers (migration habitat). The Three Dam Removal Alternative would increase minimum flow requirements in multiple reaches of Battle Creek (Section 4.3, "Hydrology"). The increased flow would improve passage conditions over natural barriers, facilitating upstream habitat use and increasing survival and spawning success of adult chinook salmon and steelhead. This beneficial impact is similar to Impact 4.1-13 described above under the Five Dam Removal Alternative. However, the minimum flow requirements would be lower than minimum flow requirements under the Five Dam Removal Alternative. The lower flow requirements may not provide the same level of adult passage that would be realized under the Five Dam Removal Alternative (Table 4.1-7).

Impact 4.1-66 Beneficial—Increased survival of adults and increased spawning success because removal of dams and the construction of more effective fish ladders would facilitate passage of chinook salmon and steelhead (migration habitat). This beneficial impact is the same as Impact 4.1-14 described above under the Five Dam Removal Alternative, with the additional benefit of removing Eagle Canyon

Diversion Dam and without the benefit that is associated with removal of South, Soap, and Ripley Diversion Dams under the Five Dam Removal Alternative. The removal of dams and construction of ladders would substantially improve fish passage.

Impact 4.1-67 Beneficial—Potentially increased spawning success and fry production because eliminating the discharge of North Fork Battle Creek water to South Fork Battle Creek would facilitate the return of adult chinook salmon and steelhead to natal spawning habitat in South Fork and North Fork Battle Creek (migration habitat). Under the Three Dam Removal Alternative, tailrace connectors would be constructed between South Powerhouse and Inskip Canal and between Inskip Powerhouse and Coleman Canal. The absence of significant North Fork Battle Creek water in South Fork Battle Creek would facilitate return of adult chinook salmon and steelhead to natal spawning habitat in North Fork Battle Creek. This beneficial impact is the same as Impact 4.1-15 described above under the Five Dam Removal Alternative, with the exception that water from North Fork Battle Creek would discharge to South Fork Battle Creek during an outage at Inskip Powerhouse. Based on the historical frequency of outages at Inskip Powerhouse (Table 4.1-11), however, the input of North Fork Battle Creek water would likely be infrequent and have minimal effect on false attraction of adult steelhead and chinook salmon.

Impact 4.1-68 Beneficial—Substantially increased survival of juvenile steelhead and chinook salmon during downstream movement and migration as a result of eliminating some diversions and constructing fish screens at the remaining diversions from North Fork and South Fork Battle Creek (entrainment). Under the Three Dam Removal Alternative, diversions would no longer occur at Eagle Canyon, Wildcat, and Coleman Diversion Dams (Table 4.1-5). Fish screens would be constructed on all remaining diversions at North Battle Creek Feeder, South, and Inskip Diversion Dams. The fish screens are designed as described under the Five Dam Removal Alternative. This beneficial impact is similar to Impact 4.1-16 described above under the Five Dam Removal Alternative. Without the fish screens, substantial entrainment would continue to occur at the hydropower diversions (Table 4.1-9).

Impact 4.1-69 Beneficial—Reduction of predation-related mortality as a result of removing dams and improving fish ladders (predation, pathogens, and food). The benefits related to reduced predation are similar to those described under the Five Dam Removal Alternative, Impact 4.1-17, with an additional potential benefit with removal of Eagle Canyon Diversion Dam and a lesser benefit with South Diversion Dam remaining.

Impact 4.1-70 Beneficial—Substantially increased production of food for fish resulting from increased minimum instream flows (predation, pathogens, and food). This beneficial impact is similar to Impact 4.1-18 described above under the Five Dam Removal Alternative. In response to increased minimum flow requirements, the summer stream surface area would increase by approximately 59 acres (54%) under the Three Dam Removal Alternative (Table 4.1-10). The increase in surface area may increase food availability for fish species, including juvenile chinook salmon and steelhead.

Cumulative Impacts

Cumulative adverse impacts on fish and aquatic species associated with the Proposed Action and past, present, or reasonably foreseeable future projects would not occur in the Battle Creek watershed because no other projects (including related projects described in Chapter 6) would contribute to the cumulative decline of fish species or the degradation of fish habitat in Battle Creek.

Upon implementing the Proposed Action, steelhead and winter- and spring-run chinook salmon, species listed under the ESA, are expected to increase substantially in abundance. The increased population abundance of steelhead and winter- and spring-run chinook salmon associated with the Proposed Action is likely to increase the resistance and resilience of the populations in Battle Creek.

Downstream of the Restoration Project area, several modifications are proposed for the Coleman National Fish Hatchery (managed by USFWS), including screening of the hatchery's water intakes and modifying the hatchery's barrier weir and upstream fish ladder. Construction of an ozonation water treatment plant and water filtration system has already been completed. To correct sediment and disease problems at the Coleman National Fish Hatchery, USFWS has expanded the hatchery's water treatment and filtration system, which will minimize the risk of catastrophic hatchery events and optimize the hatchery's production capabilities. In addition, USFWS has initiated a process to modify the hatchery's intakes, which currently do not meet federal or state guidelines, to protect salmonids at water diversions. In anticipation of Restoration Project implementation, management of the hatchery's fish barrier weir and upstream ladder will be modified to accommodate the movement of naturally produced salmon and steelhead so they can access the best stream reaches at the right times. Each modification proposed for the Coleman National Fish Hatchery would benefit salmonids at the hatchery and potentially the populations in Battle Creek as well.

Additional future projects that would be beneficial to anadromous fish include DWR's proposition to place spawning-sized gravel in the lower reaches of Battle Creek to double or triple the area available for salmon spawning. DFG has also proposed enhancing existing spawning gravel supplies on a ¼-mile stretch of Baldwin Creek and improving a partial natural barrier on Baldwin Creek.

In summary, the Proposed Action and past, present, or probable future projects, including those proposed by USFWS for the Coleman National Fish Hatchery, by

DWR for Battle Creek, and by DFG for Baldwin Creek, would substantially benefit fish populations in the Battle Creek watershed.

Table 4.1-3. Distribution of Potential Natural Barriers and Diversion Dams That May Impede Fish Passage

Location (River Mile)	Type of Barrier/ Name of Dam	Distance to Next Upstream Barrier (miles)
North Battle Creek		
13.48	Absolute Barrier	0
11.48	Falls/Cascade	2.00
11.46	Falls	2.02
11.45	Falls/Cascade	2.03
11.31	Cascade/Chute	2.17
11.10	Falls	2.38
10.79	Falls/Cascade	2.69
10.78	Falls/Cascade	2.70
10.72	Falls/Cascade	2.76
10.48	Rock Creek	-
9.92	Falls	3.56
9.35	North Battle Creek Feeder Diversion Dam	4.13
6.96	Falls	6.52
6.02	Falls	7.46
5.40	Falls/Cascade	8.08
5.29	Eagle Canyon Diversion Dam	8.19
4.50	Falls	8.98
2.48	Wildcat Diversion Dam	11.00
2.36	Falls	11.12
2.16	Subsurface Flow	11.32
South Battle Creek		
18.85	Absolute Barrier	0
14.35	South Diversion Dam	4.50
11.68	Cascade	7.17
7.96	Inskip Diversion Dam	10.89
3.81	Falls/Cascade/Chute	15.04
3.61	Falls/Cascade	15.24
3.40	Falls/Cascade/Chute	15.45
3.15	Falls	15.70
2.54	Coleman Diversion Dam	16.31

Table 4.1-4. Effective Flows at Fish Ladders Under the Action Alternatives

	Effective Flow Range (cfs)			
Name of Dam	Five Dam Removal Alternative	No Dam Removal Alternative	Six Dam Removal Alternative	Three Dam Removal Alternative
North Battle Creek Feeder Diversion Dam	4 to 110[1]	4 to 110[1]	4 to 110[1]	4 to 110[1]
Eagle Canyon Diversion Dam	20 to 71[1]	20 to 71[1]	Dam removed	Dam removed
Wildcat Diversion Dam	Dam removed	30 to 80	Dam removed	Dam removed
South Diversion Dam	Dam removed	35 to 80	Dam removed	35 to 80
Inskip Diversion Dam[2]	35[3] to 170	35[3] to 170	35[3] to 170	35[3] to 170
Coleman Diversion Dam	Dam removed	35 to 80	Dam removed	Dam removed
Lower Ripley Creek Diversion Dam	Dam removed	No fish ladder, No fish passage	Dam removed	No fish ladder, No fish passage
Soap Creek Diversion Dam	Dam removed	No fish ladder, No fish passage	Dam removed	No fish ladder, No fish passage

Notes:

1 Kennedy, DWR (2001).

2 Gravel may accumulate in the entrance pool to the fish ladder at Inskip Diversion Dam under the proposed design leading to an ongoing operations impact between the dam and the ladder.

3 The fish ladder at Inskip Diversion Dam could function at (as yet unspecified) lower flows if the orifices were blocked (Kennedy, DWR 2001).

Table 4.1-6. Estimated Survival of Fry and Juvenile Life Stages Attributable to Water Temperature Conditions in Battle Creek for the Minimum Flow Requirements under Each Alternative

		Alternatives				
Species	Life Stage	No Action	Five Dam Removal	No Dam Removal	Six Dam Removal	Three Dam Removal
Steelhead	Fry	78%	88%	86%	88%	87%
	Juvenile	44%	74%	91%	74%	66%
Spring-Run Chinook Salmon	Fry	20%	28%	35%	28%	25%
	Juvenile	60%	100%	100%	100%	100%
Winter-Run Chinook Salmon	Fry	5%	12%	12%	12%	10%
	Juvenile	44%	46%	56%	46%	37%
Late Fall-Run Chinook Salmon	Fry	61%	72%	71%	72%	68%
	Juvenile	58%	66%	79%	66%	59%

Table 4.1-7. Potential Steelhead and Chinook Salmon Passage over Natural Barriers in Battle Creek for Minimum Required Instream Flows[1] under All Alternatives

Stream Reach	Barrier Location[2] (river mile)	Minimum Passage Flow[3] (cfs)	Potential passage by species for each alternative				
			No Action	Five Dam Removal	No Dam Removal	Six Dam Removal	Three Dam Removal
North Fork Battle Creek							
Keswick	11.48	All flows	None[4,5]	None[4,5]	None[4,5]	None[4,5]	None[4,5]
	11.46	90*	None[5]	None[5]	None[5]	None[5]	None[5]
	11.45	90*	None[5]	None[5]	None[5]	None[5]	None[5]
	11.31	90*	None[5]	None[5]	None[5]	None[5]	None[5]
	11.10	7	None[5]	None[5]	None[5]	None[5]	None[5]
	10.79	7	None[5]	None[5]	None[5]	None[5]	None[5]
	10.78	20	None[5]	None[5]	None[5]	None[5]	None[5]
	10.72	90*	None[5]	None[5]	None[5]	None[5]	None[5]
	9.92	90*	None[5]	None[5]	None[5]	None[5]	None5
North Battle Feeder	6.96	30*	None[5]	Steelhead, spring- and winter-run chinook salmon (all months)	Steelhead, spring- and winter-run chinook salmon (September-April; winter run not supported in May-June)	Steelhead, spring- and winter-run chinook salmon (all months)	Steelhead, spring- and winter-run chinook salmon (September-April; winter run not supported in May-June)
	6.02	30*	None[5]				
	5.40	35	None[5]				
Eagle Canyon	4.50	30*	None[5]				
Wildcat	2.36	20	None[5]				
	2.16	20	None[5]				

Stream Reach	Barrier Location[2] (river mile)	Minimum Passage Flow[3] (cfs)	Potential passage by species for each alternative				
			No Action	Five Dam Removal	No Dam Removal	Six Dam Removal	Three Dam Removal
South Fork Battle Creek							
South	11.68	50	None[5]	Steelhead, spring- and winter-run chinook salmon (all months)	None[5]	Steelhead, spring- and winter-run chinook salmon (all months)	None5
Inskip	3.81	30*	None[5]		None[4,5]		None4,5
	3.61	40	None[5]		None[5]		None5
	3.40	<5	None[4,5]		Steelhead, spring- and winter-run chinook salmon		Steelhead, spring- and winter-run chinook salmon
	3.15	20	None[5]				

Notes:

* Indicates that the exact flow need is unknown and could be lower or higher than indicated.

1 The minimum required instream flows are discussed in Appendix J.

2 Location is the distance upstream from the confluence of the North and South Forks of Battle Creek

3 Minimum passage flow is from the analysis by Thomas R. Payne and Associates (1998)

4 Although chinook salmon or steelhead could pass this barrier, downstream barriers prevent access.

5 The conclusion does not consider that high flows of short duration in response to storms would occur and provide passage during wetter months and years.

Table 4.1-8. Proportion of South Fork Flow Composed of North Fork Water Downstream of Coleman Diversion Dam for the No Action and No Dam Removal Alternatives

Flow	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
No Action Alternative												
10th percentile	65%	65%	65%	65%	65%	65%	65%	66%	65%	65%	65%	65%
30th percentile	64%	61%	60%	63%	65%	65%	65%	65%	65%	65%	65%	65%
50th percentile	58%	55%	54%	57%	57%	64%	65%	65%	65%	65%	65%	63%
70th percentile	47%	48%	48%	52%	51%	60%	65%	65%	65%	65%	65%	58%
90th percentile	39%	42%	37%	43%	48%	51%	65%	65%	65%	65%	50%	43%
No Dam Removal Alternative												
10th percentile	57%	57%	57%	57%	61%	60%	58%	57%	58%	58%	59%	54%
30th percentile	59%	60%	60%	60%	62%	61%	59%	59%	59%	59%	60%	57%
50th percentile	58%	55%	54%	57%	57%	62%	60%	59%	59%	60%	61%	60%
70th percentile	47%	48%	48%	52%	51%	60%	61%	60%	60%	61%	62%	58%
90th percentile	39%	42%	37%	43%	48%	51%	62%	61%	61%	61%	50%	43%

Note: North Fork flow would not be discharged into the South Fork under most operations expected for the Five Dam Removal, Six Dam Removal and Three Dam Removal Alternatives.

Table 4.1-9. Proportion of Flow Diverted at Each Diversion Dam for All Alternatives, Median Value for All Months and All Years

	Alternative				
Diversion Dam	No Action	Five Dam Removal *	No Dam Removal *	Six Dam Removal *	Three Dam Removal *
North Fork Feeder	89%	0%	16%	0%	16%
Eagle Canyon	89%	45%	47%	R	R
Wildcat	79%	R	26%	R	R
South	85%	R	53%	R	53%
Inskip	96%	36%	75%	36%	30%
Coleman	97%	R	77%	R	R

Notes:

* indicates that fish screens would minimize entrainment loss of fish.

R indicates the dam has been removed and diversion no longer occurs.

Table 4.1-10. Approximate Summer Stream Surface Area (acres) by Reach for Minimum Required Instream Flows for Each Alternative

	Alternative				
	No Action	Five Dam Removal	No Dam Removal	Six Dam Removal	Three Dam Removal
Below Keswick	7.7	7.7	7.7	7.7	7.7
Below NFBC Feeder	9.9	15.1	14.1	15.1	14.1
Below Eagle	5.8	9.2	8.9	9.2	8.9
Below Wildcat	5.7	8.0	7.8	8.0	7.8
Above South Dam	23.2	23.2	23.2	23.2	23.2
Below South Dam	19.4	24.2	22.2	24.2	22.2
Below Inskip Dam	16.1	22.6	21.5	22.6	21.5
Below Coleman Dam	7.4	10.8	10.2	10.8	10.2
Below Confluence	13.7	54.6	52.6	54.6	52.6
Total	108.9	175.3	168.3	175.3	168.3

Table 4.1-11. Number of days of powerhouse outages on Battle Creek, 1983–2001.

	Year											
Site	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1983 South	-	-	-	-	3	-	-	-	-	-	-	-
Inskip	-	-	-	-	-	3	-	-	-	-	-	-
Coleman	-	-	-	-	-	-	-	-	-	-	5	-
1984 South	-	-	-	-	-	-	-	-	-	13	-	-
Inskip	-	-	-	-	-	-	-	-	-	-	-	12
Coleman	-	-	-	-	-	-	-	-	-	-	7	-
1985 South	1	4	-	-	-	-	-	-	7	6	-	-
Inskip	-	-	-	-	-	-	-	-	-	-	17	-
Coleman	-	-	-	-	-	-	-	-	-	7	-	-
1986 South	-	-	-	-	-	-	-	-	-	9	-	-
Inskip	-	-	-	-	-	-	-	-	-	11	13	-
Coleman	-	-	-	2	9	-	-	-	-	-	-	-
1987 South	-	-	-	-	-	-	-	-	-	15	-	-
Inskip	-	-	-	-	-	-	-	21	23	-	-	-
Coleman	-	-	-	-	3	-	-	-	-	-	-	-
1988 South	-	-	-	-	-	-	-	-	-	3	-	-
Inskip	-	-	-	-	-	-	-	-	-	20	21	-
Coleman	-	-	-	-	-	-	-	-	9	-	-	-
1989 South	-	-	-	-	-	-	-	-	-	4	-	-
Inskip	-	-	-	-	-	-	-	-	-	7	-	-
Coleman	-	-	-	-	-	-	-	-	23	-	-	-
1990 South	-	-	-	-	-	-	-	-	-	8	-	-
Inskip	-	-	-	-	-	-	-	-	6	10	-	-
Coleman	-	-	-	-	-	1	-	3	7	-	-	-
1991 South	-	-	-	-	-	-	-	-	-	6	-	-
Inskip	-	-	-	-	-	-	-	2	-	-	-	-
Coleman	-	-	-	-	-	-	-	-	11	-	-	-
1992 South	-	-	-	-	-	-	-	-	-	9	-	-
Inskip	-	-	-	-	-	-	-	-	-	7	-	-
Coleman	-	-	-	-	-	-	-	14	28	-	-	-
1993 South	-	-	-	-	-	-	-	-	-	2	-	-
Inskip	-	-	-	-	-	-	-	1	2	-	-	-
Coleman	6	1	-	-	-	-	-	-	2	-	-	-

Table 4.1-11. Continued

		Year											
Site		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1994	South	-	-	-	-	-	-	-	-	-	1	-	-
	Inskip	-	-	-	-	-	-	-	-	8	-	-	-
	Coleman	-	-	-	-	-	-	-	1	-	-	-	-
1995	South	-	-	-	-	-	-	-	-	-	1	-	-
	Inskip	-	-	-	-	-	-	-	-	-	2	-	-
	Coleman	-	-	-	-	14	-	-	-	1	-	-	4
1996	South	-	-	-	-	-	-	-	-	1	-	-	-
	Inskip	-	-	-	-	-	-	-	2	-	-	-	-
	Coleman	-	-	-	-	-	-	-	3	1	-	-	-
1997	South	-	-	1	-	-	-	-	-	2	-	-	-
	Inskip	28	24	-	-	-	-	-	-	-	-	-	-
	Coleman	1	-	-	-	-	-	-	6	30	3	-	-
1998	South	-	-	22	8	-	-	-	-	-	-	-	-
	Inskip	-	-	-	1	-	-	-	-	-	-	-	-
	Coleman	-	-	-	-	-	9	-	-	-	-	7	6
1999	South	0	0	2	-	-	-	-	-	-	-	-	-
	Inskip	-	-	3	-	-	-	-	-	-	-	-	-
	Coleman	-	-	-	2	-	-	-	-	-	-	-	-
2000	South	-	-	-	2	-	-	-	-	-	-	-	-
	Inskip	-	-	3	-	-	-	-	-	-	-	-	-
	Coleman	-	-	20	-	-	9	-	-	-	-	-	-
2001	South	-	-	1	-	-	-	-	-	-	-	-	-
	Inskip	-	-	1	-	-	-	-	-	-	-	-	-
	Coleman	-	-	1	-	30	30	9	-	-	-	-	-

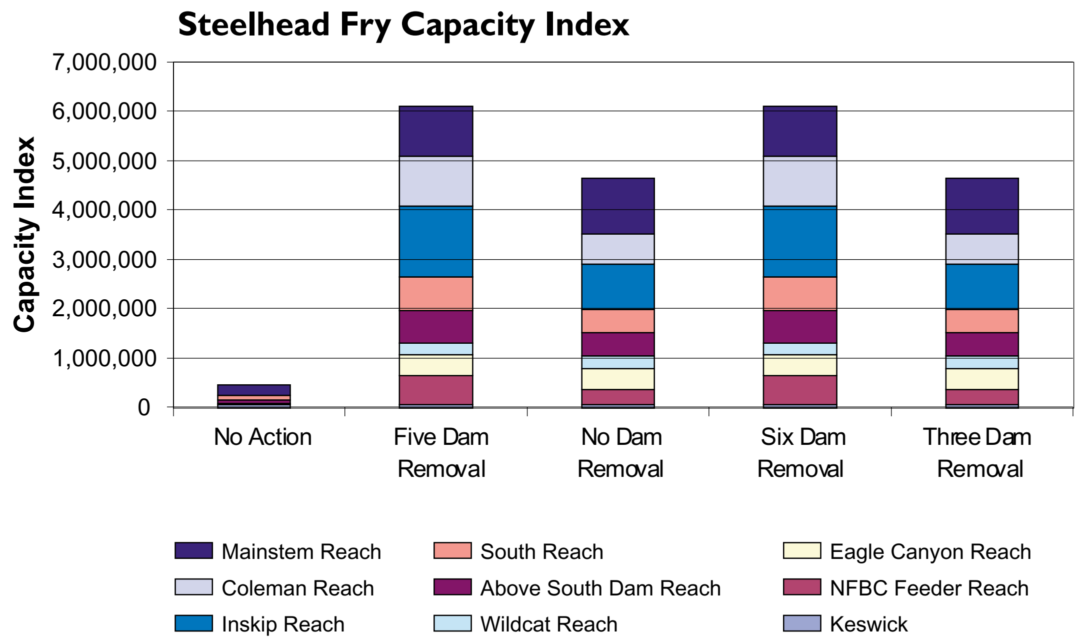
Figure 4.1-1. Seasonal Occurrence of Selected Life Stages of Anadromous Salmonids in the Upper Sacramento River

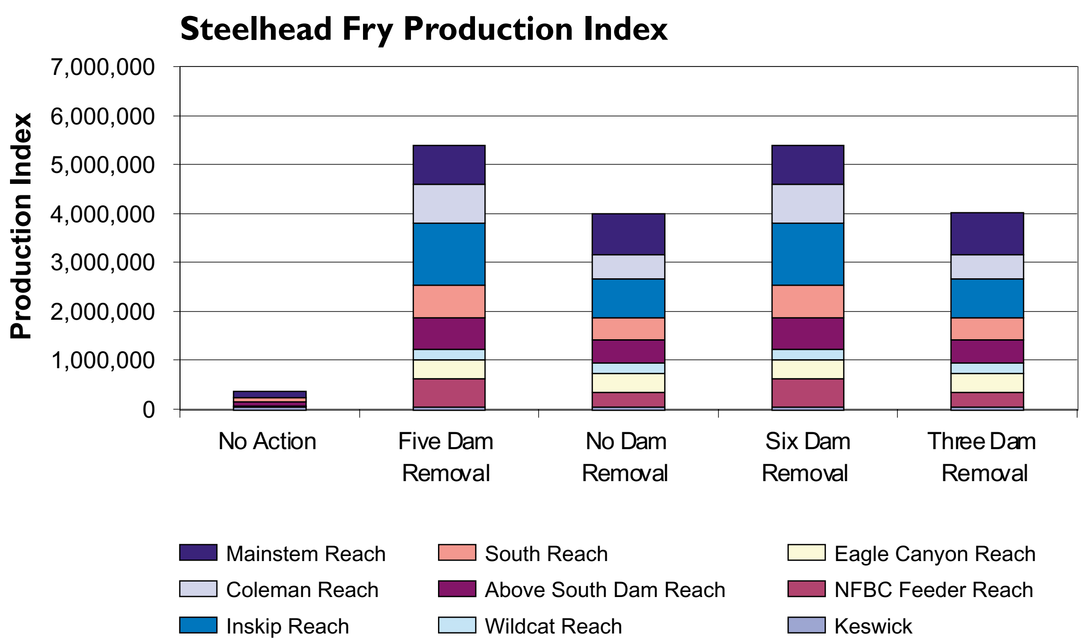
Life Stage	Species	Month											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Adult Migration	Steelhead												
	Winter-run chinook				X								
	Spring-run chinook					X							
	Fall-run chinook										X		
	Late fall–run chinook	X											
Spawning	Steelhead												
	Winter-run chinook						X						
	Spring-run chinook									X			
	Fall-run chinook											X	
	Late fall–run chinook		X										
Juvenile Residence	Steelhead												
	Winter-run chinook												
	Spring-run chinook												
	Fall-run chinook												
	Late fall–run chinook												

Notes

Source: Schafter 1980; Vogel and Marine 1991.

X denotes the approximate peak of life stage if a significant peak occurs.

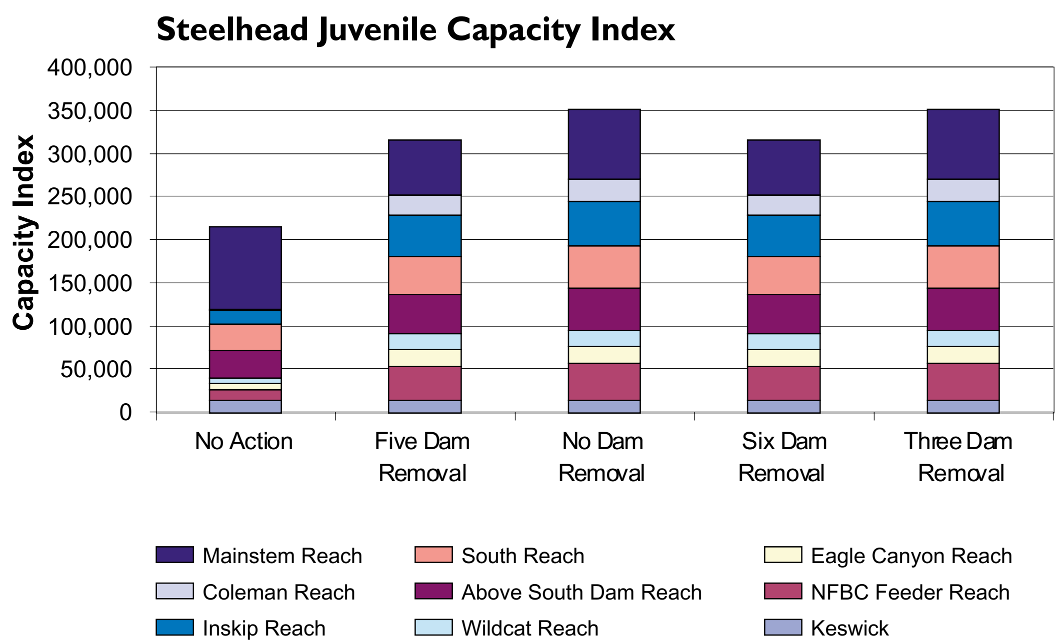


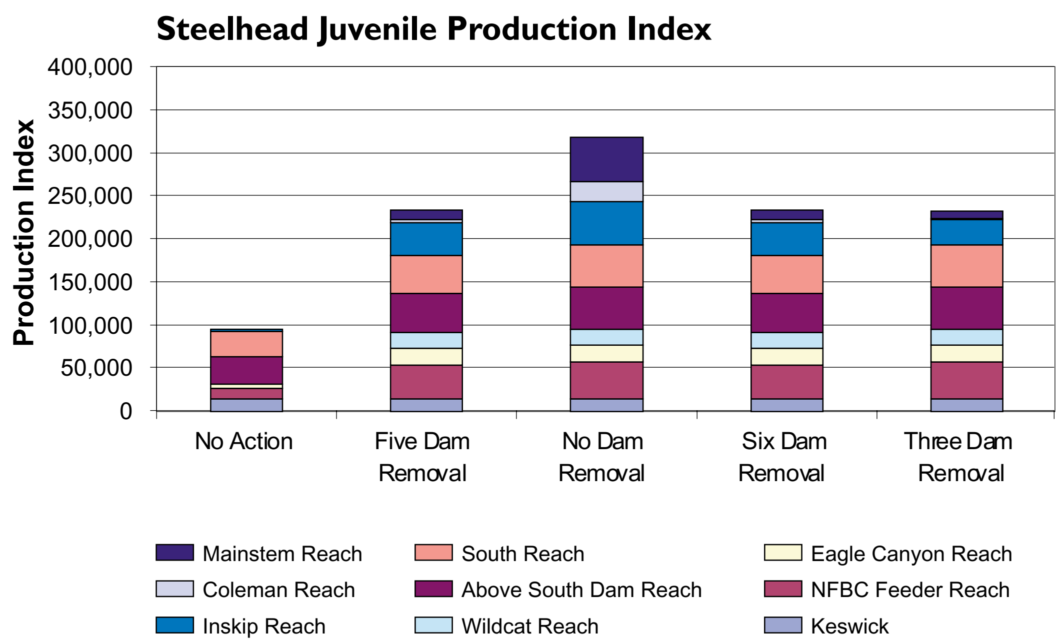


Note:
Indices are based on the minimum flow requirements for each alternative.

03035.03-004

Figure 4.1-2
Effects of Spawning Area and Water Temperature on Capacity and Production Indices for Steelhead in All Reaches of Battle Creek

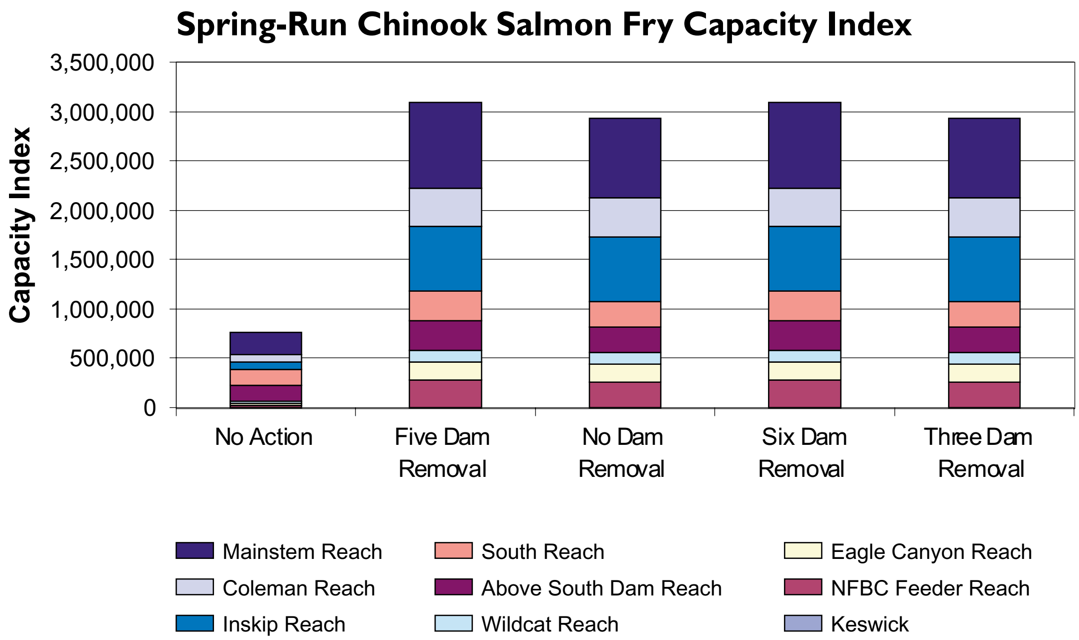


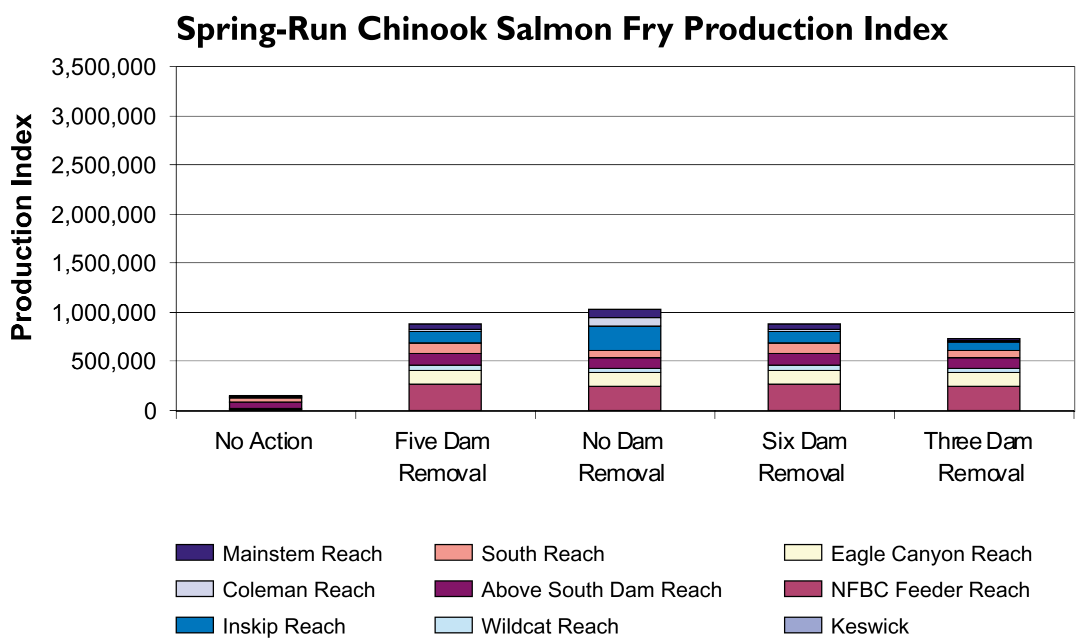


Note:
Indices are based on the minimum flow requirements for each alternative.

03035.03-004

Figure 4.1-3
Effects of Rearing Area and Water Temperature on Capacity and Production Indices for Steelhead in All Reaches of Battle Creek

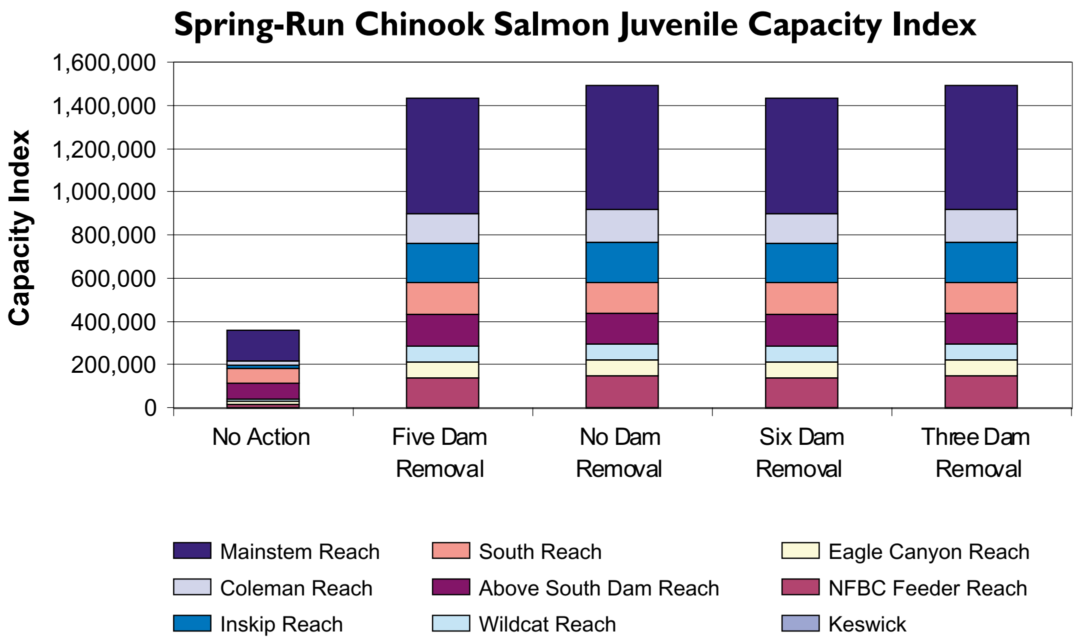


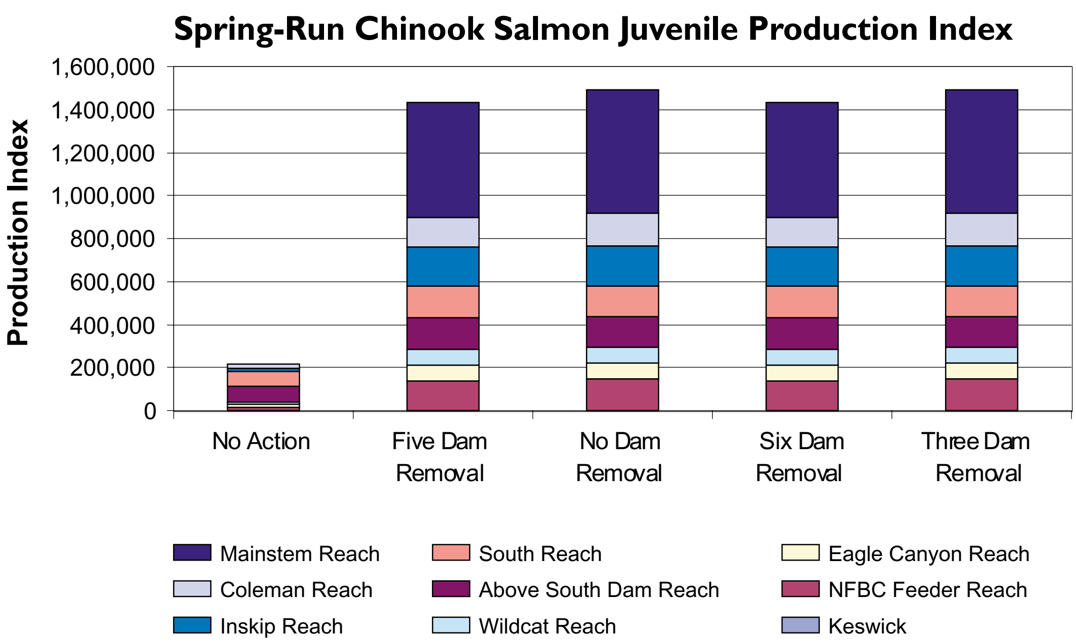


Note:
Indices are based on the minimum flow requirements for each alternative.

03035.03-004

Figure 4.1-4
Effects of Spawning Area and Water Temperature on Capacity and Production Indices for Spring-Run Chinook Salmon in All Reaches of Battle Creek

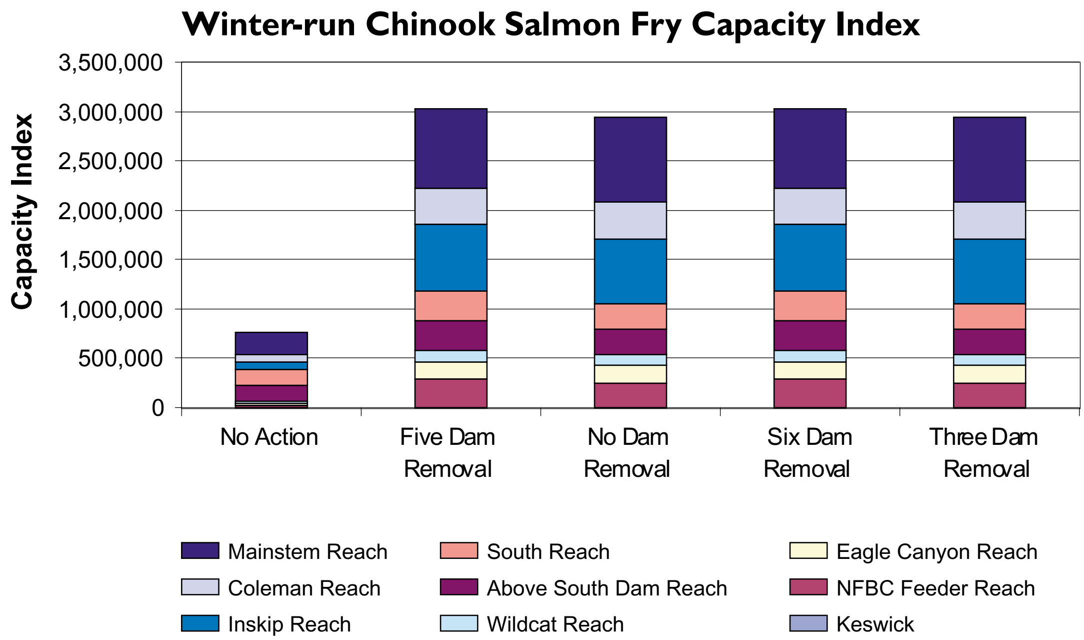


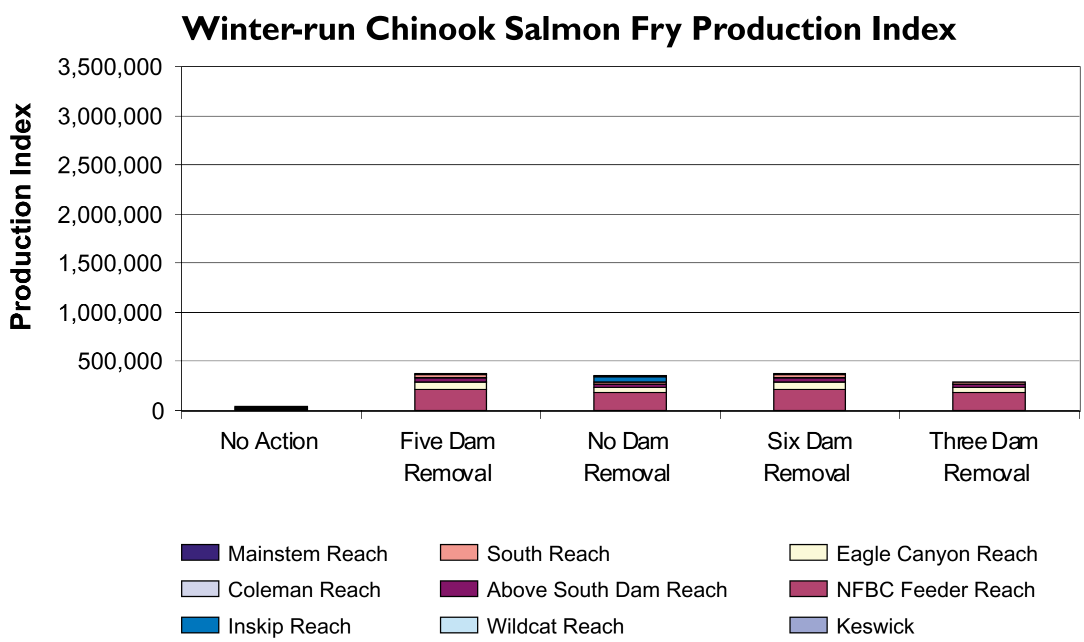


Note:
Indices are based on the minimum flow requirements for each alternative.

03035.03-004

Figure 4.1-5
Effects of Rearing Area and Water Temperature on Capacity and Production Indices for Spring-run Chinook Salmon in All Reaches of Battle Creek



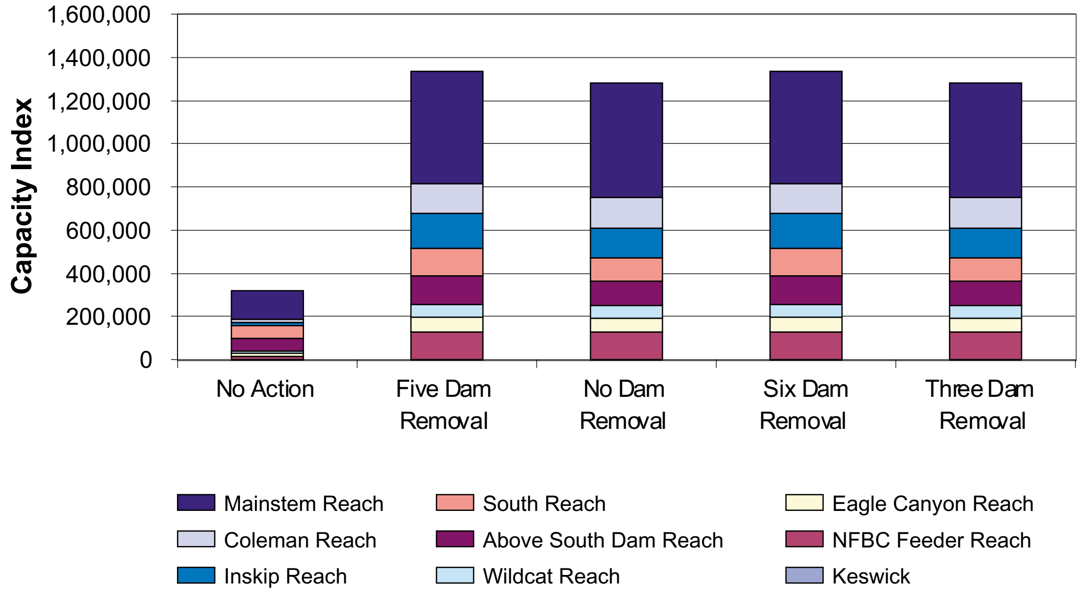


Note:
Indices are based on the minimum flow requirements for each alternative.

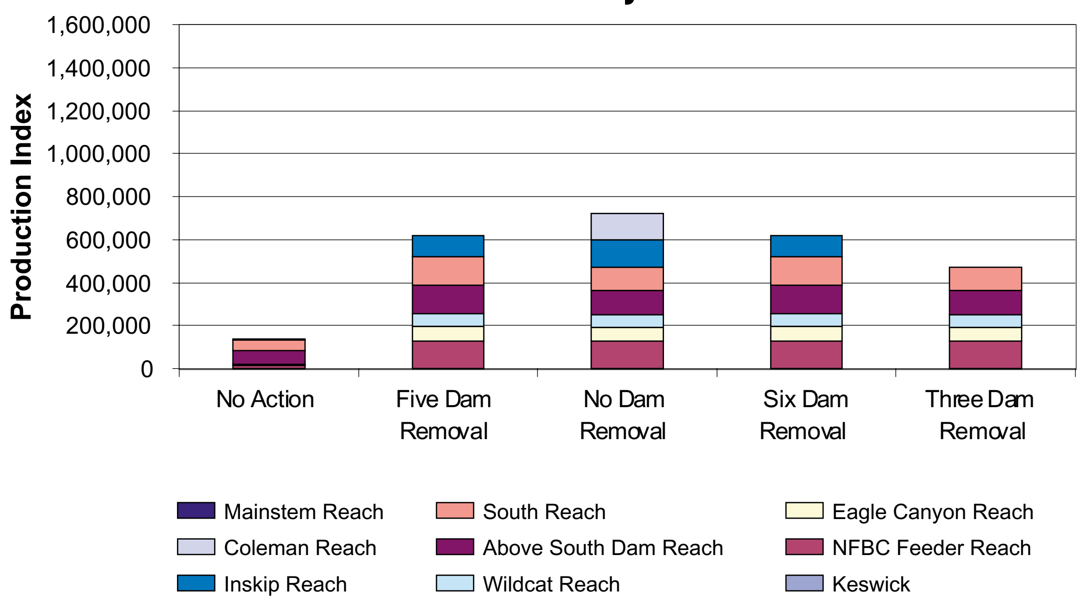
03035.03-004

Figure 4.1-6
Effects of Spawning Area and Water Temperature on Capacity and Production Indices for Winter-run Chinook Salmon in All Reaches of Battle Creek

Winter-run Chinook Salmon Juvenile Capacity Index



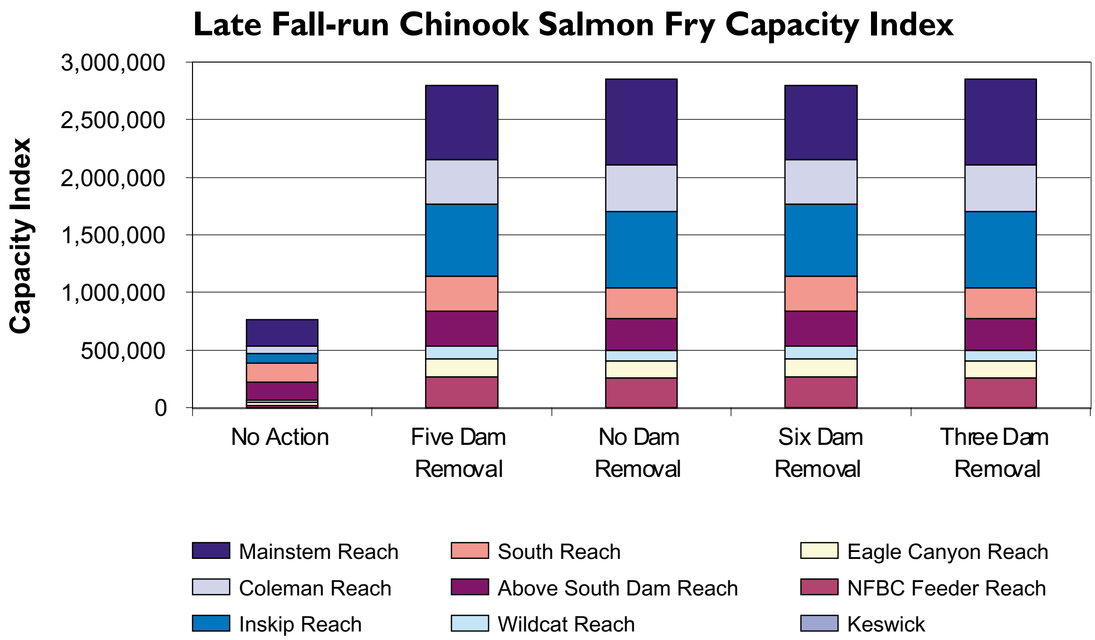
Winter-run Chinook Salmon Juvenile Production Index

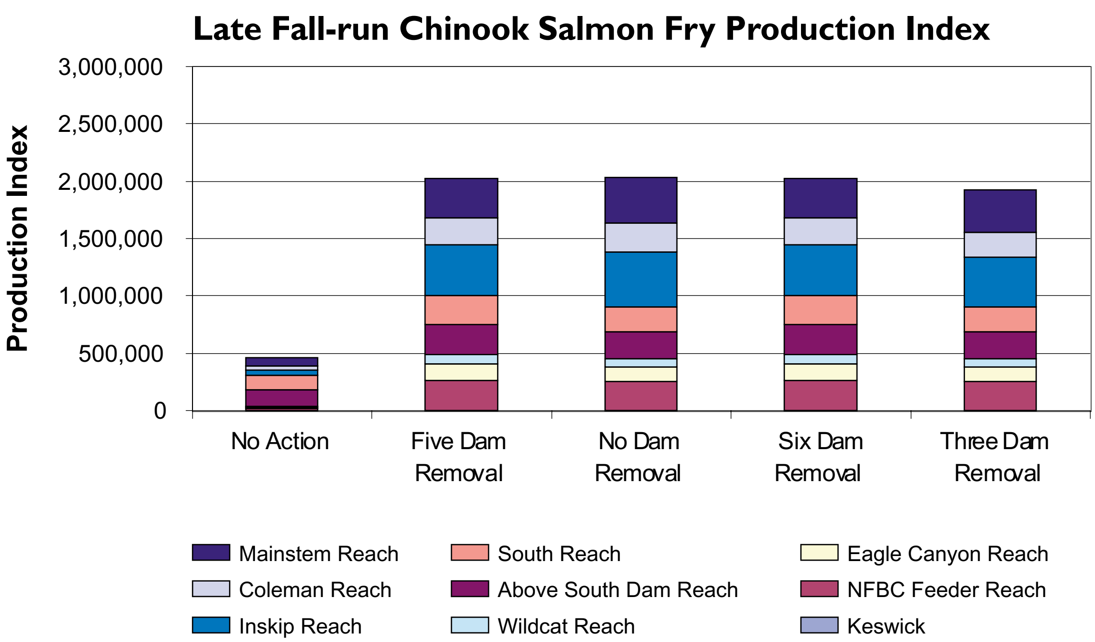


Note:
Indices are based on the minimum flow requirements for each alternative.

03035.03-004

Figure 4.1-7
Effects of Rearing Area and Water Temperature on Capacity and Production Indices for Winter-run Chinook Salmon in All Reaches of Battle Creek

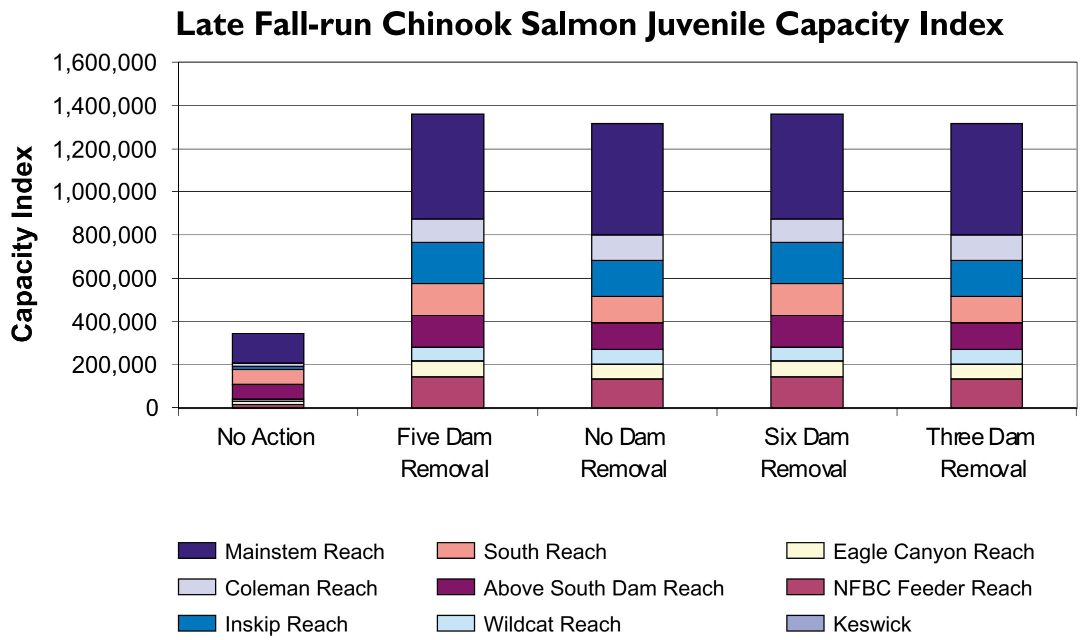


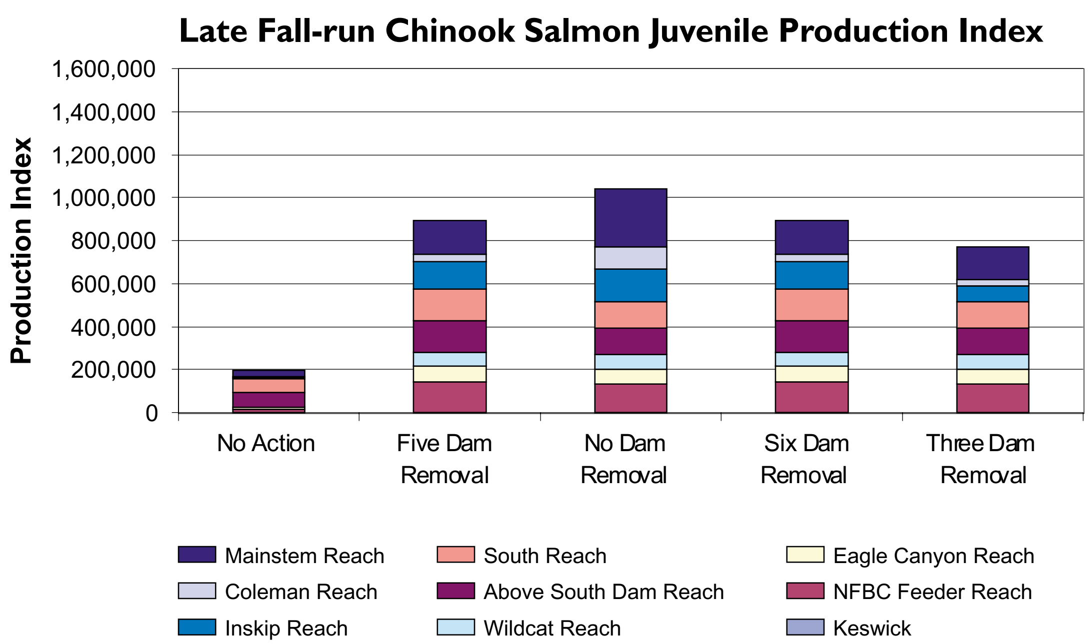


Note:
Indices are based on the minimum flow requirements for each alternative.

03035.03-004

Figure 4.1-8
Effects of Spawning Area and Water Temperature on Capacity and Production Indices for Late Fall-run Chinook Salmon in All Reaches of Battle Creek





Note:
Indices are based on the minimum flow requirements for each alternative.

03035.03-004

Figure 4.1-9
Effects of Rearing Area and Water Temperature on Capacity and Production Indices for Late Fall-run Chinook Salmon in All Reaches of Battle Creek