CENTRAL VALLEY
FLOOD MANAGEMENT
PLANNING PROGRAM

FloodSAFE
CALIFORNIA

Public Draft

2012 Central Valley Flood Protection Plan

Attachment 9C: Fish Passage Assessment

January 2012

STATE OF CALIFORNIA
THE NATURAL RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

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1.0 Introduction

The Central Valley Flood Protection Act of 2008 requires DWR to develop a Central Valley Flood Protection Plan (CVFPP) that, among other objectives, improves habitat quantity, diversity, and connectivity and contributes to the recovery and stability of native species populations. This includes riverine aquatic habitats and anadromous fish species. One of the challenges to long-term viability of these fish is the obstacles that hinder or block their passage between the ocean and spawning streams in the Central Valley watershed.

This report identifies fish passage obstacles and recommends actions for modifying the Central Valley flood management system that could contribute to the recovery of native anadromous[1] fish in the Central Valley.

Within the geographical context of the CVFPP Systemwide Planning Area, this report discusses:

- The importance of ecological flows and floodplain flooding for fish
- The anadromous species present
- Anadromous fish population status and the reduction from their historic ranges
- Reasons for their decline, with a particular focus on physical passage barriers and stranding related to flood management
- The implications of passage barriers under climate change effects
- An identification and ranking of passage barriers and stranding areas
- A description of tested approaches for improving passage around major dams

Fish passage barriers can include, but are not limited to, dams, weirs, grade control structures, pumping stations, flood control gates, levees that cross or block stream channels, road crossings, and features of the flood control channels and bypasses that strand fish. Fish passage actions include

[1] Anadromous fish hatch from eggs laid in freshwater streams, migrate as juveniles to saltwater, and after living and growing in ocean waters return as adults to spawn in freshwater to complete their life cycle.

identifying barriers, evaluating and assessing the magnitude that each barrier impedes migration, and fixing barriers to allow unimpeded migration. These actions will assist in increasing and improving habitat connectivity and promoting the recovery of anadromous fish populations in the Sacramento-San Joaquin River Flood Management System.

The geographic scope of this report is the Systemwide Planning Area (Figure 1-1). This area includes lands that receive protection from the current facilities and operation of the Sacramento-San Joaquin River Flood Management System.[2] This area includes facilities that provide significant systemwide benefits (such as reservoirs on major tributaries) or that protect urban areas within the Sacramento and San Joaquin valleys. State Plan of Flood Control (SPFC) structures and components are contained within the Systemwide Planning Area. The structures and components, constructed over the last 150 years include dams, reservoirs, levees, channels, weirs, bypasses, and other flood control structures that provide varying levels of flood protection within the Central Valley.

[2] The Sacramento-San Joaquin River Flood Management System includes facilities of the SPFC and other flood management facilities that provide significant systemwide benefits for managing flood risks, or that protect urban areas, within the Sacramento-San Joaquin Valley (California Water Code, Section 9611).

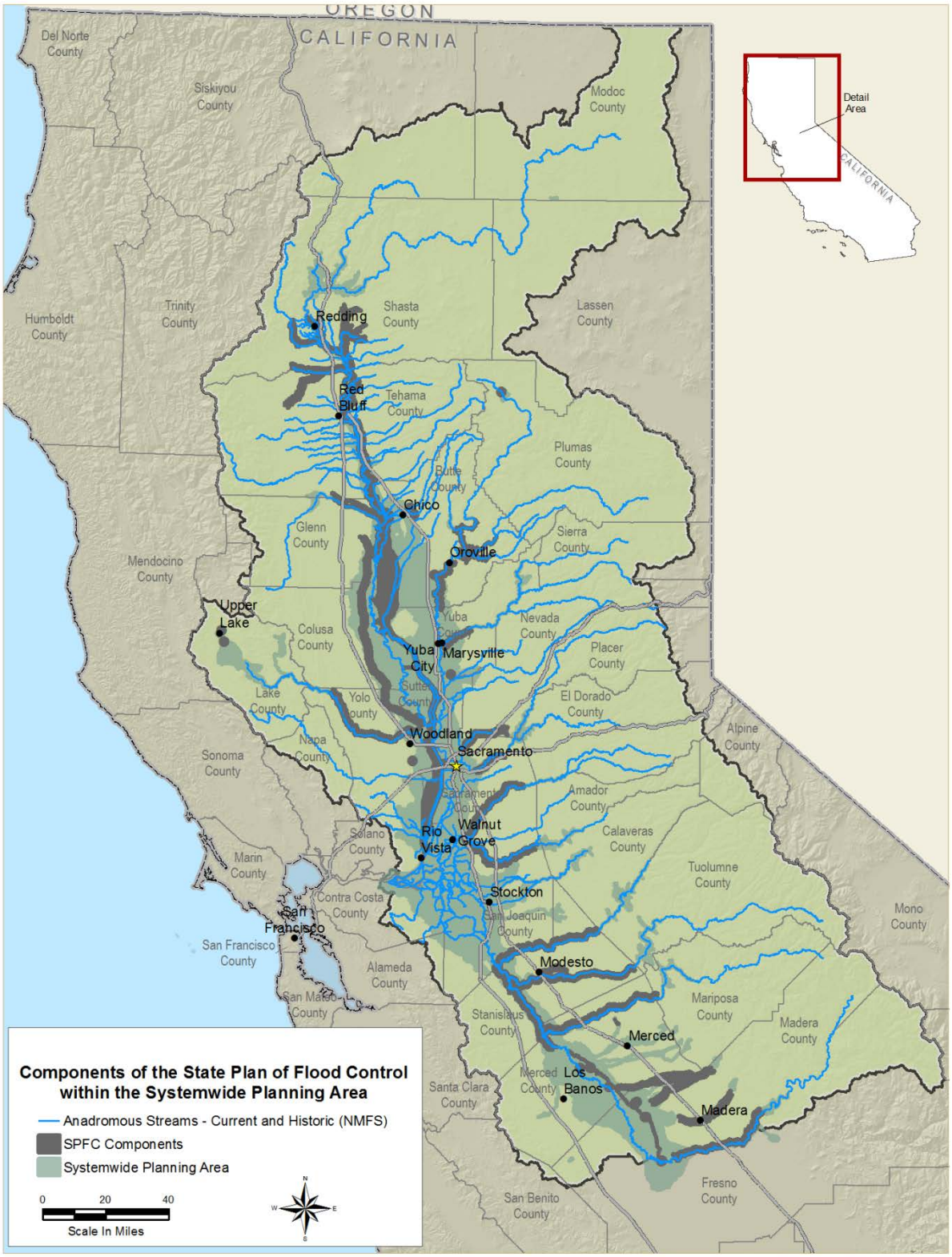

Figure 1-1. The Systemwide Planning Area and State Plan of Flood Control

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2.0 The Importance of Ecological Flows and Floodplain Flooding

Floods that periodically inundate the floodplains adjacent to rivers provide widespread ecosystem benefits. They can dramatically alter riverine landscapes, and benefit fish communities, food webs, and biological productivity (Junk et al., 1989; Feyrer et al., 2006b).

2.1 Floodplains

Floodplains are important components of aquatic ecosystems. They can provide widespread benefits at multiple trophic levels, ranging from individual organisms to ecosystems (Junk et al., 1989; Sommer et al., 2008). Floodplain habitat is particularly important to fish populations, where access to floodplain habitat produces increases in fish production, abundance, species diversity, and growth (Feyrer et al., 2004, Jeffres et al., 2008). For example, the fish communities of Yolo and Sutter bypasses appear to be structured primarily by the underlying physical habitat characteristics of each floodplain and secondarily by flood flows (Feyrer et al., 2006b). Results from several studies suggest that salmonids benefit from floodplains (Feyrer et al., 2007) because juveniles that use floodplain habitats in the Yolo Bypass (Sommer et al., 2001) and the Cosumnes River (Jeffres et al., 2008) consume more prey and grow faster than those in mainstem habitats. Sommer et al. 2001 found that survival rates of juvenile salmon may have been better in the Yolo Bypass in 1998 when flows were of a higher duration and magnitude than in 1999. The possible improvement in wet-year survival of salmon may have been due to increased access to floodplain rearing habitat, reduced water temperature, reduced predation losses, and other factors (Sommer et al., 2001). Floodplains also benefit other native fishes and support lower trophic levels, including drift invertebrates, phytoplankton, and zooplankton.

Fish yield and production seem to be a function of accessible floodplain habitat (Junk et al., 1989). Feyrer et al. (2007) documented enhanced growth and production of age-0 Sacramento splittail (*Pogonichthys macrolepidotus*), a native floodplain-dependent minnow, in floodplain habitat. Feyrer et al. (2007) found evidence that food web pathways supporting age-0 splittail in riverine and floodplain habitats were affected by flows connecting the two habitats. This suggests that flow and connectivity have an important effect on trophic relationships in river-floodplain systems.

Connection between a river and its floodplain enhances production of lower trophic levels, such as in the floodplain of the Sacramento River, where drift insects (primarily chironomids) were one to two orders of magnitude more abundant than in the adjacent river channel during 1998 and 1999 flood events (Sommer et al., 2001). The increased productivity is likely to be a significant benefit to secondary consumers, including salmon (Sommer et al., 2004).

River-floodplain connectivity also provides increased amounts of foraging and spawning habitat for fish. Studies have shown that inundation of the Yolo Bypass creates one of the major rearing habitats for downstream migrating juvenile Chinook salmon (*Oncorhynchus tshawytscha*), which take advantage of rearing areas created by seasonally inundated vegetation and an enriched food web in the floodplain (Sommer et al., 2001, 2004, 2005, 2008). Significantly larger wild Chinook salmon are captured at the downstream end of the Yolo Bypass than at the upstream end, and juvenile salmon in the Yolo Bypass floodplain grow substantially faster than the adjacent Sacramento River, illustrating the importance of this habitat (Sommer et al., 2001, 2005).

National Oceanic and Atmospheric Administration (NOAA) Fisheries recognized the importance of floodplain habitat in the Biological and Conference Opinion for the Central Valley Project (CVP) and State Water Project (SWP) (NOAA Fisheries, 2009b). Action I.6.1 requires the U.S. Bureau of Reclamation (Reclamation) and California Department of Water Resources (DWR) to "restore floodplain rearing habitat for juvenile winter-run and spring-run Chinook salmon, and Central Valley steelhead (*Oncorhynchus mykiss*), in the lower Sacramento River Basin. This objective may be achieved at the Yolo Bypass, and/or through actions in other suitable areas of the lower Sacramento River."

The Yolo Bypass is also an adult anadromous fish migration corridor when inundated. Structures within the Yolo Bypass have been a documented source of migratory delay to, and loss of, adult salmon, steelhead and green sturgeon (Harrell 2003 et al., NOAA Fisheries 2009b). Better and more regular upstream passage is needed to make it a migration corridor without barriers that hinder the movement of fish.

Another phenomenon important for migrating adult Chinook salmon is hydrologic banding.[3] In the Yolo Bypass, salmon pass through the floodplain on their journey to spawn in the upstream channels of Putah Creek, and the Sacramento River and its tributaries (Harrell and Sommer, 2003). Sommer et al. (2008) found that photographs of hydrologic banding

[3] Hydrologic bands are plumes of water from different sources that do not mix.

in the Yolo Bypass provide clues as to the likely routes that salmon take as they rely on chemical cues to migrate upstream.

Floodplain habitat in California has frequently been lost through the channelization of rivers, including construction of levees and channel straightening, deepening, and lining (Mount, 1995). Impacts of hydraulic mining, especially in the Yuba and Feather rivers, caused changes in sediment deposition within channels and floodplains, loss of channel capacity, and aggradation of river courses (Mount, 1995). A variety of activities, including water storage, conveyance, flood management, and navigation enhancements, have contributed to river modification and impaired natural floodplain inundation. Recent modeling studies have indicated that these factors can also affect habitats integral to the floodplain as well as their fisheries (Feyrer, 2006b).

2.2 Flows

Two primary factors that affect the operations of large reservoirs are regulatory and environmental requirements.

2.2.1 Regulatory requirements

Regulatory restrictions include flood management, water, and energy supply obligations; requirements of the Central Valley Project Improvement Act, the 1995 Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary, the Federal Endangered Species Act, California Fish and Game Code Section 5937[4], and terms and conditions of water right permits. In order to meet regulatory objectives, reservoir operations must be based on consideration of many factors, including current and anticipated hydrological conditions; water supply forecasts; demand for water and electricity; the location, movement, and condition of fish; water temperature; coldwater pool availability; and water quality conditions in the Sacramento-San Joaquin River Delta (Delta) (Surface Water Resources Inc., 2004).

2.2.2 Environmental requirements

Flows released for environmental (ecological) considerations (Peak and Ecological Flow Technical Advisory Committee, 2010) are typically divided into three types:

[4] California Fish and Game Code 5937 requires that the owner of any dam shall allow sufficient water at all times to pass through a fishway, or in the absence of a fishway, allow sufficient water to pass over, around or through the dam, to keep in good condition any fish that may be planted or exist below the dam.

1. Low-flow thresholds ("subsistence flows") that prevent direct mortality of aquatic species. Subsistence flows are often used as short-term emergency bypass flows needed to keep populations of aquatic species alive and avoid fish kills or other serious acute impacts due to poor water quality.

2. "Base flows" that provide minimal or optimal habitat for target aquatic species, including flows that occur outside of freshets and storm events. The biological objectives of base flows include providing adequate protection of habitat for aquatic species, and upstream/downstream and mainstream/tributary connectivity (such as fish passage flows). Base flows include minimum bypass flows, which are defined by the State Water Resources Control Board as the minimum instantaneous flow rate of water that is important for managing the protection of steelhead and salmon life history needs, such as: (1) maintaining natural abundance and availability of spawning habitat; (2) minimizing unnatural adult exposure, stress, vulnerability, and delay during adult spawning migration; and (3) sustaining high quality and abundant juvenile salmonid winter rearing habitat (State Water Resources Control Board, Division of Water Rights, 2010).

3. Elevated "channel and habitat maintenance flows" are needed to maintain and create instream and riparian/floodplain habitat. These flows have a significant effect on the habitat of listed anadromous fish within the Systemwide Planning Area. Elevated releases (i.e., flood releases) are essential to the maintenance of habitat both within the floodplain and in the stream channel. The timing, duration, and frequency of elevated flows influence the effectiveness of habitat maintenance. These flows serve many purposes, including:

    a. Moving cobbles and gravels that remove fine sediments (silt, sand, fine gravel), thereby improving fish spawning and rearing habitat and macroinvertebrate rearing habitat;

    b. Scouring and filling the stream channel to prevent the encroachment of riparian vegetation, allowing the stream to retain its bed form rather than losing conveyance capacity and stream habitat space;

    c. Retaining bed configuration that supports the formation and maintenance of riffles, pools and other channel habitats, and creating and maintaining off-channel habitat;

    d. Creating conditions for the replenishment of streamside vegetation such as cottonwoods (*Populus* spp.) to maintain long-term riparian functions; and,

e. Maintaining recruitment, movement, and functionality of large woody debris in the stream.

4. Elevated "biological triggering flows" that stimulate and facilitate important life stage behavior such as migration or spawning in target species.

Large pulse flows act as biological triggers for anadromous fish. Fish and other aquatic organisms tie important activities such as migration or spawning to changes in environmental conditions such as water temperature, turbidity, daily sunlight, or flow rate. Some known scenarios where variability in streamflow or elevated flows cause aquatic organisms to initiate important phases of their life cycle include:

- Increases in flows to initiate upstream or downstream migration of fish (Jager, et al., 2003);
- Elevated flows to initiate spawning activity;
- Elevated flow periods to allow for the use of off channel, floodplain, or side channel habitat on large and small rivers; and,
- Changes in flow that initiate different life stage activities in aquatic insects.

The environmental flows discussed above are all important for maintaining ecological processes in riverine corridors, and illustrate the interconnectedness of flow vs. life stages (spawning, rearing, and migration).

2.2.3 Example of Project to Restore Flows - San Joaquin River

The operation of Friant Dam is an important example of the necessity of providing adequate stream flows to the reaches downstream from a large dam. The San Joaquin River Restoration Program (SJRRP) is a direct result of a settlement reached in September 2006 on an 18-year lawsuit (NRDC, et al., vs. Kirk Rodgers, et al, 2006). The SJRRP is designed to implement this settlement and to restore flows and naturally reproducing and self-sustaining populations of salmon to the San Joaquin River between the Friant Dam and the Merced River.

Proposition 84 (the Safe Drinking Water, Water Quality and Supply, Flood Control, River and Coastal Protection Bond Act of 2006) provided $100 million to implement this court settlement. The funds are designated for channel and structural improvements and related research pursuant to the

court settlement. In collaboration with Reclamation, DWR's South Central Region Office has lead responsibility for the Department's involvement in the San Joaquin River Restoration Program.

The settlement establishes two goals:

- **Restoration** – To restore and maintain fish populations in "good condition" in the mainstem of the San Joaquin River below Friant Dam to the confluence of the Merced River, including naturally reproducing and self-sustaining populations of salmon and other fish.

- **Water Management** – To reduce or avoid adverse water supply impacts to all of the Friant Division long-term contractors that may result from the Interim Flows and Restoration Flows provided for in the settlement.

The settlement also identifies Interim Flows, which were released and are to continue until full Restoration Flows begin. The intent of the Interim Flows is to collect relevant data on flows, temperatures, fish needs, seepage losses, and water recirculation, recapture, and reuse (San Joaquin River Restoration Program, 2009).

The ecological functionality intended for the actions to reoperate Friant Dam was provided through a review of expert testimony submitted to the U.S. Eastern District Court of California during litigation. Based on the expert testimony, the overall ecological intent of the flow schedules provided in Exhibit B of the settlement can be summarized as follows:

- Provide for salmon life history needs (spring-run Chinook, fall-run Chinook), including:
  - Adult migration
  - Adult holding (spring-run Chinook only)
  - Spawning and incubation
  - Juvenile rearing
  - Juvenile outmigration
- Support other native fish and warm-water game fish[5]

[5] While ecological flows for native fish are supported by fisheries groups, the proliferation of warm-water game fish has been an ongoing concern. Warm-water fish include predators of juvenile Chinook salmon that could potentially cluster near flood control structures and gravel pits. (Comments received from A. Leon Cardona, 2011).

These flow schedules for the protection of native fishes are an example of "base flows" as described above.

In addition, the flow schedules intend to provide channel and habitat maintenance flows that (1) maintain geomorphic processes (especially gravel mobility) and (2) support recruitment and maintenance of riparian vegetation (San Joaquin River Restoration Program, 2009).

Under the settlement, spring-run and fall-run Chinook salmon are to be reintroduced to the San Joaquin River between Friant Dam and the confluence with the Merced River by December 31, 2012. The implementing agencies are currently working to implement the Reintroduction Strategy (NRDC, et al., vs. Kirk Rodgers, et al, 2006; San Joaquin River Restoration Program, 2011b). Recently, the SJRRP has performed work to identify fish passage barriers on the San Joaquin River from Friant Dam to the Merced River. This work includes literature research, field visits, and evaluations (Pers. comm. Romero, 2011).

For more information about SJRRP, see http://www.restoresjr.net/background.html)

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3.0 Listed Anadromous Fish Within the Systemwide Planning Area

This report focuses on three species of anadromous fish that use the Central Valley: Chinook salmon, steelhead, and green sturgeon (*Acipenser medirostris*). Table 3-1 lists these three species (and important runs) and provides comparative information about their life history stages and seasonality. Anadromous fish are fish species that hatch from eggs laid in freshwater streams, migrate as juveniles to saltwater, and after living and growing in ocean waters then return as adults to spawn in freshwater to complete their life cycle.

Table 3-1. Anadromous Fish in the Upper Sacramento River

Species	Adult Immigration	Adult Holding	Typical Spawning	Egg Incubation	Juvenile Rearing	Juvenile Emigration
Winter-run Chinook salmon	December – July	January – May	April – August	April – October	July – March	July – March
Spring-run Chinook salmon	April – July	May – September	August – October	August – December	October – April	October - May
Fall-run Chinook salmon	July – December	n/a	October – December	October - March	December – June	December – July
Late Fall-run Chinook salmon	October – April	n/a	January – April	January – June	April – November	April – December
CA Central Valley Steelhead	August – March	September – December	December – April	December – Jun	Year round	January – October
Green sturgeon	February – June	June – November	March – July	April – June	May – August	May – December

Source: NOAA Fisheries, 2009b.

Key:
n/a = not applicable

California Chinook salmon are similar in morphology and are distinguished mainly by genetic and life history traits (e.g., run timing) (Moyle et al., 2008). The distinct populations within the species generally referred to as "runs" or "stocks," are named after the season in which they begin their freshwater spawning migrations, and are genetically and geographically distinct. In California's Central Valley, there are four genetically distinct runs: fall, late-fall, winter, and spring (Table 3-1).

Steelhead in California occur in six populations[6] (Evolutionary Significant Units (ESU) and Distinct Population Segments (DPS)) recognized by NOAA Fisheries. The populations are morphologically identical to one another and are distinguished by genetic characteristics. California populations of steelhead have complex systematic relationships (Moyle, 2002), and while California's six populations have essentially discrete geographic boundaries, adjacent populations have some degree of genetic similarity. The DPS of steelhead that is distributed in the Central Valley and the Systemwide Planning Area is the California Central Valley Steelhead.

Sturgeon occur in temperate waters throughout the Northern Hemisphere. Twenty-five species are currently extant, of which eight species are found in North America, and only two occur in California: white sturgeon (*Acipenser transmontanus*) and green sturgeon (Moyle, 2002). On the basis of genetic analyses and evidence of spawning site fidelity, NOAA Fisheries determined that green sturgeon occur in at least two DPS (Adams et al., 2002): a "Northern DPS" consisting of populations from coastal watersheds northward of and including the Eel River, and a "Southern DPS" consisting of populations from Coastal California and Central Valley watersheds south of the Eel River (NOAA Fisheries, 2010a, 2010b).

Federal and State agencies have listed several populations of anadromous fish as Threatened or Endangered, or a Species of Concern under the federal Endangered Species Act and California Endangered Species Act, respectively:

- Sacramento River winter-run Chinook salmon are listed by the State and federal governments as "Endangered."
- Central Valley steelhead, Central Valley spring-run Chinook salmon, and the Southern DPS of North American green sturgeon are listed by the federal government as "Threatened." Central Valley spring-run Chinook salmon is also listed by the State as "Threatened."
- Central Valley fall-run and late-fall run Chinook salmon are listed by the federal government as "Species of Concern" and by the State as "Species of Special Concern."

[6] The Endangered Species Act (ESA) defines a "species" to include any distinct population segment of any species of vertebrate fish or wildlife. For Pacific salmon, NOAA Fisheries Service considers an evolutionarily significant unit (ESU) a "species" under the ESA. For Pacific steelhead, NOAA Fisheries Service has delineated distinct population segments (DPS) for consideration as "species" under the ESA (NOAA Fisheries 2009).

4.0 Historic and Current Populations of Listed Anadromous Fish in the Systemwide Planning Area

4.1 Chinook Salmon

4.1.1 Spring-Run Chinook Salmon

The basic life history of spring-run Chinook salmon is to migrate upstream in spring, hold through the summer in deep, cold water pools, and then spawn in early fall, with juveniles emigrating after either a few months or a year while rearing in fresh water (Table 3-1).

Lindley et al. (2004) identified 26 historical populations within the spring-run Chinook salmon ESU; 19 were independent[7] populations, and seven were dependent populations. Only three independent populations of spring-run Chinook that occurred historically are extant, in Deer, Mill, and Butte creeks (in Tehama and Butte counties). Extant dependent populations have increased to nine and occur in Battle, Antelope, Big Chico, Clear, Beegum, and Thomes creeks, as well as in the Yuba River, the Feather River downstream of Oroville Dam, and in the mainstem Sacramento River below Keswick Dam (NOAA Fisheries, 2009a) (Figure 4-1). Within these regions, Chinook distribution is determined by water temperature and accessibility of spawning, rearing, and holding habitats (Moyle et al., 2008).

[7] Lindley et al. (2004) used several characteristics, including distance from a basin to its nearest neighbor (at least 50 km), the basin size (generally at least 500 km^2), and significant environmental differences between basins inside of the distance criterion, as well as data on population genetics and dynamics to decide whether populations were independent or dependent.

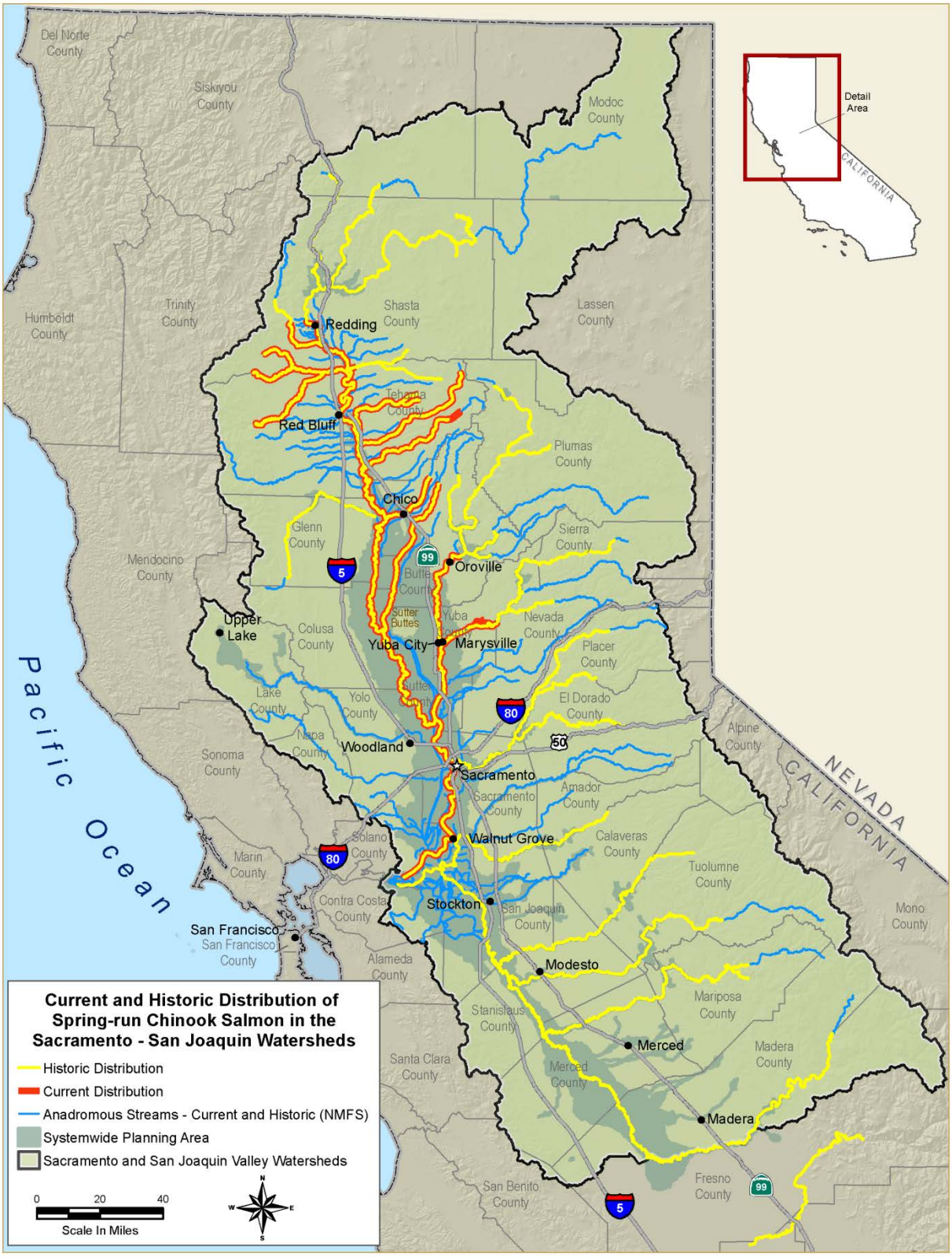


Figure 4-1. Current and Historic Spring-Run Chinook Salmon Distribution

Blockage of upstream summer holding habitat has created a greater potential for spring-run salmon to hybridize with other runs because the runs are no longer spatially and temporally separated (DWR, 2005). The Feather River population depends on Feather River Fish Hatchery production. Recent studies on this stock (Garza et al., 2008 as cited in NOAA Fisheries, 2011b; O'Malley et al., 2007) found subtle, but significant, differentiation between the Feather River Hatchery spring- and fall-run stocks. Genetic analysis (Garza et al., 2008 as cited in NOAA Fisheries, 2011b), suggests that the Feather River Hatchery spring-run population is a remnant of the ancestral Feather River spring-run that has been hybridized with fall-run Chinook.

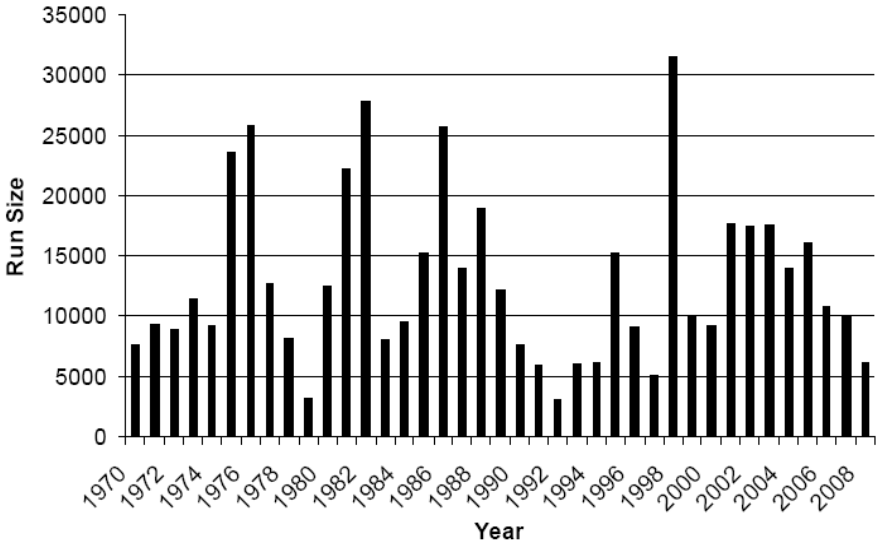
Current population estimates for spring-run Chinook salmon vary. However, the annual spawning run size of spring-run Chinook salmon on the Yuba River generally ranges from a few hundred to a few thousand fish with the annual trend closely following the annual abundance trend of the Feather River Hatchery spring-run Chinook salmon population (NOAA Fisheries, 2011b). The relatively recent installation of a Vaki Riverwatcher system at Daguerre Point Dam is providing more accurate estimates of spring-run Chinook population size in the lower Yuba River. The upper Sacramento River downstream of Keswick Dam may support a small spring-run Chinook salmon population, but that population is likely to be highly hybridized with fall-run Chinook salmon, and the status of that population is poorly documented (NOAA Fisheries, 2009a).

Since 1970, Central Valley spring-run Chinook salmon population levels have fluctuated significantly from highs near 30,000 fish to lows near 3,000. The 5-year average spring-run Chinook salmon abundance in the late 1990s was 8,500 fish, compared with 40,000 fish in the 1940s (NOAA Fisheries, 2008a.) (Figure 4-2).

4.1.1 Sacramento River Winter-Run Chinook Salmon

Sacramento River winter-run Chinook salmon have a life history that differs considerably in its timing from the other three Central Valley runs. Their spawning migration[8] lasts from December to July (NOAA Fisheries, 2009b), with runs peaking in mid-March (Moyle et al., 2008). They enter fresh water as sexually immature adults and migrate to the Sacramento River downstream from Keswick Dam, where they hold for several months until spawning from April through early August (Moyle et al., 2008).

[8] Descriptions of salmon run timing vary among published sources and are known to vary among years depending on environmental conditions.



Source: (NOAA Fisheries, 2009a)

Figure 4-2. Estimated Spring-Run Chinook Salmon Run Size (1970 – 2008)

Most winter-run fry migrate past Red Bluff Diversion Dam (RBDD) in summer or early fall (Moyle et al., 2008), but many rear in the river below Red Bluff for several months before they reach the Sacramento-San Joaquin (Delta) in early winter. Juveniles enter the Delta from November through March where they complete smoltification and migrate to the ocean (del Rosario et al., in review). Most juvenile winter-run Chinook salmon have migrated out of the Delta toward the ocean by the end of April (del Rosario et al., in review).

Historically, there were four independent populations of winter-run Chinook salmon: Little Sacramento River, Pit River-Fall River-Hat Creek, McCloud River, and Battle Creek (Figure 4-3). The first three of these areas are blocked by Shasta and Keswick dams (Lindley et al., 2004).

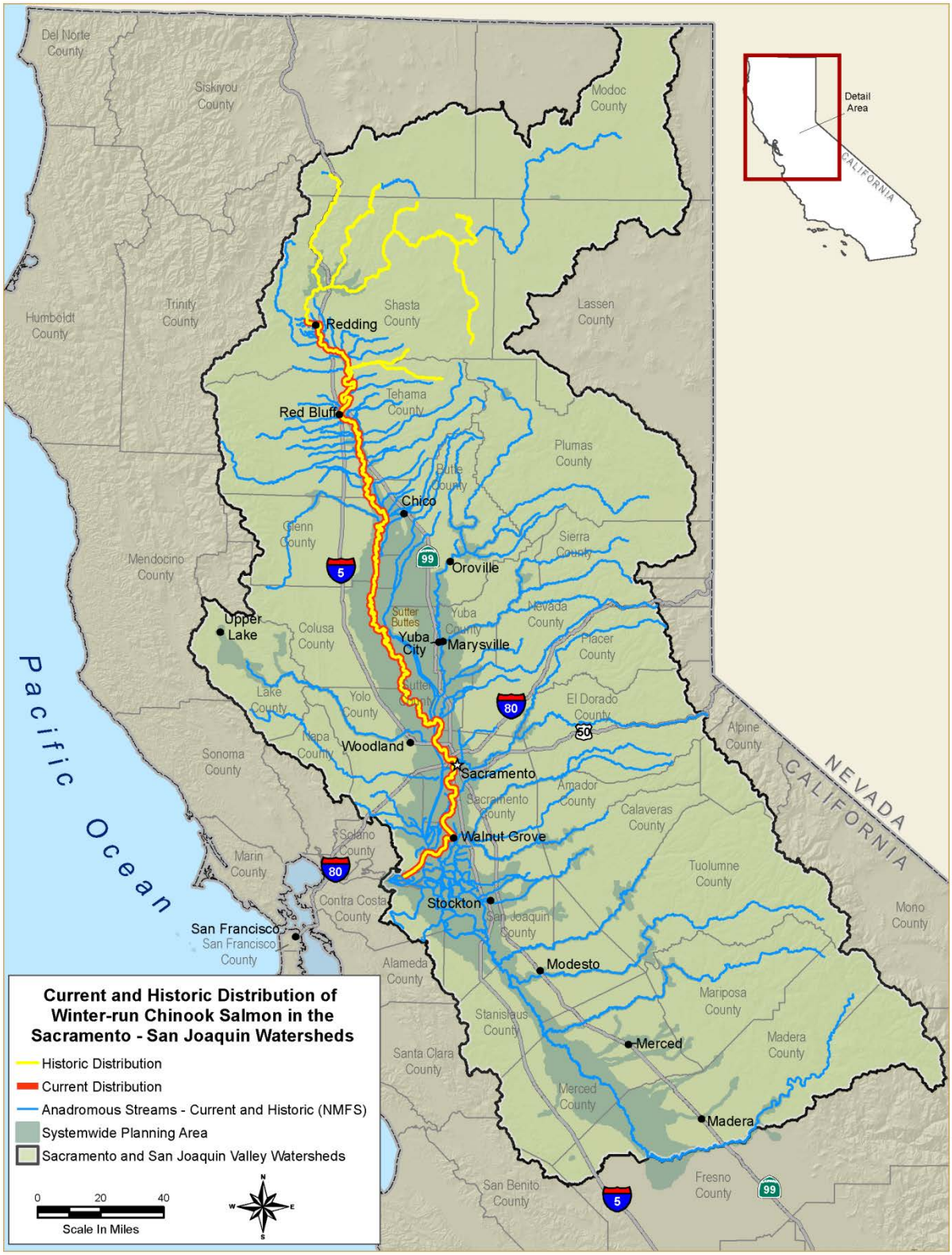


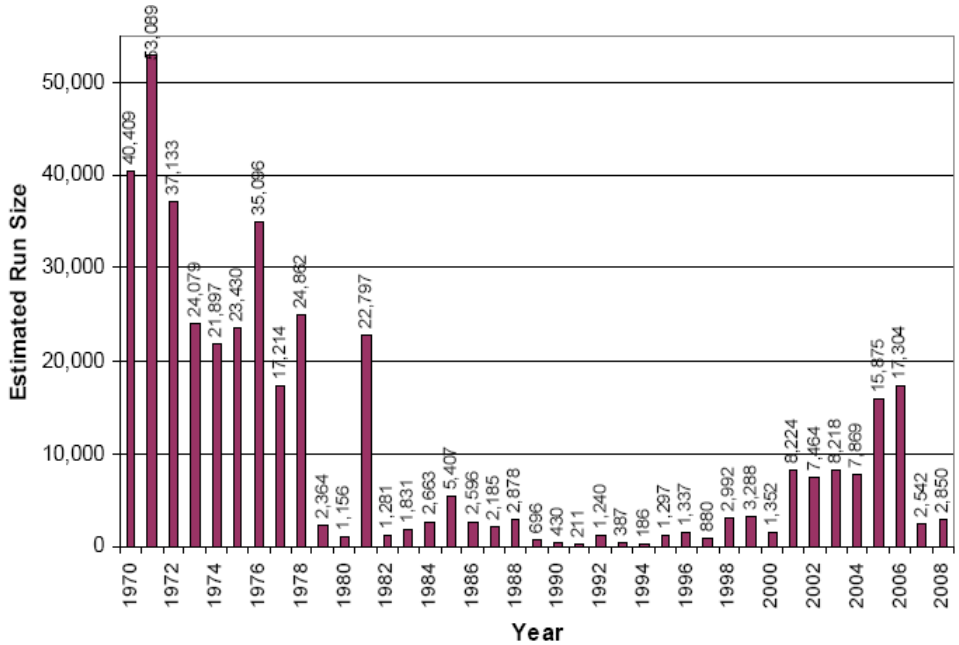
Figure 4-3. Current and Historic Winter-Run Chinook Salmon Distribution

Winter-run Chinook salmon no longer inhabit Battle Creek as a self-sustaining population, probably because hydropower operations make conditions for eggs and fry unsuitable (Lindley et al., 2007). In addition, access to much of the basin was blocked until recently by the Coleman National Fish Hatchery barrier weir (Lindley et al., 2007). However, a collaborative partnership (including state and federal resource agencies, Pacific Gas and Electric Company, public watershed groups, and other stakeholders) is implementing the Battle Creek Salmon and Steelhead Restoration Project. This restoration project will eventually remove five dams on Battle Creek, install fish screens and ladders on three dams, and end the diversion of water from the North Fork to the South Fork (NOAA Fisheries 2011c). Upon its completion, the project will re-establish approximately 42 miles of winter-run and spring-run Chinook salmon and steelhead habitat on Battle Creek, plus an additional six miles on its tributaries. For information, see: http://www.usbr.gov/mp/battlecreek/index.html (Reclamation, 2011).

Currently, there is one independent population of winter-run Chinook salmon inhabiting the area of cool water between Keswick Dam and Red Bluff, where cold-water releases from Shasta Reservoir, combined with artificial gravel additions, have created suitable habitat (Moyle et al., 2008). This area was not historically used by winter-run Chinook salmon for spawning (Lindley et al., 2004). Winter-run Chinook salmon have avoided hybridization with fall-run Chinook in this area, unlike spring-run Chinook salmon, due to their temporal isolation from the fall-run salmon.

The U.S. Fish and Wildlife Service (USFWS) manages a conservation hatchery program for winter-run Chinook salmon that is located at the Livingston Stone National Fish Hatchery. This hatchery program supplements the natural population according to strict guidelines developed in conjunction with NOAA Fisheries. Based on a review of available genetic and other information, this hatchery stock was considered part of the Sacramento River winter-run Chinook ESU and was listed in 2005 (NOAA Fisheries, 2011c).

The population of winter-run Chinook salmon that spawns below Keswick Dam increased in abundance from the mid-1990s through 2006, although the abundance remained well below historic levels. Since 2006, the increasing trend in winter-run Chinook salmon abundance has reversed during the more recent period of unfavorable ocean conditions (2005-06) and drought (2007-09).



Source: (NOAA Fisheries 2009a & c)

Figure 4-4. Estimated Sacramento Winter-Run Chinook Salmon Run Size (1970 – 2008)

4.1.2 Fall-Run Chinook Salmon

Central Valley fall-run Chinook salmon primarily migrate upstream in the fall as mature fish, although they have been recorded migrating from June through December, and a portion of the population returns as immature fish (Moyle et al., 2008). Peak spawning time is typically in October through November but can continue through December. Juveniles mostly emerge in December through March and rear in natal streams for one month to seven months, usually moving downstream into the main rivers within a few weeks after emerging and then enter the San Francisco Estuary as both fry and smolts (Moyle et al., 2008) (Table 3-1).

Using modern genetic techniques, late-fall-run Chinook salmon are distinguishable from the other runs, although late-fall-run Chinook were only recognized as a distinct run in 1966 after the construction of the RBDD (Williams, 2006). NOAA Fisheries manages late-fall-run Chinook as part of the Central Valley fall-run ESU because of their close relationship to it (Moyle et al., 2008).

Central Valley fall-run Chinook salmon historically spawned in all major rivers of the Central Valley, migrating as far south as the Kings River, and north to the upper Sacramento, McCloud, and Pit rivers (Figure 4-5). There were also small runs in smaller Central Valley streams and creeks (Moyle et al., 2008).

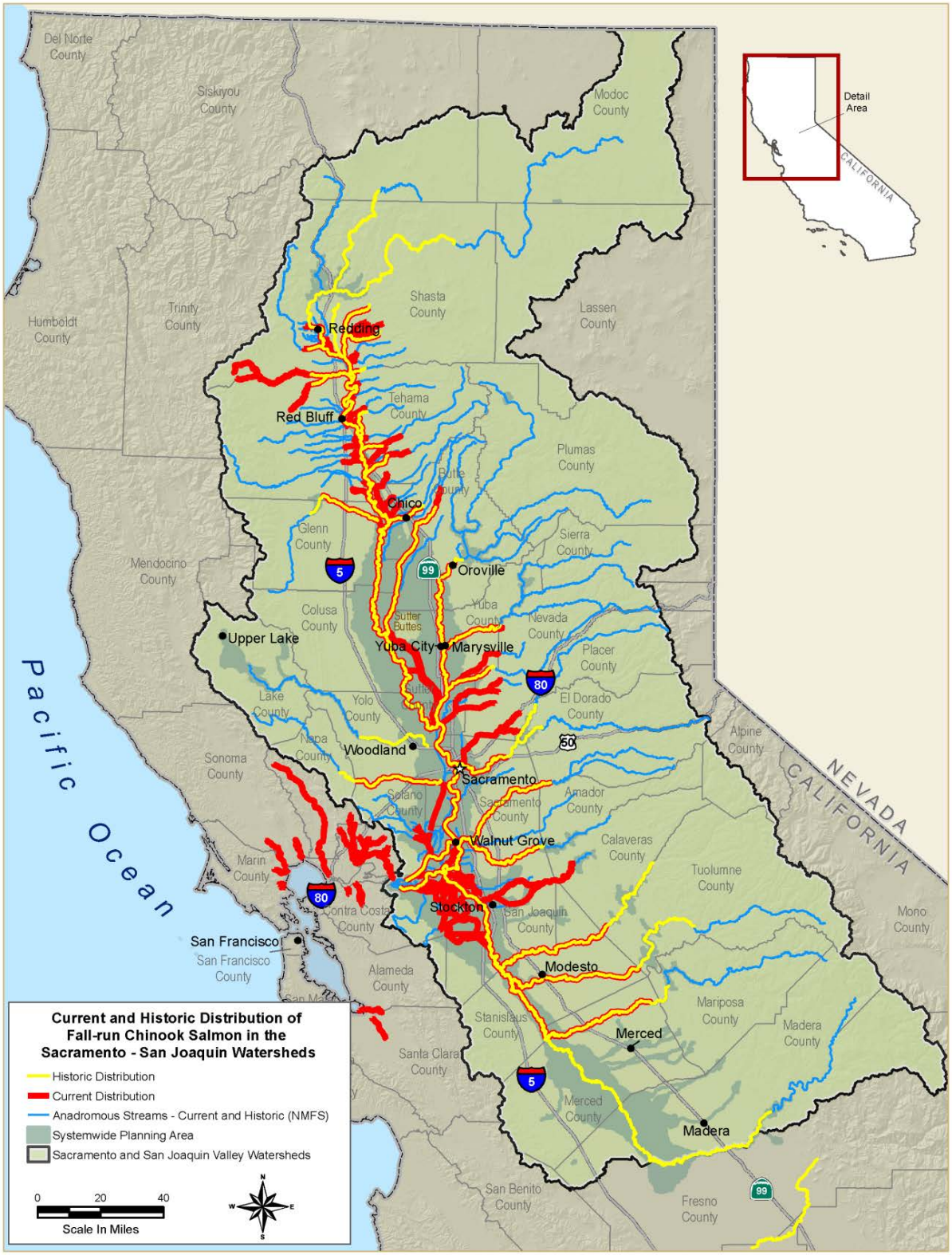


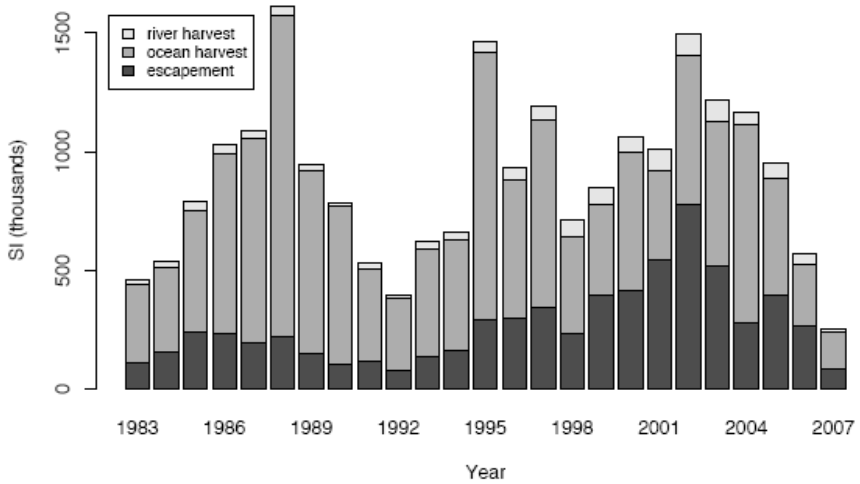
Figure 4-5. Current and Historic Fall-Run Chinook Salmon Distribution

A large portion of the fall-run Chinook salmon population contributing to ocean fisheries is raised in hatcheries, including Feather River Hatchery, Mokelumne River Hatchery, Coleman National Fish Hatchery on Battle Creek, and Nimbus Hatchery on the American River (Lindley et al., 2009).

Currently, fall-run Chinook salmon spawn upstream as far as the first impassible dam (e.g., Keswick Dam on the Sacramento River), although on the San Joaquin side of the Central Valley, they only reach the Merced River because Friant Dam has cut off all natural flows to the lower San Joaquin River (Moyle et al., 2008). Restoration in the San Joaquin River is ongoing (See section 2.2.1 of this report). In the upper Sacramento River, the relative proportions of fall-run spawning in the mainstem and in Battle Creek have approximately reversed over the last half-century, with more fish now spawning in Battle Creek than in the Sacramento River upstream of Red Bluff (Williams, 2006).

Spawning populations of late-fall-run Chinook salmon occur in several tributaries of the Sacramento River, including Battle, Cottonwood, Clear and Mill creeks, and in the Feather River (Stillwater Sciences, 2007). However, the sizes of these spawning populations are relatively small, with the exception of Battle Creek where late-fall-run Chinook are artificially propagated at the Coleman National Fish Hatchery (Stillwater Sciences, 2007). Incidental observations of late fall-run Chinook salmon have been reported to occur in the lower Yuba River (Lower Yuba River Accord Management Team Planning Group, 2010).

Fall-run Chinook have always been the most abundant salmon run in the Central Valley (Moyle, 2002). From the 1870s through early 1900s, annual in-river harvest in the Central Valley often totaled 4 million to 10 million pounds of Chinook, approaching or exceeding the total annual harvest by statewide ocean fisheries in recent decades. Maximum annual stock size (including harvest) of Central Valley Chinook salmon before the 20th century has been estimated conservatively at 1 million to 2 million spawners with fall-run salmon totals perhaps reaching 900,000 fish (Yoshiyama et al., 1998). Annual escapement of fall-run Chinook salmon has remained relatively stable from the 1960s through the 1990s, totaling between 100,000 and 350,000 adults per year. However, escapement began to fluctuate more erratically in the present decade, climbing to a peak of 775,000 in 2002 but then falling rapidly to near-record lows in 2007 (estimated spawning escapement of 88,000) (Figure 4-6) (Lindley et al., 2009).



Source: Lindley et al., 2009

Figure 4-6. Sacramento River Fall-Run Chinook Escapement, Ocean Harvest, and River Harvest (1983 – 2007)

4.2 Central Valley Steelhead

Steelhead and rainbow trout are the same species, with steelhead referring to the anadromous form of the species. Central Valley steelhead typically[9] begin their spawning migration in fall, winter, and spring, and spawn relatively soon after freshwater entry. Spawning occurs January through March, but can extend into spring and possibly early summer months (McEwan, 2001). Rearing takes place during the summer and juvenile steelhead emigrate from natal streams during fall, winter, and spring high flows (Table 3-1) (NOAA Fisheries, 2009b).

Historically, Central Valley steelhead were distributed throughout the Sacramento and San Joaquin rivers (McEwan, 2001). Steelhead were found from the upper Sacramento and Pit rivers (both now inaccessible due to Shasta and Keswick dams) south to the Kings River and possibly the Kern River systems, and in both east- and west-side Sacramento River tributaries (NOAA Fisheries, 2009b).

Naturally spawning stocks of steelhead are known to occur in the Sacramento River and tributaries, Mill, Deer, Antelope, and Butte creeks, and the Feather, Yuba, American, Mokelumne, Calaveras, and Stanislaus rivers. Steelhead smolts have been found in Auburn Ravine, Dry Creek,

[9] Descriptions of salmon run timing vary among published sources and are known to vary among years depending on environmental conditions.

and have been monitored in the Stanislaus River since 2003 (Figure 4-7) (McEwan, 2001; FISHBIO Environmental, 2011; NOAA Fisheries, 2009a). Steelhead are also present in the Tuolumne River, Merced River, and Cow, Battle, Cottonwood, Clear, and Big Chico creeks (DWR, 2005; NOAA Fisheries, 2009a).

Naturally spawning populations may exist in many other streams but are undetected due to lack of monitoring programs (NOAA Fisheries, 2009b). According to Lindley et al. (2006), historically there were approximately 81 independent populations of steelhead in the Central Valley.

Four hatcheries raise steelhead in the Central Valley, producing an average of 1.5 million yearlings per year: Feather River Hatchery, Mokelumne River Hatchery, Coleman National Fish Hatchery on Battle Creek, and Nimbus Hatchery on the American River (Moyle et al., 2008).

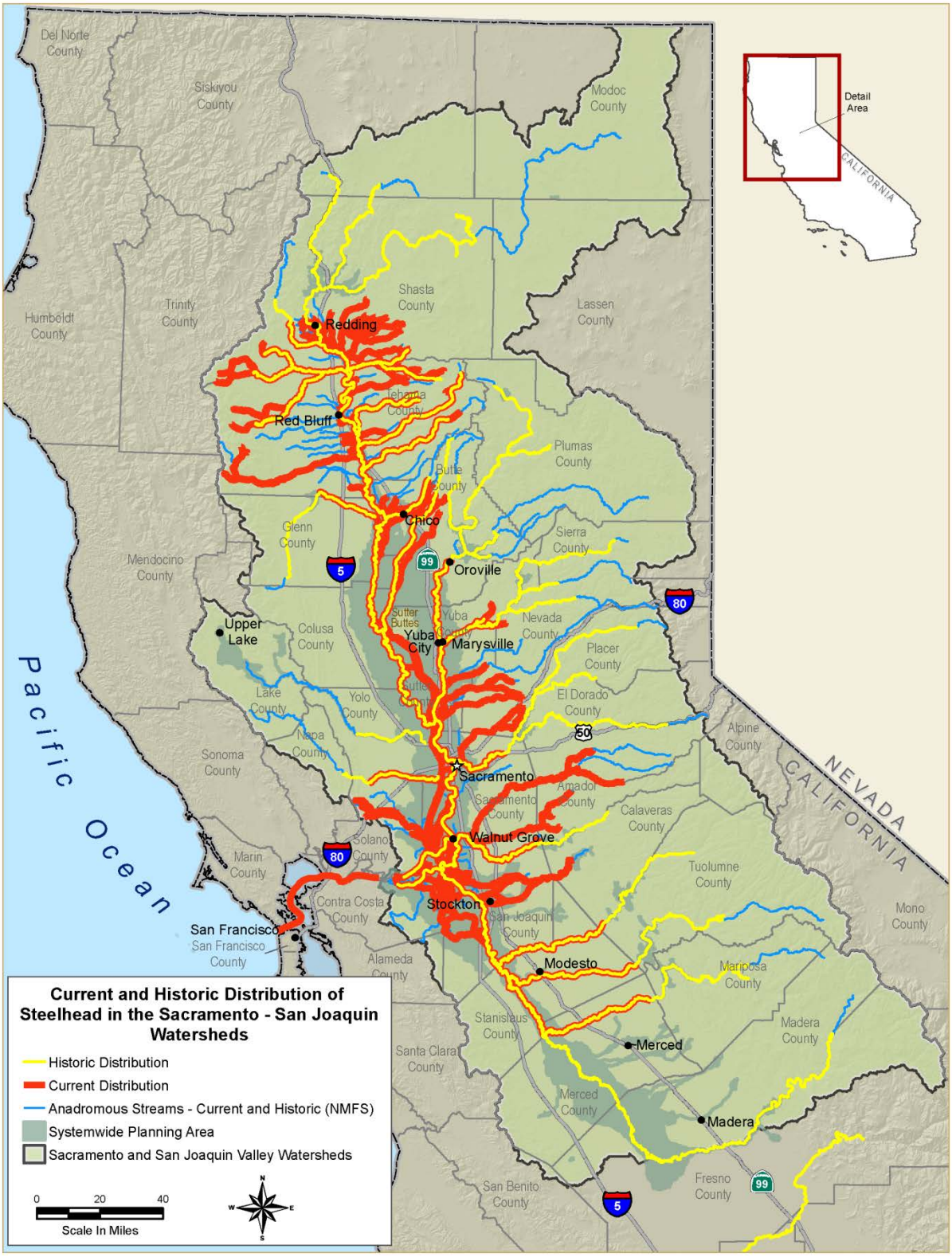


Figure 4-7. Current and Historic Central Valley Steelhead Distribution

From 1967 to 1993, steelhead counts at the RBDD on the Sacramento River provided an indicator of the magnitude of the decline of Central Valley hatchery and wild steelhead stocks. Steelhead counts declined from an average annual count of 11,187 adults for the 10-year period beginning in 1967, to 2,202 adults annually in the 1990s (McEwan, 2001). After 1993, the RBDD gates were raised during the winter to minimize adverse impacts on winter-run Chinook salmon. Because of this change in gate operations, adult steelhead could no longer be counted at RBDD during winter. Recnet trends in estimated natural steelhead spawning upstream from RBDD to 2005 are shown in Figure 4-8.

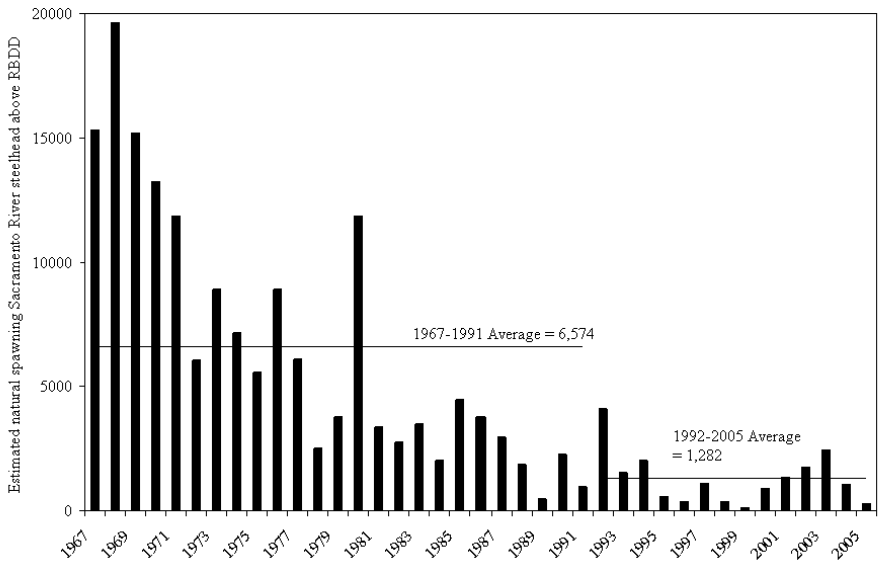


Figure 4-8. Steelhead Population Trends in the Sacramento River, Upstream from Red Bluff Diversion Dam from 1967 to 2005

4.3 Green Sturgeon

Little is known about the timing or location of spawning for green sturgeon, although recent studies have provided additional information (Poytress et al., 2010; Poytress et al. 2011). Heublein et al. (2009) describes the timing and movement patterns of migrating green sturgeon and identifies likely spawning reaches. Upstream migration of adult green sturgeon appears to begin in February and lasts until late July (Stillwater Sciences, 2007). Green sturgeon spawn between March and July in the mainstem Sacramento River as far upstream as Keswick Dam. Adult sturgeon are found in the Delta and the San Francisco Bay Estuary, including northern San Francisco, San Pablo, and Suisun bays, from

March, or earlier, through October (Kelly et al., 2007), with some individuals outmigrating from the Sacramento River in December and February (NOAA Fisheries, 2010a).

Green sturgeon larvae begin to emerge and move downstream in May, with peak passage occurring at RBDD in June and July (Stillwater Sciences, 2007). Green sturgeon juveniles rear in the Sacramento River and the Delta and bays for 1 year to 4 years before migrating out to sea as subadults (NOAA Fisheries, 2010a) (Table 3-1).

Spawning, rearing, feeding, and migratory habitat for all life stages of green sturgeon found within the Systemwide Planning Area include the following estuaries, bays, and freshwater rivers and streams within the Central Valley: the Delta; the San Francisco, San Pablo, and Suisun bays; the Sacramento River upstream to Keswick Dam; the lower Feather River upstream to Oroville Dam; and the lower Yuba River upstream to the Daguerre Point Dam (NOAA Fisheries 2010a). Designated Critical Habitat of green sturgeon is shown on Figure 4-9.

Population abundance information for green sturgeon is limited (Beamesderfer, 2002; Adams et al., 2002; NOAA Fisheries, 2005; Beamesderfer, 2007). In terms of overall annual relative abundance, it appears that green sturgeon populations declined from 1995 to 1999 and then remained relatively stable from 2002 to 2006 (Stillwater Sciences, 2007).

Above RBDD, Israel (2006) estimated a maximum spawning population of 32 spawners in 2002, 64 in 2003, 44 in 2004, 92 in 2005, and 124 in 2006 (with an average of 71) (NOAA Fisheries, 2009b). Below RBDD, green sturgeon larvae were captured in rotary screw traps: 517 individuals in 1994 and 291 individuals were captured between 1996 and 2000 (Heublein et al., 2009).

Abundance information has also been collected at two DWR facilities, the John E. Skinner Fish Facility and the Harvey O. Banks Pumping Plant. Abundance data for green sturgeon were recorded at the John E. Skinner Fish Facility in Tracy between 1968 and 2001. The average number of green sturgeon entrained per year at the facility before 1986 was 732; from 1986 on, the average entrained per year was 47. At the Harvey O. Banks Pumping Plant, the average number of green sturgeon entrained per year before 1986 was 889; from 1986 to 2001, the average entrained per year was 32 (NOAA Fisheries, 2009b).

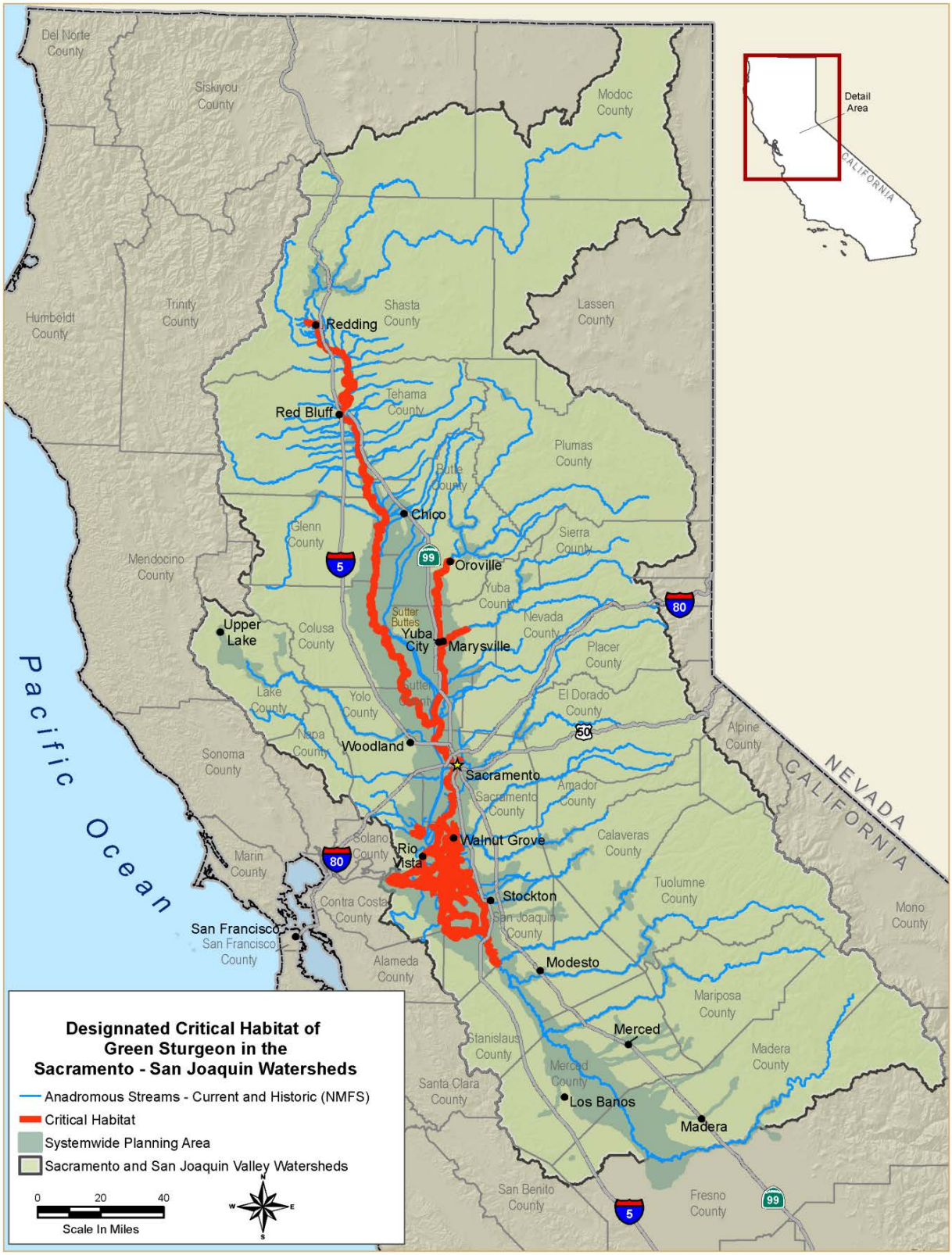


Figure 4-9. Critical Habitat for Green Sturgeon in the Central Valley

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5.0 Reasons for the Decline in Anadromous Fish Populations

Several factors have contributed to the decline of Chinook salmon, steelhead, and green sturgeon populations in the Central Valley. However, the single biggest cause has been the construction of massive dams and diversions on all major rivers (Moyle, 2002; NOAA Fisheries, 2005).

Other structures besides dams that block or delay migrating fish from accessing habitat include: road crossings, bridges, culverts, flood control channels, erosion control structures, canal and pipeline crossings, flow measurement weirs, pumping plants, borrow pits, and gravel mining pits (DWR, 2005; PSMFC, 2011).

In the Sacramento-San Joaquin system, dams have denied Chinook salmon access to more than half the stream reaches they once used and to more than 80 percent of their historical holding and spawning habitat (Moyle, 2002). Shasta and Keswick dams block winter-run Chinook salmon access to more than approximately 100 miles of historical habitat in the Little Sacramento River, Pit River-Fall River-Hat Creek, and McCloud River (Lindley et al., 2004).

Approximately 80 percent to 90 percent of spring-run Chinook spawning and rearing habitat has been lost due to water system developments in the Central Valley watersheds, and large rim dams (e.g., Shasta and Oroville dams) and hydropower development projects have prevented spring-run Chinook salmon from accessing significant areas of upstream summer holding and spawning habitat (DWR, 2005). Within the Systemwide Planning Area, NOAA Fisheries has identified several major dams that affect spring-run Chinook salmon migration, including: Englebright Dam, Oroville Dam, Keswick Dam, Shasta Dam, RBDD, and the Anderson Cottonwood Irrigation District diversion dam[10] (NOAA Fisheries, 2009a).

Barriers to spawning habitat are a major anthropogenic threat to fall-run Chinook salmon (Stillwater, 2007). Lindley et al. (2009) attributed the collapse of the fall-run population in 2007 and 2008 to a combination of unfavorable ocean conditions and anthropogenic effects such as the

[10] The Anderson Cottonwood Irrigation District diversion dam was improved in 2001 with the installation of new fish ladders and fish screens around the diversion. However, NOAA Fisheries indicates that diversion dam operations could still impact Chinook salmon (NOAA Fisheries 2009b).

presence of large dams and levees, which block access to spawning and rearing habitat.

Lindley et al. (2006) estimated that approximately 80 percent of stream habitat that was historically available to anadromous Central Valley steelhead is now behind impassable dams, and that 38 percent of the populations identified have lost their entire habitat. In addition, NOAA Fisheries (2009a) highlighted steelhead passage issues at the following structures within the Systemwide Planning Area: Friant Dam, La Grange Dam, Don Pedro Dam, Goodwin Dam, New Melones Dam, McSwain Dam, Crocker Huffman Dam, Camanche Dam, Pardee Dam, and Bellota Weir.

The principal threat to green sturgeon has been the loss of access to habitat for spawning and rearing, now upstream from impassable dams (NOAA Fisheries, 2005). The presence of Keswick Dam currently blocks sturgeon passage to upstream sites (Adams et al., 2002; NOAA Fisheries, 2010b). The RBDD gates have been known to delay migration, block the migratory corridor, and block access to 53 miles of the Sacramento River with suitable water quality conditions for green sturgeon spawning and rearing from May 15 through September 15 of each year (NOAA Fisheries, 2009b). Early gate closures before May 15 resulted in mortality of green sturgeon (NOAA Fisheries, 2009b). However, this should be eliminated with the implementation of the Red Bluff Fish Passage Improvement Project, which is expected to be completed in 2012. As part of the project, a screened pumping plant will be constructed that will allow the RBDD gates to be permanently placed in the open position for free migration of salmon and sturgeon (Reclamation 2011b). Passage to 5 miles of spawning habitat downstream from Keswick Dam is blocked by the Anderson Cottonwood Irrigation District Diversion Dam (installed April to November) (NOAA Fisheries 2009b). The continued presence of green sturgeon adults below Oroville Dam suggests that sturgeon are trying to migrate to upstream spawning areas now blocked by the dam.

In addition to fish passage barriers, sturgeon are susceptible to stranding within floodplains and bypasses (NOAA Fisheries, 2009b). Most channels and floodplains have irregular surfaces, and as flows recede, fish can become trapped in isolated pools, old channels, and in depressions formed as water flows around vegetation, large woody debris, or other features. The pools and depressions create areas in which the fish can become stranded. Unless water levels increase or the depressions are fed by subsurface flow, fish will desiccate or become easy prey for a variety of predators (Sullivan, and Chinnici, 2009).

In this report DWR defines stranding as occurrences when fish are trapped in areas that are inundated when flood flows move outside the active channel into bypasses, side channels, backwaters, floodplains, and then the flows recede. In particular, stranded fish are those trapped in scour holes that occur within bypasses, in abandoned gravel or mining pits that are adjacent to the active channel, or in side channels that become isolated from the main river channel.

NOAA Fisheries (2009b) identified stranding that occurs under two types of flow releases: releases made for flood control and those made to meet Delta water quality objectives and demands. Both types of releases can result in rapid flow increases for a period of time followed by rapid flow decreases. The abrupt decrease in flows can result in redd[11] dewatering and isolation, isolation of side channels and backwaters, and draining of floodplains. DWR did not include stranding that occurs within the active channel because of flow decreases in response to Delta water quality objectives or export demands in this analysis. In addition, people sometimes refer to situations where a fish cannot pass a manmade structure, like a weir, as stranding, but DWR defines that as a fish passage barrier, and addresses those situations in the barrier section of this report.

In addition to fish passage barriers blocking habitat and stranding identify other factors contribute to the decline of Chinook salmon, steelhead, and green sturgeon populations (Moyle 2002, Moyle et. al, 2008, NOAA Fisheries 2005, 2009b, and DFG 2011):

- Lack of in-stream flow (i.e., San Joaquin River restoration, Section 2.2.1)
- Altered flow regimes
- Fishing, both in the ocean and in streams
- Entrainment of juveniles in diversions
- Loss of floodplain and estuarine rearing habitat by diking and draining
- Predation
- Competition from hatchery reared juveniles
- Diseases, native and introduced
- Pollution and pesticides

[11] A redd is a nest dug by a female salmon in gravel in a creek, stream or river.

- Unsuitable water temperatures
- Loss of riparian forests
- Siltation of spawning areas
- Effects of introduced fish, invertebrates, and plants
- Periods of drought
- Extreme flooding events
- Unusual ocean conditions
- Climate change effects (see Section 6.0)

Although there are many factors that have contributed to the decline of salmonid and sturgeon populations in the Central Valley, this report focuses on fish passage barriers and stranding that occur within the Systemwide Planning Area.

6.0 Climate Change

Fish passage barriers and other impediments to migration (e.g., stranding) have contributed to the decline of anadromous fish in the Central Valley. Climate change will bring an additional level of variability to our water system and will compound the negative effect barriers have on anadromous fish populations. Successful long-term efforts to provide self-sustaining populations of anadromous fish need to plan for the potential impacts of climate change and to develop ways to accommodate those changes for anadromous fish. Current climate change models predict a range of impacts that should be considered in water supply and flood management systems.

Impacts that are likely to be particularly detrimental for salmonid species include:

- Sea-level rise, which leads to increased salinities in the Delta. Anadromous fish using Central Valley streams and rivers need to pass through the Delta on their way to and from the Pacific Ocean
- More frequent intense winter storms, high stream flow events, and floods
- Less snowpack and earlier snowmelt, with higher peak flows in winter, less spring runoff, and much lower summer flows
- Considerably warmer stream, river, and ocean water temperatures during the summer

Decreases in Sierra Nevada snowpack will have negative implications for anadromous fish. The Central Valley's largest source of fresh water is the Sierra Nevada snowpack. The snowpack melts slowly in the spring and in some years, even into the summer. There are 395 reservoirs with a capacity of at least 50 acre-feet that are fed by the Sierra Nevada snowpack. Their combined storage capacity is approximately 14 million acre-feet. The Sierra Nevada snowmelt provides an annual average 15 million acre-feet of water to those reservoirs. DWR (2008) projects a 25 percent to 40 percent reduction in the Sierra snowpack by 2050 because of warmer storms resulting in less snowfall.

As a result of a decrease in snow pack and earlier snowmelt, stream flows are expected to be lower during the summer months and extending into the fall. It is common for adult fish migrating to spawning grounds to

encounter obstacles that require high flow conditions in order to pass. If climate change results in reduced stream flows this could impede or halt their progress. A delay in the arrival to spawning grounds may decrease reproductive success and increase fish mortality (California Natural Resources Agency 2009). This decrease in summer flows will further limit access to available cold water habitat that salmonids require, particularly as temperatures in many stream and rivers increase (Moyle et al., 2008).For example, lower flows in the summer will affect spring-run Chinook salmon by reducing the size and frequency of deep pools used for holding, leading to crowding and increased mortality.

Reduced stream water depth and higher air temperatures will increase stream water temperatures to levels that are potentially unhealthy for coldwater fish. Salmonids are temperature-sensitive and rely on precipitation and snow melt. The projected changes in inland water temperatures with changing seasonal flows is projected to place additional stress on these species, contributing to the need for increased resources for monitoring and restoration efforts.

Lindley et al. (2007) examined the effects of climate warming on the availability of spring-run Chinook salmon over-summer habitat. Their analysis suggests that a 2-degree-Celsius increase in water temperatures might eliminate summer holding habitat for Butte Creek, where one of three viable populations of spring-run Chinook salmon in the Central Valley remain.Given the possible conditions that may exist in Central Valley streams as the climate warms, many researchers and agencies have recognized the need to evaluate opportunities to provide Central Valley salmonid species access to currently inaccessible habitat (DWR, 2007, 2008; NMFS, 2009b; and California Natural Resources Agency, 2009). In addition, to recover Central Valley salmonids, some populations will need to be established in areas now blocked by dams (Lindley et al. 2007). As temperatures increase, providing fish passage to areas upstream from reservoirs could eliminate or reduce the need for cold water releases and give water managers additional flexibility in meeting downstream water supply and flood protection needs.

7.0 Identification and Prioritization of Passage Barriers in the Systemwide Planning Area

Dams and other barriers have played an important role in the decline of salmon, steelhead, and green sturgeon in the Central Valley. The effects of climate change will compound the decline. Flood management structures, such as weirs, and flood operations have resulted in passage barriers, reductions in flows, and risk of mortality due to stranding. To achieve the environmental objectives of the Central Valley Flood Protection Act, DWR will need to work collaboratively with others to remove fish passage barriers and reduce stranding within the Systemwide Planning Area will be crucial.

To help inform such a collaborative effort, this section provides an assessment of existing barriers and stranding. It also shows the results of an interim process for identifying priority barriers. This process will be furthered refined by the interagency Fish Passage Forum (see Section 7.3)

7.1 Identification of Barriers

7.1.1 Methods

A Geographic Information System (GIS) analysis of existing spatial data sets was undertaken to determine the known and potential fish passage barriers and stranding areas in the Systemwide Planning Area. Geospatial data that describe anadromous fish passage barriers and anadromous fish distributions were obtained from official sources (e.g., CalFish Passage Assessment Database, NOAA Fisheries, California Department of Fish and Game (DFG)). These data sets and expert knowledge were used to identify stranding areas and to determine the number and distribution of known and potential barriers to anadromous fish passage within the Systemwide Planning Area on the basis of barrier location, barrier status, and barrier type. See Appendix A for a detailed description of methods.

Fish passage barriers can be total, temporal, or partial barriers for anadromous fish during migration (Table 7-1). Total barriers block all fish migration. Temporal and partial barriers may block fish passage for a certain life stage and/or only under certain flow conditions. For example, a

partial barrier may block juvenile spring-run and steelhead from migrating downstream.

Table 7-1. Definitions of Barrier Status

Barrier Status	Definition
Temporal	Impassable to all fish at certain flow conditions
Partial	Impassable to some fish during part or all life stages at all flows
Total	Impassable to all fish at all flows
Potential	The structure needs to be assessed or evaluated to determine if it is a temporal, partial or total barrier

Source: Adapted from Taylor and Love, 2003
Barriers can also be temporal and partial but for purposes of this report the barrier status categories are simplified.

7.1.2 Barrier Results

The GIS analysis, expert knowledge, and available written information identified 189 barriers in the Systemwide Planning Area (Figure 7-1 and Table 7-2). In addition, 45 DWR diversions were identified because of their impacts on fish entrainment.[12] Of the 189 barriers identified, 14 are components of the SPFC. Appendix B lists all 234 barriers and diversions.

Twenty-five total barriers were identified within the Systemwide Planning Area. These barriers block approximately 900 miles of salmonid habitat (Figure 7-2). The remaining partial, temporal, and potential barriers impair anadromous fish migration through approximately 3,000 miles of habitat.

Table 7-2. Number of Barriers and Diversions in the Systemwide Planning Area

Status	Number in the Systemwide Planning Area
Total	25
Partial[1]	23
Temporal[1]	46
Potential (needs assessment)	95
Screened and Unscreened Diversions	45
All Barriers and Diversions	234

[1] Barriers can also be temporal and partial but for purposes of this report the barrier status categories are simplified so that the numbers in Table 7-2 add up.

[12] The 44 DWR-owned diversions occur in the Delta and 1 outfall gate at Knights Landing Ridge Cut. NOAA (2009a) recommends any unscreened diversions in the Delta be evaluated for population level effects, and those diversions with substantial impacts be screened. DWR should implement that recommendation. Adult attraction and/or delay issues should be assessed and addressed as needed at the Knights Landing Ridge Cut Outfall Gates.

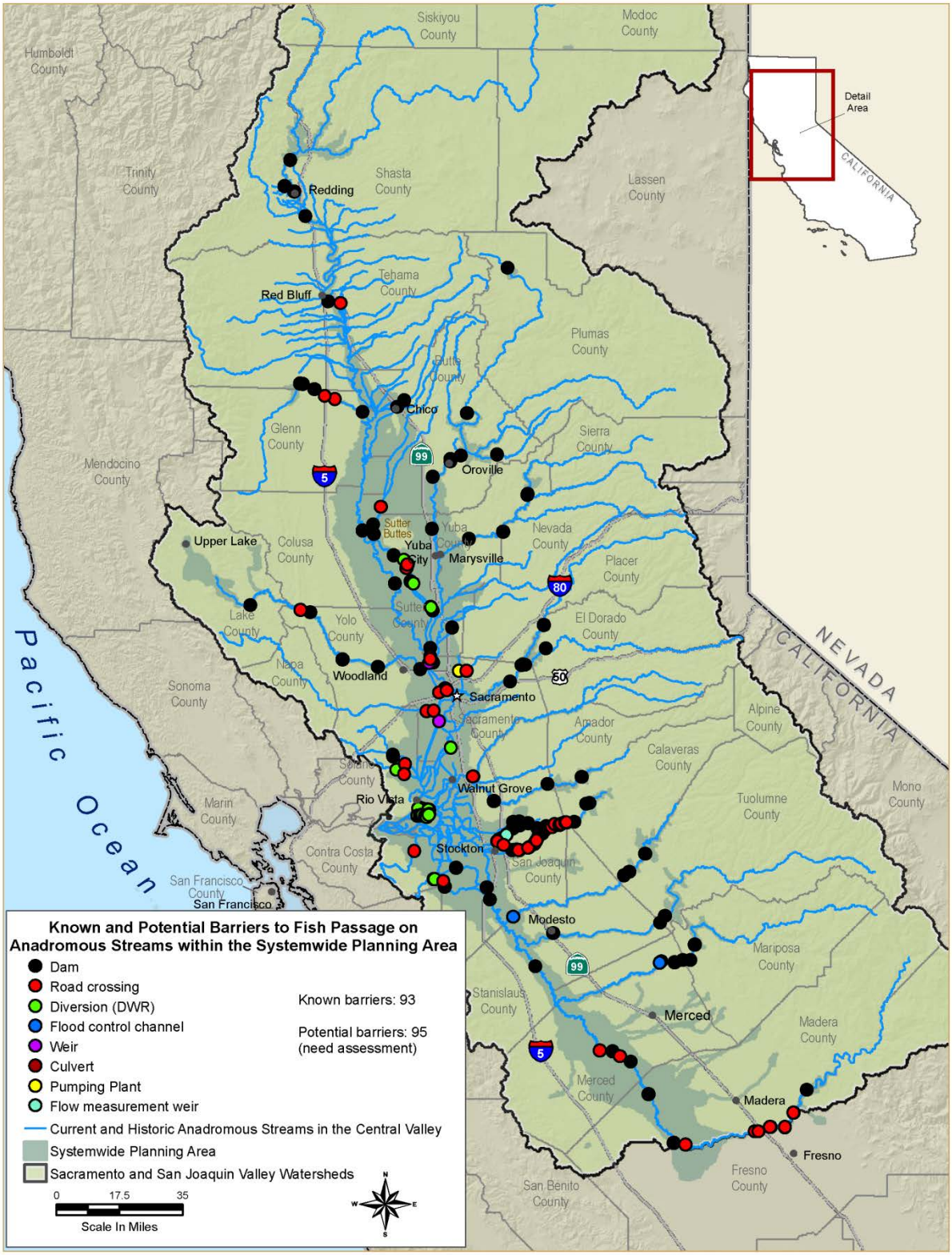
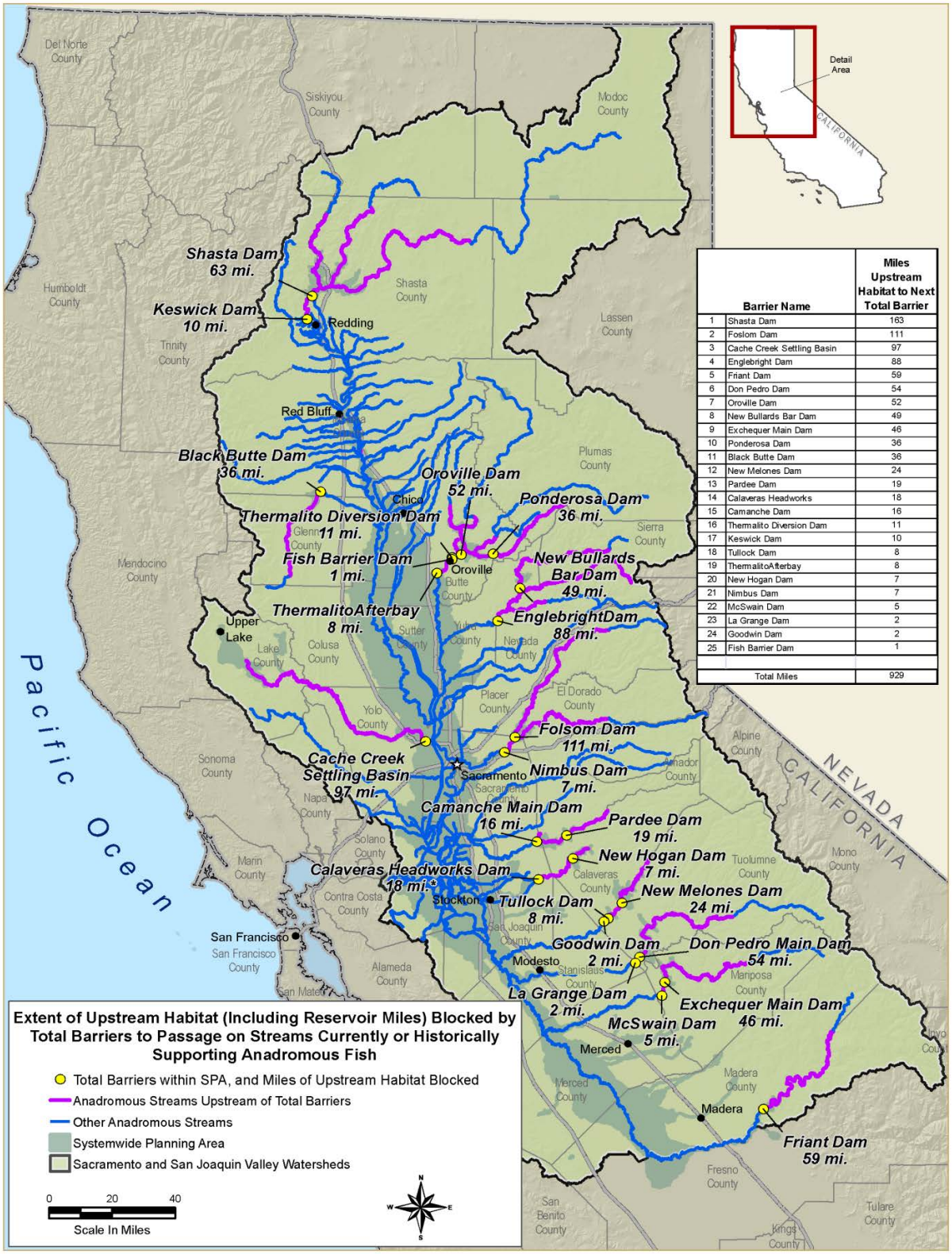


Figure 7-1. Known and Potential Barriers, Including DWR-Owned Diversions, in the Systemwide Planning Area



	Barrier Name	Miles Upstream Habitat to Next Total Barrier
1	Shasta Dam	163
2	Foslom Dam	111
3	Cache Creek Settling Basin	97
4	Englebright Dam	88
5	Friant Dam	59
6	Don Pedro Dam	54
7	Oroville Dam	52
8	New Bullards Bar Dam	49
9	Exchequer Main Dam	46
10	Ponderosa Dam	36
11	Black Butte Dam	36
12	New Melones Dam	24
13	Pardee Dam	19
14	Calaveras Headworks	18
15	Camanche Dam	16
16	Thermalito Diversion Dam	11
17	Keswick Dam	10
18	Tullock Dam	8
19	ThermalitoAfterbay	8
20	New Hogan Dam	7
21	Nimbus Dam	7
22	McSwain Dam	5
23	La Grange Dam	2
24	Goodwin Dam	2
25	Fish Barrier Dam	1
	Total Miles	929

Figure 7-2. Miles of Habitat Upstream from Total Barriers in the Systemwide Planning Area

About half of the 189 barriers in the Systemwide Planning Area have not been assessed to determine if they either block or impair fish migration. CVFPP fish passage surveys, following DFG (2003) protocols, should be done at all potential barriers within the Systemwide Planning Area to determine the passage status of the barriers. If barriers need remediation, fish passage solutions (repairs or new construction) that meet NOAA Fisheries and DFG standards should be implemented.

Many of the barriers within the Systemwide Planning Area are small dams, road culverts, or low-water road crossings. Most of these are temporal or partial barriers, but this does not minimize their impact. A temporal and partial barrier can delay or block listed species, resulting in take[13]. When population levels are low, such as with spring-run or winter-run Chinook salmon, saving an individual fish is important. The methods used to provide fish passage at small dams, road culverts, or low-water road crossings are well documented, and solutions can be implemented quickly at low cost to provide immediate benefit to anadromous fish populations. Since these projects can be implemented quickly, remediation of these structures can occur during the planning stages for fish passage at larger structures. Information on fish passage at large dams is provided in a subsequent section.

7.2 Stranding Risks

Stranding may be a problem associated with flood bypasses, in-stream gravel extraction, and rapid changes in flows.

7.2.1 Flood Bypasses

Conflicting information is available on whether stranding is a significant problem within the Central Valley flood bypasses. It may be a potential problem within the following flood bypasses (Figure 7-3):

- Yolo Bypass/Sacramento Bypass
- Colusa Bypass
- Butte Sink
- Sutter Bypass/Tisdale Bypass
- Chowchilla Canal Bypass/ Eastside Bypass/Mariposa Bypass system

[13] The term "take" means to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct (Endangered Species Act, Section 3 (19)).

Figure 7-3. Locations of Known Stranding Sites[14] Within the Systemwide Planning Area

[14] It is known that the San Joaquin River contains in-channel and captured pits that have the potential to strand salmon (Mussetter Engineering, Inc., 2005). However, DWR did not have enough information to delineate specific pits on Figure 7-3. Therefore, the entire San Joaquin River is marked as a potential stranding site.

Floodplain habitat carries the risk of stranding when water levels drop. Flood flows from the Sacramento River spill into the Yolo and Sutter bypasses and the Butte Overflow Basin. Sommer et al. (2005) described stranding rates on the Yolo Bypass floodplain as being relatively low. This finding is consistent with other studies that report juvenile salmonids are relatively mobile and that most avoid being stranded during moderate rates of stage change. However, other researchers reported that stranding occurs in scour holes, borrow pits, depressions, ponds, and sumps when flows recede within the Yolo Bypass, Butte Overflow Basin, and Sutter Bypass (Pers. comm. T. Cannon, T. Schroyer, J. Navicky, 2011). For example, DFG rescued salmon, steelhead and green sturgeon trapped in scour holes when flood flows receded in the Yolo Bypass in 2011 (Weiser, 2011). While some studies indicate that the impact of floodplain stranding on juvenile salmon is low, other biologists indicate that stranding may have a more significant impact on fish than previously thought; the scale and level of impacts due to stranding are often undocumented and unknown.

Federal and State efforts are being made to address stranding issues within the Yolo Bypass. The NOAA Fisheries' Recovery Plan (2009a) and the Bay-Delta Conservation Plan Working Draft (BDCPSC, 2010) include recommendations to eliminate stranding in the Yolo Bypass, including: modification of the Fremont Weir, modification of the Yolo Bypass by grading, removal of existing berms and other earthwork, and improvement of the Sacramento Weir and Tule Canal/Toe Drain. These actions would reduce stranding of covered fish species in isolated ponds (BDCPSC, 2010).

The Chowchilla Canal Bypass/ Eastside Bypass/Mariposa Bypass system reduces the magnitude of flood flows into the main channel of the San Joaquin River. If high flows are sent into the bypass system, fish, including juvenile salmon, are likely to be carried in with the water, with potential for stranding if flows are suddenly reduced. As noted above, studies have shown that in the Yolo Bypass, native fishes including juvenile salmon are very good at leaving the bypass as flows drop. Solutions to the stranding problem at the Chowchilla Bypass system may involve operation of the Chowchilla Bifurcation gates and releases from the dam (avoiding water shutoff and using secondary pulse flows to push fish out of the bypasses) (Moyle, 2005).

7.2.2 In-stream Gravel Extraction

The presence of gravel pits, with the potential for stranding, has been identified in the following areas:

- Sacramento Valley: American River, Cottonwood Creek, Thomes Creek, Stony Creek, and Yuba River

- San Joaquin Valley: Merced River, Tuolumne River, San Joaquin River, and Stanislaus River

Gravel pits can adversely affect salmon, steelhead, and other fishes as they move up or downstream. Stranding primarily occurs after the river stage rises and allows fish to move into newly inundated areas along channel margins. The likelihood and extent of entrapment effects associated with floodplain mining are directly related to the pit's proximity to the active stream channel, pit size relative to the stream, and the frequency of flood inundation (Packer et al., 2005).

With floodplain pit mining, the risk of fish entrapment is due to two processes: (1) floods overtopping the pit perimeter, and (2) natural migration of the channel into the excavated area. Ponded water isolated from the main channel may strand or entrap fish carried there during high-water events. Fish in these ponded areas could experience higher temperatures, lower dissolved oxygen, increased predation compared to fish in the main channel, an altered food web, desiccation if the area dries out, and freezing (Packer et. al., 2005).

Bar scalping (or "skimming") is the extraction of gravel from the surface of gravel bars. To avoid stranding fish in shallow holes after high flows inundate the bar and then recede, fish and wildlife agencies in California and Washington typically require that the bar, which originally would typically have a steep margin and relatively flat top, be left after scalping with a smooth slope upwards from the edge of the low water channel at a 2 percent gradient (Kondolf et al., 2002).

NOAA Fisheries recommends that gravel extraction sites be situated outside the active floodplain and that the gravel not be excavated from below the water table. In other words, dry-pit mining on upland outcrops, terraces, or the floodplain is preferable to any of the in-stream alternatives. Bar skimming is generally preferable to wet-pit mining (deep water dredging) within the active channels if no upland or floodplain sources are reasonably available (Packer et. al., 2005).

Significant channel and pit remediation has been conducted to restore salmon in the Tuolumne and Merced rivers (Mussetter Engineering, Inc., 2005). According to Dr. Michael Harvey (Mussetter Engineering, Inc., 2005), the San Joaquin River has about 1,300 acres of in-channel and captured pits, the Merced River has about 290 acres of pits, and the Tuolumne River has about 170 acres of pits. DWR (2002) prepared conceptual designs to restore several isolated ponds and captured mining pits within the Oakdale Recreation Area, located in the lower portion of the Stanislaus River.

7.2.3 Rapid Changes in Flows

Rapid reductions in flows in rivers can potentially strand fish. Downstream from Englebright Dam on the Yuba River, when flood waters rose high and then dropped quickly, fish, including young-of-the-year salmon, were stranded in side channels and side ponds (Pers. Comm., J. Nelson, 2011). Studies of potential stranding within the Yuba River are ongoing (Pers. Comm., J. Nelson, 2011). The USFWS has conducted investigations on the effects of flow fluctuations on anadromous salmonid redd dewatering and juvenile stranding in the Yuba River between Englebright Dam and the Feather River as part of a six-year effort that began in 2001 (USFWS, 2010).

In the lower American River, flow fluctuations have been documented to result in steelhead redd dewatering and isolation, fry stranding, and fry and juvenile isolation (NOAA Fisheries, 2009b). Redd dewatering can affect salmonid embryos and alevins by impairing development and causing direct mortality due to desiccation, insufficient oxygen levels, waste metabolite toxicity, and thermal stress (NOAA Fisheries, 2009b). Isolation of redds in side channels can result in direct mortalities due to these factors, as well as starvation and predation of emergent fry. NOAA Fisheries (2009b) limits the rate of flow reductions in Nimbus Dam releases, thereby reducing the risk of stranding and isolating steelhead.

7.2.4 Research Needs

There is no consensus among researchers on the extent and impact of stranding within Central Valley floodplains. Sommer et al. (2005) indicated that the stranding rate of juvenile salmonids in the Yolo Bypass is low. This was consistent with juvenile salmonid findings from other areas. However, the impact to sturgeon was not discussed in these studies, and the perception continues that floodplain and gravel pit stranding has an impact on fish. Consequently, individual CVFPP restoration projects should include an evaluation of the extent and impact of stranding in gravel pits and in areas where floodplain inundation is considered. A brief literature review should be completed to determine if the impacts of stranding differ for adult versus juvenile salmonids, and to confirm the need for green sturgeon stranding studies. The literature review will indicate if more research is needed to understand the effects of stranding on the population dynamics of juvenile and adult salmon, steelhead, and sturgeon in the regions where stranding is known to occur. Finally, results from existing and future stranding research should be more broadly disseminated to minimize perceptions that are not supported by research.

7.3 Prioritization of Fish Passage Barriers and Stranding Areas

DWR identified 189 fish passage barriers within the Systemwide Planning Area. If all these structures are made passable, more than 4,000 miles[15] of anadromous fish habitat from the western edge of the legal Delta to the headwaters will become fully accessible. Because funding and staffing often limit progress that can be made on addressing barriers, it is common practice to prioritize barriers for fixing. The Fish Passage Forum (Forum) is developing a prioritized list of fish passage barriers in California. The Forum is an association of public, private, and governmental organizations that promote collaboration among private landowners, community groups, and public agencies on fish passage restoration programs and activities that contribute to the protection and recovery of listed anadromous salmonid species throughout California. The Forum was formalized with the creation of a Memorandum of Understanding, which DWR signed in 2006. Other members of the Forum include California Resources Agency, DFG, California Department of Transportation, Coastal Conservancy, NOAA Fisheries, U.S. Forest Service, U.S. Fish and Wildlife Service, CalTrout, Southern California Steelhead Coalition, Five County Salmon Conservation Group, FishNet 4C, Friends of the River, Pacific States Marine Fisheries Commission, and U.S. Army Corps of Engineers (USACE).

The Forum began developing a method to rank fish passage barriers using biologically based criteria in 2010. The method will be a statewide first-cut ranking process that filters identified barriers based on objective and measurable attributes. The process includes an assumption that individual agencies, funding entities, and local groups will apply second-cut ranking criteria that are specific to their goals and allow them to further narrow down potential barrier treatment priorities. Once the Forum's prioritization method is developed it will have the support of 14 State, federal, and local agencies throughout California, providing a powerful tool in justifying funding, in strategic planning and design efforts, and gaining consensus for restoration efforts implemented through the CVFPP.

7.3.1 Interim Prioritization Process

Because the Forum's criteria and methodology are still in development and have not been adopted by the Forum, DWR developed an interim prioritization process to rank the 189 barriers within the Systemwide Planning Area. Once the Forum's ranking methodology is finalized, the ranking of barriers identified in this report should be revised using the

[15] See Attachment 9C.1 for a description of the methods used to calculate the total miles that would be fully accessible.

Forum's final ranking method and CVFPP second-cut criteria. These revised rankings can be valuable for informing the development of the Conservation Strategy and for updating the 2017 CVFPP.

For the purposes of this report, DWR's interim prioritization process uses the criteria of biological importance, linkage to SPFC facilities, geographical location, and urgency:

- **Biological importance** – this criterion is based on the NOAA Fisheries (2009a) ranking of recovery actions. NOAA's highest priority actions (Priority 1) are "those critical actions that must be taken to prevent extinction or to prevent the species from declining irreversibly." Priority 2 actions as those that "must be taken to prevent a significant decline in species population/habitat quality or in some other significant negative impact short of extinction."

- **Linkage to SPFC facilities** – Current funding from Proposition 1E for improving flood management requires that the funding be spent on improving SPFC facilities. Thus, those barriers that are SPFC facilities are considered higher priority than others that are not.

- **Geographical location** – Priority order is based on the NOAA

  Fisheries (2009a) order shown in Table 7-3.

Table 7-3. Geographic Priorities Identified by NOAA Fisheries

Priority	NOAA Fisheries Geographic Regions (NOAA Fisheries, 2009a)
1	Delta
2	Lower Sacramento River
3	Middle Sacramento River
4	Upper Sacramento River
5	Northern Sierra Nevada Diversity Group
6	Basalt and Porous Lava Diversity Group
7	Northwestern California Diversity Group
8	Southern Sierra Diversity Group

Source: NOAA Fisheries, 2009a
Key:
NOAA = National Oceanic and Atmospheric Administration

- **Urgency** is based on NOAA fisheries (2009a) regulatory guidelines. This interim process identifies the following three timeframes for urgency:

  - **Short term** – actions likely to be completed within five years, or required to be completed within five years by regulatory deadlines (NOAA Fisheries, 2009b).

  - **Moderate term** – actions that can be potentially accomplished by 2025, given additional funding from federal, State, and other sources, or required to completed by or before 2025 by regulatory deadlines (NOAA Fisheries, 2009b).

  - **Long term** – actions that are unlikely to be completed by 2025 due to their complexity, need for substantial funding, or lack of regulatory deadlines.

In summary, the highest priority actions recommended for the 2012 CVFPP planning process are those actions that are most biologically important (NOAA Priority 1), linked to SPFC facilities, and most urgent (NOAA short term followed by moderate term).

Assuming that Proposition 1E funding, with its SPFC constraints, suffices to fund additional fish passage improvements beyond Priority 1 actions, the next set of recommended priority actions would be NOAA Priority 2 actions, linked to SPFC facilities, and most urgent (NOAA moderate term followed by long term).

As for non-SPFC fish passage barriers, DWR has several programs (other than flood management) that are involve working with other agencies to address fish passage issues at major dams and other facilities. DWR flood managers need to be aware of these other priority actions to ensure good coordination and reduce potential conflicts. Efforts to improve passage at non-SPFC facilities may have the potential to benefit downstream flood management, providing opportunities to achieve SPFC flood management goals. Future flood management funding could be developed to direct some funding toward implementing non-SPFC projects that support flood management goals.

Attachment 9C.1 provides additional details on the GIS methods used in the *Interim Prioritization Process*.

7.3.2 Interim Prioritization Results – Short Term

Based on the interim process described above, short term priority fish passage actions include actions at two SPFC facilities and actions at several other non-SPFC facilities (Attachment 9C.2, Table 9C.2-2). These are actions of high biological importance (NOAA Priority 1) and of an urgent nature (within the next 5 years). As described above, current funding from Proposition 1E for improving flood management requires that this funding be spent on improving SPFC facilities, so flood managers will need to seek other funding sources to assist at non-SPFC facilities.

The two SPFC facilities are Sutter Bypass and Yolo Bypass. At the Sutter Bypass, actions include conducting assessments and making improvements at Willow Slough Weir and Weir No. 2 in the East Barrow Canal. Although not identified as specific SPFC facilities, the two facilities are contained within the Sutter Bypass. Construction of a new fish ladder at Willow Slough Weir was completed in 2010 but testing still needs to be done to confirm that the ladder is functioning to NOAA Fisheries and DFG standards. Construction of a new fish ladder at Weir No. 2 began in 2011 and should be completed in 2012.

In the Yolo Bypass, short term priority actions are at Fremont Weir, Lisbon Weir, Toe Drain and Tule Canal, and structures in the South Fork of Putah Creek. DWR will need to coordinate several funding sources to assist DFG in providing an interim solution for fish passage at the existing Fremont Weir fish ladder by 2012. The interim measure would provide passage through Fremont Weir (a SPFC facility) until a permanent solution is developed (see moderate-term actions below), as required by the SWP and CVP biological opinion. Priority short term fish passage actions at non-SPFC facilities are in the Stockton area and at Red Bluff Diversion Dam. In the Stockton area, DWR's Fish Passage Improvement Program has been working with Stockton East Water District, DFG, USFWS, and other stakeholders to implement fish passage improvements in the Calaveras River, Mormon Slough, and Stockton Diverting Canal. DWR's design of a rock ramp roughened channel for fish passage improvement at Budiselich Dam was constructed in September of 2011. DWR, in cooperation with Stockton East Water District, should complete fish passage designs at the Caprini low-flow road crossing and assist Stockton East Water District in implementing the improvements by December 2013.

At the Red Bluff Diversion Dam, Reclamation is implementing the Red Bluff Fish Passage Improvement Project, which is expected to be completed in 2012. This is in response to the biological opinion for the long-term operations of the CVP and SWP (NOAA Fisheries, 2009b) As part of the project, a screened pumping plant will be constructed that will

allow the RBDD gates to be permanently placed in the open position for free migration of salmon and sturgeon (Reclamation 2011b).

In addition to improving fish passage, the top five areas for evaluating and reducing fish stranding are the Yolo and Sacramento bypasses, American and Yuba river side channels, and the Stanislaus River gravel pits. A complete list of prioritized areas where stranding should be evaluated is in Attachment 9C.3, Table 9C.3-1.

7.3.3 Interim Prioritization Results – Moderate Term

Based on the interim process described above, moderate term priority fish passage actions include actions at two SPFC facilities (Yolo Bypass and Sacramento Weir) and actions at several other non-SPFC facilities (Attachment 9C.2, Table 9C.2-3). These include actions that are of a less urgent nature (within the next 10 years) than short term actions. As described above, current funding from Proposition 1E for improving flood management requires that the funding be spent on improving SPFC facilities, so flood managers will need to seek other funding sources to assist at non-SPFC facilities.

The only action at a SPFC facility of high biological importance (NOAA Priority 1) for this time frame is at the Yolo Bypass. Additional work is needed to build on the interim passage solution described above (under short-term priorities).

DWR and Reclamation are required by the SWP and CVP biological opinion (NOAA Fisheries, 2009b) to submit a plan by December 2011 for high-quality, reliable anadromous fish passage through the Yolo Bypass, (the permanent solution). The permanent solution should be a comprehensive fish passage plan that provides for fish passage at Fremont Weir, Lisbon Weir, other structures in the South Fork of Putah Creek, and within the Yolo Bypass (Toe Drain and Tule Canal), and addresses straying of anadromous fish upstream through the Knights Landing Ridge Cut and the impacts of the Knights Landing Outfall Gates. NOAA Fisheries (2009b) requires DWR to implement fish passage solutions at many of the structures within the bypass by 2015 but recognizes that actions at some structures require participation by willing partners. DWR will need to complete fish passage assessments at structures where passage status is unknown. Implementing fish passage solutions at all of the important Yolo Bypass structures will require use of multiple funding sources and participation of willing partners and/or owners.

Moderate term fish passage actions at non-SPFC facilities (but still of high biological importance – NOAA Priority 1) include addressing several major dams and multiple smaller obstructions. DWR's State Water Project

and Reclamation's Central Valley Project are leading efforts to improve fish passage at Keswick, Shasta, Folsom, Nimbus, New Melones, Tulloch and Goodwin dams. These two programs are responding to the biological opinion and conference opinion for the long-term operations of the CVP and SWP (NOAA Fisheries, 2009b), which requires Reclamation, with DWR's assistance, to determine the feasibility of providing fish passage at these dams by 2018. If it is determined to be feasible, Reclamation, with DWR's assistance, will construct fish passage facilities at those sites by 2020.

Other non-SPFC projects in the moderate term, high biologic importance category include providing fish passage at Webster Dam, Sack Dam, Englebright Dam, New Bullards Bar Dam, and numerous smaller barriers in the Calaveras River system.

In addition to the actions of high biological importance (NOAA Priority 1) above, five other passage improvements of moderate importance (NOAA Priority 2) also need to be worked on in the next 10 years. These improvements are at Tisdale Weir (SPFC facility) and at the following non SPFC facilities: One Mile Dam (Big Chico Creek), Daguerre Point Dam (Yuba River), Crocker Diversion Dam (Merced River), and Mendota Pool Dam and Diversion.

NOAA also identifies other passage improvements of lower biological importance (Priority 3) that could be worked on in the next 10 years. The four SPFC facilities are Colusa Weir, Big Chico Flood Control, Sand Slough Control Structure, and Cache Creek Settling Basin. Non-SPFC facilities include New Hogan Dam and over 100 other barriers in the Statewide Planning Area.

The full list of known and potential barriers that should be fixed and/or assessed within the Systemwide Planning Area in the next 10 years is in Attachment 9C.2, Table 9C.2-3.

7.3.4 Interim Prioritization Results – Long Term

Long term (more than 10 years) actions are to improve fish passage at thirteen other major dams in the Statewide Planning Area (Attachment 9C.2, Table 9C.2-4). Although they are not SPFC facilities, the dams of highest biological importance (NOAA Priority 1) are Camanche Main, Pardee, Don Pedro Main, and La Grange dams. Dams of moderate biological importance (Priority 2) for this time frame include three SPFC dams (Oroville Dam and Thermalito Diversion and Afterbay) and four non-SPFC dams (Black Butte, Exchequer, Friant, and McSwain dams).

Improving fish passage at these sites is a long-term goal because there are no regulatory deadlines tied to the actions, additional funding will be required to complete the work, and substantial stakeholder involvement and cooperation is needed to make the effort a success. To initiate these actions, DWR can seek opportunities to:

- Incorporate fish passage evaluations at SPFC structures in water supply planning studies
- Participate in interagency/stakeholder forums evaluating fish passage at these sites or on these rivers (Yuba River Multi-Part Forum, Calaveras River, etc.)
- Identify funding to support DWR staff and/or contracts to coordinate and carry out the evaluations
- Develop and implement a plan, with assistance from State and federal agencies and other stakeholders, for addressing feasibility of fish passage at these structures in a comprehensive and strategic manner.

8.0 Possible Solutions for Fish Passage at Large Dams

Numerous known fish passage barriers have been identified within the Systemwide Planning Area. More than 150 of these barriers are small dams, road culverts, or low-water road crossings, and the technologies used to provide fish passage at these types of barriers are well known. Providing fish passage at the 25 large dams identified in this report is more of a challenge. The technologies used at smaller structures, such as fishways, have been tried, often with mixed success. In addition, other technologies have been developed to handle passage over high structures, such as locks and lifts, but these have had limited success.

In the northwest United States, many large dams have fish passage for upstream and downstream migrants, and more will follow through the Federal Energy Regulatory Commission (FERC) relicensing process and NOAA Fisheries biological opinions. In California, all of the large dams, such as Shasta or Oroville, were constructed without upstream or downstream fish passage. Instead, hatcheries were built to compensate for lost habitat for salmonid species. In addition, since the dams at major reservoirs that ring the Central Valley did not provide passage, many of the hydropower facilities located at higher elevations were not provided with fish passage either (CEC, 2005). Providing fish passage at large dams would be a new effort within California, and it is further complicated by the disagreement among State and federal agencies on whether it is prudent or even possible to do so.

As an initial step, DWR's Fish Passage Improvement Program has developed a report investigating fish passage at large dams. The report, *Technologies for Passing Fish at Large Dams*, is divided into three major sections. The first section, Problems with Dams, gives the reader a basic understanding of the problems that dams create for migratory fish, especially salmon and steelhead. The second section, Types of Fish Passage Technologies, provides a general overview of fish passage technologies. The third section, Fish Passage Case Studies, describes specific fish passage technologies being used at large dams around the world.

The case studies describe in detail the upstream and downstream technologies used at specific dam projects throughout the world. They provide a general overview of the project, the history of fish passage at the

project, and the current upstream and downstream technologies being used. The dams were generally chosen because of the height that the technology overcomes, the uniqueness of the technology, the possible relevance to projects in California, or because the passage facility was recently constructed. Dams with fish passage facilities to be constructed are also included. The aim was to include all the various methods used for fish passage at large dams. In addition, case studies of large dams that have been or soon will be removed were included. All dam heights listed refer to hydraulic height unless otherwise noted.

For this document, short summaries of the case studies are provided. The summaries are grouped by passage direction, upstream or downstream, and further into volitional and non-volitional passage. Volitional fish passage, such as fishways for upstream migrants and fish bypasses for downstream migrants, is fish passage made continuously without collection and transport (NMFS, 2008). Therefore, these types of passage facilities let the fish choose when to move past a dam, as they provide a constant hydraulic connection from the reservoir upstream from the dam to the river downstream from the dam. Other technologies rely on humans or machines to provide assistance in the passing of fish. Examples of these technologies are lifts, locks, and trap and transport. These technologies do not have a constant hydraulic connection, and may take hours for one “load” of fish to be moved.

In general, NOAA Fisheries prefers volitional passage, as opposed to collection and transport, for all salmonid passage facilities. This is mainly due to the risks associated with handling and transporting migrating salmonids, and the long-term uncertainty of funding, maintenance, and operation of these types of programs. Further, collection and transport programs may not operate at the start and end of migration periods because there are only a few individual fish present. This practice is likely to have an adverse effect on salmon population diversity. In contrast, volitional passage facilities operate every day, year round. However, there may be locations where collection and transport may be the best option for fish passage, due to height of the dam, possible temperature issues with a long fishway, or passage being needed past multiple dams (NMFS, 2008).

8.1 Large Dams with Volitional Upstream Passage

8.1.1 Fishways

Fishways are the only method to volitionally pass fish over a dam. Styles of fishways are nature-like (made with rock and other natural materials), and baffle- and pool-type (fish ladders). There are not many dams with hydraulic heads above 100 feet that have fishways. Two hydroelectric projects with fishways to circumvent higher heads are in Oregon, the Pelton Round Butte Project (230 feet) on the Deschutes River and the North Fork Project (200 feet) on the Clackamas River. The North Fork Project also has a new fishway at River Mill Dam. The nine most downstream dams on the Columbia River and the four dams on the lower Snake River all have fishways. Finally, a fishway will be constructed at the Carmen-Smith Project's Trailbridge Dam on the McKenzie River in Oregon. Examples of fishways at projects outside of the United States are the Itaipu Hydroelectric Project in South America and the Tongland Hydroelectric Project in Scotland, which are described later in this section.

Pelton Round Butte Hydroelectric Project – Deschutes River, Oregon

Portland General Electric's (PGE) Pelton Round Butte Project consists of three dams (listed from downstream to upstream), 25-foot-high Reregulating Dam, 204-foot-high Pelton Dam, and 425-foot-high Round Butte Dam, on the Deschutes River (PGE and CTWSRO, 2004). The project's 2.84-mile-long pool and weir fishway were built in 1957 and passed fish from below the Reregulating Dam to above Pelton Dam, a hydraulic vertical gain of approximately 230 feet (Ratliff et al., 1999). The fishway was only partially successful at passing adult salmonids during the initial years of the project and is not currently being used for passage. The exact cause of fishway rejection is unknown, but it is thought that vegetative growth in the fishway during the late spring and summer (including the 0.5-mile-long canal section that develops emergent vegetation), not only changed the water chemistry, but also changed the odor fish encountered when entering the fishway. To the adult migrants that wanted to pass, the fishway smelled like a tributary to which they were not cued (Don Ratliff, personal communication, October 7, 2010). The lower 600 feet of the fishway is currently used in the project's collection and transport operation, and upper portions of the fishway are used for the rearing of hatchery produced salmonid fry (Ratliff and Schulz, 1999).

North Fork Hydroelectric Project – Clackamas River, Oregon

The North Fork Project's 1.7-mile-long pool and weir fishway passes Chinook and Coho salmon, and steelhead up about 200 vertical feet from below Faraday Dam to above North Fork Dam (Taylor, 1999). It is the

longest operating fishway in the world (PGE, 2011). Until 1998, fish could travel unimpeded up the entire length of the fishway to exit above North Fork Dam (PGE, 1999). Currently, all fish are trapped approximately 600 feet up the fishway and all wild salmonids are either returned to the fishway to continue upstream or trucked above North Fork Dam. All hatchery returns are recycled downriver or used for fishing opportunities (Bartlett, 2006). From 1988 through 1998, 66 percent of Chinook salmon entering the fishway passed its entire length and 34 percent volitionally entered the fish trap (PGE, 1999). Flows in the upper portion of the fishway are maintained at about 43 cubic feet per second (cfs), with provisions at the fishway entrance to increase flows to about 140 cfs to attract fish (Gunsolus and Eicher, 1970 in PGE, 1999). The fishway exit structure into North Fork Reservoir was designed to accommodate 19 feet of variation in the forebay.

The North Fork Project also has a newly constructed fishway at River Mill Dam, just a couple of miles downstream from Faraday Dam. The River Mill Dam fishway was completed in 2006 and is a Half Ice Harbor pool-and-weir-type, which passes fish over the 70-foot-high dam. Typical pools in the fishway measure 6 feet wide by 10 feet long by 6.5 feet deep. The fishway has two entrances, a primary entrance next to the powerhouse discharge and a secondary one adjacent to the spillway. The fishway has many 180 degree bends as it snakes its way up the right bank of the river. Flow in the fishway ranges from about 20 cfs to 24 cfs. Early observations of the fishway showed no concentrations of fish or unusual behavior, and fish appeared to pass the fishway with little effort (Bartlett and Cramer, 2006).

Carmen-Smith Hydroelectric Project – McKenzie River, Oregon

Eugene Water and Electric Board is designing a fishway for the Carmen Smith Project's Trailbridge Dam on the McKenzie River. The fishway will be a Half Ice Harbor-type and will aid the passage of spring-run Chinook salmon, bull trout, coastal cutthroat trout, and Pacific lamprey. The fishway entrance will be on the right bank of the river just downstream from a new tailrace barrier. The fishway will consist of pools and transport channels, and is designed to overcome a maximum of 86 feet of water surface differential between the reservoir at full pool and the river downstream from the new tailrace barrier. It has 9-inch steps between each pool to accommodate non-anadromous (resident) fish. The number and configuration of the pools is still to be determined, but the types of pools that will be used have been determined. The majority of the pools (approximately 113) will be standard size (8 feet wide by 9 feet long), but some may be replaced by long pools (8 feet wide by 11 feet long) to reduce the total length of transport channel. In addition, there may be some resting pools (8 feet wide by 13.5 feet long) to break up long lengths of transport

channel. There will be 16 exit pools, to handle the 12 feet of reservoir fluctuation, which are designed with 45-degree beveled gates that exit into the reservoir. Within the fishway there will also be several hundred feet of transport channel, constructed of concrete in a rectangular cross section (3 feet wide by 4.33 feet deep). The velocity in the transport channels will be 2 feet per second and the design flow for the fishway is 26 cfs. (Andrew Talabere, Personal Communications, August 24, 2010, and October 20, 2010).

Columbia and Lower Snake Rivers – Washington/Oregon

All of the nine Columbia River dams downstream of the Chief Joseph Dam (River Mile 545) and the four lower Snake River dams have fishways. Hydraulic head at the dams ranges from 40 feet to 105 feet. All but Lower Granite Dam and Little Goose Dam, the uppermost dams on the lower Snake River, have multiple fishways, mainly of the pool-and-weir type with orifices. The fishways are generally arranged with one near each bank of the river. The fishway passage success rate for adult salmonids is generally about 95 percent (USACE, 1997).

Itaipu Hydroelectric Project – Parana River, Brazil/Paraguay

The approximately 6.2-mile-long fishway at Itaipu Dam is the longest of its kind in the world. The fishway is composed of multiple sections, including a nature-like fishway using an existing river channel, fish ladders, and artificial pools. The elevation gain from the bottom to the top of the fishway is 394 feet and the mean flow through the fishway is 424 cfs. There are 11 gates that are used to control water discharge through the fishway system. From the opening of the fishway in December 2002 to January 2010, there have been 135 species of fish found throughout the fishway; this includes about 40 species of long- and medium-migratory-distance fish (Fernandez, 2010). Studies have shown, however, that the number of species found in the uppermost reaches of the canal decreased significantly compared to the lowest reach, which suggests that many species are not able to navigate all reaches of the fishway system (Makrakis et al., 2007).

Tongland Hydroelectric Project – River Dee, Scotland

The pool-type fishway at Tongland Dam was constructed during the time of dam construction and was completed in 1934. The total elevation gain provided by the fishway is approximately 69 feet. In 1960, improvements to the fishway were made to convert the access between pools from orifices to overflow weirs in most locations. Some orifices are still in use in the fishway. In 1999, baffles were installed in the upper pools of the fishway to make it easier for Atlantic salmon to pass. The total flow released through the fishway is approximately 9 cfs year-round, with an additional 28 cfs released from the dam during the period of salmon migration. A

Vaki Riverwatcher fish counter is installed in one of the resting pools to record adult salmon ascending the fishway.

From 2006 to 2008, a Passive Integrated Transponder (PIT) tag study was done by Galloway Fisheries Trust, Dee District Salmon Fishery Board, and Marine Scotland Science, to identify any problems with the fishway. Fish were tagged downstream from the fishway in a fish trap adjacent to Tongland Power Station and PIT detectors were located throughout the fishway. Of the 44 fish that were tagged, 35 percent were recorded at the lowest PIT detector at the fishway. It was found that fish moved through the fishway exclusively during daylight hours. Data analysis also showed that salmon that entered the fishway moved through it within 2 days. Some tagged fish were not recorded at the fishway, so further study needs to be done to determine the cause of this (Galloway Fisheries Trust and The Carnie Consultancy, 2010).

8.2 Large Dams with Non-Volitional Upstream Passage

Non-volitional upstream passage at large dams can be achieved by several methods, including lifts, locks, and collection and transport. These methods are used where vertical passage heights are excessive or when passage is needed for species that do not readily use fishways (CEC, 2005).

Fish lifts move fish over a barrier by mechanical means. Fish locks are devices that raise fish over dams, similar to the way boats are raised in a navigation lock. In North America, fish lifts have been preferably used over fish locks to pass fish over high dams (Clay, 1995). At Keswick Dam on the Sacramento River, a fish lift is used as part of a collection and transport facility. Locks built at dams on the Columbia River (Bonneville, The Dalles, and McNary) and at other locations in the United States were abandoned in favor of pool-type fishways. Likewise, most locks in France are considered to be unsuccessful and some have been replaced by pool-type fishways (Larinier, 2000).

Collection and transport operations have been used successfully for moving adults upstream from long reservoirs or multiple reservoirs. This technology has also been used for interim passage until construction of other fish passage technologies, such as fishways or lifts, is completed. At high-head dams, collecting and transporting adult migrants may be the only feasible passage method. A potential benefit of this type of system is that it needs much less flow than pool-type ladders, which may make it the most feasible fish passage option for drought periods in California (CC, 2005).

In the Pacific Northwest, most projects at high-head dams (greater than 100 feet) are or will be using the collection-and-transport method to move adult migrating salmonids upstream from a dam or multiple dams. Examples include the Baker River, Cowlitz River, Lewis River, Pelton-Round Butte, Cougar, Cle Elum, and Cushman projects.

8.2.1 Lifts

Touvedo Dam – Lima River, Portugal

At 140-foot-high Touvedo Dam on the Lima River, a fish lift is used for passing Atlantic salmon, sea trout, and other fish species. No other fish passage technologies were considered during the development of the project. There are three entrances to the lift located within the tailrace of the powerhouse. A maximum attraction flow of 159 cfs is evenly distributed among the three entrances; velocities in the entrances range from 5.5 feet per second to 8.2 feet per second. More detailed information about the fish lift was not available.

A study in the late 1990s found that cyprinids (Iberian nase, Iberian barbell, Iberian dace, Iberian red roach), salmonids (brown trout and Atlantic salmon), and European eel used the fish lift to pass upstream (Santos et al., 2002). Velocities within the entrance channel were within the ranges of critical swimming speeds for fish (Larinier, 1992, as cited in Santos et al., 2002). Cyprinids used the lift more often at night, while trout and eels passed during the day.

Keswick Dam – Sacramento River, California

At 118-foot-high Keswick Dam, the fish trapping facilities are located in the center of the dam, between the powerhouse and the spillway. The facilities consist of a pool-type fishway, a brail lift, and a 1,000-gallon elevator. After fish ascend the fishway, they pass through a fyke weir and are contained in a large fiberglass brail enclosure. The brail is raised and trapped fish are directed into a 1,000-gallon fish tank elevator that transports them up the face of the dam. At the top of the dam, the tank is dumped into a fish transport truck.

8.2.2 Locks

Ardnacrusha Hydroelectric Project – River Shannon, Ireland

In 1959, a Borland-MacDonald fish lock was constructed at Ardnacrusha Dam to provide upstream passage of adult Atlantic salmon. The average working head is approximately 94 feet. The lock at Ardnacrusha is different from the typical Borland lock because it has a vertical cylindrical chamber as opposed to the typical sloping chamber. Fish enter the base of the 15-foot-diameter cylinder, the downstream gate shuts, and water fills

the cylinder until the fish are raised to the forebay level. Attraction flow is provided by a 27-inch-diameter pipe that has two branches, one dispersing water at the base of the cylinder and the other discharging through nozzles outside of the gate entrance.

Baker River Hydroelectric Project – Washington

See Section 8.2.3 Collection and Transport for a description of the lock used at Puget Sound Energy's (PSE) adult fish collection facility on the Baker River.

8.2.3 Collection and Transport

Baker River Hydroelectric Project – Washington

In 2010, PSE completed construction of an adult fish collection facility downstream from Lower Baker Dam near the town of Concrete, Washington. The facility replaces the original trap that was built in 1958. The new fish trap is highly automated. Fish enter a fish lock seven feet in diameter and 60 feet tall, which raises fish from the river level to the facilities on the river bank. There is a programmable control system and operator's booth for sorting fish by species and separating them into six holding pools. From the holding pools, fish are transferred to trucks via automated systems with minimal handling of fish. (PSE, 2010)

Cle Elum Dam Project – Yakima River, Washington

At 124-foot-high Cle Elum Dam on the Yakima River in Washington, Reclamation is planning to build a collection-and-transport system. A fishway will lead adult migrants into a collection facility where they will be held for truck transport to locations in and upstream from the reservoir. Flows in the fishway will be less than 10 cfs and will come from the stilling basin downstream from the dam. The target species for passage are sockeye, Coho, and Chinook salmon, steelhead, and bull trout (Reclamation, 2010).

Cougar Dam Project – South Fork McKenzie River, Oregon

Cougar Dam is a 467-foot-high structure on the South Fork McKenzie River in Oregon. USACE completed a $10.4 million adult fish collection facility in 2010 as part of their collection-and-transport system. The facility uses a Half Ice Harbor fishway to get fish to the collection facility. Water pumped from the tailrace of the power plant is used at the facility and in the fishway. At the facility, spring-run Chinook salmon, bull trout, and resident fish species are sorted and then loaded onto trucks for transport to locations above Cougar Reservoir. Rather than crowding fish mechanically, the facility was designed to let fish make their own way up the fishway and into the truck tank with as little impediment as possible. The goal is to get at least 1,000 adult spring-run Chinook salmon into the upper watershed

each year (Palmer, 2010). That goal has not been reached as of yet, but the USACE has passed several hundred spring-run Chinook salmon as well as hundreds of resident species. Aside from a few minor issues, the facility is working well (Greg Taylor, Personal Communication, November 7, 2011).

Cowlitz River Hydroelectric Project – Washington

Tacoma Power uses the Cowlitz River Hydroelectric Project to generate power, and provide flood protection, water supply, and recreational opportunities. It includes two large dams (listed from downstream to upstream), 230-foot-high Mayfield Dam and 529-foot-high Mossyrock Dam, located on the Cowlitz River in Washington State. A third large dam on the river, just upstream from Riffe Lake (Mossyrock Dam's reservoir) is Lewis County Public Utility District's 120-foot-high Cowlitz Falls Dam (FERC, 2002), the only dam in its Cowlitz Falls Project. Tacoma Power uses a collection-and-transport system to pass spring- and fall-run Chinook salmon, coho salmon, and steelhead past the dams and reservoirs. Migrating adults are collected at the Cowlitz Salmon Hatchery and Cowlitz Trout Hatchery downstream from Mayfield Dam and sorted by species and destination. Hatchery fish are kept at the hatchery to produce the next generation of salmon or trucked upstream. Wild salmon are transported to sites on the Tilton, Cowlitz, and Cispus rivers to continue their upstream migration (Tacoma Power, 2010a). The number of adults (Chinook salmon, coho salmon, steelhead trout, and cutthroat trout) annually transported upstream in the last eight years ranges from 18,000 to 112,000 (Tacoma Power, 2004, 2006, 2008, 2009, 2010b).

Cushman Hydroelectric Project – Skokomish River, Washington

Tacoma Power's Cushman Hydroelectric Project is located on the Skokomish River in Washington. It consists of two dams (listed from downstream to upstream), 215-foot-high Cushman No. 2 and 250-foot-high Cushman No. 1. Through Federal Energy Regulatory Commission (FERC) relicensing, Tacoma Power developed an Upstream Fish Passage Plan in 2010. From the plan, a fish collection trap will be constructed at the base of Cushman No. 2 Dam. Flows between 70 cfs and 280 cfs will pass through the new North Fork Powerhouse at the base of Cushman No. 2 Dam and into the trap, providing holding water and attraction flows at the trap entrance. Fish will be attracted or crowded into a hopper and then lifted to the top of the dam via a railed tramway. At the top of the dam, fish will be sorted and loaded onto trucks to be transported to hatcheries or Lake Cushman upstream from Cushman Dam No. 1 (Tacoma Power, 2010c).

Lewis River Hydroelectric Project – Washington

PacifiCorp's Lewis River Project consists of three main dams (listed from downstream to upstream), 230-foot-high Merwin Dam, 309-foot-high Yale Dam, and 400-foot-high Swift No. 1 Dam, on the Lewis River in

southwestern Washington (NMFS, 2006). Through FERC relicensing and their 2004 Settlement Agreement, PacifiCorp will provide upstream and downstream passage at project dams. Adult spring-run Chinook and Coho salmon, and winter-run steelhead will be trapped below Merwin Dam and transported by trucks upstream from Swift No. 1 Reservoir. Hatchery fish will be initially used to kick-start the reintroduction program and over time, and as naturally produced fish increase in number, hatchery supplementation will be tapered off (PacifiCorp, 2004). The fish collection facility will consist of new fish trap entrances with increased attraction flow, a new fish lift, and holding, sorting, marking, sampling, and truck-loading areas that will use water-to-water fish transfer protocols. The final design for the facility is completed, and construction is planned to begin in 2012 (R2, 2011).

Pelton Round Butte Hydroelectric Project-Deschutes River, Oregon

PGE's Pelton Round Butte Project consists of three dams (listed from downstream to upstream), 25-foot-high Reregulating Dam, 204-foot-high Pelton Dam, and 425-foot-high Round Butte Dam, on the Deschutes River (PGE and CTWSRO, 2004). The project has a fish trap built in 1956 and located below the Reregulating Dam, which was originally constructed to collect fish for passage around the construction activities at the Reregulating and Pelton dams. It has been used since 1972 for collecting upstream migrants for transport to the Round Butte Hatchery at the base of Round Butte Dam (Ratliff et al., 1999; ODFW, 2010).

Since 2007, steelhead and spring-run Chinook fry from the hatchery have been annually released upstream from Lake Billy Chinook, the reservoir formed by Round Butte Dam. Fry will be released every year until adults start being transported to the upper watershed. PGE completed a downstream migrant collection facility in December 2009, and, as of September 2010, had collected and transported nearly 100,000 juvenile fish (PGE, 2010).

Upstream passage for adult migrating salmonids has not begun yet, but is tentatively scheduled to start in 2012. That is when adults that originated in the upper watershed from the fry releases should return (Don Ratliff, personal communication, October 7, 2010). The returning adults will be collected at the Pelton Fish Trap and trucked to Lake Billy Chinook. To get ready for their release into Lake Billy Chinook, a facility, consisting of a concrete fish release vault positioned near the shore with a truck access point, was constructed in 2010 (PGE and CTWSRO, 2009; Don Ratliff, personal communication, October 7, 2010).

8.3 Large Dams with Volitional Downstream Passage

Typically, downstream migrants can pass a dam by three methods: turbines, spillways, or bypass systems (USACE, 2002). In addition, juvenile migrants can pass dams by using the fishways or navigation locks, but, since the percentage of fish passed by these methods is very small, DWR did not discuss them in the report.

8.3.1 Turbine Passage

One of the goals of downstream fish passage is to keep fish from passing through turbines. Studies of juvenile salmon have shown that fish reluctantly, after delays in the forebay, enter the turbine intakes. Even then, these fish seek refuge in the gatewells, slots used for inserting solid barriers that keep water from entering the turbines during maintenance (Coutant et al., 2006). Fish that do pass through turbines can become injured or die by a number of mechanisms. These include rapid and large pressure changes, shear stresses, cavitation, turbulence, collision with turbine parts, and squeezing through narrow openings between moving and fixed parts (Cada, 2001).

The survival of fish during turbine passage is influenced by the size and type of turbine, speed of revolution, hydraulic head, and mode of operation, as well as the characteristics of the fish, such as species, size, life stage, and condition (CEC, 2005).

Two types of turbines are generally used at large dams, Francis and Kaplan. The mortality rate for juvenile salmonids passing through Francis and Kaplan turbines varies greatly, from under 5 percent to more than 90 percent in Francis turbines, and from under 5 percent to approximately 20 percent in Kaplan turbines (FAO, 2001). The large Kaplan turbines at the mainstem Columbia and Snake River dams have an average survival rate (including both direct and indirect effects) of about 88 percent (Cada, 2001). Studies show that a correlation exists between peripheral turbine blade velocity and fish mortality for the Francis design but not the Kaplan design (EPRI, 1987). Fish size also affects mortality rate, as larger fish have a greater chance of colliding with turbine parts (OTA, 1995).

At California's large dams, Francis turbines are commonly used. For example, the Shasta and Keswick (Sacramento River), Folsom (American River), Narrows 2 (Englebright Dam on the Yuba River), New Melones (Stanislaus River), and Hyatt (Oroville Dam on the Feather River) power plants all have Francis-type turbines (Reclamation, 2011).

8.3.2 Spillway Passage

One way to keep fish out of turbine intakes is to pass them at a spillway. Since their reservoir capacities are small, spillways are often used to pass excess water at the Colombia and lower Snake River dams. These dams can also be operated to use their spillways to pass fish by not passing as much water through their power plants. But since large hydropower generation, flood management, water storage dams in California do not use their spillways except to pass excess water when their reservoirs are full, fish passage at these types of spillways is not a viable option.

8.3.3 Bypass Systems

The final type of volitional downstream passage is the bypass system. These are constructed exclusively for fish passage, but can be modifications of other structures such as an ice-and-trash chute, and generally consist of a barrier to guide the fish over to a pipe or flume in which the fish and water flow to an outfall point downstream from the dam.

Some of the Columbia River dams, such as Rocky Reach and Bonneville, have bypass systems that pass fish to the river below the dam. In addition, some larger flood control, water storage projects, such as the Cowlitz River and North Fork projects, also use bypasses leading directly to the river downstream.

Rocky Reach Hydroelectric Project – Columbia River, Washington

The permanent surface collection system at Rocky Reach Dam was completed in 2003. It includes 29 pumps to create a strong attraction flow into the collector. There are two entrances into the surface collector with 3,000 cfs of flow per entrance. After entering one of the two surface collector channels, flow is dewatered through fine screening from 3,000 cfs down to 120 cfs. The flow from the collector channels enters into the bypass pipe. Vertical barrier intake screens in two of the turbine units also deliver 120 cfs of flow and fish into the bypass pipe. The water and fish are transported in the bypass pipe several hundred yards downstream from the dam where they are released into the river. The total design, engineering, and construction costs for the system were $107 million (Hemstrom, 2010a).

The bypass efficiency (proportion of smolts using the bypass compared to turbines and spillway) is 50 percent to 70 percent for steelhead, 40 percent to 50 percent for sockeye, and 40 percent to 47 percent for Chinook. Smolt survival studies have shown that smolts are averaging 99.9 percent survival through the bypass system (Hemstrom, 2010b).

Bonneville Hydroelectric Project – Columbia River, Washington/Oregon

The second powerhouse at Bonneville Dam has a juvenile bypass system. Fish are screened within the powerhouse and are diverted into a 48-inch transport pipe that transports fish downstream from the dam. In 2004, a corner collector was built at the second powerhouse to augment the juvenile bypass system. The corner collector was designed to operate over flows of 3,375 to 6,570 cfs. Roughly 30 percent of all downstream migrants that pass through Bonneville Dam go through the corner collector (BPA, 2006). The corner collector was created by modifying the existing ice-and-trash chute intake area and adding a concrete channel to transport fish downstream from the powerhouse. The non-turbine routes are estimated to pass about 90 percent of all juvenile fish at the Second Powerhouse with an estimated survival rate exceeding 95 percent (Salmonrecovery.gov, 2004). In 2008, a prototype Behavioral Guidance System (BGS), 700 feet long and 10 feet deep, was installed in the forebay of the second powerhouse. The purpose of the BGS was to increase the passage of juvenile salmon into the corner collector. Studies were implemented to evaluate the effectiveness of the prototype BGS.

North Fork Hydroelectric Project – Clackamas River, Oregon

Portland General Electric uses a fishway and a bypass pipe to pass downstream migrants past all three of its dams. Smolts migrating downstream from the upper Clackamas River encounter North Fork Dam, the uppermost dam for the Project, and enter a collection system that passes them into the project's 1.7-mile-long pool and weir fishway. The juvenile fish travel about 1.5 miles down the fishway to a separator, which diverts them into a holding tank where they are identified and counted. Fish are then released into a 20 inch pipe that carries them downstream about five miles where they are released into the river below River Mill Dam (PGE, 2011).

Cowlitz River Hydroelectric Project – Washington

At Tacoma Power's Cowlitz River Project, a downstream migrant bypass facility passes fish around 230-foot-high Mayfield Dam. The facility was constructed in the early 1960s and consists of two vertical louver intake structures that funnel fish into a bypass channel. The bypass channel then directs the fish to a secondary separator, where they are guided through the dam to a holding and counting facility, then emptied into the river below the powerhouse using a pipe and chute (NOAA Fisheries, 2004). The bypass annually passes an estimated 25,000 to 250,000 salmonid smolts (Zapel et al., 2002).

8.4 Large Dams with Non-Volitional Downstream Passage

8.4.1 Collection and Transport

Collection and transport is the method for non-volitional downstream passage at large dams. At the dams on the Columbia and lower Snake rivers, downstream migrants are sometimes collected and transported downstream from the lowest dam on the Columbia River. At high flood control, water storage dams, collection and transport is becoming the main method for downstream passage. At some dams, downstream migrants are collected at a screening facility attached to the intake of the power plant. At other locations, the floating surface collector (FSC) has emerged as a preferred method to pass downstream migrants. PSE completed its FSC at Upper Baker Dam in 2008, and since then, many other entities have followed in its footsteps. Tacoma Power is currently designing an FSC for its Cushman Hydroelectric Project on the Skokomish River and will most likely do the same to improve downstream passage on the Cowlitz River. In addition, PacifiCorp is currently designing an FSC for its Lewis River Hydroelectric Project. Finally, USACE is looking at a FSC as an alternative for downstream passage at Cougar Dam on the South Fork McKenzie River.

Lower Granite Dam – Snake River, Washington

For downstream passage at 100-foot-high Lower Granite Dam on the Snake River, one of the methods used is a collection-and-transport system. Fish enter a bypass system through one of 18 bulkhead slot orifices located at the upstream powerhouse intake. Fish pass into a collection channel, move down the collection channel and pass through a downwell into a 42-inch pipe that transports them 1,700 feet downstream to a holding and loading facility. At the facility, fish are separated and can be loaded onto a truck or barge to be transported approximately 285 river miles downstream to be released below Bonneville Dam, the furthest downstream dam in the system (USACE, 2010).

Pelton Round Butte Hydroelectric Project – Deschutes River, Oregon

PGE's Pelton Round Butte Project consists of three dams (listed from downstream to upstream), 25-foot-high Reregulating Dam, 204-foot-high Pelton Dam, and 425-foot-high Round Butte Dam, on the Deschutes River (PGE and CTWSRO, 2004). In December 2009, the construction of a Selective Water Withdrawal Tower and its associated fish collection facility was completed at a cost of $108 million. The fish collection facility sits at the top of the tower and captures downstream migrant salmonids attempting to emigrate from Lake Billy Chinook, the reservoir created by Round Butte Dam. Through the primary downstream migration period

(February to June), nearly all the water used for generation at the Round Butte Powerhouse will be withdrawn from the surface of the reservoir through the fish screening facility. The facility uses large v-shaped screens for primary screening. The fish are captured, separated into four size categories, and distributed into separate holding, processing, and release or loading facilities. Most of the collected fish are transported by truck about 10 river miles downstream for release below Reregulating Dam (Ratliff et al., 2009).

Baker River Hydroelectric Project – Washington

Baker River Hydroelectric Project's $50 million FSC was completed in the spring of 2008. It is the primary facility for downstream passage of outmigrating juvenile salmonids from Baker Lake to the Skagit River. The FSC is a 130-foot-by-60-foot barge located upstream from Upper Baker Dam, and is outfitted with conventional v-screens within a floating channel with attraction flow created by pumps. The FSC has the capacity for 1,000 cfs attraction flow, but currently only provides 500 cfs. Guide nets that help funnel fish into the FSC are located on both sides of the collector and extend from the FSC to the opposing lake shores. The FSC also includes fish holding tanks and a sampling facility. Fish are transported by barge from the FSC to loading facilities on the dam, where they are loaded onto flatbed trucks or trailers for transport downstream from Upper Baker and Lower Baker dams. Since the FSC has been in operation, record numbers of juvenile sockeye salmon have been collected, with an efficiency estimated at 90 percent to 95 percent, and transported downstream.

8.5 Dam Removals

The best method to provide fish passage at a dam is to remove it. While allowing unimpeded fish passage, dam removal also offers the restoration of natural processes, such as sediment, woody debris, and nutrient transport, and reestablishes watershed connectivity. However, it is possible that removing a dam can have negative effects on a watershed, such as removing a reliable source of cold water and allowing fish passage for undesirable species that were formerly blocked by the dam.

8.5.1 Removed Dams

Marmot Dam – Sandy River, Oregon

Marmot Dam was located on the Sandy River about 30 miles southeast of Portland before its removal in 2007. Marmot Dam was 47 feet high (structural height) and a part of the Bull Run Hydroelectric Project, which generated up to 22 megawatts of power (Major et al., 2008). The dam originally had a fishway for passage that was frequently damaged in flood

events and required repairs and maintenance throughout its life (Taylor, 1998). Through the FERC relicensing process, PGE decided that the costs of upgrading and maintaining the fish passage facilities outweighed the power revenue that the hydroelectric project generated. Marmot Dam is one of the largest dams (in terms of height and volume of stored sediment) to have been removed in the western United States. The reservoir behind the dam stored approximately 1,000,000 cubic yards of sediment, and its management was one of the main issues to be solved during the dam removal process. PGE chose the informally termed "blow and go" option, in which the dam is removed as quickly as possible with minimal prior removal of stored sediment. The earthen coffer dam protecting the dam removal site was breached on October 19, 2007, and by mid- January 2008, about 400,000 cubic yards of the stored sediment was eroded by the river (Major et al., 2008).

Saeltzer Dam – Clear Creek, California

Saeltzer Dam was located on Clear Creek about six miles upstream of the confluence with the Sacramento River before its removal in 2000. Saeltzer Dam was approximately 15 feet high (structural height) and 200 feet long. It was constructed in 1903 to divert water for agriculture and cattle ranching (Boyle Engineering Corp 1986). A pool and weir fishway was constructed in 1958 to replace the original ladder but spring-run Chinook salmon and steelhead were never observed using the ladder or in upstream areas. Since the ladders did not appear to pass spring-run Chinook salmon and steelhead, the dam blocked access to 10 miles of cold water habitat available upstream for these species. Ten solutions for fish passage problems at Saeltzer Dam were evaluated for feasibility and cost (Rectenwald 2000). An interagency and stakeholder group ultimately focused on three: 1) rehabilitating the dam and installing a fish screen and ladder, 2) removing the existing dam and constructing a new dam with a ladder and screen at a new location, and 3) removing the dam and transferring the water rights to diversion points outside the watershed (Rectenwald 2000). The group selected option 3. About 13,000 cubic yards of sediment were excavated from behind the dam before the dam was removed in 2000 (Rectenwald 2000). By 2005, about 50,000 cubic yards of stored sediment were eroded by Clear Creek (Clayton-Niederman & Gilbreath 2005). Since 2001, the highest steelhead redd densities have been seen in the reaches upstream of where Saeltzer Dam was located (USFWS 2007, as cited in NMFS 2009a).

8.5.2 Dams to be Removed

Condit Dam – White Salmon River, Washington

Condit Dam is a 125-foot-high (structural height) barrier to fish passage on the White Salmon River, a tributary to the Columbia River, which was

removed beginning in October 2011 (Frank Shrier, Personal Communication, September 9, 2010). The hydroelectric project is owned by PacifiCorp and has a power generating capacity of 14.7 megawatts. The reservoir, Northwestern Lake, contains approximately 2.3 million cubic yards of captured sediment. Fish ladders were part of Condit's original design, but these facilities washed out twice during floods in the dam's early years. After the facilities washed out for the second time, the Washington State Fisheries Department required the former owner, Northwestern Electric, to contribute to construction of a state fish hatchery rather than rebuild the fish ladders (PacifiCorp, 2005).

In 1996, as part of the relicensing of the hydroelectric project, FERC issued a Final Environmental Impact Statement, which dictated required conditions for continued use of Condit Dam. Some of the conditions included installation of fish passage facilities and higher in-stream flows. With the new conditions, continuing hydroelectric operations at Condit Dam would have been uneconomical for PacifiCorp and its customers. PacifiCorp entered into a settlement process, where it was decided that it would shut down power generation and remove Condit Dam (PacifiCorp, 2005). Removing the dam will open up as much as 33 miles of spawning and rearing habitat for anadromous salmonids (NMFS, 2006).

Elwha River Dams – Elwha River, Washington

Removal of Elwha and Glines Canyon dams, located on the Elwha River in Olympic National Park, began in fall 2011 (USDOI NPS, 2011). Elwha Dam is 98 feet high and is located about five miles upstream from the mouth of the Elwha River at the Strait of Juan de Fuca. Glines Canyon Dam is 200 feet high and is approximately eight miles upstream from Elwha Dam. Elwha Dam produces up to 14.8 megawatts of power and Glines Canyon dam produces as much as 13.3 megawatts (American Rivers, 2010). Sediment management is a significant issue in the removal of the dams, as Elwha Dam's reservoir contains roughly 5 million cubic yards of sediment and the reservoir for Glines Canyon Dam contains approximately 13 million cubic yards. Much of the sediment will be slowly released to reduce impacts on downstream habitat (USDOI NPS, 2011).

Since the construction of the Elwha River dams, anadromous fish population and habitat has declined dramatically. With no fish passage facilities, these dams restrict fish from entering 90 percent of the watershed. Extensive environmental review in the early 1990s determined that removal of the dams was the only way to restore native anadromous fish stocks and the river's ecosystem. Removal of the dams will restore the river to its natural state, allowing all five species of Pacific salmon (Chinook, Coho, chum, pink, and sockeye) and other anadromous fish to reach their historic spawning and rearing habitat (USDOI NPS, 2011).

The Elwha River Ecosystem and Fisheries Restoration Act of 1992 stated that water quality on the Elwha River must be protected before dam deconstruction can commence. The completion of a $25.5 million water treatment plant in Port Angeles has initiated the beginning phases of dam removal (Bodilly, 2010). Needed flood protection levee improvements and construction of a new fish hatchery are also currently underway (USDOI NPS, 2011).

8.6 Conclusions

As the case studies indicate, fish passage is provided at many large dams throughout the world. In the northwest United States, many large dams have fish passage and many more will follow in the next few years. Fish passage is provided at the lower nine Columbia River dams and the four Lower Snake River dams, with hydraulic heights ranging from 40 feet to 105 feet. At the higher flood control, water storage dams in the northwest, not all the large dams have fish passage, but many do or will in the near future.

In Washington, 27 dams have hydraulic heads greater than 150 feet. Of these, four include Grand Coulee Dam (no fish passage mainly due to its 15-mile-long reservoir upstream) and those under the influence of the Grand Coulee Dam. Almost all of the others are multipurpose dams, used for flood control, water storage, power generation, and recreation, among other things. Of these 23 dams, eight are at or above a historical natural barrier to fish passage, leaving 15 dams where fish passage could be a viable option. Of these, eight dams currently have fish passage, including 277-foot Lower Baker Dam and 304-foot Upper Baker Dam on the Baker River and 230-foot Mayfield Dam and 529-foot Mossyrock Dam on the Cowlitz River. Of the remaining seven dams, five dams have fish passage projects in design and one is scheduled for removal starting in 2011, leaving only one dam without an active fish passage project. Collection and transport is the only method used (or to be used for those in design) for upstream passage at these large dams. Downstream passage is accomplished by fish bypass or collection-and-transport facilities.

In Oregon, fewer large multipurpose dams have fish passage. The Pelton-Round Butte Project (with 204-foot Pelton Dam and 425-foot Round Butte Dam) on the Deschutes River and the North Fork Project (145-foot North Fork Dam, 56-foot Faraday Dam, and 70-foot River Mill Dam) on the Clackamas River, are the only projects with constructed facilities for both upstream and downstream passage. Of the eight dams in the Willamette River watershed with hydraulic heights greater than 150 feet, only 467-foot Cougar Dam on the South Fork McKenzie River and 181-foot Fall Creek

Dam have fish passage. Both dams have a collection-and-transport operation for upstream passage but no downstream passage facilities. A downstream passage facility for Cougar Dam is in the planning stages and should be operational in the next couple of years. Through the National Marine Fisheries Service (NMFS) Biological Opinion for the Willamette Projects, upstream fish passage will be implemented in the next few years for those dams blocking access to the upper reaches of the watershed. Downstream passage will be implemented more slowly, as Cougar Dam's downstream facility will be the test case for the watershed.

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9.0 Recommendations and Conclusions

This report focuses on fish passage actions that, if implemented, could contribute to the recovery of anadromous fish in the Central Valley. DWR identified 189 known and potential fish passage barriers in the Systemwide Planning Area, 14 of them components of the SPFC. If all the barriers are removed and/or repaired, approximately 1,500 miles[16] of anadromous fish habitat from western edge of the legal Delta to the headwaters will become fully accessible for migration, spawning, and rearing. This should greatly increase and improve habitat connectivity and promote the recovery of anadromous fish populations in the Sacramento-San Joaquin River Flood Management System.

9.1 Recommended Priorities for Removing Fish Passage Barriers

This report identified fish passage barriers in the CVFPP Systemwide Planning Area and used an interim prioritization process to rank them. The interim ranking was conducted to meet the needs and scheduling of the 2012 CVFPP. The Forum, a statewide interagency collaboration, is developing a more robust and broadly supported ranking system, but that system is not ready for use at this time. Once that prioritization is complete, the barriers identified in this report should be re-ranked using the Forum's prioritization method. This will ensure that barriers within the Flood System are addressed in a manner consistent with the rest of the State and should provide interagency buy-in for CVFPP fish passage actions.

A summary of the interim priorities for improving fish passage, especially at SPFC structures, is in Table 9-1. The table is divided into three main sections: structures that NOAA Fisheries identified as being Priority 1 and Priority 2 actions in the Central Valley salmonid recovery plan (NOAA Fisheries, 2009a), and those that were not included in the recovery plan. The priority is based on the geographic location and the potential for providing the greatest benefit for the greatest number of anadromous species. Structures are divided into two columns: those that are part of SPFC and those that are not. The time frames are based on time frames associated with the CVFPP investment strategy, deadlines set by the 2009

[16] See Attachment 9C.1 for a description of the methods used to calculate the total miles that would be fully accessible.

Biological Opinion for the long-term operations of the CVP and SWP (NOAA Fisheries, 2009b & 2011a), and direction from the Central Valley salmonid recovery plan (NOAA Fisheries, 2009a).

The Biological Opinion requires:

- DWR and Reclamation to submit a plan for fish passage at Fremont Weir by December 2011, with implementation of the plan starting by June 2012.
- DWR and Reclamation to evaluate the feasibility of providing fish passage at Shasta, Folsom, Nimbus, Keswick, New Melones, Tulloch and Goodwin dams by December 2018.
- Reclamation to operate RBDD with gates out all year to allow unimpeded passage for listed anadromous fish no later than May 15, 2012.

The Central Valley salmonid recovery plan (NOAA Fisheries, 2009a) recommends that the State evaluate the feasibility of providing fish passage at Oroville (a SPFC structure), Black Butte, Exchequer Main, and Friant dams[17]. Providing fish passage at these structures is necessary "to prevent a significant decline in species population/habitat quality or in some other significant negative impact short of extinction."

DWR's investments in improving both the Central Valley flood management system and its associated ecosystem will be initially constrained by funding from Proposition 1E, which requires a link to the SPFC. Thus, Proposition 1E funding decisions will focus on those barriers in the SPFC column, as compared to non-SPFC barriers. By focusing on just SPFC structures, the DWR flood management programs will contribute toward improvements for anadromous fish at those facilities, but not toward improvements at other important non-SPFC barriers. If choices need to be made between Priority 1 and Priority 2 barriers, managers should select Priority 1 structures since improvements at those structures will benefit the most anadromous species.

[17] New Hogan Dam was originally included as a Priority 2 action in the Central Valley salmonid recovery plan (NOAA Fisheries, 2009a). Because the Calaveras River downstream of New Hogan Dam already has the potential (with passage and flow improvements) to support a viable steelhead population, passage upstream of New Hogan Dam is currently not a high priority for NOAA Fisheries (pers.com. B. Ellrott 2011).

Table 9-1. State Plan of Flood Control Fish Passages Priorities

Biological Importance – Priority	Time Frame	SPFC	Non-SPFC
1	Within the next 5 years	• Fremont Weir planning and implementation[1] • Willow Slough Weir (Sutter Bypass - East Borrow Canal) • Weir No. 2 (Sutter Bypass – East Borrow Canal)	• Planning and implementation for 15 Yolo Bypass barriers Budiselich Dam and Caprini Low-Flow (Stockton Diverting Canal and Mormon Slough) • Red Bluff Diversion Dam[2]
	Within the next 10 years	• Fremont Weir implementation Sacramento Weir	• Implementation fish passage solutions at 15 Yolo Bypass barriers • Keswick Dam[3] • Shasta Dam • Folsom Dam (American River) • New Melones and Tulloch dams (Stanislaus River) • 39 Calaveras River/Mormon Slough/ Stockton Diverting Canal barriers • Webster Dam (Mosher Slough near Stockton) • Sack Dam • Goodwin Dam • Harry L. Englebright Dam (Yuba River) • New Bullards Bar Dam (N. Yuba River)
	More than 10 years		• La Grange Dam (Tuolumne River) • Camanche and Pardee dams (Mokelumne River) • Don Pedro Dam (Tuolumne River)
2	Within the next 10 years	• Tisdale Weir	• One Mile Dam With Pool Fish Ladder (Big Chico Creek) • Daguerre Point Dam (Yuba River) • Crocker Diversion Dam (Snelling) (Merced River) • Mendota Pool Dam And Diversion
	More than 10 years	• Oroville Dam (Feather River)[4] • Fish Barrier Dam (Feather River) • Thermalito Diversion Dam and Afterbay	• Black Butte Dam (Stony Creek) • Exchequer Main Dam (Merced River) • Friant Dam • McSwain Dam (Merced River)

Table 9-1. State Plan of Flood Control Fish Passages Priorities (contd.)

Biological Importance – Priority	Time Frame	SPFC	Non-SPFC
3	Within the next 10 years	• Colusa Weir • Big Chico Flood Control • Sand Slough Control Structure • Cache Creek Settling Basin	• New Hogan Dam[5] • More than 100 structures (not included earlier in this table) throughout the Systemwide Planning Area

Notes:

[1] The biological opinion for the long-term operations of the CVP and SWP (NOAA Fisheries, 2009b & 2011a) requires DWR and Reclamation to submit a plan for fish passage at Fremont Weir by December 2011. The biological opinion requires the agencies, to the maximum extent of their authorities, and in cooperation with other agencies, begin implementation of the plan by June 2012.

[2] Reasonable and Prudent Alternative I.3.1 of the biological opinion for the long-term operations of the CVP and SWP (NOAA Fisheries, 2009b) states "No later than May 15, 2012, Reclamation shall operate RBDD with gates out all year to allow unimpeded passage for listed anadromous fish." Because of this regulatory deadline, Red Bluff Diversion Dam was moved up to the "Within the next 5 years" time frame.

[3] The biological opinion for the long-term operations of the CVP and SWP (NOAA Fisheries, 2009b) requires DWR to participate in the fish passage steering committee that is evaluating the feasibility of providing fish passage at Shasta, Keswick, Nimbus, Folsom, New Melones, Tulloch and Goodwin dams.

[4] The Central Valley salmonid recovery plan (NOAA Fisheries, 2009a) recommends that the State evaluate the feasibility of providing fish passage at Oroville, Black Butte, New Hogan, Exchequer Main, and Friant dams. Providing fish passage at these structures is necessary "to prevent a significant decline in species population/habitat quality or in some other significant negative impact short of extinction."

[5] Because the Calaveras River downstream of New Hogan Dam already has the potential (with passage and flow improvements) to support a viable steelhead population, passage upstream of New Hogan Dam is currently not a high priority for NOAA Fisheries (pers.com. B. Ellrott 2011).

Key:

SPFC = State Plan of Flood Control

As opportunities arise to use or leverage other funding that is not constrained to SPFC facilities, DWR should collaborate with others to address non-SPFC barriers. This approach will achieve the most biological benefit since DWR and willing partners will address all fish passage barriers in the Systemwide Planning Area.

Thus, recommended priorities for CVFPP implementation would follow this sequence:

- SPFC-related barriers of Priority 1 Biological Importance
    - Provide an interim passage solution at Fremont Weir (SPFC structure) (in cooperation with DFG and USACE) until a permanent passage solution is constructed
    - Develop and begin implementation (in cooperation with DFG, Reclamation, and USACE) of a Yolo Bypass fish passage plan, including Fremont Weir (SPFC structure) in 2012, as required by the biological opinion for the SWP and CVP (NOAA Fisheries, 2009b & 2011a)
    - Complete installation of a new fish ladder, and evaluate the ladder to confirm it operates to NOAA Fisheries and DFG standards, at Willow Slough Weir (SPFC structure)
    - Secondarily, pursue opportunities to collaborate with other DWR programs, Reclamation and other organizations to provide fish passage at other Priority 1 barriers with longer time frames. DWR should:
        - Complete fish passage modifications at Fremont Weir as part of the comprehensive Yolo Bypass fish passage effort
        - Evaluate the fish passage delay at Sacramento Weir and construct a fish passage solution, if needed
- Non SPFC-related barriers of Priority 1 Biological Importance
    - Pursue opportunities to use new funding to collaborate with others to fix non-SPCF barriers, with an initial focus on those barriers that can be addressed within five years. These include 15 Yolo Bypass barriers, Weir No. 2, Budiselich Dam, Red Bluff Diversion Dam, and Caprini low-flow road crossing.
    - Evaluate, in cooperation with Reclamation, the feasibility of providing fish passage at Shasta, Keswick, Nimbus, Folsom, New

Melones, and Tulloch dams by December 2018. If determined to be feasible, work with Reclamation to construct fish passage facilities at these dams by 2020 (NOAA Fisheries, 2009b)

  – Collaborate with others to evaluate fish passage opportunities at Englebright, La Grange, Camanche, Pardee, New Bullards Bar and Don Pedro dams, as recommended in the Central Valley salmonid recovery plan (NOAA Fisheries, 2009a)

- SPFC-related barriers of Priority 2 Biological Importance
  - Improve fish passage at Tisdale Weir
  - Collaborate with others to evaluate fish passage opportunities at Oroville Dam and its related facilities as recommended in the Central Valley salmonid recovery plan (NOAA Fisheries, 2009a).
- Non-SPFC-related barriers of Priority 2 Biological Importance
  - To achieve the most ecological benefit within the next 10 years or more, DWR, in cooperation with willing partners, should also make significant headway assessing potential non-SPFC barriers and fixing known fish passage barriers throughout the Systemwide Planning Area.

9.2 Improve Fisheries Habitat

In addition to removing fish passage barriers, restoration programs, such as the San Joaquin River Restoration Program, are vital to the restoration and maintenance of fish populations, including Chinook salmon and steelhead. DWR, with the cooperation of both private parties and public agencies, should continue to implement restoration projects to improve fisheries habitat and to ensure adequate in-stream flows to restore fish populations and habitat within the Systemwide Planning Area.

As part of this habitat restoration effort, DWR should take steps to increase the extent, quality, and inundation of floodplain habitats through setback levees, and restoration and enhancement of existing floodplain habitats. Floodplains are critical components of aquatic ecosystems, and access to floodplain habitat increases fish productivity, abundance, and growth.

DWR should work with reservoir operators to provide ecologically sustainable river flows that maintain natural channel and floodplain

characteristics. River-floodplain connectivity and condition is closely tied with reservoir operations and seasonal flows.

9.3 Improve Scientific Understanding of Stranding Effects

Stranding has been identified in 10 locations of the Systemwide Planning Area. Research in the Yolo Bypass indicates that the impact of stranding on juvenile salmon is low, but a perception remains that stranding has an impact on listed anadromous species. As DWR investigates options to increase floodplain inundation, DWR should collaborate with DFG, Reclamation, USFWS, and other agencies to:

- Evaluate the extent and impact of stranding on listed anadromous species, especially green sturgeon, in any floodplain inundation projects. but especially in flood control bypasses.
- Evaluate the extent of stranding in the Stanislaus River gravel pits and other locations.
- See, through outreach, that results from the stranding studies are broadly disseminated to the biological community.

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11.0 Acronyms and Abbreviations

BGS ..... Behavioral Guidance System

cfs ..... cubic feet per second

CVFPP ..... Central Valley Flood Protection Plan

Delta ..... Sacramento-San Joaquin River Delta

DFG ..... California Department of Fish and Game

DPS ..... Distinct Population Segment

DWR ..... California Department of Water Resources

ESU ..... Evolutionarily Significant Unit

FERC ..... Federal Energy Regulatory Commission

Forum ..... The Fish Passage Forum

FSC ..... floating surface collector

GIS ..... Geographic Information System

NOAA Fisheries ..... National Oceanic and Atmospheric Administration's National Marine Fisheries Service

PAD ..... Passage Assessment Database

PGE ..... Portland General Electric

PIT ..... Passive Integrated Transponder

PSE ..... Puget Sound Energy

RBDD ..... Red Bluff Diversion Dam

Reclamation ..... U.S. Department of the Interior, Bureau of Reclamation

RM ..... River Miles

SPFC ..... State Plan of Flood Control

USACE ..... U.S. Army Corps of Engineers

USFWS ..... U.S. Fish and Wildlife Service

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Attachment 9C.1. Methods Used in Geographic Information System Analysis of Known and Potential Fish Passage Barriers in the Systemwide Planning Area

A GIS analysis was undertaken to determine the known and potential fish passage barriers in the Systemwide Planning Area, using existing spatial data sets, obtained from official sources that describe anadromous fish passage barriers and anadromous fish distributions. These data sets were used to determine the number and distribution of known barriers to anadromous fish passage within the Systemwide Planning Area.

The geographic data sets used in this analysis, and their sources (Table 9C.1-1), are:

- Current and historic distributions of anadromous fish (fall-run, spring-run, winter-run Chinook; steelhead; green sturgeon) in the Central Valley watersheds

- Streams in the Central valley watersheds that are currently or historically used by anadromous fish

  - Source: Central Valley Recovery Coordinator, National Marine Fisheries Service, Protected Resources Division

  - Layer is based on (matched to) the cdfg_100k_2003_6 shapefile, a widely used, medium-resolution GIS dataset representing stream hydrology in California, produced by California Department of Fish and Game (metadata link: http://www.calfish.org/Portals/0/DataMaps/DataDownLoad/cdfg_100k_2003_6.htm; last updated 2003)

- Passage Assessment Database (PAD), the most comprehensive available dataset identifying known and potential barriers to anadromous fish passage

  - Source: Calfish: http://www.calfish.org

- September 2010 release

- Components of State Plan of Flood Control (SPFC)
  - Source: California Department of Water Resources (DWR) Division of Flood Management, Central Valley Flood Planning Office

- Systemwide Planning Area
  - Source: DWR Division of Flood Management, Central Valley Flood Planning Office

The first level of analysis focused on barriers on anadromous streams that are listed in the CalFish PAD within the Systemwide Planning Area, and determining which components of the SPFC were fish passage barriers. This was defined in the following steps:

- All historic and current anadromous streams that intersect Systemwide Planning Area were identified, and the segments that actually fell inside the Systemwide Planning Area were cut ('clipped') at the Systemwide Planning Area boundary to identify only reaches within the Systemwide Planning Area.

- All entries in the PAD that occur on anadromous stream reaches within the Systemwide Planning Area were identified
  - PAD points within 300 meters of an anadromous stream reach within the Systemwide Planning Area were included in the analysis
    - The different layers used in the analysis have different degrees of positional accuracy; therefore, a "buffer" is required to select the points that should be located on an anadromous stream
    - A 300-meter buffer was determined by trial and error to be an appropriate, and conservative, distance

- PAD entries that were not relevant to the analysis were excluded on the basis of attributes in the PAD data
  - Diversions not owned by DWR or were not identified as part of the SPFC were excluded
    - Barriers with 'site type' = 'diversion' AND 'structure owner' <> 'DWR', whose names did not indicate they were part of the SPFC

- Nonstructural (i.e., natural) barriers
  - ‘SITETYPE’ = ‘nonstructural’
- Barriers that are in database but are no longer barriers
  - ‘BARSTATUS’ = ‘not a barrier’ OR TRTSTATUS ‘ ‘Completed’

Barrier status within the PAD defines how much of a barrier the structure is for fish. Within the PAD, the barrier status options include total, partial, temporal, and others. Table 9C.1-2 defines the barrier status options. If barrier status of a PAD structure was unknown, DWR designated the structure as a potential barrier needing to be assessed for fish passage status.

Table 9C.1-1. Sources of Geographic Data Used in this Analysis

Population	Time frame	Source
Fall-run Chinook	current	California Central Valley Chinook data taken from Sari Sommarstrom dataset. Sommarstrom dataset originally prepared for defining Central Valley Essential Fish Habitat.
Fall-run Chinook	historic	The lines in this file represent the estimated historical distribution of fall run Chinook salmon in selected rivers/streams in the Central Valley of California. The data used to produce this file were derived from a DFG Contributions to the Biology of Central Valley Salmonids 2001 paper by Yoshiyama et al. entitled "Historical and Present Distribution of Chinook Salmon in the Central Valley Drainage of California.”
Spring-run Chinook	current	The lines in this file represent the estimated present distribution of spring-run Chinook salmon in selected rivers/streams in the Central Valley of California. The data used to produce this file were derived from a DFG Contributions to the Biology of Central Valley Salmonids 2001 paper by Yoshiyama et al. entitled "Historical and Present Distribution of Chinook Salmon in the Central Valley Drainage of California.”
Spring-run Chinook	historic	The lines in this file represent the estimated historical distribution of spring-run Chinook salmon in selected rivers/streams in the Central Valley of California. The data used to produce this file were derived from a DFG Contributions to the Biology of Central Valley Salmonids 2001 paper by Yoshiyama et al. entitled "Historical and Present Distribution of Chinook Salmon in the Central Valley Drainage of California.”
Central Valley Steelhead	current	CCV_Steelhead_Distribution_06_2005' depicts steelhead presence as well as habitat type and quality in the California Central Valley ESU. The data was compiled by the NOAA Fisheries SWR in an effort to designate Critical Habitat for steelhead in California. The linework for this layer is based on the DFG and PSMFC 1:100,000 scale stream-based routed hydrography. SWR biologists divided the routed hydrography into stream segments using the best available information to represent local steelhead distribution and habitat. As a result, each segment has its own unique identifier (GIS_Link) and related presence and habitat information. The data set is in shapefile format and can be included as a map layer in a GIS. This data set is an update of 'CCV_Steelhead_Draft_2004

Table 9C.1-1. Sources of Geographic Data Used in this Analysis (cont.)

Population	Timeframe	Source
Central Valley Steelhead	historic	The lines in this file represent the estimated historical distribution of steelhead in selected rivers/streams in the Central Valley of California. The data used to produce this file were derived from a DFG Contributions to the Biology of Central Valley Salmonids 2001 paper by Yoshiyama et al. entitled "Historical and Present Distribution of Chinook Salmon in the Central Valley Drainage of California."
Winter-run Chinook	current	The lines in this file represent the estimated historical distribution of steelhead in selected rivers/streams in the Central Valley of California. The data used to produce this file were derived from a DFG Contributions to the Biology of Central Valley Salmonids 2001 paper by Yoshiyama et al. entitled "Historical and Present Distribution of Chinook Salmon in the Central Valley Drainage of California."
Winter-run Chinook	historic	The lines in this file represent the estimated historical distribution of steelhead in selected rivers/streams in the Central Valley of California. The data used to produce this file were derived from a DFG Contributions to the Biology of Central Valley Salmonids 2001 paper by Yoshiyama et al. entitled "Historical and Present Distribution of Chinook Salmon in the Central Valley Drainage of California."
Green Sturgeon	current	The data was created by extracting stream lines from NHD medium resolution shapefile that represented Green Sturgeon Critical Habitat. This dataset's features were modified to better match up to the corresponding Estuaries and were cut at locations where the NMFS CHRT determined green sturgeon have been observed or where Head of Tide was determined. The attributes were also scaled down to reduce size of the database.

Key:
CHRT = Critical Habitat Review Team
DFG = California Department of Fish and Game
ESU = Evolutionary Significant Unit
NHD = National Hydrography Dataset
NOAA Fisheries = National Marine Fisheries Service
PSMFC = Pacific States Marine Fisheries Commission
SWR = Southwest Regional Office

Table 9C.1-2. Definitions of Barrier Status from the Passage Assessment Database

Total	A complete barrier to fish passage for all anadromous species at all life stages at all times of year
Partial	Only a barrier to certain species or life stages.
Temporal	Only a barrier at certain times of year.
Temporal and Partial	Only a barrier to certain species or life stages and only at certain times of year.
Temporal and Total	Total barrier only at certain times of year.
Not a Barrier	Structure/site has been determined not to be a barrier to any species or life stages, and is passable year-round.
Structure may not be in existence	Data were obtained from an old dataset, and are likely to have been removed or washed away.
Unknown	Dataset had no information about barrier status.

- Components of the SPFC that are known or potential barriers, but that are not included in the PAD, were identified and added to the barrier dataset
    - Geographic data files describing components of the SPFC were obtained from DWR Division of Flood Management, Central Valley Flood Planning Office
    - SPFC components that were already entered in the PAD were identified, and their barrier status was determined from the PAD entry
    - All SPFC components not in the PAD were added to the dataset
    - Available information and expert knowledge was used to assign barrier status to SPFC components; if no information was available a status of "No information" was assigned

To gather the expert knowledge mentioned above, DWR held two meetings of biologists familiar with fish passage issues in the Central Valley. DWR presented maps showing the barriers identified using the PAD and reports. The biologists updated and added to the barrier information DWR had.

Calculation of Habitat Extent Upstream from Barriers

The length of potential habitat that would opened up by removal of total barriers to fish passage was calculated as a means of quantifying the potential benefit to anadromous fish of its removal. Each barrier entry in the PAD that is identified as a total barrier to fish passage, which is also on an anadromous stream and is within the Systemwide Planning Area, was selected, and the amount of upstream channel it blocks was calculated.

- Total barriers were selected from the set of barriers identified in the previous step
    - Barriers on anadromous streams (within 300 meters) within the Systemwide Planning Area
    - Select only the total barriers (BARSTATUS – 'Total')
- All other total barriers on those streams were selected, regardless of whether the barrier was within the Systemwide Planning Area, which

identified all total barriers upstream from those within the Systemwide Planning Area

- Anadromous streams that had those total barriers were identified, and each steam was 'clipped' at the barrier locations
- Sums of stream segment lengths between each barrier and the watershed headwaters were calculated (in miles) to provide an estimate of the miles of stream that could be accessible to anadromous fish if that barrier was removed.

Ranking of Barriers

All barriers identified in this analysis were ranked on the basis of (1) what, if any, action priority they were assigned in the National Oceanic and Atmospheric Administration (NOAA) Fisheries Central Valley Recovery Plan (NOAA 2009a), (2) whether they were an actual component of the SPFC and (3) what geographic priority they are assigned on the basis of the Central Valley Recovery Plan's ranking of geographic areas (Table 9C.1-3). Results of this ranking are in Attachment 9C.2.

Table 9C.1-3. Geographic Priorities Identified by NOAA Fisheries

Priority	Geographic Region (as defined by NOAA Fisheries (2009) Within the State Plan of Flood Control
1	Delta
2	Lower Sacramento River
3	Middle Sacramento River
4	Upper Sacramento River
5	Northern Sierra Nevada Diversity Group
6	Basalt and Porous Lava Diversity Group
7	Northwestern California Diversity Group
8	Southern Sierra Diversity Group

Source: 2009a
Key:
NOAA = National Oceanic and Atmospheric Administration

Attachment 9C.2. Prioritized Known and Potential Fish Passage Barriers and DWR-Owned Diversions in the Systemwide Planning Area

Table 9C.2-1. Prioritized Known and Potential Fish Passage Barriers and DWR Owned Diversions in the Systemwide Planning Area

Rank	Stream	Site	County	Type	Status	CVRP Priority	SPFC Component	CVRP Geographic Priority	PAD ID
1	East Borrow Canal	Willow Slough Weir[1]	Sutter	Dam	Temporal	1	X	2 - Lower Sacramento River	737025
1	Sacramento River	Fremont Weir[2]	Yolo	Dam	Temporal	1	X	2 - Lower Sacramento River	704343
1	Sacramento River	Sacramento Weir	Yolo	Dam	Needs assessment	1	X	2 - Lower Sacramento River	700222
2	Old River	State Water Project-Clifton Court	Contra Costa	Diversion	Screened	1		1 - Delta	700212
2	S.F. Putah Creek	DFG (Yolo)	Yolo	Road crossing	Needs assessment	1		1 - Delta	704788
2	S.F. Putah Creek	DFG (Yolo)	Yolo	Road crossing	Needs assessment	1		1 - Delta	704789
2	S.F. Putah Creek	Weir	Yolo	Dam	Needs assessment	1		1 - Delta	704775
2	S.F. Putah Creek Side Chan	DFG (Yolo)	Yolo	Road crossing	Needs assessment	1		1 - Delta	704794
2	S.F. Putah Creek Side Chan	DFG (Yolo)	Yolo	Road crossing	Needs assessment	1		1 - Delta	704795
2	Toe Drain	Culvert	Yolo	Road crossing	Needs assessment	1		1 - Delta	704451
2	Toe Drain	Culvert	Yolo	Road crossing	Needs assessment	1		1 - Delta	704448

Table 9C.2-1. Prioritized Known and Potential Fish Passage Barriers and DWR-Owned Diversions in the Systemwide Planning Area (contd.)

Rank	Stream	Site	County	Type	Status	CVRP Priority	SPFC Component	CVRP Geographic Priority	PAD ID
2	Toe Drain	Culvert	Yolo	Road crossing	Needs assessment	1		1 - Delta	704338
2	Toe Drain	Culvert	Yolo	Road crossing	Needs assessment	1		1 - Delta	704452
2	Toe Drain	Culvert	Yolo	Road crossing	Needs assessment	1		1 - Delta	704342
2	Toe Drain	Culvert/Flashboard	Yolo	Road crossing	Needs assessment	1		1 - Delta	704449
2	Toe Drain	Culvert/Flashboard	Yolo	Road crossing	Needs assessment	1		1 - Delta	704450
2	Toe Drain	Lisbon Weir[3]	Yolo	Dam	Partial	1		1 - Delta	
2	Tule Canal	Culvert	Yolo		Temporal	1		1 - Delta	
2	Tule Canal	Wallace Weir	Yolo	Dam	Temporal	1		1 - Delta	
3	East Borrow Canal	Weir No. 2[4]	Sutter	Dam	Partial	1		2 - Lower Sacramento River	703964
4	Sacramento River	Keswick Dam	Shasta	Dam	Total	1		4 - Upper Sacramento River	718711
4	Sacramento River	Red Bluff Diversion Dam	Tehama	Dam	Partial	1		4 - Upper Sacramento River	718713

Table 9C.2-1. Prioritized Known and Potential Fish Passage Barriers and DWR-Owned Diversions in the Systemwide Planning Area (contd.)

Rank	Stream	Site	County	Type	Status	CVRP Priority	SPFC Component	CVRP Geographic Priority	PAD ID
4	Sacramento River	Shasta Dam	Shasta	Dam	Total	1		4 - Upper Sacramento River	718710
5	American River	Folsom Dam	Sacramento	Dam	Total	1		5 - Northern Sierra Nevada Diversity Group	718795
5	Mokelumne River	Camanche Main Dam	San Joaquin	Dam	Total	1		5 - Northern Sierra Nevada Diversity Group	718812
5	Mokelumne River	Pardee Dam	Calaveras	Dam	Total	1		5 - Northern Sierra Nevada Diversity Group	718827
5	North Yuba River	New Bullards Bar Dam	Yuba	Dam	Total	1		5 - Northern Sierra Nevada Diversity Group	718761
5	Yuba River	Harry L. Englebright Dam	Nevada	Dam	Total	1		5 - Northern Sierra Nevada Diversity Group	718765
6	Calaveras River	Calaveras Headworks	San Joaquin	Dam	Total	1		8 - Southern Sierra Diversity Group	735098
6	Calaveras River	Cherryland Flashboard Dam	San Joaquin	Dam	Temporal	1		8 - Southern Sierra Diversity Group	735090
6	Calaveras River	Dam	Calaveras	Dam	Partial	1		8 - Southern Sierra Diversity Group	704310
6	Calaveras River	Deteriorated Low-Flow Road Crossing	San Joaquin	Road crossing	Temporal	1		8 - Southern Sierra Diversity Group	735104
6	Calaveras River	Eight Mile Flashboard Dam	San Joaquin	Dam	Temporal	1		8 - Southern Sierra Diversity Group	735094

Table 9C.2-1. Prioritized Known and Potential Fish Passage Barriers and DWR-Owned Diversions in the Systemwide Planning Area (contd.)

Rank	Stream	Site	County	Type	Status	CVRP Priority	SPFC Component	CVRP Geographic Priority	PAD ID
6	Calaveras River	Gotelli #1 Flashboard Dam	San Joaquin	Dam	Temporal	1		8 - Southern Sierra Diversity Group	735097
6	Calaveras River	Gotelli Low-Flow Road Crossing (River Mile 35.3)	San Joaquin	Road crossing	Temporal	1		8 - Southern Sierra Diversity Group	735105
6	Calaveras River	Gotelli Low-Flow Road Crossing (River Mile 6.2)	San Joaquin	Road crossing	Temporal	1		8 - Southern Sierra Diversity Group	735088
6	Calaveras River	Gravel Pit Pond	San Joaquin	Dam	Temporal	1		8 - Southern Sierra Diversity Group	735100
6	Calaveras River	McAllen Flashboard Dam	San Joaquin	Dam	Temporal	1		8 - Southern Sierra Diversity Group	735089
6	Calaveras River	McGurk Earth Dam	San Joaquin	Dam	Temporal & Partial	1		8 - Southern Sierra Diversity Group	737024
6	Calaveras River	McGurk Low-Flow Road Crossing	San Joaquin	Road crossing	Partial	1		8 - Southern Sierra Diversity Group	735099
6	Calaveras River	Murphy Flashboard Dam	San Joaquin	Dam	Temporal	1		8 - Southern Sierra Diversity Group	735093
6	Calaveras River	New Hogan Dam Road Bridge	Calaveras	Dam	Partial	1		8 - Southern Sierra Diversity Group	704323
6	Calaveras River	Old Dog Ranch Low-Flow Road Crossing	San Joaquin	Road crossing	Temporal	1		8 - Southern Sierra Diversity Group	735102
6	Calaveras River	Old DWR Stream Gauge Weir	San Joaquin	Flow measurement weir	Temporal	1		8 - Southern Sierra Diversity Group	737023

Table 9C.2-1. Prioritized Known and Potential Fish Passage Barriers and DWR-Owned Diversions in the Systemwide Planning Area (contd.)

Rank	Stream	Site	County	Type	Status	CVRP Priority	SPFC Component	CVRP Geographic Priority	PAD ID
6	Calaveras River	Old Wooden Bridge	San Joaquin	Road crossing	Temporal	1		8 - Southern Sierra Diversity Group	735087
6	Calaveras River	Pezzi Flashboard Dam	San Joaquin	Dam	Temporal	1		8 - Southern Sierra Diversity Group	735092
6	Calaveras River	Rubble Dam Upstream from Bellota Weir	Stanislaus	Dam	Temporal	1		8 - Southern Sierra Diversity Group	704320
6	Calaveras River	Solari Ranch Flashboard Dam	San Joaquin	Dam	Temporal	1		8 - Southern Sierra Diversity Group	735091
6	Calaveras River	Tully Flashboard Dam	San Joaquin	Dam	Temporal	1		8 - Southern Sierra Diversity Group	735095
6	Calaveras River	Williams Crossing	San Joaquin	Road crossing	Needs assessment	1		8 - Southern Sierra Diversity Group	735103
6	Calaveras River	Wilson's Low-Flow Road Crossing	San Joaquin	Road crossing	Temporal	1		8 - Southern Sierra Diversity Group	735101
6	Mormon Slough	Avansino Street Flashboard Dam	San Joaquin	Dam	Temporal	1		8 - Southern Sierra Diversity Group	735121
6	Mormon Slough	Bellota Weir	San Joaquin	Dam	Partial	1		8 - Southern Sierra Diversity Group	703864
6	Mormon Slough	Bonomo Flashboard Dam	San Joaquin	Dam	Temporal	1		8 - Southern Sierra Diversity Group	735118
6	Mormon Slough	Caprini Low-Flow Road Crossing	San Joaquin	Road crossing	Temporal	1		8 - Southern Sierra Diversity Group	735110

Table 9C.2-1. Prioritized Known and Potential Fish Passage Barriers and DWR-Owned Diversions in the Systemwide Planning Area (contd.)

Rank	Stream	Site	County	Type	Status	CVRP Priority	SPFC Component	CVRP Geographic Priority	PAD ID
6	Mormon Slough	Fine Road Flashboard Dam	San Joaquin	Dam	Temporal	1		8 - Southern Sierra Diversity Group	735122
6	Mormon Slough	Fujinaka Low-Flow Road Crossing	San Joaquin	Road crossing	Temporal	1		8 - Southern Sierra Diversity Group	735114
6	Mormon Slough	Highway 26 Flashboard Dam	San Joaquin	Dam	Temporal	1		8 - Southern Sierra Diversity Group	735123
6	Mormon Slough	Hosie Flashboard Dam	San Joaquin	Dam	Temporal	1		8 - Southern Sierra Diversity Group	735120
6	Mormon Slough	Hosie Low-Flow Road Crossing	San Joaquin	Road crossing	Temporal	1		8 - Southern Sierra Diversity Group	735119
6	Mormon Slough	Lavaggi Flashboard Dam	San Joaquin	Dam	Temporal	1		8 - Southern Sierra Diversity Group	735111
6	Mormon Slough	Main Street Flashboard Dam	San Joaquin	Dam	Temporal	1		8 - Southern Sierra Diversity Group	735108
6	Mormon Slough	Panella Flashboard Dam	San Joaquin	Dam	Temporal	1		8 - Southern Sierra Diversity Group	735109
6	Mormon Slough	Piazza Flashboard Dam	San Joaquin	Dam	Temporal	1		8 - Southern Sierra Diversity Group	735117
6	Mormon Slough	Prato Flashboard Dam	San Joaquin	Dam	Temporal	1		8 - Southern Sierra Diversity Group	735115
6	Mosher Slough	Webster Dam	San Joaquin	Dam	Partial	1		8 - Southern Sierra Diversity Group	704472

Table 9C.2-1. Prioritized Known and Potential Fish Passage Barriers and DWR-Owned Diversions in the Systemwide Planning Area (contd.)

Rank	Stream	Site	County	Type	Status	CVRP Priority	SPFC Component	CVRP Geographic Priority	PAD ID
6	San Joaquin River	Sack Dam	Fresno	Dam	Partial	1		8 - Southern Sierra Diversity Group	704635
6	Stanislaus River	Goodwin Dam	Calaveras	Dam	Total	1		8 - Southern Sierra Diversity Group	718977
6	Stanislaus River	New Melones Dam	Tuolumne	Dam	Total	1		8 - Southern Sierra Diversity Group	718821
6	Stanislaus River	Tulloch Dam	Tuolumne	Dam	Total	1		8 - Southern Sierra Diversity Group	718976
6	Stockton Diversion Canal	Central Traction Railroad crossing	San Joaquin	Bridge	Partial	1		8 - Southern Sierra Diversity Group	
6	Stockton Diverting Canal	Budiselich Dam	San Joaquin	Dam	Temporal	1		8 - Southern Sierra Diversity Group	735107
6	Tuolumne River	Don Pedro Main Dam	Tuolumne	Dam	Total	1		8 - Southern Sierra Diversity Group	718978
6	Tuolumne River	La Grange Dam	Stanislaus	Dam	Total	1		8 - Southern Sierra Diversity Group	718979
7	Sacramento River	Tisdale Weir	Sutter	Dam	Temporal	2	X	2 - Lower Sacramento River	720308
8	Feather River	Fish Barrier Dam	Butte	Dam	Total	2	X	5 - Northern Sierra Nevada Diversity Group	718748

Table 9C.2-1. Prioritized Known and Potential Fish Passage Barriers and DWR-Owned Diversions in the Systemwide Planning Area (contd.)

Rank	Stream	Site	County	Type	Status	CVRP Priority	SPFC Component	CVRP Geographic Priority	PAD ID
8	Feather River	Oroville Dam	Butte	Dam	Total	2	X	5 - Northern Sierra Nevada Diversity Group	718746
8	Feather River	Thermalito Diversion Dam	Butte	Dam	Total	2	X	5 - Northern Sierra Nevada Diversity Group	718747
8	Unnamed Tributary	Thermalito Afterbay	Butte	Dam	Total	2	X	5 - Northern Sierra Nevada Diversity Group	719986
9	San Joaquin River	Twitchell Island	Sacramento	Diversion	Unscreened	2		1 - Delta	700810
9	San Joaquin River	Twitchell Island	Sacramento	Diversion	Unscreened	2		1 - Delta	700807
9	San Joaquin River	Twitchell Island	Sacramento	Diversion	Unscreened	2		1 - Delta	700811
9	San Joaquin River	Twitchell Island	Sacramento	Diversion	Unscreened	2		1 - Delta	700808
9	San Joaquin River	Twitchell Island	Sacramento	Diversion	Unscreened	2		1 - Delta	700809
9	San Joaquin River	Twitchell Island	Sacramento	Diversion	Unscreened	2		1 - Delta	700814
9	San Joaquin River	Twitchell Island	Sacramento	Diversion	Unscreened	2		1 - Delta	700813
9	Sevenmile Slough	Twitchell Island	Sacramento	Diversion	Unscreened	2		1 - Delta	700804
9	Sevenmile Slough	Twitchell Island	Sacramento	Diversion	Unscreened	2		1 - Delta	700801

Table 9C.2-1. Prioritized Known and Potential Fish Passage Barriers and DWR-Owned Diversions in the Systemwide Planning Area (contd.)

Rank	Stream	Site	County	Type	Status	CVRP Priority	SPFC Component	CVRP Geographic Priority	PAD ID
9	Sevenmile Slough	Twitchell Island	Sacramento	Diversion	Unscreened	2		1 - Delta	700796
9	Sevenmile Slough	Twitchell Island	Sacramento	Diversion	Unscreened	2		1 - Delta	700797
9	Sevenmile Slough	Twitchell Island	Sacramento	Diversion	Unscreened	2		1 - Delta	700799
9	Sevenmile Slough	Twitchell Island	Sacramento	Diversion	Unscreened	2		1 - Delta	700805
9	Sevenmile Slough	Twitchell Island	Sacramento	Diversion	Unscreened	2		1 - Delta	700798
9	Sevenmile Slough	Twitchell Island	Sacramento	Diversion	Unscreened	2		1 - Delta	700795
9	Sevenmile Slough	Twitchell Island	Sacramento	Diversion	Unscreened	2		1 - Delta	700794
9	Sevenmile Slough	Twitchell Island	Sacramento	Diversion	Unscreened	2		1 - Delta	700792
9	Sevenmile Slough	Twitchell Island	Sacramento	Diversion	Unscreened	2		1 - Delta	700793
9	Sevenmile Slough	Twitchell Island	Sacramento	Diversion	Unscreened	2		1 - Delta	700800
9	Threemile Slough	Twitchell Island	Sacramento	Diversion	Unscreened	2		1 - Delta	700803
9	Threemile Slough	Twitchell Island	Sacramento	Diversion	Unscreened	2		1 - Delta	700806
10	Dry Creek	Culvert	Sacramento	Road crossing	Needs assessment	2		2 - Lower Sacramento River	717226

Table 9C.2-1. Prioritized Known and Potential Fish Passage Barriers and DWR-Owned Diversions in the Systemwide Planning Area (contd.)

Rank	Stream	Site	County	Type	Status	CVRP Priority	SPFC Component	CVRP Geographic Priority	PAD ID
11	Big Chico Creek	One Mile Dam With Pool Fish Ladder	Butte	Dam	Temporal	2		5 - Northern Sierra Nevada Diversity Group	704198
11	Yuba River	Daguerre Point Dam	Yuba	Dam	Partial	2		5 - Northern Sierra Nevada Diversity Group	720147
12	Stony Creek	Black Butte Dam	Tehama	Dam	Total	2		7 - Northwestern California Diversity Group	718715
13	Calaveras River	New Hogan Dam[5]	Calaveras	Dam	Total	2		8 - Southern Sierra Diversity Group	718828
13	Merced River	Crocker Diversion Dam (Snelling)	Merced	Dam	Temporal	2		8 - Southern Sierra Diversity Group	718981
13	Merced River	Exchequer Main Dam	Mariposa	Dam	Total	2		8 - Southern Sierra Diversity Group	718975
13	Merced River	McSwain Dam	Mariposa	Dam	Total	2		8 - Southern Sierra Diversity Group	718983
13	San Joaquin River	Friant Dam	Fresno	Dam	Total	2		8 - Southern Sierra Diversity Group	718954
13	San Joaquin River	Mendota Pool Dam And Diversion	Madera	Dam	Partial	2		8 - Southern Sierra Diversity Group	718840
14	Colusa Basin Drain	Knights Landing Ridge Cut Outfall Gates	Yolo	Diversion	Unscreened		X	2 - Lower Sacramento River	
14	Sacramento River	Colusa Weir	Colusa	Dam	Needs assessment		X	2 - Lower Sacramento River	720139

Table 9C.2-1. Prioritized Known and Potential Fish Passage Barriers and DWR-Owned Diversions in the Systemwide Planning Area (contd.)

Rank	Stream	Site	County	Type	Status	CVRP Priority	SPFC Component	CVRP Geographic Priority	PAD ID
15	Big Chico Creek	Big Chico Flood Control	Butte	Dam	Partial		X	5 - Northern Sierra Nevada Diversity Group	704194
15	Feather River, N Fork	Chester Diversion Dam	Plumas	Dam	Partial		X	5 - Northern Sierra Nevada Diversity Group	718744
16	San Joaquin River	Sand Slough Control Structure	Merced	Dam	Partial		X	8 - Southern Sierra Diversity Group	704663
17	Cache Creek	Cache Creek Settling Basin	Yolo	Dam	Total		X	--	719846
18	Barker Slough	North Bay Aqueduct Pumping Plant	Solano	Diversion	Screened			1 - Delta	702946
18	Cache Slough	Culvert	Solano	Road crossing	Needs assessment			1 - Delta	702936
18	Grizzly Slough	Culvert	Sacramento	Road crossing	Needs assessment			1 - Delta	703342
18	Grizzly Slough	Siphon	Sacramento	Diversion	Unscreened			1 - Delta	703381
18	Italian Slough	Clifton Court	Contra Costa	Diversion	Unscreened			1 - Delta	702313
18	Italian Slough	DWR	Contra Costa	Diversion	Unscreened			1 - Delta	702289
18	Italian Slough	DWR	Contra Costa	Diversion	Unscreened			1 - Delta	702290
18	Italian Slough	DWR	Contra Costa	Diversion	Unscreened			1 - Delta	702291

Table 9C.2-1. Prioritized Known and Potential Fish Passage Barriers and DWR-Owned Diversions in the Systemwide Planning Area (contd.)

Rank	Stream	Site	County	Type	Status	CVRP Priority	SPFC Component	CVRP Geographic Priority	PAD ID
18	Lindsey Slough	Harry Petersen	Solano	Road crossing	Needs assessment			1 - Delta	702950
18	Marsh Creek	Private Ford	Contra Costa	Road crossing	Needs assessment			1 - Delta	713452
18	Middle River	Temporary Rock Barrier – Middle River	San Joaquin	Dam	Temporal			1 - Delta	712740
18	Old River	Coney Island	San Joaquin	Road crossing	Needs assessment			1 - Delta	702115
18	Old River	Head Of Old River Barrier	San Joaquin	Dam	Temporal			1 - Delta	712739
18	Old River	Temporary Rock Barrier – Old River At Tracy	San Joaquin	Dam	Temporal			1 - Delta	712741
18	Paradise Cut	Paradise Dam	San Joaquin	Dam	Needs assessment			1 - Delta	720251
18	Sacramento River	DWR Pump Stand (Hood)	Sacramento	Diversion	Unscreened			1 - Delta	700389
18	Sacramento River	DWR Test Facility Intake Pipe (Hood)	Sacramento	Diversion	Unscreened			1 - Delta	700390
18	Ulatis Creek	Maine Prairie Water District	Solano	Dam	Temporal			1 - Delta	703002
18	Unnamed Tributary	Clifton Court Forebay	Contra Costa	Dam	Needs assessment			1 - Delta	719749
18	Unnamed Tributary	Maine Prairie [3]	Solano	Dam	Needs assessment			1 - Delta	719341

Table 9C.2-1. Prioritized Known and Potential Fish Passage Barriers and DWR-Owned Diversions in the Systemwide Planning Area (contd.)

Rank	Stream	Site	County	Type	Status	CVRP Priority	SPFC Component	CVRP Geographic Priority	PAD ID
19	Cross-Canal	Coppin Dam	Sutter	Dam	Temporal			2 - Lower Sacramento River	704926
19	East Borrow Canal	Culvert/Flashboard	Sutter	Road crossing	Needs assessment			2 - Lower Sacramento River	703978
19	East Borrow Canal	Culvert/Flashboard	Sutter	Road crossing	Needs assessment			2 - Lower Sacramento River	703976
19	East Borrow Canal	Culvert/Flashboard	Sutter	Road crossing	Needs assessment			2 - Lower Sacramento River	703975
19	East Borrow Canal	Culvert/Flashboard	Sutter	Road crossing	Needs assessment			2 - Lower Sacramento River	703977
19	East Borrow Canal	DWR #3 Old	Sutter	Diversion	Unscreened			2 - Lower Sacramento River	704176
19	East Borrow Canal	DWR #3 Old	Sutter	Diversion	Unscreened			2 - Lower Sacramento River	704177
19	East Borrow Canal	DWR Pumping Station #1 New	Sutter	Diversion	Unscreened			2 - Lower Sacramento River	704187
19	East Borrow Canal	DWR Pumping Station #2 New	Sutter	Diversion	Unscreened			2 - Lower Sacramento River	704179
19	East Borrow Canal	DWR Pumping Station #2 New	Sutter	Diversion	Unscreened			2 - Lower Sacramento River	704180
19	East Borrow Canal	DWR Pumping Station #2 New	Sutter	Diversion	Unscreened			2 - Lower Sacramento River	704183

Table 9C.2-1. Prioritized Known and Potential Fish Passage Barriers and DWR-Owned Diversions in the Systemwide Planning Area (contd.)

Rank	Stream	Site	County	Type	Status	CVRP Priority	SPFC Component	CVRP Geographic Priority	PAD ID
19	East Borrow Canal	DWR Pumping Station #2 New	Sutter	Diversion	Unscreened			2 - Lower Sacramento River	704178
19	East Borrow Canal	DWR Pumping Station #3 New	Sutter	Diversion	Unscreened			2 - Lower Sacramento River	704173
19	East Borrow Canal	DWR Pumping Station #3 New	Sutter	Diversion	Unscreened			2 - Lower Sacramento River	704174
19	East Borrow Canal	DWR Pumping Station #3 New	Sutter	Diversion	Unscreened			2 - Lower Sacramento River	704175
19	East Borrow Canal	DWR Pumping Station #3 New	Sutter	Diversion	Unscreened			2 - Lower Sacramento River	704172
19	East Borrow Canal	DWR Station #1 Old	Sutter	Diversion	Unscreened			2 - Lower Sacramento River	704186
19	East Borrow Canal	DWR Station #1 Old	Sutter	Diversion	Unscreened			2 - Lower Sacramento River	704185
19	East Borrow Canal	DWR Station #2 Old	Sutter	Diversion	Unscreened			2 - Lower Sacramento River	704184
19	Sacramento River	Elkhorn Weir (Historical)	Yolo	Dam	Structure may not be in existence			2 - Lower Sacramento River	720163
19	Sacramento River	Sac 80 HOV California Department of Transportation Fish Passage Project	Sacramento	Road crossing	Needs assessment			2 - Lower Sacramento River	735370

Table 9C.2-1. Prioritized Known and Potential Fish Passage Barriers and DWR-Owned Diversions in the Systemwide Planning Area (contd.)

Rank	Stream	Site	County	Type	Status	CVRP Priority	SPFC Component	CVRP Geographic Priority	PAD ID
19	West Borrow Canal	Butte Slough Irrigation Co., Weir 5	Sutter	Dam	Needs assessment			2 - Lower Sacramento River	703954
19	West Borrow Canal	Frank Guisti, Weir	Sutter	Road crossing	Needs assessment			2 - Lower Sacramento River	703956
19	West Borrow Canal	Frank Guisti, Weir	Sutter	Road crossing	Needs assessment			2 - Lower Sacramento River	703957
19	West Borrow Canal	Weir 1	Sutter	Dam	Needs assessment			2 - Lower Sacramento River	703959
20	Craig Creek	Hwy 99 Fish Passage Project	Tehama	Road crossing	Needs assessment			3 - Middle Sacramento River	737012
20	Stony Creek	Culvert	Glenn	Road crossing	Needs assessment			3 - Middle Sacramento River	717652
21	Sacramento River	Anderson Cottonwood Dam (ACID)	Shasta	Dam	Partial			4 - Upper Sacramento River	718712
21	Sacramento River	Middle Stake Fish Weir (Historical)	Shasta	Dam	Structure may not be in existence			4 - Upper Sacramento River	720231
22	American River	Folsom Left Wing	Sacramento	Dam	Needs assessment			5 - Northern Sierra Nevada Diversity Group	719927
22	American River	Folsom Prison	Sacramento	Dam	Needs assessment			5 - Northern Sierra Nevada Diversity Group	716173
22	American River	Nimbus Dam	Sacramento	Dam	Total			5 - Northern Sierra Nevada Diversity Group	718794

Table 9C.2-1. Prioritized Known and Potential Fish Passage Barriers and DWR-Owned Diversions in the Systemwide Planning Area (contd.)

Rank	Stream	Site	County	Type	Status	CVRP Priority	SPFC Component	CVRP Geographic Priority	PAD ID
22	Butte Creek	Driver Cut Weir	Sutter	Dam	Partial			5 - Northern Sierra Nevada Diversity Group	703757
22	Butte Creek	RD 833	Sutter	Dam	Partial			5 - Northern Sierra Nevada Diversity Group	703756
22	Feather River	Fthrrv_D1_38.485_09	Sutter	Dam	Temporal			5 - Northern Sierra Nevada Diversity Group	717632
22	Mallard Slough	White Mallard Duck Club	Colusa	Road crossing	Needs assessment			5 - Northern Sierra Nevada Diversity Group	703776
22	Mallard Slough	White Mallard Duck Club	Colusa	Road crossing	Needs assessment			5 - Northern Sierra Nevada Diversity Group	703778
22	Natomas East Main Drainage Canal	Pumping Plant	Sacramento		Needs assessment			5 - Northern Sierra Nevada Diversity Group	
22	North Fork American River	Diversion	Placer	Dam	Needs assessment			5 - Northern Sierra Nevada Diversity Group	716129
22	North Fork Feather River	Big Bend Dam	Butte	Dam	Temporal			5 - Northern Sierra Nevada Diversity Group	715750
22	North Yuba River	Colgate Head	Yuba	Dam	Needs assessment			5 - Northern Sierra Nevada Diversity Group	716398
22	South Fork American River	Natomas Diversion	El Dorado	Dam	Needs assessment			5 - Northern Sierra Nevada Diversity Group	715794
22	South Fork Feather River	Ponderosa Dam	Butte	Dam	Total			5 - Northern Sierra Nevada Diversity Group	737345

Table 9C.2-1. Prioritized Known and Potential Fish Passage Barriers and DWR-Owned Diversions in the Systemwide Planning Area (contd.)

Rank	Stream	Site	County	Type	Status	CVRP Priority	SPFC Component	CVRP Geographic Priority	PAD ID
23	Stony Creek	Dam	Glenn	Dam	Needs assessment			7 - Northwestern California Diversity Group	717644
23	Stony Creek	Dam	Tehama	Dam	Needs assessment			7 - Northwestern California Diversity Group	717641
23	Stony Creek	Stony Creek Gravel Dam	Glenn	Dam	Needs assessment			7 - Northwestern California Diversity Group	718714
23	Stony Creek	Tehama-Colusa Irrigation	Glenn	Road crossing	Needs assessment			7 - Northwestern California Diversity Group	717650
23	Stony Creek	Tehama-Colusa Irrigation	Glenn	Road crossing	Needs assessment			7 - Northwestern California Diversity Group	717648
24	Merced River	Ingalsbe Slough Dam	Merced	Dam	Needs assessment			8 - Southern Sierra Diversity Group	737067
24	Merced River	Merced Falls Dam	Merced	Dam	Needs assessment			8 - Southern Sierra Diversity Group	718982
24	Merced River	Mrcdrv_D1_47.189_09	Merced	Flood control channel	Needs assessment			8 - Southern Sierra Diversity Group	737068
24	Mokelumne River	Woodbridge Diversion Dam	San Joaquin	Dam	Partial			8 - Southern Sierra Diversity Group	718813
24	Mosher Slough	Bear Creek Diversion Dam	San Joaquin	Dam	Partial			8 - Southern Sierra Diversity Group	704500

Table 9C.2-1. Prioritized Known and Potential Fish Passage Barriers and DWR-Owned Diversions in the Systemwide Planning Area (contd.)

Rank	Stream	Site	County	Type	Status	CVRP Priority	SPFC Component	CVRP Geographic Priority	PAD ID
24	Mosher Slough	Lyon Dam	San Joaquin	Dam	Partial			8 - Southern Sierra Diversity Group	704495
24	San Joaquin River	Culvert	Fresno	Road crossing	Needs assessment			8 - Southern Sierra Diversity Group	704525
24	San Joaquin River	Culvert	Fresno	Road crossing	Needs assessment			8 - Southern Sierra Diversity Group	704549
24	San Joaquin River	Culvert	Fresno	Road crossing	Needs assessment			8 - Southern Sierra Diversity Group	704665
24	San Joaquin River	Culvert	Fresno	Road crossing	Needs assessment			8 - Southern Sierra Diversity Group	704546
24	San Joaquin River	Culvert	Fresno	Road crossing	Needs assessment			8 - Southern Sierra Diversity Group	704534
24	San Joaquin River	Culvert	Fresno	Road crossing	Needs assessment			8 - Southern Sierra Diversity Group	704527
24	San Joaquin River	Culvert	Fresno	Road crossing	Needs assessment			8 - Southern Sierra Diversity Group	704526
24	San Joaquin River	Culvert	Fresno	Road crossing	Needs assessment			8 - Southern Sierra Diversity Group	704550
24	San Joaquin River	Culvert	Fresno	Road crossing	Needs assessment			8 - Southern Sierra Diversity Group	704533
24	San Joaquin River	Culvert	Madera	Road crossing	Needs assessment			8 - Southern Sierra Diversity Group	704606
24	San Joaquin River	Culvert	Madera	Road crossing	Needs assessment			8 - Southern Sierra Diversity Group	704641

Table 9C.2-1. Prioritized Known and Potential Fish Passage Barriers and DWR-Owned Diversions in the Systemwide Planning Area (contd.)

Rank	Stream	Site	County	Type	Status	CVRP Priority	SPFC Component	CVRP Geographic Priority	PAD ID
24	San Joaquin River	Culvert	Madera	Road crossing	Needs assessment			8 - Southern Sierra Diversity Group	704605
24	San Joaquin River	Culvert	Merced	Road crossing	Needs assessment			8 - Southern Sierra Diversity Group	704677
24	San Joaquin River	Culvert	Madera	Road crossing	Needs assessment			8 - Southern Sierra Diversity Group	704606
24	San Joaquin River	Culvert	Merced	Road crossing	Needs assessment			8 - Southern Sierra Diversity Group	704687
24	San Joaquin River	Culvert	Madera	Road crossing	Needs assessment			8 - Southern Sierra Diversity Group	704585
24	San Joaquin River	Culvert	Fresno	Road crossing	Needs assessment			8 - Southern Sierra Diversity Group	704665
24	San Joaquin River	Culvert	Fresno	Road crossing	Needs assessment			8 - Southern Sierra Diversity Group	704548
24	San Joaquin River	Culvert	Fresno	Road crossing	Needs assessment			8 - Southern Sierra Diversity Group	704548
24	San Joaquin River	Culvert	Fresno	Road crossing	Needs assessment			8 - Southern Sierra Diversity Group	704666
24	San Joaquin River	Culvert	Fresno	Road crossing	Needs assessment			8 - Southern Sierra Diversity Group	704666
24	San Joaquin River	Culvert	Fresno	Road crossing	Needs assessment			8 - Southern Sierra Diversity Group	704550
24	San Joaquin River	Culvert	Fresno	Road crossing	Needs assessment			8 - Southern Sierra Diversity Group	704549

Table 9C.2-1. Prioritized Known and Potential Fish Passage Barriers and DWR-Owned Diversions in the Systemwide Planning Area (contd.)

Rank	Stream	Site	County	Type	Status	CVRP Priority	SPFC Component	CVRP Geographic Priority	PAD ID
24	San Joaquin River	Culvert	Fresno	Road crossing	Needs assessment			8 - Southern Sierra Diversity Group	704534
24	San Joaquin River	Culvert	Fresno	Road crossing	Needs assessment			8 - Southern Sierra Diversity Group	704527
24	San Joaquin River	Culvert	Fresno	Road crossing	Needs assessment			8 - Southern Sierra Diversity Group	704525
24	San Joaquin River	Culvert	Fresno	Road crossing	Needs assessment			8 - Southern Sierra Diversity Group	704526
24	San Joaquin River	Culvert	Fresno	Road crossing	Needs assessment			8 - Southern Sierra Diversity Group	704546
24	San Joaquin River	Culvert	Madera	Road crossing	Needs assessment			8 - Southern Sierra Diversity Group	704585
24	San Joaquin River	Culvert	Madera	Road crossing	Needs assessment			8 - Southern Sierra Diversity Group	704605
24	San Joaquin River	Culvert	Madera	Road crossing	Needs assessment			8 - Southern Sierra Diversity Group	704641
24	San Joaquin River	Culvert	Fresno	Road crossing	Needs assessment			8 - Southern Sierra Diversity Group	704533
24	San Joaquin River	Helm Canal	Fresno	Dam	Needs assessment			8 - Southern Sierra Diversity Group	704667
24	San Joaquin River	Patterson	Stanislaus	Dam	Needs assessment			8 - Southern Sierra Diversity Group	716338
24	San Joaquin River	Stevenson Weir	Merced	Dam	Needs assessment			8 - Southern Sierra Diversity Group	715956

Table 9C.2-1. Prioritized Known and Potential Fish Passage Barriers and DWR-Owned Diversions in the Systemwide Planning Area (contd.)

Rank	Stream	Site	County	Type	Status	CVRP Priority	SPFC Component	CVRP Geographic Priority	PAD ID
24	Stanislaus River	Stnsrv_D1_5.719_09	San Joaquin	Flood control channel	Needs assessment			8 - Southern Sierra Diversity Group	737171
24	Tuolumne River	Dennett Dam	Stanislaus	Dam	Partial			8 - Southern Sierra Diversity Group	
24	Unnamed Tributary	Davis No 2	San Joaquin	Dam	Needs assessment			8 - Southern Sierra Diversity Group	719242
25	Cache Creek	Capay Dam	Yolo	Dam	Needs assessment			--	720131
25	Cache Creek	Clear Lake	Lake	Dam	Needs assessment			--	720062
25	Cache Creek	Clear Lake Imp Dam	Lake	Dam	Needs assessment			--	718900
25	Cache Creek	Moore Dam	Yolo	Dam	Needs assessment			--	720237
25	Cache Creek	Rayhouse Road Crossing	Yolo	Road crossing	Needs assessment			--	717208
25	Cache Creek	Yolo Co. Flood Control	Yolo	Dam	Partial			--	717186

Notes:
[1] A new fish ladder was installed at Willow Slough Weir in 2010. As long as the ladder evaluation confirms that it meets NOAA Fisheries and DFG fish passage criteria, this structure will no longer be a barrier.
[2] Fremont Weir is on the short-term and moderate-term lists. Interim passage could be provided within 1 year. Permanent fish passage may take longer than 5 years because of the project's complexity, level of controversy, and participation of willing partners.
[3] The fish passage plan for the Yolo Bypass should address providing passage at Fremont Weir, Lisbon Weir, numerous structures within the Toe Drain, Tule Canal, and South Fork of Putah Creek, and address straying upstream through the Knights Landing Ridge Cut and the interaction of the Knights Landing Ridge Cut Outfall Gates.
[4] A new fish ladder is being installed at Weir No. 2 in 2011 and 2012.
[5] Because the Calaveras River downstream of New Hogan Dam already has the potential (with passage and flow improvements) to support a viable steelhead population, passage upstream of New Hogan Dam is currently not a high priority for NOAA Fisheries (pers.com. B. Ellrott 2011). DWR staff left New Hogan Dam as Priority 2 because that is how it is listed by NOAA (2009a). New Hogan Dam should be moved to a lower priority for implementation.

Key:
CVRP = Central Valley Recovery Plan
DFG = California Department of Fish and Game
ID = Identification Number
HOV = Highway Occupancy Vehicle
PAD = Passage Assessment Database
S.F. = South Fork
SPFC = State Plan of Flood Control

Table 9C.2-2. Fish Passage Actions Within the Systemwide Planning Area That Should be Implemented Within 5 Years

Rank	Stream	Site	County	Status	Type	CVRP Priority	SPFC Component	CVRP Geographic Priority	PAD ID
1	East Borrow Canal	Willow Slough Weir[1]	Sutter	Temporal	Dam	1	X	2 - Lower Sacramento River	737025
1	East Borrow Canal	Weir No. 2[3]	Sutter	Partial	Dam	1	X	2 - Lower Sacramento River	703964
1	Sacramento River	Fremont Weir[2]	Yolo	Temporal	Dam	1	X	2 - Lower Sacramento River	704343
2	S.F. Putah Creek	DFG (Yolo)	Yolo	Needs assessment	Road crossing	1		1 - Delta	704788
2	S.F. Putah Creek	DFG (Yolo)	Yolo	Needs assessment	Road crossing	1		1 - Delta	704789
2	S.F. Putah Creek	Weir	Yolo	Needs assessment	Dam	1		1 - Delta	704775
2	S.F. Putah Creek Side Chan	DFG (Yolo)	Yolo	Needs assessment	Road crossing	1		1 - Delta	704794
2	S.F. Putah Creek Side Chan	DFG (Yolo)	Yolo	Needs assessment	Road crossing	1		1 - Delta	704795
2	Toe Drain	Culvert	Yolo	Needs assessment	Road crossing	1		1 - Delta	704338
2	Toe Drain	Culvert	Yolo	Needs assessment	Road crossing	1		1 - Delta	704342
2	Toe Drain	Culvert	Yolo	Needs assessment	Road crossing	1		1 - Delta	704448
2	Toe Drain	Culvert	Yolo	Needs assessment	Road crossing	1		1 - Delta	704451
2	Toe Drain	Culvert	Yolo	Needs assessment	Road crossing	1		1 - Delta	704452
2	Toe Drain	Culvert/Flashboard	Yolo	Needs assessment	Road crossing	1		1 - Delta	704449

Table 9C.2-2. Fish Passage Actions Within the Systemwide Planning Area That Should be Implemented Within 5 Years (contd.)

Rank	Stream	Site	County	Status	Type	CVRP Priority	SPFC Component	CVRP Geographic Priority	PAD ID
2	Toe Drain	Culvert/Flashboard	Yolo	Needs assessment	Road crossing	1		1 - Delta	704450
2	Toe Drain	Lisbon Weir	Yolo	Partial	Dam	1		1 - Delta	
2	Tule Canal	Culvert	Yolo	Temporal		1		1 - Delta	
2	Tule Canal	Wallace Weir	Yolo	Temporal	Dam	1		1 - Delta	
4	Sacramento River	Red Bluff Diversion Dam	Tehama	Partial	Dam	1		4 - Upper Sacramento River	718713
6	Mormon Slough	Caprini Low-Flow Road Crossing	San Joaquin	Temporal	Road crossing	1		8 - Southern Sierra Diversity Group	735110
6	Stockton Diverting Canal	Budiselich Dam	San Joaquin	Temporal	Dam	1		8 - Southern Sierra Diversity Group	735107

Notes:
[1] A new fish ladder was installed at Willow Slough Weir in 2010. As long as the ladder evaluation confirms that it meets NOAA Fisheries and DFG fish passage criteria, this structure will no longer be a barrier.
[2] Fremont Weir is on the short-term and moderate-term lists. Interim passage could be provided within 1 year. Permanent fish passage may take longer than 5 years because of the project's complexity, level of controversy, and participation of willing partners.
[3] A new fish ladder is being installed at Weir No. 2 in 2011 and 2012.

Key:
CVRP = Central Valley Recovery Plan
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ID = Identification Number
PAD = Passage Assessment Database
S.F. = South Fork
SPFC = State Plan of Flood Control

Table 9C.2-3. Fish Passage Actions Within the Systemwide Planning Area That Should be Implemented Within 10 Years

Rank	Stream	Site	County	Type	Status	CVRP Priority	SPFC Component	CVRP Geographic Priority	PAD ID
1	Sacramento River	Fremont Weir[1]	Yolo	Dam	Temporal	1	X	2 - Lower Sacramento River	704343
1	Sacramento River	Sacramento Weir	Yolo	Dam	Needs assessment	1	X	2 - Lower Sacramento River	700222
4	Sacramento River	Keswick Dam	Shasta	Dam	Total	1		4 - Upper Sacramento River	718711
4	Sacramento River	Shasta Dam	Shasta	Dam	Total	1		4 - Upper Sacramento River	718710
5	American River	Folsom Dam	Sacramento	Dam	Total	1		5 - Northern Sierra Nevada Diversity Group	718795
6	Calaveras River	Calaveras Headworks	San Joaquin	Dam	Total	1		8 - Southern Sierra Diversity Group	735098
6	Calaveras River	Cherryland Flashboard Dam	San Joaquin	Dam	Temporal	1		8 - Southern Sierra Diversity Group	735090
6	Calaveras River	Dam	Calaveras	Dam	Partial	1		8 - Southern Sierra Diversity Group	704310
6	Calaveras River	Deteriorated Low-Flow Road Crossing	San Joaquin	Road crossing	Temporal	1		8 - Southern Sierra Diversity Group	735104
6	Calaveras River	Eight Mile Flashboard Dam	San Joaquin	Dam	Temporal	1		8 - Southern Sierra Diversity Group	735094
6	Calaveras River	Gotelli #1 Flashboard Dam	San Joaquin	Dam	Temporal	1		8 - Southern Sierra Diversity Group	735097
6	Calaveras River	Gotelli Low-Flow Road Crossing (River Mile 35.3)	San Joaquin	Road crossing	Temporal	1		8 - Southern Sierra Diversity Group	735105
6	Calaveras River	Gotelli Low-Flow Road Crossing (River Mile 6.2)	San Joaquin	Road crossing	Temporal	1		8 - Southern Sierra Diversity Group	735088

Table 9C.2-3. Fish Passage Actions Within the Systemwide Planning Area That Should be Implemented Within 10 Years (contd.)

Rank	Stream	Site	County	Type	Status	CVRP Priority	SPFC Component	CVRP Geographic Priority	PAD ID
6	Calaveras River	Gravel Pit Pond	San Joaquin	Dam	Temporal	1		8 - Southern Sierra Diversity Group	735100
6	Calaveras River	McAllen Flashboard Dam	San Joaquin	Dam	Temporal	1		8 - Southern Sierra Diversity Group	735089
6	Calaveras River	McGurk Earth Dam	San Joaquin	Dam	Temporal & Partial	1		8 - Southern Sierra Diversity Group	737024
6	Calaveras River	McGurk Low-Flow Road Crossing	San Joaquin	Road crossing	Partial	1		8 - Southern Sierra Diversity Group	735099
6	Calaveras River	Murphy Flashboard Dam	San Joaquin	Dam	Temporal	1		8 - Southern Sierra Diversity Group	735093
6	Calaveras River	New Hogan Dam Road Bridge	Calaveras	Dam	Partial	1		8 - Southern Sierra Diversity Group	704323
6	Calaveras River	Old Dog Ranch Low-Flow Road Crossing	San Joaquin	Road crossing	Temporal	1		8 - Southern Sierra Diversity Group	735102
6	Calaveras River	Old DWR Stream Gauge Weir	San Joaquin	Flow measurement weir	Temporal	1		8 - Southern Sierra Diversity Group	737023
6	Calaveras River	Old Wooden Bridge	San Joaquin	Road crossing	Temporal	1		8 - Southern Sierra Diversity Group	735087
6	Calaveras River	Pezzi Flashboard Dam	San Joaquin	Dam	Temporal	1		8 - Southern Sierra Diversity Group	735092
6	Calaveras River	Rubble Dam Upstream from Bellota Weir	Stanislaus	Dam	Temporal	1		8 - Southern Sierra Diversity Group	704320
6	Calaveras River	Solari Ranch Flashboard Dam	San Joaquin	Dam	Temporal	1		8 - Southern Sierra Diversity Group	735091
6	Calaveras River	Tully Flashboard Dam	San Joaquin	Dam	Temporal	1		8 - Southern Sierra Diversity Group	735095

Table9 C.2-3. Fish Passage Actions Within the Systemwide Planning Area That Should be Implemented Within 10 Years (contd.)

Rank	Stream	Site	County	Type	Status	CVRP Priority	SPFC Component	CVRP Geographic Priority	PAD ID
6	Calaveras River	Williams Crossing	San Joaquin	Road crossing	Needs assessment	1		8 - Southern Sierra Diversity Group	735103
6	Calaveras River	Wilson's Low-Flow Road Crossing	San Joaquin	Road crossing	Temporal	1		8 - Southern Sierra Diversity Group	735101
6	Mormon Slough	Avansino Street Flashboard Dam	San Joaquin	Dam	Temporal	1		8 - Southern Sierra Diversity Group	735121
6	Mormon Slough	Bellota Weir	San Joaquin	Dam	Partial	1		8 - Southern Sierra Diversity Group	703864
6	Mormon Slough	Bonomo Flashboard Dam	San Joaquin	Dam	Temporal	1		8 - Southern Sierra Diversity Group	735118
6	Mormon Slough	Fine Road Flashboard Dam	San Joaquin	Dam	Temporal	1		8 - Southern Sierra Diversity Group	735122
6	Mormon Slough	Fujinaka Low-Flow Road Crossing	San Joaquin	Road crossing	Temporal	1		8 - Southern Sierra Diversity Group	735114
6	Mormon Slough	Highway 26 Flashboard Dam	San Joaquin	Dam	Temporal	1		8 - Southern Sierra Diversity Group	735123
6	Mormon Slough	Hosie Flashboard Dam	San Joaquin	Dam	Temporal	1		8 - Southern Sierra Diversity Group	735120
6	Mormon Slough	Hosie Low-Flow Road Crossing	San Joaquin	Road crossing	Temporal	1		8 - Southern Sierra Diversity Group	735119
6	Mormon Slough	Lavaggi Flashboard Dam	San Joaquin	Dam	Temporal	1		8 - Southern Sierra Diversity Group	735111
6	Mormon Slough	Main Street Flashboard Dam	San Joaquin	Dam	Temporal	1		8 - Southern Sierra Diversity Group	735108
6	Mormon Slough	Panella Flashboard Dam	San Joaquin	Dam	Temporal	1		8 - Southern Sierra Diversity Group	735109

Table 9C.2-3. Fish Passage Actions Within the Systemwide Planning Area That Should be Implemented Within 10 Years (contd.)

Rank	Stream	Site	County	Type	Status	CVRP Priority	SPFC Component	CVRP Geographic Priority	PAD ID
6	Mormon Slough	Piazza Flashboard Dam	San Joaquin	Dam	Temporal	1		8 - Southern Sierra Diversity Group	735117
6	Mormon Slough	Prato Flashboard Dam	San Joaquin	Dam	Temporal	1		8 - Southern Sierra Diversity Group	735115
6	Mosher Slough	Webster Dam	San Joaquin	Dam	Partial	1		8 - Southern Sierra Diversity Group	704472
6	San Joaquin River	Sack Dam	Fresno	Dam	Partial	1		8 - Southern Sierra Diversity Group	704635
6	Stanislaus River	Goodwin Dam	Calaveras	Dam	Total	1		8 - Southern Sierra Diversity Group	718977
6	Stanislaus River	New Melones Dam	Tuolumne	Dam	Total	1		8 - Southern Sierra Diversity Group	718821
6	Stanislaus River	Tulloch Dam	Tuolumne	Dam	Total	1		8 - Southern Sierra Diversity Group	718976
6	Stockton Diversion Canal	Central Traction Railroad crossing	San Joaquin	Bridge	Partial	1		8 – Southern Sierra Diversity Group	
7	Sacramento River	Tisdale Weir	Sutter	Dam	Temporal	2	X	2 - Lower Sacramento River	720308
10	Dry Creek	Culvert	Sacramento	Road crossing	Needs assessment	2		2 - Lower Sacramento River	717226
11	Big Chico Creek	One Mile Dam With Pool Fish Ladder	Butte	Dam	Temporal	2		5 - Northern Sierra Nevada Diversity Group	704198
11	Yuba River	Daguerre Point Dam	Yuba	Dam	Partial	2		5 - Northern Sierra Nevada Diversity Group	720147
13	Merced River	Crocker Diversion Dam (Snelling)	Merced	Dam	Temporal	2		8 - Southern Sierra Diversity Group	718981

Table 9C.2-3. Fish Passage Actions Within the Systemwide Planning Area That Should be Implemented Within 10 Years (contd.)

Rank	Stream	Site	County	Type	Status	CVRP Priority	SPFC Component	CVRP Geographic Priority	PAD ID
13	San Joaquin River	Mendota Pool Dam And Diversion	Madera	Dam	Partial	2		8 - Southern Sierra Diversity Group	718840
14	Sacramento River	Colusa Weir	Colusa	Dam	Needs assessment		X	2 - Lower Sacramento River	720139
15	Big Chico Creek	Big Chico Flood Control	Butte	Dam	Partial		X	5 - Northern Sierra Nevada Diversity Group	704194
15	Feather River, N Fork	Chester Diversion Dam	Plumas	Dam	Partial		X	5 - Northern Sierra Nevada Diversity Group	718744
16	San Joaquin River	Sand Slough Control Structure	Merced	Dam	Partial		X	8 - Southern Sierra Diversity Group	704663
18	Cache Slough	Culvert	Solano	Road crossing	Needs assessment			1 - Delta	702936
18	Grizzly Slough	Culvert	Sacramento	Road crossing	Needs assessment			1 - Delta	703342
18	Lindsey Slough	Harry Petersen	Solano	Road crossing	Needs assessment			1 - Delta	702950
18	Marsh Creek	Private Ford	Contra Costa	Road crossing	Needs assessment			1 - Delta	713452
18	Middle River	Temporary Rock Barrier – Middle River	San Joaquin	Dam	Temporal			1 - Delta	712740
18	Old River	Coney Island	San Joaquin	Road crossing	Needs assessment			1 - Delta	702115
18	Old River	Head Of Old River Barrier	San Joaquin	Dam	Temporal			1 - Delta	712739
18	Old River	Temporary Rock Barrier – Old River At Tracy	San Joaquin	Dam	Temporal			1 - Delta	712741

Table 9C.2-3. Fish Passage Actions Within the Systemwide Planning Area That Should be Implemented Within 10 Years (contd.)

Rank	Stream	Site	County	Type	Status	CVRP Priority	SPFC Component	CVRP Geographic Priority	PAD ID
18	Paradise Cut	Paradise Dam	San Joaquin	Dam	Needs assessment			1 - Delta	720251
18	Ulatis Creek	Maine Prairie Water District	Solano	Dam	Temporal			1 - Delta	703002
18	Unnamed Tributary	Clifton Court Forebay	Contra Costa	Dam	Needs assessment			1 - Delta	719749
18	Unnamed Tributary	Maine Prairie[3]	Solano	Dam	Needs assessment			1 - Delta	719341
19	Cross-Canal	Coppin Dam	Sutter	Dam	Temporal			2 - Lower Sacramento River	704926
19	East Borrow Canal	Culvert/Flashboard	Sutter	Road crossing	Needs assessment			2 - Lower Sacramento River	703978
19	East Borrow Canal	Culvert/Flashboard	Sutter	Road crossing	Needs assessment			2 - Lower Sacramento River	703977
19	East Borrow Canal	Culvert/Flashboard	Sutter	Road crossing	Needs assessment			2 - Lower Sacramento River	703976
19	East Borrow Canal	Culvert/Flashboard	Sutter	Road crossing	Needs assessment			2 - Lower Sacramento River	703975
19	Sacramento River	Sac 80 HOV California Department of Transportation Fish Passage Project	Sacramento	Road crossing	Needs assessment			2 - Lower Sacramento River	735370
19	West Barrow	Butte Slough Irrigation Co., Weir 5	Sutter	Dam	Needs assessment			2 - Lower Sacramento River	703954
19	West Barrow	Frank Guisti, Weir	Sutter	Road crossing	Needs assessment			2 - Lower Sacramento River	703957
19	West Barrow	Frank Guisti, Weir	Sutter	Road crossing	Needs assessment			2 - Lower Sacramento River	703956

Table 9C.2-3. Fish Passage Actions Within the Systemwide Planning Area That Should be Implemented Within 10 Years (contd.)

Rank	Stream	Site	County	Type	Status	CVRP Priority	SPFC Component	CVRP Geographic Priority	PAD ID
19	West Barrow	Weir 1	Sutter	Dam	Needs assessment			2 - Lower Sacramento River	703959
20	Craig Creek	Hwy 99 Fish Passage Project	Tehama	Road crossing	Needs assessment			3 - Middle Sacramento River	737012
20	Stony Creek	Culvert	Glenn	Road crossing	Needs assessment			3 - Middle Sacramento River	717652
21	Sacramento River	Anderson Cottonwood Dam (ACID)	Shasta	Dam	Partial			4 - Upper Sacramento River	718712
22	American River	Folsom Left Wing	Sacramento	Dam	Needs assessment			5 - Northern Sierra Nevada Diversity Group	719927
22	American River	Folsom Prison	Sacramento	Dam	Needs assessment			5 - Northern Sierra Nevada Diversity Group	716173
22	American River	Nimbus Dam	Sacramento	Dam	Total			5 - Northern Sierra Nevada Diversity Group	718794
22	Butte Creek	Driver Cut Weir	Sutter	Dam	Partial			5 - Northern Sierra Nevada Diversity Group	703757
22	Butte Creek	RD 833	Sutter	Dam	Partial			5 - Northern Sierra Nevada Diversity Group	703756
22	Feather River	Fthrrv_D1_38.485_09	Sutter	Dam	Temporal			5 - Northern Sierra Nevada Diversity Group	717632
22	Mallard Slough	White Mallard Duck Club	Colusa	Road crossing	Needs assessment			5 - Northern Sierra Nevada Diversity Group	703778
22	Mallard Slough	White Mallard Duck Club	Colusa	Road crossing	Needs assessment			5 - Northern Sierra Nevada Diversity Group	703776

Table 9C.2-3. Fish Passage Actions Within the Systemwide Planning Area That Should be Implemented Within 10 Years (contd.)

Rank	Stream	Site	County	Type	Status	CVRP Priority	SPFC Component	CVRP Geographic Priority	PAD ID
22	North Fork American River	Diversion	Placer	Dam	Needs assessment			5 - Northern Sierra Nevada Diversity Group	716129
22	North Fork Feather River	Big Bend Dam	Butte	Dam	Temporal			5 - Northern Sierra Nevada Diversity Group	715750
22	North Yuba River	Colgate Head	Yuba	Dam	Needs assessment			5 - Northern Sierra Nevada Diversity Group	716398
22	South Fork American River	Natomas Diversion	El Dorado	Dam	Needs assessment			5 - Northern Sierra Nevada Diversity Group	715794
23	Natomas East Main Drainage Canal	Pumping Plant	Sacramento		Needs assessment			5 – Northern Sierra Nevada Diversity Group	
23	Stony Creek	Dam	Glenn	Dam	Needs assessment			7 - Northwestern California Diversity Group	717644
23	Stony Creek	Dam	Tehama	Dam	Needs assessment			7 - Northwestern California Diversity Group	717641
23	Stony Creek	Stony Creek Gravel Dam	Glenn	Dam	Needs assessment			7 - Northwestern California Diversity Group	718714
23	Stony Creek	Tehama-Colusa Irrigation	Glenn	Road crossing	Needs assessment			7 - Northwestern California Diversity Group	717650
23	Stony Creek	Tehama-Colusa Irrigation	Glenn	Road crossing	Needs assessment			7 - Northwestern California Diversity Group	717648
24	Merced River	Ingalsbe Slough Dam	Merced	Dam	Needs assessment			8 - Southern Sierra Diversity Group	737067

Table 9C.2-3. Fish Passage Actions Within the Systemwide Planning Area That Should be Implemented Within 10 Years (contd.)

Rank	Stream	Site	County	Type	Status	CVRP Priority	SPFC Component	CVRP Geographic Priority	PAD ID
24	Merced River	Merced Falls Dam	Merced	Dam	Needs assessment			8 - Southern Sierra Diversity Group	718982
24	Merced River	Mrcdrv_D1_47.189_09	Merced	Flood control channel	Needs assessment			8 - Southern Sierra Diversity Group	737068
24	Mokelumne River	Woodbridge Diversion Dam	San Joaquin	Dam	Partial			8 - Southern Sierra Diversity Group	718813
24	Mosher Slough	Bear Creek Diversion Dam	San Joaquin	Dam	Partial			8 - Southern Sierra Diversity Group	704500
24	Mosher Slough	Lyon Dam	San Joaquin	Dam	Partial			8 - Southern Sierra Diversity Group	704495
24	San Joaquin River	Culvert	Fresno	Road crossing	Needs assessment			8 - Southern Sierra Diversity Group	704666
24	San Joaquin River	Culvert	Merced	Road crossing	Needs assessment			8 - Southern Sierra Diversity Group	704677
24	San Joaquin River	Culvert	Fresno	Road crossing	Needs assessment			8 - Southern Sierra Diversity Group	704549
24	San Joaquin River	Culvert	Fresno	Road crossing	Needs assessment			8 - Southern Sierra Diversity Group	704550
24	San Joaquin River	Culvert	Fresno	Road crossing	Needs assessment			8 - Southern Sierra Diversity Group	704550
24	San Joaquin River	Culvert	Fresno	Road crossing	Needs assessment			8 - Southern Sierra Diversity Group	704665
24	San Joaquin River	Culvert	Fresno	Road crossing	Needs assessment			8 - Southern Sierra Diversity Group	704548
24	San Joaquin River	Culvert	Fresno	Road crossing	Needs assessment			8 - Southern Sierra Diversity Group	704666

Table 9C.2-3. Fish Passage Actions Within the Systemwide Planning Area That Should be Implemented Within 10 Years (contd.)

Rank	Stream	Site	County	Type	Status	CVRP Priority	SPFC Component	CVRP Geographic Priority	PAD ID
24	San Joaquin River	Culvert	Fresno	Road crossing	Needs assessment			8 - Southern Sierra Diversity Group	704548
24	San Joaquin River	Culvert	Madera	Road crossing	Needs assessment			8 - Southern Sierra Diversity Group	704585
24	San Joaquin River	Culvert	Madera	Road crossing	Needs assessment			8 - Southern Sierra Diversity Group	704585
24	San Joaquin River	Culvert	Madera	Road crossing	Needs assessment			8 - Southern Sierra Diversity Group	704605
24	San Joaquin River	Culvert	Madera	Road crossing	Needs assessment			8 - Southern Sierra Diversity Group	704605
24	San Joaquin River	Culvert	Madera	Road crossing	Needs assessment			8 - Southern Sierra Diversity Group	704606
24	San Joaquin River	Culvert	Madera	Road crossing	Needs assessment			8 - Southern Sierra Diversity Group	704606
24	San Joaquin River	Culvert	Fresno	Road crossing	Needs assessment			8 - Southern Sierra Diversity Group	704665
24	San Joaquin River	Culvert	Fresno	Road crossing	Needs assessment			8 - Southern Sierra Diversity Group	704527
24	San Joaquin River	Culvert	Madera	Road crossing	Needs assessment			8 - Southern Sierra Diversity Group	704641
24	San Joaquin River	Culvert	Merced	Road crossing	Needs assessment			8 - Southern Sierra Diversity Group	704687
24	San Joaquin River	Culvert	Fresno	Road crossing	Needs assessment			8 - Southern Sierra Diversity Group	704525
24	San Joaquin River	Culvert	Fresno	Road crossing	Needs assessment			8 - Southern Sierra Diversity Group	704525

Table 9C.2-3. Fish Passage Actions Within the Systemwide Planning Area That Should be Implemented Within 10 Years (contd.)

Rank	Stream	Site	County	Type	Status	CVRP Priority	SPFC Component	CVRP Geographic Priority	PAD ID
24	San Joaquin River	Culvert	Fresno	Road crossing	Needs assessment			8 - Southern Sierra Diversity Group	704526
24	San Joaquin River	Culvert	Fresno	Road crossing	Needs assessment			8 - Southern Sierra Diversity Group	704549
24	San Joaquin River	Culvert	Fresno	Road crossing	Needs assessment			8 - Southern Sierra Diversity Group	704527
24	San Joaquin River	Culvert	Madera	Road crossing	Needs assessment			8 - Southern Sierra Diversity Group	704641
24	San Joaquin River	Culvert	Fresno	Road crossing	Needs assessment			8 - Southern Sierra Diversity Group	704533
24	San Joaquin River	Culvert	Fresno	Road crossing	Needs assessment			8 - Southern Sierra Diversity Group	704533
24	San Joaquin River	Culvert	Fresno	Road crossing	Needs assessment			8 - Southern Sierra Diversity Group	704534
24	San Joaquin River	Culvert	Fresno	Road crossing	Needs assessment			8 - Southern Sierra Diversity Group	704534
24	San Joaquin River	Culvert	Fresno	Road crossing	Needs assessment			8 - Southern Sierra Diversity Group	704546
24	San Joaquin River	Culvert	Fresno	Road crossing	Needs assessment			8 - Southern Sierra Diversity Group	704546
24	San Joaquin River	Culvert	Fresno	Road crossing	Needs assessment			8 - Southern Sierra Diversity Group	704526
24	San Joaquin River	Helm Canal	Fresno	Dam	Needs assessment			8 - Southern Sierra Diversity Group	704667
24	San Joaquin River	Patterson	Stanislaus	Dam	Needs assessment			8 - Southern Sierra Diversity Group	716338

Table 9C.2-3. Fish Passage Actions Within the Systemwide Planning Area That Should be Implemented Within 10 Years (contd.)

Rank	Stream	Site	County	Type	Status	CVRP Priority	SPFC Component	CVRP Geographic Priority	PAD ID
24	San Joaquin River	Stevenson Weir	Merced	Dam	Needs assessment			8 - Southern Sierra Diversity Group	715956
24	Stanislaus River	Stnsrv_D1_5.719_09	San Joaquin	Flood control channel	Needs assessment			8 - Southern Sierra Diversity Group	737171
24	Unnamed Tributary	Davis No 2	San Joaquin	Dam	Needs assessment			8 - Southern Sierra Diversity Group	719242
25	Cache Creek	Capay Dam	Yolo	Dam	Needs assessment			--	720131
25	Cache Creek	Clear Lake	Lake	Dam	Needs assessment			--	720062
25	Cache Creek	Clear Lake Imp Dam	Lake	Dam	Needs assessment			--	718900
25	Cache Creek	Moore Dam	Yolo	Dam	Needs assessment			--	720237
25	Cache Creek	Rayhouse Road Crossing	Yolo	Road crossing	Needs assessment			--	717208
25	Cache Creek	Yolo Co. Flood Control	Yolo	Dam	Partial			--	717186
25	Tuolumne River	Dennett Dam	Stanislaus	Dam	Partial			8 – Southern Sierra Diversity Group	

Notes:
[1] Fremont Weir is on the short-term and moderate-term lists. Interim passage could be provided within 1 year. Permanent fish passage may take longer than 5 years because of the project's complexity, level of controversy, and participation of willing partners.

Key:
CVRP = Central Valley Recovery Plan
DWR = California Department of Water Resources
ID = Identification Number
PAD = Passage Assessment Database
RD = Reclamation District
SPFC = State Plan of Flood Control

Table 9C.2-4. Long-Term Fish Passage Actions Within the Systemwide Planning Area That Require Work Beginning in 2012 Through 2022 or Longer

Rank	Stream	Site	County	Type	Status	CVRP Priority	SPFC Component	CVRP Geographic Priority	PAD ID
5	Mokelumne River	Camanche Main Dam	San Joaquin	Dam	Total	1		5 - Northern Sierra Nevada Diversity Group	718812
5	Mokelumne River	Pardee Dam	Calaveras	Dam	Total	1		5 - Northern Sierra Nevada Diversity Group	718827
5	North Yuba River	New Bullards Bar Dam	Yuba	Dam	Total	1		5 - Northern Sierra Nevada Diversity Group	718761
5	Yuba River	Harry L. Englebright Dam	Nevada	Dam	Total	1		5 - Northern Sierra Nevada Diversity Group	718765
6	Tuolumne River	Don Pedro Main Dam	Tuolumne	Dam	Total	1		8 - Southern Sierra Diversity Group	718978
6	Tuolumne River	La Grange Dam	Stanislaus	Dam	Total	1		8 - Southern Sierra Diversity Group	718979
8	Feather River	Fish Barrier Dam	Butte	Dam	Total	2	X	5 - Northern Sierra Nevada Diversity Group	718748
8	Feather River	Oroville Dam	Butte	Dam	Total	2	X	5 - Northern Sierra Nevada Diversity Group	718746
8	Feather River	Thermalito Diversion Dam	Butte	Dam	Total	2	X	5 - Northern Sierra Nevada Diversity Group	718747
8	Unnamed Tributary	Thermalito Afterbay	Butte	Dam	Total	2	X	5 - Northern Sierra Nevada Diversity Group	719986
12	Stony Creek	Black Butte Dam	Tehama	Dam	Total	2		7 - Northwestern California Diversity Group	718715

Table 9C.2-4. Long-Term Fish Passage Actions Within the Systemwide Planning Area That Require Work Beginning in 2012 Through 2022 or Longer (contd.)

Rank	Stream	Site	County	Type	Status	CVRP Priority	SPFC Component	CVRP Geographic Priority	PAD ID
13	Calaveras River	New Hogan Dam[1]	Calaveras	Dam	Total	2		8 - Southern Sierra Diversity Group	718828
13	Merced River	Exchequer Main Dam	Mariposa	Dam	Total	2		8 - Southern Sierra Diversity Group	718975
13	Merced River	Mcswain Dam	Mariposa	Dam	Total	2		8 - Southern Sierra Diversity Group	718983
13	San Joaquin River	Friant Dam	Fresno	Dam	Total	2		8 - Southern Sierra Diversity Group	718954
17	Cache Creek	Cache Creek Settling Basin	Yolo	Dam	Total		X	--	719846
22	South Fork Feather River	Ponderosa Dam	Butte	Dam	Total			5 - Northern Sierra Nevada Diversity Group	737345

Notes:
[1] Because the Calaveras River downstream of New Hogan Dam already has the potential (with passage and flow improvements) to support a viable steelhead population, passage upstream of New Hogan Dam is currently not a high priority for NOAA Fisheries (pers.com. B. Ellrott 2011). DWR staff left New Hogan Dam as Priority 2 because that is how it is listed by NOAA Fisheries (2009a). New Hogan Dam should be moved to a lower priority for implementation.

Key:
CVRP = Central Valley Recovery Plan
DFG = California Department of Fish and Game
ID = Identification Number
HOV = Highway Occupancy Vehicle
PAD = Passage Assessment Database
S.F. = South Fork
SPFC = State Plan of Flood Control

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Attachment 9C.3. Prioritized List of Potential Stranding Areas in the Systemwide Planning Area

Prioritization of stranding areas is shown below. The interim prioritization process, as previously discussed, was used to prioritize stranding areas. The process recognizes the importance of stranding areas within the Systemwide Planning Area, as well as the Priority 1 actions and Geographic Priorities from the NOAA Fisheries (2009a) Recovery Plan (see Table 9C.3-1).

Table 9C.3-1. Prioritized List of Potential Stranding Areas in the Systemwide Planning Area

SPFC Component	CVRP Priority	CVRP Geographic Priority	Site	Rank
X	1	2	Yolo Bypass	1
X	1	2	Sacramento Bypass	1
	1	2	American River side channels	2
	1	5	Yuba River side channels	3
	1	8	Stanislaus River (gravel pits)	4
	1	8	Tuolumne River gravel pits	4
X		2	Colusa Basin Drain	5
X		4	Colusa Bypass	6
X		4	Tisdale Bypass	6
X		8	Chowchilla Bypass system	7
		8	Merced River gravel pits	8
	Depends	8,0, or 1	San Joaquin gravel pits[18] (More detail needed on exact locations)	To be determined

Key:
CVRP = Central Valley Recovery Plan
SPFC = State Plan of Flood Control

[18] It is known that the San Joaquin River contains in-channel and captured pits that have the potential to strand salmon (Mussetter Engineering, Inc., 2005). However, DWR did not have enough information to delineate specific pits on Figure 7-3 or in Table 9C.3-1. Therefore, the entire San Joaquin River is marked as a potential stranding site.

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