Chapter 3 Existing Habitat Conditions and Status of Fish Populations

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Chapter 3 Existing Habitat Conditions and Status of Fish Populations

Introduction

This chapter describes streams identified as priorities for restoration by the US Fish and Wildlife Service (1995 and 1997), California Department of Fish and Game (1993), or CALFED (2000). The Fish Passage Improvement Program also identified other priority projects to improve fish passage in these drainages. The priority fish passage improvement projects were identified according to FPIP criteria or were priority projects already identified by State or federal agencies. See Chapter 1 for a discussion of these criteria. The descriptions of fish population and habitat conditions provide the supporting biological and habitat quality information for the priority projects described in Chapter 4.

The information is essential in assessing the benefits of modifying an instream structure to provide fish better access to upstream habitat. The descriptions address geography, historical, and current anadromous fish populations, spawning and rearing habitat conditions for anadromous fish, the types and sources of habitat data, and a summary of recent fish passage and stream restoration projects on the stream. Figures 4-1 and 4-3 through 4-5 in Chapter 4 identify program areas and program priority waterways (as well as their accompanying known structures discussed in Chapter 4).

The streams discussed in Chapter 3 are grouped into geographical areas. The information presented on yearly population estimates for each stream have been extrapolated from the Department of Fish and Game (DFG) GrandTab data collected from 1952 to the present. Over the years salmonid numbers have been estimated by various means; a description of those methods is available from the California Central Valley Salmon Spawner Stock Reports (See Appendix F).

Tables 3-1, 3-2, and 3-3 present a summary of the type of data available on each stream. Tables 3-4, 3-5, and 3-6 identify information on fish passage conditions at structures on the same streams in the Sacramento and San Joaquin River basins. Appendix G contains a bibliography of the literature and a list of personal communications cited in each of the stream summaries, organized alphabetically by stream name. An extensive online bibliography of reports and other documents about Chinook salmon in the Central Valley can be found at the Web site[1].

Chapter 4

Appendix F

Table 3-1 Sacramento River matrix

Table 3-2 Lower Sacramento River matrix

Table 3-3 San Joaquin River matrix

Table 3-4 Sacramento River passage matrix

Table 3-5 Lower Sacramento River passage matrix

Table 3-6 San Joaquin River passage matrix

Appendix G

[1] Online bibliography of Chinook salmon in the Central Valley at http://swr.ucsd.edu/hcd/cvscb.htm

Sacramento River and Tributaries

There are other creeks in the Sacramento River region with potential fish passage barriers other than the ones included in this section (see Appendix A). Antelope Creek in Tehama County is one such creek. The US Department of Agriculture (USDA) Forest Service, Lassen National Forest, has prepared an extensive analysis of the Antelope Creek watershed (2000) which provides habitat data, water quality and flow information, escapement numbers, etc. FPIP will work with the interagency team to identify additional priority creeks in the future.

Appendix A

Sacramento River, Upstream of Keswick Dam

On the Sacramento River, Shasta and Keswick dams are total barriers to fish migration. Shasta Dam, completed in 1944 by US Bureau of Reclamation (USBR), blocks more than 600 miles of historical anadromous fish habitat in upstream tributaries to Shasta Lake. Keswick Dam impounds water in Keswick Lake, which is immediately downstream of Shasta Dam. This area formerly supported all four runs of salmon. Although methods do exist to facilitate fish passage over rim dams, none are in place or being discussed in this location at this time.

Battle Creek, Tehama County

Potential Impediments to Anadromous Fish Migration

The main stem of Battle Creek has four structures that act as potential impediments to adult anadromous fish migration: the (1) Coleman National Fish Hatchery (CNFH) barrier weir that diverts returning hatchery fish into the hatchery for brood stock collection each year from September through early March; (2) the CNFH Intake 3 diversion weir that diverts water for the hatchery; (3) the Orwick seasonal gravel diversion dam, which diverts up to 50 cubic feet per second (cfs) into an irrigation canal near PG&E's Coleman Powerhouse; and (4) the tailrace from PG&E's Coleman Powerhouse, which has been known to attract adult Chinook salmon and steelhead into an area with little spawning habitat (USFWS 2001a). In addition, all of the mentioned diversions are unscreened or have screens that do not meet DFG's criteria for proper fish passage of out-migrating juvenile fish.

CNFH, 6 miles upstream from the mouth of Battle Creek, is operated by the US Fish and Wildlife Service (USFWS). The hatchery was built in 1942 to help preserve significant runs of Chinook salmon threatened by the loss of natural spawning areas after construction of Shasta Dam on the Sacramento River (USFWS 2001b).

In the mid-1990s, the fish ladders at Eagle Canyon on North Fork Battle Creek and PG&E's Coleman Dam on South Fork Battle Creek were intentionally closed primarily to manage populations of spring-run Chinook salmon and steelhead. Closing the ladders limited the amount of stream available for spring-run salmon and steelhead that passed the CNFH barrier weir, making it easier for fish to pair for spawning (DFG 1995), preventing entrainment into unscreened diversions, and preventing passage to habitat having insufficient flow. Recently, the fall and late-fall runs of Chinook salmon have been partially restricted to about 6 miles between the mouth of Battle Creek and the CNFH barrier weir.

North Fork Battle Creek has three dams: Wildcat Dam, Eagle Canyon Dam and North Battle Creek Dam, all of which are downstream of a natural barrier to anadromous fish migration. These three structures divert water for hydroelectric power production. South Fork Battle Creek also has three hydroelectric diversions downstream of the natural barrier to fish migration: South Diversion Dam, Inskip Dam, and Coleman Dam. South Fork Battle Creek has two tributaries, Ripley Creek and Soap Creek that are navigable by anadromous fish. There is one diversion on each of the tributaries.

General Description

Battle Creek originates at an elevation of more than 7,000 feet on the western slope of the Cascade Range in Lassen National Forest. It flows westerly 60 miles to its confluence with the Sacramento River at river mile (RM) 271. There are two main branches, the north and south forks, which converge about 12 miles upstream of the Sacramento River confluence. Battle Creek's drainage area is 360 square miles. The monthly mean flow ranges from 265 cfs to 766 cfs with a median flow of 516 cfs. The total storage capacity for all the reservoirs in the watershed is 1,502 acre-feet (USFWS 2001a).

Fish Populations

Battle Creek is one of the most important Chinook salmon spawning streams in the Central Valley. Historically, the creek supported self-sustaining populations of all four runs of Chinook salmon, as well as steelhead trout. It has been recognized that Battle Creek may be the only waterway besides the Sacramento River that can sustain all five Central Valley salmonid runs (NMFS FISHERIES and others 1999). Before hydroelectric development, about 53 miles of the creek were accessible to these species. Today, CNFH and closed fish ladders at PG&E’s Coleman and Eagle Canyon dams control the amount of creek that is accessible to anadromous species; however, plans are under way open upstream habitat. The upstream ladder in the barrier weir at CNFH is closed September through early March, and the fish are held in the creek downstream of the hatchery, although some fish can pass over the weir at flows greater than 350 cfs (USFWS 2001b). The fall and late-fall salmon are counted at CNFH.

Since 1952, DFG has used carcass counts combined with those fish taken into the CNFH (Figure 3-1) to estimate fall-run Chinook salmon populations. All available spawning habitat (about 4 miles), which is used by fall-run Chinook salmon downstream of the hatchery, is surveyed to count spawners. The combined fall-run salmon populations of the CNFH and Battle Creek have ranged from a high of 463,296 in 2002 to a low of 3,300 in 1966. (GrandTab, DFG, Red Bluff Office, contact Colleen Harvey Arrison, 2004). From 1953 to 1967, the total average fall-run was 17,000 adults (UFWS 1995). From 1952 to 2003, the total average fall-run was 39,311 (GrandTab, DFG, Red Bluff Office, contact Colleen Harvey Arrison, 2004).

Figure 3-1 Battle Creek fall-run Chinook salmon yearly population estimates

USFWS conducted fish counts at CNFH for all four runs of Chinook salmon and for steelhead in Battle Creek since 1995. Between 1995 and 1997, USFWS generated partial estimates for spring-run using a video camera in the fish ladder at the CNFH barrier weir. These partial estimates indicate Battle Creek has a run of 50 to 100 adult spring-run Chinook salmon (USFWS 1996). DFG also compiled a list of spring-run numbers between the years 1989 and 2003 (some years not included in survey). The numbers range from a low of 2 in 1990 to a high of 94 in 2003 with an average of 45 (GrandTab, DFG, Red Bluff Office, contact Colleen Harvey Arrison, 2004).

In 1997, the winter-run Chinook propagation program was moved from CNFH to Livingston Stone National Fish Hatchery, to promote escapement to the main stem Sacramento River (USFWS 2001b). However, monitoring efforts showed that three natural-origin, winter-run Chinook migrated past the CNFH barrier weir in 2000 (USFWS 2001b). During 1995–1997, DFG counted 88, 325, and 44 winter-run Chinook, respectively (GrandTab, DFG, Red Bluff Office, contact Colleen Harvey Arrison, 2004).

Late-fall run Chinook salmon have been counted periodically at the CNFH since 1977 (Figure 3-2). A low of 43 late-fall run Chinook salmon were recorded in 1982 and a high of 7,075 late-fall run Chinook salmon were recorded in 1999. An average of 1,292 late-fall run Chinook salmon were counted during the years of 1977-2003 (some years not included in survey) (GrandTab, DFG, Red Bluff Office, contact Colleen Harvey Arrison, 2004).

Figure 3-2 Battle Creek late-fall run Chinook salmon yearly population estimates

Steelhead trout have been reported in Battle Creek, but surveys for spawning adults have not occurred for several years. Thus, little is known about the size of the naturally spawning steelhead population. However, natural-origin adult steelhead returning to Battle Creek are integrated with hatchery-origin steelhead for an artificial propagation program at CNFH (USFWS 2000). Steelhead propagated at CNFH are considered part of the Central Valley steelhead evolutionarily significant units (ESU) but are not listed as threatened under ESA (see Chapter 1).

In 1996 federal and State agencies (USFWS, USBR, National Marine Fisheries Service [NMFS], and DFG) joined with PG&E, a local watershed group, and other stakeholders to cooperatively restore natural populations of salmon and steelhead to Battle Creek (USFWS 2004). The agencies and PG&E signed a memorandum of understanding with the intent to decommission five PG&E dams and associated structures. These actions were undertaken in the hopes of "restoring" approximately 42 miles of Battle Creek. Since 1995 instream flows have been increased through interim flow agreements between the agencies and PG&E. Also in 1995, DFG requested that adult steelhead in excess of hatchery broodstock requirements (2,000 adults) be released upstream of the Coleman NFH barrier weir in hopes of reestablishing a self-sustaining natural population.

In the mid-1990s, it was impossible to distinguish hatchery raised steelhead from naturally spawned steelhead. Beginning with brood year 1998, all hatchery juveniles released from Coleman NFH and other Central Valley hatcheries were marked with an adipose fin-clip. Also in 1998 a juvenile monitoring program in Battle Creek was initiated to help estimate natural production upstream of the barrier weir. Since the 2001 spawning season, hatchery and natural origin steelhead could be identified. Returns of natural steelhead to Battle Creek have ranged from 131 the first year of the program to 410 during the 2002–2003 spawning season (USFWS 2004).

The USFWS intends to continue releasing hatchery and natural steelhead upstream of the barrier weir through the 2006–07 return year (which will conclude five years of genetic monitoring and approximately one steelhead generation). The USFWS will then discontinue release of hatchery steelhead upstream of the barrier weir but continue to release unclipped steelhead to spawn naturally for another five years. After this second 5-year period the USFWS will evaluate the genetic and demographic data and decide whether to reinstitute the supplementation program or continue passing only naturally spawning adults upstream (USFWS 2004).

Water Quality

Battle Creek water is generally high quality because of the many cold springs that feed into it and because it receives significant snowmelt during the spring and summer. CNFH uses three water source diversions to supply its operations. The primary water supply for CNFH is taken from the Coleman Powerhouse tailrace and originates from South Fork Battle Creek, but contains some north fork water because of interbasin transfers. There may be some water temperature effect resulting from this diversion.

The CNFH barrier weir limits the migration of fall-run and late-fall run salmon past the hatchery due to concerns of introducing fish diseases into the hatchery water supply and to prevent fall-run salmon from hybridizing with threatened spring-run salmon. However, an ozone water treatment system, constructed in 1999 and being tested at CNFH, should significantly reduce the problem of fish pathogens at CNFH (USFWS 2001b).

In 2000–2001, the California Department of Water Resources (DWR) monitored nutrients in Battle Creek upstream and downstream of the CNFH barrier weir to determine whether nutrient levels were correlated with the presence of fall-run Chinook carcasses in Battle Creek. Nutrients including dissolved ammonia, dissolved orthophosphate, total phosphorus, and dissolved nitrates plus nitrites were sampled weekly beginning in September 2000, before the onset of fall-run Chinook spawning in lower Battle Creek, and continued until January 6, 2001.

A strong correlation between the Chinook salmon population estimate generated by DFG carcass-counts in lower Battle Creek and the levels of dissolved ammonia and orthophosphate at Jelly's Ferry Road Bridge, a half-mile downstream from the CNFH barrier weir, provides indirect evidence that fall-run salmon carcasses contributed substantial nutrients to Battle Creek (DWR 2001b). However, further studies are needed to determine whether the nutrients added to Battle Creek by decomposing salmon carcasses have any effect on the levels of dissolved oxygen in the creek.

Hydrology

Mean monthly flows from 1961 to 2000 are shown in Figure 3-3. High flows generally occur during the winter and spring with a maximum monthly average of 766 cfs. Low flows generally occur during mid to late summer and have a minimum monthly average flow of 265 cfs.

Figure 3-3 Mean monthly flows from 1961 to 2000 on Battle Creek, near Coleman Fish Hatchery

Habitat Quality

Battle Creek has an unusual combination of desirable habitat features including an abundance of cold water springs, high natural flows, and relatively constant flows during the summer. Prime quality spawning, holding, and rearing habitat for steelhead, winter-run, and spring-run Chinook is upstream of Wildcat and Coleman dams on the north and south forks of Battle Creek, respectively. The habitat and water temperatures in these upper stream reaches are excellent for all life stages of salmon and steelhead (CH2MHill 1998). In contrast, the best quality habitat for fall-run and late-fall run salmon is downstream of Wildcat and Coleman dams (Ward and Kier 1999).

Habitat Data

A fish barrier study and an instream flow study conducted by Thomas Payne and Associates in the 1980s and 1990s formed the basis for the biological goals of the Battle Creek Salmon and Steelhead Restoration Plan (Ward and Kier 1999). The results of the two studies were used to help the Battle Creek Working Group's (BCWG) Biological Team categorize the contribution that distinct stream reaches could have toward the recovery of each of the five salmonid runs (Ward and Kier 1999). In addition, temperature modeling was used to estimate creek water temperatures under a number of different restorable flow regimes (Ward and Kier 1999).

The US Geological Survey (USGS) has maintained a streamflow gaging station on Battle Creek downstream of CNFH since 1961 (USGS 2001). DWR operates two streamflow gaging stations in the Battle Creek watershed near Manton, one on North Fork Battle Creek and one on South Fork Battle Creek. Both gaging stations were installed during 2000 (DWR 2001a).

DWR has 22 thermographs measuring water temperature in Battle Creek. The thermographs at Jelly's Ferry Bridge and downstream of CNFH were installed in 1993 and 1995, respectively. The other 20 thermographs were installed in 1998 and range from Jelly's Ferry Bridge downstream of the North Battle Creek Dam on the north fork and downstream of South Diversion Dam on the south fork. Field parameters such as dissolved oxygen, pH, electrical conductivity, turbidity, and alkalinity are also collected.

Riparian vegetation along Battle Creek was mapped between 1996 and 1998 by California State University, Chico (CSUC) Geographic Information Center as part of the Sacramento River Stream Corridor Protection Program and is available from CSUC as an ArcView project file.

Fisheries and Restoration Projects

The most significant factors preventing salmon and steelhead from fully utilizing the upper watershed of Battle Creek are low flows and inadequate passage created by hydroelectric and hatchery water supply diversions. Restoration of naturally spawning anadromous fish populations in Battle Creek upstream of CNFH will require changes in the operation of PG&E hydropower plants and the traditional operation of the hatchery. As part of the goal to "restore the Battle Creek watershed for naturally produced anadromous salmonids, while integrating CNFH operations," USFWS is planning to reduce impacts of its activities on naturally produced salmonids in Battle Creek. This includes studies on methods to improve fish passage at the barrier weir and installation of state-of-the-art fish screens to exclude naturally produced fish from each of three hatchery water intakes (USFWS 1998b). A Senate Bill 1086 plan identified the potential to restore Battle Creek by working cooperatively with PG&E on providing adequate instream flows (Resources Agency 1989). In 1995, The Resources Agency representatives and PG&E started to discuss ways to improve fish passage on Battle Creek. These meetings eventually led to the development of the Battle Creek Salmon and Steelhead Restoration Project. This project is focused on increasing and enhancing habitat for Chinook salmon and steelhead trout.

In June 1999, federal and State agencies comprising the CALFED Bay-Delta Restoration Program signed a $51 million agreement with PG&E that will open up 42 miles of inaccessible stream reaches (Ward 1997). The restoration proposal includes the following:

- Increasing the minimum instream flows from the present 3-5 cfs year round to 35-88 cfs adjusted seasonally
- Decommissioning five diversion dams—Wildcat, Coleman, South, Lower Ripley Creek, and Soap Creek—and transferring their associated water rights to instream uses
- Screening and enlarging ladders at three diversion dams—Inskip, Eagle Canyon, and North Battle Creek
- Constructing new infrastructure that eliminates mixing of north and south fork water and significantly reduce redundant screening requirements (CNFH 2000)

In February 1997, the BCWG was established to gather all interested parties affected by the Battle Creek restoration work. BCWG met to develop restoration efforts in a collaborative atmosphere and gather broad community acceptance. BCWG was involved in the development of the Battle Creek Salmon and Steelhead Restoration Plan (Ward and Kier 1999), which was prepared by Kier Associates.

In April 1997, DWR engineers met with staff from PG&E, DFG, USFWS, USBR, and other agencies to begin investigating fish passage solutions on Battle Creek. These investigations led to the development of three preliminary engineering technical reports on dam removal, power facilities reconfiguration, and fish facilities construction. The dam removal and power facilities reconfiguration reports were completed by USBR in May 2000, and the fish facility construction report was completed by DWR in May 2000. Preliminary designs are completed and have been sent to CALFED to support the restoration proposal. The environmental document, a Supplemental Environmental Impact Statement/Revised Environmental Impact Report (SEIS/REIR), went out for a 60-day public review; the comment period ended April 29, 2005 (EPA 2005). The final EIS/EIR will be approved in June 2005. The NEPA Record of Decision and CEQA Findings are scheduled to e approved in July 2005. The Federal Energy Regulatory Commission (FERC) Determination will be made between August and October 2005.

For further information, see Web site http://calwater.ca.gov/CBDA/AgendaItems_2-9-10-05/Presentation/Agenda_Item_10-4.pdf

In October 1998, USFWS Red Bluff Office began monitoring juvenile Chinook salmon and steelhead out-migration from the Battle Creek watershed. The monitoring is funded by the Comprehensive Assessment and Monitoring Program (USFWS 2001b). Snorkel counts of adult salmon and steelhead in various portions of the watershed were begun in 1996 and expanded to include spring-run and winter-run in 2001 (Jim Smith 16 Aug 2004 pers comm). The goal of the monitoring project is to obtain relative abundance and distribution data on Chinook salmon and steelhead in Battle Creek. [The information will be used to assess the suitability of the current habitat and provide baseline data to help evaluate restoration activities (Ward 1997). Counts of salmon and steelhead in the upstream ladder of the CNFH barrier weir will be used to monitor the success of Battle Creek restoration efforts (Kier Associates 2001).

Big Chico Creek, Butte County

Potential Impediments to Anadromous Fish Migration

Big Chico Creek has no major reservoirs, but has five small dams and three natural barriers that could impede anadromous fish migration. Four barriers do not have fish passage facilities, but fish are able to get past inadequate flow conditions.

One-mile Dam is managed by the city of Chico’s Park Department to create a public swimming pool in Bidwell Park during the summer. In winter, the park department installs a shorter flashboard structure to allow a fish ladder to operate. Winter flows deposit large amounts of gravel and debris in the pool area requiring additional maintenance and leaving the creek downstream from the dam depleted of gravel. In 1997 an Anadromous Fish Restoration Project (AFRP) was successfully completed that allowed creek flows to by-pass the pool during routine annual cleaning, preventing sediment and debris from being carried downstream and interfering with spawning gravels used by fall-run and late-fall run Chinook salmon and steelhead. The city of Chico carried on a sediment and benthic macroinvertebrate monitoring study to verify the success of this project. The project is functioning so well that USFWS reduced the City’s monitoring requirement (D. Beardsley 2004 Jul 30 pers comm). According to Paul Ward (2004 Jul 30 pers comm), One-mile Dam is currently more an issue of sediment accumulation and how to operate a swimming pool in a flowing stream.

At Five-Mile Dam, a 1963 US Army Corps of Engineers (USACE) flood control project split Big Chico Creek flood flows into three channels, Big Chico Creek, Sycamore, and Lindo Channel. Unfortunately, design of the flow control structures creates an upstream stilling basin during flood events. This causes gravel to fall out upstream of the diversion, creating a gravel bar that blocks the flow to Lindo Channel unless gravel is mechanically removed. Lindo Channel has often ceased to flow, sometimes trapping adults and downstream migrants several times during a single season (USFWS 1995).

The Iron Canyon fish ladder, built in the late 1950s for fish passage through Upper Bidwell Park, has been severely damaged, delaying or preventing upstream migration of adult spring-run salmon, which then must hold or even oversummer downstream of the ladder where temperatures, human harassment, and poaching are serious problems (USFWS 1995). In addition, altered hydraulics have made fish passage at Bear Hole, a natural constriction in the channel downstream of Iron Canyon, difficult at low flows. Repairing the fish ladder was given a medium priority ranking in the AFRP Final Restoration Plan. DWR's Northern District staff have recently completed an AFRP-funded technical analysis on the Iron Canyon fish ladder. The recommended solution is now being addressed in a grant proposal for a "value-engineering" analysis. In the meantime, DFG continues to monitor and make repairs as needed until a long-term solution is implemented (Ward 2004 Jul 28 pers comm). Projects given a high priority included: relocating and screening the M&T Ranch diversion; replenishing spawning gravel in reaches modified for flood control; repairing the Lindo Channel weir and fishway at Five-Mile Diversion; and improving cleaning procedures at One-Mile Pool (Ward 2004 Jul 28 pers comm).

Under certain high flow conditions fish can pass the major barriers, primarily the Iron Canyon barriers. Under normal and low flows the fish passage is more problematic (Ward 2004 Jul 28 pers comm).

General Description

Big Chico Creek begins around 6,000 feet elevation in the Lassen National Forest of the Cascade Range. It flows westerly about 45 miles to its confluence with the Sacramento River at RM 193. It drains about 72 square miles. Average annual discharge is 102,100 acre-feet (DFG 1965). Summer flows drop to an average of 30 cfs while flow during the winter averages more than 300 cfs (CH2MHill 1993).

Fish Populations

Historically and today, 24 miles of the creek are accessible to fall-run, late-fall run, and spring-run Chinook salmon, and Central Valley steelhead (NMFS 2000). Large boulders dislodged in the early 1900s blocked access beyond Iron Canyon at RM 14.2. In 1958 construction of a series of small fish ladders restored access. The primary adult holding area is in the reach upstream of Iron Canyon to Higgins Hole. Lower Big Chico Creek, Mud creek, and Lindo Channel are also used during winter months as non-natal rearing habitat for juvenile winter-run and spring-run Chinook salmon (Maslin and others 1999).

DFG has conducted spring-run Chinook salmon surveys periodically since 1956 (Figure 3-4). Sporadic surveys of adult holding areas have been conducted since 1986. Starting in 1992, annual snorkel surveys were made of the adult holding area from Iron Canyon to Higgins Hole. Juvenile out-migration is monitored from December through June by using fyke nets placed in the creek near the Five Mile Recreation Area (DFG 1998). Spring-run Chinook salmon populations have ranged from a high of 1,000 in 1958 to none in 1971, 1984, 1985, 1990, and 1992. In 2003 the population estimate was 81 fish. The average fish count during the time period of 1958–2003 was 95 (GrandTab, DFG, Red Bluff Office, contact Colleen Harvey Arrison, 2004).

Figure 3-4 Big Chico Creek spring-run Chinook salmon yearly population estimates

Average estimates for steelhead numbers in the 1950s and 1960s were about 150 in Big Chico Creek. Steelhead runs were much likely larger in Sacramento River tributaries before the 1900s (USFWS 1995).

Water Quality

Water quality in Big Chico Creek and Lindo Channel is degraded by cadmium, mercury, and other metals in mine drainage for the upper watershed and by runoff from the urban area. The urban area runoff typically consists of residual petroleum compounds, pesticides, solid pollutants, and other waste products that enter the creek via storm drains (Resources Agency 1989).

CSUC undertook an intensive fecal coliform study as a continuation of past studies on fecal coliform concentrations in Big Chico Creek. Currently, during the swim season (Memorial Day through Labor Day), coliform counts are taken twice daily downstream of Sycamore Pool. During the offseason, coliform counts are taken monthly. The City is also requiring water quality testing on drainage off of the Bidwell Municipal Golf Course (Beardsley 30 Jul 2004 pers comm).

During the summer, all of the flow remains in the main stem of Big Chico Creek. The flows in Lindo Channel and Mud Creek become intermittent (CH2MHill 1998). There is some evidence that temperatures in the summer holding reach for adult spring-run Chinook salmon, from Iron Canyon to Higgins Hole, may approach critical levels in late summer, particularly in low-flow years (USFWS 1995).

Hydrology

Mean monthly flows in Big Chico Creek from 1930 to 1986 are shown in Figure 3-5. Yearly peak flows occur in mid-February when flows reach 391 cfs. The lowest flows for the period of record occur during the summer and extend into the early fall months receiving flows as low as 25 cfs.

Figure 3-5 Mean monthly flows from 1930 to 1986 on Big Chico Creek near Chico in Butte County

DWR operates two streamflow gaging stations in Big Chico Creek from Bidwell Golf Course to Rose Avenue within the city limits. The golf course and Rose Avenue gaging stations have been collecting continuous records since 1997 and 1956, respectively (DWR 2001).

An AFRP funded and managed project to install gaging stations that provide real-time flow monitoring was undertaken in 1996. Big Chico Creek has one station, Antelope Creek two, Mill and Deer Creek each have three, and Butte Creek has eight.

Habitat Quality

Higgins Hole, the upstream limit of spring-run Chinook salmon, is the best summer holding habitat in Big Chico Creek. During the summer months, mean daily temperatures in the pools at Higgins Hole range from 64 °F to 68 °F.

For more information on water temperature data, go to http://www.nd.water.ca.gov/PPAs/SurfaceWater/index.cfm

A 1993 DFG survey concluded that habitat type quantity and quality, pool conditions, and riffle distribution from Five-Mile Dam to the mouth appeared suitable for juvenile salmonid occupation. Most of the land adjacent to the lower creek within the valley floor is developed for agriculture. The valley portions of Big Chico Creek support dense riparian vegetation (Brown 1996).

Habitat Data

DFG conducted stream habitat surveys from Five-Mile Dam to the mouth of Big Chico Creek in 1993 and 1994. A quantitative and qualitative study of physical habitat in Big Chico Creek from Five-Mile Dam to Higgins Hole upstream was conducted in 1994 by DFG and funded by DWR (Brown 1996).

DWR's Northern District office has performed a total watershed water quality analysis on Big Chico Creek from May 1997 through April 1999. The water samples collected were examined for coliform bacteria, minerals, nutrients, metals and suspended solids. A toxicology analysis was also performed to see if anything in the water was adversely affecting living organisms.

DWR has recorded water temperatures in Big Chico Creek since January 1993. There are eight thermographs in the creek starting at Big Chico Creek just upstream of the confluence with Mud Creek to Ponderosa Way. Field parameters such as dissolved oxygen, pH, electrical conductivity, turbidity, and alkalinity are also collected.

For information on surface water quality and temperature data, go to Web site: http://www.nd.water.ca.gov/PPAs/SurfaceWater/index.cfm

Riparian vegetation along Big Chico Creek was mapped between 1996 and 1998 by CSUC Geographic Information Center as part of the Sacramento River Stream Corridor Protection Program and is available from CSUC as an ArcView project file.

Fisheries and Restoration Projects

The Big Chico Creek watershed Alliance is leading an ongoing project committed to the overall preservation and restoration of the creek (Ward 1997). The project seeks to provide unimpeded migration for salmon and steelhead over a greater range of flow conditions (Ward 1997). DWR's Northern District has completed a preliminary engineering investigation for fish passage improvements at Iron Canyon and Bear Hole on Big Chico Creek funded through the USFWS-AFRP. The next step is to prepare an updated feasibility plan, select a tentative design and work plan, and prepare an updated cost analysis all to be funded by AFRP (C. Anderson 2004 Aug 11 pers comm).

The city of Chico has had concerns regarding the blockage of gravel flowing downstream, safety, and the costs of maintaining One-Mile Dam. As a result of these concerns, the city has investigated different options for the modification of the structure to enhance the passage of bed load and debris, fish passage, and to improve safety. The city retained the services of Borcalli and Associates to develop the most efficient alternative for modification of the dam. Borcalli and Associates recommended installation of an inflatable, steel dam that would raise and lower hinged steel gates with an inflatable bladder. This would involve little modification to the existing structure. The Park Department was seeking funding assistance for the project, estimated to cost $450,000, and had targeted construction for late summer and fall of

2002. Construction has been delayed and the city is still looking for additional funding.

The city of Chico completed a project in 1987 to restore the riparian habitat that was lost during floods in Lindo Channel, a tributary to Big Chico Creek. DWR funded a project on Big Chico Creek to enhance a 600-foot section of the creek in upper Bidwell Park. This project was completed December 31, 1994. In June 1994, the Streaminders of Chico completed a project to repair a 125-foot section of the creek that had been eroded (Ward 1997).

Other projects include a new pumping station built in 1997 to replace the old M&T pumps on Big Chico Creek. The One-Mile (Sycamore) Pool was modified in 1997 by the city of Chico to decrease downstream siltation and turbidity. The modification involved installing a bypass pipe around the pool to allow removal of bedload deposits (USFWS 1998).

Butte Creek, Butte, Sutter and Colusa Counties

Potential Impediments to Anadromous Fish Migration

The lower portion of Butte Creek consists of two subareas: the Sutter Bypass and Butte Sink. The East-West Diversion Weir and Weir #5 near the upstream end of the Sutter Bypass divide the flow of Butte Creek into the East Borrow Canal and West Borrow Canal. There are seven migration impediments in the Sutter Bypass, three of which have been rebuilt and are no longer impediments. East-West Diversion, Weir #2, and Willow Slough are on the east side. East-West Diversion has been rebuilt and is no longer a problem. Weir #2 and Willow Slough will probably be rebuilt in the next several years. On the west side there are Weir #5 (rebuilt), Weir #3 (rebuilt), and the Guisti Weir and Weir #1 (currently under planning for either removal or modification) (Ward 2004 Aug 11 pers comm).

Many channels in the Butte Sink subarea route water through rich farmlands and private duck clubs. The subarea has 13 migration impediments, including eight in Butte Creek, 3 in Cherokee Canal, and 2 in Sanborn Slough. In Sanborn Slough the bifurcation structure and mile-long canal structure have been rebuilt. In the southeast part of Butte Sink, the North, End and Morton Weir complex have been rebuilt, and the Tarke and 833 outfalls are currently being rebuilt. In the northwest part of Butte Sink and the main portion of Butte Creek, the Drumheller Slough structure has been rebuilt, and the White Mallard structure and associated diversion will be replaced in the next several years (Ward 2004 Aug 11 pers comm).

To find out more about the many AFRP ongoing projects in the Butte Creek watershed visit http://www.delta.dfg.ca.gov/afrp/ws_projects.asp?code=BUTTC

There are also several impediments upstream of Highway 99, including Quartz Bowl Falls (a natural barrier) and the Centerville Diversion Dam. A multi-agency team conducted a cursory technical review of impediments upstream of Highway 99. The team concluded that natural barriers starting with the Quartz Bowl barrier and five that are equal to or larger in the immediate vicinity of the PG&E Centerville Head Dam, would block upstream migration of salmon and steelhead.

DFG also concluded that salmon and steelhead did not get upstream of the Quartz Bowl Falls on a regular basis. In about 25 years of conducting surveys, DFG has seen salmon in the reach between Quartz Bowl Falls and Centerville Head Dam about 3 times. They occurred when spring flows were greater than 2000 cfs. (Ward 2004 Aug 12 pers comm).

General Description

Butte Creek originates at more than 7,000 feet elevation along the western slope between the Cascade Range and the Sierra Nevada. It meanders southwesterly about 89 miles, flowing into the Sacramento River at two points: through the Butte Slough Outfall flap gates at RM 139 and through the Sutter Bypass at RM 80. The upper watershed encompasses about 150 square miles (AFRP Butte Creek Watershed Data Sheet).

Butte Creek is a complex system with water imports from other sources, agricultural diversions, and agricultural return flows. Beneficial uses include hydroelectric generation, irrigation, water transport, gravel extraction, gold mining, recreation, fishing, waterfowl habitat, salmon production, and flood bypass. Fish passage through the Butte Creek system is affected by about 22 major structures (most have been rebuilt) and 60-80 minor structures, mainly small pump diversions (Ward 2004 Aug 12 pers comm).

Fish Populations

Butte Creek is currently one of the most productive spring-run salmon streams in the Sacramento Valley. The adult spring-run fish migrate up the Sutter Bypass and into Butte Creek, navigating past numerous diversions to spawning areas in the upper Butte Creek system (Jones and Stokes 1998). As mentioned above, DFG believes that spring-run Chinook salmon rarely get upstream of Quartz Bowl Falls located about a mile downstream Centerville Head Dam near DeSabla Powerhouse (Ward 2004 Aug 12 pers comm). Steelhead have been reported as being restricted to the lower reaches of the canyon and tributaries such as Dry Creek (McEwan and Jackson 1996) but are now said to be seen as far upstream as salmon (Ward 2004 Sep 3 pers comm). Historically, some spring-run Chinook salmon and Central Valley steelhead may have spawned in reaches farther upstream. However, DFG believes that it is unlikely that salmon and steelhead ever got past the 5 major barriers immediately upstream of the Centerville Head Dam, and the 40–50 others between that point and Butte Meadows (Ward 2004 Aug 12 pers comm). Today, about 53 miles of the creek are accessible to fall-run, late-fall run, and spring-run Chinook salmon and Central Valley steelhead (NMFS 2000).

Since 1993, DFG has performed adult spring-run snorkel studies once a year between Centerville Head Dam and the Parrott-Phelan Diversion Dam. Since and including the 2001 spawning season, carcass surveys have also been completed in this same reach. Holding adult spring-run salmon are counted between mid-July and late August. Spring-run population estimates based upon snorkel surveys have ranged from a high of 20,259 in 1998 to a low of 10 in 1979 (Figure 3-6). The 2003 population estimate using snorkel surveys alone was 4,398 fish. The yearly average spring-run Chinook numbers from the years 1960–2003 were 2,156 fish (GrandTab, DFG, Red Bluff Office, contact Colleen Harvey Arrison, 2004).

Figure 3-6 Butte Creek spring-run Chinook salmon yearly population estimates

DFG has been evaluating spring-run data collected during snorkel surveys in Butte, Deer, and Mill Creeks and since 2001, carcass surveys in Butte Creek as well (Table 3-7). During 2002 there were an estimated 3,431 fish that died prior to spawning. Thus the total estimated 2002 escapement was about 16,028 as compared to the snorkel estimate of 8,785. An estimated 11,231 spring-run Chinook died before spawning in 2003. Adding that number to the 6,063 spawner carcasses counted, there were approximately 17,294 spring-run counted compared to 4,398 from snorkel surveys alone. Because in both years some mortalities had occurred prior to the snorkel surveys, comparisons are at best difficult, but the carcass surveys are probably a more precise estimate of the actual population. Based upon the present comparison of carcass survey numbers to snorkel survey numbers, the snorkel surveys appear to be considerably underestimating spring-run numbers. DFG will be evaluating survey techniques in an effort to secure more accurate escapement numbers for spring-run salmon in the future (Ward 2004 Aug 16 pers comm).

Table 3-7 Butte Creek spring-run Chinook salmon escapement estimates comparing snorkel surveys and spawning surveys (carcass survey)

Fall-run counts were conducted sporadically from 1965 to 2003 (Figure 3-7). The low and high fish counts during the 1995 to 2003 time frame were 445 (1995) and 3415 (2002), respectively. The average fall-run Chinook count during the same time period (1995-2003) was 1,383 (GrandTab, DFG, Red Bluff Office, contact Colleen Harvey Arrison, 2004).

Figure 3-7 Butte Creek fall-run Chinook salmon yearly population estimates

In 1995, a study began to monitor downstream migrating juvenile spring-run Chinook salmon in Butte Creek. Critical information obtained includes time of emergence, instream rearing and emigration patterns, size at emigration, duration of emigration, and a measure of relative abundance. Baseline data on ocean harvest, inland escapement, straying rates, age-structure, and genetic integrity data. An additional purpose of the study is to code wire tag as many spring-run juvenile salmon as possible so that growth and timing can be monitored as juveniles move downstream (DFG 1998). Data on temperature, holding patterns, spawning patterns, spawning capacity, and pre-spawn mortalities are reported in Hill and Webber (1999), Ward and others (2004a, 2004b, 2004c, 2004d, and 2004e).

Water Quality

Water quality conditions affect survival and growth of juvenile Chinook salmon rearing and migration through Butte Sink. Water temperature and dissolved oxygen are the primary water quality concerns. Given the generally shallow water depth, less than 4 feet during controlled conditions, and the flow-through nature of the system, dissolved oxygen is not expected to be a concern. Temperature, especially extremes, on the other hand, can have direct and indirect negative effects on the different life stages from egg through spawning adult (Boles 1998). Water temperatures during the period when flows are managed and juvenile Chinook salmon is present, October through 15 January, are likely near optimal ranges. Water temperature could be a concern during both the month of October and in late spring (see Jones and Stokes 1999 California State University Chico [1998] and Ward and others [2004d] for additional discussion of temperature data and effects specific to Butte Creek).

Potential agriculture contaminants enter the stream with irrigation return water that is unmonitored. Increased agricultural return to the total flow during the diversion season can increase the effects of contaminants on fish (USFWS 2000).

Hydrology

Butte Creek is perennial, with peaks in streamflow during storms and spring runoff. Instream flows downstream of Gorrill Dam during irrigation season, between mid-July and September, are typically less, with flows in the range of 5 to 25 cfs in most years (CH2MHill 1996).

The hydrology of lower Butte Creek varies substantially (Jones and Stokes 1998). During winter and spring of wet years, the Butte Sink and Sutter Bypass are flooded most of the time. During dry years, waterflows are low. Water imported from the Sacramento and Feather Rivers substantially augments natural flows during dry years (Jones and Stokes 1998).

Flows from the gage station near Chico show mean monthly flows from 1930 to 2000 (Figure 3-8). It should be noted that diversions from the west branch of the Feather River are included in the station near Chico. For example, since 1931 the total annual average volume at the gage has been about 289,000 acre-feet of which about 47,000 acre-feet (16 percent) was from the west branch of the Feather (DWR 1993). Peak flow occurs during mid-February at 826 cfs and the lowest flows throughout the year occur in September at 119 cfs.

Figure 3-8 Mean monthly flow from 1930 to 2000 on Butte Creek near Chico in Butte County

DWR operates eight streamflow-gaging stations on Butte Creek. The stations are between Durham and the Sacramento Slough near Karnak, and have been taking continuous recorded records since 1958. DWR also operates a gage at the Parrott-Phelan Diversion and at the Toadtown diversion (BW12) from the west branch of the Feather. Streamflow data can be accessed through California Data Exchange Center (CDEC) (DWR 2001).

California Data Exchange Center is online at http://cdec.water.ca.gov/

Habitat Quality

Habitat in the Butte Creek system is complex and varies by time and place. The reach between the Centerville Head Dam and the Centerville Powerhouse is relatively remote and has deeply incised canyons and deep spring-fed pools that provide the best summer adult holding potential on the entire creek (DFG 1998).

The reach from the Centerville Powerhouse down to Parrot-Phelan Dam has undergone and continues to undergo significant residential development. The reach contains the remainder of the summer adult holding habitat and most of the potential spawning habitat for spring-run fish (DFG 1998).

Agriculture has heavily impacted the valley reach from Parrot-Phelan Diversion to the Butte Sink. Within this reach, the Western Canal Water District has conveyed Feather River water into and across Butte Creek. Levee installation, maintenance, and repair have altered natural stream processes such as channel meander and have affected riparian vegetation. Downstream of Highway 162, return agriculture drainage flows into Butte

Creek, which may detrimentally affect migration and water quality (DFG 1998).

The Butte Sink area is between the Gridley-Colusa Highway and Butte Slough Outfall gates on the Sacramento River south of Colusa. Within the Butte Sink, duck clubs and agriculture divert and reroute flows. Additionally, major drains and flood overflows converge into the Butte Sink and alter water quality and attraction flows that detrimentally affect migration and rearing of salmon (DFG 1998).

In the Sutter Bypass, flows are regulated through the Butte Slough Outfall gates about 5 miles south of Colusa, to accommodate both flood control and agriculture. There are various flow control structures that directly impact both migrating adults and migrating and rearing juvenile spring-run salmon (DFG 1998).

Habitat Data

DWR has measured water temperatures in Butte Creek since September 1994. There are thermographs at 12 locations from the Sutter Bypass to upstream of DeSabla Powerhouse. Water temperature data can be accessed through CDEC. Field parameters such as dissolved oxygen, pH, electrical conductivity, turbidity, and alkalinity are also collected. DFG and PG&E are currently implementing a very intensive investigation of water temperatures in the holding and spawning reach upstream of Parrott-Phelan Diversion (Ward and others 2004d).

DWR's Northern District office started a comprehensive watershed water quality analysis of Butte Creek in October 2000 that commenced until March 2002. Water samples were collected on Butte Creek at 12 locations from Sutter Bypass to upstream of DeSabla Powerhouse and an additional 3 locations on Little Butte Creek downstream of Magalia Dam. The water samples were analyzed for coliform bacteria, minerals, nutrients, metals and suspended solids. Benthic macroinvertebrate samples were taken in appropriate riffle areas throughout Butte Creek as well as particle size distribution analysis. Toxicology analyses were also performed to see if anything in the water was adversely affecting living organisms.

For more information regarding this study, contact Jerry Boles or Scott McReynolds at DWR Northern District, (530) 529-7300.

Riparian vegetation along Butte Creek was mapped between 1996 and 1998 by CSUC Geographic Information Center as part of the Sacramento River Stream Corridor Protection Program and is available from CSUC as an ArcView project file.

Additional data, including temperature and flow data, on Butte Creek can be obtained at http://cdec.water.ca.gov/cgi-progs/staMeta?station_id=BCK.

Fisheries and Restoration Projects

There are fish passage problems at diversion dams and pumping sites throughout the Butte Creek system, and several agencies and water districts have been working to restore the creek's salmon populations while preserving the integrity of the water users' operations. The Western Canal Water District led a project to restore unimpeded fish passage through the middle reaches of the main stem of Butte Creek. As a result, five diversion dams were removed: Western Canal Main Dam, Western Canal East Channel Dam, Point Four Dam, McGowan Dam, and McPherrin Dam.

In the early 1990s, DFG led a multi-agency effort in cooperation with landowners that led to several structural improvements in the Butte Creek system. In 1994, DFG designed and inspected construction of a fish screen at Parrott-Phelan Diversion Dam. In 1995, DFG completed preliminary designs and DWR prepared final designs and with DFG inspected construction of a pool and chute fish ladder at the PPDD. DWR then completed preliminary engineering designs for new fish ladders and fish screens at Durham Mutual, Adams, and Gorrill Diversion Dams. Fish ladders and screens were constructed at those three sites in 1997. DWR also completed a preliminary engineering investigation of fish passage and flow control improvements at the Sanborn Slough/Butte Creek Bifurcation Structure near Gridley. The flow control and fish ladder structure was constructed in 1999.

DWR plans to conduct preliminary engineering investigations for additional sites in the creek system, including pumping plants along the east side of the Sutter Bypass. Design and construction of fish screens at the three pumping plants are part of the Lower Butte Creek Project, a multifaceted plan to improve fish passage through the Lower Butte Creek system. The LBCP is being coordinated by Ducks Unlimited, and with various private consulting firms working on flow improvements and designs at several structures. DWR's Northern District office began a two-year watershed analysis on Butte Creek in 2002 to evaluate water quality, determine suitability of the aquatic habitat to support aquatic species, and determine the suitability of the water to support beneficial uses. It will also establish baseline conditions to gauge effectiveness of restoration.

Clear Creek, Shasta County

Potential Impediments to Anadromous Fish Migration

Whiskeytown Dam and reservoir, with a capacity of 241,000 acre-feet, stores natural creek flows and water diverted from the Trinity River at Lewiston Dam through the Clear Creek Tunnel (DWR 1986). Whiskeytown Dam is impassible, making it the upstream limit of anadromous fish migration.

Saeltzer Dam on Clear Creek was removed in November 2000. It was downstream from Whiskeytown Dam and 6 miles upstream of the confluence with the Sacramento River. Along with reduced flow, it limited anadromous species in the creek. A sheet piling dam, constructed by the USBR to protect the Anderson-Cottonwood Irrigation District Canal's inverted siphon, still remains but is not considered a barrier to fish passage. Even though it appears as a potential barrier, it does not appear to significantly hinder fish passage due to the stepped spillway in the center combined with a deep plunge pool (DWR 1986).

General Description

Clear Creek, the first major natural tributary to the Sacramento River downstream of Shasta Dam, originates in the Trinity Mountains west of Shasta Lake about 3,000 feet elevation. It flows southeasterly about 50 miles to its confluence with the Sacramento River at RM 289, south of Redding. It drains roughly 238 square miles. The average annual yield in Clear Creek before 1963 was 302,000 acre-feet. Since the construction of Whiskeytown

Dam in 1963, the average annual yield in Clear Creek averaged 112,000 acre-feet, a 63 percent reduction in flow (North State Resources 1999).

Fish Populations

Historically, 25 miles of the creek were accessible to fall-run and late-fall run Chinook salmon, and Central Valley steelhead (NMFS 2000). Spring-run Chinook salmon probably migrated to the uppermost reaches. Azevedo and Parkhurst (1958) mentioned seeing spring-run salmon in 1956 for the first time since 1949, but gave no estimate of the population size (DFG 1998). Steelhead have been reported in Clear Creek downstream of Saeltzer Dam. However, the creek has not been surveyed for spawning adults; therefore, the status is unknown (McEwan and Jackson 1996). After the construction of Whiskeytown and Saeltzer Dams, only 6 miles of the creek were accessible to fall-run and late-fall run Chinook salmon (NMFS 2000). However, with the removal of Saeltzer Dam, approximately 10 more miles of habitat are now available.

DFG has conducted fall-run Chinook salmon carcass tag and recapture studies since 1953. The surveys have been conducted within the major spawning areas from Saeltzer Dam to about 4 miles downstream. Fall-run spawning populations have ranged from a high of 16,071 fish in 2002 to a low of 60 fish in 1978 (Figure 3-9). The average fall-run Chinook salmon population from the year 1953 to year 2003 (not all years included in survey) was 3,569 (GrandTab, DFG, Red Bluff Office, Contact Colleen Harvey Arrison, 2004).

Figure 3-9 Clear Creek fall-run Chinook salmon yearly population estimates

Late-fall run Chinook salmon surveys were conducted in 1982 and 1984, yielding fish counts of 875 and 200, respectively. No spring-run Chinook salmon were found during a survey conducted from 1963-1966, and 1968-1969. From 1993–1995 there were 1, 0, and 2 spring-run Chinook salmon counted, respectively. A survey in 1998 counted 47 spawning spring-run Chinook, and a survey in 2003 found 25 spawning spring-run Chinook (GrandTab, DFG, Red Bluff Office, Contact Colleen Harvey Arrison, 2004).

Water Quality

In the past, water temperatures during late spring and summer were often life threatening for salmon and steelhead rearing in the lower portion of Clear Creek, between the former Saeltzer Dam site and the Sacramento River. When releases from Whiskeytown Dam were 50 cfs, water temperatures commonly reached a maximum of 75 °F, a lethal level for salmonids (North State Resources 1999). Under the Interim Biological Opinion for spring-run Chinook salmon and steelhead (20 Sep 2002), NMFS requires the USBR to meet summer water temperature criteria at the IGO gage to support steelhead and spring-run Chinook. The criteria are 60 °F from June through September 15 and 56 °F from September 15 through October 31 (Tucker 2004 pers comm).

USBR is required to meet these criteria under the Biological Opinion for the Central Valley Project. NMFS works closely with USFWS and USBR to ensure those criteria are met (Brown 2004 pers comm).

Hydrology

The completion of Whiskeytown Dam and the operation of the USBR facilities have significantly altered the hydrology of Clear Creek. Instream flow has been dramatically reduced from historical flow regimes, especially from winter through spring. The recommended releases from Whiskeytown Dam to Clear Creek are 200 cfs from October to April and 150 cfs for the rest of the year with variable springtime releases depending on water-year type (North State Resources 1999).

Monthly mean flow on Clear Creek near French Gulch is 211 cfs (Figure 3-10). Flows during the summer become exceptionally low, down to 15 cfs. The highest flows during the year for this gage station are during the winter when flows reach a mean 543 cfs for period of record.

Figure 3-10 Mean monthly flows from 1950 to 1993 on Clear Creek near Idria

USGS operates a streamflow gaging station on Clear Creek near IGO. The station has been in place since September 1940 (USGS 2001).

Habitat Quality

Riparian habitat along Clear Creek has been significantly affected by gold dredging, gravel extraction, water diversion, and flow regulation. These impacts include removal of some riparian forests, alteration of floodplain morphology by mining, and encroachment of riparian vegetation into the low-flow stream channel due to flow regulation. On floodplain surfaces, the existing riparian vegetation occurs between large tailing piles and other landscapes disturbed by historical gold and gravel mining (North State Resources 1999).

Clear Creek has also experienced fishery habitat degradation, including sedimentation from decomposed granite sand, removal of spawning gravel by gravel mining, and gravel trapped behind Whiskeytown Dam. A gravel recruitment/replenishment program has been implemented by the Western Shasta Resource Conservation District (WSRCD) to replace the lost recruitment and removed spawning gravel. Three locations have been used for the Clear Creek gravel augmentation: (1) just downstream of Whiskeytown Dam, (2) at the Placer Road Bridge, and (3) downstream of the former Saeltzer Dam. A total of 85,000 tons of gravel have been injected into Clear Creek since 1996, according to Michael Harris of the Western Shasta Resource Conservation District in Redding. The suitability of gravel in Clear Creek for salmon spawning was investigated in 1965 and 1982. The quality of Clear Creek spawning gravel has declined markedly since 1965. In 1982, 13 riffles downstream of Saeltzer Dam and five riffles upstream were surveyed, and size composition of streambed samples was analyzed. None of the samples taken in 1982 met DFG criteria for suitable spawning gravel, whereas 75 percent of those taken in 1965 met the criteria (DWR 1986).

Coordinated efforts to restore a mined area on public lands within the lower Clear Creek watershed (downstream of Whiskeytown Dam) have been implemented through the Hubbard Mine Reclamation Project. The purpose of this project is to increase healthy spawning areas for salmonids by reducing sedimentation (Ward 1997).

Habitat Data

DWR has recorded stream temperatures near the Redding Wastewater Treatment Plant at RM 0.3 since 1993. DWR installed additional thermographs at the Saeltzer Dam site, RM 6, and the ACID siphon, RM 1.2, in October 1995. DFG installed a thermograph near the Placer Road Crossing, RM 10.4, in October 1995. From September 1991 through May 1995, DFG maintained seasonal thermographs near both the Placer Road Crossing and at the National Environmental Education Camp (Brown 1995).

DWR's Northern District office performed a total watershed water quality analysis on Clear Creek from October 1997 through August 1999. The water samples collected were examined for coliform bacteria, minerals, nutrients, metals, and suspended solids. A toxicology analysis was also performed to see if anything in the water was adversely affecting living organisms.

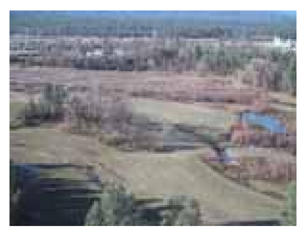
The USFWS conducted stream width surveys during varying flow releases in 1995. Portions of Clear Creek that include the primary spawning areas for salmon were surveyed on foot in September, October, and November 1995. Flows at IGO were 72, 99, and 144 cfs respectively. Stream width measurements were made, photographs were taken, and the number and condition of salmon were visually estimated (Brown 1995).

Riparian vegetation along Clear Creek was mapped between 1996 and 1998 by CSUC Geographic Information Center as part of the Sacramento River Stream Corridor Protection Program and is available from CSUC as an ArcView project file.

Fisheries and Restoration Projects

The Saeltzer Dam Fish Passage and Flow Protection Project, led by USBR, increased and improved anadromous fish habitat in Clear Creek. Saeltzer Dam, a 15-foot-high by 200-foot-long concrete diversion dam at RM 6.2 and built in 1903, was demolished in November 2000. Elimination of the dam opened up 10 miles of cold-water habitat downstream of Whiskeytown Dam. Increased flow releases from Whiskeytown Dam will improve water quality and temperature conditions in the creek (North State Resources 1999).

There have been several recent projects in the Clear Creek watershed. The Lower Clear Creek Floodway Rehabilitation Project (Photo 3-1 and 3-2) is a three-phase project. Two phases of the project are complete, and an annual monitoring program for avian, geomorphic, and riparian revegetation is under way. Additional funds are being requested from CALFED for the final phase of construction. To date, 1.8 miles of the Lower Clear Creek channel have been rehabilitated. As a result, the number of fall-run Chinook salmon returning to Lower Clear Creek each year have increased from 2,546 in 1994 to 16,071 in 2002 and more than 10,000 in 2003.



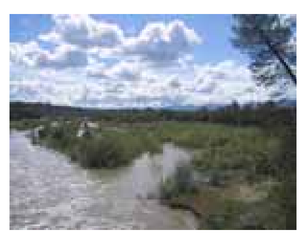


Photo 3-1 and 3-2 The Lower Clear Creek Floodway Rehabilitation overview (top photo) and the new floodplain at work/

The Lower Clear Creek Vegetation Management project, led by WSRCD, was started January 1, 1996, and is expected to continue. It is a coordinated effort to protect the Lower Clear Creek watershed and inhabitants from wildfire and promote a healthy ecosystem. Another ongoing habitat restoration project is the Spawning Gravel Injection project, also led by WSRCD. It started in January 1996. WSRCD led the Hubbard Mine

Reclamation project, completed in April 1998. It restored upland areas and reduced erosion (Ward 1997).

Channel and habitat restoration efforts along Lower Clear Creek will now be reviewed by the Lower Clear Creek Adaptive Management Forum. The forum, initiated by the USFWS AFRP and CALFED, require that currently funded restoration projects on Lower Clear Creek downstream of Whiskeytown Dam include adaptive management in their design schemes. Forum members met with the Lower Clear Creek Restoration Team in April 2002, and published the Lower Clear Creek Adaptive Management Forum Report (2003) summarizing the comments and recommendations of the Panel.

The Lower Clear Creek Adaptive Management Forum Report can be found at http://www.delta.dfg.ca.gov/afrp/documents/ClearCrkAMF.pdf.

Deer Creek, Tehama County

Potential Impediments to Anadromous Fish Migration

Deer Creek has five physical barriers in the lower portions of the watershed. The Stanford-Vina Ranch Diversion Dam and the Cone-Kimball Diversion Dam supply water to the Stanford-Vina Ranch Irrigation Company. The North Main Diversion Canal passes 20 cfs north; the south diversion canal carries about 50 cfs. The Cone-Kimball diversion passes 5 cfs, the equivalent of 10 acre-feet per day. The Deer Creek Irrigation Company Dam provides water to the Deer Creek Irrigation District, which supplies irrigation water to 1,785 acres, primarily almond and walnut orchards. The district's average diversion rate for the month of June is 29 cfs. The last barrier is a canal (Deer Creek Watershed Conservancy 1998). Historically these water diversions caused instream flows to decrease to such a level as to block access for late-migrating adults.

General Description

Deer Creek watershed is one of three sub-watersheds in the Lassen National Forest whose headwaters originate near Lassen Peak in the southernmost extension of the Cascade Mountains. The upper Deer Creek watershed has streams with moderate to steep slopes adjacent to the main channels and is essentially long and narrow. Elevations range from 7,866 feet at the Butt Mountain summit to 340 feet at its confluence with Sacramento River. Forty percent of the basin lies above 4,000 feet, which accounts for the high potential for snowpack accumulation and spring snowmelt runoff. Annual precipitation ranges from 70 inches in the upper watershed (5,272 feet MSL at Wilson Lake) to 20 inches on the valley floor near the Sacramento River confluence (175 feet MSL). The climate is Mediterranean in nature. Winters are cool and wet. Summers are long, hot and dry. Vegetation ranges from sub-alpine fir forests at the highest elevations, blending into mixed confer forests as elevation decreases. The foothills support oak and pine species. Irrigated agricultural practices are the primary land use on the lowest elevations.

Soils are primarily andesitic and rhyolitic in nature and are disposed to episodic failures triggered by extreme precipitation events (Almanor Ranger District Lassen National Forest 2000). Mass wasting occurs in various places throughout the watershed especially where rhyolitic soils are prevalent.

The upper reaches of the watershed are relatively difficult to access and, because of the unstable nature of the soils, have remained in a more or less natural state. Land use around Lassen National Park is gradually changing, however, and impacts from roads, grazing, logging, and recreation are taking their toll. Other factors causing concern are downstream ranching, other agricultural pursuits, and urbanization. As population increases conversion from agriculture to residential uses is likely to increase as well. However, unlike most watersheds in the Sacramento Valley, headwater stream habitat in the drainages around Mount Lassen is relatively undisturbed. Deer Creek has 25 miles of accessible anadromous fish habitat within the Lassen National Forest, which owns 53 percent of Deer Creek. Its 13 sub-watersheds total 146,611 acres and drain 208 square miles. The watershed length is 60 miles (Almanor Ranger District Lassen National Forest 2000).

The Deer Creek watershed, along with the Mill Creek watershed are said to contain wildlife populations and habitats of State and possibly national significance (Sato and England 1988 as reported in Almanor Ranger District Lassen National Forest 2000). Fish populations include Central Valley spring-run Chinook salmon (listed as both State and federally threatened) and Central Valley steelhead (listed as federally threatened). The Deer Creek watershed, along with the Mill Creek watershed, support naturally spawning populations of Central Valley steelhead and Chinook salmon and are considered “anchors” for the successful recovery of both of these species in the Sacramento River drainage (Almanor Ranger District Lassen National Forest 2000).

Fish Populations

Deer Creek continues to support its historical fishery assemblages and is, along with Mill and Antelope creeks, “considered essential for the recovery and perpetuation of wild stocks of spring-run Chinook salmon or winter-run steelhead in the Central Valley” (Reynolds and others 1993; McEwan and Jackson 1996 as reported in Almanor Ranger District Lassen National Forest 2000) due to general good watershed health and available habitat. In addition, the native, nonanadromous fish fauna is quite extensive, especially in the Lower Canyon Reach. Nonetheless, natural events such as mass wasting and anthropogenic activities such as road construction, timber extraction, water diversions, grazing, wild fire management, and other activities have severely limited current fisheries stocks in Deer Creek and adjacent watersheds.

Spring-run Chinook salmon. There are no historical accounts of spring-run escapement numbers in the Central Valley. Estimates were made early on by DFG using fishery records of the commercial gill net catch and upstream spawning estimates and by evaluating carrying capacity in streams supporting wild runs. From this data, DFG estimated that 170,000 spring-run used the Sacramento River system and 100,000 spring-run used the San Joaquin systems in 1850 (DFG 1982). Spring-run escapement numbers have since been generated between 1947 and the present. Today spring-run populations are only found in Battle Creek, Butte Creek, Mill Creek, and Deer Creek with occasional remnant populations using Big Chico, Cottonwood, and Antelope creeks (Yoshiyama and others 1996). Spring-run

Chinook populations are surviving in Deer Creek primarily because of the excellent habitat. The upper canyon area downstream of the Upper Falls to Highway 32 Bridge is prime holding and spawning habitat. Twenty-five percent of the total adult spring-run in the Deer Creek watershed hold in this reach (Colleen Harvey Arrison 1997 as reported by DCWC). Water quality is excellent and although temperatures occasionally rise above acceptable limits, Elam Creek and possibly other tributaries may be important sources of cooler water (Deer Creek Watershed Conservancy 1998c). Lassen National Forest Almanor Range District has been conducting snorkel surveys on Deer Creek since 1992. Data recorded on spring-run counts for Deer Creek are presented in Figure 3-11.

Figure 3-11 Deer Creek spring-run Chinook salmon yearly population estimates

The Comprehensive Assessment and Monitoring Program Annual Report for 2000 reported estimates of natural spring-run production for three creeks and the Sacramento River for 1995 through 2000. Deer Creek estimated natural production for 1995 was 5,342, just under a third of the estimated total natural production. The CAMP total estimated natural production for 2000 was 10, 935. The Deer Creek estimated natural production for 2000 was 1,255 or 11 percent of the total estimated natural production.

Central Valley steelhead. Historically, Central Valley streams supported a total run size of approximately 40,000 adults, three-quarters of which were using the Sacramento River system upstream of the Feather River confluence (Almanor Ranger District Lassen National Forest 2000). DFG in 1996 estimated that the population may have been less than 10,000 fish. During the same inventory year, NMFS (1996 as reported in Almanor Ranger District Lassen National Forest 2000) estimated that population numbers may have been as low as 4,000 (Almanor Ranger District Lassen National Forest 2000).

Fall-run and late-fall run Chinook salmon. Fall-run and occasionally late-fall run Chinook utilize and are found in small numbers in Deer Creek. The fall-run migrate into the watershed between October and December with peak run occurring in early November (Almanor Ranger District Lassen National Forest 2000). Fall-run are known to spawn in the lower portions of the Lower Canyon (Deer Creek Watershed Conservancy 1998c). Late-fall run Chinook migrate into the Sacramento River between mid-October and mid-April. Spawning takes place from January through mid-April (DFG 1993 as reported in Almanor Ranger District Lassen National Forest 2000).

Colleen Harvey Arrison reported in the Deer Creek Watershed Management Plan, Existing Conditions Report that according to the best available GrandTab data from the last 20 years for Deer Creek spring-run and fall-run Chinook salmon and steelhead, adult returns have been consistently lower than historical levels (Deer Creek Watershed Conservancy 1998). Historically, there were 2,000 to 4,000 spring-run, up to 12,000 fall-run, and 1,000 steelhead in Deer Creek. In 1997, GrandTab counts were less than 2,000 spring-run, 500 fall-run, and several hundred steelhead. In its Existing Conditions Report (1998) the Deer Creek Watershed Conservancy (DCWC) wrote that DFG and Reynolds and others (1993) believe that Deer Creek supports all four runs of Chinook salmon.

Water Quality

DWR maintains a station at Highway 99 on Deer Creek that measures surface water quality. The station has been in operation since 1952 and is still operating. In an Existing Conditions Report the Deer Creek Watershed Conservancy Habitat Restoration Group prepared a chapter on Deer Creek Surface Water Quality in 1997 that reviewed data collected by the station from 1988 to the present.

Information in the DWR database can be found at http://deercreekconservancy.com/CHAP7.0/7waterquality.doc.

Generally speaking, the canyon reaches, upstream of the USGS gage, have excellent water quality (Roby 2005 Apr pers comm). Nutrient values measured during the period of record in general fell below US Environmental Protection Agency freshwater aquatic life maximum contaminant levels for ammonia and organic nitrogen as well as dissolved nitrite, nitrate, ammonia, dissolved orthophosphate, and total phosphorus. Mineral concentrations usually measured by the Central Valley Regional Water Quality Control Board were found to be acceptable for all stated beneficial uses. Minor elements (arsenic and copper) were well below established water quality standards.

The standard water quality field measurements, dissolved oxygen, pH, conductivity, alkalinity, and turbidity were all within acceptable limits (Deer Creek Watershed Conservancy 1997).

The greatest source of water quality inputs in the canyon reaches results from the unstable sloughing of andesite/basalt soil complexes on canyon shelves and walls resulting in debris flows. Erosion naturally occurs off the bed, banks, and inner gorge slopes. Sloughing is also a result of land use disturbances from roads, landings, and skid trails. A road inventory undertaken by the Almanor Ranger District of Lassen National Forest discovered that 70 percent of the erosion was caused by only 5 percent of the road segments. Ken Roby, a fisheries biologist with the Almanor Ranger District, indicated (2005 Apr pers comm) that the district has been focusing its work on repairs to that 5 percent of sites causing the greatest amount of problems. The valley reach has inputs from agricultural and other anthropogenic activities.

Hydrology

Deer Creek drains approximately 208 square miles (Kondolf 1997 as reported in Deer Creek Watershed Conservancy 1998). The average flow passed is 317 cfs. The high annual mean is 700 cfs; the low annual mean is 86.2 cfs. The average annual runoff for the years between 1912 and 1995 was 230,500 acre-feet as measured by the USGS Gage (#11383500) operating in Deer Creek near Vina (Deer Creek Watershed Conservancy 1998a). This location is 9 miles upstream of the confluence with the Sacramento River and is close to the mouth of the canyon. Mean monthly flow as recorded from this gage can be seen on Figure 3-12.

Figure 3-12 Mean monthly flows from 1912 to 1995 on Deer Creek near Vina, Tehama County

During the 5-month period from November to March, 76 percent of the total annual average precipitation occurs. Peak precipitation occurs between December and January (Deer Creek Watershed Conservancy 1998b). The watershed has no reservoirs or large diversions upstream of the Vina gage.

There are three major diversions on the Creek downstream of the Canyon mouth. The maximum flow, recorded on December 10, 1937, for the period of record is 23,800 cfs. The minimum flow, recorded on December 13, 1932, was 43 cfs (Deer Creek Watershed Conservancy 1998).

Habitat Quality

As discussed earlier, the Deer Creek watershed has the greatest amount of high quality spring-run Chinook salmon habitat in the Sacramento and San Joaquin River drainages. It is inaccessible for most of its length and provides excellent spawning and rearing habitat.

The DCWC divides Deer Creek into seven reaches. The Butt Mountain Reach is 2.25 miles in length and extends from the head waters to Deer Creek Meadows. This reach of creek flows through steep, narrow canyons and over large boulders. Rainbow trout are the only fish observed in this reach (Sato and Moyle 1988 as reported by Deer Creek Watershed Conservancy 1998c). The Deer Creek Meadows Reach, next downstream, extends a distance of 4.0 miles. Deer Creek Meadows to the east is characterized by andesitic soils. Gurnsey Creek to the west contains rhyolitic soils that are highly erodible. The only salmonids present are rainbow trout and brown trout to a lesser degree (Deer Creek Watershed Conservancy 1998c). The Highway 32 reach, next downstream, has several bridge crossings and three campgrounds that make this reach the most accessible to campers and fishers. A fish ladder in the upper portions of the reach excludes salmon from using the higher watershed. Steelhead can access 13 additional miles of potential habitat when the fish ladder is open, usually from late-fall to early spring. In spite of all these possible impacts, this reach of Deer Creek (from Upper Falls to the Highway 32 Bridge) is a prime holding and spawning habitat for spring-run. Colleen Harvey Arrison reported in the Existing Conditions Report that typically 25 percent of the total adult spring-run Chinook salmon population hold in this reach (Deer Creek Watershed Conservancy 1998).

The Upper Canyon Reach extends from the lowermost Highway 32 Bridge crossing 14.3 miles downstream and provides prime holding and spawning habitat. Cold water native fishes predominate here, and resident rainbow trout are said to reach their highest relative abundance densities in this section (Deer Creek Watershed Conservancy 1998c). The lower portion of the reach downstream of the Lower Falls has long, deep pools with short, steep drops ideal for spring-run Chinook salmon holding. The Lower Canyon Reach extends 18 miles downstream and possesses many long, deep runs and large boulder riffles. Ken Roby, fisheries biologist with the Lassen National Forest, found that the Canyon reaches both have adequate pools and gravels but the pool use tends to decrease in the downstream direction (1997 pers comm in Deer Creek Watershed Conservancy 1998c). Likewise, this reach is the downstream limit of spring-run Chinook salmon holding habitat and rainbow trout distribution during the summer (Deer Creek Watershed Conservancy 1998c).

The Valley Floor and Mouth reaches have the most impacted habitat. The former reach runs 9.5 miles downstream. Stream banks are steep and incised and access is difficult. Here and at the Mouth Reach the most exotic species are found. Here also the three irrigation diversions are found, and so water temperature and transport flows can adversely affect migrating and rearing salmonids. However, in 1989, the Stanford-Vina Irrigation Company and the Deer Creek Irrigation District voluntarily began providing minimum instream flows to allow upstream and downstream migrating salmon and steelhead to pass. Refer to the third paragraph under Fisheries Restoration Projects below for additional information.

Habitat Data

The DCWC has been actively coordinating with stakeholders including landowners, the public and State and federal agencies to identify and implement actions that will preserve or enhance the Deer Creek watershed for multiple beneficial uses including enhancing fisheries. Identification and prioritization of actions has led to several reports and studies that have provided and continue to provide useful information about the Deer Creek watershed. The Deer Creek Existing Conditions Report (1997 and 1998) provides a series of chapters developed over a period of two years that include among other things, an overview of Deer Creek watershed. There are chapters on hydrology and water resources, erosion and sedimentation, water quality, fisheries and aquatic resources, and other chapters on biological and historical resources, recreation and social issues. Much of the data contained in this chapter on Deer Creek was extracted from the conditions report. The Deer Creek Annual Report for 2001 provided a list of watershed management strategies with recommendations for how to implement those strategies.

Another report, The Deer Creek Watershed Management Plan and Watershed Management Strategy (1998) outlines federal and State programs and provides relevancy to Deer Creek and the Deer Creek watershed. Among other things, the plan supports the existing forum actions to improve anadromous fish habitat and sustain healthy ecosystem functions, identifies problematical, unresolved actions for Deer Creek identified in the AFRP restoration plan (USFWS 2001), and encourages the support of educational opportunities with CSUC and UC Davis to promote water quality monitoring, rangeland monitoring, and limiting factors analyses.

The Almanor Ranger District Lassen National Forest staff in coordination with a watershed analysis team published the Watershed Analysis for Mill, Deer and Antelope Creeks (2000). The analysis provides a complete summary of the watershed areas and appendices on geology, soils, wildlife and aquatic species, anadromous fish habitat, riparian-dependent herptiles, erosion, stream discharge, and several other appendices on social and cultural issues.

DFG is maintaining and monitoring all of the fish screens and ladders on Deer Creek and, in addition to ensuring maximum efficiency at those structures, is gathering data as well. The USFWS-AFRP instituted a real-time flow monitoring and feed-back system for Deer, Big Chico and Butte creeks that went active in 1996. Three gaging stations are on Deer Creek to provide water quality data during the upstream migration of spring-run Chinook salmon adults and the downstream migrations of juvenile spring-run and late-fall run Chinook salmon and steelhead. The project, now completed, enabled installation and operation of 19 real-time flow-monitoring stations on Deer, Mill, Big Chico, Butte and Antelope creeks that provide data on flow, temperature, and turbidity at a variety of locations.

Another USFWS-AFRP managed project provides water quality monitoring information from 12 sites on Deer Creek whose purpose is to establish a long-term water quality monitoring program on Deer and Mill creeks. This program is a partnership between DWR, DFG, the Mill and Deer Creek Watershed Conservancies and other interested parties. In this project, monitoring stations are located along the main stem of the creeks. Data information collected includes temperature, dissolved oxygen, pH, turbidity, minerals, nutrients, trace metals, fecal coliform bacteria, bedload sediment, macroinvertebrates, pesticides, and fish tissue analysis among other elements. Monitoring station placement was completed in May 2000.

To review results, visit the AFRP Web site at http://www.delta.dfg.ca.gov/afrp/project.asp?code=1997-27.

Fisheries and Restoration Projects

Initiated by the DCWC and signed in 1995 by then Governor Pete Wilson, AB-1413 has and continues to provide protection for Deer Creek by requiring State approval or permits for construction or new dams.

In 1984 DWR managed the Deer Creek Sand and Gravel Removal Project. The project was designed to remove gravel and modify the creek bed. Although the first year of operations impacted spawning salmonids, the project continued through 1987. DWR's Northern District provided planning and field oversight during that time.

There are no mandated instream flow requirements for water rights holders/diverters, and the water rights exceed natural streamflow. In an effort to ameliorate this problem, Stanford Vina Ranch Irrigation Company responding to requests from DFG initiated voluntary system shut downs which provide "transport windows" for migrating anadromous salmonids (Hanna 1997 as reported by Deer Creek Watershed Conservancy 1998). SVRIC has also made fish ladder improvements and constructed a holding pool downstream of their dam to aid upstream migrating adults. In addition, a water exchange project has been proposed that may mitigate impacts caused by low flows. Replacement water may come from wells or other resources. Initiating a water exchange agreement will require funding.

Several other USFWS-AFRP projects were undertaken on Deer Creek. One began in 1997 and resulted in the acquisition of 2.5 miles of riparian corridor amounting to the protection of 468 acres of riparian habitat on the valley floor and foothill reaches of Deer Creek. A second project protects a Nature Conservancy conservation easement by fencing off two sections of streambank; one 8,000 feet and the other 6,500 feet. The fenced areas will allow for continued riparian development and protection without grazing or trampling pressures. The project, which also provides protection to stream banks and the return of some natural channel processes, was completed in 2004. Landowners have signed an agreement to maintain the fences for at least 30 years. The last project involved identifying erosion sites and the type and severity of impacts. Then landowners (US Forest Service and Collins Pine) working together determined the best solutions for each of the problems (for example, culverts or rock fords or low water crossings) with staff from CSUC and Meadowbrook Consulting Firm. Next, the appropriate environmental documentation and permits needed for implementation were identified. For the next step, the stakeholders will prepare the environmental documents and conduct the necessary outreach.

Mill Creek, Tehama County

Potential Impediments to Anadromous Fish Migration

There are no major reservoirs on Mill Creek, but the two diversions, Ward Dam and Upper Diversion Dam, have historically diverted most of the natural summertime streamflow, particularly during dry years. Clough Dam, a private diversion serving the properties of two local landowners, was partially washed out in the 1997 flood. DWR was awarded a California Bay-Delta Authority contract through USBR to design and remove the remains of Clough Dam and construct an inverted siphon pipe 10 feet below Mill Creek to carry water diverted at the Upper Diversion Dam to water users. The dam was removed in 2002, and the project was completed on June 30, 2003.

General Description

Mill Creek originates on the southern slope of Mount Lassen at an elevation of about 7,000 feet. It flows westerly about 60 miles to its confluence with the Sacramento River at RM 230, a mile north of Tehama. It drains about 134 square miles. The monthly mean runoff ranges from 105 to 465 cfs with a median runoff of 333 cfs (USFWS 1998).

Fish Populations

Mill Creek supports self-sustaining populations of spring-run and fall-run Chinook salmon and Central Valley steelhead. Historically and today, 44 miles of the creek are accessible to these species (NMFS 2000). Spring-run salmon have been observed spawning at an elevation of 5,300 feet in Mill Creek, the highest known spawning activity in California (DFG 1993).

DFG has conducted annual fall-run Chinook salmon population surveys using carcass mark-and-recapture techniques since 1952. Surveys are conducted from the canyon mouth, about a mile upstream of the Upper Diversion Dam, to the confluence with the Sacramento River. Fall-run salmon populations have ranged from a high of about 16,000 in 1952 to a low of 150 in 1965 (Figure 3-13). The average fall-run salmon population from 1952 to 2003 (not all years sampled) was 2,062 fish. In 2003 the population estimate was 2,426 fish (GrandTab, DFG, Red Bluff Office, contact Colleen Harvey Arrison, 2004).

Figure 3-13 Mill Creek fall-run Chinook salmon yearly population estimates

Differing methods to count spring-run Chinook in Mill Creek have been used since 1947, making population comparisons between years problematic. From 1947 to 1953, estimates of spring-run Chinook salmon were completed by the USFWS based on spawning area surveys or aerial redd counts (Fry 1960). From 1952 through 1964, DFG operated a counting station at the Clough Dam fish ladder. From 1965 to the mid-1980s, carcass surveys were done in the major spawning areas from Lassen National Forest Boundary to about 2 miles downstream of the confluence with Little Mill Creek. Between 1986 and 1996 an electronic fish counter was used to count spring-run passing Clough Dam. Since 1997, a redd count survey has been conducted to estimate the spring-run population, where a 1:1 male to female ratio and a 1:1 female to redd ratio is assumed. Spring-run spawning populations have ranged from a high of 3,500 in 1975 to a low of 61 in 1993. Figure 3-14 displays the estimated Chinook numbers from 1960 to 2003. The average spring-run population from 1960 to 2003 was 882 fish. The 2003 population was estimated at 1,426 fish (GrandTab, DFG, Red Bluff Office, contact Colleen Harvey Arrison, 2004).

Figure 3-14 Mill Creek spring-run Chinook salmon yearly population estimates

A counting station operated at Clough Dam from 1952 through 1964 counted between 417 to 2,292 steelhead annually with an average 10-year count of 1,160 steelhead. In 1993, a fish counter was installed in Mill Creek at Clough Dam. The counter was in place from mid-October 1993 to mid-January 1994 but did not operate continuously due to a malfunction and high flows. Fourteen steelhead were visually counted, which yielded a total estimate of 28 adult steelhead passing Clough Dam. This estimate should be considered a minimum estimate because of discontinuous operation of the counter (DWR and USBR 1999).

Since 1995, DFG has operated a rotary screw trap in Mill Creek to monitor yearling spring-run, fall-run and spring-run fry and steelhead smolt out-migration timing and length frequencies at emigration. This trap provides real-time out-migrant data for the Interagency Ecological Program's Salmon Protection Decision Process. The trap is at the Upper Diversion Dam and is operated from October through May.

A watershed analysis was undertaken in the Lassen National Forest lands as part of Pacfish (Interim Strategies for Managing Anadromous Fish-producing Watersheds on Federal Lands in Eastern Oregon, Washington, Idaho, and portions of California). A watershed analysis team evaluated the native fish assemblages found within the watersheds of Antelope, Deer and Mill creeks. Inventories indicated that the three watersheds still support the majority of their original fish assemblages (USFWS 2000).

Water Quality

Mill Creek differs from other eastside streams because of its high silt load and turbidity during the spring snowmelt. Much of this silt originates from naturally occurring volcanic ash in Lassen Volcanic National Park (DFG 1993).

Mill Creek supports three water diversions. During the irrigation season, instream flows may drop low enough to prevent late migrating adults from moving upstream (USFWS 2000). In dry years, when natural streamflows are low and diversions are operating, increased pre-July water temperatures in the lower reaches of Mill Creek can create a thermal barrier, preventing or delaying spring-run migration. The highest 2-month month (July/August) average maximum surface temperature monitored was 66 °F. Water surface temperature data and visual observations made for the watershed analysis indicate that conditions are suitable for adult salmon holding in the upper watershed even when surface temperatures rise to 71 °F (USFWS 2000).

Hydrology

Mill Creek receives streamflow from both seasonal rainfall and snowmelt. From 1929 to 1994, Mill Creek had an average annual runoff of 215,000 acre-feet, equivalent to a mean annual flow of 297 cfs, and a median flow of 175 cfs. Stream discharge peaks during the winter through spring and declines during the summer (Figure 3-15). It is caused by natural reductions in runoff and water diversions. Typically, water is diverted from April through October (CH2MHill 1998).

Figure 3-15 Mean monthly flows from 1928 to 2000 on Mill Creek near Los Molinos, Tehama County

USGS operates a streamflow gaging station on Mill Creek near Los Molinos. The station has been in place since 1909, but only fragmentary records exist from 1909 to 1913. Continuous streamflow water records exist from October 1928 (USGS 2001).

Habitat Quality

Potential fall-run salmon spawning areas on the valley floor of Mill Creek consist primarily of large cobbles and boulders with very little, good-quality spawning gravel. The majority of the spawning gravel is trapped behind the diversion dams until they become full and the excess is washed downstream or is flushed from the stream by storms. The upper reaches of the creek contain deep, cold pools, which provide excellent spring-run holding habitat.

Habitat Data

DWR has measured water temperature in Mill Creek since January 1993. There are thermographs at eight locations starting at the mouth of the creek to just downstream of Highway 36. Field parameters such as dissolved oxygen, pH, electrical conductivity, turbidity, and alkalinity are also collected.

DWR's Northern District office performed a total watershed water quality analysis on Mill Creek from May 1997 through April 2000. The water samples were examined for coliform bacteria, minerals, nutrients, metals and suspended solids. A toxicology analysis was also performed to see if anything in the water was adversely affecting living organisms.
Riparian vegetation along Mill Creek was mapped between 1996 and 1998 by CSUC Geographic Information Center as part of the Sacramento River Stream Corridor Protection Program and is available from CSUC as an ArcView project file.

The USDA Forest Service prepared a watershed analysis for Mill, Deer, and Antelope creeks in 2000. In addition to the Watershed analysis, appendices were included for the following data: geology and geomorphology, terrestrial and aquatic species, an anadromous fish habitat evaluation, erosion and watershed disturbance, stream discharge, herpetiles, recreational use, fire and fuels, fuel loading, and fire risk assessment (USFS 2000).

Fisheries and Restoration Projects

Ward Dam was rebuilt in 1997, and DFG personnel constructed a new modified pool and chute ladder. The fish ladder provides passage at lower flow conditions whereas the dam is considered passable at higher flow conditions.

A new fish screen was constructed by DFG personnel in the Los Molinos Mutual Water Co. (LMMWC) diversion ditch to replace an instream fish screen at the Upper Diversion Dam. The new screen, completed in early 2000, is better protected from high flows in its new location downstream of the old screen.

The Clough Dam Siphon and Fish Screen Project, led by DWR, began in 1998 was completed June 30, 2003. This project was designed to improve upstream fish passage for adult salmon and steelhead by removing the remains of Clough Dam, a private diversion dam, and constructing an inverted siphon under Mill Creek that delivers landowners their water right by way of a private diversion ditch (Ward 1997).

There are four ongoing watershed projects in the Mill Creek drainage. The Lower Mill Creek Riparian Restoration Project is funded by the Mill Creek Conservancy and The Nature Conservancy. The objective is to maintain and restore riparian habitat along the lower reaches of Mill Creek to help sustain cool water temperatures for fall-run, late-fall run, and spring-run Chinook salmon and steelhead trout.

The Deer and Mill Creek Watershed Project started in 1994 and is funded by the State Water Resources Control Board (SWRCB). The purpose is to develop coordinated resource plans to address fisheries, habitat, and watershed impacts to fisheries and increase waterflows to benefit spring-run Chinook salmon (Ward 1997).

USDA Forest Service is leading the Deer, Mill, and Antelope Creek Stabilization Project, funded by CALFED. The project objective is to reduce generation of fine sediments from upland and riparian road-related sources in the respective watersheds (Ward 1997).

The Mill Creek Water Exchange Program was started in the mid-1990s. The LMMWC has worked with the resource agencies to develop and implement the water exchange program. The program trades groundwater for stream diversion water, increasing streamflows and improving fish passage in the lower reaches of the creek.

The Water Exchange Program is a three-party agreement between DFG, DWR, and the LMMWC. The WEP is funded by State Water Contractors, DWR, and DFG. Phase I included the construction of a new well and restoration of an existing well. During critical migration periods, groundwater is used to augment LMMWC's water requirement in exchange for leaving an equivalent amount of water in Mill Creek. This was an improvement but more water was needed during low flow times. Under Phase II a second, on-going renewable agreement was initiated whereby the LMMWC and landowner with priority water rights forgo diversion of 16 cfs from Mill Creek when additional flows are needed for spring-run. This allows the project to provide instantaneous releases of up to 25 cfs. In exchange, the project pays the landowner's cost to operate an irrigation well.

Undiverted water not required for fishery purposes can be used by LMMWC. Parties involved are working through the Mill Creek Conservancy to make the agreements more permanent and to add incremental flows.

In September 2004, the Mill Creek Conservancy was awarded a grant by USBR to investigate and develop a long term or permanent water management program, conduct a fish passage study and monitoring, complete an irrigation system efficiency assessment, and conduct a study of the potential for additional use of groundwater in the LMMWC service areas. Information from this study could provide guidance in generating increased instream flows for fish passage during critical periods (Bundy 2004 Jun pers comm).

Established in 1994, the Mill Creek Conservancy and its partners have completed several projects including a Watershed Management Strategy Report in partnership with CH2MHILL. The conservancy also lobbied and successfully passed in 1995, AB 1413, the Deer and Mill Creek Protection Act, that precluded any new dams or diversions on Mill and Deer creeks. It has also partnered on restoration projects with The Nature Conservancy, secured several conservation easements, completed habitat restoration and water monitoring efforts using local high school volunteers, and is facilitating a feral cattle removal program. To date, more than 150 head of cattle have been removed (Burt Bundy 2004 Jun pers comm).

Sacramento River, Upstream of Feather River

Potential Impediments to Anadromous Fish Migration

On the main stem, there are two diversion dams, Red Bluff Diversion Dam and Anderson Cottonwood Irrigation District Dam, which impede anadromous fish migration during the spring and summer. ACID has completed two state-of-the-art fish ladders that will significantly improve passage for salmonids at their dam. Keswick Dam, just downstream of Shasta Dam, is a total barrier to migration.

Shasta Dam, completed in 1944 by USBR, blocks more than 600 miles of historical anadromous fish habitat in upstream tributaries to Shasta Lake. Downstream of Keswick Dam, the river still supports all four runs of Chinook salmon, as well as Central Valley steelhead.

General Description

The Sacramento River Basin covers nearly 27,000 square miles, making it the largest river system in California. The river’s tributaries stretch into the Sierra Nevada, the Coast Range, the Cascade Range, and the Modoc Plateau, with headwaters emanating from above 10,000 feet elevation. California’s premier river produces about a third of the state’s natural runoff and provides benefits that enrich the entire state. The Sacramento River system contributes greatly to the state’s and entire Pacific Northwest sport and commercial salmon fishing industries, producing more than 70 percent of the salmon caught off the California coast (Resources Agency 1989). The following information pertains to the Sacramento River upstream of the Feather River confluence.

Fish Population

Historically, about 382 miles of the Sacramento River was accessible to all four runs of Chinook salmon, Central Valley steelhead, Sacramento splittail, green and white sturgeon, striped bass, and American shad (NMFS 2000). Today, only 302 miles are accessible (NMFS 2000). The river serves primarily as a corridor for anadromous fish accessing tributary streams. In addition, about 7,996 winter-run Chinook spawned in the river between Red Bluff and Keswick Dam (DFG 2002), and fall-run also spawn and rear in the river.

Fish counts at Red Bluff Diversion Dam (RBDD) have been conducted by a cooperative arrangement with USFWS and DFG. USFWS operates a video-monitoring camera in the fish ladder, while DFG operates a fish trap and provides a population estimate. Until 1994, the gates at RBDD were down year-round and fish could be counted throughout the migration period. Today, the gates are down from May 15 to September 15, and the methodology for counting all runs of Chinook salmon has to be extrapolated from historical data.

Annual fall-run size declined from an average of 179,000 adults during 1953 to 1966 to an average of 77,000 adults during 1967-1991 (USFWS 1995). Since 1967, DFG has estimated fall-run Chinook salmon populations from RBDD to Keswick Dam. The fall-run estimates have ranged from a high of 133,365 in 1999 to a low of 5,718 in 1998. The average fall-run Chinook salmon population for the years 1967–2003 was 51,816 fish (GrandTab, DFG, Red Bluff Office, contact Colleen Harvey Arrison, 2004). The DFG numbers reflect total escapement into the Sacramento River upstream of the RBDD, excluding the tributaries. This includes fish that are in-river and are transferred to the CNFH. Figure 3-16 displays the fall-run Chinook salmon estimates from 1952 to 2003.

Figure 3-16 Sacramento River from Red Bluff Diversion Dam to Keswick Dam fall-run Chinook salmon yearly population estimates

DFG has conducted carcass surveys for late-fall run Chinook salmon since 1998. The population estimates passing RBDD using the carcass surveys from 1998 to 2003 averaged 16,824 late-fall run Chinook salmon, with a high of 38,239 fish in 1998 and a low of 5,346 fish in 2003. Previous yearly surveys from 1971 to 1996 averaged 10,233 late-fall run Chinook salmon (Figure 3-17) (GrandTab, DFG, Red Bluff Office, contact Colleen Harvey Arrison, 2004).

Figure 3-17 Sacramento River from Red Bluff Diversion Dam to Keswick Dam late-fall run Chinook salmon yearly population estimates

Before construction of Shasta and Keswick dams in 1944 and 1950, respectively, winter-run Chinook salmon were reported to spawn in the upper reaches of the Little Sacramento, McCloud, and lower Pit rivers (Moyle and others 1989 in USFWS 1995) and Slater (1963 in USFWS 1995) stated that this run was small and limited to the McCloud River. California archives indicate the run may have numbered over 200,000. The run was estimated at 80,000 adults by the mid 1960s (USBR 1986 in USFWS 1995). Since 1970, DFG has conducted winter-run Chinook salmon population estimates passing RBDD (Figure 3-18). The winter run population estimates have ranged from a high of 53,089 in 1971 to a low of 186 in 1994. The average from 1970 to 2003 was 10,285 fish. The 2003 population estimate was 8,190 (GrandTab, DFG, Red Bluff Office, contact Colleen Harvey Arrison, 2004).

Figure 3-18 Sacramento River from Red Bluff Diversion Dam to Keswick Dam winter-run Chinook salmon yearly population estimates

Spring-run Chinook salmon held and spawned in the middle reaches of the San Joaquin, Feather, upper Sacramento, McCloud, and Pit rivers upstream of present major dams. Smaller runs occurred in tributaries large and cold enough to support adults during the summer holding period. By 1966, only remnant populations of this run were present downstream of these dams (USFWS 1995). The average spring-run Chinook salmon population from RBDD to Keswick Dam from 1969 to 2003 was 6,749 fish. However, fish numbers show a steady decline, especially in the 1990s (Figure 3-19) (GrandTab, DFG, Red Bluff Office, contact Colleen Harvey Arrison, 2004).

Figure 3-19 Sacramento River from Red Bluff Diversion Dam to Keswick Dam spring-run Chinook salmon yearly population estimates

Annual estimates of total Sacramento River steelhead runs upstream of the American and Feather rivers at the Fremont Weir ranged from 14,340 to 28,400 from 1953 to 1959, and averaged 20,500 (Skinner 1962 in USFWS 1995).

DFG has been keeping a running record of aerial redd counts for all Chinook salmon runs since 1969 on Sacramento River reaches between Keswick Dam to the Red Bluff Diversion Dam and RBDD to Princeton Ferry. Based on aerial redd counts done in 2003, 99 percent of the winter-run redds counted occurred upstream of the RBDD. One hundred percent of the spring-run redds counted occurred upstream of the RBDD. Of the fall-run and late-fall run redds counted, 75 and 95 percent, respectively, occurred upstream of the RBDD (DFG 2004).

Water Quality

Warmer water in the Sacramento River has been a major factor in the decline of winter-run Chinook salmon. High water temperatures result mostly from inadequate carryover storage in Shasta Lake and other reservoirs (McEwan and Jackson 1996). To compensate, a temperature control device was installed at Shasta Dam to help alleviate the problem of warm water releases through the power-generating turbines, and a temperature-control curtain was placed in Whiskeytown Reservoir where water is diverted to the Sacramento River (DFG 1993).

The existing water temperature requirements were set forth in a 1991 Biological Opinion from NOAA's NMFS for winter-run Chinook salmon.

Hydrology

The annual mean flow at Keswick from 1964 to 1999 was 10,330 cfs, ranging from a high of 18,230 cfs in 1974 to a low of 5,390 cfs in 1992. The annual mean flow at Verona, from 1946 to 1999, was 20,050 cfs, ranging from a high of 39,150 cfs in 1983 to a low of 7,178 cfs in 1977. For mean monthly flows on Sacramento River near Red Bluff from 1902 to 1968, see Figure 3-20.

Figure 3-20 Mean monthly flows from 1902 to 1968 on Sacramento River near Red Bluff

DWR operates four streamflow gage stations in the Sacramento River from Vina to Butte City. The Vina gaging station has been collecting records since 1946. Streamflow data can also be accessed through CDEC (DWR 2001).

Habitat Quality

Shasta and Keswick Dams have significantly altered gravel recruitment and distribution into the Sacramento River contributed by upstream tributaries. The lack of gravel recruitment to salmon and steelhead spawning beds in the river is most acute in the uppermost 15 miles (Resources Agency 1989). Also, many of the tributaries downstream of Shasta Dam have been gravel-mined for decades, reducing bedload replenishment to the river.

About 150 years ago, the Sacramento River was bordered by up to 500,000 acres of riparian forest, with bands of vegetation spreading 4 to 5 miles. As agriculture and urban areas developed along the river, the riparian vegetation was gradually reduced. Today, less than 5 percent of the original acreage remains (Resources Agency 1989). Many factors have resulted in this considerable reduction of riparian habitat including flood control channelization, timber and fuel harvesting, dam and levee construction, and bank protection.

Habitat Data

DWR has measured water temperature in the Sacramento River since 1987. There are six thermographs from Keswick Dam to Knights Landing. The temperature data can be accessed through CDEC.

California Data Exchange Center Web site: http://cdec.water.ca.gov/

Riparian vegetation along the Sacramento River was mapped between 1996 and 1998 by CSUC Geographic Information Center, as part of the Sacramento River Stream Corridor Protection Program and is available from CSUC as an ArcView project file.

Fisheries and Restoration Projects

Several restoration projects have begun along the Sacramento River because of the dramatic decline over the past several decades in salmon and steelhead populations and riparian habitat. The Upper Sacramento River Fisheries and Riparian Management Plan, led by the Resources Agency, were completed in 1989. The document spelled out plans for riparian habitat protection and fishery restoration and recommended that legislation be enacted to allow for implementation of the plans.

The Central Valley Project Improvement Act (CVPIA) of 1992 was enacted for the protection, restoration, and enhancement of fish and wildlife and their habitats. The act also dedicated 800,000 acre-feet of Central Valley Project water for fish and wildlife purposes, provided for anadromous fish restoration, and created a restoration fund financed by water and power users. Completed fish protection and enhancement projects include construction of fish screens and ladders along the Sacramento River and its tributaries, water quality improvement projects, and habitat preservation and restoration programs.

Increases in anadromous fish populations, which can be at least partially attributed to these projects, have already been observed. Several structural fish passage projects have been completed, or are nearing completion, on the Sacramento River. These include the Glenn-Colusa Irrigation District

(GCID) Hamilton City Pumping Plant fish screens, the Red Bluff Diversion Dam Research Pumping Plant, the Red Bluff Diversion Dam (RBDD) Fish Passage Improvement Project, the Anderson Cottonwood Irrigation District Dam Fish Passage Project, and numerous other fish screen facilities at irrigation pumps.

The objectives of the Red Bluff Diversion Dam Fish Passage Improvement Project, jointly coordinated by the Tehama-Colusa Canal Authority (TCC) and USBR, are to substantially improve:

- The long-term ability to reliably pass anadromous fish and other species of concern, both upstream and downstream, past the Red Bluff Diversion Dam
- The long-term ability to reliably and cost-effectively move sufficient water into the TCC and meet the needs of the water districts (CH2MHill 2001).

Preliminary engineering designs for the three alternative operational scenarios determined to be the most viable approaches to resolving the fish passage and water supply issues at RBDD were completed in February 2001 (CH2MHill 2001). Alternative projects include combinations of improved fish ladders, improvements to pumping capabilities, and seasonal or complete removal of the dam gates, or creation of a bypass channel facility (Ward 1997).

USBR completed and forwarded its Biological Assessment to the USFWS and NMFS in March of 2004. It received a no jeopardy Biological Opinion for delta smelt in July 2004 from the USFWS. NMFS will likely return their Biological Opinion in September (Zentner2004 Aug 9 pers comm). USBR will then consider the upcoming OCAP (Operations Criteria and Plan) decision (coordinated operation of SWP and CVP), the USFWS and NMFS Biological Opinions, and finalize its environmental document (SEIS/REIR) prior to initiating any further action at RBDD.

The Anderson Cottonwood Irrigation District Dam Fish Passage Project, funded by CALFED, will allow an additional 3.5 miles of the Sacramento River between ACID Dam and Keswick Dam to be more easily accessible to all runs of Chinook salmon, steelhead, and sturgeon species for spawning and rearing during irrigation season when the dam is installed. The project modified a seasonal flashboard dam by constructing two fish ladders and a fish screen. The right bank pool and chute fish ladder and fish screen were completed in 2000. The left bank vertical slot fish ladder, complete with public fish viewing facilities, was completed in 2001 (Ward 1997).

Feather River, Butte and Sutter Counties

The Lake Oroville Dam was completed in 1968 and is the tallest earthen dam in the United States. Oroville Dam is owned and operated by DWR. Lake Oroville is a primary water storage facility for the State Water Project. It also functions for flood control and power generation. Directly downstream of Oroville Dam is the Thermalito Diversion Pool. This pool is designed to allow water to either enter the Feather River or be diverted into the Thermalito Power Canal. This split occurs just upstream of the Thermalito Diversion Pool Dam. The Power Canal will transfer the water into the

Thermalito Forebay and eventually the Thermalito Afterbay where the water will be transferred to one of a series of agricultural canals or back to the Feather River. Immediately downstream of the Thermalito Diversion Pool Dam is the Fish Barrier Pool that is inundated by the Fish Barrier Dam. The Fish Barrier Dam is an impassable barrier for fish.

The construction of the dam made the upper portion of the Feather River inaccessible to migrating salmon and steel head trout that used it for spawning grounds. To make up for the lost spawning area, the Feather River Fish Hatchery was constructed. The hatchery is immediately downstream of the Fish Barrier Dam. Current estimates suggest that approximately 80 percent of the salmon and steelhead spawn downstream of the hatchery and 20 percent spawn in the hatchery.

Downstream of the Lake Oroville complex, there are no man-made barriers to fish passage. There are well documented methods for fish passage upstream of rim dams in the Pacific Northwest, and some of these methods could be used in California. There is discussion and an ongoing effort to study the feasibility of fish passage upstream of Lake Oroville (refer to the Types of Structural Fish Passage Barriers section in Chapter 2 for a discussion of fish passage methods that have been used at other large dams).

Yuba River, Yuba County

Potential Impediments to Anadromous Fish Migration

The Harry L. Englebright Lake Dam, constructed in 1941 to hold back hydraulic mining debris, is the upstream limit for anadromous species. Most of the water released from Englebright is passed through the Narrows 1 and 2 powerhouses for hydroelectric power generation. The 0.2-mile of river between the dam and powerhouses has no flowing water except when the reservoir is spilling. Downstream of the powerhouses the river enters the Narrows, a 1.3-mile-long bedrock gorge where the river forms a single large, deep, boulder-strewn pool. Deer Creek flows into Yuba River in the midst of the Narrows reach (Yuba County Water Agency 2003). Downstream of the Narrows, the river canyon opens into a wide alluvial floodplain where large volumes of hydraulic mining debris remain from past gold mining.

Downstream from Englebright, Daguerre Point Dam may block fish at certain flows. Three water diversion facilities are at or near the dam. It was originally built to retain hydraulic mining debris and now has no appreciable water storage because it is filled with sediment. According to John Nelson, DFG Region II, the three diversions generally extract water from late March through January (peak diversion season from March to October) with a potential diversion rate of 1,085 cfs. However, it is important to note that water diversions at Daguerre Point rarely approach capacity (Yuba County Water Agency 2003). Daguerre Point Dam has two fish ladders on opposite ends of the dam. While the fish ladders are functional at most flows, they only provide optimal fish passage within a narrow range of flows. Additionally, stored gravels upstream of the dam may block or limit the ability of fish to access the exits of the fish ladders. This gravel must be excavated to allow fish to fully ascend the ladders.

General Description

The Yuba River originates on the western slope of the Sierra Nevada at an elevation of about 8,200 feet. It flows westerly about 77 miles to its confluence with the Feather River near the town of Marysville. Rainfall and snowmelt are the major sources of water in the watershed. Annual precipitation ranges from a low of 30 inches in the western part of the watershed, to a high of about 80 inches in the northern and southeastern portions of the drainage (PG&E 1989). The river drains about 1,339 square miles with a total storage capacity of 1,377,000 acre-feet. The upper portion of the Yuba River Basin is drained by the north, middle, and south forks, which join upstream of Englebright Lake to form the main stem of the Yuba River.

Fish Populations

Historically, the Yuba River supported 15 percent of the annual fall-run Chinook salmon in the Sacramento River system (Yoshiyama and others 1996). A total of 77 miles of the river was accessible to fall-run, late-fall run, and spring-run Chinook salmon and Central Valley steelhead. Now, only 24 miles are accessible to these species (NMFS 2000).

The Yuba River historically supported a fall and spring Chinook salmon run. The spring-run extended into the North Fork, perhaps as far upstream as Sierra City; the Middle Fork near the confluence with the North Fork; the South Fork perhaps as far upstream as Poorman Creek; and Dry Creek at least 5 to 6 miles upstream from its confluence with the Yuba River. The fall-run likely migrated as far as Downieville on the North Fork, up the Middle Fork near the confluence with the North Fork; within 1 to 2 miles of the mouth of the South Fork; and up Dry Creek at least 5 to 6 miles According to unpublished and undated DFG files, steelhead were observed near Downieville on the North Fork and probably ascended as far upstream as Love Falls; Bloody Run Creek on the Middle Fork; Poorman Creek on the South Fork; and Dry and Deer Creek on the main stem (Yoshiyama and others 1996).

DFG has conducted fall-run Chinook salmon surveys from 1953 to 1989. The Yuba County Water Agency has continued the surveys since 1990. The surveys have been conducted in the major spawning areas, from the Narrows to the Marysville dump, about a mile downstream of Hallwood Boulevard. Fall-run salmon populations have ranged from a high of 39,367 in 1982 to 1,205 in 1957 (Figure 3-21). The average population for fall-run Chinook salmon between the years of 1953 and 2003 (1990 not sampled) was 14,855. The 2003 population was 28,897 fish (GrandTab, DFG, Red Bluff Office, contact Colleen Harvey Arrison, 2004).

Figure 3-21 Yuba River fall-run Chinook salmon yearly population estimates

A remnant population of spring-run Chinook salmon persists and is maintained by fish produced in the river (DFG 1993). In 1998, Julie Brown, DFG biologist, surveyed spring-run redd distribution counting 105 redds between September 15 and October 15.

From 1970 though 1979, DFG planted yearling steelhead from the CNFH. In 1984, the run size was estimated at 2,000 steelhead (DFG 1984 in McEwan and Jackson 1996). It is unknown whether the present steelhead stock is of native origin or is derived from stocking of hatchery fish. In any event, the stock today is managed as a naturally sustaining population and is essentially the only wild steelhead fishery remaining in the Central Valley (McEwan and Jackson 1996).

Water Quality

Existing water quality data were collected and analyzed by DFG for the Yuba River from New Bullards Bar Dam downstream to the confluence with the Feather River. The information was used to describe water quality since 1950. The analysis concluded that the general physical water quality of the lower Yuba River is quite good and well within acceptable ranges for salmonids and other key freshwater biota (DFG 1991). Concentrations of some minor or trace elements infrequently exceed US Environmental Protection Agency (1986) criteria, and detectable concentrations of some pesticides and industrial chemicals have been found in water, fish tissue, or sediment samples but not at levels considered unsafe or harmful to freshwater biota (DFG 1991).

Low flows and elevated water temperatures resulting from water diversions have affected anadromous populations of the lower Yuba River (DFG 1991). Potential effects of water temperatures on anadromous fish were assessed by DFG by comparing thermal preferences of each species' life stage to existing temperatures in the lower Yuba River, downstream of Englebright Dam, during the water years from 1973 through 1978.

The highest survival rate in salmon eggs has been found to be between 53 and 57.5 ˚F. Mortality of the fry that survive incubation periods in waters of greater that 57.5 ˚F are in excess of 50 percent (Boles 1988). Additionally, indirect biotic influences created from warmer temperatures may affect salmon survival. Warmer temperatures may adversely alter the composition of available salmon feed, promote disease causing bacteria, and increase survival of predators. Also, water temperatures exceeding 57.5 ˚F will increase fry metabolism thus creating smaller hatchlings that are less suited for survival (Boles 1988). DFG found in-river temperatures at Marysville to be near or above 57 °F until after mid-October and regularly into November. DFG found water temperatures near Marysville may often exceed preferred juvenile Chinook salmon rearing temperatures by early April; by June, even water that is released from Englebright Dam may exceed the preferred ranges (DFG 1991).

In 1991, DFG requested the SWRCB revise existing streamflow and temperature requirements on the lower Yuba River in accordance with recommendations set forth in the Lower Yuba River Fisheries Management Plan (DFG 1991). A 1992 SWRCB draft decision was not acted upon and a subsequent hearing in 2000 resulted in revised instream flow requirements. The decision requires some specified actions to provide suitable water temperatures for anadromous fish and to reduce fish losses at water diversion facilities; however, it states that it is not always feasible to achieve suitable water temperatures for protection of salmon and steelhead. Temperature problems remain a concern under certain conditions and flows.

Hydrology

The monthly mean flow for the gage station in Marysville on the Yuba River is 2,341 cfs. Flows range from 833 cfs during the summer to 4,740 cfs during the winter and spring (Figure 3-22).

Figure 3-22 Mean monthly flows from 1943 to 2000 on Yuba River near Marysville

Streamflow and water temperature records are available from a USGS gaging station on the Yuba River about 4.2 miles northeast of Marysville. Streamflow records since 1943 are available (USGS 2001).

Habitat Quality

Hydraulic gold mining, gravel mining, and channelization have disturbed the riparian habitat in the lower reaches of the Yuba River. Downstream of Daguerre Point Dam, the river is comprised primarily of alternating pools, runs, and riffles with a gravel and cobble substrate that is suitable for salmon spawning under adequate flows and temperatures (CH2MHill 1998).

The habitat upstream of Daguerre Point Dam has a higher ratio of pool to riffles, more frequent spawning gravel, and more shaded riverine aquatic habitat than that downstream of the dam (USFWS 1995).

The lower 500 feet of Deer Creek (Nevada County), a tributary downstream of Englebright Dam, has limited access because waterfalls block the passage of salmon. Steelhead trout have been found upstream of the falls during wet years (DFG 1991); however, Lake Wildwood maintenance drawdown operations in early fall create siltation and stranding problems for Chinook salmon and steelhead trout (J. Navickky 2004 pers comm).

Dry Creek enters the Yuba River about 10.3 miles downstream of Englebright Dam. Mearle Collins Reservoir regulates the streamflow in this creek. Steelhead and fall-run Chinook salmon are known to use Dry Creek (CH2MHill 1998).

Habitat Data

Beak Consultants performed an instream flow study on the lower Yuba River for DFG. The results indicated that weighted usable area is highest for spawning Chinook salmon at 600–700 cfs. Thus, when fall flows in the lower Yuba River drop below 600 cfs, spawning habitat may become more limited (USFWS 1995).

Riparian vegetation along the Yuba River was mapped from 1996 to 1998 by CSUC Geographic Information Center, as part of the Sacramento River Stream Corridor Protection Program and is available from CSUC as an ArcView project file.

Fisheries and Restoration Projects

In 1998, the CALFED Ecosystem Restoration Program recommended a study of the potential decommissioning of Englebright Dam to improve fish passage on the Yuba River. The South Yuba River Citizens League submitted a proposal to CALFED responding to this recommendation. Following a series of public meetings, in 1999 CALFED established the

Upper Yuba River Studies Program as a stakeholder-driven collaborative process to discuss improved fish passage at Englebright Dam.

Currently, there are multiple planned and ongoing resource restoration projects within the Yuba River watershed with the goal of increasing and stabilizing anadromous fish populations. Agencies involved in these projects include but are not limited to California State Parks, CALFED, DFG, PG&E, Yuba County Department of Agriculture, California Department of Food and Agriculture, USDA Forest Service, and various local and city organizations. These projects range from removal of non-native species for enhancement of natural riparian vegetation to establishing cooperative relationships between federal land managing agencies and local citizen groups. Other projects include improved sediment management, fish screening alternatives at diversions, habitat improvement and restoration, and improved fish passage (Ward 1997).

The AFRP funded a 1998 preliminary engineering evaluation for development of barrier structures to prevent access of anadromous fish into the goldfields. In 1999, AFRP funded a project to develop fish screen and diversion bypass feasibility alternatives at the Hallwood-Cordura Irrigation District Diversion (USFWS 1998).

In 1999, USFWS funded a USACE Preliminary Fish Passage Improvement Study of fish passage alternatives at Daguerre Point Dam (USACE 2001).

Initiated in 2001, DWR and the Corps are preparing a joint draft EIR/EIS to evaluate the Daguerre Point Dam Fish Passage Improvement Project on the Yuba River. The project has a goal to improve upstream and downstream fish passage for native anadromous fish species at the dam and contribute to overall population recovery for the spring-run Chinook salmon and steelhead. The completion date of the EIR/EIS depends on ongoing negotiations between DWR and USACE regarding USACE's status as being the lead agency for finalization of the NEPA work.

The Yuba River Temperature Monitoring Project report was prepared for USFWS and distributed in February 1999. Water temperatures were monitored in the main stem Yuba River, north fork, middle fork, and the south fork from the headwater reservoirs to the confluence with the Feather River during the summer of 1998. The object of that report was to provide an initial basinwide estimate of thermal diversity in the Yuba River watershed under spring and summer conditions (USFWS 1998).

DFG and AFRP are funding the Yuba River Chinook salmon and steelhead life history evaluation. Rotary screw traps are installed on the Yuba River at Hallwood Boulevard, about 6 miles upstream of Marysville. The sampling location covers about 18 miles of spawning habitat. The objectives of the project are to document timing of emergence, size, and condition at emigration, duration of emigration, and a measure of abundance (USFWS 1998).

The Lower Yuba River Technical Working Group is also supporting the development of a long-term restoration planning document to assist in prioritizing actions to complete restoration and enhancement of salmonid habitat, according to Ted Frink of DWR FPIP.

American River, El Dorado, Placer and Sacramento Counties

The American River Division of the Central Valley Project provides water for irrigation, municipal and industrial use, hydroelectric power, and recreation. Flood control is provided through a system of dams. The Nimbus Dam was completed in 1955. Nimbus Dam, which forms Lake Natoma, is approximately 7 miles downstream of Folsom Dam. USBR owns and operates both Nimbus Dam and Folsom Dam, which was completed in 1956. Folsom Dam forms Folsom Lake, the most popular multi-use year round facility in the California State Park System. The completion of Folsom and Nimbus dams blocked access to natural spawning grounds for use by salmon and steelhead trout. To help compensate for this loss, the Nimbus Fish Hatchery was constructed downstream from Nimbus Dam. Downstream of Nimbus Dam, there are no man-made barriers to fish passage. There are well documented methods for fish passage upstream of rim dams in the Pacific Northwest, and some of these methods could be used in California. However, at this time there is no discussion to facilitate fish passage upstream of Folsom Dam.

Lower Sacramento River and Delta Tributaries

There are other creeks in the Lower Sacramento River and Delta region with potential fish passage barriers other than the ones included in this section (see Appendix A). FPIP will work with the interagency team to identify additional priority creeks in the future.

Cosumnes River, Sacramento County

Potential Impediment to Anadromous Fish Migration

In most years Latrobe Falls, a natural barrier to upstream migration, restricts anadromous fish to the lower 41 miles of the main stem Cosumnes. In extremely wet years a second channel forms around the falls and fish have access to 11 more miles of the stream before they are stopped by another natural barrier (CH2MHill 1998). Downstream of Latrobe Falls there are five dams and one road crossing, which present barriers to migration at low flows.

General Description

The Cosumnes River watershed drains 550 square miles from its headwaters in the Eldorado National Forest in the western Sierra Nevada to its confluence with the Mokelumne River north of Thornton at the Sacramento-San Joaquin County line. The main stem Cosumnes is 41 miles long downstream of its three upper forks (USFWS 1998). The river is not only fed by rain runoff but also receives a fair amount of snowmelt due to the elevation of its headwaters around 8,000 feet. The Cosumnes River drops to an elevation of 5 feet at its confluence with the Mokelumne River at RM 38 (USBR 2000).

Fish Populations

The Cosumnes River has historically supported a run of fall-run Chinook salmon. One 1929 historical document referenced in Yoshima and others (1996) called the salmon run on the Cosumnes "a considerable run," and run size estimates of less than 500 to 5,000 fish exist for the period 1953 to 1959. Historically, the run size has averaged about 1,000 fish, but recent runs have numbered fewer than 100 fish (DFG 1993). Fall-run Chinook salmon spawn in the Cosumnes River between Meiss Road and Michigan Bar Road. The size of the run varies greatly from year to year and is largely dependent on the flow in the river. Adult salmon are in the river from mid-November through mid-January. Juveniles are usually observed from February through May.

DFG conducted annual spawning surveys of the river from 1953 to 1989 (Figure 3-23, includes 1998 estimate). Population estimates for fall-run Chinook salmon based on those surveys ranged from zero to 5,000 fish with an average of 1,300 fish (USBR 2000). In December 1997, Keith Whitener, project ecologist with the Nature Conservancy, published an assessment of the salmon run on the Cosumnes River, which included spawner surveys and redd surveys of the area between Michigan Bar and Meiss Road (Whitener 1998). Also in December 1997, DFG conducted an aerial photography redd survey of the river in the same area. This survey found about 209 redds (Snider and Reavis 2000). Based on these two surveys, the 1997 population of fall-run Chinook salmon was 300 to 500 adult fish. A 1998 spawner escapement survey conducted by Whitener produced an estimate of between 250 and 450 fish (Whitener 1998). DFG and the Nature Conservancy did a spawner escapement survey in 1999 that resulted in a DFG estimate of 250 to 350 spawners in the river between Meiss Road and Latrobe Falls. In some years DFG plants salmon from the Nimbus Hatchery in the Cosumnes River. In 1996, 225,000 fry were planted and may have contributed to the 1998 spawning population (Snider and Reavis 2000; Kennedy and Whitener 1999).

Figure 3-23 Cosumnes River fall-run Chinook salmon yearly population estimates

USBR (2000) reports no steelhead runs have been documented on the Cosumnes claiming high summer temperatures in the river and a natural barrier to migration at RM 42 probably preclude a sustainable run of steelhead. However, according to Harris (1996), a 1994 DFG survey identified steelhead smolts in the lower Cosumnes. Rainbow trout and steelhead have also been reported by the Fishery Foundation of California (Kennedy 2003).

Water Quality

Flow and temperature are the two major water quality issues on the Cosumnes River that adversely affect migrating salmon. Water temperature in the Cosumnes River often reaches levels that are lethal to young salmon by mid-spring (USFWS 1998). Temperature data was collected near Michigan Bar Road from October 1998 to October 1999 in conjunction with a DFG spawner escapement study. From March through June the temperature ranged from 45 °F to 78 °F. Salmon catches dropped to zero during the escapement survey when water temperatures reached 65°F in early July even though flows were in excess of 200 cfs. This indicates that escapement is related to temperature (Snider and Reavis 2000). Temperature data were collected for the upper reaches of the river in 1994 during a DFG stream survey and in 1995 during a related fish and channel description (DFG 1994; DFG 1995).

Hydrology

The first and most severe problem is the lack of flow in the lower reaches of the river, especially in dry years. There is a USGS gage at Michigan Bar Road and data from it are available for the past 95 years. In the summer of most normal and dry water years the flow between Highway 99 and Twin Cities Road is often completely subsurface. This is largely due to agricultural diversions and long-term water pumping that has greatly reduced the groundwater level of the aquifer (Mount 2001). During the peak of the irrigation season there is often no flow downstream of the Meiss Road Bridge. Observations during dry years suggest that flows of 40–70 cfs are required at Michigan Bar Road in order to achieve continuous flow in the lower reaches of the river (USBR 2000). Anadromous fish must wait for fall rains to water the river channel before they can begin their migration. Yet, die-offs of fall-run Chinook salmon adults have been observed soon after rains have stopped (Kennedy 2001). Flows of at least 80–100 cfs are required for fish passage over the low flow barriers in the river (Whitener 1998). In normal to dry years, flows that high may not occur until well into the spawning season. Results from a 1998–1999 salmon spawner survey indicate that salmon do not begin spawning in the Cosumnes River until flows reach 200 cfs. In 1998, flow did not reach 200 cfs until November 24, and flows dropped to 138 cfs by December 23 (Snider and Reavis 2000). In years of low rainfall, no fish spawn in the Cosumnes River because adequate flows are not present until after the spawning season (USFWS 1998). Spring flows are usually adequate for out-migration of juveniles (DFG 1995).

The USGS has collected flow data at Michigan Bar from 1907 to the present (USGS 2001). According to the mean flow data taken at Michigan Bar Road gage station, flows during the summer reach flows as low as 15 cfs (Figure 3-24).

Figure 3-24 Mean monthly flows from 1907 to 2002 on Consumnes River, at Michigan Bar Road, Sacramento County

During winter and spring, flows reach a maximum of 1,214 cfs on average. Based on mean monthly flow data and flow levels reported in Snider and Reavis (2000), flows appear too low for spawning in late June through November. Recommended flow levels for Chinook salmon spawning have not been developed.

According to Jeff McLain (formerly with USFWS-AFRP) AFRP is assessing the needs for instream flow incremental method work in the Central Valley and prioritizing sites needing future IFIM studies. The Cosumnes River is one of the higher priorities he said. Presently, however, the FWS has no existing plans for Cosumnes IFIM studies in the near future (J.D. Wikert 2004 Sep 9 pers comm).

For information on instream flow incremental method, visit the Web site: http://www.fort.usgs.gov/products/software/ifim/ifim.asp

Habitat Quality

At higher elevations, the Cosumnes River and its tributaries are bordered by Sierra mixed conifer forest. As the river descends to the Central Valley, it traverses oak woodland, chaparral, annual grassland, and agricultural land. Along the lower reaches of the river between Interstate 5 and Highway 99, dense riparian forests of willow, cottonwood, valley oak, and white alder are present (USFWS 1998). Sediment and lack of gravel are a problem in the Cosumnes River downstream of RM 31.6; however, upstream of that there is good spawning habitat. The reach downstream of Granlees Dam is described as “an example of excellent gravel bars that contained many redds” in an assessment done by Keith Whitener (1998). Another report states that the spots with the best spawning gravel also have extensive stretches of willow/cottonwood corridors (USFWS 1995). And during a 1998–1999 survey, water clarity exceeded 6 feet in the reach between Michigan Bar Road and the Meiss Road Bridge where most spawning takes place (Whitener 1998). Downstream of the spawning area, reaches have been denuded by livestock, and fine sediment has infiltrated the gravel, making it unsuitable for spawning (USFWS 1998).

Habitat Data

Bioassessments of the creek were done in 1994 and 1995, which included electrofishing to determine what species of fish are present, temperature measurements, streamflow measurements, and descriptions of the channel and its banks. This bioassessment was done at points beginning at Michigan Bar and continuing up the main stem Cosumnes to Highway 49, up the north fork to Camp Creek and up the middle fork to Peddler Creek (DFG 1995). There is also gravel and flow information for 1956 (Westgate 1956).

Fisheries and Restoration Projects

The Fishery Foundation of California modified three of the five barriers on the Cosumnes River. In 2000 a box culvert was constructed under a road that was a low flow barrier. The two fish ladders on Granlees Diversion Dam were retrofitted to allow fish access at a wider range of flows. In 2003 the foundation installed a rock weir fish ladder at Hopland Ranch Dam that was previously unladdered. However, according to AFRP, upstream passage problems were still observed at Hopland Ranch Dam. The estimated cost of these projects was $376,510 (USBR 2000).

In 2003, the Fishery Foundation repaired Blodgett Dam, Hopland Ranch, and Mahon obstructions. Between 1999 and 2000, the foundation also fixed the fish passage problem at Onetto.

Dry Creek, Placer County

Potential Impediments to Anadromous Fish Migration

Dry Creek and its upstream tributaries have four dams and three pipeline crossings that potentially impede anadromous fish migration from the confluence with Natomas East Main Drainage Canal to the upper watershed.

General Description

Dry Creek originates in the Sierra Nevada foothills northwest of Folsom Lake. This basin is drained by Antelope Creek, Miners Ravine, and Secret Ravine, which join northeast of Roseville to form Dry Creek. Dry Creek connects with Cirby Creek and then continues its course to Rio Linda where it joins the Natomas East Main Drainage Canal. The canal flows into the

Sacramento River just north of the confluence of the American River with the Sacramento River. The drainage encompasses about 100 square miles.

Fish Populations

Historically, Dry Creek and its tributaries have supported fall-run Chinook salmon and steelhead trout from the American Basin. The American Basin has since been drained and replaced by Steelhead Creek (formerly known as Natomas East Main Drainage Canal). Historical data are sketchy for Chinook salmon. However, Gerstung (1965) estimated runs of 600 for Secret Ravine as well as 1,000 for the Dry Creek watershed for 1963. DFG conducted salmon spawning surveys in the fall of 1963 and 1964 on Secret Ravine Creek. The estimated salmon spawning in 1963 was 300 and twice that, 600-800, in 1964. The report mentions that steelhead migrate every fall, but no catch data are presented to confirm this (DFG Secret Ravine file June 1965). In 1965 the survey recorded 600 salmon in Secret Ravine, 100 in Miners Ravine and 300 in Auburn Ravine. Additionally, 10 fish each were found in Doty Ravine and Antelope Creek (DFG 1965 May memorandum). Other than these DFG files, there appears to be no significant records of historical distribution or abundance for steelhead trout in the Dry Creek drainage (Li and Fields 1999) although there are anecdotal records. Currently, fall-run Chinook salmon are found in the upstream tributaries (Antelope Creek, Miners Ravine, and Secret Ravine). The extent of upstream migration in the tributaries includes Antelope Creek just upstream of Highway 65; Miners Ravine creek at the town site of Hidden Valley; and Secret Ravine creek at Rock Springs Road (NMFS 2000).

Fish counts have been performed by the Dry Creek Conservancy for the past four years, according to Gregg Bates, director of the conservancy (Bates 2000b). The Dry Creek Conservancy observed 67 live salmon and 13 carcasses in a portion of Secret Ravine between November 11 and 13, 2000. Bates (2000a) reported that salmon were also observed in Antelope Creek, Linda Creek, Miners Ravine, and Dry Creek.

Downstream of the confluence of Secret with Miners ravine, DFG monitored juvenile salmon and steelhead emigrating between November 6, 1998, and June 2, 1999, and from January 9, 2000, through June 8, 2000. Juvenile steelhead trapped upstream in Secret Ravine in sections from Brace Road crossing near Loomis to Gilardi Road crossing ranged in fork length (FL) from 21 to 310 mm and represented young-of-the-year (YOY), yearlings, and older fish (Titus 2001 memorandum to files). In the Miners Ravine reach steelhead were only observed upstream of Dick Cook Road crossing in mid-December 1998 and again in late March 1999. These fish ranged in length from 72 to 400 mm FL. These findings suggest that the Upper Dry Creek watershed supports natural reproduction of steelhead and provides for perennial rearing (Titus 2001 memorandum to files).

Water Quality

Water quality concerns are primarily related to excessive sand being washed down the tributaries of Dry Creek, reducing the quality of riffles and the depths of pools. This has, in turn, degraded spawning and rearing conditions for salmonids and reduced invertebrate populations that are essential for salmonid food supply (Vanicek 1993). The water quality can also be affected by discharges from the Roseville sewage treatment plant southwest of Roseville.

Water temperatures can be variable depending on precipitation. The watershed is not at a high enough elevation to receive snowmelt that would buffer higher stream temperatures. Increased water temperatures can delay or prevent salmonid migration. Less favorable water temperature conditions for juvenile steelhead trout have been observed downstream of the confluence of Secret and Miners ravines (DFG 1998).

Hydrology

Streamflow data for Dry Creek are limited. USGS operated a gage near Roseville from 1963 to 1967 (USGS 2002). Mean flow for years of record range from nonexistent to 0.85 cfs (Figure 3-25). Annual peak flows were recorded by USGS from 1960 to 1973 (USGS 2002). Annual peak flows ranged from 16 cfs on February 5, 1972, to 220 cfs on February 9, 1962.

Figure 3-25 Mean monthly flows from 1963 to 1967 on Dry Creek near Roseville

Habitat Quality

Habitat quality is generally poor within the lower reaches of Dry Creek. There are few pools and few riffles and there is an excess of sand and silt. The upper tributaries (Miners Ravine and Secret Ravine) provide habitat described as good to excellent (Vanicek 1993). The upper tributaries, however, are being impacted by the excessive downward migration of sand due primarily to erosion. The sand is covering the spawning gravels and creating shallower pools. Rearing habitat for salmon, steelhead, and aquatic invertebrates has been degraded in the downstream areas resulting in poor rearing conditions for juvenile salmon during spring (Vanieck 1993). The lack of holding pools and the presence of barriers at low flows impact the upstream migration of adult salmon in the lower reaches of the Dry Creek habitat (Vanicek 1993).

The riparian habitat quality in Dry Creek and its tributaries ranges from "exceptional" to "severely encroached upon." Continuing development is causing severe impacts on riparian habitat and flood control (Bishop 1997).

The benthic macroinvertebrate fauna studied in Secret Ravine were found to be in fair condition in terms of species diversity (Fields 1999).

Habitat Data

A fisheries habitat evaluation was prepared for Dry Creek and its tributaries by Vanick (1993). Additional studies have been conducted on Secret Ravine including a hydrology and geomorphology study prepared by Swanson Hydrology and Geomorphology (Swanson 2000); a stream habitat assessment prepared by Stacy K. Li (Li and Fields 1999); a vegetation analysis prepared by Robert F. Holland (Holland 2000); and a benthic macroinvertebrate fauna analysis prepared by Wayne C. Fields Jr. (Fields 1999). In addition, an evaluation of Dry Creek and its major tributaries was completed by Debra Bishop in 1997. This evaluation contains extensive riparian habitat descriptions of various reaches of Dry, Antelope, Cirby, and Linda creeks as well as Miners, Secret, and Strap ravines (Bishop 1997).

Fisheries and Restoration Projects

Habitat improvement projects have focused on Secret Ravine and Miners Ravine because these two tributaries account for most of the available spawning and rearing habitat (NMFS 2000). Upper Dry Creek has also been the focus of restoration efforts.

A habitat survey is being prepared for Secret Ravine funded by the USFWS-AFRP. It includes habitat mapping, water-temperature monitoring, spawning habitat assessment, macroinvertebrate surveys, riparian vegetation, soil, and sedimentation evaluation and will include priority actions to restore anadromous fish resources. The project as completed in December 2000.

On February 18, 1992, Mitchell Swanson and Associates prepared a study titled "The Miners Ravine Watershed Enhancement and Restoration Plan for the Reduction of Flood Hazards and the Enhancement and Protection of Environmental Resources." It was done for the Granite Bay Community Association through DWR Urban Creek Restoration Program. The management plan addresses environmental, drainage, and erosion issues for the Miners Ravine watershed (Swanson 1992).

Placer County was awarded a grant through DWR Flood Protection Corridor Program to enhance a portion of Miner's Ravine Creek downstream of Sierra College Boulevard. The project proposal includes setting back a section of streambank and allowing portions of the historical floodplain to detain floodwaters, and restoring riparian and instream habitat. As of September 2004 the agreement between DWR and Placer County had been signed and the county was moving through the CEQA process. The County has also been working with stakeholders and the public to define recreation, fish and wildlife, and habitat portions of the proposal (Stevens 2004 Sep 15 pers comm). The group has also developed a set of selection criteria to evaluate alternatives (Keating 2004 Sep 16 pers comm).

Under the same program, during the summer of 2004, the Sacramento Area Flood Control Agency used their Flood Protection Corridor Program grant funds to remove Hayer Dam and its diversion facilities in Lower Dry Creek and installed an infiltration gallery to bring water to the Bell Agua community. Further restoration activities include removal of red Sesbania, setting back banks and planting riparian species. These improvements will enhance fish passage for fall-run Chinook salmon and steelhead.

A Secret Ravine Adaptive Management Plan was completed in December 2001. Major objectives met were defining a process to restore the Secret Ravine riparian corridor, and help meet the CVPIA goal to double natural production of Chinook salmon and steelhead. A conceptual model including life history with functional requirements for each life stage, major stressors, and remedial actions was proposed. A number of the suggested actions have been met through funding sources from other projects. Management areas and conceptual restoration designs are included in the plan.

The Dry Creek Conservancy placed 200 cubic yards of spawning gravel in Secret Ravine in fall 2000, according to Greg Bates of the Dry Creek Conservancy.

Placer County will use Proposition 204 grant funds in 2001 - 2003 for various projects such as watershed planning, a monitoring program to supplement the existing Dry Creek Conservancy program and a streambank stabilization and revegetation project on Miners Ravine.

An Urban Streams Restoration Grant from DWR was used in 2000 by the Dry Creek Conservancy for restoration purposes on Dry Creek where it flows through Royer Park in downtown Roseville.

Lower Sacramento River, Downstream of Feather River

Potential Impediments to Anadromous Fish Migration

No physical barriers exist in the Sacramento River from San Francisco Bay to the Feather River. There is a lock at the upper end of the Sacramento River Deep Water Ship Channel at the connection to the Sacramento River. This lock blocks the migration of all fish from the deep water channel back to the Sacramento River. The locks are no longer operated for shipping purposes.

Floodwater diversions into the Sutter and Yolo bypasses can subject Chinook salmon to potential upriver and downriver migration delays. The weirs on the banks of the Sacramento River can act as barriers and block the passage of fish. Fish can also be trapped in the bypasses as floodwaters recede (USFWS 1995).

General Description

The Sacramento River Basin covers nearly 27,000 square miles, making it the largest river system in California. The river’s tributaries stretch into the Sierra Nevada, the Coast Range, the Cascade Range and the Modoc Plateau, with headwaters emanating from above 10,000 feet elevation. California’s premier river conveys about a third of the state’s natural runoff and provides a wide range of recreation and water-related benefits that enrich the entire state. The Sacramento River system contributes greatly to the state’s and Pacific Northwest's sport and commercial salmon fishing industries, producing more than 70 percent of the salmon caught off the California coast (Resources Agency 1989). The following pertains primarily to the Sacramento River downstream of the Feather River.

Fish Populations

Historically, the Sacramento River supported runs of fall-run, late-fall run, spring-run, and winter-run Chinook salmon, all of which migrated through the lower Sacramento River to reach historical spawning grounds in the upper watershed (Yoshiyama and others 1996). Steelhead trout were also prevalent in the higher Sacramento River watersheds (USFWS 1995). Today, the Sacramento River supports fall-run, late-fall run, winter-run, and spring-run (DFG 1993, NMFS 2000). Steelhead trout are also present in the Sacramento River (McEwan and Jackson 1996).

Population estimates for Chinook salmon runs are only available for the upper portion of the Sacramento River and for Sacramento River tributaries such as the Feather River and American River (see *Habitat Quality* below).

The number of steelhead trout that spawn in the Sacramento River is unknown, but it is probably low. Loss of access to the headwaters has rendered the Sacramento River unsuitable for natural reproduction (McEwan and Jackson 1996). The average annual total steelhead trout run in the Sacramento River system was estimated by DFG in 1990 to be about 35,000 fish, primarily hatchery produced. Counts of steelhead trout are generally only available from the hatcheries (USFWS 1995).

DFG has also been studying the emigration of juvenile salmonids for the past several years. The study is based on a rotary screw trap placed at Knights Landing with mean trap efficiencies ranging from 0.8 to 1.45 percent. Relative abundance figures for the juvenile fall-run were 5,161,417 in 1996, 2,667,679 in 1997, and 8,458,150 in 1998. Since diversion through the Knights Landing bypass does not take place until Sacramento River flow exceeds 23,000 cfs, the exact magnitude of salmonid emigration to the Delta through the bypass cannot be calculated with these data. However, the temporal distribution and, likely, the relative abundance of juvenile salmonids migrating toward the Delta are reflected in the Knights Landing data (Snider and Titus 2000).

Water Quality

The Sacramento River Watershed Program monitors water quality characteristics including metals, PCBs, pesticides, and pathogens (Sacramento River Watershed Program 2000). The Sacramento River carries the pesticide diazinon and the heavy metals mercury, cadmium, copper, and zinc.

The Colusa Basin Drainage Canal discharges agricultural drain water into the Sacramento River at Knights Landing and at the Yolo Bypass toe drain. This agricultural runoff, which is several degrees warmer than the river, increases the river temperatures (McEwan and Jackson 1996). The drain also blocks access to most westside streams, which during some years can provide excellent spawning and early season rearing habitat (DFG 1993).

Hydrology

For water year 1999, the daily mean flow varied from 12,700 to 86,700 cfs. For period of record (since October 1948), maximum discharge was 117,000 cfs and minimum daily discharge was 3,970 cfs (USGS 2000).
Mean flows for summer reach a low of 10,070 cfs (Figure 3-26). Winter and spring flow values indicate very high flows up to 34,750 cfs. Annual mean flow for the gage station at Verona is 19,428 cfs. According to these values, salmonids have adequate flow for immigration and emigration throughout the year.

Figure 3-26 Mean monthly flows from 1929 to 2000 on Sacramento River at Verona, Sutter County

USGS maintains a hydrologic data station on the Sacramento River at Freeport. Available data include flow (since 1948), temperature (since 1960), and suspended sediment (since 1956). Other data such as water quality are measured at various times (USGS 2000).

Habitat Quality

Salmon spawning and rearing primarily occurs in the Upper Sacramento River. Fish migrate through the lower Sacramento River to the upper Sacramento River and its tributaries for spawning and rearing (NMFS 2000). The downstream limit of suitable water temperatures for spawning of fall-run Chinook salmon is generally near Hamilton City. Suitable spawning temperatures for winter- and spring-run salmon are generally limited to the reach upstream of RBDD (USFWS 1995). Water temperature is critical to steelhead trout production due to their long rearing periods in the stream. Summer temperature conditions in the low-elevation reaches downstream of dams can be very hostile to rearing steelhead trout. Spring-run Chinook salmon, also with a long rearing requirement and because of their adult migration timing suffer from high water temperatures during the summer. Winter-run and late-fall run salmon are similarly affected because of juvenile oversummering (McEwan and Jackson 1996).

Riparian vegetation has been significantly reduced along the Sacramento River. Existing riparian woodland along the Sacramento River is less than 5 percent of its historical acreage, and river edge vegetation is less than 50 percent of its historical extent (USFWS 1995). About 5 to 15 percent of historical acreage remains on tributary streams (USFWS 1995). Loss of riparian vegetation has been most severe on the Lower Sacramento River and Delta (USFWS 1995).

The Lower Sacramento River has also been extensively channelized, resulting in a narrower, deeper channel. The construction of levees and installation of rock riprap for bank stabilization purposes has caused an extensive loss of shaded riverine aquatic habitat (USFWS 1995). Gravel recruitment in the Lower Sacramento River occurs primarily from natural erosion of natural deposits on the banks of the Sacramento River. Gravel recruitment has been substantially reduced in these areas due to bank protection and levee construction (USFWS 1995).

Habitat Data

Riparian vegetation along the Sacramento River was mapped between 1996 and 1998 by CSUC Geographic Information Center as part of the Sacramento River Stream Corridor Protection Program and is available from CSUC as an ArcView project file.

The Sacramento River Watershed Program monitors water quality in the Sacramento River and several tributaries (Sacramento River Watershed Program 2000).

Fisheries and Restoration Projects

The primary issue being addressed in the Lower Sacramento River is fish passage through the Yolo Bypass and the Sacramento Deep Water Ship Channel. A topographic survey of Yolo Bypass, just downstream of the Fremont Weir, was completed in 2000 by DWR to evaluate fish passage options at the weir. Fish passage at Fremont Weir and at the Sacramento Deep Water Ship Channel is being evaluated in studies led by DWR. Habitat restoration is also being addressed although this issue is more complex because much of the lower Sacramento River is channelized and constrained by levees.

The Sacramento and San Joaquin River Basins Comprehensive Study (2000) was prepared for USACE, the State of California Reclamation Board, and various other federal and State agencies. The comprehensive study interim report (2002) recommends that projects be designed on a system-wide basis. DWR’s Hamilton City program was authorized under that authority. The “J” Weir on the right bank will be moved landward, and ecosystem restoration will enhance and protect on the waterside floodplain and habitat.

The AFRP is providing funding for fish screen design and construction at irrigation pump intakes along the lower river and into the Sacramento-San Joaquin Delta.

Murphy Creek, Amador and San Joaquin Counties

Potential Impediments to Anadromous Fish Migration

Sparrowk dam was an 8-foot-high earthen dam that was a complete barrier to anadromous fish passage. Sparrowk dam was removed in 2003. The Buena Vista Road Bridge impedes fish passage at low flows. However, this road bridge was altered in 2003 to improve fish passage.

General Description

Murphy Creek is a tributary of the Mokelumne River that traverses Amador and San Joaquin counties, entering the Mokelumne River about 0.3 of a mile downstream of Camanche Dam, which is on RM 63 of the Mokelumne River. Murphy Creek is about 6 miles long and its total watershed is about 5 square miles, ranging in elevation from 300 feet at its headwaters to 100 feet at its confluence with the Mokelumne River.

Fish Populations

Adult Chinook salmon were observed swimming past and spawning in habitat upstream of the lowest reservoir during a dam failure in the mid to late 1980s (Merz 2002 pers comm). No salmonid spawning has been documented within Murphy Creek since that time. However, East Bay Municipal Utility District (Merz 2002 pers comm) performed fish surveys and juvenile Chinook salmon and steelhead were observed in the lower reaches of the creek in the spring of 2000.

Water Quality

Water temperature and dissolved oxygen levels were measured by EBMUD (Merz 2002 pers comm). Dissolved oxygen levels in non-reservoir habitats ranged from 6.16 mg/L in pool habitat to 9.91 mg/L in riffle habitat.

Hydrology

There are no USGS or DWR stream gages on Murphy Creek. Hydrology data are not available. Field observations indicate continuous flows occur in the creek possibly supplied or augmented by lateral seepage from adjacent Camanche Reservoir.

Habitat Quality

EBMUD (2002) found that substrate within the middle reaches of Murphy Creek is suitable for Chinook salmon and steelhead spawning, and a preliminary study of hatchery Chinook salmon eggs survival suggests that successful hatching of alevins is possible. Livestock access and lack of canopy on most of the middle and lower portions of Murphy Creek may adversely impact spawning and rearing habitat for salmonids (EBMUD 2002).

Habitat Data

Pebble counts and benthic macroinvertebrate surveys were conducted by EBMUD (2002).

Fisheries and Restoration Projects

EBMUD, local landowners, and DWR's FPIP worked on a project that will improve fish passage along Murphy Creek. In August 2003, the project removed one impoundment providing water for livestock grazing, and developed a well in the vicinity of the existing impoundment to provide water to a stock watering tank. The project was funded by grants from the CALFED Bay-Delta Program ($282,500), the National Fish and Wildlife Foundation ($95,000), USFWS-AFRP ($10,000), and in-kind services from EBMUD ($115,000) and DWR's FPIP ($100,000). Fish passage during low flows were improved at the Buena Vista Road Bridge over Murphy Creek by removing about 60 square feet of the existing concrete ford downstream of the bridge. EBMUD, the landowners, and DWR also plan to increase native vegetation canopy and shrub cover, reduce non-native plant species, and limit livestock access to riparian zones by constructing and maintaining fences and gates to control livestock access.

Putah Creek, Yolo, Napa and Lake Counties

Potential Impediments to Anadromous Fish Migration

At RM 30, Monticello Dam creates Lake Berryessa with a capacity of 1.6 million acre-feet. This dam is an absolute barrier to anadromous fish passage in Putah Creek. There are four dams (including Monticello Dam) and one road crossing on Lower Putah Creek, which impede fish migration. The bypass check dam and the road crossing are seasonal barriers, which are impediments to migration when they are in the creek, but they are generally removed before upstream migration begins. The town of Winters' Percolation Dam is the unused remains of an old dam. This dam is passable at certain flows, but it is not clear what those flows are. Putah Diversion Dam and Monticello Dam (Solano Project dams) are both unladdered and impassable at all flows.

General Description

Putah Creek is 80 miles long and drains 810 square miles from its headwaters in the Mayacmas Mountains to its confluence with the Sacramento River. Putah Creek begins at an altitude of about 4,300 feet and drops to 100 feet as it reaches the Sacramento Valley. The 30-mile section of the creek downstream of the Monticello Dam is referred to as Lower Putah Creek. Only Lower Putah Creek is discussed in this river summary.

Fish populations

Historically, all 80 miles of the creek were accessible to anadromous fish. Today, only the lower 24 miles are accessible. There is evidence of historical anadromous fish species in Putah Creek. According to archeological and ethnographic research done by Schultz (cited in Trihey and Associates 1996) the Patowin people harvested Chinook salmon and sturgeon from Putah Creek through the late prehistoric period. A historical document by Shapovalov in 1947 states that both King salmon and rainbow trout were present in Putah Creek. There is also anecdotal evidence of steelhead being caught in Putah Creek as late as 1984. Angler Hal Janson testified at a 1996 trial that he caught salmon and steelhead downstream of the Monticello Dam in the late 1960s and early 1970s. In conjunction with the trial, Gary Falxa, Ph.D., a wildlife biologist and ecologist, reported seeing and rescuing stranded steelhead in a Putah Creek tributary in 1984 (Putah Creek Council 1999a).

The Native Species Recovery Plan for Lower Putah Creek, California, cites sampling of the creek by UC Davis professor Peter Moyle and students as evidence of fall-run Chinook salmon in 1975, 1983, and 1995. All three of these years were considered wet years for the creek. Sampling turned up Chinook salmon juveniles in spring 1995 at Dry Creek, Old Davis Road, and Mace Boulevard; in the spring of 1997 at Pedrick Road; and in March 1998 at Mace Boulevard. Spawning also was observed in the winter of 1997-1998 near Stevenson Road Bridge (Marchetti and Moyle 2000). Salmon were also spotted spawning in the creek in March 1999 at Russell Ranch and between Stevenson Road Bridge, Pedrick Road Bridge, and at Mace Boulevard (Putah Creek Council 1999b). A juvenile Chinook was caught in April 2000 (Putah Creek Council 2000). No estimates of run sizes have been made for Chinook salmon or steelhead on Putah Creek.

Water Quality

There are several water quality monitor programs including annual sampling by the Solano Irrigation District, monthly monitoring by USBR, and the Toxic Substance Monitoring Program initiated in 1976 by the SWRCB and conducted by DFG. Past water quality studies include a mineral analysis of surface water quality published in 1955 by the California Division of Water Resources, an analysis of groundwater for common mineral constituents conducted in 1960 by Thomasson and others, and a broad-spectrum analysis of water quality done by Evenson in 1985 (USFWS 1993).

Low waterflow has been the biggest deterrent to anadromous fish in Putah Creek since 1957 when the Solano Project dams (Monticello and Putah Diversion Dams) were built. Before 1957, Putah Creek was probably intermittent in its lower reaches. Cold water is released from Lake Berryessa via Monticello Dam. In May 2000, the outcome of several legal actions resulted in required releases from Putah Diversion Dam. The agreement specified required amounts and times of water release from the dam to provide water for the benefit of the fish and habitat of Lower Putah Creek. The required flows, to be released and measured directly at the Putah

Diversion Dam, are specified by month and range from 20 to 43 cfs in the summer and from 16 to 26 cfs in the winter. The highest flows of 46 cfs are required in April. There are also requirements that flow downstream of the Interstate 80 bridge meet required monthly averages that are slightly lower than required at Putah Diversion Dam. In years designated as drought years, these release requirements are lower in the summer, ranging from 15 to 33 cfs at Putah Diversion Dam. The agreement also established spawning flows to be released from the Diversion Dam for a three-day period between February 15 and March 31 each year. These flows are 150 cfs for the first day, 100 cfs on second, and 80 cfs on the third. And for the following 30 days, average daily flow at the Interstate 80 bridge must be 50 cfs or greater. The agreement established a committee to monitor Lower Putah Creek (Yolo Parties and Solano Parties 2000). Water release statistics for Putah Creek Diversion Dam are available from 1995 to 1999 (Ransom 2000).

Hydrology

Flow data are available from two USGS gages on Putah Creek. One gage, near the town of Guenoc in the upper watershed, has data for the past 49 years. The other gage near the town of Winters has 69 years of data (USGS 2000a, 2000b).

According to these flow values, summer months have relatively low flows down to 2.72 cfs and winter month flows up to 675 cfs with a mean annual flow of 211 cfs (Figure 3-27).

Figure 3-27 Mean monthly flows from 1904 to 2000 on Putah Creek near Guenoc, Lake County

Habitat Quality

The riparian zone surrounding Putah Creek has changed drastically in the past 120 years. Many human activities including construction of levees, channel excavation, gravel mining, groundwater extraction, and channel down cutting, have led to a deeper, narrower creek channel. This has decreased the ability of the creek to overflow onto the floodplain. As a result, the existing riparian forest is becoming dominated by valley oak, black walnut, and eucalyptus. Construction of the Solano Project dams has reduced gravel and sediment recruitment and has decreased the overall dynamics of the creek. Other factors affecting the vegetation along the creek corridor have been loss of land to agriculture, realignment of the channel, incision of the creek and steepening of the banks, dumping of trash and debris into it, burning of the riparian zone, and mechanical vegetation removal for flood control maintenance (USFWS 1993).

The portion of Putah Creek downstream of the diversion dam was formally "typified by intermittent flowing sections and more permanent deep pools, often formed as a result of beaver activity" (USFWS 1993). A May 2000 settlement agreement—the Putah Creek Accord—ended 10 years of litigation overflows in Putah Creek, and provides for continuous flow, even in drought years. The accord created the Lower Putah Creek Coordinating Committee to oversee perpetual monitoring of fish and wildlife, vegetation management and a permanent Streamkeeper. The accord further provides for pulse flows to attract Chinook salmon. Last year the pulse flow attracted a record number of spawning salmon, estimated by redd counts at over 70 fish. (Rich Marovich 2004 Jun 7 pers comm). Between Putah Diversion Dam and

Monticello Dam there are 6 miles of good cold water habitat, according to Joe Krovoza, chairman of the Putah Creek Council.

Upstream of the Putah Diversion Dam, the habitat is excellent and is considered a “Blue-Ribbon” trout stream (Rich Marovich 2004 Jun pers comm). This section of the creek has cold water year round, and 24-inch trout are not uncommon. There is some interest in examining the possibility of constructing a bypass channel in the footprint of an old remnant channel around the dam that may be easier and more cost effective to construct than a fish ladder. Solano County Water Agency is working on a county-wide habitat conservation plan with the long-range goal of acquiring easements along the creek. This may eventually make it feasible to open prime habitat to steelhead.

Habitat Data

There is extensive habitat information available in a USFWS (1993) report to Congress, Fish and Wildlife Resources Management Options for Lower Putah Creek, California. Historical fisheries and habitat information is available in a 1947 report by Shapovalov and in the Native Species Recovery Plan for Lower Putah Creek, California (Trihey and Associates 1996).

Riparian vegetation along Putah Creek was mapped from 1996 to 1998 by CSUC Geographic Information Center, as part of the Sacramento River Stream Corridor Protection Program and is available from CSUC as an ArcView project file.

Fisheries and Restoration Projects

Now that guidelines for water release down Putah Creek have been established, the political environment is much more conducive to restoration. Most interested parties are willing to work toward a healthier creek ecosystem. Owners of the three downstream barriers are open to the idea of making modifications to existing structures. However, no specific passage improvement projects have been undertaken yet other than establishment of informal protocols for operation of the seasonal check dam in the Yolo Bypass to allow salmon and steelhead passage in the fall. The Putah Creek Council and other groups have undertaken vegetation restoration projects such as tamarisk removal at various sites along the lower creek. Over 100 acres of Arundo have been removed along the 7-mile reach between Putah Creek Diversion Dam and Highway 505. Between Dry Creek and Highway 505 volunteers have removed almost 99 percent of the extant Arundo.

Other restoration efforts include an additional 4-acre site in the Winter’s Putah Creek Park between the City of Winters and Creekside Way. Revegetation took place on the top of the bank while the City restored the channel. The USFWS also helped to enhance fish habitat by installing a W-weir and log-vane structure at the Hasbrook property approximately 2 miles east of Highway 505.

The Putah Creek Council has also been actively removing solid waste and other trash. Volunteers have removed about 60 cubic yards of trash twice a year for 2002 and 2003. The Integrated Waste Management Board made available $40,000 for large equipment to remove larger impediments to flow such as abandoned automobiles. The board also provided $138,000 through their community-centered Farm and Ranch Project Program. The county received $600,000 trough a CALFED grant in 2003 to carry out physical and biological assessments. It has also mapped 128 acres of invasive weeds and identified 18,000 occurrences of invasive weeds.

San Joaquin River and Tributaries

The major tributaries off of the San Joaquin River all contain rim dams that block fish passage. Examples include the Mokelumne River (passage impeded by Camanche Dam), the Calaveras River (passage impeded by New Hogan Dam), the Stanislaus River (passage impeded by Tulloch Dam), the Tuolumne River (passage impeded by New Don Pedro Dam), and the Merced River (passage impeded by New Exchequer Dam). Currently, there are no facilities to enable fish passage upstream of rim dams in the San Joaquin River system; however, the technology and knowledge exists to facilitate fish passage upstream of rim dams and could be used on selected watersheds within the San Joaquin River system if the geographic scope of the FPIP is expanded.

Calaveras River, San Joaquin and Calaveras Counties

Potential Impediments to Anadromous Fish Migration

The Calaveras River, Mormon Slough, and the Stockton Diverting Canal have 20 seasonal flashboard dams, 11 low-flow crossings (6 have culverts), 5 weirs/permanent dams, 7 railroad crossings, and 54 bridges, one with a culvert and flashboard dam, that potentially impede anadromous fish migration between the river’s confluence with the Delta and New Hogan Dam. The seasonal flashboard dams are generally in place from mid-April through mid-October. Upstream and downstream passage may be impeded any time flashboards are in place or flows reach levels that provide inadequate depths or velocities that are too high at road crossings. FPIP gathered data regarding the size of the structures in 2001 and is now documenting the extent to which these structures impede the passage of anadromous fish under different flow conditions. New Hogan Dam is currently the upper limit of Chinook salmon migration (NMFS 2000). Historical documentation of the upper limit of Chinook salmon migration is lacking.

General Description

The Calaveras River watershed is on the western lower slope of the central Sierra Nevada. The watershed is about 400 square miles and receives its precipitation as rainfall due to a low elevation. As a result, significant flows enter the river primarily during the late fall, winter, and early spring when precipitation is heaviest. Trout fishing records in Calaveras County indicate major tributaries had permanent flows from cold springs at the 1,200–2,000 feet elevation (upstream of New Hogan Reservoir) that supplied sufficient cold water to support self-sustaining populations of German brown and rainbow trout (DFG 1963). USGS quadrangle maps show Double Springs draining into Cosgrove Creek, a tributary below New Hogan Reservoir, Spring Valley northeast of Chili Gulch, and unnamed springs scattered about the drainage above New Hogan Reservoir. Due to the seasonal concentration of precipitation in the basin predominately as rainfall, the natural flow of the Calaveras River is intermittent and can fluctuate from high flows in the winter to no flow in the summer and fall (USACE 1981).

The north and south forks of the Calaveras River join at the east end of New Hogan Reservoir to form the main stem of the Calaveras River. After leaving New Hogan Reservoir, the river continues for about 18 miles to the Bellota diversion structure that divides flow between the Calaveras River and Mormon Slough.

The Calaveras River continues westerly for about 2 miles to the Mosher Creek headgate where Mosher Creek branches off the Calaveras River. Mosher Creek continues westerly, connects to Bear Creek through the Bear Creek check structure, continues its westerly course, and then combines with Bear Creek, which eventually drains into the Delta. The Calaveras River continues its course toward the confluence with the Stockton Diverting Canal. The length of the Calaveras River between Bellota and its confluence with the diverting canal is about 19 miles. The Calaveras River continues westerly from the Stockton Diverting Canal through Stockton where it joins the San Joaquin River.

Mormon Slough continues southwesterly from Bellota and then splits into Mormon Slough and Potter Creek. Both Mormon Slough and Potter Creek continue toward Stockton in a parallel alignment. Near Stockton, Potter Creek reconnects with Mormon Slough. After an 18-mile run from Bellota, the Mormon Slough connects to the Calaveras River through the Stockton Diverting Canal. USACE built the Stockton Diverting Canal in the early 1900s to divert flows from Mormon Slough to the Calaveras River.

Fish Populations

Historically, the lower Calaveras River has probably been marginal for salmon production due to dry streambeds during summer and fall and lack of suitable habitat for spring-run salmon (Yoshiyama and others 1996). Chinook salmon used the river on an irregular basis (DFG 1993) probably only during exceptionally wet years. Since the New Hogan Dam project, winter-run salmon returned to the river in 6 different years from 1972 to 1984. The winter-run size varied from 100 to 1,000 fish (DFG 1993). It is unknown if this run predated the dams. Operation of the New Hogan Dam may have increased the frequency of the runs into the Calaveras River by creating a more constant flow (DFG 1993).

Between spring of 1972 and July 2003, DFG conducted various fish collection and observation studies downstream of New Hogan Dam. In March and April of 1972, 248 adult salmon were counted at the Stockton Diverting Canal. During the late winter/early spring run of 1973, only one 5.5-inch salmon was observed downstream of New Hogan Dam. The following season, no adults were observed, but 7 yearlings averaging 5.1 inches were seen.

During the 1975/76 season, DFG conducted two SCUBA surveys downstream of New Hogan Dam to the mouth of Cosgrove Creek. On June 3, DFG divers counted 166 Chinook salmon. Thirteen carcasses were tentatively determined to be 3-year olds based upon scale examinations. On July 8, 50 *O. mykiss* ranging in size from 125 to 455 mm were counted between New Hogan Dam and the first vehicle bridge. Nine Chinook ranging in size from 686 to 787 mm were also counted. Moribund fish were spawned out. During that same year, an opening day creel census on April 26, 1975, was taken between New Hogan Dam and the first bridge downstream and yielded 291 *O. mykiss* ranging from 140 to 489 mm in length, 2 adult salmon (737 mm and 838 mm), and one brown trout.

In 1976, 406 adult salmon were counted downstream of Bellota Weir. 1979 counts of *O. mykiss* and salmon were very low because of poor flows.

Another opening day creel census on April 24, 1985, 103 *O. mykiss* and one adult winter-run salmon were observed. During the span of 1988 to 1994, no observations of salmon were confirmed.

During a fall census in 1995, several dozen salmon and over 50 redds were counted. Subsequent informal visual surveys conducted that same year (Villa 1996) within the 5-mile reach downstream of Bellota Weir resulted in counts of between 300 and 500 salmon. DFG conducted 70 seine hauls in 1996 during an 18-week period between February and June between the Stockton Diversion Canal and New Hogan Dam; 467 juvenile fall-run Chinook were caught. Randall Baxter (2000) carried out a fly-fishing sample 100 m downstream of Bellota Weir and 200 m downstream of New Hogan Dam. Only one *O. mykiss* was caught at the first site, but 6 were caught at the dam. Counts taken between the 2000 and 2001 seasons were minimal (DFG survey data above provided by M. Simpson, S.P. S.P. Cramer & Associates 2004).

In recent years (1995 through 2005) trapping studies on the Calaveras have been carried out by S.P. Cramer & Associates (for the Stockton East Water District), DFG, and the Fishery Foundation of California. S.P. Cramer & Associates began their out migration sampling in 2002 and continued through the present. Early survey counts can be found at their Web site.

In the fall of 2003/winter 2004, ramer & Associates placed a 5-foot rotary screw trap in the Calaveras River at Shelton Road to capture *O. mykiss*. Between December 2, 2003, and January 7, 2004, 913 *O. mykiss* categorized as age 1+ were caught. Between January 14 and the 21, 88 fish categorized as age 1+ were caught. Additional juveniles were caught January 22–28 (42), January 29–February 11 (103 age 1+ and 4 YOY), and February 26–March 10 (49 age 1+ and 1 YOY). The screw traps were used through June 2004. Rotary Screw trap out-migration data, including data collected during the 2004 and 2005 season can be obtained by visiting the Web sites listed at right.

Migration data can be obtained at http://www.spcramer.com or http://www.calaverasriver.com

The presence of winter-run fish on the Calaveras River (Yoshiyama and others 1995) was reported in 6 separate years between 1972 and 1984 and numbered between 100 and 1,000 fish annually. The fish ascended the Calaveras, held and spawned in the reach just downstream of New Hogan Dam.

Steelhead trout have also been reported in the river (Li 1986); however, population estimates are unavailable.

Water Quality

Warm water is a major factor limiting anadromous fish production. Releases from New Hogan Lake directly affect temperatures. Elevated temperatures impact both spawning and rearing as well as fish migration patterns in the river (USFWS 1995). Temperature impacts can be mitigated by establishing a minimum pool size at New Hogan and a release schedule that would allow adequate minimum instream flows (USFWS 1995).

Historical, pre-dam, water temperatures within the Calaveras River downstream of New Hogan Dam during the summer and fall months would likely have been suboptimal to lethal for salmonids due to the low to no surface flows recorded at Jenny Lind (RM 37). With the operation of New Hogan Dam for irrigation and municipal flows, temperatures have become cooler year round in the reach between New Hogan Dam and Bellota Weir. For example, an examination of daily water temperatures at New Hogan Dam between 1969 and 1994 (USGS station) and 2000–2003 (SPCA thermographs) demonstrates preferable year-round temperatures for salmonid rearing (approximately 45 ºF to 60 ºF) between New Hogan Dam and Jenny Lind. Average water temperatures are within the preferred range for steelhead spawning (approximately 39 ºF to 52 ºF) immediately downstream of New Hogan during the entire spawning season and from December through late March at and upstream from Jenny Lind. Temperatures for adult upstream migrants are within the preferred range for migration (approximately 46 ºF to 52 ºF) at the lowermost thermograph (that is, Stockton East) from November to early March.

Hydrology

No dedicated fishery flows or minimum instream flows were required to mitigate for the construction of Hogan Dam and New Hogan Reservoir; thus, insufficient flow limits anadromous fish production in the Calaveras River (DFG 1993; USFWS 1995). However, adequate flows to provide fish migration opportunities have always been limited in river sections downstream of Bellota Weir. Because of seasonal concentration of precipitation in the river basin, the unimpaired natural downstream flow of the Calaveras River is intermittent and fluctuates from high flow in winter to little or no flow in the summer and fall which have contributed to the historical limited and opportunistic use of the basin by salmon and steelhead. Since construction of New Hogan Dam, anadromous fish have been unable to reach areas upstream of New Hogan Dam that may have provided suitable holding habitat during summer months.

During winter and spring, there continue to be periods of migratory opportunities but their overall frequency of occurrence and duration has been reduced (S.P. Cramer & Associates. 2003 Aug 1 pers comm). However, opportunities for steelhead migration continue to exist on a consistent basis, which provides the condition necessary for a viable steelhead population. Irrigation releases from New Hogan Dam provide consistent flows in the Calaveras River between New Hogan Dam and Bellota Weir during June through September when flows under historical conditions were nonexistent to intermittent (USGS 2004). Steelhead production is also limited by physical migration impediments mentioned earlier in the section.

Flow data are very limited for the Calaveras River. The USGS measured flows on the Calaveras River north of Linden from 1944 to 1950 and at Jenny Lind from 1907 to 1966 (USGS 2000). Pre-project conditions show average flows at Jenny Lind of 59 cfs for November which should have been sufficient for migration, especially without the current series of flashboard dams and Bellota Weir (Wikert 2004 Nov 2 pers comm). Refer to Figure 3-28 for flow data from Jenny Lind. Flows have been measured on the river at the Bellota Weir since 1997 (USGS 2002). Flow data farther downstream, beyond the irrigation diversions, are unavailable.

Figure 3-28 Mean monthly flows from 1907 to 1966 on Calaveras River at Jenny Lind

Peak flows during the winter months generally ranged from 1,000 to 5,000 cfs, but flows during the summer and fall were generally minimal to nonexistent (USGS 2000).

Habitat Quality

Most diversions, including the Bellota Weir 70 diversion, on the Calaveras River are not screened or their screens are inadequate (DFG 1993). Some diversions may entrain salmonids but the amount of entrainment depends on factors such as diversion capacity, proximity to spawning and rearing areas, and timing of operation. The magnitude of loss is currently unknown.

Upstream of Bellota, existing Calaveras River spawning gravels and riparian canopy have been described as adequate. Chinook salmon spawning habitat was surveyed 1.5 miles downstream of New Hogan Dam. Few potentially suitable spawning riffles were found. Conditions indicated relatively poor quality gravel and relatively high levels of sands and fines. Spawning habitat was not thought to be limiting due to the low escapement into the Calaveras River observed in recent years (Vick and Pederson 2000).

Habitat Data

A preliminary instream flow methodology study was prepared by USFWS in 1992. The study provided a range of required flows for winter-run salmon spawning and rearing habitat; however, it was conducted over a limited range of flow conditions (DFG 1993, Stillwater Sciences 2004).

A reconnaissance evaluation of spawning gravels within a 1.5-mile reach downstream of New Hogan Dam was conducted in 1999 (Vick and Pederson 2000). The evaluation found limited area suitable for Chinook salmon spawning in the reach between the dam and the downstream gorge.

Stillwater Ecosystem, Watershed & Riverine Sciences, Inc. (2004) published a Salmon and Steelhead Limiting Factors Analysis for the Lower Calaveras River which examines current conditions and provides data on the potential of the Calaveras River system to support populations of anadromous salmonids.

More information on this study is available at the AFRP Web site: http://www.delta.dfg.ca.gov/afrp/

Fisheries and Restoration Projects

Operation of New Hogan Dam and minimum instream flows have become discussion issues and, as a result, a more comprehensive view is now being taken of the watershed with various fishery, fish passage (between the Bellota Weir and tidewater), fish screening, and habitat evaluations either under way or proposed.

USFWS contracted with Stillwater Ecosystem, Watershed & Riverine Sciences, Inc. to conduct a reconnaissance evaluation of spawning gravels within a 1.5-mile reach downstream of New Hogan Dam. The survey was completed in 1999 (Stillwater Sciences 2000). The evaluation found habitat suitable for Chinook salmon spawning in the reach between the dam and the downstream gorge to be “relatively common.”

Through a CALFED grant, Stockton East Water District (SEWD) is contracting with CH2MHill to design a fish screen at Bellota and a rubber dam with a permanent fish ladder to replace Bellota Weir. The proposed fish screen will screen all the water going to the treatment plant year round and any controlled flow down Mormon Slough during the irrigation season when the boards at Bellota Weir are in place (for the downstream diverters and in the fish ladder).

SEWD, the Fishery Foundation, and their biological consultants are investigating the distribution, timing, and abundance of salmonids in the Calaveras system to determine appropriate fish protection and migration corridors, including opening up the Old Calaveras River section during lower winter flow periods. Currently, fish upstream of Bellota out-migrate through Mormon Slough in the nonirrigation season. The proposed facility plan is to have juvenile fish only move into Mormon Slough whenever there is uncontrolled water flowing into Mormon Slough.

SEWD is contracting with S.P. Cramer & Associates to develop a monitoring and evaluation plan to meet some of the CALFED requirements. DWR is assessing fish passage at structures in the Calaveras River, Mormon Slough, and Stockton Diverting Canal. Based on the outcomes of work undertaken by DWR, CH2MHill, the Fishery Foundation, USFWS (CVPIA AFRP), and S.P. Cramer & Associates, SEWD will work toward implementing a project.

Calaveras County Water District and SEWD have contracted to have a Watershed Management Plan prepared using a $200,000 SWRCB grant (USFWS 2000b). Phase I of the Plan was completed in April 2001. Phase II, Baseline Water Quality Monitoring, began in January 2003. Phase II is funded with a $195,000 CALFED grant.

The Fishery Foundation was awarded a $314,704 CALFED grant to study Chinook salmon and steelhead life history and habitat conditions on the Calaveras River under a cooperative agreement with the AFRP.

DWR’s FPIP began a barrier survey and evaluation in July 2001 on the Calaveras River from the confluence with the San Joaquin River to New Hogan Dam, including Mormon Slough and other primary channels. The survey has identified about 100 structures on the Calaveras River downstream of New Hogan Dam, the Stockton Diversion Canal, and Mormon Slough. Eight hydraulic models have successfully been run and the 2005 Interim Migration Barriers Assessment Report is scheduled to be complete by May 2005.

Merced River, Merced and Mariposa Counties

Potential Impediments to Anadromous Fish Migration

Merced Falls Dam, built in 1901, and New Exchequer Dam, built in 1967, are impassable barriers on the Merced River and limit upstream migration. In addition, three other dams, including Crocker-Huffman Dam (1910), Merced Fall Dam (1901), and McSwain Dam (1966), 3 roads, and 17 gravel pits are potential impediments to upstream and downstream migration.

General Description

The Merced River is 136.5 miles long and has a watershed that covers 1,273 square miles. It flows into the San Joaquin River at RM 118. Most of the water in the Merced River comes from spring snowmelt in the Sierra Nevada and rainfall in the fall and winter.

Fish Populations

Central Valley steelhead, spring-run Chinook salmon, and fall–run Chinook salmon all historically occurred on the Merced River. Unknown numbers of Chinook salmon may have reached the vicinity of Yosemite Valley, although this is not agreed upon (Yoshiyama and others 1996). Salmon most likely entered the South Fork Merced River and traveled to Peach Tree Bar, where a waterfall is a natural barrier. If this barrier was overcome, salmon would have met with another waterfall, considered impassable, 10 miles downstream of Merced Falls (Yoshiyama and others 1996).

Exchequer Dam, built in 1929, permanently barred salmon from traditional spawning grounds upstream. Naturally spawning fall–run fish have been seen in a stretch of river from Santa Fe Road to the Crocker-Huffman Diversion Dam. It is here that the Merced River Hatchery is located and spawners are caught for use as brood stock. By 1929, flows were greatly depleted by water diversion and irrigation, water temperatures became too hot, and fish that made it into the shallow waters of the lower Merced River soon perished (Yoshiyama and others 1996).

Today, fall-run, and some Central Valley steelhead occur in the Merced River (Fry 1960). Annual fall-run Chinook salmon surveys have been conducted since 1940, although data from the first two years were recorded as incomplete (Brown 1996). DFG counted 600 or fewer Chinook salmon each year between 1942 and 1969, except in 1954 when that number increased to 4,000 (Fry 1960; Brown 1996). Many factors affect population levels ranging from reduced in-river flows to increased irrigation demands, habitat conditions and fishery management decisions outside the Merced River. Fewer than 100 fish were documented each year from 1961 to 1966 (Menchen 1980). Fall-run numbers have begun to increase since 1970 due to increased streamflow released by the Merced Irrigation District (MID) and actions of the Merced River Hatchery (Yoshiyama and others 1996).

The enlargement of New Exchequer Dam increased streamflow for salmon beginning in fall 1967 (Menchen 1980). Between 1967 and 1991, the average returning number of fall-run Chinook salmon was 4,035 fish, with a low of 24 fish in 1990 and a high of 24,660 fish in 1984 (CH2MHill 1998). The fall-run Chinook salmon average from 1957-2003 was 3,910 fish, with a maximum of 29,749 in 1984 and a minimum of 20 in 1963 (GrandTab, DFG, Red Bluff Office, contact Colleen Harvey Arrison, 2004). Refer to Figure 3-29 for estimates on fall-run Chinook salmon in Merced River from 1954 to 2003.

Figure 3-29 Merced River fall-run Chinook salmon yearly population estimates

The US Department of Commerce, in their Tech Memos Series cites a paper by Busby and others (1996) as accomplishing a status assessment for steelhead stocks within the Central Valley ESU. The Busby and others (1996) paper identified one stock from the Sacramento River and reported that the Sacramento stock represents all the known populations of steelhead within the Central Valley ESU. The California Sportfishing Protection Alliance reported on their Web site: “There is no longer access for ‘threatened’ steelhead trout to the headwaters of any tributaries in the San Joaquin River, including the Merced River. All of the major tributaries, including the Merced River, have impassable dams in the lower reaches.”

Northwest Fisheries Science Center: http://www.nwfsc.noaa.gov/publications/techmemos/index.cfm

The California Sportfishing Protection Alliance Web site: http://users.rcn.com/ccate/Merced8Jul98.html

Water Quality

There are point and nonpoint discharges of contaminants such as endosulfan and toxaphene into Merced River sediment (CH2MHill 1998). Organophosphates used on orchards of stone fruit and nuts during the winter, including chlorpyrifos, diazinon, methidathion, and carbaryl, also reach the river via storm runoff (Ross and others 1996) Since January 2003, diazonon is being phased out of production although residual contamination may still be detected. DDT is still detected along parts of the Merced River, according to USGS. Potential mercury contamination of Lake McClure was noted by SWRCB (Brown 1996); however, in the nine years the Lake Don Pedro Community Services District had been running annual water sample analyses, no mercury has been detected (Kent 2004 Apr pers comm).

For further information: http://www.domyownpestcontrol.com/index.php/cPath/41?osCsid=937f74e4e6860395ffda88ae2797ff35.

During water years characterized as below-normal or dry, low flows could cause water temperatures to rise above salmonid tolerance levels at all life stages (Aceituno 2003 pers comm).

Hydrology

Low flow rates along the Merced River can impact all life stages of salmonids. Low flow rates may result in an increase in temperature, inhibiting spawning and reducing egg and juvenile survival (Boles 1988).

From 1941 until 1966, the median discharge on the Merced River near Stevinson was 200 cfs and the runoff volume was 499,400 acre-feet. Between 1967 and 1995, it was 270 cfs and 493,800 acre-feet, respectively (Mussetter Engineering 2000). The median discharge downstream of Merced Falls Dam was 860 cfs between 1902 and 1966. Runoff volume was 928,600 acre-feet (Mussetter Engineering 2000). After 1968, when the New

Exchequer Dam was completed, the annual runoff averaged 939,000 acre-feet downstream of Merced Falls Dam and had an average annual flow of 1,295 cfs. New Exchequer Dam has a maximum objective flood control release of 6,000 cfs (CH2MHill 1999, Mussetter Engineering 2000). Refer to Figure 3-30 for mean monthly flow on the Merced River from 1940 to 1955.

Figure 3-30 Mean monthly flows from 1940 to 1995 on Merced River near Stevinson

USGS collected streamflow data on the Merced River downstream of Merced Falls Dam from 1902 to 1913 and from 1917 to 1977, and near Stevinson from 1941 to 1995 (USGS 2001). DWR has collected flow data from the Cressey gage since 1941, the Snelling gage since 1930, and the Stevinson gage which was transferred from the USGS to DWR in 1996. All these flow data are available through CDEC since 1997 (DWR 2001).

Habitat Quality

Natural vegetation along the Merced River begins as coniferous forest, transitioning gradually with lowering elevation to oak woodland, chaparral, and annual grassland. During the drought years in the late 1980s and early 1990s, profuse water hyacinth growth in the lower Merced River encompassed large portions of the channel's wetted perimeter and created problems for upstream and downstream fish passage. A combination of an aggressive water hyacinth eradication program by Merced County and higher flow conditions during recent years has eliminated this passage issue for fish. More recently, to keep water hyacinth under control, the California Department of Boating and Waterways, working with local stakeholders, county agricultural commissioners, USBR, USFWS, the County of Fresno, and the County of Merced have instituted a control program. Boating and Waterways monitors water quality to ensure that herbicides do not exceed allowable limits, and that the spraying conducted in the Delta and in upstream sloughs and other waterways, has had no adverse impacts on the environment, agriculture, or public health in the area.

For more information, see http://dbw.ca.gov/PressRoom/2003/030501whstart.asp.

Much of the streambank vegetation has been removed creating an erosion issue (CH2MHill 1998). Siltation and an abundance of fine sediments are physical problems associated with mining activity and removal of streambank vegetation along the Merced River. Also, lack of gravel recruitment due to reservoir capture has been identified as a problem contributing to a reduction in spawning (CH2MHill 1998).

Habitat Data

Riparian vegetation along the Merced River was mapped in 1999 by the Sacramento and San Joaquin Rivers Basin Comprehensive Study, a USACE program, is available from USACE.

The USACE report is available on a CD or as a download on www.compstudy.org/docs/interimreport20021220/interimrpt-cover.pdf.

Also in 1999, DFG in cooperation with AFRP began to collect and synthesize GPS data for riffles on the Merced, Stanislaus, and Tuolumne rivers to update the 1989 San Joaquin Tributary Riffle Atlas.

Other studies initiated in 2000 provide instream data on the Merced and other San Joaquin tributaries and include a Feasibility Study to Develop [Eco-Friendly] Long-Term Aggregate Removal and Restoration and a PHABSIM/2D modeling effort to evaluate benefits to salmon spawning and rearing habitat created by large-scale channel restoration on the Merced.

Stillwater Sciences prepared a Report on Geomorphic and Riparian Vegetation Investigations in 2001 with data on anthropogenic modifications to the Merced River. The report also included data on sediment supply and transport; floodplain connectivity and channel migration in relation to vegetation presence and distribution. The above studies are available on the AFRP Web site.

AFRP Web site: http://www.delta.dfg.ca.gov/afrp/ws_docs.asp?code=MERCR

The Stanislaus River Fish Group Web site has available numerous documents including restoration plans for the Lower Stanislaus and conceptual models of potential salmonid limiting factors.

The Stanislaus River Fish Group Web site: http://www.delta.dfg.ca.gov/srfg/

Fisheries and Restoration Projects

The planting of yearling fall-run salmon in the Merced River by DFG began in 1965. Between 1969 and 1972, a salmon spawning channel, and two 250 by 20-foot rearing ponds were constructed in the gravel mining tailings at the base of Crocker-Huffman Dam. Four Pumps funding was approved in 1989 to modernize the Merced River Fish Facility by replacing the dirt ponds with two 500-foot concrete raceways and other improvements (completed in 1992/93 per Spaar 2005 Aug pers comm).

The artificially constructed salmon spawning channel was not found to be effective, according to Trevor Kennedy of the Fishery Foundation of California.

The Merced River Hatchery has produced nearly 18 million smolts and yearlings since 1980 of which 7.8 million (just below 50 percent) were released in to the Merced River. The remainder of the fish were used for experimental evaluation of smolt survival and production in the Stanislaus and Tuolumne Rivers as well as the South Sacramento-San Joaquin Delta (Heyne 2004 Nov 9 pers comm).

In 1996, the Magneson Pond Isolation Project was completed on a half-mile stretch of the river 2 miles upstream of Cressey. The project isolated an abandoned gravel pit and revegetated the surrounding area. Cooperating agencies included DWR and DFG and funding was provided by the Delta Pumping Plant Fish Protection (Four Pumps) Agreement (CH2MHill 1998). The DFG and DWR, through the Delta Pumping Plant Agreement, currently augment coarse sediment into the Merced River at a riffle rehabilitation site (built in 1991) identified as riffle 2. It is located just downstream from the Crocker Huffman diversion structure and is the spawning terminus for Chinook on the river (Lampa 2004 pers comm).

The Merced River Salmon Habitat Enhancement Project (MRSHEP), funded by DWR, DFG, the CALFED Bay–Delta Program, the AFRP, and local landowners, will remove predator habitat and improve fish passage by filling and eliminating gravel pits. The four-phase project began with preliminary survey, design, and conceptual plans for the entire MRSHEP reach. Isolation of the Ratzlaff pit (Phase 2), was constructed in October 1999. Phase 3 of the MRSHEP reach was completed in February 2002. The MRSHEP and the Merced River Gravel Replenishment Project were initiated to remove predator habitat by filling and eliminating gravel pits and to ensure adequate gravel production previously inhibited by mining and damming. This involves the reconfiguration of the channel and revegetation of streambanks with native vegetation. The revegetation will include the strategic placement of trees to provide stream shade. Phase 4, Lower Western Stone, is scheduled for construction in 2005 or 2006 (DWR 2000).

Projects outlined by the CVPIA include the screening of 49 small pump diversions along the river to prevent entrainment of juveniles during migration. Also, increased enforcement of pollution control, poaching regulations, screening requirements, and streambed alterations are recommended during migration (CH2MHill 1998). Additional actions include purchasing riparian and floodplain lands, reconfiguring channels and river/floodplain relationships, and eliminating routes to in-channel and off-channel predatory pools (CH2MHill 1998).

The AFRP evaluated the use of PHABSIM/2D computer modeling on spawning and rearing habitat to assess the benefits of restoration on the Merced River (USFWS 1995) as one of the components of the pre- and post-restoration project. Pre-project monitoring occurred in the summer and fall of 2000 and 2001. Post-project monitoring began in spring 2002.

Stanislaus River, San Joaquin and Stanislaus Counties

Potential Impediments to Anadromous Fish Migration

The construction of dams on the Stanislaus River began in 1858 with Tulloch Dam. The two dams that followed, Goodwin Dam, constructed in 1912 at RM 58.4, and New Melones Dam, completed in 1978 at RM 56.4, both impede spawning in upstream reaches. Goodwin Dam is the upstream limit of migration. The remains of Old Melones Dam, now covered by New Melones Lake, creates a barrier to cold water released from the reservoir into the river when reservoir levels are low. In addition to these three dams there are many potential impediments to migration including 21 gravel and quarry pits and a bridge.

General Description

The Stanislaus River runs southwest from the Sierra Nevada to RM 75 of the San Joaquin River and is 118.1 miles long. This confluence forms the legal boundary between the San Joaquin River System and the Sacramento - San Joaquin Delta (Brown 1996). The watershed is 1,075 square miles, and elevations range from 25 feet at its confluence with the San Joaquin River to 10,000 feet at its headwaters (CH2MHill 1999).

Fish Populations

Historically, Central Valley steelhead, spring-run Chinook salmon, and fall-run Chinook salmon occurred in the Stanislaus River, with the spring-run predominant. Late- fall run and winter-run Chinook populations have not been recorded in the Stanislaus River (Demko 1998). The building of Goodwin Dam in 1912 created a nearly impassable barrier at RM 58.4, making habitat on the Stanislaus River suitable only for fall-run due to reduced flows and increased water temperatures (Fry 1960). J.D. Wikert (2004) reported Chinook passing the weir in January and February with the last upstream passage on February 14, 2004. Chinook salmon were historically found near Duck Bar, which is now covered by the upper end of New Melones Lake. The North Fork of the Stanislaus River is deemed accessible to McKays Point and the Middle Fork to the reach upstream of Beardsley Lake. The South Fork, which contains no salmon, was found historically to have poor habitat (Yoshiyama and others 1996).

Old redd beds were seen in 1939 in the reach between Riverbank Bridge and Malone Power House, 9 miles of which was difficult for salmon to access (Yoshiyama and others 1996). There are spawning beds on the 23-mile stretch of river between Riverbank and Goodwin Dam, concentrated at Two-mile Bar. Rearing occurs along 51 miles of the lower Stanislaus River basin (Yoshiyama and others 1996).

Annual fall-run Chinook salmon surveys have been conducted on the Stanislaus River since 1940. The largest recorded run occurred in 1985 with 40,300 fish (Fry 1960; Brown 1996). The second highest run, occurring in 1953, totaled 35,000 fish. The smallest run was 0 in 1977 followed by 50 in 1978; fall-run escapements (GrandTab) from 1970-2003 averaged 3,954. S.P. Cramer & Associates captured 30,427 Chinook near Oakdale during 115 sampling days between February 1993 and June 1996. It also captured 2,468 Chinook salmon near Caswell Memorial State Park during 143 sampling days in 1995 and 1996. Of these, 2,424 were natural migrants (Demko 1996). Population estimates for all age classes in 1998 were 10,820 (CH2MHill 1998). Between 1992 and 1997, Yoshiyama noted estimated spawning escapement for adult fall-run Chinook was 1,390 (Yoshiyama and others 2000). An analysis of the relationship between flow and juvenile Chinook survival, recruitment and stock performed by the Stanislaus River Fish Group (2004) found that recruitment was higher under floodflows above 18,000 cfs. Although analysis errors were high, data suggests that within a particular flow range, recruitment increases rapidly up to 1,000 to 2,000 spawners. The spawner number remains relatively flat or slowly increases as spawner numbers exceed 2,000 age-3 equivalent fish. Fall-run Chinook escapement on the Stanislaus was found to be higher when at least 500 or more spawners were present 2 years after spring flooding (SRFG 2004). Target production numbers (escapement + harvest) for Stanislaus River fall-run Chinook salmon under the California Valley Project Improvement Act 1998 plan is 22,000 (AFRP). According to DFG, between the years of 1952 and 2003 (1982 not surveyed), the Stanislaus River averaged 5,362 fall-run Chinook salmon, with a maximum of 35,000 in 1953 and a minimum of zero in 1977 (Figure 3-31) (GrandTab, DFG, Red Bluff Office, contact Colleen Harvey Arrison, 2004).

Figure 3-31 Stanislaus River fall-run Chinook salmon yearly population estimates

Central Valley steelhead are thought to have historically occurred along 113 miles of the Stanislaus River. Following the construction of major dams, this was reduced to about 50 miles (DWR and USBR 1999). NMFS conducted genetic analysis of Central Valley steelhead in the river and concluded that this population is part of a distinct genetic group made up of populations in Mill Creek, Deer Creek, and the Coleman and Feather River hatcheries (Interagency Ecological Program Steelhead Project Work Team 1999).

A population survey conducted by S.P. Cramer & Associates near Caswell Memorial State Park in 1995 and 1996 resulted in the capture of four Central Valley steelhead (Demko 1996). In 1998, they captured 20 Central Valley steelhead between January and July (Demko 1998). According to The Stanislaus River Fish Group (2004), juvenile steelhead numbers extrapolated from captures in a rotary screw trap since 1996 ranged from 101 to 297 with the exception of an extrapolated count of 894 in 1999.

Water Quality

In 1996 dissolved oxygen and water temperature in the Stanislaus River spawning areas were measured. October intragravel dissolved oxygen concentrations at most of the sites were above the US Environmental Protection Agency standard of at least 80 percent saturation, although levels in the artificial redds ranged between the lethal level of 50 percent and the US Environmental Protection Agency standard of 80 percent. The lowest intragravel dissolved oxygen concentrations were adjacent to a grassy field and orchard across from the USACE Knights Ferry Recreation Area. The highest temperatures were in areas where no spawning was occurring and dissolved oxygen levels were suboptimal or lethal (Mesick 1997).

Mining in Copperopolis has resulted in higher than normal concentrations of copper in Tulloch Reservoir, which feeds into the Stanislaus River (CH2MHill 1998). Copper is acutely lethal to rainbow trout in concentrations of 1 mg/L at 5 °C, and 0.5 mg/L at warmer temperatures of 12-18 °C. Olfaction, chemosensory perception, and consequently the ability to avoid the chemical, are impaired in Chinook salmon when copper levels reach 50 μg Cu/L (Hansen and others 1999).

High nitrate concentrations were documented in the Stanislaus River in 1995 between Orange Blossom Bridge and Riverbank, suggesting that agriculture and wastewater contaminants are impacting this spawning reach. In 1996 intragravel nitrate concentrations at Honolulu Recreation Area, Orange Blossom Bridge, Valley Oak Recreation Area, and Oakdale Recreation Area were documented at levels between 0.8 and 1.0 mg/L, twice as high as the upstream sampling sites (Mesick 1997).

Figure 3-32 Pre New Melones Dam mean monthly flows from 1940 to 1977 on Stanislaus River at Ripon

Hydrology

Figures 3-32 and 3-33 demonstrate the hydrologic difference in the Stanislaus River created by the completion of the New Melones Dam in 1978. Pre-dam figures show a larger variance in cfs during the year as compared to the relatively stable yearly cfs encountered post-dam. Until 1978, the median discharge and runoff volume downstream of Goodwin Dam were 45 cfs and 525,500 acre-feet, respectively. After 1978 and the completion of New Melones Dam, the figures were 360 cfs and 578,700 acre-feet, respectively. The gage near Ripon recorded 310 cfs and 729,000 acre-feet before 1978, then 500 cfs and 701,500 acre-feet. The maximum objective flood control release from New Melones and Tulloch dams is 8,000 cfs. To avoid flooding the floodplain areas in agricultural production, the nonflood maximum release is 1,500 cfs (Mussetter Engineering 2000). Kondolf and others (2001) conducted a crude bed mobility flow evaluation at five gravel replenishment sites between Goodwin Dam and Oakdale where gravel had been added during the summer of 1999. Flows of 5,000 to 8,000

Figure 3-33 Post New Melones Dam mean monthly flows from 1979 to 2003 on Stanislaus River at Ripon

cfs were estimated as necessary to mobilize the gravel placed at these sites. They also concluded that higher flows would be needed to prevent further encroachment of riparian vegetation into the active channel. Prior to construction of New Melones Dam, a bed mobilizing flow of 5,000 to 8,000 cfs was equivalent to a 1.5- to 1.8-year return interval flow. After the construction of New Melones Dam, 5,000 cfs is approximately a 5-year flow and 8,000 cfs exceeds all flows within the 21-year study period (Kondolf and others 2001).

Stanislaus River flows were extremely low in 1976 (average 142 cfs) and 1977 (average 22 cfs), which prevented spawning in the fall of 1977 (EA Engineering, Science and Technology 1991). Flow rates between 1978 and 1999 averaged 1,500 cfs in March and 600 cfs in July to November (CH2MHill 1999). The actual non-flood maximum release is 1,500 cfs to avoid flooding the floodplain areas in agricultural production (Wikert 2004 Nov 8 pers comm). Between 1994 and 1996, Carl Mesick Consultants documented October-November streamflows between Goodwin Dam and Riverbank of 275-300 cfs in 1994 and 1995, and 350–400 cfs in 1996 (Mesick 1997). S.P. Cramer & Associates also measured streamflow at its trapping locations in 1996. The flow near Oakdale and Caswell Memorial State parks ranged from 302 cfs on February 3 to 3,975 on March 5 (Demko 1996).

According to USFWS, an instream flow of 300 cfs between October 15 and December 31 would maximize Chinook salmon spawning habitat on the Stanislaus River, 150 cfs between January 1 and February 15 would maximize egg incubation, and 200 cfs between February 15 and October would maximize juvenile habitat availability (Aceituno 1993). Although valuable the instream flow study ignores the significant contribution inundated floodplain habitat contributes to growth and survival of juvenile salmonids (Wikert 2004 Nov 8 pers comm).

Streamflow data for the Stanislaus River have been collected by USGS downstream of Goodwin Dam since 1958 and in Ripon since 1941 (USGS 2001). DWR has been collecting temperature data at Jacob Myers Park and Oakdale Recreation Area since 2001 (DWR 2001).

Habitat Quality

Vegetation along the Stanislaus River begins as coniferous forest in the Sierra, then transitions to oak woodland, foothill pine, and chaparral. In the basin, the predominant vegetation is grassland. Lack of riparian vegetation for shade has become a problem along the valley corridor due to agricultural encroachment. Areas where riparian vegetation remains (willow species, willow scrub, cottonwoods, valley oak) are largely protected by easements and title holdings of the USACE (CH2MHill 1998).

Elevated fall water temperatures may result in delayed spawning and migration, which would delay smolt out-migration and possibly decrease survival rates. An abundance of fine sediments caused by grazing, mining, mined channels, low flows, and streambank modification has also become a problem for spawning and rearing salmonids. Additional problems facing salmonids on the Stanislaus River include reduction in overall habitat space, lack of spawning gravel, entrainment at unscreened pumps, and illegal take of adult salmon by poachers. Finally, predation threatens Chinook salmon in the Stanislaus River due to increased predator habitat in abandoned gravel pits and mined channels (CH2MHill 1998).

Habitat Data

Contact Gary Lemon with DWR (glemon@water.ca.gov) for riparian habitat information generated by the Comprehensive Study.

Riparian vegetation along the Stanislaus River was mapped in 1999 by the Sacramento and San Joaquin Rivers Basin Comprehensive Study, a program of the USACE. Riparian data in GIS format were collected for the Sacramento and San Joaquin rivers and their respective major tributaries.

Fisheries and Restoration Projects

Current actions proposed under the CVPIA include improving watershed management and restoring instream and riparian habitat. They recommend replacing riparian vegetation impacted by the construction of Highway 108 and Highway 120 and providing shade, cover, food sources, and decreasing sedimentation. Proposed projects to replace and provide maintenance for gravel recruitment would increase quality and quantity of substrates available along the river (USFWS 1995). In addition, proposals exist for screening of diversions to prevent entrainment. In 1994, three spawning riffles located at RMs 47.4, 50.4, and 50.9, were rehabilitated by DWR San Joaquin District staff. Planning began in 2000 for an isolation and restoration project at the Oakdale Recreation Site, owned by USACE. However, the project is currently on hold due to funding constraints (Lampa 2004 Apr pers comm). During 1999, eighteen riffles were constructed between Knight's Ferry and the Lover's Leap stretches of the Stanislaus via CALFED funding. Funding from AFRP and DWR Four-Pumps is being allocated for a project to construct additional riffles and provide floodplain and side-channel habitat in the Lover's Leap reach of the Stanislaus (Wikert 2004 Nov pers comm). A gravel pit isolation project on the Stanislaus River, Willem's Restoration Site (approved in 1996), was stopped due to landowner concerns; no future action is planned (CH2MHill 1998).

The Stanislaus River Fish Group Web site: http://www.delta.dfg.ca.gov/srfg/

In 1999, the AFRP proposed evaluation of causes and locations of mortality on the Stanislaus River using continuous radio tagging of juvenile Chinook salmon. These studies were being carried out by S.P. Cramer & Associates and funded by the Oakdale Irrigation District (Demko 1998). Legal action was also proposed to reduce illegal harvest (USFWS 1995).

The Stanislaus River Fish Group (SRFG) is working on a plan to restore the instream and riparian habitats between Goodwin Dam and the confluence with the San Joaquin River. Its goal is to sustain native terrestrial and aquatic species in this area while meeting CVPIA goals. The fisheries summary is complete, but the rest of the plan is still in draft form. This plan will include cooperative habitat restoration projects where adjacent landowners and managers are willing (Mesick 1998).

Tuolumne River, Stanislaus and Tuolumne Counties

Potential Impediments to Anadromous Fish Migration

On the South and North Forks of the Tuolumne River, large waterfalls historically limited upstream access. By 1870, various mining projects and dams were constructed on the main Tuolumne River, leading to decreased fish passage. Wheaton Dam, built in 1871 at the falls upstream of La Grange, impeded fish passage, as did the impassable La Grange Dam when it was built on that site (RM 52) in 1893. Once Hetch Hetchy Reservoir (O'Shaughnessy Dam) was constructed in 1923, no salmon occurred upstream of this barrier (Yoshiyama and others 1996 as per Turlock Irrigation District).

Two dams on the Tuolumne River present impassable barriers, La Grange Dam at RM 54 and New Don Pedro Dam and reservoir at RM 56. In addition to these barriers, other potential impediments to upstream and downstream migration include four other dams, five bridges, and 14 gravel pits.

General Description

Fed by spring snowmelt and seasonal rain, the Tuolumne River has the highest average unimpaired flow of the San Joaquin River Basin tributaries. The Tuolumne River flows southwesterly from its source in the Sierra Nevada to its confluence with the San Joaquin River at RM 83 just west of Modesto. It runs about 161 miles and drains approximately 1,900 square miles (McBain and Trush 2000).

Fish Populations

Both fall-run and spring–run Chinook salmon historically occurred in the Tuolumne River. The first recorded Chinook salmon sighting on the Tuolumne River came from the Fremont expedition in 1845 (Ogden 1988). Clavey Falls may have partially obstructed migration, but there is evidence to support spring-run passage at this barrier. Central Valley steelhead were noted to have ascended several miles to Cherry Creek and, therefore, spring-run Chinook salmon may have done so as well. The Tuolumne River has not hosted spring-run Chinook salmon since at least 1959, due to low flows and high water temperatures in the summer (Fry 1960). Annual fall-run Chinook salmon surveys have been conducted on the Tuolumne River since 1940 (Brown 1996). The Modesto Dam was condemned in 1947, so there were no further counts at this location, and later numbers are based on DFG estimates.

The greatest number of Chinook salmon was 130,000 fish documented in 1944. The number of spawning fall-run Chinook salmon between 1952 and 2003 ranged from a high of 45,900 in 1959 to a low of almost zero in 1963 and 1990 (Figure 3-34). The average number of fall-run Chinook salmon for this time frame was 10,606 (GrandTab, DFG, Red Bluff Office, contact Colleen Harvey Arrison, 2004). The maximum production estimated for the Tuolumne River, under current habitat conditions, is an escapement of 15,000 individuals (McBain and Trush 2000) although the escapement for

Figure 3-34 Tuolumne River fall-run Chinook salmon yearly population estimates

2000 was 20,000 individuals. FERC made fish surveys at Don Pedro Project a monitoring requirement in 1971 (Heyne 2000).

At Dennett Dam near Modesto, the DFG counted 66 Central Valley steelhead in 1940 and six in 1941 (McEwan and Jackson 1996). Additional information on steelhead in the Tuolumne River can be found in the NMFS petition to FERC for reopening the Don Pedro License (Docket # P-22-99).

Federal Energy Regulatory Commission: www.ferc.gov

Water Quality and Hydrology

Variable streamflow and seasonal flooding in the Tuolumne River is critical to salmonid migration. It serves to maximize available spawning habitat by providing variable depths, removing excess silt, sand, and fine debris from gravel, and causing increased spawning on marginal habitat. Regulated baseflow at levels below 100 cfs may limit spawning to center channels and lead to redd superimposition (McBain and Trush 2000).

Seasonal storm runoff carries high levels of insecticides, including Diazinon and methidathion, from dormant orchards near the Tuolumne River (Ross and others 1996; Kratzer 1998). Daizinon and other pesticides in the Tuolumne River may exceed levels known to be toxic to aquatic life (Dubrovsky 1998). Bioaccumulation of pesticides is suspected at the confluence of the Tuolumne and the San Joaquin rivers. Organochlorines in biota exceed the National Academy of Sciences and National Academy of Engineering's recommended tissue concentrations for protection of fish–eating wildlife. These chemicals make their way into the river system during winter storms and through urban runoff (Brown 1998). The Tuolumne River is also a source of mercury (Brown 1998).

Prior to 1971, the median discharge was 760 cfs, and runoff volume was 1,052,300 acre-feet. After 1971 and the completion of New Don Pedro Dam, the median discharge was 370 cfs and the runoff volume was 731,800 acre-feet. The maximum objective flood control release from Don Pedro Dam is 9,000 cfs (Mussetter Engineering 2000).

The Modesto Irrigation District (MID) and the Turlock Irrigation District (TID) own the senior rights to water on the Tuolumne. The City and County of San Francisco owns the next rights to water on the Tuolumne, subject to the Districts' prior water rights and the Raker Act.

Individuals with riparian water rights divert approximately 19,400 acre-feet per year (DWR 1982).

Streamflow data has been collected near La Grange Dam from 1912-1997 and in Modesto in 1896 and from 1940-1997 (USGS 2001). DWR has been collecting streamflow data at these two locations since 1997 (DWR 2001)

Habitat Quality

Alluvial portions of the Tuolumne River are the areas of greatest biodiversity, containing sandbars that create topographical diversity and provide habitat for all life stages of Chinook salmon. In 1986, EA Engineering, Science, and Technology documented 2.9-million square feet of riffle area downstream of La Grange Dam when streamflow was maintained at 230 cfs. A study by the USFWS (1995) found an instream flow of 275 cfs would provide the greatest amount of salmon spawning habitat. This provided up to 13,500 spawning sites, assuming that all riffles were spawnable (EA Engineering 1993). Increased flows would progressively expose more suitable spawning ground on adjacent bars and stream margins (McBain and Trush 2000). Eleven riffles found between RM 35.5 and 40.2 had especially good and well used spawning gravel. The best and most undisturbed of these was at RM 38 (McBain and Trush 2000).

Currently, encroaching vegetation has narrowed and reduced total spawning area in these riffles by 43 percent. Floods in 1997 also impacted spawning gravel, causing scours and creating deep runs and steep riffles in reaches where bridges, dikes, and agricultural encroachment existed. Riffles 1A, 1C, 6, 9B, and 11, all downstream of Old Basso Bridge at RM 48, were some of those most directly affected (McBain and Trush 2000).

Superimposition was found to be a major factor in mortality rates from RM 50.5 (Old La Grange Bridge) to RM 47.6. An estimated 53 percent of all spawners on the Tuolumne River used this site, yet only one-fifth of total available spawning gravel is found in this location (EA Engineering 1991; McBain and Trush 2000).

Gravel quality on the river has grossly diminished due to decreased scouring and channel forming flows, increased sediment from Gasburg Creek, and elimination of coarse bedload from sources upstream of La Grange Dam. Gravel quality assessments conducted in 1987 and 1988 found that the overall survival of redds (incorporating baseline survival, red survival, emergence, and length fecundity data) was 34 percent (McBain and Trush 2000). A more recent study by the USFWS titled The Relationship between Instream Flow and Physical Habitat Availability for Chinook Salmon in the Lower Tuolumne River, California (1995a) found an instream flow of 275 cfs to provide the greatest amount of salmon spawning habitat.

Riparian vegetation removal and in-channel gravel mining have increased siltation and decreased water quality. Downstream of La Grange Dam, low flows that impede Chinook spawning and out-migration have been documented in the fall and temperatures as high as 30 °C have been recorded in the summer. Lethal temperatures for Chinook salmon range from 25.0 to 28.8 °C. Wintertime flows in the Tuolumne River are dependent upon inflow from local storm events and releases made from New Don Pedro Reservoir in response to flow control requirements imposed by USACE. Flow fluctuations in the Tuolumne River are managed in conformance with the 1996 FERC Order, which included ramping rates to reduce potential fluctuation impacts (see Section 16 of the 1995 FERC Settlement Agreement and Page 6, Paragraph 3, of the 1996 FERC Order for further clarification regarding this issue). Flows from December through February in the Tuolumne River are dependent upon inflow from local storm events and releases made from New Don Pedro Reservoir in response to flow control requirements imposed by USACE. According to Section 16 of the 1995 FERC Settlement Agreement, if releases from New Don Pedro Reservoir result in flow fluctuations, adult fish passage may be disrupted, juvenile stranding may occur, redds may become dewatered, and water quality may be impacted.

The presence of pesticides and herbicides, although not consistently documented, may also decrease salmon survival (CH2MHill 1998).

The primary predators on the Tuolumne River are largemouth and smallmouth bass. Studies conducted by the DFG estimate that these fish are responsible for up to 69 percent of the total mortality of 90,000 smolts during their 3-day migration. Predators were found to be more abundant in Section 1 (RM 25–52) than in Section 2 (RM 0–25), with the highest concentration being found in special-run pools left from in-channel aggregate mining. Largemouth bass have an estimated May population of 11,000 bass within a 52 mile reach of the Tuolumne River. Illegal harvest of adult Chinook salmon is another concern (USFWS 1995).

Habitat Data

Riparian vegetation along the Tuolumne River was mapped in 1999 by the Sacramento and San Joaquin Rivers Basin Comprehensive Study, a program of the USACE and DWR. A riparian inventory was also prepared by McBain and Trush (1997)

Contact Gary Lemon at glemon@water.ca.gov for information on comprehensive study

Fish Passage and Restoration Projects

CVPIA restoration and improvement action plans for the Tuolumne River are funded by the Tuolumne River Technical Advisory Committee and the AFRP. These plans include gravel restoration and augmentation as well as habitat protection. Large in-channel and off-channel pool connections would be physically eliminated to decrease predation by large warm water fishes. Legal action is recommended to reduce poaching, pollution, and streambed alteration. Twenty small, unscreened pumps are proposed for screening to protect juveniles.

Actions are already under way to decrease sedimentation under the supervision of the M.J. Ruddy Erosion Control Project Phase II. This project, along with the Basso Bridge Area Project and the Basso Bridge Land Acquisition Project, will clean spawning areas and secure lands with good riparian habitat for salmonids (CH2MHill 1998).

FERC license issued in 1964 (effective 1966) for the New Don Pedro Project required 20 years of fish studies after commercial operation, which occurred in 1971, and the filing of a report on those studies in 1992. In 1995 a FERC-mediated Settlement Agreement was signed by MID, TID, the City and County of San Francisco, DFG, USFWS, FERC staff, Friends of the Tuolumne, Tuolumne River Expeditions, the Tuolumne River Preservation Trust, and the San Francisco Bay Area Water Users Association. The 1995 Settlement Agreement provided for increased minimum instream flows for fishery purposes, an expanded technical advisory committee, additional monitoring and studies to be conducted through 2004, and riparian habitat restoration projects. The FERC-jurisdictional provisions of the Settlement Agreement were included in a July 1996 amendment to the FERC license. (McBain and Trush 2000).

In 1986, DFG and the districts developed a new flow management regime to incorporate the needs of Chinook salmon. This flow schedule has not yet been approved by FERC. The USFWS and the City and County of San Francisco have filed their own recommendations with FERC. FERC currently requires the release of a fall attraction pulse flow, with magnitudes up to 2,500 cfs for 3 days to reduce natural storm variability and maintain waterflow variability during the 45-day Chinook salmon spawning period (McBain and Trush 2000).

To fulfill their habitat restoration project obligations under the 1995 Settlement Agreement, TID and MID have been able to obtain grant funding commitments of $34 million in addition to $1 million from TID, MID, and the City and County of San Francisco. The habitat restoration program is administered by TID. Projects funded thus far include, but are not limited to, $2.5 million for environmental review and design work for Special Run Pools 9 and 10 Restoration Projects and the entire Mining Reach Restoration Project located between Waterford and Roberts Ferry Bridge; $3 million for construction of the SRP 9 Project completed in 2001; $4.5 million for construction of the 7-11 Reach of the Mining Reach Project completed in 2002; $7.2 million for the construction of the Ruddy Reach and $11.2 for the construction of the Warner-Deardorff Reach of the Mining Reach Project planned for 2003/2004. During the construction of the SRP 9 Project, TID placed infiltration gallery piping under the river. This gave TID the future option of using the gallery as a point of re-diversion for domestic water to be treated and supplied to municipalities within TID. Year-round re-diversion of the water for domestic purposes at SRP 9 could be beneficial for salmonid habitat within the 26 miles of river between La Grange Dam and SRP 9. DFG’s Reed Restoration Project, which was approved for $277,000 in funding under the Delta Pumps Fish Protection Agreement (4-Pumps), was halted in 1997 by landowner concerns.

Gravel has been placed in several locations along the reach located near the town of La Grange. The gravel additions in this reach are planned for multiple phases. Phase I of the project was completed in 1999, when approximately 12,500 cubic yards of gravel was placed downstream of the Old La Grange Bridge. Approximately 14,400 tons of gravel was placed in 4 different locations on the Tuolumne River in 2002, and approximately 8,000 tons of gravel was expected to be placed in the river during the summer of 2003.

A project was also proposed by AFRP (but never implemented) to evaluate the use of PHABSIM/2D modeling of spawning and ring habitat to assess benefits of restoration on the Tuolumne River (USFWS 1995).