Whiskeytown Reservoir Operations

Since 1964, a portion of the flow from the Trinity River Basin has been exported to the Sacramento River Basin through the CVP facilities. Water is diverted from the Trinity River at Lewiston Dam via the Clear Creek Tunnel and passes through the Judge Francis Carr Powerhouse as it is discharged into Whiskeytown Lake on Clear Creek. From Whiskeytown Lake, water is released through the Spring Creek Power Conduit to the Spring Creek Powerplant and into Keswick Reservoir. All of the water diverted from the Trinity River, plus a portion of Clear Creek flows, is diverted through the Spring Creek Power Conduit into Keswick Reservoir.

Spring Creek also flows into the Sacramento River and enters at Keswick Reservoir. Flows on Spring Creek are partially regulated by the Spring Creek Debris Dam. Historically (1964-1992), an average annual quantity of 1,269,000 af of water has been diverted from Whiskeytown Lake to Keswick Reservoir. This annual quantity is approximately 17 percent of the flow measured in the Sacramento River at Keswick.

Whiskeytown is normally operated to (1) regulate inflows for power generation and recreation; (2) support upper Sacramento River temperature objectives; and (3) provide for releases to Clear Creek consistent with the CVPIA Anadromous Fish Restoration Program (AFRP) objectives. Although it stores up to 241,000 af, this storage is not normally used as a source of water supply. There is a temperature curtain in Whiskeytown Reservoir.

Spillway flows below Whiskeytown Lake

Whiskeytown Lake is drawn down approximately 35,000 af per year of storage space during November through April to regulate flows for power generation. Heavy rainfall events occasionally result in spillway discharges to Clear Creek, as shown in Table 2–2 below.

Table 2–2 Days of Spilling below Whiskeytown and 40-30-30 Index from Water Year 1978 to 2002

Water Year	Days of Spilling	40-30-30 Index
1978	5	AN
1979	0	BN
1980	0	AN
1981	0	D
1982	63	W
1983	81	W
1984	0	W
1985	0	D
1986	17	W
1987	0	D
1988	0	C

Water Year	Days of Spilling	40-30-30 Index
1989	0	D
1990	8	C
1991	0	C
1992	0	C
1993	10	AN
1994	0	C
1995	14	W
1996	0	W
1997	5	W
1998	8	W
1999	0	W
2000	0	AN
2001	0	D
2002	0	D

Operations at Whiskeytown Lake during flood conditions are complicated by its operational relationship with the Trinity River, Sacramento River, and Clear Creek. On occasion, imports of Trinity River water to Whiskeytown Reservoir may be suspended to avoid aggravating high flow conditions in the Sacramento Basin.

Fish and Wildlife Requirements on Clear Creek

Water rights permits issued by the SWRCB for diversions from Trinity River and Clear Creek specify minimum downstream releases from Lewiston and Whiskeytown Dams, respectively. Two agreements govern releases from Whiskeytown Lake:

- A 1960 Memorandum of Agreement (MOA) with the DFG established minimum flows to be released to Clear Creek at Whiskeytown Dam.
- A 1963 release schedule from Whiskeytown Dam was developed and implemented, but never finalized. Although the release schedule was never formalized, Reclamation has operated according to the proposed schedule since May 1963.

Table 2–3 Minimum flows at Whiskeytown Dam from 1960 MOA with the DFG

Period	*Minimum flow (cfs)*
January 1 - February 28(29)	50
March 1 - May 31	30

Period	*Minimum flow (cfs)*
June 1 - September 30	0
October 1 - October 15	10
October 16 - October 31	30
November 1 - December 31	100
1963 FWS Proposed Normal year flow (cfs)	
January 1 - October 31	50
November 1 - December 31	100
1963 FWS Proposed Critical year flow (cfs)	
January 1 - October 31	30
November 1 - December 31	70

Spring Creek Debris Dam Operations

The Spring Creek Debris Dam (SCDD) is a feature of the Trinity Division of the CVP. It was constructed to regulate runoff containing debris and acid mine drainage from Spring Creek, a tributary to the Sacramento River that enters Keswick Reservoir. The SCDD can store approximately 5,800 af of water. Operation of SCDD and Shasta Dam has allowed some control of the toxic wastes with dilution criteria. In January 1980, Reclamation, the DFG, and the SWRCB executed a Memorandum of Understanding (MOU) to implement actions that protect the Sacramento River system from heavy metal pollution from Spring Creek and adjacent watersheds.

The MOU identifies agency actions and responsibilities, and establishes release criteria based on allowable concentrations of total copper and zinc in the Sacramento River below Keswick Dam.

The MOU states that Reclamation agrees to operate to dilute releases from SCDD (according to these criteria and schedules provided) and that such operation will not cause flood control parameters on the Sacramento River to be exceeded and will not unreasonably interfere with other project requirements as determined by Reclamation. The MOU also specifies a minimum schedule for monitoring copper and zinc concentrations at SCDDand in the Sacramento River below Keswick Dam. Reclamation has primary responsibility for the monitoring; however, the DFG and the RWQCB also collect and analyze samples on an as-needed basis. Due to more extensive monitoring, improved sampling and analyses techniques, and continuing cleanup efforts in the Spring Creek drainage basin, Reclamation now operates SCDD targeting the more stringent Central Valley Region Water Quality Control Plan (Basin Plan) criteria in addition to the MOU goals. Instead of the total copper and total zinc criteria contained in the MOU, Reclamation operates SCDD releases and Keswick dilution flows to not exceed the Basin Plan standards of 0.0056 mg/l dissolved copper and 0.016 mg/l dissolved zinc. Release rates are estimated from a mass balance calculation of the copper and zinc in the debris dam release and in the river.

In order to minimize the build-up of metal concentrations in the Spring Creek arm of Keswick Reservoir, releases from the debris dam are coordinated with releases from the Spring Creek Powerplant to keep the Spring Creek arm of Keswick Reservoir in circulation with the main water body of Keswick Lake.

The operation of Spring Creek Debris Dam is complicated during major heavy rainfall events. Spring Creek Debris Dam reservoir can fill to uncontrolled spill elevations in a relatively short time period, anywhere from days to weeks. Uncontrolled spills at Spring Creek Debris Dam can occur during flood control events in the upper Sacramento River and also during non-flood control rainfall events. During flood control events, Keswick releases may be reduced to meet flood control objectives at Bend Bridge when storage and inflow at Spring Creek Reservoir are high.

Because SC DD releases are maintained as a dilution ratio of Keswick releases to maintain the required dilution of copper and zinc, uncontrolled spills can and have occurred from Spring Creek Debris Dam. In this operational situation, high metal concentration loads during heavy rainfall are usually limited to areas immediately downstream of Keswick Dam because of the high runoff entering the Sacramento River adding dilution flow. In the operational situation when Keswick releases are increased for flood control purposes, Spring Creek Debris Dam releases are also increased in an effort to reduce spill potential.

In the operational situation when heavy rainfall events will fill Spring Creek Debris Dam and Shasta Reservoir will not reach flood control conditions, increased releases from CVP storage may be required to maintain desired dilution ratios for metal concentrations. Reclamation has voluntarily released additional water from CVP storage to maintain release ratios for toxic metals below Keswick Dam. Reclamation has typically attempted to meet the Basin Plan standards but these releases have no established criteria and are dealt with on a case-by-case basis. Since water released for dilution of toxic spills is likely to be in excess of other CVP requirements, such releases increase the risk of a loss of water for other beneficial purposes.

Shasta Division and Sacramento River Division

The CVP’s Shasta Division includes facilities that conserve water in the Sacramento River for (1) flood control, (2) navigation maintenance, (3) agricultural water supplies, (4) M&I water supplies (5) hydroelectric power generation, (6) conservation of fish in the Sacramento River, and (7) protection of the Sacramento-San Joaquin Delta from intrusion of saline ocean water. The Shasta Division includes Shasta Dam, Lake, and Powerplant; Keswick Dam, Reservoir, and Powerplant, and the Shasta Temperature Control Device.

The Sacramento River Division was authorized after completion of the Shasta Division. It includes facilities for the diversion and conveyance of water to CVP contractors on the west side of the Sacramento River. The division includes the Sacramento Canals Unit, which was authorized in 1950 and consists of the Red Bluff Diversion Dam (RBDD), the Corning Pumping Plant, and the Corning and Tehama-Colusa Canals.

The unit was authorized to supply irrigation water to over 200,000 acres of land in the Sacramento Valley, principally in Tehama, Glenn, Colusa, and Yolo counties. Black Butte Dam, which is operated by the Corps, also provides supplemental water to the Tehama-Colusa Canals as it crosses Stony Creek. The operations of the Shasta and Sacramento River divisions are presented together because of their operational inter-relationships.

Shasta Dam is located on the Sacramento River just below the confluence of the Sacramento, McCloud, and Pit Rivers. The dam regulates the flow from a drainage area of approximately 6,649 square miles. Shasta Dam was completed in 1945, forming Shasta Lake, which has a maximum storage capacity of 4,552,000 af. Water in Shasta Lake is released through or around the Shasta Powerplant to the Sacramento River where it is re-regulated downstream by Keswick Dam. A small amount of water is diverted directly from Shasta Lake for M&I uses by local communities.

Keswick Reservoir was formed by the completion of Keswick Dam in 1950. It has a capacity of approximately 23,800 af and serves as an afterbay for releases from Shasta Dam and for discharges from the Spring Creek Powerplant. All releases from Keswick Reservoir are made to the Sacramento River at Keswick Dam. The dam has a fish trapping facility that operates in conjunction with the Coleman National Fish Hatchery on Battle Creek. During the construction of Shasta Dam, the Toyon Pipeline was constructed to supply water from the Sacramento River to the camp used to house the workers at Toyon. The pipeline remains in use today, supplying M&I water to small communities in the area.

Flood Control

Flood control objectives for Shasta Lake require that releases be restricted to quantities that will not cause downstream flows or stages to exceed specified levels. These include a flow of 79,000 cfs at the tailwater of Keswick Dam, and a stage of 39.2 feet in the Sacramento River at Bend Bridge gauging station, which corresponds to a flow of approximately 100,000 cfs. Flood control operations are based on regulating criteria developed by the Corps pursuant to the provisions of the Flood Control Act of 1944. Maximum flood space reservation is 1.3 million af, with variable storage space requirements based on an inflow parameter.

Flood control operation at Shasta Lake requires the forecasting of runoff conditions into Shasta Lake, as well as runoff conditions of unregulated creek systems downstream from Keswick Dam, as far in advance as possible. A critical element of upper Sacramento River flood operations is the local runoff entering the Sacramento River between Keswick Dam and Bend Bridge.

The unregulated creeks (major creek systems are Cottonwood Creek, Cow Creek, and Battle Creek) in this reach of the Sacramento River can be very sensitive to a large rainfall event and produce large rates of runoff into the Sacramento River in short time periods. During large rainfall and flooding events, the local runoff between Keswick Dam and Bend Bridge can exceed 100,000 cfs.

The travel time required for release changes at Keswick Dam to affect Bend Bridge flows is approximately eight to ten hours. If the total flow at Bend Bridge is projected to exceed 100,000 cfs, the release from Keswick Dam is decreased to maintain Bend Bridge flow below 100,000 cfs. As the flow at Bend Bridge is projected to recede, the Keswick Dam release is increased to evacuate water stored in the flood control space at Shasta Lake. Changes to Keswick Dam releases are scheduled to minimize rapid fluctuations in the flow at Bend Bridge.

The flood control criteria for Keswick releases specify releases should not be increased more than 15,000 cfs or decreased more than 4,000 cfs in any two-hour period. The restriction on the rate of decrease is intended to prevent sloughing of saturated downstream channel embankments caused by rapid reductions in river stage. In rare instances, the rate of decrease may have to be accelerated to avoid exceeding critical flood stages downstream.

Fish and Wildlife Requirements in the Sacramento River

Reclamation operates the Shasta, Sacramento River, and Trinity River divisions of the CVP to meet (to the extent possible) the provisions of SWRCB Order 90-05 and the winter-run Chinook salmon BO. An April 5, 1960, MOA between Reclamation and the DFG originally established flow objectives in the Sacramento River for the protection and preservation of fish and wildlife resources. The agreement provided for minimum releases into the natural channel of the Sacramento River at Keswick Dam for normal and critically dry years. Since October 1981, Keswick Dam has operated based on a minimum release of 3,250 cfs for normal years from September 1 through the end of February, in accordance with an agreement between Reclamation and DFG. This release schedule was included in Order 90-05, which maintains a minimum release of 3,250 cfs at Keswick Dam and RBDD from September through the end of February in all water years, except critically dry years.

Table 2–4 Current minimum flow requirements and objectives (cfs) on the Sacramento River below Keswick Dam

Water year type	*MOA*	*WR 90-5*	*MOA and WR 90-5*	*1993 NOAA Fisheries winter-run BO*
Period	*Normal*	*Normal*	*Critically dry*	*All*
January 1 - February 28(29)	2600	3250	2000	3250
March 1 - March 31	2300	2300	2300	3250
April 1 - April 30	2300	2300	2300	---[a]
May 1 - August 31	2300	2300	2300	---[a]
September 1 - September 30	3900	3250	2800	---[a]
October 1 - November 30	3900	3250	2800	3250
December 1 - December 31	2600	3250	2000	3250

[a] No regulation.

The 1960 MOA between Reclamation and the DFG provides that releases from Keswick Dam (from September 1 through December 31) are made with minimum water level fluctuation or change to protect salmon, and if when doing so, is compatible with other operations requirements. Releases from Shasta and Keswick Dams are gradually reduced in September and early October during the transition from meeting Delta export and water quality demands to operating the system for flood control and fishery concerns from October through December.

The reasonable and prudent alternative (RPA) contained in the 1993 NOAA Fisheries BO required a minimum flow of 3,250 cfs from October 1 through March 31. Also, as part of the RPA, ramping constraints for Keswick release reductions from July 1 through March 31 are required as follows:

- Releases must be reduced between sunset and sunrise.
- When Keswick releases are 6,000 cfs or greater, decreases may not exceed 15 percent per night. Decreases also may not exceed 2.5 percent in one hour.
- For Keswick releases between 4,000 and 5,999 cfs, decreases may not exceed 200 cfs per night. Decreases also may not exceed 100 cfs per hour.
- For Keswick releases between 3,250 and 3,999 cfs, decreases may not exceed 100 cfs per night.
- Variances to these release requirements are allowed under flood control operations.

Reclamation usually attempts to reduce releases from Keswick Dam to the minimum fishery requirement by October 15 each year and to minimize changes in Keswick releases between October 15 and December 31. Releases may be increased during this period to meet unexpected downstream needs such as higher outflows in the Delta to meet water quality requirements, or to meet flood control requirements. Releases from Keswick Dam may be reduced when downstream tributary inflows increase to a level that will meet flow needs. To minimize release fluctuations, the base flow is selected with the intent of maintaining the desired target storage levels in Shasta Lake from October through December.

A recent change in agricultural water diversion practices has affected Keswick Dam release rates in the fall. This program is generally known as the Rice Straw Decomposition and Waterfowl Habitat Program. Historically, the preferred method of clearing fields of rice stubble was to systematically burn it. Today, rice field burning is being phased out due to air quality concerns and goals and is being replaced by a program of rice field flooding that decomposes rice stubble and provides additional waterfowl habitat. The result has been an increase in water demand to flood rice fields in October and November, which has increased the need for higher Keswick releases in all but the wettest of fall months.

The recent change in agricultural practice has not been incorporated into the systematic modeling of agricultural practices and hydrology effects, and therefore, the OCAP CALSIM basis used here does not incorporate this effect. The increased water demand for fall rice field flooding and decomposition on the Sacramento River can produce a conflict during this timeframe with the goal of fall fishery flow stability management.

Minimum Flow for Navigation – Wilkins Slough

Historical commerce on the Sacramento River resulted in the requirement to maintain minimum flows of 5,000 cfs at Chico Landing to support navigation. Currently, there is no commercial traffic between Sacramento and Chico Landing, and the Corps has not dredged this reach to preserve channel depths since 1972. However, long-time water users diverting from the river have set their pump intakes just below this level. Therefore, the CVP is operated to meet the navigation flow requirement of 5,000 cfs to Wilkins Slough, (gauging station on the Sacramento River), under all but the most critical water supply conditions, to facilitate pumping.

At flows below 5,000 cfs at Wilkins Slough, diverters have reported increased pump cavitation as well as greater pumping head requirements. Diverters are able to operate for extended periods at flows as low as 4,000 cfs at Wilkins Slough, but pumping operations become severely affected and some pumps become inoperable at flows lower than this. Flows may drop as low as 3,500 cfs for short periods while changes are made in Keswick releases to reach target levels at Wilkins Slough, but using the 3,500 cfs rate as a target level for an extended period would have major impacts on diverters.

No criteria have been established specifying when the navigation minimum flow should be relaxed. However, the basis for Reclamation’s decision to operate at less than 5,000 cfs is the increased importance of conserving water in storage when water supplies are not sufficient to meet full contractual deliveries and other operational requirements.

Water Temperature Operations in the Upper Sacramento River

Water temperature in the upper Sacramento River has been recognized as a key factor of the habitat needs for Chinook salmon stocks inhabiting the river. Water temperature on the Sacramento River system is influenced by several factors, including the relative water temperatures and ratios of releases from Shasta Dam and from the Spring Creek Powerplant. The temperature of water released from Shasta Dam and the Spring Creek Powerplant is a function of the reservoir temperature profiles at the discharge points at Shasta and Whiskeytown, the depths from which releases are made, the seasonal management of the deep cold water reserves, ambient seasonal air temperatures and other climatic conditions, tributary accretions and water temperatures, and residence time in Keswick, Whiskeytown and Lewiston Reservoirs, and in the Sacramento River.

SWRCB Water Rights Order 90-05 and Water Rights Order 91-01

In 1990 and 1991, the SWRCB issued Water Rights Orders 90-05 and 91-01 modifying Reclamation's water rights for the Sacramento River. The orders included a narrative water temperature objective for the Sacramento River and stated Reclamation shall operate Keswick and Shasta Dams and the Spring Creek Powerplant to meet a daily average water temperature of 56° F at RBDD in the Sacramento River during periods when higher temperature would be harmful to fisheries.

Under the orders, the water temperature compliance point may be modified when the objective cannot be met at RBDD. In addition, Order 90-05 modified the minimum flow requirements initially established in the 1960 MOA for the Sacramento River below Keswick Dam. The water right orders also recommended the construction of a Shasta Temperature Control Device (TCD) to improve the management of the limited cold water resources.

Pursuant to SWRCB Orders 90-05 and 91-01, Reclamation configured and implemented the Sacramento-Trinity Water Quality Monitoring Network to monitor temperature and other parameters at key locations in the Sacramento and Trinity Rivers. The SWRCB orders also required Reclamation to establish the Sacramento River Temperature Task Group to formulate, monitor, and coordinate temperature control plans for the upper Sacramento and Trinity Rivers. This group consists of representatives from Reclamation, SWRCB, NOAA Fisheries, FWS, DFG, Western, DWR, and the Hoopa Valley Indian Tribe.

Each year, with finite cold water resources and competing demands usually an issue, the Temperature Task Group has been effective in devising operation plans with the flexibility to provide the best protection consistent with the CVP's temperature control capabilities and considering the annual needs and seasonal spawning distribution monitoring information for winter-run and fall-run Chinook salmon. In every year since the SWRCB issued the orders, those plans have included modifying the RBDD compliance point to make best use of the cold water resources based on the location of spawning Chinook salmon.

Shasta Temperature Control Device

Construction of the TCD at Shasta Dam was completed in 1997. This device is designed for greater flexibility in managing the cold water reserves in Shasta Lake while enabling hydroelectric power generation to occur and to improve salmon habitat conditions in the upper

Sacramento River. The TCD is also designed to enable selective release of water from varying lake levels through the power plant in order to manage and maintain adequate water temperatures in the Sacramento River downstream of Keswick Dam.

Prior to construction of the Shasta TCD, Reclamation released water from Shasta Dam's low-level river outlets to alleviate high water temperatures during critical periods of the spawning and incubation life stages of the winter-run Chinook stock. Releases through the low-level outlets bypass the power plant and result in a loss of hydroelectric generation at the Shasta Powerplant. The release of water through the low-level river outlets was a major facet of Reclamation's efforts to control upper Sacramento River temperatures from 1987 through 1996.

The seasonal operation of the TCD is generally as follows: during mid-winter and early spring the highest elevation gates possible are utilized to draw from the upper portions of the lake to conserve deeper colder resources (see Table 2–5). During late spring and summer, the operators begin the seasonal progression of opening deeper gates as Shasta Lake elevation decreases and cold water resources are utilized. In late summer and fall, the TCD side gates are opened to utilize the remaining cold water resource below the Shasta Powerplant elevation in Shasta Lake.

Table 2–5 Shasta Temperature Control Device Gates with Elevation and Storage

TCD Gates	Shasta Elevation with 35 feet of submergence	Shasta Storage
Upper Gates	1035	~3.65 MAF
Middle Gates	985	~2.50 MAF
Pressure Relief Gates	850	~0.67 MAF
Side Gates		

The seasonal progression of the Shasta TCD operation is designed to maximize the conservation of cold water resources deep in Shasta Lake, until the time the resource is of greatest management value to fishery management purposes. Recent operational experience with the Shasta TCD has demonstrated significant operational flexibility improvement for cold water conservation and upper Sacramento River water temperature and fishery habitat management purposes. Recent operational experience has also demonstrated the Shasta TCD has significant leaks that are inherent to TCD design and operational uncertainties that cumulatively impair the seasonal performance of the Shasta TCD to a greater degree than was anticipated in previous analysis and modeling used to describe long-term Shasta TCD benefits.

ESA related Upper Sacramento River temperature objectives.

In February 1993, NOAA Fisheries issued the long-term BO for the Operation of the Federal CVP and the SWP for the Sacramento River winter-run Chinook salmon. The BO includes a RPA addressing CVP operations criteria for temperature control objectives. The Shasta-Trinity Division section of the 1993 RPA includes the following operational elements relating to temperature control objectives. This section of the RPA was not modified in the 1995 amendment to the BO.

Under the current RPA, Reclamation must make its February 15 forecast of deliverable water based on an estimate of precipitation and runoff at least as conservatively as 90 percent probability of exceedance. Subsequent updates of water delivery commitments must be based on at least as conservatively as 90 percent probability of exceedance forecast.

The use of the conservatively based forecasting approach reduces the risk of over committing potential annual cold water reserves by limiting the Central Valley water supply estimates to a one in ten chance of remaining annual hydrologic conditions being drier than the estimate. This forecasting strategy places an allocation emphasis on reserving sufficient cold water resources during the winter-run Chinook salmon incubation and spawning seasons. The BO also requires a technical demonstration that the water temperature compliance point for winter–run needs can be met using the 90 percent hydrology.

Under the current RPA, Reclamation must maintain a minimum end-of-water-year (September 30) carryover storage in Shasta Reservoir of 1.9 million af. The 1.9 million af Shasta Reservoir carryover target is intended to increase the probability of sufficient cold water resources to maintain suitable water temperature conditions for the following water year winter–run incubation and spawning season needs.

The carryover target does not ensure that adequate cold water reserves (and therefore, winter–run incubation and spawning habitat water temperature) are available during the year the 1.9 million af carryover is required. The BO recognized that it may not be possible to maintain the minimum carryover of 1.9 million af in the driest ten percent of hydrologic circumstances. If Reclamation forecasts end-of-water-year storage levels in Shasta will drop below 1.9 million af, re-initiation of consultation is required prior to the first water allocation announcement for that year.

The current RPA sets water temperature compliance location(s) from April 15 through October 31 for winter–run needs based on a systematic set of Shasta carryover and annual hydrologic conditions.

The BO segregates annual Shasta Reservoir carryover and hydrologic conditions in order to assess the potential cold water resources available from Trinity Reservoir and Shasta Reservoir and to determine a strategy for water temperature compliance location. Generally, the BO sets the compliance location at Bend Bridge on the Sacramento River in conditions of high carryover storage or above normal hydrologic conditions.

For lower carryover storage conditions and dry or critical hydrologic conditions, the BO sets the compliance location at a further upstream location of Jelly’s Ferry on the Sacramento River. For low carryover storage and critical or very critical hydrologic conditions (generally associated with extended drought conditions) the BO requires re-initiation of consultation to determine the temperature compliance location.

In almost every year since 1993, Reclamation has reconsulted with NOAA Fisheries to modify the compliance point or allow short-term fluctuation above the 56° F objective because of insufficient cold water resources, extreme ambient air temperature events, or high downstream tributary flows of warm water. The reconsultation actions have been coordinated through the SRTTG to the extent possible. Decisions by Reclamation to reconsult and the resulting decisions by NOAA Fisheries have reflected the best available information on cold water resources and locations of Chinook salmon spawning activity.

Reclamation's Proposed Upper Sacramento River temperature objectives

Since the issuance of the temperature objectives contained in the February 1993 NOAA Fisheries BO, the long-term cold water management operation of the Trinity-Shasta reservoir system has been changed and influenced by several significant water management actions that have occurred during the intervening period. The water management actions include:

- Implementation of CVPIA Section 3406 (b)(2)
- Implementation of SWRCB Delta D-1641
- Continuing implementation of the Trinity River ROD as currently ordered by the District Court
- Installation and actual performance characteristics of the Shasta TCD

Each of these water management actions has changed the availability and the management of cold water resources to the Upper Sacramento River. Future actions addressed in the Proposed Action will affect temperature control as demands on the yield of Shasta Reservoir increase.

Concurrently, the spawning distribution of salmon in the upper Sacramento River has changed. Improved fish passage management actions at RBDD and the Anderson-Cottonwood Irrigation District (ACID) Diversion Dam have allowed winter-run salmon to utilize spawning habitat closer to Keswick Dam. Recent review of the spawning distribution for winter-run salmon has shown conclusively the vast majority spawn above the Ball's Ferry location, with only minor spawning below the Ball's Ferry location.

Reclamation will continue a policy of developing annual operations plans and water allocations based on a conservative 90 percent exceedance forecast. Reclamation is not assuming a minimum end-of-water-year (September 30) carryover storage in Shasta Reservoir.

In continuing compliance with Water Rights Orders 90-05 and 91-01 requirements, Reclamation will implement operations to provide year round temperature protection in the upper Sacramento River, consistent with intent of Order 90-05 that protection be provided to the extent controllable. Among factors that affect the extent to which river temperatures will be controllable will include Shasta TCD performance, the availability of cold water, the balancing of habitat needs for different species in spring, summer, and fall, and the constraints on operations created by the combined effect of the projects and demands assumed to be in place in the future.

Based on cumulative affects of changes to cold water resources and spawning distribution changes, Reclamation has analyzed the capability to manage water temperatures in the upper Sacramento River under future conditions. Reclamation used the water temperature model with an updated calibration of the Shasta TCD and the salmon mortality model with the recent spawning distribution to compare results of targeting different compliance points. One set of results represented operating to target compliance points identified in the 1993 BO. Another set of results represented operating to target compliance at Ball's Ferry, which is further upstream. The analysis under future conditions supports moving the target compliance point upstream to avoid exhausting the available cold water resources too early in the salmon spawning and rearing season.

Under all but the most adverse drought and low Shasta Reservoir storage conditions, CVP facilities should be operated to provide water temperature control at Ball’s Ferry or at locations further downstream (as far as Bend Bridge) based on annual plans developed in coordination with the SRTTG. Reclamation and the SRTTG will take into account projections of cold water resources, numbers of expected spawning salmon, and spawning distribution (as monitoring information becomes available) to make the decisions on allocation of the cold water resources.

Locating the target temperature compliance at Ball’s Ferry (1) reduces the need to compensate the warming effects of Cottonwood Creek and Battle Creek during the spring runoff months with deeper cold water releases and (2) improves the reliability of cold water resources through the fall months. Reclamation proposes this change in Sacramento River temperature control objectives to be consistent with the capability of the CVP to manage cold water resources and to use the process of annual planning in coordination with the Sacramento River Temperature Task Group to arrive at the best use of that capability.

Anderson-Cottonwood Irrigation District Diversion Dam

Since 1916, water has been diverted into the ACID Canal for irrigation along the west side of the Sacramento River between Redding and Cottonwood. The United States and ACID signed a contract (Number 14-06-200-3346A) providing for the project water service and agreement on diversion of water. ACID diverts to its main canal (on the right bank of the river) from a diversion dam located in Redding about five miles downstream from Keswick Dam. The diversion dam consists of boards supported by a pinned steel superstructure anchored to a concrete foundation across the Sacramento River. The boards are manually set from a walkway supported by the steel superstructure. The number of boards set in the dam varies depending upon flow in the river and desired head in the canal.

Because the diversion dam is a flashboard dam installed for seasonal use only, close coordination is required between Reclamation and ACID for regulation of river flows to allow safe installation and removal of the flashboards. The contract between ACID and the United States allows for ACID to notify Reclamation as far in advance as possible each time it intends to install or remove boards from its diversion dam. Reclamation similarly notifies ACID each time it intends to change releases at Keswick Dam. In addition, during the irrigation season, ACID notifies Reclamation of the maximum flow the diversion dam can safely accommodate (with the current setting of boards). Reclamation notifies ACID (at least 24 hours in advance) of any change in releases at Keswick Dam that exceed such maximum flow designated by ACID.

The irrigation season for ACID runs from April through October. Therefore, around April 1 of each year, ACID erects the diversion dam. This consists of raising the steel superstructure, installing the walkway, and then setting the boards. Around November 1 of each year, the reverse process occurs. The dates of installation and removal can vary depending on hydrologic conditions. Removal and installation of the dam cannot be done safely at flows greater than 6,000 cfs. ACID usually requests Reclamation to limit the Keswick release to a 5,000 cfs maximum for five days to accomplish the installation and removal of the dam. As indicated previously, there may be times during the irrigation season when the setting of the boards must be changed due to changes in releases at Keswick Dam. When boards must be removed due to an increase at Keswick, the release may initially have to be decreased to allow work to be done safely. If an emergency exists, Reclamation personnel from the Northern California Area Office can be dispatched to assist ACID in removing the boards.

Keswick release rate decreases required for the ACID operations are limited to 15 percent in a 24-hour period and 2.5 percent in any one hour. Therefore, advance notification is important when scheduling decreases to allow for the installation or removal of the ACID dam.

Red Bluff Diversion Dam Operations

The RBDD, located on the Sacramento River approximately two miles southeast of Red Bluff, is a gated structure with fish ladders at each abutment. When the gates are lowered, the impounded water rises about 13 feet, creating Lake Red Bluff and allowing gravity diversions through a set of drum screens into the a stilling basin servicing the Tehama-Colusa and Corning Canals.

The Tehama-Colusa Canal is a lined canal extending 111 miles south from the RBDD and provides irrigation service on the west side of the Sacramento Valley in Tehama, Glenn, Colusa, and northern Yolo counties. The RBDD diverts water to the Corning and Tehama-Colusa Canals. Construction of the Tehama-Colusa Canal began in 1964 and was completed in 1965. Gates were first closed in 1967 with the startup of the State pumps in the Delta.

The Corning Pumping Plant lifts water approximately 56 feet from the screened portion of the settling basin into the unlined, 21 mile-long Corning Canal. The Corning Canal was completed in 1959 to serve water to the CVP contractors in Tehama County that could not be served by gravity from the Tehama-Colusa Canal. Both Canals are operated by the Tehama-Colusa Canal Authority (TCCA). The gates are currently lowered on May 15 to impound water for diversion and raised on September 15 to allow river flow-through.

Since 1986, the RBDD gates have been raised during winter months to allow passage of winter-run Chinook salmon. Since the 1993 NOAA Fisheries BO for winter-run Chinook salmon, the gates have been raised from September 15 through May 14 each year. This eight-month gates-up operation has eliminated passage impedance of upstream migration for all species which need to migrate above the RBDD to spawn, with the exception of 70 percent of the spring-run Chinook and an estimated 35 percent of the green sturgeon migrants (TCCA and Reclamation, 2002).

Reclamation proposes the continued operation of the RBDD using the eight-month gate-open procedures of the past ten years. However, Reclamation proposes to change the status of the research pumping plant from research to production status, along with adding a fourth pump if funding becomes available and the cost-benefit ratios prove favorable. Should a fourth pump be added, Reclamation would install another centrifugal pump. Reclamation also proposes the continued use of rediversions of CVP water stored in Black Butte Reservoir to supplement the water pumped at RBDD during the gates-out period. This water is rediverted with the aid of temporary gravel berms through an unscreened, constant head orifice (CHO) into the Tehema-Colusa Canal.

This arrangement has successfully met the water demand for the past ten years, but the supply has consistently been quite tight. To date, Reclamation has not had to use the provision of the RPA of the winter-run BO allowing up to one closure per year of the gates for up to ten days. While mandatory use of this temporary gates closure provision has been minimized so far, it was used in 1997, a year with an exceptionally dry spring. Its use in another year was avoided only at the last minute by an exceptionally heavy, late storm. Reclamation will implement with NOAA Fisheries a decision-making protocol to ensure such gate closure decisions can be achieved on short notice.

American River Division

The American River originates in the mountains of the Sierra Nevada range, drains a watershed of approximately 1,895 square miles, and enters the Sacramento River at river mile 60 in the City. The American River contributes approximately 15 percent of the total flow in the Sacramento River. The American River watershed ranges in elevation from 23 feet to over 10,000 feet, and receives approximately 40 percent of its flow from snowmelt. Development on the American River began in the earliest days of the California Gold Rush, when numerous small diversion dams, flumes, and canals were constructed. Currently, 19 major reservoirs in the drainage area have a combined storage capacity of about 1.8 million af.

Folsom Lake, the largest reservoir in the watershed, was formed with the completion of Folsom Dam in 1956 and has a capacity of 977,000 af. Folsom Dam, located approximately 30 miles upstream from the confluence with the Sacramento River, is operated by Reclamation as a major component of the CVP. Water released from Folsom Lake is used to generate hydroelectric power, meet downstream water rights obligations, contribute to Delta inflow requirements, and provide water supplies to CVP contractors.

Releases from Folsom Dam are re-regulated approximately seven miles downstream by Nimbus Dam. This facility is also operated by Reclamation as part of the CVP and began operation in 1955. Nimbus Dam creates Lake Natoma, which serves as a forebay for diversions to the Folsom South Canal. This CVP facility began operation in 1973 and serves water to agricultural and M&I users in Sacramento County. The first two reaches of the canal, extending to just south of Highway 104, were completed in 1973. Construction of the remainder of the canal has been suspended pending reconsideration of alternatives. Releases from Nimbus Dam to the American River pass through the Nimbus Powerplant, or,at flows in excess of 5,000 cfs, the spillway gates.

Although Folsom Lake is the main storage and flood control reservoir on the American River, numerous other small reservoirs in the upper basin provide hydroelectric generation and water supply. None of the upstream reservoirs has any specific flood control responsibilities. The total upstream reservoir storage above Folsom Lake is approximately 820,000 af. Ninety percent of this upstream storage is contained by five reservoirs: French Meadows (136,000 af); Hell Hole (208,000 af); Loon Lake (76,000 af); Union Valley (271,000 af); and Ice House (46,000 af).

French Meadows and Hell Hole reservoirs, located on the Middle Fork of the American River, are owned and operated by the Placer County Water Agency (PCWA). The PCWA provides wholesale water to agricultural and urban areas within Placer County. For urban areas, the PCWA operates water treatment plants and sells wholesale treated water to municipalities that provide retail delivery to their customers. The cities of Rocklin and Lincoln receive water from the PCWA. Loon Lake (also on the Middle Fork), and Union Valley and Ice House reservoirs on the South Fork, are all operated by the Sacramento Municipal Utilities District (SMUD) for hydropower purposes.

American River Operations

The Corps constructed major portions of the American River Division under the authorization of Congress. The American River Basin Development Act of 1949 subsequently authorized its integration into the CVP. The American River Division includes facilities that provide conservation of water on the American River for flood control, fish and wildlife protection, recreation, protection of the Delta from intrusion of saline ocean water, irrigation and M&I water supplies, and hydroelectric power generation. Initially authorized features of the American River Division included Folsom Dam, Lake, and Powerplant; Nimbus Dam and Powerplant, and Lake Natoma.

Flood control requirements and regulating criteria are specified by the Corps and described in the Folsom Dam and Lake, American River, California Water Control Manual (Corps 1987). Flood control objectives for Folsom require the dam and lake are operated to:

- Protect the City and other areas within the lower American River floodplain against reasonable probable rain floods.
- Control flows in the American River downstream from Folsom Dam to existing channel capacities, insofar as practicable, and to reduce flooding along the lower Sacramento River and in the Delta in conjunction with other CVP projects.
- Provide the maximum amount of water conservation storage without impairing the flood control functions of the reservoir.
- Provide the maximum amount of power practicable and be consistent with required flood control operations and the conservation functions of the reservoir.

From June 1 through September 30, no flood control storage restrictions exist. From October 1 through November 16 and from April 20 through May 31, reserving storage space for flood control is a function of the date only, with full flood reservation space required from November 17 through February 7. Beginning February 8 and continuing through April 20, flood reservation space is a function of both date and current hydrologic conditions in the basin.

If the inflow into Folsom Reservoir causes the storage to encroach into the space reserved for flood control, releases from Nimbus Dam are increased. Flood control regulations prescribe the following releases when water is stored within the flood control reservation space:

- Maximum inflow (after the storage entered into the flood control reservation space) of as much as 115,000 cfs, but not less than 20,000 cfs, when inflows are increasing.
- Releases will not be increased more than 15,000 cfs or decreased more than 10,000 cfs during and two-hour period.
- Flood control requirements override other operational considerations in the fall and winter period. Consequently, changes in river releases of short duration may occur.

In February 1986, the American River Basin experienced a significant flood event. Folsom Dam and Reservoir moderated the flood event and performed the flood control objectives, but with serious operational strains and concerns in the lower American River and the overall protection of the communities in the floodplain areas. A similar flood event occurred in January 1997. Since then, significant review and enhancement of lower American River flooding issues has occurred and continues to occur. A major element of those efforts has been the SAFCA-sponsored flood control plan diagram for Folsom Reservoir.

Since 1996, Reclamation has operated according to modified flood control criteria, which reserve 400 to 670 thousand af of flood control space in Folsom and in a combination of three upstream reservoirs. This flood control plan, which provides additional protection for the Lower American River, is implemented through an agreement between Reclamation and the SAFCA. The terms of the agreement allow some of the empty reservoir space in Hell Hole, Union Valley, and French Meadows to be treated as if it were available in Folsom.

The SAFCA release criteria are generally equivalent to the Corps plan, except the SAFCA diagram may prescribe flood releases earlier than the Corps plan. The SAFCA diagram also relies on Folsom Dam outlet capacity to make the earlier flood releases. The outlet capacity at Folsom Dam is currently limited to 32,000 cfs based on lake elevation. However, in general the SAFCA plan diagram provides greater flood protection than the existing the Corps plan for communities in the American River floodplain.

Required flood control space under the SAFCA diagram will begin to decrease on March 1. Between March 1 and April 20, the rate of filling is a function of the date and available upstream space. As of April 21, the required flood reservation is about 225,000 af. From April 21 to June 1, the required flood reservation is a function of the date only, with Folsom storage permitted to fill completely on June 1.

Fish and Wildlife Requirements in the Lower American River

The minimum allowable flows in the lower American River are defined by SWRCB Decision 893 (D-893) which states that, in the interest of fish conservation, releases should not ordinarily fall below 250 cfs between January 1 and September 15 or below 500 cfs at other times. D-893 minimum flows are rarely the controlling objective of CVP operations at Nimbus Dam. Nimbus Dam releases are nearly always controlled during significant portions of a water year by either flood control requirements or are coordinated with other CVP and SWP releases to meet downstream Sacramento-San Joaquin Delta WQCP requirements and CVP water supply objectives.

Power regulation and management needs occasionally control Nimbus Dam releases. Nimbus Dam releases are expected to exceed the D-893 minimum flows in all but the driest of conditions. It should be noted that discussions are underway among Reclamation, members of the Water Forum, and Management Agencies concerning modification of Reclamation's water rights permits to effect an increase to minimum flows in the lower American River. Until such an action is presented to and adopted by the SWRCB, minimum flows will be limited by D-893. Releases of additional water are made pursuant to Section 3406 (b)(2) of the CVPIA.

Water temperature control operations in the lower American River are affected by many factors and operational tradeoffs. These include available cold water resources, Nimbus release schedules, annual hydrology, Folsom power penstock shutter management flexibility, Folsom Dam Urban Water Supply TCD management, and Nimbus Hatchery considerations. Shutter and TCD management provide the majority of operational flexibility used to control downstream temperatures.

During the late 1960's, Reclamation designed a modification to the trashrack structures to provide selective withdrawal capability at Folsom Dam. Folsom Powerplant is located at the foot of Folsom Dam on the right abutment. Three 15-foot diameter steel penstocks for delivering water to the turbines are embedded in the concrete section of the dam. The centerline of each penstock intake is at elevation 307.0 feet and the minimum power pool elevation is 328.5 feet. A reinforced concrete trashrack structure with steel trashracks protects each penstock intake.

The steel trashracks, located in five bays around each intake, extend the full height of the trashrack structure (between 281 and 428 feet). Steel guides were attached to the upstream side of the trashrack panels between elevation 281 and 401 feet. Forty-five 13-foot steel shutter panels (nine per bay) and operated by the gantry crane, were installed in these guides to select the level of withdrawal from the reservoir. The shutter panels are attached to one another in a configuration starting with the top shutter in groups of 3-2-4.

Selective withdrawal capability on the Folsom Dam Urban Water Supply Pipeline became operational in 2003. The centerline to the 84-inch diameter Urban Water Supply intake is at elevation 317 feet. An enclosure structure extending from just below the water supply intake to an elevation of 442 feet was attached to the upstream face of Folsom Dam. A telescoping control gate allows for selective withdrawal of water anywhere between 331 and 401 feet elevation under normal operations.

The current objectives for water temperatures in the lower American River address the needs for steelhead incubation and rearing during the late spring and summer, and for fall–run Chinook spawning and incubation starting in late October or early November.

The steelhead temperature objectives in the lower American River, as provided by NOAA Fisheries, state:

> "Reclamation shall, to the extent possible, control water temperatures in the lower river between Nimbus Dam and the Watt Avenue Bridge (RM 9.4) from June 1 through November 30, to a daily average temperature of less than or equal to 65°F to protect rearing juvenile steelhead from thermal stress and from warm water predator species. The use of the cold water pool in Folsom Reservoir should be reserved for August through October releases."

Prior to the ESA listing of steelhead and the subsequent BOs on operations, the cold water resources in Folsom Reservoir were used to lower downstream temperatures in the fall when fall-run Chinook salmon entered the lower river and began to spawn. The flexibility once available is now gone because of the need to use the cold water to maintain suitable summer steelhead rearing conditions. The operational objective in the fall spawning season is to provide 60°F or less in the lower river, as soon as available cold water supplies can be used.

A major challenge is determining the starting date at which time the objective is met. Establishing the start date requires a balancing between forecasted release rates, the volume of available cold water, and the estimated date at which time Folsom Reservoir turns over and becomes isothermic. Reclamation will start providing suitable spawning temperatures as early as possible (after November 1) to avoid temperature related pre-spawning mortality of adults and reduced egg viability. Reclamation will be balanced against the possibility of running out of cold water and increasing downstream temperatures after spawning is initiated and creating temperature related effects to eggs already in the gravel.

The cold water resources available in any given year at Folsom Lake needed to meet the stated water temperature goals are often insufficient. Only in wetter hydrologic conditions is the volume of cold water resources available sufficient to meet all the water temperature objectives. Therefore, significant operations tradeoffs and flexibilities are considered part of an annual planning process for coordinating an operation strategy that realistically manages the limited cold water resources available.

The management process begins in the spring as Folsom Reservoir fills. All penstock shutters are put in the down position to isolate the colder water in the reservoir below an elevation of 401 feet. The reservoir water surface elevation must be at least 25 feet higher than the sill of the upper shutter (426 feet) to avoid cavitation of the power turbines. The earliest this can occur is in the month of March, due to the need to maintain flood control space in the reservoir during the winter. The pattern of spring run-off is then a significant factor in determining the availability of cold water for later use. Folsom inflow temperatures begin to increase and the lake starts to stratify as early as April. By the time the reservoir is filled or reaches peak storage (sometime in the May through June period), the reservoir is highly stratified with surface waters too warm to meet downstream temperature objectives. There are, however, times during the filling process when use of the spillway gates can be used to conserve cold water.

In the spring of 2003, high inflows and encroachment into the allowable storage space for flood control required releases that exceeded the available capacity of the power plant. Under these conditions, standard operations of Folsom calls for the use of the river outlets that would draw upon the cold water pool. Instead, Reclamation reviewed the release requirements, SOD issues, reservoir temperature conditions, and the benefits to the cold water pool and determined that it could use the spillway gates to make the incremental releases above powerplant capacity, thereby conserving cold water for later use. The ability to take similar actions, (as needed in the future), will be evaluated on a case-by-case basis.

A temperature control management strategy must be developed that balances conservation of cold water for later use in the fall, with the more immediate needs of steelhead during the summer. The planning and forecasting process for the use of the cold water pool begins in the spring as Folsom Reservoir fills. Actual Folsom Reservoir cold water resource availability becomes significantly more defined through the assessment of reservoir water temperature profiles and more definite projections of inflows and storage. Technical modeling analysis of the projected lower American River water temperature management can begin. The significant variables and key assumptions in the analysis include:

Starting reservoir temperature conditions;Forecasted inflow and outflow quantities;

Assumed meteorological conditions;

Assumed inflow temperatures; and,

Assumed Urban Water Supply TCD operations.

A series of shutter management scenarios are then incorporated into the model to gain a better understanding of the potential for meeting both summer steelhead and fall salmon temperature needs. Most annual strategies contain significant tradeoffs and risks for water temperature management for steelhead and fall–run salmon goals and needs due to the frequently limited cold water resource. The planning process continues throughout the summer. New temperature forecasts and operational strategies are updated as more information on actual operations and ambient conditions is gained. This process is shared with the AROG.

Meeting both the summer steelhead and fall salmon temperature objectives without negatively impacting other CVP project purposes requires the final shutter pull be reserved for use in the fall to provide suitable fall-run Chinook salmon spawning temperatures. In most years, the volume of cold water is not sufficient to support strict compliance with the summer temperature target at the downstream end of the compliance reach (Watt Avenue Bridge) and reserve the final shutter pull for salmon or, in some cases, continue to meet steelhead objectives later in the summer. A strategy that is used under these conditions is to allow the annual compliance location water temperatures to warm towards the upper end of the annual water temperature design value before making a shutter pull. This management flexibility is essential to the annual management strategy to extend the effectiveness of cold water management through the summer and fall months.

The Urban Water Supply TCD has provided additional flexibility to conserve cold water for later use. Initial studies are being conducted evaluating the impact of warmer water deliveries to the water treatment plants receiving the water. As water supply temperatures increase into the upper-60°F range, treatment costs, the potential for taste and odor and disinfection byproducts, and customer complaints increase. It is expected that the TCD will be operated during the summer months and deliver water that is slightly warmer than that which could be used to meet downstream temperatures (60°F to 62°F), but not so warm as to cause significant treatment issues.

Water temperatures feeding the Nimbus Fish Hatchery were historically too high for hatchery operations during some dry or critical years. Temperatures in the Nimbus Hatchery are generally in the desirable range of 42° F to 55° F, except for the months of June, July, August, and September. When temperatures get above 60° F during these months, the hatchery must begin to treat the fish with chemicals to prevent disease. When temperatures reach the 60° F to 70° F range, treatment becomes difficult and conditions become increasingly dangerous for the fish. When temperatures climb into the 60° F to 70° F range, hatchery personnel may confer with Reclamation to determine a compromise operation of the temperature shutter at Folsom Dam for the release of cooler water.

The goal is to maintain the health of the hatchery fish while minimizing the loss of the cold water pool for fish spawning in the river during fall. This is done on a case-by-case basis and is different in various months and year types. Temperatures above 70° F in the hatchery usually mean the fish need to be moved to another hatchery. The real time implementation needs for the CVPIA AFRP objective flow management and SWRCB D-1641 Delta standards from the limited water resources of the lower American River has made cold water resource management at Folsom Lake a significant compromise coordination effort. Reclamation consults with the FWS, NOAA Fisheries, and the DFG utilizing the B2IT process (see CVPIA section) when making the difficult compromise decisions. In addition, Reclamation communicates and coordinates with the AROG on real time decision issues.

The Nimbus Fish Hatchery and the American River Trout Hatchery were constructed to mitigate the loss of riverine habitat caused by the construction of Nimbus and Folsom Dam. The hatcheries are located approximately one-quater mile downstream from Nimbus Dam on the south side of the American River To meet the mitigation requirement, annual production goals are approximately 4.2 million salmon smolts and 430,000 steelhead yearlings.

A fish diversion weir at the hatcheries blocks Chinook salmon from continuing upstream and guides them to the hatchery fish ladder entrance. The fish diversion weir consists of eight piers on 30-foot spacing, including two riverbank abutments. Fish rack support frames and walkways are installed each fall via an overhead cable system. A pipe rack is then put in place to support the pipe pickets (¾-inch steel rods spaced on 2½-inch centers). The pipe rack rests on a submerged steel I-beam support frame that extends between the piers and forms the upper support structure for a rock filled crib foundation. The rock foundation has deteriorated with age and is subject to annual scour which can leave holes in the foundation that allow fish to pass if left unattended.

Fish rack supports and pickets are installed around September 15 of each year and correspond with the beginning of the fall-run Chinook salmon spawning season. A release equal to or less than 1,500 cfs from Nimbus Dams is required for safety and to provide full access to the fish rack supports. It takes six people approximately three days to install the fish rack supports and pickets. In years after high winter flows have caused active scour of the rock foundation, a short period (less than eight hours) of lower flow (approximately 500 cfs) is needed to remove debris from the I-beam support frames, seat the pipe racks, and fill holes in the rock foundation. Compete installation can take up to seven days, but is generally completed in less time. The fish rack supports and pickets are usually removed at the end of fall-run Chinook salmon spawning season (mid-January) when flows are less than 2,000 cfs. If Nimbus Dam releases are expected to exceed 5,000 cfs during the operational period, the pipe pickets are removed until flows decrease.

East Side Division

New Melones Operations

The Stanislaus River originates in the western slopes of the Sierra Nevada Mountain Range and drains a watershed of approximately 900 square miles. The average unimpaired runoff in the basin is approximately 1.2 million af per year; the median historical unimpaired runoff is 1.1 million af per year. Snowmelt contributes the largest portion of the flows in the Stanislaus River, with the highest runoff occurring in the months of April, May, and June. Agricultural water supply development in the Stanislaus River watershed began in the 1850’s and has significantly altered the basin’s hydrologic conditions.

Currently, the flow in the lower Stanislaus River is primarily controlled by New Melones Reservoir, which has a storage capacity of about 2.4 million af. The reservoir was completed by the Corps in 1978 and approved for filling in 1983. New Melones Reservoir is located approximately 60 miles upstream from the confluence of the Stanislaus River and the San Joaquin River and is operated by Reclamation. Congressional authorization for New Melones integrates New Melones Reservoir as a financial component of the CVP, but it is authorized to provide water supply benefits within the defined Stanislaus Basin per a 1980 ROD before additional water supplies can be used out of the defined Stanislaus Basin.

New Melones Reservoir is operated primarily for purposes of water supply, flood control, power generation, fishery enhancement, and water quality improvement in the lower San Joaquin River. The reservoir and river also provide recreation benefits. Flood control operations are conducted in conformance with the Corps' operational guidelines.

Another major water storage project in the Stanislaus River watershed is the Tri-Dam Project, a hydroelectric generation project that consists of Donnells and Beardsley Dams, located upstream of New Melones Reservoir on the middle fork Stanislaus River, and Tulloch Dam and Powerplant, located approximately six miles downstream of New Melones Dam on the main stem Stanislaus River.

Releases from Donnells and Beardsley Dams affect inflows to New Melones Reservoir. Under contractual agreements between Reclamation, the Oakdale Irrigation District (OID), and South San Joaquin Irrigation District (SSJID), Tulloch Reservoir provides afterbay storage to re-regulate power releases from New Melones Powerplant. The main water diversion point on the Stanislaus River is Goodwin Dam, located approximately 1.9 miles downstream of Tulloch Dam.

Goodwin Dam,constructed by OID and SSJID in 1912, creates a re-regulating reservoir for releases from Tulloch Powerplant and provides for diversions to canals north and south of the Stanislaus River for delivery to OID and SSJID. Water impounded behind Goodwin Dam may be pumped into the Goodwin Tunnel for deliveries to the Central San Joaquin Water Conservation District and the Stockton East Water District.

Twenty ungaged tributaries contribute flow to the lower portion of the Stanislaus River, below Goodwin Dam. These streams provide intermittent flows, occurring primarily during the months of November through April. Agricultural return flows, as well as operational spills from irrigation canals receiving water from both the Stanislaus and Tuolumne Rivers, enter the lower portion of the Stanislaus River. In addition, a portion of the flow in the lower reach of the Stanislaus River originates from groundwater accretions.

Flood Control

The New Melones Reservoir flood control operation is coordinated with the operation of Tulloch Reservoir. The flood control objective is to maintain flood flows at the Orange Blossom Bridge at less than 8,000 cfs. When possible, however, releases from Tulloch Dam are maintained at levels that would not result in downstream flows in excess of 1,250 cfs to 1,500 cfs because of seepage problems in agricultural lands adjoining the river associated with flows above this level. Up to 450,000 af of the 2.4 million af storage volume in New Melones Reservoir is dedicated for flood control and 10,000 af of Tulloch Reservoir storage is set aside for flood control. Based upon the flood control diagrams prepared by the Corps, part or all of the dedicated flood control storage may be used for conservation storage, depending on the time of year and the current flood hazard.

Requirements for New Melones Operations

The operating criteria for New Melones Reservoir are affected by (1) water rights, (2) in stream fish and wildlife flow requirements (including Interior's CVPIA 3406 (b)(2) fishery management objectives), (3) SWRCB D-1641 Vernalis flow requirements, (4) dissolved oxygen (DO) requirements, (5) SWRCB D-1641 Vernalis water quality requirements, (6) CVP contracts, and (7) flood control considerations. Water released from New Melones Dam and Powerplant is re-regulated at Tulloch Reservoir and is either diverted at Goodwin Dam or released from Goodwin Dam to the lower Stanislaus River.

Flows in the lower Stanislaus River serve multiple purposes concurrently. The purposes include water supply for riparian water rights, fishery management objectives, and DO requirements per SWRCB D-1422. In addition, water from the Stanislaus River enters the San Joaquin River where it contributes to flow and helps improve water quality conditions at Vernalis. D-1422, issued in 1973, provided the primary operational criteria for New Melones Reservoir and permitted Reclamation to appropriate water from the Stanislaus River for irrigation and M&I uses. D-1422 requires the operation of New Melones Reservoir include releases for existing water rights, fish and wildlife enhancement, and the maintenance of water quality conditions on the Stanislaus and San Joaquin Rivers.

Water Rights Obligations

When Reclamation began operations of New Melones Reservoir in 1980, the obligations for releases (to meet downstream water rights) were defined in a 1972 Agreement and Stipulation among Reclamation, OID, and SSJID. The 1972 Agreement and Stipulation required Reclamation release annual inflows to New Melones Reservoir of up to 654,000 af per year for diversion at Goodwin Dam by OID and SSJID, in recognition of their prior water rights. Actual historical diversions prior to 1972 varied considerably, depending upon hydrologic conditions. In addition to releases for diversion by OID and SSJID, water is released from New Melones Reservoir to satisfy riparian water rights totaling approximately 48,000 af annually downstream of Goodwin Dam.

In 1988, following a year of low inflow to New Melones Reservoir, the Agreement and Stipulation among Reclamation, OID, and SSJID was superseded by an agreement that provided for conservation storage by OID and SSJID. The new agreement required Reclamation to release New Melones Reservoir inflows of up to 600,000 af each year for diversion at Goodwin Dam by OID and SSJID.

In years when annual inflows to New Melones Reservoir are less than 600,000 af, Reclamation provides all inflows plus one-third the difference between the inflow for that year and 600,000 af per year. The 1988 Agreement and Stipulation created a conservation account in which the difference between the entitled quantity and the actual quantity diverted by OID and SSJID in a year may be stored in New Melones Reservoir for use in subsequent years. This conservation account has a maximum storage limit of 200,000 af, and withdrawals are constrained by criteria in the agreement.

In stream Flow Requirements

Under D-1422, Reclamation is required to release 98,000 af of water per year, with a reduction to 69,000 af in critical years, from New Melones Reservoir to the Stanislaus River on a distribution pattern to be specified each year by DFG for fish and wildlife purposes. In 1987, an agreement between Reclamation and DFG provided for increased releases from New Melones to enhance fishery resources for an interim period, during which habitat requirements were to be better defined and a study of Chinook salmon fisheries on the Stanislaus River would be completed.

During the study period, releases for in stream flows would range from 98,300 to 302,100 af per year. The exact quantity to be released each year was to be determined based on a formulation involving storage, projected inflows, projected water supply, water quality demands, projected CVP contractor demands, and target carryover storage. Because of dry hydrologic conditions during the 1987 to 1992 drought period, the ability to provide increased releases was limited. FWS published the results of a 1993 study which recommended a minimum in stream flow on the Stanislaus River of 155,700 af per year for spawning and rearing (Aceituno 1993).

Bay-Delta Vernalis Flow Requirements

SWRCB D-1641 sets flow requirements on the San Joaquin River at Vernalis from February to June. These flows are commonly known as San Joaquin River base flows.

Table 2–6 San Joaquin Base Flows-Vernalis

Water Year Class	February-June Flow (cfs)*
Critical	710-1140
Dry	1420-2280
Below Normal	1420-2280
Above Normal	2130-3420
Wet	2130-3420

*the higher flow required when X2 is required to be west of Chipps Island

Reclamation committed to provide these flows during the interim period of the Bay-Delta Accord. Since D-1641 has been in place, the San Joaquin base flow requirements have at times, been an additional demand on the New Melones water supply beyond that anticipated in the Interim Plan of Operation (IPO). The IPO describes the commitment Reclamation made regarding the operation of New Melones Reservoir.

Dissolved Oxygen Requirements

SWRCB D-1422 requires that water be released from New Melones Reservoir to maintain DO standards in the Stanislaus River. The 1995 revision to the WQCP established a minimum DO concentration of 7milligrams per liter (mg/l), as measured on the Stanislaus River near Ripon.

Vernalis Water Quality Requirement

SWRCB D-1422 also specifies that New Melones Reservoir must operate to maintain average monthly level total dissolved solids (TDS), commonly measured as a conversion from electrical conductivity, in the San Joaquin River at Vernalis as it enters the Delta. SWRCB D-1422 specifies an average monthly concentration of 500 parts per million (ppm) TDS for all months. Historically, releases have been made from New Melones Reservoir for this standard, but due to shortfalls in water supply, Reclamation has not always been successful in meeting this objective.

In the past, when sufficient supplies were not available to meet the water quality standards for the entire year, the emphasis for use of the available water was during the irrigation season, generally from April through September. SWRCB D-1641 modified the water quality objectives at Vernalis to include the irrigation and non-irrigation season objectives contained in the 1995 Bay-Delta WQCP. The revised standard is an average monthly electric conductivity 0.7 mS/cm (approximately 455 ppm TDS) during the months of April through August, and 1.0 mS/cm (approximately 650 ppm TDS) during the months of September through March.

CVP Contracts

Reclamation entered into water service contracts for the delivery of water from New Melones Reservoir, based on a 1980 hydrologic evaluation of the long-term availability of water in the Stanislaus River Basin. Based on this study, Reclamation entered into a long-term water service contract for up to 49,000 af per year of water annually (based on a firm water supply), and two long-term water service contracts totaling 106,000 af per year (based on an interim water supply). Because diversion facilities were not yet fully operational and water supplies were not available during the 1987 to 1992 drought, water was not made available from the Stanislaus River for delivery to CVP contractors prior to 1992.

New Melones Interim Plan of Operations (IPO)

Proposed CVP operations on the Stanislaus River are derived from the New Melones IPO. The IPO was developed as a joint effort between Reclamation and FWS, in conjunction with the Stanislaus River Basin Stakeholders (SRBS). The process of developing the plan began in 1995 with a goal to develop a long-term management plan with clear operating criteria, given a fundamental recognition by all parties that New Melones Reservoir water supplies are over-committed on a long-term basis, and consequently, unable to meet all the potential beneficial uses designated as purposes.

In 1996, the focus shifted to the development of an interim operations plan for 1997 and 1998. At an SRBS meeting on January 29, 1997, a final interim plan of operation was agreed to in concept. The IPO was transmitted to the SRBS on May 1, 1997. Although meant to be a short-term plan, it continues to be the guiding operations criteria in effect for the annual planning to meet beneficial uses from New Melones storage.

In summary, the IPO defines categories of water supply based on storage and projected inflow. It then allocates annual water release for in stream fishery enhancement (1987 DFG Agreement and CVPIA Section 3406(b)(2) management), SWRCB D-1641 San Joaquin River water quality requirements (Water Quality), SWRCB D-1641 Vernalis flow requirements (Bay-Delta), and use by CVP contractors.

Table 2–7 Inflow characterization for the New Melones IPO

Annual water supply category	*March-September forecasted inflow plus end of February storage (thousand af)*
Low	0 - 1400
Medium-low	1400 - 2000
Medium	2000 - 2500
Medium-high	2500 - 3000
High	3000 - 6000

Table 2–8 New Melones IPO flow objectives (in thousand af)

Storage plus inflow		*Fishery*		*Vernalis water quality*		*Bay-Delta*		*CVP contractors*	
From	*To*	*From*	*To*	*From*	*To*	*From*	*To*	*From*	*To*
1400	2000	98	125	70	80	0	0	0	0
2000	2500	125	345	80	175	0	0	0	59
2500	3000	345	467	175	250	75	75	90	90
3000	6000	467	467	250	250	75	75	90	90

From inspection of the above IPO allocation structure, two key New Melones-Stanislaus River water policies are inferred:

1) When the water supply condition is determined to be in the “Low” IPO designation, no CVP operations guidance is given. It is assumed Reclamation would meet with the SRBS group to coordinate a practical strategy to guide New Melones Reservoir annual operations under the very limited water supply conditions.

2) The IPO only supports meeting the SWRCB D-1641 Vernalis Base flow standards from Stanislaus River water resources when the water supply condition are determined to be in the “High” or “Medium-High” IPO designation, and then are limited to 75,000 af of reservoir release.

The IPO supports only limited reservoir release volumes towards meeting the Vernalis salinity standards. The limited reservoir release volumes dedicated in the IPO may not fully meet the annual SWRCB standard requirement for the Vernalis salinity standard in the “Medium Low” and “Medium” years. If the Vernalis salinity standard cannot be met using the IPO designated Goodwin release pattern, then additional volume is dedicated to meeting the salinity standard. The permit obligations must be met before an allocation can be made to CVPIA Section 3406 (b)(2) uses or CVP contracts. This is a consequence of Vernalis salinity standards existing prior to passage of CVPIA.

In water years 2002 and 2003, Reclamation deviated from the IPO to provide additional releases for Vernalis salinity and Vernalis base flow standards. Several consecutive years of dry hydrology in the San Joaquin River Basin have demonstrated the limited ability of New Melones to fully satisfy the demands placed on its yield. Despite the need to consider annual deviations, the IPO remains the initial guidance for New Melones Reservoir operations.

CVPIA Section 3406 (b)(2) releases from New Melones Reservoir consist of the portion of the fishery flow management volume utilized that is greater than the 1987 DFG Agreement and the volume used in meeting the Vernalis Base flows.

San Joaquin River Agreement/Vernalis Adaptive Management Plan

Adopted by the SWRCB in D-1641, the SJRA includes a 12-year experimental program providing for flows and exports in the lower San Joaquin River during a 31-day pulse flow period during April and May. It also provides for the collection of experimental data during that time to further the understanding of the effects of flows, exports, and the barrier at the head of Old River on salmon survival. This experimental program is commonly referred to as the VAMP.

Within the SJRA, the IPO has been assumed as the baseline operation for New Melones Reservoir, which forms part of the existing flow condition. The existing flow condition is used to compute the supplemental flows which will be provided on the San Joaquin River to meet the target flows for the 31-day pulse during April and May. These supplemental flows will be provided from other sources in the San Joaquin River Basin under the control of the parties to the SJRA.

The parties to the SJRA include several agencies that contribute flow to the San Joaquin, divert from or store water on the tributaries to the San Joaquin, or have an element of control over the flows in the lower San Joaquin River. These include Reclamation; OID; SSJID; Modesto ID; Turlock ID; Merced ID; and the San Joaquin River Exchange Contractors. The VAMP is based on coordination among these participating agencies in carrying out their operations to meet a steady target flow objective at Vernalis.

The target flow at Vernalis for the spring pulse flow period is determined each year according to the specifications contained in the SJRA. The target flow is determined prior to the spring pulse flows as an increase above the existing flows, and so “adapts” to the prevailing hydrologic conditions. Possible target flows specified in the agreement are (1) 2000 cfs, (2) 3200 cfs, (3) 4450 cfs, (4) 5700 cfs, and (5) 7000 cfs.

The Hydrology Group develops forecasts of flow at Vernalis, determines the appropriate target flow, devises an operations plan including flow schedules for each contributing agency, coordinates implementation of the VAMP flows, monitors conditions that may affect the objective of meeting the target flow, updates and adjusts the planned flow contributions as needed, and accounts for the flow contributions. The Hydrology Group includes designees with technical expertise from each agency that contributes water to the VAMP. During VAMP the Hydrology group communicates via regular conference calls, shares current information and forecasts via e-mail and an internet website. The Hydrology group has two lead coordinators, one from Reclamation's CVO and one designated by the SJRG.

CVP-SWP operations forecasts include Vernalis flows that meet the appropriate pulse flow targets for the predicted hydrologic conditions. The flows in the San Joaquin River upstream of the Stanislaus River are forecasted for the assumed hydrologic conditions. The upstream of the Stanislaus River flows are then adjusted so when combined with the forecasted Stanislaus River flow based on the IPO, the combined flow would provide the appropriate Vernalis flows consistent with the pulse flow target identified in the SJRA. An analysis of how the flows are produced upstream of the Stanislaus River is included in the SJRA Environmental Impract Statement(EIS)/Environmental Impact Report (EIR). For purposes of CVP-SWP operations forecasts, the flows are simply assumed to exist at the confluence of the Stanislaus and San Joaquin Rivers, and the assessment of CVP-SWP operations in the Delta effects begins downstream of that point.

The VAMP program has two distinct components, a flow objective and an export restriction. The flow objectives were designed to provide similar protection to those defined in the WQCP. fishery releases on the Stanislaus above that called for in the 1987 DFG Agreement are typically considered WQCP (b)(2) releases. The export reduction involves a combined State and Federal pumping limitation on the Delta pumps. The combined export targets for the 31 days of VAMP are specified in the SJRA: 1500 cfs (when target flows are 2000, 3200, 4450, or 7000 cfs), and 2250 cfs (when target flow is 5700 cfs, or 3000 cfs [alternate export target when flow target is 7000 cfs]). Typically, the Federal pumping reduction is considered a WQCP (b)(2) expense and the State reduction is covered by EWA actions. In 2003, however, EWA also provided coverage for a portion of the Federal pumping reduction.

Water Temperatures

Water temperatures in the lower Stanislaus River are affected by many factors and operational tradeoffs. These include available cold water resources in New Melones reservoir, Goodwin release rates for fishery flow management and water quality objectives, as well as residence time in Tulloch Reservoir, as affected by local irrigation demand.

The current stated goal for water temperatures in the lower Stanislaus River is 65° F at Orange Blossom Bridge for steelhead incubation and rearing during the late spring and summer. This goal is often unachieved. Fall pulse attraction flows for salmon managed by FWS resources helps to transport cold water resources from New Melones Reservoir into Tulloch Reservoir before the spawning season begins.

Friant Division

This division operates separately from the rest of the CVP and is not integrated into the CVP OCAP, but its operation is part of the CVP for purposes of the project description. Friant Dam is located on the San Joaquin River, 25 miles northeast of Fresno where the San Joaquin River exits the Sierra foothills and enters the valley. The drainage basin is 1,676 square miles with an average annual runoff of 1,774,000 af. Completed in 1942, the dam is a concrete gravity structure, 319 feet high, with a crest length of 3,488 feet. Although the dam was completed in 1942, it wasn't placed into full operation until 1951.

The dam provides flood control on the San Joaquin River, provides downstream releases to meet senior water rights requirements above Mendota Pool, and provides conservation storage as well as diversion into Madera and Friant-Kern Canals. Water is delivered to a million acres of agricultural land in Fresno, Kern, Madera, and Tulare Counties in the San Joaquin Valley via the Friant-Kern Canal south into Tulare Lake Basin and via the Madera Canal northerly to Madera and Chowchilla IDs. A minimum of five cfs is required to pass the last water right holding located about 40 miles downstream near Gravelly Ford.

Flood control storage space in Millerton Lake is based on a complex formula, which considers upstream storage in the Southern California Edison reservoirs. The reservoir, Millerton Lake, first stored water on February 21, 1944. It has a total capacity of 520,528 af, a surface area of 4,900 acres, and is approximately 15 miles long. The lake's 45 miles of shoreline varies from gentle slopes near the dam to steep canyon walls farther inland. The reservoir provides boating, fishing, picnicking, and swimming.

San Felipe Division

Construction of the San Felipe Division of the CVP was authorized in 1967 (Figure 2–6). The San Felipe Division provides a supplemental water supply (for irrigation, M&I uses) in the Santa Clara Valley in Santa Clara County, and the north portion of San Benito County. It prevents further mining of the groundwater in Santa Clara County and replaces boron-contaminated water in San Benito County.

The San Felipe Division was designed to supply about 216,000 af annually by the year 2020. Water is delivered to the service areas not only by direct diversion from the distribution systems, but also through the expansion of the large groundwater recharge operation now being carried out by local interests. The majority of the water supply, about 150,000 af, is used for M&I purposes.

The facilities required to serve Santa Clara and San Benito Counties include 54 miles of tunnels and conduits, two large pumping plants, and one reservoir. About 50 percent of the water conveyed to Santa Clara County is percolated to the underground for agricultural and M&I uses, and the balance is treated for direct M&I delivery. Nearly all of the water provided to San Benito County is delivered via surface facilities. A distribution system was constructed in San Benito County to provide supplemental water to about 19,700 arable acres.

Water is conveyed from the Delta of the San Joaquin and Sacramento Rivers through the DMC. It is then pumped into the San Luis Reservoir and diverted through the 1.8 miles of Pacheco Tunnel Reach 1 to the Pacheco Pumping Plant. Twelve 2,000-horse-power pumps lift a maximum of 480 cfs a distance varying from 85 feet to 300 feet to the 5.3 mile-long Reach 2 of Pacheco Tunnel. The water then flows through the tunnel and without additional pumping, through 29 miles of concrete, high-pressure pipeline, varying in diameter from 10 feet to 8 feet and a mile-long Santa Clara Tunnel. The pipeline terminates at the Coyote Pumping Plant, which is capable of pumping water to Coyote Creek or the Calero Reservoir.

Santa Clara Valley Water District operates the Pacheco Tunnel, Pacheco Pumping Plant, Santa Clara Tunnel and Coyote Pumping Plant.

The Hollister Conduit branches off the Pacheco Conduit eight miles from the outlet of the Pacheco Tunnel. This 19.1 mile-long high-pressure pipeline, with a maximum capacity of 83 cfs, terminates at the San Justo Reservoir.

The 9,906 af capacity San Justo Reservoir is located about three miles southwest of the City of Hollister. The San Justo Dam is an earthfill structure 141 feet high with a crest length of 722 feet. This project includes a dike structure 66 feet high with a crest length of 918 feet. This reservoir regulates San Benito County's import water supplies, allows pressure deliveries to some of the agricultural lands in the service area, and provides storage for peaking of agricultural water.

The San Benito County Water District operates San Justo Reservoir and the Hollister Conduit.

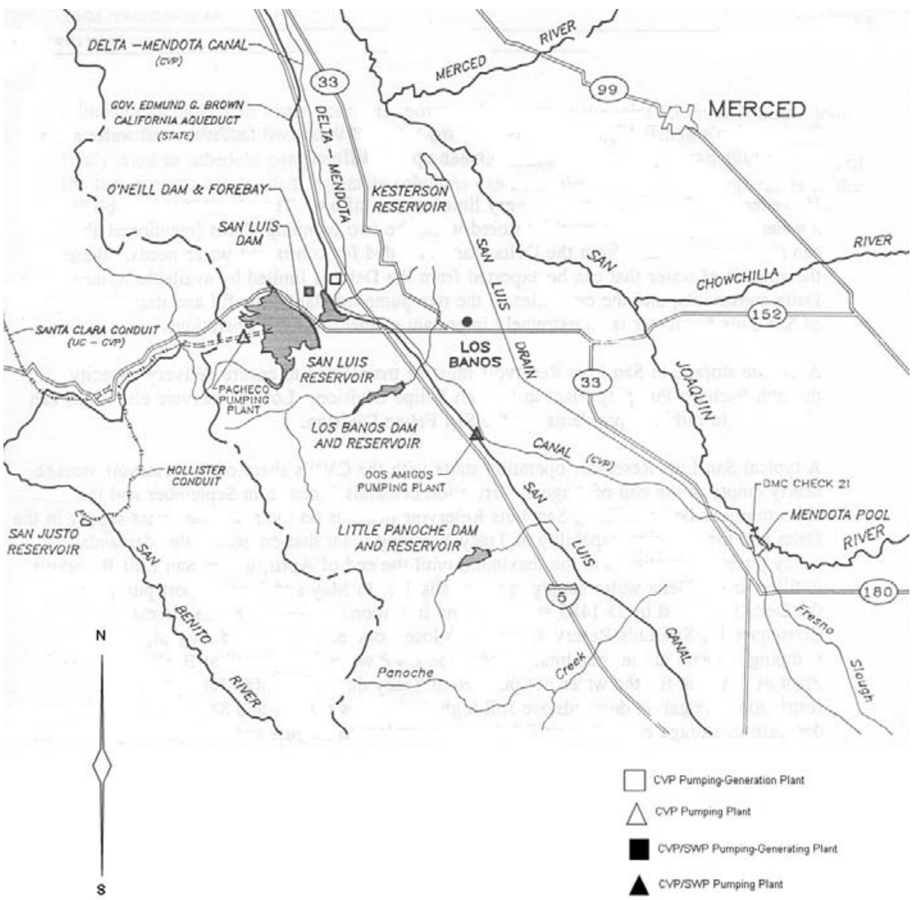


Figure 2–6 West San Joaquin Division and San Felipe Division

State Water Project

The DWR holds contracts with 29 public agencies throughout Central and Southern California for water supplies from the SWP. Water stored in the Oroville facilities, along with surplus water from the Sacramento-San Joaquin Delta are captured in the Delta and conveyed through several facilities to SWP contractors. The operation of these facilities is the subject of this project description. The facilities include the primary conservation storage complex on the Feather River, export facilities located in the North and South Delta, tidally operated gates in the Suisun Marsh, and operable barriers in the South Delta.[4]

Feather River

SWP Oroville Facilities

Oroville Dam and its appurtenances comprise a multi-purpose project encompassing water conservation, power generation, flood control, recreation, and fish and wildlife enhancement. Oroville Lake stores winter and spring runoff that is released into the Feather River, as necessary, for project purposes. Pumped storage capability permits maximization of the power value produced by these releases.

The Oroville facilities are shown in Figure 2–7. Two small embankments, Bidwell Canyon and Parish Camp Saddle Dams, complement Oroville Dam in containing Lake Oroville. The lake has a surface area of 15,858 acres, a storage capacity of 3,538,000 af, and is fed by the North, Middle, and South forks of the Feather River. Average annual unimpaired runoff into the lake is about 4.5 million af.

A maximum of 17,000 cfs can be released through the Edward Hyatt Powerplant, located underground near the left abutment of Oroville Dam. Three of the six units are conventional generators driven by vertical-shaft, Francis-type turbines. The other three are motor-generators coupled to Francis-type, reversible pump turbines. The latter units allow pumped storage operations. The intake structure has an overflow type shutter system that determines the level from which water is drawn.

Approximately four miles downstream of Oroville Dam and Edward Hyatt Powerplant is the Thermalito Diversion Dam. Thermalito Diversion Dam consists of a 625-foot long, concrete gravity section with a regulated ogee spillway that releases water to the low flow channel of the Feather River. On the right abutment is the Thermalito Power Canal regulating headwork structure.

The purpose of the diversion dam is to divert water into the two-mile long Thermalito Power Canal that conveys water in either direction and creates a tailwater pool (called Thermalito Diversion Pool) for Edward Hyatt Powerplant. The Thermalito Diversion Pool acts as a forebay when Hyatt is pumping water back into Lake Oroville. On the left abutment is the Thermalito Diversion Dam Powerplant, with a capacity of 600 cfs that releases water to the low flow section of the Feather River.

Thermalito Power Canal hydraulically links the Thermalito Diversion Pool to the Thermalito Forebay (11,768 af), which is the off-stream regulating reservoir for Thermalito Powerplant. Thermalito Powerplant is a generating-pumping plant operated in tandem with the Edward Hyatt Powerplant. Water released to generate power in excess of local and downstream requirements is conserved in storage and, at times, pumped back through both powerplants into Lake Oroville during off-peak hours. Energy price and availability are the two main factors that determine if a

[4] Permanent operable barriers are planned for future construction and operation. Only the operation of these facilities is included in this project description. Construction effects will be addressed through a separate consultation process.

pumpback operation is economical. A pumpback operation most commonly occurs when energy prices are high during the weekday on-peak hours and low during the weekday off-peak hours or on the weekend. The Oroville Thermalito Complex has a capacity of approximately 17,000 cfs through the powerplants, which can be returned to the Feather River via the Afterbay's river outlet.

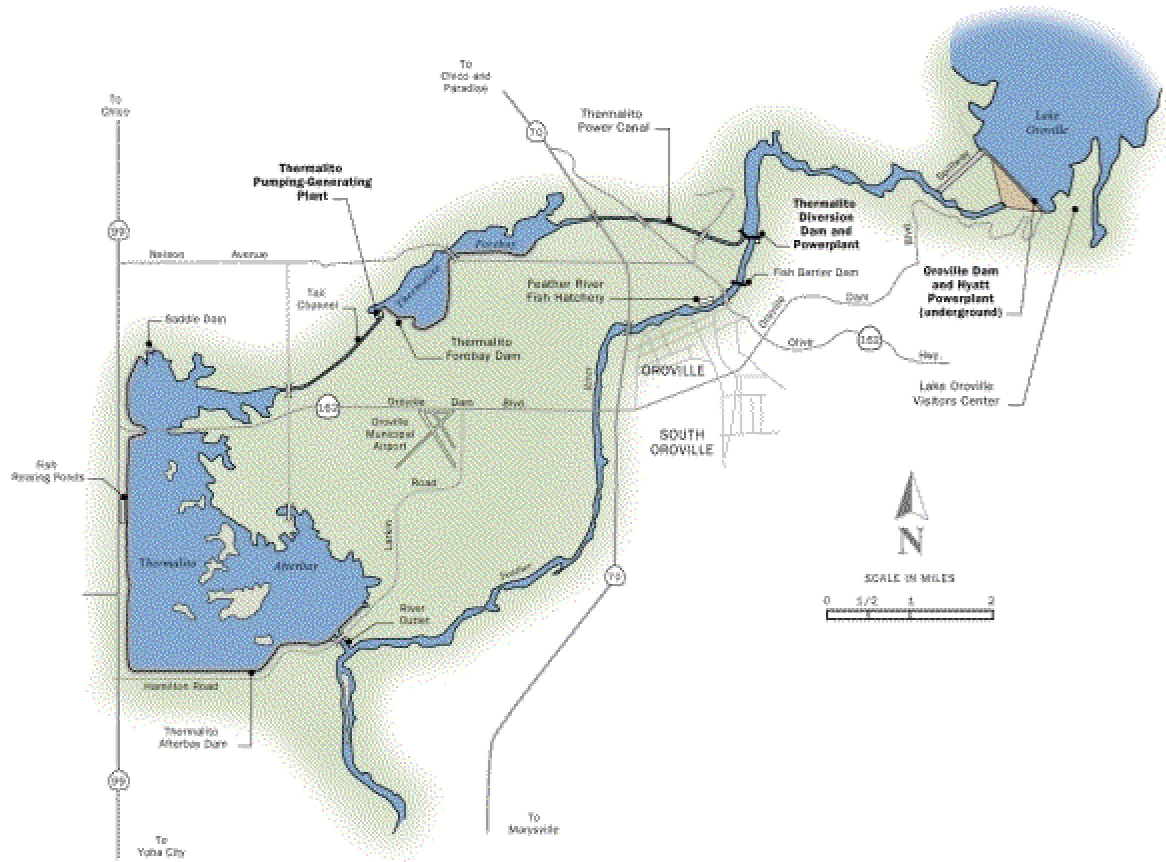


Figure 2–7 Oroville Facilities on the Feather River

Local agricultural districts divert water directly from the Afterbay. These diversion points are in leiu of the traditional river diversion exercised by the local districts whose water rights are senior to the SWP. The total capacity of Afterbay diversions during peak demands is 4,050 cfs.

The DFG operates the Feather River Fish Hatchery for the production of Chinook salmon and steelhead. The hatchery is located downstream of the Thermalito Diversion Dam. Water is provided to the hatchery via a pipeline from the diversion dam. The Feather River Fish Barrier Dam is downstream of the Thermalito Diversion Dam and immediately upstream of the Feather River Fish Hatchery. The flow over the dam maintains fish habitat in the low flow channel of the Feather River between the dam and the Afterbay outlet. The Fish Barrier Dam prevents further upstream migration by adult salmon and steelhead and helps direct them to the fish ladder entrance located on the right (west) embankment.

Temperature Control

The August 1983 agreement between DWR and DFG, "Concerning the Operation of the Oroville Division of the State Water Project for Management of Fish & Wildlife" sets criteria for flow and temperature for the low flow section of the Feather River, the fish hatchery, and the reach of the Feather River below the river outlet to the confluence with the Sacramento River.

In addition to fish and wildlife obligations, a May 1969 agreement between DWR and the Joint Water Districts recognizes the rights of the Districts to water (at temperatures reasonably related to achieving agricultural production) that would have been available if Oroville Dam had not been constructed. The 1985 agreement among DWR, Western Canal Water District and PG&E contains similar language.

Flood Control

Flood control operations at Oroville Dam are conducted in coordination with DWR's Flood Operations Center and in accordance with the requirements set forth by the Corps. The Federal Government shared the expense of Oroville Dam, which provides up to 750,000 af of flood control space. The spillway is located on the right abutment of the dam and has two separate elements: a controlled gated outlet and an emergency uncontrolled spillway. The gated control structure releases water to a concrete-lined chute that extends to the river. The uncontrolled emergency spill flows over natural terrain.

Table 2–9 Water Year/Days in Flood Control/40-30-30 Index

Water Year	Days in Flood Control	40-30-30 Index
1981	0	D
1982	35	W
1983	51	W
1984	16	W
1985	0	D
1986	25	W
1987	0	D
1988	0	C
1989	0	D
1990	0	C
1991	0	C
1992	0	C
1993	8	AN
1994	0	C
1995	35	W
1996	22	W

1997	57	W
1998	0	W
1999	58	W
2000	0	AN
2001	0	D
2002	0	D

DWR Feather River Fish Studies

DWR initiated fish studies in the lower Feather River in 1991. The present program consists of several elements to monitor salmonid spawning, rearing, and emigration and to document presence and relative abundance of non-salmonid fishes. The focus and methods used for these studies were altered in 2003 as a result of consultations with NOAA Fisheries, DFG, and others to gather information needed to relicense the Oroville facilities with the Federal Energy Regulatory Commission (FERC).

SWP/CVP Delta Facilities

CVP Facilities

The CVP's Delta Division includes the DCC, the CCWD diversion facilities, the Tracy Pumping Plant, the TFCF), and the DMC. The DCC is a controlled diversion channel between the Sacramento River and Snodgrass Slough. The CCWD diversion facilities utilize CVP water resources to serve district customers directly and to operate CCWD's Los Vaqueros Project. The Tracy Pumping Plant diverts water from the Delta to the head of the DMC.

Delta Cross Channel operations

The DCC is a gated diversion channel in the Sacramento River near Walnut Grove and Snodgrass Slough. Flows into the DCC from the Sacramento River are controlled by two 60-foot by 30-foot radial gates. When the gates are open, water flows from the Sacramento River through the cross channel to channels of the lower Mokelumne and San Joaquin Rivers toward the interior Delta. The DCC operation improves water quality in the interior Delta by improving circulation patterns of good quality water from the Sacramento River towards Delta diversion facilities.

Reclamation operates the DCC in the open position to (1) improve the transfer of water from the Sacramento River to the export facilities at the Banks and Tracy Pumping Plants, (2) improve water quality in the southern Delta, and (3) reduce salt water intrusion rates in the western Delta. During the late fall, winter, and spring, the gates are often periodically closed to protect out-migrating salmonids from entering the interior Delta. In addition, whenever flows in the Sacramento River at Sacramento reach 20,000 to 25,000 cfs (on a sustained basis) the gates are closed to reduce potential scouring and flooding that might occur in the channels on the downstream side of the gates.

Flow rates through the gates are determined by Sacramento River stage and are not affected by export rates in the south Delta. The DCC also serves as a link between the Mokelumne River and the Sacramento River for small craft, and is used extensively by recreational boaters and fishermen whenever it is open. Because alternative routes around the DCC are quite long, Reclamation tries to provide adequate notice of DCC closures so boaters may plan for the longer excursion.

SWRCB D-1641 DCC standards provide for closure of the DCC gates for fisheries protection at certain times of the year. From November through January, the DCC may be closed for up to 45 days for fishery protection purposes. From February 1 through May 20, the gates are closed for fishery protection purposes. The gates may also be closed for 14 days for fishery protection purposes during the period May 21 through June 15. Reclamation determines the timing and duration of the closures after consultation with FWS, DFG, and NOAA Fisheries. Consultation with the CALFED Ops Group will also satisfy the consultation requirement.

The CALFED Ops Group typically relies on monitoring for fish presence and movement in the Sacramento River and Delta, the salvage of salmon at the Tracy and Skinner facilities, and hydrologic cues for the timing of DCC closures, subject also to current water quality conditions in the interior and western Delta. From mid-June to November, Reclamation usually keeps the gates open on a continuous basis. The DCC is also usually opened for the busy recreational Memorial Day weekend, if this is possible from a fishery, water quality, and flow standpoint.

The Spring-run Chinook Salmon Protection Plan (SRPP) included “Indicators of Sensitive Periods for Salmon” such as hydrologic changes, detection of spring-run salmon or spring-run salmon surrogates at monitoring sites or the salvage facilities, and turbidity increases at monitoring sites to trigger the SRPP process. In November 2000, the SRPP was replaced by a CALFED Ops Group plan designed to provide broader protections for juvenile salmon emigrating through the Delta from October through January.

The Chinook Salmon Protection Decision Process (also known as the Salmon Decision Tree) is used by the fishery agencies and project operators to facilitate the often complex coordination issues surrounding DCC gate operations and the purposes of fishery protection closures, Delta water quality, and/or export reductions. Inputs such as fish lifestage and size development, current hydrologic events, fish indicators (such as the Knight's Landing Catch Index and Sacramento Catch Index), and salvage at the export facilities, as well as current and projected Delta water quality conditions, are used to determine potential DCC closures and/or export reductions. The coordination process has worked well during the recent fall and winter DCC operations and is expected to be used in the present or modified form in the future.

Tracy Pumping Plant

The CVP and SWP use the Sacramento River and Delta channels to transport water to export pumping plants in the south Delta. The CVP’s Tracy Pumping Plant, about five miles north of Tracy, consists of six available pumps. The Tracy Pumping Plant is located at the end of an earth-lined intake channel about 2.5 miles long. At the head of the intake channel, louver screens (that are part of the TFCF) intercept fish, which are then collected and transported by tanker truck to release sites away from the pumps. Tracy Pumping Plant diversion capacity is approximately 4,600 cfs during the peak of the irrigation season and approximately 4,200 cfs during the winter non-irrigation season before the Intertie, described on page 2-81. The capacity limitations at the Tracy Pumping Plant are the result of a DMC freeboard constriction near

O'Neill Forebay, O'Neill Pumping Plant capacity, and the current water demand in the upper sections of the DMC.

Tracy Fish Collection Facility

The TFCF uses behavioral barriers consisting of primary and secondary louvers to guide targeted fish into holding tanks before transport by truck to release sites within the Delta. Hauling trucks used to transport salvaged fish to release sites contain an eight parts per thousand salt solution to reduce stress. The CVP uses two release sites, one on the Sacramento River near Horseshoe Bend and the other on the San Joaquin River immediately upstream of the Antioch Bridge. During a recent facility inspection, TFCF personnel noticed significant decay of the transition boxes and conduits between the primary and secondary louvers. The temporary rehabilitation of these transition boxes and conduits was performed during the fall and winter of 2002.

When compatible with export operations, and technically feasible, the louvers are operated with the objective of achieving water approach velocities: for stripped bass of approximately one foot per second (ft/s) from May 15 through October 31, and for salmon of approximately three ft/s from November 1 through May 14. Channel velocity criteria are a function of bypass ratios through the facility.

Fish passing through the facility are sampled at intervals of no less than ten minutes every two hours. Fish observed during sampling intervals are identified to species, measured to fork length, examined for marks or tags, and placed in the collection facilities for transport by tanker truck to the release sites away from the pumps.

Contra Costa Water District Diversions Facilities

CCWD diverts CVP water from the Delta for irrigation and M&I uses. Prior to 1997, CCWD's primary diversion facility in the Delta originated at Rock Slough, about four miles southeast of Oakley. At Rock Slough, the water is lifted 127 feet by a series of four pumping plants into the Contra Costa Canal (CCC), a 47.7-mile canal that terminates in Martinez Reservoir. Two short canals, Clayton and Ygnacio, are integrated into the distribution system. The Clayton Canal is no longer in service

Rock Slough diversion capacity of 350 cfs gradually decreases to 22 cfs at the terminus. Historically, actual Rock Slough pumping rates have ranged from about 50 to 250 cfs with seasonal variation. Rock Slough Pumping Plant is an unscreened facility. The fish-screening of the Rock Slough Pumping Plant is directed under the CVPIA and is included in the CCWD's BO for the Los Vaqueros Project. Reclamation, in collaboration with CCWD, is responsible for constructing the fish screen. Reclamation asked for an extension until December 2008 to allow completion of current CALFED project studies that might affect frequency of usage of the Rock Slough intake and therefore, the screen design.

As part of the Los Vaqueros Project, CCWD also diverts from the Delta on Old River near Highway 4 at a fish-screened diversion facility with a capacity of 250 cfs. The Los Vaqueros Project was constructed to improve the delivered water quality and emergency storage reliability to CCWD's customers. The Old River facility allows CCWD to directly divert up to 250 cfs of CVP water to a blending facility with the existing CCC, in addition to the Rock Slough direct diversions. The Old River facility can also divert up to 200 cfs of CVP and Los Vaqueros water rights water for storage in the 100,000 af Los Vaqueros Reservoir.

The water rights for the Los Vaqueros Project were approved by SWRCB Decision 1629. A NOAA Fisheries BO for the Los Vaqueros winter-run Chinook salmon was provided on March 18, 1993. A FWS BO for Los Vaqueros covering delta smelt was provided on September 9, 1993 and clarified by letter on September 24, 1993. The FWS BO requires CCWD to preferentially divert CVP water from the fish-screened Old River intake from January through August each year.

The FWS BO also requires CCWD to operate all three of its intakes (including CCWD's Mallard Slough intake) and Los Vaqueros Reservoir as an integrated system to minimize impacts to endangered species. The 1993 BO calls for monitoring at all three intakes to determine diversion of water at Rock Slough, Old River, and Mallard Slough to minimize take of delta smelt during the spawning and rearing period.

Due to the water quality objectives of the Los Vaqueros Project, CCWD's total diversions from the Delta are reduced during the late summer and fall when Delta water quality and flows are the poorest of the annual cycle. The CCWD fills the Los Vaqueros Reservoir only when Delta water quality conditions are good, which generally occurs from January to July.

Additionally, under the Los Vaqueros BOs, CCWD is required to cease all diversions from the Delta for thirty days in the spring if stored water is available in Los Vaqueros Reservoir above emergency storage levels and to use releases from the reservoir to meet CCWD demands. To provide additional fisheries protection, CCWD is not allowed to divert water to Los Vaqueros storage for an additional forty-five day period in the winter or spring months.

The CCWD's third diversion facility in the Delta is located at the southern end of a 3,000 foot long channel running due south of Suisun Bay, near Mallard Slough (across from Chipps Island). The old Mallard Slough Pump Station was replaced in 2002 with a new pump station that has a state-of-the-art fish screen. The Mallard Slough Pump Station can pump up to 39.3 cfs,but is only used by CCWD during periods of very high Delta outflows (about 40,000 cfs or greater), when the water quality is good enough in Suisun Bay to meet CCWD's delivered chloride goal of 65 mg/L.

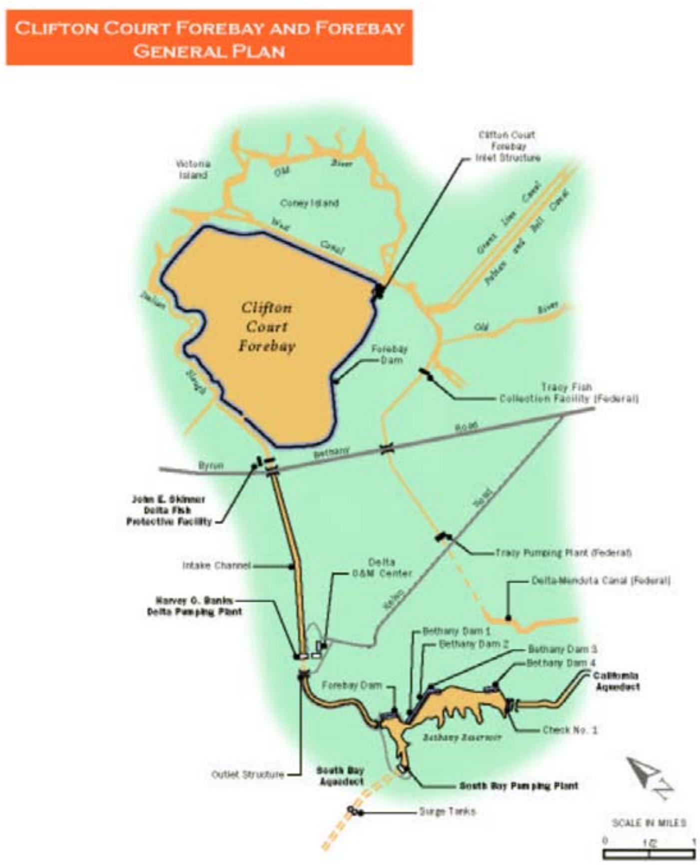
The CCWD has one license and one permit for Diversion and Use of Water issued by the SWRCB, which authorize CCWD to divert up to 26,780 af per year at Mallard Slough. Although the Mallard Slough intake is very small and is only used under extremely high Delta outflow conditions, it is an integral part of CCWD's operations. In 2003, CCWD used Mallard Slough (in conjunction with storage in Reclamation's Contra Loma Reservoir) to optimize its ability to fill Los Vaqueros Reservoir while the Rock Slough intake was out of service for replacement of a section of the CCC. All three Delta intake facilities are being considered in this project description chapter.

CVP-SWP Delta Export Facilities Operations Coordination

The Delta serves as a natural system of channels to transport river flows and reservoir storage to the CVP and SWP facilities in the south Delta, which export water to the Projects' service areas. Reclamation and DWR closely coordinate the operations of the Tracy and Banks Pumping Plants with operations of the joint CVP and SWP San Luis Reservoir near Los Banos (Figure 2–8). The Tracy Pumping Plant is usually operated at a constant and uninterrupted rate. When water supply supports it, the Tracy Pumping Plant is usually operated to the capacity limits of the DMC, except when restrictions are imposed by regulatory or fishery requirements. Currently, maximum daily diversions into the Clifton Court Forebay (CCF) are governed by agreement with the Corps. This agreement allows for daily diversion rates of about 13,250 af on a three-day average and 13,870 af on a daily average[5].

Between mid-December and mid-March, an additional amount of water may be diverted equal to one-third of the San Joaquin River (as measured at Vernalis) when the river flow is 1,000 cfs or greater. The CCF is operated to minimize effects to water levels during the low-low tide of the day. Banks Pumping Plant has eleven fixed speed pumps of varying size, which are run to the extent possible during off-peak power periods to convey water into the CA.

The DWR proposes to operate the CCF at a higher rate than is currently used. Referred to as "8500 Banks," the higher rate would result in greater utilization of the full pumping capability of the Banks Pumping Plant. Details regarding the increased diversion rates are covered under the section titled "8500 cfs Operational Criteria.".



[5]Up to an additional 500 cfs of diversion may be allowed from July through September as part of the Environmental Water Account operations. See the section titled "The CALFED Environmental Water Account" for further details.

Figure 2–8 Clifton Court Forebay, Tracy and Banks Pumping Plants

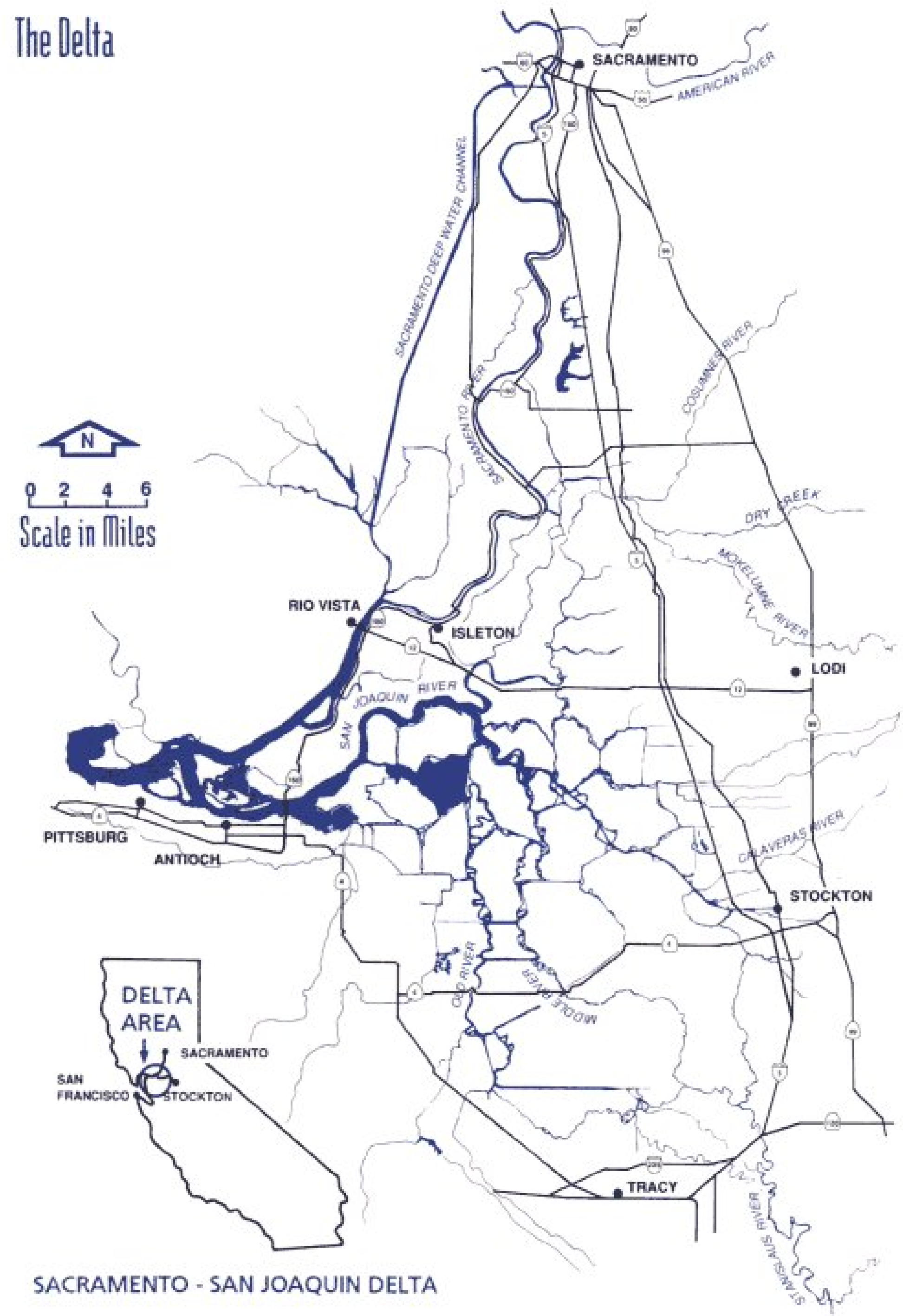


Figure 2–9 Sacramento-San Joaquin Delta

Sacramento-San Joaquin Delta- SWP Facilities

SWP facilities in the southern Delta include CCF, John E. Skinner Fish Facility, and the Harvey O. Banks Pumping Plant. CCF is a 31,000 af reservoir located in the southwestern edge of the Delta, about ten miles northwest of Tracy. CCF provides storage for off-peak pumping, moderates the effect of the pumps on the fluctuation of flow and stage in adjacent Delta channels, and collects sediment before it enters the CA. Diversions from Old River into CCF are regulated by five radial gates.

The John E. Skinner Delta Fish Protective Facility is located west of the CCF, two miles upstream of the Harvey O. Banks Delta Pumping Plant. The Skinner Fish Facility screens fish away from the pumps that lift water into the CA. Large fish and debris are directed away from the facility by a 388-foot long trash boom. Smaller fish are diverted from the intake channel into bypasses by a series of metal louvers, while the main flow of water continues through the louvers and towards the pumps. These fish pass through a secondary system of screens and pipes into seven holding tanks, where they are later counted and recorded. The salvaged fish are then returned to the Delta in oxygenated tank trucks.

The Harvey O. Banks Delta Pumping Plant is in the south Delta, about eight miles northwest of Tracy and marks the beginning of the CA. By means of eleven pumps, including two rated at 375 cfs capacity, five at 1,130 cfs capacity, and four at 1,067 cfs capacity, the plant provides the initial lift of water 244 feet into the CA. The nominal capacity of the Banks Pumping Plant is 10,300 cfs.

Other SWP operated facilities in and near the Delta include the North Bay Aqueduct (NBA), the Suisun Marsh Salinity Control Gates (SMSCG), Roaring River Distribution System, and up to four temporary barriers in the south Delta. Each of these facilities is discussed further in later sections.

Clifton Court Forebay

CCF is a regulated reservoir at the head of the CA in the south Delta. Inflows to the CCF are controlled by radial gates, which are generally operated during the tidal cycle to reduce approach velocities, prevent scour in adjacent channels, and minimize impacts to water level in the south Delta. Generally, the concern is potential effects to the lower of the two low tides in during the day; thus, the gates are operated in a manner to reduce the impact to this low tide condition.

When a large head differential exists between the outside and the inside of the gates, theoretical inflow can be as high as 15,000 cfs for a short time. However, existing operating procedures identify a maximum design rate of 12,000 cfs, which prevents water velocities from exceeding three ft/s to control erosion and prevent damage to the facility. Figure 2–10 shows an example of when the gates could be opened and still minimize impacts to the lowest tide of the day.

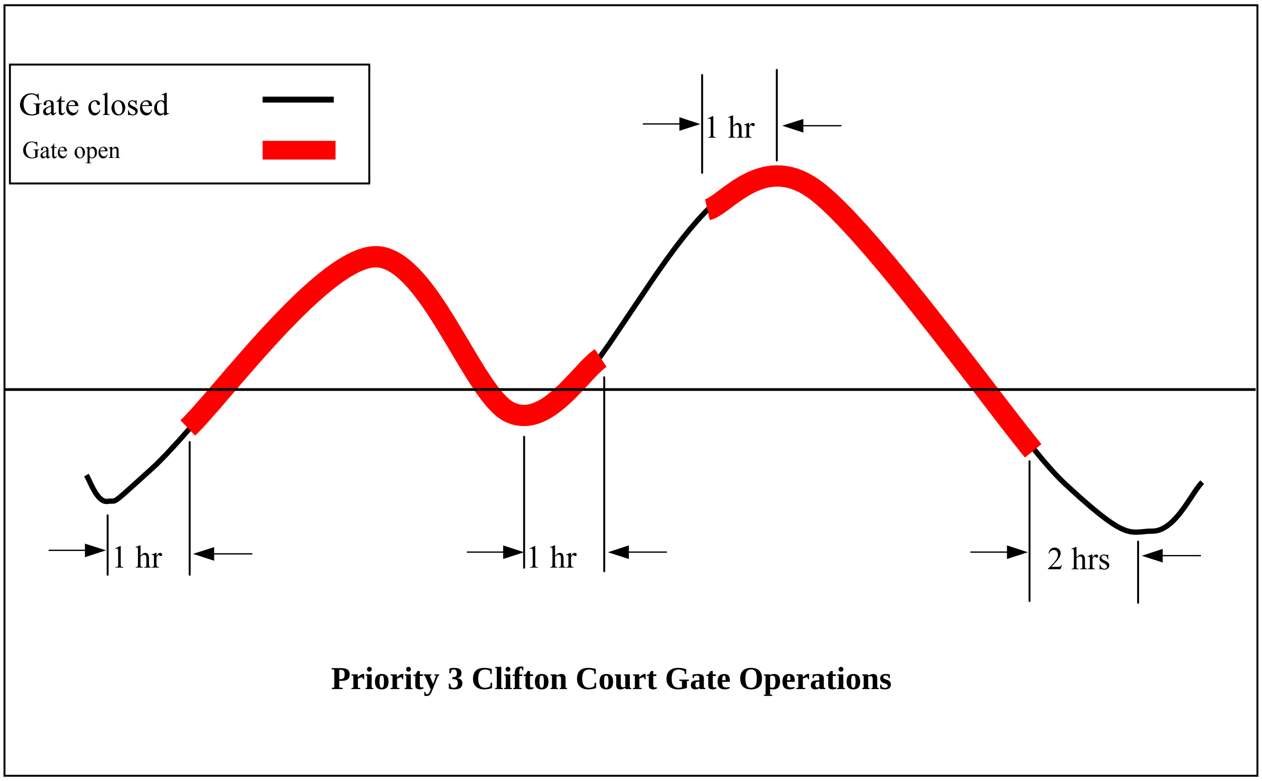


Figure 2–10 Clifton Court Gate Operations

North Bay Aqueduct Intake at Barker Slough

The Barker Slough Pumping Plant diverts water from Barker Slough into the NBA for delivery in Napa and Solano Counties. Maximum pumping capacity is 175 cfs (pipeline capacity). During the past few years, daily pumping rates have ranged between 0 and 140 cfs.

The NBA intake is located approximately ten miles from the main stem Sacramento River at the end of Barker Slough. Each of the ten NBA pump bays is individually screened with a positive barrier fish screen consisting of a series of flat, stainless steel, wedge-wire panels with a slot width of 3/32 inch. This configuration is designed to exclude fish 25 mm or larger from being entrained. The bays tied to the two smaller units have an approach velocity of about 0.2 ft/s. The larger units were designed for a 0.5 ft/s approach velocity, but actual approach velocity is about 0.44 ft/s. The screens are routinely cleaned to prevent excessive head loss, thereby minimizing increased localized approach velocities.

South Delta Temporary Barriers

The South Delta Temporary Barriers (SDTB) are not a project element for purposes of this biological assessment or the resulting consultation. A description of the SDTB is included only to provide information on a related project. A separate biological assessment has been prepared for the Temporary Barriers Project (DWR 1999a).

The existing SDTB Project consists of installation and removal of temporary rock barriers at the following locations:

- Middle River near Victoria Canal, about 0.5 miles south of the confluence of Middle River, Trapper Slough, and North Canal.
- Old River near Tracy, about 0.5 miles east of the DMC intake.
- Grant Line Canal near Tracy Boulevard Bridge, about 400 feet east of Tracy Boulevard Bridge.
- The head of Old River at the confluence of Old River and San Joaquin River.

The barriers on Middle River, Old River near Tracy, and Grant Line Canal are tidal control facilities designed to improve water levels and circulation for agricultural diversions and are in place during the growing season. Installation and operation of the barriers at Middle River and Old River near Tracy can begin May 15, or as early as April 15 if the spring head of Old River barrier is in place. From May 16 to May 31 (if the head of Old River barrier is removed) the tide gates are tied open at both Middle River and Old River near the Tracy barriers. After May 31, the Middle River, the Old River near Tracy, and the Grant Line Canal barriers are permitted to be operational until September 30.

During the spring, the barrier at the head of Old River is designed to reduce the number of out-migrating salmon smolts entering Old River. During the fall, the head of Old River barrier is designed to improve flow and DO conditions in the San Joaquin River for the immigration of adult fall-run Chinook salmon. Operations of the head of Old River barrier are typically between April 15 to May 15 for the spring barrier, and between early September to late November for the fall barrier. Installation and operation of the barrier also depend on San Joaquin flow conditions. DWR was permitted to install and operate these barriers between 1992 and 2000. In 2001, DWR obtained approvals to extend the Temporary Barriers Project for an additional 7 years.

West San Joaquin Division

San Luis Operations

As part of the West San Joaquin Division, the San Luis Unit was authorized in 1960 to be built and operated jointly with the State of California. The San Luis Unit consists of the following: (1) B. F. Sisk San Luis Dam and San Luis Reservoir (joint Federal-State facilities); (2) O'Neill Dam and Forebay (joint Federal-State facilities); (3) O'Neill Pumping-Generating Plant (Federal facility); (4) William R. Gianelli Pumping-Generating Plant (joint Federal-State facilities); (5) San Luis Canal (joint Federal-State facilities); (6) Dos Amigos Pumping Plant (joint Federal-State facilities); (7) Coalinga Canal (Federal facility); (8) Pleasant Valley Pumping Plant

(Federal facility); and (9) the Los Banos and Little Panoche Detention Dams and Reservoirs (joint Federal-State facilities).

The management of the San Luis Unit depends on the operation of the northern features of the CVP, while simultaneously influencing the operation of the northern CVP system. This relationship results from the need to deliver about half of the CVP's annual water supply through the DMC and the San Luis Unit, while essentially all of the water supply must originate from the northern Central Valley.

To accomplish the objective of providing water to CVP contractors in the San Joaquin Valley, three conditions must be considered: (1) water demands and anticipated water schedules for CVP water service contractors and exchange contractors must be determined; (2) a plan to fill and draw down San Luis Reservoir must be made; and (3) coordinating Delta pumping and utilizing San Luis Reservoir must be established. Only after these three conditions are made can the CVP operators incorporate the DMC and San Luis operations into plans for operating the northern CVP system.

Water Demands--DMC and San Luis Unit

Water demands for the DMC and San Luis Unit are primarily composed of three separate types: CVP water service contractors, exchange contractors, and wildlife refuge contracts. A significantly different relationship exists between Reclamation and these three groups. Exchange contractors "exchanged" their senior rights to water in the San Joaquin River for a CVP water supply from the Delta. Reclamation thus guaranteed the exchange contractors a firm water supply of 840,000 af per annum, with a maximum reduction under defined hydrologic conditions of 25 percent.

Conversely, water service contractors did not have water rights to "exchange." Agricultural water service contractors also receive their supply from the Delta, but their supplies are subject to the availability of CVP water supplies that can be developed and reductions in contractual supply can exceed 25 percent. Wildlife refuge contracts provide water supplies to specific managed lands for wildlife purposes and the CVP contract water supply can be reduced under critically dry conditions by up to 25 percent.

Combining the contractual supply of these three types of contractors with the pattern of requests for water is necessary to achieve the best operation of the CVP. In most years, because of reductions in CVP water supplies due to insufficient Delta pumping capability, sufficient supplies are not available to meet all water demands. In some dry or drought years, water deliveries are limited because of insufficient northern CVP reservoir storage to meet all in stream fishery objectives, including water temperatures, and to utilize the delivery capacity of Tracy Pumping Plant. The scheduling of water demands, together with the scheduling of the releases of supplies from the northern CVP to meet those demands, is a CVP operational objective intertwined with the Trinity, Sacramento, and American River operations.

San Luis Reservoir Operations

Two means of moving water from its source in the Delta are available for the DMC and the San Luis Unit (Figure 2–11). The first is Reclamation's Tracy Pumping Plant, which pumps water into the DMC. The second is the State's Banks Pumping Plant, which pumps water into the State

Aqueduct. During the spring and summer, water demands and schedules are greater than Reclamation's and DWR's capability to pump water at these two facilities, and water stored in the San Luis Reservoir must be used to make up the difference.

Figure 2–11 San Luis Complex

The San Luis Reservoir has very little natural inflow, therefore, if it is to be used for a water supply, the water must be stored during the fall and winter months when the two pumping plants can export more water from the Delta than is needed for scheduled water demands. Because the amount of water that can be exported from the Delta is limited by available water supply, Delta constraints, and the capacities of the two pumping plants, the fill and drawdown cycle of San Luis Reservoir is an extremely important element of CVP operations.

Adequate storage in San Luis Reservoir must be maintained to ensure delivery capacity through Pacheco Pumping Plant to the San Felipe Division. Lower reservoir elevations can also result in turbidity and water quality treatment problems for the San Felipe Division users.

A typical San Luis Reservoir annual operation cycle starts with the CVP's share of the reservoir storage nearly empty at the end of August. Irrigation demands decrease in September and the opportunity to begin refilling San Luis Reservoir depends on the available water supply in the northern CVP reservoirs and the pumping capability at Tracy Pumping Plant that exceeds water demands. Tracy Pumping Plant operations generally continue at the maximum diversion rates until early spring, unless San Luis Reservoir is filled or the Delta water supply is not available. As outlined in the Department of the Interior Decision on Implementation of Section 3406 (b)(2) of the CVPIA, Tracy Pumping Plant diversion rates may be reduced during the fill cycle of the San Luis Reservoir for fishery management.

In April and May, export pumping from the Delta is limited by SWRCB D-1641 San Joaquin River pulse period standards as well as B2/EWA fishery management during the spring months. During this same time, CVP-SWP irrigation demands are increasing. Consequently, by April and May the San Luis Reservoir has begun the annual drawdown cycle. In some exceptionally wet conditions, when excess flood water supplies from the San Joaquin River or Tulare Lake Basin occur in the spring, the San Luis Reservoir may not begin its drawdown cycle until late in the spring.

In July and August, the Tracy Pumping Plant diversion is at the maximum capability and some CVP water may be exported using excess Banks Pumping Plant capacity as part of a Joint Point of Diversion operation. Irrigation demands are greatest during this period and San Luis continues to decrease in storage capability until it reaches a lowpoint late in August and the cycle begins anew.

San Luis Unit Operation--State and Federal Coordination

The CVP operation of the San Luis Unit requires coordination with the SWP since some of its facilities are entirely owned by the State and others are joint State and Federal facilities. Similar to the CVP, the SWP also has water demands and schedules it must meet with limited water supplies and facilities. Coordinating the operations of the two projects avoids inefficient situations (for example, one entity pumping water at the San Luis Reservoir while the other is releasing water).

Total San Luis Unit annual water supply is contingent on coordination with the SWP needs and capabilities. When the SWP excess capacity is used to support CVP JPOD water for the CVP, it may be of little consequence to SWP operations, but extremely critical to CVP operations. The availability of excess SWP capacity by the CVP is contingent on the ability of the SWP to meet its SWP contractors' water supply commitments. Additionally, close coordination by CVP and SWP is required to ensure that water pumped into O'Neill Forebaydoes not exceed the CVP's capability to pump into San Luis Reservoir or into the San Luis Canal at the Dos Amigos Pumping Plant.

Although secondary to water concerns, power scheduling at the joint facilities is also a mutual coordination concern. Because of time-of-use power cost differentials, both entities will likely want to schedule pumping and generation simultaneously. When facility capabilities of the two projects are limited, equitable solutions can be achieved between the operators of the SWP and the CVP.

With the existing facility configuration, the operation of the San Luis Reservoir could impact the water quality and reliability of water deliveries to the San Felipe Division, if San Luis Reservoir is drawn down too low. This operation could have potential impacts to resources in Santa Clara and San Benito Counties. Implementation of a solution to the San Luis low point problem would allow full utilization of the storage capacity in San Luis Reservoir without impacting the San Felipe Division water supply. Any changes to the operation of the CVP and SWP, as a result of solving the low point problem, would be consistent with the operating criteria of the specific facility. For example, any change in Delta pumping that would be the result of additional effective storage capacity in San Luis Reservoir, would be consistent with the operating conditions for the Banks and Tracy Pumping Plants.

A solution to the San Luis Reservoir low point problem is also included in the long-term operation of the CVP and SWP, and is also part of this consultation. Solving the low point problem in San Luis Reservoir was identified in the August 28, 2000, CALFED ROD as a complementary action which would avoid water quality problems associated with the low point and increase the effective storage capacity in San Luis Reservoir up to 200,000 af. This action, while not implemented at present, is part of the future proposed action on which Reclamation is consulting. All site-specific and localized actions of implementing a solution to the San Luis Reservoir low point problem, such as construction of any physical facilities in or around San Luis Reservoir and any other site-specific effects, will be addressed in a separate consultation.

Suisun Marsh

Suisun Marsh Salinity Control Gates

The SMSCG are located about two miles northwest of the eastern end of Montezuma Slough, near Collinsville (Figure 2–12). The SMSCG span Montezuma Slough, a width of 465 feet. In addition to permanent barriers adjacent to each levee, the structure consists of the following components (from west to east): (1) a flashboard module which provides a 68-foot wide maintenance channel through the structure during June through September when the flashboards are not installed (the flashboards are only installed between September and May, as needed, and can be removed if emergency work is required. Installation and removal of the flashboards requires a large, barge-mounted crane); (2) a radial gate module, 159 feet across, containing three radial gates, each 36 feet wide; and (3) a boat-lock module, 20 feet across, which is operated when the flashboards are in place.

An acoustic velocity meter is located about 300 feet upstream (south) of the gates to measure water velocity in Montezuma Slough. Water level recorders on both sides of the structure allow operators to determine the difference in water level on both sides of the gates. The three radial gates open and close automatically using the water level and velocity data.

Operation of the SMSCG began in October 1988. The facility was implemented as Phase II of the Plan of Protection for the Suisun Marsh. Operating the SMSCG is essential for meeting eastern and central marsh standards in SWRCB D-1641 and the Suisun Marsh Preservation Agreement, and for lowering salinity in the western marsh. Gate operation retards the upstream flow of higher salinity water from Grizzly Bay during flood tides while allowing the normal flow of lower salinity water from the Sacramento River near Collinsville during ebb tides.

During full operation, the gates open and close twice each tidal day. The net flow through the gates during full operation is about 1,800 cfs in the downstream direction when averaged over one tidal day. Typically in summer, when the gates are not operating and the flashboards are removed, the natural net flow in Montezuma Slough is low and often in the upstream direction from Grizzly Bay toward Collinsville.

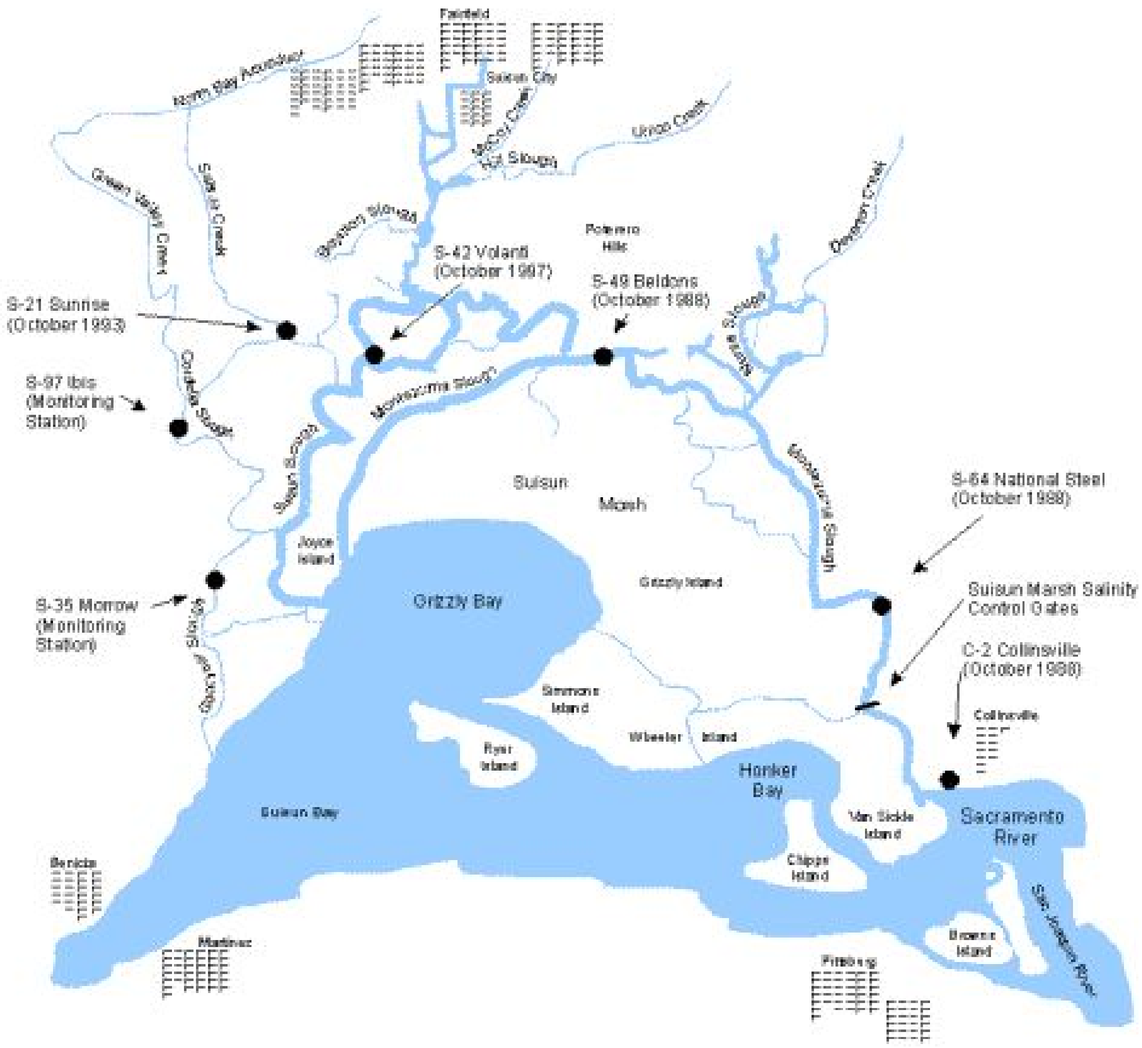


Figure 2–12 Suisun Bay and Suisun Marsh showing the location of the Suisun Marsh Salinity Control Gates and Salinity Control Stations

SMSCG are not in operation June 1 through August 31. When not in operation, the maintenance channel is open, the flashboards are stored in the maintenance yard, the three radial gates are held open, and the boat lock is closed.

The SMSCG are operated (as needed) from September through May 31 to meet SWRCB and Suisun Marsh Preservation Agreement (SMPA) standards in October through May. Operation of the SMSCG will commence in September if high-tide channel water salinity is above 17 mS/cm at any trigger station (2 mS/cm below the October standard)[6]. Trigger stations are S-35, S-42, S-49, and S-64 (Figure 2–12). Otherwise, the operation will occur October 1 through May 31 if two consecutive high tide salinities are within 2 mS/cm below the current and subsequent months' standards at any trigger station. The flashboards are installed prior to operation.

The operation is suspended (with the radial gates held open) when two consecutive high tide salinities are below 2 mS/cm of the current and subsequent months' standards at all trigger stations. Flashboards are removed when it is determined that salinity conditions at all trigger stations will remain below standards for the remainder of the control season through May 31. SWP operators can exercise discretion with the operations of the SMSCG deviating from the stated triggers as they deem appropriate for the conditions, forecasts, or to accommodate special activities.

SMSCG Fish Passage Study

A three-year study to evaluate whether a modified flashboard system could reduce the delay in adult salmon immigration was initiated in September 1998. For this study, the flashboards were modified, creating two horizontal slots to allow fish passage during gate operation. The first two field seasons were conducted during September and November 1998 and 1999. Salinity was monitored during the evaluation to determine if SWRCB salinity standards could be met with the modified flashboards in place.

Results from the first two years of the modified flashboard system indicated the slots did not provide improved passage for salmon at the SMSCG. The reason(s) for this is still unknown. In addition, the 1999 study showed no statistical difference in passage numbers between the full operation configuration (no slots) and when the flashboards and gates were out of the water. In both 1998 and 1999 there was no statistical difference in time of passage (average hours, indicating delay) between the full operation configurations (no slots) and when the flashboards and gates were out of the water.

Because preliminary results from the modified SMSCG test indicate the slots resulted in less passage than the original flashboards, the SMSCG Steering Group decided to postpone the third year of the test until September 2001 and to reinstall the original flashboards if gate operation was needed during the 2000-2001 control season. The SMSCG Steering Group is evaluating leaving the boat lock open as a means of providing unimpeded passage to adult salmon migrating upstream. Studies were completed during the 2001-2002 and 2002-2003 control seasons and plans are in place for the 2003-2004 control season. The studies included three phases, in varying order, each year:

1. Full Open Operation. The SMSCG flashboards are out, the gates are fixed in the up position, and the boat lock is closed.
2. Full Bore Operation with Boat Lock Open. The SMSCG flashboards are in, the gates are tidally operated, and the boat lock is held open.

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[6]Since 1988, the SMSCG have been operated in September during five years (1989, 1990, 1993, 1994, and 1999), either for testing the effectiveness of gate operations, to help reduce channel salinity for initial flooding of managed wetlands during drought conditions, or to test salmon passage.

3. Full Bore Operation with Boat Lock Closed. The SMSCG flashboards are in, the gates are tidally operated, and the boat lock is closed.

Roaring River Distribution System

The Roaring River Distribution System (RRDS) was constructed during 1979 and 1980 as part of the Initial Facilities in the Plan of Protection for the Suisun Marsh. The system was constructed to provide lower salinity water to 5,000 acres of both public and privately managed wetlands on Simmons, Hammond, Van Sickle, Wheeler, and Grizzly Islands. Construction involved enlarging Roaring River Slough and extending its western end. Excavated material was used to widen and strengthen the levees on both sides of the system.

The RRDS includes a 40-acre intake pond (constructed west of the new intake culverts) that supplies water to Roaring River Slough. Motorized slide gates in Montezuma Slough and flap gates in the pond control flows through the culverts into the pond. A manually operated flap gate and flashboard riser are located at the confluence of Roaring River and Montezuma Slough to allow drainage back into Montezuma Slough for controlling water levels in the distribution system and for flood protection. DWR owns and operates this drain gate to ensure the Roaring River levees are not compromised during extremely high tides.

Water is diverted through a bank of eight 60-inch diameter culverts into the Roaring River intake pond on high tides to raise the water surface elevation in RRDS above the adjacent managed wetlands. Managed wetlands north and south of the RRDS receive water, as needed, through publicly and privately owned turnouts on the system.

The intake to the RRDS is screened to prevent entrainment of fish larger than approximately 25 mm. DWR designed and installed the screens using DFG criteria. The screen is a stationary vertical screen constructed of continuous-slot stainless steel wedge wire. All screens have 3/32-inch slot openings. After the listing of delta smelt, RRDS diversion rates have been controlled to maintain an average approach velocity below 0.2 ft/s at the intake fish screen. Initially, the intake culverts were held at about 20 percent capacity to meet the velocity criterion at high tide. Since 1996, the motorized slide gates have been operated remotely to allow hourly adjustment of gate openings to maximize diversion throughout the tide.

Routine maintenance of the system is conducted by DWR and primarily consists of maintaining the levee roads. DWR provides routine screen maintenance. RRDS, like other levees in the marsh, have experienced subsidence since the levees were constructed in 1980. In 1999, DWR restored all 16 miles of levees to design elevation.

Morrow Island Distribution System

The Morrow Island Distribution System (MIDS) was constructed in 1979 and 1980 as part of the Initial Facilities in the Plan of Protection for the Suisun Marsh. The systems was constructed to provide water to privately managed wetlands on Morrow Island and to channel drainage water from the adjacent managed wetlands for discharge into Grizzly Bay rather than Goodyear Slough. The MIDS is used year-round, but most intensively from September through June.

When managed wetlands are filling and circulating, water is tidally diverted from Goodyear Slough just south of Pierce Harbor through three 48-inch culverts. Drainage water from Morrow

Island is discharged into Grizzly Bay by way of the C-Line Outfall (two 36-inch culverts) and into the mouth of Suisun Slough by way of the M-Line Outfall (three 48-inch culverts), rather than back into Goodyear Slough. This helps prevent increases in salinity due to drainage water discharges into Goodyear Slough. The M-Line ditch is approximately 1.6 miles in length and the C-Line ditch is approximately 0.8 miles in length.

The FWS 1997 BO included a requirement for screening the diversion of the MIDS. Reclamation and DWR continue to coordinate with the FWS and NOAA Fisheries in the development of alternatives to screening that may provide greater benefit for listed aquatic species in Suisun Marsh.

Goodyear Slough Outfall

The Goodyear Slough Outfall was constructed in 1979 and 1980 as part of the Initial Facilities. A channel approximately 69-feet wide was dredged from the south end of Goodyear Slough to Suisun Bay (about 2,800 feet). The Outfall consists of four 48-inch culverts with flap gates on the bay side and vertical slide gates on the slough side. The system was designed to increase circulation and reduce salinity in Goodyear Slough by draining water from the southern end of Goodyear Slough into Suisun Bay. The system also provides lower salinity water to the wetland managers who flood their ponds with Goodyear Slough water. No impacts to fish occur in the outfall since fish moving from Goodyear Slough into the outfall would end up in Suisun Bay.

Lower Joice Island Unit

The Lower Joice Island Unit consists of two 36-inch diameter intake culverts on Montezuma Slough near Hunter Cut and two 36-inch diameter culverts on Suisun Slough, also near Hunter Cut. The culverts were installed in 1991. The facilities include combination slide/flap gates on the slough side and flap gates on the landward side. In 1997, DWR contracted with the Suisun Resources Conservation District to construct a conical fish screen on the diversion on Montezuma Slough. The fish screen was completed and has been operating since 1998.

Cygnus Unit

A 36-inch drain gate with flashboard riser was installed in 1991 on a private parcel located west of Suisun Slough and adjacent to and south of Wells Slough. The property owner is responsible for the operation and maintenance of the gate. No impacts to fish are known to occur because of operation of the drain.

Intro of CVPIA Section 3406 (b)(2)

On May 9, 2003, the Department of the Interior issued its Decision on Implementation of Section 3406 (b)(2) of the CVPIA. Dedication of (b)(2) water occurs when Reclamation takes a fishery protection action on behalf of the FWS (and in consultation with NOAA Fisheries and the DFG), pursuant to the primary purpose of Section 3406 (b)(2) or contributes to the AFRP’s flow objectives for CVP streams. Dedication of (b)(2) water also assists in meeting WQCP fishery objectives and helps meet the needs of fish listed under the ESA as threatened or endangered since the enactment of the CVPIA.

The May 9, 2003, decision describes the means by which the amount of dedicated (b)(2) water is determined. Planning and accounting for (b)(2) actions are done cooperatively and occur primarily through weekly meetings of the (b)(2) Interagency Team. Actions usually take one of two forms - in stream flow augmentation below CVP reservoirs or CVP Tracy pumping reductions in the Bay-Delta. Chapter 8 of this BA contains a more detailed description of (b)(2) operations, as characterized in the CALSIM modeling for the CVP OCAP, assumptions and results of the modeling are summarized.

CVPIA 3406 (b)(2) operations on Clear Creek

Dedication of (b)(2) water on Clear Creek provides actual in stream flows below Whiskeytown Dam greater than the fish and wildlife minimum flows specified in the 1963 proposed release schedule (Table 2–3). In stream flow objectives are usually taken from the AFRP's plan, in consideration of spawning and incubation of fall–run Chinook salmon. Augmentation in the summer months is usually in consideration of water temperature objectives for steelhead and in late summer for spring–run Chinook salmon.

In 2000, the McCormick-Saeltzer Dam was removed on Clear Creek thereby removing a significant fishery passage impediment. As part of the overall dam removal effort, a new agreement was reached among Townsend Flat Water Ditch Company, its shareholders, FWS, and Reclamation. Townsend Flat Water Ditch Company had an annual diversion capability of up to 12,500 af of Clear Creek flows at McCormick-Saeltzer Dam. With the dam removed, Reclamation will provide (under the new agreement) Townsend with up to 6,000 af of water annually. If the full 6,000 af is delivered, then 900 af will be dedicated to (b)(2) according to the August 2000 agreement.

CVPIA 3406 (b)(2) operations on the Upper Sacramento River

Dedication of (b)(2) water on the Sacramento River provides actual in stream flows below Keswick Dam greater than the fish and wildlife requirements specified in WR 90-5 and the Winter-run Biological Opinion. In stream flow objectives from October 1 to April 15 (typically April 15 is when water temperature objectives for winter-run Chinook salmon become the determining factor) are usually selected to minimize dewatering of redds and provide suitable habitat for salmonid spawning, incubation, and rearing.

CVPIA 3406 (b)(2) operations on the Lower American River

Dedication of (b)(2) water on the American River provides actual in stream flows below Nimbus Dam greater than the fish and wildlife requirements previously mentioned in the American River Division. In stream flow objectives from October through May generally aim to provide suitable habitat for salmon and steelhead spawning, incubation, and rearing. While considering impacts to temperature operations through the summer into fall, objectives for June to September endeavor to provide suitable flows and water temperatures for juvenile steelhead rearing.

Flow Fluctuation and Stability concerns

Through CVPIA, Reclamation has funded studies by DFG to better define the relationships of Nimbus release rates and rates of change criteria in the lower American River to minimize the negative effects of necessary Nimbus release changes on sensitive fishery objectives. Reclamation is presently using draft criteria developed by DFG. The draft criteria have helped reduce the incidence of anadromous fish stranding relative to past historic operations. The operational downside of the draft criteria is that ramping rates are relatively slow and can potentially have significant effects to water storage at Folsom Reservoir if uncertain future hydrologic conditions do not refill the impact to storage at Folsom Reservoir.

The operational coordination for potentially sensitive Nimbus Dam release changes is conducted through the B2IT process. An ad hoc agency and stakeholders group (known as AROG) was formed in 1996 to assist in reviewing the criteria for flow fluctuations. Since that time, the group has addressed a number of operational issues in periodic meetings and the discussions have served as an aid towards adaptively managing releases, including flow fluctuation and stability, and managing water temperatures in the lower American River to better meet the needs of salmon and steelhead trout.

CVPIA 3406 (b)(2) operations on the Stanislaus River

Dedication of (b)(2) water on the Stanislaus River provides actual in stream flows below Goodwin Dam greater than the fish and wildlife requirements previously mentioned in the East Side Division, and is generally consistent with the IPO for New Melones. In stream fishery management flow volumes on the Stanislaus River, as part of the IPO, are based on the New Melones end-of-February storage plus forecasted March to September inflow as shown in the IPO. The volume determined by the IPO is a combination of fishery flows pursuant to the 1987 DFG Agreement and the FWS AFRP in stream flow goals. The fishery volume is then initially distributed based on modeled fish distributions and patterns used in the IPO.

Actual in stream fishery management flows below Goodwin Dam will be determined in accordance with the Department of the Interior Decision on Implementation of Section 3406 (b)(2) of the CVPIA. Reclamation and FWS have begun developing a long-term operations plan for New Melones . This plan will be coordinated with the Agencies at weekly B2IT meetings, along with the stakeholders and the public before it is finalized.

CVPIA 3406 (b)(2) operations in the Delta

Export curtailments at the CVP Tracy Pumping Plant and increased CVP reservoir releases required to meet SWRCB D-1641, as well as direct export reductions for fishery management using dedicated (b)(2) water at the CVP Tracy Pumping Plant, will be determined in accordance with the Department of the Interior Decision on Implementation of Section 3406 (b)(2) of the CVPIA. Direct Tracy Pumping Plant export curtailments for fishery management protection will be based on recommendations of FWS, after consultation with Reclamation, DWR, NOAA Fisheries and DFG pursuant to the weekly B2IT coordination meetings. See the Adaptive Management section for the other coordination groups, i.e., DAT, OFF, WOMT and EWAT.

Environmental Water Account Operations in the Delta

As specified in the CALFED ROD, the EWA has been implemented to provide sufficient water, and combined with the Ecosystem Restoration Program (ERP), to address CALFED's fish protection and restoration/recovery needs while enhancing the predictability of CVP and SWP operations and improving the confidence in and reliability of water allocation forecasts. In the Delta environment, EWA resources and operational flexibility are used as both a real time fish management tool to improve the passage and survival of at-risk fish species in the Delta environment and for specific seasonal planned fish protection operations at the CVP and SWP Delta pumps.

The EWA agencies include Reclamation, FWS, NOAA Fisheries, DWR, and DFG (Agencies) have established protocols for the expenditure of water resources following the guidance given in the CALFED ROD. EWA resources may be used to temporarily reduce SWP Delta exports at Banks Pumping Plant for fish protection purposes above SWRCB D-1641 requirements and to coordinate with the implementation of Section 3406(b)(2) fish actions pursuant to the CVPIA. EWA resources also may be used to temporarily reduce CVP Tracy Pumping Plant export for fish protection purposes above the resources available through Section 3406(b)(2) of the CVPIA.

The EWA is a cooperative management program, whose purpose is to provide protection to the at-risk native fish of the Bay-Delta estuary through environmentally beneficial changes in CVP/SWP operations at no uncompensated water cost to the projects' water users. It is a tool to increase water supply reliability and to protect and recover at-risk fish species.

The EWA described in the CALFED ROD is a four-year program, which the EWA Agencies have been implementing since 2000. However, the EWA Agencies believe a long-term EWA is critical to meet the CALFED ROD goals of increased water supply reliability to water users, while at the same time assuring the availability of sufficient water to meet fish protection and restoration/recovery needs. Thus, the EWA Agencies envision implementation of a long-term EWA as part of the operation of the CVP and SWP. However, inclusion of the EWA in this description does not constitute a decision on the future implementation of EWA. Future implementation of a long-term EWA is subject to NEPA and the California Environmental Quality Act (CEQA).

The EWA allows these Agencies to take actions to benefit fish. An example action would be curtailing project exports by reducing pumping during times when pumping could be detrimental to at-risk fish species. EWA assets are then used to replace project supplies that would have otherwise been exported, but for the pumping curtailment. Used in this way, the EWA allows the EWA Agencies to take actions to benefit fish without reducing water deliveries to the projects' water users.

The commitment to not reduce project water deliveries resulting from EWA actions to benefit fish is predicated on three tiers of protection, as recognized in the CALFED ROD. These three tiers are described as follows:.

- **Tier 1 (Regulatory Baseline)**. Tier 1 is baseline water and consists of currently existing BOs, water right decisions and orders, CVPIA Section 3406(b)(2) water, and other regulatory actions affecting operations of the CVP and SWP. Also included in Tier 1 are other environmental statutory requirements such as Level 2 refuge water supplies.

Although the OCAP BOs will be part of Tier 1, the long-term EWA described in those BOs will not be considered part of Tier 1. If Tier 1 changes significantly over time (from that which was analyzed in the OCAP BOs), Reclamation and DWR will reinitiate consultation on those BOs.

- **Tier 2 (EWA)**. Tier 2 is the EWA and provides fish protection actions supplemental to the baseline level of protection (Tier 1). Tier 2 consists of EWA assets, which combined with the benefits of CALFED's ERP, will allow water to be provided for fish actions when needed without reducing deliveries to water users. EWA assets will include purchased (fixed) assets, operational (variable) assets, and other water management tools and agreements to provide for specified level of fish protection. Fixed assets are those water supplies which are purchased by the EWA Agencies, and will provide the following quantities south of the Delta: (1) 210, 000 af in critical years, (2) 230,000 af in dry years, and (3) 250,000 af in all other year types.[7] These purchased quantities are approximations and subject to some variability. Operational assets are those water supplies made available through CVP and SWP operational flexibility. Some examples include the flexing of the export-to-inflow ratio standard required to for meeting Delta water quality and flows, and ERP water resulting from upstream releases pumped at the SWP Banks Pumping Plant. Water management tools provide the ability to convey, store, and manage water that has been secured through other means. Examples include dedicated pumping capacity, borrowing, banking, and entering into exchange agreements with water contractors. Chapter 8 of this BA contains a more detailed description of EWA operations, as characterized in the CALSIM modeling for the CVP OCAP.
- **Tier 3 (Additional Assets)**. In the event the EWA Agencies deem Tiers 1 and 2 levels of protection insufficient to protect at-risk fish species in accordance with ESA requirements, Tier 3 would be initiated. Tier 3 sets in motion a process based upon the commitment and ability of the EWA Agencies to make additional water available, should it be needed. This Tier may consist of additional purchased or operational assets, funding to secure additional assets if needed, or project water if funding or assets are unavailable. It is unlikely that protection beyond those described in Tiers 1 and 2 will be needed to meet ESA requirements. However, Tier 3 assets will be used when Tier 2 assets and water management tools are exhausted, and the EWA Agencies determine that jeopardy to an at-risk fish species is likely to occur due to project operations, unless additional measures are taken. In determining the need for Tier 3 protection, the EWA Agencies would consider the views of an independent science panel.

With these three tiers of protection in place that are subject to changes based on NEPA/CEQA review, or new information developed through ESA/CESA/ Natural Community Conservation Planning Act (NCCPA) review or the CALFED Science Program, the EWA Agencies will provide long-term regulatory commitments consistent with the intent set forth in the CALFED ROD. The commitments are intended to protect the CVP and SWP exports at the Tracy and Banks Pumping Plants from reductions in water supplies for fish protection beyond those required in Tier 1.

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[7]The year types are defined in Water Right Decision 1641 from the State Water Resources Control Board.

Water Transfers

California Water Law and the CVPIA promote water transfers as important water resource management measures to address water shortages provided certain protections to source areas and users are incorporated into the water transfer. Water transferees generally acquire water from sellers who have surplus reservoir storage water, sellers who can pump groundwater instead of using surface water, or sellers who will idle crops or substitute a crop that uses less water in order to reduce normal consumptive use of surface diversions.

Water transfers (relevant to this document) occur when a water right holder within the Delta or Sacramento-San Joaquin watershed undertakes actions to make water available for transfer by export from the Delta. Transfers requiring export from the Delta are done at times when pumping and conveyance capacity at the CVP or SWP export facilities are available to move the water. Additionally, operations to accomplish these transfers must be carried out in coordination with CVP and SWP operations, such that project purposes and objectives are not diminished or limited in any way.

In particular, parties to the transfer are responsible for providing for any incremental changes in flows required to protect Delta water quality standards. Reclamation and the DWR will work to facilitate transfers and will complete them in accordance with all existing regulations and requirements. This document does not address the upstream operations that may be required to produce water for transfer. Also, this document does not address the impacts of water transfers to terrestrial species. Such effects would require a separate ESA consultation with FWS and NOAA Fisheries.

Purchasers of water for water transfers may include Reclamation, DWR, SWP contractors, CVP contractors, other State and Federal agencies, or other parties. DWR and Reclamation have operated water acquisition programs to provide water for environmental programs and additional supplies to SWP contractors, CVP contractors, and other parties. The DWR programs include the 1991, 1992, and 1994 Drought Water Banks and Dry Year Programs in 2001 and 2002.

Reclamation operated a forbearance program in 2001 by purchasing CVP contractors' water in the Sacramento Valley for CVPIA in stream flows, and to augment water supplies for CVP contractors south of the Delta and wildlife refuges. DWR, Reclamation, FWS, NOAA, and DFG cooperatively administer the EWA. Reclamation administers the CVPIA Water Acquisition Program for Refuge Level 4 supplies and fishery in stream flows. The CALFED ERP will, in the future, acquire water for fishery and ecosystem restoration.

The Sacramento Valley Water Management Agreement is a water rights settlement among Sacramento Valley water rights holders, Reclamation, DWR, and the CVP and SWP export water users which establishes a water management program in the Sacramento Valley. This program will provide new water supplies from Sacramento Valley water rights holders (up to 185,000 af per year) for the benefit of the CVP and SWP.

This program has some of the characteristics of a transfer program in that water will be provided upstream of the Delta and increased exports may result. In the past, CVP and SWP contractors have also independently acquired water in the past and arranged for pumping and conveyance through SWP facilities. State Water Code provisions grant other parties access to unused conveyance capacity, although SWP contractors have priority access to capacity not being used by the DWR to meet SWP contract amounts.

The CVP and SWP may provide Delta export pumping for transfers using surplus capacity that is available, up to the physical maximums of the pumps, consistent with prevailing operations constraints such as E/I ratio, conveyance or storage capacity, and the protective criteria established that may apply as conditions on such transfers. For example, pumping for transfers may have conditions for protection of Delta water levels, water quality, or fish.

The surplus capacity available for transfers will vary a great deal with hydrologic conditions. In general, as hydrologic conditions get wetter, surplus capacity diminishes because the CVP and SWP are more fully using export pumping capacity for Project supplies. CVP has little surplus capacity, except in the drier hydrologic conditions. SWP has the most surplus capacity in Critical and some Dry years, less or sometimes none in a broad middle range of hydrologic conditions, and some surplus again in some Above Normal and Wet years when demands may be lower because contractors have alternative supplies.

The availability of water for transfer and the demand for transfer water may also vary with hydrologic conditions. Accordingly, since many transfers are negotiated between willing buyers and sellers under prevailing market conditions, price of water also may be a factor determining how much is transferred in any year. This document does not attempt to identify how much of the available and useable surplus export capacity of the CVP and SWP will actually be used for transfers in a *particular* year, but recent history, the expectations for EWA, and the needs of other transfer programs suggest a growing reliance on transfers.

This project description assumes the majority of transfers would occur during July through September and would increase Delta exports from 200,000-600,000 af in most years, once the 8,500 cfs Banks capacity is operational (see Chapter 8 - Modeling Results Section sub-heading Transfers for post-processed results on available capacity at Tracy and Banks). Such future transfers would occur within the Banks 8,500 cfs capacity, and the Tracy 4,600 cfs capacity described in this document, and in no case would transfers require higher rates of pumping than those. The range of 200,000-600,000 af describes the surplus export capacity estimated to be available in July-September (primarily at Banks) in about 80 percent of years when 8,500 cfs Banks is in place (see Figure 8-152).

Under these conditions, transfer capability will often be capacity-limited. In the other 20 percent of years (which are critical and some fry years), both Banks and Tracy have more surplus capacity, so capacity most likely is not limited to transfers. Rather, either supply or demand for transfers may be a limiting factor. In some dry and critical years, water transfers may range as high as 800,000[8]-1,000,000 af depending on the severity of the water supply situation, cross-Delta capacity, and available supplies upstream.

During dry or critical years, low project exports and high demand for water supply could make it possible to transfer larger amounts of water. Low project exports in other months may also make it advantageous to expand the "normal transfer" season. Transfers outside the typical July

[8] DWR's 1991 Drought Water Bank purchased over 800,000 af, and conveyed approximately 470,000 af of purchased water across the Delta.

through September season may be implemented when transferors provide water on a "fish-friendly" pattern. Real-time operations would be implemented as needed to avoid increased incidental take of listed species.

Reclamation and DWR coordinate the implementation of transfers in the B2IT, the EWAT, and WOMT to ensure the required changes in upstream flows and Delta exports are not disruptive to planned fish protection actions. Reclamation and DWR will continue to use these groups for routine coordination of operations with transfers during the July through September season. Reclamation and DWR will also use these groups to help evaluate proposed transfers that would expand the transfer season or involve transfers in amounts significantly greater than the typical range anticipated by this project description, i.e., 200,000-600,000 af per year.

Although supply, demand, and price of water may at times be limiting factors, it would not be unreasonable to assume that in many years, all the available CVP and SWP capacity to facilitate transfers will be used.

Intertie Proposed Action

The proposed action, known as the DMC and CA Intertie (DMC/CA Intertie), consists of construction and operation of a pumping plant and pipeline connections between the DMC and the CA. The DMC/CA Intertie alignment is proposed for DMC milepost 7.2 where the DMC and the CA are about 500 feet apart.

The DMC/CA Intertie would be used in a number of ways to achieve multiple benefits, including meeting current water supply demands, allowing for the maintenance and repair of the CVP Delta export and conveyance facilities, and providing operational flexibility to respond to emergencies. The Intertie would allow flow in both directions, which would provide additional flexibility to both CVP and SWP operations. The Intertie includes a 400 cfs pumping plant at the DMC that would allow up to 400 cfs to be pumped from the DMC to the CA. Up to 950 cfs flow could be conveyed from the CA to the DMC using gravity flow.

The DMC/CA Intertie will be operated by the San Luis and Delta Mendota Water Authority (Authority). A three-way agreement among Reclamation, DWR, and the Authority would identify the responsibilities and procedures for operating the Intertie. The Intertie would be owned by Reclamation. A permanent easement would be obtained by Reclamation where the Intertie alignment crossed State property.

Location

The site of the proposed action is an unincorporated area of Alameda County, west of the City of Tracy. The site is situated in a rural area zoned for general agriculture and is under Federal and State ownership. The DMC/CA Intertie would be located at milepost 7.2 of the DMC, connecting with milepost 9.0 of the CA.

Operations

The Intertie would be used under three different scenarios:

1. Up to 400 cfs would be pumped from the DMC to the CA to help meet water supply demands of CVP contractors. This would allow Tracy Pumping Plant to

pump to its authorized capacity of 4,600 cfs, subject to all applicable export pumping restrictions for water quality and fishery protections.

2. Up to 400 cfs would be pumped from the DMC to the CA to minimize impacts to water deliveries due to required reductions in water levels on the lower DMC (south of the Intertie) or the upper CA (north of the Intertie) for system maintenance or due to an emergency shutdown.
3. Up to 950 cfs would be conveyed from the CA to the DMC using gravity flow to minimize impacts to water deliveries due to required reductions in water levels on the lower CA(south of the Intertie) or the upper DMC (north of the Intertie) for system maintenance or due to an emergency shutdown.

The DMC/CA Intertie provides operational flexibility between the DMC and CA. It would not result in any changes to authorized pumping capacity at Tracy Pumping Plant or Banks Delta Pumping Plant.

Water conveyed at the Intertie to minimize reductions to water deliveries during system maintenance or an emergency shutdown on the DMC or CA could include pumping of CVP water at Banks Pumping Plant or SWP water at Tracy Pumping Plant through use of JPOD. In accordance with COA Articles 10(c) and 10(d), JPOD may be used to replace conveyance opportunities lost because of scheduled maintenance, or unforeseen outages. Use of JPOD for this purpose could occur under Stage 2 operations defined in SWRCB D-1641, or could occur as a result of a Temporary Urgency request to the SWRCB. Use of JPOD does not result in any net increase in allowed exports at CVP and SWP export facilities.

To help meet water supply demands of the CVP contractors, operation of the Intertie would allow the Tracy Pumping Plant to pump to its full capacity of 4,600 cfs, subject to all applicable export pumping restrictions for water quality and fishery protections. When in use, water within the DMC would be transferred to the CA via the Intertie. Water diverted through the Intertie would be conveyed through the CA to San Luis Reservoir.

Freeport Regional Water Project

Reclamation and the Freeport Regional Water Authority (FRWA) are proposing to construct and operate the FRWP, a water supply project to meet regional water supply needs. FRWA, a joint powers agency formed under State law by the Sacramento County Water Agency (SCWA) and (EBMUD, is the State lead agency, and Reclamation is the Federal lead agency. A separate BO will be prepared for all other terrestrial and aquatic species related to the construction of the project.

Reclamation proposes to deliver CVP water pursuant to its respective water supply contracts with SCWA and EBMUD through the FRWP, to areas in central Sacramento County. SCWA is responsible for providing water supplies and facilities to areas in central Sacramento County, including the Laguna, Vineyard, Elk Grove, and Mather Field communities, through a capital funding zone known as Zone 40.

The FRWP has a design capacity of 286 cfs (185 millions of gallons per day [MGD]). Up to 132 cfs (85 MGD) would be diverted under Sacramento County's existing Reclamation water service contract and other anticipated water entitlements and up to 155 cfs (100 MGD) of water would be diverted under EBMUD's amended Reclamation water service contract. Under the terms of its amendatory contract with Reclamation, EBMUD is able to take delivery of Sacramento River water in any year in which EBMUD's March 1 forecast of its October 1 total system storage is less than 500,000 af. When this condition is met, the amendatory contract entitles EBMUD to take up to 133,000 af annually. However, deliveries to EBMUD are subject to curtailment pursuant to CVP shortage conditions and project capacity (100 MGD), and are further limited to no more than 165,000 af in any three-consecutive-year period that EBMUD's October 1 storage forecast remains below 500,000 af. EBMUD would take delivery of its entitlement at a maximum rate of 100 MGD (112,000 af/ per year). Deliveries would start at the beginning of the CVP contract year (March 1) or any time afterward. Deliveries would cease when EBMUD's CVP allocation for that year is reached, when the 165,000 af limitation is reached, or when EB MUD no longer needs the water (whichever comes first). Average annual deliveries to EBMUD are approximately 23,000 af. Maximum delivery in any one water year is approximately 99,000 af.

The primary project components are (1) an intake facility on the Sacramento River near Freeport, (2) the Zone 40 Surface Water Treatment Plant (WTP) located in central Sacramento County, (3) a terminal facility at the point of delivery to the Folsom South Canal (FSC), (4) a canal pumping plant at the terminus of the FSC, (5) an Aqueduct pumping plant and pretreatment facility near Camanche Reservoir, and (6) a series of pipelines carrying water from the intake facility to the Zone 40 Surface WTP and to the Mokelumne Aqueducts. The existing FSC is part of the water conveyance system. See Chapter 9 for modeling results on annual diversions at Freeport in the American River Section, Modeling Results Section sub-heading.

SCWA provides water to areas in central Sacramento County

The long-term master plan for Zone 40 envisions meeting present and future water needs through a program of conjunctive use of groundwater and surface water; or if surface water is not available, through groundwater until surface water becomes available. SCWA presently has a CVP entitlement of 22,000 af through Reclamation. SCWA has subcontracted 7,000 af of this entitlement to the City of Folsom. CVP water for SCWA is currently delivered through the City of Sacramento's (City) intake and treatment facilities based on SCWA need and available city capacity. SCWA's CVP contract also allows it to divert at the location identified as Freeport on the Sacramento River south of downtown Sacramento. SCWA expects to be able to provide additional anticipated surface water entitlements to serve Zone 40 demands, including an assignment of a portion of Sacramento Municipal Utility District's (SMUD) existing CVP water supply contract, potential appropriative water rights on the American and Sacramento Rivers, and potential transfers of water from areas within the Sacramento Valley. Total long-term average Zone 40 water demand is estimated to be 109,500 af per year. Long-term average surface water use is expected to be 68,500 af per year.

East Bay Municipal Utility District

EBMUD is a multi-purpose regional agency that provides water to more than 1.3 million M&I customers in portions of Contra Costa and Alameda Counties in the region east of San Francisco

Bay (East Bay). EBMUD obtains most of its supply from Pardee Reservoir on the Mokelumne River, with the remainder collected from local runoff in East Bay terminal reservoirs.

On July 26, 2001, EBMUD and Reclamation entered into an amendatory CVP contract that sets forth three potential diversion locations to allow EBMUD to receive its CVP supply. One of these locations is Freeport. EBMUD's CVP supply is 133,000 af in any one year, not to exceed 165,000 af in any consecutive three-year period of drought when EBMUD total system storage is forecast to be less than 500,000 af. Subject to certain limitation, the contract also provides for a delivery location on the lower American River and EBMUD retains the opportunity to take delivery of water at the FSC should other alternatives prove infeasible. Additional environmental review is required prior to diversion under the contract.

Water supply forecasts are used in the preparation of operation projections. The water supply forecast is a March 1 forecast of EBMUD's October 1 total system storage, as revised monthly through May 1, as more reliable information becomes available. The main parameters considered in the operation projection are the water supply forecast of projected runoff, water demand of other users on the river, water demand of EBMUD customers, and flood control requirements. According to the terms of its CVP contract with Reclamation, these forecasts determine when EBMUD would be able to take delivery of CVP water through the new intake facility near Freeport to supplement its water supplies and retain storage in its Mokelumne River and terminal reservoir systems.

Under the terms of its amendatory contract with Reclamation, EBMUD is able to take delivery of Sacramento River water in any year in which EBMUD's March 1 forecast of its October 1 total system storage is less than 500,000 af. When this condition is met, the amendatory contract entitles EBMUD to take up to 133,000 af annually. However, deliveries to EBMUD are subject to curtailment pursuant to CVP shortage conditions and project capacity (100 MGD), and are further limited to no more than 165,000 af in any three-consecutive-year period that EBMUD's October 1 storage forecast remains below 500,000 af.

EBMUD would take delivery of its entitlement at a maximum rate of 100 MGD (112,000 af/ per year). Deliveries would start at the beginning of the CVP contract year (March 1) or any time afterward. Deliveries would cease when EBMUD's CVP allocation for that year is reached, when the 165,000 af limitation is reached, or when EBMUD no longer needs the water (whichever comes first). Average annual deliveries to EBMUD are approximately 23,000 af. In the modeling the maximum delivery in any one water year is approximately 99,000 af. It is possible that they could take their full entitlement if there were not shortages imposed.

The City has joined FRWA as an associate member. The City's main interests lie in the design and construction of FRWA project facilities that may be located in the City or on various City properties on rights-of-way. A City representative sits on the FRWA Board of Directors as a non-voting member.

Water Deliveries Associated With The CCWD Settlement Agreement

Under the Contra Costa Waster District (CCWD) settlement agreement, FRWA and EBMUD agreed to "wheel" 3,200 acre-feet per year (af/y) of water for the CCWD. Wheeling is the transmission of water owned by one entity through the facilities owned by another. In this agreement, CCWD water that is normally diverted from the Delta would be diverted from the

Sacramento River and conveyed to CCWD through FRWP facilities, Reclamation's Folsom South Canal, and EBMUD's Mokelumne Aqueduct facilities, at which point CCWD's Los Vaqueros Pipeline intersects the Mokelumne Aqueduct. Unless there are unavoidable conditions that reduce the capacity of the system and prevent function, water would be wheeled to CCWD annually. CCWD would take delivery of a small portion of its Central Valley Project (CVP) supply at the FRWP intake (unlike the past, in which Rock Slough or Old River intakes in the Delta were used).

In the settlement agreement with the Santa Clara Valley Water District (SCVWD), EBMUD would make 6,500 af of its CVP water allocation available to SCVWD in any drought year in which EBMUD would take delivery of Sacramento River water. If the following year is also a drought year in which EBMUD continues to take delivery of Sacramento River water, SCVWD is obligated to return up to 100% of the 6,500 af of water to EBMUD. At EBMUD's discretion, the water may be returned in the following year. If drought conditions do not persist for a second or third year, SCVWD would keep the water and would compensate EBMUD for its Reclamation costs. Since SCVWD would take delivery of the EBMUD CVP water at the Tracy pumping plant, and EBMUD would take delivery of SCVWD's CVP water at Freeport, no additional facilities would be constructed.

The settlement agreements modify the location of CVP deliveries, while the total quantities delivered remain unchanged. In normal and wet years, Delta inflow would be reduced by 3,200 af. This volume is equal to an average reduction of 4 cubic feet per second (cfs). During normal and wet years, Sacramento River flow nearly always exceeds 14,000 cfs, and the anticipated average change would be less than 0.03%. Delta diversions would be reduced by an identical amount, offsetting the minor change in flow. In the first year of a drought, inflow to the Delta would be increased by a nearly identical amount, and this increase would be offset by an identical increase in Delta pumping, resulting in no substantial change. In the second year of a drought, Delta inflow may be decreased by as much as 13 cfs on the average. This decrease (0.1%) remains minor compared to the typical flows of 10,000 cfs in the Sacramento River and is offset by decreased pumping in the Delta. Potential Delta effects associated with changes in pumping location are discussed in Chapter 10.

Items for Early Consultation

There are some items that are part of the early consultation, Operation of Components of the South Delta, CVP/SWP Integration and the long-term EWA.

Operation of Components of the South Delta Improvement Project

Introduction

DWR and Reclamation have agreed to jointly pursue the development of the South Delta Improvement Project (SDIP) to address regional and local water supply needs, as well as the needs of the aquatic environment. Overall, the SDIP components are intended to meet the project purpose and objectives by balancing the need to increase the current regulatory limit on inflow to the CCF with the need to improve local agricultural diversions and migratory conditions for

Central Valley fall and late fall-run Chinook salmon in the San Joaquin River. Two key operational features of the SDIP are included as part of this project description.[9]

8500 cfs Operational Criteria

From March 16 through December 14 - the maximum allowable daily diversion rate into CCF shall meet the following criteria: (1) the three-day running average diversion rate shall not exceed 9,000 cfs, (2) the seven-day running average diversion rate shall not exceed 8,500 cfs, and (3) the monthly average diversion rate shall not exceed 8,500 cfs.

From December 15 through March 15 - the maximum allowable daily diversion rate into CCF shall meet the following criteria: (1) the seven-day running average shall not exceed 8,500 cfs or 6,680 cfs plus one-third of the seven-day running average flow of the San Joaquin River at Vernalis when the flow exceeds 1,000 cfs (whichever is greater), and (2) the monthly average diversion rate shall not exceed 8,500 cfs.

Permanent Barrier Operations

Head of Old River

Barrier operation (closing the barrier) would begin at the start of the VAMP spring pulse flow period, which typically begins around April 15. Operation is expected to continue for 30 consecutive days following the start of the VAMP.

If, in the opinion of the FWS, NOAA Fisheries, and DFG, the barrier needs to be operated at a different time or for a longer period, it may be operated provided the following criteria are met:

- It is estimated that such operation would not increase take of species in excess of the take authorized by the original proposed operation.
- The San Joaquin River flow at Vernalis is less than 10,000 cfs.
- There is a verified presence of out-migrating salmon or steelhead in the San Joaquin River.
- South Delta Water Agency agricultural diverters are able to divert water of adequate quality and quantity.

During the fall months of October and November, the barrier would be operated to improve flow in the San Joaquin River, thus assisting in avoiding historically present hypoxia conditions in the lower San Joaquin River near Stockton. Barrier operation during this period would be conducted at the joint request of DFG, NOAA Fisheries and FWS.

The Head of Old River Barriers (HORB) may be operated at other times provided that the following criteria are met:

[9] This project description does not include any aspect of the SDIP that is not explicitly identified in the text. Examples of SDIP actions that are not included are construction of permanent barriers and dredging. Both of these activities will be covered by subsequent consultation.

- FWS, NOAA Fisheries, and DFG determine that such operation would not increase take of species in excess of the take authorized by the BO for OCAP.
- The San Joaquin River flow at Vernalis is not above 5,000 cfs.
- FWS, NOAA Fisheries, and DFG determine that any impacts associated with barrier operation during this period will not result in additional impacts to threatened and endangered (T&E) species that are outside the scope of impacts analyzed by the BO for OCAP.

Middle River, Old River near the DMC and Grant Line Canal

From April 15 through November 30, barriers on the Middle River and Old River near the DMC and Grant Line Canal would be operated (closed) on an as needed basis to protect water quality and stage for south Delta agricultural diverters (low water levels in Middle River, Old River and Grant Line Canal would not drop below 0.0 mean sea level (MSL) and the 30-day running average electroconductivity (EC) at San Joaquin River at Brandt Bridge, Old River near Middle River and Old River at Tracy Road Bridge would not exceed 0.7 mmhos/cm).

From December 1 through April 15, barriers on the Middle River and Old River near the DMC and Grant Line Canal would be operated (closed) on an as needed basis to protect water quality and stage for south Delta agricultural diverters (low water levels in Middle River, Old River and Grant Line Canal would not drop below 0.0 MSL and the 30-day running average EC at San Joaquin River at Brandt Bridge, Old River near Middle River and Old River at Tracy Road Bridge would not exceed 1.0 mmhos/cm). However, during this period, the barriers may only be operated with permission from the FWS, NOAA Fisheries, and DFG if the following criteria are met:

- FWS, NOAA Fisheries, and DFG determine that such operation would not increase take of species in excess of the take authorized by the BO for OCAP.
- The San Joaquin River flow at Vernalis is not above 5,000 cfs.
- FWS, NOAA Fisheries, and DFG determine that any impacts associated with barrier operation during this period will not result in additional impacts to T&E species that are outside the scope of impacts analyzed by the BO for OCAP.

DWR is also investigating whether the use of low head pumps at barrier locations can further improve water quality at Brandt Bridge. The amount of pumping and the precise location of the pumps have not been determined, nor has the benefit that might be realized by low head pumps been quantified. If DWR concludes there is a benefit to operating low head pumps, it will incorporate the proposed action into the SDIP Action Specific Implementation Plan (ASIP) process. Such an inclusion will require re-initiation of consultation with the services regarding potential effects on listed species. Thus, low head pumps will not be included in the OCAP project description.

Long-term EWA

There is an assumption in the future studies of an EWA similar to the today level studies (see chapter 8). Purchase assets are the same in the today and future, variable assets may differ under the future proposed actions. Refer to the previous discussion of EWA beginning on page 2-77.

Transfers

The capability to facilitate transfers is expanded by the implementation of the 8,500 cfs Banks capacity. Available surplus capacity for transfers will increase in most years. The early consultation includes the increased use of the SWP Delta export facilities for transfers that will derive from the increase in surplus capacity associated with implementation of the 8,500 cfs Banks. As mentioned in the project description under the heading Water Transfers, in all but the driest 20 percent of water years, surplus capacity during the typical transfer season of July through September is usually a factor limiting the amount of transfers that can be accomplished. With the 8,500 cfs Banks, the range of surplus capacity available for transfers (in the wetter 80 percent of years) increases from approximately 60,000-460,000 acre feet per year, to 200,000-600,000 acre feet per year. Transfers in the drier 20 percent of years are not limited by available capacity, but rather by either supply or demand. In those years, transfers could still range up to 800,000-1,000,000 acre feet per year, either with or without the 8,500 cfs Banks. Refer to the Water Transfers section for additional discussion.

CVP and SWP Operational Integration

For many years, Reclamation and DWR have considered and attempted to increase the level of operational coordination and integration. Such coordination allows one project to utilize the other's resources to improve water supply reliability and reduce cost. As such, Reclamation and DWR plan to integrate the strengths of the CVP and SWP (storage and conveyance, respectively) to maximize water supplies for the benefit of both CVP and SWP contractors that rely on water delivered from the Bay-Delta in a manner that will not impair in-Delta uses, and will be consistent with fishery, water quality, and other flow and operational requirements imposed under the Clean Water Act (CWA) and ESA. The Project Agencies have agreed to pursue the following actions:

- Convey water for Reclamation at the SWP. Upon implementation of the increase to 8,500 cfs at Banks, DWR will divert and pump 100,000 af of Reclamation's Level 2 refuge water before September 1. This commitment will allow Reclamation to commit up to 100,000 af of conveyance capacity at Tracy Pumping Plant, formally reserved for wheeling refuge supplies, for CVP supplies.
- Adjust in-basin obligations. Upon implementation of the increase to 8,500 cfs at Banks, Reclamation will supply up to 75,000 af from its upstream reservoirs to alleviate a portion of the SWP's in-basin obligation.
- Prior to implementation of the increase to 8,500 cfs at Banks, DWR will provide up to 50,000 acre feet of pumping and conveyance of Reclamation's Level 2 refuge water. Likewise, Reclamation will supply up to 37,500 acre feet from its upstream storage to alleviate a portion of the SWP's obligation to meet in-basin uses. It should be noted that the biological effects analyzed in this document are for the full 100,000 acre feet of conveyance

and up to 75,000 acre feet of storage, as may occur when the 8,500 Banks is operational. The biological effects of the 50,000 acre feet of conveyance and up to 37,500 acre feet of storage which may occur at the existing permitted Banks capacity, are not analyzed separately, since it is assumed that those effects are encompassed by the analysis of the larger amounts and capacities that may occur when the 8,500 Banks is operational.

- Upstream Reservoir Coordination. Under certain limited hydrologic and storage conditions, when water supply is relatively abundant in Shasta, yet relatively adverse in Oroville, SWP may rely on Shasta storage to support February allocations based on 90 percent exceedence projections, subject to the following conditions. When the CVP's and the SWP's February 90 percent exceedence forecasts project September 30 SWP storage in Oroville Reservoir to be less than 1.5 million acre feet, and CVP storage in Shasta Reservoir to be greater than approximately 2.4 million acre feet, the SWP may, in order to provide allocations based on a 90 percent exceedence forecast, rely on water stored in Shasta Reservoir.
    - Should the actual hydrology be drier than the February 90 percent exceedence forecast, the SWP may borrow from Shasta storage an amount of water equal to the amount needed to maintain the allocation made under the 90 percent exceedence forecast, not to exceed 200,000 acre feet.
    - Storage borrowing will be requested by April 1. Upon the request to borrow storage, Reclamation and DWR will develop a plan within 15 days to accomplish the potential storage borrowing. The plan will identify the amounts, timing, and any limitation or risk to implementation and will comply with conditions on Shasta Reservoir and Sacramento River operations imposed by applicable biological opinions. Water borrowed by the SWP shall be provided by adjustments in Article 6 accounting of responsibilities in the COA.
- Reclamation and DWR have agreed to share water provided by Sacramento Valley interests to alleviate in-basin requirements. The water will be split 60 percent for the SWP and 40 percent for the CVP. Refer to the previous discussion of Water Transfer beginning on page 2-79.
- Maximize use of San Luis Reservoir storage. DWR, in coordination with Reclamation and their respective contractors, will develop an annual contingency plan to ensure San Luis Reservoir storage remains at adequate levels to avoid water quality problems for CVP contractors diverting directly from the reservoir. This action is expected to continue for five years, at which time Reclamation and DWR will re-evaluate the need for the action. The plan will identify actions and triggers to provide up to 200,000 af of source shifting, allowing Reclamation to utilize the CVP share of San Luis Reservoir more effectively to increase CVP allocations.

  Additionally, a solution to the San Luis Reservoir low point problem is also in the long-term operation of the CVP and SWP, and is also part of this consultation. Solving the low point problem in San Luis Reservoir was identified in the August 28, 2000, CALFED ROD as a complementary action which would avoid water quality problems associated with the low point and increase the effective storage capacity in San Luis Reservoir up to 200,000 af. This action, while not implemented at present, is part of the future proposed action on which Reclamation is consulting. All site-specific and localized actions of implementing a solution to the San Luis Reservoir low point problem, such as construction of any physical facilities in or around San Luis Reservoir and any other site-specific effects, will be addressed in a separate consultation.

Chapter 3 Basic Biology and Life History and Baseline for Central Valley Steelhead

Species as a Biological Concept and Regulatory Criterion

Scientists categorize organisms in hierarchical categories that reflect the best available information regarding their evolutionary histories. The higher levels of classification such as Phyla, represent lineage divergence that has been occurring for hundreds of millions of years (Kozloff 1990). This divergence obscures the evolutionary relationships among the various Phyla because many of the evolutionary intermediates (also known as "missing links") have died out. However, wide divergence means determination of which organisms constitute a Phylum is relatively unambiguous. In other words, the extinction of the intermediates has resulted in relatively discrete groups, each consisting of similar organisms, rather than a gradation from one set of subtle diagnostic characteristics to another.

In contrast, as the taxonomic resolution gets finer (that is, moves from Phylum down toward species) the evolutionary relationships become more evident, but the increasing number of intermediate character states makes categorization more subjective. Salmonid fishes provide a good example of this. The evolutionary relationships among the salmonids are fairly well understood down to the genus level, perhaps even to the level of the formally recognized species (Stearley and Smith 1993). However, the formally recognized species are notoriously variable (Bernatchez 1995; Smith et al. 1995; Utter et al. 1995). The two salmonids covered by this BA, *Oncorhynchus mykiss* (rainbow trout/steelhead) and *Oncorhynchus tshawytscha* (Chinook salmon), are no exception, and provide an excellent example of the difficulty that arises when trying to place these fish into sub-specific taxonomic groups. Rainbow trout/steelhead and Chinook salmon responded to the plethora of local conditions encountered over their broad historical ranges with genetic, ecological, and behavioral adaptations. This plasticity resulted in a large number of individual stocks, which have been wholly or partially reproductively isolated from each other for varying amounts of time (Healey and Prince 1995; Utter et al. 1995; NOAA Fisheries 1998; Teel et al. 2000). This relatively recent and varied stock divergence means that a continuum of genetic and ecological characteristics exists within the species groups.

The Federal ESA was designed to protect the evolutionary legacy of species, and it allows for protection of "distinct population segments" (NRC 1995). Similarly, the California Endangered Species Act (CESA) allows for "subspecies" to be listed. NOAA Fisheries has chosen the Evolutionarily Significant Unit (ESU), as the distinct population segment of Pacific salmon appropriate for listing under the Federal ESA (Waples 1995). Two criteria are used to determine whether a population constitutes an ESU. First, the population must be "substantially reproductively isolated from other conspecific population units," and second, the population must represent "an important component in the evolutionary legacy of the species" (Waples 1995). Nonetheless, given the scientific uncertainty surrounding species classification and the contemporary scientific understanding of population genetics and population dynamics, the

National Research Council (NRC) (1995) supported the scientific validity of ESA protection for unique subspecific lineages like ESUs.

Busby et al. (1996) and NOAA Fisheries (1998) reviewed genetics study results for West Coast steelhead and Chinook salmon populations, and determined that Sacramento-San Joaquin steelhead populations are sufficiently distinct genetically from other West Coast populations, including those distributed along the northern California coast to comprise ESUs. NOAA Fisheries (1998) also determined that Central Valley fall-run and late fall-run, spring-run, and winter-run Chinook salmon all comprised ESUs. Therefore, each of these is considered a "species" for purposes of the Federal ESA.

Status

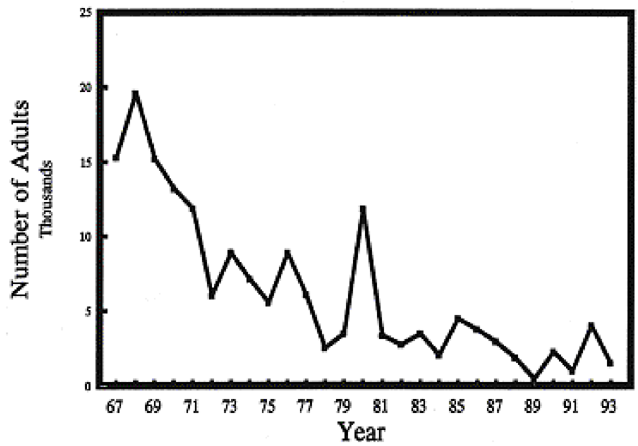
Populations of naturally spawned Central Valley steelhead are at lower levels than were found historically (Figure 3–1) and are composed predominantly of hatchery fish. Steelhead require cool water to rear through the summer and much of this habitat is now above dams. The California Fish and Wildlife Plan of 1965 estimated the combined annual run size for Central Valley and San Francisco Bay tributaries to be about 40,000 during the 1950s (DFG 1965, as cited in McEwan and Jackson 1996). The spawning population during the mid-1960s for the Central Valley basin was estimated at nearly 27,000 (DFG 1965, as cited in McEwan and Jackson 1996). These numbers likely consisted of both hatchery and wild steelhead. McEwan and Jackson (1996) estimated the annual run size for the Central Valley basin to be less than 10,000 by the early 1990s. Much of the abundance data since the mid-1960's was obtained at the Red Bluff Diversion Dam fish ladders when gates were closed during much of the steelhead migration. Current abundance estimates are unavailable for naturally spawned fish since gate operations were changed, so the extent to which populations have changed following the 1987–94 drought is unknown. NOAA Fisheries listed naturally spawned Central Valley steelhead as threatened under the Federal ESA in 1998. NOAA Fisheries (2003) status review estimated the Central Valley steelhead population at less than 3,000 adults. This document is primarily limited to a discussion of the status of Central Valley steelhead stocks in habitats influenced by CVP and SWP operations. According to McEwan (2001) the primary stressors affecting Central Valley steelhead are all related to water development and water management, and the greatest stressor is the loss of spawning and rearing habitat due to dam construction.

The Central California Coast Steelhead ESU was listed as a threatened species on August 18, 1997. The Central California Coast Steelhead ESU extends from the Russion River on the north to the San Lorezno River on the south and includes Suisun Bay, San Pablo Bay, and San Francisco Bay. Because the project area overlaps this ESU these fish are being addressed in this BA. CVP and SWP operations are not expected to influence conditions significant to steelhead in these areas so effects to Central California Coast Steelhead are not anticipated. The steelhead effects analysis throughout this BA does not identify any effects of the project on steelhead that occur in the Central California Coast ESU so they therefore are not specifically referenced except in the determination of effects.

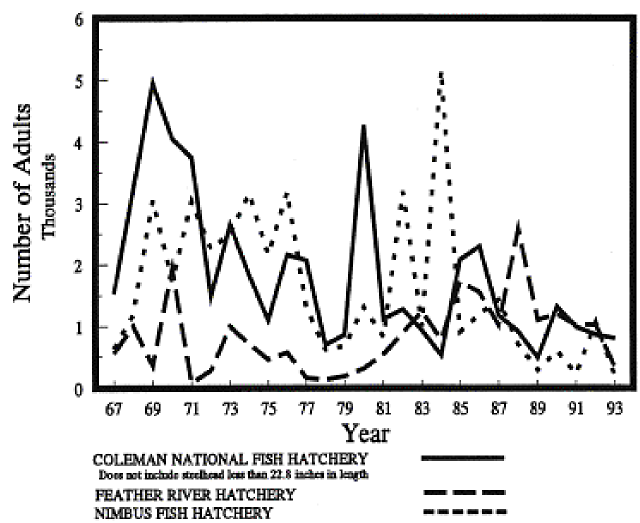
Taxonomy

Steelhead is a name used for anadromous rainbow trout (*Oncorhynchus mykiss*), a salmonid species native to western North America and the Pacific coast of Asia. In North America, steelhead are found in Pacific coast drainages from southern California to Alaska. In Asia, they are found in coastal streams of the Kamchatka Peninsula, with scattered populations on the Siberian mainland (Burgner et al. 1992, as cited in McEwan and Jackson 1996). Known spawning populations are found in coastal streams along much of the California coast, as well as in the Central Valley.

Only two subspecies of North American rainbow trout contain both resident (non-migratory) and anadromous (migratory or sea-run) forms: coastal rainbow trout (*O. m. irideus*), and Columbia River redband trout (*O. m. gairdneri*). Columbia River redband trout occur in tributaries of the upper Columbia River east of the Cascades (McEwan and Jackson 1996). Coastal rainbow trout occupy coastal streams from California to Alaska, including tributaries to the San Francisco Estuary. All California steelhead populations are *O. m. irideus*, including those in the Central Valley.



Adjusted adult steelhead counts at Red Bluff Diversion Dam on the Sacramento River, 1967-1993.



Adult steelhead counts at Coleman, Feather River, and Nimbus fish hatcheries, 1967-1993.

Figure 3–1 Adult steelhead counts at RBD, 1967–93 (top) and adult steelhead counts at Coleman National Fish Hatchery, Feather River Fish Hatchery, and Nimbus Hatchery, 1967-93 (bottom). Source: McEwan and Jackson 1996.

Rainbow trout/steelhead and other members of the family Salmonidae are characterized as having a streamlined body, emarginate to forked tail, an adipose fin, and an auxiliary process near the pelvic fins. They have nine to 13 branchiostegal rays, no basibranchial teeth, and a large number of pyloric cecae (Moyle 1976). They have 10 to 12 dorsal fin rays and eight to 12 anal fin rays. The lateral line has 119 to 138 scales. Resident adults have small irregular black spots on their back and on most fins, a pink to red stripe on their side, a black edge on the adipose fin, and distinct radiating rows of black spots on the caudal fin (Page and Burr 1991). The upper jaw barely extends beyond the eye in small juveniles and females, but extends well beyond the eye in large males. Dorsal coloration can be highly variable ranging from steel blue to yellow-green to brown. Ventral coloration ranges from silver to pale yellow-green. Small juveniles have five to 10 widely spaced, short, oval parr marks. Steelhead are distinguished from resident adults by their silver coloration. Yearling steelhead are also silvery and lack parr marks (Moyle and Cech 1988).

Historically, resident rainbow trout and steelhead were considered separate subspecies or different species altogether. However, researchers have found little or no morphologic or genetic differentiation between the two forms inhabiting the same stream system (Behnke 1972; Allendorf 1975; Allendorf and Utter 1979; Busby et al. 1993; Nielson 1994, all as cited in McEwan and Jackson 1996), indicating there is substantial interbreeding. However, differences in mitochondrial DNA have been found by some researchers (Wilson et al. 1985, as cited in McEwan and Jackson 1996). Based on the cumulative genetic evidence, researchers have proposed that steelhead and related resident rainbow trout with the potential to interbreed be considered as one unit for restoration and management purposes (Busby et al. 1993, as cited in McEwan and Jackson 1996; NOAA Fisheries 1996).

NOAA Fisheries (1998) divided West Coast steelhead into 15 ESUs based on distinct genetic characteristics, freshwater ichthyogeography, and other parameters. Most steelhead stocks found in the Central Valley comprise the Central Valley ESU, which recent genetic data indicates is distinct from other coastal steelhead stocks (Busby et al. 1996, NOAA Fisheries 1997b, 1998). DNA analysis of steelhead tissue samples collected from the Coleman National Fish Hatchery, Feather River Hatchery, Deer and Mill Creeks, and the Stanislaus River demonstrated these stocks are genetically similar to each other. Coleman National Fish Hatchery and Feather River Hatchery steelhead stocks are considered part of the Central Valley ESU since broodstock histories and genetic evidence show these two stocks are similar to naturally spawned steelhead in Deer and Mill Creeks.

NOAA Fisheries (1998, 1999) does not consider Nimbus Hatchery and Mokelumne River Fish Installation stocks to be part of the Central Valley ESU. Genetic analysis indicated steelhead from the American River (collected from both the Nimbus Hatchery and the American River) are genetically more similar to Eel River steelhead (Northern California ESU) than other Central Valley steelhead stocks. Eel River steelhead were used to found the Nimbus Hatchery stock. Mokelumne River rainbow trout (hatchery produced and naturally spawned) are genetically most similar to Mount Shasta Hatchery trout, but also show genetic similarity to the northern California ESU (Nielsen 1997, as cited in NOAA Fisheries 1997b). Further analysis is warranted as the Mokelumne River Fish Installation obtains steelhead eggs from the Nimbus Hatchery and this relationship should become evident through future genetic analyses.

Steelhead Biology and Life History

Steelhead, as currently defined, is the anadromous form of rainbow trout (McEwan and Jackson 1996). However, as stated above, steelhead life history can be quite variable with some populations reverting to residency when flow conditions block access to the ocean. The following is an idealized life history for Central Valley stocks. McEwan and Jackson (1996) provided an extensive summary of the biology of coastal and Central Valley stocks and a list of useful references that contain more detailed information.

Adult migration from the ocean to spawning grounds occurs during much of the year, with peak migration occurring in the fall or early winter (Figure 3–2). Migration through the Sacramento River main stem begins in July, peaks at the end of September, and continues through February or March (Bailey 1954; Hallock et al. 1961, both as cited in McEwan and Jackson 1996). Counts made at Red Bluff Diversion Dam (RBDD) from 1969 through 1982 (Hallock 1989, as cited in McEwan and Jackson 1996) and on the Feather River (Painter et al. 1977; DWR unpublished) follow the above pattern, although some fish were counted as late as April and May. Weekly counts at Clough Dam on Mill Creek during a 10-year period from 1953 to1963 showed a similar migration pattern as well. The migration peaked in mid-November and again in February. This second peak is not reflected in counts made in the Sacramento River main stem (Bailey 1954; Hallock et al. 1961, both as cited in McEwan and Jackson 1996) or at RBDD (Hallock 1989, as cited in McEwan and Jackson 1996).

Central Valley steelhead (also known as winter steelhead) mature in the ocean and arrive on the spawning grounds nearly ready to spawn. In contrast, summer steelhead, or stream-maturing steelhead, enter freshwater with immature gonads and typically spend several months in fresh water before spawning. The optimal temperature range during migration is unknown for Central Valley stocks. Based on northern stocks, the optimal temperature range for migrating adult steelhead is 46° F to 52° F (Bovee 1978; Reiser and Bjornn 1979; Bell 1986, all as cited in McEwan and Jackson 1996). The reported minimum depth for successful passage is about 7 inches (Reisner and Bjornn 1979, as cited in McEwan and Jackson 1996). Depth is usually not a factor preventing access to spawning areas in the rivers currently under consultation because migration normally occurs during high outflow months. However, excessive water velocity (>10to 13 ft/s) and obstacles may prevent access to upstream spawning grounds.

Historically, Central Valley steelhead spawned primarily in upper stream reaches and smaller tributaries, although steelhead spawn in most available channel types in unimpounded stream reaches of the Pacific Northwest (Montgomery et al. 1999). Due to water development projects, most spawning is now confined to lower stream reaches below dams. In a few streams, such as Mill and Deer Creeks, steelhead still have access to historical spawning areas. Peak spawning generally occurs from December through April (McEwan and Jackson 1996) (Figure 3–2).

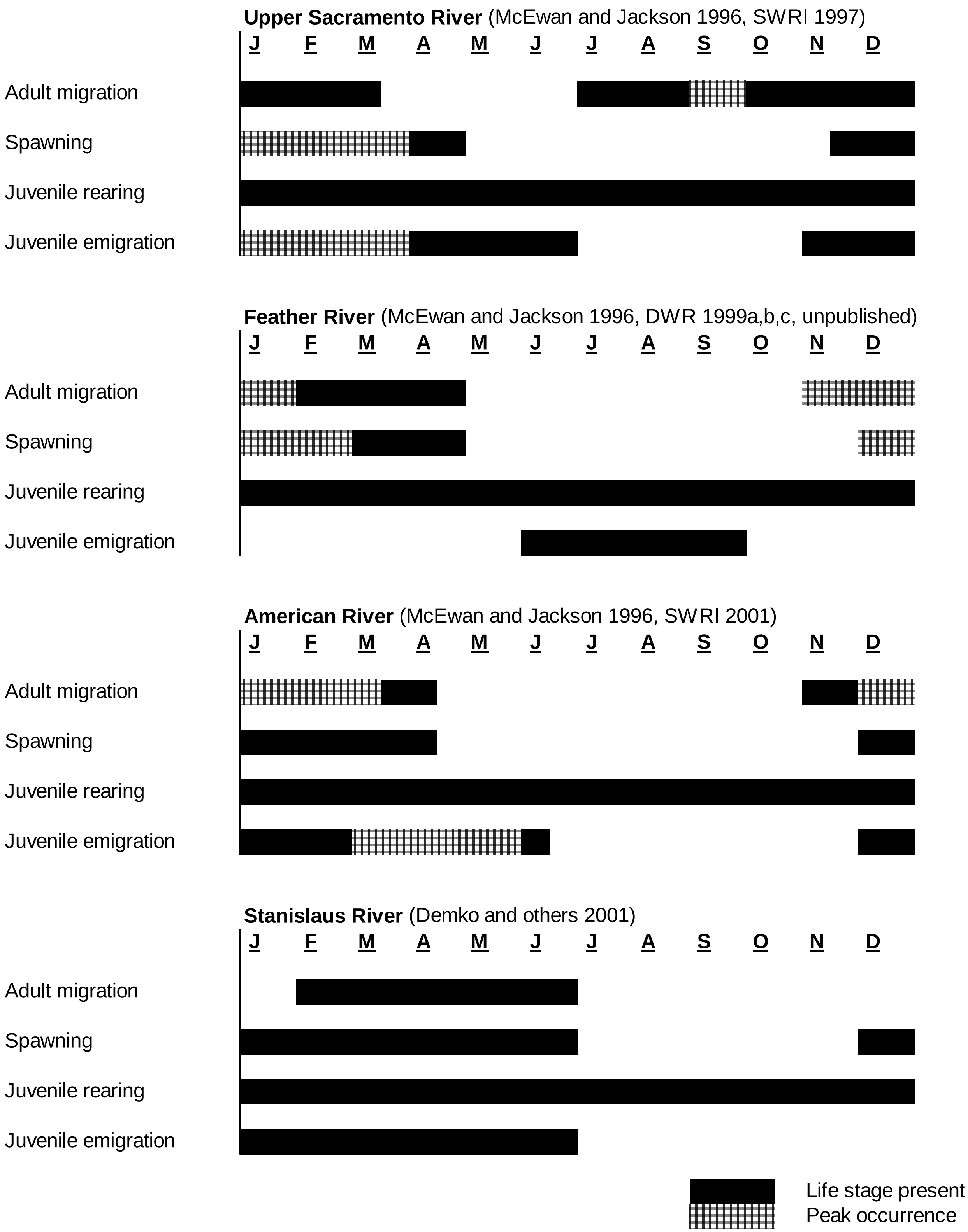


Figure 3–2 Steelhead life cycle for various Central Valley streams.

The female excavates a redd (nest) in the gravel and deposits her eggs, while an attendant male fertilizes them. Fecundity is directly related to body size (Moyle 1976). Spawning females average about 4,000 eggs, but the actual number produced varies among stocks and by the size and age of the fish (Leitritz and Lewis 1976). The eggs are covered with gravel when the female excavates another redd upstream. Spawning occurs mainly in gravel substrates (particle size range of about 0.2–4.0 inches). Sand-gravel and gravel-cobble substrates are also used, but these must be highly permeable and contain less than 5 percent sand and silt to provide sufficient oxygen to the incubating eggs. Adults tend to spawn in shallow areas (6–24 inches deep) with moderate water velocities (about 1 to 3.6 ft/s) (Bovee 1978, as cited in McEwan and Jackson 1996). The optimal temperature range for spawning is 39° F to 52° F in northern steelhead populations (Bovee 1978; Reiser and Bjornn 1979; Bell 1986, all as cited in McEwan and Jackson 1996).

Unlike Chinook salmon, steelhead do not die after spawning (McEwan and Jackson 1996). Some may return to the ocean and repeat the spawning cycle for two or three years. The percentage of adults surviving spawning is generally low for Central Valley steelhead, but varies annually and between stocks.

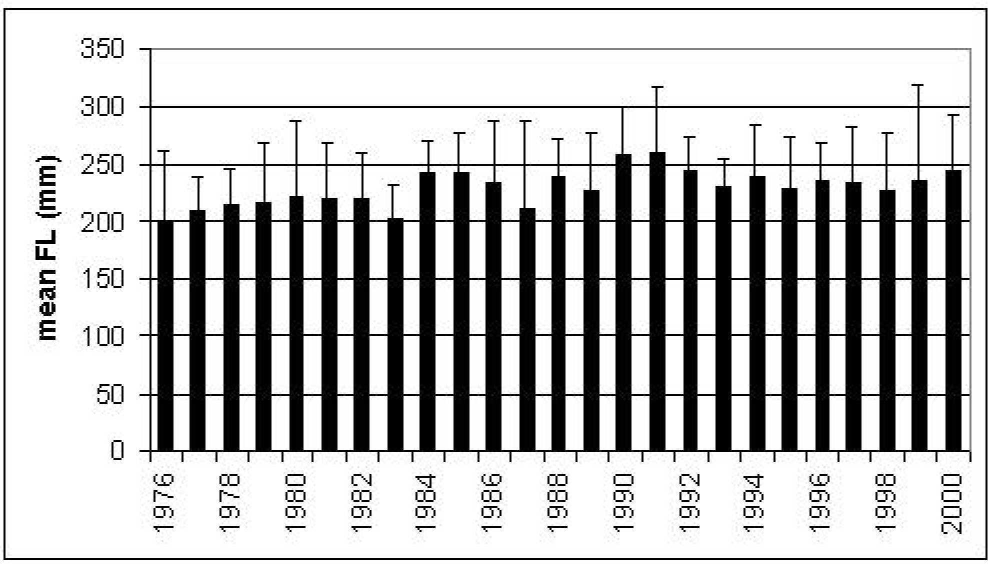


Figure 3–3 Mean FL (mm) plus standard deviation of steelhead collected in the FWS Chipps Island Trawl, 1976-2000.

The time required for egg development is approximately four weeks, but is temperature-dependent (McEwan and Jackson 1996). For northern steelhead populations, optimal egg development occurs at 48° F to 52° F. Egg mortality may begin at temperatures above 56° F in northern populations (Bovee 1978; Reiser and Bjornn 1979; and Bell 1986, all as cited in McEwan and Jackson 1996). After hatching, the yolk-sac fry or alevins remain in the gravel for another four to six weeks (Shapovalov and Taft 1954, as cited in McEwan and Jackson 1996). Upon emergence from the gravel, the fry move to shallow protected areas associated with the stream margin (Royal 1972; Barnhart 1986, both as cited in McEwan and Jackson 1996). Steelhead fry tend to inhabit areas with cobble-rubble substrate, a depth less than 14 inches, and temperature ranging from 45° F to 60° F (Bovee 1978, as cited in McEwan and Jackson 1996).

Older juveniles use riffles and larger juveniles may also use pools and deeper runs (Barnhart 1986, as cited in McEwan and Jackson 1996). However, specific depths and habitats used by juvenile rainbow trout can be affected by predation risk (Brown and Brasher 1995).

Juvenile Central Valley steelhead may migrate to the ocean after spending one to three years in fresh water (McEwan and Jackson 1996). Fork length (FL) data for steelhead emigrating past Chipps Island suggest the Central Valley stocks show little variability in size at emigration (Figure 3–3). Only 0.4 percent of the steelhead collected in the FWS Chipps Island Trawl between 1976 and 1997 were less than 120 mm FL. This should be considered a maximum proportion of young-of-the-year (YOY) emigrants because the gear efficiency of the midwater trawl decreases as fish size increases (McLain 1998), meaning the abundance of large fish relative to smaller fish is underestimated by the gear.

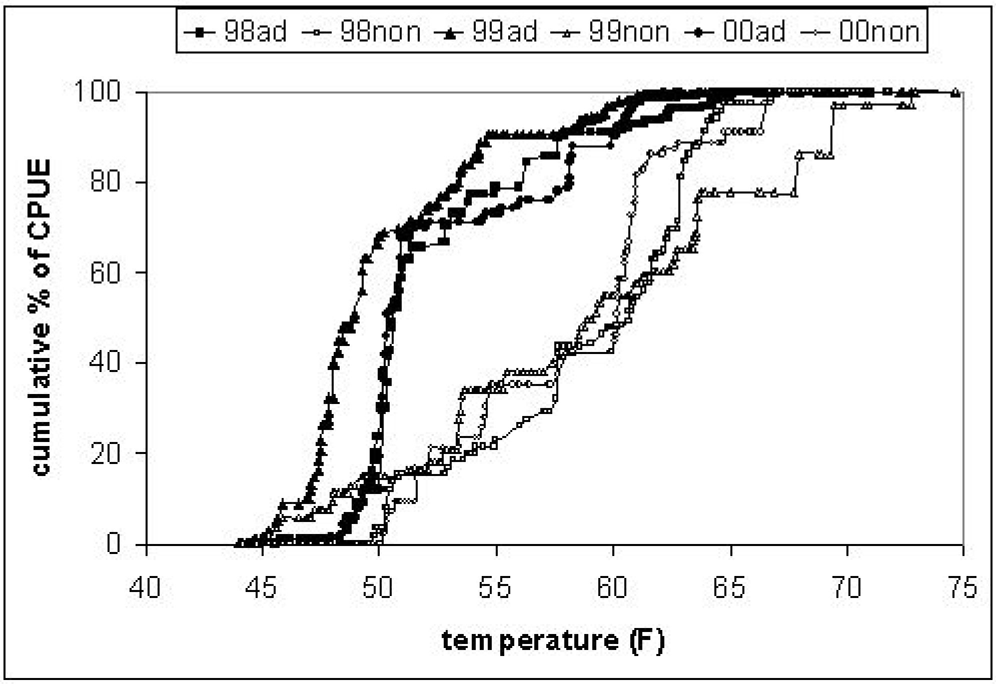


Figure 3–4 Cumulative percentage of steelhead per 10,000 m^3 in the FWS Chipps Island Trawl v. surface water temperature at Chipps Island. Solid symbols represent hatchery fish and open symbols represent wild fish.

During their downstream migration, juveniles undergo smoltification, a physiologic transformation enabling them to tolerate increased salinity. In addition, the juveniles lose their parr marks, become silvery, and produce deciduous scales. Temperatures under 57° F are considered optimal for smolting in northern populations. Data for steelhead smolts emigrating past Chipps Island generally agree with findings for northern populations. Slightly more than 60 percent of the steelhead smolts collected in the FWS Chipps Island trawl between 1998 and 2000 were collected at temperatures > 57 ° F (Figure 3–4). However, this is likely biased by high proportions of hatchery fish that migrate over a shorter period of time than naturally spawned fish.

Steelhead are present at Chipps Island between at least October and July based on catch data from the FWS Chipps Island Trawl (Figure 3–5). It appears that adipose fin-clipped steelhead have a different emigration pattern than unclipped steelhead. In all three years, adipose fin-clipped steelhead showed distinct peaks in catch per unit effort (CPUE) between January and March corresponding with time of release, whereas unclipped steelhead CPUE were more evenly distributed over a period of six months or more. Presumably, these differences are an artifact of the method and timing of hatchery releases.

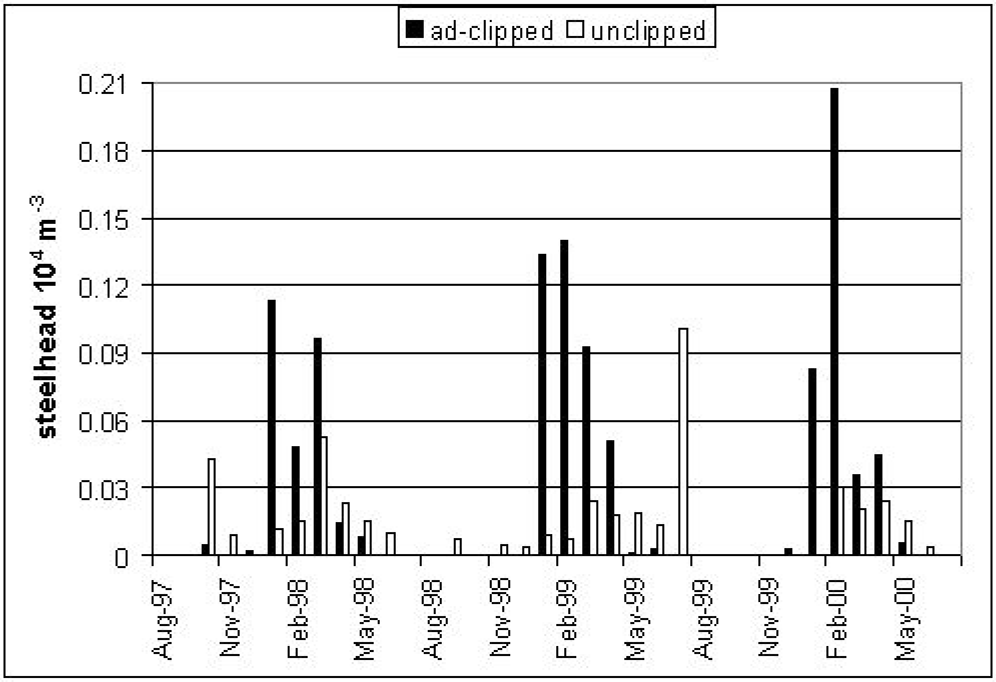


Figure 3–5 CPUE of adipose fin-clipped (black bars) and unclipped (white bars) steelhead from the FWS Chipps Island Trawl, August 1997 through July 2000.

Once in the ocean, steelhead remain there for one to four growing seasons before returning to spawn in their natal streams (Burgner et al. 1992, as cited in McEwan and Jackson 1996). Little data are available on the distribution of Central Valley stocks in the ocean, but at least some California steelhead stocks may move into the north Pacific Ocean, as do the more northerly-distributed stocks.

Historical and Current Distribution and Abundance of Central Valley Steelhead

Steelhead ranged throughout many of the tributaries and headwaters of the Sacramento and San Joaquin Rivers prior to dam construction, water development, and watershed perturbations of the 19th and 20th centuries (McEwan and Jackson 1996). Based on the historical distribution of Chinook salmon, steelhead probably inhabited tributaries above Shasta Dam such as the Little Sacramento, McCloud, Fall, and Pit Rivers, and many tributaries on the west side of the Sacramento Valley, such as Stony and Thomes Creeks (Yoshiyama et al. 1996, 1998).

There is little historical documentation regarding steelhead distribution in the San Joaquin River system, presumably due to the lack of an established steelhead sport fishery in the San Joaquin basin (Yoshiyama et al. 1996). However, based on historical Chinook salmon distribution in this drainage and on the limited steelhead documentation that does exist, steelhead were present in the San Joaquin River and its tributaries from the Kern River northward. During very wet years, steelhead could access the Kern River through the Tulare Basin.

Steelhead distribution in Central Valley drainages has been greatly reduced (McEwan and Jackson 1996). Steelhead are now primarily restricted to a few remaining free-flowing tributaries and to stream reaches below large dams, although a few steelhead may also spawn in intermittent streams during wet years. Naturally spawning steelhead populations have been found in the upper Sacramento River and tributaries below Keswick Dam, Mill, Deer, and Butte Creeks, and the Feather, Yuba, American, and Mokelumne Rivers (CMARP 1998). However, the records of naturally spawning populations depend on the presence of fish monitoring programs. Recent implementation of monitoring programs has found steelhead in additional streams, such as Auburn Ravine, Dry Creek, and the Stanislaus River. It is possible that naturally spawning populations exist in many other streams but are undetected due to lack of monitoring or research programs. Although impassable dams prevent resident rainbow trout from emigrating, populations with steelhead ancestry may still exist above some dams (Dennis McEwan, personal communication, 1998).

As stated above, the adult Central Valley steelhead population was estimated to number about 27,000 during the early 1960s (DFG 1965, as cited in McEwan and Jackson 1996). Historical counts of steelhead passing RBDD, which included both Coleman Hatchery and naturally spawned fish are shown in Figure 3–1. The counts showed an obvious decline in steelhead returns to the upper Sacramento River between 1967 and 1993. Current escapement data are not available for naturally spawned steelhead in most tributaries, in large part because of the curtailment of gate operations at RBDD and the lack of steelhead population monitoring in most of the Central Valley. A continual decline is not apparent in the time series of returning steelhead trapped at Nimbus (Figure 3–6) and Feather River (Figure 3–7) hatcheries, where data for post-drought years are available. The estimated number of steelhead spawning in the Amercan River in 2002 was 32 percent of the number that entered Nimbus Hatchery (Hannon and Healey, 2002). An estimated 201 - 400 steelhead spawned in the American River in 2002 and 243 - 486 spawned in 2003, based on one to two redds per female. Some escapement monitoring surveys have been initiated in upper Sacramento River tributaries (Beegum, Deer, and Antelope Creeks) using snorkel methods similar to spring-run Chinook escapement surveys.

Although Coleman Hatchery production was included in counts at RBDD, these time series indicate that abundance patterns may differ between wild and hatchery stocks (and also between individual hatchery stocks), confounding interpretation of factors influencing Central Valley steelhead at the population or regional levels. Abundance patterns are conversely related for wild and hatchery fish and may influence each other as shown in Oregon and Washington (NOAA Fisheries, 2003). The following provides an overview of the status of steelhead in Sacramento and San Joaquin tributaries under consultation. More detailed assessments of steelhead status in the Central Valley were provided by McEwan and Jackson (1996) and Busby et al. (1996).

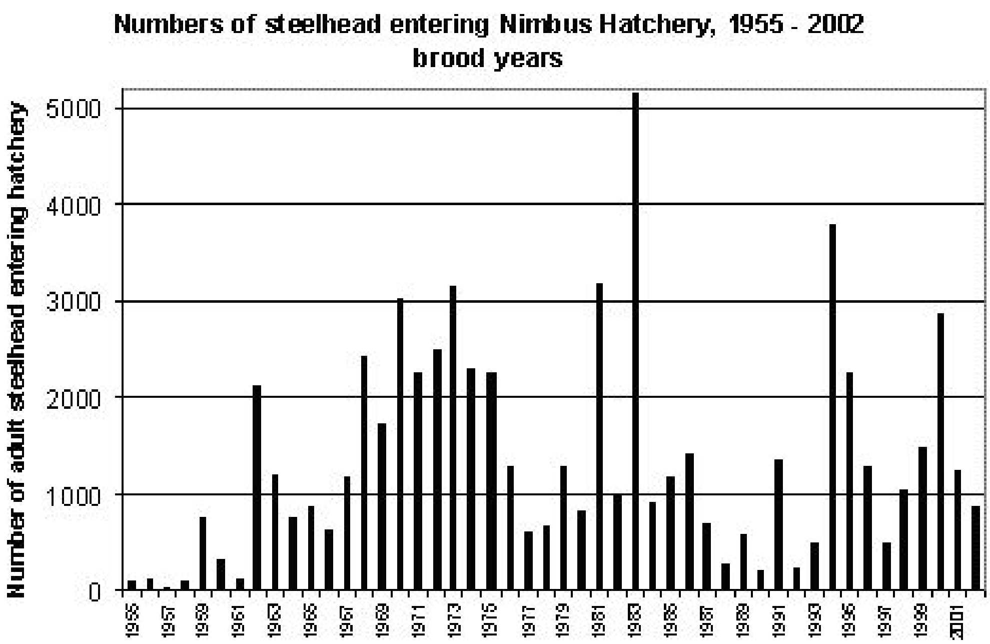


Figure 3–6 Adult steelhead counts at Nimbus Hatchery, brood years 1955-2001. The 2002 brood year means those fish returning to spawn in late 2002 through spring 2003.

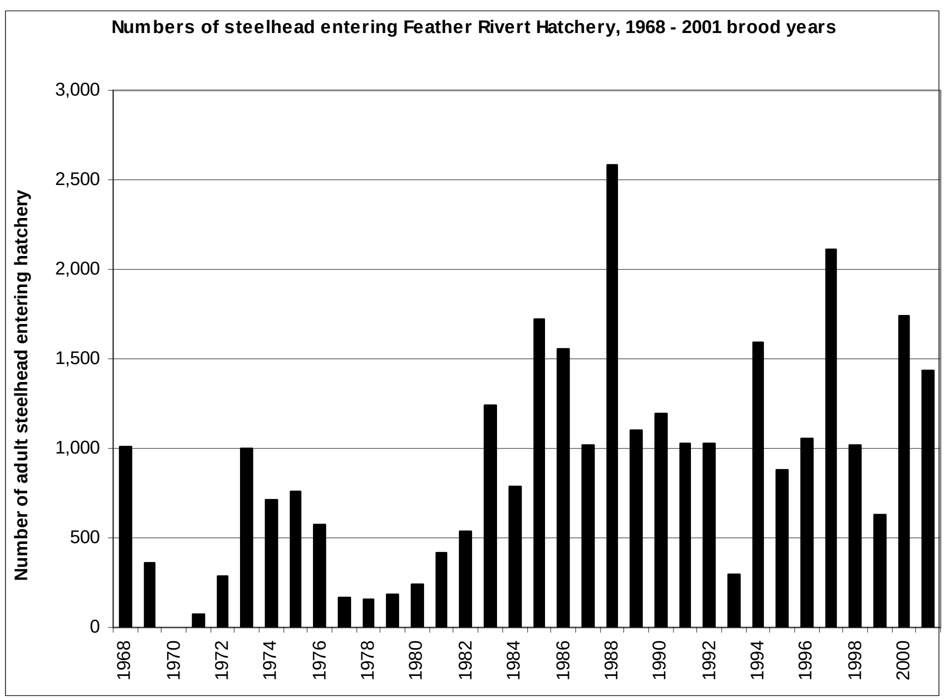


Figure 3–7 Adult steelhead counts at Feather River Hatchery, brood years 1969-2001.

Clear Creek

Historically, steelhead probably ascended Clear Creek past the French Gulch area, but access to the upper basin was blocked by Whiskeytown Dam in 1964 (Yoshiyama et al. 1996). Operation of Whiskeytown Dam can produce suitable cold water habitat downstream to Placer Road Bridge depending on flow releases (DFG 1998). McCormick-Saeltzer Dam, which limited steelhead migrations through ineffective fish ladders, was removed in 2000 allowing steelhead potential access to good habitat up to Whiskeytown Dam. The FWS has conducted snorkel surveys targeting spring-run Chinook (May through September) since 1999. Steelhead/rainbow are enumerated and separated into small, medium, and large (>22 inches) during these surveys; but because the majority of the steelhead run is unsurveyed, no spawner abundance estimates have been attempted (Jess Newton, personal communication, 2001). Redd counts were conducted during the 2001-02 run and found that most spawning occurred upstream, near Whiskeytown Dam. Because of the large resident rainbow population, no steelhead population estimate could be made (Matt Brown, personal communication, June 2002). A remnant “landlocked” population of rainbow trout with steelhead ancestry may exist in Clear Creek above Whiskeytown Dam (Dennis McEwan, personal communication, 1998).

Summertime water temperatures are often critical for steelhead rearing and limit rearing habitat quality in many streams. Figure 3–8 shows that water temperatures in Clear Creek at Igo are maintained below 65° F year-round using releases of cool Whiskeytown reservoir water.

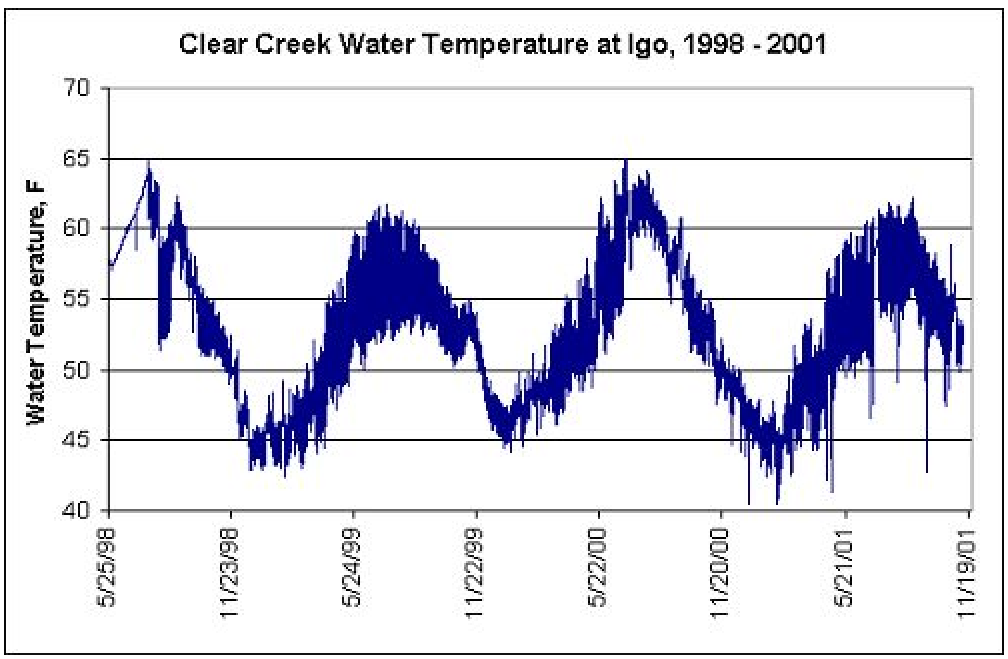


Figure 3–8 Clear Creek water temperature at Igo, 1998-2001 (CDEC).

Feather River

Historically, the Feather River supported a large steelhead population (McEwan and Jackson 1996). Today the run is supported almost entirely by the Feather River Hatchery and is restricted to the region downstream of the fish hatchery dam. The hatchery produces about 400,000 yearling steelhead each year to mitigate for Oroville Dam and losses at the SWP Delta facilities.

Angler surveys by Painter et al. (1977) indicated adult steelhead were present in the Feather River from September through April. However, peak immigration probably occurs from September through January. Most of the fish spawn in the hatchery, although some spawn in the low flow channel. During 2003 redd construction probably began in late December, peaked in late January, and was essentially complete by the end of March. Redd surveys counted 75 steelhead redds and revealed that 48% of all redds were in the upper mile of the river between Table Mountain Bicycle Bridge and lower auditorium riffle in 2003 (Kindopp and Kurth 2003).

Screw trap monitoring indicates steelhead fry are present in the river as early as March (DWR 1999b). Snorkel surveys in 1999, 2000, and 2001 showed young steelhead reared through the summer at suitable locations throughout the low flow channel, primarily along the margins of the channels under riparian cover and in secondary channels with riparian cover (Cavallo et al 2003). The highest densities of YOY steelhead were observed at the upstream end of the low flow channel and in an artificial side channel fed by hatchery discharge. Summer water temperatures below Thermalito Afterbay Outlet are relatively high (>70° F), and snorkel surveys in 1999, 2000, and 2001 found almost no steelhead rearing below the outlet. Most YOY steelhead observed in the surveys were 55 to 75 mm FL by August and September, when many fish moved into higher velocity areas in the channel, away from channel margins. Snorkel surveys conducted in September and October 1999 found many steelhead in the 200 to 400 mm size range. These fish apparently represent early adult returns or resident rainbows. Adipose fin-clipped steelhead were also observed among these fish. By mid-September and October, some YOY steelhead were still present, but most YOY steelhead appear to leave the system before fall of their first year. Rotary screw trapping indicates most steelhead leave before summer (Cavallo et al 2003).

American River

Historically, steelhead occurred throughout the upper reaches of the American River (McEwan and Jackson 1996). From 1850 through 1885, hydraulic mining caused the deposition of large quantities of sediment in the American River basin, silting over spawning gravel and nearly exterminating the salmon runs (Gerstung 1989, as cited in Yoshiyama et al. 1996). A series of impassable dams was constructed between 1895 and 1939. Fish ladders were later constructed around these dams, but many of them had passage problems. Access was restricted to the 27-mile reach below Old Folsom Dam after floodwater destroyed its fish ladder in 1950 (Gerstung 1971, as cited in Yoshiyama et al. 1996). Nimbus and Folsom Dams were completed in 1955 and 1956, respectively. Steelhead are now restricted to a 23-mile stretch below Nimbus Dam, although a remnant population of rainbow trout with steelhead ancestry may exist in the north fork of the American River (Dennis McEwan, personal communication, 1998).

Adult steelhead migrate into the lower American River from November through April, with peak immigration during December through March (SWRI 1997). Juvenile steelhead rear in the lower American River for one or more years and migrate out of the river during January through June (Snider and Titus 2000). Juvenile steelhead were monitored from July to October 2001 to detect the effects of warmer than normal water temperatures on steelhead abundance and distribution. Juvenile steelhead with good condition factors were found as far downstream as Paradise Beach through July and at Watt Avenue through August. Water temperatures during this period in these areas regularly rose to above 70° F (Figure 3–9). All steelhead recaptures occurred in the same reach of the river as tagging occurred, indicating many fish remained in the same location for extended periods.

The lower American River population is supported almost entirely by Nimbus Hatchery, although natural spawning does occur (Hannon et al 2003). The hatchery produces about 400,000 steelhead yearlings annually to mitigate for Folsom and Nimbus Dam. The hatchery included Eel River steelhead in its founding stock. Genetic analysis indicates Nimbus Hatchery produced steelhead are more closely related to Eel River steelhead than other Central Valley stocks and are therefore not considered part of the Central Valley ESU (Busby et al. 1996; NOAA Fisheries 1997b).

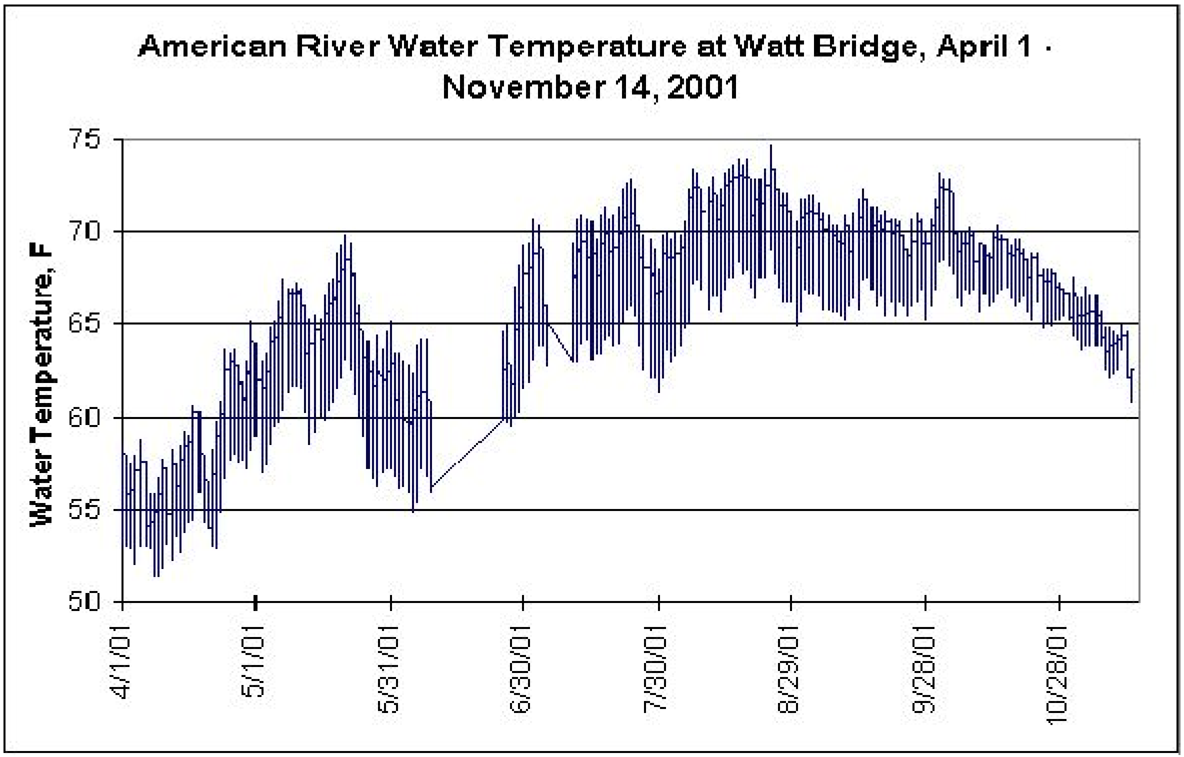


Figure 3–9 American River water temperature at Watt Avenue bridge, April 1 to November 14, 2001.

Currently, all hatchery produced steelhead are adipose clipped to identify them as hatchery fish. Occasionally a few are missed but the majority get clipped. During the 2000-01 steelhead run, the first year that marked fish began to return, 2,877 steelhead adults entered the hatchery through the fish ladder. Of these, 50 steelhead, or 1.7 percent, were not adipose clipped, indicating they came from steelhead that spawned in the river . Informal reports from anglers indicate that the percentage of unclipped (wild) fish in the river is higher than the percentage entering the hatchery. During the 2001-02 steelhead run, 1,435 steelhead entered the hatchery and 69 (4.8 percent) of those were unclipped. During the 2002 – 2003 steelhead run, 27 out of 935 (2.9 percent) of the steelhead that entered the hatchery were unclipped. Hannon and Healey (2002) conducted redd surveys in 2002 to begin an index of in-river spawning steelhead abundance. They counted 159 redds and estimated the number of in-river spawning steelhead to be 400 based on a male to female ratio of 1.52 : 1.0 (determined from fish entering the hatchery) and one redd per female. Redd density was higher in the upper seven mile reach but redds were present down to the lowest riffle in the river at Paradise Beach. Redd depths were measured in 2001 and 2002 to assess affects from flow changes. The shallowest redds measured had 20 cm (8 inches) of water over them. Table 3–1 shows American River steelhead spawning distribution in 2002 and 2003 delineated into the reaches used in the Chinook salmon mortality model.

Table 3–1 American River steelhead spawning distribution, 2002 and 2003, (Hannon et al 2003).

	American River Steelhead redds					
Reach	**2002 redds**	**2002%**	**2003 redds**	**2003%**	**Total**	**Total %**
Above weir	no surveys		10	5%		
Nimbus to Sunrise bridge	80	51%	75	35%	165	**45%**
Sunrise to Ancil Hoffman	32	21%	52	24%	84	**23%**
Ancil Hoffman to Arden Rapids (use Goethe bike bridge)	3	2%	25	12%	28	**8%**
Arden Rapids (Goethe bridge) to Watt bridge	27	17%	51	24%	78	**21%**
Watt to Fairbairn water intake	1	1%	1	0%	2	**1%**
Fairbairn to H Street bridge	0	0%	0	0%	0	**0%**
H Street bridge to Paradise Beach	13	8%	0	0%	13	**4%**
Paradise Beach to 16th st		0%		0%	0	**0%**
16th st to Sacramento River		0%		0%	0	**0%**
Total	156	100%	214	100%	370	**100%**

Stanislaus River

Historically, steelhead distribution extended into the headwaters of the Stanislaus River (Yoshiyama et al. 1996). Dam construction and water diversion for mining and irrigation purposes began during and after the Gold Rush. Goodwin Dam, constructed in 1913, was probably the first permanent barrier to significantly affect Chinook salmon access to upstream habitat. Goodwin Dam had a fishway, but Chinook could seldom pass it. Steelhead may have been similarly affected. The original Melones Dam, completed in 1926, permanently prevented access to upstream areas for all salmonids. Currently, steelhead can ascend over 58 miles up the Stanislaus River to the base of Goodwin Dam. Although steelhead spawning locations are unknown in the Stanislaus, most is thought to occur upstream of the city of Oakdale where gradients are slightly higher and more riffle habitat is available.

The Fishery Foundation of California (Kennedy and Cannon 2002) has monitored habitat use by juvenile steelhead/rainbow since March 2000 by snorkeling seven sites from Oakdale to Goodwin Dam every other week. Steelhead fry began to show up in late March and April at upstream sites with densities increasing into June and distribution becoming more even between upstream and downstream sites through July. Beginning in August and continuing through the winter months, densities appeared highest at upstream sites (Goodwin to Knights Ferry). Age one+ fish were observed throughout the year with densities generally higher at upstream sites (Goodwin to Knights Ferry). Low densities were observed from late December until April. It is unknown whether fish left the system in December or if, with the cooler winter water temperatures, they were less active and more concealed during the day.

Since 1993, catches of juvenile steelhead/rainbow in rotary screw traps (RSTs) indicate a small portion of the Stanislaus River steelhead/rainbow population displays downstream migratory characteristics at a time that is typical of steelhead migrants elsewhere. The capture of these fish in downstream migrant traps and the advanced smolting characteristics exhibited by many of the fish indicate that some steelhead/rainbow juveniles may migrate to the ocean in spring. However, it is not known whether the parents of these fish were anadromous or fluvial. Resident populations of steelhead/rainbow in large streams are typically fluvial (they migrate within freshwater) and migratory juveniles look much like smolts. Further work is needed to determine the parental life histories that are producing migratory juveniles. A portable weir has been proposed in the Stanislaus River near the mouth, in part to determine migration characteristics of adult steelhead/rainbow and allow scale samples to be taken to determine the extent of anadromy. Anglers captured adults up to 12 pounds in the Stanislaus in 2001.

Smolts have been captured each year since 1995 in RSTs at Caswell State Park and at Oakdale (Demko et al. 2000). Captures occurred throughout the time the traps were run, generally January through June. Most fish were between 175 and 300 mm at the Caswell site, with only six fish in seven years less than 100 mm. Larger numbers of fry were captured upstream at Oakdale. During 2001, 33 smolts were captured at Caswell and 55 were captured at Oakdale, the highest catch of all years. The higher catch in 2001 was likely due to more fish present and not better trap efficiencies (Doug Demko, personal communication, 2001). Trap efficiencies for Chinook in 2001 ranged from 5 percent to 19 percent at Caswell and from 1 percent to 30 percent at Oakdale and were generally correlated with flow. RSTs are generally not considered efficient at catching fish as large as steelhead smolts.

Genetic analysis of rainbow trout captured below Goodwin Dam show that this population has closest genetic affinities to upper Sacramento River steelhead (NOAA Fisheries 1997b).

The most consistent data available on rainbow/steelhead in the San Joaquin River is collected at the Mossdale trawl site on the lower San Joaquin River (Marston 2003). Figure 3–10 shows that counts were highest in the initial years of the Mossdale trawl survey in 1988–90.

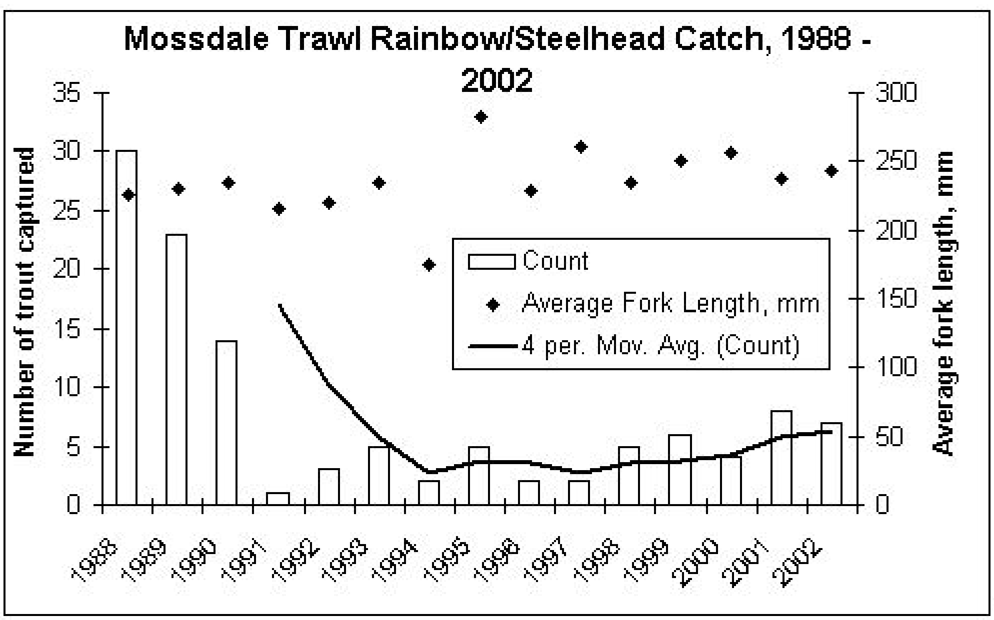


Figure 3–10 Mossdale Trawl rainbow/steelhead catch, 1988-2002 (Marston 2003).

Sacramento-San Joaquin Delta

The Delta serves as an adult and juvenile migration corridor, connecting inland habitat to the ocean. The Delta may also serve as a nursery area for juvenile steelhead (McEwan and Jackson 1996). Estuaries are important nursery grounds for other coastal steelhead populations. However, the historical and current role of the Delta as a steelhead nursery habitat is unknown. Based on fish facility salvage data (Table 3-8) most steelhead move through the delta from November through June with the peak salvage occurring during February, March, and April. The majority of steelhead salvaged range from 175 to 325 mm with the most common size in the 226 to 250 mm range (Figure 3–11). Unlcipped fish tended to have a higher proportion of larger individuals than clipped fish.

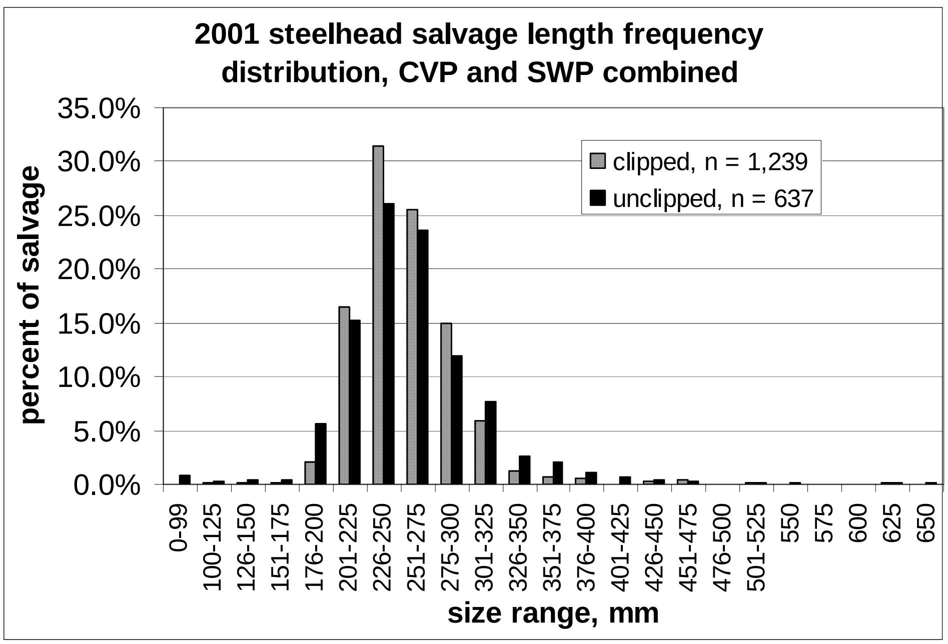


Figure 3–11 Length frequency distribution of clipped and unclipped steelhead salvaged at the CVP and SWP in 2001.

Mokelumne River

Figure 3–12 shows steelhead returns to the Mokelumne River Hatchery from 1965 to 1998. More recent returns, from 1999 through 2003 have been less than 100 steelhead each year. Recently one out of 60 (1.7%) steelhead that returned to the hatchery was unclipped.

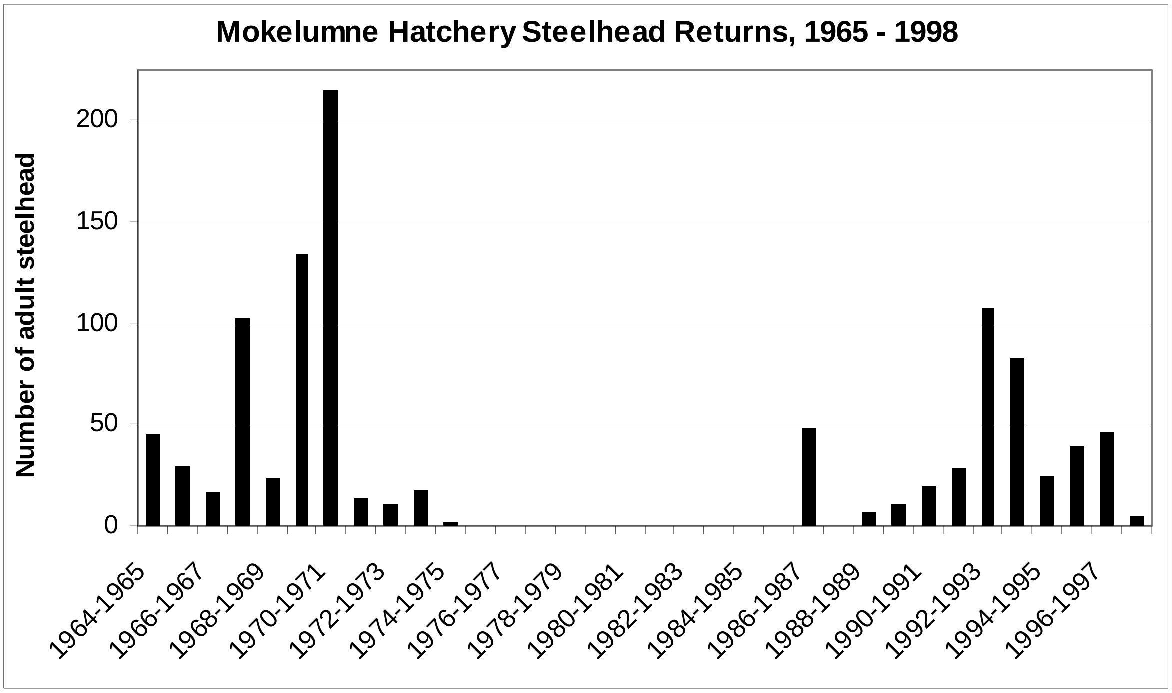


Figure 3–12 Steelhead returns to Mokelumne River Hatchery, 1965 – 1998.

Chapter 4 Factors That May Influence Steelhead Distribution and Abundance

Water Temperature

Water temperatures that are too low or too high can kill steelhead by impairing metabolic function, or indirectly by increasing the probability of disease, predation, or other secondary mortality factors (Leitritz and Lewis 1976; Reiser and Bjornn 1979, both as cited in McEwan and Jackson 1996). Steelhead temperature tolerances vary among life stages (Bovee 1978; Reiser and Bjornn 1979; Bell 1986, all as cited in McEwan and Jackson 1996) and stocks (Myrick 1998, 2000; Nielson et al. 1994a) (Table 4–1). In this BA, temperature recommendations of McEwan and Jackson (1996) are used for all life stages except fry and juveniles, which have recently been studied using local stocks in a laboratory situation (Myrick 1998, 2000). Except for Myrick (1998, 2000), these temperature criteria are based on Pacific Northwest stocks and may not be completely representative of local strains. Additional studies to help determine the temperature needs of local strains may be conducted during the DWR's relicensing of Oroville Facilities with the FERC.

Myrick (1998, 2000) found the preferred temperatures for Mokelumne River Fish Installation, Feather River Hatchery, and naturally spawned Feather River steelhead placed into thermal gradients were between 62.5° F and 68° F (17° C and 20° C). This is considerably warmer than the rearing temperature recommended by McEwan and Jackson (1996). Feather River snorkel survey observations and temperature data from summer 1999 also appear to corroborate Myrick's (1998, 2000) results. Young of the year steelhead in the American River during August 2001 were observed in snorkel surveys, captured by seining, and PIT tagged in habitats with a daily average temperature of 72° F and a daily maximum over 74° F (DFG and USBR unpublished data).

Table 4–1 Recommended water temperatures (°F) for all life stages of steelhead in Central Valley streams from McEwan and Jackson (1996) and Myrick (1998, 2000).

Life stage	*Temperature recommendation (°F)*
Migrating adult	46–52
Holding adult	?
Spawning	39–52
Egg incubation	48–52
Juvenile rearing	<65
Smoltification	<57

Flow

Adverse effects to steelhead stocks in the Sacramento and San Joaquin Rivers have been mostly attributed to water development (McEwan and Jackson 1996). Specific examples include inadequate in stream flows caused by water diversions, rapid flow fluctuations due to water conveyance needs and flood control operations, inadequate cold water releases from upstream reservoirs, loss of spawning and rearing habitat due to dams, and juvenile entrainment into unscreened or poorly screened water diversions.

Measures to protect and restore salmon will usually benefit steelhead. However, adequate habitat conditions must be maintained all year for steelhead to benefit. Life history differences between steelhead and Chinook salmon may also lead to different, and potentially conflicting, flow requirements for each species. While the most important flow needs for steelhead are for cold water during the summer and early fall, increased flows for Chinook salmon are typically scheduled for the spring and mid-fall migration periods. In some cases, such as the temperature criteria for winter-run Chinook from Keswick to RBDD, reservoir operations coincide with steelhead requirements. However, this is not a common situation. Differences in the timing of flow needed by different species can create difficult management dilemmas, particularly during an extended drought.

In the upper Sacramento River basin, problems of outflow and temperature are closely related (McEwan and Jackson 1996). Low summer and fall outflows can reduce the quality of steelhead rearing habitat because of associated increases in water temperature.

Sacramento River

FWS (2003) developed spawning flow-habitat relationships for steelhead spawning habitat in the Sacramento River below Keswick Dam using the Physical Habitat Simulation (PHABSIM) component of the in stream flow incremental methodology (IFIM). Relationships were developed by cross section and by stream segments but were not aggregated into river-wide flow-habitat relationships.

Steelhead spawning wetted usable area peaked at 3,250 cfs in the reach upstream of the Anderson-Cottonwood Irrigation District (ACID) Diversion Dam when the dam boards are out and when the boards are in. Between ACID dam and Cow Creek spawning area also peaked at 3,250 cfs. In the lower reach, from Cow Creek to Battle Creek, spawning area peaked at about 13,000 cfs but did not vary significantly in a flow range between about 6,000 and 14,000 cfs.

The minimum Sacramento River flow allowed is 3,250 cfs. This flow level provides adequate physical habitat to meet the needs of all steelhead life stages in the Sacramento River. Flows during the summer greatly exceed this amount to meet temperature requirements for winter-run. The winter-run temperature requirements result in water temperatures suitable for year-round rearing of steelhead in the upper Sacramento River.

Clear Creek

Denton (1986) used the IFIM to estimate optimal Clear Creek flows for salmon and steelhead. The resultant estimate of optimal flows from the IFIM study is shown in Figure 4–4. Summer-rearing habitat resulting from high water temperatures appeared to be the limiting factor for steelhead. Optimal steelhead flows in the upstream (above the former Saeltzer Dam site) reach were 87 cfs for spawning and 112 cfs for juvenile rearing. Optimum flows for steelhead in the reach below Saeltzer Dam were predicted to be 250 cfs in all months except April when they drop to 225 cfs and May 1 through 15 when they are 150 cfs. Denton (1986) recommended that tributary streamflows occurring below Whiskeytown Dam should be included in computing the additional releases required from Whiskeytown Dam to meet the total recommended fishery flow needs.

Feather River

In 2002, DWR conducted an in stream flow incremental methodology (IFIM) habitat analysis for the lower Feather River (DWR 2004). This analysis drew on the earlier IFIM work of Sommer et al. (2001), but added an additional 24 transects and included additional fish observations. The river segments above (the low flow channel, LFC) and below (the high flow channel, HFC) were modeled separately due to their distinct channel morphology and flow regime. The WUA for steelhead spawning in the LFC had no distinct optimum over the range of flow between 150 and 1,000 cfs. However, in the HFC, a maximum WUA was observed at a flow just under 1,000 cfs. The difference in these results can be attributed to the relative scarcity of suitable steelhead spawning gravels in the LFC segment of the Feather River.

American River

FWS (1997) measured 21 cross sections of the American River in high density Chinook spawning areas. They estimated the flows at which the greatest usable spawning area would be available to steelhead and Chinook based on measurements of water velocity, water depth, and substrate size from steelhead and Chinook redds in the American River. There was low variability in weighted usable spawning area (WUA) throughout the range of flows analyzed (1,000 to 6,000 cfs). Table 4–2 shows the average of the weighted usable spawning area from the 21 cross sections expressed as 1,000 square feet of spawning area per 1,000 feet of stream. WUA for steelhead peaked at a flow of 2,400 cfs. All flows from 1,000 cfs to 4,000 cfs provided at least 84 percent of the maximum WUA.

Table 4–2 Average WUA (expressed as 1,000 square feet of spawning area per 1,000 feet of stream) from 21 cross sections measured in 1995 in high density Chinook spawning areas. Summarized from FWS 1997.

Nimbus Release (cfs)	*Steelhead Average WUA*	*Chinook Average WUA*
1000	31	62
1200	33	71
1400	34	78
1600	35	82
1800	36	84
2000	36	83
2200	36	81
2400	37	78
2600	36	74
2800	36	69
3000	36	65
3200	36	60
3400	35	56
3600	34	52
3800	32	48

Nimbus Release (cfs)	*Steelhead Average WUA*	*Chinook Average WUA*
4000	31	45
4200	29	42
4400	27	38
4600	26	36
4800	24	33
5000	23	31
5200	22	28
5400	21	26
5600	20	25
5800	19	23
6000	19	21

Snider et al. (2001) evaluated effects of flow fluctuations in the American River on steelhead and salmon. They defined flow fluctuations as unnatural rapid changes in stream flow or stage over short periods resulting from operational activities of dams and diversions. They recommended ramping flows in the American River of 100 cfs/hour or less at flows less than 4,000 cfs to reduce stranding of steelhead caused by rapid dewatering of habitat. They further recommended avoiding flow increases to 4,000 cfs or more during critical rearing periods. These are January through July for YOY salmon and steelhead, and October through March for yearling steelhead and non-natal rearing winter-run Chinook salmon, unless the higher flows can be maintained throughout the entire period. For the maintenance of sufficient spawning habitat and to keep water flowing through redds they recommended precluding flow fluctuations that decrease flow below 2,500 cfs during critical spawning periods (December through May).

Ayres Associates (2001) used detailed topography of the river to model sediment mobilization at various flows in the American River. They found that at 115,000 cfs (the highest flow modeled) particles up to 70 mm median diameter would be moved in the high density spawning areas around Sailor Bar and Sunrise Avenue. Preferred spawning gravel size is 50−125 mm (2−5 inches) in diameter.

Snider et al. (2001) produced survival indices for Chinook salmon based on number of redds v. the population estimate of outmigrating juveniles over seven years of monitoring. They found that high flows in January had the largest effect on survival according to the following equation: Survival = 11,200*(January maximum flow, cfs)$^{-0.28}$. The higher the flow in January, the lower the survival index, although the confidence bounds in this relationship are large. January is the period with the greatest number of Chinook eggs in the gravel so supposedly the high flows are reducing survival of incubating eggs by scouring or suffocating the eggs and alevins in redds. Because steelhead spawn in similar habitat and require similar incubation conditions high flows may affect incubating steelhead eggs in a similar manner. Few attempts have been made to estimate steelhead spawning population or juvenile populations so no such relationship can be examined for steelhead.

Monitoring has shown that juvenile steelhead numbers in the river decrease throughout the summer such that the available rearing habitat is not fully seeded with fish. Therefore the rearing population in the river is not likely limited by density dependent factors. More likely water temperature and potentially predator fish species such as striped bass limit the rearing population of steelhead in the American River. Flows of about 1,500 cfs or greater have sufficient thermal mass to maintain much of the water temperature benefits of cool Folsom releases downstream to Watt Avenue. During years with a low coldwater pool, there may not be enough cold water to last through summer and fall into the peak Chinook spawning period in November.

Stanislaus River

Aceituno (1993) applied the in stream flow incremental methodology to the Stanislaus River between Riverbank and Goodwin Dam (24 river miles) to help to determine in stream flow needs for Chinook salmon and steelhead. Table 4–3 gives the resulting in stream flow recommendations for rainbow and steelhead based on PHABSIM results. Macrohabitat conditions such as water quality, temperature, and the value of outmigration, attraction, and channel maintenance flows were not included in the analysis.

Table 4–3 In stream flows that would provide the maximum weighted usable area of habitat for rainbow trout and steelhead trout in the Stanislaus River between Goodwin Dam and Riverbank, California (Aceituno 1993).

Life stage	*In stream flow (cfs)*	
	for rainbow trout	*for steelhead*
Spawning	100	200
Fry	50	50
Juvenile	150	150
Adult	400	500

Habitat Availability

Large-scale loss of spawning and rearing habitat has been attributed as having the single greatest effect on steelhead distribution and abundance (McEwan and Jackson 1996). Historically, steelhead spawned and reared primarily in mid- to high-elevation streams where water temperatures remained suitable all year. Yoshiyama et al. (1996) estimated that 82 percent of the historical Chinook salmon spawning and rearing habitat has been lost. The percentage of habitat loss for steelhead is presumably greater, because steelhead were more extensively distributed than Chinook salmon. Steelhead could have used numerous smaller tributaries not used by Chinook salmon due to steelhead’s upstream migration during periods of higher flow, superior leaping ability, ability to use a wider variety of spawning gravels, and ability to pass through shallower water. The estimated number of historical, pre-impassable dam, and post-impassable dam river miles available to steelhead in the Sacramento, Feather, American, and Stanislaus Rivers and Clear Creek is provided in Table 4–4. The extent of historical habitat is based on Chinook salmon distribution and should be considered minimum estimates for steelhead. Potential migration barriers also occur in many other streams (

Table 4–5).

Table 4–4 Estimated number of historical, pre-dam, and post-dam river miles available to steelhead (includes main stem migratory, spawning, and rearing habitat). Source: Yoshiyama et al. (1996).

	Historical	*Pre-dam*	*Post-dam*	*Lower Dam Completed*
Clear Creek	25	25	16	1963
Sacramento River	493	493	286	1945
Feather River	211	<211	67 (64)	1968
American River	161	27	23 (28)	1955
Stanislaus River	113	113	58 (46)	1912

Table 4–5 Summary of potential salmonid migration barriers on Central Valley streams. Adapted from Yoshiyama et al. (1996).

Stream[a] and passable structures	*Notes*	*First impassable barrier*	Operator
Sacramento River			
Red Bluff Diversion Dam	FB, SC, FL	Keswick Dam	Reclamation
Anderson-Cottonwood Irrigation District Diversion Dam	FB, SC, FL		ACID
Clear Creek			
		Whiskeytown Dam	Reclamation
Battle Creek			
Coleman National Fish Hatchery Weir and various PG&E dams (e.g. Wildcat)	FL[b]	Coleman South Fork Diversion Dam; Eagle Canyon Dam (being laddered as part of restoratorion program)	PG&E
Antelope Creek	DW	mouth	Edwards Ranch; Los Molinos Mutual Water Co.
Mill Creek			
Ward Diversion Dam	SC, SL, FL	Morgan Hot Spring	Los Molinos Mutual Water Co.
Clough Diversion Dam	BR		
Upper Diversion Dam	SC, SL, FL		Los Molinos Mutual Water Co.
Deer Creek			
Stanford-Vina Diversion Dam	SC, FL	Upper Deer Creek Falls	Stanford-Vina Irrigation Co.
Cone-Kimball Diversion Dam	SC, SO		Stanford-Vina Irrigation Co.
Deer Creek Irrigation Co. Diversion	SC, SO		Deer Creek Irrigation Co.

Stream[a] and passable structures	*Notes*	*First impassable barrier*	Operator
Lower and Upper Deer Creek Falls	FL		
Butte Creek			
Parrott-Phelan Diversion Dam	SC, FL	Centerville Head Dam or Quartz Bowl Barrier (barrier most years)	M&T Ranch
Durham-Mutual Diversion Dam	SC, FL		Durham-Mutual Water Co.
Gorill Diversion Dam	SC, FL		Gorrill Ranch
Adams Diversion Dam	SC, FL		Rancho Esquon Investment Co.
Butte Slough Outfall Gates			
Sanborn Slough	FL		USFWS/RD1004
East-West Weir	FL		Butte Slough ID
Weir 2	FL		DWR
Weir 5	FL, SC		Butte Slough ID
Weir 3	FL		Butte Slough ID
Weir 1	FL		USFWS
Stony Creek			
Glenn-Colusa Irrigation District Canal (Formerly a gravel berm was used, but water canal is now piped under river.)	BR	Black Butte Dam	Corps
TCCA rediversion berm (Absent during adult migration)	UN		
Orland North Canal Diversion	FB, UN		
Yuba River			
Daguerre Point Dam	UN, FL	Englebright Dam	Corps and Yuba County Water Agency
Feather River		Feather River Fish Barrier Dam	DFG
American River		Nimbus Dam	Reclamation
Putah Creek		Putah Diversion Dam	Solano County Water Agency
Yolo Bypass[c]		Fremont Weir	DWR
Mokelumne River			
Woodbridge (Lodi Lake) Dam	FL, FB	Camanche Dam	EBMUD
CVP and SWP influenced channels			
Calaveras River[d]			
Bellota Dam	UN with FB	New Hogan Dam	Corps

Stream[a] and passable structures	*Notes*	*First impassable barrier*	Operator
Stanislaus River		Goodwin Dam	Reclamation
Tuolumne River		La Grange Dam	TID
Merced River			
		Crocker-Hoffman Dam	MID
San Joaquin River			
Hill's Ferry Fish Barrier	10/1 - 12/31	Alaskan Weir	DFG
BR = breached; DW = dewatered at some point throughout the year; FB = flashboards removed during winter; FL = fish ladder; SC = screened diversion; SL = sloped dam; SO = salmon can swim over dam; and UN = unscreened diversion.	a	a	a

[a] Only streams with barriers are listed.

[b] Not currently operational.

[c] Harrell and Sommer, In press.

[d] Tetra Tech (2001).

Habitat Suitability

Fish Passage, Diversion and Entrainment

As described above, upstream passage of steelhead has been most severely affected by large dams blocking access to headwaters of the Sacramento and San Joaquin Rivers on most major tributaries (McEwan and Jackson 1996). The remaining areas below major dams may not have optimal habitat characteristics. For example, lower elevation rivers have substantially different flow, substrate, cover, nutrient availability, and temperature regimes than headwater streams. In addition, small dams and weirs may impede upstream migrating adults, depending on the effectiveness of fish ladders at various flows or whether the boards are removed from the weirs during the migration period. Salmonids are able to pass some of these dams and weirs under certain conditions, but studies have not been conducted to fully evaluate fish passage at all structures at all flows. In particular, there is concern that high flows over small dams and weirs may obscure the attraction flows at the mouths of the ladders, effectively blocking upstream migration (CALFED 1998).

Sacramento River

Until recently, three large-scale, upper Sacramento River diversions (RBDD, ACID, and Glenn-Colusa Irrigation District (GCID)) have been of particular concern as potential passage or entrainment problems for steelhead (McEwan and Jackson 1996). The GCID diversion is now screened using large flat-plate screens. Operational controls in effect to protect winter-run Chinook (a reduction in diversion rate to reduce approach velocities to 0.33 feet per second (ft/s)) are likely to provide protection to steelhead as well. In addition, construction to double the screen area, increase the number of bypass structures, and provide a new downstream control structure was completed in 2001. A gradient control structure in the main stem of the river at mile 206 was completed in 2001 to provide suitable flow conditions through the side channel for operation of the diversion.

The ACID diversion dam created fish passage problems and requires a substantial reduction in Keswick Reservoir releases to adjust the dam flashboards, which can result in dewatered redds, stranded juveniles and high water temperatures. Reclamation helped modify the flash boards in the 1990s to facilitate adjustment at higher flows, reducing the risk of dewatering redds. New fish ladders and fish screens were installed around the diversion and were operated starting the summer 2001 diversion period.

Salmonid passage problems at RBDD have been well-documented (Vogel and Smith 1986; Hallock 1989; FWS 1987, 1989, 1990b; Vogel et al. 1988, all as cited in DFG 1998). Vogel (1989, as cited in DFG 1998) estimated the entrainment of young salmon from 1982 through 1987 averaged approximately 350,000 fish per year. The fish louver and bypass system originally constructed at RBDD was replaced with rotary drum screens and an improved bypass system, which began operation in April 1990. The drum screen facility was monitored to assess juvenile salmon entrainment into the Tehama-Colusa Canal through 1994 (FWS 1998). No fish were collected in monitoring efforts in 1990 to 1992 or 1994. In 1993, 33 salmon were entrained resulting in an estimated 99.99 percent screening efficiency. The drum screen facility at RBDD is highly efficient at reducing salmonid entrainment when properly operated.

Facilities improvements have been second only to the implementation of "gates-out" operation of RBDD for improving juvenile salmonid survival (FWS 1996). The RBDD gates were raised during the non-irrigation season beginning in 1986-87 to improve fish passage conditions, especially for winter-run Chinook salmon. The initial gates-out period of four months was incrementally increased to eight months by 1994-95. During the current gates-out operation (September 15 through May 14) fish passage conditions are "run of the river" and essentially all adverse effects associated with fish passage are eliminated. Water deliveries at the RBDD are limited during these eight months to diversions through a series of screened, temporary pumps and at the RBDD Research Pumping Plant (FWS 1998). Although the historical counts of juvenile steelhead passing RBDD do not differentiate steelhead from resident rainbow trout, approximately 95 percent of steelhead/rainbow trout juvenile emigrants pass during the gates-out period based on historical emigration patterns at RBDD (DFG 1993, as summarized in FWS 1998).

Immigrating adult steelhead must also negotiate RBDD to gain access to natal streams, including the upper Sacramento River, Clear Creek, and Battle Creek. Approximately 84 percent of adult steelhead immigrants pass RBDD during the gates-out period based on average run timing at RBDD. Therefore, most steelhead have had unimpeded passage past RBDD since 1994-95 (DFG 1993, as summarized in FWS 1998; Tehama-Colusa Canal Authority (TCCA) and Reclamation, 2002). Radio-tagged salmon typically are delayed up to 21 days during the gates in period, but no data specific to steelhead are available (TCCA and Reclamation, 2002).

In addition to the problems created by large-scale diversions, there are an estimated 300 smaller unscreened diversions on the Sacramento River between Keswick Dam and the Delta (McEwan and Jackson 1996) and another 2,000 or so in the Delta itself. Operation of these diversions has the potential to entrain juvenile steelhead. However, no steelhead were observed during several years of sampling agricultural diversions in the Delta (Cook and Buffaloe 1998), and only 1 steelhead was collected during a two-year study of the large Roaring River Diversion in Suisun Marsh before it was screened (Pickard et al. 1982b).

The diversions at the RBDD during the gates-out period are supplemented by rediversions of CVP water stored in Black Butte Reservoir through the Constant Head Orifice (CHO) on the Tehama-Colusa Canal. This rediversion requires the use of a temporary berm that potentially blocks upstream passage and impedes downstream passage of salmonids and creates an entrainment hazard for downstream migrating juveniles. Over 90 percent of the flow is into the CHO at peak diversions during late May, creating a significant hazard for juveniles present upstream of the diversion. Few salmonids are present above the CHO. Recent monitoring data, following installation of the GCID siphon downstream of the CHO caught few salmonids, suggesting this rediversion hazard poses little risk to salmonids. While the data are limited, it appears the salmonids move downstream to the mouth of the creek before rediversions begin, which generally coincides with the rise of temperature above 56° F (Reclamation 1998, 2002, and 2003).

The Sacramento-San Joaquin Delta

The Delta serves as a migration corridor to the upper Sacramento and San Joaquin River basins for adult and juvenile steelhead. It may also serve as a rearing habitat for juveniles that move into the Delta before they enter salt water, but this has not been studied. Presumably, one of the anthropogenic factors that may influence steelhead abundance and distribution in the Delta is CVP and SWP operations. However, little data are available to determine the extent to which CVP and SWP Delta operations affect steelhead population abundance. However, we present what little data are available as an initial assessment of potential effects.

DWR and Reclamation (1999) reported significant linear relationships exist between total monthly export (January through May) and monthly steelhead salvage at both Delta fish facilities. The months included in the analysis were based on months that steelhead consistently appeared in salvage between 1992 and 1998. Scatterplots of 1993 through 2003 CVP and SWP steelhead salvage vs exports are shown in Figure 4–1 and Figure 4–2, respectively. A generalized linear modeling approach confirmed that salvage and total monthly exports are positively correlated, at least at the SWP (Michael Chotkowski, personal communication, 2000).

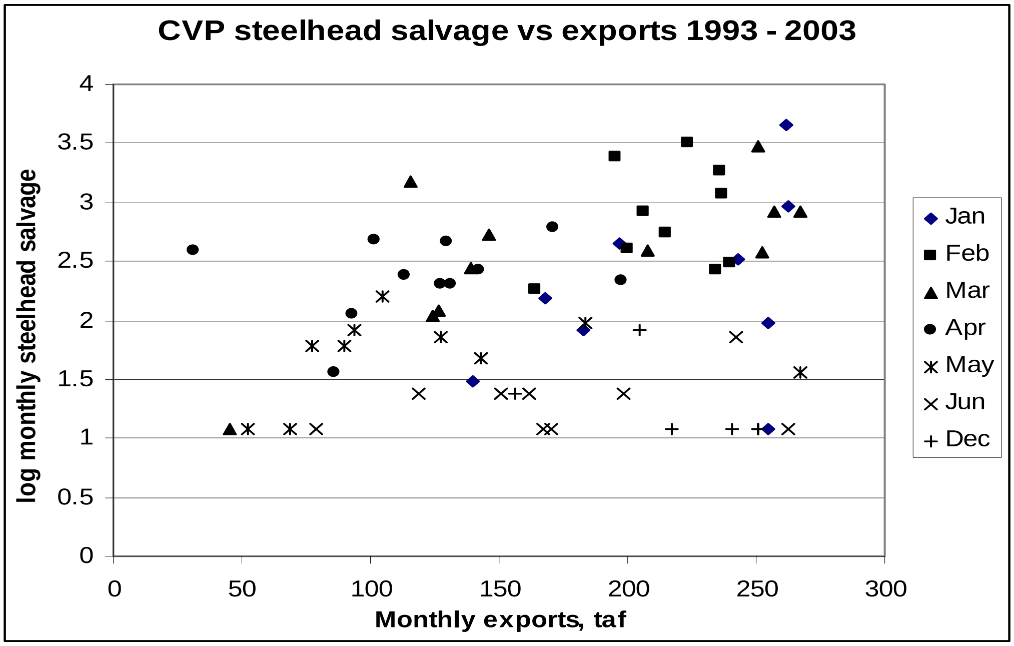


Figure 4–1 Scatterplot of total monthly CVP export in acre feet vs $\log_{10}$ total monthly CVP steelhead salvage, 1993-2003

Future take predictions based on past salvage would be highly speculative so are not attempted . There has been a general decrease in steelhead salvage since 1992 (Table 4–6). This is presumably due to changes in the timing of exports from spring to summer resulting from implementation of the Bay-Delta Accord. Alternatively it is possible that steelhead abundance has continually declined, but this seems less likely since the returns to Nimbus and Feather River Hatcheries since 1992 have not demonstrated such a decline (Figures 2–6 and 2–7). Returns to these hatcheries are not correlated to each other (Spearman $R = -0.32$, $P = 0.09$). The lack of correlation in returns to Nimbus and Feather River Hatcheries does not support the hypothesis that a single factor operating outside the river of origin, such as Delta operations, has a dominant effect on the abundance patterns of all Central Valley steelhead.

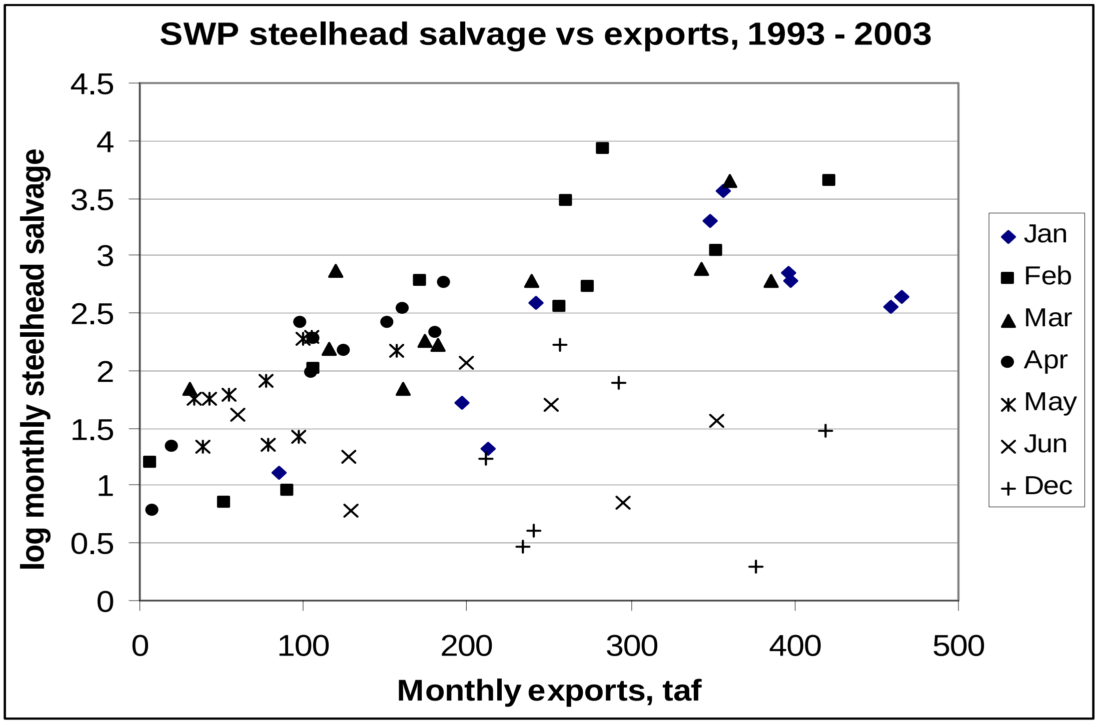


Figure 4–2 Scatterplot of total monthly SWP export in acre feet vs $\log_{10}$ total monthly SWP steelhead salvage, 1993-2003.

In addition to being correlated to amount of water exported, steelhead salvage is positively correlated to December through June CPUE of steelhead in the FWS Chipps Island Trawl (Spearman $R = 0.89$, $P = 0.02$; Figure 4–3), which we consider the best available estimate of juvenile steelhead year class strength. In other words, the Delta facilities take more steelhead when there are more steelhead. This suggests steelhead salvage at the facilities is an indicator of juvenile year class strength. A similar relationship has been found for splittail (Sommer et al. 1997). Both the steelhead and splittail relationships with salvage contrast those reported for delta smelt and longfin smelt, species whose abundance estimates are somewhat inversely correlated to salvage. Like the hatchery data presented above, the Chipps Island data, which includes both hatchery and naturally spawned juveniles, do not indicate steelhead numbers have continually declined since year-round sampling was initiated in 1994.

The currently available data suggest salvage represents small percentages of hatchery and wild steelhead smolts. The estimated percentages of hatchery smolts in combined (SWP and CVP) salvage ranged from 0.01 percent to 0.4 percent of the number released from 1998 through 2000. The estimated percentages of the wild steelhead smolt populations salvaged were higher, but were still less than 1 percent each year and ranged from 0.06 percent to 0.9 percent (Nobriga and Cadrett 2001). Typically for salmonids 1 – 2% of smolts survive to return as adults. At a 2% smolt to adult survival each steelhead smolt lost represents .02 adult or one potential adult for each 50 smolts lost at the pumps. A high percentage of the unclipped steelhead captured at the CVP salvage facility in 2003 had fin erosion indicating they were likely hatchery fish that missed getting clipped. These fish are currently counted as unclipped and assumed to be wild. Lloyd Hess (personal communication 2003) recommended updating the data sheet to include unclipped steelhead that display physical characteristics of hatchery reared steelhead. Table 4–7 shows total salvage of unclipped steelhead from 1993 through March 2003 and Table 4–8 shows average salvage of steelhead (clipped and unclipped) from 1981 through 2002.

Table 4–6 Combined marked and unmarked steelhead salvage for the 1994 through 2002 emigration seasons (for example, 1994 = October 1993 through July 1994), and percentage of combined salvage occurring between the December through June period depicted in Figure 3-3.

Emigration season	*Combined salvage*	*Percent of salvage from December through June*
1992	18,729	100
1993	18,583	100
1994	1,594	100
1995	2,605	100
1996	5,376	100
1997	1,057	88
1998	926	82
1999	2,544	99.5
2000	9,463	96
2001	12,909	99
2002	3,590	100

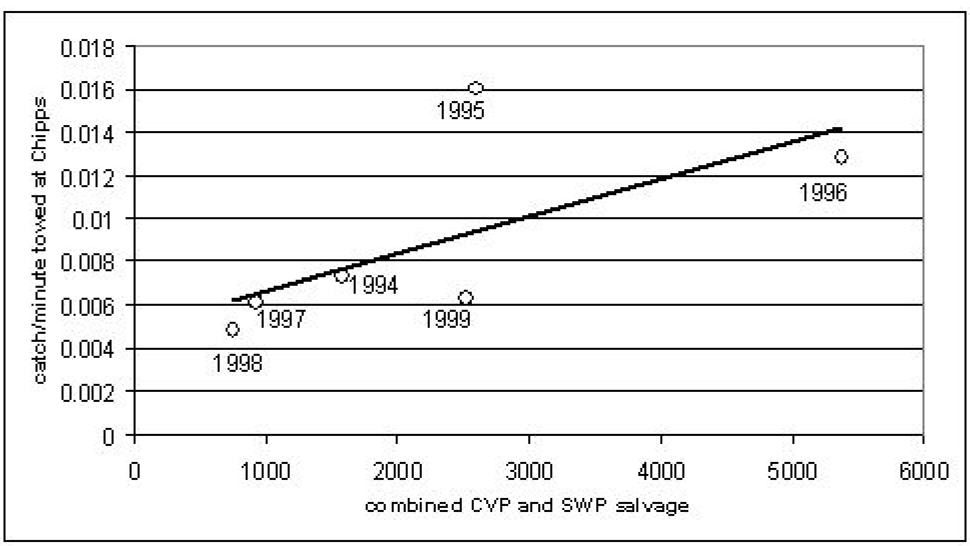


Figure 4–3 Relationship between total combined CVP and SWP steelhead salvage December through June, and December through June steelhead catch per minute trawled at Chipps Island, December 1993 through June 1999.

This was apparently not the typical historical emigration pattern for the majority of Central Valley spring-run Chinook (NOAA Fisheries 1998). Yearling emigration occurs from October-March and may be triggered in part by precipitation events. In some years however, under certain flow and/or water temperature conditions, greater proportions of juveniles in Mill and Deer Creeks may emigrate as fry or fingerlings soon after emergence. The bulk of Butte and Big Chico Creek production emigrates as fry from natal tributaries in December and January (Brown 1995 as cited in DFG 1998). Some also emigrate as fingerlings from February through May, and as yearlings from October through February. In contrast, no yearling emigration has been detected in the Feather River (DWR 1999c, 1999d).

Juvenile rearing habitat must provide adequate space, cover, and food supply (DFG 1998). Optimal upstream habitat includes abundant in stream and overhead cover (for example, undercut banks, submergent and emergent vegetation, logs, roots, other woody debris, and dense overhead vegetation) to provide refuge from predators, and a sustained, abundant supply of invertebrate and larval fish prey. Further downstream, fry use low velocity areas where substrate irregularities and other habitat features create velocity refuges and they may increasingly rely on turbidity as cover (Gregory and Levings 1998).

Juvenile Chinook, including spring-run also rear in ephemeral habitats including the lower reaches of small intermittent streams (Maslin et al. 1997) and in floodplain areas (Sommer et al. 2001b). Growth rates and mean condition factors were higher for juvenile Chinook rearing in intermittent tributaries than in the heavily channelized Sacramento River (Moore 1997). Similarly, growth rates and bioenergetic status was found to be significantly higher for juvenile Chinook rearing in the intermittent habitat of the Yolo Bypass floodplain than in the adjacent reach of the Sacramento River (Sommer et al. 2001b). These results highlight the importance of off-channel habitats to young Central Valley salmon.

It is not known how similar the rearing patterns of Central Valley spring-run are to the fall-run since the Delta rearing patterns of spring-run Chinook have not been studied. Juvenile emigration is thought to alternate between active movement, resting, and feeding. The amounts of time spent doing each are unknown (DFG 1998), but studies have generally shown feeding is most intense during daylight or crepuscular periods (Sagar and Glova 1988). Juvenile outmigration monitoring results from throughout the Central Valley and elsewhere indicate active emigration is most prevalent at night. Juvenile fall-run salmon may rear for up to several months within the Delta before ocean entry (Kjelson et al. 1982). Rearing within the Delta occurs principally in tidal fresh water habitats. Juveniles typically do not move into brackish water until they have undergone smoltification, after which NOAA Fisheries studies indicate they move quickly to the ocean.

Chironomidae (midges) are typically cited as an important prey for juvenile Chinook upstream of the Delta (Sasaki 1966; Merz and Vanicek 1996; Moore 1997; Sommer et al. 2001b), whereas crustaceans may be more important in the western Delta (Sasaki 1966; Kjelson et al. 1982). Juvenile Chinook diets often vary by habitat type, resulting in differences in caloric intake and growth rate (Rondorf et al. 1990; Moore 1997; Sommer et al. 2001b). However, it remains unclear whether these spatial differences in feeding and growth translate into improved survival (Sommer et al. 2001b).

Before entering the ocean, juvenile Chinook undergo smoltification, a physiologic transformation that prepares them for the transition to salt water (Moyle 1976). The transformation includes lowered swimming stamina and increased buoyancy, which make the fish more likely to be passively transported by currents (Saunders 1965, Folmar and Dickhoff 1980, Smith 1982, all as cited in DFG 1998). It is believed to be optimal for smoltification to be completed as fish near the low salinity zone of an estuary (DFG 1998). Too long a migration delay after the process begins may cause the fish to miss a biological window of optimal physiological condition for the transition (Walters et al. 1978, as cited in DFG 1998). Chinook salmon that complete the juvenile and smolt phases in the 50° F to 64° F range are optimally prepared for saltwater survival (Myrick and Cech 2001). The optimal thermal range during smoltification and seaward migration was estimated to be 50° F to 55° F (Boles et al. 1988), based largely on studies of steelhead and Coho salmon in the Northwest.

Ocean Distribution

CWT recoveries from harvested hatchery released spring–run provide information on ocean distribution and harvest of adult spring–run. Table 5–2 shows that most recoveries of hatchery released spring–run (all from Feather River Hatchery) occur off the California Coast but some do occur along the Oregon Coast. Recent CWT studies conducted on Butte Creek spring-run have shown 12% in the Garibaldi to Coos Bay area, 14% Crescent City to Fort Bragg, 44% Fort Ross to Santa Cruz, and 30% Monterey to Point Sur (DFG 2003).

Table 5–2 Recovery locations of hatchery released spring-run and estimated number recovered, 1978 – 2002 (RMIS database). All are from the Feathery River Hatchery. Location identifiers with less than 8 recoveries (48 of them) are not shown.

Sum of estimated_number	run_year																						
recovery_location_name	1978	1979	1980	1981	1983	1984	1985	1986	1987	1988	1989	1990	1993	1994	1995	1996	1998	1999	2000	2001	2002	Grand Total	percentag
FORT ROSS-PIGEON PT	787	1,981	539	51	12	177	248	400	412	488	404		11	96	236	8	129	568	430			**6,976**	**23.3%**
FEATHER RIVER																			414	42	4,412	**4,867**	**16.2%**
PIGEON PT.-POINT SUR	159	478	219	14		116	33	375	320	260	186	17		5	216	22		244	970	744	315	**4,693**	**15.7%**
FEATHER R HATCHERY																			342	749	420	**1,511**	**5.0%**
NEWPORT TROLL 4						6	3	60	58	104	66				60	6		37	63	773	236	**1,470**	**4.9%**
PT.REYES-PIGEON PT.																				631	829	**1,460**	**4.9%**
C.VIZCAINO-NAVARR.HD	87	424	71	8		9	16	84	15	140	24				6	5		11	23	57	89	**1,068**	**3.6%**
FORT ROSS-POINT SUR											139	10		24	45			551	280			**1,049**	**3.5%**
COOS BAY TROLL 5						5	18	106	60	118	58	4						107	108	298	108	**989**	**3.3%**
POINT SUR-CA/MEX.BOR						4		141	95	60				10	168	3			146	76	41	**744**	**2.5%**
PT.ARENA-PT.REYES																				476	239	**715**	**2.4%**
SPAN.FLAT-C.VIZCAINO						15	18	81	85	149	44	3			3			14	33	60	55	**560**	**1.9%**
BIG LAG.-CENTERV.BEA	8	147	15		3		20	11	53	3	18	3			5			35	29	54	33	**438**	**1.5%**
NAVARRO HD-FORT ROSS							5	32	154	44	11			2					2			**249**	**0.8%**
COLUSA TO RBDD																				239		**239**	**0.8%**
GARIBALDI TROLL 3								14	11	10	5				12			15	19	94	38	**218**	**0.7%**
AMERICAN RIVER																			43		126	**169**	**0.6%**
SPAN.FLAT-PT.ARENA																				32	135	**167**	**0.6%**
CA/OR BOR-FA.KLAM.RC	18	20	4	4		31	17	6	14	8	16								14	5		**157**	**0.5%**
WINCHESTER B TROLL 5							4	29	15	33	18							11	12	25	5	**153**	**0.5%**
LOW FLOW AREA																				153		**153**	**0.5%**
WINCHESTER B SPORT 5					4		3		14	26	2								10	56	29	**144**	**0.5%**
BROOKINGS SPORT 6					3	2	22	3	28	27	4	2				2		3	7	18	21	**142**	**0.5%**
NAVARRO HD-PIGEON PT										40	66											**106**	**0.4%**
PIGEON PT-CA/MEX.BOR															11			2	38		37	**88**	**0.3%**
MARINE AREA 2						1	6	9	10	19	2						3	19		9	8	**85**	**0.3%**
AMER.R. TO COLUSA																				40	40	**80**	**0.3%**
SIUSLAW BAY TROLL 5									12	29	14							10	6			**71**	**0.2%**
HIGH FLOW AREA																				66		**66**	**0.2%**
SPAN.FLAT-NAVARRO HD										41	11								8			**60**	**0.2%**
PORT ORFORD TROLL 5								3	3	1	5							5	2	23	11	**53**	**0.2%**
C.VIZCAINO-FORT ROSS										28	10							13				**50**	**0.2%**
CA/OR BDR.- HMBT.JET																				27	21	**48**	**0.2%**
PT.REYES-PT.SUR																				40	4	**44**	**0.1%**
NEWPORT TROLL 5							1		11		1							2	3	12	13	**44**	**0.1%**
MARINE AREA 4									4	7	3	3						12	3	7	2	**40**	**0.1%**
BROOKINGS TROLL 6								12	9	4				2				6	2	3		**38**	**0.1%**
NEWPORT SPORT 4					3		3	3											6	12	7	**34**	**0.1%**
COOS BAY TROLL	6	17	11																			**34**	**0.1%**
BROOKINGS TROLL		30		2																		**32**	**0.1%**
BATTLE CREEK																				17	15	**32**	**0.1%**
COOS BAY SPORT 5								4		4									5	4	15	**32**	**0.1%**
ASTORIA TROLL 2							2	5		9										10		**27**	**0.1%**
MARINE AREA 1	4	3						5		3								3			7	**25**	**0.1%**
YUBA RIVER																			2		21	**23**	**0.1%**
COOS BAY TROLL 4															7					10	4	**22**	**0.1%**
PT.ARENA-PIGEON PT.																					20	**20**	**0.1%**
ASTORIA SPORT 2																				15	4	**19**	**0.1%**
PT.SN.PEDRO-PIGN.PT.																				6	14	**19**	**0.1%**
NEWPORT TROLL		19																				**19**	**0.1%**
RBDD TO ACID																				18		**18**	**0.1%**
TEHAMA-COLUSA FF		4	8	2		1	2															**17**	**0.1%**
NEWPORT TROLL 3								2	1		6									5	3	**17**	**0.1%**
WSPT LONG BE											14							3				**17**	**0.1%**
1A PLUS 1B										16												**16**	**0.1%**
DEPOE BAY SPORT 4								2	2	2								1			10	**16**	**0.1%**
FLORENCE SPORT 5									4	9	2											**15**	**0.0%**
SWTR 114-000						8				4												**13**	**0.0%**
1A (BUOY10 - BRIDGE)																				6	6	**12**	**0.0%**
WSPT CREE IS																			12			**12**	**0.0%**
OCEAN SPORT AREA 72						4			4	2												**10**	**0.0%**
MARINE AREA 3										9								1				**10**	**0.0%**
FA.KLA.RC-BIG LAGOON										10												**10**	**0.0%**
SWTR 111-000										10												**10**	**0.0%**
CLEAR CREEK																				7	3	**9**	**0.0%**
PACIFIC CITY TROLL 3									3	6												**9**	**0.0%**
SWTR 021-000						9																**9**	**0.0%**
HIGH SEAS 1 47N 124W																			9			**9**	**0.0%**
MARINE AREA 5 TROLL									7	2												**8**	**0.0%**
SWTR 023-234						8																**8**	**0.0%**
COLEMAN NFH			1						5	2												**8**	**0.0%**
OCEAN SPORT AREA 82							3		2		2											**8**	**0.0%**
NWTR 025-000										4								4				**7**	**0.0%**

Winter–run Life History and Habitat Requirements

The following information on winter-run Chinook salmon biology is from the proposed winter-run Chinook recovery plan (NOAA Fisheries 1997).

Adult winter–run Chinook salmon return to freshwater during the winter but delay spawning until the spring and summer. Juveniles spend about five to nine months in the river and estuary systems before entering the ocean. This life history pattern differentiates the winter–run Chinook from other Sacramento River Chinook runs and from all other populations within the range of Chinook salmon (Hallock and Fisher 1985, Vogel 1985, DFG 1989).

In addition to their unique life history patterns, the behavior of winter-run Chinook adults as they return to spawn differentiates the population. Adults enter freshwater in an immature reproductive state similar to spring-run Chinook, but winter-run Chinook move upstream much more quickly and then hold in the cool waters below Keswick Dam for an extended period before spawning (Moyle et al. 1989.)

The habitat characteristics in areas where winter-run adults historically spawned suggest unique adaptations by the population. Before construction of Shasta Dam, winter-run Chinook spawned in the headwaters of the McCloud, Pit, and Little Sacramento Rivers and Hat Creek as did spring-run Chinook salmon. Scofield (1900) reported that salmon arriving "earlier" than spring-run (presumable winter–run) ascended Pit River Falls and entered the Fall River while the succeeding spring-run Chinook remained to spawn in the waters below. This implies that winter-run Chinook, unlike the other runs, ascended to the highest portions of theheadwaters, and into streams fed mainly by the flow of constant-temperature springs arising from the lavas around Mount Shasta and Mount Lassen. These headwater areas probably provided winter-run Chinook with the only available cool, stable temperatures for successful incubation over the summer (Slater 1963).

Adult Spawning Migration and Distribution

Sacramento River winter-run Chinook salmon enter San Francisco Bay from November through May or June. Their migration past RBDD at river mile 242 begins in mid-December and continues into early August. The majority of the run passes RBDD between January and May, with the peak in mid-March (Hallock and Fisher 1985). In general, winter-run Chinook spawn in the area from Redding downstream to Tehama. However, the spawning distribution, as determined by aerial redd surveys is somewhat dependent on both the operation of the gates at RBDD, river flow, and probably temperature. At present, winter-run Chinook salmon are found only in the Sacramento River below Keswick Dam.

Timing of spawning and fry emergence

Winter-run Chinook spawn from late-April through mid-August with peak spawning in May and June. Fry emergence occurs from mid-June through mid-October. Once fry emerge, storm events may cause en masse emigration pulses. Martin et al. (2001) evaluated brood years (BYs) 1995-99 and found that emergence began in July during all BYs with peak dispersal occurring in September.

Juvenile Emigration

During 1995-1999 the pre-smolt/smolt emigration (> 45 mm fork length) started in September with 100 percent of production passing RBDD two to three months prior to the next BY. Between 44 and 81 percent of winter-run production used areas below RBDD for nursery habitat and the relative utilization above and below RBDD appeared to be influenced by river discharge during fry emergence (Martinet al.,2001). Emigration past Red Bluff (RM 242) may begin in late July, generally peaks in September, and can continue until mid-March in drier years (Vogel and Marine 1991). They are found above Deer Creek from July through September and spread downstream to Princeton (RM 164) between October and March (Johnsonet al.,1992). The peak emigration of winter-run through the Delta generally occurs from January through April, but the range of emigration may extend from September up to June. Distinct emigration pulses appear to coincide with high precipitation and increased turbidity (Hood 1990).

Scale analysis indicates that winter-run Chinook smolts enter the ocean at an average FL of about 118 mm, while fall-run smolts average about 85 mm FL (DFG unpublished data). This suggests that winter-run juveniles reside in fresh and estuarine waters for five to nine months, exceeding freshwater residence of fall-run Chinook by two to four months.

It is believed that winter-run Chinook salmon, like all Central Valley Chinook, remain localized primarily in California coastal waters. Coded wire tag returns indicate that only 4 percent of winter–run hatchery production recoveries from ocean waters occurred in Oregon (RMIS database).

Historical and Current Distribution and Abundance of Winter-run Chinook Salmon

The following is a summary of original winter–run distribution from Yoshiyama et al. (2001). The winter–run, unique to the Central Valley (Healey 1991), originally existed in the upper Sacramento River system (Little Sacramento, Pit, McCloud and Fall Rivers) and in Battle Creek. There is no evidence that winter runs naturally occurred in any of the other major drainages before the era of watershed development for hydroelectric and irrigation projects. The winter–run typically ascended far up the drainages to the headwaters (CFC 1890). All streams in which winter–run were known to exist were fed by cool, constant springs that provided the flows and low temperatures required for spawning, incubation, and rearing during the summer season (Slater 1963) when most streams typically had low flows and elevated temperatures.

Access to approximately 58 percent of the original winter–run habitat has been blocked by dam construction (Table 5–3). The remaining accessible habitat occurs in the Sacramento River below Keswick Dam and in Battle Creek. Access to all of the original winter-run spawning habitat in the Sacramento River was blocked by Shasta and Keswick Dams. The population now spawns downstream of Keswick Dam. Until recent years, salmon passage was not allowed above the Coleman Hatchery barrier weir. In recent years there have been no winter–run spawning in Battle Creek. All winter–run production occurs in the Sacramento River (DFG 2003).

Table 5–3 Historical upstream limits of winter–run Chinook salmon in the California Central Valley drainage (from Yoshiyama et al. 2001).

Stream	*Upstream distributional limit*	Miles of stream historically available	Miles of stream currently available	Miles lost	Percent lost
Mainsteam Sacramento River	none	299	286	13	4
Pit River	Mouth of Fall River	99	0	99	100
Fall River	Source springs near Dana, about 9 miles above mouth				
McCloud River	Lower McCloud Falls	50	0	50	100
Upper (Little) Sacramento River	Vicinity of Box Canyon Dam (Mt. Shasta City) and Lake Siskiyou (Box Canyon Reservoir)	52	0	52	100
Battle Creek North Fork	Falls 3 miles above Volta Powerhouse	43	43[a]	0	0
Digger Creek	Vicinity of Manton, possibly higher				
South Fork	Falls near highway 36 crossing				
Total		543	329	214	39

[a] Yoshiyama et al. (2001) lists Battle Creek as having unobstructed passage for winter–run but according to Kier Associates (2000) the fish ladders around existing dams are ineffective and need replacement. Length of habitat below/above the lower barriers was not given.

Most of the winter–run production occurs in the Sacramento River. Yearly winter–run escapement is estimated by counts in traps at the top of fish ladders at RBDD (Figure 5–2). These counts show recent escapements are much reduced from escapements in the 1960s and 1970s. In recent years carcass escapement counts have been compared to ladder counts. The population estimates from carcass counts (Peterson estimates) showed higher numbers of winter–run than the ladder counts (Martin et al. 2001).

The Cohort Replacment Rate (CRR) is a parameter used to describe the number of future spawners produced by each spawner and is thus a measure of whether the population is increasing or decreasing. This spawner-to-spawner ratio is defined as the number of naturally produced and naturally spawning adults in one generation divided by the number of naturally spawning adults (regardless of parentage) in the previous generation. As such, the ratio describes the rate at which each subsequent generation, or cohort, replaces the previous one, and can be described as a natural CRR. When this rate is 1.0, the subsequent cohort exactly replaces the parental cohort and the population is in equilibrium, neither increasing or decreasing. When the rate is less than 1.0, subsequent cohorts fail to fully replace their parents and abundance declines. If the ratio is greater than 1.0, there is a net increase in the number of fish surviving to reproduce naturally in each generation and abundance increases.

Figure 5–3 shows that winter–run CRRs were generally less than one from 1967–90, i.e., the population was declining. CRRs have been greater than one every year since 1990 except 1998, indicating a generally increasing population in recent years. For these calculations, the escapement returns from each BY in subsequent years were divided by the total escapement in each parent BY. For any BY, the subsequent year class produced returned two years later as grilse, and three and four years later as adults. The calculations assumed that 5 percent of the adult returns were four-year olds, and 95 percent of adult returns were three-year olds, an average based on 2001 winter-run scale aging data (Alice Low, personal communication, 2002).

The number of grilse in the population is probably over-estimated in the current RBDD counts. Current RBDD estimates are based on the late portion of the run, passing the dam after May 15 when the dam gates are closed. Historically, when dam counts were made year-round, there was a greater proportion of grilse in the later portion of the run. The proportion of grilse tends to be highly variable from year to year. The carcass count escapement data is believed to provide better abundance estimates, but there is not enough carcass survey data yet to draw any conclusions. Table 5–4 shows a comparison between RBDD fish ladder counts and carcass counts.

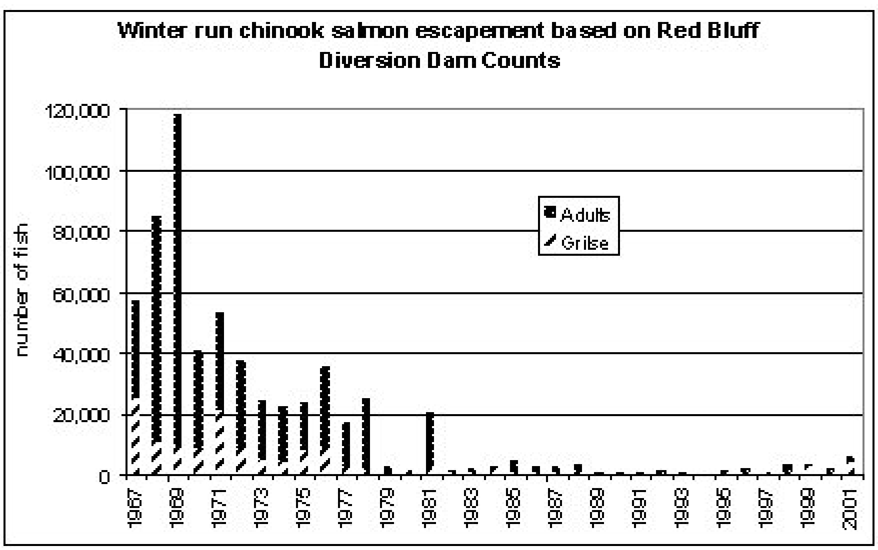


Figure 5–2 Sacramento River winter–run Chinook escapement based on RBDD counts.

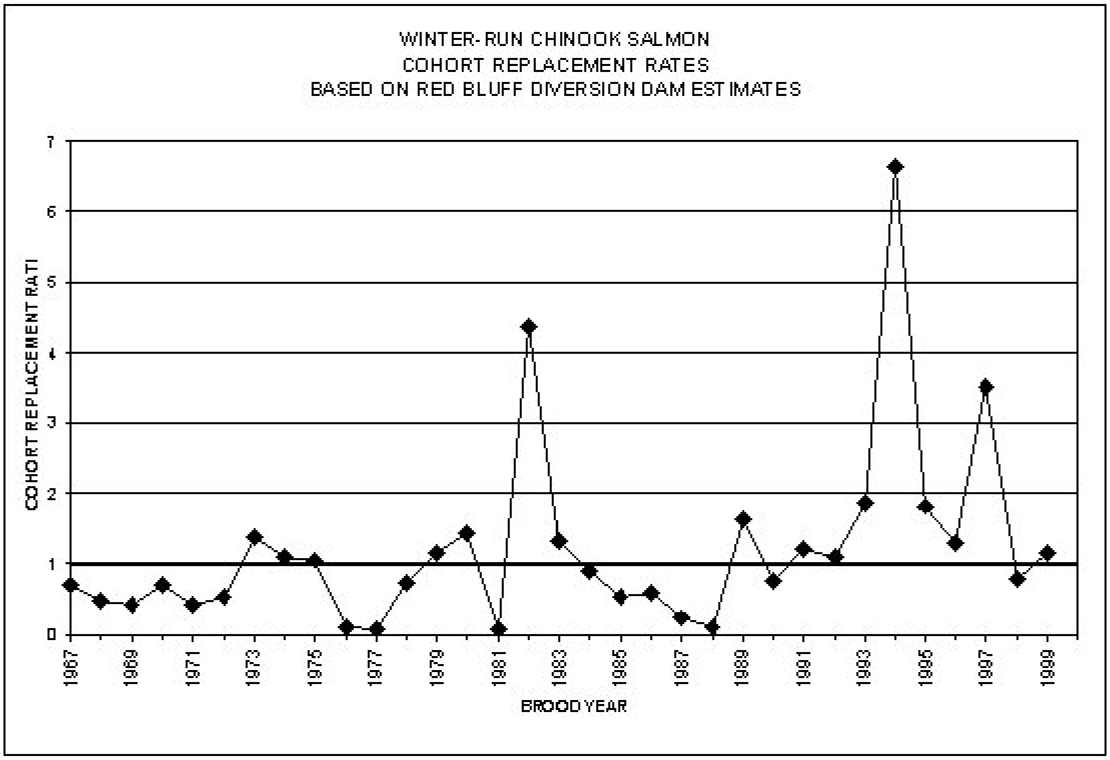


Figure 5–3 Sacramento River winter–run Chinook salmon CRRs based on RBDD escapement estimates.

Rates were calculated by taking the BY escapement and dividing it by the sum of grilse two years later, three-year olds three years later, and four-year olds four years later assuming that 95 percent of adults are three-year olds and 5 percent are four years old, ie the 1999 CRR is based on adult returns in 2000 - 2002 (age distributions based on 2001 scale data).

Table 5–4 Comparison of RBDD winter-run Chinook escapement v. carcass count (Peterson estimate) winter-run escapement.

	Grilse RBDD	Adult RBDD	Total RBDD	Carcass Count
1996	629	708	1,337	820
1997	352	528	880	2,053
1998	924	2,079	3,002	5,501
1999	2,466	822	3,288	2,262
2000	789	563	1,352	6,670
2001	3,827	1,696	5,523	12,797
		Mean	2,564	5,017
		Standard Deviation	1,748	4,416

Aerial redd counts provide information on spatial distribution of spawners and number of redds constructed by winter–run Chinook. The California Department of Fish and Game conducted yearly aerial redd surveys for Chinook spawning in the upper Sacramento River since 1969. The surveys attempted to enumerate winter-run redds beginning in the 1980s. Table 5–5 shows the distribution of redds by reach summarized by time period. RBDD gate operations were changed from1989-93 to the current September 15 through May 15 gates up operation. Redd distribution showed a clear shift to nearly all redds now occurring in locations upstream of RBDD. New fish ladders at the ACID diversion dam began operating in 2001. Almost no winter–run redds were counted upstream of the ACID dam prior to 2001. Surveys counted 484 winter–run redds upstream of the ACID dam in 2001 and 297 redds in 2002. Table 5–5 shows winter–run spawning distribution since 2001. The spawning distribution over this period is used in the temperature model for assessing water temperature effects on spawning and incubating Chinook salmon eggs.

Table 5–5 Sacramento River winter-run Chinook salmon spawning distribution from aerial redd surveys grouped by 1987-92, 1993-2002, and all years combined (data source: Killam 2002).

River Reach	Years 87-92	Yearly average	% distrib.	Years 93-2002	Yearly average	% distrib.	Years 87-2002	Yearly average	% distrib.
Keswick to A.C.I.D. Dam.	17	3	1	836	84	20	853	53	14
A.C.I.D. Dam to Highway 44 Bridge	411	69	23	1211	121	29	1622	101	27
Highway 44 Br. to Airport Rd. Br.	544	91	30	1883	188	45	2427	152	40
Airport Rd. Br. to Balls Ferry Br.	159	27	9	118	12	3	277	17	5
Balls Ferry Br. to Battle Creek.	62	10	3	65	7	2	127	8	2
Battle Creek to Jellys Ferry Br.	88	15	5	15	2	0	103	6	2
Jellys Ferry Br. to Bend Bridge	166	28	9	55	6	1	221	14	4
Bend Bridge to Red Bluff Diversion Dam	23	4	1	0	0	0	23	1	0
Red Bluff Diversion Dam to Tehama Br.	226	38	12	12	1	0	238	15	4
Tehama Br. To Woodson Bridge	124	21	7	0	0	0	124	8	2
Woodson Bridge to Hamilton City Br.	4	1	0	0	0	0	4	0	0
Hamilton City Bridge to Ord Ferry Br.	0	0	0	0	0	0	0	0	0
Ord Ferry Br. To Princeton Ferry.	0	0	0	0	0	0	0	0	0
Total	1824	304	100	4195	420	100	6019	376	100

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