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# STEELHEAD RESTORATION PLAN

# FOR

# THE AMERICAN RIVER

November 1991

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State of California
The Resources Agency
DEPARTMENT OF FISH AND GAME

# STEELHEAD RESTORATION PLAN FOR THE AMERICAN RIVER

by

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1991

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# INTRODUCTION

Steelhead trout, *Oncorhynchus mykiss*, were once abundant in California coastal and Central Valley drainages, from the Mexican to the Oregon borders. Population numbers have declined significantly in recent years, especially in the tributaries of the Sacramento River. The once-renowned steelhead fishery on the lower American River (below Nimbus Dam) has declined to such low levels in recent years that many have become concerned about the continued existence of the run. Without implementation of specific measures to restore the steelhead population, numbers will probably remain depressed or continue to decline.

This document provides management direction for the restoration and maintenance of the American River steelhead population. It is not intended to supersede other fishery management plans for the lower American River, but should be incorporated into overall management of the American River anadromous fishery. A major focus of this plan will be to increase natural production in the river, pursuant to Fish and Game Commission (FGC) directives and State policy. Objectives of this plan are:

1. To restore and maintain naturally produced steelhead as an integral component of the American River ecosystem, for its intrinsic values and for the maintenance of the biodiversity of the river environment.

2. To restore the population to a level which will sustain a quality steelhead fishery and provide for other, nonconsumptive uses.

The first objective can only be achieved by restoring the habitat conditions that are necessary for steelhead reproduction and survival. A major focus of this plan is to specify needed habitat conditions and to identify means to achieve these needed conditions so that natural, in-river production is maximized and maintained.

Anadromous fishes of the American River were relegated to the lower 23 miles of the river with the closure of Nimbus Dam in 1955, which marked the completion of the Folsom Unit of the Central Valley Project (CVP). Nearly all of the historical steelhead spawning and rearing habitat of the American River is located upstream of Nimbus Dam. Given the small percentage of steelhead habitat that remains, natural production alone will probably not be sufficient to restore the run to levels which can sustain a fishery and provide for adequate nonconsumptive uses. Therefore, supplementation of the population by artificial production will be necessary to achieve the second objective of this plan.

The recent court decision involving the Environmental Defense Fund et al. v. East Bay Municipal Utility District (EDF v. EBMUD) has focused much attention on the lower American River. This court case examined the adequacy of the current minimum flow standards and EBMUD's right to divert water at Lake Natoma via the Folsom South Canal. The court mandated that a multi-year cooperative study program be undertaken to address the lack of information regarding the biological and physical systems of the lower river. The Lower American River Fishery and Aquatic Resources Investigations, which is overseen by a court appointed Special Master, is currently developing a study plan and methodology to address the lack of information. The principal investigators in this program are the Department of Fish and Game (DFG), EBMUD, Sacramento County, and their representatives, and they will soon be initiating Phase 2 of their investigations.

Policies and laws pertaining to the management of steelhead in California are:

Steelhead Trout Policy, which places management emphasis on maintenance of habitat and precludes resident trout planting in steelhead waters.

Steelhead and Salmon Policy, which states that hatchery production will be limited to supplementation of natural production.

Trout and Steelhead Conservation and Management Act, which states that it is a policy of the State to maintain wild stocks of salmonids.

Salmon, Steelhead, and Anadromous Fisheries Program Act (SB2261), which mandates that:

1) DFG develop a program to significantly increase the natural production of salmon, steelhead, and other anadromous fishes by the year 2000.

2) Existing natural anadromous fish habitat shall not be diminished further without offsetting the impacts of the lost habitat.

3) It is a policy of the State to recognize and encourage the participation of the public in mitigation, restoration, and enhancement programs.

Fish and Game Mitigation Policy, which states that it is DFG's position that all potential impacts on fish and wildlife resources from development projects must be addressed and evaluated. DFG will seek implementation of means to prevent, or fully offset impacts to resources and losses of habitat.

Fish and Game Water Policy, which directs DFG to review and comment on water development projects and proposed projects affecting aquatic habitat, and to oppose the issuance of permits, licenses, and appropriations of funds for projects which have not prevented or adequately compensated for damages to aquatic resources.

## DESCRIPTION OF THE AREA

The lower American River flows from Nimbus Dam through the densely populated Sacramento metropolitan area to its confluence with the Sacramento River, a distance of 23 miles (Fig. 1). The upper one-half of the lower river is bounded on the north by an escarpment of 50 feet or more in height. The lower one-half is bounded by offset flood control levees designed to contain flood flows of 115,000 cubic feet per second (cfs). The channel in the upper reaches consists of extensive gravels and cobbles, while downstream it is mostly sand and gravel.

About 5,000 acres of floodplain and adjacent lands are administered by Sacramento County as the American River Parkway. Much of the Parkway consists of undeveloped riparian forests, grasslands, wetlands, and dredger tailings. It is considered to be a very valuable asset to the City, County, and State, as described in the following excerpt from Snider and Gerstung (1986):

> "The significance of the lower American River fish resources is clearly demonstrated by its economic and recreation contribution to the people of California. One out of every six salmon caught in the ocean commercial and sport fisheries is produced in the American River (U.S. Fish and Wildlife Service [USFWS] 1984). This annually accounts for over 1 million pounds of harvested salmon. In addition, between 150,000 and 200,000 angler days are annually spent on the river: the estimated annual yield averages 15,000

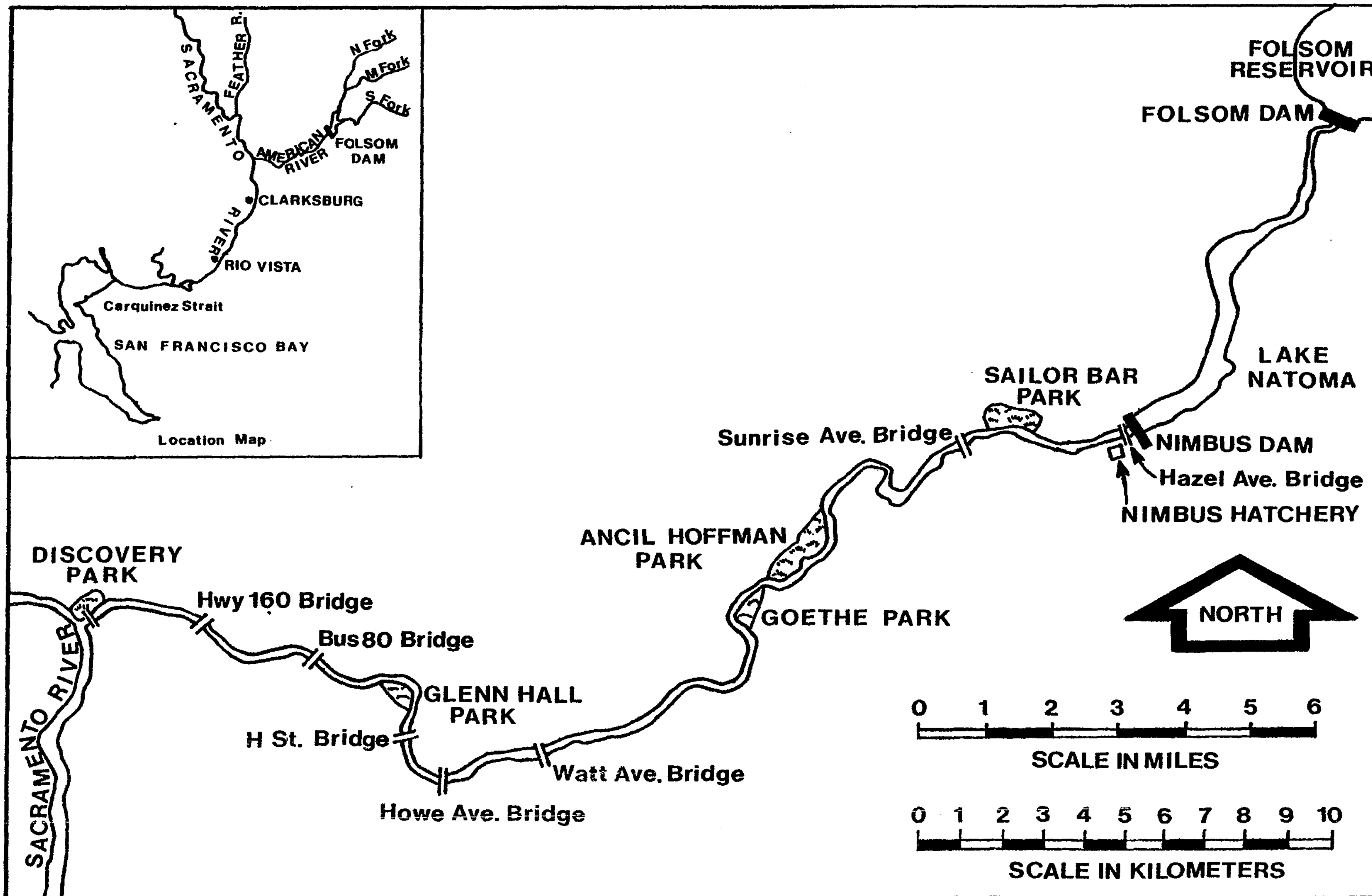


Figure 1. Lower American River, Sacramento County, California.

chinook salmon, 5,000 steelhead, 20,000 American shad, and 1,000 striped bass (Hooper 1970, Gerstung 1971, Staley 1976, Meinz 1981 and DFG file reports). The market and nonmarket values of the commercial and sport fisheries average $15 million and $24 million, respectively (Meyer 1985).

"The importance of the lower American River to the people of the State has been further demonstrated by federal, state and county governments. In recognition of its outstanding fishery and recreational attributes, the California Legislature included the lower American River in the State Wild and Scenic River System in 1972. Similarly, it was included in the National Wild and Scenic River System in 1980. The County of Sacramento and the State have also expended considerable time and expense to provide continued access and recreational use of the river and adjacent land, by establishing the American River Parkway."

## STEELHEAD POPULATIONS

### Native Runs

Relatively little is known about the native American River steelhead populations. The only available information prior to 1950 exists in the form of counts of steelhead passing through the fishway on the old Folsom Dam from 1943 through 1947. These counts show that the majority of steelhead were spring-run, which passed through the ladder in May, June, and July (USFWS and CDFG, 1953). Steelhead were counted in smaller numbers during all other months of the year except August and September. Counts of spring-run steelhead range from 200 in 1944 to 1,252 in 1946.

In 1950 flood waters destroyed the ladder and no attempt was made to rebuild it because Folsom Dam, which was to be a complete barrier to migrating fish, was under construction a short distance upstream. As a result, spring-run steelhead no longer had access to their upstream spawning and rearing areas and it is unlikely that these fish could have survived the high summer temperatures of the river below the ladder. Thus, the spring-run was probably eliminated shortly after 1950. Remnants of the fall and winter runs probably were able to survive by spawning in the lower river.

In 1955 Nimbus Dam was closed and this became the upstream terminus of anadromous fish migration. Construction of Nimbus Salmon and Steelhead Hatchery was completed in 1955 to mitigate for losses of salmon and steelhead caused by the construction of Folsom and Nimbus dams. In the winter of 1955-1956 the hatchery began to take adult steelhead for artificial production.

<u>Introduced Stocks</u>

Steelhead returns were low for the first four years of hatchery operation. This is probably a reflection of the poor condition of the population due to the lack of access to upstream spawning areas from 1950 to 1955, with no hatchery maintenance program to mitigate.

In response to the low number of returning adults in 1957, Nimbus Fish Hatchery began importing steelhead eggs from Snow Mountain Hatchery on the Eel River. This practice continued until 1962. The first returns of adult fish from this stock occurred in 1959; in 1960 these fish began to return in greater numbers. By 1963 the run had recovered to such a degree that egg importation to augment the hatchery take was no longer needed. In 1963 approximately 200 spawners were transferred to the Mokelumne River Fish Installation.

Summer-run steelhead eggs were imported from the Skamania Hatchery on the Washougal River, Washington in 1969, 1970, 1973, and 1974 and from the Roaring River Hatchery on the Siletz River, Oregon in 1971 (Meyer 1985). These fish were raised at Nimbus Hatchery and planted in the American and Sacramento rivers in an attempt to establish a summer-run fishery on the lower American River (Meyer 1985). This program was terminated in 1976 because of low returns and the fact that most of the adults did not begin to ascend the river until July or August, (the same time as the early fall-run migrants), thus negating any angling benefits.

To enhance the early migrant steelhead fishery on the lower American River, adult fall-run steelhead were trapped in the Sacramento River in 1972-73 and spawned at Nimbus Hatchery. The progeny of these fish were released into the American River as subyearlings and yearlings. There is no information available as to return rates or angler harvest and this program was not continued in subsequent years.

Because of a low return to the hatchery in 1978, steelhead eggs were imported from the Mad River Hatchery and raised at the Nimbus Hatchery. These fish were planted as yearlings.

In 1979 and 1980, another attempt was made to establish a summer-run on the lower American River. Eggs were imported from the Skamania Hatchery on the Washougal River, Washington, hatched at the Silverado Field Operations Base in Yountville, and raised at the Nimbus Hatchery. These fish were released into the Sacramento River in 1980 and 1981 as yearlings.

In 1980 and 1981, fingerlings and yearlings obtained from the Coleman National Fish Hatchery on Battle Creek were released in the American and Sacramento rivers.

In 1983, approximately 100,000 steelhead eggs were imported from Warm Springs Hatchery on the Russian River. Sixty-six thousand yearlings were raised and planted at Rio Vista.

In 1988 and 1989 approximately 500,000 steelhead eggs were imported from the Mad River Hatchery; these fish were planted as yearlings.

In 1990, approximately 235,000 steelhead eggs were imported from Warm Springs Hatchery on the Russian River. Yearlings raised from these eggs were planted in the Clarksburg vicinity of the Sacramento River.

Existing Populations

The destruction of the old Folsom Dam fish ladder, the closure of Nimbus Dam, and the introduction of exotic strains of steelhead have probably caused the extirpation of the native American River steelhead population. The existing run (referred to as the Nimbus strain) most closely resembles, in morphology and behavior, the Eel River strain from which it was probably derived. There is a run of smaller-sized steelhead that appear in the river in spring. These fish are possibly representatives of the native Central Valley fall-run strain (Fred Meyer, DFG Assoc. Fish. Biol., pers. comm.).

If introgression of the Nimbus strain has occurred, it was probably due to hybridization with the Washougal strain and possibly with the Coleman strain. The Washougal steelhead arrived at the hatchery at the same time as the Nimbus strain, which indicates they were probably spawning in the river at the same time (Ron Ducey, Nimbus Fish Hatchery Manager, pers. comm.). Other strains of steelhead that were introduced (Mad River, Warm Springs) were originally derived from Eel River stock (Ron Ducey, pers. comm.), therefore interbreeding with these strains has probably not led to significant hybridization of the Nimbus strain.

The existing Nimbus strain of steelhead ascends the American River in late summer and continues through March or April. The majority of the migration occurs from January through March, and this is the period when the hatchery takes spawners for egg production. Natural spawning takes place from December through April (Gerstung 1985). Fry emergence is dependent on water temperature, but usually occurs in April and May and can extend through June.

Because of limited rearing habitat and heavy angling mortality, Gerstung (1985) estimated that natural production contributed less than 5% to spawning escapement. Results of a fin marking experiment led Staley (1976) to conclude that the hatchery was producing the bulk of the run.

There are no comprehensive estimates available for current annual run size of American River steelhead. Staley's (1976) mark and recapture estimates for 1971-72 and 1973-74 (19,583 and 12,274, respectively) are the only estimates of American River steelhead run size available. Although hatchery counts are available for each year of hatchery operations, these are not good indicators of run size. These numbers represent fish that are observed or spawned in the hatchery and do not reflect fish that are denied access to the ladder before and after the hatchery takes fish for spawning.

Possible reasons for the decline of American River steelhead include: direct effects from the current 5-year drought; unknown repercussions from the 1986 flood event in the American River system; stressful temperatures in the lower American River for the past several years; rapid flow fluctuations and timing of water releases; yearling release site and timing; unknown ocean related problems; increased State Water Project (SWP) and CVP water exports. The latter problem is suspected of being a major impact on all Central Valley anadromous fish species but, because it is beyond the scope of this plan, will not be addressed in this document.

## HYDROLOGY

The American River watershed drains over 1,880 square miles. It originates at the crest on the west slope of the Sierra Nevada and is a tributary to the Sacramento River. The major tributaries are the North, Middle, and South forks of the American River. Numerous storage, hydroelectric, and diversion facilities in the watershed have greatly altered flow regimes. There are 14 major reservoirs on the American River with a total storage capacity of nearly 1.9 million acre feet (Table 1).

Table 1. Major storage facilities on the American River System.

| Facility | Capacity[1] |
|---|---|
| Folsom Lake | 1,010 |
| Union Valley Reservoir | 277 |
| Hell Hole Reservoir | 208 |
| French Meadows Reservoir | 134 |
| Loon Lake | 77 |
| Icehouse Reservoir | 46 |
| Caples Lake | 22 |
| Stumpy Meadows | 20 |
| Lake Edison | 20 |
| Slab Creek | 17 |
| Lake Clementine | 15 |
| Silver Lake | 12 |
| Lake Valley Reservoir | 8 |
| Lake Natoma | 8 |

[1]Capacity is in thousands of acre feet

## Project Development

The South Fork American River has been extensively developed for storage and power generation by the Pacific Gas and Electric Company and the Sacramento Municipal Utility District (Fig. 2). Major storage and hydroelectric facilities on the Middle Fork American River have been developed by the Placer County Water Agency (Fig. 3). There is relatively little water development on the North Fork American River (Lake Clementine, Lake Valley Reservoir, and Big Reservoir).

Folsom Dam was completed in 1955 and is the largest storage facility in the American River system with a capacity of 1,010,000 acre feet. Flow fluctuations from power generation at Folsom Lake are re-regulated by Lake Natoma which also serves as a diversion point for the Folsom South Canal. These facilities are controlled by the U.S. Bureau of Reclamation (USBR).

The only additional storage facility proposed on the American River system (North Fork American River) is Auburn Dam, which was initially designed to store 2.3 million acre-feet, more than all present storage facilities combined.

## Flow

The average yearly flow in the lower American River prior to and after construction of Folsom Dam has remained relatively unchanged, although the flow regime has changed greatly (State Water Resources Control Board 1988a) (Fig. 4).

Flows in the lower American River are currently regulated by State Water Resources Control Board (SWRCB) Decision 893 (D893). D893 requires a minimum flow release of 500 cfs from September 15 through January 1 and a minimum flow release of 250 cfs during the remainder of the year (Fig. 4). Flows have only approached these levels during the 1976-77 drought and during the current drought (water years 1989, 1990, and 1991). Available project water has not been fully utilized and flows have been relatively higher because project demands have not reached sufficient amounts to require minimum flows. However, with the recent listing of winter-run chinook salmon as threatened, water stored in Folsom Lake has been increasingly used to meet water quality standards in the Sacramento-San Joaquin estuary (Delta) and CVP water deliveries to agriculture. Water stored in Lake Shasta, which was previously used to meet Delta water quality standards, is now being held to

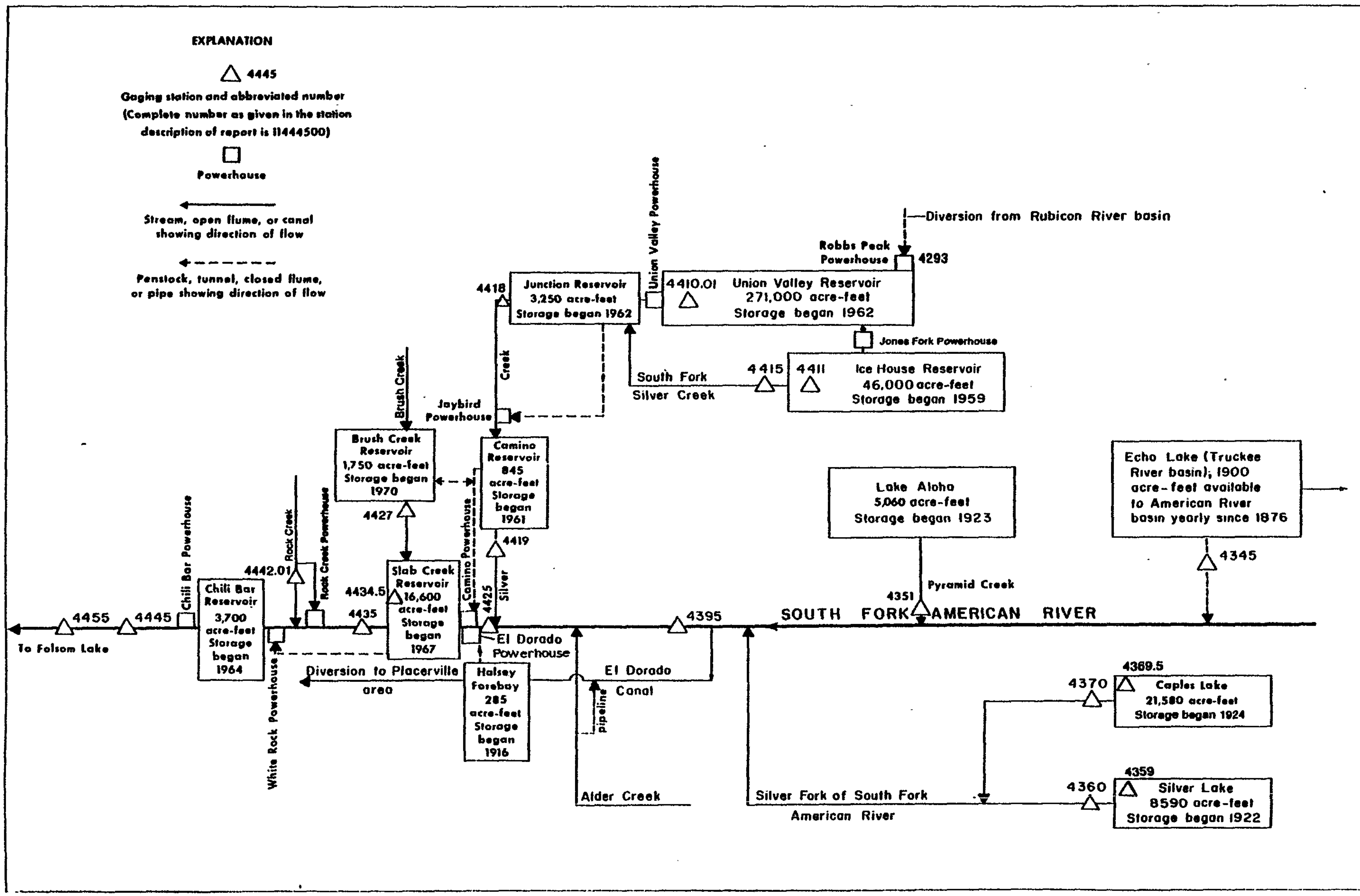


Figure 2. Diversions and storage in the South Fork American River Basin (from USGS Water Resources Data, California, 1989).



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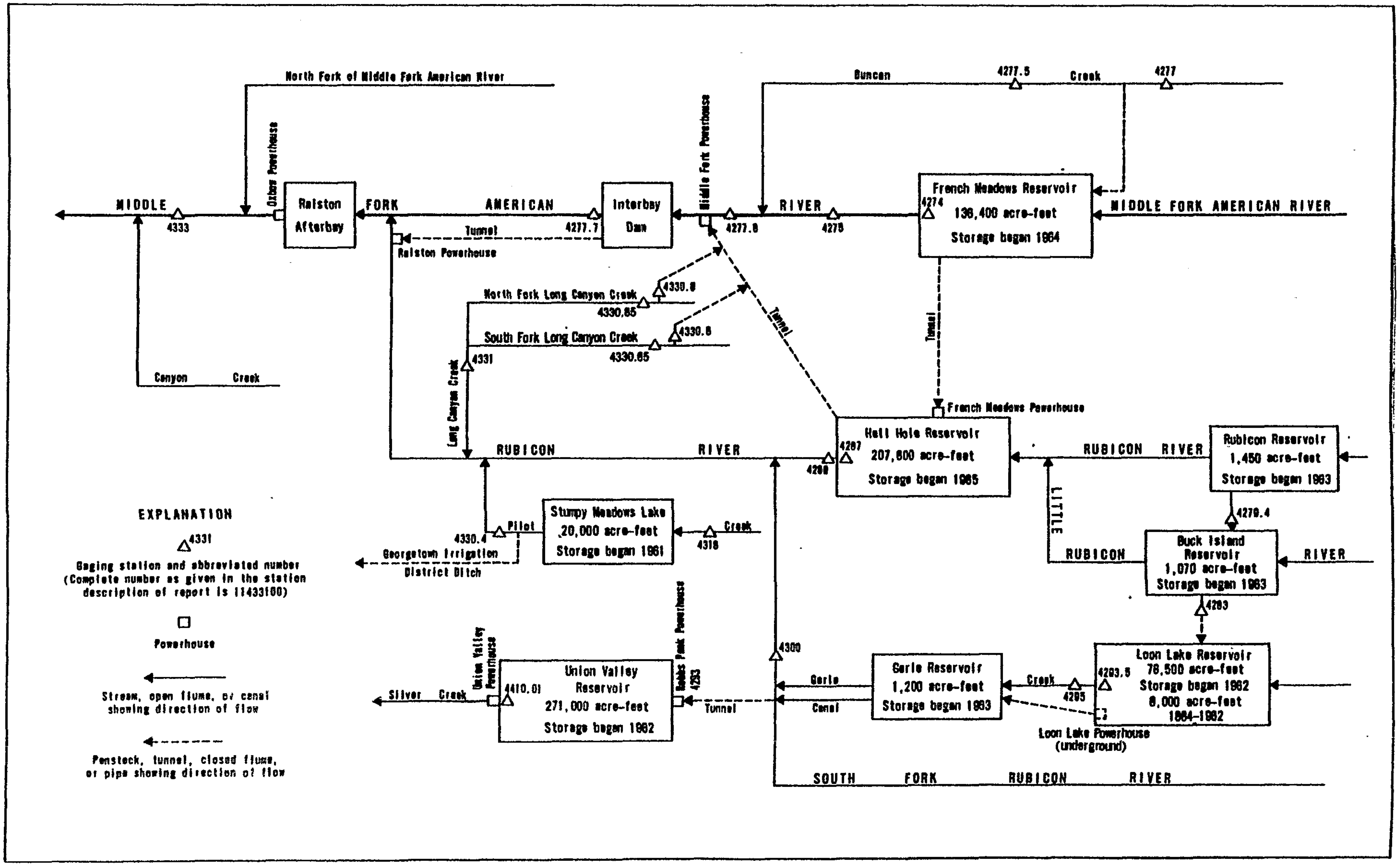


Figure 3. Diversions and storage in the Middle Fork American River Basin (from USGS Water Resources Data, California, 1989).

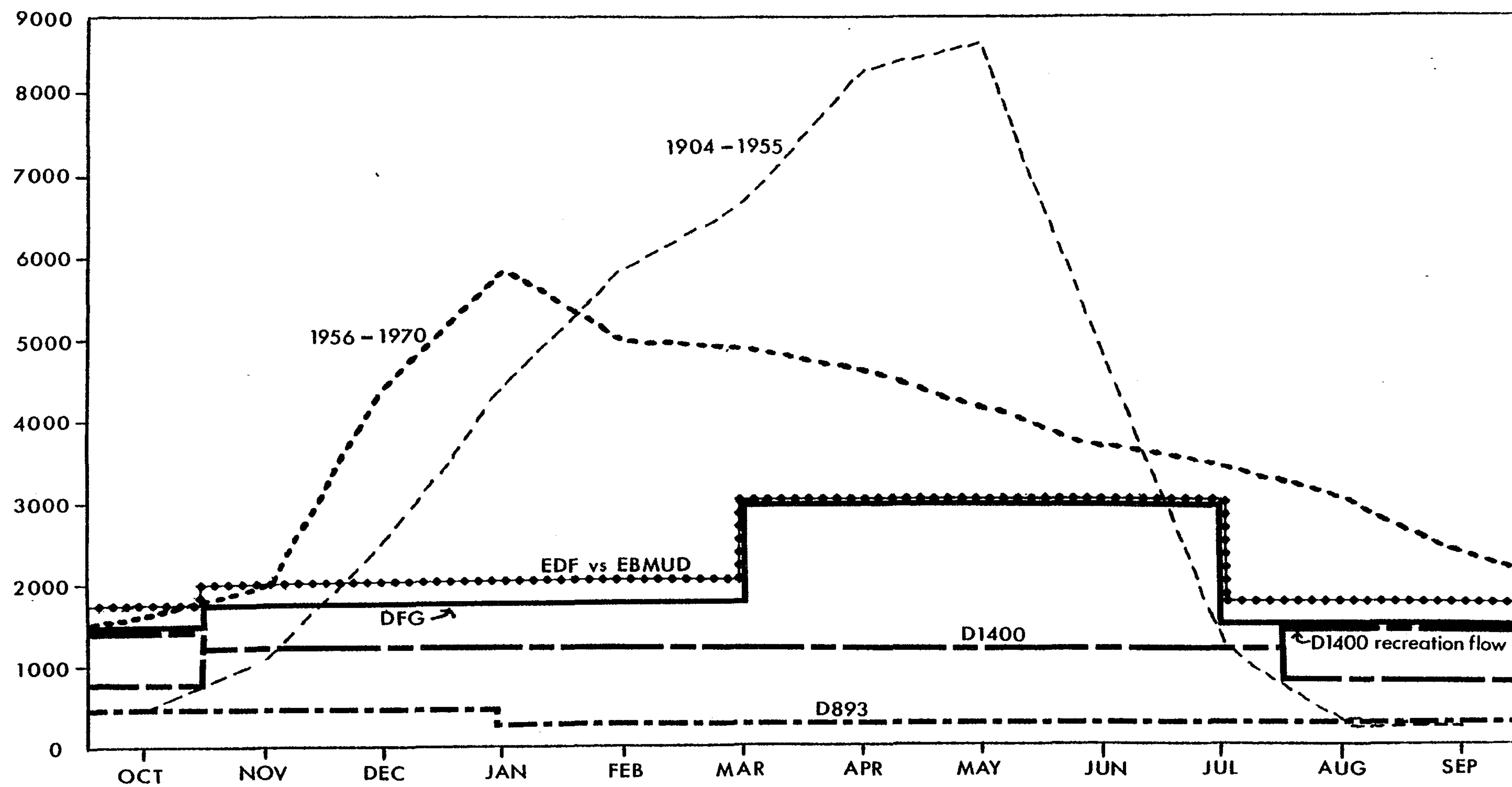


Figure 4. Comparison of current (D893) and proposed (D1400, EDF v. EBMUD, DFG) minimum flow standards for the lower American River with pre- and post- Folsom Project mean monthly flows (modified from Snider and Gerstung, 1986).

maintain maximum amounts of "cold" water for release during winter-run chinook salmon spawning and incubation.

The D893 water rights decision and corresponding flows in the lower American River will be superseded if Auburn Dam is built as originally proposed. Flows will be regulated by the SWRCB Decision 1400 (D1400) (Fig. 4). This would require fish maintenance flow releases of 1,250 cfs from October 15 through July 15 and 800 cfs during the remainder of the year. There is a 1,500 cfs recreational flow requirement from July 16 through October 14 which supersedes D1400 during this time period, except in dry and critically dry years (SWRCB 1988a).

Adherence to D1400 minimum flow standards would probably result in a reduction in flows for most years and could have significant effects on the anadromous fishes of the lower American River (Fig 4) when project water demands become greater. The USFWS (1980) estimates that a reduction in flow from the present regime to that specified in D1400 would destroy 43% of the existing chinook salmon run, reducing the run size from 46,000 to 26,500 fish. Reduction in steelhead numbers would probably be as drastic.

The EDF v. EBMUD court decision has challenged the adequacy of the above flows (D893 and D1400). Challenged were the proposed diversions to East Bay Municipal Utility District via the Folsom South Canal and the impacts on the instream beneficial uses and the flow necessary to maintain the resources in the lower American River (SWRCB 1988b, Snider and Gerstung 1986). This court decision establishes minimum flow standards that are much higher than D893 and D1400 standards: 3000 cfs between March 1 and June 30, 1750 cfs between July 1 and October 14, and 2000 cfs between October 15 and February 28 (Fig. 4). Because the court decision establishes these minimum flow requirements as conditions for diversion of water from the lower American River by EBMUD, the applicability of these standards to CVP operations when EBMUD is not diverting is in question. Until decided otherwise, D893 still governs minimum flow releases.

DFG has recommended a range of flows to optimize migration, spawning, and survival of salmon and steelhead (Snider and Gerstung 1986). The minimum flows of this range are very similar to the EDF v. EBMUD court established flows (Fig. 4). D893 standards are not adequate to maintain populations of salmon and steelhead, and releases such as those specified by DFG or the EDF v. EBMUD court decision are needed to maintain optimum steelhead production (Snider and Gerstung 1986).

## Flow Fluctuations

Because Folsom Reservoir is the nearest CVP facility to the Sacramento-San Joaquin estuary, it is extensively relied upon to provide outflow to meet Delta water quality standards. This results in rapid flow fluctuations in the lower American River as the USBR strives to meet these standards and deliver irrigation water to CVP contractors (Fig. 5). This situation has become more critical in recent years due to the need to maintain adequate conditions in the upper Sacramento River for winter run chinook salmon, which has resulted in an increase in the reliance on Folsom Reservoir to meet project obligations.

These fluctuations can be of great magnitude, both in terms of volume of discharge and surface elevations of the river. For example, releases from Nimbus changed from a daily mean flow of 329 cfs on June 1, 1990 to 7500 cfs on July 11, 1990, which resulted in a surface elevation change (at the Fair Oaks gauging station) of about five feet (Felix Smith, pers. comm.). Fluctuations of lesser magnitude but over shorter time periods are common.

There has been a change in timing of flow fluctuations also. Historically, fluctuations during the fall and winter were caused by natural rainfall patterns, but the dry season flows were low and steady (John Williams, court appointed Special Master, EDF v. EBMUD, pers. comm.). Varying water demands of the CVP have shifted the timing of these fluctuations to late spring and summer. The biological implications of this shift are not well understood.

Fluctuations can cause major impacts during the spawning and egg incubation period by exposing redds. Many of these fluctuations result in decreases of surface elevation which are within the range of preferred steelhead spawning depths (6-24 inches) (Bovee 1978) and can result in dewatering of redds, especially if the majority of spawning occurred while flows were high. Major fluctuations occurring at critical times will devastate a year-class of naturally-produced steelhead.

Rapid flow fluctuations have indirect effects on microhabitat as well. Rapid decreases cause a reduction in the littoral and backwater areas, which results in a reduction of available fish microhabitat and areas of high productivity. Increases followed by rapid decreases expose aquatic invertebrates that have colonized the newly wetted areas, resulting in disruption of life cycles and reduced production of fish food organisms. Rapid changes also reduce or alter available steelhead holding and rearing areas.

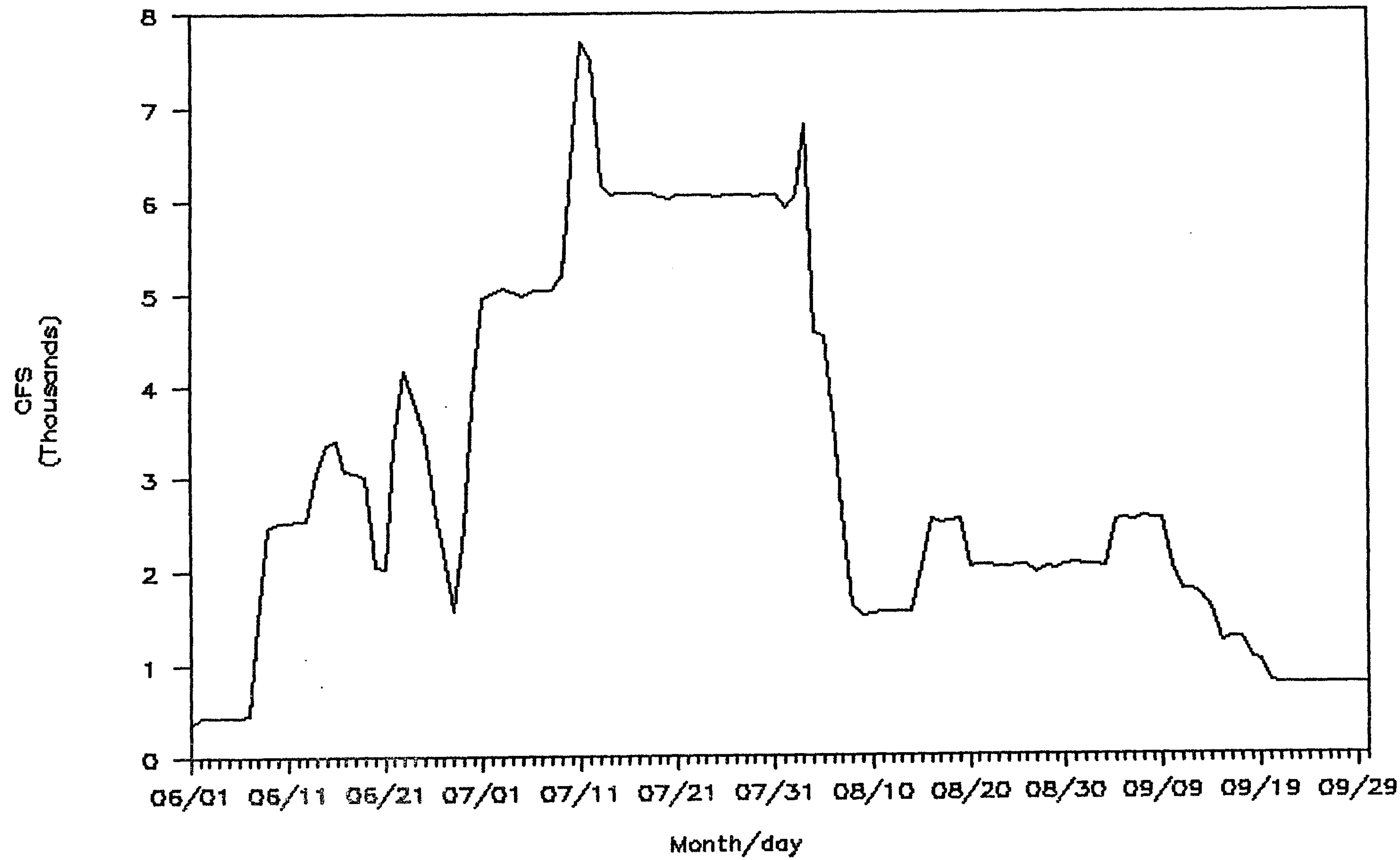


Figure 5. Mean daily flows in the lower American River, June 1 - Sept. 30, 1990.

Rapid fluctuations in flow result in stranding of substantial numbers of juvenile steelhead and salmon that are rearing in the river. When flows increase, juvenile salmonids not ready to emigrate will move to the littoral areas of the stream to avoid the high velocities in the main channel and to take advantage of the newly formed habitat. When flows suddenly decrease, many of these fish become trapped in isolated pools and backwaters, where they perish due to increasing water temperatures, decreasing oxygen, or predation. Fish rescue operations to move stranded juveniles back to the river are carried out by DFG personnel, are quite labor-intensive, and have a low rate of success.

The low stream gradient and wide floodplain of the lower American River renders it particularly susceptible to large-scale stranding of juvenile salmonids. Initial observations of the hydraulic characteristics of the lower American River indicate that the most critical stranding problems occur when flows are reduced below 1,500 cfs after a rapid increase in flow has occurred (William Snider, CDFG Assoc. Fish. Biol., pers. comm.). At or near this flow, the low gradient riffles associated with bar complexes become pockets of edgewater which become isolated from the main channel. It is in these areas that the majority of juvenile salmonids become stranded.

Flow fluctuations during the summer and fall may affect juvenile steelhead rearing habitat by increasing temperatures in the deeper pools and holding areas. These pools may be deep enough for temperature stratification to occur, which results in bottom temperatures that are more conducive to summer survival than what is measured and reported for the river. These areas may provide refugia for juvenile steelhead to survive high summer and fall temperatures.

Numerous flow fluctuations generate velocities that thoroughly mix the pools which result in a uniform temperature throughout. Rapid decreases could expose the cooler areas of the pools to warmer atmospheric conditions, resulting in warmer, more homogeneous temperatures throughout the pools. Temperature stratification of pools and deeper areas of the lower American River have not been investigated, but this research should be included in the <u>Lower American River Fishery and Aquatic Resources Investigations</u> mandated by the EDF v. EBMUD court decision (William Snider, pers. comm.).

Adoption of the flow standards set by the recent EDF v. EBMUD court decision (minimum flow of 1,750 cfs) should alleviate many of the problems associated with stranding and also provide for adequate microhabitat conditions, as described in Snider and Gerstung (1986). These flow conditions may not be adequate to maintain coldwater temperatures in the pools and holding areas necessary for over-summer survival of juveniles. More information about temperature gradients in these habitats is needed to assess the impacts of flow fluctuations on these habitats.

## HABITAT CRITERIA

Adult steelhead enter the lower American River from August through March with the peak of the run entering in January. Spawning occurs from December through April. The newly emerged fry move to quiet water areas associated with the stream margin. Soon after, they move to riffles which are optimum feeding locations. When they have grown to about 4 inches in length they move to slower, deeper water. They then spend up to 2 years in the river before migrating to the ocean. To maintain natural rearing habitat, suitable conditions must be maintained year round.

Microhabitat data have not been developed for steelhead in the lower American River. If specific habitat criteria data have not been developed for a specific species and system, it is DFG policy to use criteria presented by Bovee (1978) for all life stages of steelhead (Table 2).

### Depth

The preferred depth for steelhead spawning is approximately 14 inches and ranges from 6 to 24 inches (Bovee 1978). Fry prefer water approximately 8 inches in depth and utilize water 2 to 14 inches deep, while juveniles prefer a water depth of 10 inches but utilize water 10 to 20 inches deep (Bovee 1978).

### Velocity

Water velocities of 10 to 13 ft/s begin to greatly hinder the swimming ability of adult steelhead and may retard migration (Reiser and Bjornn 1979). Steelhead spawn in areas with water velocities ranging from 1 to 3.6 ft/s but prefer velocities of about 2 ft/s (Bovee 1978). The ability to spawn in higher velocities is a function of size: larger steelhead can establish redds and spawn in faster currents than smaller steelhead (Barnhart 1986).

Table 2. Habitat use criteria for three life stages of steelhead trout.

| Total depth | | Mean column velocity | | Substrate | |
|---|---|---|---|---|---|
| ft[1] | Probability | fps[2] | Probability | Code[3] | Probability |
| **Spawning** | | | | | |
| 0.00 | 0.00 | 0.00 | 0.00 | 0.0 | 0.00 |
| 0.40 | 0.00 | 1.00 | 0.00 | 4.0 | 0.00 |
| 0.50 | 0.20 | 1.15 | 0.08 | 4.3 | 0.40 |
| 0.85 | 0.60 | 1.40 | 0.40 | 5.0 | 0.84 |
| 1.00 | 0.94 | 1.50 | 0.60 | 5.4 | 1.00 |
| 1.15 | 1.00 | 1.70 | 0.80 | 5.6 | 1.00 |
| 1.22 | 1.00 | 1.85 | 0.96 | 5.7 | 0.96 |
| 1.40 | 0.88 | 2.00 | 1.00 | 6.0 | 0.26 |
| 1.90 | 0.40 | 2.20 | 0.96 | 6.2 | 0.10 |
| 2.20 | 0.20 | 2.70 | 0.64 | 6.5 | 0.00 |
| 2.60 | 0.08 | 3.30 | 0.20 | | |
| 2.80 | 0.04 | 3.70 | 0.00 | | |
| 3.00 | 0.02 | | | | |
| 3.50 | 0.00 | | | | |
| **Fry** | | | | | |
| 0.00 | 0.00 | 0.00 | 0.06 | 0.0 | 0.00 |
| 0.10 | 0.08 | 0.10 | 0.12 | 3.0 | 0.00 |
| 0.20 | 0.80 | 0.20 | 0.30 | 4.0 | 0.03 |
| 0.30 | 0.96 | 0.30 | 0.90 | 4.5 | 0.12 |
| 0.60 | 1.00 | 0.50 | 1.00 | 4.7 | 0.16 |
| 0.70 | 1.00 | 0.60 | 1.00 | 5.2 | 0.60 |
| 1.00 | 0.96 | 0.70 | 0.96 | 5.4 | 0.90 |
| 1.20 | 0.60 | 0.80 | 0.80 | 5.5 | 0.98 |
| 1.40 | 0.44 | 1.00 | 0.72 | 5.6 | 1.00 |
| 1.80 | 0.24 | 1.50 | 0.52 | 6.3 | 1.00 |
| 2.00 | 0.14 | 1.80 | 0.40 | 6.4 | 0.98 |
| 2.40 | 0.06 | 2.20 | 0.14 | 6.6 | 0.82 |
| 2.70 | 0.02 | 2.50 | 0.04 | 6.8 | 0.42 |
| 6.00 | 0.02 | 2.70 | 0.00 | 7.0 | 0.26 |
| | | | | 7.4 | 0.12 |
| | | | | 8.0 | 0.00 |

1 Feet

2 Feet per second

3 See Appendix A for definition of substrate codes



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Table 2. Continued.

| Total depth | | Mean column velocity | | Substrate | |
|---|---|---|---|---|---|
| ft[1] | Probability | fps[2] | Probability | Code[3] | Probability |
| Juvenile | | | | | |
| 0.00 | 0.00 | 0.00 | 0.00 | 0.0 | 0.00 |
| 0.30 | 0.20 | 0.10 | 0.00 | 3.0 | 0.00 |
| 0.60 | 0.66 | 0.20 | 0.20 | 4.0 | 0.18 |
| 1.00 | 0.96 | 0.28 | 0.90 | 4.4 | 0.26 |
| 1.20 | 1.00 | 0.45 | 0.97 | 5.0 | 0.44 |
| 2.00 | 0.64 | 0.60 | 1.00 | 5.4 | 0.60 |
| 3.00 | 0.35 | 1.20 | 1.00 | 6.0 | 0.96 |
| 4.00 | 0.13 | 1.40 | 0.97 | 6.1 | 1.00 |
| 5.00 | 0.00 | 1.50 | 0.96 | 6.8 | 1.00 |
| | | 2.30 | 0.40 | 6.9 | 0.96 |
| | | 2.50 | 0.16 | 7.0 | 0.88 |
| | | 3.00 | 0.04 | 7.4 | 0.40 |
| | | 4.20 | 0.00 | 8.0 | 0.00 |

[1] Feet

[2] Feet per second

[3] See Appendix A for definition of substrate codes

### Substrate

Adult steelhead have been reported to spawn in substrates from 0.2 to 4.0 inches in diameter (Reiser and Bjornn 1979). Based on the Bovee (1978) classification, the preferred substrate for spawning is gravel-sized material. Fry and juvenile steelhead prefer approximately the same size of substrate material (cobble/rubble) which is slightly larger than that preferred by adult steelhead for spawning (gravel) (Bovee 1978). The gravel must be highly permeable to keep the incubating eggs well oxygenated and should contain less than 5% (by volume) sand and silt.

At the present population levels, lack of adequate spawning gravels is probably not a limiting factor (Fred Meyer, DFG Assoc. Fish. Biol., pers. comm.). There are localized areas in the river where gravel is becoming sparse, particularly in the upper portion of the lower river (within a mile of Nimbus Dam). These areas had good spawning gravels in previous years (Fred Meyer, pers. comm.), but due to lack of gravel recruitment because of Nimbus Dam, spawning habitat has become less suitable. Studies proposed as part of the Lower American River Fishery and Aquatic Resources Investigation will be evaluating steelhead spawning requirements and should give insight into adequacy of spawning gravels.

### Temperature

The preferred water temperature for various life stages of steelhead are well documented (Bell 1986, Bovee 1978, Reiser and Bjornn 1979). These temperature ranges are:

| | |
|---|---|
| adult migration: | 46 to 52°F |
| spawning: | 39 to 52°F |
| incubation and emergence: | 48 to 52°F |
| fry and juvenile rearing: | 45 to 60°F |
| smoltification: | < 57°F |

A detailed discussion of water temperatures effects in the lower American River is given in the following section.

## WATER TEMPERATURE

Water temperature is a primary factor affecting growth and survival of fishes in the lower American River (Leidy et al. 1987). Anadromous salmonids are intolerant of high water temperature and they are more susceptible to water temperature-associated stress than other fish species inhabiting the lower American River (Rich 1987). As water temperature exceeds the optimum range, an increasing physiological burden is placed on the fish. Acute stress associated with exceedingly high temperature results in immediate death. Temperatures below this point, but higher than optimum, result in chronic stress which can reduce egg viability and decrease survival by lowering disease resistance, reducing growth rates, and decreasing the fish's ability to escape predators (Leidy et al. 1987). Fish compensate for temperatures that are higher than optimum either physiologically by increasing metabolism and reducing growth, or behaviorally by seeking cooler water. High water temperatures also create habitat conditions that are more favorable to warmwater predators, such as native squawfish and nonnative striped bass and sunfish.

The environmental factor that is probably the most limiting to natural production of steelhead in the American River is high water temperature during summer and fall (Snider and Gerstung 1986). Optimum rearing temperature of American River steelhead is between 39-60°F and temperatures exceeding this are considered stressful (Leidy et al. 1987, Rich 1987). Water temperature frequently exceeds 60°F at the Nimbus Fish Hatchery water intake during summer and fall, especially during July through October (Table 3). River temperatures further downstream are higher due to the increased exposure to warmer atmospheric conditions.

Water temperatures in the lower American River are not conducive to juvenile steelhead survival. Steelhead primarily spawn in headwater tributaries of large rivers, where water temperatures are cool enough for juvenile rearing. Prior to the construction of Folsom and Nimbus dams, the main portion of the American River steelhead run arrived in the lower American River in May and June and it is unlikely that these fish could have endured the high summer water temperatures in the lower river and survived to spawn the following winter. There is no evidence that steelhead spawned in the lower American River prior to the construction of Folsom and Nimbus dams (USFWS and DFG 1953). Juvenile steelhead probably don't survive the summer and fall in appreciable numbers, or they move out of the American River to seek cooler water. In any event, they aren't found in the lower American River in appreciable numbers in late summer or fall and they don't significantly contribute to the adult spawning population. Naturally-produced steelhead account for less than 5% of the American River run (Snider and Gerstung 1986).

Leidy et al. (1987), analyzed April through October temperature conditions in the lower American River under current (post-Folsom Dam) hydrologic conditions, using the

Table 3. Exceedance of upper limit of optimum rearing temperature for steelhead in the lower American River, April through November, 1981 - 1990. (source: Nimbus Fish Hatchery annual reports).

| | April | | May | | June | | July | |
|---|---|---|---|---|---|---|---|---|
| | max temp | no. days daily max exceeds 60°F | max temp | no. days daily max exceeds 60°F | max temp | no. days daily max exceeds 60°F | max temp | no. days daily max exceeds 60°F |
| 1981 | 57 | 0 | 61 | 1 | 62 | 21 | 64 | 31 |
| 1982 | 55 | 0 | 54 | 0 | ? | ? | 62 | 2 |
| 1983 | 52 | 0 | 57 | 0 | 66 | 1 | 60 | 0 |
| 1984 | 53 | 0 | 60 | 0 | 57 | 0 | 64 | 19 |
| 1985 | 57 | 0 | 57 | 0 | 61 | 2 | 66 | 30 |
| 1986 | 55 | 0 | 57 | 0 | 59 | 0 | 63 | 12 |
| 1987 | 59 | 0 | 63 | 11 | 64 | 23 | 66 | 31 |
| 1988 | 54 | 0 | 61 | 6 | 63 | 23 | 70 | 31 |
| 1989 | 55 | 0 | 55 | 0 | 59 | 0 | 63 | 22 |
| 1990 | 61 | 1 | 63 | 10 | 64 | 6 | 70 | 26 |

| | August | | September | | October | | November | |
|---|---|---|---|---|---|---|---|---|
| 1981 | 66 | 31 | 69 | 30 | 64 | 19 | 58 | 0 |
| 1982 | 63 | 15 | 63 | 30 | 62 | 15 | 58 | 0 |
| 1983 | 70 | 11 | 66 | 30 | 64 | 8 | 59 | 0 |
| 1984 | 68 | 31 | 69 | 30 | 67 | 27 | 62 | 3 |
| 1985 | 68 | 29 | 77 | 27 | 66 | 31 | 63 | 9 |
| 1986 | 64 | 31 | 66 | 30 | 66 | 31 | 63 | 13 |
| 1987 | 68 | 31 | 70 | 30 | 68 | 31 | 66 | 24 |
| 1988 | 75 | 31 | 75 | 30 | 70 | 31 | 66 | 17 |
| 1989 | 64 | 31 | 66 | 30 | 64 | 28 | 61 | 4 |
| 1990 | 73 | 31 | 70 | 30 | 70 | 30 | 63 | 6 |

QUAL2E dynamic water quality simulation model. They found that present flows resulted in stressful water temperature conditions and that there was 100% exceedence of the upper optimum water temperature limit for rearing (60°F) for the months of July through October. Exceedence of this upper temperature limit also occurred in April, May, and June, ranging from about 3% exceedence for April at Sailor Bar to about 95% exceedence for June at Watt Avenue.

The model also predicted that the median daily water temperature at the river mouth for July and August could reach 68°F and 70°F, respectively, under post-Folsom conditions. Temperature conditions were more extreme when D1400 flow conditions were modeled: temperatures occurring in late July could be as high as 73°F.

The factors most affecting lower American River water temperature are Folsom Reservoir storage and flow released from Nimbus Dam. Water elevation of the reservoir determines the volume of cold water in the hypolimnion of the reservoir that is available to be released to the river. The amount of cold water in storage during late summer and fall is dependent upon releases into the river during the previous spring and early summer. High spring and early summer releases deplete the pool, and often the coldwater pool is exhausted by August, September, or October. Lower releases in the spring and summer (approximately 1,500 - 3,000 cfs) could save enough of the coldwater pool, undernormal or wet year conditions, so that cold water is available through October (J. Humphrey, Ott Water Engineers, Inc., pers. comm.). However, it is not known if the cold water that is available in late summer-early fall would be enough to cool the river below steelhead stress levels. Folsom storage levels and Nimbus releases that are needed to produce temperatures that are conducive to steelhead survival in the lower American River during summer and fall need to be developed.

Reducing spring and early summer releases to maintain adequate river temperatures for steelhead in the late summer and fall period may not be conducive to maintaining adequate environmental conditions for fall-run and late fall-run chinook salmon incubation, rearing, and emigration. Before releases to achieve adequate rearing temperatures for steelhead can be recommended, temperature modeling must be completed. Both steelhead and chinook salmon life history requirements must be examined in this context to determine when and how often there will be enough water to benefit both species. Temperature modeling is currently being done as part of the Lower American River Fishery and Aquatic Resources Investigations. This investigation of river temperatures and Folsom storage is a substantial effort that should allow much better predictions of the effects of given flow regimes on water temperatures than have been available in the past (John Williams, pers. comm.).

Water temperatures at Nimbus Fish Hatchery during late summer and fall are above optimum for steelhead, even during good water years, and high temperatures have been a major problem every year of the current drought (Ron Ducey, pers. comm.). Optimal temperature for steelhead rearing at the hatchery is 58°F. Fish begin showing signs of stress at 60° to 62°F. At 62° to 65°F fish start becoming distressed because of the low oxygen concentration of the water. High temperatures promote the growth of disease organisms and weaken the fish's immunity: outbreaks of columnaris, PKD, and redmouth occur regularly during episodes of high temperatures. Treatments for these diseases are expensive, leave the fish weakened, and contribute significantly to the cost and ineffectiveness of raising steelhead to yearling size.

## ANGLING

A substantial number of rainbow trout[1] are caught in the lower American River each year. These trout come from several sources: escapement from the American River Hatchery, movement downstream from rainbow trout plants above Nimbus Dam, natural spawning of steelhead in the lower American River, and from plants of excess fry and fingerling steelhead from Nimbus Hatchery. The primary source of rainbow trout in the lower American River below Goethe Park is a result of steelhead yearlings planted from the Feather River Hatchery and Coleman National Fish Hatchery which have failed to emigrate and have residualized in the delta and river system.

Extensive creel censuses on the lower American River have not been completed and accurate estimates of angler harvest are difficult to derive. Although Hooper (1970) conducted a creel census from February 22, 1969 through July 2, 1969, it did not cover the majority of the steelhead sport fishing season which typically begins in September and extends through March. He estimated that total numbers of anglers and angling hours expended were 56,957 and 118,886, respectively. During the census period the average catch per hour for rainbow trout was 0.01 fish (range 0.001 to 0.03). During that same time period the average catch per

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[1] Rainbow trout greater than 40 cm are generally considered to be steelhead.

hour for steelhead was 0.02 fish (range 0.001 to 0.08). The total estimated rainbow trout and steelhead caught during the census period was 1,554 and 2,058, respectively.

Staley (1976) conducted intensive creel censuses during the 1971-1972 and 1973-1974 steelhead sport fishing seasons. He estimated that anglers fished 150,508 hours and caught 5,369 steelhead[1] during the 1971-1972 season. During the 1973-1974 season the estimated catch was 3,265 steelhead. Staley (1976) estimated the harvest rates for steelhead to be in the mid-20 percentile. Gerstung (1985) estimated that 2,000 to 5,000 rainbow trout were caught each year from the lower American River. Creel censuses by Meyer (1981, 1982, 1983, 1984, and 1986) during the sport fishing season from 1981 through 1986, estimated the steelhead harvest from 3,158 to 4,614.

Tagging studies indicate that approximately 50% of yearling steelhead released in the lower American River are harvested as juveniles while those released in the lower Sacramento River are harvested as juveniles at rates of less than 6% (Staley 1976). There is an indication that a substantial but unquantified number of juvenile steelhead are caught in the Napa River, the San Francisco Bay (Frank Gray, DFG Assoc. Fish. Bio., pers. comm.), and in the Sacramento-San Joaquin Delta (Forrest Reynolds, DFG Fish and Wildlife Prog. Mgr., pers. comm.) indicating that the actual harvest rate of juvenile steelhead may be greater than expected.

The current daily bag and possession limit allows a total of two fish, in combination of trout and salmon, throughout the lower American River. The open season is regulated by location: the reach from Nimbus Dam to the Hazel Avenue Bridge piers is open all year; from the Hazel Avenue Bridge piers to the U.S. Geological Survey gauging station cable crossing near the Nimbus Hatchery fish rack site is open April 1 through September 14; from the U.S. Geological Survey gauging station cable crossing to the Sacramento Municipal Utility District power line crossing near the southwest boundary of Ancil Hoffman Park is open January 1 through October 31; the remainder of the river downstream is open all year. The existing closures are designed to protect spawning salmon, and steelhead and salmon that congregate at the hatchery ladder entrance when the racks are in place.

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[1] Staley considered any rainbow trout greater than 35.6 cm fork length to be a steelhead.





D-020586

There have been several proposals by local and statewide angling organizations to change the current angling regulations. These proposals include: an immediate closure to all fishing on the lower American River; the adoption of five-year rolling closures of different portions of the river; and a reduction in bag and possession limits. The intent of these proposals is to increase steelhead spawning in the river.

The Fish and Game Commission declined to adopt these regulation changes. Their decision was based on DFG's conclusion that increasing the number of steelhead that spawn in the river will not significantly increase future steelhead populations because survival of juvenile steelhead is probably very low, due to current adverse environmental conditions in the river (inadequate flows, high water temperatures, predation, delta pumps, etc.). DFG contends that more restrictive angling regulations would deny recreational fishing opportunities while providing no significant benefit to the fishery, but that restrictions may be warranted in the future (DFG 1991).

One such restriction that should be considered is implementation of catch-and-release (zero-bag limit) angling for naturally produced steelhead. This would require that the angler differentiate between natural and hatchery produced fish, either by adipose fin clip or some other means.

## ARTIFICIAL PRODUCTION

The Nimbus Fish Hatchery was constructed in 1955 by the USBR to mitigate for blocked access to upstream habitat and lost habitat as a result of the construction of Folsom and Nimbus dams. The hatchery is operated by DFG with operating costs reimbursed by USBR. Currently, the hatchery is undergoing phase three of a five-phase modernization plan. The completion of the modernization plan should increase the quality of the steelhead yearlings produced by providing a better water circulation system, but will not provide for an increase in the number produced (Ron Ducey, Nimbus Fish Hatchery Manager, pers. com). Production of yearling steelhead above the 430,000 currently produced would require enlargement of the hatchery.

The modernization plans do not address the high water temperature problems that occur during summer and fall at the hatchery. There are no formal plans or processes underway at present to fix this problem.

In addition to the 430,000 yearlings produced each year at Nimbus Fish Hatchery, 300,000 to 800,000 'excess' steelhead are reared to fingerling size and planted in April and May at the foot of the fish ladder or elsewhere in the lower American River. The number of yearlings currently produced is an increase over the 350,000 annual production of the 1970's (Ron Ducey, pers. comm.). Further increases in hatchery production will probably not achieve an increase in adult run size at this time, given that environmental conditions which have led to the population decline still exist.

If an increase in hatchery production is warranted in the future, a possible method to achieve this without enlarging the hatchery would be to pen-rear steelhead in Lake Natoma. There would be problems with siting a facility of this sort at Lake Natoma however: vandalism due to the close proximity to urbanized areas and ease of public access, and high water temperatures would be the most notable (Ron Ducey, pers. comm.). A thorough evaluation of the feasibility of a pen-rearing operation would be needed if this is to be considered as a viable means of increasing hatchery production.

For the past two years, steelhead yearlings have been released in the Sacramento River near Clarksburg. For eleven years prior to this, yearlings were released at Rio Vista or near the Carquinez Strait. The lower delta releases were done to eliminate the through-delta mortality associated with salmonid emigration in the Sacramento-San Joaquin system. This may however, have led to an increase in juvenile residualization in the delta and adult straying, and a reduction in numbers of returning adults to the American River.

## REINTRODUCTION

The major obstacle to restoring natural production of steelhead in the American River is the fact that the American River is no longer suitable for steelhead. Steelhead are typically tributary spawners: historically, under natural conditions, the majority of migrating adults would take advantage of high spring flows to access headwater streams where adequate temperatures and other habitat conditions provided a suitable environment for juveniles, which must rear in fresh water for at least one year. The lower reaches of large Central Valley rivers, such as the American, were historically used by steelhead as migration corridors to access their preferred spawning and rearing areas. With the completion of the Folsom Project, steelhead were confined to the lowermost 23 miles of the river system, where habitat conditions are generally not suitable for natural spawning and rearing.

The Salmon, Steelhead, and Anadromous Fisheries Program Act (SB 2261) mandates that the DFG strive to double the natural production of salmon and steelhead. It is unlikely that numbers of naturally-produced steelhead will significantly increase to the point they will constitute the majority of the American River run, under existing or potentially improved conditions. If SB 2261 mandates are to be met in the American River, DFG must examine other means to significantly increase natural production.

One such method is to reestablish anadromous steelhead populations in the American River system above Folsom Reservoir. Possible scenarios that should be evaluated include 1) construction of passage facilities over Nimbus and Folsom dams, or 2) trapping and trucking the fish, similar to the program on the Columbia River. A phased approach to reintroduction should be undertaken to evaluate the reproductive potential of steelhead in the waters above Folsom Reservoir and the feasibility of providing access.

The initial evaluation will entail a thorough literature review of other such efforts throughout the west coast of North America to assess the feasibility of providing access around Nimbus and Folsom dams for adults and outmigrating smolts. Next, a survey of the system to assess suitable spawning and rearing habitat and to identify barriers and other impediments to upstream and downstream migration will be undertaken. The potential limit of anadromous waters will be delineated by identifying the upstream limits to migration on the three major forks and their tributaries.

The second phase of studies will require biological evaluations. Adult steelhead will be trapped at the Nimbus Fish Hatchery and trucked and released above Folsom Reservoir. An investigation of reproductive success and juvenile survival will be undertaken. Other biological aspects, such as emigration timing, habitat preference, distribution, and angler harvest will also be investigated.

If it is determined that steelhead can reproduce successfully and survive in the upper American River system, the third phase of investigations should be initiated. This would entail feasibility and engineering studies to determine the best method to provide adult and juvenile steelhead access to and from the waters above Folsom Reservoir. The fourth phase would be to begin construction and/or implementation of measures to allow steelhead to access the upper American River system.

Reintroduction of steelhead above Folsom Dam could result in changes in current fishing regulations and trout stocking practices in this area. DFG has in recent years planted up to 29,000 fry and 9,000 catchable trout annually in the South Fork American River near Coloma and 15,000 fry annually in the lower Middle Fork American River. In addition, Folsom Reservoir receives about 25,000 catchable trout annually. These areas now receive substantial angling pressure, and angling opportunities for catchable trout could be reduced or eliminated under current FGC policies which preclude stocking of resident trout in anadromous waters. The FGC can, and does, grant exceptions to this policy which would allow for the continuance of a catchable trout program above Folsom Dam. Possible impacts to the catchable trout program and angling opportunities should be considered when evaluating the potential for reintroduction of steelhead above Folsom Dam.

## CONCLUSIONS AND RECOMMENDATIONS

### Natural Production

American River steelhead have declined to such low levels that restoration of the population is the primary management concern. Natural production, which presently contributes less than 5% to the adult population, has been low since completion of the Folsom Project blocked access to headwater tributaries, which are the primary spawning and rearing areas of steelhead. The continuing drought and increased water exports have compounded this problem so that the present contribution of naturally-produced steelhead to the adult population is negligible.

To be consistent with SB 2261 mandates, the population of naturally-produced adults should be doubled from current levels. Increasing the percentage of naturally-produced adults to 10% of the total adult population would more than double the current number of naturally-produced adults, at current population levels. If restoration measures that are outlined in this plan are implemented, it is foreseeable that natural production could be increased so that habitat utilization is maximized. To be consistent with other FGC policies, which state that natural production should be maximized whenever possible and hatchery production shall be limited to supplementation of natural production, we should strive to maximize the natural production of steelhead in the American River. We believe that a reasonable goal for naturally-produced adult steelhead in the American River is 30% of the total spawning population, at current hatchery production levels.

The focus of the plan is to specify the necessary habitat conditions and means to achieve these conditions so that natural production is optimized, pursuant to SB 2261 mandates. Our primary recommendation is to restore habitat conditions that will sustain natural production of steelhead in the lower American River. We believe that the Public Trust responsibilities of USBR obligates them to provide the necessary flows, temperatures, and river regulation to restore this resource. Specific recommendations to optimize natural production are given below.

Flow. D893 flow standards are not adequate to maintain populations of steelhead. Implementation of D1400 minimum flow standards would probably result in a reduction in flows from the current flow regime in most years, and would have a drastic effect on both salmon and steelhead populations. Flows necessary to optimize salmon and steelhead spawning and rearing habitat have been identified (Snider and Gerstung 1986) and are the basis of the EDF v. EBMUD court established flow standards. We recommend that the SWRCB adopt the EDF v. EBMUD court established minimum flow standards for the lower American River, specifically:

| | |
|---|---|
| Oct 15 - Feb: | 2000 cfs |
| March - June: | 3000 cfs |
| July - Oct 14: | 1750 cfs |

Fluctuations. Because of the necessity to maintain adequate habitat conditions for the winter-run chinook salmon in the upper Sacramento River, reliance on Folsom Reservoir to meet delta water quality standards and CVP water contract obligations has increased. This has resulted in rapid and erratic flow fluctuations which can have disastrous effects on habitat and egg and juvenile survival. We recommend that USBR adjust overall CVP operations and procedures so that these problems are eliminated, without sacrificing delta water quality or habitat conditions in the upper Sacramento for winter-run chinook salmon. Sacrificing one public trust responsibility to maintain another is not appropriate and is not the intent of the Endangered Species Act. If Folsom Reservoir is to continue to be operated as the primary facility to meet CVP water quality obligations, then USBR should initiate a reoperation study to identify impacts to the lower American River and mitigation to reduce or offset these impacts.

To minimize dewatering of redds, we recommend that flows during incubation (January-May) be no less than flows that occurred during spawning (December-February).





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More information about temperature gradients in pool habitats is needed to assess the impacts of flow fluctuations. Specifically:

1) Assess the importance of these habitats to juvenile steelhead during summer and fall.

2) Determine temperatures at various pool depths under different flow conditions.

3) Determine the effect that flow fluctuations have on temperatures in these habitats.

Temperature. The most limiting environmental factor to natural production of steelhead in the American River is inadequate temperatures during summer and fall. Temperatures frequently exceed 60°F, the upper temperature limit for optimum steelhead rearing, and can be as high as 75°F. Juvenile steelhead probably don't survive the summer and fall in appreciable numbers, or they move out of the American River to seek cooler water. To increase natural production in the river, habitat conditions must be restored that will allow the survival of steelhead through the summer and fall.

Until such time that river flows and storage standards to maintain optimum temperatures for steelhead can be determined, we recommend that, in addition to flows and temperatures needed to optimize salmon production, adequate river temperatures are maintained that will maximize steelhead habitat. Specifically: water temperatures should be no greater than 52°F during spawning, incubation, and emergence (December through May) and no greater than 60°F during fry and juvenile rearing (June through November). Maintenance of preferred temperatures should alleviate the temperature problems at the Nimbus Fish Hatchery. In addition, a minimum pool of water should be maintained in Folsom Reservoir from June through October for purposes of maintaining the coldwater pool.

Modeling of flow and storage needs to be done to determine minimum reservoir storage levels and releases necessary to maintain preferred temperatures for steelhead during summer and fall. Temperature modeling studies addressing river temperatures and Folsom Reservoir storage levels are being undertaken as part of the Lower American River Fishery and Aquatic Resources Investigations.

To study and evaluate options to provide optimum water temperatures, flows, and regulation for steelhead, we recommend that a Lower American River Water Temperature and

Flow Task Force be created. This working group should consist of representatives of DFG, USBR, USFWS, and knowledgeable members of concerned constituent groups, and would be responsible for evaluating need and availability of water for instream uses, means to provide adequate temperatures, flows, and river regulation, and Folsom Project operations.

Microhabitat Criteria. Steelhead microhabitat requirements specific to the lower American River are currently being developed by a cooperative study involving DFG and Sacramento County. Specific recommendations for microhabitat restoration will be made when this additional information is available.

Gravel Restoration. The adequacy of spawning gravel and the need for restoration should be assessed. Preliminary gravel surveys have been initiated as part of The Lower American River Fishery and Aquatic Resources Investigations and additional gravel studies for steelhead and chinook salmon will be undertaken this year. The proposed studies will assess the quality, size distribution, and utilization of gravel in spawning areas and in potentially suitable, nonused areas. These investigations will provide information on the suitability of currently unused spawning areas in the river and will provide input to evaluate the benefits of spawning gravel augmentation or cleaning programs for improving spawning habitat.

If spawning gravels are found to be limiting, gravel restoration projects will be directed first toward restoring suitable conditions in the upper portion of the river below Nimbus Dam. Gravel restoration will not be undertaken except in conjunction with measures to increase survival of naturally-produced juveniles.

## Angling Regulations.

The intent of the recent proposals to change angling regulations is to increase steelhead spawning in the river. We believe that increasing the number of steelhead that spawn in the river will not significantly increase future steelhead populations until survival of juvenile steelhead is increased. Survival of juvenile steelhead is currently very low due to current adverse environmental conditions in the river, and more restrictive angling regulations will probably not provide significant benefits to the fishery.

An ongoing evaluation of juvenile steelhead survival should be undertaken to provide baseline information and to assess the effectiveness of restoration measures. Angling regulations should be reevaluated when specific restoration measures are implemented and a real potential for an increase in natural steelhead production exists.

An evaluation should be undertaken to assess the feasibility and effectiveness of catch-and-release fishing for naturally-produced steelhead.

## Artificial Production

The Nimbus Fish Hatchery will continue to release yearlings in the Clarksburg vicinity of the Sacramento River until a study is undertaken to determine the effectiveness of the different release sites. A literature review and study to determine the optimum fish size and timing of release will also be undertaken.

The hatchery will continue to improve and implement sound management practices to conserve the genetic variability of the Nimbus strain by taking early migrant and late migrant fish for spawning, and randomly selecting egg lots that are to be raised to yearling size. Steelhead strains that are not of Nimbus or Eel River derivation will not be introduced into the system.

USBR should address the water temperature problem at the hatchery. Means to fix this problem should be investigated and implemented so that USBR can properly mitigate for the loss of steelhead spawning areas caused by the Folsom Project.

To adequately manage naturally-produced steelhead and to determine if future natural production is contributing to the population of returning adults, naturally-produced fish must be distinguishable from hatchery-produced fish. A trial program to mark all, or a constant fractional number, of hatchery-produced steelhead will be undertaken. This will also serve to identify trends in returning hatchery fish, identify the contribution of naturally spawned fish to the hatchery program, and provide a means for the angler to differentiate natural from hatchery-produced fish if a catch-and-release regulation is implemented. A hatchery marking program for all Central Valley salmon and steelhead hatcheries will be addressed in more detail in the Statewide Steelhead Management Plan that is currently being developed.

We believe local angling organizations are willing to volunteer to assist DGF in this tagging program. A volunteer effort of this type is within the mandates of

SB 2261, which state that it is a policy of the state to recognize and encourage public participation in anadromous fish restoration efforts.

Reintroduction

It is unlikely that numbers of naturally-produced steelhead will significantly increase to the point they will constitute the majority of the American River run, under existing or potential improved conditions. If SB 2261 mandates are to be met in the American River, DFG should begin to evaluate the feasibility of reestablishing anadromous runs of steelhead in the American River system above Folsom Reservoir.

DFG should begin an initial evaluation which will entail a literature review and an assessment of the feasibility of providing passage around Folsom Dam.

## IMPLEMENTATION

A lower American River Water Temperature and Flow Task Force will be created to evaluate means to achieve the habitat conditions that are recommended in this plan. This working group should consist of representatives of DFG, USBR, USFWS, and knowledgeable members of concerned constituent groups. This group will evaluate need and availability of water for instream uses, means to provide adequate temperatures for the river and hatchery, means to provide adequate flows and river regulation, and Folsom Project operations.

Investigations mandated by the EDF v. EBMUD court decision provide an existing framework to undertake the studies proposed in this plan. Investigations involving steelhead life history, juvenile survival, temperature modeling, microhabitat criteria, spawning habitat requirements, and adult spawning escapement estimates should be undertaken within this framework. All of these parameters of steelhead life history and survival are very much affected by American River regulation and water development and fall within the purview of the Lower American River Fishery and Aquatic Resources Investigations. Sources to help fund some of these studies will be investigated.

The original contract between USBR and DFG for the operation of Nimbus Fish Hatchery states: "The state, as part of the hatchery operations, shall make annual estimates of the number of salmon and steelhead spawning in the American River below Nimbus Dam". To our knowledge, steelhead spawning escapement estimates for the American River have never been made. We believe that these estimates are essential to evaluating the success of mitigation, and this should be part of the overall hatchery program. DFG Region 2 personnel should undertake this task on an annual basis, with associated costs for new regional staff positions reimbursed by USBR.

DFG is in the process of developing a statewide steelhead management plan which will address the need for marking hatchery-produced steelhead on a statewide basis. The implementation of a marking program at Nimbus Hatchery will be addressed in this document, in context with statewide steelhead management goals. Implementation of catch-and-release regulations for naturally-produced steelhead will also be addressed in this document.

DFG will begin an initial evaluation to assess the feasibility of providing passage so that steelhead can be reintroduced to the waters above Folsom Dam.

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APPENDIX A

The following is a list of substrate codes used in the probability curves:

| SUBSTRATE | CODE NUMBER |
|---|---|
| Plant detritus/ organic material | 1 |
| Mud/soft clay | 2 |
| Silt | 3 |
| Sand | 4 |
| Gravel | 5 |
| Cobble/rubble | 6 |
| Boulder | 7 |
| Bedrock | 8 |

Note:

Gradations between code numbers refer to a rough proportion between one substrate type and another. For example, a 5.5 substrate code would indicate a gravel/cobble mixture with approximately equal portions of each particle size. A code of 4.8 would indicate a mix of approximately 80% gravel and 20% sand, whereas a code of 5.2 would mean 80% gravel and 20% cobble.

From Bovee, 1978.

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