IMPACTS ON LOWER AMERICAN RIVER SALMONIDS AND RECOMMENDATIONS ASSOCIATED WITH FOLSOM RESERVOIR OPERATIONS TO MEET DELTA WATER QUALITY OBJECTIVES AND DEMANDS

DRAFT REPORT

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1.0 BACKGROUND

Releases from Folsom, Oroville, and Shasta reservoirs, are made, in part, to meet in-Delta and export demands, water quality objectives such as electrical conductivity levels and chloride concentrations at multiple compliance points, and X2 and Delta outflow. Of the three reservoirs, the shortest travel time to the Sacramento-San Joaquin Delta (Delta) is from Folsom Reservoir (one day *vs.* three days from Oroville and five days from Shasta). Folsom Reservoir also has the highest potential to refill (United States Bureau of Reclamation (Reclamation) 1992). In the Long-term Central Valley Project Operations Criteria and Plan, Reclamation states (Page 89): "*It is therefore logical to assume that in the absence of other constraints, Folsom would always be the likely source when more then (sic) one water source is available because of its high refill potential* (Reclamation 1992)." Therefore, Folsom Reservoir is often used as a *"real-time, first response facility"* to meet Delta water quality objectives because of unanticipated events, reluctance to conduct export reductions (refer to Section 4.0 Delta Water Quality Compliance Recommendations), or a combination thereof. Use of Folsom Reservoir as a *"real-time, first response facility"* may potentially impact salmonids in the lower American River by affecting river flows and water temperatures during several life stages of fall-run Chinook salmon (*Oncorhynchus tshawytscha*) and steelhead (*O. mykiss*). Potential effects (e.g., fluctuating river flows, and reduced reservoir water storage and coldwater pool) associated with Folsom Reservoir operations to meet Delta water quality objectives and demands are described below. For the purpose of this document, X2 and Delta outflow compliance is particularly emphasized when references are made to Delta water quality objectives and demands.

Effects of flow fluctuations on lower American River salmonids have been examined by the California Department of Fish and Game (CDFG) and Reclamation (CDFG 2001; Reclamation 2002). Through these studies, reservoir operations that cause river flows to exceed, then decrease below certain water surface elevations have been identified as a source of mortality to lower American River salmonids because of redd dewatering, fry stranding and juvenile isolation. Redd dewatering is reported to occur when flows are decreased from commonly observed spawning flow levels (e.g., 1,000 to 4,000 cubic feet per second (cfs)) (CDFG 2001). Rapid flow decreases from flow levels that inundated low and medium sloping gravel bars when salmonid fry are present in the lower American River (i.e., late-December through May) reportedly can result in fry stranding (CDFG 2001). Also, as flows in the lower American River approach and exceed 4,000 cfs, many areas in the lower American River channel reportedly become inundated and subsequently are newly available to rearing fish (CDFG 2001). Thus, reductions in flow, once flows reach 4,000 cfs, have the potential to isolate juvenile salmonids (CDFG 2001).

High water temperatures also adversely impact lower American River salmonids. Water temperatures identified by the National Oceanic and Atmospheric Administration, National Marine Fisheries Service (NOAA Fisheries) to protect steelhead juvenile rearing (e.g., ≤ 65°F) (NOAA Fisheries 2002) and fall-run Chinook salmon spawning and embryo incubation (e.g., ≤

56°F) (NOAA Fisheries 1997) are difficult to achieve in the lower American River, and utilizing Folsom Reservoir as a *"real-time, first response facility"* to meet Delta water quality objectives and demands exacerbates the problem. Folsom Reservoir storage reductions potentially decrease the coldwater pool available for management of water temperatures for steelhead over-summer juvenile rearing and fall-run Chinook salmon spawning and embryo incubation.

Another consequence of using Folsom Reservoir as a *"real-time, first response facility"* to meet Delta water quality objectives and demands is that hydropower generation may be foregone because of the need to bypass water in the fall, in order to provide cold water to the lower American River for fall-run Chinook salmon spawning and embryo incubation. In general, beginning in April, Folsom Reservoir thermally stratifies into a warm top layer (i.e., epilimnion) and a cold bottom layer (i.e., hypolimnion). This stratification occurs because the denser cold water remains in the deeper zones of the reservoir. Once thermal stratification occurs, the volume of cold water decreases as water is withdrawn from the cold water strata, and as the reservoir warms throughout the summer. The coldwater pool in Folsom Reservoir reaches its lowest volume during the fall. In order to provide cold water to the lower American River during the fall, when cold water only resides below the penstock inlet ports used for hydropower generation, the low level river outlets must be utilized, resulting in foregone hydropower generation. The lower reservoir outlets were used and hydropower generation was foregone during 2001 and 2002. Hence, in addition to biological concerns associated with Folsom Reservoir operations to meet Delta water quality objectives and demands, power generation and economic considerations also exist.

The intent of this document is to: (1) describe potential impacts that may occur to anadromous salmonids in the lower American River associated with current Folsom Reservoir operations to meet Delta water quality objectives and demands; (2) document reported impacts to anadromous salmonids in the lower American River that have occurred due to meeting Delta water quality objectives and demands; (3) provide Delta water quality compliance recommendations in order to minimize impacts on lower American River anadromous salmonids; and (4) recommend interim flow fluctuation objectives for Folsom Reservoir operations that would better protect anadromous salmonids in the lower American River from impacts associated with Delta-related changes in Nimbus Dam releases.

In an effort to document reported impacts on lower American River anadromous salmonids resulting from Folsom Reservoir operations to meet Delta water quality objectives and demands, Reclamation's Nimbus Dam release logs, resource agency reports, and American River Operations Group (AROG) notes were examined. AROG is an interagency group including Reclamation, the U.S. Fish and Wildlife Service (USFWS), NOAA Fisheries, CDFG, and stakeholders such as Save the American River Association. Concurrent Nimbus Dam release logs, agency reports, and AROG notes were available for the period extending from January 2001 through July 2004. In addition to the impacts on lower American River salmonids that are presented in this document, other unreported impacts also may have occurred during this period because monitoring was not conducted during many release events and, consequently, impacts were not documented. Moreover, juvenile isolation events have been documented prior to the time period included in this analysis. For example, CDFG (2001) reported relatively large numbers of isolated juvenile salmonids on numerous occasions from 1997 through 2000.

2.0 POTENTIAL IMPACTS

The following discussion specifically identifies and describes potential flow and water temperature impacts on lower American River salmonids that are associated with increased water releases from Folsom Reservoir to meet Delta water quality objectives and demands.

1. **Redd Dewatering and Isolation** – The dewatering of redds in the main channel, or isolation of redds in river side channels, can result from flow reductions from levels at which spawning initially occurred. Redd dewatering can affect salmonid embryos and alevins by impairing development and causing direct mortality due to desiccation, insufficient oxygen levels, waste metabolite toxicity, and thermal stress (Becker and Neitzel 1985; Reiser and Whitney 1983). Isolation of redds in side channels can result in direct mortalities due to these factors, as well as starvation and predation of emergent fry. The primary period of concern for redd dewatering and isolation extends from about mid October through May, corresponding to fall-run Chinook salmon and steelhead spawning and incubation period in the lower American River.

2. **Fry Stranding** – Salmonid fry can become stranded on dewatered gravel bars as flows, that once inundated the gravel bar, recede. Stranding has been reported to occur under both natural and regulated flow fluctuations, but most large stranding events have generally been attributed to rapid flow fluctuations caused by reservoir and hydropower operations (Hunter 1992). The vulnerability of fry to stranding is a function of their behavioral response to changing flows, which depends on species, water temperature, time of year, and time of day (Bradford et al. 1995; Bradford 1997). Newly emerged fry appear to be most vulnerable to stranding because of their limited swimming ability, their tendency to use the substrate as cover, and their preference for shallow river margins (Cannon and Kennedy 2003; Jackson 1992). As fry grow into larger juveniles, they tend to inhabit deeper, higher-velocity areas associated with main channel habitats where they are less susceptible to stranding (Cannon and Kennedy 2003; Jackson 1992; DWR 2003).

   Most fall-run Chinook salmon fry emigrate shortly after emergence in winter and early spring, and have left the lower American River by late April (SWRI 2001). Most steelhead fry emerge from the substrate from March through May and rear in the lower American River year-round (SWRI 2001). Slow, gradual flow ramping rates may be important in minimizing salmonid fry stranding in the lower American River from late-December through May.

3. **Juvenile Isolation** – Chinook salmon and steelhead juvenile isolation (i.e., trapping of juveniles in side channels, potholes, depressions, etc. within and outside the active channel, with no access to the free-flowing river) occurs when flows increase to levels that inundate side-channel or off-channel depressions and subsequently recede, trapping the fish in unconnected pockets of water.

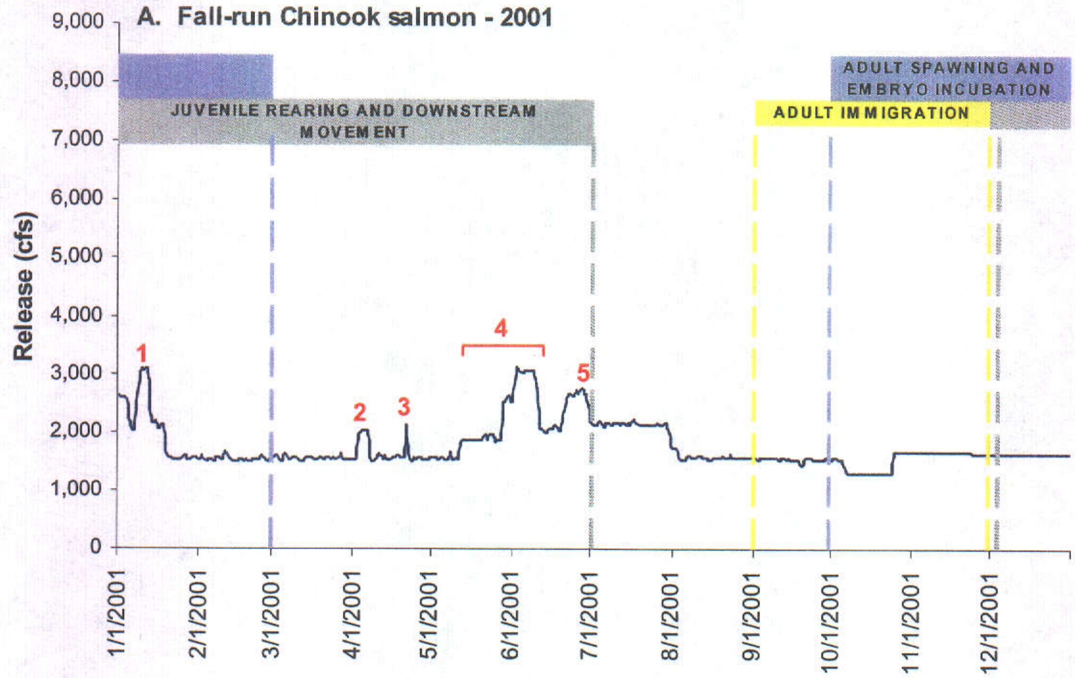
   Some juvenile fall-run Chinook salmon do not emigrate shortly after emergence, and may rear in the lower American River through May and into June, whereas juvenile steelhead may rear in the lower American River year-round. Decreasing the rate of flow reductions following a release from Folsom Reservoir to meet Delta water quality objectives and demands may not minimize salmonid losses due to juvenile isolation. Juvenile isolation in off-channel habitats may occur regardless of the rate of flow reductions, because of favorable rearing conditions, the distance of these habitats from the main river, and an apparent reluctance of juveniles to move away from protective cover (Bradford et al. 1995; Higgins and Bradford 1996; Bradford 1997; JSA 1999).

4. **Depletion of Folsom Reservoir Water Storage** – The use of Folsom Reservoir as a *"real-time, first response facility"* to meet Delta water quality objectives and demands may result in reduced storage and, consequently, may reduce water availability for instream flows during the Chinook salmon adult immigration and spawning period (September through December). Reductions in Folsom Reservoir storage resulting from compliance with Delta water quality objectives and demands in one year can be carried through a series of years, particularly during drought conditions.

5. **Depletion of Folsom Reservoir Coldwater Pool** – The coldwater pool at Folsom Reservoir is limited and, thus, has to be carefully managed to provide cool water for juvenile steelhead over-summer rearing, and Chinook salmon spawning in the fall. In many years, careful and efficient use of the temperature control devices at Folsom Reservoir (at the penstock inlet port and at the intake for local municipal supply) still results in less than desirable water temperature conditions in the lower American River for juvenile steelhead over summer rearing, and fall-run Chinook salmon spawning. Using Folsom Reservoir as a *"real-time, first response facility"* to meet Delta water quality objectives and demands can result in additionally depleting an already limited coldwater supply.

3.0 DOCUMENTED IMPACTS

The following series of figures (**Figures 1 through 4**) illustrate the reliance on Folsom Reservoir to meet Delta water quality objectives and demands and the associated documented impacts to lower American River anadromous salmonids. Documented impacts include impacts that were either reported in agency reports or documented by AROG. The figures display the mean daily Nimbus Dam release rates from January 2001 through July 2004, the temporal distribution of the appropriate life stage for Chinook salmon or steelhead, and each reported release event associated with meeting Delta water quality objectives and demands. The reasons for flow changes indicated in the figures are those taken directly from Reclamation's Nimbus Dam release logs. Specific details of each sequentially numbered release event (i.e., release events associated with meeting Delta water quality objectives and demands) are described below the figure, as well as whether effects to lower American River resources were documented.



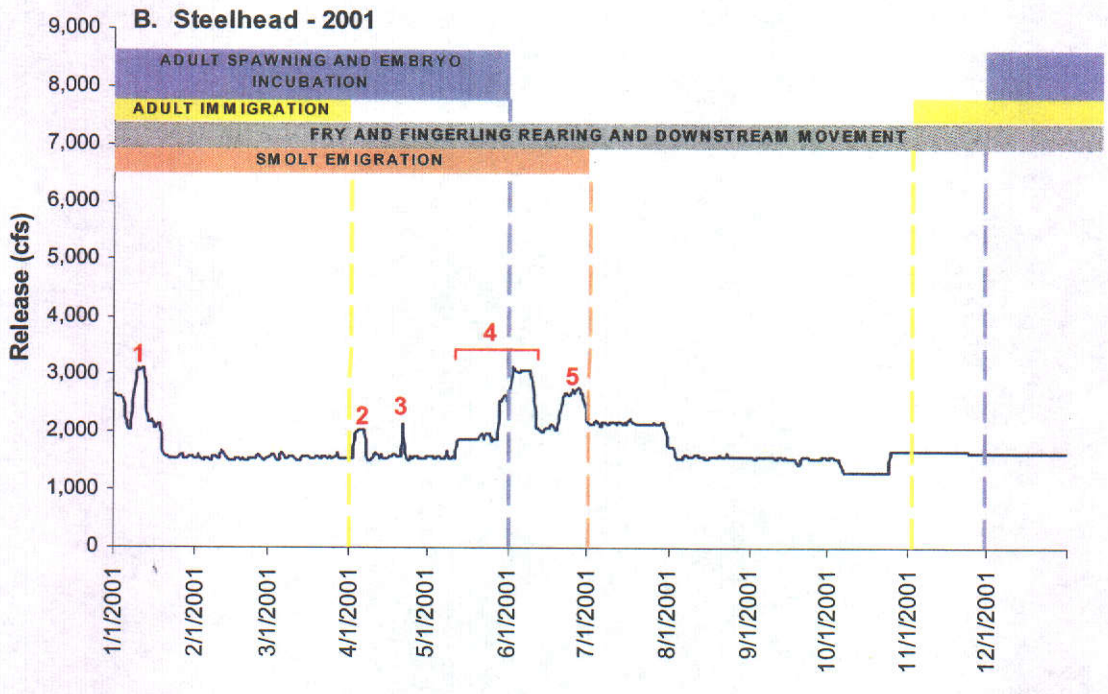


Figure 1. Mean daily release rates from Nimbus Dam in 2001. The life stage timings for fall-run Chinook salmon (A) and steelhead (B) are displayed. Sequential red numbers indicate release events attributed to either Delta water quality objectives or Delta demands in Reclamation's Nimbus Dam release logs.

DESCRIPTION OF RELEASE EVENTS - 2001

Details of each individual release event are described below, including whether effects to lower American River resources were documented.

1 On January 8, 2001, releases from Nimbus Dam were increased from approximately 2,000 cfs to approximately 3,000 cfs in order to meet Delta water quality objectives, and were subsequently reduced to approximately 1,500 cfs by mid-January. No effects to lower American River resources were documented by resource agency reports or AROG notes as a result of either the release rate increase or the subsequent release rate decrease. However, a flow decrease from approximately 3,000 cfs to 1,500 cfs by mid-January would result in a water surface elevation decrease of about 1.4 feet at the U.S. Geological Survey Fair Oaks gage. A water surface elevation reduction of this magnitude has the potential to dewater steelhead redds that may have been constructed at the higher flow level.

2 On April 3, 2001, releases from Nimbus Dam were increased from approximately 1,500 cfs to approximately 2,000 cfs in order to meet Delta water quality objectives and export demands. No effects to lower American River resources were documented by resource agency reports or AROG notes as a result of either the release rate increase or the subsequent release rate decrease.

3 On April 20, 2001, releases from Nimbus Dam were increased from approximately 1,500 cfs to approximately 2,500 cfs in order to meet Delta outflow requirements. No effects to lower American River resources were documented by resource agency reports or AROG notes as a result of either the release rate increase or the subsequent release rate decrease.

4 Starting on May 12, 2001, releases from Nimbus Dam were increased from approximately 1,500 cfs up to approximately 3,000 cfs on June 2, 2001 in order to meet Delta water quality objectives. No effects to lower American River resources were documented by resource agency reports or AROG notes as a result of either the release rate increase or the subsequent release rate decrease. However, refer to Additional Impact Considerations, below, for additional discussion.

5 On June 20, 2001, releases from Nimbus Dam were increased from approximately 2,000 cfs to approximately 2,600 cfs in order to meet Delta requirements. No effects to lower American River resources were documented by resource agency reports or AROG notes as a result of either the release rate increase or the subsequent release rate decrease. However, refer to Additional Impact Considerations, below, for additional discussion.

ADDITIONAL IMPACT CONSIDERATIONS - 2001

From May 12, 2001 through July 2001, Folsom Reservoir storage was reduced by approximately 183,000 acre-feet (af) in order to meet Delta water quality objectives and demands (Reclamation unpublished data [b]; Reclamation Website). This reduction in Folsom Reservoir storage may have reduced the coldwater pool available for management of water temperatures for steelhead over-summer juvenile rearing and fall-run Chinook salmon spawning and embryo incubation. The estimated volume of cold water remaining in Folsom Reservoir in August was considerably lower in 2001 (i.e., 95,000 af < 60°F) than in either 2002 (i.e., 155,000 af < 60°F) or 2003 (i.e., 270,00 af < 60°F) (Reclamation unpublished data [a]). Because the coldwater pool was low in 2001, the flexibility of cold water management may have been diminished during portions of the periods of fall-run Chinook salmon adult immigration (i.e., September through December) and fall-run Chinook salmon adult spawning and embryo incubation (i.e., October through March) (SWRI 2001). In November 2001, the average daily water temperature at Watt Avenue in the lower American River was 61°F (California Department of Water Resources (DWR) Website). Pronounced pre-spawning adult mortality as well as increased latent mortality to incubating embryos reportedly can result when ripe adult female Chinook salmon are exposed to water temperatures beyond the 56°F to 60°F range (McCullough 1999). Pre-spawning mortality of fall-run Chinook salmon was reported by CDFG to be approximately 67 percent during the 2001 adult immigration and adult spawning season, presumably because of high water temperatures (Healy 2004 *in* Lamb 2004).

In the fall of 2001, hydropower generation had to be foregone because water needed to be bypassed in order to provide cold water to the lower American River for fall-run Chinook salmon spawning and embryo incubation. The cost of foregoing hydropower generation was approximately 4,293 megawatt hours (Van Tran 2004 pers. comm.).

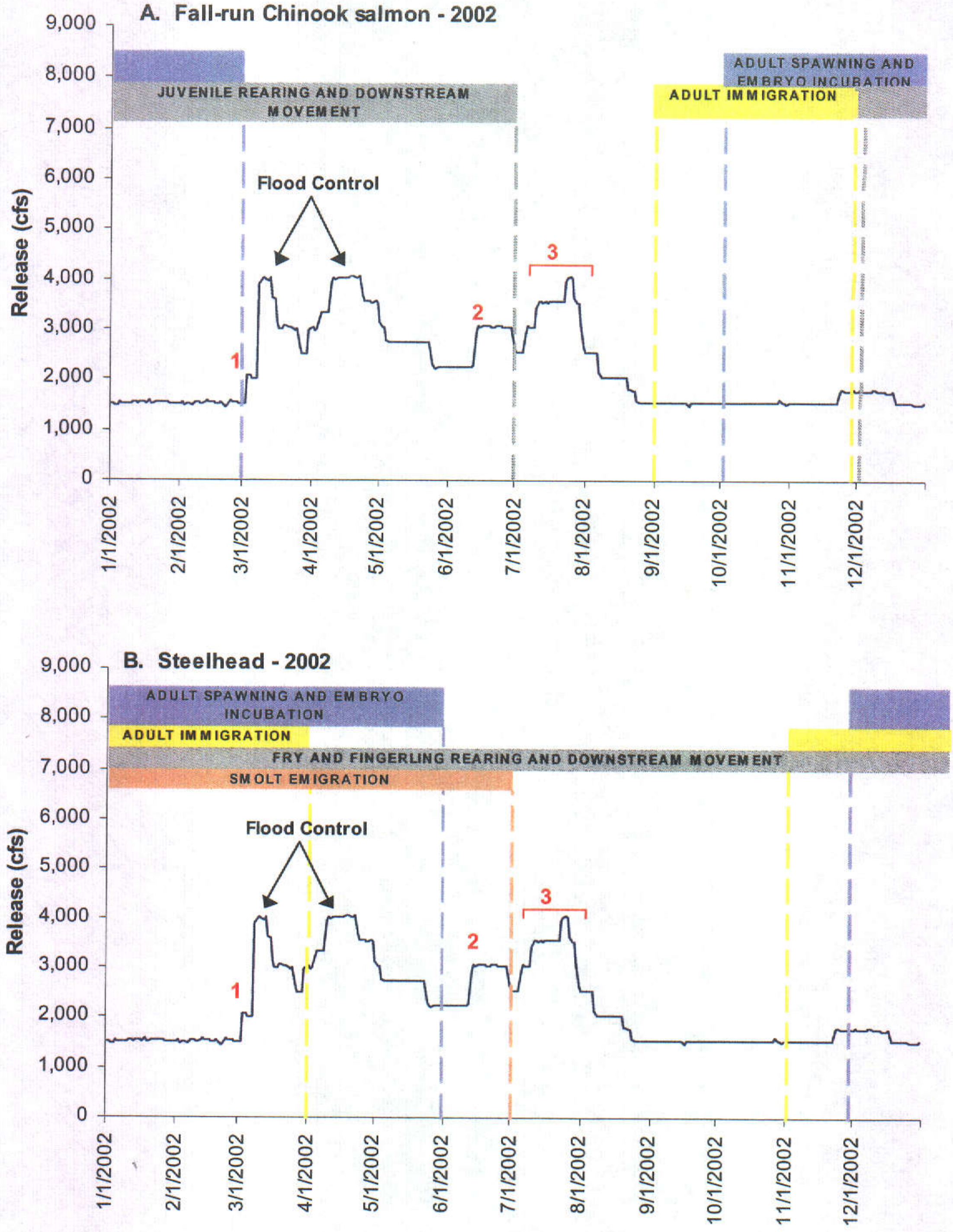


Figure 2. Mean daily release rates from Nimbus Dam in 2002. The life stage timings for fall-run Chinook salmon (A) and steelhead (B) are displayed. Sequential red numbers indicate release events attributed to either Delta water quality objectives or Delta demands in Reclamation's Nimbus Dam release logs.

DESCRIPTION OF RELEASE EVENTS - 2002

Details of each individual release event are described below, including whether effects to lower American River resources were documented.

1 On March 2, 2002, releases from Nimbus Dam were increased from approximately 1,500 to approximately 2,000 cfs in order to meet Delta demands. No effects to lower American River resources were documented by resource agency reports or AROG notes as a result of either the release rate increase or the subsequent release rate decrease.

2 On June 13, 2002, releases from Nimbus Dam were increased from approximately 2,200 cfs to approximately 3,000 cfs in order to meet Delta demands. No effects to lower American River resources were documented by resource agency reports or AROG notes as a result of either the release rate increase or the subsequent release rate decrease. However, refer to Additional Impact Considerations, below, for additional discussion.

3 Starting on July 5, 2002, releases from Nimbus Dam were increased from approximately 2,500 cfs up to approximately 4,000 cfs on July 23, 2002 in order to meet Delta demands. No effects to lower American River resources were documented by resource agency reports or AROG notes as a result of either the release rate increase or the subsequent release rate decrease. However, refer to Additional Impact Considerations, below, for additional discussion.

ADDITIONAL IMPACT CONSIDERATIONS - 2002

The release rate increases that occurred on June 13, 2002 and July 5, 2002 to meet Delta demands contributed to reduced carryover storage and potentially contributed to reduced flow release rate and Folsom Reservoir coldwater pool that otherwise could have been available for release during the fall-run Chinook salmon spawning and incubation period.

In the fall of 2002, hydropower generation had to be foregone because water needed to be bypassed in order to provide cold water to the lower American River for fall-run Chinook salmon spawning and embryo incubation. The cost of foregoing hydropower generation was approximately 6,520 megawatt hours, at a replacement cost of approximately $173,291, which was paid to the Western Area Power Administration through the Environmental Water Account (EWA) (Van Tran pers. comm. 2004). Because the EWA has limited assets (largely based on available funding and asset prices), using EWA assets to reimburse foregone hydropower generation may translate in a lost opportunity to use these assets for other fishery protection or enhancement actions. Therefore, using Folsom Reservoir as a *"real-time, first response facility"* to meet Delta water quality objectives and demands may ultimately result in commitments of EWA assets that otherwise could have been used for other direct fishery protection or enhancement actions in the Sacramento-San Joaquin Delta and/or in Central Valley Project (CVP) rivers, including the lower American River.

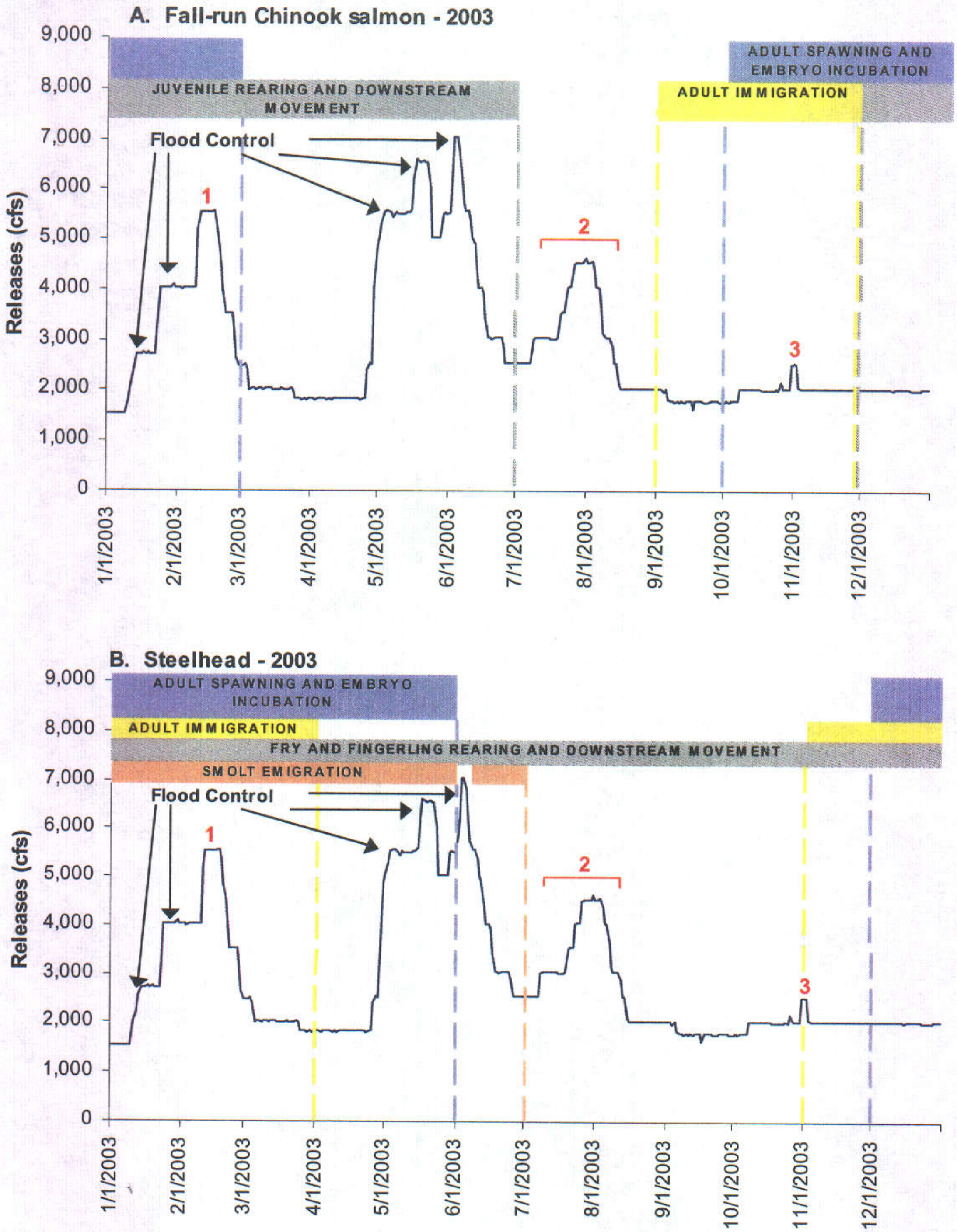


Figure 3. Mean daily release rates from Nimbus Dam in 2003. The life stage timings for fall-run Chinook salmon (A) and steelhead (B) are displayed. Sequential red numbers indicate release events attributed to either Delta water quality objectives or Delta demands in Reclamation's Nimbus Dam release logs.

DESCRIPTION OF RELEASE EVENTS - 2003

Details of each individual release event are described below, including whether effects to lower American River resources were documented.

1 On February 10, 2003, releases from Nimbus Dam were increased from approximately 4,000 cfs to approximately 5,500 cfs in order to meet Delta water quality objectives. As the Nimbus Dam release rate decreased from approximately 5,500 cfs on February 18, 2003 to approximately 1,800 cfs on March 25, 2003, several impacts on anadromous salmonids in the lower American River were reported. On February 20, 2003, CDFG reported that steelhead were spawning in some side channels that became inundated when releases increased above 4,000 cfs, and that some salmon stranding occurred as releases were decreased from 5,000 cfs to 4,500 cfs (AROG unpublished data). On February 24, 2003, NOAA Fisheries reported that some steelhead fry were isolated near the Sunrise area, and that 60 percent of steelhead redds were constructed when flows were greater than 4,000 cfs (AROG unpublished data). On February 25, 2003, CDFG reported that some salmon fry were being stranded, and that approximately 10 steelhead redds at the lower Sunrise side channel were at risk if Nimbus Dam releases were reduced further (AROG unpublished data). Hannon et al. (2003) reported that five steelhead redds were dewatered and ten steelhead redds were isolated in a backwater pool at the lower Sunrise side channel when flows decreased below approximately 3,000 cfs on February 27, 2003. On March 4, 2003, CDFG reported that by the end of February, juvenile Chinook salmon had been stranded near the upper and lower Sunrise areas, and that three steelhead redds near the lower Sunrise area had been dewatered (AROG unpublished data). CDFG reported that up to 10,000 Chinook salmon fry had been stranded on the island near the lower Sunrise area (Healey 2004 pers. comm.). On March 17, 2003, NOAA Fisheries reported that as releases were reduced from 5,500 cfs, seven steelhead redds were dewatered and five additional steelhead redds were isolated from flowing water at the lower Sunrise side channel (AROG unpublished data). On April 10, 2003, CDFG reported that the lower Sunrise side channel had become isolated from flowing water (AROG unpublished data).

2 Starting on July 8, 2003, releases from Nimbus Dam were increased from approximately 2,500 cfs up to approximately 4,500 cfs on July 26, 2003 in order to meet Delta demands. No effects to lower American River resources were documented by resource agency reports or AROG notes as a result of either the release rate increase or the subsequent release rate decrease. However, refer to Additional Impact Considerations, below, for additional discussion.

3 On October 31, 2003, releases from Nimbus Dam were increased from approximately 2,000 cfs to approximately 2,500 cfs in order to meet Delta demands. No effects to lower American River resources were documented by resource agency reports or AROG notes as a result of either the release rate increase or the subsequent release rate decrease.

ADDITIONAL IMPACT CONSIDERATIONS – 2003

The release rate increases that occurred starting on July 8, 2003 to meet Delta demands contributed to reduced carryover storage and potentially contributed to reduced flow release rate and Folsom Reservoir coldwater pool that otherwise could have been available for release during the fall-run Chinook salmon spawning and incubation period.

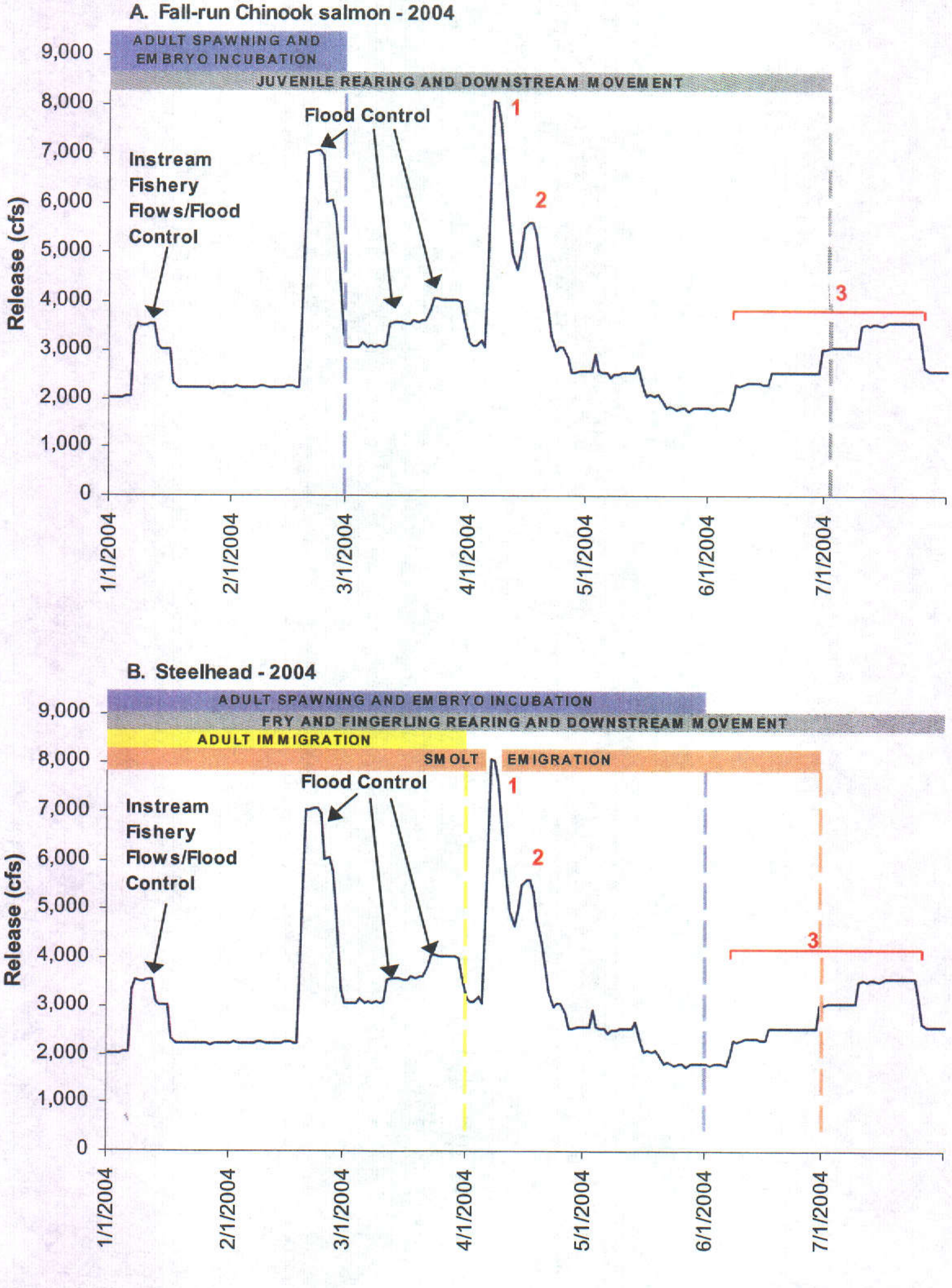


Figure 4. Mean daily release rates from Nimbus Dam in 2004. The life stage timings for fall-run Chinook salmon (A) and steelhead (B) are displayed. Sequential red numbers indicate release events attributed to either Delta water quality objectives or Delta demands in Reclamation's Nimbus Dam release logs.

DESCRIPTION OF RELEASE EVENTS - 2004

Details of each individual release event are described below, including whether effects to lower American River resources were documented.

1 On April 6, 2004, releases from Nimbus Dam were increased from approximately 3,000 cfs to approximately 8,000 cfs in order to meet Delta water quality objectives. No effects to lower American River salmonids were documented by resource agency reports or AROG notes as a result of either the release rate increase or the subsequent release rate decrease.

2 Starting on April 13, 2004, releases from Nimbus Dam were increased from approximately 4,200 cfs up to approximately 5,500 cfs on April 14, 2004 in order to meet Delta water quality objectives. By the end of April 2004, releases from Nimbus Dam were reduced to 2,500 cfs. On April 28, 2004, CDFG reported that seining surveys within the isolation areas along the lower Sunrise side channel indicated that more than 2,000 juvenile Chinook salmon/seine haul and 40 juvenile steelhead/seine haul had been isolated from the main channel (CDFG unpublished data). CDFG seining surveys also collected more than 300 juvenile Chinook salmon/seine haul from an isolated area near Sunrise Boulevard (not the lower Sunrise side channel) and from an area near Watt Avenue (CDFG unpublished data). CDFG also reported that many of the steelhead redds near the lower Sunrise area were isolated (AROG unpublished data). CDFG reported that by keeping release rates above 2,500 cfs from the end of April until May 15, 2004, most steelhead redds vulnerable to dewatering were protected through emergence; five steelhead redds were dewatered near the lower Sunrise area (AROG unpublished data).

3 Starting on June 7, 2004, releases from Nimbus Dam were increased from approximately 1,750 cfs up to approximately 3,500 cfs on July 10, 2004 in order to meet Delta demands. No effects to lower American River salmonids were documented by resource agency reports or AROG notes as a result of either the release rate increase or the subsequent release rate decrease. However, refer to Additional Impact Considerations, below, for additional discussion.

ADDITIONAL IMPACT CONSIDERATIONS - 2004

In 2004, approximately 172,000 af of water was released from Folsom Reservoir in order to meet Delta water quality objectives and demands, subsequently reducing reservoir storage (Reclamation unpublished data [b]; Reclamation Website). Storage reductions have the potential to reduce the coldwater pool. The estimated volume of cold water remaining in Folsom Reservoir in August 2004 (i.e., 90,000 af < 60°F) was the lowest that it has been in August in recent years, including the volume remaining in August 2001 (i.e., 95,000 af < 60°F) (Reclamation unpublished data [a]). Because the estimated volume of cold water remaining in Folsom Reservoir in August 2004 (i.e., 90,000 af < 60°F) was lower than the volume remaining in August 2001 (i.e., 95,000 af < 60°F), CDFG reportedly expected that the level of pre-spawning mortality of fall-run Chinook salmon in 2004 would be similar to the level that occurred in 2001 (i.e., 67% pre-spawning mortality) (Healy 2004 *in* Lamb 2004). However, a combination of milder air temperatures and precipitation during the fall caused Folsom Reservoir water temperatures to decrease, allowing relatively large volumes of cold water to become available for fall-run Chinook salmon spawning in the lower American River. For example, the estimated volume of cold water available in Folsom Reservoir by mid-November (i.e., 340,000 af < 60°F) was ten times greater than the estimated volume that was available in mid-October (i.e., 30,000 af < 60°F) (Reclamation unpublished data [a]). As a result, by early November, the anticipated high level of pre-spawning mortality of fall-run Chinook salmon, reportedly was no longer a concern for CDFG (Titus 2004 *in* Leavenworth 2004).

According to Hannon and Deason (2004), steelhead spawning habitat is available at the lower Sunrise side channel at flows greater than approximately 4,000 cfs. Prior to February 19th, during the 2004 steelhead spawning season, flows in the lower American River reached a maximum of approximately 3,500 cfs and, thus, steelhead spawning habitat was not available at the lower Sunrise side channel. Hannon and Deason (2004) reported that 11 steelhead redds were constructed at the lower Sunrise side channel between February 19, 2004 and February 28, 2004, when a flood control release from Nimbus Dam increased flows in the lower American River from approximately 2,200 cfs on February 18, 2004 up to a maximum of approximately 7,000 cfs on February 20, 2004 (Reclamation unpublished data [b]). Flow levels remained above 4,000 cfs from February 19, 2004 through February 28, 2004 (Reclamation Website). From February 24, 2004 through March 1, 2004, daily flow decreases were made and consequently five steelhead redds were observed to be dewatered at the lower Sunrise side channel (Hannon and Deason 2004). Thus, inundating the lower Sunrise side channel for 11 days (i.e., February 19th through February 28th) during the steelhead spawning period and, then, decreasing flows such that the side channel becomes isolated from free flowing surface water, has been shown to result in steelhead redd dewatering (Hannon and Deason 2004) and also may result in redd isolation.

4.0 DELTA WATER QUALITY COMPLIANCE RECOMMENDATIONS

In order to minimize impacts on lower American River salmonids associated with Folsom Reservoir operations to meet Delta water quality objectives and demands, two general procedural recommendations (i.e., Adaptive Management Recommendation and Integrated CVP/SWP Operational Approach Recommendation) for Delta water quality compliance have been developed and are described below. Also, these recommendations should be considered to more readily achieve the lower American River flow fluctuation interim objectives that are described in the next section.

Adaptive Management Recommendation

The first recommendation specifically addresses the February through June Delta outflow requirement as stated by the State Water Resources Control Board (SWRCB) in *Water Right Decision 1641* (D-1641). This requirement is met if: (1) the minimum daily Delta outflow, calculated as a three-day running average, is 7,100 cfs; (2) the daily average electrical conductivity (EC) at the confluence of the Sacramento and the San Joaquin rivers is less than or equal to 2.64 mmhos/cm; or (3) the 14-day running average EC at the confluence of the Sacramento and the San Joaquin rivers is less than or equal to 2.64 mmhos/cm. In an effort to better protect lower American River salmonids that may be adversely affected by changes in water management intended to achieve compliance with the Delta outflow requirement, modifications to the current implementation of this requirement should be considered.

One potential modification is to implement an adaptive water management approach that, through increased interagency coordination, considers the habitat requirements of upstream salmonids and achieves required hydrologic conditions in the Delta. For example, if upstream reservoir releases are anticipated to be increased solely to meet the D-1641 February through June outflow requirement, then the following three-step procedure should be implemented. This three-step procedure was based upon, and modified from, information provided by Contra Costa Water District (Denton 2004 pers. comm.) and the SWRCB (SWRCB 2004).

1. If increased releases from Nimbus Dam are anticipated, then the management agencies (i.e., NOAA Fisheries, USFWS, and CDFG) should determine whether:
   - lower American River salmonids will be at risk in consideration of hydrologic, operational, and biologic conditions (**Appendix A**); and
   - EWA or CVP Improvement Act (CVPIA) Section 3406 (b)(2) water assets can be used to avoid anticipated impacts to lower American River salmonids by:
     - using previously acquired EWA water upstream of the Delta;
     - using EWA assets to purchase additional water upstream of the Delta to compensate for foregone water used for export reductions;
     - making available EWA water assets south of the Delta to Project water contractors; or
     - using CVPIA 3406 (b)(2) assets dedicated to the Delta (e.g., export reductions).

2. CVP/SWP operators should then determine if alternative compliance strategies are feasible, such as the alternatives described below. These alternatives should be considered separately or in combination, as appropriate.
   - The use of EWA or (b)(2) water assets to mitigate for water foregone by CVP/SWP contractors as a result of the increased uncertainty in forecasting compliance requirements related to the longer travel times from Shasta (5 days) and Oroville (3 days) reservoirs relative to Folsom Reservoir (1 day).

   - The reduction of Delta exports after a runoff event, as soon as necessary, to continue meeting outflow compliance during the descending limb of the hydrograph to achieve the required number of compliance days within a given month. This approach takes advantage of relatively higher flows into the Delta immediately following the peak of a runoff event, and thereby minimizes the potential need for greater total volumes of water released from upstream reservoirs later in the month to achieve outflow compliance if the hydrograph continued to decline throughout the month.

     However, a risk associated with early reduction of Delta exports is that total monthly CVP exports may be limited by the physical capacity of the Tracy facilities, thereby potentially reducing total monthly exports and annual CVP deliveries.

   - As an alternative to reducing Delta exports, increase Delta inflow from Folsom Reservoir releases after a runoff event, during the descending limb of the hydrograph, to achieve the required number of compliance days within a given month. This approach also minimizes the potential need for greater total volumes of water released from upstream reservoirs later in the month to achieve outflow compliance if the hydrograph continued to decline throughout the month. Another potential advantage of this approach is provision of more stable flows throughout a given month during the February through June period.

A risk associated with this approach is that Folsom Reservoir storage could be reduced unnecessarily if: (1) a natural runoff event in the American River Basin occurred later in the month, which would have provided Delta inflow from Folsom Reservoir sufficient for compliance without the need of additional inflow; and/or (2) runoff occurred in the Sacramento River or San Joaquin River basins sufficient to provide for the needed additional outflow.

3. If alternative compliance strategies are deemed infeasible and actions anticipated to adversely affect lower American River salmonids cannot be avoided, then the Data Assessment Team (DAT) and Operations and Fish Forum (OFF) should convene to develop operational recommendations. Disputes within the joint DAT and OFF group would be resolved by the Water Operations Management Team (WOMT). Joint DAT and OFF operational recommendations would be considered by WOMT as alternatives to historically employed operations (i.e., increased releases from Nimbus Dam) to achieve compliance with the D-1641 February through June Delta outflow requirement. These alternatives could consist of modifying Delta outflow compliance by changing the magnitude of total Delta outflow and/or the number of compliance days required. Temporary modifications of Delta outflow compliance requirements would be contingent upon the following approval process (SWRCB 2004). If alternative Delta outflow compliance strategies are proposed by WOMT, then those alternative compliance strategies would be effective immediately and would be presented to the Executive Director of the SWRCB. If the Executive Director does not object to the alternative compliance strategies within 10 days, these strategies would remain in effect for the remainder of the given month. Presently, neither the WOMT or the executive director possess the authority to implement alternative compliance strategies to meet delta water quality objectives and demands. These recommendations, therefore, promote that this authority is formally introduced through an amendment to D-1641.

INTEGRATED CVP/SWP OPERATIONAL APPROACH RECOMMENDATION

The second recommendation addresses the need for an integrated CVP/SWP operational approach to meet Delta water quality objectives and demands, in order to reduce Folsom Reservoir's role as a *"real-time, first response facility,"* and thereby minimize impacts on anadromous salmonids in the lower American River. Utilizing Folsom Reservoir as a *"real-time, first response facility"* to meet Delta water quality objectives and demands may result in: (1) reduced storage and instream flows, particularly during the Chinook salmon adult immigration and spawning period; (2) reduced interannual carryover storage; and (3) a depleted coldwater pool, which may limit the ability to manage water temperatures in the lower American River for juvenile steelhead over summer rearing, and fall-run Chinook salmon spawning.

- Considering the modifications described in the Adaptive Management Recommendations, an integrated approach to meeting Delta water quality objectives and demands that relies more equitably upon releases from Shasta, Oroville, and Folsom reservoirs should be developed and implemented.

It is recognized that difficulties are associated with implementing a program that utilizes releases from Shasta, Oroville, and Folsom reservoirs in order to meet Delta water quality objectives and demands. Because there is a reservoir-specific lag time for releases to reach the Delta (i.e., approximately 5 days from Shasta Reservoir, 3 days from Oroville Reservoir, and 1 day from Folsom Reservoir), the effectiveness of an integrated approach is limited by the ability of operators to accurately anticipate Delta water quality objectives and demands. Variable meteorological and tidal conditions influence the ability to predict the magnitude and timing of releases required to meet water quality objectives. Nevertheless, the feasibility of developing and implementing a system-wide program that results in the most efficient utilization of Folsom Reservoir should be evaluated.

5.0 LOWER AMERICAN RIVER FLOW FLUCTUATION INTERIM OBJECTIVES

Described below are specific lower American River flow fluctuation interim objectives that, to the extent possible, should not be compromised because of Delta-related changes in Nimbus Dam releases.

As previously described, meeting Delta water quality objectives and demands has resulted in flow fluctuations and potential impacts on anadromous salmonids in the lower American River. In an effort to minimize potential flow fluctuation impacts associated with meeting Delta water quality objectives and demands, interim flow fluctuation objectives were developed for the lower American River. To develop these interim objectives, several documents were reviewed including *Evaluation of Effects of Flow Fluctuations on the Anadromous Fish Populations in the Lower American River* (CDFG 2001) and *Biological Opinion on the Effects of the Proposed Long-Term Operations, Criteria and Plan for the Central Valley Project in Coordination with Operations of the State Water Project* (NOAA Fisheries 2004a). Upon considering: (1) the separate ramping recommendations stated in CDFG (2001) and NOAA Fisheries (2004a), which are intended to minimize salmonid fry stranding; and (2) the flow threshold recommendation stated in CDFG (2001), which is intended to minimize salmonid juvenile isolation, the interim objectives described below are recommended. The bases for these interim objectives are presented in **Appendix B**. To the extent possible, Delta water quality objectives and demands should not affect release operations from Nimbus Dam in a manner that would compromise these lower American River flow fluctuation interim objectives.

1. At flow levels ≤5,000 cfs, flow reductions should not exceed more than 500 cfs/day, and not more than 100 cfs/hour. Consistent with NOAA Fisheries (2004a), each year from January 1 through April 31, Reclamation should coordinate with NOAA Fisheries, CDFG, and USFWS to implement and fund monitoring in order to estimate the incidental take of salmonids associated with reductions in Nimbus Dam releases; and
2. Minimize occurrences of flow increases to 4,000 cfs or more, year-round, to minimize losses of juvenile Chinook salmon and steelhead due to isolation.

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Appendix A: Risk Assessment Considerations for Lower American River Water Management during February through June

Risk Assessment	February	March	April	May	June
Hydrologic Considerations	1. Precipitation to date 2. Runoff to date 3. Runoff forecast probability (e.g., 90%, 50%) 4. Degree of confidence in risk assessment	1. Precipitation to date 2. Runoff to date 3. Runoff forecast probability (e.g., 90%, 50%) 4. Degree of confidence in risk assessment	1. Precipitation to date 2. Runoff to date 3. Runoff forecast probability (e.g., 90%, 50%) 4. Degree of confidence in risk assessment	1. Precipitation to date 2. Runoff to date 3. Runoff forecast probability (e.g., 90%, 50%) 4. Degree of confidence in risk assessment	1. Precipitation to date 2. Runoff to date 3. Runoff forecast probability (e.g., 90%, 50%) 4. Degree of confidence in risk assessment
Fish Protection Considerations	1. Chinook salmon and steelhead redd dewatering and redd isolation 2. Chinook salmon and steelhead fry stranding 3. Steelhead juvenile isolation	1. Chinook salmon and steelhead redd dewatering and redd isolation 2. Chinook salmon and steelhead fry stranding 3. Steelhead juvenile isolation	1. Steelhead redd dewatering and redd isolation 2. Chinook salmon and steelhead fry stranding 3. Chinook salmon and steelhead juvenile isolation 4. Coldwater pool availability for steelhead juvenile over-summer rearing and Chinook salmon adult fall spawning	1. Steelhead redd dewatering and redd isolation 2. Steelhead fry stranding 3. Chinook salmon and steelhead juvenile isolation 4. Coldwater pool availability for steelhead juvenile over-summer rearing and Chinook salmon adult fall spawning	1. Steelhead fry stranding 2. Chinook salmon and steelhead juvenile isolation 3. Coldwater pool availability for steelhead juvenile over-summer rearing and Chinook salmon adult fall spawning
System Operation Considerations	1. Flood control 2. Storage a. Upstream of Folsom Reservoir b. Folsom Reservoir c. North CVP d. Oroville Reservoir 3. Delta water quality objectives at multiple compliance points[a] 4. Low hydrologic, tidal, and meteorological forecast certainty 5. Reservoir refill potential (e.g., Folsom Reservoir has a 50% chance of refill at 300 TAF end-of-September storage) 6. Release lag time to reach Delta (e.g., 5d from Shasta, 3d from Oroville, 1d from Folsom)	1. Flood Control 2. Storage a. Upstream of Folsom Reservoir b. Folsom Reservoir c. North CVP d. Oroville Reservoir 3. Delta water quality objectives at multiple compliance points[a] 4. Moderate hydrologic forecast certainty; low tidal and meteorological forecast certainty 5. Reservoir refill potential (e.g., Folsom Reservoir has a 50% chance of refill at 300 TAF end-of-September storage) 6. Release lag time to reach Delta (e.g., 5d from Shasta, 3d from Oroville, 1d from Folsom)	1. Flood Control 2. Storage a. Upstream of Folsom Reservoir b. Folsom Reservoir c. North CVP d. Oroville Reservoir 3. Delta water quality objectives at multiple compliance points[a] 4. Moderate hydrologic forecast certainty; low tidal and meteorological forecast certainty 5. Folsom Reservoir release vs. cold water conservation 6. Reservoir refill potential (e.g., Folsom Reservoir has a 50% chance of refill at 300 TAF end-of-September storage) 7. Release lag time to reach Delta (e.g., 5d from Shasta, 3d from Oroville, 1d from Folsom)	1. Flood Control 2. Storage a. Upstream of Folsom Reservoir b. Folsom Reservoir ▪ end-of-September carryover ▪ coldwater pool c. North CVP d. Oroville Reservoir 3. Delta water quality objectives at multiple compliance points[a] 4. High hydrologic forecast certainty; low tidal and meteorological forecast certainty 5. Folsom Reservoir release vs. cold water conservation 6. Release lag time to reach Delta (e.g., 5d from Shasta, 3d from Oroville, 1d from Folsom)	1. Storage a. Folsom Reservoir ▪ end-of-September carryover ▪ end-of-September coldwater pool b. North CVP c. Oroville Reservoir 2. Delta water quality objectives at multiple compliance points[a] 3. High hydrologic forecast certainty; low tidal and meteorological forecast certainty 4. Folsom Reservoir release vs. cold water conservation 5. Releases upstream of Folsom Reservoir 6. Release lag time to reach Delta (e.g., 5d from Shasta, 3d from Oroville, 1d from Folsom)

List of Acronyms and Abbreviations:
CVP = Central Valley Project; d = day; TAF = Thousand Acre Feet

[a] Please refer to State Water Resources Control Board Water Right Decision 1641 for specific water quality objectives.

APPENDIX B: BASES FOR LOWER AMERICAN RIVER FLOW FLUCTUATION INTERIM OBJECTIVES

Information from CDFG (2001) and NOAA Fisheries (2004a) was reviewed to develop the lower American River flow fluctuation interim objectives.

CDFG (2001) stated the following recommendations for the operation of Folsom Reservoir:

1. *Ramping rates should not exceed 100 cfs per hour when flows are ≤4,000 cfs;*
2. *Flow increases to 4,000 cfs or more should be avoided during critical rearing periods (January-July for YOY salmon and steelhead and October-March for yearling steelhead and non-natal rearing winter-run Chinook salmon) unless they can be maintained throughout the entire period; and,*
3. *Flow fluctuations that decrease flow below 2,500 cfs during critical spawning periods should be precluded: October-December for chinook (sic) salmon and December-May for steelhead.*

Although CDFG (2001) contained much descriptive information, development of the 4,000 cfs flow threshold recommendation was not fully described. Further studies may be required in order to more completely understand how salmonids may be affected by flow fluctuations in the lower American River. Concurrent with providing flow recommendations intended to protect salmonids in the lower American River, CDFG (2001) also acknowledges that their recommendations should be further validated (Page 48): "*A high resolution survey of the morphology of the lower American River should be conducted and integrated with hydrology to enable specific siting of locations controlling inundation of potential isolation areas as a function of flow.*"

In NOAA Fisheries (2004a), flow ramping criteria for the lower American River are stated (**Table 1**).

Table 1. Lower American River flow ramping criteria, as presented in NOAA Fisheries (2004a), titled *Biological Opinion on the Effects of the Proposed Long-Term Operations, Criteria and Plan for the Central Valley Project in Coordination with Operations of the State Water Project (SWP).*

Lower American River Daily Rate of Flow Change (cfs)	Amount of Flow Decrease in 24 hrs (cfs)	Maximum Flow Change Per Step (cfs)
20,000 to 16,000	4,000	1,350
16,000 to 13,000	3,000	1,000
13,000 to 11,000	2,000	700
11,000 to 9,500	1,500	500
9,500 to 8,300	1,200	400
8,300 to 7,300	1,000	350
7,300 to 6,400	900	300
6,400 to 5,650	750	250
5,650 to 5,000	650	250
< 5,000	500	100

The ramping criteria presented in Table 1 apply (Page 223) … "*During periods outside of flood control operations and to the extent controllable during flood control operations.*" NOAA Fisheries (2004a) provides further detail by stating (Page 224):

> *From January 1 through April 31 each year, Reclamation must coordinate with NOAA Fisheries, DFG, and FWS to implement and fund monitoring of steelhead egg and juvenile stranding or dewatering events in order to estimate the incidental take associated with flow reductions in this time period from Nimbus Dam to the American River. All efforts shall be made to minimize dewatering of steelhead redds or adverse effects to incubating eggs, fry or juveniles.*

Supporting documentation or rationale for the ramping criteria described above was not included in NOAA Fisheries (2004a) or in preceding OCAP biological opinions (NOAA Fisheries 2000, 2001, 2002, 2004b). However, communications with NOAA Fisheries indicate that the ramp down rates were based on consultations with Reclamation, and were intended to minimize the stranding and isolation of steelhead fry (Oppenheim 2004 pers. comm.).

Operating Nimbus Dam releases to the lower American River according to the ramping criteria in NOAA Fisheries (2004a) would require nine days to decrease releases from 20,000 cfs to 5,000 cfs. Such extended periods of ramp down from high releases could potentially affect water storage and coldwater pool availability subsequent to the ramp down event. These potential effects to water storage and coldwater pool availability in Folsom Reservoir could impact the flexibility and management of water temperatures in the lower American River in the summer and fall, potentially causing adverse impacts, in the form of thermal stress, to juvenile steelhead rearing during the summer and Chinook salmon spawning during the fall.

The ramping criteria stated in NOAA Fisheries (2004a) for flow levels below 5,000 cfs are more rigorous than the ramping criteria proposed by CDFG (2001). NOAA Fisheries (2004a) limits ramp down rates to no more than 100 cfs/hour and no more than 500 cfs/day, whereas CDFG (2001) recommends flow reductions of no more than 100 cfs/hour with no specific daily maximum. Because CDFG (2001) does not specify a daily maximum reduction in flows, lower American River flows could be decreased by up to 2,400 cfs/day. Therefore, the more restrictive ramping criteria presented in NOAA Fisheries (2004a) were selected as interim objectives for flows ≤5,000 cfs (Section 5.0).