2002 ANNUAL TECHNICAL REPORT

VIEW REPORT

2002

SAN JOAQUIN RIVER GROUP AUTHORITY

Head of Old River Barrier

2002 ANNUAL TECHNICAL REPORT

On Implementation and Monitoring of the San Joaquin River Agreement and the Vernalis Adaptive Management Plan

Prepared by

SAN JOAQUIN RIVER GROUP AUTHORITY

Prepared for the

CALIFORNIA STATE WATER RESOURCES CONTROL BOARD

In Compliance with D-1641

JANUARY 2003

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EXECUTIVE SUMMARY

The San Joaquin River Agreement (SJRA) is the cornerstone of a history-making commitment to implement the State Water Resources Control Board (SWRCB) 1995 Water Quality Control Plan (WQCP) for the lower San Joaquin River and the San Francisco Bay-Delta Estuary (Bay-Delta). Using a consensus-based approach, the SJRA united a large and diverse group of agricultural, urban, environmental and governmental interests.

The 2002 Annual Technical Report comprises the consolidated annual SJRA Operations Report and Vernalis Adaptive Management Plan (VAMP) Monitoring Report. The VAMP 2002 program represents the third year of formal compliance with SWRCB Decision 1641 (D-1641). D-1641 requires the preparation of an annual report documenting the implementation and results of the VAMP program. Specifically, this report includes the following information on the implementation of the SJRA: the hydrologic chronicle; management of the additional SJRA water; installation, operation, and monitoring of the Head of Old River Barrier (HORB); results of the juvenile Chinook salmon smolt survival investigations; discussion of complementary investigations; and, conclusions and recommendations. Condition 4.b of D-1641 directs the Department of Water Resources (DWR) and the U.S. Bureau of Reclamation (USBR) to send the Executive Director, SWRCB the results of the fishery monitoring studies on an annual basis and Condition 7 of D-1641 directs Merced, Modesto, Turlock, South San Joaquin and Oakdale irrigation districts to submit a report detailing district operations as a result of the SJRA. By letter dated September 8, 2000, the SWRCB approved combining these two reports into a single comprehensive report due the SWRCB on January 31, of each year.

The 2002 Annual Technical Report comprises the consolidated annual SJRA Operations Report and Vernalis Adaptive Management Plan (VAMP) Monitoring Report.

A key part of this landmark agreement is the VAMP. VAMP is designed to protect juvenile Chinook salmon migrating from the San Joaquin River through the Sacramento-San Joaquin Delta. VAMP is also a scientifically recognized experiment to determine how salmon survival rates change in response to alterations in San Joaquin River flows and State Water Project (SWP)/Central Valley Project (CVP) exports and the installation of the HORB.

VAMP employs an adaptive management strategy to use current knowledge of hydrology and environmental conditions to protect Chinook salmon smolt passage, while gathering information to allow more efficient protection in the future. In addition to providing improved protection for juvenile Chinook salmon emigrating from the San Joaquin River system, specific experimental objectives of VAMP 2002 included:

- Quantification of Chinook salmon smolt survival between Durham Ferry and Jersey Point using recapture locations at Antioch and Chipps Island, under conditions of a San Joaquin River flow at Vernalis of 3,200 cfs, with an installed HORB, and SWP/CVP export rate of 1,500 cfs; and
- Comparison of juvenile Chinook salmon survival between Durham Ferry and Mossdale for use in comparing results of VAMP 2002 with results from earlier survival studies where coded-wire tagged (CWT) salmon releases occurred at Mossdale.

The VAMP 2001 Annual Technical Report presented a series of conclusions and recommended modifications to the VAMP experimental design and/or program implementation. The 2001

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recommendations were used, in part, as the basis for developing the 2002 VAMP test program. For example, the 2001 report recommended weekly measurements of San Joaquin River flow at the Vernalis gage, continued hydrology investigations to estimate ungaged flows (accretions, depletions) to improve hydrologic predictions, and continued coordination among tributary operators to facilitate implementation of the VAMP test flow conditions. As part of the 2002 program, the VAMP Hydrology Group, working in cooperation with tributary operators and USGS, was able to improve our understanding of San Joaquin River hydrology, provide measurements of Vernalis flow, and provide effective coordination of releases from upstream tributaries.

*To the extent possible, **VAMP** survival testing should be conducted at flow and export extremes to IMPROVE THE ABILITY of the program to detect differences in juvenile Chinook salmon survival.*

Contained in the 2001 report were several recommendations including modification of the HORB trash screen design and routine maintenance, continued refinement of operational criteria for culverts, securing all necessary permits for construction of the barrier, measuring flows within each of the culverts, continuing monitoring to evaluate potential impacts of seepage, and improving the experimental design of fishery monitoring in the HORB investigations. These recommendations were addressed as part of the 2002 VAMP program. In addition, the Department of Water Resources (DWR) was successful in securing all of the necessary permits and approvals from the regulatory agencies for the installation of the HORB over the next five years. The landowner access permits for the HORB continue to be renewed annually.

The 2001 report recommended that, to the extent possible, VAMP survival testing be conducted at flow and export extremes to improve the ability of the program to detect differences in juvenile Chinook salmon survival among target flow and export conditions. Hydrologic conditions within the San Joaquin River watershed were not suitable for testing extreme target conditions as part of the VAMP 2002 program. These and other recommendations from the 2001 VAMP program were used to improve the overall experimental design and implementation of the 2002 VAMP investigations. Recommendations made based upon analysis of the VAMP 2002 program will also be used, in a similar way, by the VAMP Hydrology and Fishery Biology Groups in developing and implementing the experimental design for the 2003 VAMP studies.

Based on data gathered during the experimental mark-recapture studies that occurred over a 31-day period in April and May 2002, a set of conclusions and recommendations has been developed. These conclusions and recommendations provide guidance and a foundation for design and implementation of future VAMP operations. Key conclusions and recommendations derived from VAMP 2002 include:

- VAMP 2002 is the third year of full implementation of the program. Average Vernalis flow during the VAMP period was 3,300 cfs. SWP and CVP export rate averaged 1,430 cfs. The VAMP period was between April 15 and May 15, 2002.
- Relative recovery rates of CWT salmon released at Durham Ferry and Jersey Point using recaptures at Antioch and Chipps Island indicated that there was no statistical ($P>0.05$) difference between the two replicates conducted in 2002.
- The proportion of CWT salmon released and recaptured from the combined Durham Ferry and Mossdale groups relative to the proportion of CWT salmon released and recaptured from the Jersey Point (control) releases showed that the relative

proportions during 2002 (target flow 3,200 cfs and 1,500 cfs exports) were not significantly different (P>0.05) than the proportions from the VAMP 2000 study (target flow 5,700 cfs and 2,250 cfs exports) or VAMP 2001 study (target flow 4,450 cfs and 1,500 cfs exports).

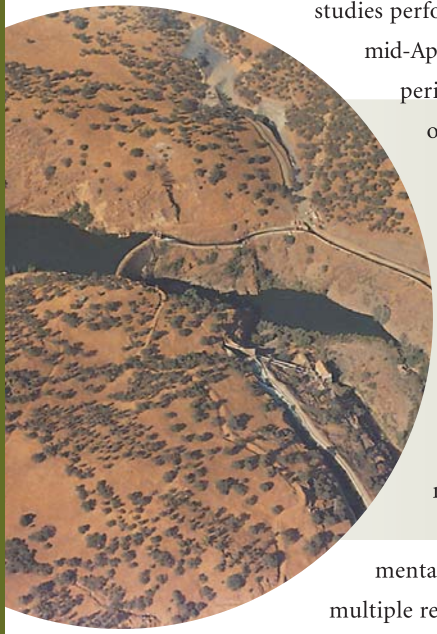
- Streamflow data at Vernalis were improved by weekly flow measurements and rating curve verification, however estimation of ungaged flow (accretions and depletions) requires further investigation for use in establishing annual VAMP target flows. Alternative methods of measuring flow at Vernalis and/or alternative measurement locations should also be investigated.
- The design of the HORB was unchanged for this year, however rock debris and on going construction activities during the final phases of construction after closure of the barrier proved to be a problem for fishery sampling. Recommendations were made to delay salmon releases at Durham Ferry and Mossdale in future years for a period of approximately 5 days after HORB closure to allow time for gravel and rock to flush from the culverts and to improve fishery sampling at the site. It is recommended that there be improved maintenance of the culverts to reduce debris accumulation.
- Accurate flow measurements in the San Joaquin River and the Old River near the HORB continue to limit the accuracy of the entrainments correlations. Flows are currently based on extrapolating from upstream measurements, some spot flow measurements in the Old River and San Joaquin River, as well as, estimates of flow through the culverts and seepage through the HORB.
- Construction of multiple barriers within the south delta during the spring has the potential to delay completion of the construction of HORB and release of the coded wire tagged salmon as part of the VAMP. This delay may contribute to exposure of juvenile Chinook salmon to elevated water temperatures. Due to the high risk of losing major salmon protection benefits and biasing experimental conditions, it is strongly recommended that construction of the HORB be completed on schedule to avoid delays in implementing survival investigations.
- It is also recommended that flow measurements be made to document flow through HORB culverts and the resultant flow within the San Joaquin River downstream of the confluence with Old River.
- The variability in conducting salmon smolt survival studies in the lower San Joaquin River and Delta makes it difficult to detect statistically significant differences in salmon survival between VAMP flow and export target conditions, which are relatively similar. It is strongly recommended that, when possible, target flow and export conditions be selected to conduct survival tests at VAMP flow and export extremes to improve the ability to detect potential differences in salmon smolt survival among test conditions.
- Approximately 77 percent of the unmarked salmon migrating past Mossdale between March 15 and June 30, 2002 migrated during the VAMP period (April 15 through May 15) and were, therefore protected by increased San Joaquin River flow, installation of the HORB and decreased export pumping.
- The selection and management of VAMP flow conditions should, if possible, minimize or avoid requiring upstream tributary flows that adversely affect habitat quality or survival of natural salmon produced within the tributaries. It is therefore recommended that upstream tributary and VAMP studies are coordinated as much as possible.
- Estimates of salmon survival rates under flow and export conditions tested in 2000, 2001, and 2002 have not been found to be significantly different. Survival tests at extreme target levels (e.g., 7,000 cfs flow and 1,500 cfs exports) are important to obtain. The VAMP program provides improved protection for juvenile salmon when compared to “without-VAMP” conditions. Further tests, over a wider range of flow and export conditions, are needed to evaluate the respective roles of San Joaquin River flow and SWP/CVP exports on juvenile Chinook salmon smolt survival. The report recommends that the VAMP experimental test program be continued.

CHAPTER 1 | INTRODUCTION

The Vernalis Adaptive Management Plan (VAMP) was implemented between April 15 and May 15, 2002 to protect juvenile Chinook salmon and evaluate the relationship between San Joaquin River flow and State (SWP) and federal (CVP) water project exports on survival of juvenile Chinook salmon migrating through the Sacramento–San Joaquin Delta. This represents the third official year of the VAMP experiment.

EXPERIMENTAL DESIGN ELEMENTS

The VAMP experimental design measures salmon smolt survival rates under six different combinations of flow and export rates. The experimental design includes two mark-recapture studies performed each year during the mid-April to mid-May outmigration period that provide estimates of salmon survival under each set of conditions. Chinook salmon survival indices under each of the experimental conditions are then calculated based on the numbers of marked salmon released and the number recaptured.



The VAMP 2002 experimental design included both multiple release locations (Durham Ferry, Mossdale, and Jersey Point), and multiple recapture locations (Antioch, Chipps Island, SWP and CVP salvage operations, and in the ocean fisheries Figure 1-1). Two sets of releases were made at Durham Ferry, Mossdale, and Jersey Point. The use of data from multiple release and recapture locations allows for a more thorough evaluation of juvenile Chinook salmon survival as compared to recapture data from only one sampling location and/or one series of releases. The VAMP coded-wire tag (CWT) releases (Durham Ferry, Mossdale, and Jersey Point) and recapture locations (Antioch and Chipps Island) will be consistent from one year to the next, providing a greater opportunity to assess salmon smolt survival over a range of Vernalis flows, SWP/CVP exports, and with and without the presence of the Head of Old River Barrier (HORB). Releases at Jersey Point serve as controls for recaptures at Antioch and Chipps Island, thereby allowing the calculation of survival estimates based on the ratio of survival indices from marked salmon recaptured from upstream (e.g., Durham Ferry and Mossdale) and downstream (control release at Jersey Point) releases. The use of ratio estimates as part of the VAMP study design substantially reduces the bias associated with differential gear collection efficiency within and among years, improves the precision associated with the individual survival estimates, and improves confidence in detecting differences in salmon smolt survival as a function of Vernalis flows and SWP/CVP exports.

A quality assurance/quality control program has been used as a routine part of VAMP tests, including the 2002 CWT tagging at the Merced River Fish Hatchery to provide information useful in quantifying CWT tag retention and improving tag efficiency. Modifications were also made during the 2002 program to improve releases at Durham Ferry through coordination with the local landowner to curtail operation of an agricultural diversion pump located immediately downstream of the release site, coincident with each of the two Durham Ferry releases. In addition, the 2002 VAMP program continued use of the net pen studies to determine the health and survival of test fish released as part of VAMP. Efforts also continued to improve the procedure used to statistically analyze VAMP survival and recovery information, however additional improvements remain to be made in the ability to measure flow passing through the HORB culverts and the resultant flow within the San Joaquin River downstream of the confluence with Old River. Measurements in the future of San Joaquin River flow downstream of the HORB will be used to evaluate the relationship between San Joaquin River flow and juvenile Chinook salmon survival.

Additional complimentary studies, including survival studies for juvenile Chinook salmon released into the Mokelumne River tributaries and radio tracking of salmon migrating downstream though Delta channels, were incorporated into the 2002 VAMP investigations.

FIGURE 1–1

Sacramento-San Joaquin Estuary

Location of VAMP 2002 Release Sites (Durham Ferry, Mossdale and Jersey Point), Recovery Locations (Antioch and Chipps Island), and Head of Old River Barrier Location Within the Sacramento-San Joaquin River Delta/Estuary.

CHAPTER 2 | VAMP HYDROLOGIC PLANNING AND IMPLEMENTATION

This section documents the planning and implementation undertaken by the Hydrology Group of the San Joaquin River Technical Committee (SJRTC) for the 2002 VAMP investigations. Implementation of VAMP is guided by the framework provided in the SJRA and anticipated hydrologic conditions within the watershed.

The Hydrology Group was established for the purpose of forecasting hydrologic conditions and for planning, coordinating, scheduling and implementing the flows required to meet the test flow target in the San Joaquin River near Vernalis. The Hydrology Group is also charged with exchanging information relevant to the forecasted flows, and coordinating with others in the SJRTC, in particular the Biology Group, responsible for planning and implementing the salmon smolt survival study.

Participation in the Hydrology Group is open to all interested parties, with the core membership consisting of the designees of the agencies responsible for the water project operations that would be contributing flow to meet the target flow. In 2002, the agencies belonging to the Hydrology Group included: Merced Irrigation District (Merced), Turlock Irrigation District (TID), Modesto Irrigation District (MID), Oakdale Irrigation District (OID), South San Joaquin Irrigation District (SSJID), San Joaquin River Exchange Contractors (Exchange Contractors), and the U.S. Bureau of Reclamation (USBR). Though not a water provider, the California Department of Water Resources (DWR) was closely involved with the coordination of operations relating to the installation of the HORB and the planning of delta exports consistent with the VAMP.

VAMP FLOW AND SWP/CVP EXPORTS

The VAMP investigations are designed to collect data and information on the relationship between San Joaquin River flow and Delta exports (SWP and CVP pumping at the Tracy and Banks pumping plants) on the survival rates of juvenile Chinook salmon emigrating from the San Joaquin River system. The VAMP provides for a 31-day pulse flow (target flow) at the Vernalis gage during the months of April and May, along with a corresponding reduction in SWP/CVP exports, as shown in Table 2-1. The magnitude of the pulse flow is based on San Joaquin River flow that would occur during the pulse period absent the VAMP, referred to as the existing flow.

As part of the development of the VAMP experimental design, the VAMP Hydrology and Biology Groups jointly identified a level of variation in San Joaquin River flow and SWP/CVP export rate thought to be within an acceptable range for specific VAMP test conditions. In developing the criteria, the VAMP Hydrology and Biology Groups examined both the ability to effectively monitor and manage flows and exports within various ranges (e.g., the ability to accurately manage and regulate export rates is substantially greater than the ability to manage San Joaquin River flows) and the flow and export differences among VAMP targets (Table 2-1). Through these discussions, the technical committees agreed that SWP/CVP export rates would be managed to a level of plus or minus 2.5% of a given export rate target. Furthermore, the technical committees agreed that, to the extent possible, it would be desirable that exports be allocated approximately evenly between SWP and CVP diversion facilities.

The ability to manage and regulate San Joaquin River flows was more difficult due to variation in unregulated flows, uncertainty in real-time flows due to changing channel conditions, lags and delays in transit time, and a variety of other factors. Concern was expressed that variation in San Joaquin River flow on the order of plus or minus 10% would potentially result in overlapping flow conditions between two VAMP targets. To minimize the probability of overlapping flow conditions among VAMP targets, the technical committees explored an operational guideline of plus or minus 5% flow variation at the Vernalis gage, however, system operators expressed concern about the ability to maintain flows within this range. As a result of these discussions and analysis, the

TABLE 2–1
VAMP Vernalis Flow and Delta Export Targets

EXISTING FLOW (CFS)	VAMP TARGET FLOW (CFS)	DELTA EXPORT TARGET RATES (CFS)
0 to 1,999	2,000	
2,000 to 3,199	3,200	1,500
3,200 to 4,449	4,450	1,500
4,500 to 5,699	5,700	2,250
5,700 to 7,000	7,000	1,500 or 3,000
Greater than 7,000	Provide stable flow to the extent possible	

joint Hydrology and Biology Groups agreed to a target range variation of plus or minus 7% of the Vernalis flow target as a guideline for evaluating the VAMP experimental conditions. It was recognized by the Hydrology and Biology Groups that these guidelines were not absolute conditions, but was to be used by the VAMP hydrology fisheries workgroups to evaluate experimental test conditions and the potential effect of flow and export variation in our ability to detect and assess variation in juvenile Chinook salmon survival rates among VAMP test conditions.

Under the SJRA, the following SJRGA agencies have agreed to provide the supplemental water, limited to a maximum of 110,000 acre-feet, needed to achieve the VAMP target flows shown in Table 2-1: Merced, OID, SSJID, Exchange Contractors, MID and TID.

The 2,000 cfs VAMP target flow shown in Table 2-1 does not represent a VAMP experiment data point but is used to define the supplemental water volume to be provided by the SJRGA agencies. In preparation of the conceptual framework for the VAMP it was recognized that in extremely dry conditions the San Joaquin River flow and associated exports would be determined in accordance with the existing biological opinions under the Endangered Species Act and the 1994 Bay-Delta Accord. In consideration of these factors, when the existing flow is less than 2000 cfs, the USBR, in accordance with the SJRA, shall act to purchase additional water from willing sellers to fulfill the requirements of existing biological opinions.

Based upon hydrologic conditions, the target flow in a given year could either be increased to the next highest value ("double-step") or the supplemental water requirement could be eliminated entirely. A numerical procedure has been established in the SJRA to determine the target flow. The SWRCB San Joaquin Valley Water Year Hydrologic Classification ("60-20-20" classification) is given a numerical indicator as shown in Table 2-2.

TABLE 2–2

San Joaquin Valley Water Year Hydrologic Year Classifications Used in VAMP

60-20-20 WATER YEAR CLASSIFICATION	VAMP NUMERICAL INDICATOR
Wet	5
Above Normal	4
Below Normal	3
Dry	2
Critical	1

"Double-step" flow years occur when the sum of last year's numerical indicator and the 90 percent exceedence forecast of the current year's numerical indicator is seven (7) or greater.

If the sum of the two previous years' numerical indicators and the 90 percent exceedence forecast of the current year's numerical indicator is four (4) or less, indicative of an extended dry period, no VAMP supplemental water will be provided. The USBR, however, has a continuing obligation to meet San Joaquin River flows pursuant to the March 6, 1995 Delta Smelt Biological Opinion.

Under the SJRA, the maximum amount of supplemental water to be provided to meet VAMP target flows in any given year is 110,000 acre-feet. Based on the targets outlined in Table 2-1, in a double-step year up to 157,000 acre-feet of supplemental water may be required. If the VAMP target flow requires more than 110,000 acre-feet of supplemental water, then additional water may be acquired on a willing seller basis.

HYDROLOGIC PLANNING

Hydrology Group Meetings

Beginning in February 2002, and continuing until early April, the Hydrology Group held five planning and coordination meetings (February 13, March 13, March 28, April 3 and April 10). At these meetings, forecasts of hydrologic and operational conditions on the San Joaquin River and its tributaries were discussed and refined.

Monthly Operation Forecasts

As part of the early planning efforts, monthly operation forecasts were developed by the Hydrology Group to estimate the existing flow at Vernalis. Inflows to the tributary reservoirs used in these forecasts were based on DWR Bulletin 120 runoff forecasts. The monthly operation forecasts used the 90 percent and 50 percent probability of exceedence runoff forecasts. The initial monthly operation forecast was prepared in early February and presented at the February 13 Hydrology Group meeting. The 90 percent exceedence forecast called for a VAMP target flow of 3,200 cfs with a need for about 30,000 acre-feet of supplemental water; the 50 percent exceedence forecast called for a VAMP target flow of 4,450 cfs with a need for about 76,000 acre-feet of supplemental water. Hydrologic projections and planning were subsequently refined as additional information became available in March and April.

Daily Operation Plan

Starting in mid-March, the Hydrology Group began development of a daily operation plan, updating it as hydrologic conditions and operational requirements changed. The daily operation plan calculated an estimated mean daily flow at Vernalis based on estimates of the daily flow at the major tributary control points, estimates of ungaged flow between those control points and Vernalis, and estimates of flow in the San Joaquin River above the major tributaries. The following key assumptions were used in the development of the daily operation plan:

(**1**) The travel times for flows from the tributary control points and upper San Joaquin River to the Vernalis gauge are assumed as follows:

a. Merced River at Cressey to Vernalis	3 days
b. San Joaquin River above Merced River to Vernalis	2 days
c. Tuolumne River at LaGrange to Vernalis	2 days
d. Stanislaus River below Goodwin Dam to Vernalis	2 days

(**2**) Based upon a review of the historical flow record, the ungauged flow at Vernalis was assumed to be constant throughout the VAMP period and equal to the trending value entering the period. By definition, the ungauged flow is that unmeasured flow entering the system between Vernalis and the upstream measuring points and is calculated as follows:

Vernalis Ungauged =

VNS - GDWlag - LGNlag - CRSlag - USJRlag

where:

VNS = San Joaquin River near Vernalis

GDWlag = Stanislaus River below Goodwin Dam lagged 2 days

LGNlag = Tuolumne River below LaGrange Dam lagged 2 days

CRSlag = Merced River at Cressey lagged 3 days

USJRlag = San Joaquin River above Merced River lagged 2 days (USJR is not a gauged flow but is the calculated difference between the gauged flows at the San Joaquin River at Newman (NEW) and the Merced River near Stevinson (MST)).

A disagreement occurred between members of the Hydrology Group on how to compute the existing flow for the Stanislaus River. It was agreed that the existing flow would be the flow set by the New Melones Interim Operations Plan (IOP); however, there was disagreement on what level of exceedence forecast should be used when applying the IOP. The USBR uses a 90% exceedence forecast for developing water supply allocations. The U.S. Fish and Wildlife Service (USFWS) however, has suggested that since the IOP was developed based on a long-term planning model which used a set of known (perfect foresight) inflows, the 50% exceedence data set would best match what was used in the long-term modeling. At this time, the USBR and the USFWS are working to reach a common understanding on this issue.

By definition, the VAMP 31-day pulse flow period can occur anytime between April 1 and May 31. Until the VAMP flow period is specifically defined, it is assumed for the purposes of planning to be April 15 through May 15. Flexibility of the VAMP flow period exists so that it can coincide with the period of peak salmon out-migration. Other factors, including installation of HORB, availability of juvenile salmon at the hatchery, and manpower and equipment availability for salmon releases and recapture need to be considered in determining the timing of the VAMP period.

The 60-20-20 classification for water year 2001 was “dry”, giving it a VAMP numerical indicator of 2. There was no possibility of a dry period offramp (numerical indicator of previous two plus current year total of 4 or less) because the classification for water year 2000 was “above normal” with a numerical indicator of 4. In order to trigger the “double-step” criteria, the April 1 90 percent exceedence forecast for water year 2002 would need to be for a “wet” year, with a VAMP numerical indicator of 5. The early 90% exceedence forecasts (Jan., Feb. and Mar.) were indicating a “dry” or “critical” year, making it very unlikely that 2002 would be a “double-step” year; therefore, planning efforts concentrated on the “single step” criteria. In fact, the 90 percent exceedence forecast on April 1 for the San Joaquin Valley was for a “dry” year, resulting in the 2002 VAMP following the “single step” criteria.

The initial Daily Operation Plan was prepared on March 13, and was modified as hydrologic conditions and operational requirements changed. Table 2-3 summarizes the various iterations of and demonstrates the evolutionary nature of the daily operation plan. Copies of the daily operation plans are provided in Appendix A.

In early March DWR announced that the HORB would be completed by April 15, therefore the period of April 15 through May 15 was designated as the target flow period. Due to regulatory and operational constraints, Merced needs approximately 7 days of lead time to effect a flow change at Vernalis (48 hours regulatory notice on operation change and approximately 5 days travel time from New Exchequer Dam to Vernalis), therefore the target flow needed to be defined by April 8. Based on the available data the Hydrology Group set the target flow at 3,200 cfs at its meeting on April 8.

TABLE 2–3

Summary of 2002 VAMP Daily Operation Plans Prepared During Planning Phase

VAMP FORECAST DATE	PULSE PERIOD	ASSUMED UNGAUGED FLOW AT VERNALIS (CFS)	EXISTING FLOW (CFS)	VAMP TARGET FLOW (CFS)	SUPPLEMENTAL WATER NEEDED TO MEET TARGET FLOW (1,000 AF)
March 13	April 15–May 15	400	2,150	3,200	64.30
		800	3,130	3,200	4.12
March 22	April 15–May 15	400	2,450	3,200	46.16
		600	2,880	3,200	19.47
March 28	April 15–May 15	400	2,531	3,200	41.16
		600	3,525	4,450	56.91
April 08	April 15–May 15	400	2,842	3,200	22.04
April 09	April 15–May 15	400	2,742	3,200	28.19

TABLE 2–4

Summary of USGS Flow Measurements at the San Joaquin River Near Vernalis Gage

DATE	RIVER STAGE (FT)	MEASURED FLOW (CFS)	CDEC REPORTED REAL-TIME FLOW (CFS)	PERCENT DIFFERENCE	RATING SHIFT
March 5 at 9:30	9.61	1,990	1,940	+2.6%	No
March 27 at 8:26	9.82	2,120	2,120	0.0%	No
April 3 at 9:59	9.30	1,670	1,696	-1.5%	No
April 10 at 9:17	9.48	1,810	1,838	-1.5%	No
April 17 at 8:53	10.75	2,990	2,973	+0.6%	No
April 24 at 10:52	11.00	3,220	3,219	0.0%	No
May 1 at 9:26	11.20	3,340	3,426	-2.6%	No
May 8 at 9:00	11.18	3,340	3,408	-2.0%	No

Normally, the USGS measures the flow at Vernalis to check the current rating shift on a monthly basis. The real-time flows reported by the USGS and CDEC are dependent on the most current rating shift, therefore a new measurement and shift can result in a sudden and significant change in the reported real-time flow. In order to minimize the potential for these sudden and significant changes, arrangements were made with the USGS to measure the flow at Vernalis on a weekly basis between March 27 and May 8. The results of these measurements are summarized in Table 2-4. As can be seen in Table 2-4, the Vernalis gage site was relatively stable and no rating shifts were applied during the target flow period.

IMPLEMENTATION

Operation Conference Calls

During implementation of the VAMP pulse flow, conference calls were conducted on a regular basis to discuss the status of the pulse flow and to make changes to the operation plan if needed. The calls were held at 6:30 a.m. so that potential operational changes could be implemented on that day. The conference calls were held every Monday, Wednesday and Friday, starting on April 12 and ending on May 10.

Operation Monitoring

The planning and implementation of the VAMP spring pulse flow operation was accomplished using the best available real-time data from the sources listed in Table 2-5. The CDEC real-time data has not been reviewed for accuracy or adjusted for rating shifts; the USGS real-time data has had some preliminary review and adjustment. During the VAMP flow period, the real-time flows at Vernalis and in the San Joaquin River tributaries were continuously monitored. Similarly, the computed ungaged flow at Vernalis and the flow in the San Joaquin River upstream of the Merced River were continuously updated. The monitoring was necessary to verify that supplemental water deliveries were adhering to tributary allocations contained in the SJRA to the extent possible, as well as to determine if changes in hydrologic conditions would require changes to the operation plan.

TABLE 2–5

Real-time Flow Data and Sources

MEASUREMENT LOCATION	REAL-TIME DATA SOURCE
San Joaquin River near Vernalis	USGS
Stanislaus River below Goodwin Dam	USBR Goodwin Dam daily operation report
Tuolumne River below LaGrange Dam (LGN)	USGS
Merced River at Cressey (CRS)	CDEC
Merced River near Stevinson (MST)	CDEC
San Joaquin River at Newman (NEW)	USGS

The daily operation plan was updated throughout the VAMP flow period. A summary of the updated daily operation plans is provided in Table 2-6. Copies of the updated daily operation plans are provided in Appendix A.

RESULTS OF OPERATIONS

The final accounting for the VAMP operation is accomplished using provisional mean daily flow data available from USGS and DWR. The provisional data has been reviewed and adjusted for rating shifts but is still considered preliminary and subject to change. Plots of the real-time and provisional flows at the primary measuring points are provided in Appendix A to illustrate the differences between the real-time and the provisional data.

The mean daily flow at the Vernalis gage averaged 3,300 cfs during the VAMP test flow period, with a maximum of 3,610 cfs and a minimum of 2,840 cfs. The average flow for the test flow

TABLE 2–6

Summary of 2002 VAMP Daily Operation Plans Prepared During Implementation Phase

VAMP FORECAST DATE	VAMP PERIOD	ASSUMED UNGAUGED FLOW AT VERNALIS (CFS)	EXISTING FLOW (CFS)	VAMP TARGET FLOW (CFS)	SUPPLEMENTAL WATER NEEDED TO MEET TARGET FLOW (1,000 AF)
April 16	April 15–May 15	300	2,645	3,200	34.10
April 19	April 15–May 15	300	2,623	3,200	35.49
April 25	April 15–May 15	300	2,636	3,200	34.68
May 09	April 15–May 15	450	2,747	3,200	27.88

FIGURE 2–1

2002 VAMP–San Joaquin River Near Vernalis–With and Without VAMP

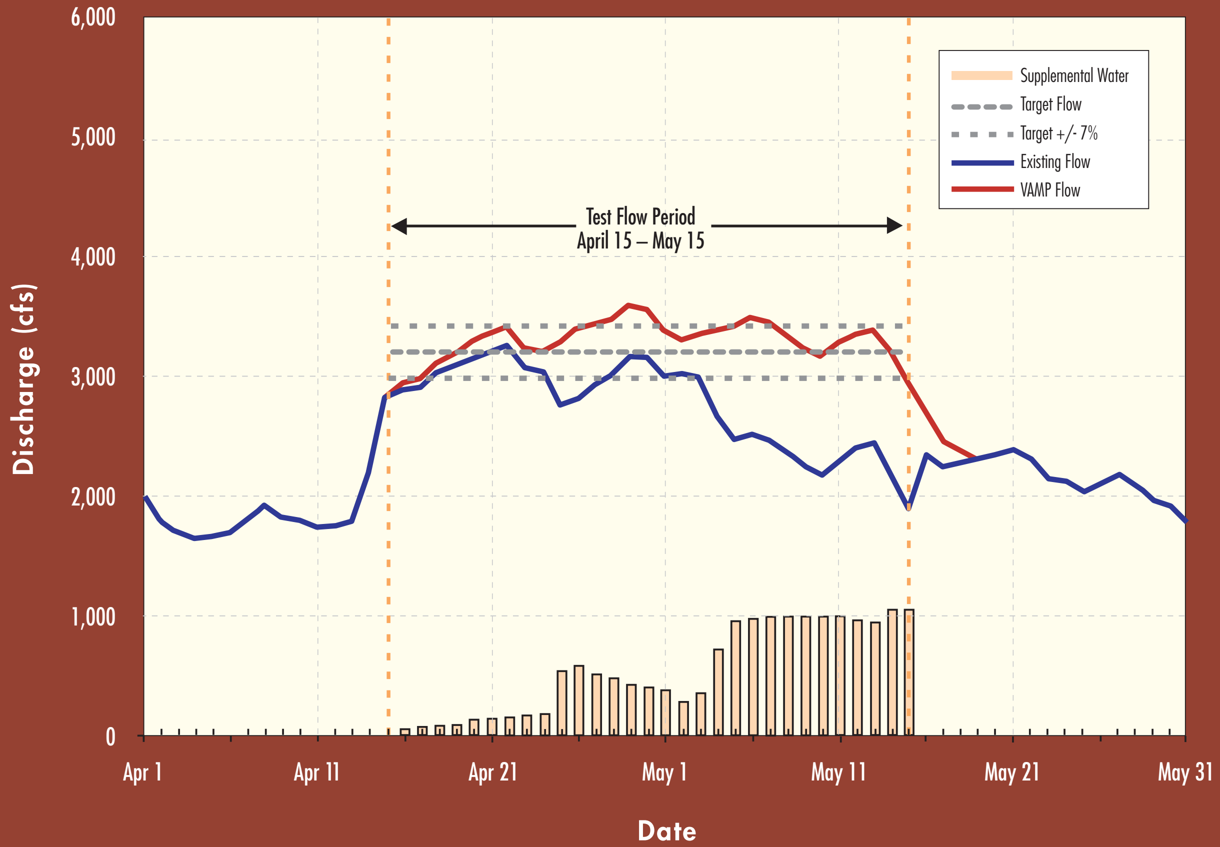


FIGURE 2–2

2002 VAMP–San Joaquin River Near Vernalis With Lagged Contributions From Primary Sources

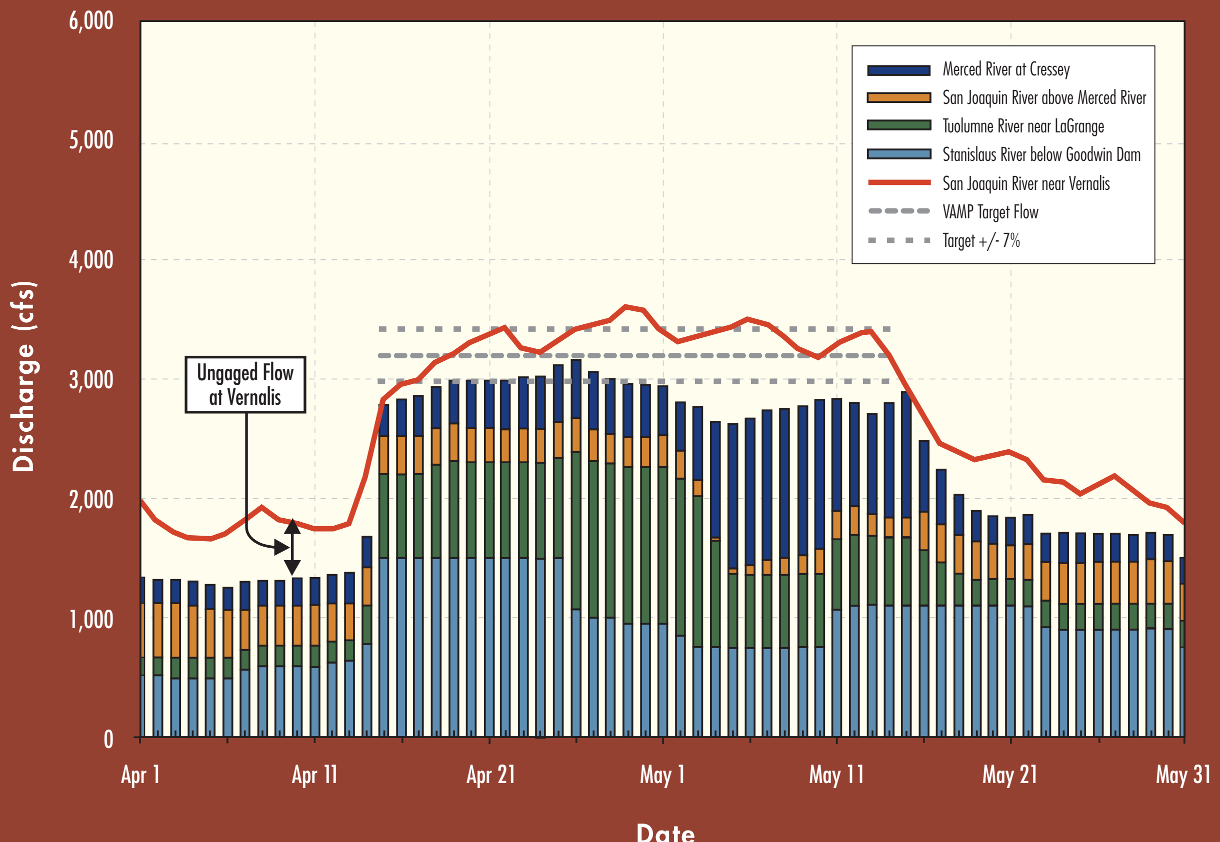


FIGURE 2–3

2002 VAMP–Ungaged Flow at Vernalis During Test Flow Period

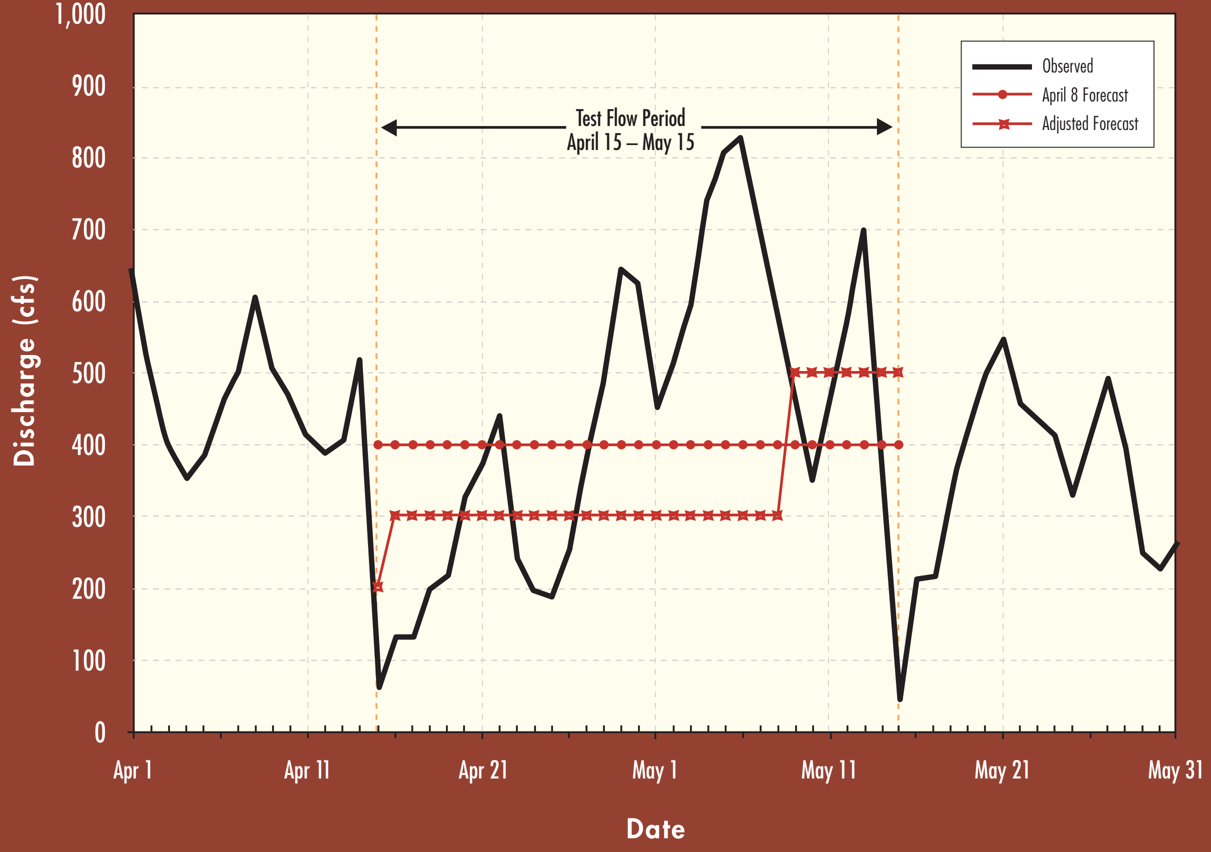


FIGURE 2–4

2002 VAMP–Federal and State Exports [Source: USBR Delta Operations Report]

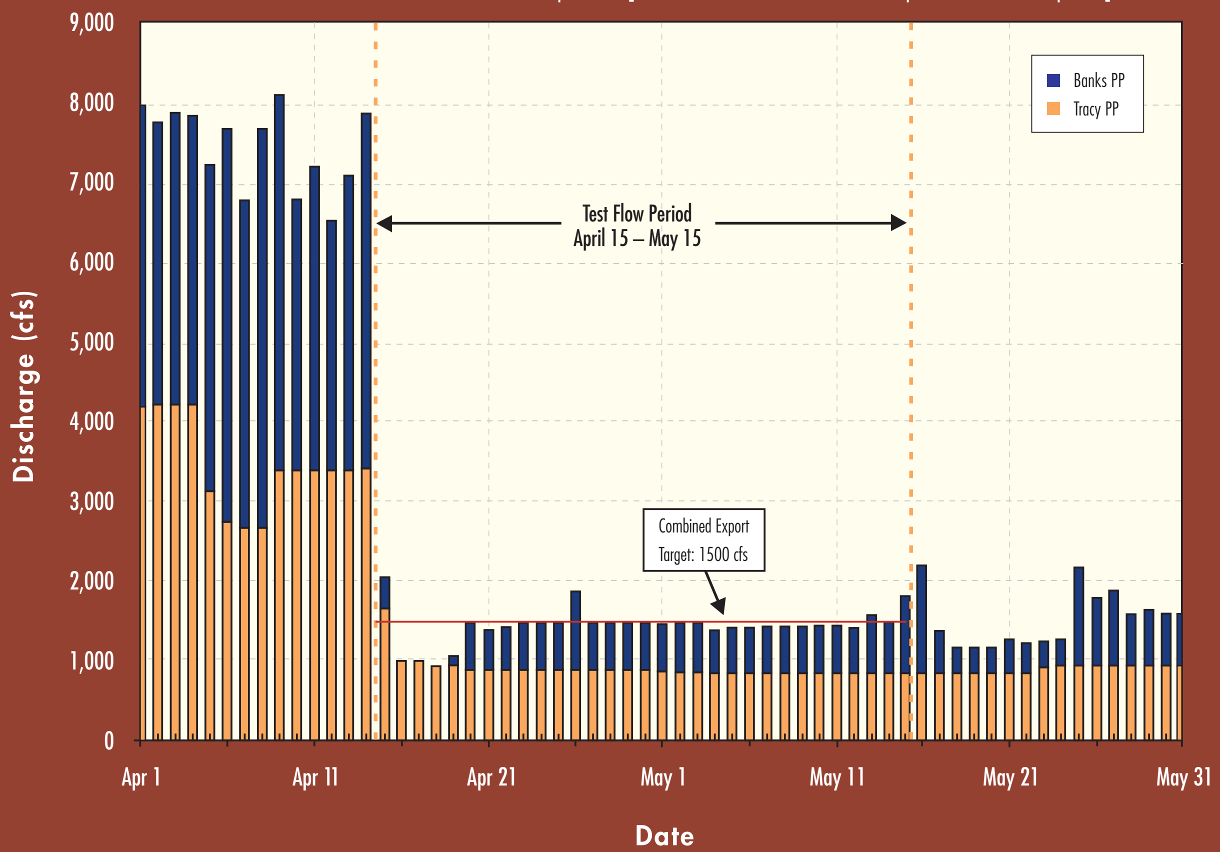


FIGURE 2–5

2002 VAMP–SJRA Storage Impacts–Lake McClure (Merced River), October 2001 through December 2002

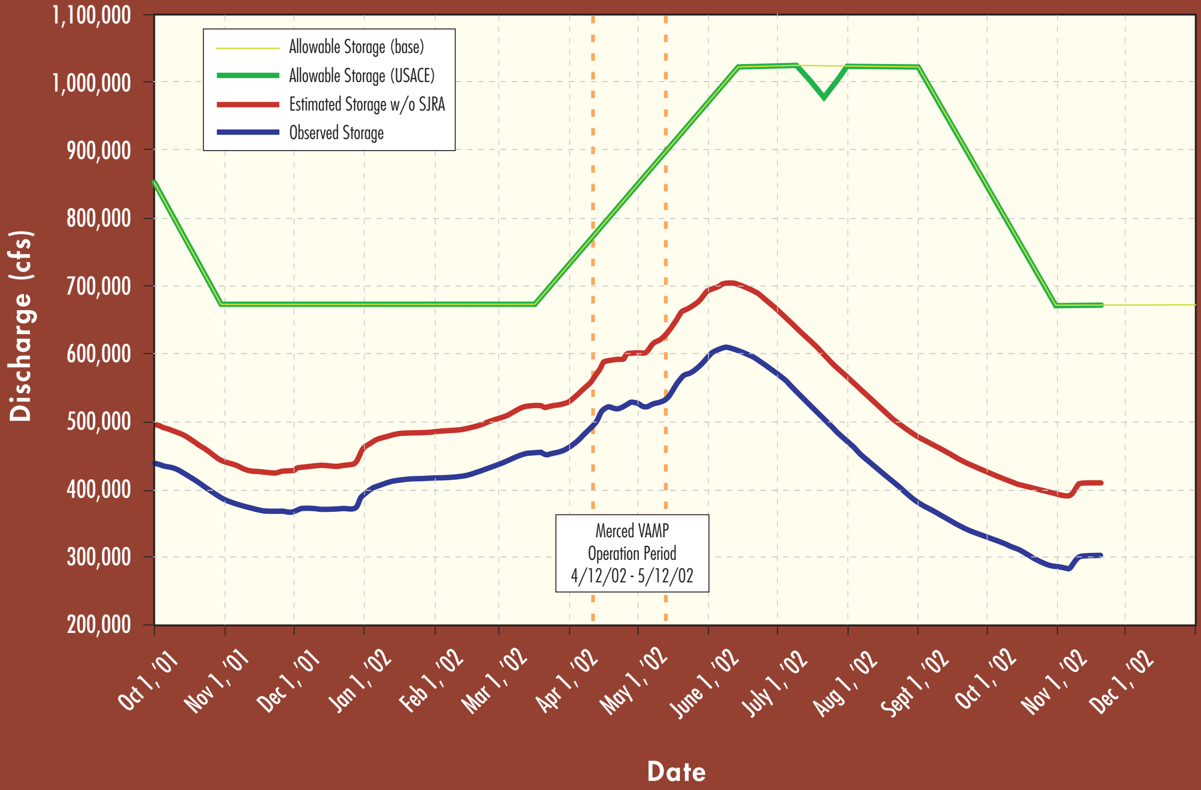
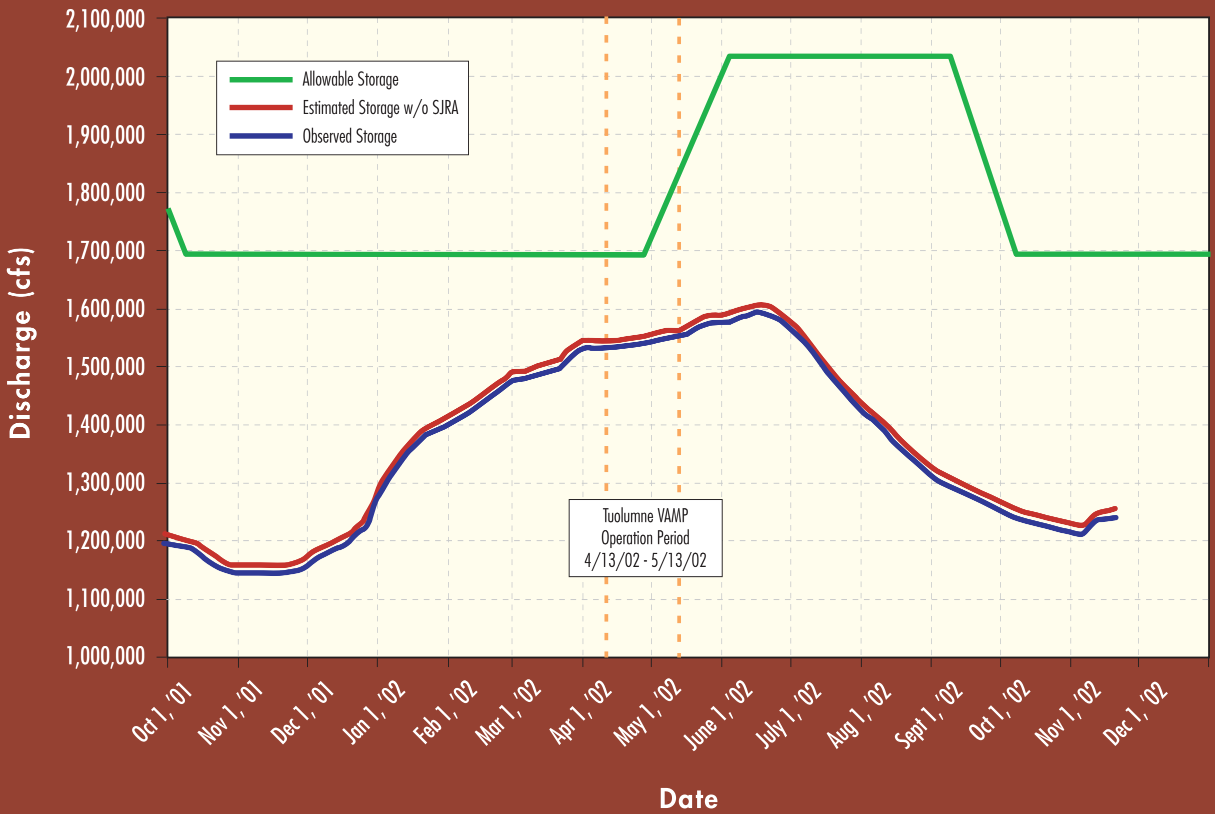


FIGURE 2–6

SJRA Storage Impacts–New Don Pedro Reservoir (Tuolumne River), October 2001 through December 2002



period absent the VAMP supplemental water (existing flow) was estimated to be 2,760 cfs. The VAMP operation resulted in a 20 percent increase in flow at Vernalis during the target flow period. Figure 2-1 shows the flow at Vernalis with and without the VAMP pulse flow. Figure 2-2 shows the sources of the flow at Vernalis. A total of 33,430 acre-feet of supplemental water was provided during the VAMP test flow period. A daily summary of VAMP operations, along with supporting data, is provided in Appendix A.

In planning for the VAMP operation the ungaged flow at Vernalis is the most difficult factor to forecast for the test flow period. The Daily Operation Plan is developed assuming a steady ungaged flow during the test flow period, but in reality there will be day to day fluctuations due to a number of unpredictable factors including weather, pre-existing conditions, irrigation operations, as well as mathematical uncertainties introduced by using mean daily flows and assumed travel times rounded to the nearest day. During the implementation phase of the VAMP operation, the forecast ungaged flow will not necessarily be adjusted as a result of the day to day fluctuations, but will be adjusted if the general trend appears to be deviating from the existing forecast. This is all illustrated in Figure 2-3, which shows in hindsight the observed ungaged flow along with that forecast prior to the test flow period on April 8 and the adjusted forecast that was modified on an ongoing basis in an attempt to account for deviation from the existing forecast.

The combined CVP and SWP export rate averaged 1,430 cfs during the 31-day period, about 5 percent below the target of 1,500 cfs. The daily SWP and CVP exports during the VAMP test period are shown in Figure 2-4.

SJRG member agencies have entered into the Division Agreement, which allocates responsibility of the members for providing VAMP supplemental water. The distribution of supplemental water for the 2002 VAMP operation, compared to the distribution called for under the Division Agreement, is summarized in Table 2-7.

Hydrologic Impacts

The VAMP supplemental water contributions, with the exception of that provided by the Exchange Contractors and OID/SSJID, are supplied from reservoir storage: Lake McClure on the Merced River and New Don Pedro Reservoir on the Tuolumne River. Due to the extended nature of the VAMP, a 12-year plan, the storage impacts can potentially carry over from year to year. Reservoir storage impacts are reduced or eliminated when the reservoirs make flood control releases.

As noted in the 2001 Annual Technical Report, the storage impact in Lake McClure on the Merced River following the 2001 VAMP operation was 55,650 acre-feet. As per the SJRA, Merced provided 12,500 acre-feet of supplemental water in the Fall of 2001 (see Chapter 3), resulting in a total SJRA storage impact on Lake McClure at the end of 2001 of 68,150 acre-feet. There were no opportunities to make up for any of this impact during the winter, therefore the entire impact of 68,150 acre-feet carried over into the 2002 VAMP operation period. With the 25,840 acre-feet of supplemental water provided by Merced for the 2002 VAMP operation along with 1,270 acre-feet of operational ramp-down water, the current impact of the SJRA on Lake McClure storage is 95,260 acre-feet. Figure 2-5 shows Lake McClure storage for water year 2002 with and without the SJRA.

As noted in the 2001 Annual Technical Report, the storage impact in New Don Pedro Reservoir on the Tuolumne River following the 2001 VAMP operation was 14,060 acre-feet. There were no opportunities to make up for any of this impact during the winter, therefore the entire impact of 14,060 acre-feet carried over into the 2002 VAMP operation period. No supplemental water was provided from New Don Pedro Reservoir for the 2002 VAMP; therefore the current storage impact due to the SJRA remains at 14,060 acre-feet. Figure 2-6 shows New Don Pedro Reservoir storage for water year 2002 with and without the SJRA.

In the 2001 Annual Technical Report, a cumulative storage impact to New Melones of 54,210 acre-feet was identified. This statement was not correct. The water provided by OID/SSJID for both the VAMP pulse flow and the "additional" water is made available from their diversion entitlements. Thus, there are no storage impacts in New Melones due to either VAMP or the "additional" water purchase.

TABLE 2–7

2002 VAMP–Distribution of Supplemental Water

AGENCY	DIVISION AGREEMENT DISTRIBUTION (ACRE–FEET)	SUPPLEMENTAL WATER PROVIDED (ACRE–FEET)	DEVIATION FROM DIVISION AGREEMENT (ACRE–FEET)
Merced I.D.	25,000	25,840	+840
Oakdale I.D./ South San Joaquin I.D.	8,430	7,590	–840
Exchange Contractors	0	0	0
Modesto I.D./ Turlock I.D.	0	0	0

CHAPTER 3 | ADDITIONAL WATER SUPPLY ARRANGEMENTS & DELIVERIES

MERCED IRRIGATION DISTRICT

The SJRA includes a provision (Paragraph 8.4) stating that "Merced Irrigation District (Merced) shall provide, and the USBR shall purchase 12,500 acre-feet of water...during October of all years." The SJRA also states in Paragraph 8.4.4 that "Water purchased pursuant to Paragraph 8.4 may be scheduled for months other than October provided Merced, DFG and USFWS all agree." This water is referred to as the Fall SJRA Transfer Water. The daily schedule for the Fall SJRA Transfer Water is to be developed by Department of Fish and Game (DFG), United States Fish and Wildlife Services (USFWS) and Merced ID.

The schedule for the 2002 Fall SJRA Transfer was finalized on October 3, 2002, with the TRANSFER COMMENCING on October 15, 2002.

The schedule for the 2002 Fall SJRA Transfer was finalized on October 3, 2002, with the transfer commencing on October 15, 2002. The schedule is provided in Appendix B, Table B-1. As with the VAMP operation, the final accounting for the Fall Transfer will be done using provisional flow data.

The 2001 Fall SJRA Transfer was in progress at the time of publication of the 2001 Annual Technical Report and therefore only preliminary data was provided in the 2001 report. The final data for the 2001 Fall SJRA Transfer are included in Appendix B, Table B-2, of this report.

OAKDALE IRRIGATION DISTRICT

Pursuant to Paragraph 8.5 of the SJRA, "Oakdale Irrigation District (OID) shall sell 15,000 acre-feet of water to the USBR in every year of (the) Agreement...In addition to the 15,000 acre-feet, Oakdale will sell the difference between the water made available to VAMP under the SJRGA agreement and 11,000 acre-feet." This water is referred to as the Difference water.

OID provided 3,795 acre-feet of supplemental water for the year 2002 VAMP, resulting in 7,205 acre-feet of Difference water. Therefore, pursuant to Paragraph 8.5 of the Agreement, OID sold a total of 22,205 acre-feet of water to the USBR in 2002.

Release of the OID additional water by the USBR began on October 20, 2002 and is scheduled to be completed by February 28, 2003. The preliminary daily schedule as of October 30, 2002 for the release of the OID additional water is provided in Appendix B, Table B-3.

CHAPTER 4 | HEAD OF OLD RIVER BARRIER

BARRIER DESIGN, INSTALLATION AND OPERATION

In early April 2002, DWR installed and operated the temporary HORB. The spring HORB is a component of the south delta Temporary Barriers Project (TBP). The TBP mitigates for low water levels in the south delta and improves water circulation and quality for agricultural purposes. The HORB, as currently configured, is now fully permitted though 2005.

The spring HORB was first constructed in 1992. Since then, the barrier has been installed in 1994, 1996, 1997 (w/two culverts), 2000, 2001, and 2002. In 2000-2002 the barrier was installed with six culverts. The HORB was not installed in 1993, 1995 and 1998 due to high San Joaquin River flows. The HORB was not installed in 1999 due to landowner access problems. The HORB, a key component of VAMP, is intended to increase San Joaquin River Chinook salmon smolt survival by preventing them from entering Old River.

The HORB was originally designed to withstand a San Joaquin River flow of about 3,000 cfs. Through the years, the design and installation of the HORB has been revised on several occasions to accommodate different needs. Beginning in 2001, the barrier design included two versions. A "low-flow" barrier when San Joaquin River target flows are below 7,000 cfs would be built to a height of 10 feet mean sea level (MSL). A "high-flow" barrier for target flow of 7,000 cfs would be built to a height of 11 feet MSL and additional material would be placed to raise the abutments to 13 feet MSL. Both barrier versions are equipped with six 48-inch diameter operable culverts and an overflow weir back-filled with clay. In 2002, the low-flow version was installed.

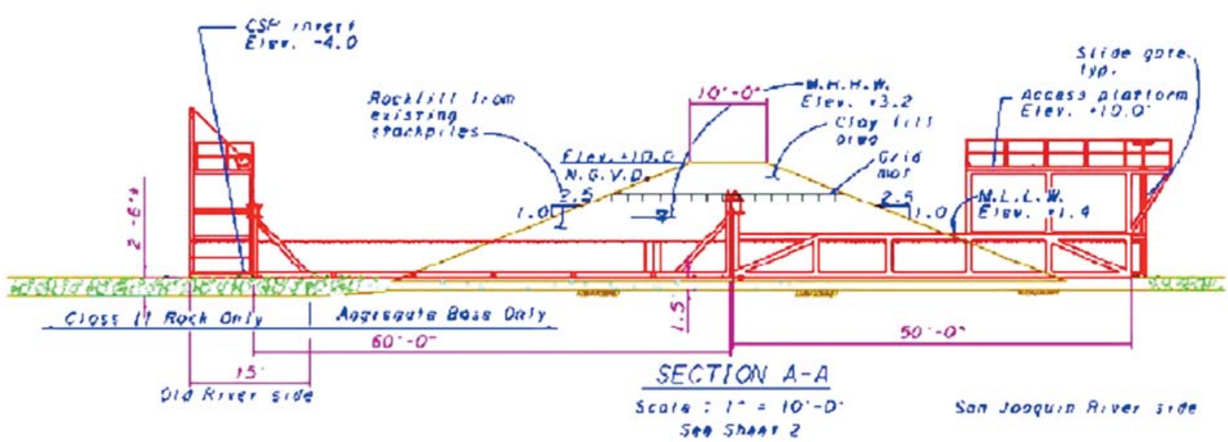
The dimensions of the 2002 HORB (Figure 4-1) were similar to the 2000 and 2001 HORB. The base width of the HORB in 2002 was 100 feet and the crest elevation was 10 feet MSL. The top of HORB was constructed with a 75-foot wide notch, protected with concrete grid mats and back-filled with clay. The HORB was designed to safely operate with flows corresponding to stages up to 8.5 feet MSL.

To help mitigate anticipated low water levels in the south delta (downstream of the HORB) caused by the operation of the HORB, two open culverts were installed in the barrier in 1997, and six operable culverts were installed beginning in 2000. Operation of the culverts is controlled by a slide gate control structure located on the upstream side of HORB. DWR relied on daily modeling and field data collection to monitor water levels at three locations within the south Delta to determine when and how long to operate the culverts. Generally, the model forecasts would tend to forecast low-low water levels lower than actual levels observed in the field. Consequently, DWR would make decisions regarding the culvert operations that would take this into consideration. It is expected that refinements to the model over time will provide modeling results that correspond more closely with field measurements.

The downstream outlet of each culvert was designed so fyke nets could be attached to evaluate fish passage. DFG staff conducted a fishery-monitoring program as part of the 2002 HORB operations.

FIGURE 4–1

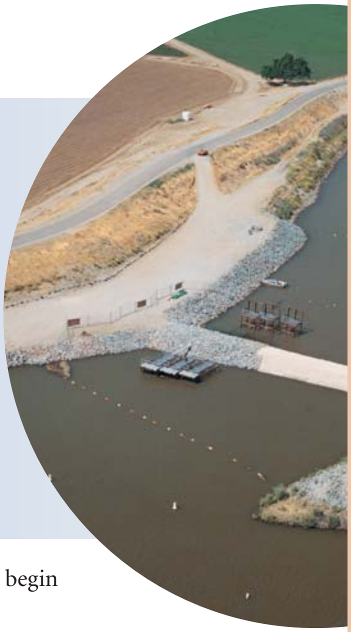
Head of Old River Barrier (HORB)



Permitting and Construction

The various permit conditions that are placed on the Temporary Barriers Program, by the USFWS, National Marine Fisheries Service (NMFS), and DFG, require that the earliest in-water construction activities that can be conducted on the Head of Old River (HOR), Middle River (MR), and Old River at Tracy (ORT) barriers, during the Spring barrier installation period, are limited to no earlier than April 7. In addition, construction of the northern abutment and boat ramps of the Grant Line Canal (GLC) barrier and construction of out-of-water portions of the HOR, MR, and ORT barriers may not be started any earlier than April 1. Full closure of the GLC barrier is not required but construction of the north abutment and boat ramps must be completed to the extent that full barrier closure and operation can be readily achieved in a reasonable time frame, if and when directed by DWR. The permit conditions also require that all the above work be completed by April 15th, a total of 15 working days. Following is a brief summary of the various permit conditions:

> The downstream outlet of each culvert was designed so fyke nets could be attached to evaluate fish passage. DFG staff conducted a fishery-monitoring program as part of the 2002 HORB operations.



USFWS Biological Opinion

1) The spring HORB barrier installation may begin on April 1 but in-water work shall not occur until April 7, except for construction necessary to place the scour pad and the pad for the culverts (item No. 8, page 6);

2) DWR may begin construction of the Middle River barrier on April 1 but in-water work shall not occur until after April 7 (item No. 1, page 4);

3) DWR may begin construction of the Old River at Tracy barrier on April 1 but in-water work shall not commence before April 7 (item No. 2, page 4);

4) DWR may begin construction of the northern abutment and the boat ramp of the GLC barrier on April 1 provided that the HOR barrier is being constructed concurrently (item No. 3, page 5).

NMFS Biological Opinion

1) the spring HORB installation shall begin on April 1 (item 8, page 8);

2) the MR barrier construction may begin on April 7 (item 1, page6);

3) the ORT barrier construction may begin on April 1 (item2, page 6);

4) the northern abutment and boat ramp of the GLC barrier may begin construction on April 1 provided that the HORB is being constructed concurrently (item 3, page 7).

DFG 1601–HORB

HORB Spring Installation–All work in or near the stream zone will be confined to the period beginning no earlier than April.

DFG 1601–Agricultural Barriers

MR–All work in or near the stream zone will be confined to the period beginning no earlier than March 1.

ORT–All work in or near the stream zone will be confined to the period beginning no earlier than April 1.

GLC–All work in or near the stream zone will be confined to the period beginning no earlier than April 1.

TABLE 4–1

Flow in Old River Downstream of the Head of Old River Barrier–2002

DATE	MEAN DAILY FLOW (CFS)	DAILY MAX FLOW (CFS)	DAILY MIN FLOW (CFS)	DATE	MEAN DAILY FLOW (CFS)	DAILY MAX FLOW (CFS)	DAILY MIN FLOW (CFS)
April 1	870	1567	419	May 02	278	763	-113
April 2	898	1590	287	May 03	328	717	-164
April 3	889	1418	101	May 04	291	828	-169
April 4	858	1409	96	May 05	234	745	-76
April 5	758	1315	-26	May 06	364	750	-123
April 6	727	1111	-13	May 07	327	772	-33
April 7	616	1047	93	May 08	274	794	-197
April 8	596	1100	276	May 09	362	691	-11
April 9	543	1211	138	May 10	366	644	-83
April 10	471	1157	13	May 11	258	679	-73
April 11	577	1136	147	May 12	356	844	-36
April 12	519	1016	45	May 13	568	888	324
April 13	347	1015	-128	May 14	525	811	220
April 14	487	1372	-486	May 15	458	674	169
April 15	680	1821	77	May 16	417	661	0
April 16	538	832	49	May 17	371	648	115
April 17	541	822	225	May 18	388	575	142
April 18	412	838	-158	May 19	232	548	-161
April 19	259	687	-194	May 20	218	537	-33
April 20	229	577	-140	May 21	294	540	-11
April 21	232	851	-201	May 22	325	585	35
April 22	160	751	-233	May 23	331	607	-55
April 23	169	495	-226	May 24	409	1651	-239
April 24	205	559	-259	May 25	683	1612	-33
April 25	249	538	-148	May 26	923	1870	305
April 26	328	626	20	May 27	854	1752	-12
April 27	238	494	-66	May 28	713	1582	-129
April 28	180	595	-243	May 29	471	1334	23
April 29	241	638	-73	May 30	413	858	0
April 30	187	534	-225	May 31	492	889	68
May 01	200	766	-127				

In addition to the above conditions, water users of the South Delta Water Agency (SDWA) and the fisheries agencies impose separate mitigation requirements on DWR for installation and operation of the HORB by itself. As a result, DWR's contractor must sequentially close and start operation of the MR and ORT barriers, and complete as much construction of north abutment and boat ramps on the GLC barrier as possible, before they can close and operate the HORB.

From the contractors point of view there are really two milestones that must be completed in sequence. First and foremost is to obtain closure and operation of the barriers in accordance with the conditions imposed by the project permits/biological opinions and mitigation requirements. The second is to satisfy DWR's contract specifications. The first milestone can be achieved within the required 15 working days but it is unlikely that the contractor can complete the entire amount of work required to satisfy DWR's contract specifications within the same time period.

Therefore, the contractor's construction activities consist of placing enough materials to make sure they obtain closure and operation by April 15th, then following closure they continue placing barrier material above the water line until barrier construction is completed in accordance with DWR's contract specifications. The contractor then conducts site cleanup and demobilizes from the site. This is why work usually continues beyond the April 15 deadline.

Barrier Operations and Monitoring Plan

A barrier operations and monitoring plan was developed based on forecasting and monitoring of tidal conditions. DWR determined the number of culverts to be opened at the HORB so that water levels at Old River near Tracy Road Bridge, Middle River near

Howard Road and Grant Line Canal near Tracy Road Bridge would remain above 0.0 feet MSL. Based on modeling results and/or field monitoring of water levels in the south delta, all six culvert slide gates remained open from April 15 to May 24, 2002 when the HORB was breached.

The average daily flow through the culverts varied in response to tidal and San Joaquin River flow conditions. The characteristics of the flow through the culverts are complicated in that the flow rate is influenced by many variables, including the culvert inlet geometry, slope, size, culvert roughness, and approach and tail water conditions. An approximation of the combined net flow through the culverts, including any seepage through the barrier, was accomplished by measuring the flow in Old River just downstream of the HORB using Acoustic Doppler technology. A fixed Acoustic Doppler Current Meter was operated approximately 840 feet downstream of the HORB which recorded velocity measurements every 15 minutes during the period the HORB was operated (April 15 through May 24, 2002). The flow in Old River was then calculated using the known cross-sectional area of the channel as a function of the stage elevation at that location.

The mean daily flow measured in Old River during the operation of the HORB ranged from 160 to 568 cubic feet per second as shown in Table 4-1. These figures ignore the first and the last day of operation which is skewed by flows occurring before and after the HORB was closed or breached. On May 24, the barrier was breached, which accounts for the maximum flow of 1,651 cfs shown in Table 4-1. The negative flows listed indicate the channel below the HORB was filling on a flood tide; however, this does not mean that flows through the culverts were negative. As long at the river stages on the upstream side of the barrier remain higher than the downstream side, flows through the culverts will always be positive.

Barrier Emergency Response Plan

In addition to the operation and monitoring plan, DWR has also prepared an "Emergency Operations Plan for the Spring HORB". The plan provided that if the daily measured or forecasted flow at Vernalis exceeded a flow that would correspond to stage at the HORB of 10.0 feet MSL, and the stage was likely to exceed 11.0 feet MSL (the height of the barrier under the "high-flow" target), the barrier would be removed. Operation of the HORB was uneventful this year. Vernalis flows and stages at the barrier were not high enough in 2002 to warrant action under the emergency operations plan.

Seepage Monitoring

A seepage-monitoring program was initiated in April 2000 and continued this year, to evaluate the effects of HORB operations on seepage and groundwater on Upper Roberts Island.

Three seepage monitoring well sites were chosen in 2000 on Upper Roberts Island. Each site had two shallow wells, positioned 10 feet and 100 feet from the toe of the levee to monitor the seepage gradient to and from the San Joaquin River. In addition, a deeper well was drilled at Site 1 (near the Head of Old River) to determine vertical gradients.

In addition to the groundwater monitoring wells, a temporary gage was installed in April 2000 to record water surface elevations in the San Joaquin River, about 1,500 feet downstream of the HORB. Installation of a permanent tide gage was completed in early 2002. The water surface elevations in the San Joaquin River are compared to groundwater levels on Upper Roberts Island to determine how groundwater levels change relative to changing water level conditions in the river.

In November 2002, DWR completed a "Reclamation District 544 Seepage Monitoring Study". This is an ongoing study to document the seepage monitoring results from Upper Robert Island. (Copies of the report are available from DWR). Based on the 2000 and 2001 data, it is apparent that the San Joaquin River stage influences groundwater levels on Upper Roberts Island. When stage increases in the river, groundwater levels will rise toward the land surface, but not as rapidly as the river stage rises. However, over the monitoring period, river stage did not reach levels sufficient to raise groundwater levels to the point where seepage into crop root zones might occur.

Given the results of the seepage monitoring since April 2000, DWR expects that if a VAMP target flow of 7,000 was implemented, stages near the HORB would rise to about 7 1/2 to 8 feet MSL. This would translate to groundwater levels in the monitoring well closest to the levee of about 6 1/2 to 7 feet MSL. Because the ground surface elevation is 13 feet MSL near site 1, DWR concludes that seepage should not impact the root zone of crops that could be planted in this area.

The monitoring program will be continued in order to gather more data, particularly during high flow periods in the spring.

FISHERY MONITORING AT THE HEAD OF OLD RIVER BARRIER

During the VAMP 2002 test period, all six culverts in the HORB were operational. The six culverts are installed to maintain water quality and water levels in the south delta downstream of the HORB. Since the culverts are not screened, juvenile Chinook salmon and other fish species that pass near the culverts are vulnerable to entrainment. A fishery monitoring program was designed and implemented by the DFG to evaluate and quantify fish entrainment at the HORB. The specific objectives of the 2002 fishery investigations were:

- Determine the total number of juvenile Chinook salmon and other fish species entrained through the culverts at the HORB (Entrainment Monitoring).
- Determine the percentage of coded-wire tagged (CWT) salmon released at Mossdale and Durham Ferry entrained into Old River (Entrainment Monitoring).
- Determine tidal and diel effects on juvenile Chinook salmon entrainment (Entrainment Special Study).

Results of these fishery investigations are intended, in part, to provide information on the design and operation of a future permanent operable barrier at the head of Old River.

Materials and Methods

As part of the VAMP 2002 studies, a total of 148,502 CWT salmon smolts were released at Durham Ferry and Mossdale on April 18 and 19, respectively. Another 147,842 were released at the same locations on April 25 and 26. Salmon from the VAMP releases were used in the Entrainment Monitoring studies. For the Entrainment Special Study, eight uniquely color-marked groups of juvenile Chinook salmon (approximately 3,000 fish per group) were marked with photonic fluorescent microspheres at the Merced River Hatchery. The salmon were transported to the HORB and placed in live cages where they were held at least 10 hours before release. Each color-marked group was released approximately one mile upstream of the HORB, in the middle of the San Joaquin River. The color-marked releases coincided with the two VAMP salmon releases. On the night of April 19, one group was released on the ebb tide and one group on the flood tide. The following day, a group was released on the subsequent ebb and flood tides. The process was repeated on April 25.

Fish entrained into the culverts were caught with fyke nets. The nets have a 48 inch cylindrical mouth tapering down to a 1-foot square cod-end, are made of 1/4 inch braided mesh, and five of the nets are 60 feet long and one is 40 feet long. A live-box (15.5 x 19.5 x 36 inches), constructed of perforated aluminum sheet metal, was attached to the cod-end of each net. Each live-box has an aluminum baffle designed to reduce water velocities within the live-box and improve survival of captured fish. The fyke nets were attached to the culvert flanges on April 17. The nets were attached to the culverts by closing the culvert slide gates on the upstream side of the barrier, raising the flanges that slide over the culvert outfalls, and then strapping the nets over the flange. The 40 foot net was attached to culvert number 1 and the 60 foot nets were used on the remaining culverts. The culverts were numbered 1 through 6 with number 1 located next to the shoreline and number 6 located near mid-channel (Figure 4-2). On April 18, the flanges, with the attached fyke nets, were lowered down to the culvert outfalls and the live-boxes were attached to the cod-end of the nets to commence sampling.

The fyke nets were checked on every tide change until May 1. From May 1 through May 11, the nets were checked twice a day; in the morning and the evening. On May 12, the nets were removed. The nets were checked by closing the culvert slide gate, for a period of 30 to 45 minutes, which enabled the live-boxes to be pulled onto a boat so that the fish could be removed and placed into buckets. Once all the nets had been checked and reset, the collected fish were processed. The fish were speciated and counted. Fork lengths (mm) were recorded for up to 50 salmon per live-box. Salmon were checked for a clipped adipose fin and for the presence of a color mark on the dorsal, anal, or caudal fin. Salmon that had a clipped adipose fin were saved for CWT processing. The color and location of the dyed fin was noted for each color-marked salmon. During each net check, culvert

FIGURE 4–2
Culvert Numbers for HORB 2002

number, date, time, water temperature, tidal stage, and diel period was recorded. Except for the CWT smolts, all processed fish were released downstream of the fyke nets into Old River.

Entrainment Monitoring

Loss indices for the CWT salmon released as part of the VAMP survival studies at Durham Ferry and Mossdale were calculated based on data collected from April 18 to May 11. The loss index represents the percentage of CWT salmon entrained into the HORB culverts. As in previous years, the loss index is calculated using the equation:

$$I = (TC/TR)(TT/ST)$$

Where:

TC = Total number of CWT salmon collected in culvert fyke nets
TR = Total number of CWT released
TT = Total time (hours) during the test period
ST = Total time (hours) sampled at HORB during the test period

However, this year, for the nine occasions when a culvert was not monitored and/or the sample was lost, the total catch for the missing culvert was estimated by using the average of the other culverts for that sample period. Consequently, all sampling time is accounted for and TT/ST = 1, and the loss index is equal to TC/TR.

Catch-Per-Unit-Effort (CPUE) for salmon was calculated as the number of fish collected per hour. The percentage of color-marked salmon recovered in the fyke nets compared to the total number released was used as an index of entrainment vulnerability at the HORB.

RESULTS AND DISCUSSION

Results

The HORB was closed on April 15; however, construction on the barrier continued for another week. Due to the large gravel pad in front of the culverts and/or the ongoing construction and the water currents, gravel was swept through the culverts into the nets during the first three days of sampling. Nine samples were lost or not taken because it required considerable time and effort to retrieve the rock filled net from the bottom of the river. Several of the lost samples occurred during a critical time when the CWT and color-marked salmon were approaching the barrier.

The DFG monitored the HORB culverts for 25 days and collected 381 samples. The nets sampled 3,379 hours out of a possible 3,429 hours. Almost 18,000 fish were collected representing at least 28 species and 14 families of fish. No delta smelt, one juvenile steelhead, and 30 adult splittail were entrained. The most abundant species was Chinook salmon, followed by white catfish

TABLE 4–2

The raw abundance and composition of fishes entrained at the HORB in 2002. Chinook salmon catch is divided into CWT VAMP and nonVAMP released salmon, unmarked salmon, and color-marked salmon.

Cyprinidae	1
Red Shiner	1
Black Bullhead	1
Centrarchidae	1
Steelhead	**1**
American Shad	1
Prickly Sculpin	2
Sacramento Pikeminnow	2
Petromyzontidae	3
White Crappie	4
Tule Perch	4
Shimofuri Goby	5
Warmouth	9
Green Sunfish	10
Largemouth Bass	12
Golden Shiner	14
Sacramento Sucker	15
Black Crappie	19
Redear Sunfish	26
Brown Bullhead	26
Striped Bass	27
Bigscale Logperch	27
Splittail	**30**
Goldfish	37
Inland Silverside	88
Bluegill	118
Common Carp	199
Channel Catfish	560
Threadfin Shad	1,219
White Catfish	6,925
Total Chinook Salmon	**8,467**
CWT VAMP Salmon	4,145
CWT NonVAMP Salmon	1,213
Unmarked Salmon	2,748
Color-Marked Salmon	361
Total	**17,854**

FIGURE 4–3

The total daily catch of salmon smolts entrained at the HORB in 2002. The total catch is divided into nonVAMP, VAMP, and unmarked salmon.

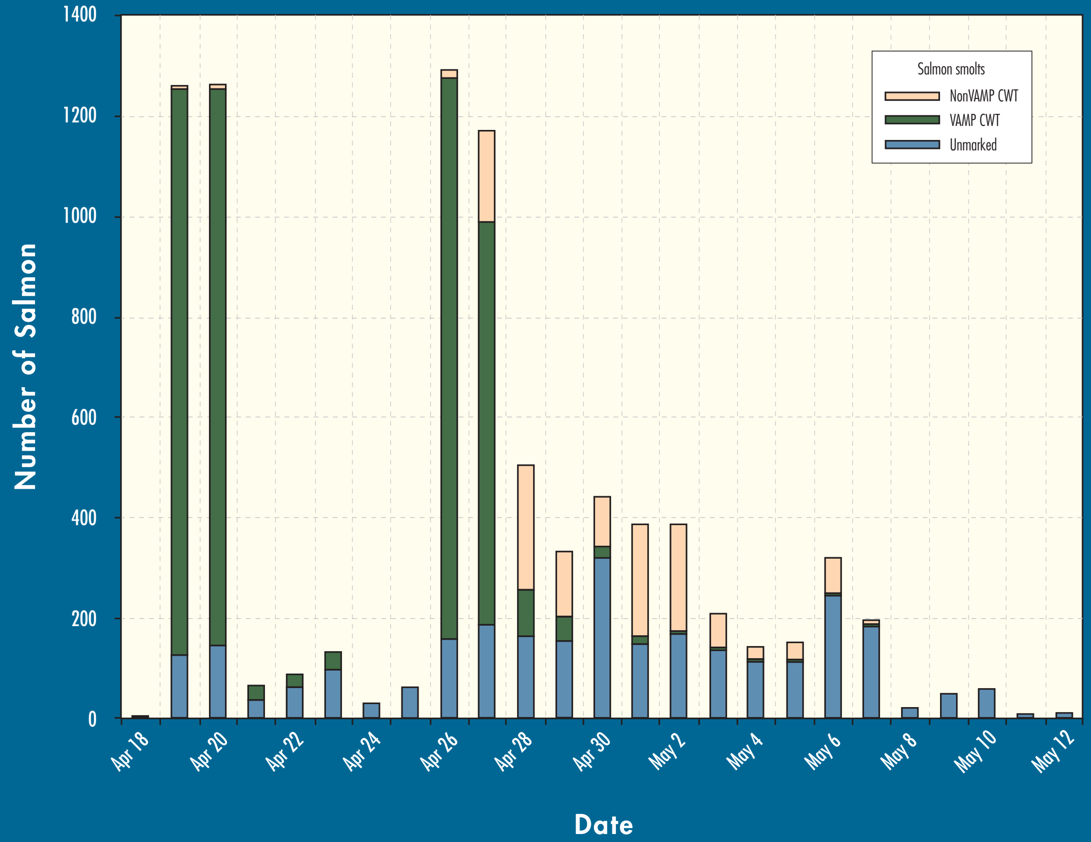


FIGURE 4–4

The number of CWT salmon caught by sampling period during the first VAMP releases in 2002. River stage for Old River is indicated by the line.

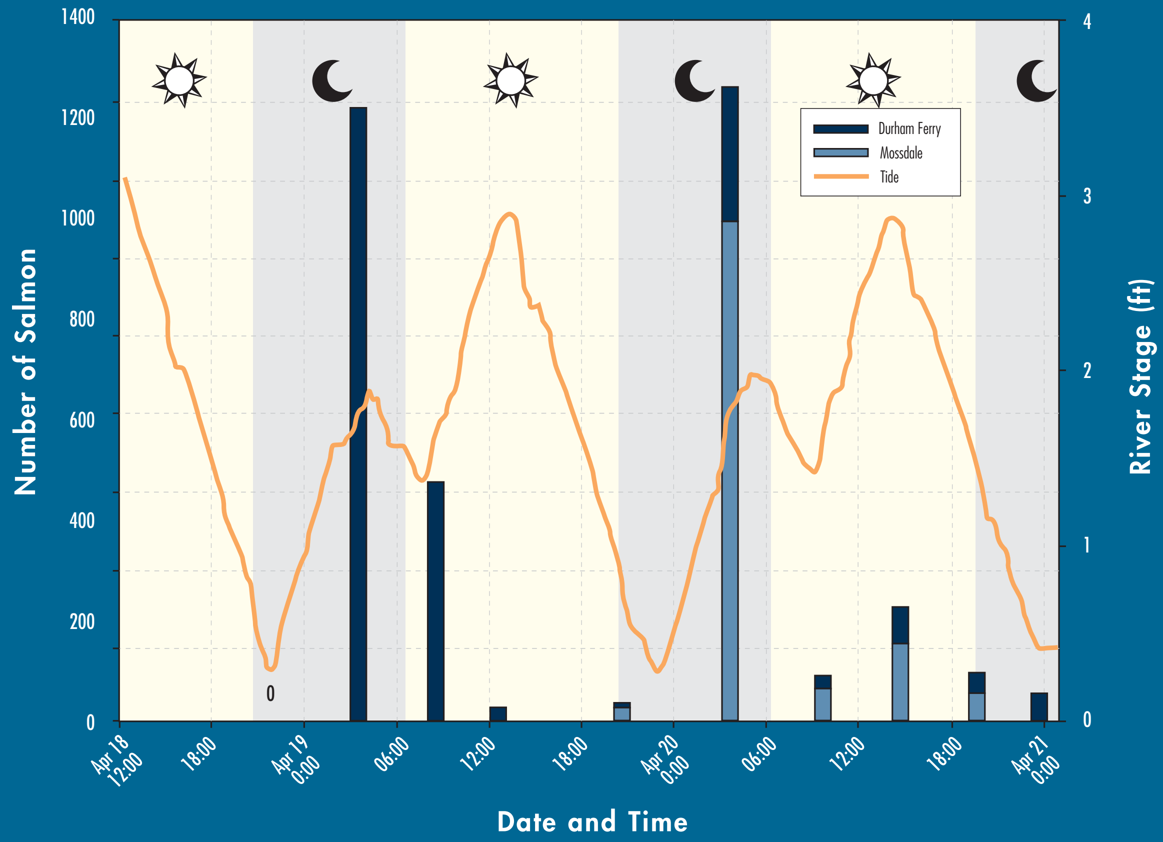


FIGURE 4–5

The number of CWT salmon caught by sampling period during the second VAMP releases in 2002. River stage for Old River is indicated by the line.

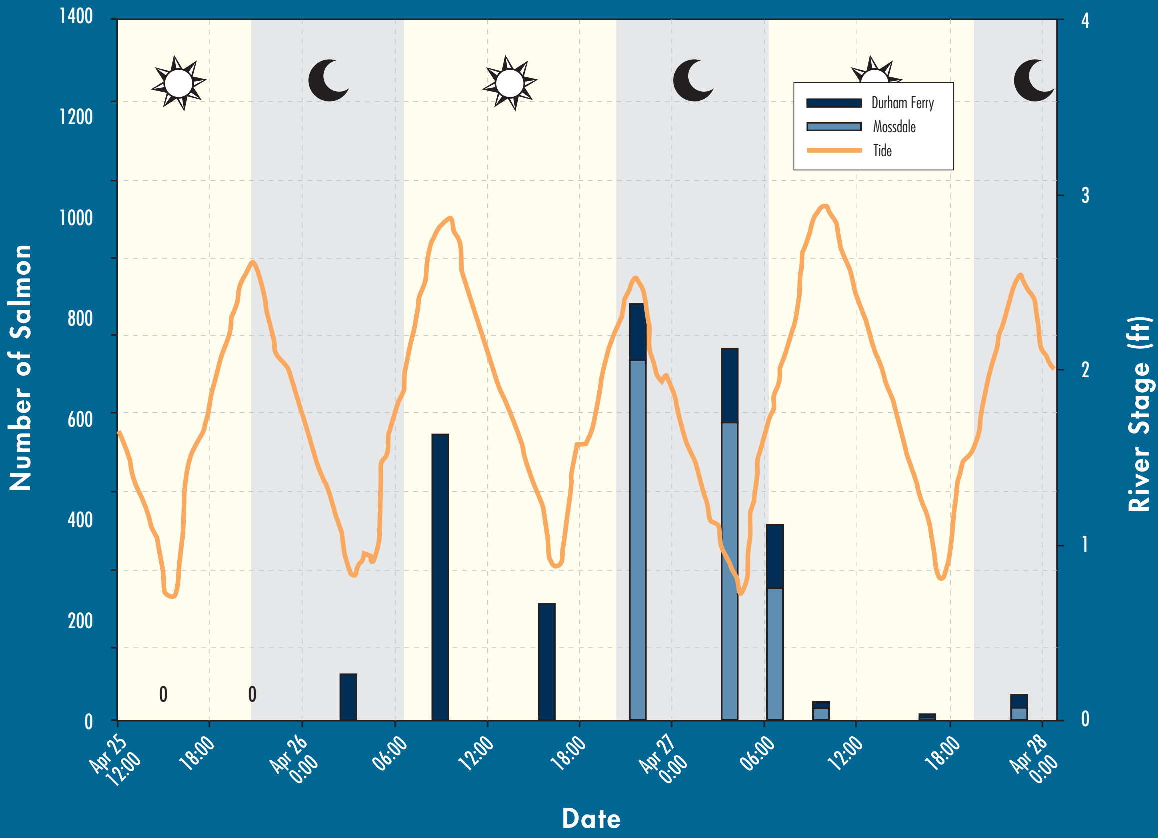
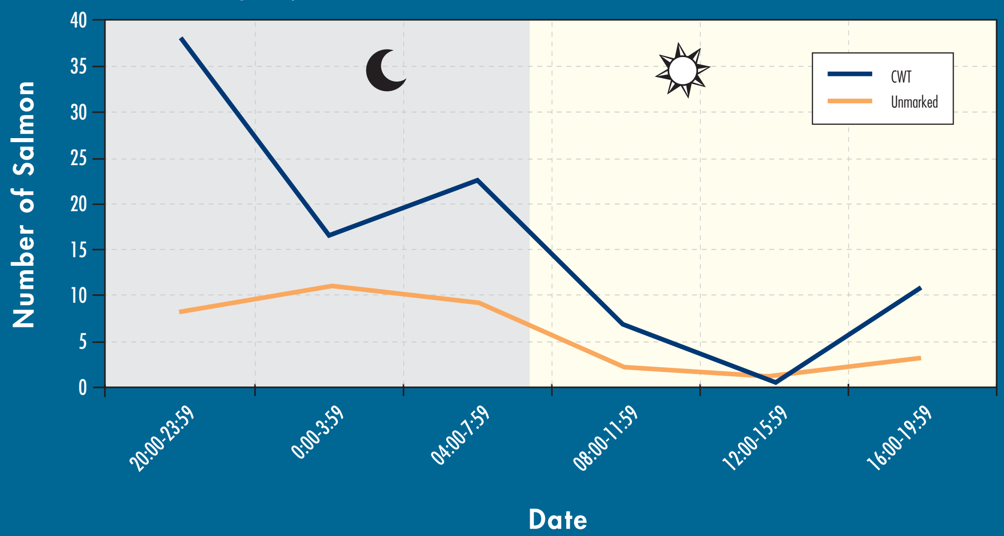


FIGURE 4–6

The average number of CWT and unmarked salmon caught over 24 hours, grouped into 4 hour time blocks.



(*Ictalurus catus*) (Table 4-2). CWT salmon dominated the catch in April and white catfish dominated the catch in May. Of the 8,493 salmon caught; 5,358 had a CWT; 2,748 were unmarked; and 361 had a color mark.

This year the number of CWT salmon increased 323 % over last year's CWT salmon entrainment (1,268 salmon). Salmon smolts were caught throughout the monitoring period although most of the VAMP released salmon were caught within a couple days of their release (Figure 4-3). During the first VAMP salmon release, it appears most of the Durham Ferry CWT salmon were entrained on the night of April 18 and the Mossdale released salmon were entrained on the night of April 19 (Figure 4-4). During the second VAMP release, the Durham Ferry salmon were entrained at a lower rate and few were caught on the night of April 25 (Figure 4-5). In contrast, the Mossdale salmon were entrained at a high rate on the night of April 26. The loss indices for the first Durham Ferry and Mossdale salmon releases were 1.6% and 1.7%, respectively. The loss indices for the second Durham Ferry and Mossdale releases were 1.0% and 2.3%, respectively. The overall loss index for the VAMP released salmon was 1.5%. This year's overall loss index is higher than the previous two years' indices of 0.5% and 0.8%.

TABLE 4–3

The percentage of color-marked salmon entrained for various diel and tidal stages. Due to some salmon escaping from their live-cages, the number of salmon released was estimated for the second releases.

NUMBER OF FISH RELEASED	DIEL	TIDE	FISH ENTRAINED	PERCENT RECOVERED
First Releases (19 & 20 April)				
3,032	Night	Flood	159	5.2%
3,009	Night	Ebb	46	1.5%
3,281	Day	Flood	15	0.5%
3,008	Day	Ebb	62	2.1%
Second Releases (25 & 26 April)				
2,990	Night	Flood	71	2.4%
3,000	Night	Ebb	10	0.3%
3,000	Day	Flood	39	1.3%
3,000	Day	Ebb	5	0.2%

Entrainment of the VAMP released salmon peaked during the late evening to midnight time block, and bottomed out in the afternoon at less than one fish per hour (Figure 4-6). The unmarked smolts had a steady rate of entrainment through the night and a relatively low rate during the day. For the entire monitoring duration, the average CPUE for the VAMP smolts per culvert was 1.6 ± 4.0. The highest CPUEs occurred soon after the VAMP releases, with a maximum CPUE of 32.5 on April 19. The average unmarked smolt CPUE (0.9 ± 1.3) was much lower than the VAMP CPUE. The highest unmarked CPUEs occurred in late April and early May, with a maximum CPUE of 7.5 on April 30.

To address tidal and diel effects, color-marked smolts were released on various tidal and diel period combinations. The first releases went well; however, some problems were encountered during the second release when an unknown number of smolts escaped from the holding pens before their intended release. The color-marked salmon were entrained within 5 hours at the HORB (Figure 4-7). Entrainment rates were higher for the first releases (2.3%) than the second releases (1.0%), but the overall entrainment rate (1.7%) was similar to the entrainment of the CWT smolts (Table 4-3). More smolts were caught at night than during the day, and more smolts were entrained during the flood than the ebb tide.

Salmon entrainment through the middle culvert was high this year (Figure 4-8). The remaining culverts entrained a similar amount of salmon, although the outside culverts (numbers 1 and 6) had a slightly lower overall entrainment rate. Culvert number 4 entrained 39% of the smolts during the day. On the day-ebb tides, culverts numbers 4 and 5 combined entrained almost 75% of the smolts (Table 4-4).

A current velocity meter (Swoffer Instruments, Inc., model 2100) was used on three occasions to estimate flows through each of the culverts. Velocity measurements were made near a low slack tide, a high slack tide, and on the ebb that was close to high slack. Due to the staff shortage and time constraints, only the ebb flow estimates occurred while we were monitoring the fyke nets. The other two readings took place after the fyke nets were removed at the end of the monitoring period. Results from the limited data gathered suggest culverts 2 through 6 had similar flows, and that culvert 1 averaged a little over 10 cfs less than the others (Table 4-4). Flows through the culverts were twice as high during low tide than high tide.

FIGURE 4–7

The total number of unmarked, color marked, and VAMP salmon caught by culvert. The total catch per culvert was adjusted for missing samples.

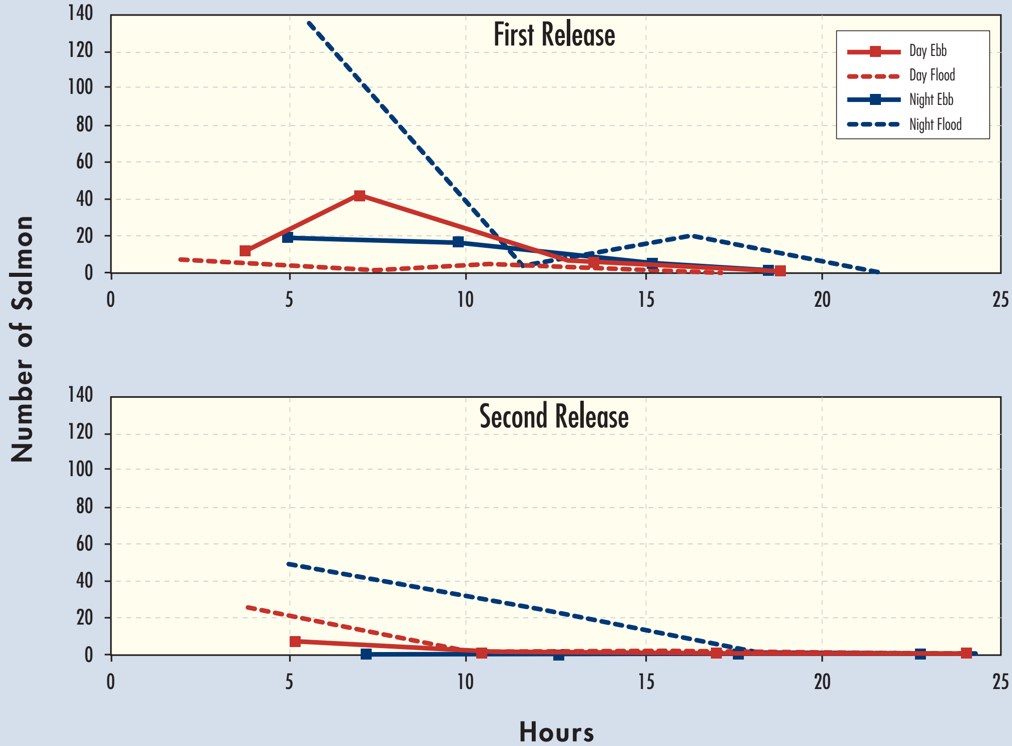


FIGURE 4–8

The total number of unmarked, color marked,and VAMP salmon caught by culvert. The total catch per culvert was adjusted for missing samples.

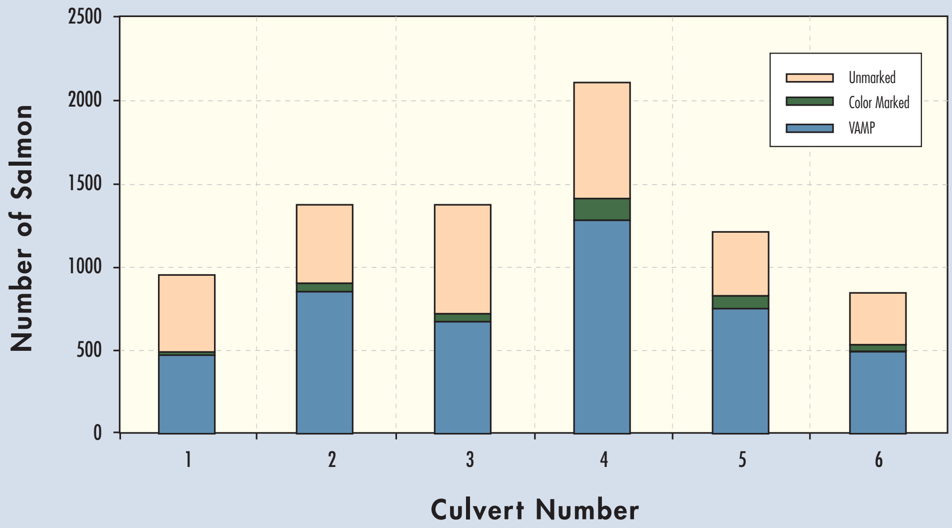


TABLE 4–4

The percentage of the VAMP salmon entrained, by culvert, for various diel and tidal stage combinations (top); and the average flow per culvert taken on three separate occasions (bottom).

ENTRAINMENT (PERCENT)								
DAY/ NIGHT	TIDE	Culvert Number						TOTAL
		1	2	3	4	5	6	
Day	Flood	8	18	13	38	11	12	100
Day	Ebb	7	3	6	46	28	9	100
Night	Flood	8	20	16	24	19	13	100
Night	Ebb	17	21	15	28	12	6	100
Wtd. Avg.		10	19	15	29	17	11	100
WATER FLOW (CFS)								
DATE	TIDE	Culvert Number						AVERAGE
		1	2	3	4	5	6	
May 16	High Slack	34	42	46	43	42	44	42
May 15	Ebb	48	55	57	53	63	58	56
May 07	Low Slack	70	92	88	92	91	90	87

Discussion

Despite a staff shortage and some sampling difficulties, the DFG successfully monitored fish entrainment at the HORB. Although the culvert monitoring duration increased 38% over 2001, the amount of fish entrained tripled. The increased catch was due primarily to Chinook salmon, white catfish and threadfin shad (*Dorosoma petensense*) which together comprised 93% of the total entrainment. The higher salmon entrainment this year could be due, in part, to less accumulation of debris in front of the culverts; the lower VAMP flows on the San Joaquin River which results in a higher proportion of the river flowing through the culverts; other environmental factors; and factors related to the barrier configuration and operation which may affect the hydraulics surrounding the barrier.

Similarly, the loss indices for the VAMP salmon were higher this year than in previous years. The loss indices within the two 2002 VAMP salmon releases varied. The loss indices for the first VAMP salmon release at Durham Ferry and Mossdale were similar. The loss indices for the second VAMP release were considerably different. The second Durham Ferry salmon release had a low loss index (1.0%) whereas the second Mossdale release, the following day, had a relatively high loss index (2.3%). The low loss index of the second Durham Ferry release was due to the low entrainment of salmon on the night of their release. In contrast, most of the entrained Mossdale salmon were caught the night of their release and they had a relatively high loss index. Typically, VAMP salmon entrainment is highest the night of their release.

The difference in the second VAMP loss indices could be due to slightly different salmon migration routes down the San Joaquin River, differential mortality, temporary debris obstruction of the culverts, and a combination of other environmental and behavioral factors. The majority of the Durham Ferry salmon could have migrated down the center or far side of the channel and avoided the HORB, and the Mossdale fish could have migrated closer to the HORB and were entrained. However, the Mossdale Kodiak Trawl (MKT) results indicate a similar catch trend between releases that was observed at the HORB. The MKT samples for fish in the middle of the San Joaquin River, just upstream of the HORB. The MKT only caught 250 VAMP salmon from the second Durham Ferry release compared to 573 salmon from the first release. The MKT caught more Mossdale VAMP salmon from the second release (41) compared to the first release (24). The MKT data suggests the lower loss indices at the HORB could be reflective of fewer salmon migrating pass the barrier. It is possible the second Durham Ferry released salmon experienced a high rate of mortality before reaching the HORB. The potential source of mortality affecting the second release group is unknown.

In contrast with the loss indices at the HORB, survival estimates from Chipps Island and Antioch (Chapter 5) suggest the second VAMP salmon release at Durham Ferry had a slightly higher survival than the release at Mossdale. The apparently higher numbers of Mossdale salmon at the HORB did not translate to higher survival through the Delta. In fact, few salmon from the second Durham Ferry and Mossdale releases were recovered at Chipps Island and Antioch indicating overall VAMP salmon survival was poor.

More CWT salmon were caught at night than during the day, and more were caught on the flood than the ebb tide. Both the VAMP salmon and unmarked salmon entrainment was relatively low in the afternoon. The larger catch of VAMP salmon at night could be confounded by their daytime release upstream of the barrier. Due to the timing of the VAMP release and the distance of the release sites from the HORB, most of these fish probably reached the barrier at night.

Tidal stage may effect entrainment. The river stage gage near the HORB on Old River indicated a relatively low tide near dusk during the first VAMP releases. The low tide creates a large head difference between water levels upstream and downstream of the barrier. The amount of water passing through the culverts depends on this head difference. Although the head difference at the HORB was shrinking on the ensuing flood tide after dusk, the CWT salmon approaching the barrier were still experiencing a large head difference. Over the next seven hours, on both nights (the ensuing high tide was still relatively low), entrainment of VAMP salmon was high. During the second VAMP release, the high tides occurred at dusk which resulted in less head difference as the smolts were approaching the barrier. This may have affected the number of smolts entrained at the barrier. Even with this smaller head difference, more smolts were still entrained at night than during the day.

Results from the Entrainment Special Study are similar to last year's Entrainment Special Study results. More color-marked salmon were entrained on a flood tide than on an ebb tide, and more were entrained at night than during the day. Marked salmon were entrained at the highest rate during a night-flood, although a large number of color-marked salmon were entrained on the day-ebb during the first release. As with the VAMP released salmon, more salmon were entrained during the first release than the second release. However, the lower entrainment index for the second release was confounded by some color-marked salmon escaping their live-cages.

Results from the 2002 Entrainment Monitoring Study and the Entrainment Special Study suggest salmon are more vulnerable to entrainment at night and on the flood tide. Even the unmarked salmon entrainment is higher at night than during the day. However, the VAMP salmon releases are not timed to address tidal-diel effects and their daytime releases may confound the diel results. The tidal effects on entrainment are still unclear. Water velocities through the culverts are greatest near a low slack tide which should result in the highest entrainment. This was not always the case. Some of the highest catches occurred during the flood. The changing hydraulics surrounding the barrier as the tide changes effects flows near the culverts which could affect entrainment. Also salmon smolt behavior and relative abundance near the barrier probably plays an important role in entrainment vulnerability.

Overall, the highest salmon entrainment occurred in culvert number 4 and the lowest in culvert numbers 1and 6. In contrast, in 2001, culvert number 6 entrained the most fish and entrainment in each culvert decreased as the culverts got closer to shore. This year, culvert number 4 entrained the most fish, and culvert numbers 1 and 6 entrained the fewest. However, since the remaining culverts had similar flows, the reason for the high entrainment in culvert number 4 and the low entrainment in culvert number 6 is still unclear. The reason for the difference in culvert entrainment this year from last year is also unclear. Lower flows on the San Joaquin River and slight differences in culvert angles could affect the flow through the culvert and thus, entrainment.

Unfortunately, the first VAMP release occurred while the HORB was under construction. A lot of time was wasted and several samples lost due to gravel accumulation in the nets. Future VAMP salmon studies should schedule their salmon releases after the completion of the barrier, typically 5 days after the HORB is "closed". To better address diel affects, VAMP should schedule one of the Mossdale releases for night. A night release, instead of the usual day release, could shed some light on entrainment at the HORB. A more systematic monitoring of flows through the culverts during future VAMP salmon releases would help us understand salmon entrainment as related to tide. Future studies should also assess juvenile Chinook salmon mortality associated with the barrier.

CHAPTER 5 | SALMON SMOLT SURVIVAL INVESTIGATIONS

One of the primary objectives of the VAMP program is to identify the respective roles of San Joaquin River flow, and SWP and CVP export rates with the HORB in place on the survival of juvenile Chinook salmon emigrating from San Joaquin River tributaries. This section describes the methods used in conducting the VAMP 2002 Chinook salmon smolt survival investigations, and presents results of the calculated survival indices and absolute survival estimates for juvenile Chinook salmon during the VAMP 2002 test period. Additional data and information related to the salmon survival investigations are presented in Appendix C.

CODED-WIRE TAGGING

Merced River Hatchery Chinook salmon smolts, released as part of VAMP 2002, were coded-wire tagged (CWT) between March and early April. After the salmon were tagged, they were held in the hatchery for up to 21 days before being released. A sub-sample of the salmon were measured for length and checked for retention of the CWTs a day or two prior to release. The sub-sample was typically comprised of 100 to 300 salmon collected from the top, middle, and bottom of the release group's raceway. Each tag code within a release group was held separately at the hatchery with the exception of the two Durham Ferry releases where each release was made up of four tag codes that were held together in one section of the raceway.

Although tag retention is usually quite high, as a double check on the tag detector, all salmon from the sub-sample that had no tag detected were sacrificed. These sacrificed salmon were dissected to determine whether they contained an un-magnetized tag. A separate sub-sample of 25 salmon was sacrificed from each release group; the tags were removed and read to detect any incorrect tag codes in the raceways. Table 5-1 summarizes results of the CWT retention rate and the estimate of the effective numbers of salmon released to calculate survival indices. Tag retention rates were determined to be similar to last year, with an overall loss rate of 9.5% among all VAMP groups. The tag retention loss rates varied from 0.5% to 15%. It is recommended that this loss rate be reduced for future VAMP studies.

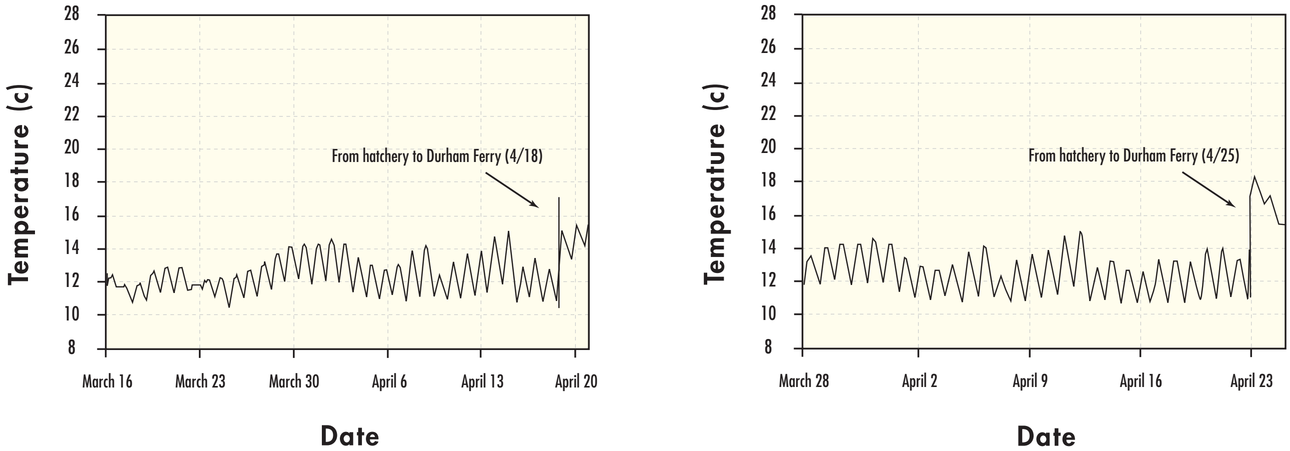
TABLE 5–1

Coded Wire Tag Retention Rates and Effective Release Numbers for Juvenile Salmon Released for VAMP 2002.

RELEASE DATE	TAG CODE	RELEASE SITE	AVERAGE FL (mm)	NUMBER TAGGED	TOTAL LOSS	TAG RETENTION	NUMBER RELEASED	EFFECTIVE RELEASE
April 18	06-44-71	Durham Ferry	83	25,251	123	95.19%	25,128	23,919
April 18	06-44-72	Durham Ferry	83	26,576	129	95.19%	26,447	25,175
April 18	06-44-73	Durham Ferry	83	25,201	123	95.19%	25,078	23,872
April 18	06-44-74	Durham Ferry	83	26,124	127	95.19%	25,997	24,747
April 19	06-44-57	Mossdale	84	25,864	227	99.52%	25,637	25,514
April 19	06-44-58	Mossdale	82	26,301	251	97.01%	26,050	25,271
April 22	06-44-59	Jersey Point	85	25,793	262	97.14%	25,531	24,801
April 22	06-44-60	Jersey Point	83	25,339	269	96.24%	25,070	24,127
April 25	06-44-70	Durham Ferry	80	25,969	138	95.54%	25,831	24,679
April 25	06-44-75	Durham Ferry	80	25,947	138	95.54%	25,809	24,658
April 25	06-44-76	Durham Ferry	80	26,078	139	95.54%	25,939	24,782
April 25	06-44-77	Durham Ferry	80	25,654	136	95.54%	25,518	24,380
April 26	06-44-78	Mossdale	79	26,357	281	94.03%	26,076	24,519
April 26	06-44-79	Mossdale	81	25,977	261	96.52%	25,716	24,821
April 30	06-44-80	Jersey Point	82	25,328	295	96.00%	25,033	24,032
April 30	06-44-81	Jersey Point	82	25,483	289	90.82%	25,194	22,881

FIGURE 5–1

Results of Water Temperature Monitoring at the Merced River Fish Hatchery.



CWT RELEASES

Two sets of CWT salmon releases were made as part of the 2002 VAMP experiment. The first set occurred at 1215 hours on April 18 at Durham Ferry, at 1535 hours on April 19 at Mossdale and at 1010 hours on April 22 at Jersey Point. The second set of releases was made at Durham Ferry at 1050 hours on April 25, Mossdale at 1620 hours on April 26, and Jersey Point at 1535 hours on April 30.

Approximately 100,000 salmon, in four distinct tag lots of about 25,000 fish, were released at Durham Ferry, while approximately 50,000 fish, in two tag lots, were used at each Mossdale and Jersey Point release (Table 5-1). Prior to VAMP 2000, each release was made such that all tag lots were trucked from the hatchery mixed and released as a single group. However, during VAMP 2000, 2001 and 2002, a new transport trailer with three tanks allowed each separate CWT lot to be transported to its release site in a separate tank and distinctly released. As mentioned earlier, the four tag lots comprising each of the groups released at Durham Ferry were already mixed at the hatchery and were therefore transported in a large single tank release truck. This year both Durham Ferry releases were made from the more desirable location alongside the river, instead of from the top of the levee. The nearby agricultural diversion was turned off from the time of the releases until several hours after the release to allow the tagged salmon time to disperse from the release site.

Releases at Jersey Point were made at the beginning of the flood tide to increase dispersion of the tagged fish before they passed Antioch and Chipps Island. Releases at Mossdale and Durham Ferry were not made on any specific tidal condition.

The water temperature both in the hatchery truck and in the receiving waters was measured at the release site immediately prior to release. These, as well as additional release and recovery data, are provided in Table 5-2.

WATER TEMPERATURE MONITORING

Water temperature was monitored during the VAMP 2002 study using individual computerized temperature recorders (e.g., Onset Stowaway Temperature Monitoring/Data Loggers). The water temperature was measured at locations along the longitudinal gradient of the San Joaquin River and interior delta channels between Durham Ferry and Chipps Island - locations along the migratory pathway for the juvenile Chinook salmon released as part of these tests (Appendix C-1). Water temperature was recorded at 24-minute intervals throughout the period of the VAMP 2002 investigations. Water temperature was also recorded within the hatchery raceways at the Merced River Hatchery coincident with the period when juvenile Chinook salmon were being tagged.

Results of water temperature monitoring within the Merced River Hatchery showed that juvenile Chinook salmon were reared in and acclimated to water temperatures of approximately 11-14 C (52- 57F) prior to release into the lower San Joaquin River Figure 5-1. Results of water temperature monitoring at Durham Ferry, Mossdale, and Jersey Point following the first and second sets of VAMP 2002 releases are compared in Figures 5-2, 5-3, and 5-4. Results of water temperature monitoring showed that water temperatures at the release locations and throughout the lower San Joaquin River and delta (Appendix C-2) were higher than those at the hatchery. Water temperatures measured within the lower San Joaquin River and delta were not expected to result in mortality or adverse effects to emigrating juvenile Chinook salmon released as part of the VAMP 2002 investigations.

TABLE 5–2

Release and Recovery Information for Coded Wire Tag Groups Released for VAMP 2002.

TAG CODE	RELEASE SITE	DATE	TRUCK TEMP F°	RIVER TEMP F°	NUMBER RELEASED	AVG. SIZE (mm)	NUMBER RECOVERED AT ANTIOCH	PERCENT SAMPLED AT ANTIOCH	SURVIVAL INDEX AT ANTIOCH	GROUP INDEX AT ANTIOCH
06-44-71	Durham Ferry		54.5	59	23,919	83	11	0.391	0.085	
06-44-72	Durham Ferry		54.5	59	25,175	83	20	0.391	0.146	
06-44-73	Durham Ferry		54.5	59	23,872	83	12	0.391	0.093	
06-44-74	Durham Ferry		54.5	59	24,747	83	20	0.391	0.149	
Total		April 18			97,713		63	0.391		0.119
06-44-57	Mossdale		55.4	57.2	25,514	84	13	0.388	0.095	
06-44-58	Mossdale		55.4	51.8	25,271	82	29	0.388	0.213	
Total		April 19			50,785		42	0.388		0.153
06-44-59	Jersey Point		59	64.4	24,801	85	101	0.387	0.758	
06-44-60	Jersey Point		59	64.4	24,127	83	89	0.386	0.688	
Total		April 22			48,928		190	0.386		0.724
06-44-70	Durham Ferry		60.8	62.6	24,679	80	6	0.399	0.044	
06-44-75	Durham Ferry		60.8	62.6	24,658	80	2	0.384	0.015	
06-44-76	Durham Ferry		60.8	62.6	24,782	80	4	0.382	0.030	
06-44-77	Durham Ferry		60.8	62.6	24,380	80	6	0.392	0.045	
Total		April 25			98,499		18	0.398		0.033
06-44-78	Mossdale		55.4	63.5	24,519	79	3	0.399	0.022	
06-44-79	Mossdale		55.4	63.5	24,821	81	4	0.400	0.029	
Total		April 26			49,340		7	0.400		0.026
06-44-80	Jersey Point		52.7	63.5	24,032	82	43	0.399	0.323	
06-44-81	Jersey Point		52.7	63.5	22,881	82	32	0.398	0.253	
Total		April 30			46,913		75	0.398		0.289

FIGURE 5–2

Water Temperature Monitoring Results at Durham Ferry.

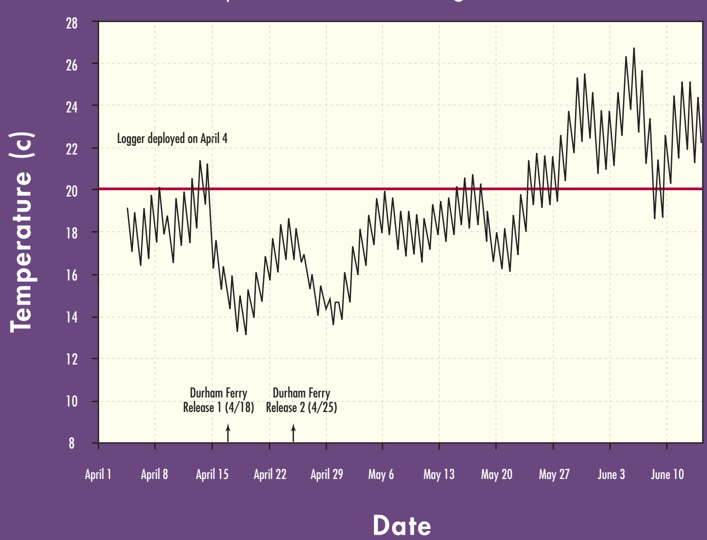
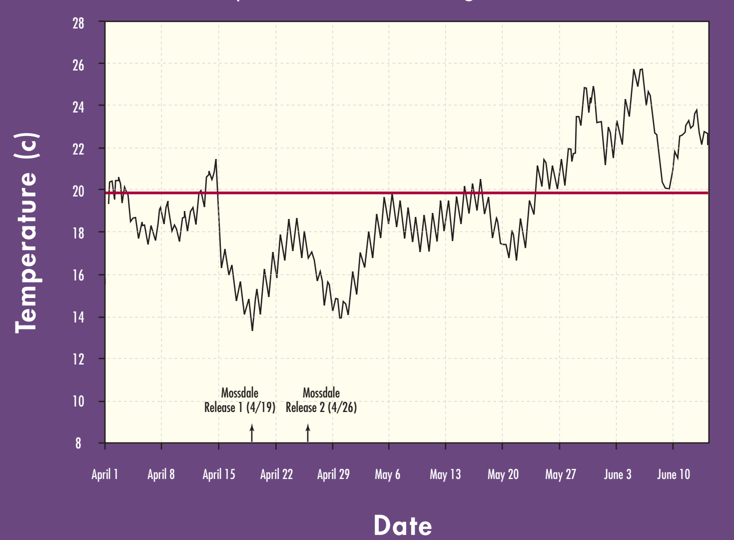


FIGURE 5–3

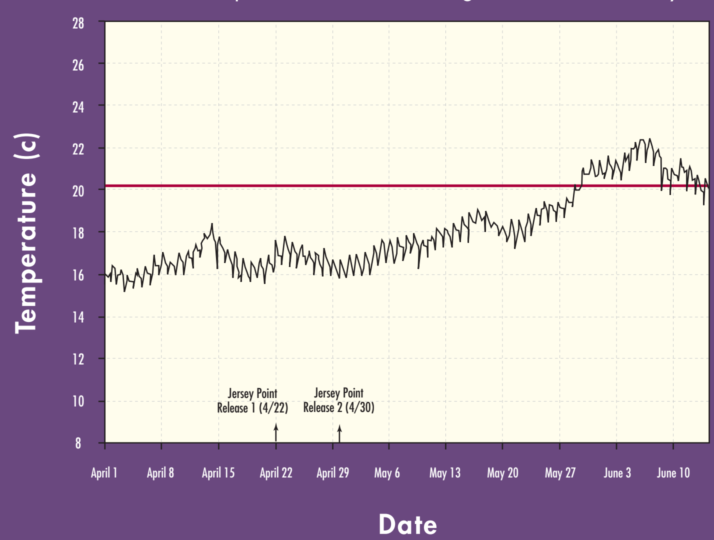
Water Temperature Monitoring Results at Mossdale.



	NUMBER RECOVERED AT CHIPPS	PERCENT SAMPLED AT CHIPPS	SURVIVAL INDEX AT CHIPPS	GROUP INDEX AT CHIPPS	EXPANDED SALVAGE CVP	EXPANDED SALVAGE SWP	ABSOLUTE SURVIVAL ANTIOCH	ABSOLUTE SURVIVAL CHIPPS ISLAND	ABSOLUTE DF-MD SURVIVAL ANTIOCH	ABSOLUTE DF-MD SURVIVAL CHIPPS
	4	0.277	0.078		12	12				
	9	0.264	0.176		60	36				
	4	0.273	0.080		0	27				
	4	0.278	0.076		24	36				
	21	0.265		0.105			0.16	0.13	0.77	0.86
	6	0.272	0.112		24	90				
	7	0.273	0.132		72	48				
	13	0.273		0.122			0.21	0.15		
	46	0.273	0.882		0	12				
	37	0.266	0.132		24	12				
	83	0.266		0.830						
	3	0.273	0.058		36	6				
	5	0.259	0.102		0	24				
	3	0.275	0.057		24	25				
	4	0.266	0.080		24	36				
	15	0.257		0.077			0.11	0.16	1.2	1.5
	2	0.273	0.039		12	93				
	3	0.260	0.060		0	24				
	5	0.260		0.051			0.09	0.11		
	18	0.265	0.367		0	0				
	28	0.270	0.589		0	0				
	46	0.265		0.480						

FIGURE 5–4

Water Temperature Monitoring Results at Jersey Point.



POST-RELEASE-LIVE-CAR STUDIES

Survival and Condition

The post-release survival and condition of marked salmon was evaluated as part of the VAMP program using sub-samples of marked salmon from each release group. Approximately 200 salmon from each tag code were held at the respective release site in net pens for 48 hours after release and were evaluated for overall short-term mortality which might be associated with the handling, transport and release process. In addition to the 200 salmon held for 48 hours, 25 salmon from each tag code were evaluated for condition immediately after release. Another 25 salmon were held and evaluated using the same condition parameters after the 48-hour holding period. The remaining salmon were measured, weighed and sacrificed for further coded wire tag verification if necessary. Due to the mixed tag codes in the Durham Ferry releases two net pens with approximately 200 fish each were held in order to maintain consistency with the other net pen studies. To assess overall condition, fork length in millimeters, weight in grams, and six other characteristics as described in Table 5-3 were examined. Obvious abnormalities or deformities were also noted.

Results of the evaluations of marked fish in the net pens, both immediately after release and 48 hours later, showed few abnormalities in the condition assessed characteristics, and are shown in Appendix C-3. Scale loss ranged from 1-40% and averaged 5.7%. All fish examined were noted to have normal coloration, no fin hemorrhaging, normal eye characteristics and normal gill color. Of the 1,433 salmon assessed, four (0.3%) were found to have a poor or incomplete fin clip. A total of three fish had some type of deformity, two of which had eroded pectoral fins (not uncommon for hatchery raised fish) and one that had a partial operculum. The percentage of salmon deformed within the sample group (0.2%) was within the normal range for hatchery-raised fish.

Out of 2301 fish examined as part of this year' VAMP net pen experiments, no mortalities were observed.

Tag Quality Control

The subset of 25 salmon from each tag group (a total of 25 from each of the Durham Ferry net pens) evaluated for condition as described above were sacrificed to verify purity of tag codes. The additional 200+ fish from each release that were held were archived in a freezer. Though rare, on few occasions in the past, salmon from different release groups have been mixed at some point prior to release. While performing quality control checks on the April 18 Durham Ferry releases, one errant tag code was discovered. A total of 201 tags were read to verify tag code purity. After reading all tags, it was determined that the apparent error was likely the result of tags being lost and found, and not reported as lost, in the lab. All remaining fish will be held for a period to allow tag processing for further evaluation if necessary.

Physiology

Physiological studies were conducted on samples of the juvenile salmon used in the VAMP study by the California-Nevada Fish Health Center (Nichols and Foot 2002). These results are summarized below.

Physiological tests were conducted on a subset of the smolts released at Durham Ferry, Mossdale and Jersey Point at the hatchery before transport to the release site and after they had been

TABLE 5–3
Smolt Condition Characteristics

	NORMAL	ABNORMAL
Eyes	Normally shaped	Bulging
Color	High contrast dark dorsal surface and light sides	Low contrast dorsal surface and sides, coppery color
Fin Hemorrhaging	No blood or red at base of fins	Blood at base of fins
Percent Scale Loss	Lower relative numbers better based on 0-100% scale loss	Higher relative numbers worse based on 0-100% scale loss
Gill Color	Dark beet red to cherry red gill filaments	Light red to gray gill filaments
Vigor	Active swimming (prior to anesthesia)	Lethargic or motionless (prior to anesthesia)

held in the live cars for approximately 24 hours. At the hatchery, 144 fish were examined for virus, systemic bacteria, gill ATPase activity, blood hematocrit value, plasma total protein concentration, plasma chloride concentration, external and internal signs of disease, and other abnormalities. From live cars, a total of 216 fish were assessed for gill ATPase activity, plasma total protein concentration, plasma chloride concentration, internal and external abnormalities, and *Tetracapsula bryosalmonae* (*Tb*) prevalence of infection. No bacterial or viral pathogens were detected in any of the fish examined. Overall 93 of 201 (46%) of fish examined were infected with the kidney parasite *Tb*, the myxosporean causing Proliferative Kidney Disease (PKD). Infection rates ranged from 29% to 70% among individual release groups with 99% of infected fish in the early stage of PKD (Clifton-Hadley et. al. 1987). This stage was characterized by the initial invasion of the kidney blood sinuses by the parasite and minor inflammatory changes. No evidence of anemia was seen in the blood hematocrit values from any of the live car groups but the disease may progress even after the fish enter salt water (Hedrick and Aronstien 1987) and PKD related anemia could arise weeks after release.

Gill Na+/K+-ATPase activity levels were similar among and between hatchery and live car groups. There was no significant change in the 1-6 days between hatchery and 24-hour post-release samples. All sample groups demonstrated elevated gill ATPase activity consistent with salmon in an advanced stage of smoltification.

Plasma total protein concentrations of some individual fish were slightly elevated, although no protein values were outside of normal ranges for juvenile Chinook. Elevated plasma protein values would not necessarily indicate reduced survival for the affected fish. Possible reasons for this site effect include variations in time since last feeding (mild starvation), differences in transport, or site-specific water quality.

Plasma chloride values further supported the "stress event" observed in the hatchery total protein values. All live car groups had depressed plasma chloride values relative to baseline hatchery values ($p<0.001$, t-test) indicating they were under stress probably due to sampling. Hatchery fish were dip-netted directly from the raceway and quickly euthanized, while capture from the live car took longer. Even with this added stress of sampling, plasma chloride values of live car groups remained within the normal range for juvenile salmonids.

In summary, all 6 release groups were in good health and at a similar state of smolt development when sampled at the hatchery and 24-hours post-release. No biologically significant differences were observed in pathogen infections, gill Na+/K+-ATPase activities, or blood chemistry values. Early infections of *Tb* were common, with clinical signs of Proliferative Kidney Disease (PKD) in only 1% of fish examined. Short-term survival of all groups was not likely to be impacted by their health. Health problems resulting from PKD (e.g. anemia) could have arisen several weeks post-release but are not discussed in this part of the report.

Results of the evaluations of marked fish in the net pens, both immediately after release and 48 hours later, showed ***FEW*** *abnormalities in the condition assessed characteristics.*

CWT RECOVERY EFFORTS

CWT salmon were recaptured at Antioch and Chipps Island, at CVP and SWP fish salvage facilities and during sampling at upper Old River near the barrier (See Figure 1-1) CWT salmon released upstream of, and at, Mossdale were also recovered in DFG Kodiak trawls at Mossdale but are not discussed in this part of the report. Juvenile Chinook salmon with an adipose fin clip (which identifies CWT salmon) caught at any of these sampling locations were sacrificed, labeled, and frozen pending CWT processing. Coded-wire tag processing was done by USFWS (Stockton) for fish recovered at Chipps Island, Antioch, and SWP/CVP salvage facilities. DFG Bay Delta Branch and Region IV assisted in processing the fish captured at the HORB fyke nets.

Coded wire tag processing entails dissecting each tagged fish to obtain the half (0.5 millimeter) or full (1 millimeter) cylindrical tag from the snout. Tags are then placed under a dissecting microscope and the numbers are read and recorded in a database. Tags were read twice, with any discrepancies resolved by a third reader. All tags are archived for future reference. It should be noted that many tags recovered at Chipps Island, Antioch, SWP/CVP salvage, and other locations are from coded wire tag releases not affiliated with VAMP. Since it is unknown until after reading the tag, which tags are from the VAMP study, all tags recovered are read.

SWP/CVP Salvage Recapture Sampling

Sampling at the CVP and SWP fish salvage facilities was conducted approximately every two hours. The number of marked salmon collected (raw salvage) was "expanded" based on the number of minutes sampled during each two hour time period. The estimated expanded total number of CWT salmon, from each release group, was obtained by adding together the expanded number of each tag group for all time periods. Only the CWT salmon recovered in the raw salvage collections were sacrificed for tag decoding. Expanded salvage is only a portion of the direct loss experienced by juvenile salmon at the facilities as it does not include losses prior to, and associated with, pre-screen predation, screening, handling and trucking.

Expanded CVP and SWP salvage estimates of marked salmon released as part of the VAMP 2002 studies are shown in Table 5-2. Salvage numbers at both the CVP and SWP were higher in 2002 than in 2001 but continued to be lower than salvage numbers in years without the HORB installed. It is likely that the smolts migrated to the CVP and SWP via Turner or Columbia Cuts, river junctions off the San Joaquin River downstream of the head of Old River.

Antioch Recapture Sampling

Fishery sampling was conducted in the vicinity of Antioch on the lower San Joaquin River using a Kodiak trawl. The Kodiak trawl has a graded stretch mesh, from 2-inch mesh at the mouth to 1/2-inch mesh at the cod-end. Its overall length is 65 feet, and the mouth opening is six feet deep and 25 feet wide. The net was towed between two skiffs, sampling in an upstream direction. Trawls were performed parallel to the left bank, mid-channel, and right bank to sample CWT salmon emigrating from the San Joaquin River. Each sample was approximately 20 minutes in duration.

All fish collected were transferred immediately from the Kodiak trawl to buckets filled with river water, where the fish were held during processing. Data collected during each trawl included fish identification, measuring the fork length of fish collected, tow start time, duration and location in the channel. Mortality and damage to fish collected was documented to comply with the Endangered Species Act permit requirements.

Juvenile Chinook salmon with an adipose fin clip were retained for later CWT processing while unmarked salmon, steelhead, delta smelt, splittail, and other fish were released at a location downstream of the sampling site immediately after identification, enumeration and measurement.

Sampling at Antioch was initiated April 4 and continued through May 15. Each day between 5:00 a.m. and 9:00 p.m., anywhere from 8 to 31, 20-minute tows were conducted. All told, 1,088 Kodiak trawl samples were collected, representing a total sampling duration of 21,582 minutes. During the sampling, a total of 6,134 unmarked juvenile Chinook salmon and 1,822 salmon with an adipose fin clip (CWT) were collected. In addition, 963 Delta smelt, 195 splittail, and 50 unmarked steelhead, and 52 adipose-clipped steelhead were caught in the sampling.

Chipps Island Recapture Sampling

As part of VAMP recovery efforts at Chipps Island, trawling shifts were conducted twice daily between April 4 and May 28, once daily from May 29 to June 8, and once daily Monday through Friday from June 9 through the end of the month. The first shift was begun just before dawn, while the second shift ended at or after sunset in order to incorporate the crepuscular periods of Chinook movement. It is hypothesized, based on an analysis of salmon smolts caught during twenty-four hour sampling at Jersey Point in 1997, that a greater number of salmon would be caught around dawn and dusk. Both targeting this crepuscular period and doubling the total trawl effort at Chipps Island were intended to increase the numbers of CWT salmon recaptured and reduce the variability in VAMP survival indices. This second shift has been conducted during the spring releases since 1998.

The trawl at Chipps Island was towed at the surface using a net with a mouth opening 10 feet deep by 30 feet wide, with a total net length of 82 feet. Aluminum hydrofoils were used on the top bridles and steel depressors along with a weighted lead line were used on the bottom bridles to keep the mouth of the net open. The net was variable mesh net starting with 4-inch mesh at the mouth and ending with a 1/4 inch cod end.


CALIFORNIA

To sample across the channel, trawling at Chipps Island was conducted in three distinct lanes, one each in the north, south and middle of the channel. Each lane was generally sampled at least three times per shift, with one lane sampled a fourth time during each shift. This lane was chosen at random or selected by the boat operator based on flow conditions.

Coded wire tagged salmon released as part of the VAMP program were recovered at Chipps Island between April 24 and May 19. A total of 182 VAMP CWT salmon were recovered at Chipps Island. During the April 24 and May 19 VAMP recovery period, a total of 6,463 unmarked salmon, 1164 CWT salmon from other non-VAMP experiments, 165 delta smelt, 360 Sacramento splittail, 15 clipped steelhead, and 15 non-clipped steelhead, were also collected at Chipps Island.

the total number of minutes in the time period. The percent of time sampled for the VAMP 2002 release groups at Chipps Island was about 27 percent, while at Antioch it averaged 39 percent.

Survival indices were calculated for each separate tag code to provide a sense of the variability associated with the overall group survival index. To generate the group survival index, the recovery numbers and release numbers are combined for the tag codes within a release group. This results in a slightly different index than would be generated by taking the mean of the survival indices of the individual tag codes within a group.

The individual and group survival indices to Antioch and Chipps Island of the CWT salmon released as part of VAMP 2002 are shown in Table 5-2. As in past years, survival indices from the release locations to Antioch were sometimes lower than to Chipps Island. It is expected that indices to Antioch would be greater than to Chipps Island since Antioch is closer to the release locations and the percent of time sampled is greater and the channel width is narrower at Antioch. It may be the inherent variability associated with catching the marked fish that sometimes causes more to be caught at Chipps Island.

Although the survival indices indicated that the first groups released survived at a higher rate than the second group, comparisons using the absolute estimates of survival moderated this ***DIFFERENCE.***

VAMP CHINOOK SALMON CWT SURVIVAL INDICES

Survival indices were calculated for marked salmon released at Durham Ferry, Mossdale, and Jersey Point and recovered at Antioch and Chipps Island. Survival indices were calculated by dividing the number of CWT salmon recovered (R) by the effective number released (E) and multiplying the fraction of time (T) and channel width (W) sampled as shown by the formula (R/E)*T*W. The fraction of the channel width sampled at Chipps Island (0.00769) was the net width (30 feet) divided by an estimate of the channel width (3,900 feet). The fraction of the channel width sampled at Antioch (0.01388) was also based on the net width (25 feet) and an estimate of the channel width (1,800 feet). The fraction of time sampled, at both locations, was calculated based on the number of minutes sampled, between the first and last day of catching each particular tag code or group, divided by the total number of minutes in the time period.

The first and second Durham Ferry releases had survival indices to Antioch of 0.12 and 0.03, respectively. Survival indices to Chipps Island were 0.11 for the first group and 0.08 for the second. While differences between the two groups at Chipps Island did not appear meaningful, those at Antioch did. The individual tag code survival indices at Antioch for the two groups did not overlap and thus there appeared to be a difference in survival between the first and second Durham Ferry groups.

The two Mossdale releases showed similar differences between the first and second releases. The first and second releases had survival indices to Antioch of 0.15 and 0.03 and 0.12 and 0.05 to

Chipps Island, respectively. Again none of the individual tag code survival indices overlapped between groups indicating a real difference between the two groups at both recovery locations.

Similarly, the two Jersey Point groups also appeared to survive at different rates; with the first group surviving at a higher rate than the second. The first group released on April 22 had a survival index to Antioch of 0.72. The second group released on April 30 had an index to Antioch of 0.29. Chipps Island recoveries demonstrated the same apparent difference between groups with the first group having an index of 0.83 and the second group having an index of 0.48.

Why survival was lower for the second groups (releases at Durham Ferry, Mossdale, and Jersey Point), relative to the first groups is unknown. Flow and export conditions were similar for both sets of releases. Water temperatures increased for the releases in the second group, but increases were small and all temperatures at release were below 65 degrees (Table 5-3).

ABSOLUTE CHINOOK SALMON SURVIVAL ESTIMATES AND DIFFERENTIAL COMBINED RECOVERY RATES

More important than the differences in survival indices between sets of releases is the comparison of absolute survival estimates, where the survival indices of the upstream release groups are divided by the survival indices of the downstream groups (recovered at the same location). It is most useful for comparisons between groups, recovery locations and years.

In 2002, we have also used the differential combined recovery rates as an estimate of survival. The combined recovery rate for each release group was obtained by summing the recoveries from Antioch and Chipps Island and dividing by the number released. The differential combined recovery rate was the combined recovery rate of an upstream group relative to the downstream group and is another way to estimate survival between release locations. The differential recovery rate is similar to calculating absolute survival estimates, but does not expand each estimate by the fraction of the time and space sampled. The differential recovery rates and the absolute survival estimates should be similar as 1) the fraction of the time sampled is similar between groups within a recovery location and 2) the fraction of space sampled at each recovery location is a constant. Neither would change the relative differences between groups. However, combining the recovery numbers from Antioch and Chipps Island may result in differences using the two methods in estimating survival.

Variance and standard errors were also calculated for the differential combined recovery rates based on the Delta method provided by Dr. Ken Newman (pers. comm). The differential recovery rates plus or minus two standard errors are roughly equivalent to the 95% confidence intervals. Plus or minus one standard error equates to roughly the 68% confidence intervals. (Ken Newman, personal communication). It is not clear how similar variances, standard errors or confidence intervals could be generated using the absolute survival estimates.

In comparing survival between reaches and replicates the confidence intervals were used to determine if estimates were significantly different. If the 95% confidence intervals overlapped they were not considered statistically different. Differences observed using the lower level of confidence 68% are noted.

The use of absolute survival estimates and differential combined recovery rates are more powerful for use in comparing survival rates, since the use of ratios between upstream and downstream groups theoretically standardizes for differences in catch efficiency between recovery locations and/or years. Both types of estimates of survival have been calculated for VAMP 2002. An additional estimate of absolute survival will be possible from recoveries in the ocean fishery, 2 to 4 years following release.

Although the survival indices indicated that the first groups released survived at a higher rate than the second group, comparisons using the absolute estimates of survival moderated this difference (Table 5-2). Absolute survival between Durham Ferry and Mossdale and Jersey Point was still somewhat higher for the first releases using the Antioch recovery information. Absolute survival for the two sets of releases was similar using the Chipps Island recovery information, but it is uncertain if these differences are significant.

Results using the differential combined recovery rates also indicated the first groups appeared to survive at a higher rate than the second groups, with the first Durham Ferry and Mossdale groups relative to Jersey Point being higher than the second groups (Table 5-4). Estimates of 95% confidence intervals (plus and minus 2 standard errors) indicated differences were not significant at the $p<0.05$ level. The first Mossdale to Jersey Point estimate was greater than the second using the lower level of confidence (68%) (Table 5-4 and Figure 5-5).

One surprise was that the second group released at Durham Ferry appeared to survive at a higher rate than the second group released at Mossdale. This result was shown using both absolute

TABLE 5–4

2002 Smolt Survival Differential Recovery Rates

	REC. AT ANTIOCH	REC. AT CL	# RELEASED	A+C	A+C/R	S DF TO MD	S MD TO JP	S DF TO JP	S DF/MD-JP
Durham Ferry (DF) 1	11	4	23,920	15	0.00062				
	20	9	25,176	29	0.00115				
	12	4	23,872	16	0.00067				
	20	4	24,747	24	0.00096				
Total	63	21	97,715	84	0.00085	0.793			
Mossdale (MD) 1	13	6	25,515	19	0.00074			0.154	
	29	7	25,272	36	0.00142				
Total	42	13	50,787	55	0.00108		0.194		
Jersey Point (JP) 1	101	46	24,802	147	0.00592				
	89	37	24,128	126	0.00522				
Total	190	83	48,930	273	0.00557				
Durham Ferry (DF) 2	6	3	24,680	9	0.00036				
	2	5	24,659	7	0.00028				
	4	3	24,783	7	0.00028				
	6	4	24,381	10	0.00041				
Total	18	15	98,503	33	0.00033	1.377			
Mossdale (MD) 2	3	2	24,519	5	0.00020			0.129	
	4	3	24,820	7	0.00028				
Total	7	5	9,339	12	0.00024		0.094		
Jersey Point (JP) 2	43	18	24,032	61	0.00253				
	32	28	22,880	60	0.00262				
Total	75	46	46,912	121	0.00257				
Combined									
DF (1&2)	81	36	196,218	117	0.00059	0.891			
MD (1&2)	49	18	100,126	67	0.00066		0.162		
JP (1&2)	265	129	95,842	394	0.00411			0.145	
DF/MD (1&2)	130	54	296,344	184	0.00062				0.151

S – Differential Recovery Rate • 1SE – One Standard Error • 2SE – Two Standard Errors

S-2SE	S+2SE	S-1SE	S+1SE
0.518	1.069	0.656	0.931
0.115	0.192	0.134	0.173
0.136	0.251	0.165	0.222
0.448	2.305	0.913	1.841
0.078	0.180	0.104	0.155
0.037	0.151	0.065	0.122
0.618	1.164	0.754	1.027
0.119	0.205	0.141	0.184
0.114	0.175	0.129	0.160
0.124	0.177	0.137	0.164

survival estimates and differential combined recovery rates of the Durham Ferry/Jersey Point groups relative to the Mossdale/Jersey Point groups (Tables 5-2 and 5-4). However, the difference in recovery rates was not significant at either the 68 percent or 95 percent confidence level. Durham Ferry is 11 miles further upstream than Mossdale and is expected to include additional mortality.

Both differential recovery rate estimates of survival between Durham Ferry and Mossdale were not significantly different from each other using either confidence levels (Table 5-4). Thus the differential recovery rates of the two groups were combined and survival between Durham Ferry and Mossdale was estimated at 0.89. These data appear to show that there is substantial variability within recovery rate estimates and that survival was relatively high between the two locations.

In 2000 it did appear that survival was less for groups released at Durham Ferry relative to those released at Mossdale using the absolute survival estimates generated from information at Antioch. This difference led to the recommendation of making releases at both Durham Ferry and Mossdale in future years. When looking at the 2000 data using combined differential recovery rates, the variability was such it was not clear that survival was greater for the Mossdale group. The recovery rate of the first Mossdale group relative to the first Jersey Point group was not significantly different (at the $p<0.05$ level) from the first Durham Ferry group relative to the first Jersey Point group. The same was true for the second set of releases. The first Mossdale/Jersey recovery rate was significantly greater than the second Durham Ferry/ Jersey Point group at both levels of significance (Figure 5-6).

In 2001 and 2002 differential recovery rates indicated that survival between Durham Ferry and Jersey Point and Mossdale and Jersey Point was not statistically different ($p<0.05$), thus we can infer survival between Durham Ferry and Mossdale was high in these years. Surprisingly, the survival was higher in 2001 for the first Durham Ferry group relative to the Jersey Point group than the first Mossdale group relative to the Jersey Point group using the lower level of significance (Figure 5-7). It is uncertain how the Durham Ferry groups could survive at a higher rate than the Mossdale groups, but it probably is possible. Continuation of releasing groups at both sites, will allow detection of mortality between Durham Ferry and Mossdale if it does occur and become significant in the future. If survival between locations is shown not to be statistically significant then groups can be combined.

FIGURE 5–5

Differential Recovery Rates of CWT Smolts Released at Mossdale and Jersey Point (MD-JP) and Durham Ferry and Jersey Point (DF-JP) for the First (1) and Second (2) Groups in 2002. The Estimate and Plus and Minus 1 and 2 Standard Error(s) is Provided.

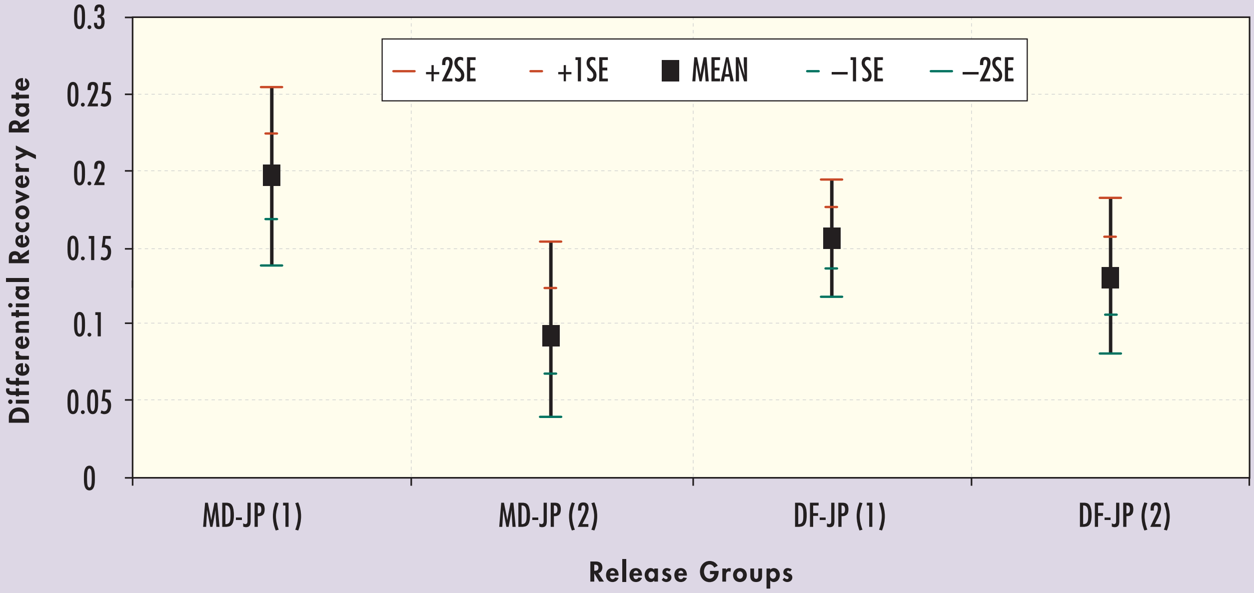
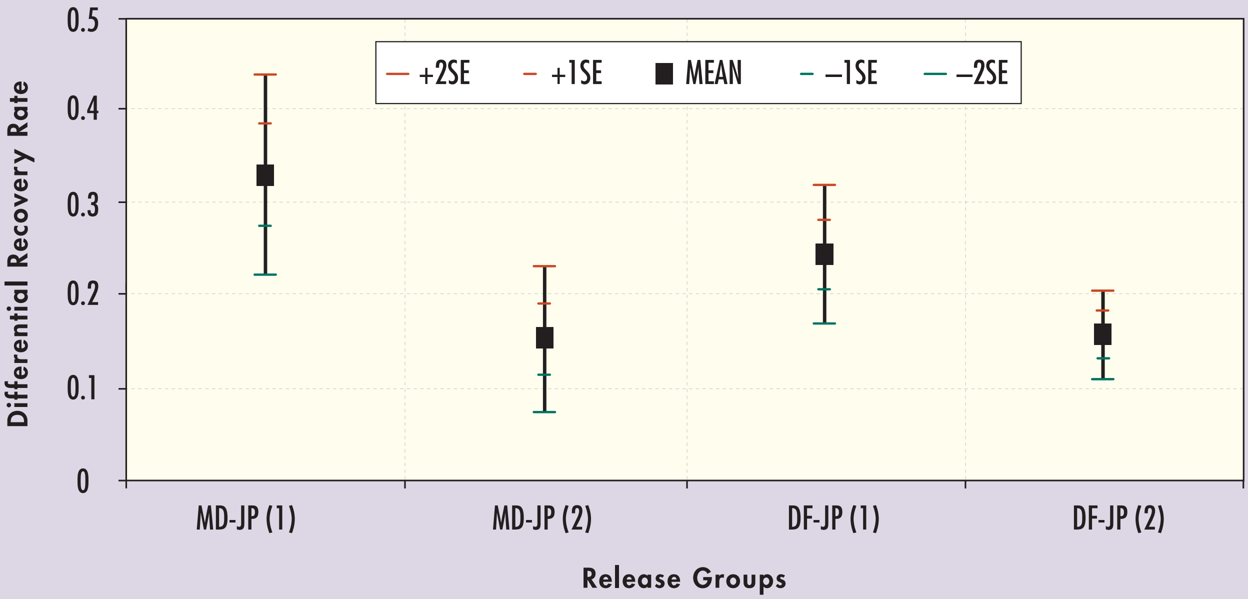


FIGURE 5–6

Differential Recovery Rates of CWT Smolts Released at Mossdale and Jersey Point (MD-JP) and Durham Ferry and Jersey Point (DF-JP) for the First (1) and Second (2) groups in 2000. The Estimate and Plus and Minus 1 and 2 Standard Error(s) is Provided.



In 2002, absolute survival for the Durham Ferry and Mossdale groups relative to the Jersey Point groups ranged between 0.09 and 0.21 and averaged 0.14. Differential recovery rates ranged between 0.09 and 0.19. As mentioned earlier, the combined recovery rates relative to the Jersey Point groups was not significantly different between the Durham Ferry and Mossdale groups using the 95% confidence levels. Thus it may be appropriate to combine these recovery rate estimates. Similarly, if replicates are not statistically different, they could be combined. The confidence intervals around each differential recovery rate provide a means to assess whether groups should be combined.

Differential recovery rates of the first and second Durham Ferry groups relative to the Jersey Point releases were not statistically different. Similarly, differential recovery rates for the first and second Mossdale groups relative to the Jersey Point groups were also not significantly different. (Note the two replicates from Mossdale to Jersey Point were significantly different using a 68% confidence interval.) In addition, the differential recovery rates of the Durham Ferry/Jersey Point estimates were not significantly different than the Mossdale/Jersey Point estimates, thus combined estimates were generated (Table 5-4). The combined Durham Ferry/Mossdale to Jersey Point estimate of survival using the combined differential recovery rates was 0.15 - not much different than the average absolute estimate of survival (0.14).

Similar estimates of differential recovery rates with the 95% confidence intervals were calculated for past VAMP years (2000 and 2001)(Tables 5-5 and 5-6). (Note there was an error in the 2001 Annual Report in reporting these estimates. - They have been recalculated and included in this report.) Differential recovery rate replicates in those years were also not significantly different from each other at the 95 percent confidence level. Thus they were combined into one estimate of recovery rate for the Durham Ferry/Mossdale groups relative to the Jersey Point groups. Some replicates were significantly different at a lower significance level (~68%). For instance, the Mossdale to Jersey Point and Durham Ferry to Jersey Point replicates in 2000 were significantly different at this lower level of significance. In addition, the combined Durham Ferry/Jersey Point estimates were significantly lower than the Mossdale/Jersey Point estimates in 2001 at this lower level of confidence

TRANSIT TIME

Data on transit times for marked salmon from the release to recapture sites during VAMP 2002 is summarized in graphic form in Appendix C-4. CWT salmon released April 18 at Durham Ferry took between 7 and 19 days to arrive at Antioch and 8 to 22 days to arrive at Chipps Island. The April 19th release at Mossdale release took between 6 and 11 days to arrive at Antioch and 7 and

FIGURE 5–7

Differential Recovery Rates of CWT smolts released at Mossdale and Jersey Point (MD-JP) and Durham Ferry and Jersey Point (DF-JP) for the first (1) and second (2) groups in 2001. The estimate and plus and minus 1 and 2 standard error(s) is provided.

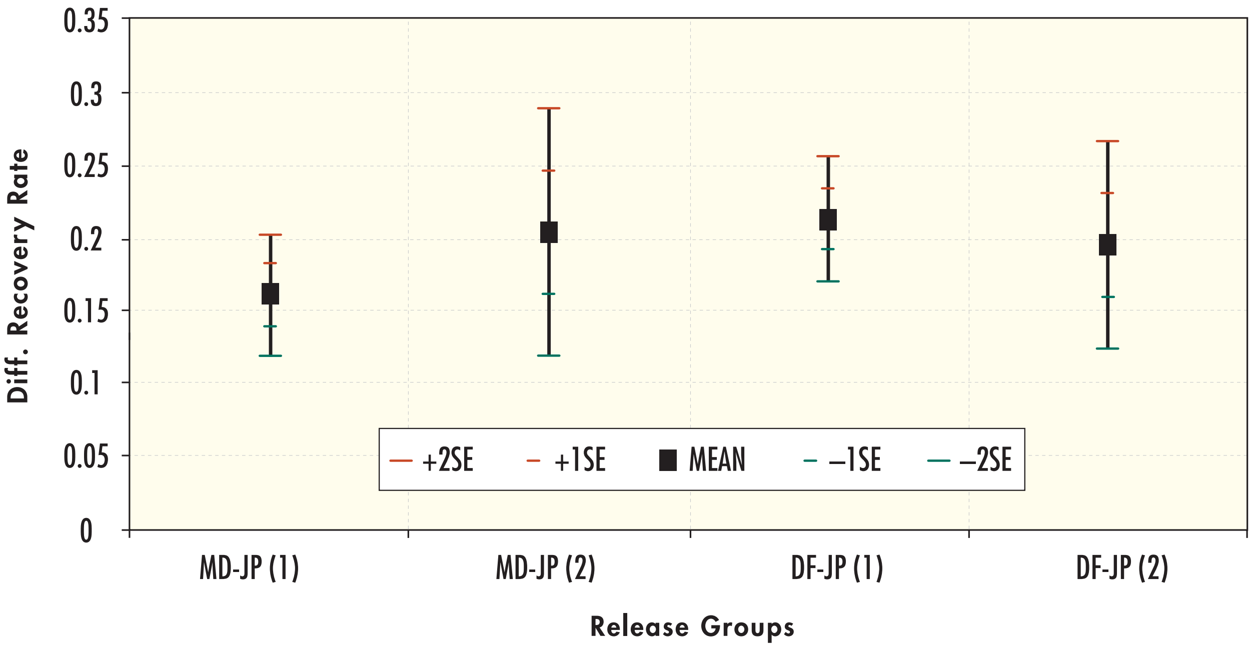


TABLE 5–5

2000 Smolt Survival Differential Recovery Rates

	REC. AT ANTIOCH	REC. AT CL	# RELEASED	A+C	A+C/R	S DF TO MD	S MD TO JP	S DF TO JP	S DF/MD-JP
Durham Ferry (DF) 1	6	7	23,629	13	0.00055				
	10	10	24,177	20	0.00082				
	11	11	24,457	22	0.00089				
Total	27	28	72,263	55	0.00076	0.733			
Mossdale (MD) 1	14	9	23,465	23	0.00098				
	16	9	22,784	25	0.00109				
Total	30	18	46,249	48	0.00103		0.328		
Jersey Point (JP) 1	50	24	25,527	74	0.00289				
	47	41	25,824	88	0.00340				
Total	97	65	51,351	162	0.00315			0.241	
Durham Ferry (DF) 2	8	7	23,698	15	0.00063				
	15	5	26,805	20	0.00074				
	8	10	23,889	18	0.00075				
Total	31	22	74,392	53	0.00071	1.036			
Mossdale (MD) 2	9	7	23,288	16	0.00068		0.150		
Jersey Point (JP) 2	76	48	25,572	124	0.00484				
	76	30	24,661	106	0.00429				
Total	152	78	50,233	230	0.00457			0.155	
Combined									
DF (1&2)	58	50	146,655	108	0.00073	1.066			
MD (1&2)	39	25	69,537	48	0.00069		0.178		
JP (1&2)	249	143	101,584	392	0.00385			0.190	
DF/MD (1&2)	97	75	216,192	156	0.00072				0.186

S – Differential Recovery Rate • 1SE – One Standard Error • 2SE – Two Standard Errors

S-2SE	S+2SE	S-1SE	S+1SE
0.443	1.022	0.588	0.878
0.220	0.437	0.274	0.383
0.166	0.316	0.203	0.278
0.445	1.628	0.741	1.332
0.072	0.227	0.111	0.188
0.108	0.202	0.131	0.179
0.814	1.319	0.940	1.193
0.114	0.243	0.146	0.211
0.149	0.232	0.170	0.211
0.149	0.224	0.168	0.205

17 days to reach Chipps Island. Jersey Point release groups were recovered between 2 and 14 days after release at Antioch and between 2 and 21 days at Chipps Island. The April 25 Durham Ferry release group arrived at Antioch between 7 and 18 days and between 7 and 15 days at Chipps Island. The April 26 release group at Mossdale was recovered at Antioch between 7 and 14 days and between 9 and 19 days at Chipps Island. The second Jersey Point release group was recovered between 1 and 14 days after release at Antioch and 1 and 19 days after release at Chipps Island. The transit time from release location to Antioch and Chipps Island of both sets of releases was similar. It is interesting that the Jersey Point groups were recovered over as long or longer period than those released upstream.

Transit times appeared slower in 2002, than in 2001. In 2001, recovery dates were as early as 4 days after releases were made at Durham Ferry and Mossdale. River flows were lower in 2002 than in 2001 (approximately 3,300 cfs versus 4,200 cfs, respectively), which may have increased travel time in 2002. The number of individual recoveries by tag code and the number of minutes towed per day for both Antioch and Chipps Island recoveries are shown in Appendix C-4.

ROLE OF FLOW AND EXPORTS ON ABSOLUTE SURVIVAL AND RECOVERY RATES

Historically, April–June, San Joaquin River flow and flow relative to exports was correlated to adult escapement in the San Joaquin basin 2 1/2 years later (Figures 5-8 and 5-9). Both relationships are statistically significant ($p<0.01$) with the flow/exports variable accounting for slightly more of the variability than the relationship with flow alone ($r^2= 0.44$ vs. $r^2 = 0.58$, respectively). These relationships appeared to indicate that adult escapement in the San Joaquin basin was affected by the amount of flow in the San Joaquin River and exports from the CVP and SWP during the spring months when the juveniles migrated through the river and Delta to the ocean. VAMP was designed to further define the mechanisms behind this relationship using smolt survival through the Delta and testing lower San Joaquin River flows with the presence of the HORB.

Survival of juvenile Chinook salmon emigrating from the San Joaquin River system has been evaluated within the framework established by the VAMP experimental design since the spring of 2000. Similar and complementary studies in the south delta were conducted prior to the official implementation of VAMP.

TABLE 5–6

2001 Smolt Survival Differential Recovery Rates

	REC. AT ANTIOCH	REC. AT CL	# RELEASED	A+C	A+C/R	S DF TO MD	S MD TO JP	S DF TO JP	S DF/MD-JP
Durham Ferry (DF) 1	28	14	23,354	42	0.00179				
	30	22	22,837	52	0.00227				
	18	17	22,491	35	0.00155				
Total	76	53	68,682	129	0.00187	1.325			
Mossdale (MD) 1	18	17	23,000	35	0.00152				
	15	14	22,177	29	0.00130				
Total	33	31	45,177	64	0.00141		0.159		
Jersey Point (JP) 1	156	50	24,443	206	0.00842				
	173	61	24,992	234	0.00936				
Total	329	111	49,435	440	0.00890			0.211	
Durham Ferry (DF) 2	8	2	24,025	10	0.00041				
	11	5	24,029	16	0.00066				
	10	2	24,177	12	0.00049				
Total	29	9	72,231	38	0.00052	0.958			
Mossdale (MD) 2	8	4	23,878	12	0.00050				
	11	4	25,308	15	0.00059				
Total	19	8	49,186	27	0.00054		0.201		
Jersey Point (JP) 2	43	17	25,909	60	0.00231				
	53	27	25,465	80	0.00314				
Total	96	44	51,374	140	0.00272			0.193	
Combined									
DF (1&2)	105	62	140,913	167	0.00118	1.228			
MD (1&2)	52	39	94,363	91	0.00096		0.167		
JP (1&2)	425	155	100,809	580	0.00575			0.205	
DF/MD (1&2)	157	101	235,276	258	0.00109				0.190

S – Differential Recovery Rate • 1SE – One Standard Error • 2SE – Two Standard Errors

S-2SE	S+2SE	S-1SE	S+1SE
0.920	1.730	1.123	1.528
0.116	0.201	0.137	0.180
0.168	0.253	0.189	0.232
0.476	1.440	0.717	1.199
0.116	0.286	0.159	0.243
0.122	0.263	0.157	0.228
0.908	1.549	1.068	1.388
0.129	0.205	0.148	0.186
0.169	0.242	0.187	0.224
0.162	0.219	0.176	0.204

The differential relative recovery rates of all releases each year were combined as they were not significantly different from each other at the 95 percent confidence level. These combined estimates and their 95 percent confidence intervals for the three years of VAMP releases (2000 - 2002) are shown in relation to the log of the average San Joaquin River flow at Vernalis on Figure 5-10. The average river flow was from the two-10 day periods after release. Data obtained in 1994 and 1997 are added but do not have comparable confidence intervals at this time. The relative recovery rates with the confidence intervals are also shown in comparison to average Vernalis flow/combined exports for the 10 days after release (Figure 5-11). The relationship of relative recovery rate to San Joaquin River flow is improved by incorporating exports. Relationships without the 1994 and 1997 are similar (Figures 5-10 and 5-11). While recovery rates do appear to increase as flows and flows relative to exports increase ($p<0.05$) data points that have confidence intervals around them are not significantly different from each other.

Given the relatively high variability inherent in conducting salmon smolt survival studies within the lower San Joaquin River and Delta, and modeling conducting by Ken Newman (November, 2001) the lack of statistically significant differences between relative recovery rates from similar flow-export conditions was not unexpected. Results of these analysis underscore the importance of collecting salmon smolt survival data under the most extreme flow-export conditions identified as VAMP targets. Flows of 7,000 cfs and exports of 1,500 cfs would provide the highest flow/export ratio (4.7) to test and increase our chances of detecting significant differences in recovery rates between VAMP targets.

THE ROLE OF HORB ON SURVIVAL

The relationship to date between absolute survival between Mossdale and Jersey Point and San Joaquin River flow at Vernalis and exports with and without the barrier in upper Old River is shown in Figure 5-12. Differential recovery rates are not reported since without barrier releases do not have comparable estimates. Replicates of survival estimates within a year measured with the HORB have not been combined as the differential recovery rates were in Figure 5-11. Thus while comparisons can be made between regression lines, variance around each data point is not yet available. Two regression lines have been developed based on survival data with and without the HORB. Statistically neither regression line is significant, although prior to adding the data from 1999, the without barrier relationship was significant. The

FIGURE 5–8

Flow at Vernalis (Mean April 15-June 15) Between 1951-1998 Versus San Joaquin Basin Escapement (2 ½ Years Later).

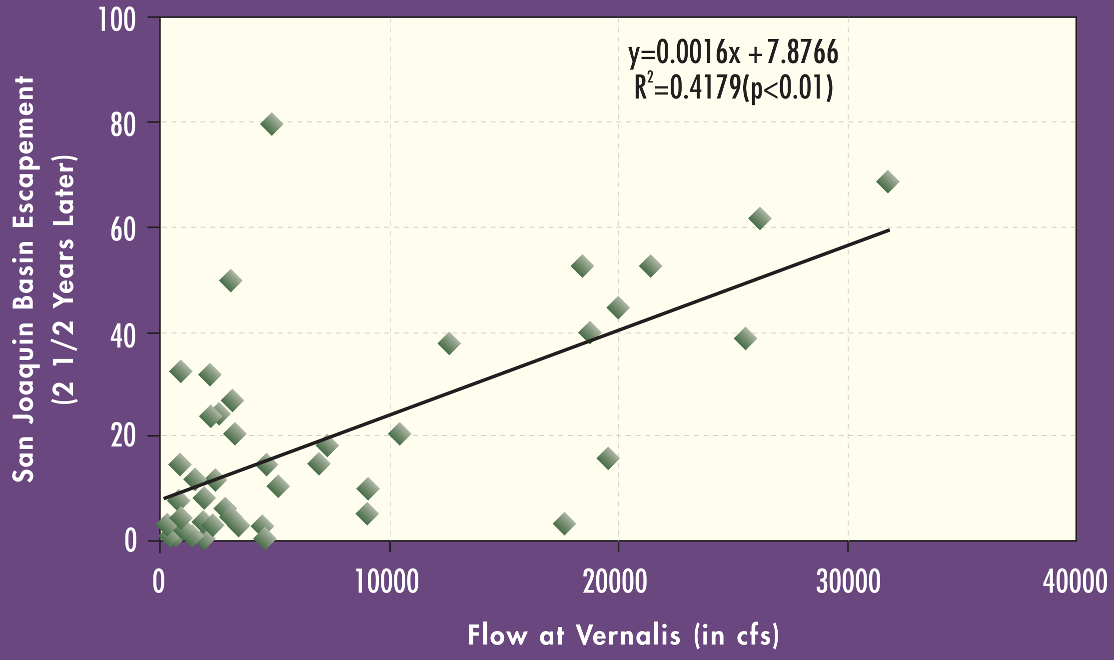


FIGURE 5–9

Mean Spring Flows/Delta Exports (Mean April 15-June 15) Between 1951-1998 and San Joaquin Basin Escapement (2 ½ Years Later).

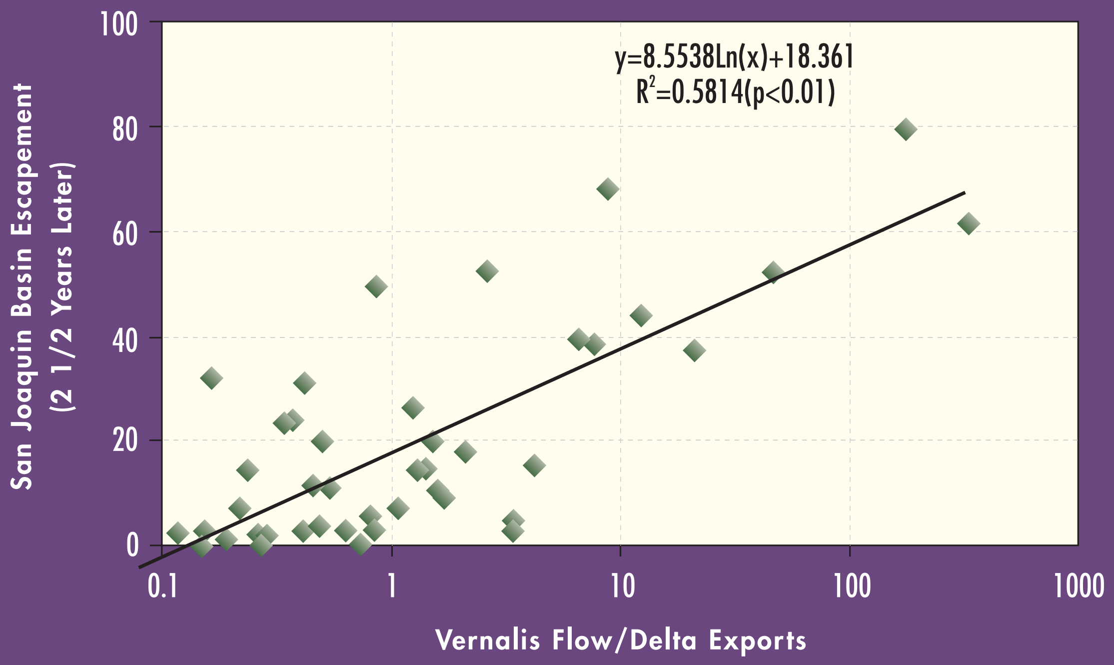


FIGURE 5–10

Survival (Plus and Minus 1 and 2 SE) From Durham Ferry/Mossdale to Jersey Point With HORB in Place Versus Flow at Vernalis, 2000-2002. 2000-2002 Vernalis Flows Were Averaged for Both 10 day Periods After Release. 1994 and 1997 Data are Added but do not Have SE. The Equation Without the 1994 and 1997 Data Added is Similar at y=0.0621Ln(x) – 0.3445 (R^2=0.6371).

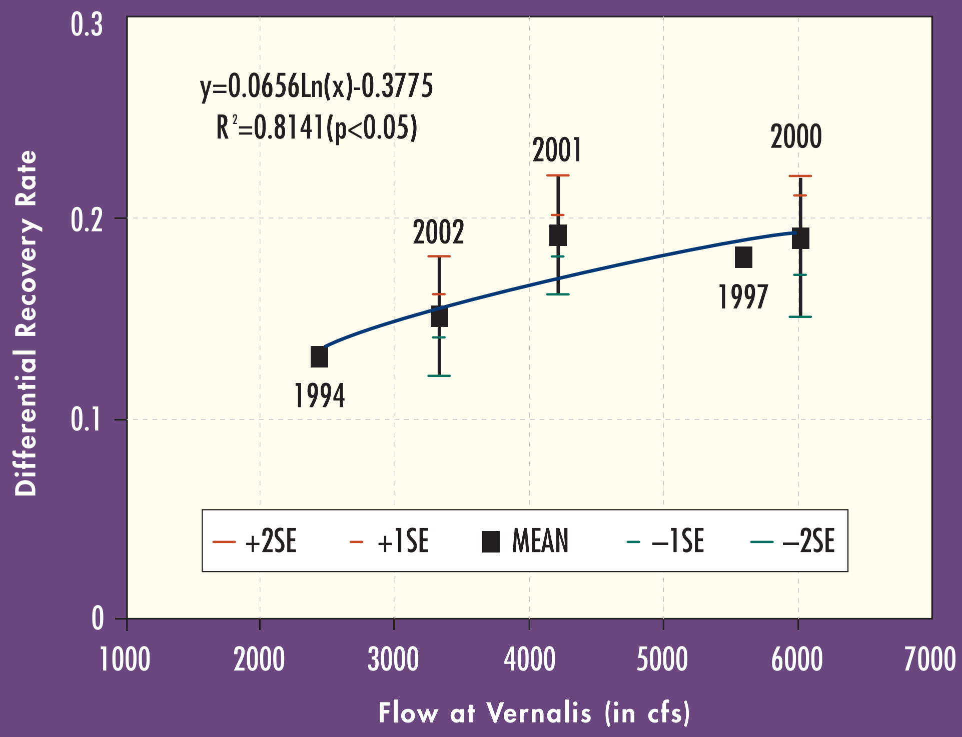
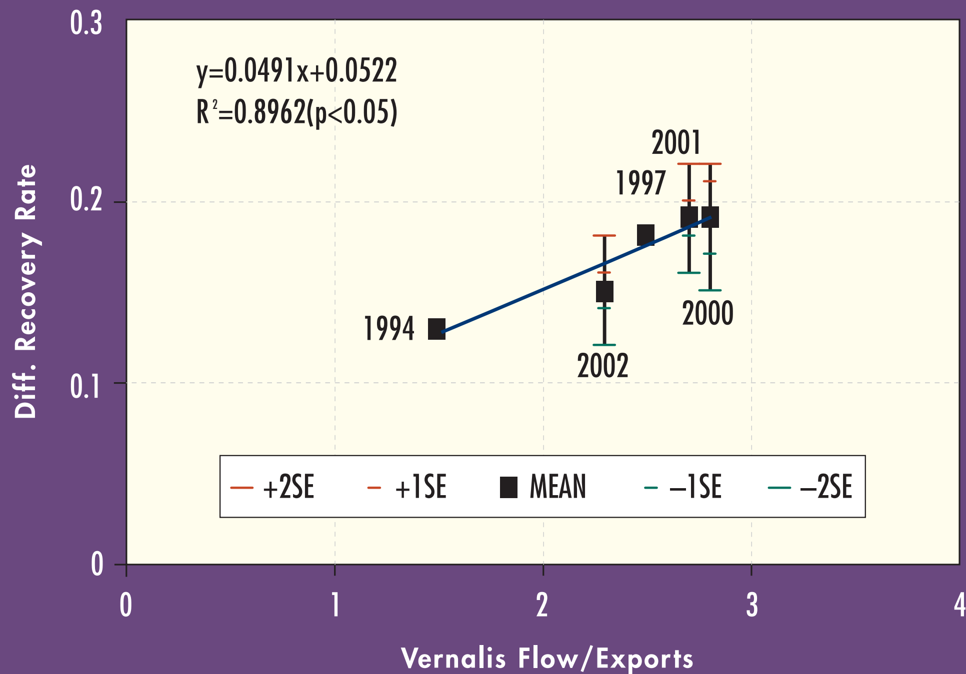


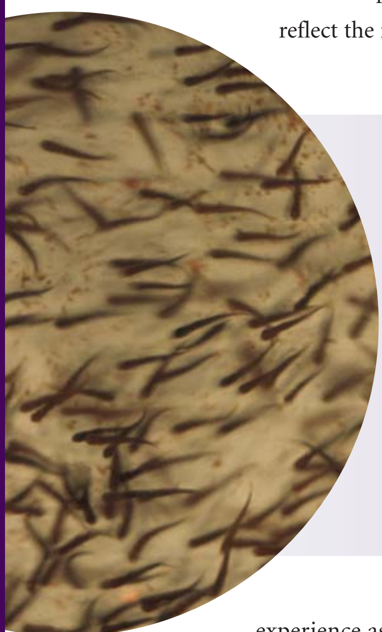
FIGURE 5–11

Survival (Plus and Minus 1 and 2 SE) From Durham Ferry/Mossdale to Jersey Point With HORB in Place, Versus Inflow at Vernalis/exports, Average of Both 10 day Periods After Release, 2000-2002. 1994 and 1997 Data are Added but do not Have SE. The Equation Without 1994 and 1997 is y=0.0857x – 0.0462, R^2=0.9643.



barrier appears to generally increase survival at any one flow/export level, although the survival was high in 1999 without a barrier. We have hypothesized that data collected in 1999, could be biased high as sampling was interrupted during collection of the downstream control group (Brandes, 2000).

Figure 5-12 shows the relationship between absolute salmon smolt survival and San Joaquin River flow at Vernalis relative to exports with the HORB. A better estimate of flow would be the net flow on the San Joaquin River downstream of upper Old River because of the different permeability of the HORB (culvert operations) over the years. The estimated flow in the San Joaquin River downstream of upper Old River would better reflect the river flow the juvenile salmon



experience as they migrate down the San Joaquin River. This estimate has been calculated in past years by subtracting the estimated mean daily flow in upper Old River 840 feet downstream of the barrier from the USGS gaged mean daily flow at Vernalis.

It appears as exports increase relative to flow, survival (differential recovery rates) decreases. Although the relationship is significant the individual recovery rates are not significantly different from one another. One source of variability that could be reduced is the variable permeability of the HORB within and among years. During the five years the barrier has been installed (and comparable survival studies conducted) the design and permeability has changed. In 1994, the HORB was installed without culverts, while in 1997 the barrier had two open culverts that diverted approximately 300 cfs into upper Old River. In 2000, the HORB had six gated culverts, with two open during the Mossdale and first Durham Ferry release and four open during the second Durham Ferry release. In 2001 and 2002, six culverts were installed and operated throughout the VAMP test period. It is estimated that approximately 400 cfs of San Joaquin River flow moved through the culverts in 2001 and 2002 (Simon Kwan, personal communication). The amount of water flowing through the culverts is based on the head differential between the San Joaquin River and Old River. This changes as flow/stage on the river changes and as the tide changes, even if all 6 culverts remain open for the remaining 9 years of the study. The varying designs and changes in the culvert operations of the barrier add variability to the survival measurements, making it more difficult to detect significant differences between closely related flow/export ratios.

In the five years of measuring survival with the barrier in place, the flow/export ratio has only varied from 1.5 (1994) to 2.9. These are very small differences in target conditions of which to measure survival. The ratios in the relationship between flow/export and adult escapement vary from 0.1 to 1000.

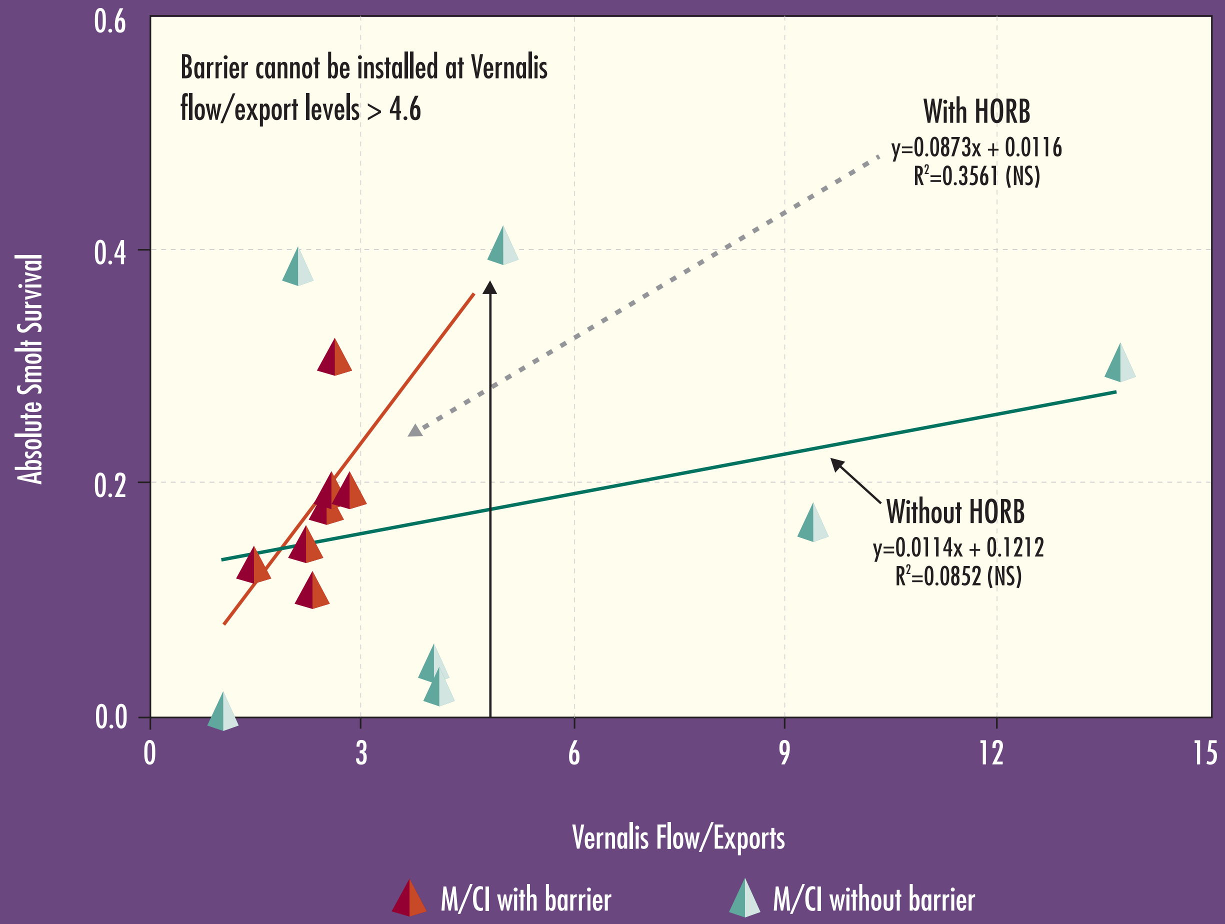
In the five years of measuring survival with the barrier in place, the flow/export ratio has only varied from 1.5 (1994) to 2.9. These are very small differences in TARGET CONDITIONS of which to measure survival.

OCEAN RECOVERY INFORMATION FROM RECENT YEARS

Ocean recovery data of CWT salmon groups can contribute to a more complete understanding and evaluation of salmon smolt survival studies. These data can provide another independent estimate of the ratio of survival of a test release group relative to a control release group, or "absolute survival", and can be compared with estimates based on juvenile salmon recoveries at Chipps Island and Antioch. Past recoveries at Jersey Point (1997-1999) can not be compared since the Jersey Point trawling site was located upstream of the Jersey Point release site and a ratio between the upstream and downstream sites can not be generated. Recovery from trawling at Antioch began in 2000. The ocean harvest data may be particularly reliable due to the number of tag recoveries and the extended recovery period.

FIGURE 5–12

Estimates of Survival Versus Vernalis Flow/Exports With and Without a HORB.



Adult recovery data are gathered from commercial and sport ocean harvest checked at various ports by DFG. The Pacific States Marine Fisheries Commission database of ocean harvest CWT data was the source of recoveries through 2001. The ocean CWT recovery data accumulate over a 1-4 year period following the year a study release is made as nearly all of a given year class of salmon have either been harvested or spawned by age 5. Consequently, these data are essentially complete for releases made through 1996 and 1997 and partially available for CWT releases made from 1998-2000. Once the data for these and later releases are available they will be used to compare the three independent estimates of survival (using Antioch, Chipps Island, and ocean recoveries): based on VAMP releases starting in 2000.

Survival estimates based on ocean recoveries for salmon produced at the Merced River Hatchery, and released as part of south delta survival evaluations from 1996-2000 were compared to survival estimates based on Chipps Island and Antioch recoveries (Table 5-7). Releases over that period were made at several locations: Dos Reis (on the San Joaquin River downstream of the upper Old River junction), Mossdale, Durham Ferry, and Jersey Point. Ocean absolute survival ratios were very similar to those at Chipps Island for the releases made in 1996, and 1999, and 2000 and at Antioch for the Mossdale and second Durham Ferry releases in 2000. Although ocean absolute survival ratios were higher than those to Chipps Island for releases in 1997 and 1998 and to Antioch for the first Durham Ferry release in 2000, they were generally similar (in the mid-range of survival).

Results of this comparative analysis of survival estimates for Chinook salmon produced in the Merced River Hatchery show (1) there is generally good agreement between survival estimates based on juvenile CWT salmon recoveries in Chipps Island and Antioch trawling and adult recoveries from the ocean fishery, (2) survival estimates using Chipps Island or Antioch recoveries were lower in some years than estimates based on ocean recoveries, and (3) additional comparisons need to be made, as more data becomes available from VAMP releases for recoveries at Antioch,

TABLE 5–7

Survival Indices Based on Chipps Island, Antioch and Ocean Recoveries of Merced Hatchery Salmon Released as Part of South Delta Studies Between 1996 and 2000.

RELEASE YEAR	SAN JOAQUIN RIVER *(Merced River Origin)* TAG NO.	RELEASE NUMBER	RELEASE SITE	RELEASE DATE	CHIPPS IS. RECOVS.	ANTIOCH RECOVS.
			Juvenile Salmon CWT Releases			
1996	H61110412	25,633	DOS REIS	MAY 01 '96	2	
	H61110413	28,192	DOS REIS	MAY 01 '96	3	
	H61110414	18,533	DOS REIS	MAY 01 '96	1	
	H61110415	36,037	DOS REIS	MAY 01 '96	5	
	H61110501	53,337	JERSEY PT	MAY 03 '96	39	
	Effective Release	107,961	DOS REIS		11	
	Effective Release	51,737	JERSEY PT		39	
1997	H62545	50,695	DOS REIS	APR 29 '97	9	
	H62546	55,315	DOS REIS	APR 29 '97	7	
	H62547	51,588	JERSEY PT	MAY 02 '97	27	
	Effective Release	106,010	DOS REIS		16	
	Effective Release	51,588	JERSEY PT		27	
	H62548	46,728	DOS REIS	MAY 08 '97	5	
	H62549	47,254	JERSEY PT	MAY 12 '97	18	
1998	61110809	26,465	MOSSDALE	APR 16 '98	25	
	61110810	25,264	MOSSDALE	APR 16 '98	31	
	61110811	25,926	MOSSDALE	APR 16 '98	32	
	61110806	26,215	DOS REIS	APR 17 '98	33	
	61110807	26,366	DOS REIS	APR 17 '98	23	
	61110808	24,792	DOS REIS	APR 17 '98	34	
	61110812	24,598	JERSEY PT	APR 20 '98	87	
	61110813	25,673	JERSEY PT	APR 20 '98	100	
	Effective Release	77,655	MOSSDALE		88	
	Effective Release	77,373	DOS REIS		90	
	Effective Release	50,271	JERSEY PT		187	
1999	064606	25,005	MOSSDALE	APR 20 '99	2	
	062642	24,715	MOSSDALE	APR 19 '99	8	
	062643	24,725	MOSSDALE	APR 19 '99	15	
	062644	25,433	MOSSDALE	APR 19 '99	13	
	062645	25,014	DOS REIS	APR 19 '99	20	
	062646	24,841	DOS REIS	APR 19 '99	19	
	0601110815	24,927	JERSEY PT	APR 21 '99	34	
	062647	24,193	JERSEY PT	APR 21 '99	25	
	Effective Release	99,878	MOSSDALE		38	
	Effective Release	49,855	DOS REIS		39	
	Effective Release	49,120	JERSEY PT		59	
2000	06-45-63	24,457	DURHAM FERRY	APR 17 '00	11	11
	06-04-01	23,529	DURHAM FERRY	APR 17 '00	7	6
	06-04-02	24,177	DURHAM FERRY	APR 17 '00	10	10
	06-44-01	23,465	MOSSDALE	APR 18 '00	9	14
	06-04-02	22,784	MOSSDALE	APR 18 '00	9	16
	06-44-03	25,527	JERSEY PT	APR 20 '00	24	50
	06-04-04	25,824	JERSEY PT	APR 20 '00	41	47
	Effective Release	72,163	DURHAM FERRY		28	27
	Effective Release	46,249	MOSSDALE		18	30
	Effective Release	51,351	JERSEY PT		65	97
	601060914	23,698	DURHAM FERRY	APR 28 '00	7	8
	601060915	26,805	DURHAM FERRY	APR 28 '00	5	15
	0601110814	23,889	DURHAM FERRY	APR 28 '00	10	8
	0601061001	25,572	JERSEY PT	May 1 '00	48	76
	0601061002	24,661	JERSEY PT	May 1 '00	30	76
	Effective Release	74,392	DURHAM FERRY		22	31
	Effective Release	50,233	JERSEY PT		78	152

NOTE: Ocean recoveries are based on data through 2001

EXPANDED ADULT OCEAN RECOVS. (AGE 1+ TO 4+) TOTAL	CHIPPS ISLAND	ANTIOCH	OCEAN CATCH
	Juvenile Salmon CWT Survival Estimates		
3			
37			
8			
10			
187			
58	0.14		0.15
187			
183			
167			
351			
350	0.29		0.49
351			
91	0.28		0.48
191			
61			
40			
58			
47			
35			
61			
110			
90			
159	0.30		0.51
143	0.31		0.46
200			
57			
101			
119			
112			
138			
191			
244			
302			
389	0.32		0.35
329	0.65		0.59
546			
10			
10			
20			
10			
9			
50			
24			
40	0.31	0.20	0.38
19	0.31	0.34	0.29
74			
4			
4			
0			
14			
32			
8	0.19	0.14	0.12
46			

Chipps Island, and the ocean fishery. Information on survival of juvenile salmon and the contribution to the adult salmon population will be valuable in evaluating the biological benefits of changes in flow and export rates under VAMP.

SAN JOAQUIN RIVER SALMON PROTECTION

One of the VAMP objectives is to provide improved conditions and increased survival of juvenile Chinook salmon smolts produced in the San Joaquin River tributaries during their downstream migration through the lower river and delta. It is hoped that these actions to improve conditions for the juveniles would translate to greater adult escapement in future years, especially during low flows, when escapement 2 1/2 years later has been extremely low in the San Joaquin basin (Figure 5-13).

To determine if VAMP in 2002 was successful in protecting juvenile salmon emigrating from the San Joaquin River tributaries, estimates of survival were compared with VAMP and in the absence of VAMP. Catches of unmarked salmon at Mossdale and in salvage at the CVP and SWP facilities were also compared prior to and during the VAMP period.

Unmarked Salmon Recovered at Mossdale

In assessing VAMP's objective to provide increased protection for the natural production of juvenile salmon migrating from the San Joaquin River tributaries, an estimate of survival was calculated with VAMP and in the absence of VAMP. The equation of survival to flow/exports was used to estimate survival under both conditions (Figure 5-11). With VAMP the flow/export ratio during the VAMP period was 2.3. This flow/export ratio generated a survival of 0.15. Without the export curtailments and flow augmentation due to VAMP the flow/export rate was estimated to be 0.35 (given the barrier was still in without the VAMP flow and exports). At this level of flow/export rate survival was estimated to have been 0.08. The export curtailments and increase in flows from VAMP essentially doubled survival from 0.08 to 0.15.

The original time period for VAMP (April 15 to May 15) was chosen based on historical data that indicated a high percentage of the juvenile salmon emigrating from the San Joaquin tributaries was passing into the delta at Mossdale during that time period. The average catch per minute per day of unmarked juvenile salmon caught in Kodiak trawling at Mossdale between March 15 and June 30, 2002 is shown in Figure 5-14. Unmarked salmon do not have an adipose clip and could be fish from the Merced River Hatchery or juveniles from natural spawning. An assessment of the percent of catch per unit effort over time indicated that the

FIGURE 5–13

Natural and Hatchery Escapement Returning to the San Joaquin Basin Between 1953 and 2001.

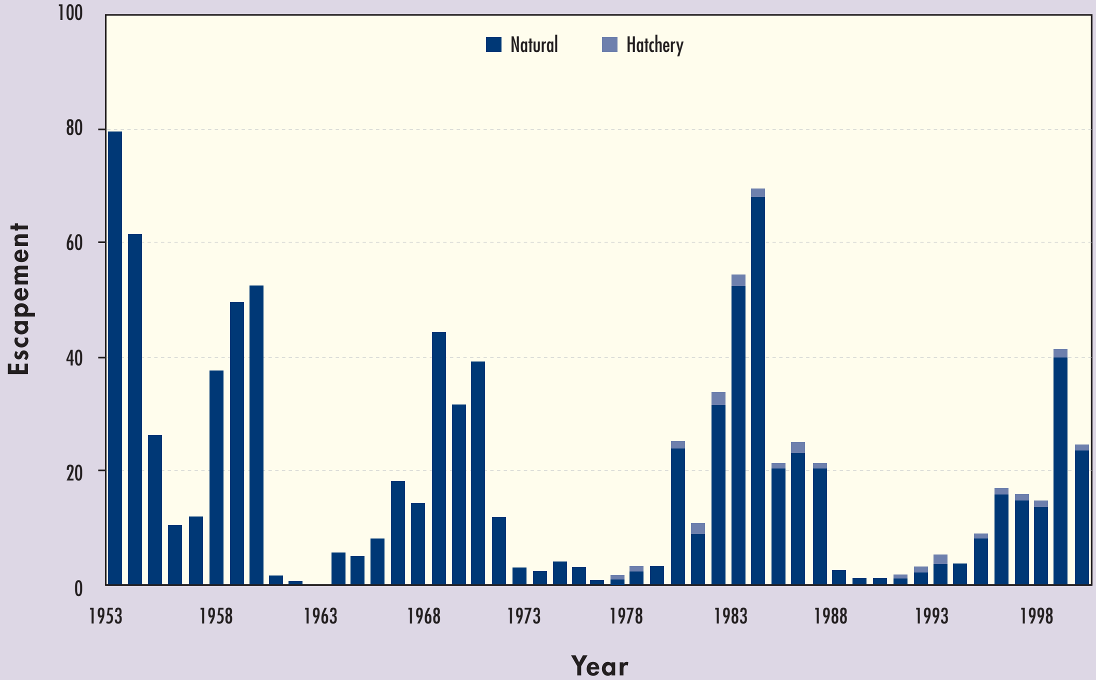


FIGURE 5–14

Catch Per Cubic Meter of all Unmarked Juvenile Chinook Salmon in the Mossdale Kodiak Trawl, March 15, 2002 Through June 30, 2002.

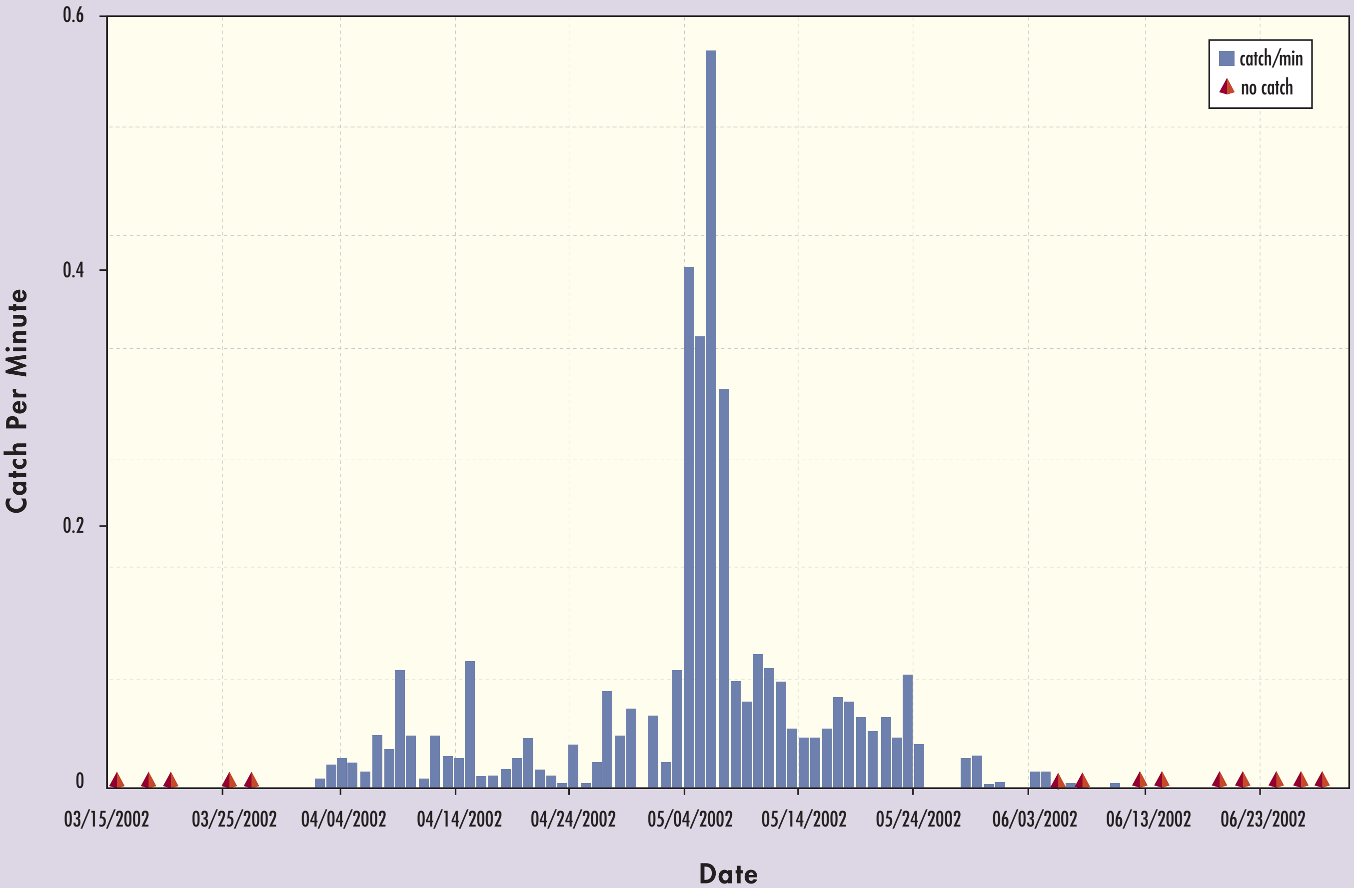
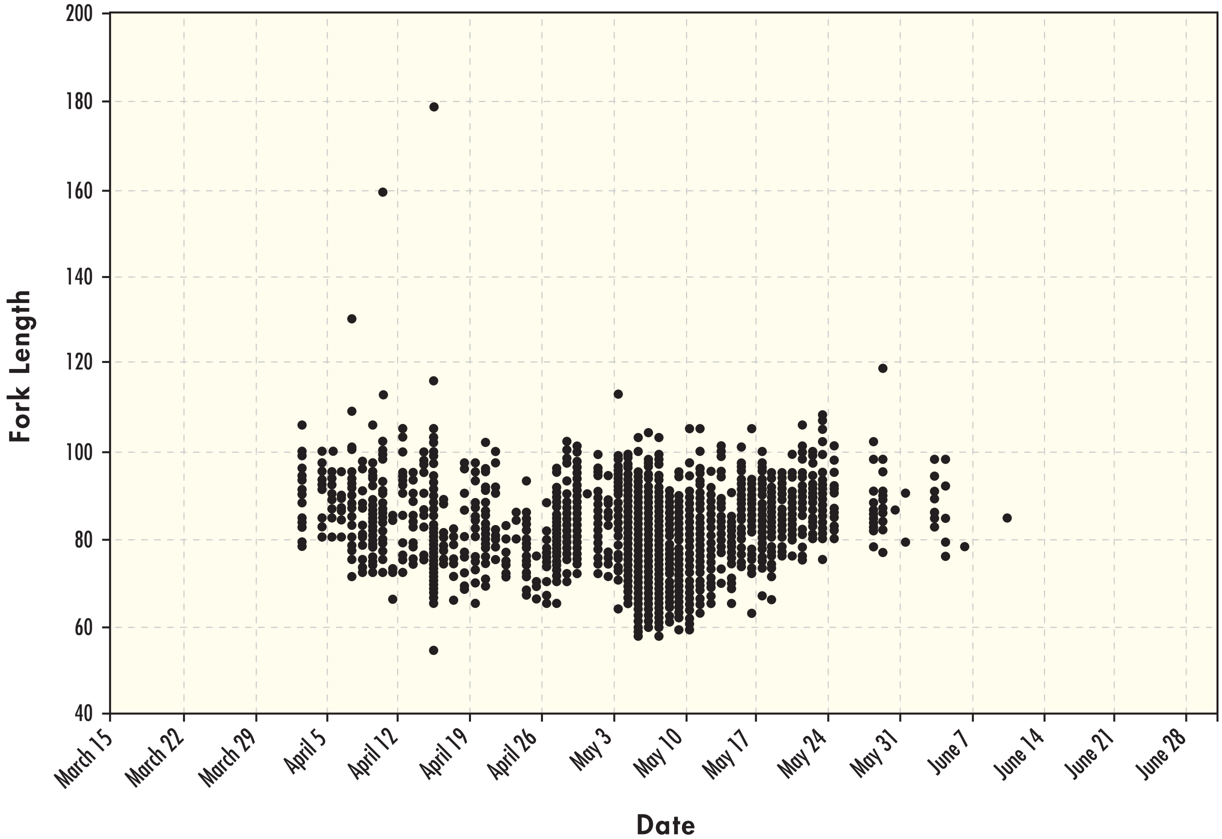


FIGURE 5–15

Individual Fork Lengths for Unmarked Juvenille Chinook in the Mossdale Kodiak Trawl, March 15, 2002 Through June 30, 2002.



majority of juvenile salmon (77%) migrated past Mossdale during the VAMP period. Delaying removal of the HORB until May 24, continuing export curtailments and ramping exports into early June protected an even greater percent of the population (91%). Reducing flows may stimulate movement of the juvenile salmon out of the system. Continuing the export curtailments and keeping the barrier in place for a week after the VAMP period provided some protection to these later out-migrants. These additional protection measures after VAMP appear to have been beneficial to protecting a greater proportion of the population of unmarked juvenile salmon emigrating from the San Joaquin basin.

Each unique size in millimeters of the juvenile salmon caught in the trawl at Mossdale between March 15 and June 30 is shown in Figure 5-15. In early April there were large juvenile salmon observed in the catch. These may be yearlings that have over-summered in the San Joaquin tributaries. Additional protection in early April may be warranted for this component of the population.

Salmon Salvage and Losses at Delta Export Pumps

Fish salvage operations at the CVP and SWP export facilities capture unmarked salmon for transport by tanker truck and release downstream in the western Sacramento-San Joaquin delta. The untagged salmon are either naturally produced or hatchery salmon, potentially from any source in the Central Valley. It is not certain which unmarked salmon recovered are of San Joaquin basin origin, although the timing of salvage and fish size can be compared with Mossdale trawl data and CWT recovery data at the facilities to provide some general indications.

The salvage at the facilities is based on expansions from subsamples taken throughout the day. Approximately 4-5 salmon are estimated to be lost per salvaged salmon in the SWP Clifton Court Forebay based on high predation rates. The CVP pumps divert directly from the Old River channel and the loss estimates range from about 50-80% of the number salvaged, or about 6- 8 times less per salvaged salmon than for the SWP. The loss estimates do not include any indirect mortality in the delta due to water export operations or additional mortality associated with trucking and handling. Salvage density of salmon is the number of salvaged fish per acre-foot of water pumped.

The number of juvenile salmon that migrated through the system, the placement of the HORB, and the amount of water pumped by each facility are some of the factors that influence the number and density of juvenile salmon salvaged and lost. Density may be the best indicator of when the most juvenile salmon were moving through the salvage system.

FIGURE 5–16

2002 SWP Salmon Salvage and Loss.

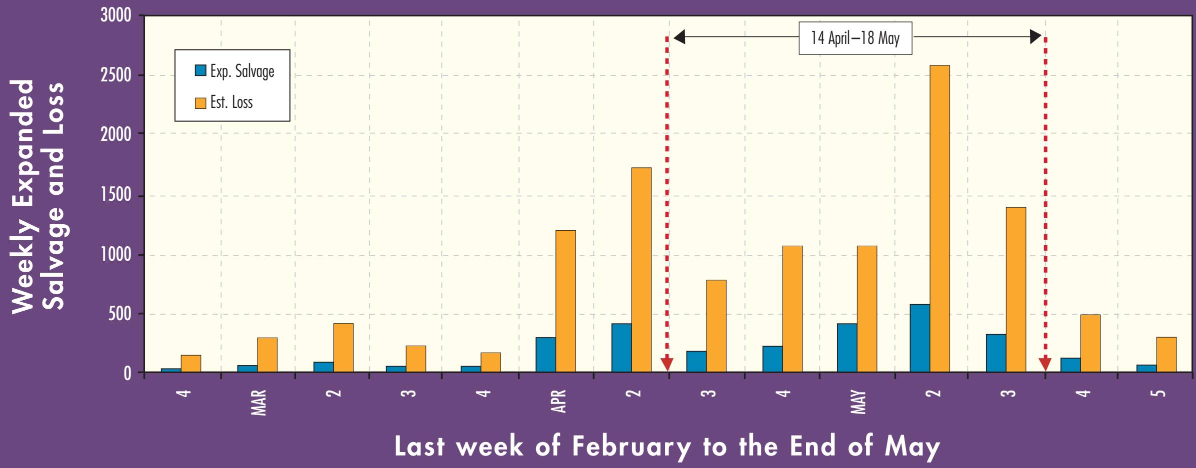


FIGURE 5–17

2002 CVP Salmon Salvage and Loss.

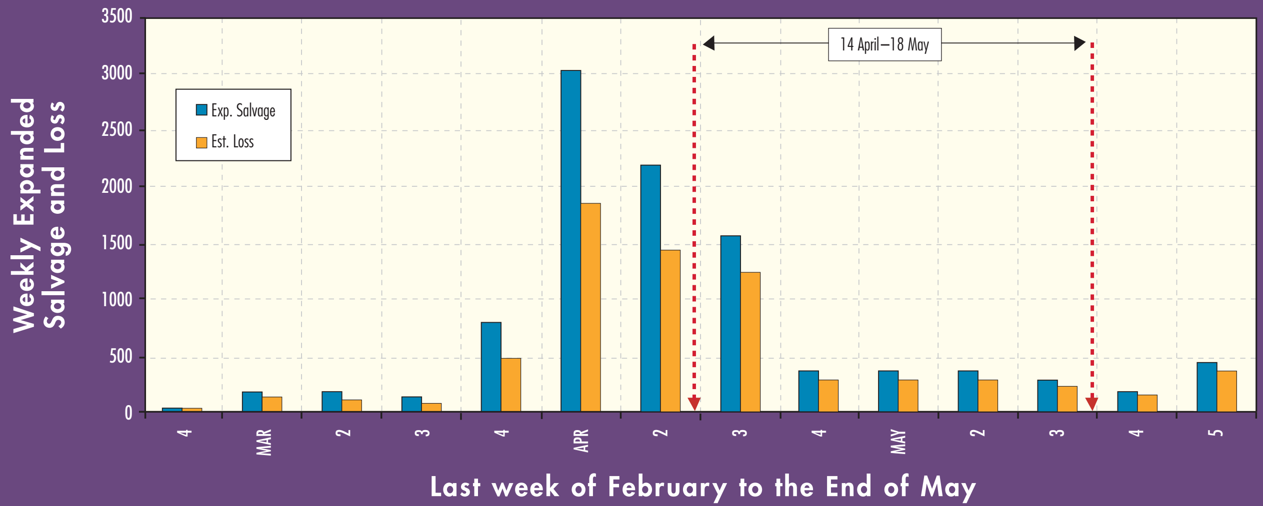
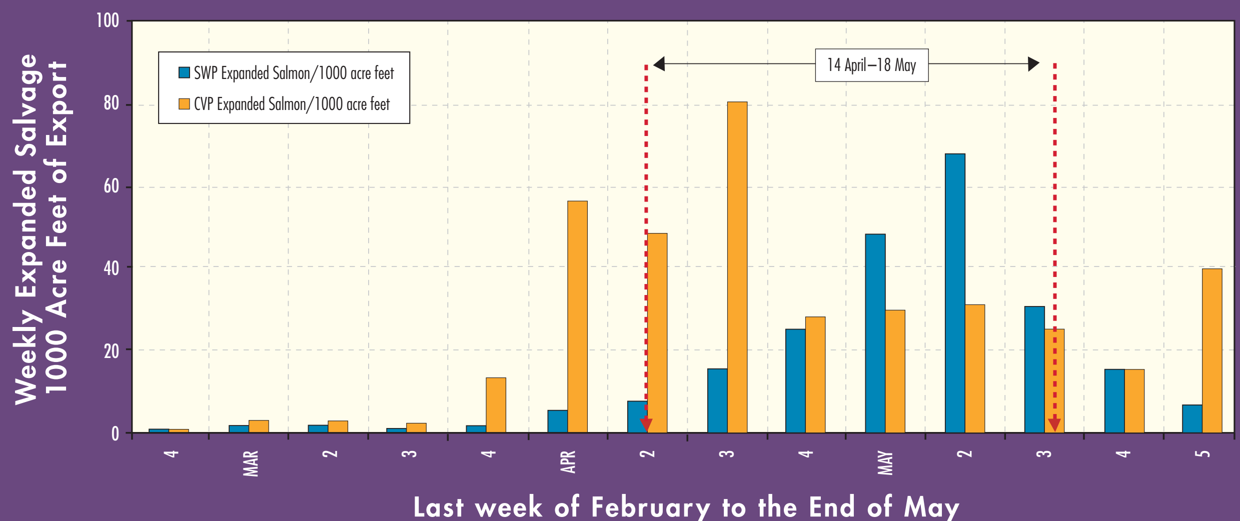


FIGURE 5–18

2002 SWP & CVP Expanded Salmon Salvage Density.



A review of the weekly salvage data around the 2002 VAMP period indicates that the highest salvage and losses occurred during the second week of May at the SWP and in the second week prior to the VAMP period at the CVP (Figures 5-16 and 5-17). Salmon density was highest in the first week of the VAMP period at the CVP facility, which also had high densities in the two preceding weeks, and in the fourth week of the VAMP period at the SWP facility (Figure 5-18). The salvage, loss and density information indicates that the salmon protection measures of VAMP may have been beneficial if they were implemented in the first half of April, similar to 2000 and 2001. Reducing exports during this earlier period of time would not only provide better conditions for juvenile salmon emigrating from the San Joaquin River basin, but from the Sacramento River basin as well.

It is recommended that these ***CONDITIONS*** *be tested as soon as possible to determine if VAMP should continue or if the study design needs to be changed.*

Juvenile spring-, winter-, and fall- run Chinook salmon migrate through the Delta in early April from the Sacramento River basin. Compared to the previous two years, salvage, losses, and density were several times lower in 2002, indicating that overall juvenile abundance was much less this year at the fish facilities.

The size distribution of unmarked salmon during April and May in the Mossdale trawl (Figure 5-15) and at the salvage facilities (Figure 5-19): Source E. Chappell, DWR) were generally similar in 2002, as was observed in 2001.

Results of these analysis showed that the VAMP 2002 test period coincided with much of the peak period of salmon smolt emigration. Reductions in SWP and CVP exports and increased San Joaquin River flow provided improved conditions for salmon survival, although starting the VAMP period two weeks earlier may have had substantial benefits. Additional VAMP studies are required, however, to improve quantification of biological benefits over a broader range of environmental conditions.

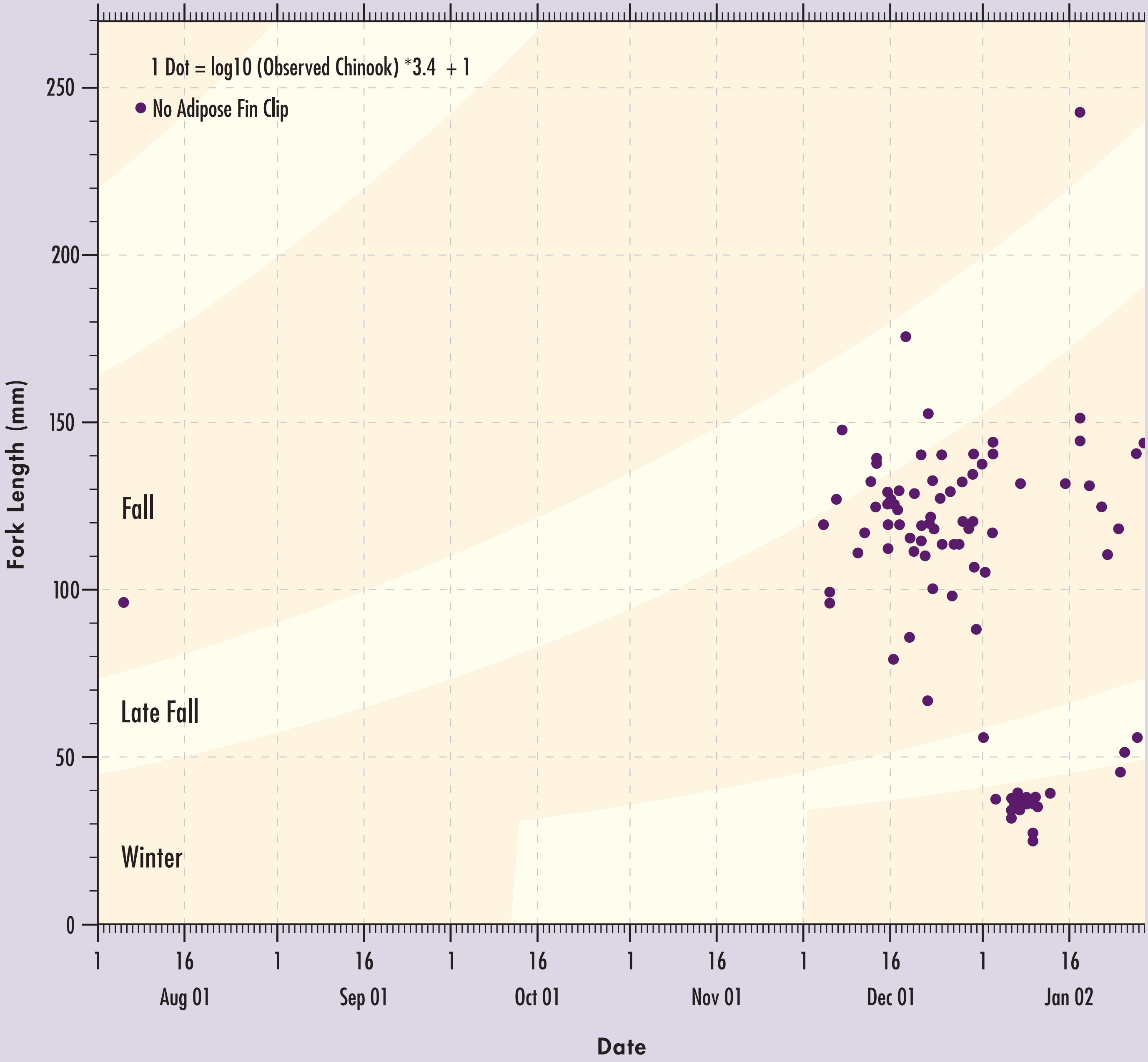
Summary and Recommendations

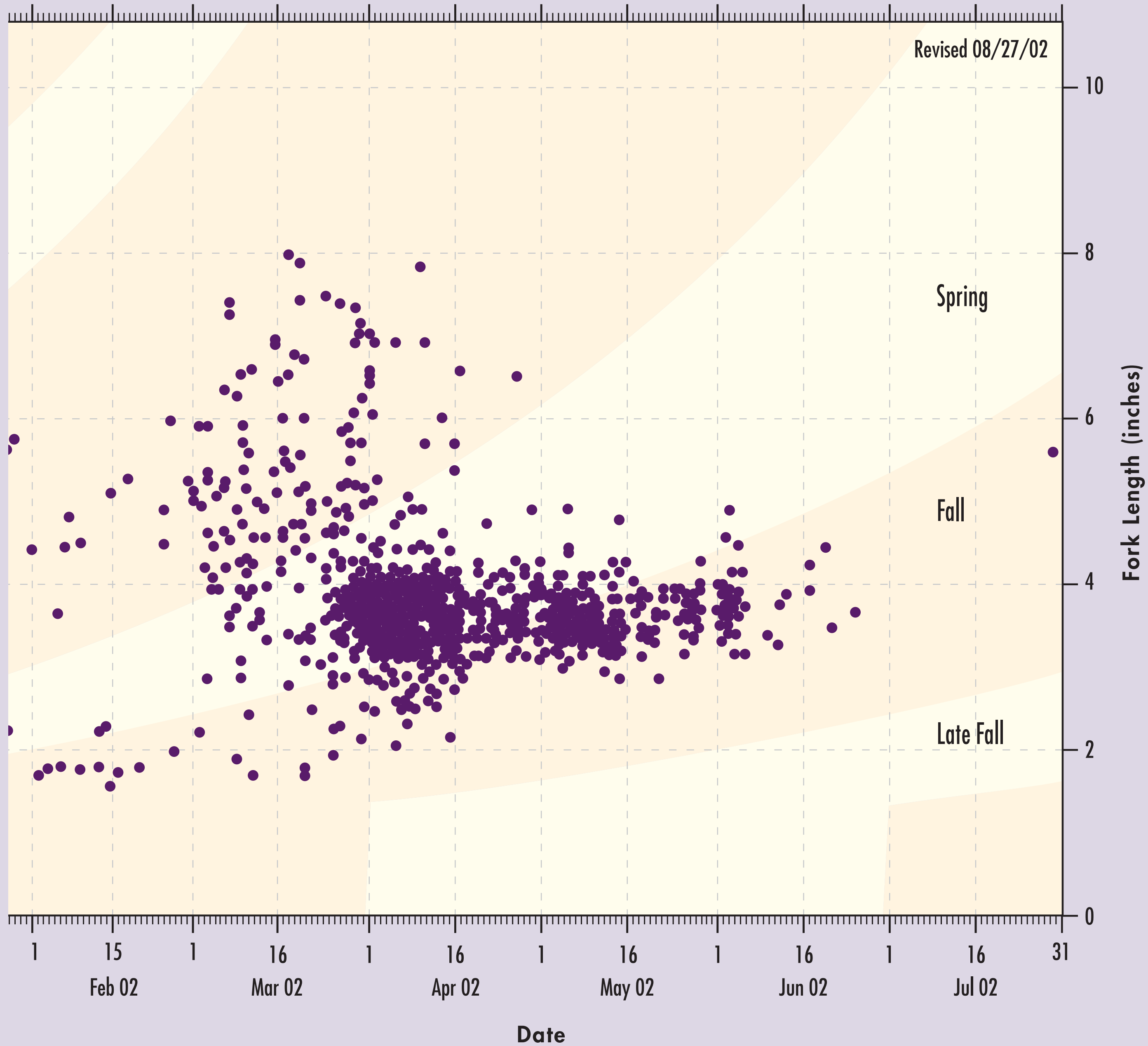
The variability in survival (recovery rates) at any one flow or flow/export with the HORB makes any preliminary conclusions uncertain based on VAMP results to date. Measuring survival within the narrow ranges of flow and export targets within the VAMP design further limits our ability to detect significant differences between targets.

Future studies should prioritize, to the extent possible, flows of 7000 cfs and exports of 1500 cfs to achieve the highest target ratio (4.7) within the VAMP design to better enable us to determine the role of flow and export on salmon smolt survival. It is recommended that these conditions be tested as soon as possible to determine if VAMP should continue or if the study design needs to be changed. It is uncertain how such a condition can be prescribed independently of the hydrology within the existing San Joaquin River Agreement, but the idea should be explored by the VAMP Management Team. Also continued assessment of past data is recommended such that other methodologies or criteria for determining statistical differences between groups may be developed.

FIGURE 5–19

Observed Chinook Salvage at the SWP & CVP Delta Fish Facilities 8/01/01 through 7/31/02.




Revised 08/27/02
Spring
Fall
Late Fall
Fork Length (inches)
0
2
4
6
8
10
1
15
1
16
1
16
1
16
1
16
1
16
31
Feb 02
Mar 02
Apr 02
May 02
Jun 02
Jul 02
Date

CHAPTER 6 | COMPLIMENTARY STUDIES RELATED TO THE VAMP

During the 2002 VAMP period several studies were performed that were considered to be complimentary and are summarized below for the reader. The studies included (1) Survival Estimates for CWT Releases Made in the San Joaquin Tributaries; (2) Radio-Tagged Juvenile Chinook Salmon Release Studies; (3) Striped Bass Predation Monitoring; and (4) the Mokelumne River Juvenile Chinook Salmon Survival Study.

SURVIVAL ESTIMATES FOR CWT RELEASES MADE IN THE SAN JOAQUIN TRIBUTARIES

CWT salmon releases were made in the San Joaquin River tributaries between March 31 and May 4 as part of independent (complimentary) fishery investigations. Releases were made in the upper Merced River (Merced River Fish Facility) and lower Merced River (Hatfield State Park), upper Tuolumne River (La Grange) and on the mainstem San Joaquin River just downstream of the confluence with the Tuolumne River (Old Fisherman's Club). Groups of CWT salmon were also released in the upper (Knights Ferry) and lower (Two Rivers) Stanislaus River.

Group survival indices for salmon released in the tributaries and recovered at Antioch ranged between 0.002 and 0.04 (Appendix C-5). Group survival indices ranged between 0.005 and 0.05 to Chipps Island (Appendix C-5). These indices were much lower than in 2001, where indices ranged from 0.03 to 0.20. These indices include both the survival upstream as well as through the delta. Vernalis flows were lower in 2002 (3,300 cfs vs. 4,200 cfs). The tributary flows were also likely lower.

Comparison of survival indices of the upstream groups relative to the downstream groups provides an index of survival through the tributaries. The survival estimates through the tributaries are provided in Appendix C-5. Survival through the Merced River ranged between 0.0 and 0.11. Again, survival through the tributaries was greater in 2001, with estimates through the Merced River ranging between 0.17 and 0.52. Survival through the Tuolumne Rivers was higher, with upstream release recoveries at Antioch greater than the downstream releases. Using Chipps Island recovery information survival ranged from 0.47 to 0.84 in 2002. In 2001 survival through the Tuolumne River was 0.20. Recoveries from the upstream groups were higher than the downstream group at both Antioch and Chipps Island for releases made on the Stanislaus River in 2002. No recoveries were made from either the upstream or downstream groups on the Stanislaus in 2001.

Survival through the Merced appeared low in 2002, while it appeared higher on the Tuolumne and Stanislaus Rivers in 2002 than in 2001. Recovery numbers from these groups are small and the inherent variability associated with the probability of capture may be the reason estimates are greater than 1.0.

Information on the transit time between release and recovery of the CWT groups released in the San Joaquin River mainstem and tributaries at both Antioch and Chipps Island is summarized in Appendix C-6. As observed for VAMP releases, recovery times were generally similar between Antioch and Chipps Island for the various groups released upstream in the mainstem San Joaquin and tributaries.

RADIO TAGGING STUDIES IN THE LOWER SAN JOAQUIN RIVER

(Contributed by Dave Vogel, Natural Resource Scientists, Inc.)

During April 2002, Natural Resource Scientists, Inc. released and monitored radio-tagged juvenile Chinook salmon in the lower San Joaquin River. Field data collection for this project was designed to acquire information on specific behavior (movements) as juvenile Chinook salmon migrated through delta channels just prior to and during VAMP implementation. The study expanded upon the techniques NRS developed in prior studies on juvenile salmon using radio telemetry, including recent studies at the Delta Cross Channel, north Delta, and south Delta.

Juvenile Chinook salmon with surgically-implanted miniature (1 gram) radio transmitters were released in the San Joaquin River near Fourteen-Mile Slough (downstream of Stockton). Twelve to 14 radio-tagged salmon were released on each of the following dates: April 2, April 10 (pre-VAMP), and April 16, and April 23 (during VAMP). The radio-tagged fish were tracked for 3-4 days after release using mobile receivers on two inboard jet boats. Individual fish movements, migration rates, and behavior in response to tidal cycles and flow splits in Delta channels were important parameters assessed from field observations. In particular, the project was intended to evaluate what occurs during the telemetered salmon migration past the flow splits at Turner Cut, Columbia Cut, and lower Middle and

FIGURE 6–1

Locations of Radio-Tagged Juvenile Salmon Released on April 2, 2002.

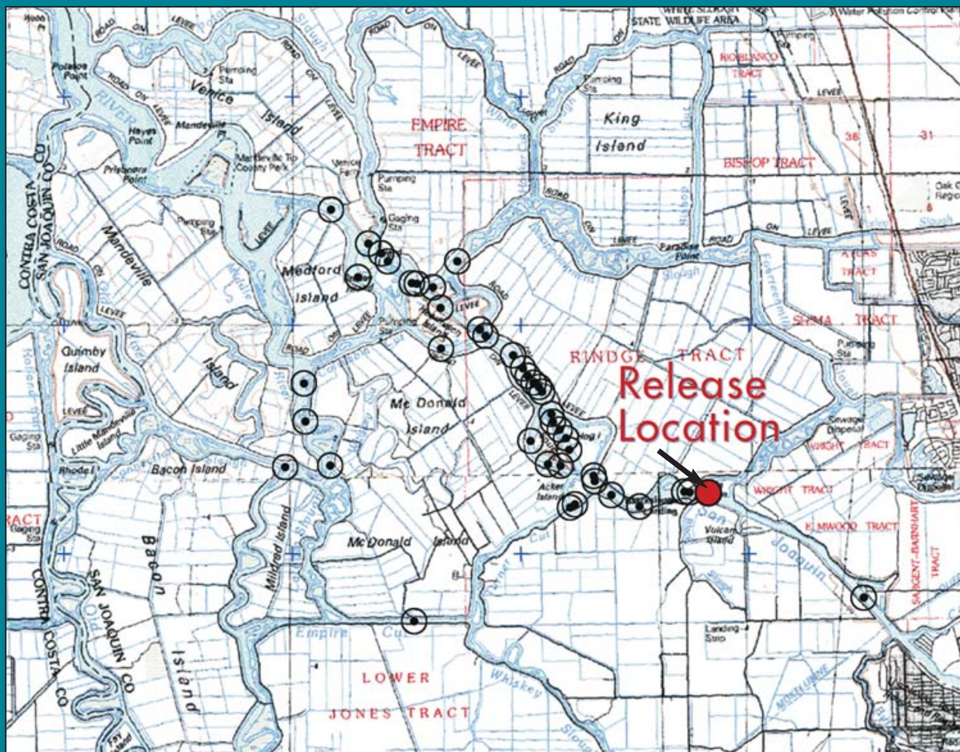
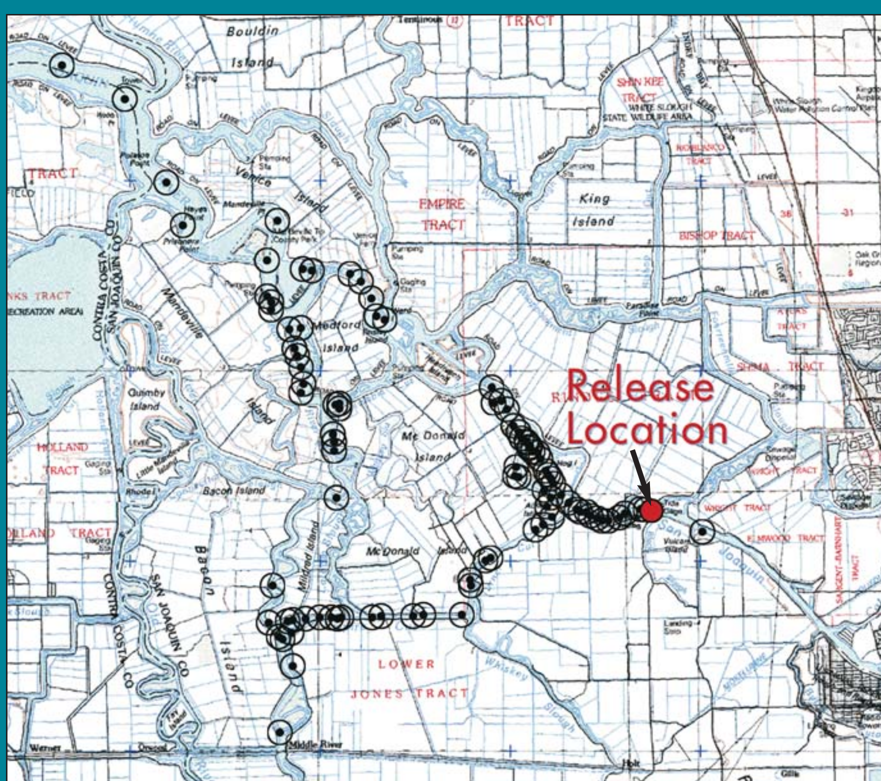


FIGURE 6–2

Locations of Radio-Tagged Juvenile Salmon Released on April 10, 2002.



Old rivers. Each time a radio-tagged fish was located, the exact position (via GPS), time, and any relevant biological and behavioral observations were recorded. Figures 6-1, 6-2, 6-3, and 6-4 show preliminary data on locations of radio-tagged juvenile Chinook salmon released and tracked in the Delta during the four weeks of experiments.

A report on this project will be completed after receipt of DWR tidal flow data measured in the San Joaquin River near Rough and Ready Island.

STRIPED BASS PREDATION MONITORING PROGRAM

(Contributed by Heather McIntire, California Department of Fish and Game)

In early March, EPA (Bruce Herbold) suggested USFWS and DFG coordinate the Striped Bass Predation Monitoring Program with the VAMP smolt release at Mossdale and Durham Ferry. The Striped Bass Predation Monitoring Program is a requirement of DFG's Striped Bass Management Program's ESA Conservation Plan. Based on previous scheduling, DFG collected striped bass at the HORB on April 3, 16, and 25. Salmon releases at Mossdale occurred on the April 19 and 26. Because the smolt release schedules were not confirmed until the day before releases, DFG was unable to coordinate a boat operator and crew to sample immediately during the releases.

DFG sampled striped bass by gillnet and hook and line. Three days of sampling yielded 2 striped bass, 176 catfish, 1 bluegill and 1 black crappie. The stomachs of both striped bass were flushed by gastric lavage and one was sacrificed after lavage to confirm the stomach was empty. Neither fish had any remains in the stomach.

Fishing upstream of the Mossdale bridge on April 16 and 25, yielded a total of 5 striped bass which had empty stomachs based on gastric lavage and dissection. Three of these 5 fish were sacrificed to confirm stomach contents.

MOKELUMNE RIVER JUVENILE CHINOOK SALMON SURVIVAL STUDIES

The East Bay Municipal Utility District (EBMUD) conducted a series of juvenile Chinook salmon survival studies in the lower Mokelumne River during spring 2002 that complement VAMP investigations. Juvenile Chinook salmon from the Mokelumne River Fish Hatchery were coded-wire tagged (CWT) for use in these tests. The experimental design included release of CWT salmon into the north fork Mokelumne River (approximately 52,000-54,000 CWT salmon in each release group), the south fork Mokelumne River at New Hope Landing (approximately 103,000 CWT salmon in each release), and a downstream control release at Jersey Point (approximately 51,000–52,000 CWT salmon in each release). Releases were made prior to the 2002 VAMP test period (releases were made on April 4 into the north fork and south fork of the Mokelumne River and April 11 at Jersey Point) and during the VAMP test period (releases were made April 18 into the north fork and south fork Mokelumne River and April 23 at Jersey Point). CWT Chinook salmon were subsequently recovered in fishery sampling at Antioch and Chipps Island, in addition to recoveries in SWP and CVP salvage operations. Hydrologic conditions prior to and during the VAMP test period, including San Joaquin River flows and SWP and CVP export rates, are discussed in Section 2.

CWT CHINOOK salmon were subsequently recovered in fishery sampling at Antioch and Chipps Island, in addition to recoveries in SWP and CVP salvage operations.

FIGURE 6–3

Locations of Radio-Tagged Juvenile Salmon Released on April 16, 2002.

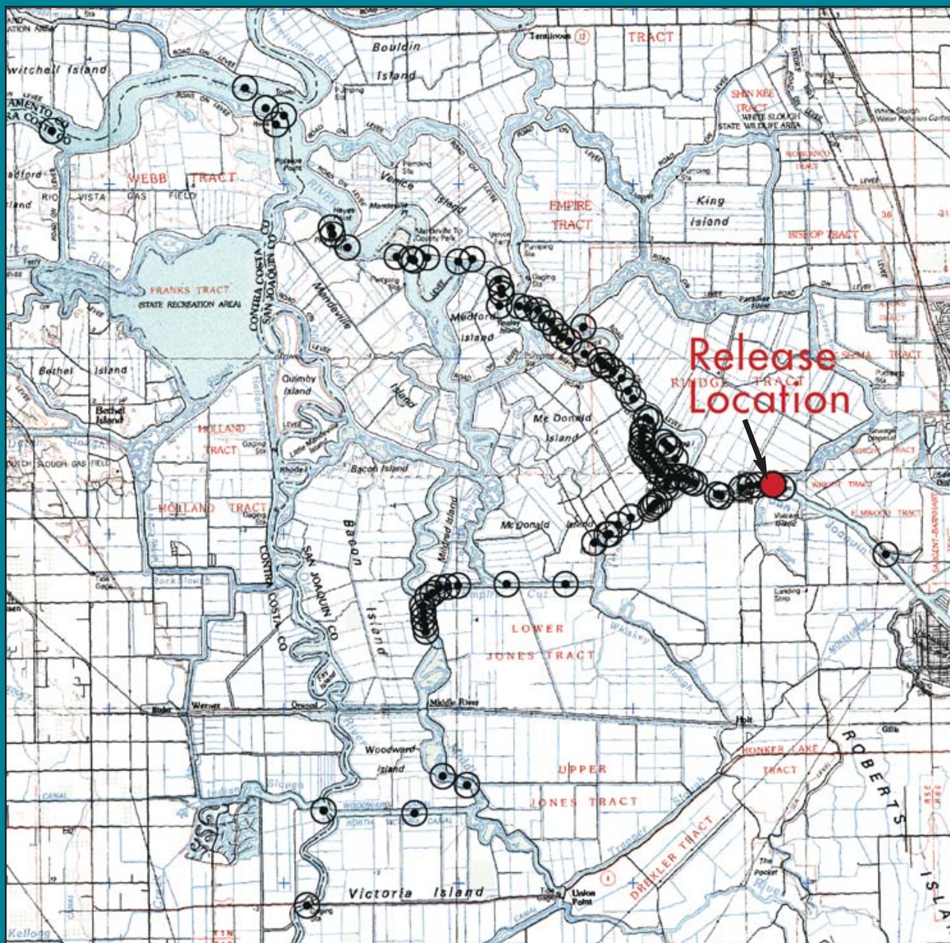
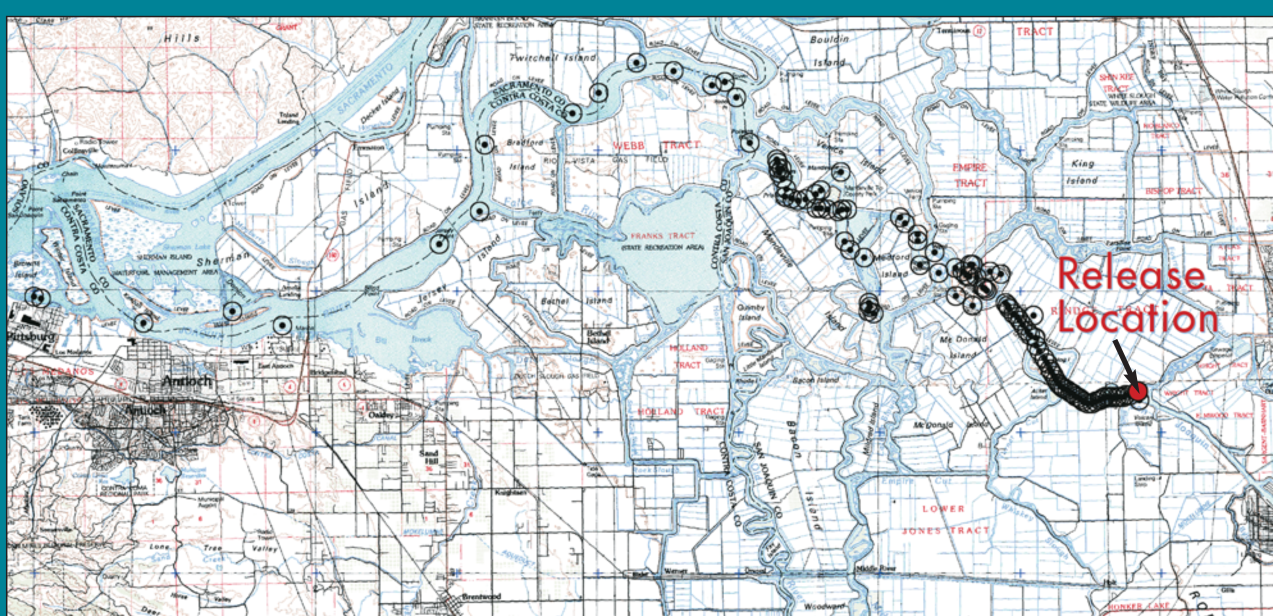


FIGURE 6–4

Locations of Radio-Tagged Juvenile Salmon Released on April 23, 2002.



As part of the Chinook salmon survival studies, EBMUD monitored water temperatures within the Mokelumne River Fish Hatchery, north fork Mokelumne River, south fork Mokelumne River at New Hope Landing, and Jersey Point. Results of water temperature monitoring within the Mokelumne River Hatchery showed that water temperatures typically ranged from approximately 11-13 C (52-55 F) within the raceways prior to release of the CWT Chinook salmon. Water temperatures within the north fork Mokelumne River ranged from approximately 16-19 C (61-66 F) which were similar to water temperatures observed in the south fork Mokelumne River during both the first and second sets of releases. Water temperature observed during the period of these salmon survival studies was within the range considered to be suitable for juvenile emigrating Chinook salmon.

Results of recaptures of CWT Chinook salmon at Chipps Island released prior to the VAMP test period showed that the absolute estimate of survival (based upon the ratio of survival indices calculated for each north and south fork Mokelumne River release group and adjusted for sampling effort, and the downstream Jersey Point control) of juvenile salmon released in the south fork Mokelumne River (survival rate equals 0.10) was greater than the survival rate for fish released into the north fork Mokelumne River (survival rate equals 0.03). In contrast, survival rates for Chinook salmon released during the pre-VAMP period and recaptured at Antioch showed higher survival from the north fork Mokelumne river (survival rate equals 0.27) than observed for salmon from the south fork Mokelumne River (survival rate 0.15). Factors contributing to the contradictory survival results for the pre-VAMP period between recaptures at Antioch and Chipps Island could not be determined from results of the 2002 tests.

For those CWT juvenile Chinook salmon released during the VAMP period and recaptured at Chipps Island, absolute survival rates were comparable between the north fork (survival rate equals 0.11) and south fork Mokelumne River (survival rate equals 0.12). Survival rates during the VAMP period for recaptures at Antioch were similar to results based on recaptures at Chipps Island.

Results of these complimentary survival studies provide insight into the survival of juvenile Chinook salmon emigrating from the lower Mokelumne River through the Delta and the potential effects of changes in San Joaquin River flow and SWP/CVP export rates may have on juvenile Chinook salmon survival.

Results of these complimentary survival studies provide insight into the survival of juvenile Chinook salmon emigrating from the lower MOKELUMNE RIVER...

CHAPTER 7 | CONCLUSIONS AND RECOMMENDATIONS

The 2002 VAMP experimental investigation of juvenile Chinook salmon survival, implemented during spring 2002, represents the third year under the SWRCB D-1641. The Vernalis target flow was 3200 cfs, with SWP and CVP export flow of 1500 cfs. The HORB was successfully installed and maintained throughout the VAMP test period. Estimates of juvenile Chinook salmon smolt survival were calculated based upon releases of CWT juvenile salmon produced in the Merced River Hatchery and released at Durham Ferry, Mossdale, and Jersey Point.

Marked salmon were subsequently recaptured in sampling at the HORB, SWP and CVP export facility salvage, and through intensive fishery sampling at Antioch and Chipps Island. Based upon the data and experience gained during the VAMP 2002 investigations, conclusions and recommendations have been developed, as summarized in Table 7-1. The conclusions and recommendations include both technical and policy/management issues that will affect the design and implementation of VAMP 2003 operations and investigations.

TABLE 7–1

Summary of VAMP 2002 Conclusions and Recommendations

CONCLUSIONS	RECOMMENDATIONS
Real-time flow data at Vernalis were improved by weekly flow measurements. 2002 funding provided by CALFED grant.	Continue weekly flow measurements. Investigate alternative flow measurement methods and/or locations. Obtain additional funding for USGS weekly Vernalis gage verification.
Estimation of ungaged flows (accretions, depletions) at Vernalis was improved.	Continue hydrology investigation to improve predictions of ungaged flows.
Disagreement over forecasting New Melones releases impacted planning for tributary flows and related operations.	Hydrology and/or management committee should resolve forecasting issues prior to 2003 VAMP and a set of written procedures for operational planning within each tributary should be established.
Coordination with upstream tributary operations was successful.	Continue coordination among tributary operators.
Maintenance frequency of the HORB was increased.	Continue frequent maintenance of HORB culverts.
HORB construction continued after barrier closure causing debris (rock) problems for fishery sampling after closure of HORB.	Delay CWT releases for five days after HORB closure to allow time for gravel to be flushed from the culverts.
Operation of the HORB was successful in maintaining south delta water levels.	Continue to refine operational criteria for culverts.
Closure of HORB is dependent on completion of other barriers. Construction of multiple barriers in south delta channels may delay HORB closure.	Schedule construction to avoid delay in HORB installation and closure.
An estimate of the flow through HORB culverts needs to be taken so that a continuous record of flow through the culverts can be reported.	Take flow measurements within each culvert and/or install water stage recorders upstream and downstream of the barrier.
HORB did not cause seepage impacts on upper Roberts Island.	Continue seepage monitoring.

CONCLUSIONS CONTINUED	RECOMMENDATIONS CONTINUED
The use of fyke nets was successful in collecting entrained fish at the culverts.	Continue monitoring culverts using fyke nets to document fish entrainment.
A larger number of CWT salmon than expected were collected at HORB.	Increase effort and budget for CWT processing.
The index of salmon entrainment at HORB was substantially higher in 2002 compared to 2001.	Continue barrier monitoring and analysis of factors affecting entrainment.
2002 studies were successful in determining salmon entrainment at HORB culverts, but did not estimate mortality associated with HORB.	Evaluate methods to estimate mortality associated with HORB
CWT loss rate remained similar to 2001 at a rate of about 9.5 percent with a range between 0.5 and 15.0 percent.	Continue CWT quality control to improve retention rates.
The release at Durham Ferry was improved by having the diversion pump at the site curtail operation.	Continue to curtail diversion pump operations during releases – coordinate release schedule with landowner.
Water temperatures were suitable during both sets of releases.	Avoid seasonal delays in barrier installation and survival testing to allow releases when most suitable water temperatures.
Results of net pen studies showed high survival of test fish.	Continue net pen studies and fish health inspections.
Physiological studies provided useful information on fish health and condition and indicated all test fish were healthy.	Re-evaluate physiological tests and modify protocol prior to 2003 VAMP to document fish health and condition within hatchery and at time of release.
Using current statistical methods, differences in survival rates among flows and export rates tested in 2000, 2001, and 2002 were not found to be statistically significant.	Continue to evaluate alternative statistical methods to assess differences in survival rates between release locations, flows, and export conditions.
Differences in survival from Durham Ferry in 2002 were not significantly different from 2000 or 2001. It appears greater differences in flow and export rate may be needed to detect differences in survival.	Conduct survival testing at VAMP flow and export extremes when water is available to do so. Recommend testing at 7,000 cfs flow and 1,500 cfs exports to determine survival under higher flow:export ratio.
San Joaquin River flow downstream of HORB is important to evaluating salmon survival.	Measure the flow in the San Joaquin River downstream of head of Old River.
Complimentary studies to evaluate mechanisms affecting survival of fish from tributaries and across the Delta were conducted .	Encourage an expansion of complementary studies to provide additional information on factors and mechanisms affecting salmon survival.
Relatively few CWT salmon from VAMP releases were recovered at the SWP and CVP salvage facilities.	Continue salvage monitoring to document direct losses at SWP/CVP export facilities.
Estimates of salmon survival rates under flow and export conditions tested in 2000, 2001, and 2002 have not been found to be significantly different. The VAMP program provides improved protection for juvenile salmon when compared to "pre-VAMP" conditions.	Continue VAMP test program. Further tests, over a wider range of flow and export conditions, are needed to evaluate the respective roles of San Joaquin River flow and SWP/CVP exports on juvenile Chinook salmon smolt survival.

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SIGNATORIES TO THE SAN JOAQUIN RIVER AGREEMENT

U.S. BUREAU OF RECLAMATION

U.S. FISH AND WILDLIFE SERVICE

CALIFORNIA DEPARTMENT OF WATER RESOURCES

CALIFORNIA DEPARTMENT OF FISH AND GAME

OAKDALE IRRIGATION DISTRICT*

SOUTH SAN JOAQUIN IRRIGATION DISTRICT*

MODESTO IRRIGATION DISTRICT*

TURLOCK IRRIGATION DISTRICT*

MERCED IRRIGATION DISTRICT*

SAN JOAQUIN RIVER EXCHANGE CONTRACTORS WATER AUTHORITY*

- *Central California Irrigation District*
- *Firebaugh Canal Water District*
- *Columbia Canal Company*
- *San Luis Canal Company*

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www.sjrg.org/agreement.htm

Page 3 — **SWRCB Decision 1641**
www.waterrights.ca.gov/hearings/Decisions.htm

Page 4 — **VAMP 2001 Annual Technical Report**
www.sjrg.org/technicalreport/2001_tech_report.htm

Page 8 — **VAMP Experimental Design**
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DFG - Bay Delta
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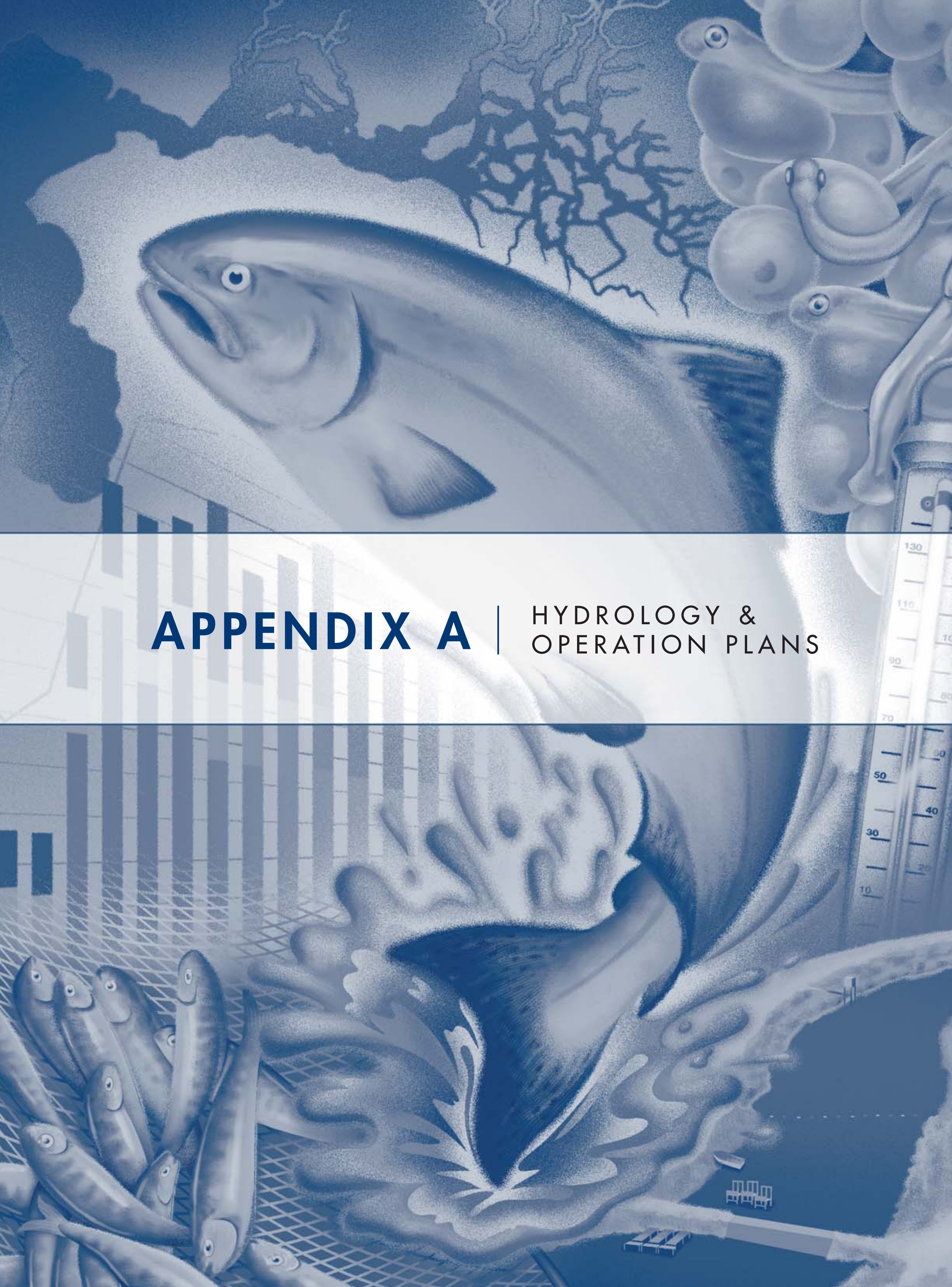


APPENDIX A | HYDROLOGY & OPERATION PLANS

DAILY OPERATION PLAN, MARCH 13, 2002

Pulse Period: April 15–May 15 • Flow Target: 3,200cfs

Ungaged Flow at Vernalis = 400cfs • (A) Dry~90% Exceedence

	San Joaquin River near Vernalis							Merced River at Cressey			Exchange Contractors	Tuolumne River at LaGrange				Stanislaus River below Goodwin				
	Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	Cum. VAMP Suppl. Flow	VAMP Flow	SJR above Merced R. (2-day lag)	Ungaged Flow above Vernalis	Existing Flow	VAMP Suppl. Flow	VAMP Flow (3-day lag)	VAMP Suppl. Flow (3-day lag)	Desired FERC Pulse	Existing Flow – Adjusted FERC Pulse	VAMP Suppl. Flow	VAMP Flow (2-day lag)	Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	VAMP Flow (2-day lag)	Maintain Priority Flow Level M=Merced T=Tuol.
	(cfs)	(cfs)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	
	[calc]	[calc]		[calc]	[calc]					[calc]					[calc]				[calc]	
Apr 01						290	400	250		250		150	150		150	637			637	
Apr 02						286	400	250		250		150	150		150	637			637	
Apr 03						283	400	250		250		150	150		150	637			637	
Apr 04	1,723				1,723	280	400	250		250		150	150		150	637			637	
Apr 05	1,720				1,720	276	400	250		250		150	150		150	637			637	
Apr 06	1,717				1,717	273	400	250		250		150	150		150	637			637	
Apr 07	1,713				1,713	270	400	250		250		150	150		150	637			637	
Apr 08	1,710				1,710	267	400	250		250		150	150		150	637			637	
Apr 09	1,707				1,707	263	400	250		250		150	150		150	637			637	
Apr 10	1,704				1,704	260	400	250		250		150	150		150	637			637	
Apr 11	1,700				1,700	257	400	250	250	500		150	150		150	637			637	
Apr 12	1,697				1,697	253	400	250	750	1,000		150	150		150	637			637	
Apr 13	1,694	0			1,694	250	400	250	800	1,050		650	650	0	650	637	225	0	862	
Apr 14	1,690	250			1,940	247	400	250	800	1,050		650	650	0	650	637	225	0	862	
Apr 15	2,187	975	0	1.93	3,162	243	400	250	800	1,050		650	650	0	650	637	225	0	862	
Apr 16	2,184	1,025	0	3.97	3,209	240	400	250	805	1,055		650	650	0	650	637	225	0	862	
Apr 17	2,180	1,025	0	6.00	3,205	237	400	250	810	1,060		650	650	0	650	637	225	0	862	
Apr 18	2,177	1,025	0	8.03	3,202	234	400	250	810	1,060		650	650	0	650	637	225	0	862	
Apr 19	2,174	1,030	0	10.08	3,204	230	400	250	815	1,065		650	650	0	650	637	225	0	862	
Apr 20	2,171	1,035	0	12.13	3,206	227	400	250	815	1,065		650	650	0	650	637	225	0	862	
Apr 21	2,167	1,035	0	14.18	3,202	224	400	250	820	1,070		650	650	0	650	637	225	0	862	
Apr 22	2,164	1,040	0	16.24	3,204	220	400	250	590	840		650	650	0	650	637	225	0	862	
Apr 23	2,161	1,040	0	18.31	3,201	217	400	250	190	440		650	650	240	890	637	225	0	862	
Apr 24	2,157	1,045	0	20.38	3,202	214	400	250	190	440		650	650	650	1,300	637	225	0	862	
Apr 25	2,154	1,055	0	22.47	3,209	210	400	250	195	445		650	650	650	1,300	637	225	0	862	
Apr 26	2,151	1,065	0	24.59	3,216	207	400	250	200	450		650	650	650	1,300	637	225	0	862	
Apr 27	2,147	1,065	0	26.70	3,212	204	400	250	200	450		650	650	650	1,300	637	225	0	862	
Apr 28	2,144	1,070	0	28.82	3,214	201	400	250	200	450		650	650	650	1,300	637	225	0	862	
Apr 29	2,141	1,075	0	30.95	3,216	197	400	250	200	450		650	650	650	1,300	637	225	0	862	
Apr 30	2,138	1,075	0	33.08	3,213	194	400	250	600	850		650	650	650	1,300	637	225	0	862	
May 01	2,134	1,075	0	35.22	3,209	191	400	250	860	1,110		650	650	250	900	677	185	0	862	
May 02	2,131	1,075	0	37.35	3,206	187	400	250	860	1,110		650	650	0	650	677	185	0	862	
May 03	2,168	1,035	0	39.40	3,203	184	400	250	860	1,110		650	650	0	650	677	185	0	862	
May 04	2,164	1,045	0	41.47	3,209	181	400	250	865	1,115		650	650	0	650	677	185	0	862	
May 05	2,161	1,045	0	43.55	3,206	177	400	250	870	1,120		650	650	0	650	677	185	0	862	
May 06	2,158	1,045	0	45.62	3,203	174	400	250	875	1,125		650	650	0	650	677	185	0	862	
May 07	2,154	1,050	0	47.70	3,204	171	400	250	875	1,125		650	650	0	650	677	185	0	862	
May 08	2,151	1,055	0	49.80	3,206	168	400	250	880	1,130		650	650	0	650	677	185	0	862	
May 09	2,148	1,060	0	51.90	3,208	164	400	250	880	1,130		650	650	0	650	677	185	0	862	
May 10	2,145	1,060	0	54.00	3,205	161	400	250	880	1,130		650	650	0	650	677	185	0	862	
May 11	2,141	1,065	0	56.11	3,206	158	400	250	880	1,130		650	650	0	650	677	185	0	862	
May 12	2,138	1,065	0	58.22	3,203	154	400	250	750	1,000		650	650	0	650	677	185	0	862	
May 13	2,135	1,065	0	60.34	3,200	151	400	250	250	500		650	650	0	650	677	185	0	862	
May 14	2,131	1,065	0	62.45	3,196	148	400	250		250		400	400		400	677			677	
May 15	2,128	935	0	64.30	3,063	144	400	250		250		250	250		250	677			677	
May 16	1,875	250			2,125	141	400	250		250		175	175		175	677			677	
May 17	1,721	0			1,721	138	400	250		250		175	175		175	677			677	
May 18	1,643	0			1,643	135	400	250		250		175	175		175	677			677	
May 19	1,640	0			1,640	131	400	250		250		175	175		175	677			677	
May 20	1,637	0			1,637	128	400	250		250		175	175		175	677			677	
May 21	1,633	0			1,633	125	400	250		250		175	175		175	677			677	
May 22	1,630	0			1,630	121	400	250		250		175	175		175	677			677	
May 23	1,627	0			1,627	118	400	250		250		175	175		175	677			677	
May 24	1,623	0			1,623	115	400	250		250		175	175		175	677			677	
May 25	1,620	0			1,620	111	400	250		250		175	175		175	677			677	
May 26	1,617	0			1,617	108	400	250		250		175	175		175	677			677	
May 27	1,613	0			1,613	105	400	250		250		175	175		175	677			677	
May 28	1,610	0			1,610	102	400	250		250		175	175		175	677			677	
May 29	1,607	0			1,607	98	400	250		250		175	175		175	677			677	
May 30	1,604	0			1,604	95	400	250		250		175	175		175	677			677	
May 31	1,600	0			1,600	92	400	250		250		140	140		140	677			677	
	VAMP period																			
Mean (cfs):	2,154	1,046			3,200	201	400	250	675	925		650	650	163	813	654	208	0	862	
Suppl. Water (TAF)		64.30							41.50		0.00			10.00			12.80	0.00		

Pulse flow period

Period of desired flow stability

DAILY OPERATION PLAN, MARCH 13, 2002

Pulse Period: April 15–May 15 • Flow Target: 3,200cfs

Ungaged Flow at Vernalis = 800cfs • (B) AVG~50% Exceedence

San Joaquin River near Vernalis							Merced River at Cressey			Exchange Contractors	Tuolumne River at LaGrange				Stanislaus River below Goodwin					
Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	Cum. VAMP Suppl. Flow	VAMP Flow	SJR above Merced R. (2-day lag)	Ungaged Flow above Vernalis	Existing Flow	VAMP Suppl. Flow	VAMP Flow (3-day lag)	VAMP Suppl. Flow (3-day lag)	Desired FERC Pulse	Existing Flow – Adjusted FERC Pulse	VAMP Suppl. Flow	VAMP Flow (2-day lag)	Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	VAMP Flow (2-day lag)	Maintain Priority Flow Level M=Merced T=Tuol.	
(cfs)	(cfs)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)		
[calc]	[calc]		[calc]	[calc]					[calc]					[calc]				[calc]		
					548	800	250		250		150	150		150	685			685		Apr 01
					544	800	250		250		150	150		150	685			685		Apr 02
					540	800	250		250		150	150		150	685			685		Apr 03
2,429				2,429	536	800	250		250		150	150		150	685			685		Apr 04
2,425				2,425	532	800	250		250		150	150		150	685			685		Apr 05
2,421				2,421	528	800	250		250		150	150		150	685			685		Apr 06
2,417				2,417	524	800	250		250		150	150		150	685			685		Apr 07
2,413				2,413	520	800	250		250		150	150		150	685			685		Apr 08
2,409				2,409	516	800	250		250		150	150		150	685			685		Apr 09
2,405				2,405	512	800	250		250		150	150		150	685			685		Apr 10
2,401				2,401	508	800	250		250		150	150		150	685			685		Apr 11
2,397				2,397	504	800	250	250	500		150	150		150	685			685		Apr 12
2,393	0			2,393	500	800	250	300	550		845	680	0	680	685		0	685		Apr 13
2,389	0			2,389	496	800	250	300	550		845	680	0	680	685	0	0	685		Apr 14
2,915	250	0	0.50	3,165	491	800	250	300	550		845	680	0	680	685	0	0	685		Apr 15
2,911	300	0	1.09	3,211	487	800	250	300	550		845	680	0	680	685	0	0	685		Apr 16
2,906	300	0	1.69	3,206	483	800	250	300	550		845	680	0	680	685	0	0	685		Apr 17
2,902	300	0	2.28	3,202	478	800	250	60	310		845	680	0	680	685	0	0	685		Apr 18
2,898	300	0	2.88	3,198	474	800	250	60	310		845	680	0	680	955	0	0	955		Apr 19
2,893	300	0	3.47	3,193	469	800	250	60	310		845	680	0	680	955	0	0	955		Apr 20
3,159	60	0	3.59	3,219	465	800	250	50	300		845	680	0	680	955	0	0	955		Apr 21
3,154	60	0	3.71	3,214	461	800	250	50	300		845	680	0	680	955	0	0	955		Apr 22
3,150	60	0	3.83	3,210	456	800	250	45	295		845	680	0	680	955	0	0	955		Apr 23
3,146	50	0	3.93	3,196	452	800	250	0	250		845	690	0	690	955	0	0	955		Apr 24
3,141	50	0	4.03	3,191	448	800	250	0	250		845	1,300	0	1,300	415	0	0	415		Apr 25
3,147	45	0	4.12	3,192	443	800	250	0	250		845	1,300	0	1,300	415	0	0	415		Apr 26
3,213	0	0	4.12	3,213	439	800	250	0	250		845	1,300	0	1,300	415	0	0	415		Apr 27
3,208	0	0	4.12	3,208	435	800	250	0	250		845	1,300	0	1,300	415	0	0	415		Apr 28
3,204	0	0	4.12	3,204	430	800	250	0	250		845	1,300	0	1,300	415	0	0	415		Apr 29
3,200	0	0	4.12	3,200	426	800	250	0	250		845	1,300	0	1,300	415	0	0	415		Apr 30
3,195	0	0	4.12	3,195	421	800	250	0	250		845	800	0	800	954	0	0	954		May 01
3,191	0	0	4.12	3,191	417	800	250	0	250		845	800	0	800	954	0	0	954		May 02
3,225	0	0	4.12	3,225	413	800	250	0	250		845	800	0	800	954	0	0	954		May 03
3,221	0	0	4.12	3,221	408	800	250	0	250		845	800	0	800	954	0	0	954		May 04
3,217	0	0	4.12	3,217	404	800	250	0	250		845	800	0	800	954	0	0	954		May 05
3,212	0	0	4.12	3,212	400	800	250	0	250		845	800	0	800	954	0	0	954		May 06
3,208	0	0	4.12	3,208	395	800	250	0	250		845	800	0	800	954	0	0	954		May 07
3,204	0	0	4.12	3,204	391	800	250	0	250		845	800	0	800	954	0	0	954		May 08
3,199	0	0	4.12	3,199	386	800	250	0	250		845	800	0	800	954	0	0	954		May 09
3,195	0	0	4.12	3,195	382	800	250	0	250		845	800	0	800	954	0	0	954		May 10
3,190	0	0	4.12	3,190	378	800	250	0	250		845	800	0	800	954	0	0	954		May 11
3,186	0	0	4.12	3,186	373	800	250	0	250		845	800	0	800	954	0	0	954		May 12
3,182	0	0	4.12	3,182	369	800	250		250		845	800	0	800	954	0	0	954		May 13
3,177	0	0	4.12	3,177	365	800	250		250		500	450		450	954			954		May 14
3,173	0	0	4.12	3,173	361	800	250		250		350	300		300	954			954		May 15
2,819	0			2,819	357	800	250		250		250	175		175	954			954		May 16
2,665	0			2,665	353	800	250		250		175	175		175	954			954		May 17
2,536	0			2,536	349	800	250		250		175	175		175	954			954		May 18
2,532	0			2,532	345	800	250		250		175	175		175	954			954		May 19
2,528	0			2,528	341	800	250		250		175	175		175	954			954		May 20
2,524	0			2,524	337	800	250		250		175	175		175	954			954		May 21
2,520	0			2,520	333	800	250		250		175	175		175	954			954		May 22
2,516	0			2,516	329	800	250		250		175	175		175	954			954		May 23
2,512	0			2,512	325	800	250		250		175	175		175	954			954		May 24
2,508	0			2,508	321	800	250		250		175	175		175	954			954		May 25
2,504	0			2,504	317	800	250		250		175	175		175	954			954		May 26
2,500	0			2,500	313	800	250		250		175	175		175	954			954		May 27
2,496	0			2,496	309	800	250		250		175	175		175	954			954		May 28
2,492	0			2,492	305	800	250		250		175	175		175	954			954		May 29
2,488	0			2,488	301	800	250		250		175	175		175	954			954		May 30
2,484	0			2,484	297	800	250		250		140	140		140	954			954		May 31
					VAMP period															
3,133	67			3,200	435	800	250	67	317		845	851	0	851	798	0	0	798		Mean (cfs):
	4.12							4.12		0.00			0.00			0.00	0.00			Suppl. Water (TAF)

Pulse flow period

Period of desired flow stability

DAILY OPERATION PLAN, MARCH 22, 2002

Pulse Period: April 15–May 15 • Flow Target: 3,200cfs

Ungaged Flow at Vernalis = 400 cfs • (A) Low

	San Joaquin River near Vernalis							Merced River at Cressey				Tuolumne River at LaGrange				Stanislaus River below Goodwin				
	Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	Cum. VAMP Suppl. Flow	VAMP Flow	SJR above Merced R. (2-day lag)	Ungaged Flow above Vernalis	Existing Flow	MeID VAMP Suppl. Flow	Exch Contr VAMP Suppl. Flow	VAMP Flow (3-day lag)	Desired FERC Pulse	Existing Flow – Adjusted FERC Pulse	VAMP Suppl. Flow	VAMP Flow (2-day lag)	Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	VAMP Flow (2-day lag)	Maintain Priority Flow Level M=Merced T=Tuol. S=Stan.
	(cfs)	(cfs)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	
	[calc]	[calc]		[calc]	[calc]						[calc]				[calc]				[calc]	
Apr 01						290	400	250			250	150	150		150	637			637	
Apr 02						286	400	250			250	150	150		150	637			637	
Apr 03						283	400	250			250	150	150		150	637			637	
Apr 04	1,723				1,723	280	400	250			250	150	150		150	637			637	
Apr 05	1,720				1,720	276	400	250			250	150	150		150	637			637	
Apr 06	1,717				1,717	273	400	250			250	150	150		150	637			637	
Apr 07	1,713				1,713	270	400	250			250	150	150		150	637			637	
Apr 08	1,710				1,710	267	400	250			250	150	150		150	637			637	
Apr 09	1,707				1,707	263	400	250			250	150	150		150	637			637	
Apr 10	1,704				1,704	260	400	250			250	150	150		150	637			637	
Apr 11	1,700				1,700	257	400	250	50		300	150	150		150	637			637	
Apr 12	1,697				1,697	253	400	250	238	82	570	150	150		150	637			637	
Apr 13	1,694	0			1,694	250	400	250	248	82	580	945	945	0	945	637	393	0	1,030	
Apr 14	1,690	50			1,740	247	400	250	248	82	580	945	945	0	945	637	393	0	1,030	
Apr 15	2,482	713	0	1.41	3,195	243	400	250	258	82	590	945	945	0	945	637	393	0	1,030	
Apr 16	2,479	723	0	2.85	3,202	240	400	250	258	82	590	945	945	0	945	637	393	0	1,030	
Apr 17	2,475	723	0	4.28	3,198	237	400	250	268	82	600	945	945	0	945	637	393	0	1,030	
Apr 18	2,472	733	0	5.74	3,205	234	400	250	268	82	600	945	945	0	945	637	393	0	1,030	
Apr 19	2,469	733	0	7.19	3,202	230	400	250	268	82	600	945	945	0	945	637	393	0	1,030	
Apr 20	2,466	743	0	8.66	3,209	227	400	250	269	81	600	945	945	0	945	637	393	0	1,030	
Apr 21	2,462	743	0	10.14	3,205	224	400	250	269	81	600	945	945	0	945	637	393	0	1,030	
Apr 22	2,459	743	0	11.61	3,202	220	400	250	269	81	600	945	945	0	945	637	383	0	1,020	
Apr 23	2,456	743	0	13.08	3,199	217	400	250	269	81	600	945	945	0	945	637	383	0	1,020	
Apr 24	2,452	733	0	14.54	3,185	214	400	250	269	81	600	945	945	355	1,300	637	63	0	700	T
Apr 25	2,449	733	0	15.99	3,182	210	400	250	269	81	600	945	945	355	1,300	637	63	0	700	T
Apr 26	2,446	768	0	17.52	3,214	207	400	250	269	81	600	945	945	355	1,300	637	63	0	700	T, S
Apr 27	2,442	768	0	19.04	3,210	204	400	250	269	81	600	945	945	355	1,300	637	63	0	700	T, S
Apr 28	2,439	768	0	20.56	3,207	201	400	250	269	81	600	945	945	355	1,300	637	63	0	700	T, S
Apr 29	2,436	768	0	22.09	3,204	197	400	250	279	81	610	945	945	355	1,300	637	63	0	700	T, S
Apr 30	2,433	768	0	23.61	3,201	194	400	250	279	81	610	945	945	355	1,300	637	63	0	700	T, S
May 01	2,429	768	0	25.13	3,197	191	400	250	379	81	710	945	945	355	1,300	677	23	0	700	T, S
May 02	2,426	778	0	26.68	3,204	187	400	250	639	81	970	945	945	265	1,210	677	23	0	700	S
May 03	2,463	738	0	28.14	3,201	184	400	250	649	81	980	945	945	0	945	677	23	0	700	S
May 04	2,459	748	0	29.62	3,207	181	400	250	669	81	1,000	945	945	0	945	677	23	0	700	M
May 05	2,456	743	0	31.10	3,199	177	400	250	669	81	1,000	945	945	0	945	677	23	0	700	M
May 06	2,453	753	0	32.59	3,206	174	400	250	669	81	1,000	945	945	0	945	677	23	0	700	M
May 07	2,449	773	0	34.12	3,222	171	400	250	669	81	1,000	945	945	0	945	677	23	0	700	M
May 08	2,446	773	0	35.66	3,219	168	400	250	669	81	1,000	945	945	0	945	677	23	0	700	M
May 09	2,443	773	0	37.19	3,216	164	400	250	669	81	1,000	945	945	0	945	677	23	0	700	M
May 10	2,440	773	0	38.72	3,213	161	400	250	669	81	1,000	945	945	0	945	677	23	0	700	M
May 11	2,436	773	0	40.26	3,209	158	400	250	669	81	1,000	945	945	0	945	677	23	0	700	M
May 12	2,433	773	0	41.79	3,206	154	400	250	554	81	885	945	945	0	945	677	23	0	700	
May 13	2,430	773	0	43.32	3,203	151	400	250	200		450	945	945	0	945	677	23	0	700	
May 14	2,426	773	0	44.86	3,199	148	400	250			250	500	500		500	677			677	
May 15	2,423	658	0	46.16	3,081	144	400	250			250	350	350		350	677			677	
May 16	1,975	200			2,175	141	400	250			250	250	250		250	677			677	
May 17	1,821	0			1,821	138	400	250			250	175	175		175	677			677	
May 18	1,718	0			1,718	135	400	250			250	175	175		175	677			677	
May 19	1,640	0			1,640	131	400	250			250	175	175		175	677			677	
May 20	1,637	0			1,637	128	400	250			250	175	175		175	677			677	
May 21	1,633	0			1,633	125	400	250			250	175	175		175	677			677	
May 22	1,630	0			1,630	121	400	250			250	175	175		175	677			677	
May 23	1,627	0			1,627	118	400	250			250	175	175		175	677			677	
May 24	1,623	0			1,623	115	400	250			250	175	175		175	677			677	
May 25	1,620	0			1,620	111	400	250			250	175	175		175	677			677	
May 26	1,617	0			1,617	108	400	250			250	175	175		175	677			677	
May 27	1,613	0			1,613	105	400	250			250	175	175		175	677			677	
May 28	1,610	0			1,610	102	400	250			250	175	175		175	677			677	
May 29	1,607	0			1,607	98	400	250			250	175	175		175	677			677	
May 30	1,604	0			1,604	95	400	250			250	175	175		175	677			677	
May 31	1,600	0			1,600	92	400	250			250	140	140		140	677			677	
	VAMP period																			
Mean (cfs):	2,449	751			3,200	201	400	250	407	81	738	945	945	100	1,045	654	163	0	816	
Suppl. Water (TAF)	46.16							25.00	5.00				6.16			10.00	0.00			

Pulse flow period

Period of desired flow stability

DAILY OPERATION PLAN, MARCH 22, 2002

Pulse Period: April 15–May 15 • Flow Target: 3,200cfs

Ungaged Flow at Vernalis=600cfs • (B) High

San Joaquin River near Vernalis							Merced River at Cressey				Tuolumne River at LaGrange				Stanislaus River below Goodwin					
Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	Cum. VAMP Suppl. Flow	VAMP Flow	SJR above Merced R. (2-day lag)	Ungaged Flow above Vernalis	Existing Flow	MelD VAMP Suppl. Flow	Exch Contr VAMP Suppl. Flow	VAMP Flow (3-day lag)	Desired FERC Pulse	Existing Flow – Adjusted FERC Pulse	VAMP Suppl. Flow	VAMP Flow (2-day lag)	Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	VAMP Flow (2-day lag)	Maintain Priority Flow Level M=Merced T=Tuol.	
(cfs)	(cfs)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)		
[calc]	[calc]		[calc]	[calc]						[calc]				[calc]				[calc]		
					548	600	250			250	150	150		150	637			637		Apr 01
					544	600	250			250	150	150		150	637			637		Apr 02
					540	600	250			250	150	150		150	637			637		Apr 03
2,181				2,181	536	600	250			250	150	150		150	637			637		Apr 04
2,177				2,177	532	600	250			250	150	150		150	637			637		Apr 05
2,173				2,173	528	600	250			250	150	150		150	637			637		Apr 06
2,169				2,169	524	600	250			250	150	150		150	637			637		Apr 07
2,165				2,165	520	600	250			250	150	150		150	637			637		Apr 08
2,161				2,161	516	600	250			250	150	150		150	637			637		Apr 09
2,157				2,157	512	600	250			250	150	150		150	637			637		Apr 10
2,153				2,153	508	600	250	50		300	150	150		150	637			637		Apr 11
2,149				2,149	504	600	250	305	0	555	150	150		150	637			637		Apr 12
2,145	0			2,145	500	600	250	400	0	650	945	830	0	830	637		0	637		Apr 13
2,141	50			2,191	496	600	250	400	0	650	945	830	0	830	637	0	0	637		Apr 14
2,817	305	0	0.60	3,122	491	600	250	400	0	650	945	830	0	830	637	0	0	637		Apr 15
2,813	400	0	1.40	3,213	487	600	250	400	0	650	945	830	0	830	637	0	0	637		Apr 16
2,808	400	0	2.19	3,208	483	600	250	410	0	660	945	830	0	830	637	0	0	637		Apr 17
2,804	400	0	2.99	3,204	478	600	250	410	0	660	945	830	0	830	637	0	0	637		Apr 18
2,800	400	0	3.78	3,200	474	600	250	420	0	670	945	830	0	830	637	0	0	637		Apr 19
2,795	410	0	4.59	3,205	469	600	250	420	0	670	945	830	0	830	637	0	0	637		Apr 20
2,791	410	0	5.40	3,201	465	600	250	420	0	670	945	830	0	830	637	0	0	637		Apr 21
2,786	420	0	6.24	3,206	461	600	250	250	0	500	945	830	0	830	637	0	0	637		Apr 22
2,782	420	0	7.07	3,202	456	600	250	0	0	250	945	1,000	0	1,000	637	0	0	637		Apr 23
2,778	420	0	7.90	3,198	452	600	250	0	0	250	945	1,280	0	1,280	637	0	0	637	T	Apr 24
2,943	250	0	8.40	3,193	448	600	250	0	0	250	945	1,280	0	1,280	637	0	0	637	T	Apr 25
3,219	0	0	8.40	3,219	443	600	250	0	0	250	945	1,280	0	1,280	637	0	0	637	T, S	Apr 26
3,215	0	0	8.40	3,215	439	600	250	0	0	250	945	1,280	0	1,280	637	0	0	637	T, S	Apr 27
3,210	0	0	8.40	3,210	435	600	250	0	0	250	945	1,280	0	1,280	637	0	0	637	T, S	Apr 28
3,206	0	0	8.40	3,206	430	600	250	0	0	250	945	1,280	0	1,280	637	0	0	637	T, S	Apr 29
3,202	0	0	8.40	3,202	426	600	250	190	0	440	945	1,280	0	1,280	637	0	0	637	T, S	Apr 30
3,197	0	0	8.40	3,197	421	600	250	430	0	680	945	1,075	0	1,075	677	0	0	677	T, S	May 01
3,193	0	0	8.40	3,193	417	600	250	430	0	680	945	830	0	830	677	0	0	677	S	May 02
3,023	190	0	8.78	3,213	413	600	250	440	0	690	945	830	0	830	677	0	0	677	S	May 03
2,774	430	0	9.63	3,204	408	600	250	455	0	705	945	830	0	830	677	0	0	677	M	May 04
2,770	430	0	10.48	3,200	404	600	250	455	0	705	945	830	0	830	677	0	0	677	M	May 05
2,765	440	0	11.36	3,205	400	600	250	455	0	705	945	830	0	830	677	0	0	677	M	May 06
2,761	455	0	12.26	3,216	395	600	250	455	0	705	945	830	0	830	677	0	0	677	M	May 07
2,757	455	0	13.16	3,212	391	600	250	455	0	705	945	830	0	830	677	0	0	677	M	May 08
2,752	455	0	14.06	3,207	386	600	250	455	0	705	945	830	0	830	677	0	0	677	M	May 09
2,748	455	0	14.97	3,203	382	600	250	455	0	705	945	830	0	830	677	0	0	677	M	May 10
2,743	455	0	15.87	3,198	378	600	250	455	0	705	945	830	0	830	677	0	0	677	M	May 11
2,739	455	0	16.77	3,194	373	600	250	450	0	700	945	830	0	830	677	0	0	677		May 12
2,735	455	0	17.67	3,190	369	600	250	100		350	945	830	0	830	677	0	0	677		May 13
2,730	455	0	18.58	3,185	365	600	250			250	500	500		500	677			677		May 14
2,726	450	0	19.47	3,176	361	600	250			250	350	350		350	677			677		May 15
2,392	100			2,492	357	600	250			250	250	250		250	677			677		May 16
2,238	0			2,238	353	600	250			250	175	175		175	677			677		May 17
2,134	0			2,134	349	600	250			250	175	175		175	677			677		May 18
2,055	0			2,055	345	600	250			250	175	175		175	677			677		May 19
2,051	0			2,051	341	600	250			250	175	175		175	677			677		May 20
2,047	0			2,047	337	600	250			250	175	175		175	677			677		May 21
2,043	0			2,043	333	600	250			250	175	175		175	677			677		May 22
2,039	0			2,039	329	600	250			250	175	175		175	677			677		May 23
2,035	0			2,035	325	600	250			250	175	175		175	677			677		May 24
2,031	0			2,031	321	600	250			250	175	175		175	677			677		May 25
2,027	0			2,027	317	600	250			250	175	175		175	677			677		May 26
2,023	0			2,023	313	600	250			250	175	175		175	677			677		May 27
2,019	0			2,019	309	600	250			250	175	175		175	677			677		May 28
2,015	0			2,015	305	600	250			250	175	175		175	677			677		May 29
2,011	0			2,011	301	600	250			250	175	175		175	677			677		May 30
2,007	0			2,007	297	600	250			250	140	140		140	677			677		May 31
VAMP period																				
2,883	317			3,200	435	600	250	317	0	567	945	945	0	945	654	0	0	654		Mean (cfs):
	19.47							19.47	0.00				0.00			0.00	0.00			Suppl. Water (TAF)

Pulse flow period

Period of desired flow stability

DAILY OPERATION PLAN, MARCH 28, 2002

Pulse Period: April 15–May 15 • Flow Target: 3,200cfs

Ungaged Flow at Vernalis = 400cfs • (A) Low

	San Joaquin River near Vernalis							Merced River at Cressey				Tuolumne River at LaGrange				Stanislaus River below Goodwin				
	Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	Cum. VAMP Suppl. Flow	VAMP Flow	SJR above Merced R. (2-day lag)	Ungaged Flow above Vernalis	Existing Flow	MeID VAMP Suppl. Flow	Exch Contr VAMP Suppl. Flow	VAMP Flow (3-day lag)	Desired FERC Pulse	Existing Flow – Adjusted FERC Pulse	VAMP Suppl. Flow	VAMP Flow (2-day lag)	Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	VAMP Flow (2-day lag)	Maintain Priority Flow Level M=Merced T=Tuol. S=Stan.
	(cfs)	(cfs)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	
	[calc]	[calc]		[calc]	[calc]						[calc]				[calc]				[calc]	
Apr 01						290	400	250			250	150	150		150	637			637	
Apr 02						286	400	250			250	150	150		150	637			637	
Apr 03						283	400	250			250	150	150		150	637			637	
Apr 04	1,723				1,723	280	400	250			250	150	150		150	637			637	
Apr 05	1,720				1,720	276	400	250			250	150	150		150	637			637	
Apr 06	1,717				1,717	273	400	250			250	150	150		150	637			637	
Apr 07	1,713				1,713	270	400	250			250	150	150		150	637			637	
Apr 08	1,710				1,710	267	400	250			250	150	150		150	637			637	
Apr 09	1,707				1,707	263	400	250			250	150	150		150	637			637	
Apr 10	1,704				1,704	260	400	250			250	150	150		150	637			637	
Apr 11	1,700				1,700	257	400	250			250	150	150		150	637			637	
Apr 12	1,697				1,697	253	400	250	165	85	500	150	150		150	637			637	
Apr 13	1,694	0			1,694	250	400	250	190	85	525	945	760	0	760	800	480	0	1,280	
Apr 14	1,690	0			1,690	247	400	250	190	85	525	945	760	0	760	800	480	0	1,280	
Apr 15	2,460	730	0	1.45	3,190	243	400	250	190	85	525	945	760	0	760	800	480	0	1,280	
Apr 16	2,457	755	0	2.95	3,212	240	400	250	190	85	525	945	760	0	760	800	480	0	1,280	
Apr 17	2,453	755	0	4.44	3,208	237	400	250	200	85	535	945	760	0	760	800	480	0	1,280	
Apr 18	2,450	755	0	5.94	3,205	234	400	250	200	85	535	945	760	0	760	800	480	0	1,280	
Apr 19	2,447	755	0	7.44	3,202	230	400	250	200	85	535	945	760	0	760	800	480	0	1,280	
Apr 20	2,444	765	0	8.96	3,209	227	400	250	210	80	540	945	760	0	760	800	480	0	1,280	
Apr 21	2,440	765	0	10.47	3,205	224	400	250	210	80	540	945	760	0	760	800	480	0	1,280	
Apr 22	2,437	765	0	11.99	3,202	220	400	250	260	80	590	945	760	0	760	800	480	0	1,280	
Apr 23	2,434	770	0	13.52	3,204	217	400	250	260	80	590	945	970	10	980	790	240	0	1,030	
Apr 24	2,430	770	0	15.04	3,200	214	400	250	260	80	590	945	1,230	70	1,300	700	0	0	700	T
Apr 25	2,627	590	0	16.21	3,217	210	400	250	270	80	600	945	1,230	70	1,300	700	0	0	700	T
Apr 26	2,794	410	0	17.03	3,204	207	400	250	270	80	600	945	1,230	70	1,300	700	0	0	700	T, S
Apr 27	2,790	410	0	17.84	3,200	204	400	250	280	80	610	945	1,230	70	1,300	700	0	0	700	T, S
Apr 28	2,787	420	0	18.67	3,207	201	400	250	280	80	610	945	1,230	70	1,300	700	0	0	700	T, S
Apr 29	2,784	420	0	19.51	3,204	197	400	250	280	80	610	945	1,230	70	1,300	700	0	0	700	T, S
Apr 30	2,781	430	0	20.36	3,211	194	400	250	280	80	610	945	1,230	70	1,300	700	0	0	700	T, S
May 01	2,777	430	0	21.21	3,207	191	400	250	590	80	920	945	1,230	70	1,300	700	0	0	700	T, S
May 02	2,774	430	0	22.07	3,204	187	400	250	690	80	1,020	945	985	15	1,000	700	0	0	700	S
May 03	2,771	430	0	22.92	3,201	184	400	250	690	80	1,020	945	900	0	900	700	0	0	700	S
May 04	2,522	685	0	24.28	3,207	181	400	250	710	80	1,040	945	900	0	900	700	0	0	700	M
May 05	2,434	770	0	25.80	3,204	177	400	250	710	80	1,040	945	900	0	900	700	0	0	700	M
May 06	2,431	770	0	27.33	3,201	174	400	250	710	80	1,040	945	900	0	900	700	0	0	700	M
May 07	2,427	790	0	28.90	3,217	171	400	250	710	80	1,040	945	900	0	900	700	0	0	700	M
May 08	2,424	790	0	30.47	3,214	168	400	250	710	80	1,040	945	900	0	900	700	0	0	700	M
May 09	2,421	790	0	32.03	3,211	164	400	250	710	80	1,040	945	900	0	900	700	0	0	700	M
May 10	2,418	790	0	33.60	3,208	161	400	250	710	80	1,040	945	900	0	900	700	0	0	700	M
May 11	2,414	790	0	35.17	3,204	158	400	250	710	80	1,040	945	900	0	900	700	0	0	700	M
May 12	2,411	790	0	36.73	3,201	154	400	250	570	80	900	945	900	0	900	700	0	0	700	
May 13	2,408	790	0	38.30	3,198	151	400	250	200		450	945	900	0	900	700	0	0	700	
May 14	2,404	790	0	39.87	3,194	148	400	250			250	500	500		500	677			677	
May 15	2,401	650	0	41.16	3,051	144	400	250			250	350	350		350	677			677	
May 16	1,975	200			2,175	141	400	250			250	250	250		250	677			677	
May 17	1,821	0			1,821	138	400	250			250	175	175		175	677			677	
May 18	1,718	0			1,718	135	400	250			250	175	175		175	677			677	
May 19	1,640	0			1,640	131	400	250			250	175	175		175	677			677	
May 20	1,637	0			1,637	128	400	250			250	175	175		175	677			677	
May 21	1,633	0			1,633	125	400	250			250	175	175		175	677			677	
May 22	1,630	0			1,630	121	400	250			250	175	175		175	677			677	
May 23	1,627	0			1,627	118	400	250			250	175	175		175	677			677	
May 24	1,623	0			1,623	115	400	250			250	175	175		175	677			677	
May 25	1,620	0			1,620	111	400	250			250	175	175		175	677			677	
May 26	1,617	0			1,617	108	400	250			250	175	175		175	677			677	
May 27	1,613	0			1,613	105	400	250			250	175	175		175	677			677	
May 28	1,610	0			1,610	102	400	250			250	175	175		175	677			677	
May 29	1,607	0			1,607	98	400	250			250	175	175		175	677			677	
May 30	1,604	0			1,604	95	400	250			250	175	175		175	677			677	
May 31	1,600	0			1,600	92	400	250			250	140	140		140	677			677	
	VAMP period																			
Mean (cfs):	2,531	669			3,200	201	400	250	407	81	738	945	945	19	964	735	163	0	898	
Suppl. Water (TAF)		41.16							25.00	5.00				1.16			10.00	0.00		

Pulse flow period

Period of desired flow stability

DAILY OPERATION PLAN, MARCH 28, 2002

Pulse Period: April 15–May 15 • Flow Target: 4,450cfs

Ungaged Flow at Vernalis = 600cfs • (B) High

San Joaquin River near Vernalis							Merced River at Cressey				Tuolumne River at LaGrange				Stanislaus River below Goodwin					
Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	Cum. VAMP Suppl. Flow	VAMP Flow	SJR above Merced R. (2-day lag)	Ungaged Flow above Vernalis	Existing Flow	MelD VAMP Suppl. Flow	Exch Contr VAMP Suppl. Flow	VAMP Flow (3-day lag)	Desired FERC Pulse	Existing Flow – Adjusted FERC Pulse	VAMP Suppl. Flow	VAMP Flow (2-day lag)	Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	VAMP Flow (2-day lag)	Maintain Priority Flow Level M=Merced T=Tuol.	
(cfs)	(cfs)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)		
[calc]	[calc]		[calc]	[calc]						[calc]				[calc]				[calc]		
					548	600	250			250	150	150		150	685			685		Apr 01
					544	600	250			250	150	150		150	685			685		Apr 02
					540	600	250			250	150	150		150	685			685		Apr 03
2,229				2,229	536	600	250			250	150	150		150	685			685		Apr 04
2,225				2,225	532	600	250			250	150	150		150	685			685		Apr 05
2,221				2,221	528	600	250			250	150	150		150	685			685		Apr 06
2,217				2,217	524	600	250			250	150	150		150	685			685		Apr 07
2,213				2,213	520	600	250			250	150	150		150	685			685		Apr 08
2,209				2,209	516	600	250			250	150	150		150	685			685		Apr 09
2,205				2,205	512	600	250			250	150	150		150	685			685		Apr 10
2,201				2,201	508	600	250	150		400	150	150		150	685			685		Apr 11
2,197				2,197	504	600	250	465	85	800	150	150		150	685			685		Apr 12
2,193	0			2,193	500	600	250	570	85	905	945	945	15	960	1,295	205	0	1,500		Apr 13
2,189	150			2,339	496	600	250	570	85	905	945	945	15	960	1,295	205	0	1,500		Apr 14
3,590	770	0	1.53	4,360	491	600	250	570	85	905	945	945	15	960	1,295	205	0	1,500		Apr 15
3,586	875	0	3.26	4,461	487	600	250	580	85	915	945	945	15	960	1,295	205	0	1,500		Apr 16
3,581	875	0	5.00	4,456	483	600	250	580	85	915	945	945	15	960	1,295	205	0	1,500		Apr 17
3,577	875	0	6.73	4,452	478	600	250	600	85	935	945	945	15	960	1,295	205	0	1,500		Apr 18
3,573	885	0	8.49	4,458	474	600	250	600	85	935	945	945	15	960	1,295	205	0	1,500		Apr 19
3,568	885	0	10.24	4,453	469	600	250	600	80	930	945	945	15	960	1,295	205	0	1,500		Apr 20
3,564	905	0	12.04	4,469	465	600	250	420	80	750	945	945	15	960	1,295	205	0	1,500		Apr 21
3,559	905	0	13.83	4,464	461	600	250	270	80	600	945	945	200	1,145	1,295	205	0	1,500		Apr 22
3,555	900	0	15.62	4,455	456	600	250	270	80	600	945	945	355	1,300	1,295	205	0	1,500		Apr 23
3,551	905	0	17.41	4,456	452	600	250	330	80	660	945	945	355	1,300	1,295	205	0	1,500		Apr 24
3,546	910	0	19.22	4,456	448	600	250	360	80	690	945	945	355	1,300	1,295	150	0	1,445		Apr 25
3,542	910	0	21.02	4,452	443	600	250	360	80	690	945	945	355	1,300	1,295	135	0	1,430	T, S	Apr 26
3,538	915	0	22.84	4,453	439	600	250	360	80	690	945	945	355	1,300	1,295	135	0	1,430	T, S	Apr 27
3,533	930	0	24.68	4,463	435	600	250	360	80	690	945	945	355	1,300	1,295	135	0	1,430	T, S	Apr 28
3,529	930	0	26.53	4,459	430	600	250	370	80	700	945	945	355	1,300	1,295	135	0	1,430	T, S	Apr 29
3,525	930	0	28.37	4,455	426	600	250	370	80	700	945	945	355	1,300	1,295	135	0	1,430	T, S	Apr 30
3,520	930	0	30.22	4,450	421	600	250	375	80	705	945	945	355	1,300	1,295	135	0	1,430	T, S	May 01
3,516	940	0	32.08	4,456	417	600	250	540	80	870	945	945	355	1,300	1,295	135	0	1,430	S	May 02
3,511	940	0	33.95	4,451	413	600	250	640	80	970	945	945	200	1,145	1,295	135	0	1,430	S	May 03
3,507	945	0	35.82	4,452	408	600	250	670	80	1,000	945	945	100	1,045	1,295	135	0	1,430	M	May 04
3,503	955	0	37.72	4,458	404	600	250	670	80	1,000	945	945	95	1,040	1,295	135	0	1,430	M	May 05
3,498	955	0	39.61	4,453	400	600	250	670	80	1,000	945	945	95	1,040	1,295	135	0	1,430	M	May 06
3,494	980	0	41.55	4,474	395	600	250	670	80	1,000	945	945	95	1,040	1,295	135	0	1,430	M	May 07
3,490	980	0	43.50	4,470	391	600	250	670	80	1,000	945	945	95	1,040	1,295	135	0	1,430	M	May 08
3,485	980	0	45.44	4,465	386	600	250	670	80	1,000	945	945	95	1,040	1,295	135	0	1,430	M	May 09
3,481	980	0	47.39	4,461	382	600	250	670	80	1,000	945	945	95	1,040	1,295	135	0	1,430	M	May 10
3,476	980	0	49.33	4,456	378	600	250	670	80	1,000	945	945	95	1,040	1,295	135	0	1,430	M	May 11
3,472	980	0	51.27	4,452	373	600	250	570	80	900	945	945	95	1,040	1,295	135	0	1,430		May 12
3,468	980	0	53.22	4,448	369	600	250	200		450	945	945	95	1,040	1,295	135	0	1,430		May 13
3,463	980	0	55.16	4,443	365	600	250			250	500	500		500	723			723		May 14
3,459	880	0	56.91	4,339	361	600	250			250	350	350		350	723			723		May 15
2,438	200			2,638	357	600	250			250	250	250		250	723			723		May 16
2,284	0			2,284	353	600	250			250	175	175		175	723			723		May 17
2,180	0			2,180	349	600	250			250	175	175		175	723			723		May 18
2,101	0			2,101	345	600	250			250	175	175		175	723			723		May 19
2,097	0			2,097	341	600	250			250	175	175		175	723			723		May 20
2,093	0			2,093	337	600	250			250	175	175		175	723			723		May 21
2,089	0			2,089	333	600	250			250	175	175		175	723			723		May 22
2,085	0			2,085	329	600	250			250	175	175		175	723			723		May 23
2,081	0			2,081	325	600	250			250	175	175		175	723			723		May 24
2,077	0			2,077	321	600	250			250	175	175		175	723			723		May 25
2,073	0			2,073	317	600	250			250	175	175		175	723			723		May 26
2,069	0			2,069	313	600	250			250	175	175		175	723			723		May 27
2,065	0			2,065	309	600	250			250	175	175		175	723			723		May 28
2,061	0			2,061	305	600	250			250	175	175		175	723			723		May 29
2,057	0			2,057	301	600	250			250	175	175		175	723			723		May 30
2,053	0			2,053	297	600	250			250	140	140		140	723			723		May 31
VAMP period																				
3,525	925			4,450	435	600	250	519	81	850	945	945	163	1,108	1,295	163	0	1,458		Mean (cfs):
	56.91							31.91	5.00				10.00			10.00	0.00			Suppl. Water (TAF)

Pulse flow period

Period of desired flow stability

DAILY OPERATION PLAN, APRIL 8, 2002

Pulse Period: April 15–May 15 • Flow Target: 3,200cfs

Ungaged Flow at Vernalis = 400cfs

	San Joaquin River near Vernalis							Merced River at Cressey				Tuolumne River at LaGrange				Stanislaus River below Goodwin				
	Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	Cum. VAMP Suppl. Flow	VAMP Flow	SJR above Merced R. (2-day lag)	Ungaged Flow above Vernalis	Existing Flow	MeID VAMP Suppl. Flow	Exch Contr VAMP Suppl. Flow	VAMP Flow (3-day lag)	Desired FERC Pulse	Existing Flow – Adjusted FERC Pulse	VAMP Suppl. Flow	VAMP Flow (2-day lag)	Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	VAMP Flow (2-day lag)	Maintain Priority Flow Level M=Merced T=Tuol. S=Stan.
	(cfs)	(cfs)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	
	[calc]	[calc]		[calc]	[calc]						[calc]				[calc]				[calc]	
Apr 01					1,990	428	651	199			199	150	169		169	505			505	
Apr 02					1,810	422	476	189			189	150	171		171	504			504	
Apr 03					1,710	407	400	171			171	150	170		170	501			501	
Apr 04	1,660				1,660	390	364	173			173	150	172		172	504			504	
Apr 05	1,670				1,670	373	403	204			204	150	171		171	574			574	
Apr 06	1,710				1,710	324	473	213			213	150	172		172	603			603	
Apr 07	1,820				1,820	317	529	224			224	150	173		173	603			603	
Apr 08	1,923				1,923	314	620	250			250	150	150		150	637			637	
Apr 09	1,856				1,856	311	550	250			250	150	150		150	637			637	
Apr 10	1,825				1,825	309	500	250			250	150	150		150	637			637	
Apr 11	1,828				1,828	306	480	250			250	150	150		150	637			637	
Apr 12	1,806				1,806	303	460	250	0	0	250	150	150		150	637	363		1,000	
Apr 13	1,783	0			1,783	300	440	250	0	0	250	945	780	0	780	1,500	0	0	1,500	
Apr 14	1,760	363			2,123	297	420	250	0	0	250	945	780	0	780	1,500	0	0	1,500	
Apr 15	3,230	0	0	0.00	3,230	293	400	250	0	0	250	945	780	0	780	1,500	0	0	1,500	
Apr 16	3,227	0	0	0.00	3,227	290	400	250	0	0	250	945	780	0	780	1,500	0	0	1,500	
Apr 17	3,223	0	0	0.00	3,223	286	400	250	0	0	250	945	780	0	780	1,500	0	0	1,500	
Apr 18	3,220	0	0	0.00	3,220	283	400	250	0	0	250	945	780	0	780	1,500	0	0	1,500	
Apr 19	3,216	0	0	0.00	3,216	279	400	250	0	0	250	945	780	0	780	1,500	0	0	1,500	
Apr 20	3,213	0	0	0.00	3,213	276	400	250	0	0	250	945	780	0	780	1,500	0	0	1,500	
Apr 21	3,209	0	0	0.00	3,209	272	400	250	0	0	250	945	780	0	780	1,500	0	0	1,500	
Apr 22	3,206	0	0	0.00	3,206	269	400	250	240	0	490	945	780	0	780	1,500	0	0	1,500	
Apr 23	3,202	0	0	0.00	3,202	265	400	250	270	0	520	945	780	0	780	1,270	0	0	1,270	M
Apr 24	3,199	0	0	0.00	3,199	262	400	250	270	0	520	945	1,300	0	1,300	735	0	0	735	M,T
Apr 25	2,965	240	0	0.48	3,205	258	400	250	270	0	520	945	1,300	0	1,300	735	0	0	735	M,T
Apr 26	2,947	270	0	1.01	3,217	255	400	250	270	0	520	945	1,300	0	1,300	735	0	0	735	M,T,S
Apr 27	2,943	270	0	1.55	3,213	251	400	250	270	0	520	945	1,300	0	1,300	735	0	0	735	M,T,S
Apr 28	2,940	270	0	2.08	3,210	248	400	250	270	0	520	945	1,300	0	1,300	735	0	0	735	M,T,S
Apr 29	2,936	270	0	2.62	3,206	244	400	250	270	0	520	945	1,300	0	1,300	735	0	0	735	M,T,S
Apr 30	2,933	270	0	3.15	3,203	241	400	250	270	0	520	945	1,300	0	1,300	735	0	0	735	M,T,S
May 01	2,929	270	0	3.69	3,199	237	400	250	670	0	920	945	1,300	0	1,300	735	0	0	735	T,S
May 02	2,926	270	0	4.22	3,196	234	400	250	730	0	980	945	910	0	910	735	0	0	735	S
May 03	2,922	270	0	4.76	3,192	230	400	250	730	0	980	945	855	0	855	735	0	0	735	S
May 04	2,529	670	0	6.09	3,199	227	400	250	750	0	1,000	945	855	0	855	735	0	0	735	M
May 05	2,470	730	0	7.54	3,200	223	400	250	750	0	1,000	945	855	0	855	735	0	0	735	M
May 06	2,467	730	0	8.99	3,197	220	400	250	750	0	1,000	945	855	0	855	735	0	0	735	M
May 07	2,463	750	0	10.47	3,213	216	400	250	750	0	1,000	945	855	0	855	735	0	0	735	M
May 08	2,460	750	0	11.96	3,210	213	400	250	750	0	1,000	945	855	0	855	735	0	0	735	M
May 09	2,456	750	0	13.45	3,206	209	400	250	750	0	1,000	945	855	0	855	735	0	0	735	M
May 10	2,453	750	0	14.94	3,203	206	400	250	750	0	1,000	945	855	0	855	735	0	0	735	M
May 11	2,449	750	0	16.42	3,199	202	400	250	750	0	1,000	945	855	0	855	735	0	0	735	M
May 12	2,446	750	0	17.91	3,196	199	400	250	580	0	830	945	855	0	855	735	0	0	735	
May 13	2,442	750	0	19.40	3,192	195	400	250	170		420	945	855	0	855	735	0	0	735	
May 14	2,439	750	0	20.89	3,189	191	400	250			250	500	500		500	677			677	
May 15	2,435	580	0	22.04	3,015	187	400	250			250	350	350		350	677			677	
May 16	2,018	170			2,188	183	400	250			250	250	250		250	677			677	
May 17	1,864	0			1,864	179	400	250			250	175	175		175	677			677	
May 18	1,760	0			1,760	175	400	250			250	175	175		175	677			677	
May 19	1,681	0			1,681	171	400	250			250	175	175		175	677			677	
May 20	1,677	0			1,677	167	400	250			250	175	175		175	677			677	
May 21	1,673	0			1,673	163	400	250			250	175	175		175	677			677	
May 22	1,669	0			1,669	159	400	250			250	175	175		175	677			677	
May 23	1,665	0			1,665	155	400	250			250	175	175		175	677			677	
May 24	1,661	0			1,661	151	400	250			250	175	175		175	677			677	
May 25	1,657	0			1,657	147	400	250			250	175	175		175	677			677	
May 26	1,653	0			1,653	143	400	250			250	175	175		175	677			677	
May 27	1,649	0			1,649	139	400	250			250	175	175		175	677			677	
May 28	1,645	0			1,645	135	400	250			250	175	175		175	677			677	
May 29	1,641	0			1,641	131	400	250			250	175	175		175	677			677	
May 30	1,637	0			1,637	127	400	250			250	175	175		175	677			677	
May 31	1,633	0			1,633	123	400	250			250	140	140		140	677			677	
	VAMP period																			
Mean (cfs):	2,842	358			3,200	248	400	250	358	0	608	945	945	0	945	999	0	0	999	
Suppl. Water (TAF)		22.04							22.04	0.00				0.00			0.00	0.00		

Pulse flow period

Period of desired flow stability

DAILY OPERATION PLAN, APRIL 9, 2002

Pulse Period: April 15–May 15 • Flow Target: 3,200cfs

Ungaged Flow at Vernalis = 400cfs

San Joaquin River near Vernalis							Merced River at Cressey				Tuolumne River at LaGrange				Stanislaus River below Goodwin					
Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	Cum. VAMP Suppl. Flow	VAMP Flow	SJR above Merced R. (2-day lag)	Ungaged Flow above Vernalis	Existing Flow	MeID VAMP Suppl. Flow	Exch Contr VAMP Suppl. Flow	VAMP Flow (3-day lag)	Desired FERC Pulse	Existing Flow – Adjusted FERC Pulse	VAMP Suppl. Flow	VAMP Flow (2-day lag)	Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	VAMP Flow (2-day lag)	Maintain Priority Flow Level M=Merced T=Tuol. S=Stan.	
(cfs)	(cfs)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)		
[calc]	[calc]		[calc]	[calc]						[calc]				[calc]				[calc]		
				1,990	428	651	199			199	150	169		169	505			505		Apr 01
				1,810	422	476	189			189	150	171		171	504			504		Apr 02
				1,710	407	400	171			171	150	170		170	501			501		Apr 03
1,660				1,660	390	364	173			173	150	172		172	504			504		Apr 04
1,670				1,670	373	403	204			204	150	171		171	574			574		Apr 05
1,710				1,710	324	473	213			213	150	172		172	603			603		Apr 06
1,820				1,820	317	529	224			224	150	173		173	603			603		Apr 07
1,940				1,940	315	637	226			226	150	175		175	604			604		Apr 08
1,856				1,856	311	550	250			250	150	150		150	637			637		Apr 09
1,818				1,818	309	500	250			250	150	150		150	637			637		Apr 10
1,804				1,804	306	480	250			250	150	150		150	637			637		Apr 11
1,806				1,806	303	460	250	0	0	250	150	150	165	315	637	363		1,000		Apr 12
1,783	0			1,783	300	440	250	70	0	320	845	700	0	700	1,500	0	0	1,500		Apr 13
1,760	528			2,288	297	420	250	70	0	320	845	700	0	700	1,500	0	0	1,500		Apr 14
3,150	0	0	0.00	3,150	293	400	250	70	0	320	845	700	0	700	1,500	0	0	1,500		Apr 15
3,147	70	0	0.14	3,217	290	400	250	70	0	320	845	700	0	700	1,500	0	0	1,500		Apr 16
3,143	70	0	0.28	3,213	286	400	250	70	0	320	845	700	0	700	1,500	0	0	1,500		Apr 17
3,140	70	0	0.42	3,210	283	400	250	70	0	320	845	700	0	700	1,500	0	0	1,500		Apr 18
3,136	70	0	0.56	3,206	279	400	250	80	0	330	845	700	0	700	1,500	0	0	1,500		Apr 19
3,133	70	0	0.69	3,203	276	400	250	80	0	330	845	700	0	700	1,500	0	0	1,500		Apr 20
3,129	70	0	0.83	3,199	272	400	250	80	0	330	845	700	0	700	1,500	0	0	1,500		Apr 21
3,126	80	0	0.99	3,206	269	400	250	200	0	450	845	700	0	700	1,500	0	0	1,500		Apr 22
3,122	80	0	1.15	3,202	265	400	250	220	0	470	845	795	0	795	1,180	100	0	1,280	M	Apr 23
3,119	80	0	1.31	3,199	262	400	250	220	0	470	845	1,250	0	1,250	720	130	0	850	M,T	Apr 24
2,890	300	0	1.90	3,190	258	400	250	220	0	470	845	1,250	0	1,250	720	130	0	850	M,T	Apr 25
2,882	350	0	2.60	3,232	255	400	250	220	0	470	845	1,250	0	1,250	720	130	0	850	M,T	Apr 26
2,878	350	0	3.29	3,228	251	400	250	220	0	470	845	1,250	0	1,250	720	130	0	850	M,T	Apr 27
2,875	350	0	3.99	3,225	248	400	250	220	0	470	845	1,250	0	1,250	720	130	0	850	M,T	Apr 28
2,871	350	0	4.68	3,221	244	400	250	220	0	470	845	1,250	0	1,250	720	130	0	850	M,T	Apr 29
2,868	350	0	5.38	3,218	241	400	250	425	0	675	845	1,250	0	1,250	720	130	0	850	M,T	Apr 30
2,864	350	0	6.07	3,214	237	400	250	780	0	1,030	845	1,150	0	1,150	750	0	0	750	T,S	May 01
2,861	350	0	6.76	3,211	234	400	250	880	0	1,130	845	800	0	800	750	0	0	750	S	May 02
2,787	425	0	7.61	3,212	230	400	250	880	0	1,130	845	700	0	700	750	0	0	750	S	May 03
2,434	780	0	9.15	3,214	227	400	250	880	0	1,130	845	700	0	700	750	0	0	750	M,S	May 04
2,330	880	0	10.90	3,210	223	400	250	880	0	1,130	845	700	0	700	750	0	0	750	M,S	May 05
2,327	880	0	12.64	3,207	220	400	250	880	0	1,130	845	700	0	700	750	0	0	750	M,S	May 06
2,323	880	0	14.39	3,203	216	400	250	880	0	1,130	845	700	0	700	750	0	0	750	M,S	May 07
2,320	880	0	16.14	3,200	213	400	250	780	0	1,030	845	700	0	700	750	0	0	750	M,S	May 08
2,316	880	0	17.88	3,196	209	400	250	780	0	1,030	845	700	0	700	750	120	0	870	M	May 09
2,313	880	0	19.63	3,193	206	400	250	780	0	1,030	845	700	0	700	750	120	0	870	M	May 10
2,309	900	0	21.41	3,209	202	400	250	780	0	1,030	845	700	0	700	750	120	0	870	M	May 11
2,306	900	0	23.20	3,206	199	400	250	600	0	850	845	700	0	700	750	120	0	870		May 12
2,302	900	0	24.98	3,202	195	400	250	200		450	845	700	0	700	750	120	0	870		May 13
2,299	900	0	26.77	3,199	191	400	250			250	500	500		500	677			677		May 14
2,295	720	0	28.20	3,015	187	400	250			250	350	350		350	677			677		May 15
2,018	200			2,218	183	400	250			250	250	250		250	677			677		May 16
1,864	0			1,864	179	400	250			250	175	175		175	677			677		May 17
1,760	0			1,760	175	400	250			250	175	175		175	677			677		May 18
1,681	0			1,681	171	400	250			250	175	175		175	677			677		May 19
1,677	0			1,677	167	400	250			250	175	175		175	677			677		May 20
1,673	0			1,673	163	400	250			250	175	175		175	677			677		May 21
1,669	0			1,669	159	400	250			250	175	175		175	677			677		May 22
1,665	0			1,665	155	400	250			250	175	175		175	677			677		May 23
1,661	0			1,661	151	400	250			250	175	175		175	677			677		May 24
1,657	0			1,657	147	400	250			250	175	175		175	677			677		May 25
1,653	0			1,653	143	400	250			250	175	175		175	677			677		May 26
1,649	0			1,649	139	400	250			250	175	175		175	677			677		May 27
1,645	0			1,645	135	400	250			250	175	175		175	677			677		May 28
1,641	0			1,641	131	400	250			250	175	175		175	677			677		May 29
1,637	0			1,637	127	400	250			250	175	175		175	677			677		May 30
1,633	0			1,633	123	400	250			250	140	140		140	677			677		May 31
VAMP period																				
2,742	459			3,200	248	400	250	407	0	657	845	845	0	845	999	52	0	1,051		Mean (cfs):
	28.19							25.00	0.00				0.00			3.19	0.00			Suppl. Water (TAF)

Pulse flow period

Period of desired flow stability

DAILY OPERATION PLAN, APRIL 16, 2002

Pulse Period: April 15–May 15 • Flow Target: 3,200cfs

Ungaged Flow at Vernalis = 300cfs

	San Joaquin River near Vernalis							Merced River at Cressey				Tuolumne River at LaGrange				Stanislaus River below Goodwin				
	Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	Cum. VAMP Suppl. Flow	VAMP Flow	SJR above Merced R. (2-day lag)	Ungaged Flow above Vernalis	Existing Flow	MeID VAMP Suppl. Flow	Exch Contr VAMP Suppl. Flow	VAMP Flow (3-day lag)	FERC Pulse	Existing Flow – Adjusted FERC Pulse	VAMP Suppl. Flow	VAMP Flow (2-day lag)	Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	VAMP Flow (2-day lag)	Maintain Priority Flow Level M=Merced T=Tuol. S=Stan.
	(cfs)	(cfs)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	
	[calc]	[calc]		[calc]	[calc]						[calc]				[calc]				[calc]	
Apr 01					1,990	428	651	199			199	169	169		169	505			505	
Apr 02					1,810	422	476	189			189	171	171		171	504			504	
Apr 03					1,710	407	400	171			171	170	170		170	501			501	
Apr 04	1,660				1,660	390	364	173			173	172	172		172	504			504	
Apr 05	1,670				1,670	373	403	204			204	171	171		171	574			574	
Apr 06	1,710				1,710	324	473	213			213	172	172		172	603			603	
Apr 07	1,820				1,820	317	529	224			224	173	173		173	603			603	
Apr 08	1,940				1,940	315	637	226			226	175	175		175	604			604	
Apr 09	1,820				1,820	322	514	232			232	174	174		174	602			602	
Apr 10	1,810				1,810	296	492	242			242	170	170		170	644			644	
Apr 11	1,760				1,760	295	436	241			241	170	170		170	654			654	
Apr 12	1,760				1,760	301	418	242	0	0	242	325	322		322	637		152	789	
Apr 13	1,800	0			1,800	300	439	250	59	0	309	845	704	0	704	1,505	0	0	1,505	
Apr 14	2,068	0	152		2,220	276	567	250	68	0	318	845	708	0	708	1,504	0	0	1,504	
Apr 15	2,860	0	0	0.00	2,860	286	109	250	76	0	326	845	709	0	709	1,504	0	0	1,504	
Apr 16	3,038	59	0	0.12	3,097	290	300	250	70	0	320	845	800	0	800	1,500	0	0	1,500	
Apr 17	3,049	68	0	0.25	3,117	286	300	250	70	0	320	845	800	0	800	1,500	0	0	1,500	
Apr 18	3,140	76	0	0.40	3,216	283	300	250	70	0	320	845	800	0	800	1,500	0	0	1,500	
Apr 19	3,136	70	0	0.54	3,206	279	300	250	80	0	330	845	800	0	800	1,500	0	0	1,500	
Apr 20	3,133	70	0	0.68	3,203	276	300	250	80	0	330	845	800	0	800	1,500	0	0	1,500	
Apr 21	3,129	70	0	0.82	3,199	272	300	250	80	0	330	845	800	0	800	1,500	0	0	1,500	
Apr 22	3,126	80	0	0.98	3,206	269	300	250	150	0	400	845	850	0	850	1,500	0	0	1,500	
Apr 23	3,122	80	0	1.14	3,202	265	300	250	150	0	400	845	850	0	850	1,180	250	0	1,430	M
Apr 24	3,169	80	0	1.30	3,249	262	300	250	150	0	400	845	1,200	0	1,200	720	350	0	1,070	M,T
Apr 25	2,845	400	0	2.09	3,245	258	300	250	150	0	400	845	1,250	0	1,250	720	320	0	1,040	M,T
Apr 26	2,732	500	0	3.08	3,232	255	300	250	150	0	400	845	1,250	0	1,250	720	320	0	1,040	M,T
Apr 27	2,778	470	0	4.01	3,248	251	300	250	150	0	400	845	1,250	0	1,250	720	320	0	1,040	M,T
Apr 28	2,775	470	0	4.94	3,245	248	300	250	150	0	400	845	1,250	0	1,250	720	320	0	1,040	M,T
Apr 29	2,771	470	0	5.88	3,241	244	300	250	150	0	400	845	1,250	0	1,250	720	320	0	1,040	M,T
Apr 30	2,768	470	0	6.81	3,238	241	300	250	400	0	650	845	1,250	0	1,250	720	320	0	1,040	M,T
May 01	2,764	470	0	7.74	3,234	237	300	250	770	0	1,020	845	1,250	0	1,250	750	50	0	800	T,S
May 02	2,761	470	0	8.67	3,231	234	300	250	910	0	1,160	845	890	0	890	750	50	0	800	S
May 03	2,787	450	0	9.57	3,237	230	300	250	910	0	1,160	845	720	0	720	750	50	0	800	S
May 04	2,424	820	0	11.19	3,244	227	300	250	930	0	1,180	845	720	0	720	750	50	0	800	M,S
May 05	2,250	960	0	13.10	3,210	223	300	250	930	0	1,180	845	720	0	720	750	50	0	800	M,S
May 06	2,247	960	0	15.00	3,207	220	300	250	930	0	1,180	845	720	0	720	750	50	0	800	M,S
May 07	2,243	980	0	16.94	3,223	216	300	250	930	0	1,180	845	720	0	720	750	50	0	800	M,S
May 08	2,240	980	0	18.89	3,220	213	300	250	860	0	1,110	845	720	0	720	750	50	0	800	M,S
May 09	2,236	980	0	20.83	3,216	209	300	250	860	0	1,110	845	550	0	550	750	330	0	1,080	M
May 10	2,233	980	0	22.78	3,213	206	300	250	860	0	1,110	845	550	0	550	750	330	0	1,080	M
May 11	2,059	1,190	0	25.14	3,249	202	300	250	860	0	1,110	845	550	0	550	750	330	0	1,080	M
May 12	2,056	1,190	0	27.50	3,246	199	300	250	600	0	850	845	550	0	550	750	330	0	1,080	
May 13	2,052	1,190	0	29.86	3,242	195	300	250	200		450	845	550	0	550	750	330	0	1,080	
May 14	2,049	1,190	0	32.22	3,239	191	300	250			250	500	350		350	677			677	
May 15	2,045	930	0	34.06	2,975	187	300	250			250	350	250		250	677			677	
May 16	1,768	200			1,968	183	300	250			250	250	175		175	677			677	
May 17	1,664	0			1,664	179	300	250			250	175	175		175	677			677	
May 18	1,585	0			1,585	175	300	250			250	175	175		175	677			677	
May 19	1,581	0			1,581	171	300	250			250	175	175		175	677			677	
May 20	1,577	0			1,577	167	300	250			250	175	175		175	677			677	
May 21	1,573	0			1,573	163	300	250			250	175	175		175	677			677	
May 22	1,569	0			1,569	159	300	250			250	175	175		175	677			677	
May 23	1,565	0			1,565	155	300	250			250	175	175		175	677			677	
May 24	1,561	0			1,561	151	300	250			250	175	175		175	677			677	
May 25	1,557	0			1,557	147	300	250			250	175	175		175	677			677	
May 26	1,553	0			1,553	143	300	250			250	175	175		175	677			677	
May 27	1,549	0			1,549	139	300	250			250	175	175		175	677			677	
May 28	1,545	0			1,545	135	300	250			250	175	175		175	677			677	
May 29	1,541	0			1,541	131	300	250			250	175	175		175	677			677	
May 30	1,537	0			1,537	127	300	250			250	175	175		175	677			677	
May 31	1,533	0			1,533	123	300	250			250	140	140		140	677			677	
	VAMP period																			
Mean (cfs):	2,645	554			3,199	247	294	250	407	0	656	845	856	0	856	999	147	0	1,147	
Suppl. Water (TAF)		34.06							25.00	0.00				0.00			9.06	0.00		

Pulse flow period

Period of desired flow stability

DAILY OPERATION PLAN, APRIL 19, 2002

Pulse Period: April 15–May 15 • Flow Target: 3,200cfs

Ungaged Flow at Vernalis = 300cfs

San Joaquin River near Vernalis							Merced River at Cressey				Tuolumne River at LaGrange				Stanislaus River below Goodwin					
Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	Cum. VAMP Suppl. Flow	VAMP Flow	SJR above Merced R. (2-day lag)	Ungaged Flow above Vernalis	Existing Flow	MeID VAMP Suppl. Flow	Exch Contr VAMP Suppl. Flow	VAMP Flow (3-day lag)	FERC Pulse	Existing Flow – Adjusted FERC Pulse	VAMP Suppl. Flow	VAMP Flow (2-day lag)	Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	VAMP Flow (2-day lag)	Maintain Priority Flow Level M=Merced T=Tuol. S=Stan.	
(cfs)	(cfs)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)		
[calc]	[calc]		[calc]	[calc]						[calc]				[calc]				[calc]		
				1,990	428	651	199			199	169	169		169	505			505		Apr 01
				1,810	422	476	189			189	171	171		171	504			504		Apr 02
				1,710	407	400	171			171	170	170		170	501			501		Apr 03
1,660				1,660	390	364	173			173	172	172		172	504			504		Apr 04
1,670				1,670	373	403	204			204	171	171		171	574			574		Apr 05
1,710				1,710	324	473	213			213	172	172		172	603			603		Apr 06
1,810				1,820	317	519	224			224	173	173		173	603			603		Apr 07
1,930				1,930	315	627	226			226	175	175		175	604			604		Apr 08
1,820				1,820	322	514	232			232	174	174		174	602			602		Apr 09
1,800				1,800	296	482	242			242	170	170		170	644			644		Apr 10
1,750				1,750	295	426	241			241	170	170		170	654			654		Apr 11
1,750				1,750	301	408	242	0	0	242	325	322		322	637		152	789		Apr 12
1,790	0			1,790	300	429	250	59	0	309	845	704	0	704	1,505	0	0	1,505		Apr 13
2,048	0	152		2,200	276	547	250	68	0	318	845	708	0	708	1,504	0	0	1,504		Apr 14
2,839	0	0	0.00	2,839	286	88	250	76	0	326	845	709	0	709	1,504	0	0	1,504		Apr 15
2,901	59	0	0.12	2,960	274	163	250	78	0	328	845	782	0	782	1,503	0	0	1,503		Apr 16
2,922	68	0	0.25	2,990	285	173	250	117	0	367	845	806	0	806	1,508	0	0	1,508		Apr 17
3,054	76	0	0.40	3,130	253	245	250	118	0	368	845	804	0	804	1,503	0	0	1,503		Apr 18
3,149	78	0	0.56	3,227	279	300	250	80	0	330	845	800	0	800	1,500	0	0	1,500		Apr 19
3,110	117	0	0.79	3,227	276	300	250	80	0	330	845	800	0	800	1,500	0	0	1,500		Apr 20
3,129	118	0	1.02	3,247	272	300	250	80	0	330	845	800	0	800	1,500	0	0	1,500		Apr 21
3,126	80	0	1.18	3,206	269	300	250	120	0	370	845	800	0	800	1,500	0	0	1,500		Apr 22
3,122	80	0	1.34	3,202	265	300	250	150	0	400	845	800	0	800	1,180	320	0	1,500	M	Apr 23
3,119	80	0	1.50	3,199	262	300	250	150	0	400	845	1,300	0	1,300	720	290	0	1,010	M,T	Apr 24
2,795	440	0	2.37	3,235	258	300	250	150	0	400	845	1,300	0	1,300	720	280	0	1,000	M,T	Apr 25
2,832	440	0	3.24	3,272	255	300	250	150	0	400	845	1,300	0	1,300	720	280	0	1,000	M,T	Apr 26
2,828	430	0	4.10	3,258	251	300	250	150	0	400	845	1,300	0	1,300	720	280	0	1,000	M,T	Apr 27
2,825	430	0	4.95	3,255	248	300	250	150	0	400	845	1,300	0	1,300	720	280	0	1,000	M,T	Apr 28
2,821	430	0	5.80	3,251	244	300	250	150	0	400	845	1,300	0	1,300	720	280	0	1,000	M,T	Apr 29
2,818	430	0	6.66	3,248	241	300	250	375	0	625	845	1,300	0	1,300	720	280	0	1,000	T	Apr 30
2,814	430	0	7.51	3,244	237	300	250	780	0	1,030	845	1,300	0	1,300	750	0	0	750	T,S	May 01
2,811	430	0	8.36	3,241	234	300	250	1,025	60	1,335	845	885	0	885	750	0	0	750	M,S	May 02
2,837	375	0	9.11	3,212	230	300	250	1,050	35	1,335	845	600	0	600	750	0	0	750	M,S	May 03
2,419	780	0	10.65	3,199	227	300	250	1,050	35	1,335	845	600	0	600	750	0	0	750	M,S	May 04
2,130	1,085	0	12.81	3,215	223	300	250	1,050	35	1,335	845	600	0	600	750	0	0	750	M,S	May 05
2,127	1,085	0	14.96	3,212	220	300	250	1,050	35	1,335	845	600	0	600	750	0	0	750	M,S	May 06
2,123	1,085	0	17.11	3,208	216	300	250	1,050	35	1,335	845	600	0	600	750	0	0	750	M,S	May 07
2,120	1,085	0	19.26	3,205	213	300	250	650	0	900	845	600	0	600	750	0	0	750	S	May 08
2,116	1,085	0	21.41	3,201	209	300	250	650	0	900	845	575	0	575	750	550	0	1,300		May 09
2,113	1,085	0	23.57	3,198	206	300	250	650	0	900	845	575	0	575	750	550	0	1,300		May 10
2,084	1,200	0	25.95	3,284	202	300	250	650	0	900	845	550	0	550	750	550	0	1,300		May 11
2,081	1,200	0	28.33	3,281	199	300	250	650	0	900	845	550	0	550	750	550	0	1,300		May 12
2,052	1,200	0	30.71	3,252	195	300	250	200		450	845	550	0	550	750	550	0	1,300		May 13
2,049	1,200	0	33.09	3,249	191	300	250			250	500	450		450	677			677		May 14
2,045	1,200	0	35.47	3,245	187	300	250			250	350	350		350	677			677		May 15
1,868	200			2,068	183	300	250			250	250	250		250	677			677		May 16
1,764	0			1,764	179	300	250			250	175	175		175	677			677		May 17
1,660	0			1,660	175	300	250			250	175	175		175	677			677		May 18
1,581	0			1,581	171	300	250			250	175	175		175	677			677		May 19
1,577	0			1,577	167	300	250			250	175	175		175	677			677		May 20
1,573	0			1,573	163	300	250			250	175	175		175	677			677		May 21
1,569	0			1,569	159	300	250			250	175	175		175	677			677		May 22
1,565	0			1,565	155	300	250			250	175	175		175	677			677		May 23
1,561	0			1,561	151	300	250			250	175	175		175	677			677		May 24
1,557	0			1,557	147	300	250			250	175	175		175	677			677		May 25
1,553	0			1,553	143	300	250			250	175	175		175	677			677		May 26
1,549	0			1,549	139	300	250			250	175	175		175	677			677		May 27
1,545	0			1,545	135	300	250			250	175	175		175	677			677		May 28
1,541	0			1,541	131	300	250			250	175	175		175	677			677		May 29
1,537	0			1,537	127	300	250			250	175	175		175	677			677		May 30
1,533	0			1,533	123	300	250			250	140	140		140	677			677		May 31
VAMP period																				
2,623	577			3,200	245	283	250	407	8	664	845	845	0	845	1,000	163	0	1,162		Mean (cfs):
	35.47							25.00	0.47				0.00			10.00	0.00			Suppl. Water (TAF)

Pulse flow period

Period of desired flow stability

DAILY OPERATION PLAN, APRIL 25, 2002

Pulse Period: April 15–May 15 • Flow Target: 3,200cfs

Ungaged Flow at Vernalis = 300cfs

	San Joaquin River near Vernalis							Merced River at Cressey				Tuolumne River at LaGrange				Stanislaus River below Goodwin				
	Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	Cum. VAMP Suppl. Flow	VAMP Flow	SJR above Merced R. (2-day lag)	Ungaged Flow above Vernalis	Existing Flow	MeID VAMP Suppl. Flow	Exch Contr VAMP Suppl. Flow	VAMP Flow (3-day lag)	FERC Pulse	Existing Flow – Adjusted FERC Pulse	VAMP Suppl. Flow	VAMP Flow (2-day lag)	Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	VAMP Flow (2-day lag)	Maintain Priority Flow Level M=Merced T=Tuol. S=Stan.
	(cfs)	(cfs)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	
	[calc]	[calc]		[calc]	[calc]						[calc]				[calc]				[calc]	
Apr 01					1,990	428	651	199			199	169	169		169	505			505	
Apr 02					1,810	422	476	189			189	171	171		171	504			504	
Apr 03					1,710	407	400	171			171	170	170		170	501			501	
Apr 04	1,660				1,660	390	364	173			173	172	172		172	504			504	
Apr 05	1,670				1,670	373	403	204			204	171	171		171	574			574	
Apr 06	1,710				1,710	324	473	213			213	172	172		172	603			603	
Apr 07	1,810				1,820	317	519	224			224	173	173		173	603			603	
Apr 08	1,930				1,930	315	627	226			226	175	175		175	604			604	
Apr 09	1,820				1,820	322	514	232			232	174	174		174	602			602	
Apr 10	1,800				1,800	296	482	242			242	170	170		170	644			644	
Apr 11	1,750				1,750	295	426	241			241	170	170		170	654			654	
Apr 12	1,750				1,750	301	408	242	0	0	242	325	322		322	637		152	789	
Apr 13	1,790	0			1,790	300	429	250	59	0	309	845	704	0	704	1,505	0	0	1,505	
Apr 14	2,048	0	152		2,200	279	547	250	68	0	318	845	708	0	708	1,504	0	0	1,504	
Apr 15	2,839	0	0	0.00	2,839	292	88	250	76	0	326	845	709	0	709	1,504	0	0	1,504	
Apr 16	2,901	59	0	0.12	2,960	282	160	250	78	0	328	845	782	0	782	1,503	0	0	1,503	
Apr 17	2,922	68	0	0.25	2,990	295	167	250	117	0	367	845	806	0	806	1,508	0	0	1,508	
Apr 18	3,054	76	0	0.40	3,130	263	237	250	118	0	368	845	804	0	804	1,503	0	0	1,503	
Apr 19	3,121	78	0	0.56	3,199	265	262	250	124	0	374	845	807	0	807	1,502	0	0	1,502	
Apr 20	3,193	117	0	0.79	3,310	248	373	250	136	0	386	845	810	0	810	1,504	0	0	1,504	
Apr 21	3,252	118	0	1.02	3,370	261	428	250	141	0	391	845	810	0	810	1,503	0	0	1,503	
Apr 22	3,306	124	0	1.27	3,430	263	494	250	165	0	415	845	811	0	811	1,502	0	0	1,502	
Apr 23	3,114	136	0	1.54	3,250	291	290	250	171	0	421	845	838	0	838	1,180	324	0	1,504	M
Apr 24	3,079	141	0	1.82	3,220	276	253	250	167	0	417	845	1,310	0	1,310	720	360	0	1,080	M,T
Apr 25	2,859	489	0	2.79	3,348	258	300	250	150	0	400	845	1,300	0	1,300	720	280	0	1,000	M,T
Apr 26	2,856	531	0	3.84	3,387	255	300	250	150	0	400	845	1,300	0	1,300	720	280	0	1,000	M,T
Apr 27	2,828	447	0	4.73	3,275	251	300	250	150	0	400	845	1,300	0	1,300	720	230	0	950	M,T
Apr 28	2,825	430	0	5.58	3,255	248	300	250	150	0	400	845	1,300	0	1,300	720	230	0	950	M,T
Apr 29	2,821	380	0	6.34	3,201	244	300	250	150	0	400	845	1,300	0	1,300	720	230	0	950	M,T
Apr 30	2,818	380	0	7.09	3,198	241	300	250	350	0	600	845	1,300	0	1,300	720	230	0	950	T
May 01	2,814	380	0	7.84	3,194	237	300	250	780	0	1,030	845	1,300	0	1,300	750	0	0	750	T,S
May 02	2,811	380	0	8.60	3,191	234	300	250	1,050	0	1,300	845	895	0	895	750	0	0	750	M,S
May 03	2,837	350	0	9.29	3,187	230	300	250	1,050	0	1,300	845	600	0	600	750	0	0	750	M,S
May 04	2,429	780	0	10.84	3,209	227	300	250	1,050	0	1,300	845	600	0	600	750	0	0	750	M,S
May 05	2,130	1,050	0	12.92	3,180	223	300	250	1,050	0	1,300	845	600	0	600	750	0	0	750	M,S
May 06	2,127	1,050	0	15.00	3,177	220	300	250	1,050	0	1,300	845	600	0	600	750	0	0	750	M,S
May 07	2,123	1,050	0	17.09	3,173	216	300	250	1,050	0	1,300	845	600	0	600	750	0	0	750	M,S
May 08	2,120	1,050	0	19.17	3,170	213	300	250	600	0	850	845	600	0	600	750	0	0	750	S
May 09	2,116	1,050	0	21.25	3,166	209	300	250	600	0	850	845	575	0	575	750	540	0	1,290	
May 10	2,113	1,050	0	23.33	3,163	206	300	250	600	0	850	845	575	0	575	750	540	0	1,290	
May 11	2,084	1,140	0	25.59	3,224	202	300	250	600	0	850	845	550	0	550	750	540	0	1,290	
May 12	2,081	1,140	0	27.86	3,221	199	300	250	600	0	850	845	550	0	550	750	540	0	1,290	
May 13	2,052	1,140	0	30.12	3,192	195	300	250	200		450	845	550	0	550	750	540	0	1,290	
May 14	2,049	1,140	0	32.38	3,189	191	300	250			250	500	450		450	677			677	
May 15	2,045	1,140	0	34.64	3,185	187	300	250			250	350	350		350	677			677	
May 16	1,868	200			2,068	183	300	250			250	250	250		250	677			677	
May 17	1,764	0			1,764	179	300	250			250	175	175		175	677			677	
May 18	1,660	0			1,660	175	300	250			250	175	175		175	677			677	
May 19	1,581	0			1,581	171	300	250			250	175	175		175	677			677	
May 20	1,577	0			1,577	167	300	250			250	175	175		175	677			677	
May 21	1,573	0			1,573	163	300	250			250	175	175		175	677			677	
May 22	1,569	0			1,569	159	300	250			250	175	175		175	677			677	
May 23	1,565	0			1,565	155	300	250			250	175	175		175	677			677	
May 24	1,561	0			1,561	151	300	250			250	175	175		175	677			677	
May 25	1,557	0			1,557	147	300	250			250	175	175		175	677			677	
May 26	1,553	0			1,553	143	300	250			250	175	175		175	677			677	
May 27	1,549	0			1,549	139	300	250			250	175	175		175	677			677	
May 28	1,545	0			1,545	135	300	250			250	175	175		175	677			677	
May 29	1,541	0			1,541	131	300	250			250	175	175		175	677			677	
May 30	1,537	0			1,537	127	300	250			250	175	175		175	677			677	
May 31	1,533	0			1,533	123	300	250			250	140	140		140	677			677	
	VAMP period																			
Mean (cfs):	2,636	563			3,199	246	292	250	406	0	656	845	848	0	848	1,000	157	0	1,157	
Suppl. Water (TAF)		34.64							24.99	0.00				0.00			9.65	0.00		

Pulse flow period

Period of desired flow stability

DAILY OPERATION PLAN, MAY 9, 2002

Pulse Period: April 15–May 15 • Flow Target: 3,200cfs

Ungaged Flow at Vernalis = 450cfs

San Joaquin River near Vernalis							Merced River at Cressey				Tuolumne River at LaGrange				Stanislaus River below Goodwin					
Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	Cum. VAMP Suppl. Flow	VAMP Flow	SJR above Merced R. (2-day lag)	Ungaged Flow above Vernalis	Existing Flow	MeID VAMP Suppl. Flow	Exch Contr VAMP Suppl. Flow	VAMP Flow (3-day lag)	FERC Pulse	Existing Flow – Adjusted FERC Pulse	VAMP Suppl. Flow	VAMP Flow (2-day lag)	Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	VAMP Flow (2-day lag)	Maintain Priority Flow Level M=Merced T=Tuol. S=Stan.	
(cfs)	(cfs)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)		
[calc]	[calc]		[calc]	[calc]						[calc]				[calc]				[calc]		
				1,990	428	651	199			199	169	169		169	505			505		Apr 01
				1,810	422	476	189			189	171	171		171	504			504		Apr 02
				1,710	407	400	171			171	170	170		170	501			501		Apr 03
1,660				1,660	390	364	173			173	172	172		172	504			504		Apr 04
1,670				1,670	373	403	204			204	171	171		171	574			574		Apr 05
1,710				1,710	324	473	213			213	172	172		172	603			603		Apr 06
1,810				1,820	317	519	224			224	173	173		173	603			603		Apr 07
1,930				1,930	315	627	226			226	175	175		175	604			604		Apr 08
1,820				1,820	322	514	232			232	174	174		174	602			602		Apr 09
1,800				1,800	296	482	242			242	170	170		170	644			644		Apr 10
1,750				1,750	295	426	241			241	170	170		170	654			654		Apr 11
1,750				1,750	301	408	242	0	0	242	325	322		322	637		152	789		Apr 12
1,790	0			1,790	300	429	250	59	0	309	845	704	0	704	1,505	0	0	1,505		Apr 13
2,048	0	152		2,200	279	547	250	68	0	318	845	708	0	708	1,504	0	0	1,504		Apr 14
2,839	0	0	0.00	2,839	292	88	250	76	0	326	845	709	0	709	1,504	0	0	1,504		Apr 15
2,901	59	0	0.12	2,960	282	160	250	78	0	328	845	782	0	782	1,503	0	0	1,503		Apr 16
2,922	68	0	0.25	2,990	295	167	250	117	0	367	845	806	0	806	1,508	0	0	1,508		Apr 17
3,054	76	0	0.40	3,130	263	237	250	118	0	368	845	804	0	804	1,503	0	0	1,503		Apr 18
3,121	78	0	0.56	3,199	265	262	250	124	0	374	845	807	0	807	1,502	0	0	1,502		Apr 19
3,193	117	0	0.79	3,310	248	373	250	136	0	386	845	810	0	810	1,504	0	0	1,504		Apr 20
3,252	118	0	1.02	3,370	261	428	250	141	0	391	845	810	0	810	1,503	0	0	1,503		Apr 21
3,306	124	0	1.27	3,430	263	494	250	165	0	415	845	811	0	811	1,502	0	0	1,502		Apr 22
3,114	136	0	1.54	3,250	291	290	250	171	0	421	845	838	0	838	1,180	324	0	1,504	M	Apr 23
3,079	141	0	1.82	3,220	276	253	250	167	0	417	845	1,310	0	1,310	720	360	0	1,080	M,T	Apr 24
2,811	489	0	2.79	3,300	253	252	250	157	0	407	845	1,310	0	1,310	720	285	0	1,005	M,T	Apr 25
2,879	531	0	3.84	3,410	237	323	250	169	0	419	845	1,290	0	1,290	720	285	0	1,005	M,T	Apr 26
2,997	452	0	4.74	3,449	244	464	250	168	0	418	845	1,310	0	1,310	720	234	0	954	M,T	Apr 27
3,047	442	0	5.62	3,489	252	550	250	164	0	414	845	1,310	0	1,310	720	231	0	951	M,T	Apr 28
3,207	403	0	6.41	3,610	266	683	250	173	0	423	845	1,310	0	1,310	720	231	0	951	M,T	Apr 29
3,171	399	0	7.21	3,570	231	639	250	412	0	662	845	1,310	0	1,310	720	139	0	859	T	Apr 30
2,995	395	0	7.99	3,390	158	449	250	798	0	1,048	845	1,260	0	1,260	756	0	0	756	T,S	May 01
2,998	312	0	8.61	3,310	33	487	250	1,074	0	1,324	845	897	0	897	754	0	0	754	M,S	May 02
2,948	412	0	9.43	3,360	36	524	250	1,116	0	1,366	845	612	0	612	753	0	0	753	M,S	May 03
2,592	798	0	11.01	3,390	64	658	250	1,120	0	1,370	845	599	0	599	752	0	0	752	M,S	May 04
2,346	1,074	0	13.14	3,420	113	695	250	1,102	0	1,352	845	594	0	594	752	0	0	752	M,S	May 05
2,373	1,116	0	15.35	3,489	121	708	250	1,078	0	1,328	845	598	0	598	754	0	0	754	M,S	May 06
2,330	1,120	0	17.57	3,450	128	621	250	1,076	0	1,326	845	600	0	600	759	0	0	759	M,S	May 07
2,248	1,102	0	19.76	3,350	174	525	250	722	0	972	845	599	0	599	759	0	0	759	S	May 08
2,237	1,078	0	21.90	3,315	120	500	250	600	0	850	845	575	0	575	750	350	0	1,100		May 09
2,282	1,076	0	24.03	3,358	120	500	250	600	0	850	845	575	0	575	750	350	0	1,100		May 10
2,195	1,072	0	26.16	3,267	120	500	250	600	0	850	845	550	0	550	750	350	0	1,100		May 11
2,195	950	0	28.04	3,145	120	500	250	600	0	850	845	550	0	550	750	350	0	1,100		May 12
2,170	950	0	29.93	3,120	120	500	250	200		450	845	550	0	550	750	350	0	1,100		May 13
2,170	950	0	31.81	3,120	120	500	250			250	500	450		450	677			677		May 14
2,170	950	0	33.70	3,120	120	500	250			250	350	350		350	677			677		May 15
1,997	200			2,197	120	500	250			250	250	250		250	677			677		May 16
1,897	0			1,897	120	500	250			250	175	175		175	677			677		May 17
1,797	0			1,797	120	500	250			250	175	175		175	677			677		May 18
1,722	0			1,722	120	500	250			250	175	175		175	677			677		May 19
1,722	0			1,722	120	500	250			250	175	175		175	677			677		May 20
1,722	0			1,722	120	500	250			250	175	175		175	677			677		May 21
1,722	0			1,722	120	500	250			250	175	175		175	677			677		May 22
1,722	0			1,722	120	500	250			250	175	175		175	677			677		May 23
1,722	0			1,722	120	500	250			250	175	175		175	677			677		May 24
1,722	0			1,722	120	500	250			250	175	175		175	677			677		May 25
1,722	0			1,722	120	500	250			250	175	175		175	677			677		May 26
1,722	0			1,722	120	500	250			250	175	175		175	677			677		May 27
1,722	0			1,722	120	500	250			250	175	175		175	677			677		May 28
1,722	0			1,722	120	500	250			250	175	175		175	677			677		May 29
1,722	0			1,722	120	500	250			250	175	175		175	677			677		May 30
1,722	0			1,722	120	500	250			250	140	140		140	677			677		May 31
VAMP period																				
2,747	548			3,295	201	446	250	424	0	674	845	848	0	848	1,002	124	0	1,125		Mean (cfs):
	33.70							26.08	0.00				0.00			7.61	0.00			Suppl. Water (TAF)

Pulse flow period

Period of desired flow stability

2002 VERNALIS ADAPTIVE MANAGEMENT PLAN (VAMP)

ACCOUNTING OF SUPPLEMENTAL WATER CONTRIBUTIONS

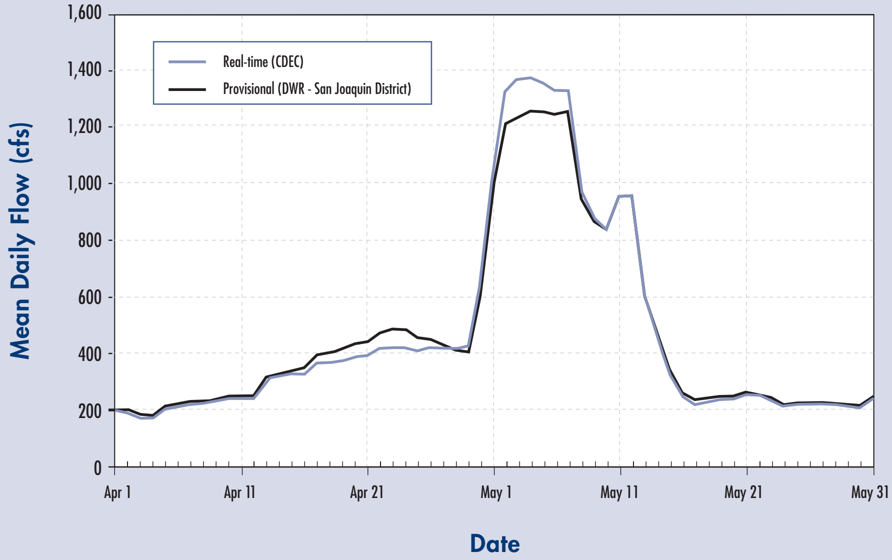
Hydrology Subgroup of the San Joaquin River Technical Committee

Pulse Flow Period: April 15–May 15

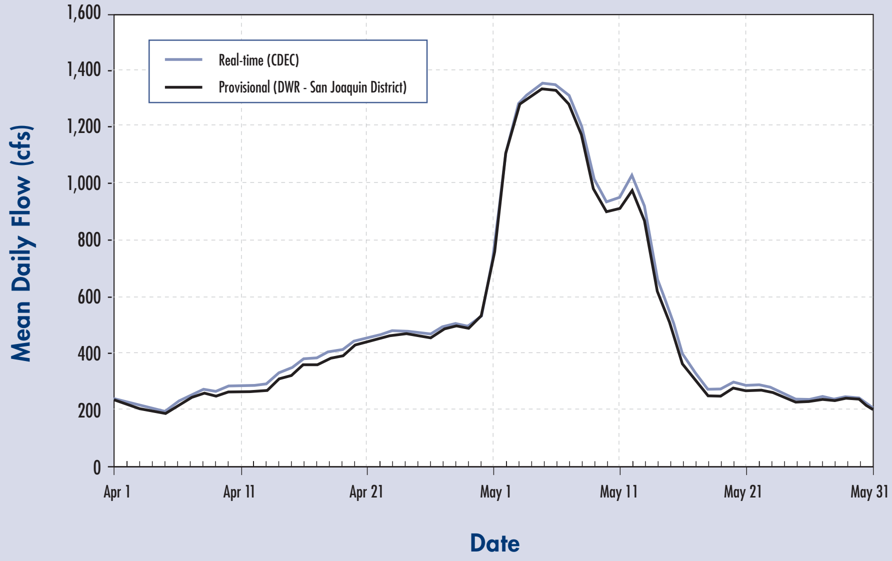
	Merced R. at Cressey (3 Day Travel Time to Vernalis)			Tuolumne R. below LaGrange Dam (2 Day Travel Time to Vernalis)			Stanislaus R. below Goodwin Dam (2 Day Travel Time to Vernalis)			SJRECWA (3 Day)	San Joaquin River at Vernalis		
	Existing Flow	Observed Flow	VAMP Suppl. Water	Existing Flow	Observed Flow	VAMP Suppl. Water	Existing Flow	Observed Flow	VAMP Suppl. Water	VAMP Suppl. Water	Existing Flow	Observed Flow	VAMP Suppl. Water
	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
Apr 01	197	197		169	169		505	505			1,990	1,990	
Apr 02	197	197		171	171		504	504			1,810	1,810	
Apr 03	182	182		170	170		501	501			1,710	1,710	
Apr 04	180	180		172	172		504	504			1,660	1,660	
Apr 05	210	210		171	171		574	574			1,670	1,670	
Apr 06	219	219		172	172		603	603			1,710	1,710	
Apr 07	229	229		173	173		603	603			1,810	1,810	
Apr 08	229	229		175	175		604	604			1,930	1,930	
Apr 09	235	235		174	174		602	602			1,820	1,820	
Apr 10	245	245		170	170		644	644			1,800	1,800	
Apr 11	246	246		170	170		654	654			1,750	1,750	
Apr 12	248	248	0	322	322		789	789		0	1,750	1,750	
Apr 13	250	314	64	704	704	0	1,505	1,505	0	0	1,790	1,790	
Apr 14	250	328	78	708	708	0	1,504	1,504	0	0	2,200	2,200	
Apr 15	250	340	90	709	709	0	1,504	1,504	0	0	2,839	2,839	0
Apr 16	250	347	97	782	782	0	1,503	1,503	0	0	2,896	2,960	64
Apr 17	250	393	143	807	807	0	1,508	1,508	0	0	2,912	2,990	78
Apr 18	250	401	151	804	804	0	1,503	1,503	0	0	3,040	3,130	90
Apr 19	250	411	161	807	807	0	1,502	1,502	0	0	3,103	3,200	97
Apr 20	250	429	179	810	810	0	1,504	1,504	0	0	3,167	3,310	143
Apr 21	250	439	189	810	810	0	1,503	1,503	0	0	3,219	3,370	151
Apr 22	250	472	222	811	811	0	1,502	1,502	0	0	3,269	3,430	161
Apr 23	250	482	232	838	838	0	1,180	1,504	324	0	3,071	3,250	179
Apr 24	250	481	231	1,310	1,310	0	720	1,080	360	0	3,031	3,220	189
Apr 25	250	453	203	1,310	1,310	0	720	1,005	285	0	2,754	3,300	546
Apr 26	250	447	197	1,290	1,290	0	720	1,005	285	0	2,818	3,410	592
Apr 27	250	427	177	1,310	1,310	0	720	954	234	0	2,933	3,449	516
Apr 28	250	406	156	1,310	1,310	0	720	951	231	0	3,001	3,489	488
Apr 29	250	400	150	1,310	1,310	0	720	951	231	0	3,179	3,610	431
Apr 30	250	612	362	1,310	1,310	0	720	859	139	0	3,162	3,570	408
May 01	250	976	726	1,260	1,260	0	756	756	0	0	3,003	3,390	387
May 02	250	1,210	960	897	897	0	754	754	0	0	3,021	3,310	289
May 03	250	1,230	980	620	620	0	753	753	0	0	2,998	3,360	362
May 04	250	1,250	1,000	607	607	0	752	752	0	0	2,664	3,390	726
May 05	250	1,250	1,000	603	603	0	752	752	0	0	2,470	3,430	960
May 06	250	1,240	990	607	607	0	754	754	0	0	2,520	3,500	980
May 07	250	1,250	1,000	608	608	0	759	759	0	0	2,459	3,459	1,000
May 08	250	937	687	607	607	0	759	759	0	0	2,360	3,360	1,000
May 09	250	862	612	584	584	0	750	1,066	316	0	2,250	3,240	990
May 10	250	833	583	591	591	0	750	1,101	351	0	2,170	3,170	1,000
May 11	250	954	704	567	567	0	750	1,113	363	0	2,287	3,290	1,003
May 12	250	956	706	566	566	0	750	1,101	351	0	2,397	3,360	963
May 13	250	595		553	553	0	750	1,106	356		2,454	3,400	946
May 14	250	463		456	456		1,107	1,107			2,155	3,210	1,055
May 15	250	335		358	358		1,105	1,105			1,868	2,930	1,062
May 16	254	254		265	265		1,105	1,105			2,345	2,690	
May 17	229	229		218	218		1,099	1,099			2,237	2,450	
May 18	234	234		219	219		1,104	1,104			2,275	2,360	
May 19	240	240		217	217		1,103	1,103			2,310	2,310	
May 20	243	243		224	224		1,095	1,095			2,340	2,340	
May 21	255	255		222	222		921	921			2,380	2,380	
May 22	248	248		218	218		899	899			2,310	2,310	
May 23	235	235		217	217		901	901			2,140	2,140	
May 24	212	212		216	216		903	903			2,120	2,120	
May 25	217	217		216	216		903	903			2,030	2,030	
May 26	217	217		217	217		901	901			2,100	2,100	
May 27	218	218		216	216		905	905			2,180	2,180	
May 28	214	214		217	217		903	903			2,080	2,080	
May 29	211	211		217	217		754	754			1,950	1,950	
May 30	209	209		223	223		581	581			1,910	1,910	
May 31	241	241		181	181		504	504			1,760	1,760	
Total Supplemental Water (TAF):			25.84			0.00			7.59	0.00			33.43
Pulse Period Average:											2,757	3,301	

Observed Flow Sources:
Merced River at Cressey (CA DWR B05155): DWR San Joaquin District, provisional data received July 2, 2002. • Tuolumne River below LaGrange Dam near LaGrange (USGS 11289650): USGS, provisional data dated July 1, 2002. • Stanislaus River below Goodwin Dam: Goodwin Reservoir Daily Operations report, OID/SSJID/Tri-Dams (published by USBR CVO) • San Joaquin River near Vernalis (USGS 11303500): USGS, provisional data dated July 1, 2002.

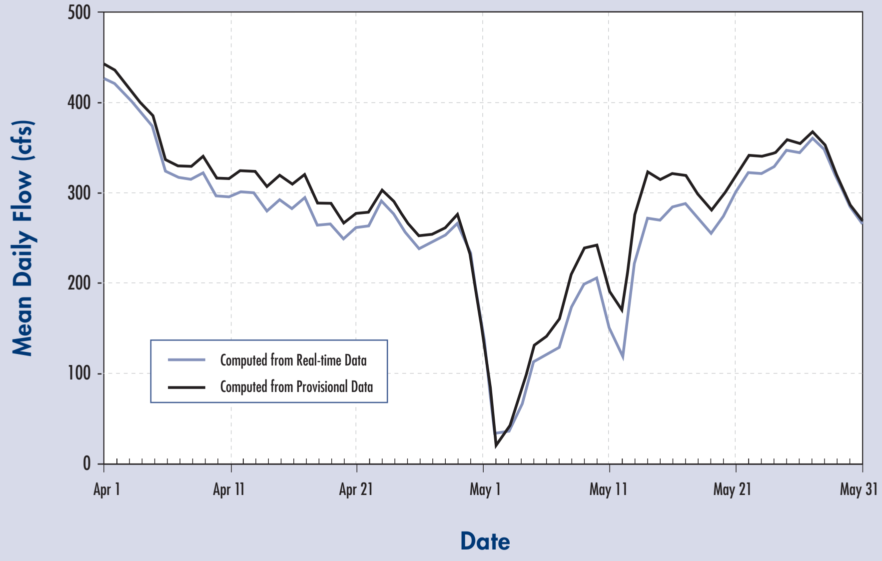
Merced River Near Cressey



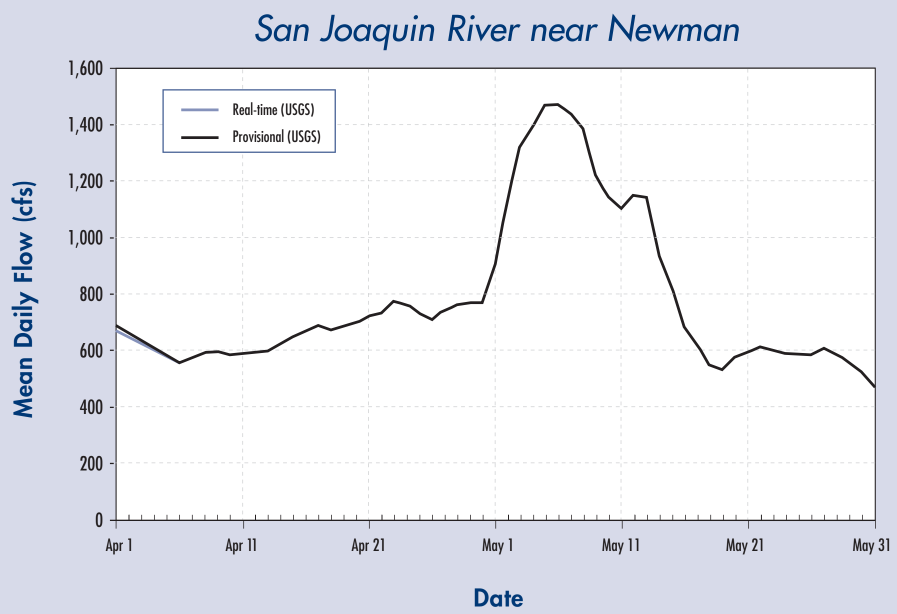
Merced River Near Stevinson

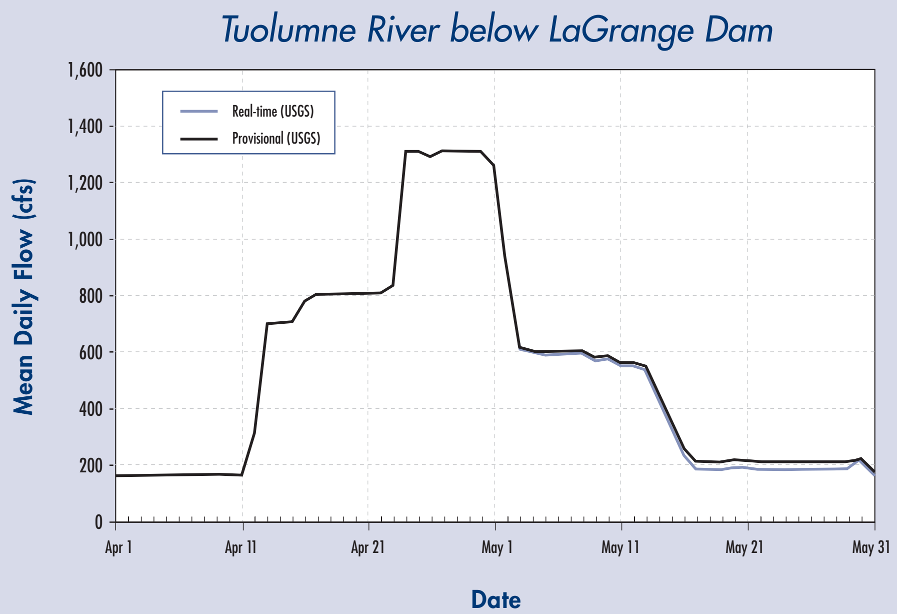


San Joaquin River Above Merced River



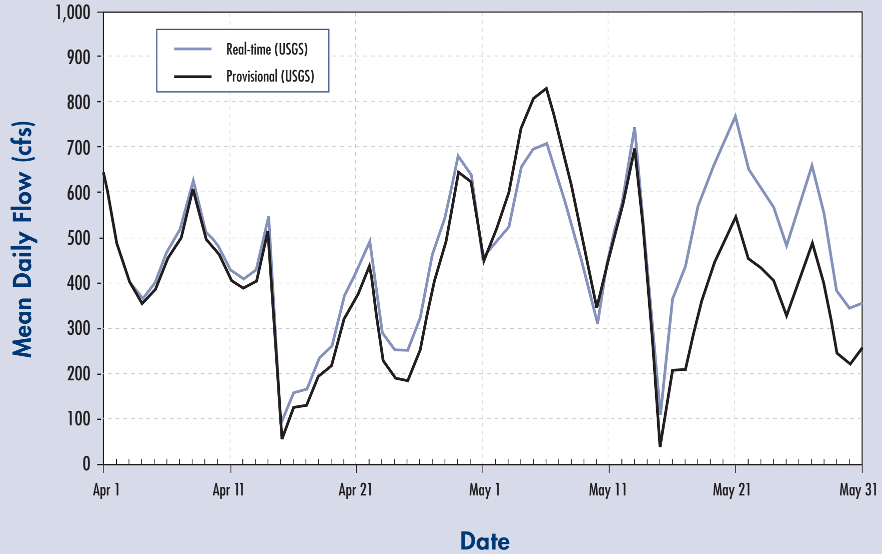
COMPARISON OF "REAL-TIME" AND PROVISIONAL FLOWS



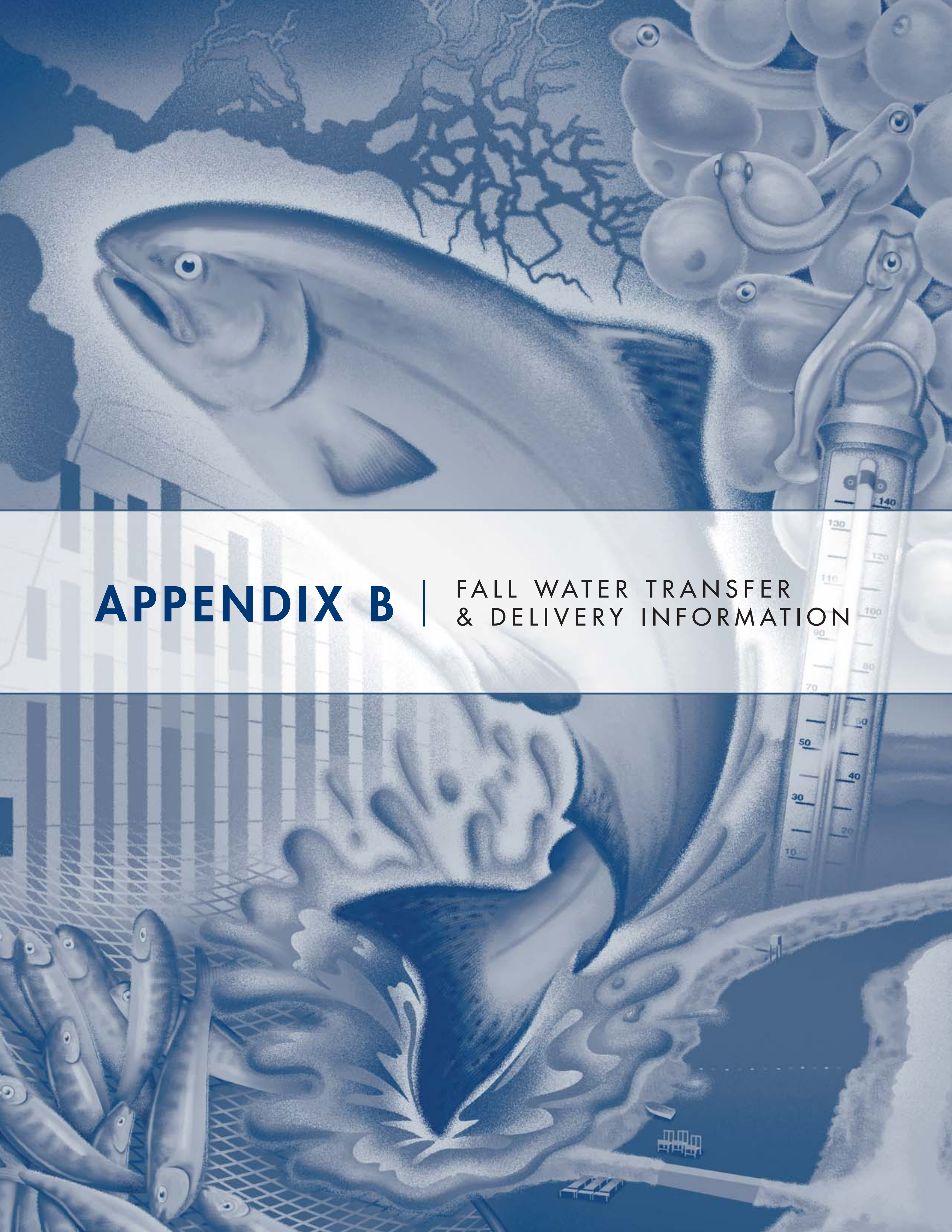


San Joaquin River near Vernalis

Ungaged Flow at Vernalis



APPENDIX B | FALL WATER TRANSFER & DELIVERY INFORMATION



MERCED IRRIGATION DISTRICT (PRELIMINARY)

2002 Fall SJRA Water Transfer • Daily Flow Schedule

	SJRA Transfer Water			
	Merced River at Cressey Base Flow	Flow	Cumulative Volume	Merced River at Cressey Target Flow
	(cfs)	(cfs)	(acre-feet)	(cfs)
Oct 01	30	0	0	30
Oct 02	30	0	0	30
Oct 03	30	0	0	30
Oct 04	30	0	0	30
Oct 05	30	0	0	30
Oct 06	30	0	0	30
Oct 07	30	0	0	30
Oct 08	30	0	0	30
Oct 09	30	0	0	30
Oct 10	30	0	0	30
Oct 11	30	0	0	30
Oct 12	30	0	0	30
Oct 13	30	0	0	30
Oct 14	30	0	0	30
Oct 15	30	220	436	250
Oct 16	85	350	1,131	435
Oct 17	85	625	2,370	710
Oct 18	85	625	3,610	710
Oct 19	85	625	4,850	710
Oct 20	85	625	6,089	710
Oct 21	85	625	7,329	710
Oct 22	85	625	8,569	710
Oct 23	85	625	9,808	710
Oct 24	85	390	10,582	475
Oct 25	85	240	11,058	325
Oct 26	85	120	11,296	205
Oct 27	85	120	11,534	205
Oct 28	85	120	11,772	205
Oct 29	85	120	12,010	205
Oct 30	85	120	12,248	205
Oct 31	85	120	12,486	205

MERCED IRRIGATION DISTRICT (FINAL)

2001 Fall Water Transfer • Daily Flow Summary

			SJRA Transfer Water			EWA Transfer Water					
	Merced River Base Flow for SJRA Transfer Water (cfs)	Merced River at Cressey Observed Mean Daily Flow (cfs)	SJRA Transfer Water (cfs)		SJRA Transfer Water Cumulative Volume (ac-ft)	Observed Livingston Spill (cfs)	Livingston Spill Applied to Transfer (cfs)	Merced River Below Livingston Spill - for Transfer (cfs)	Total EWA Transfer Water Flow (cfs)		EWA Transfer Balance (ac-ft)
		DWR Provisional	Scheduled	Observed					Scheduled	Observed	
Oct 01	30	111	0	0	0	0	0	111	0	0	0
Oct 02	30	112	0	0	0	0	0	112	0	0	0
Oct 03	30	105	0	0	0	0	0	105	0	0	0
Oct 04	30	105	0	0	0	0	0	105	0	0	0
Oct 05	30	102	0	0	0	1	0	102	0	0	0
Oct 06	30	86	0	0	0	13	0	86	0	0	0
Oct 07	30	111	0	0	0	4	0	111	0	0	0
Oct 08	30	111	0	0	0	1	0	111	0	0	0
Oct 09	30	115	0	0	0	0	0	115	0	0	0
Oct 10	30	114	0	0	0	0	0	114	0	0	0
Oct 11	30	113	0	0	0	0	0	113	0	0	0
Oct 12	30	114	0	0	0	1	0	114	0	0	0
Oct 13	30	116	0	0	0	0	0	116	0	0	0
Oct 14	30	116	0	0	0	0	0	116	0	0	0
Oct 15	30	119	0	0	0	1	0	119	0	0	0
Oct 16	85	173	0	0	0	4	0	173	85	85	169
Oct 17	85	422	0	0	0	8	0	422	335	335	833
Oct 18	85	598	0	0	0	4	0	598	510	510	1,845
Oct 19	85	684	0	0	0	3	0	684	600	599	3,033
Oct 20	85	699	0	0	0	4	0	699	610	610	4,243
Oct 21	85	732	0	0	0	0	0	732	635	635	5,503
Oct 22	85	747	0	0	0	0	0	747	635	635	6,763
Oct 23	85	738	0	0	0	0	0	738	635	635	8,023
Oct 24	85	744	0	0	0	0	0	744	635	635	9,283
Oct 25	85	738	0	0	0	0	0	738	635	635	10,543
Oct 26	85	726	0	0	0	8	0	726	635	635	11,803
Oct 27	85	716	0	0	0	0	0	716	635	631	13,055
Oct 28	85	724	0	0	0	4	0	724	635	635	14,315
Oct 29	85	737	0	0	0	11	0	737	635	635	15,575
Oct 30	85	733	0	0	0	17	0	733	635	635	16,835
Oct 31	85	735	0	0	0	46	0	735	635	635	18,095
Nov 01	220	516	0	0	0	86	86	602	380	380	18,849
Nov 02	220	466	0	0	0	111	111	577	355	355	19,553
Nov 03	220	448	0	0	0	106	106	554	315	315	20,178
Nov 04	220	429	0	0	0	91	91	520	305	300	20,773
Nov 05	220	430	0	0	0	90	90	520	305	300	21,368
Nov 06	220	430	0	0	0	96	96	526	305	305	21,973
Nov 07	220	435	0	0	0	95	95	530	305	305	22,578
Nov 08	220	442	0	0	0	101	101	543	305	305	23,183
Nov 09	220	438	0	0	0	105	105	543	305	305	23,788
Nov 10	220	444	0	0	0	107	107	551	305	305	24,393
Nov 11	220	422	0	0	0	106	106	528	305	305	24,998
Nov 12	220	394	140	140	278	67	0	394	0	0	24,998
Nov 13	220	409	140	140	555	51	0	409	0	0	24,998
Nov 14	220	397	140	140	833	14	0	397	0	0	24,998
Nov 15	220	397	140	140	1,111	4	0	397	0	0	24,998

MERCED IRRIGATION DISTRICT (FINAL)

2001 Fall Water Transfer • Daily Flow Summary

		SJRA Transfer Water			EWA Transfer Water						
Merced River Base Flow for SJRA Transfer Water (cfs)	Merced River at Cressey Observed Mean Daily Flow (cfs)	SJRA Transfer Water (cfs)		SJRA Transfer Water Cumulative Volume (ac-ft)	Observed Livingston Spill (cfs)	Livingston Spill Applied to Transfer (cfs)	Merced River Below Livingston Spill - for Transfer (cfs)	Total EWA Transfer Water Flow (cfs)		EWA Transfer Balance (ac-ft)	
	DWR Provisional	Scheduled	Observed					Scheduled	Observed		
220	397	140	140	1,388	0	0	397	0	0	24,998	Nov 16
220	402	140	140	1,666	0	0	402	0	0	24,998	Nov 17
220	401	140	140	1,944	0	0	401	0	0	24,998	Nov 18
220	402	140	140	2,221	0	0	402	0	0	24,998	Nov 19
220	412	140	140	2,499	0	0	412	0	0	24,998	Nov 20
220	410	140	140	2,777	0	0	410	0	0	24,998	Nov 21
220	411	140	140	3,055	0	0	411	0	0	24,998	Nov 22
220	408	140	140	3,332	0	0	408	0	0	24,998	Nov 23
220	423	140	140	3,610	0	0	423	0	0	24,998	Nov 24
220	431	140	140	3,888	1	0	431	0	0	24,998	Nov 25
220	419	140	140	4,165	2	0	419	0	0	24,998	Nov 26
220	416	120	120	4,403	0	0	416	0	0	24,998	Nov 27
220	420	120	120	4,641	0	0	420	0	0	24,998	Nov 28
220	424	120	120	4,879	0	0	424	0	0	24,998	Nov 29
220	428	120	120	5,117	0	0	428	0	0	24,998	Nov 30
220	435	120	120	5,355	0	0	435	0	0	24,998	Dec 01
220	426	120	120	5,593	0	0	426	0	0	24,998	Dec 02
220	448	120	120	5,831	3	0	448	0	0	24,998	Dec 03
220	422	120	120	6,069	2	0	422	0	0	24,998	Dec 04
220	416	120	120	6,307	1	0	416	0	0	24,998	Dec 05
220	414	120	120	6,545		0	414	0	0	24,998	Dec 06
220	409	120	120	6,783		0	409	0	0	24,998	Dec 07
220	410	120	120	7,021		0	410	0	0	24,998	Dec 08
220	404	120	120	7,260		0	404	0	0	24,998	Dec 09
220	401	120	120	7,498		0	401	0	0	24,998	Dec 10
220	415	120	120	7,736		0	415	0	0	24,998	Dec 11
220	407	120	120	7,974		0	407	0	0	24,998	Dec 12
220	396	120	120	8,212		0	396	0	0	24,998	Dec 13
220	405	120	120	8,450		0	405	0	0	24,998	Dec 14
220	398	120	120	8,688		0	398	0	0	24,998	Dec 15
220	393	120	120	8,926		0	393	0	0	24,998	Dec 16
220	394	120	120	9,164		0	394	0	0	24,998	Dec 17
220	395	120	120	9,402		0	395	0	0	24,998	Dec 18
220	393	120	120	9,640		0	393	0	0	24,998	Dec 19
220	401	120	120	9,878		0	401	0	0	24,998	Dec 20
220	429	120	120	10,116		0	429	0	0	24,998	Dec 21
220	425	120	120	10,354		0	425	0	0	24,998	Dec 22
220	415	120	120	10,592		0	415	0	0	24,998	Dec 23
220	406	120	120	10,830		0	406	0	0	24,998	Dec 24
220	406	120	120	11,068		0	406	0	0	24,998	Dec 25
220	403	120	120	11,306		0	403	0	0	24,998	Dec 26
220	400	120	120	11,544		0	400	0	0	24,998	Dec 27
220	403	120	120	11,782		0	403	0	0	24,998	Dec 28
220	996	120	120	12,020		0	996	0	0	24,998	Dec 29
220	1,400	120	120	12,258		0	1,400	0	0	24,998	Dec 30
220	1,030	120	120	12,496		0	1,030	0	0	24,998	Dec 31

OAKDALE IRRIGATION DISTRICT (PRELIMINARY)

Daily Schedule of Additional Water Release
Additional Water Available: 22,205 acre-feet

Subject to change

	DFG Base Fish Flow (cfs)	Total Fish Release (cfs)	Scheduled: Flow (cfs)	Scheduled: Cumulative Volume (ac-ft)
			Oakdale ID Additional Water	
Oct 19 '02	200	200	0	0
Oct 20 '02	200	350	150	298
Oct 21 '02	200	600	400	1,091
Oct 22 '02	200	700	500	2,083
Oct 23 '02	200	700	500	3,074
Oct 24 '02	200	700	500	4,066
Oct 25 '02	200	700	500	5,058
Oct 26 '02	200	700	500	6,050
Oct 27 '02	200	700	500	7,041
Oct 28 '02	200	450	250	7,537
Oct 29 '02	200	250	50	7,636
Oct 30 '02	200	250	50	7,736
Oct 31 '02	200	250	50	7,835
Nov 01 '02	200	250	50	7,934
Nov 02 '02	200	250	50	8,033
Nov 03 '02	200	250	50	8,132
Nov 04 '02	200	250	50	8,231
Nov 05 '02	200	250	50	8,331
Nov 06 '02	200	250	50	8,430
Nov 07 '02	200	275	75	8,579
Nov 08 '02	200	300	100	8,777
Nov 09 '02	200	300	100	8,975
Nov 10 '02	200	300	100	9,174
Nov 11 '02	200	300	100	9,372
Nov 12 '02	200	300	100	9,570
Nov 13 '02	200	300	100	9,769
Nov 14 '02	200	300	100	9,967
Nov 15 '02	200	300	100	10,165
Nov 16 '02	200	300	100	10,364
Nov 17 '02	200	300	100	10,562
Nov 18 '02	200	300	100	10,760
Nov 19 '02	200	300	100	10,959
Nov 20 '02	200	300	100	11,157
Nov 21 '02	200	300	100	11,355
Nov 22 '02	200	300	100	11,554
Nov 23 '02	200	300	100	11,752
Nov 24 '02	200	300	100	11,950
Nov 25 '02	200	300	100	12,149
Nov 26 '02	200	300	100	12,347
Nov 27 '02	200	300	100	12,545
Nov 28 '02	200	300	100	12,744
Nov 29 '02	200	300	100	12,942
Nov 30 '02	200	300	100	13,140
Dec 01 '02	200	275	75	13,289
Dec 02 '02	200	275	75	13,438

OAKDALE IRRIGATION

Daily Schedule of
Additional Water Available:

	DFG Base Fish Flow (cfs)	Total Fish Release (cfs)
Dec 03 '02	200	275
Dec 04 '02	200	275
Dec 05 '02	200	275
Dec 06 '02	200	275
Dec 07 '02	200	275
Dec 08 '02	200	275
Dec 09 '02	200	275
Dec 10 '02	200	275
Dec 11 '02	200	275
Dec 12 '02	200	275
Dec 13 '02	200	275
Dec 14 '02	200	275
Dec 15 '02	200	275
Dec 16 '02	200	275
Dec 17 '02	200	275
Dec 18 '02	200	275
Dec 19 '02	200	275
Dec 20 '02	200	275
Dec 21 '02	200	275
Dec 22 '02	200	275
Dec 23 '02	200	275
Dec 24 '02	200	275
Dec 25 '02	200	275
Dec 26 '02	200	275
Dec 27 '02	200	275
Dec 28 '02	200	275
Dec 29 '02	200	275
Dec 30 '02	200	275
Dec 31 '02	200	275
Jan 01 '03	175	225
Jan 02 '03	175	225
Jan 03 '03	175	225
Jan 04 '03	175	225
Jan 05 '03	175	225
Jan 06 '03	175	225
Jan 07 '03	175	225
Jan 08 '03	175	225
Jan 09 '03	175	225
Jan 10 '03	175	225
Jan 11 '03	175	225
Jan 12 '03	175	225
Jan 13 '03	175	225
Jan 14 '03	175	225
Jan 15 '03	175	225
Jan 16 '03	175	225

DISTRICT (PRELIMINARY)

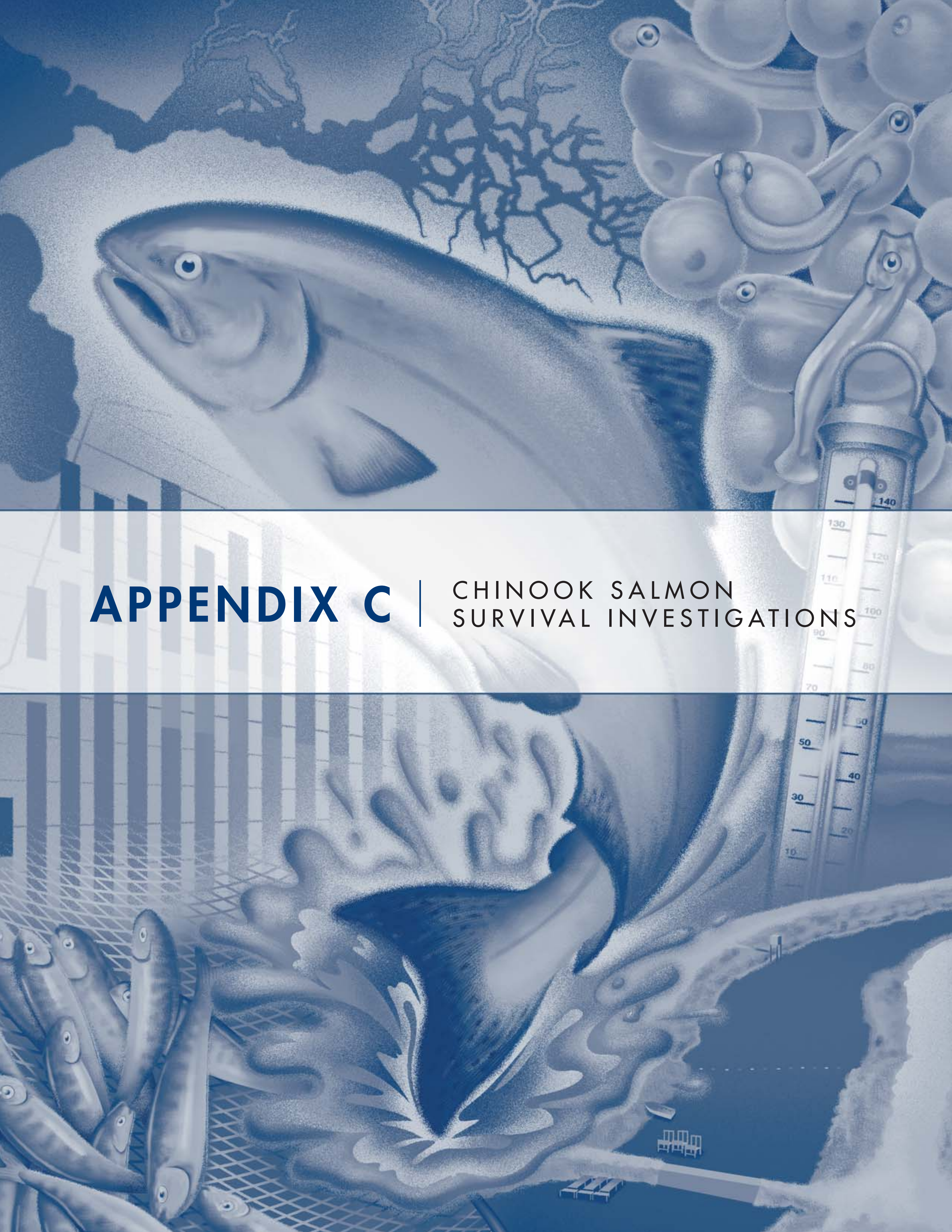
Additional Water Release
22,205 acre-feet
Subject to change

Scheduled Flow (cfs)	Scheduled Cumulative Volume (ac-ft)	
Oakdale ID Additional Water		
75	13,587	Dec 03 '02
75	13,736	Dec 04 '02
75	13,884	Dec 05 '02
75	14,033	Dec 06 '02
75	14,182	Dec 07 '02
75	14,331	Dec 08 '02
75	14,479	Dec 09 '02
75	14,628	Dec 10 '02
75	14,777	Dec 11 '02
75	14,926	Dec 12 '02
75	15,074	Dec 13 '02
75	15,223	Dec 14 '02
75	15,372	Dec 15 '02
75	15,521	Dec 16 '02
75	15,669	Dec 17 '02
75	15,818	Dec 18 '02
75	15,967	Dec 19 '02
75	16,116	Dec 20 '02
75	16,264	Dec 21 '02
75	16,413	Dec 22 '02
75	16,562	Dec 23 '02
75	16,711	Dec 24 '02
75	16,859	Dec 25 '02
75	17,008	Dec 26 '02
75	17,157	Dec 27 '02
75	17,306	Dec 28 '02
75	17,455	Dec 29 '02
75	17,603	Dec 30 '02
75	17,752	Dec 31 '02
50	17,851	Jan 01 '03
50	17,950	Jan 02 '03
50	18,050	Jan 03 '03
50	18,149	Jan 04 '03
50	18,248	Jan 05 '03
50	18,347	Jan 06 '03
50	18,446	Jan 07 '03
50	18,545	Jan 08 '03
50	18,645	Jan 09 '03
50	18,744	Jan 10 '03
50	18,843	Jan 11 '03
50	18,942	Jan 12 '03
50	19,041	Jan 13 '03
50	19,140	Jan 14 '03
50	19,240	Jan 15 '03
50	19,339	Jan 16 '03

OAKDALE IRRIGATION DISTRICT (PRELIMINARY)

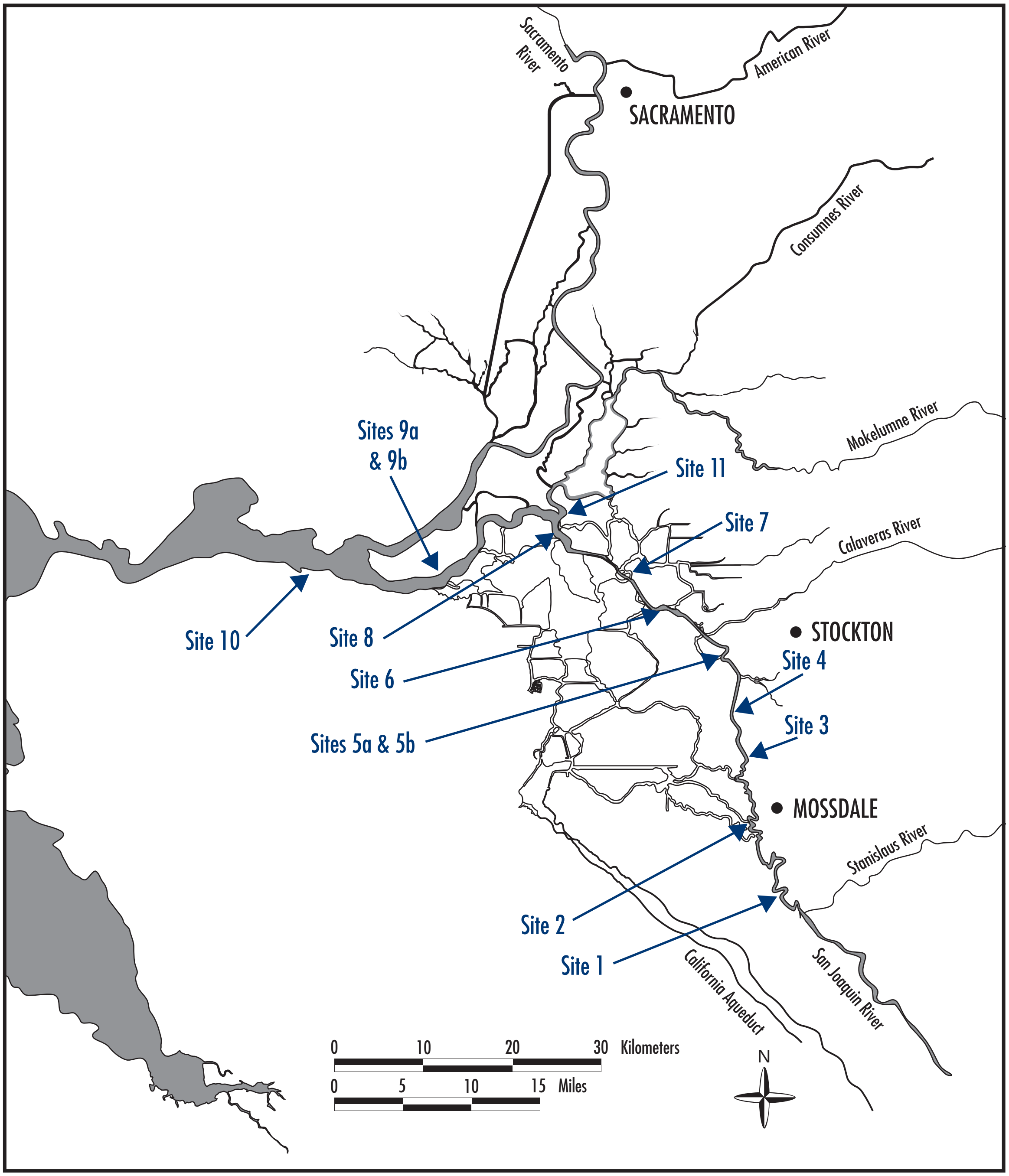
Daily Schedule of Additional Water Release
Additional Water Available: 22,205 acre-feet
Subject to change

DFG Base Fish Flow (cfs)	Scheduled Total Fish Release (cfs)	Scheduled Flow (cfs)	Scheduled Cumulative Volume (ac-ft)	
		Oakdale ID Additional Water		
175	225	50	19,438	Jan 17 '03
175	225	50	19,537	Jan 18 '03
175	225	50	19,636	Jan 19 '03
175	225	50	19,736	Jan 20 '03
175	225	50	19,835	Jan 21 '03
175	225	50	19,934	Jan 22 '03
175	225	50	20,033	Jan 23 '03
175	225	50	20,132	Jan 24 '03
175	225	50	20,231	Jan 25 '03
175	225	50	20,331	Jan 26 '03
175	225	50	20,430	Jan 27 '03
175	225	50	20,529	Jan 28 '03
175	225	50	20,628	Jan 29 '03
175	225	50	20,727	Jan 30 '03
175	200	25	20,777	Jan 31 '03
150	200	50	20,876	Feb 01 '03
150	175	25	20,926	Feb 02 '03
150	175	25	20,975	Feb 03 '03
150	175	25	21,025	Feb 04 '03
150	175	25	21,074	Feb 05 '03
150	175	25	21,124	Feb 06 '03
150	175	25	21,174	Feb 07 '03
150	175	25	21,223	Feb 08 '03
150	175	25	21,273	Feb 09 '03
150	175	25	21,322	Feb 10 '03
150	175	25	21,372	Feb 11 '03
150	175	25	21,421	Feb 12 '03
150	175	25	21,471	Feb 13 '03
150	175	25	21,521	Feb 14 '03
150	175	25	21,570	Feb 15 '03
150	175	25	21,620	Feb 16 '03
150	175	25	21,669	Feb 17 '03
150	175	25	21,719	Feb 18 '03
150	175	25	21,769	Feb 19 '03
150	175	25	21,818	Feb 20 '03
150	175	25	21,868	Feb 21 '03
150	175	25	21,917	Feb 22 '03
150	175	25	21,967	Feb 23 '03
150	175	25	22,017	Feb 24 '03
150	175	25	22,066	Feb 25 '03
150	175	25	22,116	Feb 26 '03
150	175	25	22,165	Feb 27 '03
150	175	25	22,215	Feb 28 '03



APPENDIX C | CHINOOK SALMON SURVIVAL INVESTIGATIONS

SACRAMENTO-SAN JOAQUIN ESTUARY

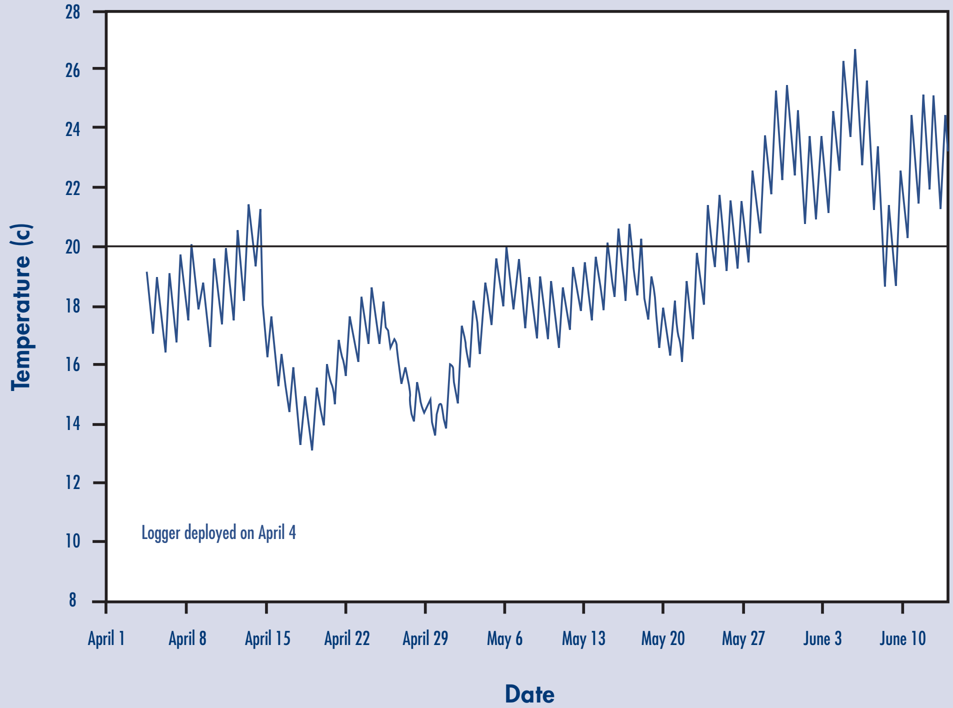


Water Temperature Monitoring Locations During the VAMP 2002 Experiment

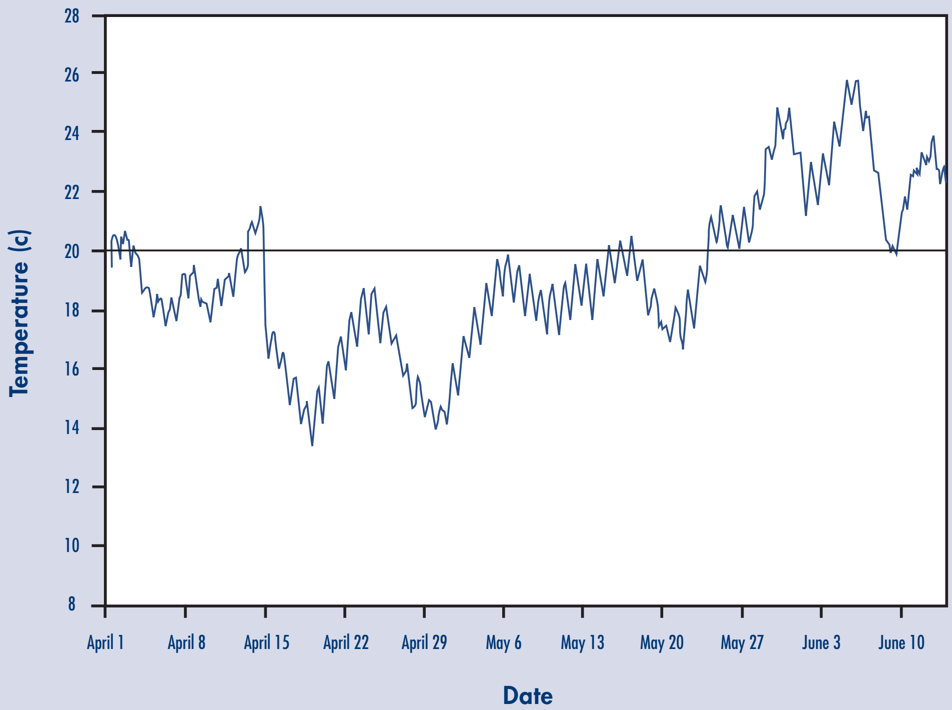
VAMP 2002 WATER TEMPERATURE MONITORING LOCATIONS

Site no.	Temperature Monitoring Location	Latitude	Longitude	Distance from Durham Ferry (mi)	Date Deployed	Date Retrieved	Notes
	Merced River Hatchery–1			n/a	March 15	April 26	In river April 18
	Merced River Hatchery–2			n/a	March 15	April 30	In river April 25
1	Durham Ferry	N 37 41.381	W 121 15.657	n/a	April 4	June 15	In 3 feet of water
2	Mossdale	N 37 47.180	W 121 18.425	11.2	April 1	June 15	In 3 feet of water
3	Dos Reis	N 37 49.808	W 121 18.665	16.4	April 1	June 15	In 3 feet of water
4	DWR Monitoring Station	N 37 51.869	W 121 19.376	19.4	April 1	June 15	In 3 feet of water
5a	Confluence–Top	N 37 56.818	W 121 20.285	26.5	April 1	June 15	2 feet below surface
5b	Confluence–Bottom	N 37 56.818	W 121 20.285	26.5	April 1	June 15	On river bottom
6	Downstream of Channel Marker 30	N 37 59.776	W 121 25.569	33.3	April 1	June 15	In 3 feet of water
7	1/2 mile Upstream of Channel Marker 13	N 38 01.940	W 121 28.769	37.3	April 1	June 15	In 3 feet of water
8	Downstream of Channel Marker 36	N 38 04.522	W 121 34.413	44.7	April 1	June 15	In 3 feet of water
9a	Jersey Point USGS Gauging Station–top	N 38 03.172	W121 41.637	56	April 1	June 15	2 feet below surface
9b	Jersey Point USGS Gauging Station–bottom	N 38 03.172	W121 41.637	56	April 1		Logger lost
10	Chipps Island	N 38 03.084	W 121 55.463	71.5	April 1	June 15	In 3 feet of water
11	Mokelumne River	N 38 06.334	W 121 34.213	40	April 1	June 15	In 3 feet of water

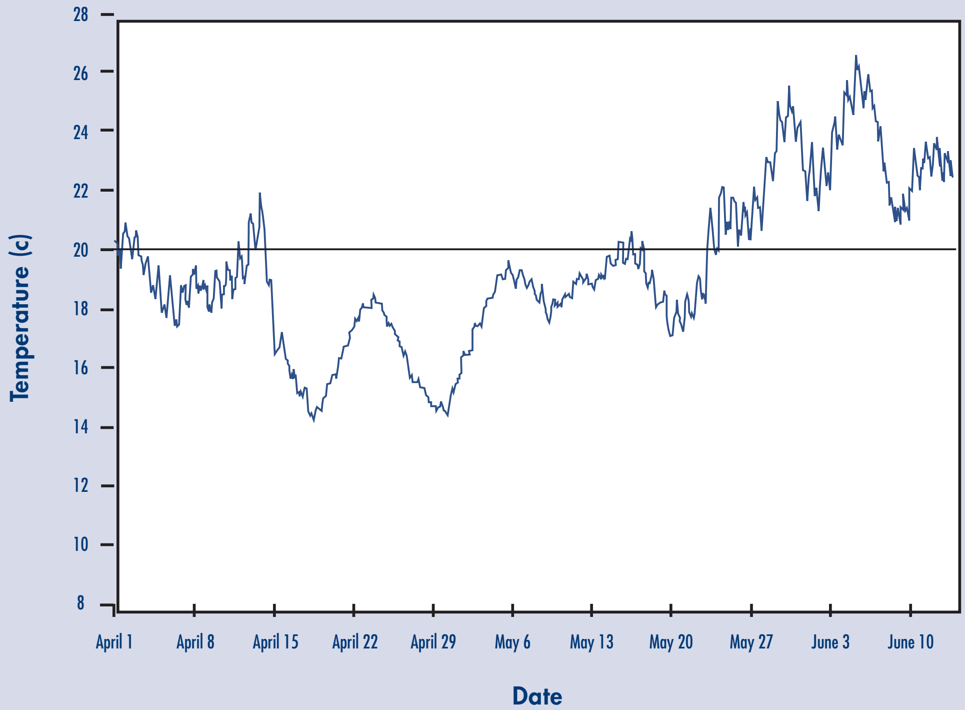
Site 1 • Durham Ferry



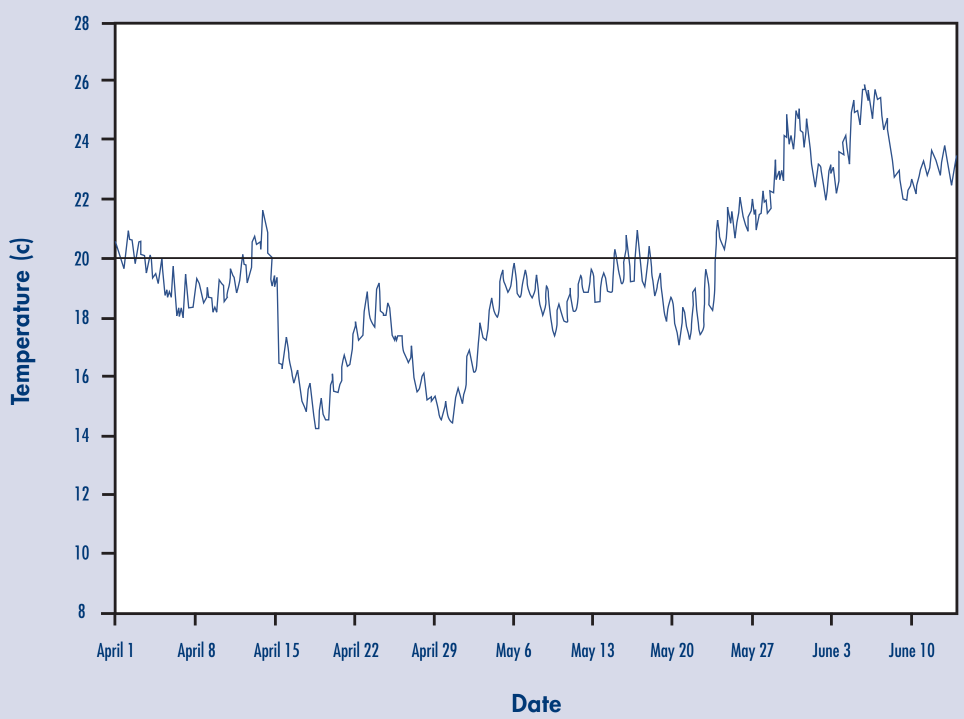
Site 2 • Mossdale



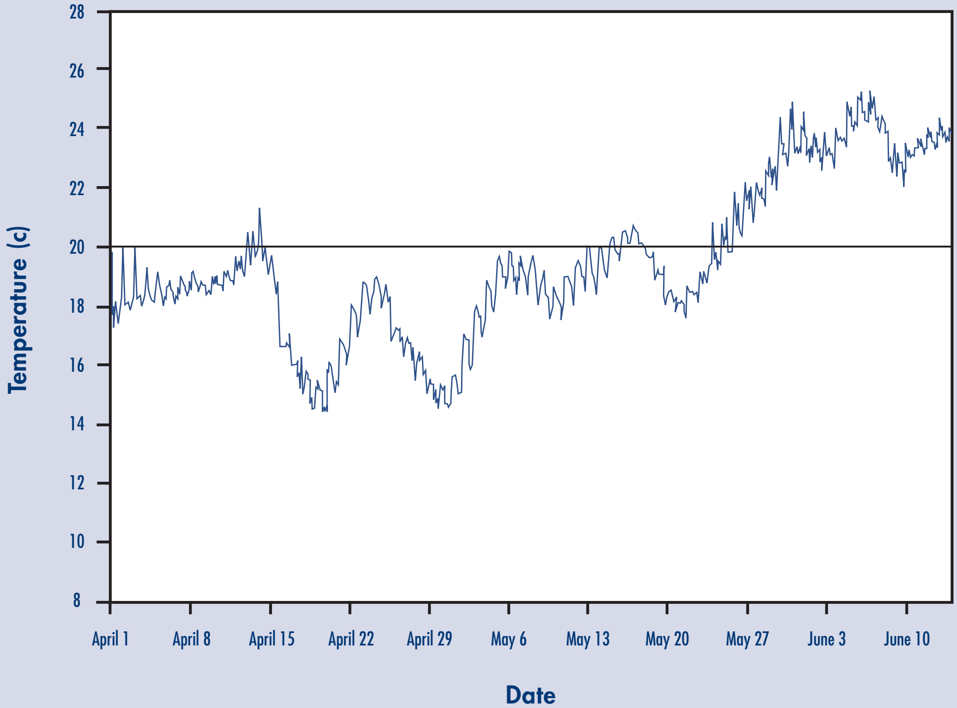
Site 3 • Dos Reis



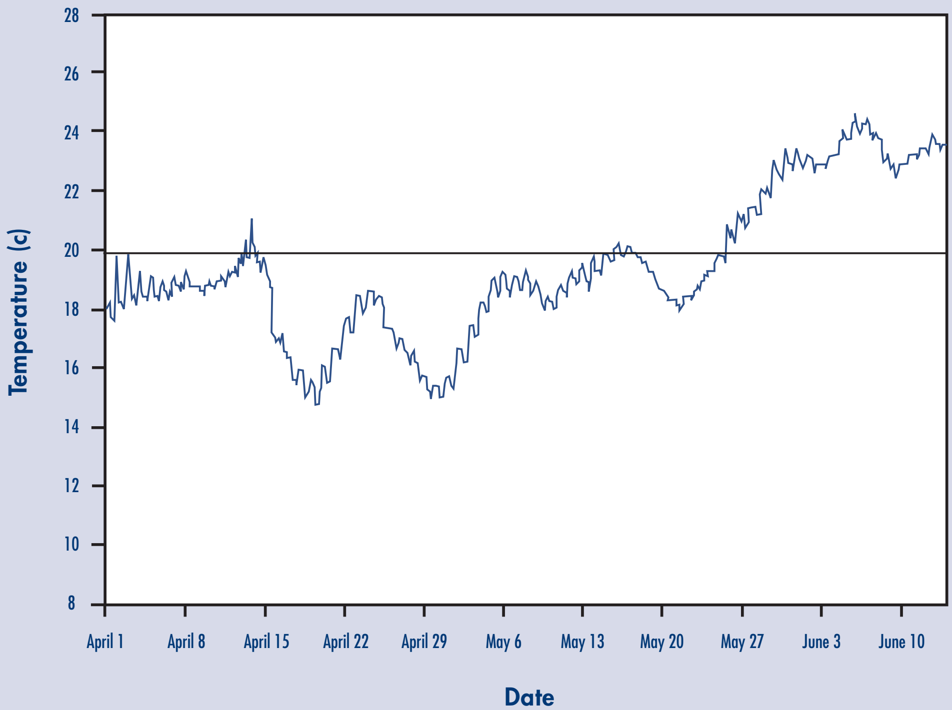
Site 4 • DWR Monitoring Station



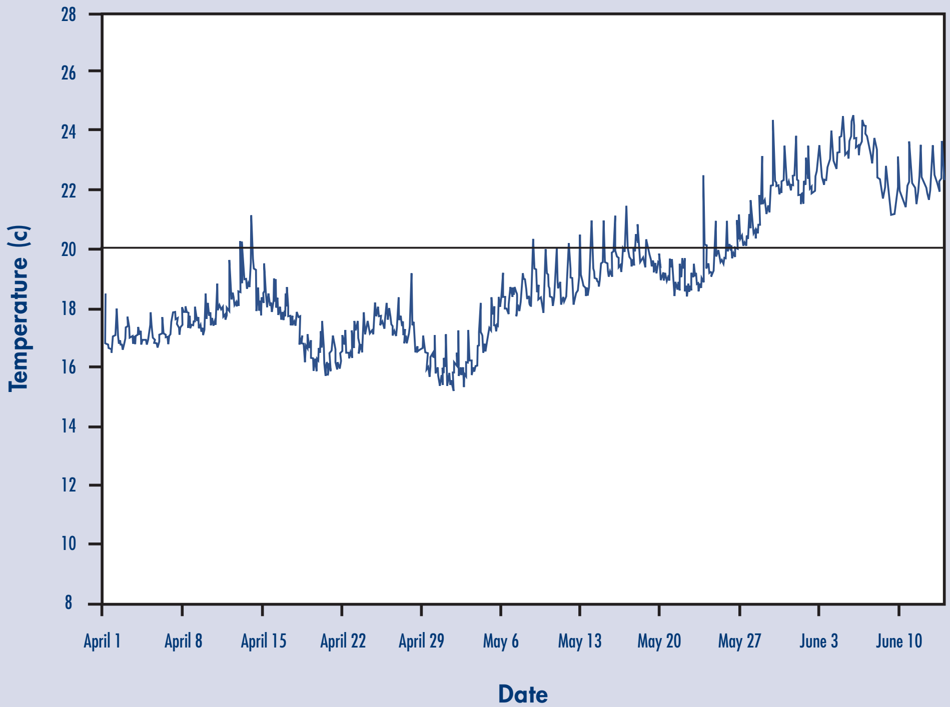
Site 5a • Confluence-Top



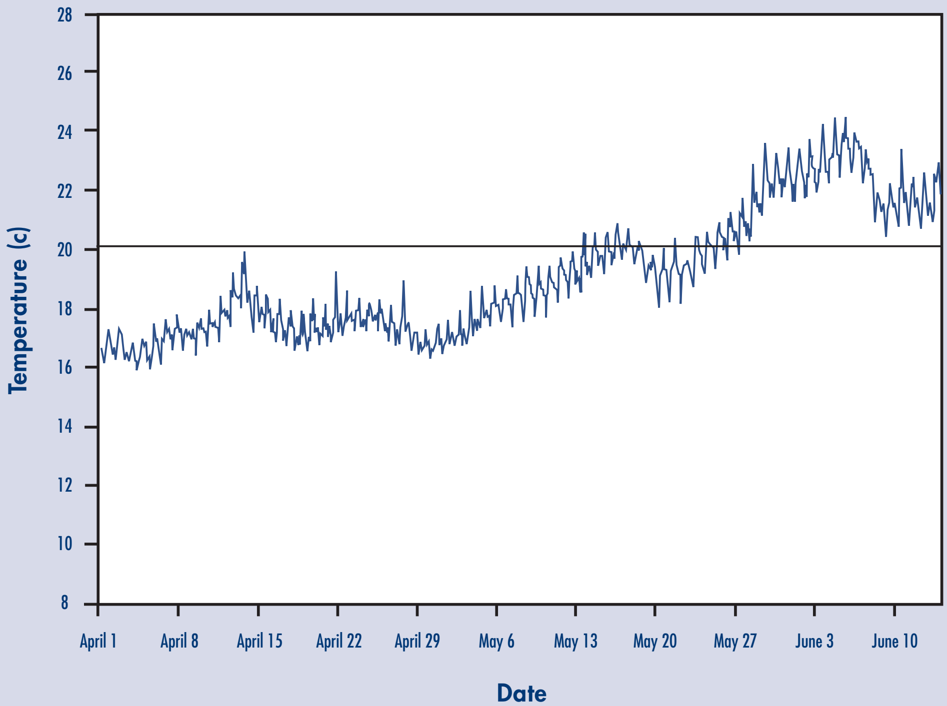
Site 5b • Confluence-Bottom



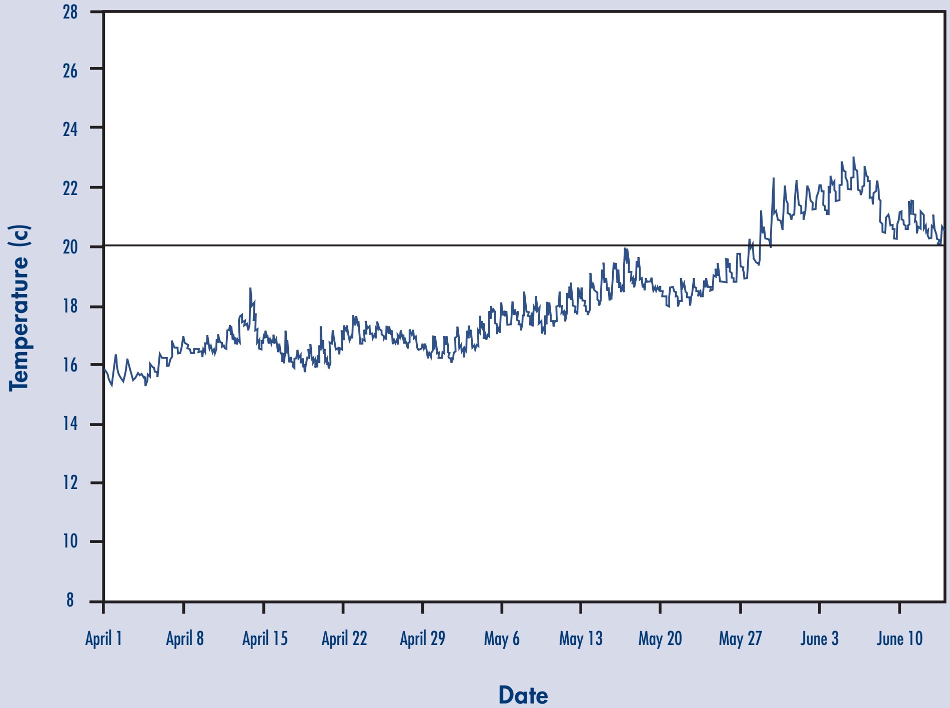
Site 6 • Downstream of Channel Marker 30



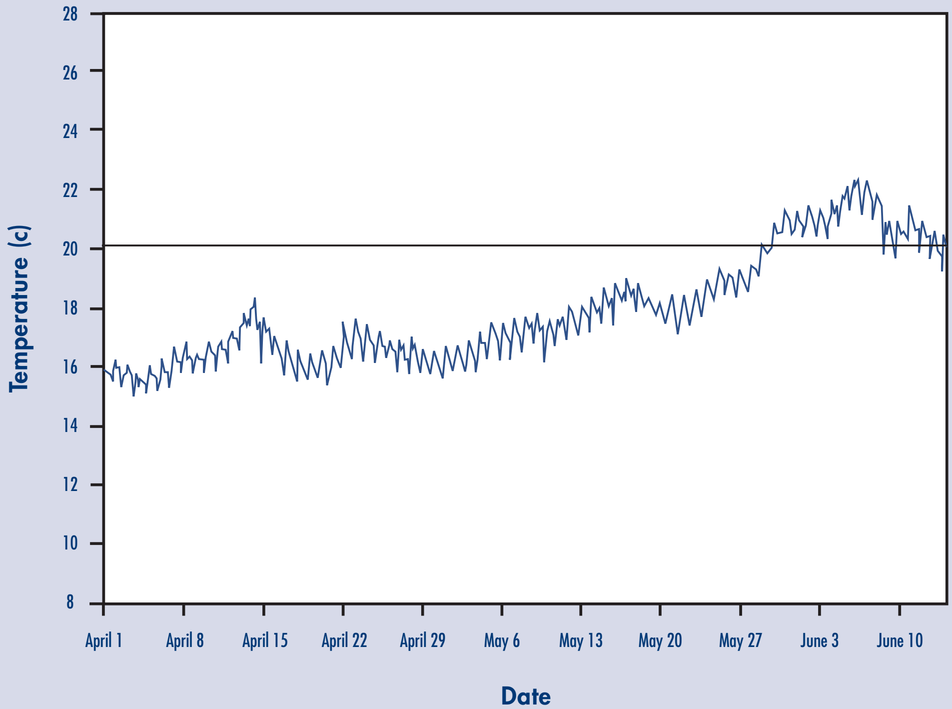
Site 7 • 1/2 Mile Upstream of Channel Marker 13



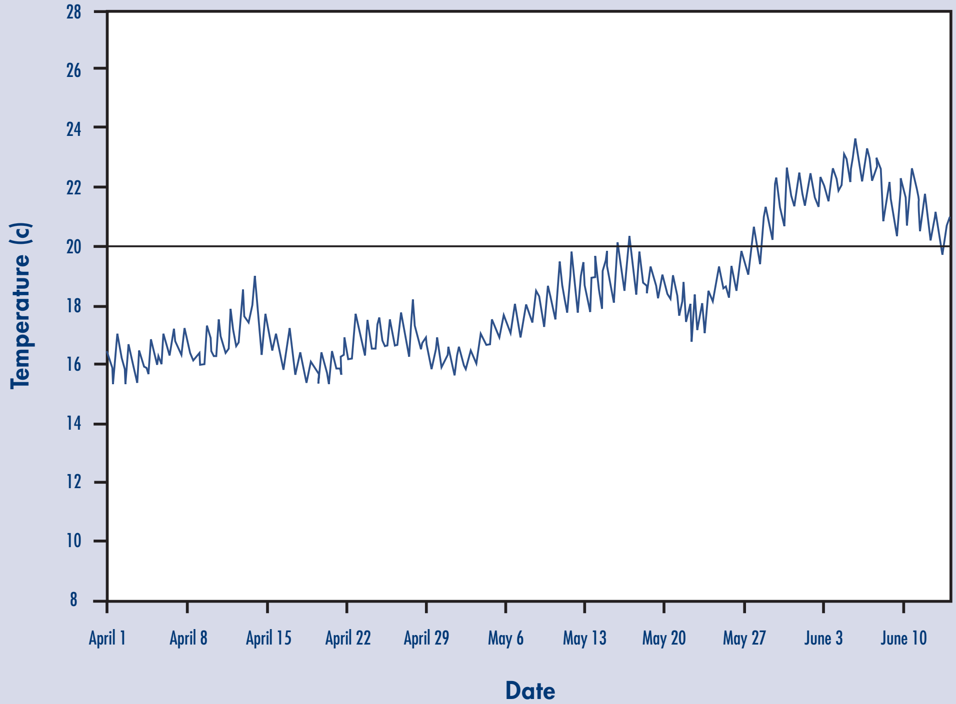
Site 8 • Downstream of Channel Marker 36



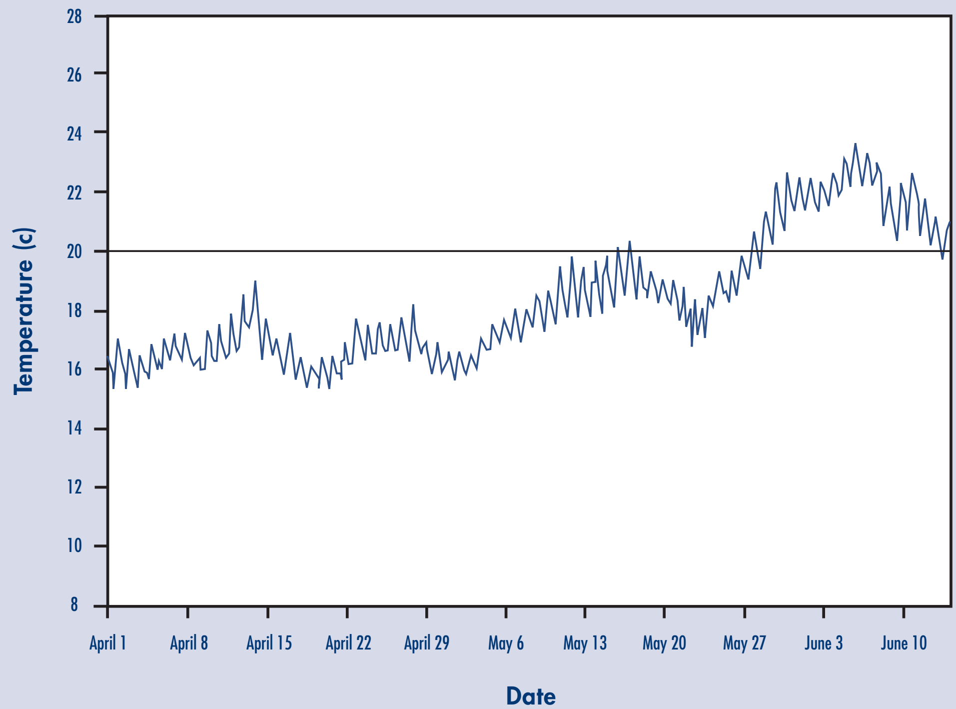
Site 9a • Jersey Point–Top



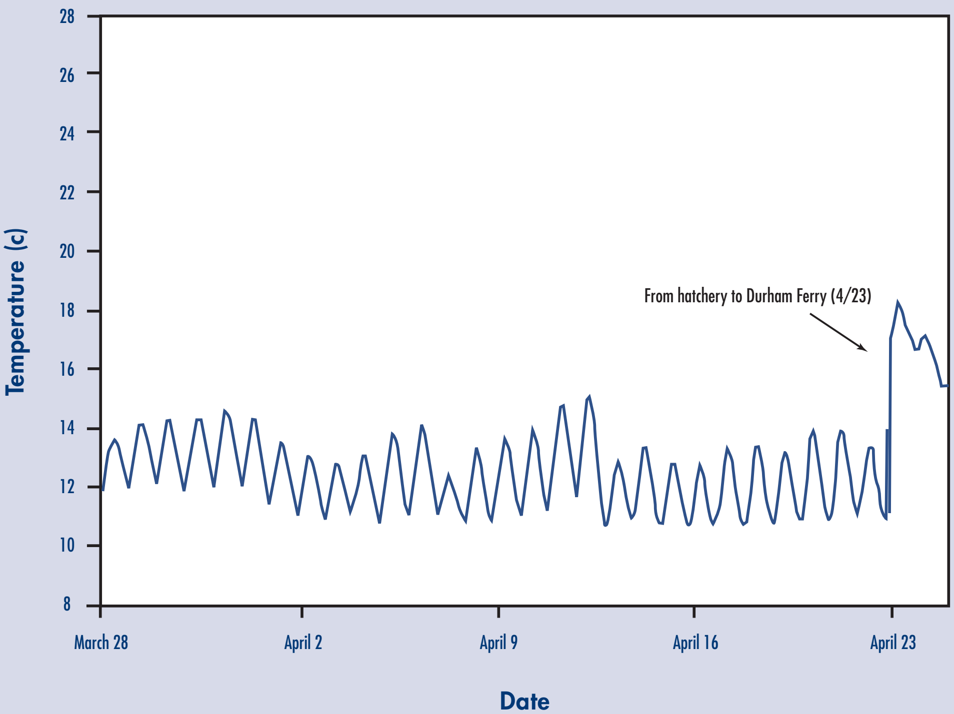
Site 10 • Chipps Island



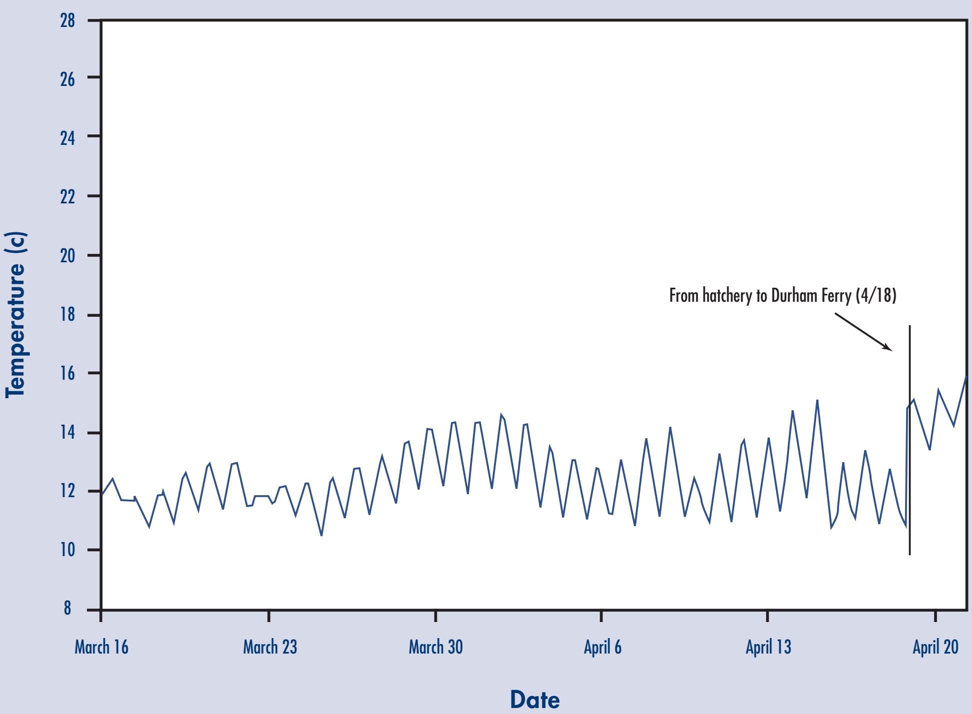
Site 11 • Mokelumne River



Merced River Fish Hatchery – 1



Merced River Fish Hatchery – 2



RESULTS OF NET PEN SAMPLING CONDUCTED IMMEDIATELY AFTER RELEASE, VAMP 2002

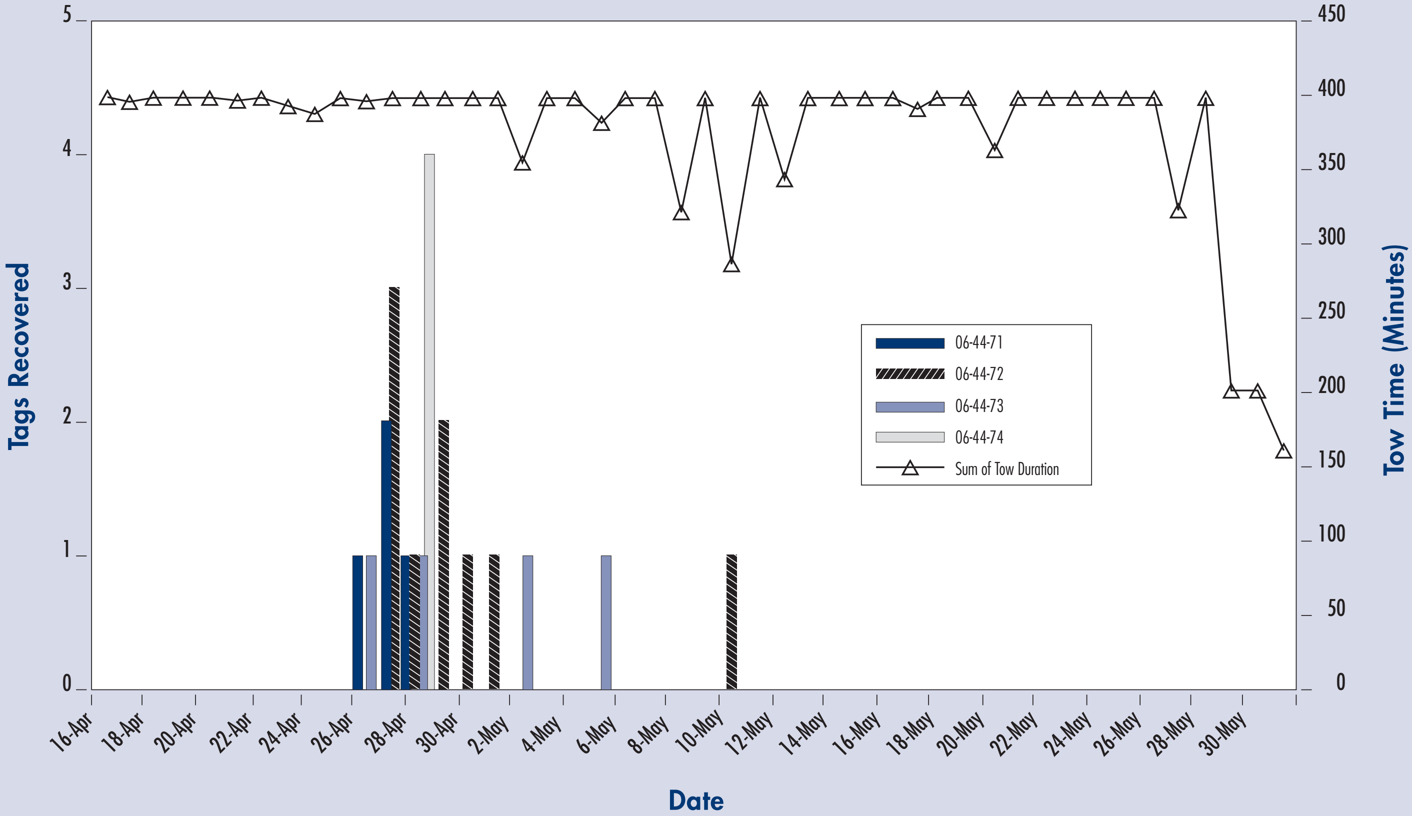
Release location, release date, tag code, number in sample	Mean fork length (and range in millimeters)	Mean weight (and range in grams)	Mean scale loss (and range in percent)	Color	Fin hemorrhaging	Eyes	Gill color	Ad clips, comments and mortalities
Durham Ferry I Pen #1	80.96(64-87)	5.82(2.7-7)	3.8(1-11)	Normal	None	Normal	Normal	0.04 (1 deformed pectoral fin)
Durham Ferry I Pen #2	82.00(74-90)	6.1 (4.4-7.7)	3.6(2-7)	Normal	None	Normal	Normal	
Mossdale I Pen #2	84.5(77-92)	6.7(4.9-8.9)	4.9(1-15)	Normal	None	Normal	Normal	0.04 (1 poor ad clip)
Mossdale I Pen #3	81.9(68-90)	5.9(3.5-8)	3.4(1-15)	Normal	None	Normal	Normal	0.04 (1 deformed pectoral fin)
Jersey Point I Pen #2	85.0(70-95)	6.7(3.6-9.4)	3.6(1-7)	Normal	None	Normal	Normal	0.08 (2 half ad clips) 0.04 (1 deformed pectoral fin)
Jersey Point I Pen #3	82.0(61-92)	6.1(2.4-8.2)	3.3(1-5)	Normal	None	Normal	Normal	0.04 (1 half ad clip) 0.04 (1 deformed pectoral fin)
Group I	82.76(61-95)	6.24(2.4-9.4)	3.77(1-15)					
Durham Ferry II Pen #1	80.1(72-89)	5.8(4.1-8.1)	5.9(2-20)	Normal	None	Normal	Normal	0.04 (1 half adipose fin clip)
Durham Ferry II Pen #2	79.24(67-93)	5.24(3.1-8.4)	12.32(1-25)	Normal	None	Normal	Normal	0.04 (1 caudal fin damage)
Mossdale II Pen #1	82.4(75-104)	6.1(4.4-12.4)	7.3(3-15)	Normal	None	Normal	Normal	0.08 (2 caudal fins damage)
Mossdale II Pen #2	80.2(70-90)	5.43(3.7-7.7)	8.08(2-25)	Normal	None	Normal	Normal	0.04 (caudal/ dorsal clip?) 0.08 (2 no adipose fin clips)
Jersey Point II Pen #2	85.2(77-96)	6.77(4.8-10)	2.44(1-5)	Normal	None	Normal	Normal	
Jersey Point II Pen #3	83.8(75-90)	6.62(4.3-9)	2.32(1-6)	Normal	None	Normal	Normal	0.08 (2 half adipose fin clips) 0.08 (2 deformed pectoral fins)
Group II	81.83(67-104)	5.99(3.1-12.4)	6.39(1-25)					

RESULTS OF NET PEN SAMPLING CONDUCTED 48 HOURS AFTER RELEASE, VAMP 2002

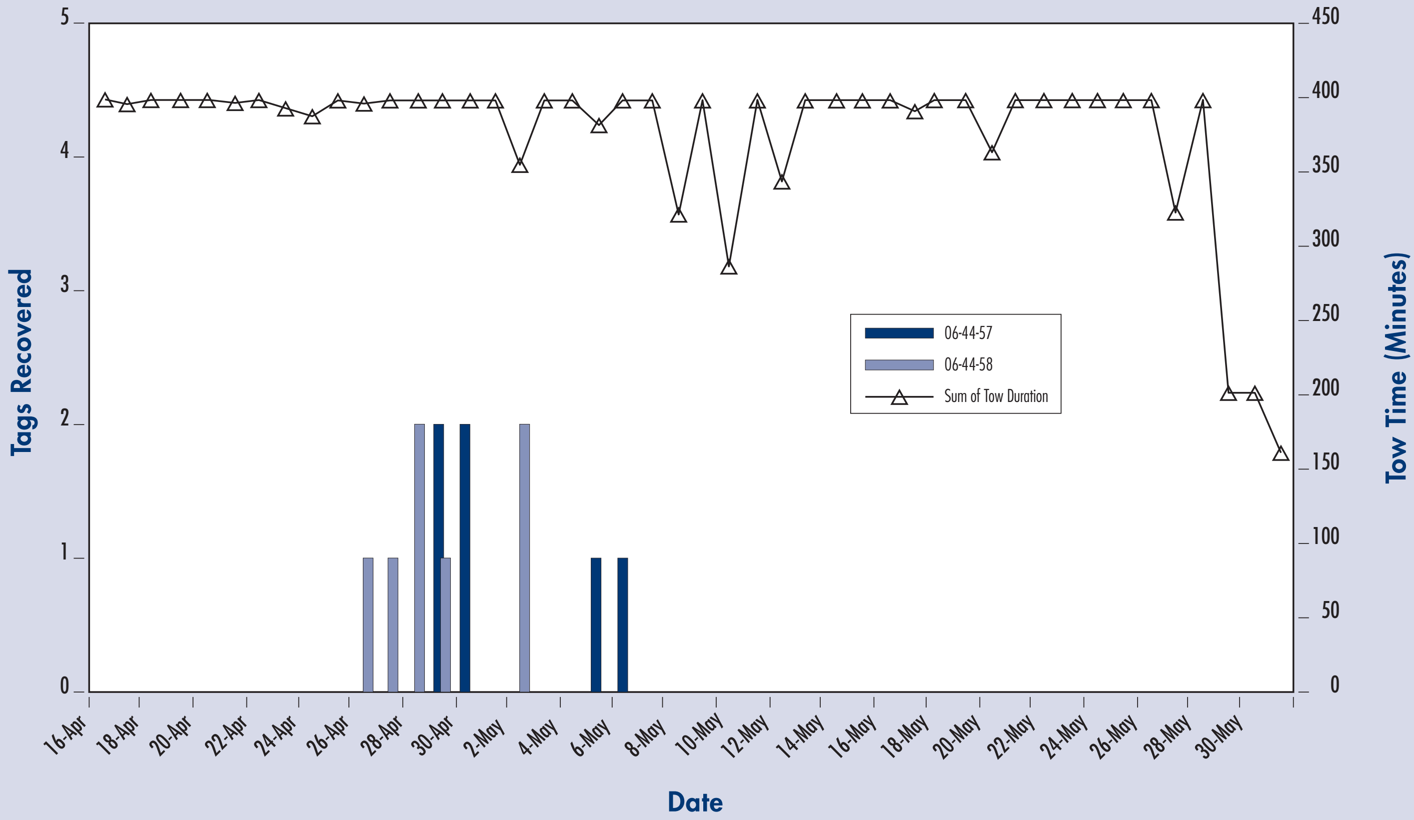
Release location, release date, tag code, number in sample	Mean fork length (and range in millimeters)	Mean weight (and range in grams)	Mean scale loss (and range in percent)	Color	Fin hemorrhaging	Eyes	Gill color	Ad clips, comments and mortalities
Durham Ferry I Pen #1	83(69-102)	6.0(3.2-11.5)	4(2-7)	Normal	None	Normal	Normal	
Durham Ferry I Pen #2	84.4(76-90)	6.2(4.5-7.7)	2.9(1.0-5.0)	Normal	None	Normal	Normal	
Mossdale I Pen #2	82.92(75-91)	6.0(4.3-7.8)	3.7(1-12)	Normal	None	Normal	Normal	
Mossdale I Pen #3	82.4(66-92)	5.8(4-8.2)	2.9(1-7)	Normal	None	Normal	Normal	0.04(scoliosis-spine)
Jersey Point I Pen #2	85.5(76-94)	6.6(4.3-8.1)	12.8(1-40)	Normal	None	Normal	Normal	0.08(half adipose clip)
Jersey Point I Pen #3	83.6(72-95)	5.9(3.8-9.1)	9.1(4.0-15.0)	Normal	None	Normal	Normal	0.04(hemmoraged eye)
Group II	83.6(66-102)	6.1(3.2-11.5)	6(1-40)					
Durham Ferry II Pen #1	80(71-94)	5.4(3.7-8.8)	12.3(2.0-30.0)	Normal	None	Normal	Normal	
Durham Ferry II Pen #2	80.64(71-93)	5.3(3.6-9.3)	6.5(1-21)	Normal	None	Normal	Normal	
Mossdale II Pen#1	80.6(70-89)	5.4(3.6-7.4)	5.2(2.0-10.0)	Normal	None	Normal	Normal	0.04(hemmoraged eye) 0.04(no adipose fin clip)
Mossdale II Pen#2	79.9(67-88)	5.3(3.2-7.0)	6.5(2.0-12.0)	Normal	None	Normal	Normal	
Jersey Point II Pen #2	82.0(71-94)	5.8(3.7-9.2)	4.3(1.0-10.0)	Normal	None	Normal	Normal	0.20(half adipose fin clip) 0.04(deformed pectoral fin)
Jersey Point II Pen #3	82.9(75-93)	6.3(4.4-8.6)	4.9(2.0-9.0)	Normal	None	Normal	Normal	0.16(half adipose fin clip) 0.04(no adipose fin clip)
Group II	80.48(67-82.9)	5.5(9.3-7.9)	6.6(1.0-30.0)					

Note: averages are for first 25 fish worked up in each pen.

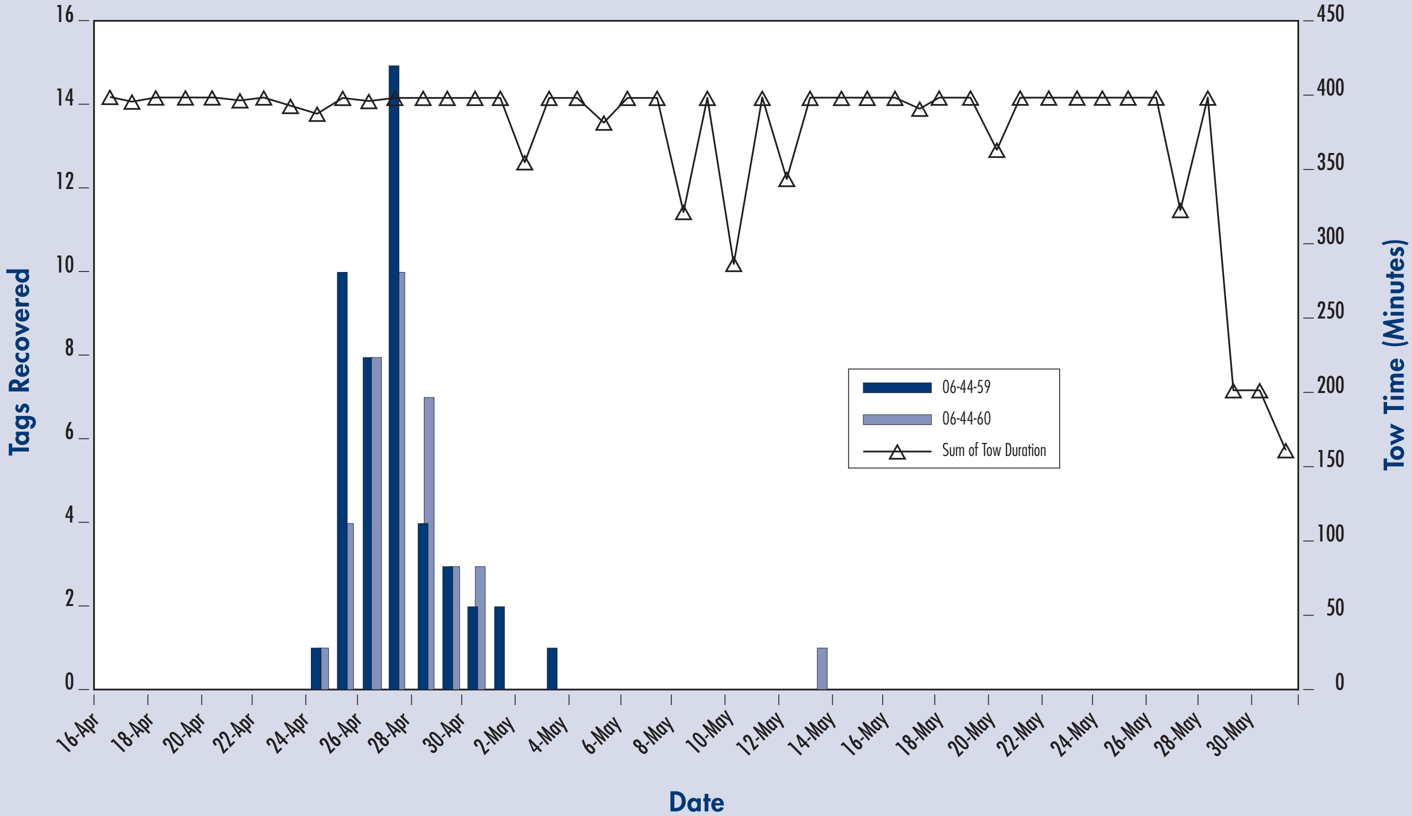
Chipps Island/Durham Ferry I



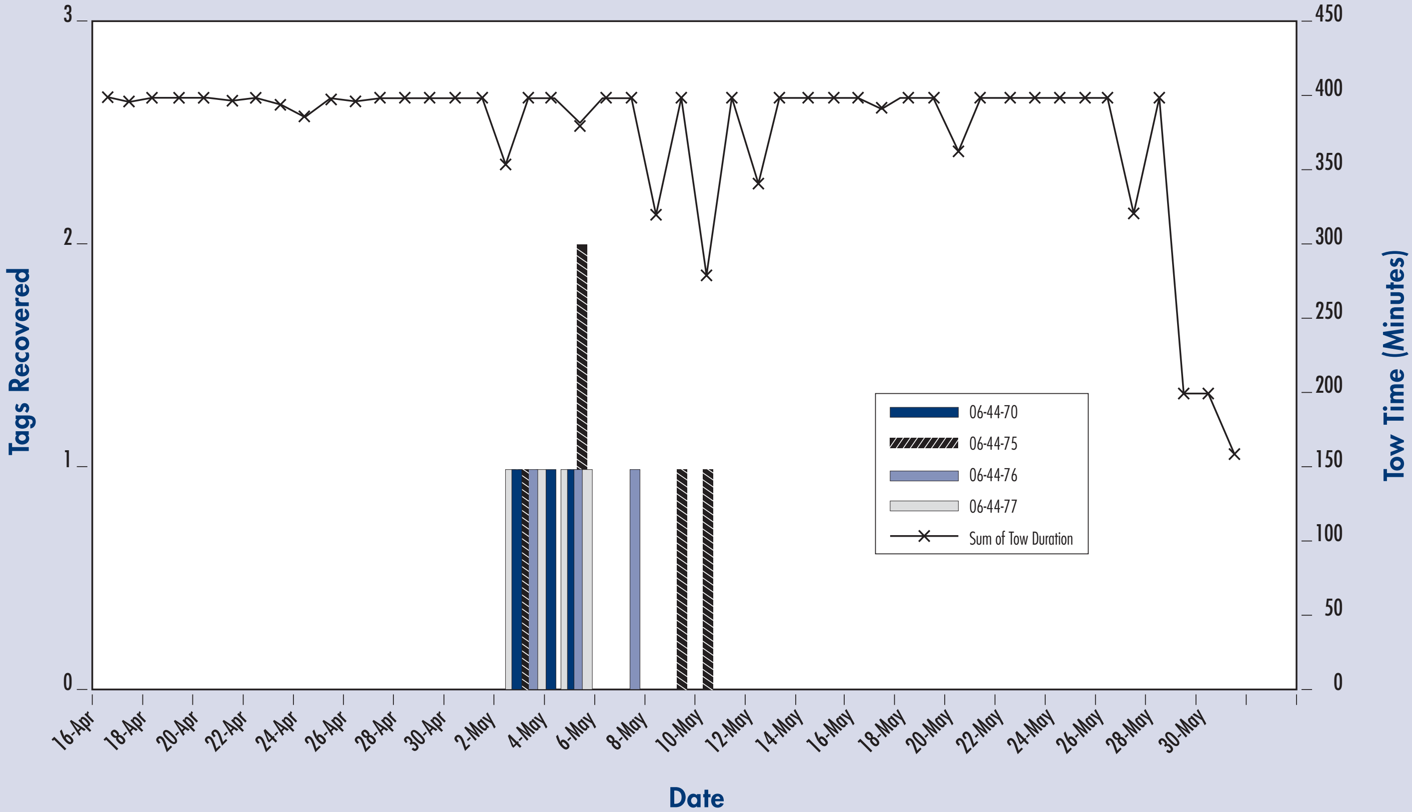
Chipps Island/Mossdale I



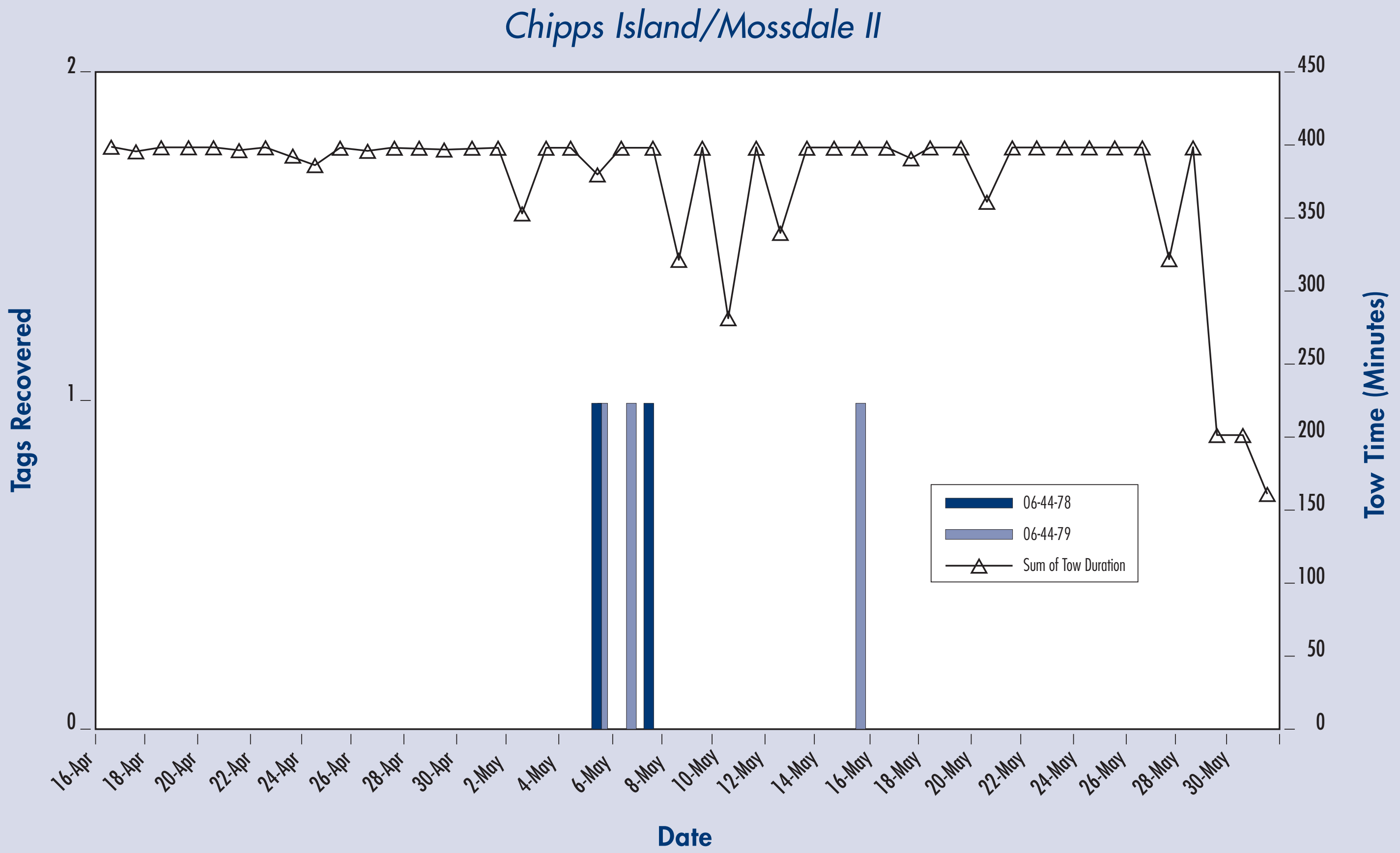
Chipps Island/Jersey Point I

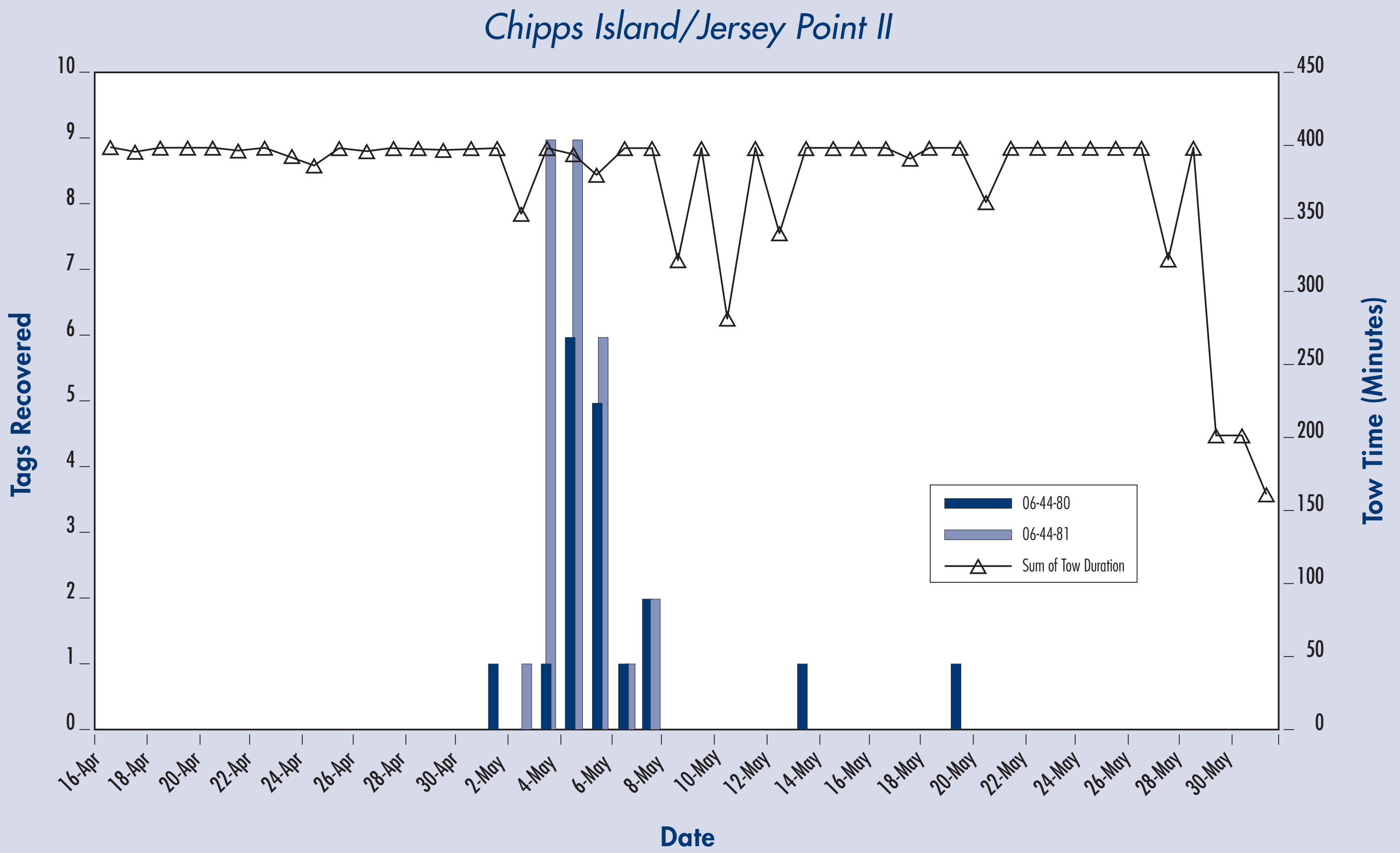


Chipps Island/Durham Ferry II

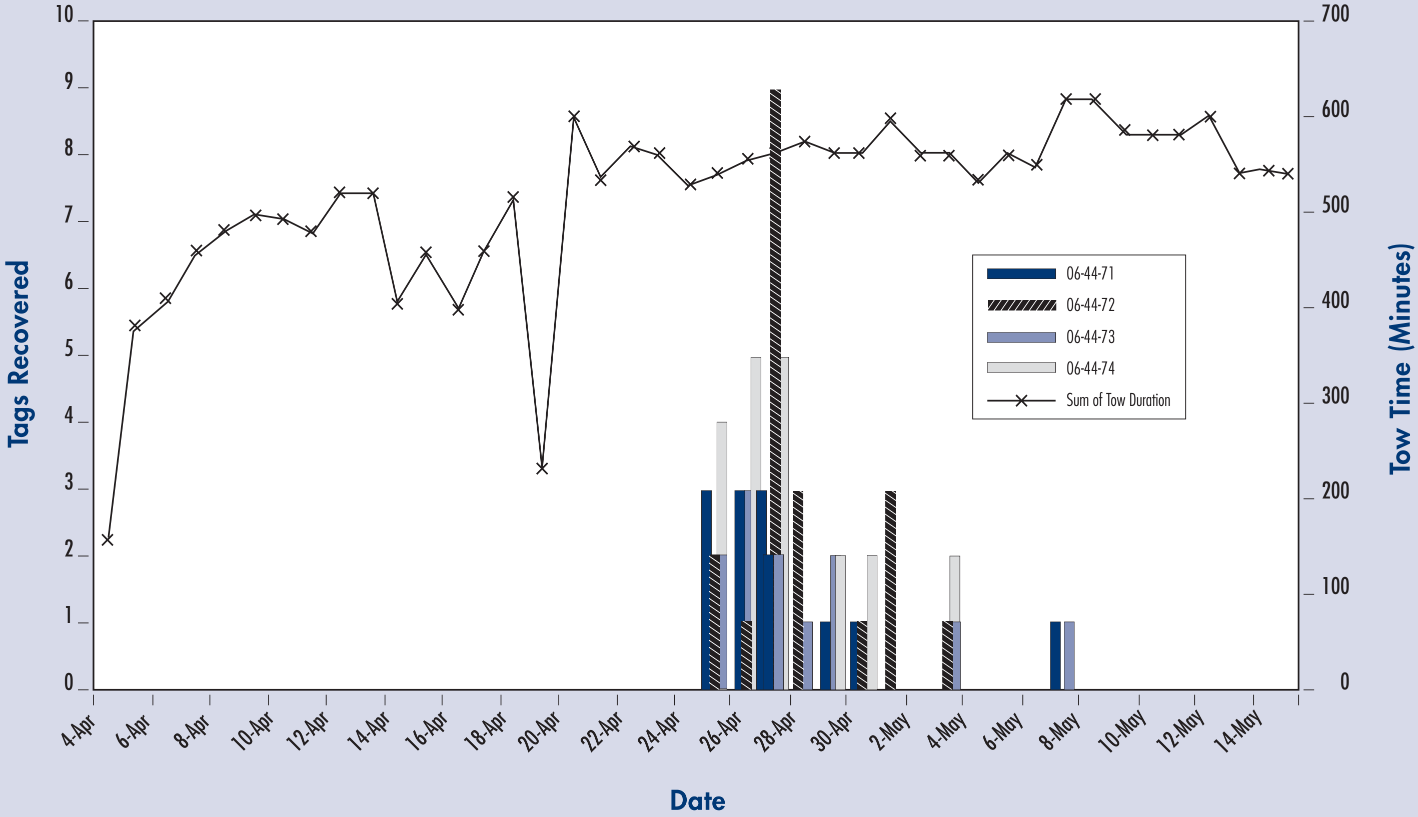


NET PEN SAMPLING RESULTS

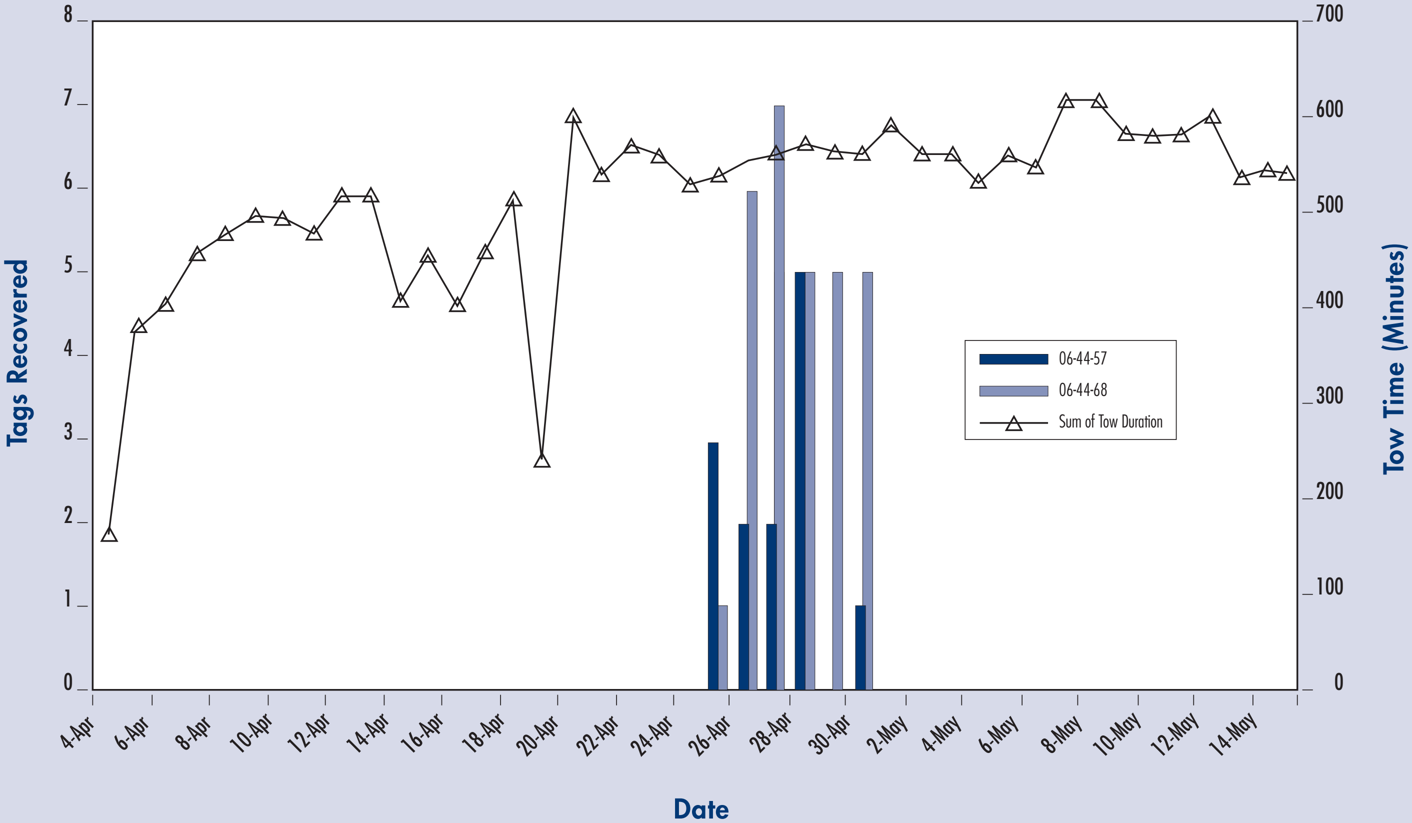




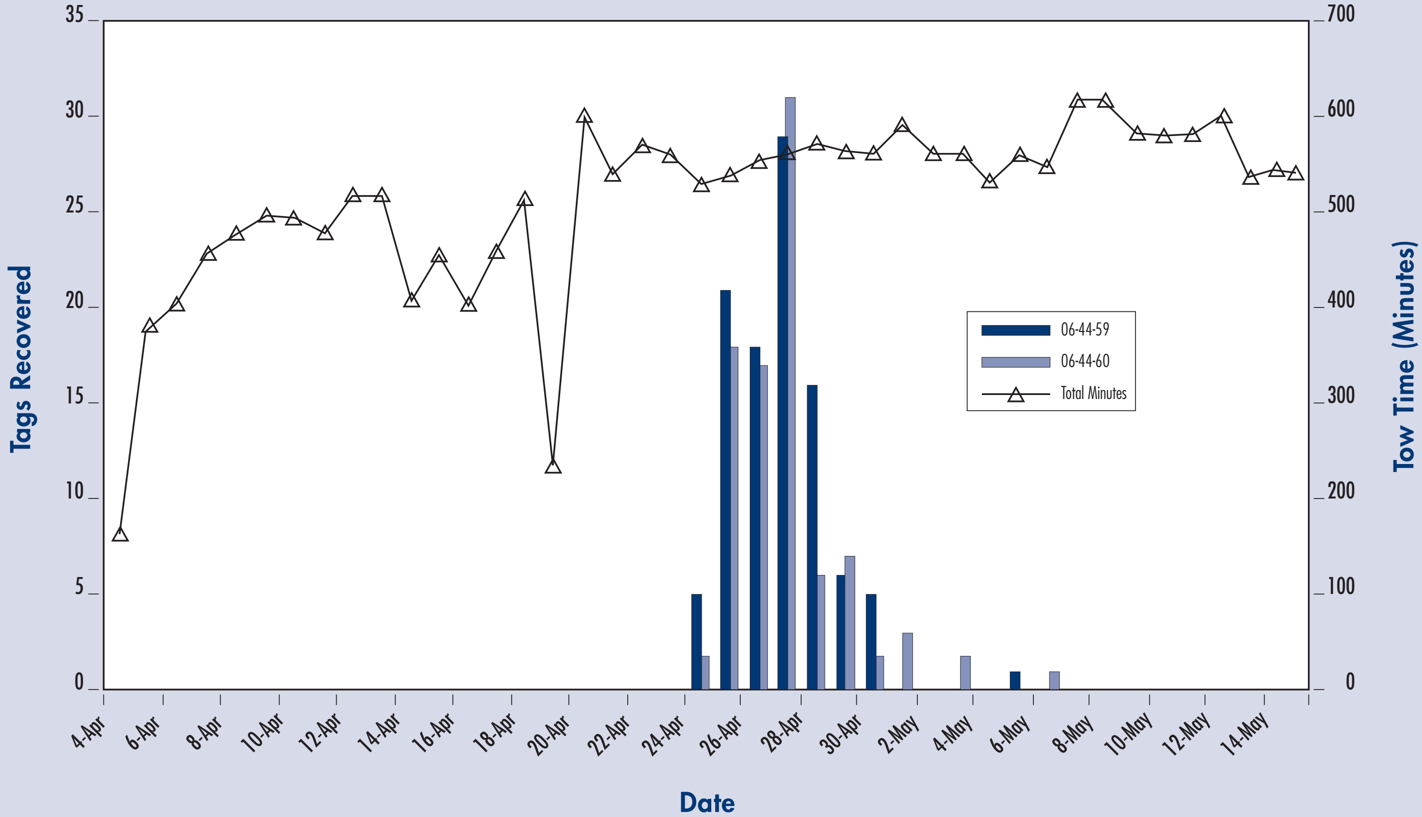
Antioch/Durham Ferry I



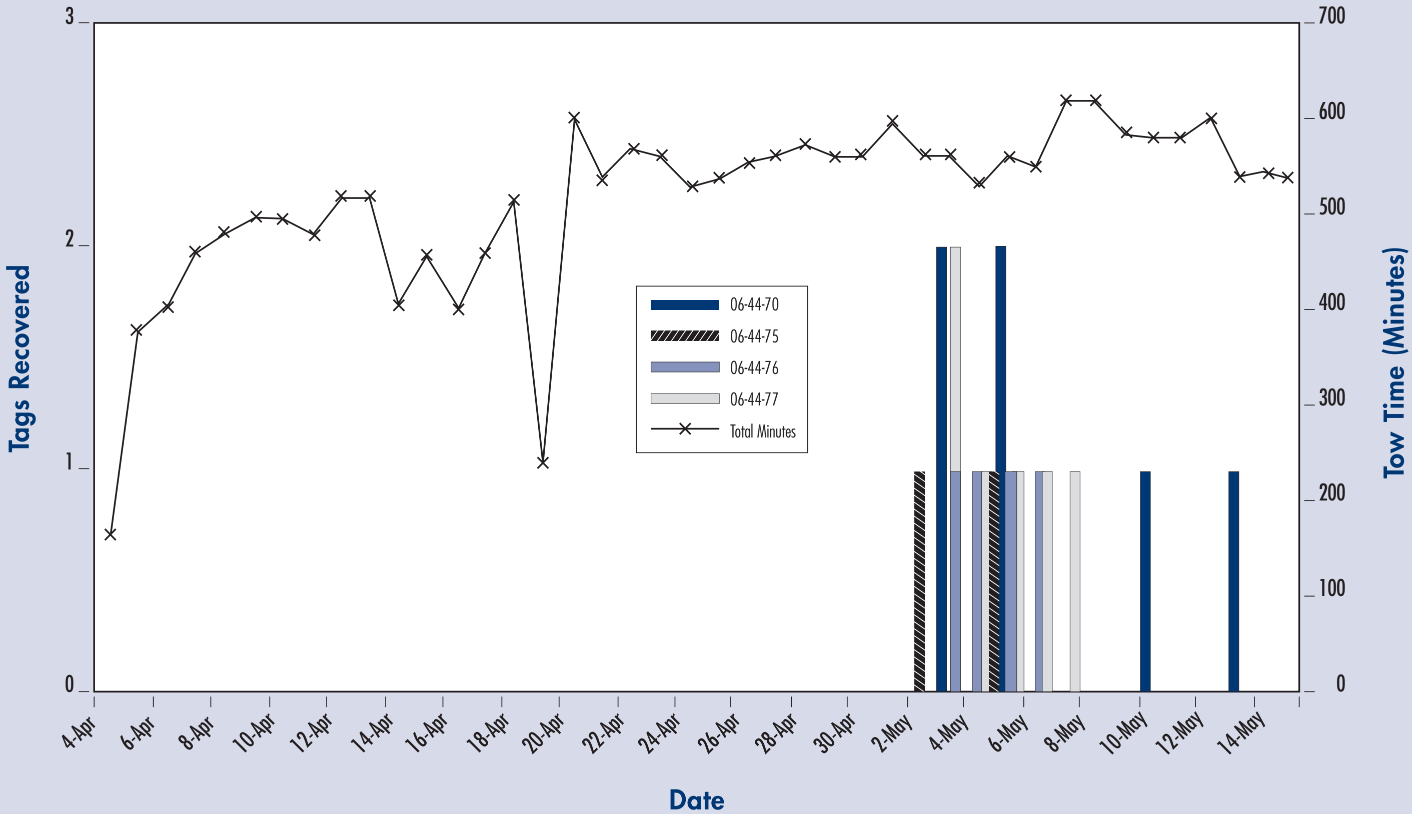
Antioch/Mossdale I



Antioch/Jersey Point I

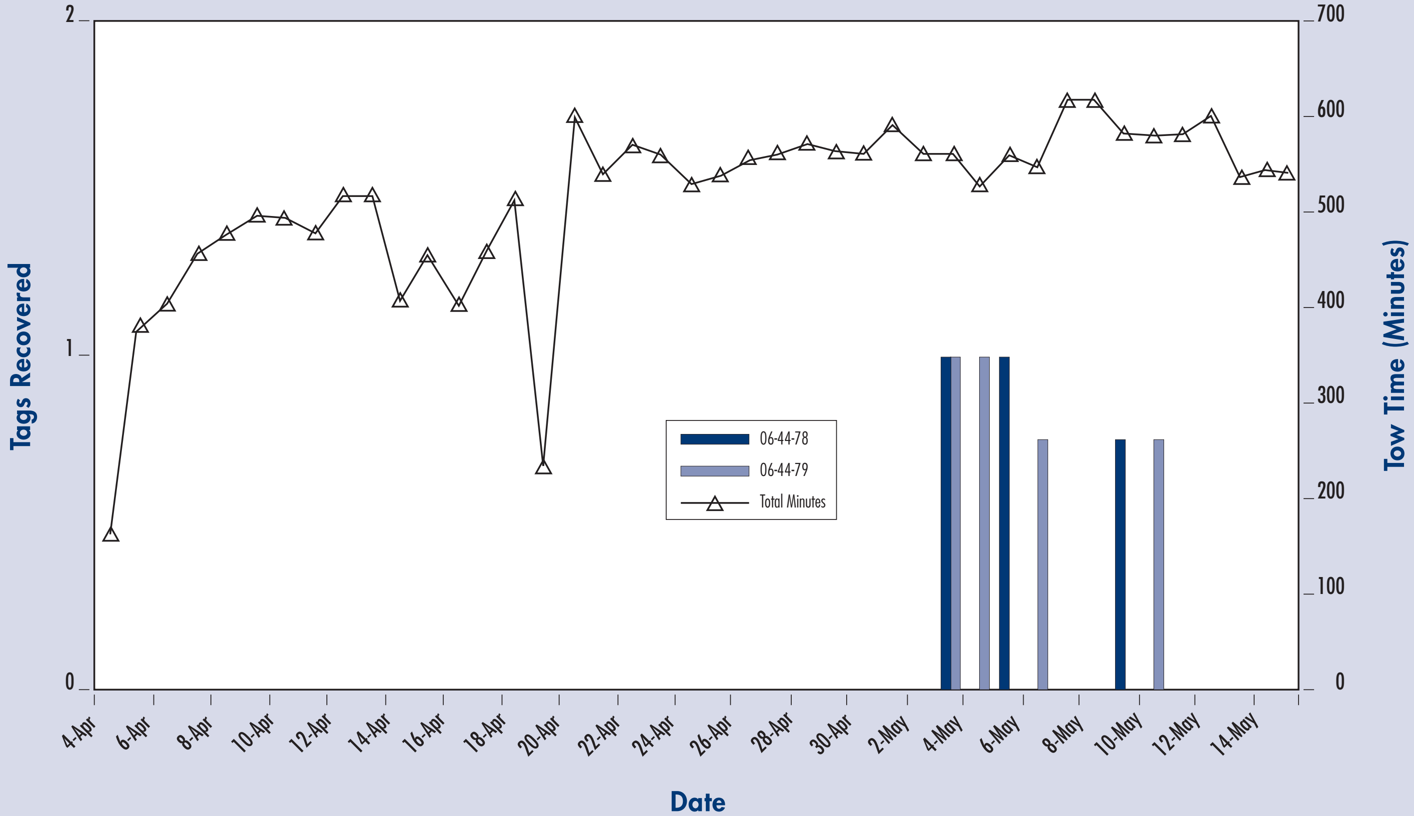


Antioch/Durham Ferry II

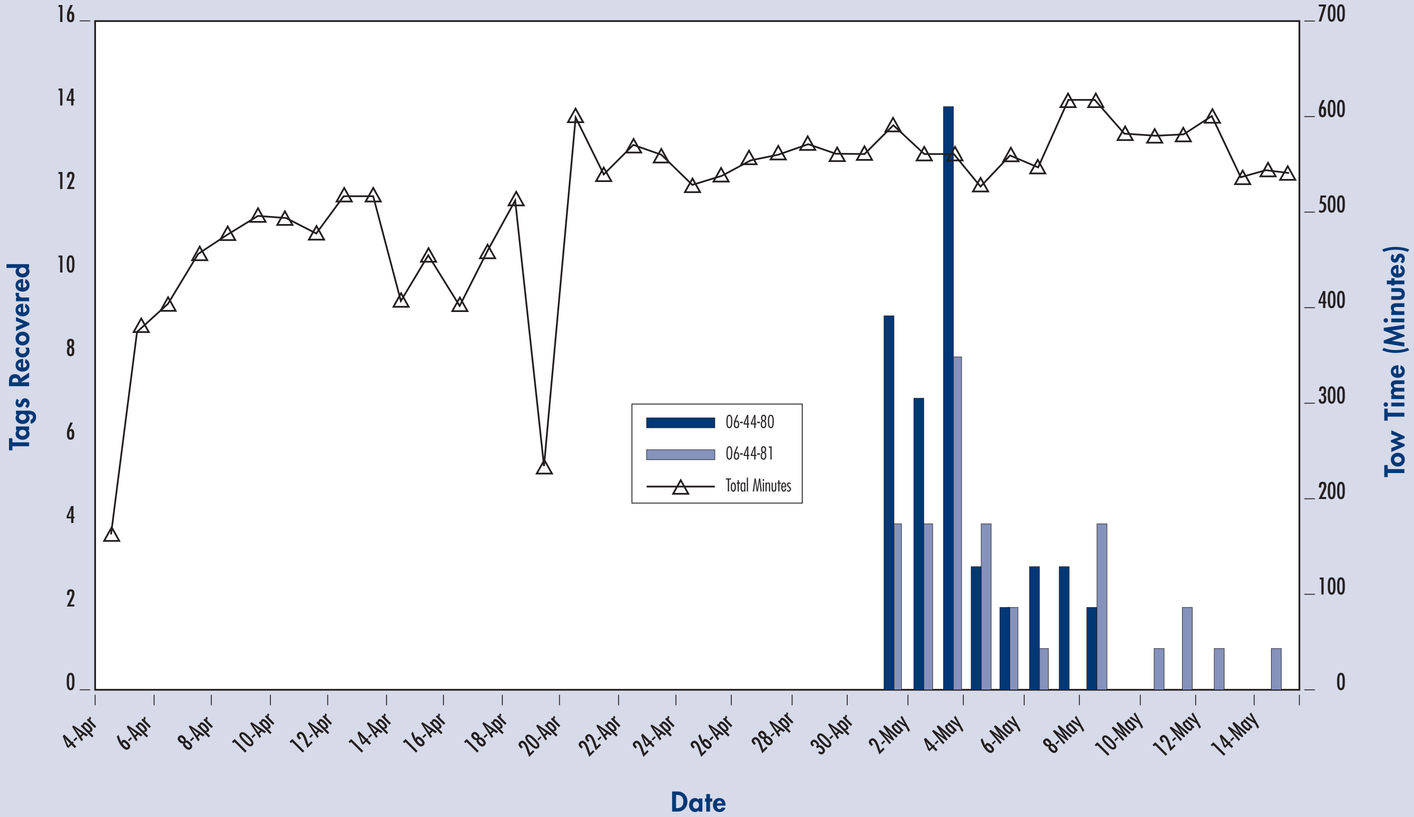


NET PEN SAMPLING RESULTS

Antioch/Mossdale II



Antioch/Jersey Point II



Release and Recovery Information for Coded Wire Tagged Smolts Released in the San Joaquin River and Tributaries in the Spring of 2002.

Tag Code	Release Site/Stock	Date	Truck Temp (F)	River Temp (F)	Number Released	Average Size (mm)
Merced River						
06-44-63	Upper Merced @ MRFF		N/P	N/P	23188	74
06-44-64	Upper Merced @ MRFF		N/P	N/P	23915	74
06-44-65	Upper Merced @ MRFF		N/P	N/P	23775	74
06-44-66	Upper Merced @ MRFF		N/P	N/P	23185	74
	Total	Mar 31			94063	
06-44-51	Hatfield State Park (MRFF)		53.6	62.6	24380	77
06-44-52	Hatfield State Park (MRFF)		53.6	62.6	24228	77
06-45-48	Hatfield State Park (MRFF)		53.6	62.6	24890	77
	Total	Apr 03			73498	
06-44-82	Upper Merced @ MRFF		N/P	N/P	22522	71
06-44-83	Upper Merced @ MRFF		N/P	N/P	23086	71
06-44-84	Upper Merced @ MRFF		N/P	N/P	23140	71
06-44-85	Upper Merced @ MRFF		N/P	N/P	22183	71
	Total	Apr 21			90931	
06-44-86	Hatfield State Park (MRFF)		53.6	60.8	23349	73
06-44-87	Hatfield State Park (MRFF)		53.6	60.8	23363	73
06-44-88	Hatfield State Park (MRFF)		53.6	60.8	23639	73
	Total	Apr 26			70351	
Tuolumne River						
06-44-06	La Grange (MRFF)		57.2	53.6	24976	86
06-44-67	La Grange (MRFF)		57.2	53.6	24813	86
06-44-68	La Grange (MRFF)		57.2	53.6	25220	86
	Total	Apr 24			75009	
San Joaquin River						
06-44-61	Old Fisherman's Club (MRFF)	Apr 26	55.4	62	25701	85
06-44-69	Old Fisherman's Club (MRFF)	Apr 29	55.4	60.8	23870	86
Stanislaus River						
06-44-46	Knight's Ferry (MRFF)		56.3	53.6	23745	82
06-44-47	Knight's Ferry (MRFF)		53.6	52.7	24236	83
	Total	May 01			47981	
06-44-48	Two Rivers (MRFF)	May 04	59	64.4	24646	84

Antioch				Chipps Island				Salvage		Tributary Survival	
Number Recovered	Percent Sampled	Survival Index	Group Index	Number Recovered	Percent Sampled	Survival Index	Group Index	Expanded CVP	Expanded SWP	Antioch	Chipps Island
1	0.316	0.010		1	0.278	0.020		12	6		
0	--	--		0	--	--		0	0		
0	--	--		0	--	--		0	0		
0	--	--		0	--	--		0	0		
1	0.316		0.002	1	0.278		0.005			0.05	0.11
10	0.345	0.086		2	0.272	0.039		480	47		
1	0.389	0.008		1	0.222	0.024		492	34		
3	0.361	0.024		3	0.180	0.087		528	55		
14	0.345		0.040	6	0.238		0.045				
0	--	--		0	--	--		0	0		
1	0.375	0.008		0	--	--		0	0		
0	--	--		0	--	--		0	0		
0	--	--		0	--	--		0	0		
1	0.375		0.002	0	--		--			0.08	0
2	0.410	0.015		2	0.250	0.045		12	6		
5	0.405	0.038		0	--	--		0	12		
2	0.404	0.015		1	0.278	0.020		0	0		
9	0.402		0.023	3	0.250		0.022				
3	0.423	0.020		1	0.264	0.020		12	12		
5	0.392	0.037		7	0.261	0.141		0	12		
3	0.378	0.023		0	--	--		12	18		
11	0.399		0.026	8	0.261		0.053				
1	0.389	0.007		6	0.273	0.111		0	6	3.7	0.47
2	0.408	0.015		3	0.260	0.063		12	15	1.7	0.84
1	0.403	0.008		2	0.257	0.043		12	0	1.04	2.09
5	0.397	0.037		2	0.194	0.055		0	6		
6	0.397		0.023	4	0.236		0.046				
3	0.398	0.022		1	0.236	0.022		0	0		

Timing of Recovery at Antioch and Chipps Island for Coded Wire Tagged Smolts Released in San Joaquin River and Tributaries in the Spring of 2002.

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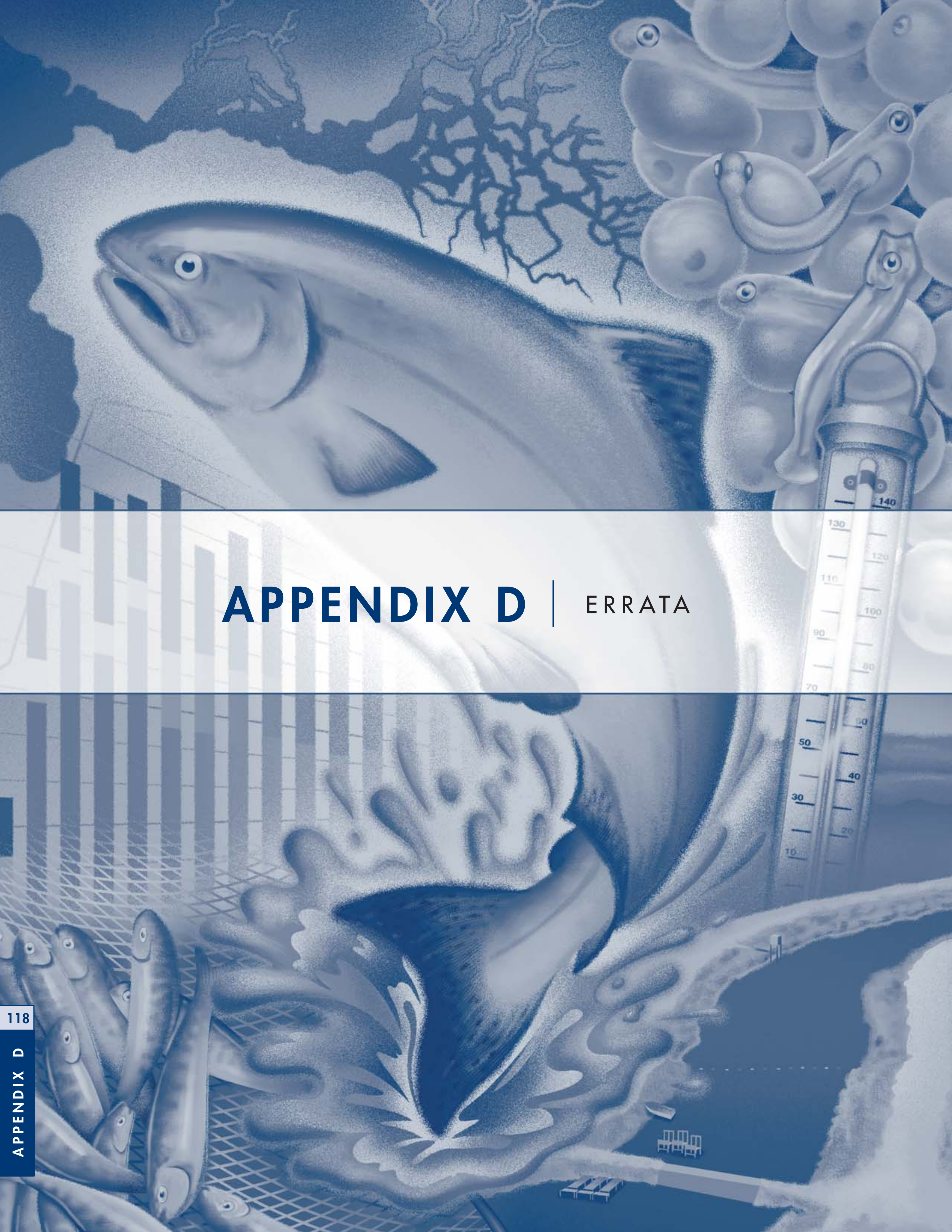
06-44-64	Upper Merced @ MRFF		N/P	N/P	23915	74
06-44-65	Upper Merced @ MRFF		N/P	N/P	23775	74
06-44-66	Upper Merced @ MRFF		N/P	N/P	23185	74
	Total	Mar 31			94063	
06-44-51	Hatfield State Park (MRFF)		53.6	62.6	24380	77
06-44-52	Hatfield State Park (MRFF)		53.6	62.6	24228	77
06-45-48	Hatfield State Park (MRFF)		53.6	62.6	24890	77
	Total	Apr 03			73498	
06-44-82	Upper Merced @ MRFF		N/P	N/P	22522	71
06-44-83	Upper Merced @ MRFF		N/P	N/P	23086	71
06-44-84	Upper Merced @ MRFF		N/P	N/P	23140	71
06-44-85	Upper Merced @ MRFF		N/P	N/P	22183	71
	Total	Apr 21			90931	
06-44-86	Hatfield State Park (MRFF)		53.6	60.8	23349	73
06-44-87	Hatfield State Park (MRFF)		53.6	60.8	23363	73
06-44-88	Hatfield State Park (MRFF)		53.6	60.8	23639	73
	Total	Apr 26			70351	
Tuolumne River						
06-44-06	La Grange (MRFF)		57.2	53.6	24976	86
06-44-67	La Grange (MRFF)		57.2	53.6	24813	86
06-44-68	La Grange (MRFF)		57.2	53.6	25220	86
	Total	Apr 24			75009	
San Joaquin River						
06-44-61	Old Fisherman's Club (MRFF)	Apr 26	55.4	62	25701	85
06-44-69	Old Fisherman's Club (MRFF)	Apr 29	55.4	60.8	23870	86
Stanislaus River						
06-44-46	Knight's Ferry (MRFF)		56.3	53.6	23745	82
06-44-47	Knight's Ferry (MRFF)		53.6	52.7	24236	83
	Total	May 01			47981	
06-44-48	Two Rivers (MRFF)	May 04	59	64.4	24646	84

Antioch						Chipps Island						
First Day Recovered	Last Day Recovered	Number Recovered	Minutes Fished	Survival Index	Group Index	First Day Recovered	Last Day Recovered	Number Recovered	Minutes Fished	Percent Sampled	Survival Index	Group Index
Apr 15	Apr 15	1	455	0.010		Apr 11	Apr 11	1	400	0.278	0.020	
--	--	0	--	--		--	--	0	--	--	--	
--	--	0	--	--		--	--	0	--	--	--	
--	--	0	--	--		--	--	0	--	--	--	
Apr 15	Apr 15	1	455		0.002	Apr 11	Apr 11	1	400	0.278		0.005
Apr 10	Apr 27	10	8937	0.086		Apr 07	Apr 11	2	1960	0.272	0.039	
Apr 27	Apr 27	1	560	0.008		Apr 12	Apr 12	1	320	0.222	0.024	
Apr 12	Apr 12	3	520	0.024		Apr 12	Apr 14	3	777	0.180	0.087	
Apr 10	Apr 27	14	8937		0.040	Apr 07	Apr 14	6	2737	0.238		0.045
--	--	0	--	--	--	--		0	--	--	--	
May 13	May 13	1	540	0.008	--	--		0	--	--	--	
--	--	0	--	--		--	--	0	--	--	--	
--	--	0	--	--		--	--	0	--	--	--	
May 13	May 13	1	540		0.002	--	--	0	--	--		--
May 06	May 12	2	4136	0.015		May 09	May 11	2	1080	0.250	0.045	
May 07	May 14	5	4671	0.038		--	--	0	--	--	--	
May 09	May 11	2	1746	0.015		May 09	May 09	1	400	0.278	0.020	
May 06	May 14	9	5221		0.023	May 09	May 11	3	1080	0.250		0.022
May 07	May 09	3	1826	0.020		May 05	May 05	1	380	0.264	0.020	
May 03	May 07	5	2820	0.037		May 3	May 11	7	3379	0.261	0.141	
May 03	May 04	3	1090	0.023		--	--	0	--	--	--	
May 03	May 09	11	4026		0.026	May 03	May 11	8	3379	0.261		0.053
May 05	May 05	1	560	0.007		May 03	May 05	6	1179	0.273	0.111	
May 05	May 08	2	2350	0.015		May 05	May 08	3	1500	0.260	0.063	
May 11	May 11	1	580	0.008		May 11	May 12	2	740	0.257	0.043	
May 9	May 14	5	3431	0.037		May 10	May 10	2	280	0.194	0.055	
May 9	May 14	6	3431		0.023	May 10	May 12	4	1020	0.236		0.046
May 11	May 13	3	1720	0.022		May 12	May 12	1	340	0.236	0.022	



APPENDIX D | ERRATA

Table 5–6:

Estimates of Survival Between Durham Ferry and Mossdale (S DF to MD) and Between Mossdale and Jersey Point (S MD to JP), and Survival minus (S–2se) and Plus (S+2se) two Standard errors. The corrected values have been highlighted in the table below.

	REC. AT ANTIOCH	REC. AT CI	# RELEASED	A+C	A+C/R	S DF TO MD	S MD TO JP	S–2SE	S+2SE
Durham 1	28	14	23,354	42	0.001798407				
	30	22	22,837	52	0.002277007				
	18	17	22,491	35	0.001556178				
	76	53	68,682	129	0.001878221	1.33		0.92	1.73
MD 1	18	17	23,000	35	0.001521739				
	15	14	22,177	29	0.001307661				
	33	31	45,177	64	0.00141665		0.16	0.12	0.20
JP 1	156	50	24,443	206	0.008427771				
	173	61	24,992	234	0.009362996				
	329	111	49,435	440	0.008900577				
Durham 2	8	2	24,025	10	0.000416233				
	11	5	24,029	16	0.000665862				
	10	2	24,177	12	0.000496339				
	29	8	72,231	38		0.96		0.48	1.44
MD 2	8	4	23,878	12	0.000502555				
	11	4	25,308	15	0.000592698				
	19	8	49,186	27	0.000548937		0.20	0.12	0.29
JP 2	43	17	25,909	60	0.002315798				
	53	27	25,465	80	0.003141567				
	96	44	51,374	140	0.002725114				

In Appendix C-5, the Expanded salvage/SWP was reported incorrectly in the 2001 Report. The tag code for the group released on April 28 in the San Joaquin River at Old Fisherman's Club was also reported incorrectly. The correct tag codes with changes are provided below.

TAGCODE	RELEASE SITE/STOCK	DATE	EXPANDED SWP
Merced River			
06-44-15	Merced River Fish Facility		0
06-44-16	Merced River Fish Facility		6
06-44-17	Merced River Fish Facility		6
06-44-18	Merced River Fish Facility		0
	Total	Apr. 21	
06-44-33	Old Fisherman's Club	Apr. 28	0

SAN JOAQUIN RIVER GROUP AUTHORITY

P.O. Box 4060, Modesto, CA 95352 • (209)526-7405 • FAX (209)526-7315

Modesto Irrigation District
Turlock Irrigation District
Oakdale Irrigation District
Merced Irrigation District
Friant Water Users Authority
City and County of San Francisco
South San Joaquin Irrigation District
San Joaquin River Exchange Contractors