Summary

EXECUTIVE SUMMARY

The San Joaquin River Agreement (SJRA) and Vernalis Adaptive Management Plan (VAMP) are 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). VAMP, officially initiated in 2000 as part of SWRCB Decision 1641, is a large-scale, long-term (12-year), experimental/management program 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 with the installation of the Head of Old River Barrier (HORB). VAMP employs an adaptive management strategy to use current knowledge of hydrology and environmental conditions to protect Chinook salmon smolts, while gathering information to allow more efficient protection in the future. Specific experimental objectives of VAMP include quantification of juvenile salmon smolt survival under a set of six San Joaquin River flow rates (3,200 to 7,000 cfs) and SWP/CVP export rates (1,500 to 3,000 cfs).

The 2004 Annual Technical Report comprises the consolidated annual SJRA Operations Report and Vernalis Adaptive Management Plan (VAMP) Monitoring Report. The VAMP 2004 program represents the fifth 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; results of the juvenile Chinook salmon smolt survival investigations; discussion of complementary investigations; and, conclusions and recommendations.

The VAMP experimental design includes two mark-recapture studies performed each year during the mid-April to mid-May juvenile salmon 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. Absolute survival estimates are calculated and used to evaluate relationships between salmon survival and San Joaquin River flow and CVP and SWP exports. The experimental design includes 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). The use of data from multiple release and recapture locations allows for more thorough

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evaluation of juvenile Chinook salmon survival as compared to recapture data from only one sampling location and/or one series of releases. The VAMP release and recapture locations are consistent from one year to the next, providing a greater opportunity to assess salmon survival over a range of Vernalis flows, SWP/CVP exports, with and without the presence of the Head of Old River Barrier. Releases at Jersey Point serve as controls for recaptures at Antioch and Chipps Island, thereby allowing calculation of survival estimates based on the ratio of survival indices from marked salmon recaptured from upstream (Durham Ferry and Mossdale) and downstream (control release at Jersey Point) releases. Use of ratio estimates as part of the VAMP study design factors out the potential differential gear efficiency at Antioch and Chipps Island within and among years.

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 2004 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 rates of 1,500 cfs; and
- Comparison of juvenile Chinook salmon survival between Durham Ferry and Mossdale for use in comparing results of VAMP 2004 with results from earlier survival studies where coded-wire tagged salmon releases occurred at Mossdale.

VAMP provides for a 31-day pulse flow (target flow) in the San Joaquin River at the Vernalis gage along with a corresponding reduction in SWP/CVP exports. The magnitude of the pulse flow is based on an estimated flow that would occur during the pulse period absent the VAMP. As part of the development of the VAMP experimental design, the VAMP hydrology and biology groups meet regularly throughout the year to review current and projected information on hydrologic conditions occurring within the San Joaquin River watershed to refine the experimental design. This facilitates communications and coordination both as part of the VAMP experimental survival program and scheduling streamflow releases on the Tuolumne, Merced, and Stanislaus rivers to facilitate experimental investigations and provide protection for juvenile salmon within the tributaries, as well as the mainstem San Joaquin River. VAMP experimental test conditions that have occurred over the past five years are summarized below:

VAMP Period	Vernalis Flow (cfs)	SWP/CVP Exports (cfs)
April 15–May 15, 2000	5,869	2,155
April 20–May 20, 2001	4,224	1,420
April 15–May 15, 2002	3,301	1,430
April 15–May 15, 2003	3,235	1,446
April 15–May 15, 2004	3,155	1,331

A total of 476,503 acre-feet has been contributed over the five years by the SJRGA. At the end of the five years reservoir deficits in New Don Pedro and Lake McClure are 11,151 acre-feet and 215,197 acre-feet respectively as of October 14, 2004 (Appendix D). These values may be offset by SJRGA water conservation activities implemented by the irrigation districts. Water deficits of the other SJRGA members that contribute water have been replenished at the beginning of each year. A total of 1,508,809 fall-run Chinook salmon smolts were produced at the Merced River Fish Facility over the five years in support of the VAMP. The annual allotment of test fish ranged from a high of 392,186 in 2002 to a low of 188,884 in 2004, with an average of about 309,000 provided in each of the other VAMP years. As a result of the relatively low return of adult salmon to the Merced River in the fall of 2003, the availability of test fish for 2004 was limited to less than 200,000 fish. This allowed for a single release of CWT salmon at Durham Ferry, Mossdale, and Jersey Point.

Temperature data were collected through the use of a series of computerized recorders at the Merced River Fish Facility, in the transport trucks, and located throughout the lower San Joaquin River and Delta. Overall the average temperature at all sites ranged from 19 to 22 C.

Of the 21,845 juvenile Chinook salmon entrained at the HORB during the first five years of VAMP, approximately 8,300 were VAMP CWT released salmon. Most of the VAMP salmon (97%) were entrained within two days of their release. A high proportion of the entrainment at the culverts occurred at night. The yearly entrainment loss index for VAMP salmon at the HORB averaged 0.8% ± 0.4% and ranged from a high of 1.5% in 2002 to a low of 0.4% in 2004. For unknown reasons the 2003 VAMP test measured the lowest survival since the VAMP was initiated, with 2004 showing only a slight improvement. The Combined Differential Recovery Rates ranged from a high in 2001 of 0.191 to a low in 2003 of 0.019. Results of the salmon survival studies suggest a general trend in which survival improves as San Joaquin River

SUMMARY

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.

flows increase and as the ratio of San Joaquin River flow to SWP/CVP exports increases. These relationships, based on data between 2000 and 2004 (including similar data obtained in 1994 and 1997), however, are not statistically significant ($p<0.05$). Hydrologic conditions occurring within the San Joaquin River watershed between 2000 and 2004 have limited the experimental flow conditions to a relatively narrow range. Further tests, over a wider range of flow and export conditions (e.g., San Joaquin River flow of 7,000 cfs and SWP/CVP export rates of 1,500 cfs), are needed to evaluate the respective roles of San Joaquin River flow and SWP/CVP exports, on juvenile Chinook salmon smolts survival. Various historical data are summarized in Appendix D.

Results of salmon migration monitoring at Mossdale between March 15 and June 30 have shown that approximately 31–76% of the juvenile Chinook salmon smolts migrate downstream from the San Joaquin River tributaries during the VAMP period and were, therefore protected by increased San Joaquin River flows, installation of the Head of Old River Barrier, and decreased export rates. The VAMP program provides improved protection for juvenile salmon when compared to “pre-VAMP” conditions.

Prior technical reports presented a series of conclusions and recommended modifications to the VAMP experimental design and/or program implementation. The 2003 recommendations were used, in part, as the basis for developing the 2004 VAMP test program. For example, the 2003 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. The 2003 report also recommends modifications to the HORB and entrainment monitoring program including a delay in salmon releases at Durham Ferry and Mossdale for approximately five days after barrier closure to allow time for gravel and rock to flush from the culverts and improve fishery sampling, measuring flows within the culverts, continue monitoring to evaluate potential impacts of seepage, monitoring fish entrainment at the culverts, and improve the experimental design of Head of Old River Barrier investigations. These and other recommendations were addressed as part of the 2004 VAMP program.

During 2004, as since 2002, the local landowner provided a short-term curtailment of agricultural diversion pumping during the release of test fish at Durham Ferry. In addition, the 2004 VAMP program continued use of the net pen studies and a fish health assessment 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 Head of Old River Barrier 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 Old River Barrier will be used in evaluating the relationship between San Joaquin River flow and juvenile Chinook salmon survival. An additional complimentary study on survival of juvenile Chinook salmon emigrating from San Joaquin River tributaries was incorporated into the 2004 VAMP investigations.

The estimated survival of CWT salmon released from Durham Ferry and Mossdale in 2004 was the second lowest measured since initiation of the VAMP. Results of health and physiological examinations indicated that the test fish were relatively healthy and should have performed adequately for outmigration assessment. Water temperatures measured within the lower San Joaquin River and Delta were within a range that may have been stressful and may have contributed to adverse effects and reduced survival of juvenile Chinook salmon released as part of the 2004 VAMP investigations.

Prior reports recommended that, to the extent possible, VAMP survival testing be conducted at high flow and low export extremes to improve the ability of the program to detect differences in juvenile Chinook salmon survival between target flow and export conditions. Hydrologic conditions within the San Joaquin River watershed did not provide conditions suitable for testing a high flow/low export relationship as part of the VAMP 2004 program. Recommendations from the 2003 VAMP program were used to improve the overall experimental design and implementation of the 2004 VAMP investigations. Recommendations made based upon analyses of the VAMP 2004 program will also be used, in a similar way, by the hydrology and fisheries technical committees in developing and implementing the experimental design for the 2005 VAMP studies.

Based on data gathered during the experimental mark-recapture studies that occurred over a 31-day period in April and May 2004, 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 studies. Key conclusions and recommendations derived from VAMP 2004 include:

- Differential recovery rates of the Durham Ferry and Mossdale groups relative to the Jersey Point group using recaptures at Antioch and Chipps Island indicated that there was no statistical ($p<0.05$) difference in survival between the Durham Ferry and Mossdale releases conducted in 2004.
- 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) showed that the relative proportions during 2004 were similar to 2003 but significantly lower than survival results from the 2002 VAMP, although flow and export conditions (target flow 3200 cfs and exports of 1500 cfs in all three years) were comparable. The factors contributing to the significantly lower survival in 2003 and 2004 are unknown.
- The relationships between salmon survival, Vernalis flow, and SWP/CVP exports were not statistically significant based on results of VAMP tests over the past five years and similar pre-VAMP data gathered in 1994 and 1997.
- Real-time streamflow data at Vernalis were improved by weekly flow measurements, however estimation of ungaged flow (accretions and depletions) requires further investigation for use in establishing annual VAMP target flows.
- DWR installed a stage recorder and fixed acoustic Doppler velocity meters in the San Joaquin River downstream of the confluence with Old River and in the Old River downstream of the HORB for use in measuring 2004 river flows.
- The design, construction, and operation of the HORB were successful in 2004. Salmon releases at Durham Ferry and Mossdale were delayed approximately five days after HORB closure to allow time for gravel and rock to flush from the culverts and to improve fisheries sampling at the site. Operation of the HORB with three to five culverts open was successful in maintaining South delta water levels. Mechanical malfunctions required varying culvert operations throughout the period.
- The index of salmon entrainment at the HORB from the single release in 2004 was substantially lower in comparison to the first releases made in 2002 and 2003 but similar to the 2001 loss. The comparisons may be limited due to the single release of test fish in 2004 and the varying culvert operations.
- The variability inherent 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, high target flow and low export conditions be selected to conduct survival tests at VAMP flow and export extremes, or equivalent, to improve the ability to detect potential differences in salmon smolt survival among test conditions.

- Approximately 72 percent of the unmarked salmon smolts migrating past Mossdale in 2004 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.
- Individual agency program and funding constraints limited the implementation of complementary studies in 2004. Complementary studies provide additional information on factors and mechanisms affecting salmon survival during migration from the lower San Joaquin River and through the Delta.
- The relationships between salmon survival rates and Vernalis flow and SWP/CVP export conditions tested in the first five years have not been found to be statistically significant. Survival tests at extreme target levels (e.g., 7,000 cfs flow and 1,500 cfs exports), or equivalent, are important to obtain. The VAMP program provides improved protection for juvenile salmon when compared to "pre-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.
- It is recommended that further effort be given to identifying and evaluating opportunities to adaptively refine and modify the VAMP experimental design to improve the level of protection provided to juvenile Chinook salmon migrating downstream in the San Joaquin River, improve the ability to detect statistically significant relationships between flow and export rates and juvenile salmon survival if they exist, reduce potential adverse impacts to aquatic resources and their habitat within the upstream tributaries, and maximize the efficient use of available water resources within the San Joaquin River watershed during VAMP implementation.
- The VAMP program has demonstrated the value of large-scale, long-duration, interdisciplinary experimental investigations that provide both protection to fishery resources while also providing important information that can be used to evaluate the performance and biological benefits of various management actions. The VAMP program has also demonstrated the value of an interdisciplinary approach, integrating fisheries and hydrology adaptively in response to current environmental conditions, in the design and successful implementation of management programs.

CHAPTER 1

Introduction

Actions associated with the Vernalis Adaptive Management Plan (VAMP) were implemented between April 15 and May 15, 2004 to protect juvenile Chinook salmon and evaluate the relationship between San Joaquin River flow and State Water Project (SWP) and federal Central Valley Project (CVP) water project exports, with the HORB, on the survival of marked juvenile Chinook salmon migrating through the Sacramento–San Joaquin Delta. Studies conducted in 2004, represent the fifth year of the VAMP experiment. Results from previous VAMP experiments are available in San Joaquin River Agreement Technical Report and San Joaquin River Group Authority, Technical Reports dated 2000, 2001, 2002, and 2003. Similar experiments were conducted prior to the official implementation of VAMP with results available in South Delta Temporary Barriers Annual Reports (DWR 2001 and DWR 1998). This report will describe the experimental design of VAMP, the hydrologic planning and implementation, the additional water supply arrangements and deliveries, the Head of Old River Barrier (HORB) design, installation, operation and fisheries monitoring, the salmon smolt survival investigation and complimentary studies related to VAMP. Conclusions and recommendations for future VAMP studies are also included.

EXPERIMENTAL DESIGN ELEMENTS

The VAMP experimental design measures salmon smolt survival through the Delta 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 juvenile salmon outmigration period that provide estimates of salmon survival under each set of conditions. During 2004, the reduced number of juvenile Chinook salmon produced at the Merced River Fish Facility limited the VAMP survival studies to one set of releases. Chinook salmon survival indices under the experimental conditions are calculated based on the number of marked salmon released and the number recaptured. Absolute survival estimates and combined differential recovery rates are also calculated and used in relationships between survival and San Joaquin River flow and CVP and SWP exports.

The VAMP 2004 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). One release was made during the 2004 VAMP study at Durham Ferry, Mossdale, and Jersey Point as a consequence of the limited number of juvenile salmon available from the MRFF. 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 release location. The VAMP coded-wire tag (CWT) releases (Durham Ferry, Mossdale, and Jersey Point) and recapture locations (Antioch and Chipps Island) are consistent from one year to the next, providing a greater opportunity to assess salmon smolt survival over the range of Vernalis flows, SWP/CVP exports, and with and without the presence of the Head of Old River Barrier (HORB). The recovery of marked fish at both Antioch and Chipps Island also 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. 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 combined differential recovery rates are calculated in a similar manner. The use of ratio estimates as part of the VAMP study design factors out the potential differential gear efficiency at Antioch and Chipps Island within and among years.

A quality assurance/quality control program has been used as a routine part of VAMP tests, and includes quantifying the number of marked fish successfully clipped and tagged. Coordination with the local landowner to curtail operation of an agricultural diversion pump located immediately downstream of Durham Ferry, coincident with the Durham Ferry release was continued in 2004. In addition, the 2004 VAMP program continued use of the net pen studies and physiological testing to assess overall condition and health of marked fish used in VAMP experiments. Improvements were also made in 2004 relative to measuring flow in the San Joaquin River downstream of the confluence with Old River. But additional improvements are needed before measurements of San Joaquin River flow downstream of the HORB are used to evaluate the relationship between San Joaquin River flow and juvenile Chinook salmon survival.

FIGURE 1–1

Sacramento–San Joaquin Estuary

Location of VAMP 2004 Release Sites

CHAPTER 1

CHAPTER 2

VAMP Hydrologic Planning & Implementation

This section documents the planning and implementation undertaken by the Hydrology Group of the San Joaquin River Technical Committee (SJRTC) for the 2004 VAMP investigations. Implementation of VAMP is guided by the framework provided in the San Joaquin River Agreement (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 2004, 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 (SJRECWA), 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 provides for a 31-day pulse flow (target flow) at the Vernalis gage on the San Joaquin River (Figure 2-1, inside front cover) during the months of April and May, along with a corresponding reduction in SWP/CVP Sacramento-San Joaquin Delta exports. The VAMP target flow and reduced Delta export are determined based on a forecast of the San Joaquin River flow absent the VAMP (Existing Flow) that would occur during the target flow period (Table 2-1). The Existing Flow is defined in the SJRA as "the forecasted flows in the San Joaquin River at Vernalis during the Pulse Flow Period that would exist absent the VAMP or water acquisitions," including such flows as minimum instream flows, water quality or scheduled fishery releases from New Melones Reservoir, flood control releases, uncontrolled reservoir spills, and/or local runoff. Achieving the target flow requires the coordinated operation of the three major San Joaquin River tributaries upstream of Vernalis: the Merced River, the Tuolumne River and the Stanislaus River.

TABLE 2-1

VAMP Vernalis Flow & Delta Export Targets

Forecasted Existing Flow (cfs)	VAMP Target Flow (cfs)	Delta Export Target Rates (cfs)
0 to 1,999	2,000 [a]	1,500 [a]
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	

[a] non-VAMP flow objectives

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 the San Joaquin River flow near Vernalis is difficult due to uncertainty and variation in unregulated flows, inaccuracy 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 Hydrology and Biology Groups agreed to a target range variation of plus or minus 7% of the Vernalis flow target. It was recognized by the Hydrology and Biology Groups that these guidelines are not absolute conditions, but are to be used by the VAMP hydrology and biology workgroups to evaluate experimental test conditions and the potential effect of flow and export variation on our ability to detect and assess variation in juvenile Chinook salmon survival rates among VAMP test conditions.

Under the SJRA, the following San Joaquin River Group Authority (SJRGA) agencies have agreed to provide the supplemental water needed to achieve the VAMP target flows, limited to a maximum of 110,000 acre-feet: Merced, OID, SSJID, SJRECWA, MID and TID. The Merced supplemental water would be provided on the Merced River from storage in Lake McClure and would be measured at the Merced River at Cressey gage. The OID and SSJID supplemental water would be provided on the Stanislaus River through diversion reductions and would be measured below Goodwin Dam. The SJRECWA supplemental water would be provided via Salt Slough, West Delta Drain, Boundary Drain and/or Orestimba Creek through system operation. The MID and TID supplemental water would be provided on the Tuolumne River from storage in New Don Pedro Reservoir and would be measured at the Tuolumne River below LaGrange Dam gage.

The target flow of 2,000 cubic feet per second (cfs) shown in Table 2-1 does not represent a VAMP experiment target flow data point, but, rather, is used to define the SJRGA supplemental water obligation when Existing Flow is less than 2,000 cfs. 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 higher value (double-step) or the supplemental water requirement could be eliminated entirely (off-ramp). These potential adjustments to the target flow are dependent on the hydrologic year type as defined by the SWRCB San Joaquin Valley Water Year Hydrologic Classification (60-20-20 classification), which is given a numerical indicator as shown in Table 2-2 to make this determination. A double-step flow year occurs when the sum of the numerical indicators for the previous year's year type and current year's forecasted 90 percent exceedence year type is seven (7) or greater, a general recognition of either abundant reservoir storage levels or a high probability of abundant runoff. An off-ramp year occurs when the sum of the numerical indicators for the two previous years' year types and the current year's forecasted 90 percent exceedence year type is four (4) or less, an indication of extended drought conditions.

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

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. 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 the USBR will attempt to acquire the needed additional water on a willing seller basis. The SJRGA will extend a "favored purchaser" offer to the USBR in accordance with the SJRA.

HYDROLOGIC PLANNING

Hydrology Group Meetings

Beginning in February 2004, and continuing until early April, the Hydrology Group held four planning and coordination meetings (February 19, March 17, March 30 and April 9). At these meetings, forecasts of hydrologic and operational conditions on the San Joaquin River and its tributaries were discussed and refined.

Monthly Operation Forecast

As part of the initial planning efforts in February, a monthly operation forecast was 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 presented at the February 19 Hydrology Group meeting. The 90 percent exceedence forecast called for a VAMP target flow of 3,200 cfs and the 50 percent exceedence forecast called for a VAMP target flow of 5,700 cfs.

Daily Operation Plan Development

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 calculates 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 travel times for flows from the tributary measurement points and upper San Joaquin River to the Vernalis gage are used in the development of the daily operation plan. The whole day increments are used because the daily operation plan is developed using mean daily flows.

FLOW TRAVEL TIMES

a. Merced River at Cressey to Vernalis . . . . 3 days

b. San Joaquin River above Merced River to Vernalis . . . . 2 days

c. Tuolumne River below LaGrange Dam to Vernalis. . . . . 2 days

d. Stanislaus River below Goodwin Dam to Vernalis . . . . 2 days

By definition, the ungaged flow at Vernalis is the unmeasured flow entering or leaving the system between the Vernalis gage and the upstream measuring points and is measured as follows:

Ungaged flow at Vernalis =

$$\mathbf{VNS - GDW_{lag} - LGN_{lag} - CRS_{lag} - USJR_{lag}}$$

where:

VNS = San Joaquin River near Vernalis

GDW_{lag} = Stanislaus River below Goodwin Dam lagged 2 days

LGN_{lag} = Tuolumne River below LaGrange Dam lagged 2 days

CRS_{lag} = Merced River at Cressey lagged 3 days

$USJR_{lag}$ = San Joaquin River above Merced River lagged 2 days (USJR is not a gaged flow but is the calculated difference between the gaged flows at the San Joaquin River at Newman (NEW) and the Merced River near Stevinson (MST)).

Of all of the assumptions required for the development of the daily operation plan, the ungaged flow estimation is the one assumption with the greatest degree of uncertainty. An extensive review of historical ungaged flows was made to determine if there were any correlations between the ungaged flow and the hydrologic conditions that could be used to reduce the uncertainty. Unfortunately, no significant correlations were found, but the review did indicate that a reasonable estimate of the ungaged flow for entering the target flow period could be projected. The daily operation plan is developed assuming a constant ungaged flow throughout the target flow period essentially equal to the value entering the period.

By definition, the VAMP 31-day pulse flow period can occur anytime between April 1 and May 31. Factors that are considered in the determination of the timing of the VAMP target flow period include installation of HORB, availability of juvenile salmon at the MRFF, and manpower and equipment availability for salmon releases and recapture. Until a specific start date is defined, a default target flow period of April 15 to May 15 is used for the VAMP operation planning. For 2004 the conditions were such that there was no apparent advantage to a different start date, therefore the target flow period was designated to be April 15 through May 15.

As part of the daily operation plan development, the determination must be made on whether the current year is likely to fall into the “off-ramp” or “double-step” category. The 60-20-20 water year classification for 2002 was “dry” (VAMP numerical indicator of two) and for 2003 was “below normal” (VAMP numerical indicator of three). Under these conditions the possibility of 2004 being an off-ramp year was eliminated since the off-ramp criterion (sum of VAMP numerical indicators for previous two plus current year equal to or less than four) was already exceeded without including the current year’s numerical indicator. Conversely, 2004 would be a “double-step” year if the 90% probability of exceedence forecast called for a 60-20-20 water year classification of “above normal” (VAMP numerical indicator of four) or “wet” (VAMP numerical indicator of five). The final determination of the current year’s VAMP numerical indicator is based on the April 1 runoff forecast, but the hydrologic conditions and forecasts prior to April are monitored so that the VAMP planning can proceed based on the most likely conditions. This year the January, February and March 90% probability of exceedence forecasts were placing 2004 in the “critical” and “dry” classifications, making the possibility of a “double-step” year remote. A drier than average March all but assured that 2004 would not be a “double-step” year. As it turned out, the April 1 90% probability of exceedence forecast classification for 2004 was “dry” (VAMP numerical indicator of two), making 2004 a normal, or single-step, VAMP year.

The initial daily operation plan was prepared on March 17, and was modified as hydrologic conditions and operational requirements changed. Table 2-3 summarizes the various iterations, and demonstrates the evolutionary nature, of the daily operation plan during the VAMP planning phase. The daily operation plans prepared during the VAMP planning phase are provided in Appendix A-1.

Tributary Flow Coordination

Although the primary goal of the VAMP operation is to provide a stable target flow in the San Joaquin River near Vernalis, an

TABLE 2-3

Summary of 2004 VAMP Daily Operation Plans

Phase	VAMP Forecast Date	VAMP Target Flow Period	Assumed Ungaged Flow at Vernalis (cfs)	Existing Flow (cfs)	VAMP Target Flow (cfs)	Supplemental Water needed to meet Target Flow (1,000 AF)
	March 17	April 15–May 15	300	2,185	3,200	62,400
			800	3,779	4,450	41,280
Planning	March 30	April 15–May 15	300	2,135	3,200	65,460
			500	3,778	4,450	41,290
	April 09	April 15–May 15	500	2,353	3,200	52,070
	April 13	April 15–May 15	500	2,352	3,200	52,170
Implementation	April 20	April 15–May 15	365	2,213	3,200	59,780
	May 03	April 15–May 15	281	2,137	3,200	63,620

TABLE 2-4

Real-time Flow Data and Sources

Measurement Location	Real-time Data Source
San Joaquin River near Vernalis	USGS, station 11303500 (http://waterdata.usgs.gov/ca/nwis/dv?format=pre&period=31&site_no=11303500)
Stanislaus River below Goodwin Dam	USBR, Goodwin Dam Daily Operation Report (http://www.usbr.gov/mp/cvo/vungvari/gdwdop.pdf)
Tuolumne River below LaGrange Dam	USGS, station 11289650 (http://waterdata.usgs.gov/ca/nwis/dv?format=pre&period=31&site_no=11289650)
Merced River at Cressey	CDEC, station CRS (http://cdec.water.ca.gov/cgi-progs/queryDgroups?s=fw2)
Merced River near Stevinson	CDEC, station MST (http://cdec.water.ca.gov/cgi-progs/queryDgroups?s=fw2)
San Joaquin River at Newman	USGS, station 11274000 (http://waterdata.usgs.gov/ca/nwis/dv?format=pre&period=31&site_no=11274000)

important consideration in the planning and operation is that the flows that are scheduled on the Merced, Tuolumne and Stanislaus Rivers to achieve this goal are beneficial and do not conflict with studies or flow requirements on those rivers. During the development of the daily operation plan, the Hydrology Group consults with DFG and the tributary biological teams to determine periods when pulse flows and stable flows are desirable on the tributaries, what flow rates are desired, what rates of change are acceptable, and what minimum and maximum flows are acceptable. The periods of desired stable flow are highlighted with bold outlines in the daily operation plans in Appendix A.

For the 2004 VAMP operation the April 9 daily operation plan called for staggered single pulse flow periods on each of the tributaries (Figure 2-2), starting on the Tuolumne River with a nine day flow of about 1,400 cfs, followed by the Stanislaus River with a ten day flow of about 1,250 cfs, and concluding on the Merced River with a ten day flow of about 1,300 cfs. Plots of the individual tributary flows during the VAMP operation are provided in Appendix A-3.

IMPLEMENTATION

Operation Conference Calls

During implementation of the VAMP pulse flow, conference calls were conducted every Monday, Wednesday and Friday between April 16 and May 10 at 6:30 A.M. to discuss the status of the pulse flow and to make operational changes if needed. The calls were held at 6:30 A.M. so that if operational changes were called for they could be implemented on that day.

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 2-4. The real-time flow data used during the implementation of the VAMP flow have varying degrees of quality. The CDEC real-time data has not been reviewed for accuracy or adjusted for rating shifts, whereas 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 are continuously monitored. Similarly, the computed ungaged flow at Vernalis and the flow in the San Joaquin River upstream of the Merced River are continuously updated. The monitoring is done to assure that

FIGURE 2-2

April 9 Forecast of San Joaquin River Basin 2004 VAMP Operation

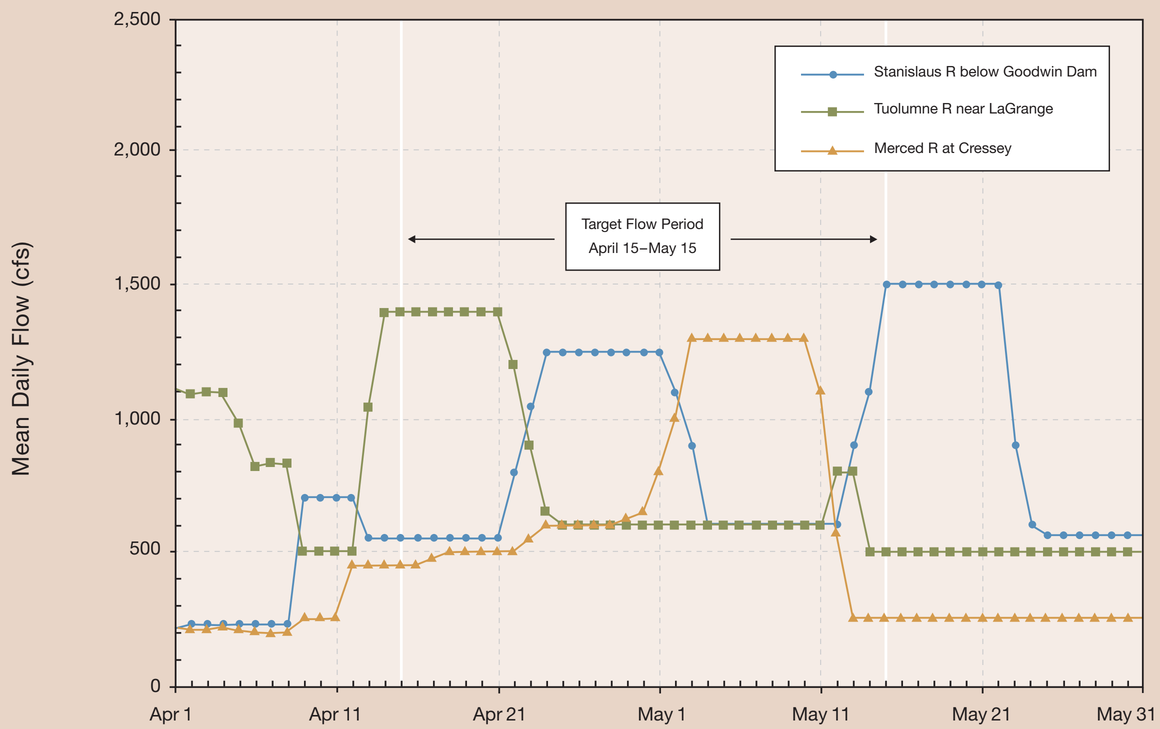

TABLE 2-5

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

Date	Gage Height	Measured Flow (cfs)	Current Rating Shift Flow (cfs)	Percent Difference	Rating Shift
3/19/04 (15:10)	12.13	4,330	4,240	2.1%	No
4/06/04 (09:50)	10.46	2,640	2,720	-3.0%	No
4/14/04 (10:20)	9.64	2,050	2,030	1.0%	No
4/20/04 (09:48)	10.85	3,130	3,070	1.9%	No
4/27/04 (10:48)	11.11	3,190	3,320	-4.1%	No
5/04/04 (10:15)	11.11	3,350	3,320	0.9%	No
5/11/04 (09:50)	11.12	3,310	3,320	-0.3%	No

the supplemental water deliveries are adhering to the tributary allocations contained in the SJRGA Division Agreement to the extent possible, as well as to determine if adjustments need to be made to the operation plan.

Normally, the USGS makes monthly measurements of the flow at Vernalis to check the current rating shift. 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 April 6 and May 11. The results of these measurements are summarized in Table 2-5. There were no rating shifts during the 2004 VAMP operation period.

The daily operation plan was updated twice during the VAMP flow period (Table 2-3). In each update the estimation of VAMP supplemental flow was adjusted to compensate for a decline in the ungaged flow. The daily operation plans prepared during the VAMP implementation phase are provided in Appendix A-1 in the April 20 and May 3 plans. Final accounting of the supplemental VAMP water contribution is provided in Appendix A-2.

RESULTS OF OPERATIONS

The final accounting for the VAMP operation was accomplished using provisional mean daily flow data available from USGS and DWR as of July 2, 2004. Provisional data is data that 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-3 to illustrate the differences between the real-time and the provisional data.

The mean daily flow at the Vernalis gage averaged 3,155 cfs during the April 15–May 15 VAMP target flow period, 1.4% below the target flow of 3,200 cfs. The maximum mean daily flow (Figure 2-3) during target flow period was 3,380 cfs on May 10 and the minimum was 2,370 cfs on April 15. The final Existing Flow was estimated to have averaged 2,088 cfs during the target flow period. The VAMP operation resulted in a 51% increase in flow at Vernalis during the target flow period and required 65,591 acre-feet of supplemental water. Figure 2-3 shows the flow at Vernalis with and without the VAMP supplemental water. Figure 2-4 shows the sources of the flow at Vernalis. Figures 2-5, 2-6 and 2-7 show the with and without VAMP flows at the tributary measurement points, Merced River at Cressey, Tuolumne River below LaGrange Dam and Stanislaus River below Goodwin Dam, respectively.

The initiation of the VAMP was based on the April 9 daily operation plan (see Appendix A-1) with a forecasted Existing Flow of 2,353 cfs and a supplemental water requirement of 52,070 acre-feet. During the target flow period the observed Existing Flow was substantially less than the forecasted Existing

FIGURE 2-3

2004 VAMP–San Joaquin River Near Vernalis With and Without VAMP

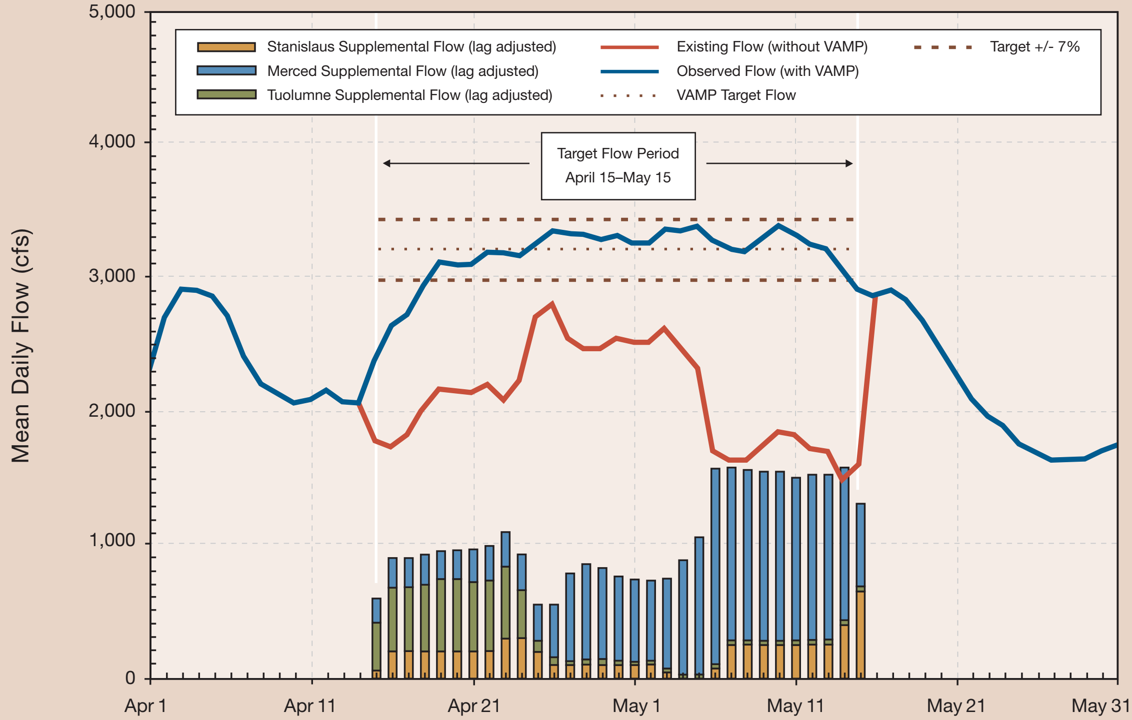

FIGURE 2-4

2004 VAMP San Joaquin River Near Vernalis With Lagged Contributions from Primary Sources

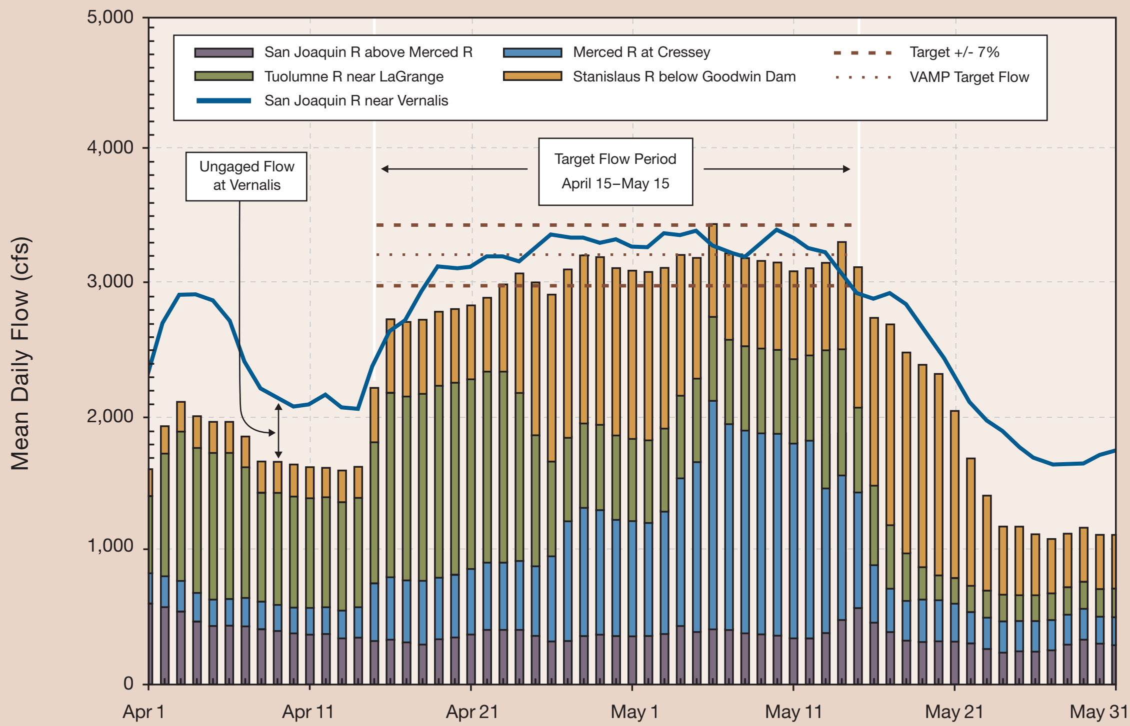

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FIGURE 2-5

2004 VAMP–Merced River at Cressey

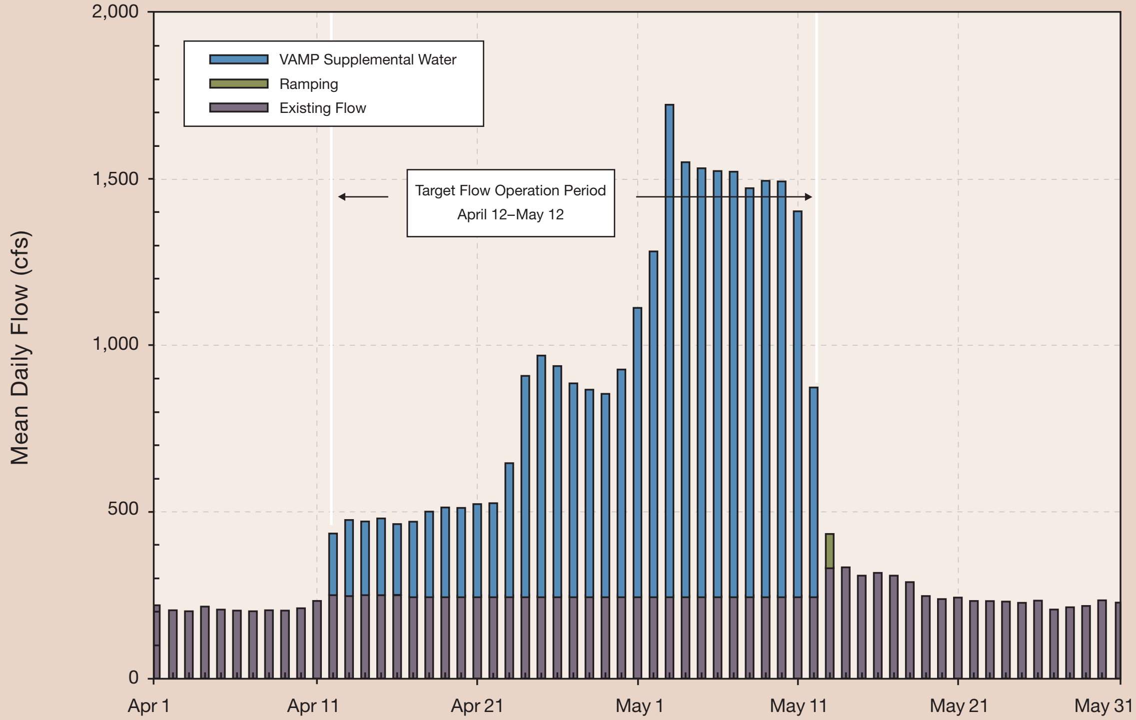


FIGURE 2-6

2004 VAMP–Tuolumne River Below LaGrange Dam

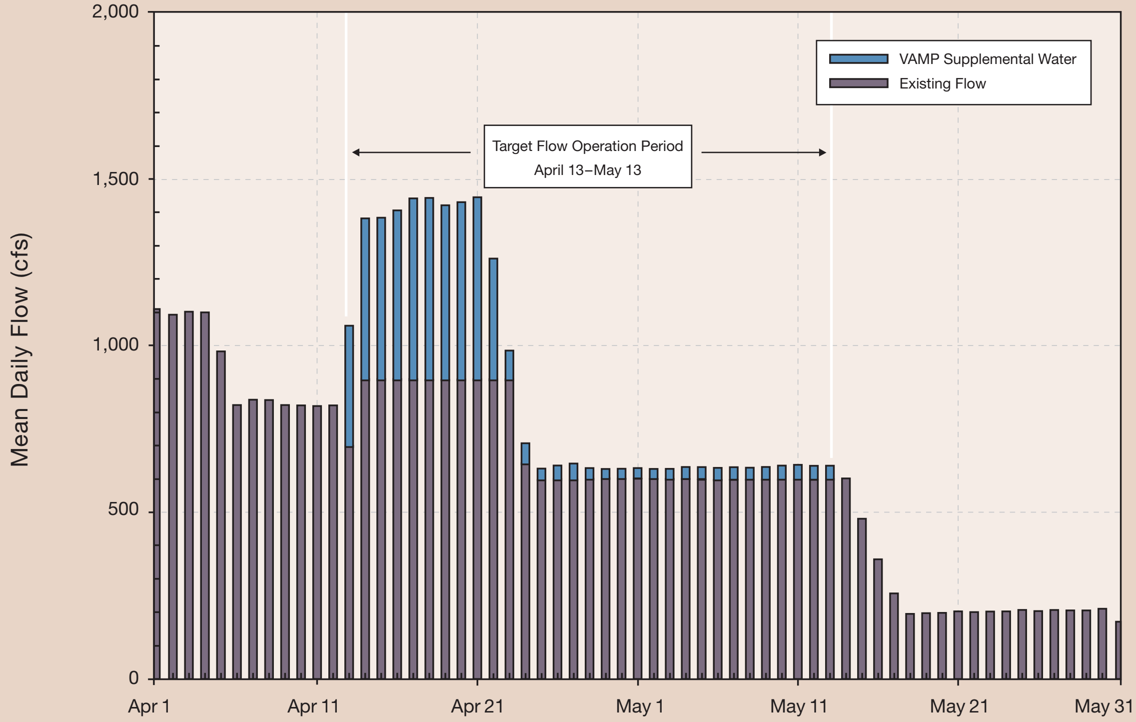


FIGURE 2-7

2004 VAMP–Stanislaus River Below Goodwin Dam

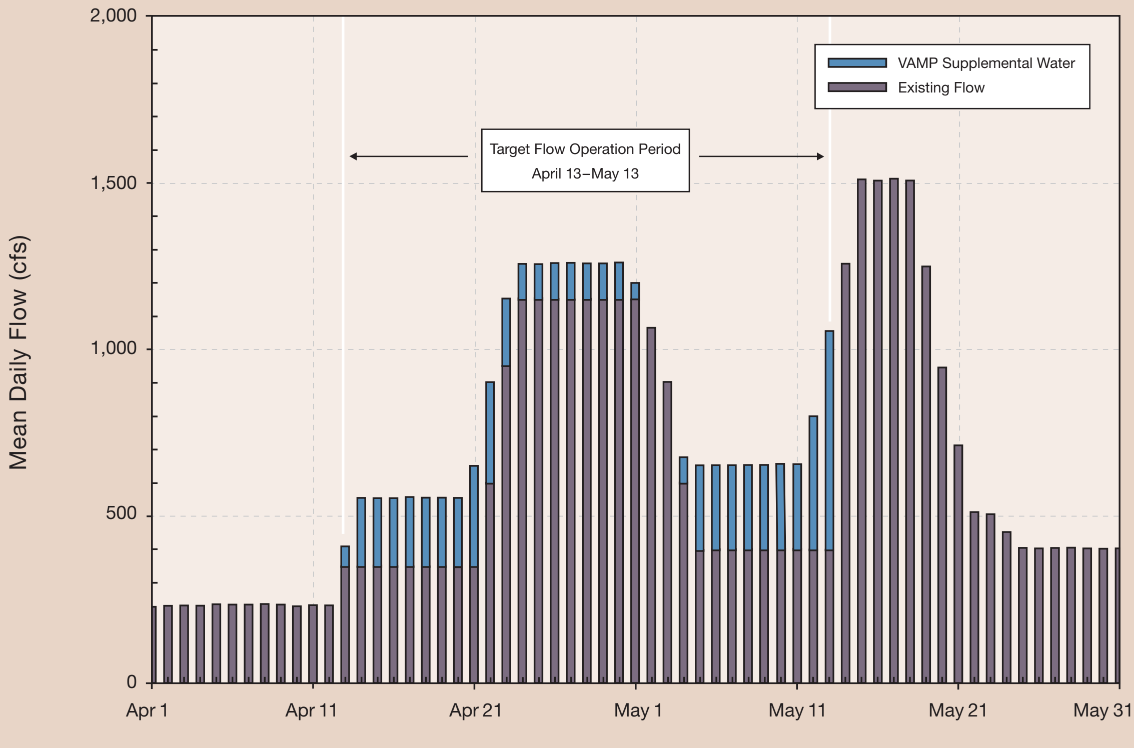
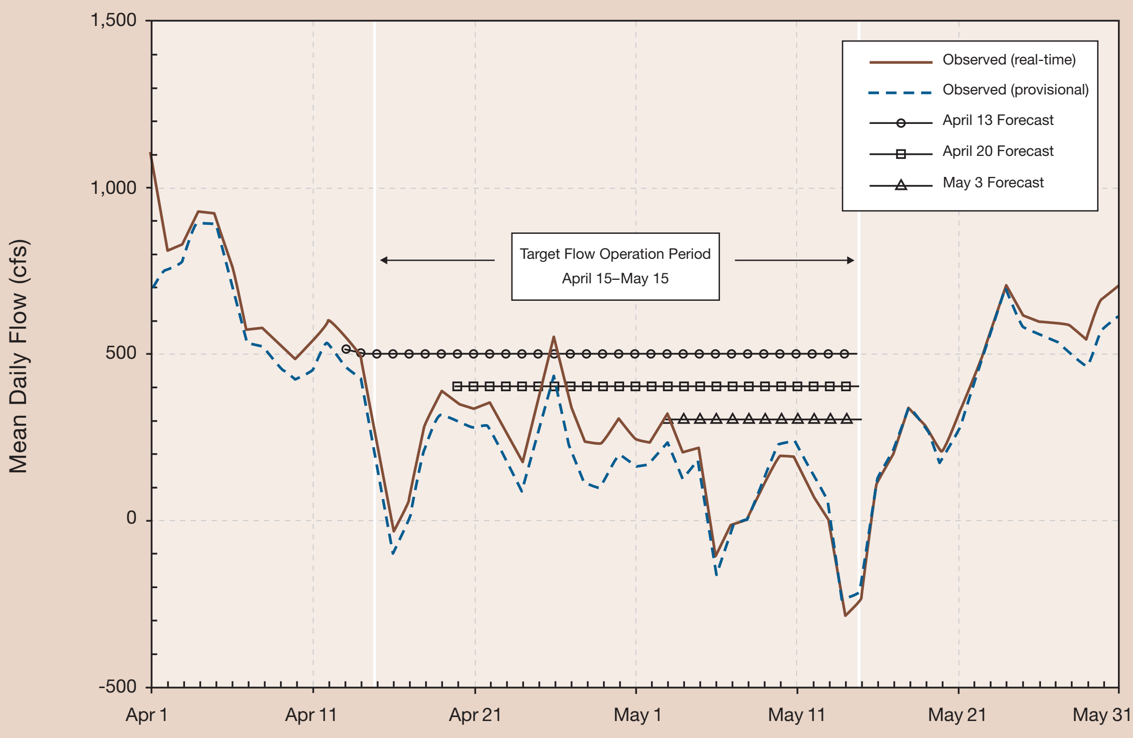


FIGURE 2-8

2004 VAMP–Ungaged Flow in San Joaquin River at Vernalis
Comparison of Forecasted and Observed



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Flow, primarily due to a significant decline in the ungaged flows from that forecasted, causing the SJRGA to contribute an additional 13,521 acre-feet of supplemental water. During the target flow period, no adjustments were made to the New Melones Reservoir water quality or scheduled fishery flow releases, which are a component of the Existing Flow. Without further analysis it is unknown if any such adjustments would have been appropriate.

In planning for the VAMP operation the ungaged flow in the San Joaquin River 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, adjustments were made to the ungaged flow based not on day-to-day fluctuations but on evidence that the ungaged flow is trending away from the forecast. This is best illustrated in Figure 2-8, which shows in hindsight the observed ungaged flow along with that forecast prior to the test flow period on April 13 and the adjusted forecasts that were modified on an ongoing basis in an attempt to account for deviation from the existing forecast.

Another unknown in the forecast equation similar to the ungaged flow is the flow in the San Joaquin River upstream of the Merced River. This unknown tends not to be as variable as the ungaged flow, but like the ungaged flow, it may be adjusted if the observed flow warrants it. During the 2004 VAMP operation no modifications were made to the upper San Joaquin River flow forecast that was used in the April 13 daily operation plan. Figure 2-9 shows the observed and forecasted upper San Joaquin River flows.

The target combined CVP and SWP Delta export rate for the 2004 VAMP was 1,500 cfs. The observed export rate averaged 1,331 cfs during the VAMP target flow period. The daily SWP and CVP exports during the VAMP test period are shown in Figure 2-10.

The SJRGA member agencies have entered into an agreement, known as the Division Agreement, which allocates the responsibility of the member agencies for providing the VAMP supplemental water. The member agencies may also enter into additional agreements among themselves regarding delivery of the supplemental water. For the 2004 VAMP, Merced I.D. and the SJRECWA entered into an agreement whereby the SJRECWA supplemental water would be provided by Merced I.D. on the Merced River. The distribution of supplemental water for the 2004 VAMP operation, compared to the distribution called for under the Division Agreement, is summarized in Table 2-6.

Hydrologic Impacts

The Merced VAMP supplemental water is provided from storage in Lake McClure on the Merced River and the MID/TID VAMP

TABLE 2-6

Distribution of Supplemental Water

Agency	Supplemental Water Provided (acre-feet)	Division Agreement Distribution (acre-feet)	Deviation from Division Agreement (acre-feet)
Merced I.D.	37,680	36,500	+1,180
Oakdale I.D./South San Joaquin I.D.	11,760	14,091	-2,331
Exchange Contractors	5,000 [a]	5,000	0
Modesto I.D./Turlock I.D.	11,151	10,000	+1,151
Total	65,591	65,591	0

[a] The Exchange Contractors supplemental water was provided by Merced I.D.

FIGURE 2-9

2004 VAMP–San Joaquin River Above Merced River
Comparison of Forecasted and Observed

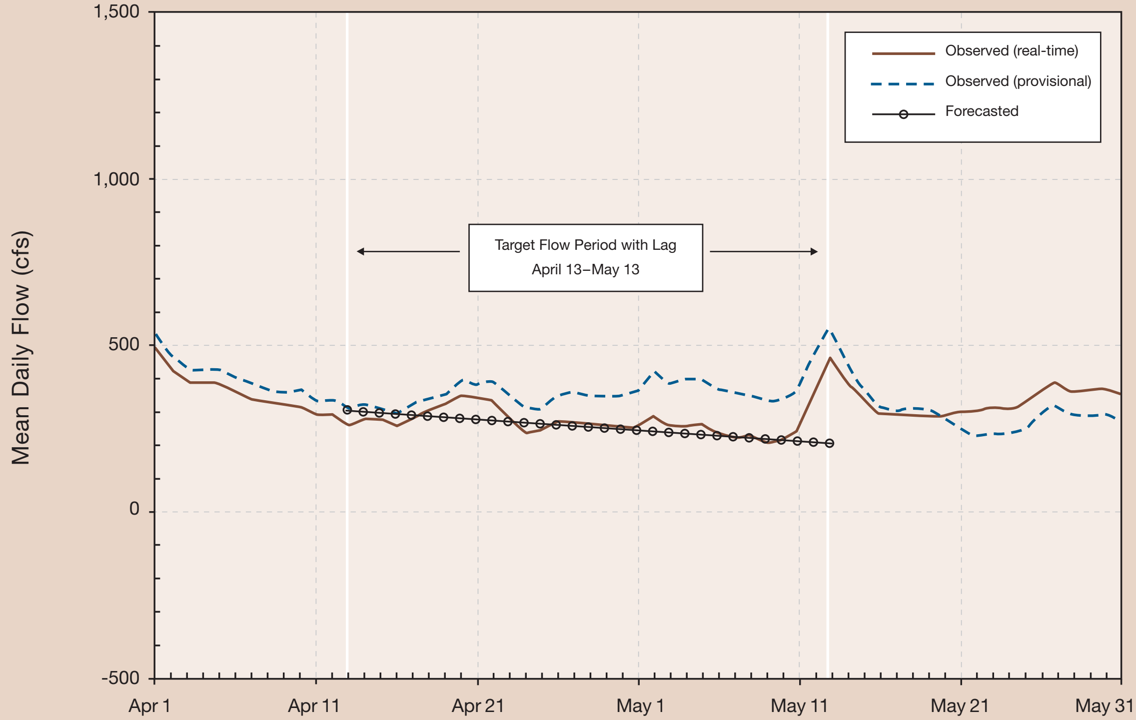
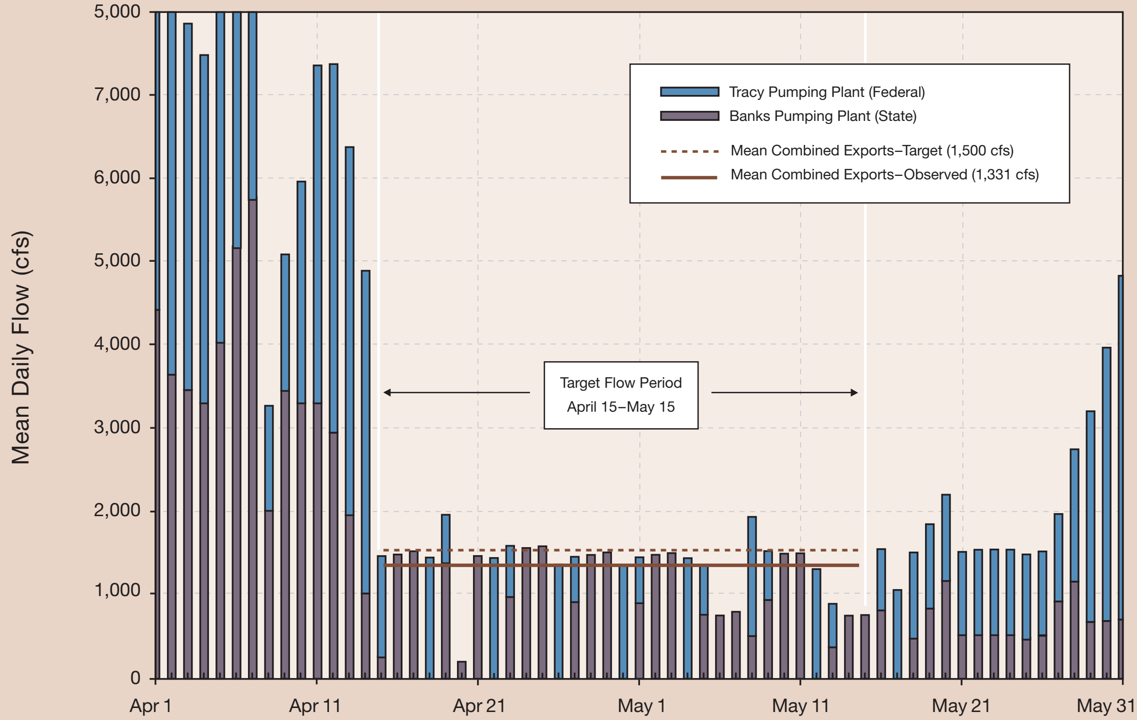


FIGURE 2-10

2004 VAMP–Federal and State Delta Exports



supplemental water is provided from storage in New Don Pedro Reservoir. The OID/SSJID VAMP supplemental water is made available from their diversion entitlements and therefore there are no storage impacts in New Melones Reservoir on the Stanislaus River due to the SJRA. 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.

The current cumulative impact of the SJRA on the storage in Lake McClure would be 215,197 acre-feet (Table 2-7), if Merced I.D. diversions from the Merced River are assumed to have been the same for both without and with SJRA conditions. However, as a result of the SJRA, Merced I.D. has undertaken a number of conservation measures that have resulted in a reduced reliance on Merced River diversions. Any reductions in Merced River diversions would offset the storage deficit shown in Figure D-1 (Appendix D). The impact of the conservation measures on Merced River diversions is in the process of being quantified and was not available at the time of publication of this report. The conservation impacts will be incorporated into next year's annual report. It should be noted that even under the assumption that the storage deficit is equal to the supplemental water contribution the SJRA has resulted in no reductions in Merced River flow during the period of 2000 through 2004 as shown in Figure D-3.

The cumulative impact of the SJRA on storage in New Don Pedro Reservoir following the 2003 VAMP operation was 23,790 acre-feet. This storage deficit was erased as a result of flood control operations in March 2004. Therefore, as a result of the 2004 VAMP operation the current impact of the SJRA on New Don Pedro Reservoir storage is 11,151 acre-feet (see Table 2-8).

The impacts of the SJRA on New Don Pedro Reservoir storage and on Tuolumne River flow for the period of 2000 through 2004 are shown in Appendix D, Figures D-2 and D-4.

SUMMARY OF HISTORICAL VAMP OPERATIONS

2004 marks the fifth year of VAMP operation in compliance with SWRCB Decision 1641. A summary of the VAMP target flows for these first five years is provided in Table 2-9. A summary of the SJRGA supplemental water contributions is provided in Table 2-10. The Hydrology Group monitors the cumulative impact of the SJRA on reservoir storage and stream flows. Plots of storage and flow impacts throughout the five years of VAMP operation are provided in Appendix D.

Over the first five years of the program considerable variation has occurred in both the flow entering the system upstream of the Merced River and the ungaged flow within the system. With each update of the daily operation plan throughout the planning and implementation phases the upstream and ungaged flows would vary causing the SJRGA to reduce or increase the contribution of supplemental water in order to support the VAMP target flow. A table summarizing the differences between the forecasted and observed Existing Flows during the five years of VAMP implementation, along with the corresponding differences in the supplemental water requirements, is provided in Appendix D-5. An analysis of the variability in the upstream and ungaged flows and how these affect the computation of the Existing and supplemental flows is warranted.

TABLE 2-7

Storage Impact History, Lake McClure (Merced River)

Calendar Year	VAMP Supplemental Water (acre-feet)*	Fall Supplemental Water (acre-feet)	SJRA Storage Impact Replenishment (acre-feet)	End of Year Cumulative Storage Impact (acre-feet)**
2000	46,750	12,500	46,750 (May 2000)	-12,500
2001	43,146	12,496	0	-68,142
2002	27,120	12,470	0	-107,732
2003	39,586	12,500	0	-159,818
2004	42,879	12,500	0	-215,197

* Includes ramping flows.
** End of Year storage impacts not adjusted for conservation actions implemented by district.

TABLE 2-8

Storage Impact History, New Don Pedro Reservoir (Tuolumne River)

Calendar Year	VAMP Supplemental Water (acre-feet)	SJRA Storage Impact Replenishment (acre-feet)	End of Year Cumulative Storage Impact (acre-feet)
2000	22,651	14,955 (Sept–Oct 2000)	-7,696
2001	14,061	7,696 (Jan–Feb 2001)	-14,061
2002	0	0	-14,061
2003	9,729	0	-23,790
2004	11,151	23,790 (March 2004)	-11,151

The SJRGA member agencies have entered into an agreement, known as the Division Agreement, which allocates the responsibility of the member agencies for providing the VAMP supplemental water.

TABLE 2-9

Summary of VAMP Flows, 2000-2004

Year	60-20-20 Water Year Hydrologic Classification	VAMP Target Flow (cfs)	Observed VAMP Flow (cfs)	Existing Flow (cfs)	VAMP Suppl. Water (acre-ft)	Delta Export Target (cfs)	Observed Delta Exports (cfs)
2000	Above Normal	5,700	5,869	4,800	77,680	2,250	2,155
2001	Dry	4,450	4,224	2,909	78,650	1,500	1,420
2002	Dry	3,200	3,301	2,757	33,430	1,500	1,430
2003	Below Normal	3,200	3,235	2,290	58,065	1,500	1,446
2004	Dry	3,200	3,155	2,088	65,591	1,500	1,331

TABLE 2-10

Summary of VAMP Supplemental Water Contributions, 2000-2004

Year	VAMP Supplemental Water (acre-ft)		Supplemental Water (acre-ft)					
			Merced ID	OID	SSJID	SJRECWA	MID	TID
2000	77,680	Observed:	46,750	[a]	[b]	8,280	15,200	7,450
		Division Agreement:	45,160	7,300	7,300	7,300	16,920	8,300
		Deviation:	+1,590	0	0	+980	-1,720	-850
2001	78,650	Observed:	42,120	7,365	7,365	7,740	7,030	7,030
		Division Agreement:	42,150	7,300	7,300	7,300	7,300	7,300
		Deviation:	-30	+65	+65	+440	-270	-270
2002	33,430	Observed:	25,840	3,795	3,795	0	0	0
		Division Agreement:	25,000	4,215	4,215	0	0	0
		Deviation:	+840	-420	-420	0	0	0
2003	58,065	Observed:	38,257	5,039	5,039	[c]	4,864.5	4,864.5
		Division Agreement:	38,065	5,000	5,000	5,000	5,000	5,000
		Deviation:	+192	+39	+39	0	-135.5	-135.5
2004	65,591	Observed:	42,680	5,880	5,880	[c]	5,575.5	5,575.5
		Division Agreement:	41,500	7,045.5	7,045.5	5,000	5,000	5,000
		Deviation:	+1,180	-1,165.5	-1,165.5	0	+575.5	+575.5

[a] Provided by Modesto ID
[b] Provided by Merced ID (54.55%), Oakdale ID (15.91%), Modesto ID (15.91%), Turlock (13.64%)
[c] Provided by Merced ID

CHAPTER 3

Additional Water Supply Arrangements & Deliveries

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." 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. The purpose of additional water supply deliveries in the fall months is to provide instream flows to attract and assist adult salmon during spawning.

MERCED IRRIGATION DISTRICT

Paragraph 8.4 of the SJRA states 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 developed by the California Department of Fish and Game (DFG), United States Fish and Wildlife Services (USFWS) and Merced ID.

The schedule for the 2004 Fall SJRA Transfer was finalized on September 28, 2004, with the transfer commencing on October 1, 2004. The transfer of the 12,500 acre-feet was completed by October 26, 2004. A daily summary of the final accounting for the 2004 Fall SJRA Transfer is provided in Appendix A, Table A-4.

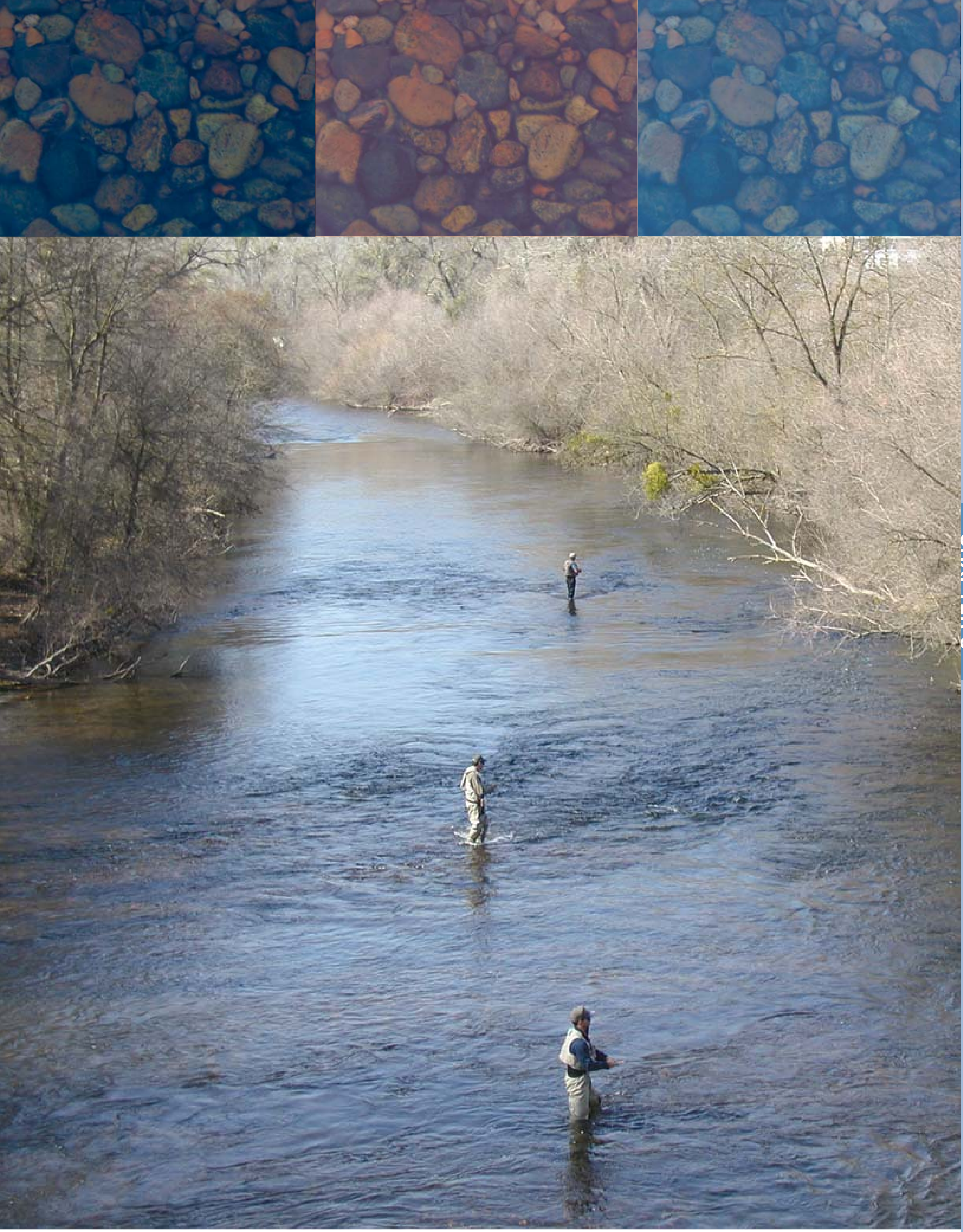
The 2003 Fall SJRA Transfer was in progress at the time of publication of the 2003 Annual Technical Report and therefore only preliminary data was provided in that report. The final data for the 2003 Fall SJRA Transfer are included in Appendix A, Table A-5 of this report.

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 5,880 acre-feet of supplemental water for the 2004 VAMP operation, resulting in 5,120 acre-feet of Difference Water (11,000 minus 5,880). Therefore, pursuant to Paragraph 8.5 of the Agreement, OID sold a total of 20,120 acre-feet of water (15,000 plus 5,120) to the USBR in 2004. The OID additional water is made available in New Melones reservoir for use by the USBR for any authorized purpose of the New Melones project.

The USBR has used and has scheduled to be used the additional OID water as follows: 1,934 acre-feet was used to provide supplemental flow in the Stanislaus River from July 16, 2004 through July 21, 2004; 3,186 acre-feet is scheduled to be used to provide an additional 25 cfs per day of flow in the Stanislaus River from November 1, 2004 through January 3, 2005; 6,694 acre-feet was used to provide a pulse flow of 800 cfs in the Stanislaus River from October 24, 2004 through October 31, 2004; and 8,306 acre-feet is scheduled to be used to provide an additional 50 cfs in the Stanislaus River from November 1, 2004 until it runs out, around January 23, 2005.



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CHAPTER 4

Head of Old River Barrier

Installation of the spring temporary Head of Old River Barrier (HORB) was completed on April 9 with the initial operation commencing on April 15. Construction clean-up continued for a short period following the initial operation. 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 and operated, is now fully permitted though 2005.

BARRIER DESIGN, INSTALLATION AND OPERATION

The spring HORB was first constructed in 1992. Since then, the barrier has been installed in 1994, 1996, 1997 (w/two culverts), 2000, 2001, 2002, 2003 and 2004. In 2000–2004 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.

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 2004, the low-flow version was installed.

The dimensions of the 2004 HORB (Figure 4-1) were similar to the 2000, 2001, 2002 and 2003 HORB. The base width of the HORB in 2004 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 beginning in 1997, and six operable culverts were installed beginning in 2000. Operation of the culverts is controlled using slide gates 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 takes this into consideration when making decisions regarding the culvert operations.

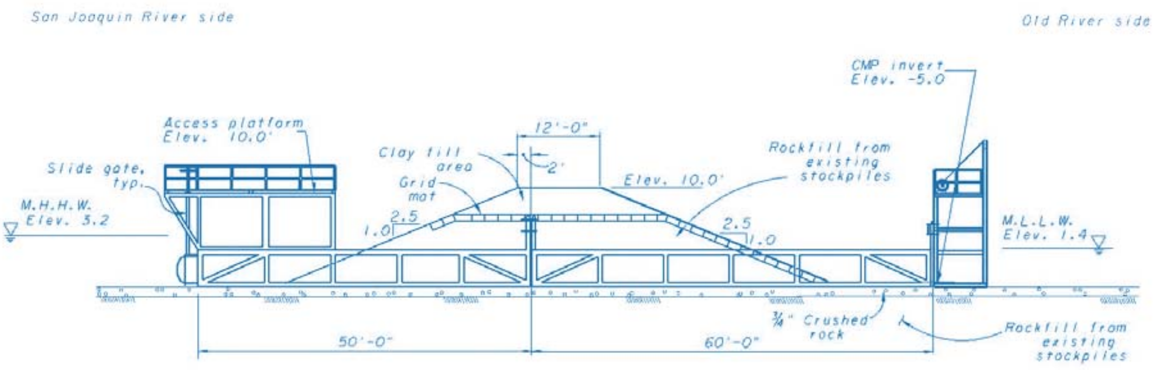
The downstream outlet of each culvert was designed so fyke nets could be attached to evaluate fish passage. DFG staff conducted a fishery-monitoring program as part of the 2004 HORB operations.

Permitting and Construction

The various permit conditions that are placed on the Temporary Barriers Program by the USFWS, National Marine Fisheries Service (NOAA), and DFG, require that the earliest in-water construction activities begin on the Head of Old River (HOR), Middle River (MR), and Old River at Tracy (ORT) barriers, during the Spring barrier installation period, 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

FIGURE 4-1

Spring Head of Old River Barrier Cross Section



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:

USFWS Biological Opinion (1-1-01-F-81)
(item and page of referenced report)

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).*

NOAA Biological Opinion (SWR-00-SA-289: MEA on the proposed ACOE permit (200000696))
(item and page of referenced report)

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, page 6);*
3) The ORT barrier construction may begin on April 1 *(item 2, 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 (2081-2001-009-BD)

1) HORB Spring Installation – All work in or near the stream zone will be confined to the period beginning no earlier than April.
2) 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

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

TABLE 4-1 HORB Culvert Gate Status						
	Culvert Number					
Date	1	2	3	4	5	6
4/14/04	x	x	x	O	O	O
4/15/04	x	x	x	O	O	O
4/16/04	x	x	x	O	O	O
4/17/04	x	x	x	O	O	O
4/18/04	x	x	x	O	O	O
4/19/04	x	x	x	O	O	O
4/20/04	x	x	x	O	O	O
4/21/04	x	x	x	O	O	O
4/22/04	x	x	x	O	O	O
4/23/04	x	x	x	O	O	P
4/24/04	x	x	x	O	O	P
4/25/04	x	x	x	O	O	P
4/26/04	x	x	x	O	O	P
4/27/04	x	x	x	O	O	P
4/28/04	O	x	O	O	P	P
4/29/04	O	x	O	O	O	O
4/30/04	O	x	O	O	O	O
5/01/04	O	x	O	O	O	O
5/02/04	O	x	O	O	O	O
5/03/04	O	x	O	O	O	O
5/04/04	O	x	O	O	O	O
5/05/04	O	x	O	O	O	O
5/06/04	O	x	O	P	O	O
5/07/04	O	x	O	P	O	O
5/08/04	O	x	O	P	O	O
5/09/04	O	x	O	P	O	O
5/10/04	O	x	O	P	O	O
5/11/04	O	x	O	P	O	O
5/12/04	O	x	O	P	O	O
5/13/04	O	x	O	P	O	O
5/14/04	P	x	O	P	O	O
5/15/04	P	x	O	P	O	O
5/16/04	P	x	O	P	O	O
5/17/04	P	x	O	P	O	O
5/18/04	P	x	O	P	O	O

O Open   P Partially Open   x Closed

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 continued work above the water beyond April 15 to cleanup the site and to demobilize.

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 and Grant Line above Doughty Cut would remain above 0.0 feet MSL and Middle River near Howard Road above 0.3 feet MSL. Based on modeling results and/or field monitoring of water levels in the south delta, three of the six culverts remained open from April 15 until May 19, 2004. Graphical results of the water level modeling are presented in Appendix B. On April 28, 2004 two additional culverts were opened and remained open until May 19, 2004. The sixth culvert slide gate (number 2 culvert) was stuck shut throughout the period the HORB was in place. A summary table of the culvert operation is provided in Table 4-1. Removal of the HORB commenced on May 19, 2004 and was completed by June 10, 2004.

Flow Measurements At and Around Barrier

DWR operates two Acoustic Doppler Current Meters (ADCM) in the vicinity of the HORB, one in the San Joaquin River 1,300 feet downstream of Old River and one in Old River 840 feet downstream of the HORB. The ADCMs record velocity measurements at a 15 minute interval from which flow values can be determined. Table 4-2 lists the daily mean, maximum and minimum flows for the April 1, 2004 through May 31, 2004 period for the two ADCMs. Both ADCMs suffered from technical difficulties that resulted in gaps in the available data for this period. The San Joaquin River below Old River ADCM had an internal battery failure that prevented data collection from April 6 at 18:15 through May 3 at 11:30. The Old River at Head ADCM

TABLE 4-2

Summary of Flows at DWR Acoustic Doppler Current Meters near HORB

Date	San Joaquin River below Old River				Old River below HORB (Old River at Head)			
	Number of Records	Mean Flow (cfs)	Maximum Flow (cfs)	Minimum Flow (cfs)	Number of Records	Mean Flow (cfs)	Maximum Flow (cfs)	Minimum Flow (cfs)
4/01/04	95	158	1,573	-1,547	(b)			
4/02/04	96	427	1,603	-1,262	(b)			
4/03/04	96	487	1,709	-1,281	(b)			
4/04/04	96	554	1,724	-1,171	(b)			
4/05/04	96	555	1,731	-1,262	(b)			
4/06/04	72		1,681	-1,221	(b)			
4/07/04	(a)				(b)			
4/08/04	(a)				(b)			
4/09/04	(a)				(b)			
4/10/04	(a)				(b)			
4/11/04	(a)				(b)			
4/12/04	(a)				(b)			
4/13/04	(a)				(b)			
4/14/04	(a)				(b)			
4/15/04	(a)				(b)			
4/16/04	(a)				(b)			
4/17/04	(a)				(b)			
4/18/04	(a)				(b)			
4/19/04	(a)				(b)			
4/20/04	(a)				(b)			
4/21/04	(a)				(b)			
4/22/04	(a)				(b)			
4/23/04	(a)				(b)			
4/24/04	(a)				(b)			
4/25/04	(a)				(b)			
4/26/04	(a)				(b)			
4/27/04	(a)				(b)			
4/28/04	(a)				(b)			
4/29/04	(a)				(b)			
4/30/04	(a)				(b)			
5/01/04	(a)				(b)			
5/02/04	(a)				(b)			
5/03/04	49		3,293	2,099	40		531	402
5/04/04	96	2,530	3,217	1,337	96	449	522	319
5/05/04	96	2,551	3,353	1,156	96	452	537	300
5/06/04	96	2,498	3,383	905	96	449	540	273
5/07/04	96	2,516	3,424	1,069	96	449	545	290
5/08/04	96	2,483	3,298	961	96	444	531	279
5/09/04	96	2,537	3,303	1,144	96	447	532	299
5/10/04	96	2,656	3,430	1,605	96	459	545	348
5/11/04	96	2,696	3,258	2,033	96	465	527	395
5/12/04	96	2,616	3,116	1,881	96	457	512	378
5/13/04	96	2,557	3,084	1,550	96	449	502	342
5/14/04	96	2,454	3,018	1,480	96	441	508	335
5/15/04	96	2,302	2,936	1,133	96	425	494	297
5/16/04	96	2,241	3,017	858	96	417	501	268
5/17/04	96	2,269	3,141	678	96	420	514	248
5/18/04	95	2,314	3,122	1,085	95	426	512	292
5/19/04	96	2,139	3,001	736	96	410	499	254
5/20/04	96	1,966	2,920	438	96	391	490	222
5/21/04	96	1,602	2,845	51	96	359	482	181
5/22/04	96	860	2,099	-970	9		334	185
5/23/04	96	826	2,107	-919	(c)			
5/24/04	96	686	1,898	-963	(c)			
5/25/04	96	508	1,760	-1,206	(c)			
5/26/04	96	421	1,632	-1,241	(c)			
5/27/04	96	438	1,489	-1,354	(c)			
5/28/04	96	400	1,530	-1,416	(c)			
5/29/04	96	368	1,501	-1,580	(c)			
5/30/04	96	301	1,467	-1,548	(c)			
5/31/04	96	274	1,589	-1,565	(c)			

[a] Internal battery failure.
[b] Meter inoperable while awaiting replacement equipment.
[c] Newly installed equipment unable to log data to data logger.

TABLE 4-3

Estimation of Total Flow Through HORB Culverts

Date	Culvert #4 Measured Flow (cfs)	Number of Fully Open Culverts [1]	Number of Partially Open Culverts [2]	Total Estimated Flow Through Culverts (cfs) [3]
4/14/04	51	3	0	204
4/15/04	65	3	0	204
4/16/04	73	3	0	204
4/17/04	73	3	0	204
4/18/04	77	3	0	204
4/19/04	81	3	0	204
4/20/04	73	3	0	204
4/21/04	72	3	0	204
4/22/04	68	3	0	204
4/23/04	75	2	1	156
4/24/04	73	2	1	156
4/25/04	76	2	1	156
4/26/04	77	2	1	156
4/27/04	72	2	1	156
4/28/04	66	3	2	244
4/29/04	67	5	0	340
4/30/04	62	5	0	340
5/01/04	64	5	0	340
5/02/04	63	5	0	340
5/03/04	62	5	0	340
5/04/04	61	5	0	340
5/05/04	59	5	0	340
5/06/04	62	5	0	340
5/07/04	30	4	1	292
5/08/04	21	4	1	292
5/09/04	21	4	1	292
5/10/04	21	4	1	292
5/11/04	22	4	1	292
5/12/04	22	4	1	292
5/13/04	22	4	1	292
5/14/04	21	3	2	244
5/15/04	20	3	2	244
5/16/04	19	3	2	244
5/17/04	19	3	2	244
5/18/04	18	3	2	244

[3] = [1] x A + [2] x B

A = Flow through fully open culvert. Assumed equal to average of measured flow through culvert #4 while fully open (4/14/04 through 5/06/04) = 68 cfs

B = Flow through partially open culvert. Assumed equal to average of measured flow through culvert #4 while partially open (5/08/04 through 5/18/04) = 20 cfs

TABLE 4-4

Estimate of Seepage Flow Through HORB

Date	Flow in Old River below HORB (Old River at Head ADCM) (cfs) [1]	Total Estimated Flow Through Culverts (cfs) [2]	Estimated Seepage Through HORB (cfs) [3] = [1] - [2]
5/04/04	449	340	109
5/05/04	452	340	112
5/06/04	449	340	109
5/07/04	449	292	157
5/08/04	444	292	152
5/09/04	447	292	155
5/10/04	459	292	167
5/11/04	465	292	173
5/12/04	457	292	165
5/13/04	449	292	157
5/14/04	441	244	197
5/15/04	425	244	181
5/16/04	417	244	173
5/17/04	420	244	176
5/18/04	426	244	182

was out of service April 1 through May 3 at 14:00 while awaiting replacement parts, and then again from May 22 at 02:15 through May 31 due to a technical problem that prevented it from logging data to the data logger.

Similar to 2003, DWR installed a Doppler "Argonaut" flow measuring device inside culvert #4. Data was recorded every 15 minutes during the period when the HORB was in operation. The flow through a completely submerged culvert is primarily dependent on the water levels at the two ends of the culvert, but is also dependent on culvert inlet geometry, slope, size and roughness. If it is assumed that all of these factors are similar for all six of the culverts, then the measured flow in culvert #4 would be a reasonable estimate of the flow in each of the other culverts. Table 4-3 summarizes the measured mean daily flows in culvert #4 and the estimation of the total flow through all of the culverts.

Since the HORB is a rock barrier there is also an unknown amount of seepage through it. The seepage through the HORB can be estimated as the difference between the measured flow at the Old River at Head ADCM and the estimated flow through the HORB culverts. For the period when both those flow records are available, May 4 through May 18, the estimated mean daily seepage averaged 152 cfs with a range of 103 cfs to 190 cfs (Table 4-4).

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. Vernalis flows and stages at the barrier were not high enough in 2004 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 has 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 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; this station is now rated and generating flow data. 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 Memorandum Report "Reclamation District 544 Seepage Monitoring Study 2001–2002". This is an ongoing study to document the seepage monitoring results from Upper Robert Island (Souverville, 2004). DWR also released the latest annual (2002–2003) report. Based on the 2000, 2001 and 2002–2003 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

All six culverts in the Head of Old River Barrier (HORB) were installed for the 2004 VAMP test period, although the number of culverts open varied throughout the period. 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 fish

monitoring program was designed and implemented by the DFG to evaluate and quantify fish entrainment at the HORB. The specific objectives of the 2004 fishery investigations were to:

- Determine the total number of juvenile Chinook salmon and other fish species entrained through the culverts at the HORB (Entrainment Monitoring); and
- Determine the percentage of coded-wire tagged (CWT) salmon, released at Mossdale and Durham Ferry, entrained into Old River (Entrainment Monitoring).

Results from 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.

FIGURE 4-2

Culverts in the HORB

Culverts in the HORB were numbered from 1 to 6, with number 1 closest to shore. Culvert number 1 through 3 were closed initially but were opened 8 days later.

CHAPTER 4

Material and Methods

As part of the 2004 VAMP studies, approximately 106,000 CWT salmon were released at Durham Ferry on April 22 and approximately 78,000 CWT salmon were released at Mossdale on April 23. Unlike in previous years, there was no replicate set of CWT releases the following week. Salmon from the VAMP releases were used in the Entrainment Monitoring studies. The secondary Entrainment Special Study was discontinued in 2004, therefore no color-marked salmon were released directly upstream of the HORB.

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, and are made of 1/4-inch braided mesh. Five of the six nets are 60 feet long and one net 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 culverts were numbered from 1 to 6 with number 1 located next to the shoreline (viewed from downstream) and number 6 located mid-channel (Figure 4-2). On April 20, the nets were attached to culvert numbers 4, 5 and 6 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 flanges. 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. Sampling began on the night of April 20. On the evening of April 28, fyke nets were attached to culvert numbers 1, 2 and 3 using the same technique. However, only culvert numbers 1 and 3 were opened that night. Culvert number 2 remained closed throughout the test period due to a malfunction in the slide gate.

The fyke nets were checked on every tide change until May 14, when the nets were removed from the culverts. The nets were checked by closing the culvert slides gate for about 30 minutes, which enabled personnel to pull the live-boxes onto a boat. Fish were removed from the live-boxes and placed into buckets. Once all the nets had been checked and reset, the collected fish were processed. All the fish were identified and counted. 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. A maximum of 50 CWT and unmarked salmon fork lengths (mm) were recorded per live-box. Culvert number, date, time, water temperature, tidal stage, and diel-period were recorded for each net check. Except for CWT smolts, all processed fish were released downstream of the fyke nets into Old River.

Loss indices for CWT salmon released as part of the VAMP survival studies at Durham Ferry and Mossdale were calculated using data collected from April 20 to May 14. The loss index rep-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resents the percentage of CWT salmon entrained into the HORB culverts. The loss index (I) is calculated using the equation:

$$I = (TC/TR)$$

where:

TC = Total number of CWT salmon collected in the fyke nets

TR = Total number of CWT released

Catch-Per-Unit-Effort (CPUE) for salmon was calculated as the number of fish collected per hour per culvert.

RESULTS

The HORB was closed on April 15; however, construction on the barrier continued into the following week. The DFG monitored the HORB culverts for 26 days, for approximately 2,450 hours, and collected 422 samples. Although the nets were attached to the open culverts for the entire test period, not all of the culverts were functioning properly. Mechanical breakdowns of the slide gates resulted in the partial opening of some of the gates throughout the monitoring period (Table 4-1). On April 20, the slide gates on culverts number 4, 5, and 6 were opened to maintain water levels downstream of the HORB. On April 23, prior to the Mossdale salmon release, the gear-box on slide gate number 6 became stripped and failed. The slide gate remained near the closed position until it was repaired the following week. All six culverts were scheduled to be opened on April 28 to maintain water levels downstream of the HORB. Failure of the operating mechanism on gate number 2 caused it to remain closed throughout the remainder of the test period. The slide gate gear box on culvert number 4 failed on May 6 and the gear-box on culvert number 1 failed on May 14.

Almost 8,000 fish were collected representing at least 29 species from 14 families of fish. No delta smelt *(Hypomesus transpacificus),* one juvenile steelhead *(Oncorhynchus mykiss),* and 22 adult splittail *(Pogonichthys macrolepidotus*) were collected. The most abundant species was white catfish *(Ictalurus catus),* followed by Chinook salmon and channel catfish *(Ictalurus punctatus)* (Table 4-5). Of the 1,805 salmon caught; 1,034 had a CWT; 756 were unmarked; and 15 had a color-mark (from fishery studies being conducted in the tributaries). Overall, the number of salmon entrained per hour (0.7) was lower than it was in the past three years (3.4 in 2003; 2.5 in 2002; 1.4 in 2001). Fork lengths were similar between the CWT (85 ± 5.8 mm) and unmarked (83 ± 8.6 mm) salmon.

Salmon smolts were caught throughout the monitoring period (Figure 4-3). Most of the VAMP-released salmon were caught within two days of their release. CWT salmon entrainment was the highest on the night of April 23, especially for Mossdale released salmon (Figure 4-4). The highest CPUEs for VAMP-released fish occurred on April 23: a CPUE of 29.2 fish/hour/culvert. The average unmarked salmon CPUE for the entire monitoring period was 0.3 ± 0.8 fish/hour/culvert. The highest unmarked salmon CPUE (7.0 fish/hour/culvert) occurred on May 9. The loss indices for Durham Ferry and Mossdale releases were each 0.4%. The overall loss index for VAMP CWT salmon was also 0.4%. This year, only one set of VAMP salmon releases occurred. As a result, comparisons will only be made between the one release this year and the first set of salmon releases in previous years. This year's overall loss index was lower than the last two years' loss indices (0.9% in 2003 and 1.4% in 2002) but similar to the 2001 loss index of 0.4%.

Initial entrainment of CWT salmon was similar to the 2002 results. Entrainment was highest in culvert number 4 and lowest in culvert number 6 (Figure 4-5). This is in contrast to 2003 when CWT salmon entrainment was highest in culvert number 6 and lowest in culvert number 4. The unmarked salmon had similar entrainment among the three culverts initially (Figure 4-5). However, once the other culverts were open on April 28, culvert number 6 entrained at least twice as many salmon as the other four culverts (Figure 4-6). More VAMP salmon were entrained at night (650) than during the day (127). Likewise, more unmarked salmon were entrained at night (600) than during the day (157).

TABLE 4-5

The raw abundance and composition of fishes entrained at the HORB in 2004. Chinook salmon catch is divided into CWT salmon, unmarked salmon and color-marked salmon.

Species	Catch
American Shad	1
Prickly Sculpin	1
Red Shiner	1
Sacramento Blackfish	1
Sacramento Pikeminnow	1
Steelhead	1
Golden Shiner	2
Goldfish	2
Tule Perch	2
Petromyzontidae Spp	3
Hitch	4
Shimofury Goby	5
Green Sunfish	7
Black Crappie	8
Largemouth Bass	8
Bigscale Logperch	8
Carp	17
Striped Bass	21
Splittail	22
Ameiurus Spp	30
Redear Sunfish	30
Inland Silverside	54
Sacramento Sucker	87
Bluegill	126
Threadfin Shad	222
Channel Catfish	258
White Catfish	5,235
Total Chinook Salmon	**1,805**
CWT VAMP Salmon	777
CWT NonVAMP Salmon	257
Unmarked Salmon	756
Color-Marked Salmon	15
Total	**7,962**

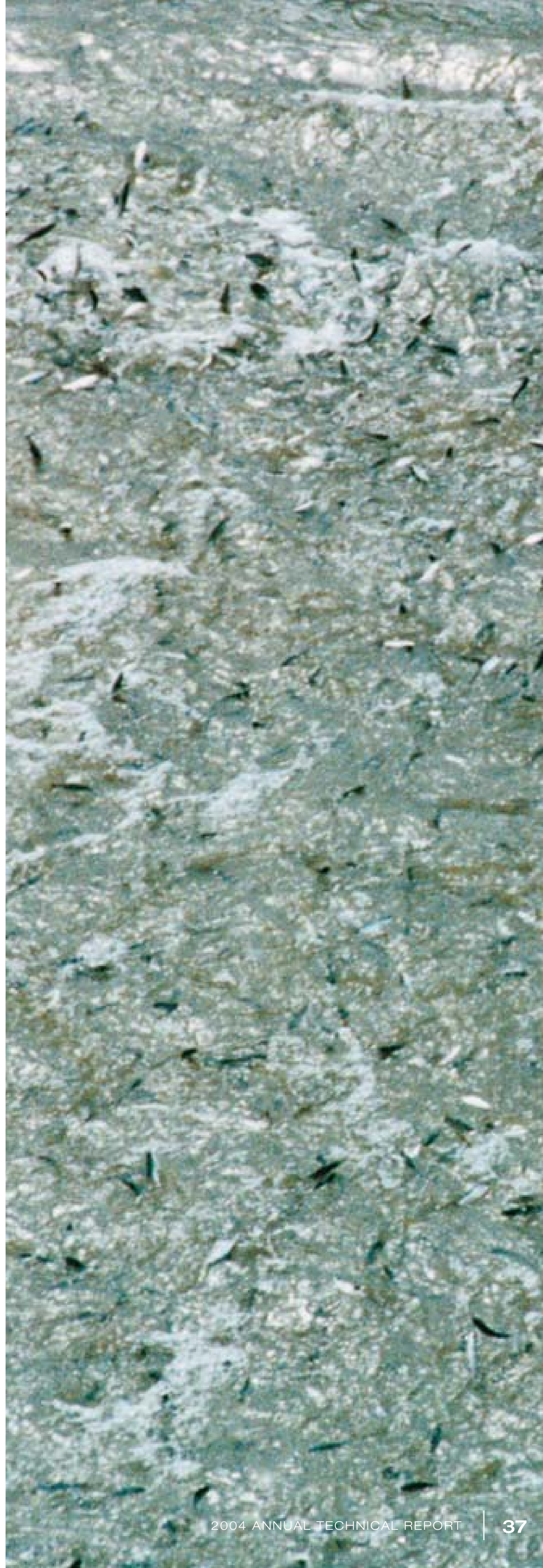


FIGURE 4-3

The daily average number of salmon entrained per culvert hour at the HORB in 2004. The catch is divided into coded wire tagged salmon (CWT) and unmarked salmon.

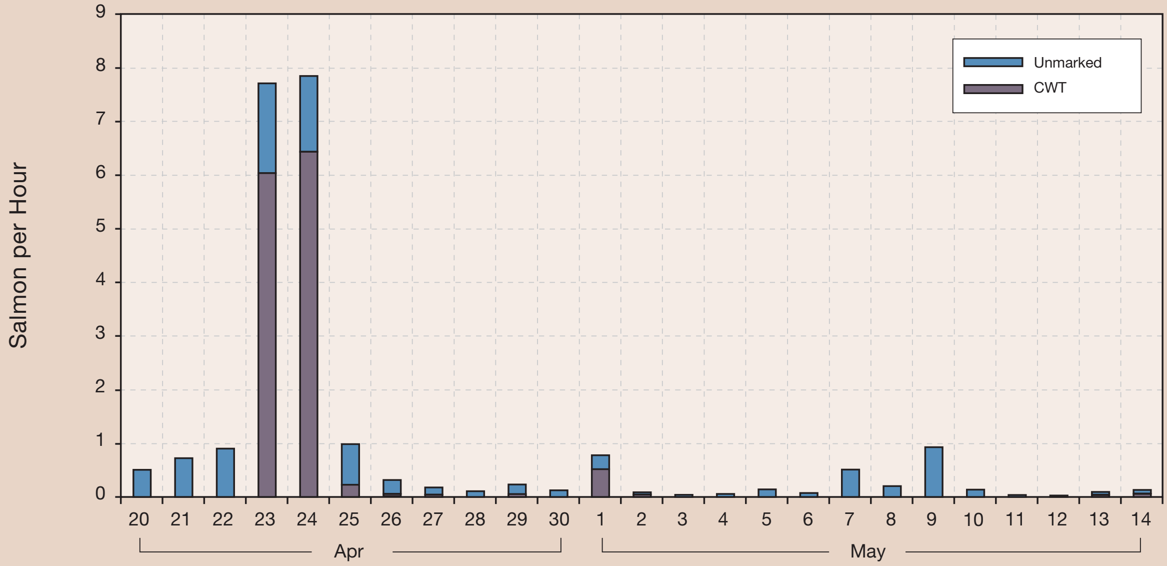


FIGURE 4-4

VAMP CWT salmon entrainment at the HORB. Salmon releases are indicated by the dashed lines. River stage at Old River is represented by the solid line.

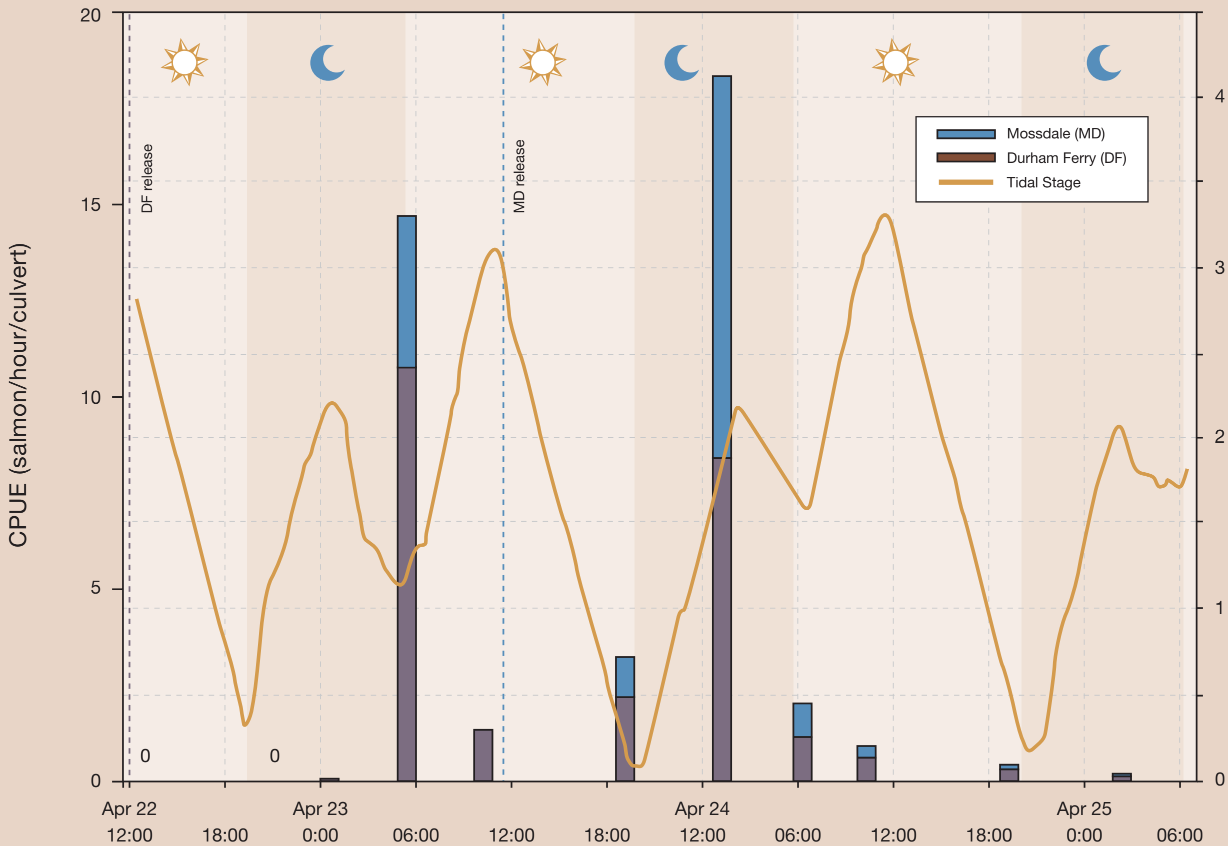


FIGURE 4-5

The total number of Unmarked, Mossdale and Durham Ferry salmon caught, by culvert, for the first eight days of monitoring: April 20 to April 28, 2004. Culverts 1–3 were closed during this time.

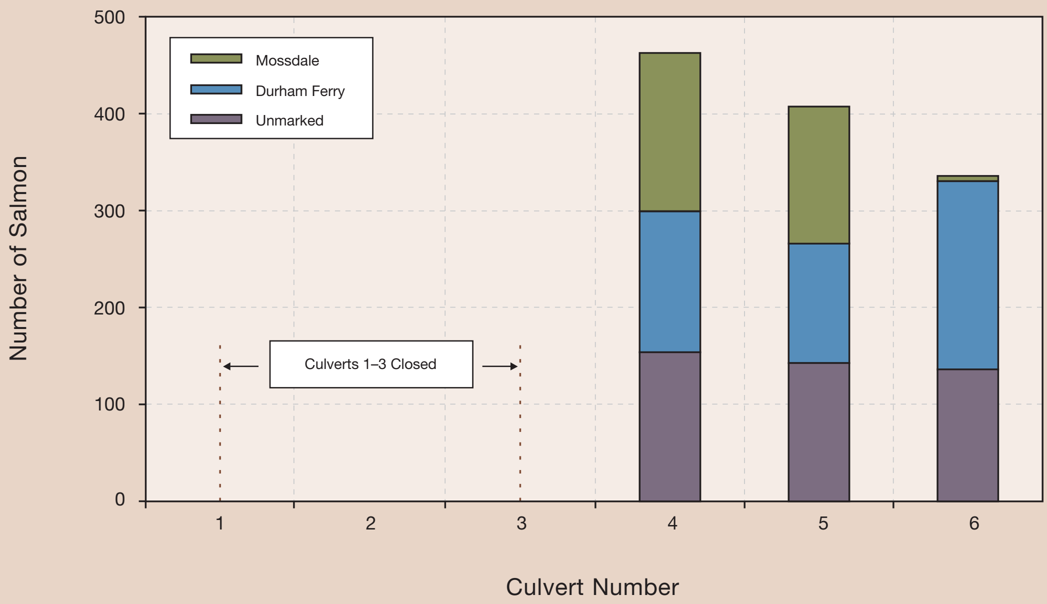
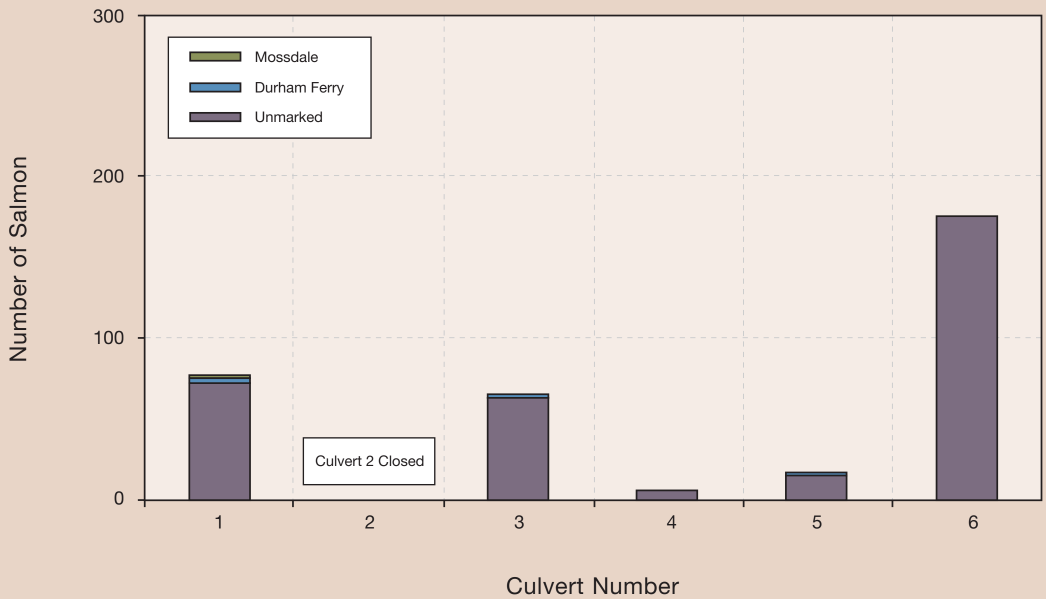


FIGURE 4-6

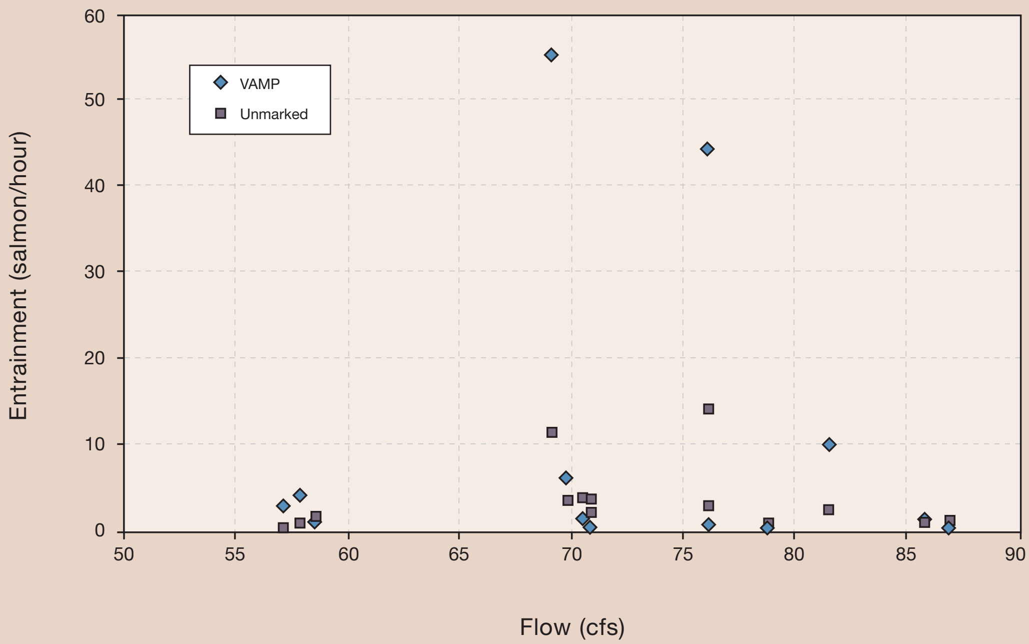
The total number of Unmarked, Mossdale and Durham Ferry released salmon caught, by culvert, from April 28 to May 14, 2004 when all 6 of the culverts were scheduled to be open. Culvert 2 broke and was never opened.



CHAPTER 4

FIGURE 4-7

The relationship between flow and salmon entertained in culvert 4 from midnight April 23 to 8:45 am on April 26, 2004



This is similar to 2002 when about 75% of both the VAMP and unmarked salmon were caught at night. Approximately 52% of the VAMP salmon and 43% of the unmarked salmon were entrained on the flood tide in 2004.

DWR installed a flow meter in culvert number 4. Flow data for culvert number 4 was recorded throughout the monitoring period (Table 4-3). Due to low salmon entrainment, entrainment-flow analyses were limited to the period when most VAMP salmon passed by the barrier: from midnight on April 23 to 8:45 am on April 26. Simple linear regression analysis indicated CWT salmon showed no significant relationship between entrainment and flow (degrees of freedom (df) = 13, Probability (P) = 0.82, Coefficient of Correlation (r^2) < 0.01). Similarly, unmarked salmon showed no significant relationship between entrainment and flow (df = 13, P = 0.86, r^2 = 0.08) (Figure 4-7).

DISCUSSION

The lower catch and broken slide gates made data comparisons among years, as well as within the 2004 VAMP period, difficult. The number of culverts fully open varied throughout the monitoring period. The culvert slide gate gear-boxes became stripped during the monitoring period, causing several of the gates to remain in the partially closed position. Because some fish were able to pass through the partially closed culverts, those culverts were still monitored for fish entrainment. Another problem arose after the CWT salmon were processed. Apparently, 65 Mossdale CWT salmon were caught before they were supposedly released upstream (Figure 4-4). We were unable to determine where the catch error occurred. The processed CWT salmon could have been misdated or labeled but all the salmon are accounted for when compared to the original field sheets. The Mossdale and Durham Ferry CWTs could have been mixed but there is no evidence of cross-contaminated tags. There is no doubt the CWT salmon were entrained in the culverts. There is only a question about when the entrainment occurred. Consequently, the questionable data was retained since the loss index calculations are not affected by when the salmon are entrained.

The color-marked salmon releases conducted in previous years were discontinued in 2004. The 2000 to 2003 color-marked study results were useful but continuing these releases

was thought to provide little additional information. It was felt that the color-marked results were similar to the larger Durham Ferry and Mossdale salmon release results and more information could be gained by using the VAMP salmon releases. However, color-marked salmon might be used in future special studies at the HORB.

More white catfish were entrained then all the other species combined. The 2004 total catfish catch was the second highest. The highest catfish catch (7,485) occurred in 2002. Over the past several years, the field crews have observed partially digested salmon smolts and catfish regurgitating smolts in the live-boxes. Most of the regurgitated salmon appear to be recently consumed which suggests catfish are preying upon salmon in the nets and in the live-boxes, or in front of the culverts. Catfish entrainment tends to increase in May after the VAMP CWT salmon have already passed the HORB. However, salmon entrained in May could be affected by catfish predation. Catfish gut content analysis is the only effective method for determining the extent of catfish predation on salmon smolts at the HORB.

Salmon entrainment appears proportional to the number of fish released upstream. In 2004, roughly half as many VAMP salmon were released upstream of the HORB than in previous years. Likewise, half as many salmon were entrained at the HORB than in previous years. Interestingly, about half as many unmarked salmon were also entrained this year compared to 2003 and about a quarter as many as in 2002. The unmarked catch is comprised of both MRFF and wild salmon. The decline in unmarked catch could be the result of fewer returning adult salmon in the fall of 2003. This resulted in lower MRFF production and lower in-stream spawning which may have caused the decline in outmigrating salmon. Also, unmarked salmon catch tends to increase around the VAMP releases. Since there was no second release, the associated unmarked salmon increase was also absent.

The HORB is fairly effective in keeping salmon on the San Joaquin side of the barrier. Less than one percent of the VAMP CWT salmon released upstream was entrained at the HORB. Salmon entrainment patterns are similar to previous years.

Approximately 85 percent of the entrained VAMP salmon were caught at night. Of the unmarked salmon entrained at the HORB, 80 percent were also caught at night. The data collected over the past four years strongly suggests salmon are more vulnerable to entrainment at night. As mentioned in previous reports, the timing of the salmon releases and the distance the fish must travel to the HORB probably affects diel entrainment patterns. A change in the VAMP salmon release times so that salmon pass the barrier midday probably would not result in the same spiked increase seen at night. This assumption could be tested with an early morning salmon release at Mossdale.

Entrainment between the flood and ebb tides were similar. Salmon entrainment is highest soon after the salmon releases at Durham Ferry and Mossdale. Peak entrainment of the fish released at Durham Ferry occurred after midnight on an ebb tide, and peak entrainment of the Mossdale-released fish occurred before midnight, the following day, on a flood tide. The tide should affect entrainment since the head difference between upstream and downstream water levels at the HORB determines flow through the culverts. If entrainment is affected by the amount of flow through the culvert, then higher salmon entrainment should occur at higher flows at a given salmon density. In culvert number 4, there was no relationship between CWT or unmarked salmon entrainment and flow. Most of the data collected to date suggest entrainment is probably more a function of the number of salmon passing the barrier. The number of VAMP salmon passing the HORB is affected by the size, timing and location of the upstream releases.

This year, the differences in overall entrainment among culverts were affected more by culvert gate operation than in previous years. The partially closed culverts made comparisons among culverts difficult. During the Durham Ferry release, culvert numbers 4, 5, and 6 were operating and entrainment was slightly higher in culvert number 6. Culvert number 6 broke just before the Mossdale release occurred. Subsequently, few Mossdale fish were entrained in that culvert. After culvert number 6 was repaired the following week, it entrained the most salmon. Culvert number 4's entrainment declined to almost nothing after it broke on May 6. The opening of additional culverts, as well as slide gate breakdowns may have changed the hydrodynamics in front of the culverts. This change could effect salmon entrainment among the culverts.

In summary, 2004 culvert gate operation differed from the previous three years. The number of culverts fully open varied throughout the monitoring period due to scheduled gate openings and gates breaking near the closed position. Entrainment results from the past four years and this year's results suggest salmon are more vulnerable to entrainment at night. Diel changes in salmon out-migration patterns are probably a factor in entrainment vulnerability. At night, salmon might be lower in the water column and pass closer to the culverts. The tidal effects on entrainment are still unclear. Water velocities through the culverts are greatest on a low tide, near slack water. However, no significant relationship was found between CWT or unmarked salmon entrainment and flow through culvert number 4. Salmon smolt behavior and relative abundance near the barrier plays an important role in entrainment vulnerability. The highest entrainment has always occurred soon after the upstream VAMP CWT salmon releases.

It is recommended that VAMP continue delaying the first salmon release by at least 5 days after the closure of the HORB. The delay allows for completion of the barrier and minimizes the field crew's exposure to heavy equipment operation. It also allows time for any loose material near the barrier to pass through the culverts before the nets are attached. The 2003 day and evening releases at Mossdale showed markedly different entrainment rates at the HORB. Another paired day-night or early morning salmon release at Mossdale would be useful in further illuminating diel entrainment patterns at the HORB. Flow monitoring on all six culverts is desirable to fully evaluate the flow versus entrainment relationship. Additional flow meters would allow comparison of flow and salmon entrainment rate among culverts.

It is recommended that VAMP continue delaying the first salmon release by at least 5 days after the closure of the HORB. The delay allows for completion of the barrier and minimizes the field crew's exposure to heavy equipment operation.

5

CHAPTER 5

Salmon Smolt Survival Investigations

One of the primary objectives of the VAMP program is to identify how San Joaquin River flows and SWP and CVP export rates, with the HORB in place, affect the survival of juvenile Chinook salmon emigrating from San Joaquin River tributaries. This section describes the methods used to conduct the Chinook salmon smolt survival investigations, and presents the calculated survival indices, absolute survival estimates and combined differential recovery rates for coded-wire tagged juvenile Chinook salmon released during the VAMP 2004 test period. We also analyzed how survival varied with flow, and flow relative to exports, with and without the HORB. Ocean recovery information on past releases and catches of unmarked juvenile salmon at Mossdale and in salvage are also discussed. Additional data and information related to the salmon survival investigations are presented in Appendix C.

CODED-WIRE TAGGING

Merced River Fish Facility (MRFF) Chinook salmon smolts, released as part of VAMP 2004, were coded-wire tagged (CWT) between March and early April. After the salmon were tagged, they were held in the MRFF for at least 21 days before being released. Sub-samples of these salmon were measured (for fork length) and checked for retention of tags a day or two prior to release. Sub-samples were comprised of approximately 200 salmon collected from the top, middle, and bottom of the release group's raceway. Although tag detection is usually high, all salmon from the sub-samples without a detected tag were sacrificed to verify the accuracy of the CWT detection process. Sacrificed salmon were dissected to determine whether they contained a non-magnetized tag, an undetected tag, or no tag. Each CWT code within a release group was held separately at the MRFF with the exception of the Durham Ferry release. This release was comprised of four CWT codes that were held together at the MRFF. At release, an additional sub-sample of 25 to 75 salmon was taken to verify CWT code. Fifty salmon were taken at Durham Ferry, 75 at Mossdale and 25 at Jersey Point.

Table 5-1 summarizes the release dates, release locations, tag codes, tag retention, and effective release numbers of salmon used to calculate survival indices, estimates, and differential recovery rates. Tag retention rates appeared to be similar to last year, with an overall retention rate of 91% among 2004 VAMP groups compared to 94.5% for 2003. Tag retention rates varied from 82.5% to 96.5%. It is highly desirable that improved retention rates continue to increase for future VAMP studies.

The effective number released (ER) was calculated using the following equation:

$$ER = (T-M)*TR$$

where:

T= estimated number transported,

M = number of mortalities during release and transport (and included those sacrificed as part of the net pen evaluations), and

TR = CWT retention rate.

CODED-WIRE TAG RELEASES

Only one set of CWT salmon releases was made as part of the 2004 VAMP experiment. The releases occurred on April 22 at Durham Ferry, April 23 at Mossdale, and April 26 at Jersey Point. There was not a second set of releases during VAMP 2004, as in past years, due to a lack of fish at MRFF.

TABLE 5-1

2004 CWT Effective Release Data

Release Date	Release Site	Tag Code	Avg FL (mm)	Number Transported	Total Mort (including Net Pen Loss)	Tag Retention %	Number Released	Effective Release
4/22/04	Durham Ferry	06-27-52	83	26,475	138	89.0	26,337	23,440
		06-27-53	82	26,459	139	82.5	26,320	21,714
		06-27-54	82	26,057	138	90.0	25,919	23,327
		06-27-55	83	26,131	139	91.5	25,992	23,783
4/23/04	Mossdale	06-46-70	82	26,439	201	96.5	26,238	25,320
		06-45-82	81	25,950	201	91.6	25,749	23,586
		06-45-83	79	25,904	201	96.5	25,703	24,803
4/26/04	Jersey Point	06-45-80	85	25,708	253	90.0	25,455	22,910

A total of approximately 200,000 CWT fish, with eight distinct tag codes were used during the 2004 VAMP experiments. Each tag code lot consisted of approximately 25,000 fish. A total of approximately 100,000 (4 tag codes) fish were released at Durham Ferry, 75,000 (3 tag codes) at Mossdale and 25,000 (1 tag code) at Jersey Point (Table 5-1). During VAMP 2004, tag codes were mixed and released at each site as one group. As with VAMP 2003, the Durham Ferry release was 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.

During the Durham Ferry release, the hose from the tank truck disconnected and approximately 150 salmon escaped out of the hose, spilling onto the ground. These were placed into a net pen, with some proportion later removed and placed back into the river during the counting of individuals for the net pen study.

The release at Jersey Point was 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.

Water temperatures in the MRFF trucks and at the release sites were measured 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 2004 study using individual computerized temperature recorders (e.g., Onset Stowaway Temperature Monitoring/Data Loggers). Water temperatures were 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 2004 investigations. Water temperatures were also recorded within the hatchery raceways at the MRFF coincident with the period when juvenile Chinook salmon were being tagged and held. These temperature recorders were later transported with the juvenile salmon released at Durham Ferry and Mossdale.

Results of water temperature monitoring within the Merced River Fish Facility showed that juvenile Chinook salmon were reared in, and acclimated to, water temperatures of approximately 10.5–16 C (51–61 F) prior to release into the lower San Joaquin River (Figures 5-1 and 5-2). Results of water temperature monitoring at Durham Ferry, Mossdale, and Jersey Point following the VAMP 2004 releases are shown in Figures 5-3, 5-4, and 5-5. 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 MRFF, which is similar to all past years. Water temperatures at the release sites as measured from these temperature recorders indicated temperatures were initially favorable but increased

TABLE 5-2

Release Information for 2004 VAMP Releases

Release Site/Stock	Release Date	Tag Code	Truck Temp (F)	River Temp (F)	Number Released	Average Size (mm)
Durham Ferry (MRFF)	4/22/04	06-27-52	55.4	60	23,440	83
		06-27-53	55.4	60	21,714	82
		06-27-54	55.4	60	23,327	82
		06-27-55	55.4	60	23,783	83
Total					**92,264**	
Mossdale (MRFF)	4/23/04	06-46-70	55.4	63	25,320	82
		06-45-82	55.4	63	23,586	81
		06-45-83	55.4	63	24,803	79
Total					**73,709**	
Jersey Point (MRFF)	4/26/04	06-45-80	57.7	71	22,910	85

quickly over the next few days (Figures 5-3 and 5-4). Water temperatures measured within the lower San Joaquin River and Delta (Figures 5-3, 5-4 and 5-5) reached levels considered to be stressful (20–22 C; 68–72 F) and may have contributed to adverse effects and reduced survival of emigrating juvenile Chinook salmon released as part of the VAMP 2004 investigations.

Water temperatures measured during the 2004 VAMP period in the lower San Joaquin River and Delta were among the highest recorded over the five-year period of VAMP investigations (Appendix D-8). Peak temperatures recorded in 2004 exceeded 20 C (68 F) at all monitoring stations. Average temperatures in the lower San Joaquin River, such as Durham Ferry, Mossdale, Dos Reis the DWR monitoring station, confluence, Channel marker 30, and Channel marker 13 (Appendix C-2) exceeded 18 C (64 F). These temperatures were generally greater than temperatures recorded during the 2000, 2002, and 2003 VAMP tests (Appendix D-8). Water temperatures observed in 2004 were similar to temperatures observed during the 2001 test period (although survival in 2004 was much less than that measured in 2001). Exposure of juvenile Chinook salmon to elevated water temperatures during out migration has been identified as one of the factors contributing to the survival of juvenile salmon. Exposure to elevated water temperatures during out migration may affect the physiology of the smolts, reduce resistance to disease, reduce growth, and increase vulnerability to predation by largemouth bass, striped bass, and other predatory fish within the lower river and delta. The incremental contribution of water temperature exposure during 2004 and previous years to observed salmon smolt survival has not been quantified. Water temperature monitoring within the Merced River Fish Hatchery and within the river and delta is recommended to continue as part of the VAMP investigations.

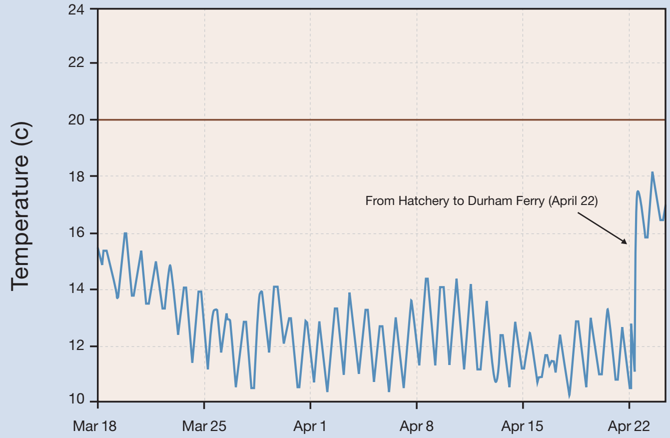
POST-RELEASE NET PEN STUDIES

Survival and Condition

The post-release survival and condition of CWT salmon were evaluated as part of the VAMP program using sub-samples of tagged salmon from each release group. Because tag codes were combined, 50 salmon from Durham Ferry, 75 from Mossdale and 25 from Jersey Point were evaluated for general condition immediately after release. To assess general condition, fork length in millimeters, weight in grams, and six other characteristics were examined (Table 5-3). Other obvious abnormalities or deformities were also noted. To assess short-term effects of handling, transport, and release, an additional sub-sample from each release group of approximately 200 fish per net pen (2 pens at Durham Ferry, 3 at Mossdale and 1 at Jersey Point) were held at the respective release sites for 48 hours. Of these, 25 were measured, weighed, and examined for the six general condition characteristics. The remaining fish were measured for length and weight and evaluated for adipose fin clips and short-term mortality. Due to the mixed tag codes for each of the releases, multiple net pens with approximately 200 fish each were held in order to maintain consistency with the other release groups and previous years. In all, 300 juvenile Chinook salmon were examined for the six general condition characteristics, and

FIGURE 5-1

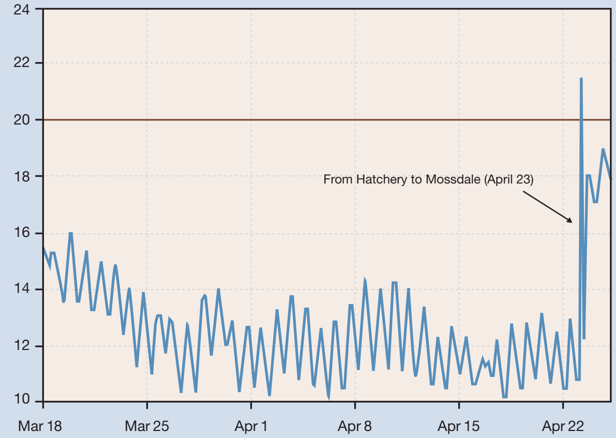
Merced River Fish Hatchery to Durham Ferry



Water temperatures measured in the Merced River Fish Facility and following release at Durham Ferry.

FIGURE 5-2

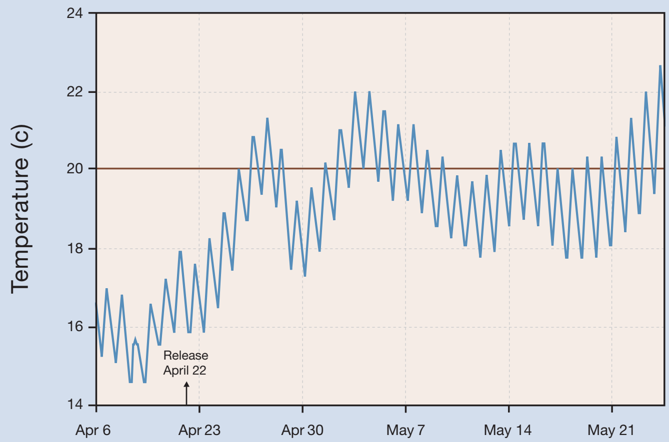
Merced River Fish Hatchery to Mossdale



Water temperatures measured in the Merced River Fish Facility and following release at Mossdale.

FIGURE 5-3

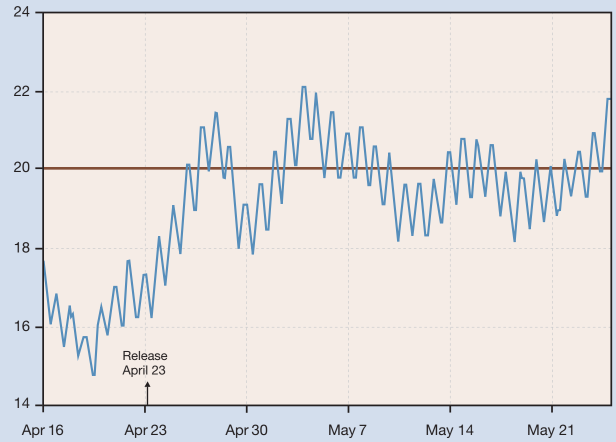
Site 1–Durham Ferry



Water temperatures measured in the San Joaquin River at Durham Ferry.

FIGURE 5-4

Site 2–Mossdale



Water temperatures measured in the San Joaquin River at Mossdale.

FIGURE 5-5

Site 9–USGS Gauging Station at Jersey Point–Top

Water temperatures measured in the San Joaquin River at Jersey Point.

CHAPTER 5

TABLE 5-3

Smolt Condition Characteristics Assessed for Post-release Net Pen Studies

	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 ore 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)

1,200 (including the 300 examined for general condition) were measured, weighed and assessed for mortality and presence/absence of adipose fin clip.

Results of the evaluations of the 300 marked salmon examined for the six general condition characteristics, from both immediately after release and 48 hours later, showed few abnormalities (see Appendix C-3). The majority of fish examined had normal coloration (99.94%), and eye characteristics (98.44%) and no fin hemorrhaging (99.97%). Fourteen percent of fish examined showed poor gill color. Scale loss ranged from 0% to 12% and averaged 2.9%. Other abnormalities included: fin rot (0.8%), jaw deformities (< 0.5%) and ragged dorsal fins (1%). In addition, this year 22 (7%) Chinook salmon had a poor or incomplete adipose fin clip, while 2 (0.5%) had no fin clip. Of the 1,200 juvenile Chinook salmon examined, there were 10 mortalities. In comparison, we observed 11 mortalities in 2003.

As mentioned previously, during the release at Durham Ferry, approximately 150 Chinook spilled onto the ground when the hose disconnected from the tank truck. Field crew that were present stated that of the 150 fish, only 4 were directly observed to have died from the incident.

Tag Quality Control

A subset of 25 salmon from each tag group, evaluated for condition as described above, was sacrificed to verify purity of tag codes. Though rare, in the past, salmon from different tag groups have been mixed at some point prior to release. In 2004, no errant tag codes were found in these groups. The remaining fish in each net pen were archived to allow for further evaluation if necessary.

Health and Physiology

Personnel from the California-Nevada Fish Health Center (FHC) conducted physiological studies on a sub-sample of the juvenile Chinook salmon used in the VAMP study (Harmen, et.al., 2004). Results of this work are summarized below.

Ninety-six Merced River Fish Facililty salmon were examined from the three release groups (32 fish per release group) following transport to release sites at Durham Ferry, Mossdale, and Jersey Point. A general health inspection for viral, *Renibacterium salmoninarum* (Bacterial Kidney Disease agent) and systemic bacterial infection was performed on 12 fish from each release group. Additional assays were conducted on the remaining 60 fish including assessment of : 1) internal and external abnormalities; 2) smolt development (gill tissue of 36 fish, 12 from each release group were analyzed for ATPase activity); and, 3) kidney tissue from 36 fish were examined for presence of *Tetracapsula bryosalmonae* (Tb), the parasite responsible for Proliferative Kidney Disease (PKD). To assess stress recovery, blood plasma levels of chloride, sodium, lactate, glucose, total protein, and cortisol were measured from the remaining 20 fish from each group.

No viral pathogens, systemic bacteria, or *R. salmoninarum* were detected in the 96 fish tested. *Tetracapsula bryosalmonae* was detected in 37% of the salmon sampled at Durham Ferry, 50% at Mossdale and 64% at Jersey Point. Only 14% or less of the infected kidneys were rated as showing moderate inflammatory changes indicating early stages of PKD.

A large percentage of the groups from Mossdale and Durham Ferry had ATPase activities associated with pre-smolting parr (83% and 42%, respectively). Jersey Point samples were not available due to samples being lost. These data indicate that these fish were not in an advanced state of smoltification at the time of release. It is uncertain how this will effect migration behavior, because, ATPase levels can change rapidly during outmigration and therefore may not have significant effects.

Plasma cortisol tended to increase with each successive release group (i.e. Durham Ferry had the least and Jersey Point had the most). It is likely that longer transport times for each release contributed to the cortisol increase. Plasma protein and chloride levels were normal and similar among all groups.

In summary, the VAMP groups used in 2004 indicated that the incidence of *Tetracapsula bryosalmonae* infection increased with each successive release group, with six of the 66 fish examined for Tb having severe infections and 27 having moderate infection. Despite this infection, fish pathologists at the U.S. Fish and Wildlife California/Nevada Fish Health Center (FHC) concluded that fish were relatively healthy and should have performed adequately for outmigration assessments.

The FHC has provided a health and physiological assessment of VAMP release groups each year from 2000 to 2004. The purpose of these assessments was to rule out survival differences due to differential health between release groups and between years. The FHC looked at health (bacterial, viral, and parasitic infections), smolt development, and stress response to determine if there were significant differences which might affect survival of one group over another. While differences in smolt development and stress response each year were noted, the FHC feels the most significant factor affecting survival was infection with Tetracapsuloides bryosalmonae (the myxosporean which causes Proliferative Kidney Disease, PKD). Incidence of infection with *T. bryosalmonae* ranged from 4% to 100% in annual VAMP study releases between 2000 and 2004 (Table 5-4). This progressive disease can reduce a fish's performance due to associated kidney dysfunction and anemia. Not only does this infection reduce the ability for annual comparisons, but also the severity of infection may increase throughout the study period contributing to higher mortality towards the end of the study.

General Conclusions:

- Severity of PKD infection and impairment due to the disease varied annually
- Severity of PKD progressed, so a group which was healthy at release may become impaired in the weeks following release
- No other infectious diseases (viral or bacterial) have been detected
- Smolt development has been similar among release groups each year (with the exception of the year 2000 first Jersey Point release having higher gill ATPase activity)
- Blood chemistry analysis showed that all release groups were physiologically capable of handling stress in 2000, 2002, 2003 and 2004; several release groups in 2001 (both Durham Ferry and second Mossdale releases) performed poorly likely due to PKD infection or extraneous handling of live boxes.
- Confounding factors in our attempts to assess the health and survival of the VAMP release groups could include differences in transport times, fish handling and site water quality.

TABLE 5-4

Prevalence of Tetracapsula bryosalmonae detected in Merced River Fish Facility Chinook Salmon Smolts, 1996–2004

Year	Sample Date(s)	Prevalence	
1996	May 1	5/8	(63%)
1997	May 1	0/10	(0%)
1998	April 17	0/6	(0%)
1999	April 20	0/6	(0%)
2000	April 18–May 2	2/45	(4%)
2001	May 1–May 12	34/34	(100%)
2002	April 19–May 1	92/201	(46%)
2003	April 21–May 2	30/48	(63%)
2004	April 22–April 26	33/66	(50%)

All samples were taken from VAMP (and precursor project) release groups. Fish were assayed by histopathological examination of posterior kidney by the CA-NV Fish Health Center.

CODED-WIRE TAG RECOVERY EFFORTS

Coded-wire tagged salmon were recaptured at Antioch and Chipps Island, at CVP and SWP fish salvage facilities, and during sampling Old River near the barrier (Figure 1-1). Coded-wire tagged salmon released upstream of, and at, Mossdale were also recovered in DFG Kodiak trawls at Mossdale but are not discussed in this 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 for CWT processing. Coded-wire tag processing was done by staff at USFWS (Stockton) for fish recovered at Chipps Island, Antioch, and SWP and CVP salvage facilities. DFG Region IV processed salmon captured in the HORB fyke net sampling.

Coded-wire tag processing consists of dissecting each tagged fish to obtain the 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. All 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 are recovered at Chipps Island, Antioch, SWP/CVP salvage facilities, and other locations. VAMP releases com-

TABLE 5-5

Recovery Information at Antioch, Chipps Island and the Fish Facility for VAMP releases in 2004

				Antioch Recoveries						
Tag Code	Release Site/ Stock	Release Date	Number Released	First Day Recovered	Last Day Recovered	Number Recovered	Minutes Finished	Percent Sampled	Survival Index	Group Index
06-27-52	Durham Ferry (MRFF)		23,440	5/04/04	5/04/04	1	584	0.406	0.008	
06-27-53	Durham Ferry (MRFF)		21,714	5/0304	5/03/04	1	620	0.431	0.008	
06-27-54	Durham Ferry (MRFF)		23,327	–	–	0	–	–	–	
06-27-55	Durham Ferry (MRFF)		23,783	–	–	0	–	–	–	
	Total	4/24/04	92,264	5/03/04	5/04/04	2	1,204	0.418		0.004
06-46-70	Mossdale (MRFF)		25,320	5/02/04	5/02/04	1	590	0.410	0.007	
06-45-82	Mossdale (MRFF)		23,586	–	–	0	–	–	–	
06-45-83	Mossdale (MRFF)		24,803	–	–	0	–	–	–	
	Total	4/23/04	73,709	5/02/04	5/02/04	1	590	0.410		0.002
06-45-80	Jersey Point (MRFF)	4/26/04	22,910	4/27/04	5/06/04	22	5,812	0.404	0.171	

prise a small portion of the total tagged salmon released in the Sacramento and San Joaquin system. Consequently, many tags recovered at Chipps Island, Antioch, the SWP and CVP salvage facilities, and other locations are from coded wire tag releases not affiliated with VAMP. In order to identify tag recoveries related to VAMP, it is necessary to read all recovered tags.

SWP and 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 CWT salmon recovered in the raw salvage collections were sacrificed for tag processing. 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, prescreen predation, screening, handling and trucking.

Expanded CVP and SWP salvage estimates of marked salmon released as part of the VAMP 2004 studies are shown in Table 5-5. Salvage numbers were low at the CVP and SWP. These results are consistent with earlier studies showing that the HORB reduces the number of CWT salmon entrained at the fish facility.

Antioch Recapture Sampling

Fish sampling was conducted in the vicinity of Antioch on the lower San Joaquin River (Figure 1-1) 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 6 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, midchannel, and right bank to sample CWT salmon emigrating from the San Joaquin River. Each sample was approximately 20 minutes in duration.

All captured fish were transferred immediately from the Kodiak trawl to buckets filled with river water, where they were held for processing. Data collected during each trawl included: species identification and fork length for each fish captured,

	Chipps Island Recoveries							Expanded Fish Facility		
	First Day Recovered	Last Day Recovered	Number Recovered	Minutes Finished	Percent Sampled	Survival Index	Group Index	CVP	SWP	Recovery Days
	–	–	0	–	–	–		24	6	
	5/03/04	5/03/04	1	400	0.278	0.022		36	0	
	5/02/04	5/02/04	1	400	0.278	0.020		24	0	
	5/01/04	5/01/04	1	400	0.278	0.020		0	6	
	5/01/04	5/03/04	3	1,200	0.278		0.015			4/26 – 5/04
	–	–	0	–	–	–				
	5/06/04	5/06/04	1	390	0.271	0.020		24	0	
	5/02/04	5/06/04	2	1,950	0.271	0.039		0	6	
	5/02/04	5/06/04	3	1,950	0.271		0.020			4/30 – 5/10
	4/28/04	5/03/04	25	2,400	0.278	0.511		12	0	5/4

tow start time and duration, and location in the channel. Any fish mortalities or injuries were 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 other fish were released at a location downstream of the sampling site immediately after identification, enumeration, and measurement.

Sampling at Antioch began April 24 and continued through May 15. Each day between 5:30 a.m. and 9:00 p.m., anywhere from 11 to 31 tows were conducted. In all, 607 Kodiak trawl samples were collected, for a total of 12,080 tow minutes. During sampling, 6,157 unmarked juvenile Chinook salmon were captured; 127 salmon with an adipose fin clip (and CWT) were collected, 25 from VAMP releases (Table 5-5) and 102 from other MRFF releases. In addition, 1,543 delta smelt, 59 Sacramento splittail, 25 unmarked steelhead, and 8 adipose fin clipped steelhead were caught during sampling.

Chipps Island Recapture Sampling

As part of VAMP 2004 recovery efforts at Chipps Island, trawling shifts were conducted twice daily between April 24 and May 22. This second shift has been conducted during the spring releases since 1998. The first shift began at sunrise, while the second shift ended at or after sunset, to incorporate the crepuscular periods of the day. Based on analysis of 24-hour sampling at Jersey Point in 1997 (Hanson Environmental, unpublished data), greater numbers of juvenile Chinook salmon appear to be caught around sunrise and sunset. Therefore, targeting this crepuscular period and doubling total trawl effort at Chipps Island should increase the number of CWT salmon recaptured and reduce variability in VAMP survival indices. Sampling continued at one shift per day between May 23 and June 18, five days per week between June 21 and July 2, and three days per week after July 2.

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 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 consisted of variable mesh starting with 4-inch mesh at the mouth and ending with a $^{1}/_{4}$-inch cod end mesh.

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. The lane sampled four times was chosen at random or selected by the boat operator based on flow conditions.

Coded-wire tagged salmon released for the VAMP 2004 program, were recovered at Chipps Island between April 28 and May 6 (Table 5-5). A total of 31 VAMP CWT salmon were recovered at Chipps Island. During the April 24 through May 22 VAMP recovery period, a total of 12,214 unmarked salmon, 579 CWT salmon from non-VAMP experiments, 37 delta smelt, 82 Sacramento splittail, 7 adipose fin clipped steelhead, and 26 unmarked steelhead were sampled at Chipps Island.

VAMP CHINOOK SALMON CWT SURVIVAL

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 (SI) were calculated using the formula:

$$SI = (R / (ER*T*W))$$

where:

R is the number recovered, ER is the effective number released, T is the fraction of time sampled, and W is the fraction of channel width sampled.

The fraction of the channel width sampled at Chipps Island (0.00769) was calculated by dividing the net width (30 feet) by the estimated channel width (3,900 feet). The fraction of the channel width sampled at Antioch (0.01388) was calculated in the same manner, with the net width being 25 feet and the channel width being 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 fraction of time sampled for the VAMP 2004 release groups at Chipps Island was about 28%, while at Antioch it was about 41% (Table 5-5).

Survival indices were calculated for each tag code to provide a sense of the variability associated with the 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.

Individual and group survival indices to Antioch and Chipps Island of the CWT salmon released as part of VAMP 2004 are shown in Table 5-5. Survival indices have been reported to three significant digits, but we realize indices are not likely that precise. Survival indices were not corrected for the number of CWT fish recovered at the HORB or in sampling at Mossdale conducted by DFG Region IV.

The survival indices of the Durham Ferry and Mossdale groups were very low as measured at Antioch (0.004 and 0.002 respectively) and Chipps Island (0.015 and 0.020 respectively) in 2004. The survival index of the Jersey Point group was higher at 0.171 and 0.511 at Antioch and Chipps Island respectively. While the raw recovery rate at Chipps Island and Antioch was similar, once recoveries were expanded for effort, indices indicated that recoveries were much lower at Antioch, indicating that the greater sampling at Antioch is not translating into additional recoveries. Indices in 2004 were similar to 2003 using the Chipps Island recoveries whereas they were much lower using the Antioch recovery information.

Survival indices for releases made at Durham Ferry and Mossdale were very low relative to releases made at Jersey Point using both sets of recovery numbers (Table 5-5).

Chinook Salmon Survival Estimates and Combined Differential Recovery Rates

The differences in survival indices are further evaluated using absolute survival estimates and combined differential recovery rates (CDRR). Absolute survival estimates (AS_i) are calculated by the formula:

$$AS_i = SI_u / SI_d$$

where:

SI_u is the survival index of the upstream group (Durham Ferry or Mossdale), SI_d is the survival index of the downstream group (Jersey Point) and i is either Antioch or Chipps Island.

Although referred to throughout this document as absolute survival estimates they are more aptly described as standardized or relative survival estimates. The combined recovery rate (CRR) is estimated by the formula:

$$CRR = R_{C+A} / ER$$

where:

R_{C+A} is the combined recoveries at Antioch and Chipps Island of a CWT group, and ER is the effective release number.

The combined differential recovery rate is calculated by the formula:

$$CDRR = CRR_u / CRR_d$$

where:

CRR_u is the combined recovery rate for the upstream group (Durham Ferry or Mossdale), and CRR_d is the combined recovery rate for the downstream group (Jersey Point).

The CDRR is another way to estimate survival between the upstream and downstream release locations. It is similar to calculating absolute survival estimates, but does not expand estimates based on the fraction of the time and space sampled. At times the differential recovery rate (DRR) is reported which is similar to the CDRR but only uses recovery numbers from one recovery location—either Chipps Island or the ocean fishery.

The CDRR and the absolute survival estimates should not be very different 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 could result in different survival estimates between the two methods.

Variance and standard errors were calculated for the CDRRs based on the Delta method recommended by Dr. Ken Newman. Plus or minus two standard errors are roughly equivalent to the 95% confidence intervals around the CDRR. Plus or minus one standard error equates to roughly the 68% confidence intervals for normally distributed data (Ken Newman, University of St. Andrews, Scotland, personal communication). In comparing survival between reaches the confidence intervals were used to determine if CDRRs were significantly different from each other. If the 95% confidence intervals overlapped, CDRRs were not considered statistically different from each other. Differences observed using the lower level of confidence (68%) is noted.

Absolute survival estimates and CDRRs should be more robust for comparing survival between groups, recovery locations, and years, since using ratios between upstream and downstream groups theoretically standardizes for differences in catch efficiency between recovery locations and years. Both estimates of absolute survival and CDRRs were calculated for CWT releases as part of VAMP 2004, as in past years. An additional estimate of absolute survival will be possible from recoveries made in the ocean fishery, two to four years following release.

Using the CDRR's the survival estimates from Durham Ferry to Jersey Point and Mossdale to Jersey Point were not different

CHAPTER 5

even though fish released at Durham Ferry are thought to incur additional mortality since it is 11 miles farther upstream than Mossdale (Table 5-6).

The CDRRs of the Mossdale and Durham Ferry groups were the same in 2004 (0.26). Pooling the groups also resulted in the pooled CDRR being the same as each of the individual estimates (0.026). The standard error of the pooled estimate was also calculated and reported (Table 5-7).

TRANSIT TIME

The recoveries of the few VAMP fish collected in 2004 were made at Antioch between April 27 and May 6 (Appendix C-4). Recoveries were made over a similar time period at Chipps Island: April 28 to May 6. Recoveries of upstream groups (Durham Ferry and Mossdale) at Chipps Island were recovered a few days earlier and a few days later than at Antioch. With so few CWT salmon recovered it is uncertain if the broader recovery period at Chipps Island is biologically meaningful. Transit times for marked salmon were estimated from the release day to the first and last day of recovery during VAMP 2004 which is included in Table 5-4.

Recoveries were made at the CVP and SWP fish facilities between April 26 and May 10 (Table 5-5), a longer period than at the other recovery location.

COMPARISON WITH PAST YEARS

Survival between Durham Ferry and Mossdale appeared high in 2004 as in past years. In 2000 through 2003, CDRRs indicated that survival between Durham Ferry and Jersey Point and Mossdale and Jersey Point was not statistically different ($p>0.05$) (SJRG, 2003 and 2004), thus we can infer survival between Durham Ferry and Mossdale was generally high in these years. However, low recovery numbers may hinder our ability to detect differences. Continued releases of CWT fish at both sites, will allow detection of mortality between Durham Ferry and Mossdale if it becomes great enough to detect in the future. If survival between locations is shown to be similar (not statistically different) then groups can be combined. When ocean recovery information becomes available it may also provide a means to assess mortality between Durham Ferry and Mossdale.

However, survival was much lower from Durham Ferry and Mossdale to Jersey Point in 2004 than for most of the releases in the past. The 2004 survival estimates were similar to those obtained in 2003. In 2004 the pooled CDRR from Durham Ferry and Mossdale to Jersey Point was 0.026, just slightly higher than that observed in 2003 (0.019). The estimate in 2003 was the lowest measured to date. Both the 2003 and 2004 data is much lower than that measured since VAMP started in 2000 (Table 5-7). Even prior to VAMP, with only Chipps Island recoveries, the lowest differential recovery rate with the HORB in place was 0.133 in 1994.

The health of the CWT fish in of itself did not appear to account for the low survival observed in 2004 or 2003. As we found in 2003, the infection and severe infection rates of *Tetracapsula bryosalmonea* (causative agent of Proliferative Kidney Disease) (PKD) was greater in 2001 than in 2004 (Table 5-8). Survival was greater in 2001 than in either 2003 or 2004 (Table 5-7).

However, as we hypothesized in 2003, the high level of PKD infection in combination with the lower flows could have increased the mortality of VAMP fish in both 2003 and 2004

TABLE 5-6

Survival Indices and Absolute survival estimates using recoveries at Antioch and Chipps Island for CWT fish released as part of VAMP 2004.

Release Site	Date	Antioch Group Index	Antioch Absolute Survival	Chipps Group Index	Chipps Absolute Survival	Combined Differential Recovery Rate
Durham Ferry	4/22/04	0.004	0.02	0.015	0.03	0.026
Mossdale	4/23/04	0.002	0.01	0.020	0.04	0.026
Jersey Point	4/26/04	0.171		0.511		
Durham Ferry and Mossdale						0.026

TABLE 5-7

Combined Differential Recovery Rate (CDRR) and standard errors for CWT salmon released at Mossdale and Durham Ferry in relation to those released at Jersey Point.

Year	CDRR	Standard Error
1994	0.133	0.099
1997	0.186	0.064
2000	0.187	0.019
2001	0.191	0.014
2002	0.151	0.013
2003	0.019	0.005
2004	0.026	0.010

TABLE 5-8

Severity of PKD infection in VAMP fish between 2000 and 2004. Number positive divided by the sample size is shown in parentheses.

Year	Infected	Severe Infection
2000	4% (2/45)	0%
2001	100% (34/34)	29% (10/34)
2002	46% (92/201)	1% (2/201)
2003	63% (30/48)	21% (10/48)
2004	50% (33/66)	9% (6/66)

since Jersey Point groups also had PKD but survived at a higher rate.

The number of days until first recovery of the Mossdale and Durham Ferry groups to Chipps Island appears to be related to San Joaquin River flow. In 2004 the number of days until first recovery was the longest since VAMP started in 2000, with recoveries made 9 days after release with flows at 3,261 cfs. The number of days until first recovery in 2003 and 2002 were similar (6–9) and had similar flow levels. In 2000 and 2001, flows were higher and travel times were faster (4 to 5 days with flows of 6,020 and 4,211 cfs, respectively) (Table 5-9).

In contrast, the number of days until last recovery for the Mossdale and Durham Ferry groups was sooner in 2004 (11 to 13 days) and 2003 (7 to 13 days) than in 2002 (ranged from 15 to 22 days after release) and 2000 (16 to 32 days) when PKD infection rate was lower. The number of days until last recovery in 2003 and 2004 was similar to that observed in 2001 (10 to 13 days) (Table 5-9). Both 2003 and 2001 had the highest percentage of fish with infection and severe infection of PKD (Table 5-8). Differences in the number of days until last recovery may reflect increased mortality over time on the individuals that took longer than the 7 to 13 days to reach the western Delta due to higher incidence of PKD in 2004, 2003 and 2001. It is possible that the combination of the first fish taking longer to reach Chipps Island due to the lower flows and the increased mortality due to the direct or indirect affects of PKD infection for the later migrants may in part explain why survival was so much lower in 2003 and 2004 than in past years.

Role of Flow and Exports

San Joaquin River flow and flow relative to exports between April and June is correlated to adult escapement in the San Joaquin basin 2 1/2 years later (SJRG 2003). Both relationships are statistically significant ($p<0.01$) with the ratio of flow to exports accounting for slightly more of the variability in escapement than flow alone ($r^2 = 0.58$ versus $r^2 = 0.42$; SJRG 2003). These relationships suggest that adult escapement in the San Joaquin basin is affected by flow in the San Joaquin River and exports by the CVP and SWP during the spring months when juveniles migrate through the river and Delta to the ocean. VAMP was designed to further define the mechanisms behind these relationships by testing how San Joaquin River flows (7,000 cfs or less) and exports, with the HORB, affect smolt survival through the Delta.

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 South Delta studies starting in 1994 were conducted prior to the official implementation of VAMP. Fish from the Feather River Hatchery had been used in south Delta studies conducted prior to 1999 (SJRG, 2002).

To assess the relationship between San Joaquin River flows and survival, pooled CDRRs from 2000 through 2004 were plotted. The CDRRs of all Durham Ferry and Mossdale releases within a year were pooled, as they were not significantly different from each other at the 95% confidence level. These pooled estimates and their 68% and 95% confidence intervals for 2004 and the past four years of VAMP releases (2000–2003) are shown in relation to the averaged San Joaquin River flow at Vernalis

TABLE 5-9

First and Last Day Recovered at Chipps Island of VAMP fish released in 2000–2004.
N/R = No second release was made at Mossdale in 2000, and at any of the release sites in 2004.

Release Location	YEAR (San Joaquin River Flow Target)				
	2000	2001	2002	2003	2004
Durham Ferry (1)	5–32	5–11	8–22	6–11	9–11
Mossdale (1)	5–16	4–11	7–17	8–13	9–13
Durham Ferry (2)	5–23	5–13	7–15	—	N/R
Mossdale (2)	N/R	5–10	9–19	7	N/R

(Figure 5-6). Similar data obtained from releases made at Mossdale in 1994 and 1997 are included but have much wider confidence intervals because fewer recoveries were made since only one recovery location (Chipps Island) was used in these years. In 2004, flows were averaged for the 10-day period after release. In prior years the two, ten-day periods after each release were used. It is obvious that the 2003 and 2004 CDRR's are much lower than would have been predicted based on past data.

The CDRRs with confidence intervals are also shown in comparison to average Vernalis flow relative to combined CVP and SWP exports for the same periods as described above for San Joaquin River flow (Figure 5-7). Prior to 2003, the relationship of relative recovery rate to San Joaquin River flow was significant and improved by incorporating exports. The CDRR obtained in 2003 and 2004 is much lower than what would have been predicted from past data and has lessened the benefit of adding exports into the relationship.

In general, the regression lines do appear to increase as flows and flows relative to exports increase, but the addition of the 2003 and 2004 data has resulted in these relationships no longer being statistically significant. As mentioned in previous years, even when the relationships were statistically significant ($p<0.05$), confidence intervals indicated data points were not significantly different from each other (SJRG, 2003).

It does not appear that flow and exports in 2003 and 2004 accounted for the low survival observed. As mentioned earlier, the VAMP target flows and CVP/SWP exports were similar in 2002, but survival was significantly higher in 2002 as shown using the CDRRs and respective confidence intervals (Figure 5-8).

The Role of HORB on Survival

In 2004, the HORB daily culvert operation was variable during the VAMP period. Initially three culverts were open, but one became blocked on April 23—the day after our Durham Ferry release and the day of our Mossdale release. Most of the fish likely passed the barrier prior to April 28, when two additional culverts were opened and one operating culvert became partially blocked (Table 4-1).

The barrier is assumed to improve survival based on studies conducted between 1985 and 1990 (Brandes and McLain, 2001). These studies indicated that smolts released in the river downstream of the Head of Old River survived at about twice the rate of those released in the Old River. And while those data were not statistically significant, placing a temporary barrier at the Head of Old River appeared to be a management action that would improve survival through the Delta for smolts originating from the San Joaquin basin. The barrier can only be operated when San Joaquin River flows are 7000 cfs or less. The highest VAMP target flow/export ratio that can be obtained with the barrier in place is 4.7 (7000 cfs flow and 1500 exports).

In Figure 5-9 the annual pooled CDRR or the DRR's are reported for Vernalis flow/export levels of less than 4.7, with and without the barrier in place. The data with the barrier is generally higher than that without the barrier, with the exception of the 1999 and 2003 and 2004 data. In previous reports, we suggested data obtained in 1999 may have been biased high due to missed sampling for the Jersey Point group that year (Brandes, 2000). However, later reporting indicates that differential recovery rates in the ocean fishery were similar to those obtained with

FIGURE 5-6

Combined Differential Recovery Rate (CDRR) and (+/– 1 and 2 Standard Errors) from Durham Ferry and Mossdale to Jersey Point with HORB in place versus San Joaquin River flow at Vernalis in cfs, VAMP years 2000–2004 and non-VAMP years 1994, 1997. Differential Recovery Rates (DRR) from data obtained in 1994 and 1997 from Chipps Island recoveries of Mossdale release were also included.

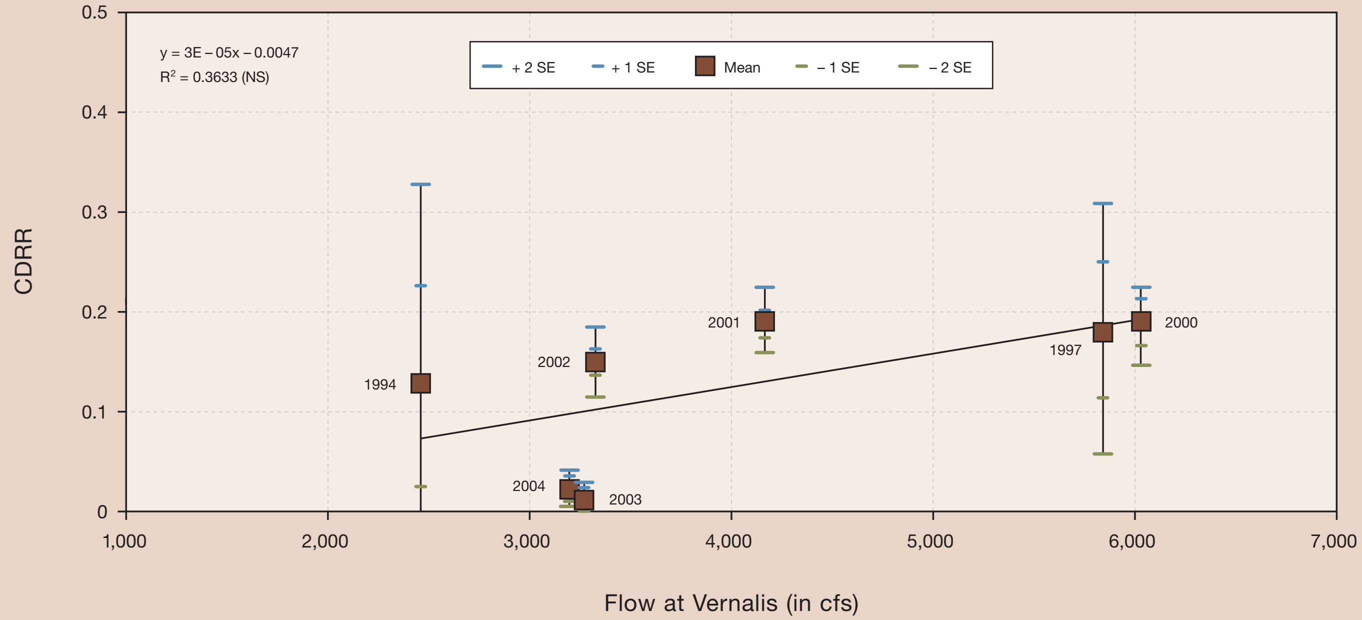


FIGURE 5-7

Combined Differential Recovery Rate (CDRR) and (+/– 1 and 2 Standard Errors) from Durham Ferry and Mossdale to Jersey Point with the HORB in place, versus inflow at Vernalis/exports, 1994, 1997, 2000–2004. Differential Recovery Rates (DRR) from data obtained in 1994 and 1997 from Chipps Island recoveries of Mossdale release were also included.

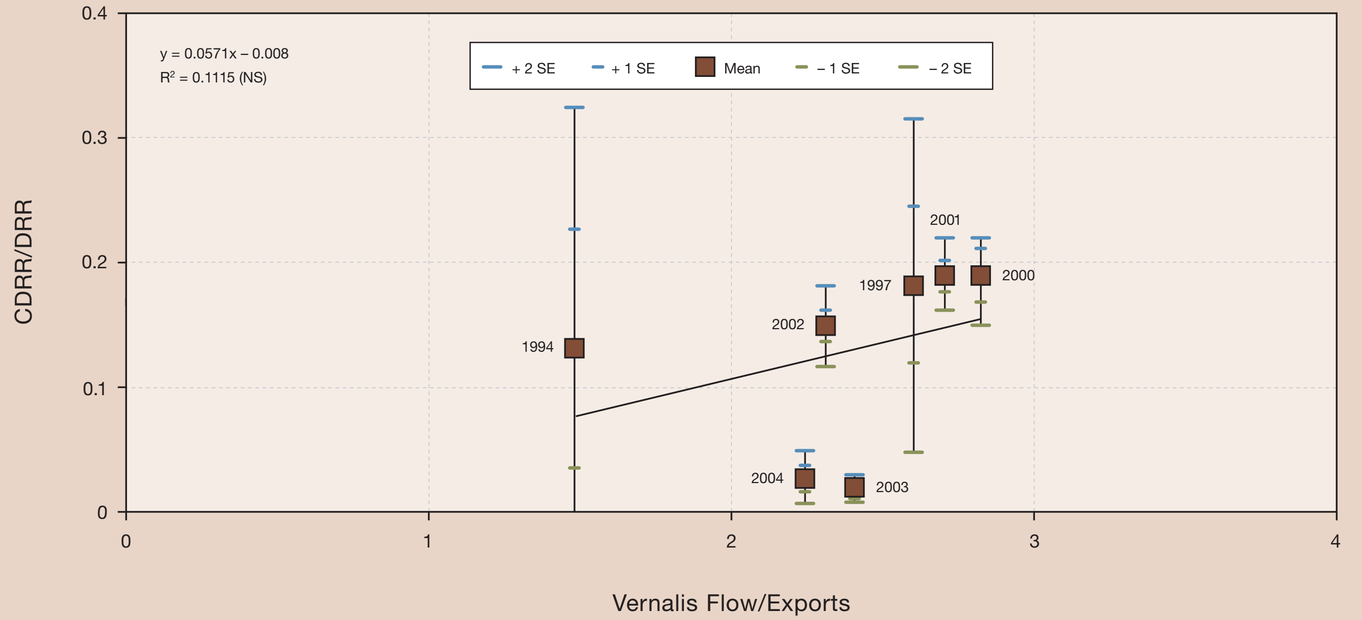


FIGURE 5-8

Combined Differential Recovery Rate (CDRR) and (+/– 1 and 2 Standard Errors) of CWT smolts released at Mossdale and Jersey Point (MD) and Durham Ferry and Jersey Point (DF) for the first release groups (1) in 2002, 2003, and 2004. CDRR were based on the sum of recoveries at Antioch and Chipps Island. Estimates for pooled CDRR's were for the two Durham Ferry and Mossdale releases in 2002 and 2003 and for the only release in 2004.

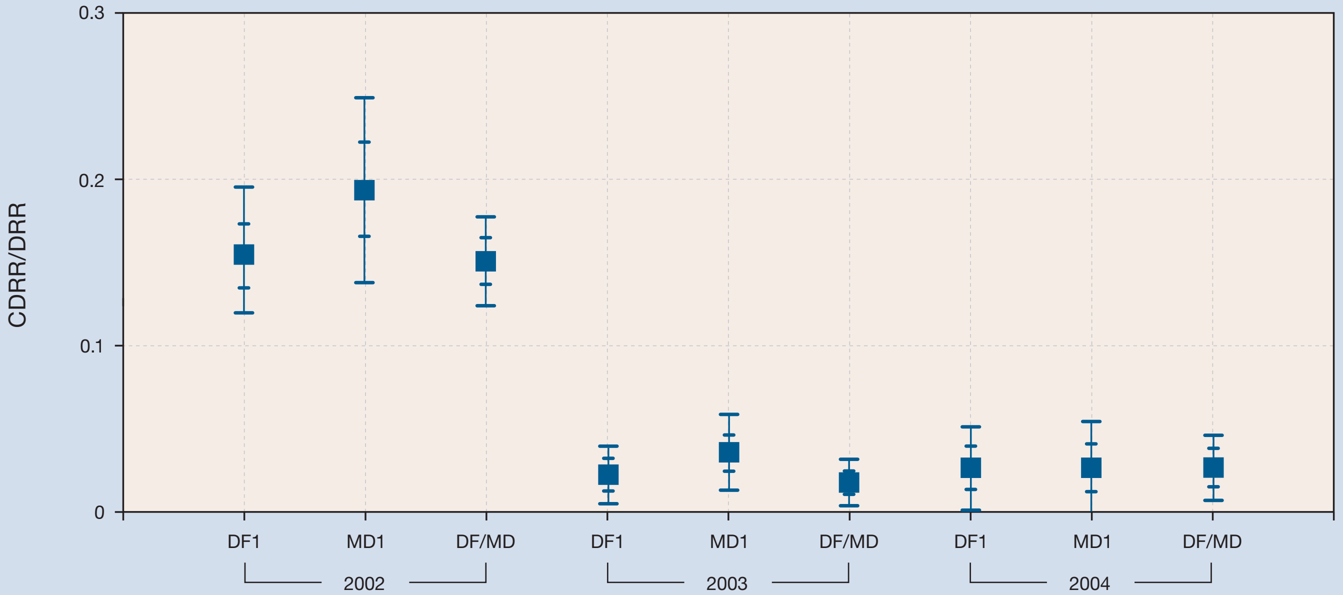


FIGURE 5-9

Combined Differential Recovery Rate (CDRR) and (+/– 1 and 2 Standard Errors) from Durham Ferry and Mossdale to Jersey Point with the HORB in place, versus inflow at Vernalis / exports, 1994, 1997, 2000–2004. Differential Recovery Rates (DRR) from data obtained in 1994 and 1997 from Chipps Island recoveries of Mossdale releases was also included.

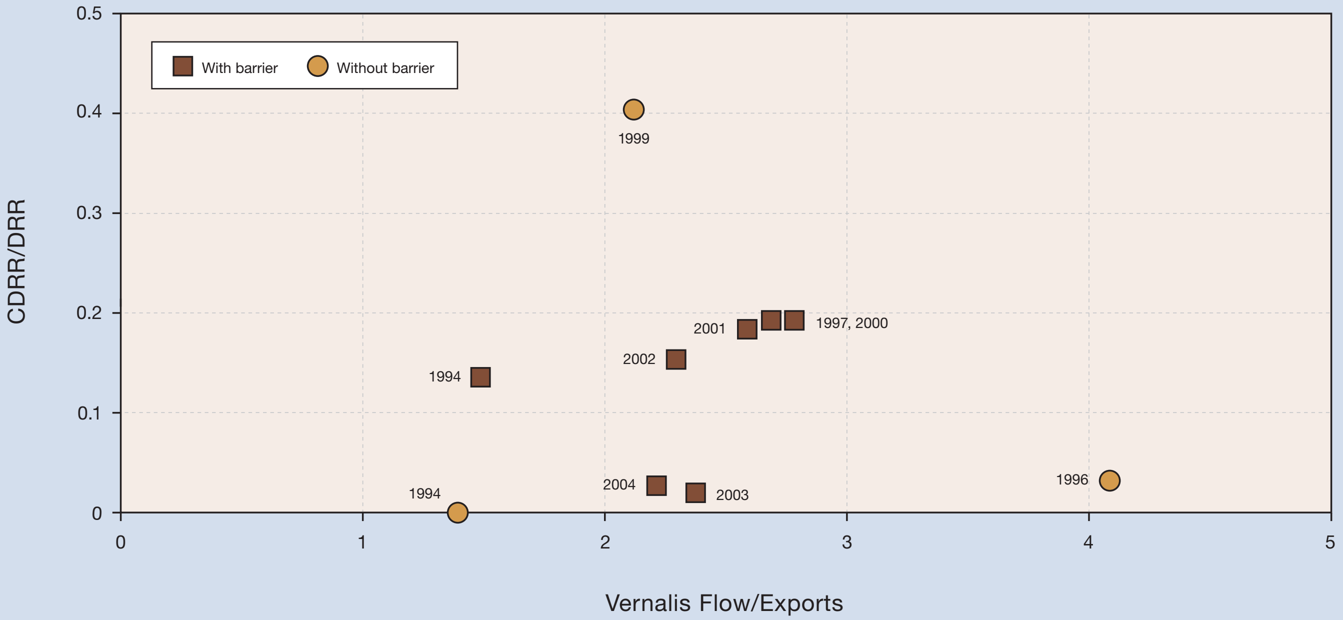
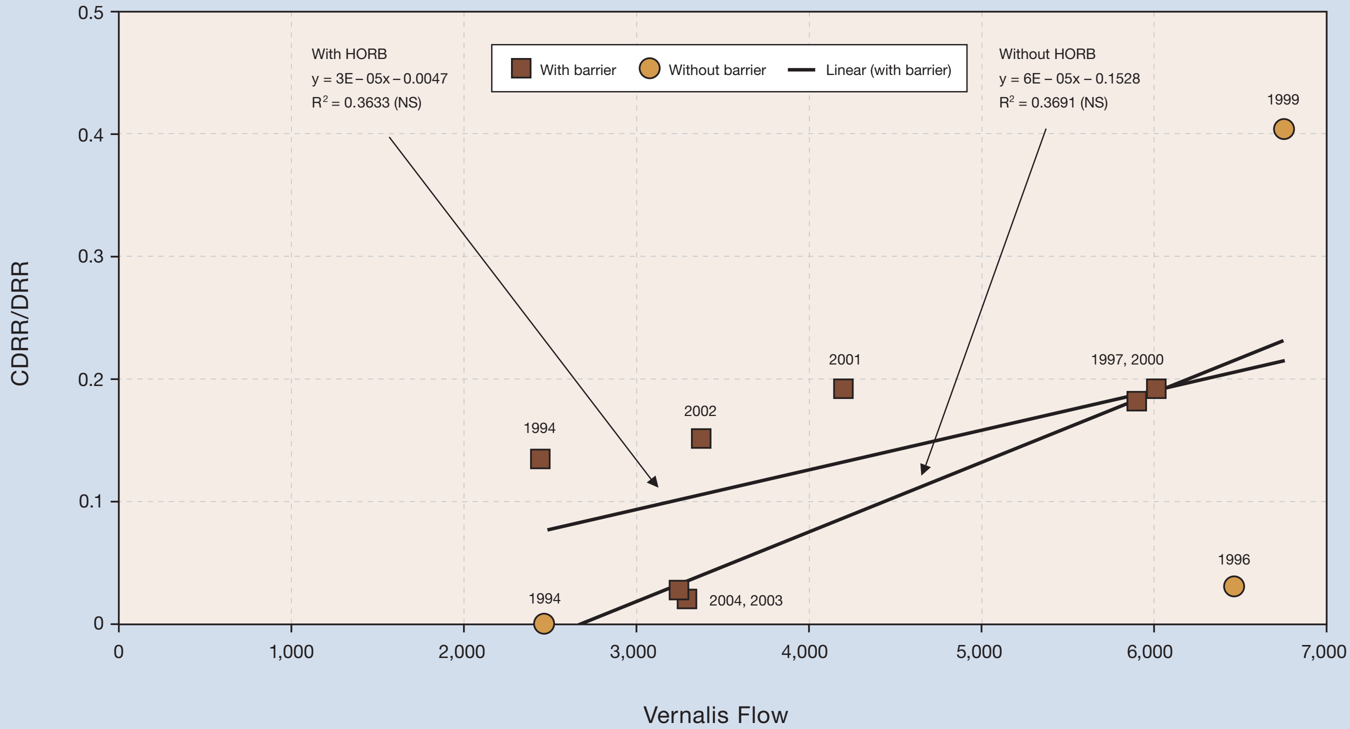


FIGURE 5-10

Combined Differential Recovery Rate (CDRR) from Durham Ferry and Mossdale to Jersey Point with the HORB in place, versus inflow at Vernalis in cfs, 2000–2004. Differential Recovery Rates (DRR) from data obtained in 1994,1996,1997 and 1999 from Chipps Island recoveries of Mossdale releases are also included. Comparable DRR's are shown for 1994, 1996, and 1999 when Vernalis flows were below 7000 cfs without the HORB.



the Chipps Island trawl, thus contradicting our suggestion that the data was biased high. The 1999 data is an instance where survival was high at a low flow/export ratio without the barrier in place. In addition, the estimated survival in 2003 and 2004, with the barrier, was low and similar to levels observed in 1994 and 1996 without a barrier in place (Figure 5-9).

The CDRR's or DRR's with and without the barrier, at San Joaquin River flows (at Vernalis) of less than 7000 cfs, are shown in Figure 5-10. These data seem to be better fitted using flow alone to show the differences in survival with and without the barrier. Survival was the highest at the highest flow even without a barrier in 1999. At the lower flows, the barrier appears to generally improve survival at any one flow. Again, the 2003 and 2004 data falls in the range of the non-barrier data at the lower flows— even though the barrier was installed and operated those two years. Measuring survival at 7000 cfs with a barrier would be informative.

The differences in the target conditions tested in VAMP so far have been small, making it difficult to measure differences in survival. In the six years of measuring survival with the HORB in place, the flow to export ratio has only varied from 1.5 (1994) to 2.9 (2000). The maximum flow to export ratio within the VAMP targets is 4.7, but as of yet it has not been tested. The ratios in the relationship between flow/export and adult escapement vary from 0.1 to 1000 (SJRG, 2003) a broader representation of how spring flows relative to exports have varied since 1951.

Varying designs and changes in the culvert operations of the HORB also make it more difficult to detect significant differences in salmon smolt survival at similar flow to export ratios. Even since the adoption of VAMP, permeability (number of culverts open during operation) of the HORB has changed. In 2000, the HORB had six gated culverts, with two open during the Mossdale and first Durham Ferry releases and four open during the second Durham Ferry release. In 2001 and 2002, six culverts were installed and operated throughout the VAMP test period. In 2003, three culverts were open during the studies. In 2004, between three and five culverts were open during the study.

The amount of water flowing through the culverts is based on the head differential between the San Joaquin River and Old River. The amount of water flow moving from the San Joaquin River into Old River would change as flow, stage and the tides change, even if the number of culverts was consistent between years. These changes in the amount of flow through the culverts and number of culverts operating between years likely affects the entrainment and resulting survival at this point in the river, adding variability in survival from factors other than flow or exports.

The flow through the culverts and seepage through the barrier affects the amount of remaining flow left in the San Joaquin River of which the salmon smolts are exposed. Using flow in the San Joaquin River at Vernalis as the estimate of flow the fish are exposed to instead of flow in the San Joaquin River downstream of the HORB adds additional variation to the relationships we are trying to identify and refine. A better estimate of flow to use in these relationships would be the net flow on the San Joaquin River downstream of upper Old River. An estimate of flow in the San Joaquin River downstream of Old River has been made in the past 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 (Chapter 4). To provide more precise estimates an Acoustic Doppler Current Profiler (ADCP) was placed in the San Joaquin River downstream of the HORB in 2003 and 2004 for the purpose of estimating the flow. This method was deemed the best way to estimate flow at this location. Problems with verification and battery malfunction have prevented a full compliment of data to be gathered during these last two VAMP studies. The ADCP data gathered in 2005 will be compared to that estimated using the mean daily flow in Old River to see how they compare and determine if it is possible to estimate San Joaquin flow downstream of Old River in past years. Future analyses will attempt to use these more refined estimates in comparing smolt survival to San Joaquin River flow.

TABLE 5-10

Release and Recovery Information for CWT Smolts Released in San Joaquin Tributaries in Spring of 2004

Tag Code	Release Site/Stock	Release Date	Truck Temp (F)	River Temp (F)	Number Released	Average Size (mm)	ANTIOCH RECOVERIES			
							First Day Recovered	Last Day Recovered	Number Recovered	Minutes Fished
06-45-92	Shaffer Bridge (MRFF)	4/19/04	N/P	N/P	23,628	85	—	—	0	—
06-45-93	Shaffer Bridge (MRFF)	4/19/04	N/P	N/P	22,440	85	05/04/04	05/04/04	1	584
	Total				**46,068**		05/04/04	05/04/04	1	584
06-45-94	Hatfield State Park (MRFF)	4/20/04	52.9	59.9	23,489	84	—	—	0	—
06-45-95	Hatfield State Park (MRFF)	4/20/04	52.9	59.9	23,037	84	—	—	0	—
	Total				**46,526**					
06-46-64	Shaffer Bridge (MRFF)	4/27/04	55.9	59	25,501	84	—	—	0	—
06-46-65	Shaffer Bridge (MRFF)	4/27/04	55.9	59	25,489	84	—	—	0	—
	Total				50,990					
06-46-66	Hatfield State Park (MRFF)	4/28/04	55.9	63.9	24,511	82	—	—	0	—
06-46-67	Hatfield State Park (MRFF)	4/28/04	55.9	63.9	25,307	82	—	—	0	—
	Total				**49,818**					
06-45-96	Upper Merced @ MRFF	5/09/04	N/P	55.9	25,028	86	—	—	0	—
06-45-97	Upper Merced @ MRFF	5/09/04	N/P	55.9	25,358	86	—	—	0	—
06-46-68	Upper Merced @ MRFF	5/09/04	N/P	55.9	25,340	86	—	—	0	—
06-46-69	Upper Merced @ MRFF	5/09/04	N/P	55.9	24,417	86	—	—	0	—
	Total				**100,143**					
06-45-81**	Hatfield State Park (MRFF)	5/12/04	47.8	65.6	24,274	89	—	—	0	—
06-45-98**	Hatfield State Park (MRFF)	5/12/04	47.8	65.6	24,897	89	—	—	0	—
06-45-99**	Hatfield State Park (MRFF)	5/12/04	47.8	65.6	24,769	89	—	—	0	—
	Total				**73,940**					

** Tag codes released on two days, 5/12 and 5/13; Drafted 9/30/04 Preliminary data

Comparison With Other Marked Fish Released From Merced River Fish Facility

Coded wire tagged salmon from the Merced River Fish Facility were released in the San Joaquin River tributaries between April 19 and May 12 as part of independent (complimentary) fishery investigations. Releases were made in the upper and lower reaches of the Merced River. These studies are reported in more detail in Chapter 6, but are discussed here as they relate to VAMP releases.

Survival indices of the downstream Merced releases (Hatfield State Park) would include mortality down the mainstem San Joaquin River as well as through the Delta. While the survival indices to Antioch and Chipps Island of these lower Merced River release groups would include some additional river mortality, if mainstem mortality was low then the indices would be comparable to survival indices of fish released at Durham Ferry and Mossdale as part of VAMP.

Survival indices of the lower Merced River groups were comparable to indices from the upstream VAMP releases. No recoveries were made at Antioch. Survival indices using Chipps Island recoveries were similar to the VAMP releases with indices ranging between 0.006–0.020 (Table 5-10). Survival indices to Chipps Island of VAMP released fish at Mossdale and Durham Ferry ranged from 0.015 to 0.020 (Table 5-5).

These data would indicate that whatever variables affected the survival of upstream released VAMP fish in 2004 also affected survival of the lower Merced groups. The mortality factor was limited to upstream groups and did not seem to affect the Jersey Point group similarly. We also found this to be true for the 2003 groups (SJRG, 2004).

ANTIOCH RECOVERIES			CHIPPS ISLAND RECOVERIES							FISH FACILITIES	
										Expanded Recoveries	
Percent Sampled	Survival Index	Group Index	First Day Recovered	Last Day Recovered	Number Recovered	Minutes Fished	Percent Sampled	Survival Index	Group Index	CVP	SWP
—	—		—	—	0	—	—	—			
0.406	0.008		—	—	0	—	—	—			
0.406		0.004	—	—	0	—	—		—		
—	—		4/30/04	4/30/04	1	400	0.278	0.020			
—	—		5/1/04	5/1/04	1	400	0.278	0.020		12	6
			4/30/04	5/1/04	2	800	0.278		0.020		
—	—		—	—	0	—	—	—			
—	—		5/16/04	5/16/04	1	400	0.278	0.018			
			5/16/04	5/16/04	1	400	0.278		0.009		
—	—		5/6/04	5/11/04	2	2388	0.276	0.038		12	
—	—		—	—	0	—	—	—		12	6
			5/6/04	5/11/04	2	2388	0.276		0.019		
—	—		—	—	0	—	—	—		24	
—	—		—	—	0	—	—	—			
—	—		—	—	0	—	—	—		12	0
—	—		—	—	0	—	—	—			
			—	—	0	—	—		—		
—	—		5/20/04	5/20/04	1	400	0.278	0.019		12	12
—	—		—	—	0	—	—	—			
—	—		—	—	0	—	—	—		36	6
			—	—	1	400	0.278		0.006		

Comparison with Sacramento River Delta Releases

As in 2003, we reviewed survival indices for juvenile salmon released at Sacramento to see how they compared to VAMP releases in 2004. The average survival index in 2004 for the three separate groups of Feather River Hatchery smolts released on April 15, April 30 and May 14 was 0.19—much lower than that measured in 2003 (0.51). This would indicate that from a relative scale survival was lower through the Sacramento River delta in 2004 than in 2003, whereas with the VAMP fish survival was low for both years. This indicates that perhaps different variables were responsible for the low VAMP survival estimates in 2003 and 2004.

OCEAN RECOVERY INFORMATION FROM PAST YEARS

Ocean recovery data of CWT salmon groups can contribute to a more thorough understanding and evaluation of salmon smolt survival studies. These data can provide another independent estimate of the ratio of recovery rate of a test release group relative to a control release group. Differential recovery rates using ocean recovery information can be compared with absolute survival estimates based on survival indices and the differential or combined differential recovery rates of juvenile salmon recovered at Chipps Island and/or Antioch, respectively. The ocean harvest data may be particularly reliable due to the number of CWT recoveries and the extended recovery period.

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 2003. The ocean CWT recovery data accumulate over a one to four year period after the year a study release is made as nearly all of a given year-classes of salmon have been either harvested or spawned by age five. Consequently, these data are essentially complete for releases made through 1999 and partially available for CWT releases made from 2000 to 2002.

Differential recovery rates based on ocean recoveries, Chipps Island recoveries or combined Antioch and Chipps Island recoveries for salmon produced at the MRFF are shown in Table 5-11. Absolute survival estimates based on Chipps Island and Antioch survival indices are also included. The earlier releases were made as part of south Delta survival evaluations (1996–1999) with the later releases associated with VAMP (2000–2002). Releases have been made at several locations: Dos Reis (on the San Joaquin River downstream of the upper Old River junction), Mossdale, Durham Ferry, and Jersey Point. The Chipps Island and Antioch survival estimates and combined differential (Antioch and Chipps Island recoveries summed) or differential recovery rates (Chipps Island recoveries only) are graphed in relation to the differential recovery rate using the ocean recovery information in Figure 5-11.

Results of this comparative analysis of survival estimates and differential recovery rates for Chinook salmon produced in the MRFF show: (1) to date, there is general, but variable, agreement between survival estimates and differential recovery rates based on juvenile CWT salmon recoveries in Chipps Island and adult recoveries from the ocean fishery, (2) there is less agreement with Antioch trawling which has fewer years of data, and (3) additional comparisons need to be made, as more data becomes available from VAMP releases for recoveries at Antioch, Chipps Island, and the ocean fishery. Information on survival of juvenile salmon and the contribution to the adult salmon population will be essential to evaluate 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 to increase the 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 assumed that these actions to improve conditions for the juveniles will translate into greater adult abundance and escapement in future years, especially during low flows, when corresponding adult escapement (2 1/2 years later) has been extremely low (SJRG, 2003).

To determine if VAMP has been successful in targeting the migration period of naturally produced juvenile salmon, catches of unmarked salmon at Mossdale and in salvage at the CVP and SWP facilities were compared prior to and during the VAMP period.

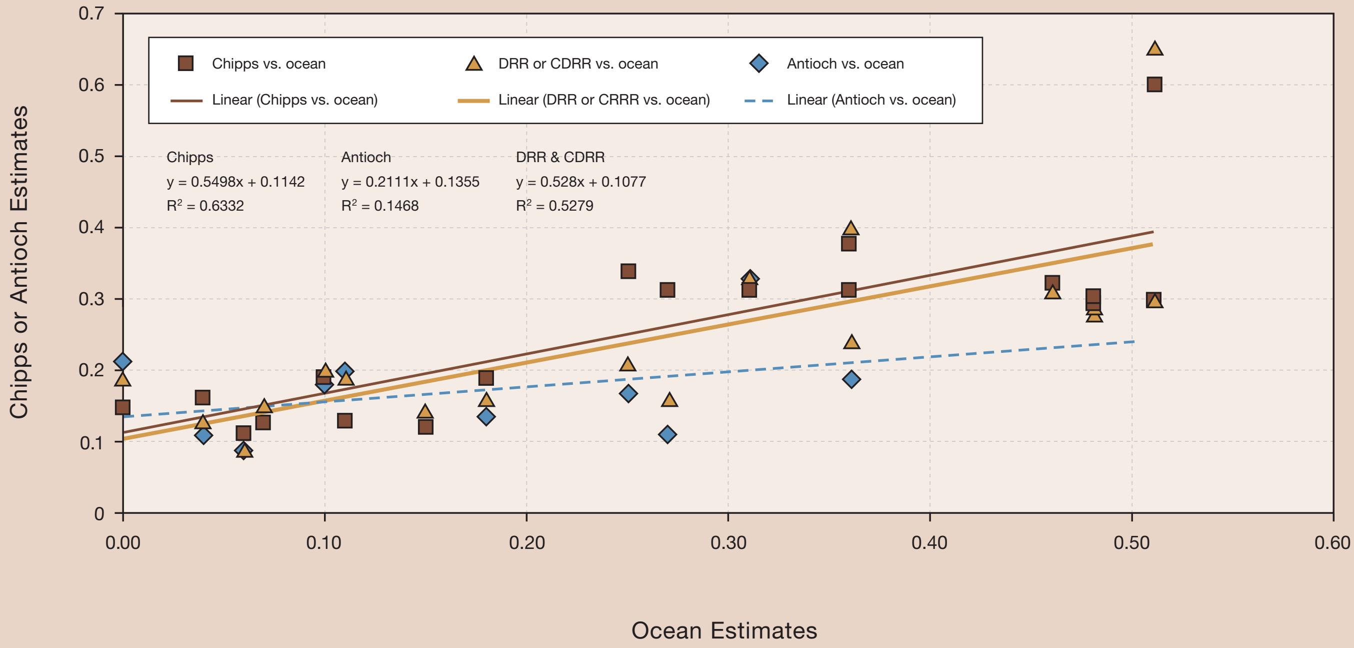
Unmarked Salmon Recovered at Mossdale

The 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 passed into the Delta at Mossdale during that time. The average catch per minute per day of unmarked juvenile salmon caught in Kodiak trawling at Mossdale between March 15 and June 30, 2004 is shown in Figure 5-12. Unmarked salmon do not have an adipose clip and could be unmarked fish from the Merced River

CHAPTER 5

FIGURE 5-11

Comparison of Antioch and Chipps Island survival estimates and differentials of combined differential recovery rates compared to differential ocean recovery rates for 1996-2002.



CHAPTER 5

TABLE 5-11

Survival Indices Based on Chipps Island, Antioch and Ocean Recoveries of Merced River Fish Facility Salmon Released as Part of South Delta Studies Between 1996 and 2002

Release Year	San Joaquin River (Merced River origin) Tag Number	Release Number	Release Site	Release Date	Chipps Island Recovs.	Antioch Recovs.	Expanded Adult Ocean Recovs. (Age 1+ to 4+) TOTAL	Chipps Island	Antioch	DRR or CDRR	Ocean Catch
		Juvenile Salmon CWT Releases						Absolute Survival Estimates		Differential Recovery Rates	
1996	H61110412	25,633	Dos Reis	5/01/96	2		3				
	H61110413	28,192	Dos Reis	5/01/96	3		37				
	H61110414	18,533	Dos Reis	5/01/96	1		8				
	H61110415	36,037	Dos Reis	5/01/96	5		10				
	H61110501	53,337	Jersey Pt	5/03/96	39		187				
	Effective Release	107,961	Dos Reis		11		58	0.12		0.14	0.15
	Effective Release	51,737	Jersey Pt		39		187				
1997	H62545	50,695	Dos Reis	4/29/97	9		183				
	H62546	55,315	Dos Reis	4/29/97	7		167				
	H62547	51,588	Jersey Pt	5/02/97	27		355				
	Effective Release	106,010	Dos Reis		16		350	0.29		0.29	0.48
	Effective Release	51,588	Jersey Pt		27		355				
	H62548	46,728	Dos Reis	5/08/97	5		91	0.30		0.28	0.48
	H62549	47,254	Jersey Pt	5/12/97	18		192				
1998	61110809	26,465	Mossdale	4/16/98	25		61				
	61110810	25,264	Mossdale	4/16/98	31		40				
	61110811	25,926	Mossdale	4/16/98	32		58				
	61110806	26,215	Dos Reis	4/17/98	33		47				
	61110807	26,366	Dos Reis	4/17/98	23		35				
	61110808	24,792	Dos Reis	4/17/98	34		61				
	61110812	24,598	Jersey Pt	4/20/98	87		110				
	61110813	25,673	Jersey Pt	4/20/98	100		91				
	Effective Release	77,655	Mossdale		88		159	0.30		0.30	0.51
	Effective Release	77,373	Dos Reis		90		143	0.32		0.31	0.46
	Effective Release	50,271	Jersey Pt		187		201				
1999	062642	24,715	Mossdale	4/19/99	8		128				
	062643	24,725	Mossdale	4/19/99	15		134				
	062644	25,433	Mossdale	4/19/99	13		132				
	062645	25,014	Dos Reis	4/19/99	20		151				
	062646	24,841	Dos Reis	4/19/99	19		219				
	0601110815	24,927	Jersey Pt	4/21/99	34		338				
	062647	24,193	Jersey Pt	4/21/99	25		381				
	Effective Release	74,873	Mossdale		36		394	0.38		0.40	0.36
	Effective Release	49,855	Dos Reis		39		370	0.60		0.65	0.51
	Effective Release	49,120	Jersey Pt		59		719				
2000	06-45-63	24,457	Durham Ferry	4/17/00	11	11	239				
	06-04-01	23,529	Durham Ferry	4/17/00	7	6	208				
	06-04-02	24,177	Durham Ferry	4/17/00	10	10	226				
	06-44-01	23,465	Mossdale	4/18/00	9	14	206				
	06-44-02	22,784	Mossdale	4/18/00	9	16	170				
	06-44-03	25,527	Jersey Pt	4/20/00	24	50	643				
	06-44-04	25,824	Jersey Pt	4/20/00	41	47	690				
	Effective Release	72,163	Durham Ferry		28	27	673	0.31	0.19	0.24	0.36
	Effective Release	46,249	Mossdale		18	30	376	0.31	0.33	0.33	0.31
	Effective Release	51,351	Jersey Pt		65	97	1333				
	601060914	23,698	Durham Ferry	4/28/00	7	8	46				
	601060915	26,805	Durham Ferry	4/28/00	5	15	42				
	0601110814	23,889	Durham Ferry	4/28/00	10	8	70				
	0601061001	25,572	Jersey Pt	5/01/00	48	76	356				
	0601061002	24,661	Jersey Pt	5/01/00	30	76	228				
	Effective Release	74,392	Durham Ferry		22	31	158	0.19	0.14	0.16	0.18
	Effective Release	50,233	Jersey Pt		78	152	584				

TABLE 5-11 (continued)

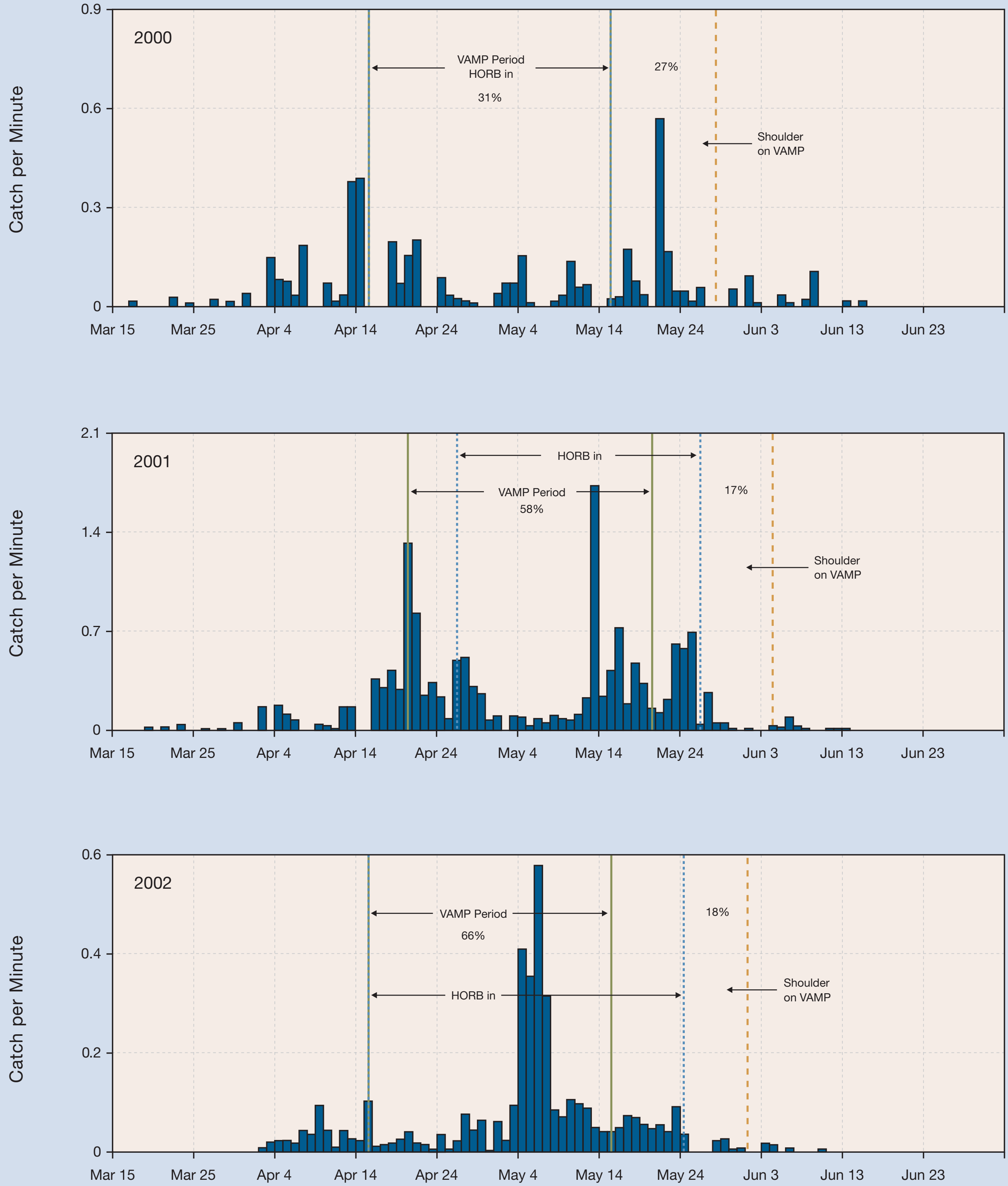
Survival Indices Based on Chipps Island, Antioch and Ocean Recoveries of Merced River Fish Facility Salmon Released as Part of South Delta Studies Between 1996 and 2002

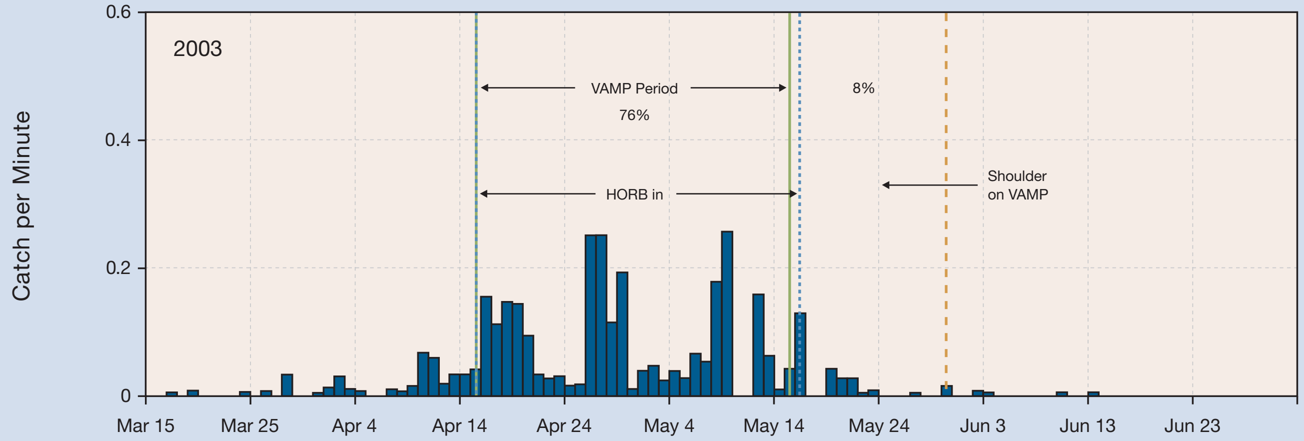
Release Year	San Joaquin River (Merced River origin) Tag Number	Release Number	Release Site	Release Date	Chipps Island Recovs.	Antioch Recovs.	Expanded Adult Ocean Recovs. (Age 1+ to 4+) TOTAL	Chipps Island	Antioch	DRR or CDRR	Ocean Catch
		Juvenile Salmon CWT Releases						Absolute Survival Estimates		Differential Recovery Rates	
2001	06-44-29	23,354	Durham Ferry	4/30/01	14	28	70				
	06-44-30	22,837	Durham Ferry	4/30/01	22	30	141				
	06-44-31	22,491	Durham Ferry	4/30/01	17	18	94				
	06-44-32	23,000	Mossdale	5/01/01	17	18	116				
	06-44-33	22,177	Mossdale	5/01/01	14	15	101				
	06-44-34	24,443	Jersey Pt	5/04/01	50	156	416				
	06-44-35	24,992	Jersey Pt	5/04/01	61	173	467				
	Effective Release	68,682	Durham Ferry		53	76	305	0.34	0.17	0.21	0.25
	Effective Release	45,177	Mossdale		31	33	217	0.31	0.11	0.16	0.27
	Effective Release	49,435	Jersey Pt		111	329	883				
	06-44-36	24,025	Durham Ferry	5/07/01	2	8	14				
	06-44-37	24,029	Durham Ferry	5/07/01	5	11	35				
	06-44-38	24,177	Durham Ferry	5/07/01	2	10	25				
	06-44-39	23,878	Mossdale	5/08/01	4	8	19				
	06-44-40	25,308	Mossdale	5/08/01	4	11	27				
	06-44-41	25,909	Jersey Pt	5/11/01	17	43	191				
	06-44-42	25,465	Jersey Pt	5/11/01	27	53	270				
	Effective Release	72,231	Durham Ferry		9	29	74	0.13	0.20	0.19	0.11
	Effective Release	49,186	Mossdale		8	19	46	0.19	0.18	0.20	0.10
	Effective Release	51,374	Jersey Pt		44	96	461				
2002	06-44-71	23,920	Durham Ferry	4/18/02	4	11	0				
	06-44-72	25,176	Durham Ferry	4/18/02	9	20	12				
	06-44-73	23,872	Durham Ferry	4/18/02	4	12	0				
	06-44-74	24,747	Durham Ferry	4/18/02	4	20	0				
	06-44-57	25,515	Mossdale	4/19/02	6	13	0				
	06-44-58	25,272	Mossdale	4/19/02	7	29	0				
	06-44-59	24,802	Jersey Pt	4/22/02	46	101	41				
	06-44-60	24,128	Jersey Pt	4/22/02	37	89	40				
	Effective Release	97,715	Durham Ferry		21	63	12	0.13	0.13	0.15	0.07
	Effective Release	50,787	Mossdale		13	42	0	0.15	0.21	0.19	0.00
	Effective Release	48,930	Jersey Pt		83	190	81				
	06-44-70	24,680	Durham Ferry	4/25/02	3	6	0				
	06-44-75	24,659	Durham Ferry	4/25/02	5	2	3				
	06-44-76	24,783	Durham Ferry	4/25/02	3	4	0				
	06-44-77	24,381	Durham Ferry	4/25/02	4	6	0				
	06-44-78	24,519	Mossdale	4/26/02	2	3	2				
	06-44-79	24,820	Mossdale	4/26/02	3	4	0				
	06-44-80	24,032	Jersey Pt	4/30/02	18	43	14				
	06-44-81	22,880	Jersey Pt	4/30/02	28	32	19				
	Effective Release	98,503	Durham Ferry		15	18	3	0.16	0.11	0.13	0.04
	Effective Release	49,339	Mossdale		5	7	2	0.11	0.09	0.09	0.06
	Effective Release	46,912	Jersey Pt		46	75	33				

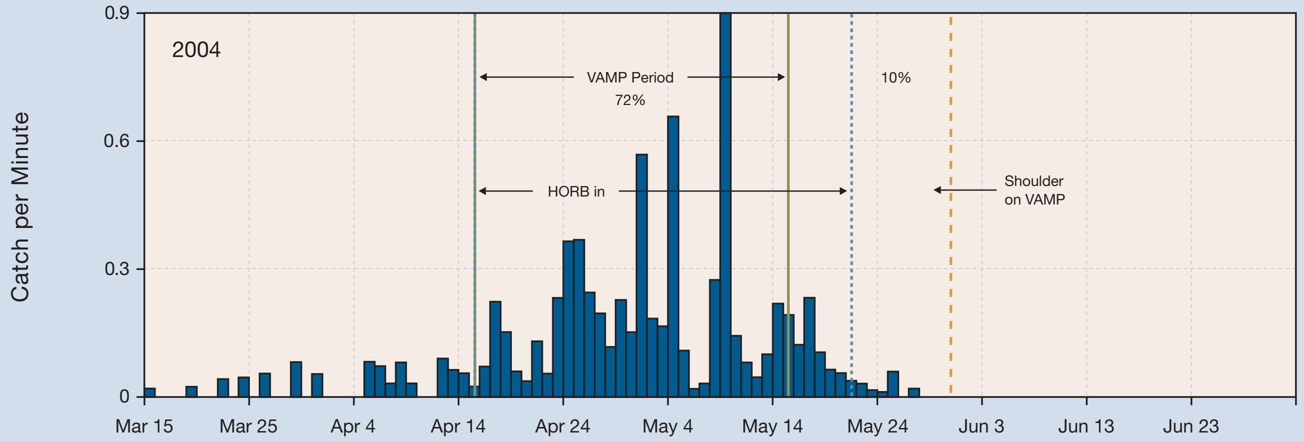
Note: Ocean recoveries are based on data through 2003.

FIGURE 5-12

Catch per minute of unmarked juvenile Chinook caught in the Mossdale Kodiak trawl between March 15 and June 30 of 2000 through 2004. Percentages equate to share of Chinook caught during the VAMP period or Shoulder period of the total catch between March 15 and June 30.




2003
VAMP Period
76%
8%
HORB in
Shoulder
on VAMP
Catch per Minute
0.6
0.4
0.2
0
Mar 15
Mar 25
Apr 4
Apr 14
Apr 24
May 4
May 14
May 24
Jun 3
Jun 13
Jun 23


2004
VAMP Period
72%
10%
HORB in
Shoulder
on VAMP
Catch per Minute
0.9
0.6
0.3
0
Mar 15
Mar 25
Apr 4
Apr 14
Apr 24
May 4
May 14
May 24
Jun 3
Jun 13
Jun 23

CHAPTER 5

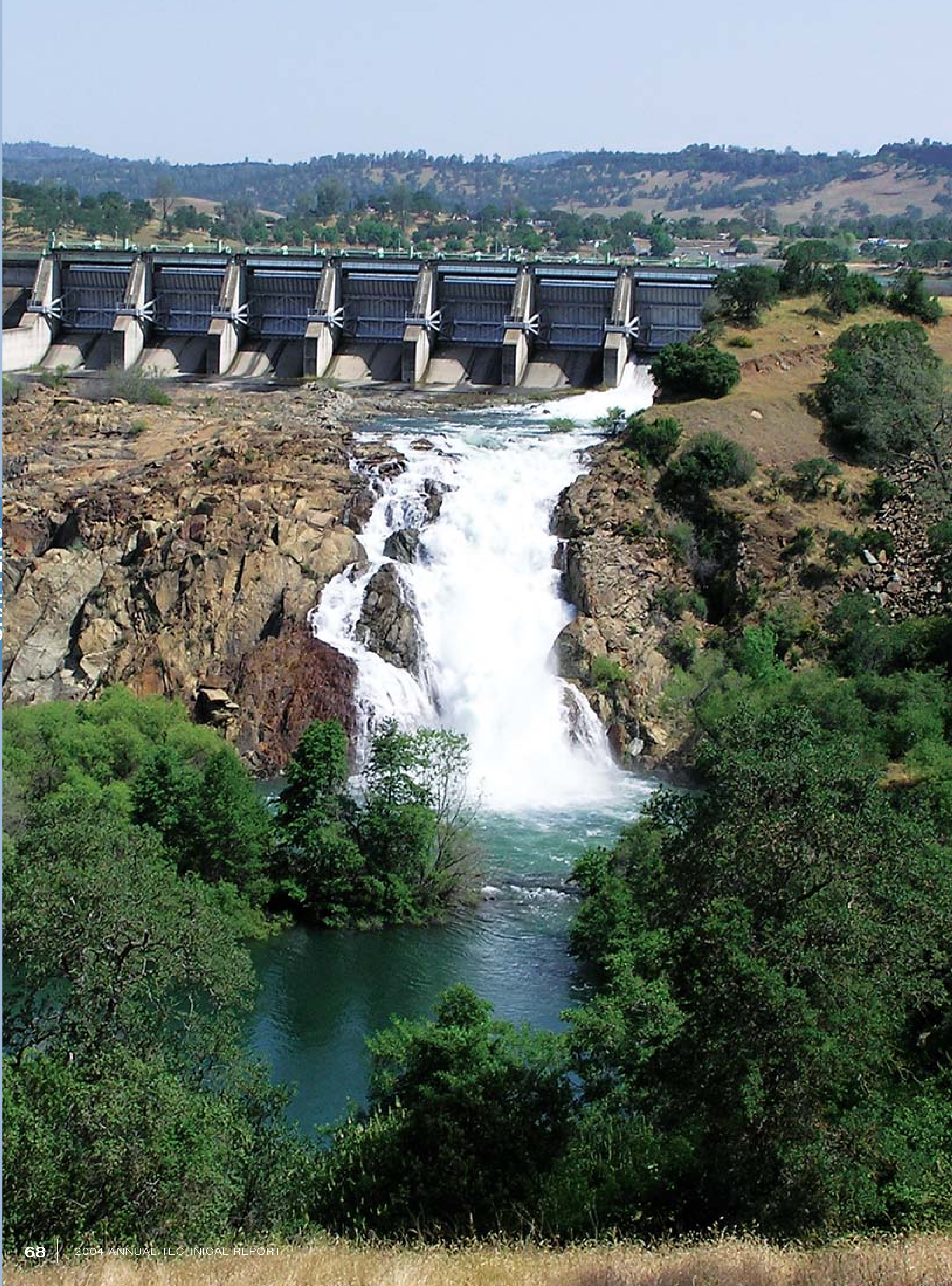
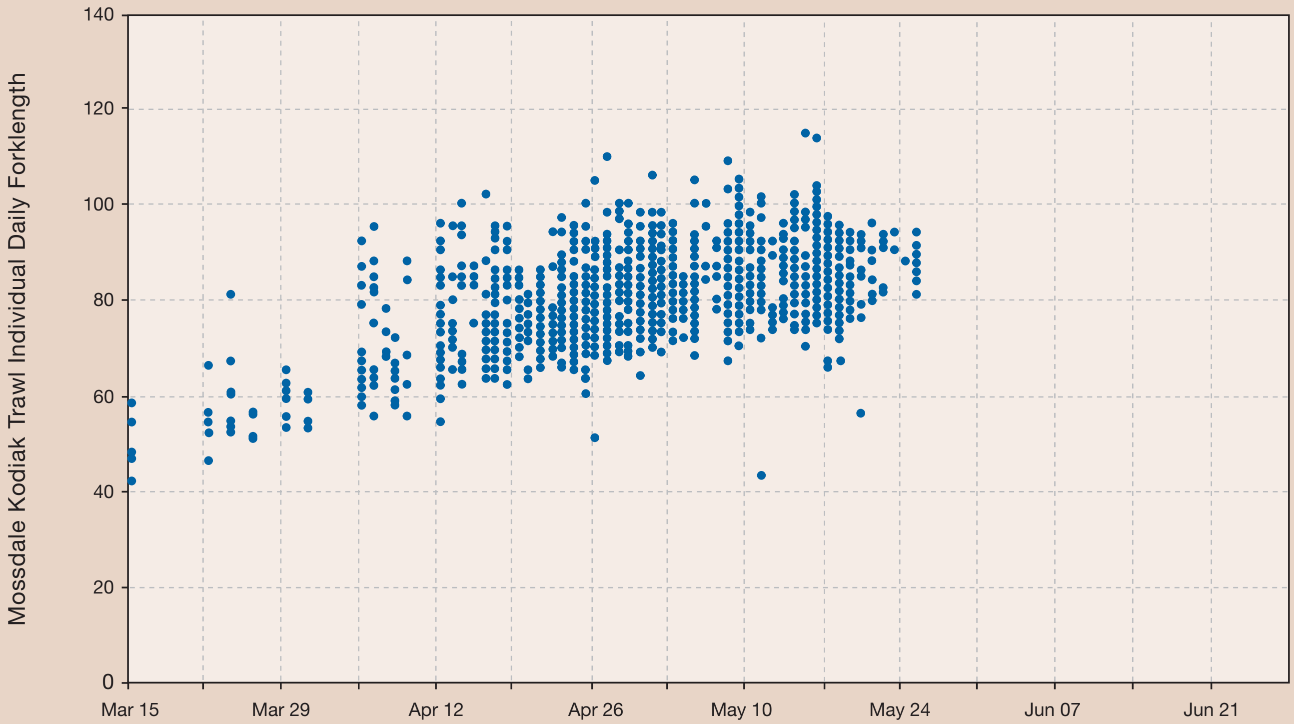


FIGURE 5-13

Mossdale Kodiak trawl individual daily forklengths of all unmarked juvenile Chinook salmon, March 15, 2004 through June 30, 2004.



CHAPTER 5

Fish Facility or juveniles from natural spawning. Approximately 72% of the unmarked catch that passed Mossdale between March 15 and June 30 passed during the VAMP period: April 15 to May 15—which is similar or higher than in past years since the VAMP has been implemented. The shoulder on VAMP that restricts exports until later in May or early June also provided protection to an additional 8 to 27% of the population over the years (Figure 5-12). The percentage of juvenile salmon migrating during the shoulder on the VAMP period in 2004 was 10%. The size of the juvenile salmon migrating past Mossdale between March 15 and June 30, 2004 is shown in Figure 5-13.

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 them downstream in the western Sacramento-San Joaquin Delta. The untagged salmon are either naturally produced or untagged MRFF 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 for Merced River Fish Facility smolts at the facilities to provide some general indications.

The salvage at the facilities is based on expansions from sub-samples taken throughout the day. Four to five 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 to 80% of the number salvaged, or about six to eight 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, additional mortality associated with trucking and handling, or post-release predation. Salvage density of salmon is the number of salvaged salmon per acre-foot of water pumped. The DFG and DWR maintain a database of daily, weekly, and monthly salvage data.

The number and density 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 of juvenile salmon salvaged and lost. Density

Releases have been made at several locations: Dos Reis (on the San Joaquin River downstream of the upper Old River junction), Mossdale, Durham Ferry, and Jersey Point.

is an indicator of when concentrations of juvenile salmon may be more susceptible to the export facilities and salvage system.

The weekly data covering the period of April 18 to May 15 approximated the 2004 VAMP period. A review of weekly data for late February through May indicates that the highest salvage and losses occurred during early to mid-March (Figures 5-14 and 5-15). Combined CVP and SWP weekly export rates at that time averaged 11,500–12,000 cfs and Vernalis flow averaged 3,400–3,600 cfs (Figure 5-16). Salmon density at the CVP facilities were very elevated in March as well, but their density was highest in the first week of May (Figure 5-17). Densities at the SWP facilities were generally lower than at the CVP, but were at their highest levels the week prior to and during most of the VAMP period (Figure 5-17). The size distribution of unmarked salmon during mid-March through May in the Mossdale trawl (Figure 5-13) was a subset of the size distribution of those salvaged at the fish facilities (Figure 5-18: Source E. Chappell, DWR). Based on comparisons with Mossdale data, it appears that some salmon salvaged prior to VAMP could have been of San Joaquin basin origin. The high salvage and density observed in early to mid March was also preceded by peak capture of fry and juvenile (pre-smolt) outmigrants in screw traps at Caswell State Park on the Stanislaus River upstream of Vernalis and at Mossdale (Figure 6-1) (Cramer 2004).

Results of these analyses showed that the 2004 VAMP test period coincided with much of the peak period of San Joaquin River salmon smolt emigration. Reductions in SWP and CVP exports and increased San Joaquin River flow likely provided improved conditions for salmon survival, although starting the VAMP period two to three weeks earlier may have had benefits for San Joaquin salmon smolts and smolts of other salmon races and stocks.

SUMMARY AND RECOMMENDATIONS

The survival estimates and CDRRs measured in 2003 and 2004 were low compared to past years. It is unclear why survival in 2003 and 2004 were so low but it does not seem to be directly related to San Joaquin River flow or CVP and SWP exports. It is also possible the low survival observed in the past two years is due to different factors. The MRFF fish were infected with the

FIGURE 5-14

2004 SWP Salmon Salvage & Loss

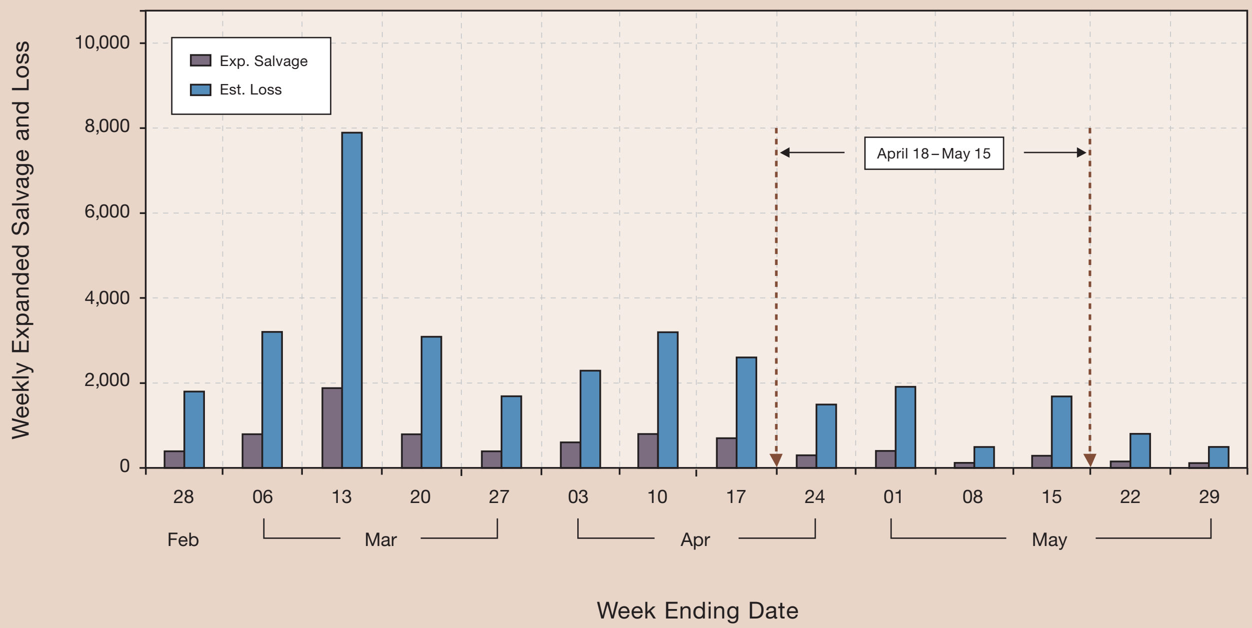
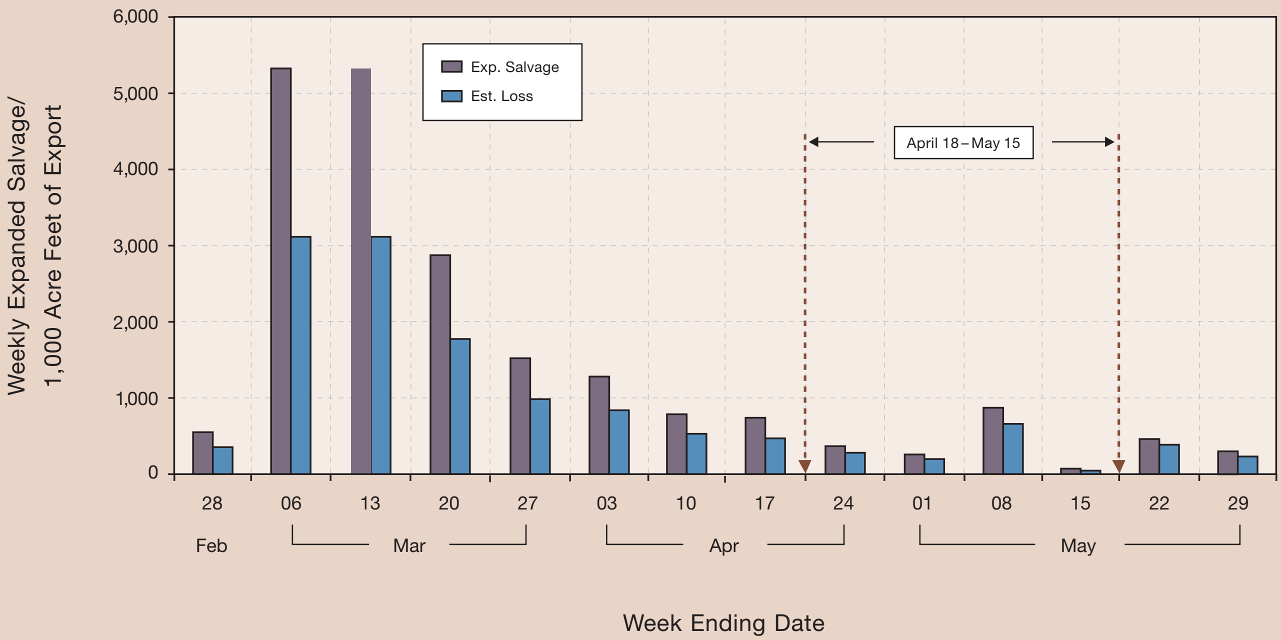


FIGURE 5-15

2004 CVP Salmon Salvage & Loss



CHAPTER 5

FIGURE 5-16

2004 Weekly Export Rates and Vernalis Flow

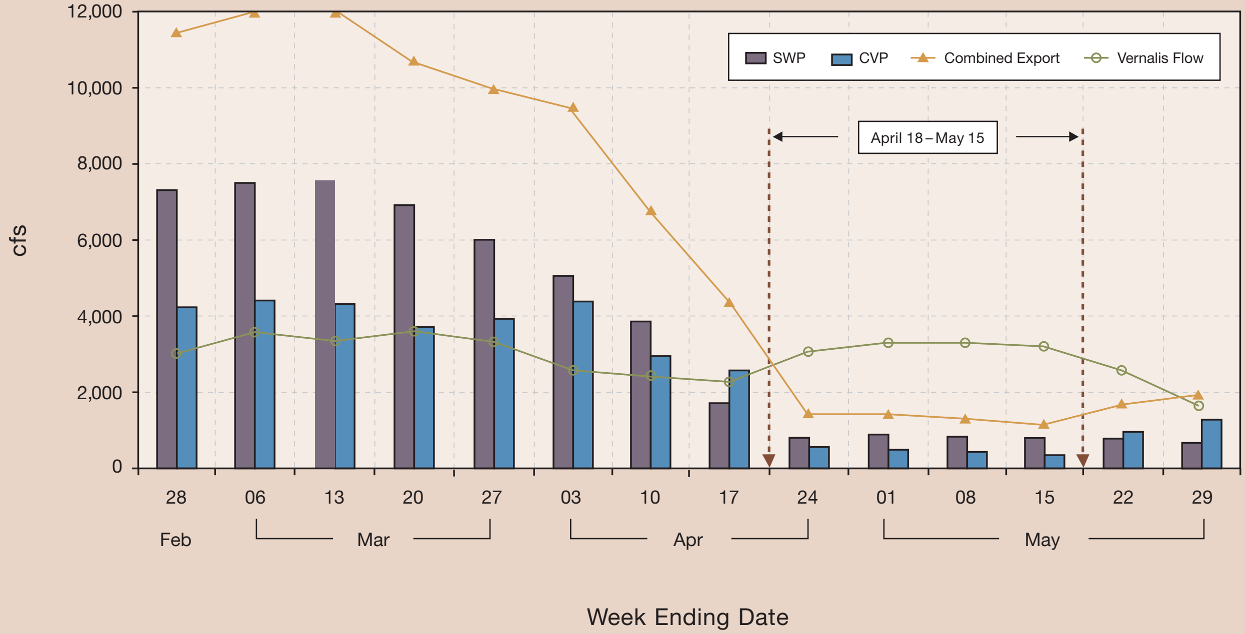
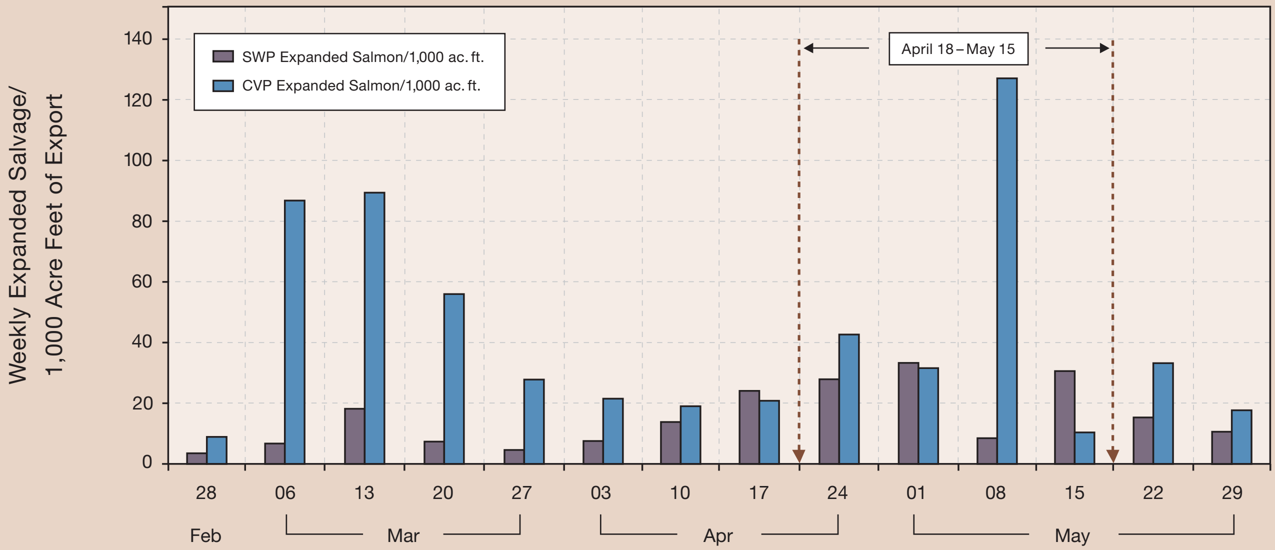


FIGURE 5-17

2004 SWP / CVP Expanded Salmon Salvage Density



parasite that causes PKD. Fish have been infected in past VAMP study years and it does not appear that the incidence of PKD was actually higher in 2003 or 2004. However, the combination of the lower flows and PKD infection may have affected the mortality of the VAMP fish in 2003 and 2004 resulting in shorter transit duration and higher mortality relative to past VAMP releases.

The high and similar mortality of the CWT groups released on the Merced River indicates that whatever increased the mortality of the VAMP fish was some condition that was common to the other marked fish released into the Merced River and lasted for several weeks. This condition also appeared to be restricted to the lower San Joaquin River and Delta or differences in the survival indices for the upstream and downstream Merced River releases would have been greater. While the causes are unclear, it would appear the condition continued into or reappeared in 2004. Repeating the study in future years will determine if this is to be continuous change in the survival rates or limited to lower flow years or just 2003 and 2004.

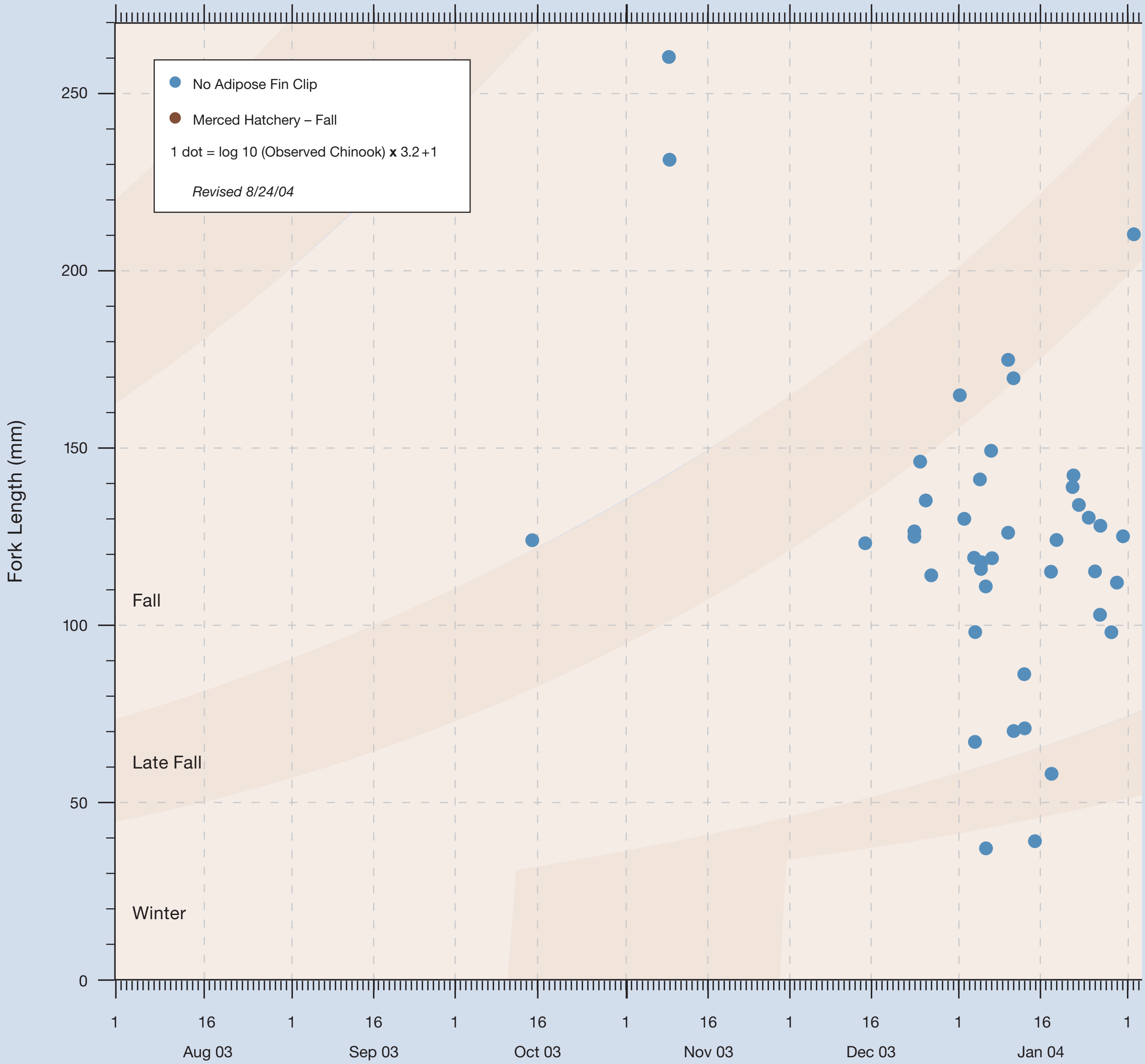
Even without the change since 2003, there have been several impediments to defining and refining the relationships between smolt survival and San Joaquin River flow and CVP and SWP exports. These impediments have been discussed in this and previous VAMP reports. The different permeability of the HORB and not having estimates of flow in the San Joaquin River downstream of the barrier add noise to our estimates of flow. In addition, using diseased MRFF fish in VAMP experiments adds a potential bias to our estimates of survival, even-though PKD is also present in wild stocks (Ken Nichols, USFWS internal memo, 12/6/02). Measuring survival within the narrowly defined flow and export VAMP targets further exacerbates the problem of noise in the variables of interest. The level of precision of our survival estimates and the noise in flow measurements limits our ability to precisely define the relationship of survival to flow and exports. Yearly, pooled estimates are now based on releases of 300,000 to 400,000 fish with two recovery locations, sampling roughly seven to ten hours per day, yet recoveries have not been great enough to statistically differentiate between survival estimates measured at VAMP target flow and exports levels obtained to date. Differences in survival may be occurring but our ability to detect them is limited.

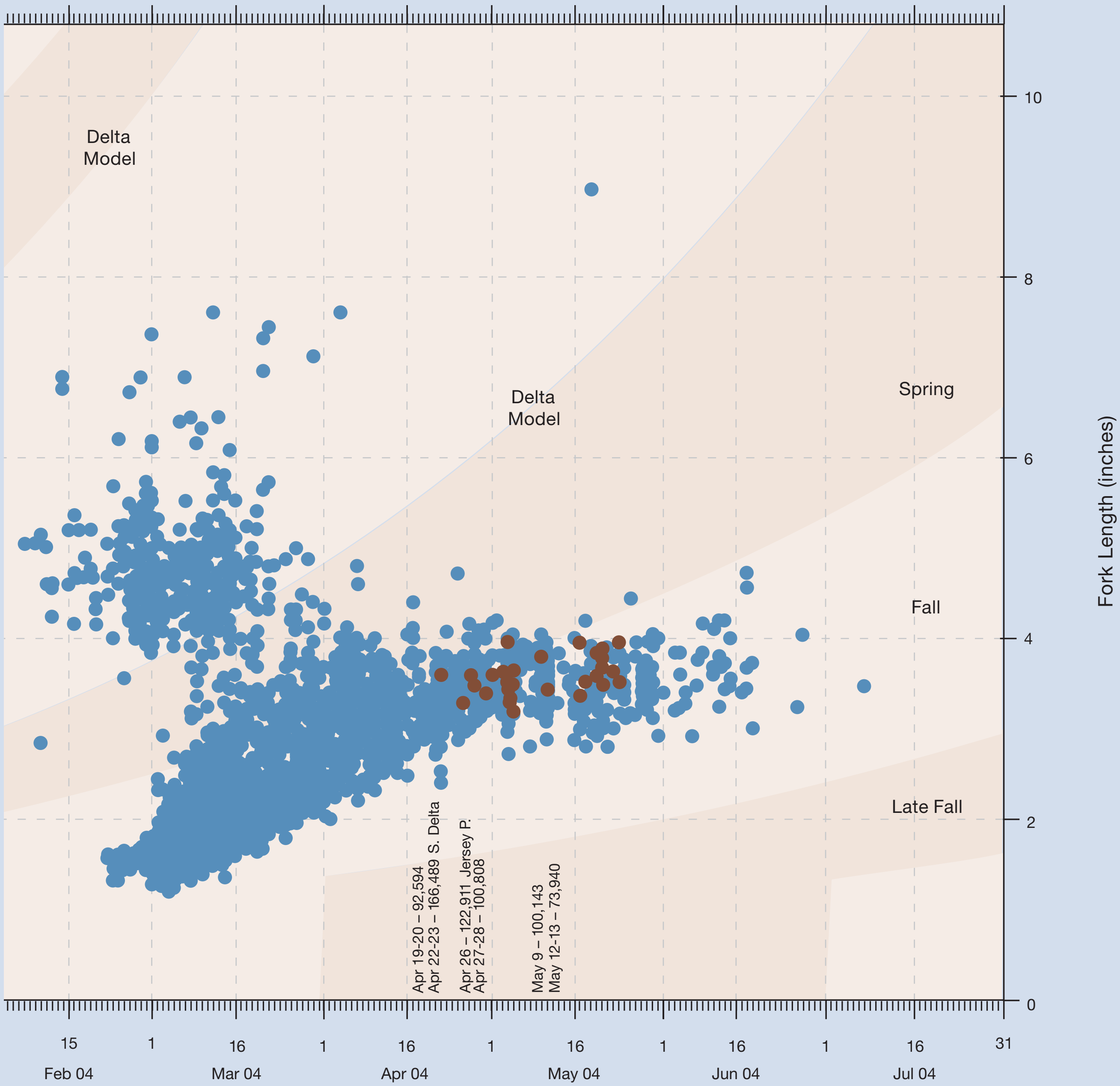
To address this dilemma, future studies should prioritize measuring survival at the highest VAMP target flow and lowest export levels. Flows of 7,000 cfs and exports of 1,500 cfs would achieve the highest inflow to export ratio (4.7) within the VAMP design and provide a new target to test. Based on information to date, the higher flow would probably increase survival and may lessen any effects or infection rate of PKD. This should increase recovery numbers such that confidence intervals may be statistically different from previously obtained CDRRs. It is uncertain how such a condition can be prescribed, independent of the hydrology, within the existing San Joaquin River Agreement, but the idea should be explored by the VAMP Management Team.

Further confidence in defining and refining the relationship of smolt survival to flow and exports could be obtained by increasing the length of the study. The fifth year of VAMP was completed in 2004 with seven years remaining in the study. Additional replication can resolve uncertainty when variation is high. Continued assessment of past data is also recommended such that other methodologies or criteria for determining statistical differences between groups may be developed.

FIGURE 5-18

Observed Chinook Salvage at the SWP & CVP Delta Fish facilities August 1, 2003 through July 31, 2004.




Delta Model
Delta Model
Spring
Fall
Late Fall
Apr 19-20 – 92,594
Apr 22-23 – 166,489 S. Delta
Apr 26 – 122,911 Jersey P.
Apr 27-28 – 100,808
May 9 – 100,143
May 12-13 – 73,940
Fork Length (inches)
0
2
4
6
8
10
15
Feb 04
1
16
Mar 04
1
16
Apr 04
1
16
May 04
1
16
Jun 04
1
16
Jul 04
31

CHAPTER 6

Complementary Studies Related to the VAMP

Throughout 2004 several fishery studies were conducted that were considered to be important to the overall understanding of the abundance and survival in the San Joaquin River basin. These are presented below to provide the reader with summary information on each study. More information can be obtained from each study manager or report author.

SURVIVAL ESTIMATED FOR CWT RELEASES MADE IN THE SAN JOAQUIN TRIBUTARIES

Contributed by Pat Brandes, U.S. Fish and Wildlife Service

CWT salmon releases were made in the Merced River between April 19 and May 12 as part of independent (complementary) fishery investigations. Three sets of releases were made in the upper Merced River (MRFF/Schaffer Bridge) and lower Merced River (Hatfield State Park).

Group survival indices for salmon released in the Merced River and recovered at Antioch ranged between 0.0 and 0.004 (Table 5-10). Group survival indices ranged between 0.0 and 0.02 to Chipps Island (Table 5-10). These indices were similar to those in 2002 and 2003, but much lower than in 2001, where indices ranged from 0.03 to 0.20 (SJRG 2004, 2003, 2002). These indices include both the survival upstream as well as through the Delta. Vernalis flows were lower in 2002, 2003 and 2004 than in 2001(3200 cfs vs 4450 cfs target flows).

Comparison of survival indices of the upstream tributary groups relative to the downstream tributary groups provides an index of survival through the tributary. Only the survival through the Merced River could be estimated from the second groups release on April 27 and 28th, because it was the only group that had recoveries from both groups at a similar recovery location (Chipps Island). Survival through the Merced River was estimated at 0.47 for this group. Survival through the Merced River ranged between 0.26 and 0.96 in 2003, although there were instances where no recoveries were made at Chipps Island. It appeared survival through the tributaries was generally high using this method of comparison and higher than for those migrating through the Delta.

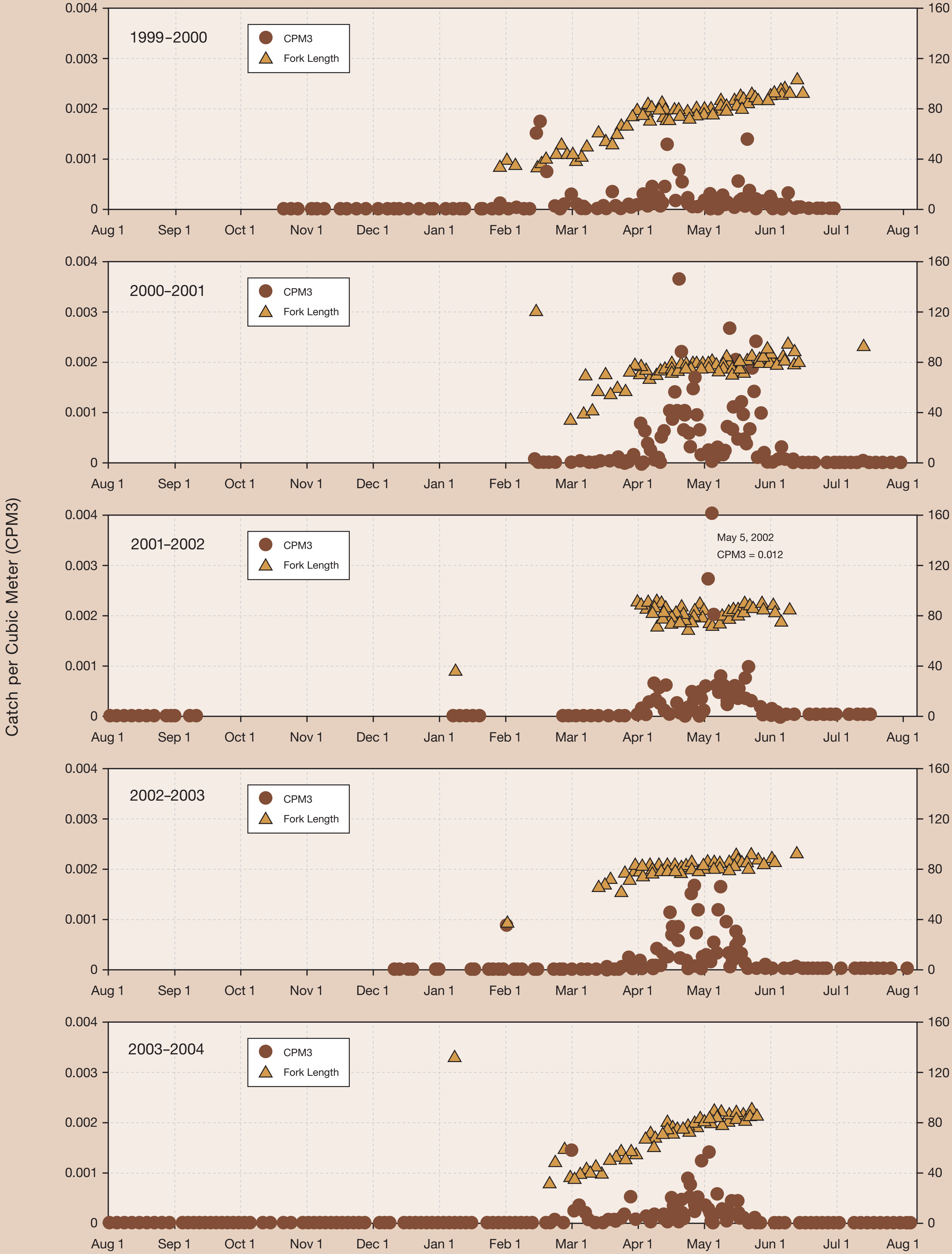
KODIAK TRAWL SAMPLING OF SALMON AT MOSSDALE

Contributed by Pat Brandes, U.S. Fish and Wildlife Service

As part of the Interagency Ecological Program (IEP), kodiak trawl sampling is conducted at Mossdale, two to three times a week throughout the year, when water and staffing levels permit. VAMP has been designed for implementation during the time juvenile salmon from the San Joaquin tributaries migrate through the Delta. Most of the salmon that migrate through the Delta during the VAMP period are smolts that are migrating directly through the Delta to the ocean. In some years, smaller sized juvenile salmon (fry) enter the Delta from the tributaries prior to mid-April. There was no evidence that many fry entered the Delta prior to March in 2004 (Figure 6-1). In most of the past years, there has been evidence of some smaller fish (and sometimes larger salmon) caught at Mossdale as they enter the Delta, as early as mid-January and February (Figure 6-2). In most years numbers were low—the year with the largest number entering the Delta was in 1999–2000. As mentioned in earlier chapters, the spring of 2000 was wetter than the springs since then. Higher flows likely bring more fry into the Delta. However, even in the years when fry from the San Joaquin tributaries enter the Delta it is likely they do not migrate all the way to the ocean until they are of smolt size. Survival for fry in the Delta compared to that upstream has not been measured for the San Joaquin tributaries, although in wet years it was found that fry survive at a higher rate when released in the Sacramento River near Red Bluff than in the north Delta (Brandes and McLain, 2001). In drier years survival was similar between the two groups (Brandes and McLain, 2001).

FIGURE 6-1

Daily catch per cubic meter and mean fork lengths of juvenile Chinook salmon in the Mossdale Kodiak trawl between for August through July periods, 1999 through 2004. Blanks indicate no sampling.



7

CHAPTER 7

Conclusions & Recommendations

The VAMP experimental investigation of juvenile Chinook salmon survival was implemented during spring 2004. The Vernalis target flow was 3,200 cfs, with a combined SWP and CVP export rate 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 MRFF 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 fisheries sampling at Antioch and Chipps Island. Based upon the data and experience gained during the VAMP 2004 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 2005 operations and investigations.

Based on testing the relationship of salmon survival rates against flow and export conditions over the first five years it has been shown that survival generally improves as flows increase and flows relative to exports increase. With the addition of the 2003 and 2004 data, the relationships between salmon survival rates and Vernalis flows to SWP/CVP exports ratios are no longer statistically significant. Opportunities will be explored for variability in test conditions that are statistically robust and biologically valid in order to obtain fish survival data over a broader range of flow and export reductions. Survival testing at high flows and low exports (a high flow/export ratio) are important to obtain. The VAMP program provides improved protection for juvenile salmon when compared to “pre-VAMP” or without “VAMP” conditions.

TABLE 7-1

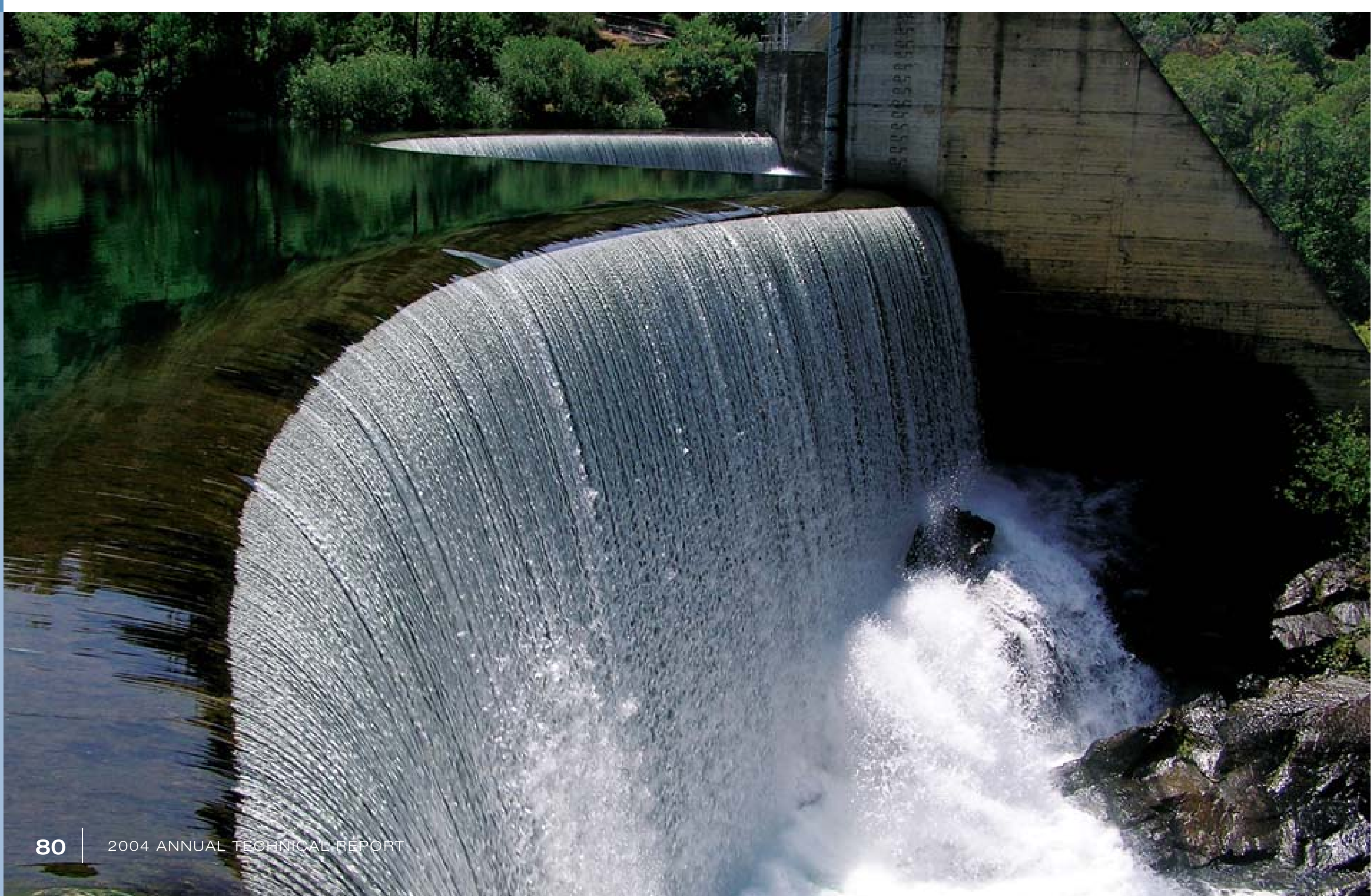
Summary of VAMP 2004 Conclusions and Recommendations

CONCLUSIONS	RECOMMENDATIONS FOR 2005
Survival from Durham Ferry and Mossdale in 2003 and 2004 was significantly less then prior years. Further evaluation of survival rate versus flow and export rate is needed to detect differences in survival.	Survival tests at extreme target levels (e.g. 7,000 cfs flow and 1,500 cfs exports), or equivalent high flow/export ratios are necessary. The VAMP tests should be continued.
Flow measurements in the Old River and in the San Joaquin River downstream of the HORB were hampered by equipment malfunctions and calibration.	Maintenance and calibration of flow measurement equipment should be performed before the initiation of the 2005 VAMP and periodically checked throughout the VAMP period.
An accurate measurement of flow diverted through the HORB is essential to better understand the flow and entrainment relationship at the barrier.	Continue measurement of flow in at least one culvert as done in 2004 with desire to measure flow in all culverts.

CONCLUSIONS CONT.	RECOMMENDATIONS CONT.
Mossdale Kodiak trawl is an important component in determining distribution of out migration from the San Joaquin Basin.	Maintain the Mossdale Kodiak trawl at existing or higher level of effort throughout year.
Observed ungaged flows (accretions, depletions) between upstream measurement points and Vernalis varied significantly from those forecasted resulting in differences between forecasted and required supplemental flows.	Hydrology committee to refine estimates of ungaged flow and develop a management scheme to accommodate variability.
Real-time streamflow data at San Joaquin River near Vernalis were improved by weekly verification of rating curves.	Continue weekly flow and calibration measurements. Investigate alternative flow measurement methods and/or locations.
Flow in the lower San Joaquin River downstream of Old River is important to evaluate the flow split at Old River and survival of salmon.	Calibrate the stage and flow monitoring system prior to and during the 2005 VAMP test period.
Coordination with upstream tributary operations was successful, though some imbalance against the Division Agreement resulted.	Continue coordination among tributary operators.
Operation of the HORB was successful in maintaining south delta water levels.	Continue to refine operational criteria for culverts, water level modeling, and groundwater level monitoring.
The use of fyke nets was successful in collecting entrained fish at the culverts.	Continue monitoring culverts using fyke nets to document fish entrainment.
The index of salmon entrainment at the HORB was significantly lower in 2004 (0.7 salmon per hour) compared to the past three years (3.4 in 2003; 2.5 in 2002; 1.4 in 2001).	Continue barrier monitoring and analysis of factors affecting entrainment.
Most salmon were entrained at night in 2004, similar to prior years. The relationship between tidal condition and salmon entrainment at HORB was variable.	Split releases at Mossdale should be re-instituted in 2005 to evaluate tidal-diel interactions affecting salmon entrainment.
2004 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.
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.
Results of net pen studies showed a 0.8 percent mortality rate in 2004 compared to 0.5 percent in 2003.	Continue net pen studies and fish health inspections.
Physiological studies provided useful information on fish health and condition. Fish pathologists concluded that fish were relatively healthy and should have performed adequately for outmigration assessments.	Recommend continued health monitoring to compare within and between year trends of health and condition.
Blood chemistry analysis showed that all release groups were physiologically capable of handling stress associated with outmigration.	Baseline data for blood chemistry analyses should be taken from unstressed fish (not subjected to stress for 24 or more hours).

CONTINUED ON NEXT PAGE

CONCLUSIONS CONT.	RECOMMENDATIONS CONT.
2003 and 2004 survival rates were the lowest since the initiation of the VAMP and were significantly lower than those in 2002 under similar flow and export conditions.	Continue to evaluate differences in survival rates between release locations, flows, and export conditions.
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.
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.
VAMP has been designed to adaptively manage experimental test conditions each year.	Continue to identify and evaluate opportunities to adaptively manage and refine the VAMP test conditions to improve protection for juvenile Chinook salmon out-migrating from the San Joaquin River, improve survival test conditions to detect differences in survival, if they exist, as a function of river flow and SWP/CVP export operations, and optimize the allocation of available water supplies each year.



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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
- Sal Luis Canal Company

Friant Water Users Authority*

Public Utilities Commission of the City
and County of San Francisco*

Natural Heritage Institute

Metropolitan Water District of
Southern California

San Luis And Delta-Mendota
Canal Water Authority

San Joaquin River Group Authority

**San Joaquin River Group Authority Members*

Useful Web Pages

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San Joaquin River Agreement
www.sjrg.org/agreement.htm

SWRCB Decision 1641
www.waterrights.ca.gov/hearings/Decisions.htm

PAGE 8

VAMP Annual Technical Reports
www.sjrg.org/technicalreport/2003_tech_report.htm

VAMP Experimental Design
www.sjrg.org/agreement.htm

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Operation Monitoring, CDEC Hourly
http://cdec.water.ca.gov/cgi-progs/
queryGroup?s=fw1

Operation Monitoring, CDEC Daily
http://cdec.water.ca.gov/cgi-progs/
queryDgroups?s=fw2

Vernalis USGS Real-Time
http://waterdata.usgs.gov/nwis/uv?format=
pre&period=1&site_no=11303500

Vernalis, USGS Daily
http://waterdata.usgs.gov/ca/nwis/dv?format=
pre&period=31&site_no=11303500

Newman, USGS Daily
http://waterdata.usgs.gov/ca/nwis/dv?format=
pre&period=31&site_no=11274000

LaGrange, USGS Daily
http://waterdata.usgs.gov/ca/nwis/dv?format=
pre&period=31&site_no=11289650

Goodwin, USBR Daily
http://www.usbr.gov/mp/cvo/vungvari/gdwdop.pdf

Cressey, CDEC Daily
http://cdec.water.ca.gov/cgi-progs/queryF?s=crs

Stevinson, CDEC Daily
http://cdec.water.ca.gov/cgi-progs/queryF?s=mst

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Temporary Barrier Program
http://sdelta.water.ca.gov/web_pg/tempmesr.html

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Reclamation District 544
Seepage Monitoring Study
http://wwwdpla.water.ca.gov/cd/groundwater/
Delta_Seepage.html

PAGE 42

HORB on Old River Tidal Stage
http://cdec.water.ca.gov/cgi-progs/queryF?s=MSD

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CVP and SWP Salvage Data
http://baydelta.water.ca.gov

USFWS Stockton
http://www.delta.dfg.ca.gov/usfws/monitoring_
main/monitoring_main.html

Pacifica States Marine Fisheries Commission
Regional Mark Information System
http://www.rmis.org

Common Acronyms & Abbreviations

ACRONYMS

ADCP	Acoustic Doppler Current Profiler
Bay-Delta	Sacramento and San Joaquin Rivers San Francisco Bay Delta
CDEC	California Data Exchange Center
CDRR	Combined Differential Recovery Rate
CFS	Cubic Feet Per Second
CPUE	Catch Per Unit Effort
CRR	Combined Recovery Rate
CVP	Central Valley Project
CWT	Coded-Wire Tagged
D-1641	Water Rights Decision 1641 of the SWRCB
DFG	California Department of Fish and Game
DWR	California Department of Water Resources
FHC	California-Nevada Fish Health Center
GLC	Grant Line Canal
HOR	Head of Old River
HORB	Head of Old River Barrier
Merced	Merced Irrigation District
MID	Modesto Irrigation District
MR	Middle River
MRFF	Merced River Fish Facility
MSL	Mean Sea Level
NOAA	National Oceanic and Atmospheric Administration
OID	Oakdale Irrigation District
ORT	Old River at Tracy
PKD	Proliferative Kidney Disease
SDWA	South Delta Water Agency
SJRA	San Joaquin River Agreement
SJRECWA	San Joaquin River Exchange Contractors Water Authority
SJRGA	San Joaquin River Group Authority
SJRTC	San Joaquin River Technical Committee
SSJID	South San Joaquin Irrigation District
SWP	State Water Project
SWRCB	State Water Resources Control Board
TBP	Temporary Barriers Project
TID	Turlock Irrigation District
USBR	United States Bureau of Reclamation
USFWS	United States Fish and Wildlife Service
USGS	United States Geologic Survey
VAMP	Vernalis Adaptive Management Plan
WQCP	Water Quality Control Plan for the Bay-Delta Estuary

APPENDIX A

Hydrology & Operation Plans

APPENDIX A–1, TABLE 1

VAMP Daily Operation Plan, March 17, 2004 (A) • Low

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

	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 Supp. 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)	
Apr 01						349	300	250			250	500	500		500	765			765	
Apr 02						346	300	250			250	500	500		500	765			765	
Apr 03						342	300	250			250	500	500		500	765			765	
Apr 04	2,161				2,161	339	300	250			250	500	500		500	765			765	
Apr 05	2,157				2,157	335	300	250			250	500	500		500	765			765	
Apr 06	2,154				2,154	332	300	250			250	500	500		500	765			765	
Apr 07	2,150				2,150	328	300	250			250	500	500		500	765			765	
Apr 08	2,147				2,147	325	300	250			250	500	500		500	765			765	
Apr 09	2,143				2,143	321	300	250			250	500	500		500	765			765	
Apr 10	2,140				2,140	318	300	250			250	500	500		500	765			765	
Apr 11	2,136				2,136	314	300	250	150		400	500	500		500	765			765	
Apr 12	2,133				2,133	311	300	250	400	90	740	500	500		500	765			765	
Apr 13	2,129	0			2,129	307	300	250	560	90	900	700	1,030	170	1,200	400	200	0	600	
Apr 14	2,126	150			2,276	304	300	250	560	90	900	700	1,030	170	1,200	400	100	0	500	
Apr 15	2,287	860	0	1.71	3,147	300	300	250	590	90	930	700	1,030	170	1,200	400	100	0	500	
Apr 16	2,284	920	0	3.53	3,204	297	300	250	600	80	930	700	1,030	170	1,200	400	100	0	500	
Apr 17	2,280	920	0	5.36	3,200	293	300	250	600	80	930	700	1,030	170	1,200	400	100	0	500	
Apr 18	2,277	950	0	7.24	3,227	290	300	250	600	80	930	700	1,030	170	1,200	400	100	0	500	
Apr 19	2,273	950	0	9.12	3,223	286	300	250	600	80	930	700	1,030	170	1,200	400	100	0	500	
Apr 20	2,270	950	0	11.01	3,220	283	300	250	600	80	930	700	1,030	170	1,200	400	100	0	500	
Apr 21	2,266	950	0	12.89	3,216	279	300	250	600	80	930	700	1,040	160	1,200	400	100	0	500	
Apr 22	2,263	950	0	14.78	3,213	276	300	250	600	80	930	700	980	160	1,140	400	100	0	500	
Apr 23	2,269	940	0	16.64	3,209	272	300	250	600	80	930	700	640	160	800	600	150	0	750	
Apr 24	2,206	940	0	18.51	3,146	269	300	250	270	80	600	700	440	160	600	1,000	150	0	1,150	
Apr 25	2,062	990	0	20.47	3,052	265	300	250	270	80	600	700	440	160	600	1,200	300	0	1,500	
Apr 26	2,259	990	0	22.43	3,249	262	300	250	270	80	600	700	440	160	600	1,200	300	0	1,500	
Apr 27	2,455	810	0	24.04	3,265	258	300	250	270	80	600	700	440	160	600	1,200	300	0	1,500	
Apr 28	2,452	810	0	25.65	3,262	255	300	250	270	80	600	700	440	160	600	1,200	300	0	1,500	
Apr 29	2,448	810	0	27.25	3,258	251	300	250	270	80	600	700	440	160	600	1,200	300	0	1,500	
Apr 30	2,445	810	0	28.86	3,255	248	300	250	270	80	600	700	440	160	600	1,200	300	0	1,500	
May 01	2,441	810	0	30.47	3,251	244	300	250	270	80	600	700	440	160	600	1,200	300	0	1,500	
May 02	2,438	810	0	32.07	3,248	241	300	250	530	80	860	700	440	160	600	1,200	300	0	1,500	
May 03	2,434	810	0	33.68	3,244	237	300	250	570	80	900	700	440	160	600	1,200	0	0	1,200	
May 04	2,431	810	0	35.29	3,241	234	300	250	920	80	1,250	700	640	160	800	900	0	0	900	
May 05	2,427	770	0	36.81	3,197	230	300	250	970	80	1,300	700	640	160	800	600	0	0	600	
May 06	2,324	810	0	38.42	3,134	227	300	250	970	80	1,300	700	640	160	800	400	100	0	500	
May 07	2,020	1,160	0	40.72	3,180	223	300	250	970	80	1,300	700	640	160	800	400	100	0	500	
May 08	1,817	1,310	0	43.32	3,127	220	300	250	970	80	1,300	700	640	160	800	400	200	0	600	
May 09	1,813	1,310	0	45.92	3,123	216	300	250	970	80	1,300	700	640	160	800	400	200	0	600	
May 10	1,810	1,410	0	48.71	3,220	213	300	250	920	80	1,250	700	640	160	800	400	200	0	600	
May 11	1,806	1,410	0	51.51	3,216	209	300	250	870	80	1,200	700	640	160	800	400	300	0	700	
May 12	1,803	1,410	0	54.31	3,213	206	300	250	670	80	1,000	700	640	160	800	400	300	0	700	
May 13	1,799	1,460	0	57.20	3,259	202	300	250	250		500	700	640	160	800	400	300	0	700	
May 14	1,796	1,410	0	60.00	3,206	199	300	250			250	500	500		500	565			565	
May 15	1,792	1,210	0	62.40	3,002	195	300	250			250	500	500		500	565			565	
May 16	1,814	250			2,064	192	300	250			250	500	500		500	565			565	
May 17	1,810	0			1,810	188	300	250			250	500	500		500	565			565	
May 18	1,807	0			1,807	185	300	250			250	500	500		500	565			565	
May 19	1,803	0			1,803	181	300	250			250	500	500		500	565			565	
May 20	1,800	0			1,800	178	300	250			250	500	500		500	565			565	
May 21	1,796	0			1,796	174	300	250			250	500	500		500	565			565	
May 22	1,793	0			1,793	171	300	250			250	500	500		500	565			565	
May 23	1,789	0			1,789	167	300	250			250	500	500		500	565			565	
May 24	1,786	0			1,786	164	300	250			250	500	500		500	565			565	
May 25	1,782	0			1,782	160	300	250			250	500	500		500	565			565	
May 26	1,779	0			1,779	157	300	250			250	500	500		500	565			565	
May 27	1,775	0			1,775	153	300	250			250	500	500		500	565			565	
May 28	1,772	0			1,772	150	300	250			250	500	500		500	565			565	
May 29	1,768	0			1,768	146	300	250			250	500	500		500	565			565	
May 30	1,765	0			1,765	143	300	250			250	500	500		500	565			565	
May 31	1,761	0			1,761	139	300	250			250	500	500		500	565			565	
	VAMP Period																			
Avg. (cfs):	2,185	1,015			3,200	255	300	250	594	81	925	700	700	163	863	681	177	0	858	
Suppl. Water (TAF)		62.40							36.50	5.00				10.00			10.91			

Target flow period

APPENDIX A–1, TABLE 2

VAMP Daily Operation Plan, March 17, 2004 (B) • High

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

	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 Supp. 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)	
Apr 01						667	800	250			250	500	500		500	1,191			1,191	
Apr 02						662	800	250			250	500	500		500	1,191			1,191	
Apr 03						658	800	250			250	500	500		500	1,191			1,191	
Apr 04	3,403				3,403	653	800	250			250	500	500		500	1,191			1,191	
Apr 05	3,399				3,399	648	800	250			250	500	500		500	1,191			1,191	
Apr 06	3,394				3,394	643	800	250			250	500	500		500	1,191			1,191	
Apr 07	3,389				3,389	638	800	250			250	500	500		500	1,191			1,191	
Apr 08	3,384				3,384	634	800	250			250	500	500		500	1,191			1,191	
Apr 09	3,379				3,379	629	800	250			250	500	500		500	1,191			1,191	
Apr 10	3,375				3,375	624	800	250			250	500	500		500	1,191			1,191	
Apr 11	3,370				3,370	619	800	250			250	500	500		500	1,191			1,191	
Apr 12	3,365				3,365	614	800	250	400	90	740	500	500		500	1,191			1,191	
Apr 13	3,360	0			3,360	610	800	250	600	90	940	1,000	1,070	25	1,095	500	700	0	1,200	
Apr 14	3,355	0			3,355	605	800	250	600	90	940	1,000	1,070	30	1,100	500	500	0	1,000	
Apr 15	3,230	1,215	0	2.41	4,445	600	800	250	600	90	940	1,000	1,070	30	1,100	500	500	0	1,000	
Apr 16	3,225	1,220	0	4.83	4,445	595	800	250	515	80	845	1,000	1,080	20	1,100	500	500	0	1,000	
Apr 17	3,220	1,220	0	7.25	4,440	590	800	250	260	80	590	1,000	980	20	1,000	900	300	0	1,200	
Apr 18	3,225	1,210	0	9.65	4,435	586	800	250	260	80	590	1,000	980	20	1,000	1,500	0	0	1,500	
Apr 19	3,520	915	0	11.46	4,435	581	800	250	260	80	590	1,000	980	20	1,000	1,500	0	0	1,500	
Apr 20	4,116	360	0	12.18	4,476	576	800	250	260	80	590	1,000	980	20	1,000	1,500	0	0	1,500	
Apr 21	4,111	360	0	12.89	4,471	571	800	250	260	80	590	1,000	980	20	1,000	1,500	0	0	1,500	
Apr 22	4,106	360	0	13.61	4,466	566	800	250	260	80	590	1,000	980	20	1,000	1,500	0	0	1,500	
Apr 23	4,101	360	0	14.32	4,461	562	800	250	270	80	600	1,000	980	20	1,000	1,500	0	0	1,500	
Apr 24	4,096	360	0	15.03	4,456	557	800	250	270	80	600	1,000	980	20	1,000	1,500	0	0	1,500	
Apr 25	4,092	360	0	15.75	4,452	552	800	250	270	80	600	1,000	980	20	1,000	1,500	0	0	1,500	
Apr 26	4,087	370	0	16.48	4,457	547	800	250	270	80	600	1,000	980	20	1,000	1,500	0	0	1,500	
Apr 27	4,082	370	0	17.22	4,452	542	800	250	280	80	610	1,000	980	20	1,000	1,500	0	0	1,500	
Apr 28	4,077	370	0	17.95	4,447	538	800	250	300	80	630	1,000	980	20	1,000	1,500	0	0	1,500	
Apr 29	4,072	370	0	18.68	4,442	533	800	250	300	80	630	1,000	980	20	1,000	1,500	0	0	1,500	
Apr 30	4,068	380	0	19.44	4,448	528	800	250	300	80	630	1,000	980	20	1,000	1,500	0	0	1,500	
May 01	4,063	400	0	20.23	4,463	523	800	250	320	80	650	1,000	980	20	1,000	1,500	0	0	1,500	
May 02	4,058	400	0	21.02	4,458	518	800	250	320	80	650	1,000	980	20	1,000	1,500	0	0	1,500	
May 03	4,053	400	0	21.82	4,453	514	800	250	320	80	650	1,000	980	20	1,000	1,500	0	0	1,500	
May 04	4,048	420	0	22.65	4,468	509	800	250	320	80	650	1,000	980	20	1,000	1,500	0	0	1,500	
May 05	4,044	420	0	23.48	4,464	504	800	250	320	80	650	1,000	980	20	1,000	1,500	0	0	1,500	
May 06	4,039	420	0	24.32	4,459	499	800	250	320	80	650	1,000	980	20	1,000	1,500	0	0	1,500	
May 07	4,034	420	0	25.15	4,454	494	800	250	630	80	960	1,000	980	20	1,000	1,500	0	0	1,500	
May 08	4,029	420	0	25.98	4,449	490	800	250	770	80	1,100	1,000	980	20	1,000	1,160	40	0	1,200	
May 09	4,024	420	0	26.82	4,444	485	800	250	770	80	1,100	1,000	980	20	1,000	860	160	0	1,020	
May 10	3,680	770	0	28.34	4,450	480	800	250	770	80	1,100	1,000	980	20	1,000	500	520	0	1,020	
May 11	3,375	1,030	0	30.39	4,405	475	800	250	670	80	1,000	1,000	1,030	20	1,050	500	520	0	1,020	
May 12	3,010	1,390	0	33.14	4,400	470	800	250	540	80	870	1,000	1,080	20	1,100	500	600	0	1,100	
May 13	3,055	1,390	0	35.90	4,445	466	800	250			250	1,000	1,080	20	1,100	500	700	0	1,200	
May 14	3,100	1,370	0	38.62	4,470	461	800	250			250	500	500		500	1,191			1,191	
May 15	3,096	1,340	0	41.28	4,436	456	800	250			250	500	500		500	1,191			1,191	
May 16	3,202	0			3,202	451	800	250			250	500	500		500	1,191			1,191	
May 17	3,197	0			3,197	446	800	250			250	500	500		500	1,191			1,191	
May 18	3,192	0			3,192	442	800	250			250	500	500		500	1,191			1,191	
May 19	3,187	0			3,187	437	800	250			250	500	500		500	1,191			1,191	
May 20	3,183	0			3,183	432	800	250			250	500	500		500	1,191			1,191	
May 21	3,178	0			3,178	427	800	250			250	500	500		500	1,191			1,191	
May 22	3,173	0			3,173	422	800	250			250	500	500		500	1,191			1,191	
May 23	3,168	0			3,168	418	800	250			250	500	500		500	1,191			1,191	
May 24	3,163	0			3,163	413	800	250			250	500	500		500	1,191			1,191	
May 25	3,159	0			3,159	408	800	250			250	500	500		500	1,191			1,191	
May 26	3,154	0			3,154	403	800	250			250	500	500		500	1,191			1,191	
May 27	3,149	0			3,149	398	800	250			250	500	500		500	1,191			1,191	
May 28	3,144	0			3,144	394	800	250			250	500	500		500	1,191			1,191	
May 29	3,139	0			3,139	389	800	250			250	500	500		500	1,191			1,191	
May 30	3,135	0			3,135	384	800	250			250	500	500		500	1,191			1,191	
May 31	3,130	0			3,130	379	800	250			250	500	500		500	1,191			1,191	
	VAMP Period																			
Avg. (cfs):	3,779	671			4,450	538	300	250	407	81	738	1,000	1,000	21	1,021	1,191	163	0	1,354	
Suppl. Water (TAF)		41.28							25.00	5.00				1.28			10.00			

Target flow period

APPENDIX A-1, TABLE 3

VAMP Daily Operation Plan, March 30, 2004 (A) • Low

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

	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 Supp. 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)	
Apr 01						349	300	250			250	500	500		500	765			765	
Apr 02						346	300	250			250	500	500		500	765			765	
Apr 03						342	300	250			250	500	500		500	765			765	
Apr 04	2,161				2,161	339	300	250			250	500	500		500	765			765	
Apr 05	2,157				2,157	335	300	250			250	500	500		500	765			765	
Apr 06	2,154				2,154	332	300	250			250	500	500		500	765			765	
Apr 07	2,150				2,150	328	300	250			250	500	500		500	765			765	
Apr 08	2,147				2,147	325	300	250			250	500	500		500	765			765	
Apr 09	2,143				2,143	321	300	250			250	500	500		500	765			765	
Apr 10	2,140				2,140	318	300	250			250	500	500		500	765			765	
Apr 11	2,136				2,136	314	300	250			250	500	500		500	765			765	
Apr 12	2,133				2,133	311	300	250	60	90	400	500	500		500	765			765	
Apr 13	2,129	0			2,129	307	300	250	60	90	400	650	1,030	170	1,200	400	600	0	1,000	
Apr 14	2,126	0			2,126	304	300	250	60	90	400	650	1,030	170	1,200	400	600	0	1,000	
Apr 15	2,287	920	0	1.82	3,207	300	300	250	60	90	400	650	1,030	170	1,200	400	600	0	1,000	
Apr 16	2,284	920	0	3.65	3,204	297	300	250	320	80	650	650	1,030	170	1,200	400	600	0	1,000	
Apr 17	2,280	920	0	5.47	3,200	293	300	250	620	80	950	650	1,030	170	1,200	400	350	0	750	
Apr 18	2,277	920	0	7.30	3,197	290	300	250	620	80	950	650	1,030	170	1,200	400	100	0	500	
Apr 19	2,273	920	0	9.12	3,193	286	300	250	620	80	950	650	1,030	170	1,200	400	100	0	500	
Apr 20	2,270	970	0	11.05	3,240	283	300	250	620	80	950	650	1,030	170	1,200	400	100	0	500	
Apr 21	2,266	970	0	12.97	3,236	279	300	250	620	80	950	650	1,040	160	1,200	400	100	0	500	
Apr 22	2,263	970	0	14.90	3,233	276	300	250	620	80	950	650	1,040	160	1,200	400	100	0	500	
Apr 23	2,269	960	0	16.80	3,229	272	300	250	620	80	950	650	790	160	950	600	90	0	690	
Apr 24	2,266	960	0	18.70	3,226	269	300	250	570	80	900	650	540	160	700	1,000	0	0	1,000	
Apr 25	2,212	950	0	20.59	3,162	265	300	250	320	80	650	650	390	160	550	1,200	0	0	1,200	
Apr 26	2,359	860	0	22.29	3,219	262	300	250	320	80	650	650	340	160	500	1,200	300	0	1,500	
Apr 27	2,405	810	0	23.90	3,215	258	300	250	320	80	650	650	340	160	500	1,200	300	0	1,500	
Apr 28	2,352	860	0	25.61	3,212	255	300	250	320	80	650	650	340	160	500	1,200	300	0	1,500	
Apr 29	2,348	860	0	27.31	3,208	251	300	250	320	80	650	650	340	160	500	1,200	300	0	1,500	
Apr 30	2,345	860	0	29.02	3,205	248	300	250	320	80	650	650	340	160	500	1,200	300	0	1,500	
May 01	2,341	860	0	30.72	3,201	244	300	250	320	80	650	650	340	160	500	1,200	300	0	1,500	
May 02	2,338	860	0	32.43	3,198	241	300	250	620	80	950	650	340	160	500	1,200	300	0	1,500	
May 03	2,334	860	0	34.14	3,194	237	300	250	690	80	1,020	650	340	160	500	1,200	0	0	1,200	
May 04	2,331	860	0	35.84	3,191	234	300	250	1,020	80	1,350	650	540	160	700	900	0	0	900	
May 05	2,327	860	0	37.55	3,187	230	300	250	1,070	80	1,400	650	540	160	700	600	0	0	600	
May 06	2,224	930	0	39.39	3,154	227	300	250	1,070	80	1,400	650	540	160	700	400	200	0	600	
May 07	1,920	1,260	0	41.89	3,180	223	300	250	1,070	80	1,400	650	540	160	700	400	200	0	600	
May 08	1,717	1,510	0	44.89	3,227	220	300	250	1,070	80	1,400	650	540	160	700	400	200	0	600	
May 09	1,713	1,510	0	47.88	3,223	216	300	250	1,070	80	1,400	650	540	160	700	400	200	0	600	
May 10	1,710	1,510	0	50.88	3,220	213	300	250	1,070	80	1,400	650	540	160	700	400	200	0	600	
May 11	1,706	1,510	0	53.87	3,216	209	300	250	1,070	80	1,400	650	540	160	700	400	200	0	600	
May 12	1,703	1,510	0	56.87	3,213	206	300	250	870	80	1,200	650	540	160	700	400	200	0	600	
May 13	1,699	1,510	0	59.86	3,209	202	300	250	350		600	650	540	160	700	400	200	0	600	
May 14	1,696	1,510	0	62.86	3,206	199	300	250	50		300	500	500		500	565			565	
May 15	1,692	1,310	0	65.45	3,002	195	300	250			250	500	500		500	565			565	
May 16	1,814	350			2,164	192	300	250			250	500	500		500	565			565	
May 17	1,810	50			1,860	188	300	250			250	500	500		500	565			565	
May 18	1,807	0			1,807	185	300	250			250	500	500		500	565			565	
May 19	1,803	0			1,803	181	300	250			250	500	500		500	565			565	
May 20	1,800	0			1,800	178	300	250			250	500	500		500	565			565	
May 21	1,796	0			1,796	174	300	250			250	500	500		500	565			565	
May 22	1,793	0			1,793	171	300	250			250	500	500		500	565			565	
May 23	1,789	0			1,789	167	300	250			250	500	500		500	565			565	
May 24	1,786	0			1,786	164	300	250			250	500	500		500	565			565	
May 25	1,782	0			1,782	160	300	250			250	500	500		500	565			565	
May 26	1,779	0			1,779	157	300	250			250	500	500		500	565			565	
May 27	1,775	0			1,775	153	300	250			250	500	500		500	565			565	
May 28	1,772	0			1,772	150	300	250			250	500	500		500	565			565	
May 29	1,768	0			1,768	146	300	250			250	500	500		500	565			565	
May 30	1,765	0			1,765	143	300	250			250	500	500		500	565			565	
May 31	1,761	0			1,761	139	300	250			250	500	500		500	565			565	
	VAMP Period																			
Avg. (cfs):	2,135	1,065			3,200	255	300	250	594	81	925	650	650	163	813	681	227	0	908	
Suppl. Water (TAF)		65.45							36.50	5.00				10.00			13.96			

Target flow period

APPENDIX A

APPENDIX A–1, TABLE 4

VAMP Daily Operation Plan, March 30, 2004 (B) • High

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

	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 Supp. 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)	
Apr 01						667	800	250			250	500	500		500	1,191			1,191	
Apr 02						662	800	250			250	500	500		500	1,191			1,191	
Apr 03						658	800	250			250	500	500		500	1,191			1,191	
Apr 04	3,403				3,403	653	800	250			250	500	500		500	1,191			1,191	
Apr 05	3,399				3,399	648	800	250			250	500	500		500	1,191			1,191	
Apr 06	3,394				3,394	643	800	250			250	500	500		500	1,191			1,191	
Apr 07	3,389				3,389	638	800	250			250	500	500		500	1,191			1,191	
Apr 08	3,384				3,384	634	800	250			250	500	500		500	1,191			1,191	
Apr 09	3,379				3,379	629	800	250			250	500	500		500	1,191			1,191	
Apr 10	3,375				3,375	624	800	250			250	500	500		500	1,191			1,191	
Apr 11	3,370				3,370	619	800	250			250	500	500		500	1,191			1,191	
Apr 12	3,365				3,365	614	800	250	50	90	390	500	500		500	1,191			1,191	
Apr 13	3,360	0			3,360	610	800	250	50	90	390	1,000	1,325	25	1,350	500	800	0	1,300	
Apr 14	3,355	0			3,355	605	800	250	50	90	390	1,000	1,325	25	1,350	500	800	0	1,300	
Apr 15	3,485	965	0	1.91	4,450	600	800	250	50	90	390	1,000	1,325	25	1,350	500	800	0	1,300	
Apr 16	3,480	965	0	3.83	4,445	595	800	250	320	80	650	1,000	1,325	25	1,350	500	800	0	1,300	
Apr 17	3,475	965	0	5.74	4,440	590	800	250	320	80	650	1,000	945	30	975	900	400	0	1,300	
Apr 18	3,470	965	0	7.66	4,435	586	800	250	320	80	650	1,000	950	20	970	1,500	0	0	1,500	
Apr 19	3,485	830	0	9.30	4,315	581	800	250	320	80	650	1,000	950	20	970	1,500	0	0	1,500	
Apr 20	4,086	420	0	10.14	4,506	576	800	250	320	80	650	1,000	950	20	970	1,500	0	0	1,500	
Apr 21	4,081	420	0	10.97	4,501	571	800	250	320	80	650	1,000	950	20	970	1,500	0	0	1,500	
Apr 22	4,076	420	0	11.80	4,496	566	800	250	320	80	650	1,000	950	20	970	1,500	0	0	1,500	
Apr 23	4,071	420	0	12.63	4,491	562	800	250	320	80	650	1,000	950	20	970	1,500	0	0	1,500	
Apr 24	4,066	420	0	13.47	4,486	557	800	250	320	80	650	1,000	950	20	970	1,500	0	0	1,500	
Apr 25	4,062	420	0	14.30	4,482	552	800	250	320	80	650	1,000	950	20	970	1,500	0	0	1,500	
Apr 26	4,057	420	0	15.13	4,477	547	800	250	320	80	650	1,000	950	20	970	1,500	0	0	1,500	
Apr 27	4,052	420	0	15.97	4,472	542	800	250	320	80	650	1,000	950	20	970	1,500	0	0	1,500	
Apr 28	4,047	420	0	16.80	4,467	538	800	250	320	80	650	1,000	950	20	970	1,500	0	0	1,500	
Apr 29	4,042	420	0	17.63	4,462	533	800	250	320	80	650	1,000	950	20	970	1,500	0	0	1,500	
Apr 30	4,038	420	0	18.47	4,458	528	800	250	320	80	650	1,000	950	20	970	1,500	0	0	1,500	
May 01	4,033	420	0	19.30	4,453	523	800	250	320	80	650	1,000	950	20	970	1,500	0	0	1,500	
May 02	4,028	420	0	20.13	4,448	518	800	250	320	80	650	1,000	950	20	970	1,500	0	0	1,500	
May 03	4,023	420	0	20.97	4,443	514	800	250	420	80	750	1,000	950	20	970	1,500	0	0	1,500	
May 04	4,018	420	0	21.80	4,438	509	800	250	420	80	750	1,000	880	20	900	1,500	0	0	1,500	
May 05	4,014	420	0	22.63	4,434	504	800	250	420	80	750	1,000	880	20	900	1,500	0	0	1,500	
May 06	3,939	520	0	23.66	4,459	499	800	250	420	80	750	1,000	880	20	900	1,500	0	0	1,500	
May 07	3,934	520	0	24.69	4,454	494	800	250	755	80	1,085	1,000	880	20	900	1,500	0	0	1,500	
May 08	3,929	520	0	25.73	4,449	490	800	250	920	80	1,250	1,000	880	20	900	1,160	0	0	1,160	
May 09	3,924	520	0	26.76	4,444	485	800	250	920	80	1,250	1,000	1,030	20	1,050	860	0	0	860	
May 10	3,580	855	0	28.45	4,435	480	800	250	920	80	1,250	1,000	1,030	20	1,050	500	360	0	860	
May 11	3,425	1,020	0	30.48	4,445	475	800	250	920	80	1,250	1,000	1,030	20	1,050	500	360	0	860	
May 12	3,060	1,380	0	33.21	4,440	470	800	250	850	80	1,180	1,000	1,030	20	1,050	500	360	0	860	
May 13	3,055	1,380	0	35.95	4,435	466	800	250	400		650	1,000	1,030	20	1,050	500	360	0	860	
May 14	3,050	1,380	0	38.69	4,430	461	800	250	50		300	500	500		500	1,191			1,191	
May 15	3,046	1,310	0	41.29	4,356	456	800	250			250	500	500		500	1,191			1,191	
May 16	3,202	400			3,602	451	800	250			250	500	500		500	1,191			1,191	
May 17	3,197	50			3,247	446	800	250			250	500	500		500	1,191			1,191	
May 18	3,192	0			3,192	442	800	250			250	500	500		500	1,191			1,191	
May 19	3,187	0			3,187	437	800	250			250	500	500		500	1,191			1,191	
May 20	3,183	0			3,183	432	800	250			250	500	500		500	1,191			1,191	
May 21	3,178	0			3,178	427	800	250			250	500	500		500	1,191			1,191	
May 22	3,173	0			3,173	422	800	250			250	500	500		500	1,191			1,191	
May 23	3,168	0			3,168	418	800	250			250	500	500		500	1,191			1,191	
May 24	3,163	0			3,163	413	800	250			250	500	500		500	1,191			1,191	
May 25	3,159	0			3,159	408	800	250			250	500	500		500	1,191			1,191	
May 26	3,154	0			3,154	403	800	250			250	500	500		500	1,191			1,191	
May 27	3,149	0			3,149	398	800	250			250	500	500		500	1,191			1,191	
May 28	3,144	0			3,144	394	800	250			250	500	500		500	1,191			1,191	
May 29	3,139	0			3,139	389	800	250			250	500	500		500	1,191			1,191	
May 30	3,135	0			3,135	384	800	250			250	500	500		500	1,191			1,191	
May 31	3,130	0			3,130	379	800	250			250	500	500		500	1,191			1,191	
	VAMP Period																			
Avg. (cfs):	3,778	671			4,450	538	300	250	407	81	738	1,000	1,000	21	1,021	1,191	163	0	1,354	
Suppl. Water (TAF)		41.29							25.00	5.00				1.29			10.00			

Target flow period

APPENDIX A

APPENDIX A-1, TABLE 5

VAMP Daily Operation Plan, April 9, 2004

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

bold numbers: observed real-time

	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 Supp. Flow	VAMP Flow (3-day lag)	Desired FERC Pulse	Existing Flow – Adjusted FERC Pulse	VAMP Suppl. Flow	VAMP Flow (2-day lag)	Existing Flow	Existing Flow (re-shaped)	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)	
Apr 01	**2,290**				**2,310**	**495**	**1,131**	**224**			**224**	500	**1,110**		**1,110**	707	**215**			**215**	
Apr 02	**2,680**				**2,710**	**424**	**802**	**209**			**209**	500	**1,090**		**1,090**	707	**226**			**226**	
Apr 03	**2,890**				**2,910**	**390**	**826**	**205**			**205**	500	**1,100**		**1,100**	707	**225**			**225**	
Apr 04	**2,890**				**2,890**	**392**	**926**	**218**			**218**	500	**1,100**		**1,100**	707	**222**			**222**	
Apr 05	**2,849**				**2,849**	**385**	**925**	**206**			**206**	500	**980**		**980**	707	**228**			**228**	
Apr 06	**2,700**				**2,700**	**362**	**781**	**199**			**199**	500	**819**		**819**	707	**226**			**226**	
Apr 07	**2,380**				**2,380**	**335**	**569**	**194**			**194**	500	**837**		**837**	707	**226**			**226**	
Apr 08	**2,190**				**2,189**	**326**	**576**	**196**			**196**	500	**833**		**833**	707	225			225	
Apr 09	2,146				2,146	318	549	250			250	500	500		500	707	707			707	
Apr 10	2,117				2,117	315	539	250			250	500	500		500	707	707			707	
Apr 11	2,251				2,251	312	530	250			250	500	500		500	707	707			707	
Apr 12	2,292				2,292	309	520	250	200	0	450	500	500		500	707	707			707	
Apr 13	2,279	0			2,279	306	510	250	200	0	450	725	700	340	1,040	707	350	200	0	550	T
Apr 14	2,266	0			2,266	303	500	250	200	0	450	725	900	500	1,400	707	350	200	0	550	T
Apr 15	2,106	740	0	1.47	2,846	300	500	250	200	0	450	700	900	500	1,400	707	350	200	0	550	T
Apr 16	2,303	900	0	3.25	3,203	297	500	250	200	0	450	700	900	500	1,400	707	350	200	0	550	T
Apr 17	2,300	900	0	5.04	3,200	293	500	250	225	0	475	700	900	500	1,400	707	350	200	0	550	T
Apr 18	2,297	900	0	6.82	3,197	290	500	250	250	0	500	700	900	500	1,400	707	350	200	0	550	T
Apr 19	2,293	900	0	8.61	3,193	286	500	250	250	0	500	700	900	500	1,400	707	350	200	0	550	T
Apr 20	2,290	925	0	10.44	3,215	283	500	250	250	0	500	700	900	500	1,400	707	350	200	0	550	T
Apr 21	2,286	950	0	12.33	3,236	279	500	250	250	0	500	700	900	500	1,400	707	350	200	0	550	T
Apr 22	2,283	950	0	14.21	3,233	276	500	250	250	0	500	700	900	300	1,200	707	600	200	0	800	T
Apr 23	2,279	950	0	16.10	3,229	272	500	250	300	0	550	700	900	0	900	707	950	100	0	1,050	T,S
Apr 24	2,526	750	0	17.58	3,276	269	500	250	350	0	600	700	650	0	650	707	1,150	100	0	1,250	S
Apr 25	2,872	350	0	18.28	3,222	265	500	250	350	0	600	700	600	0	600	707	1,150	100	0	1,250	S
Apr 26	2,819	400	0	19.07	3,219	262	500	250	350	0	600	700	600	0	600	707	1,150	100	0	1,250	S
Apr 27	2,765	450	0	19.96	3,215	258	500	250	350	0	600	700	600	0	600	707	1,150	100	0	1,250	S
Apr 28	2,762	450	0	20.86	3,212	255	500	250	350	0	600	700	600	0	600	707	1,150	100	0	1,250	S
Apr 29	2,758	450	0	21.75	3,208	251	500	250	375	0	625	700	600	0	600	707	1,150	100	0	1,250	S
Apr 30	2,755	450	0	22.64	3,205	248	500	250	400	0	650	700	600	0	600	707	1,150	100	0	1,250	S
May 01	2,751	450	0	23.53	3,201	244	500	250	550	0	800	700	600	0	600	565	1,150	100	0	1,250	S
May 02	2,748	475	0	24.48	3,223	241	500	250	500	250	1,000	700	600	0	600	565	1,060	40	0	1,100	S,M
May 03	2,744	500	0	25.47	3,244	237	500	250	850	200	1,300	700	600	0	600	565	900	0	0	900	M
May 04	2,651	590	0	26.64	3,241	234	500	250	850	200	1,300	700	600	0	600	565	600	0	0	600	M
May 05	2,487	750	0	28.13	3,237	230	500	250	850	200	1,300	700	600	0	600	565	400	200	0	600	M
May 06	2,184	1,050	0	30.21	3,234	227	500	250	850	200	1,300	700	600	0	600	565	400	200	0	600	M
May 07	1,980	1,250	0	32.69	3,230	223	500	250	850	200	1,300	700	600	0	600	565	400	200	0	600	M
May 08	1,977	1,250	0	35.17	3,227	220	500	250	850	200	1,300	700	600	0	600	565	400	200	0	600	M
May 09	1,973	1,250	0	37.65	3,223	216	500	250	850	200	1,300	700	600	0	600	565	400	200	0	600	M
May 10	1,970	1,250	0	40.13	3,220	213	500	250	850	200	1,300	700	600	0	600	565	400	200	0	600	M
May 11	1,966	1,250	0	42.60	3,216	209	500	250	350	500	1,100	700	600	0	600	565	400	200	0	600	M
May 12	1,963	1,250	0	45.08	3,213	206	500	250	150	170	570	700	600	200	800	565	400	200	0	600	M
May 13	1,959	1,250	0	47.56	3,209	202	500	250			250	700	600	200	800	565	400	500	0	900	
May 14	1,956	1,250	0	50.04	3,206	199	500	250			250	575	500		500	565	565		535	1,100	
May 15	1,952	1,020	0	52.07	2,972	195	500	250			250	450	500		500	565	565		935	1,500	
May 16	2,014	0			2,549	192	500	250			250	325	500		500	565	565		935	1,500	
May 17	2,010	0			2,945	189	500	250			250	225	500		500	565	565		935	1,500	
May 18	2,007	0			2,942	186	500	250			250	150	500		500	565	565		935	1,500	
May 19	2,004	0			2,939	183	500	250			250	150	500		500	565	565		935	1,500	
May 20	2,001	0			2,936	180	500	250			250	500	500		500	565	565		935	1,500	
May 21	1,998	0			2,933	177	500	250			250	500	500		500	565	565		935	1,500	
May 22	1,995	0			2,930	174	500	250			250	500	500		500	565	565		935	1,500	
May 23	1,992	0			2,927	171	500	250			250	500	500		500	565	565		335	900	
May 24	1,989	0			2,924	168	500	250			250	500	500		500	565	565		35	600	
May 25	1,986	0			2,321	165	500	250			250	500	500		500	565	565			565	
May 26	1,983	0			2,018	162	500	250			250	500	500		500	565	565			565	
May 27	1,980	0			1,980	159	500	250			250	500	500		500	565	565			565	
May 28	1,977	0			1,977	156	500	250			250	500	500		500	565	565			565	
May 29	1,974	0			1,974	153	500	250			250	500	500		500	565	565			565	
May 30	1,971	0			1,971	150	500	250			250	500	500		500	565	565			565	
May 31	1,968	0			1,968	147	500	250			250	500	500		500	565	565			565	
	VAMP Period																				
Avg. (cfs):	2,353	847			3,200	254	300	250	440	81	772	702	702	163	864	647	647	163	0	913	
Suppl. Water (TAF)		52.07							27.07	5.00				10.00			39.79				

Target flow period

Period of desired flow stability

APPENDIX A

APPENDIX A–1, TABLE 6

VAMP Daily Operation Plan, April 13, 2004

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

bold numbers: observed real-time

	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 Supp. Flow	VAMP Flow (3-day lag)	Desired FERC Pulse	Existing Flow – Adjusted FERC Pulse	VAMP Suppl. Flow	VAMP Flow (2-day lag)	Existing Flow	Existing Flow (re-shaped)	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)	
Apr 01	2,290				2,310	495	1,131	224			224	500	1,110		1,110	707	215			215	
Apr 02	2,680				2,710	424	802	209			209	500	1,090		1,090	707	226			226	
Apr 03	2,890				2,910	390	826	205			205	500	1,100		1,100	707	225			225	
Apr 04	2,890				2,890	392	926	218			218	500	1,100		1,100	707	222			222	
Apr 05	2,849				2,849	385	925	206			206	500	980		980	707	228			228	
Apr 06	2,700				2,700	362	781	199			199	500	819		819	707	226			226	
Apr 07	2,380				2,380	335	569	194			194	500	837		837	707	226			226	
Apr 08	2,190				2,189	326	576	196			196	500	833		833	707	228			228	
Apr 09	2,120				2,118	319	521	192			192	500	823		823	707	227			227	
Apr 10	2,060				2,060	315	479	194			194	500	820		820	707	227			227	
Apr 11	2,090				2,090	289	525	212			212	500	817		817	707	232			232	
Apr 12	2,150				2,150	292	596	250	166	0	416	500	819		819	707	231			231	
Apr 13	2,042	0			2,042	306	510	250	200	0	450	700	700	340	1,040	707	350	200	0	550	T
Apr 14	2,054	0			2,054	303	500	250	200	0	450	700	900	500	1,400	707	350	200	0	550	T
Apr 15	2,106	706	0	1.40	2,812	300	500	250	200	0	450	700	900	500	1,400	707	350	200	0	550	T
Apr 16	2,303	900	0	3.19	3,203	297	500	250	200	0	450	700	900	500	1,400	707	350	200	0	550	T
Apr 17	2,300	900	0	4.97	3,200	293	500	250	225	0	475	700	900	500	1,400	707	350	200	0	550	T
Apr 18	2,297	900	0	6.76	3,197	290	500	250	250	0	500	700	900	500	1,400	707	350	200	0	550	T
Apr 19	2,293	900	0	8.54	3,193	286	500	250	250	0	500	700	900	500	1,400	707	350	200	0	550	T
Apr 20	2,290	925	0	10.38	3,215	283	500	250	250	0	500	700	900	500	1,400	707	350	200	0	550	T
Apr 21	2,286	950	0	12.26	3,236	279	500	250	250	0	500	700	900	500	1,400	707	350	200	0	550	T
Apr 22	2,283	950	0	14.14	3,233	276	500	250	250	0	500	700	850	300	1,150	707	600	200	0	800	T
Apr 23	2,279	950	0	16.03	3,229	272	500	250	300	0	550	700	900	0	900	707	950	100	0	1,050	T,S
Apr 24	2,476	750	0	17.52	3,226	269	500	250	350	0	600	700	650	0	650	707	1,150	100	0	1,250	S
Apr 25	2,872	350	0	18.21	3,222	265	500	250	350	0	600	700	600	0	600	707	1,150	100	0	1,250	S
Apr 26	2,819	400	0	19.00	3,219	262	500	250	350	0	600	700	600	0	600	707	1,150	100	0	1,250	S
Apr 27	2,765	450	0	19.90	3,215	258	500	250	375	0	625	700	600	0	600	707	1,150	100	0	1,250	S
Apr 28	2,762	450	0	20.79	3,212	255	500	250	375	0	625	700	600	0	600	707	1,150	100	0	1,250	S
Apr 29	2,758	450	0	21.68	3,208	251	500	250	375	0	625	700	600	0	600	707	1,150	100	0	1,250	S
Apr 30	2,755	475	0	22.62	3,230	248	500	250	400	0	650	700	600	0	600	707	1,150	100	0	1,250	S
May 01	2,751	475	0	23.57	3,226	244	500	250	550	0	800	700	600	0	600	565	1,150	100	0	1,250	S
May 02	2,748	475	0	24.51	3,223	241	500	250	500	250	1,000	700	600	0	600	565	1,060	40	0	1,100	S,M
May 03	2,744	500	0	25.50	3,244	237	500	250	850	200	1,300	700	600	0	600	565	900	0	0	900	M
May 04	2,651	590	0	26.67	3,241	234	500	250	850	200	1,300	700	600	0	600	565	600	0	0	600	M
May 05	2,487	750	0	28.16	3,237	230	500	250	850	200	1,300	700	600	0	600	565	400	200	0	600	M
May 06	2,184	1,050	0	30.24	3,234	227	500	250	850	200	1,300	700	600	0	600	565	400	200	0	600	M
May 07	1,980	1,250	0	32.72	3,230	223	500	250	850	200	1,300	700	600	0	600	565	400	200	0	600	M
May 08	1,977	1,250	0	35.20	3,227	220	500	250	850	200	1,300	700	600	0	600	565	400	200	0	600	M
May 09	1,973	1,250	0	37.68	3,223	216	500	250	850	200	1,300	700	600	0	600	565	400	200	0	600	M
May 10	1,970	1,250	0	40.16	3,220	213	500	250	850	200	1,300	700	600	0	600	565	400	200	0	600	M
May 11	1,966	1,250	0	42.64	3,216	209	500	250	350	500	1,100	700	600	0	600	565	400	200	0	600	M
May 12	1,963	1,250	0	45.12	3,213	206	500	250	150	170	570	700	600	200	800	565	400	200	0	600	M
May 13	1,959	1,250	0	47.60	3,209	202	500	250			250	700	600	200	800	565	400	500	0	900	
May 14	1,956	1,250	0	50.07	3,206	199	500	250			250	575	500		500	565	565		535	1,100	
May 15	1,952	1,020	0	52.10	2,972	195	500	250			250	450	500		500	565	565		935	1,500	
May 16	2,014	0			2,549	192	500	250			250	325	500		500	565	565		935	1,500	
May 17	2,010	0			2,945	189	500	250			250	225	500		500	565	565		935	1,500	
May 18	2,007	0			2,942	186	500	250			250	150	500		500	565	565		935	1,500	
May 19	2,004	0			2,939	183	500	250			250	150	500		500	565	565		935	1,500	
May 20	2,001	0			2,936	180	500	250			250	500	500		500	565	565		935	1,500	
May 21	1,998	0			2,933	177	500	250			250	500	500		500	565	565		935	1,500	
May 22	1,995	0			2,930	174	500	250			250	500	500		500	565	565		935	1,500	
May 23	1,992	0			2,927	171	500	250			250	500	500		500	565	565		335	900	
May 24	1,989	0			2,924	168	500	250			250	500	500		500	565	565		35	600	
May 25	1,986	0			2,321	165	500	250			250	500	500		500	565	565			565	
May 26	1,983	0			2,018	162	500	250			250	500	500		500	565	565			565	
May 27	1,980	0			1,980	159	500	250			250	500	500		500	565	565			565	
May 28	1,977	0			1,977	156	500	250			250	500	500		500	565	565			565	
May 29	1,974	0			1,974	153	500	250			250	500	500		500	565	565			565	
May 30	1,971	0			1,971	150	500	250			250	500	500		500	565	565			565	
May 31	1,968	0			1,968	147	500	250			250	500	500		500	565	565			565	
	VAMP period																				
Avg. (cfs):	2,353	847			3,199	254	300	250	441	81	772	700	700	163	863	647	647	163	0	913	
Suppl. Water (TAF)		52.10							27.11	5.00				10.00			39.79				

Target flow period

Period of desired flow stability

APPENDIX A–1, TABLE 7

VAMP Daily Operation Plan, April 20, 2004

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

bold numbers: observed real-time

	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 Supp. Flow	VAMP Flow (3-day lag)	Desired FERC Pulse	Existing Flow – Adjusted FERC Pulse	VAMP Suppl. Flow	VAMP Flow (2-day lag)	Existing Flow	Existing Flow (re-shaped)	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)	
Apr 01	**2,290**				**2,310**	**495**	**1,131**	**224**			**224**	500	**1,110**		**1,110**	707	**215**			**215**	
Apr 02	**2,680**				**2,710**	**424**	**802**	**209**			**209**	500	**1,090**		**1,090**	707	**226**			**226**	
Apr 03	**2,890**				**2,910**	**390**	**826**	**205**			**205**	500	**1,100**		**1,100**	707	**225**			**225**	
Apr 04	**2,890**				**2,890**	**392**	**926**	**218**			**218**	500	**1,100**		**1,100**	707	**222**			**222**	
Apr 05	**2,849**				**2,849**	**385**	**925**	**206**			**206**	500	**980**		**980**	707	**228**			**228**	
Apr 06	**2,700**				**2,700**	**362**	**781**	**199**			**199**	500	**819**		**819**	707	**226**			**226**	
Apr 07	**2,380**				**2,380**	**335**	**569**	**194**			**194**	500	**837**		**837**	707	**226**			**226**	
Apr 08	**2,190**				**2,189**	**326**	**576**	**196**			**196**	500	**833**		**833**	707	**228**			**228**	
Apr 09	**2,120**				**2,118**	**319**	**521**	**192**			**192**	500	**823**		**823**	707	**227**			**227**	
Apr 10	**2,060**				**2,060**	**315**	**479**	**194**			**194**	500	**820**		**820**	707	**227**			**227**	
Apr 11	**2,090**				**2,090**	**289**	**525**	**212**			**212**	500	**817**		**817**	707	**232**			**232**	
Apr 12	**2,150**				**2,150**	**292**	**596**	250	**166**	0	**416**	500	**819**		**819**	707	**231**			**231**	
Apr 13	**2,080**	0			**2,080**	**259**	**548**	250	**202**	0	**452**	700	700	**360**	**1,060**	707	350	**57**	0	**407**	T
Apr 14	**2,039**	0			**2,039**	**278**	**485**	250	**191**	0	**441**	700	900	**480**	**1,380**	707	350	**202**	0	**552**	T
Apr 15	1,787	583	0	1.16	**2,370**	**274**	**228**	250	**197**	0	**447**	700	900	**480**	**1,380**	707	350	**205**	0	**555**	T
Apr 16	1,736	884	0	2.91	**2,620**	**255**	**-42**	250	**184**	0	**434**	700	900	**500**	**1,400**	707	350	**204**	0	**554**	T
Apr 17	1,834	876	0	4.65	**2,710**	**286**	**60**	250	**190**	0	**440**	700	900	**540**	**1,440**	707	350	**205**	0	**555**	T
Apr 18	2,029	901	0	6.43	**2,930**	**308**	**274**	250	**221**	0	**471**	700	900	**540**	**1,440**	707	350	**204**	0	**554**	T
Apr 19	2,171	929	0	8.28	**3,100**	**325**	**385**	250	**236**	0	**486**	700	900	**519**	**1,419**	707	350	**204**	0	**554**	T
Apr 20	2,208	934	0	10.13	3,142	283	400	250	250	0	500	700	900	500	1,400	707	350	200	0	550	T
Apr 21	2,225	944	0	12.00	3,169	279	400	250	250	0	500	700	900	500	1,400	707	350	300	0	650	T
Apr 22	2,183	936	0	13.86	3,119	276	400	250	250	0	500	700	850	300	1,150	707	600	300	0	900	T
Apr 23	2,179	1,050	0	15.94	3,229	272	400	250	350	0	600	700	900	0	900	707	950	200	0	1,150	T,S
Apr 24	2,376	850	0	17.63	3,226	269	400	250	500	0	750	700	650	0	650	707	1,150	100	0	1,250	S
Apr 25	2,772	450	0	18.52	3,222	265	400	250	600	0	850	700	600	0	600	707	1,150	100	0	1,250	S
Apr 26	2,719	450	0	19.41	3,169	262	400	250	600	0	850	700	600	0	600	707	1,150	100	0	1,250	S
Apr 27	2,665	600	0	20.60	3,265	258	400	250	600	0	850	700	600	0	600	707	1,150	100	0	1,250	S
Apr 28	2,662	700	0	21.99	3,362	255	400	250	600	0	850	700	600	0	600	707	1,150	100	0	1,250	S
Apr 29	2,658	700	0	23.38	3,358	251	400	250	600	0	850	700	600	0	600	707	1,150	100	0	1,250	S
Apr 30	2,655	700	0	24.77	3,355	248	400	250	650	0	900	700	600	0	600	707	1,150	100	0	1,250	S
May 01	2,651	700	0	26.16	3,351	244	400	250	800	0	1,050	700	600	0	600	565	1,150	50	0	1,200	S
May 02	2,648	700	0	27.54	3,348	241	400	250	700	250	1,200	700	600	0	600	565	1,060	0	0	1,060	S,M
May 03	2,644	700	0	28.93	3,344	237	400	250	1,050	200	1,500	700	600	0	600	565	900	0	0	900	M
May 04	2,551	800	0	30.52	3,351	234	400	250	1,050	200	1,500	700	600	0	600	565	600	0	0	600	M
May 05	2,387	950	0	32.40	3,337	230	400	250	1,050	200	1,500	700	600	0	600	565	400	200	0	600	M
May 06	2,084	1,250	0	34.88	3,334	227	400	250	1,050	200	1,500	700	600	0	600	565	400	200	0	600	M
May 07	1,880	1,450	0	37.76	3,330	223	400	250	1,050	200	1,500	700	600	0	600	565	400	200	0	600	M
May 08	1,877	1,450	0	40.64	3,327	220	400	250	1,050	200	1,500	700	600	0	600	565	400	200	0	600	M
May 09	1,873	1,450	0	43.51	3,323	216	400	250	1,050	200	1,500	700	600	0	600	565	400	200	0	600	M
May 10	1,870	1,450	0	46.39	3,320	213	400	250	1,050	200	1,500	700	600	0	600	565	400	200	0	600	M
May 11	1,866	1,450	0	49.26	3,316	209	400	250	500	500	1,250	700	600	0	600	565	400	200	0	600	M
May 12	1,863	1,450	0	52.14	3,313	206	400	250	300	170	720	700	600	160	760	565	400	200	0	600	M
May 13	1,859	1,450	0	55.02	3,309	202	400	250	150		400	700	600	160	760	565	400	410	0	810	
May 14	1,856	1,360	0	57.71	3,216	199	400	250			250	575	500		500	565	565		535	1,100	
May 15	1,852	1,040	0	59.78	2,892	195	400	250			250	450	500		500	565	565		935	1,500	
May 16	1,914	150	535		2,599	192	400	250			250	325	500		500	565	565		935	1,500	
May 17	1,910	0	935		2,845	189	400	250			250	225	500		500	565	565		935	1,500	
May 18	1,907	0	935		2,842	186	400	250			250	150	500		500	565	565		935	1,500	
May 19	1,904	0	935		2,839	183	400	250			250	150	500		500	565	565		935	1,500	
May 20	1,901	0	935		2,836	180	400	250			250	500	500		500	565	565		935	1,500	
May 21	1,898	0	935		2,833	177	400	250			250	500	500		500	565	565		935	1,500	
May 22	1,895	0	935		2,830	174	400	250			250	500	500		500	565	565		935	1,500	
May 23	1,892	0	935		2,827	171	400	250			250	500	500		500	565	565		335	900	
May 24	1,889	0	935		2,824	168	400	250			250	500	500		500	565	565		35	600	
May 25	1,886	0	335		2,221	165	400	250			250	500	500		500	565	565			565	
May 26	1,883	0	35		1,918	162	400	250			250	500	500		500	565	565			565	
May 27	1,880	0	0		1,880	159	400	250			250	500	500		500	565	565			565	
May 28	1,877	0	0		1,877	156	400	250			250	500	500		500	565	565			565	
May 29	1,874	0	0		1,874	153	400	250			250	500	500		500	565	565			565	
May 30	1,871	0	0		1,871	150	400	250			250	500	500		500	565	565			565	
May 31	1,868	0	0		1,868	147	400	250			250	500	500		500	565	565			565	
VAMP period																					
Avg. (cfs):	2,213	972			3,186	252	300	250	566	81	897	700	700	163	863	647	647	163	0	916	
Suppl. Water (TAF)		59.78							34.78	5.00				9.99			39.79				

Target flow period

Period of desired flow stability

APPENDIX A–1, TABLE 8

VAMP Daily Operation Plan, May 3, 2004

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

bold numbers: observed real-time

	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 Supp. Flow	VAMP Flow (3-day lag)	Desired FERC Pulse	Existing Flow – Adjusted FERC Pulse	VAMP Suppl. Flow	VAMP Flow (2-day lag)	Existing Flow	Existing Flow (re-shaped)	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)	
Apr 01	**2,290**				**2,310**	**495**	**1,131**	**224**			**224**	500	**1,110**		**1,110**	707	**215**			**215**	
Apr 02	**2,680**				**2,710**	**424**	**802**	**209**			**209**	500	**1,090**		**1,090**	707	**226**			**226**	
Apr 03	**2,890**				**2,910**	**390**	**826**	**205**			**205**	500	**1,100**		**1,100**	707	**225**			**225**	
Apr 04	**2,890**				**2,890**	**392**	**926**	**218**			**218**	500	**1,100**		**1,100**	707	**222**			**222**	
Apr 05	**2,849**				**2,849**	**385**	**925**	**206**			**206**	500	**980**		**980**	707	**228**			**228**	
Apr 06	**2,700**				**2,700**	**362**	**781**	**199**			**199**	500	**819**		**819**	707	**226**			**226**	
Apr 07	**2,380**				**2,380**	**335**	**569**	**194**			**194**	500	**837**		**837**	707	**226**			**226**	
Apr 08	**2,190**				**2,189**	**326**	**576**	**196**			**196**	500	**833**		**833**	707	**228**			**228**	
Apr 09	**2,120**				**2,118**	**319**	**521**	**192**			**192**	500	**823**		**823**	707	**227**			**227**	
Apr 10	**2,060**				**2,060**	**315**	**479**	**194**			**194**	500	**820**		**820**	707	**227**			**227**	
Apr 11	**2,090**				**2,090**	**289**	**525**	**212**			**212**	500	**817**		**817**	707	**232**			**232**	
Apr 12	**2,150**				**2,150**	**292**	**596**	250	**166**	**0**	**416**	500	**819**		**819**	707	**231**			**231**	
Apr 13	**2,080**	0			**2,080**	**259**	**548**	250	**202**	**0**	**452**	700	700	**360**	**1,060**	707	350	**57**	**0**	**407**	T
Apr 14	**2,039**	0			**2,039**	**278**	**485**	250	**191**	**0**	**441**	700	900	**480**	**1,380**	707	350	**202**	**0**	**552**	T
Apr 15	1,787	583	0	1.16	**2,370**	**274**	**228**	250	**197**	**0**	**447**	700	900	**480**	**1,380**	707	350	**205**	**0**	**555**	T
Apr 16	1,736	884	0	2.91	**2,620**	**255**	**-42**	250	**184**	**0**	**434**	700	900	**500**	**1,400**	707	350	**204**	**0**	**554**	T
Apr 17	1,834	876	0	4.65	**2,710**	**286**	**60**	250	**190**	**0**	**440**	700	900	**540**	**1,440**	707	350	**205**	**0**	**555**	T
Apr 18	2,029	901	0	6.43	**2,930**	**308**	**274**	250	**221**	**0**	**471**	700	900	**540**	**1,440**	707	350	**204**	**0**	**554**	T
Apr 19	2,171	929	0	8.28	**3,100**	**325**	**385**	250	**236**	**0**	**486**	700	900	**519**	**1,419**	707	350	**204**	**0**	**554**	T
Apr 20	2,156	934	0	10.13	**3,090**	**350**	**348**	250	**232**	**0**	**482**	700	900	**529**	**1,429**	707	350	**205**	**0**	**555**	T
Apr 21	2,156	944	0	12.00	**3,100**	**341**	**331**	250	**241**	**0**	**491**	700	900	**540**	**1,440**	707	350	**299**	**0**	**649**	T
Apr 22	2,200	970	0	13.93	**3,170**	**336**	**350**	250	**242**	**0**	**492**	700	850	**410**	**1,260**	707	600	**300**	**0**	**900**	T
Apr 23	2,099	1,071	0	16.05	**3,170**	**288**	**258**	250	**346**	**0**	**596**	700	900	**83**	**983**	707	950	**198**	**0**	**1,148**	T,S
Apr 24	2,199	951	0	17.94	**3,150**	**238**	**163**	250	**610**	**0**	**860**	700	650	**58**	**708**	707	1,150	**102**	**0**	**1,252**	S
Apr 25	2,717	523	0	18.97	**3,240**	**244**	**329**	250	**669**	**0**	**919**	700	600	**29**	**629**	707	1,150	**100**	**0**	**1,250**	S
Apr 26	2,834	506	0	19.98	**3,340**	**274**	**546**	250	**639**	**0**	**889**	700	600	**38**	**638**	707	1,150	**104**	**0**	**1,254**	S
Apr 27	2,581	739	0	21.44	**3,320**	**266**	**337**	250	**596**	**0**	**846**	700	600	**44**	**644**	707	1,150	**102**	**0**	**1,252**	S
Apr 28	2,499	811	0	23.05	**3,310**	**259**	**225**	250	**624**	**0**	**874**	700	600	**31**	**631**	707	1,150	**102**	**0**	**1,252**	S
Apr 29	2,495	785	0	24.61	**3,280**	**260**	**229**	250	**637**	**0**	**887**	700	600	**27**	**627**	707	1,150	**101**	**0**	**1,251**	S
Apr 30	2,571	729	0	26.05	**3,300**	**252**	**312**	250	**720**	**0**	**970**	700	600	**27**	**627**	707	1,150	**105**	**0**	**1,255**	S
May 01	2,498	752	0	27.55	**3,250**	**256**	**238**	250	**918**	**0**	**1,168**	700	600	**28**	**628**	565	1,150	**46**	**0**	**1,196**	S
May 02	2,481	769	0	29.07	**3,250**	**288**	**229**	250	**875**	**250**	**1,375**	700	600	**27**	**627**	565	1,160	**2**	**0**	**1,062**	S,M
May 03	2,556	794	0	30.65	3,350	237	300	250	1,050	200	1,500	700	600	0	600	565	900	0	0	900	M
May 04	2,498	947	0	32.52	3,445	234	300	250	1,050	200	1,500	700	600	0	600	565	600	50	0	650	M
May 05	2,287	1,125	0	34.76	3,412	230	300	250	1,050	200	1,500	700	600	0	600	565	400	250	0	650	M
May 06	1,984	1,300	0	37.33	3,284	227	300	250	1,050	200	1,500	700	600	0	600	565	400	250	0	650	M
May 07	1,780	1,500	0	40.31	3,280	223	300	250	1,050	200	1,500	700	600	0	600	565	400	250	0	650	M
May 08	1,777	1,500	0	43.29	3,277	220	300	250	1,050	200	1,500	700	600	0	600	565	400	250	0	650	M
May 09	1,773	1,500	0	46.26	3,273	216	300	250	1,050	200	1,500	700	600	0	600	565	400	250	0	650	M
May 10	1,770	1,500	0	49.24	3,270	213	300	250	1,050	200	1,500	700	600	0	600	565	400	250	0	650	M
May 11	1,766	1,500	0	52.21	3,266	209	300	250	650	500	1,400	700	600	0	600	565	400	250	0	650	M
May 12	1,763	1,500	0	55.19	3,263	206	300	250	380	170	800	700	600	0	600	565	400	400	0	800	M
May 13	1,759	1,500	0	58.16	3,259	202	300	250	150		400	700	600	0	600	565	400	650	0	1,050	
May 14	1,756	1,550	0	61.24	3,306	199	300	250			250	575	500		500	565	565		535	1,100	
May 15	1,752	1,200	0	63.62	2,952	195	300	250			250	450	500		500	565	565		935	1,500	
May 16	1,814	150	535		2,499	192	300	250			250	325	500		500	565	565		935	1,500	
May 17	1,810	0	935		2,745	189	300	250			250	225	500		500	565	565		935	1,500	
May 18	1,807	0	935		2,742	186	300	250			250	150	500		500	565	565		935	1,500	
May 19	1,804	0	935		2,739	183	300	250			250	150	500		500	565	565		935	1,500	
May 20	1,801	0	935		2,736	180	300	250			250	500	500		500	565	565		935	1,500	
May 21	1,798	0	935		2,733	177	300	250			250	500	500		500	565	565		935	1,500	
May 22	1,795	0	935		2,730	174	300	250			250	500	500		500	565	565		935	1,500	
May 23	1,792	0	935		2,727	171	300	250			250	500	500		500	565	565		335	900	
May 24	1,789	0	935		2,724	168	300	250			250	500	500		500	565	565		35	600	
May 25	1,786	0	335		2,121	165	300	250			250	500	500		500	565	565			565	
May 26	1,783	0	35		1,818	162	300	250			250	500	500		500	565	565			565	
May 27	1,780	0	0		1,780	159	300	250			250	500	500		500	565	565			565	
May 28	1,777	0	0		1,777	156	300	250			250	500	500		500	565	565			565	
May 29	1,774	0	0		1,774	153	300	250			250	500	500		500	565	565			565	
May 30	1,771	0	0		1,771	150	300	250			250	500	500		500	565	565			565	
May 31	1,768	0	0		1,768	147	300	250			250	500	500		500	565	565			565	
	VAMP period																				
Avg. (cfs):	2,137	1,035			3,172	260	300	250	592	81	924	700	700	171	871	647	647	190	0	913	
Suppl. Water (TAF)		63.62							36.43	5.00				10.49			39.79				

Target flow period

Period of desired flow stability

APPENDIX A–2, TABLE 1

2004 Vernalis Adaptive Management Plan (VAMP)

Final Accounting of Supplemental Water Contributions

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

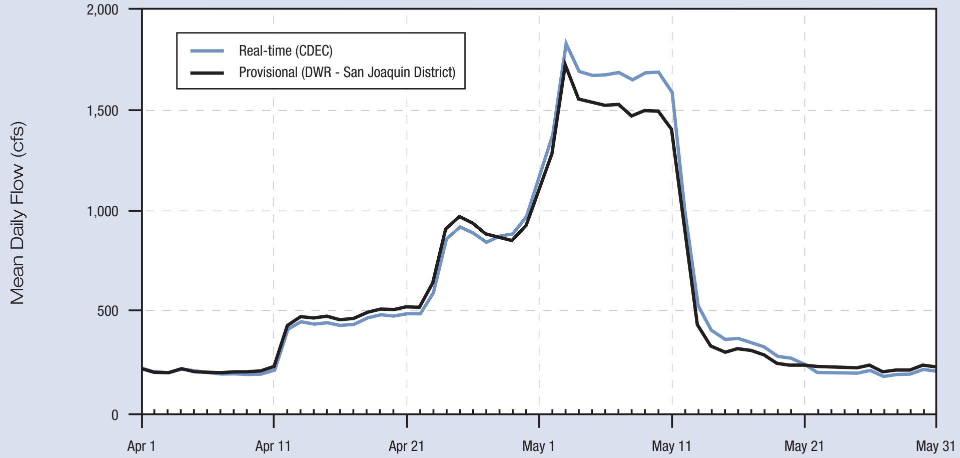
	Merced R. at Cressey (3 Day Travel Time to Vernalis)			Tuolumne R. below LaGrange Dam (2 Day Travel Time to Vernalis)			Stanislaus R. below Goodwin Dam (2 Day Travel Time to Vernalis)			Upper SJR	Vernalis Ungaged	San Joaquin River at Vernalis		
	Existing Flow	Observed Flow	VAMP Suppl. Water	Existing Flow	Observed Flow	VAMP Suppl. Water	Existing Flow	Observed Flow	VAMP Suppl. Water	Observed Flow	Observed Flow	Existing Flow	Observed Flow	VAMP Suppl. Water
	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
Apr 01	217	217		1,110	1,110		226	226		531	690	2,290	2,290	
Apr 02	201	201		1,090	1,090		231	231		457	755	2,680	2,680	
Apr 03	200	200		1,100	1,100		230	230		424	785	2,890	2,890	
Apr 04	215	215		1,100	1,100		230	230		426	895	2,890	2,890	
Apr 05	205	205		980	980		233	233		423	894	2,849	2,849	
Apr 06	202	202		820	820		233	233		400	744	2,700	2,700	
Apr 07	199	199		837	837		233	233		385	529	2,380	2,380	
Apr 08	203	203		833	833		235	235		368	522	2,180	2,180	
Apr 09	202	202		823	823		233	233		358	453	2,110	2,110	
Apr 10	208	208		820	820		227	227		364	415	2,050	2,050	
Apr 11	229	229		817	817		232	232		332	453	2,070	2,070	
Apr 12	250	432	182	819	819		231	231		336	527	2,140	2,140	
Apr 13	250	473	223	700	1,060	360	350	407	57	311	461	2,050	2,050	
Apr 14	250	468	218	900	1,380	480	350	552	202	321	424	2,039	2,039	
Apr 15	250	477	227	900	1,380	480	350	555	205	304	160	1,771	2,370	599
Apr 16	250	460	210	900	1,400	500	350	554	204	289	(106)	1,715	2,620	905
Apr 17	250	467	217	900	1,440	540	350	555	205	326	3	1,807	2,710	903
Apr 18	250	497	247	900	1,440	540	350	554	204	340	210	1,999	2,930	931
Apr 19	250	510	260	900	1,419	519	350	554	204	358	319	2,145	3,100	955
Apr 20	250	509	259	900	1,429	529	350	555	205	393	289	2,129	3,090	961
Apr 21	250	520	270	900	1,440	540	350	649	299	382	272	2,130	3,100	970
Apr 22	250	523	273	900	1,260	360	600	900	300	392	283	2,176	3,170	994
Apr 23	250	643	393	900	983	83	950	1,148	198	350	190	2,072	3,170	1,098
Apr 24	250	907	657	650	708	58	1,150	1,252	102	307	78	2,220	3,150	930
Apr 25	250	967	717	600	629	29	1,150	1,250	100	310	236	2,686	3,240	554
Apr 26	250	935	685	600	638	38	1,150	1,254	104	348	430	2,787	3,340	553
Apr 27	250	883	633	600	644	44	1,150	1,252	102	359	224	2,534	3,320	786
Apr 28	250	865	615	600	631	31	1,150	1,252	102	345	103	2,451	3,310	859
Apr 29	250	853	603	600	627	27	1,150	1,251	101	348	90	2,449	3,280	831
Apr 30	250	925	675	600	627	27	1,150	1,255	105	350	189	2,534	3,300	766
May 01	250	1,110	860	600	628	28	1,150	1,196	46	365	159	2,507	3,250	743
May 02	250	1,280	1,030	600	627	27	1,060	1,062	2	424	165	2,515	3,250	735
May 03	250	1,720	1,470	600	629	29	900	900	0	380	236	2,601	3,350	749
May 04	250	1,550	1,300	600	633	33	600	673	73	400	117	2,451	3,340	889
May 05	250	1,530	1,280	600	635	35	400	651	251	400	181	2,311	3,370	1,059
May 06	250	1,520	1,270	600	632	32	400	654	254	369	(166)	1,684	3,260	1,576
May 07	250	1,520	1,270	600	632	32	400	651	251	359	(26)	1,624	3,210	1,586
May 08	250	1,470	1,220	600	633	33	400	650	250	350	(5)	1,614	3,180	1,566
May 09	250	1,490	1,240	600	636	36	400	650	250	330	118	1,727	3,280	1,553
May 10	250	1,490	1,240	600	637	37	400	652	252	330	227	1,827	3,380	1,553
May 11	250	1,400	1,150	600	639	39	400	652	252	370	234	1,814	3,320	1,506
May 12	250	874	624	600	637	37	400	799	399	470	131	1,711	3,240	1,529
May 13	250	433		600	639	39	400	1,050	650	556	59	1,679	3,210	1,531
May 14	250	332		602	602		565	1,256		447	(246)	1,474	3,060	1,586
May 15	250	304		481	481		565	1,504		375	(219)	1,587	2,900	1,313
May 16	250	318		358	358		565	1,501		313	121	2,859	2,859	
May 17	250	308		257	257		565	1,508		304	208	2,900	2,900	
May 18	250	288		196	196		565	1,505		310	343	2,819	2,819	
May 19	245	245		200	200		565	1,247		307	273	2,660	2,660	
May 20	237	237		200	200		565	943		290	161	2,480	2,480	
May 21	237	237		201	201		565	708		253	248	2,290	2,290	
May 22	230	230		202	202		508	508		222	392	2,070	2,070	
May 23	230	230		204	204		502	502		232	551	1,950	1,950	
May 24	227	227		203	203		450	450		229	701	1,870	1,870	
May 25	225	225		207	207		403	403		243	582	1,750	1,750	
May 26	233	233		206	206		403	403		285	558	1,670	1,670	
May 27	204	204		207	207		403	403		321	540	1,620	1,620	
May 28	212	212		208	208		403	403		292	501	1,620	1,620	
May 29	215	215		207	207		402	402		286	456	1,620	1,620	
May 30	233	233		209	209		400	400		293	573	1,680	1,680	
May 31	225	225		173	173		404	404		276	612	1,719	1,719	
Avg. (cfs):	250	944		702	883		647	838		362	127	2,088	3,155	
Suppl. Water (acre-feet)			42,680[a]			11,151			11,760					65,591

[a] includes San Joaquin River Exchange Contractors Water Authority supplemental water contribution of 5,000 acre-feet.

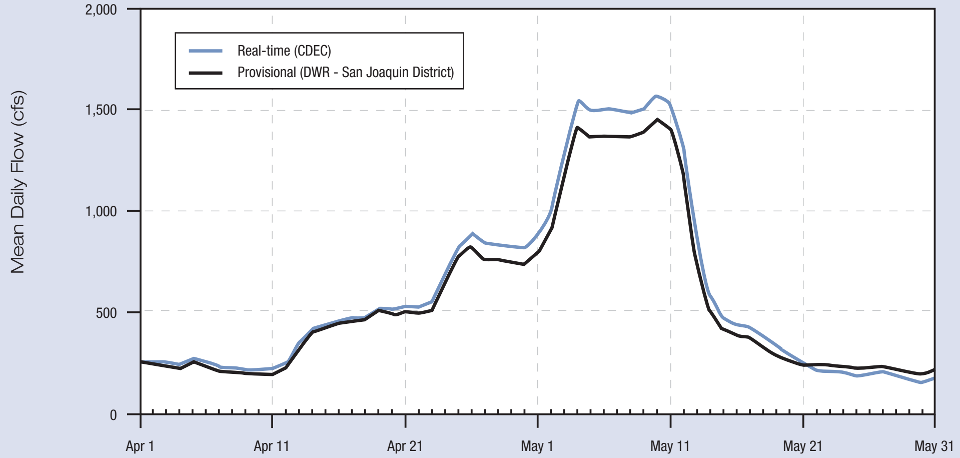
Observed Flow Sources: Merced River at Cressey (CA DWR B05155): California DWR, San Joaquin District (6/22/04) • Tuolumne River below LaGrange Dam near LaGrange (USGS 11289650): USGS (7/2/04) • Stanislaus River below Goodwin Dam: USBR, Goodwin Reservoir Daily Operations Report – OID/SSJID/Tri-Dams (5/20/04 and 6/18/04) • San Joaquin River near Vernalis (USGS 11303500): USGS (7/2/04)

A–3. Comparison of "Real-time" and Provisional Flows

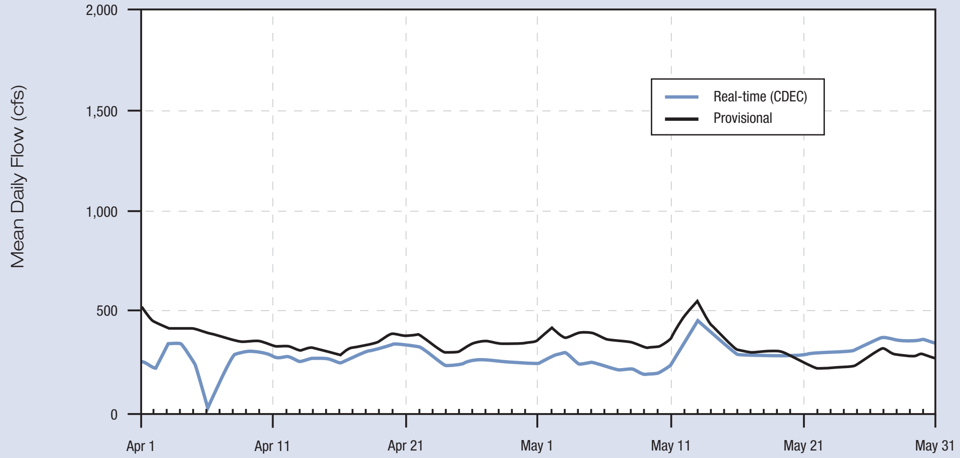
Merced River at Cressey



Merced River near Stevinson



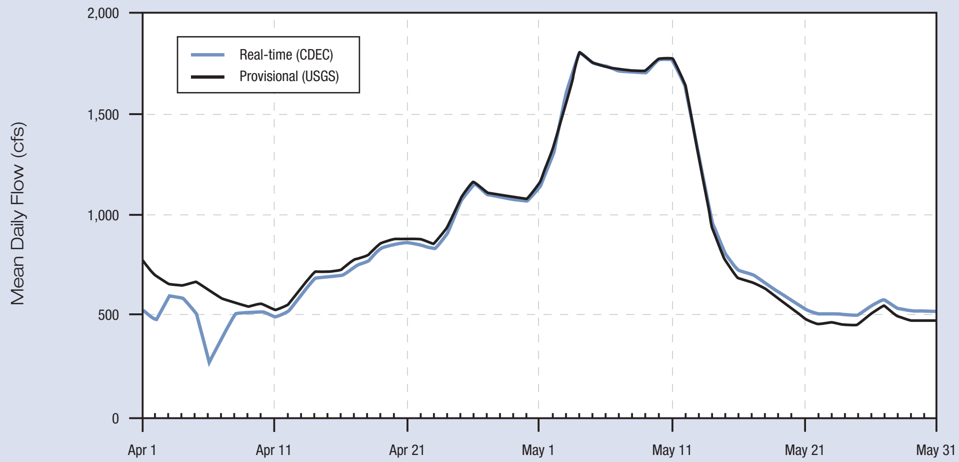
San Joaquin River above Merced River



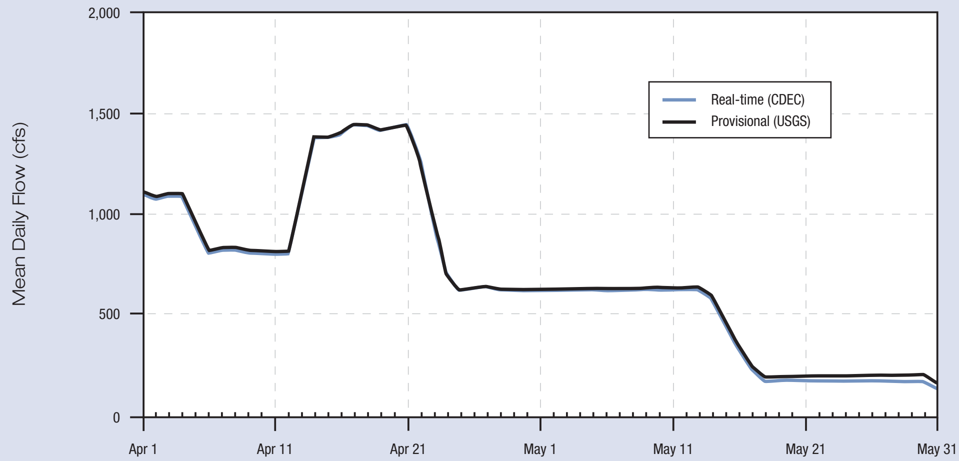
APPENDIX A

A–3. Comparison of “Real-time” and Provisional Flows

San Joaquin River near Newman



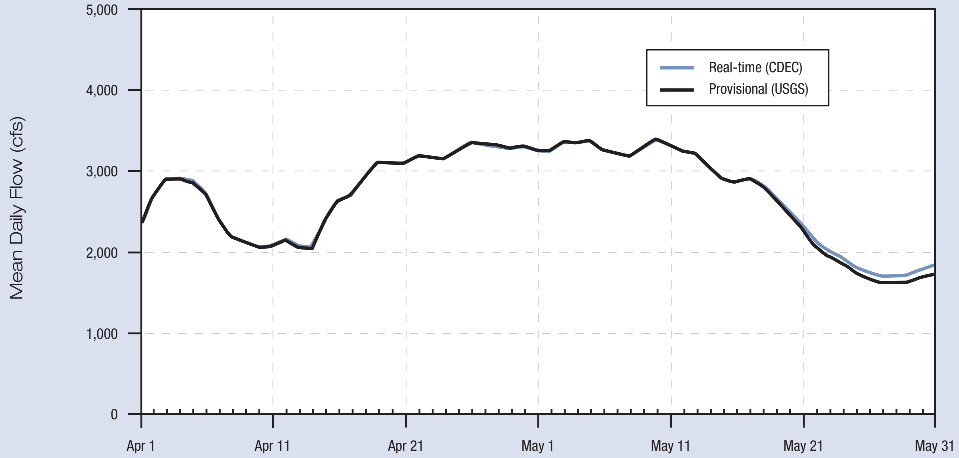
Tuolumne River below LaGrange Dam



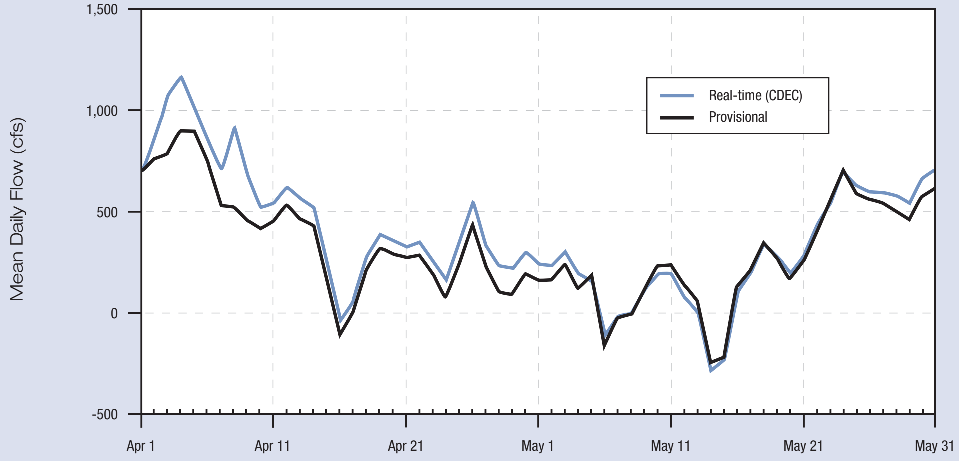
APPENDIX A

A–3. Comparison of "Real-time" and Provisional Flows

San Joaquin River near Vernalis



Ungaged Flow in San Joaquin River near Vernalis



APPENDIX A

A-4 MERCED IRRIGATION DISTRICT

SJRA Fall 2004 Water Transfer • Daily Summary (FINAL)

	SCHEDULED				OBSERVED				
	Base Flow	Transfer Water: Daily Flow Rate	Transfer Water: Cumulative Volume	Target Flow (see Note 1)	Observed Flow Merced River at Shaffer Bridge (PG&E)	Observed Flow Merced R at Cressey (DWR)	Observed Flow for Transfer (see Note 1)	Transfer Water: Daily Flow Rate	Transfer Water: Cumulative Volume
	(cfs)	(cfs)	(acre-feet)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(acre-feet)
	(1)	(2)	(3)	(4) = (1) + (2)	(5)	(6)	(7)	(8) = (7) – (1)	(9)
Oct 01	30	125	248	155	158	117	158	128	254
Oct 02	30	125	496	155	171	139	171	141	534
Oct 03	30	125	744	155	174	141	174	144	819
Oct 04	30	125	992	155	173	142	173	143	1,103
Oct 05	30	125	1,240	155	177	151	177	147	1,394
Oct 06	30	125	1,488	155	172	147	172	142	1,676
Oct 07	30	125	1,736	155	170	140	170	140	1,954
Oct 08	30	125	1,983	155	161	128	161	131	2,214
Oct 09	30	125	2,231	155	176	138	176	146	2,503
Oct 10	30	125	2,479	155	210	171	210	180	2,860
Oct 11	30	125	2,727	155	208	171	208	178	3,213
Oct 12	30	125	2,975	155	247	208	247	217	3,644
Oct 13	30	125	3,223	155	252	215	252	222	4,084
Oct 14	30	125	3,471	155	232	198	232	202	4,485
Oct 15	30	125	3,719	155	226	196	226	196	4,873
Oct 16	85	125	3,967	210	220	193	220	135	5,141
Oct 17	85	175	4,314	260	290	252	290	205	5,548
Oct 18	85	300	4,909	385	534	403	403	318	6,179
Oct 19	85	505	5,911	590	810	577	577	492	7,154
Oct 20	85	505	6,912	590	884	639	639	554	8,253
Oct 21	85	505	7,914	590	793	588	588	503	9,251
Oct 22	85	503	8,912	588	775	572	572	487	10,217
Oct 23	85	500	9,903	585	780	574	574	489	11,187
Oct 24	85	300	10,499	385	548	452	452	367	11,915
Oct 25	85	200	10,895	285	385	348	348	263	12,436
Oct 26	85	135	11,163	220	322	308	308	32	12,500
Oct 27	85	135	11,431	220	338	308	308		
Oct 28	85	135	11,699	220	274	264	274		
Oct 29	85	135	11,966	220	255	246	255		
Oct 30	85	135	12,234	220	255	244	255		
Oct 31	85	135	12,502	220	255	240	255		

[a] The Technical Appendix to the San Joaquin River Group Division Agreement states that "[T]he Merced River at Shaffer Bridge…will be used for flows between 0 and 300 cfs. …[F]or the flows above 300 cfs, measurements will be provided at the gage on the Merced River located near Cressey.

A-5 MERCED IRRIGATION DISTRICT

SJRA Fall 2003 Water Transfer • Daily Summary (FINAL)

	SCHEDULED				OBSERVED				
		Transfer Water						Transfer Water	
	Base Flow	Daily Flow Rate	Cumulative Volume	Target Flow (see Note 1)	Observed Flow Merced River at Shaffer Bridge (PG&E)	Observed Flow Merced R at Cressey (DWR)	Observed Flow for Transfer (see Note 1)	Daily Flow Rate	Cumulative Volume
	(cfs)	(cfs)	(acre-feet)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(acre-feet)
	(1)	(2)	(3)	(4) = (1) + (2)	(5)	(6)	(7)	(8) = (7) − (1)	(9)
Oct 01	30	70	139	100	109	90	109	79	157
Oct 02	30	70	278	100	118	94	118	88	331
Oct 03	30	125	526	155	144	119	144	114	557
Oct 04	30	125	774	155	157	136	157	127	809
Oct 05	30	125	1,021	155	161	141	161	131	1,069
Oct 06	30	125	1,269	155	162	137	162	132	1,331
Oct 07	30	125	1,517	155	156	131	156	126	1,581
Oct 08	30	125	1,765	155	157	134	157	127	1,833
Oct 09	30	125	2,013	155	172	149	172	142	2,114
Oct 10	30	125	2,261	155	194	174	194	164	2,440
Oct 11	30	125	2,509	155	205	188	205	175	2,787
Oct 12	30	125	2,757	155	202	190	202	172	3,128
Oct 13	30	125	3,005	155	203	179	203	173	3,471
Oct 14	30	125	3,253	155	204	182	204	174	3,816
Oct 15	30	125	3,501	155	204	188	204	174	4,161
Oct 16	85	125	3,749	210	247	236	247	162	4,483
Oct 17	85	185	4,116	270	322	301	301	216	4,911
Oct 18	85	315	4,740	400	471	389	389	304	5,514
Oct 19	85	515	5,762	600	739	554	554	469	6,444
Oct 20	85	515	6,783	600	755	586	586	501	7,438
Oct 21	85	515	7,805	600	734	579	579	494	8,418
Oct 22	85	515	8,826	600	791	615	615	530	9,469
Oct 23	85	515	9,848	600	768	610	610	525	10,510
Oct 24	85	315	10,473	400	566	495	495	410	11,324
Oct 25	85	215	10,899	300	442	412	412	327	11,972
Oct 26	85	135	11,167	220	323	332	332	247	12,462
Oct 27	85	135	11,435	220	294	304	294	19	12,500
Oct 28	85	135	11,702	220	292	297	292		
Oct 29	85	135	11,970	220	287	292	287		
Oct 30	85	135	12,238	220	252	269	252		
Oct 31	85	135	12,506	220	232	248	232		

[a] The Technical Appendix to the San Joaquin River Group Division Agreement states that "[T]he Merced River at Shaffer Bridge… will be used for flows between 0 and 300 cfs. …[F]or the flows above 300 cfs, measurements will be provided at the gage on the Merced River located near Cressey.

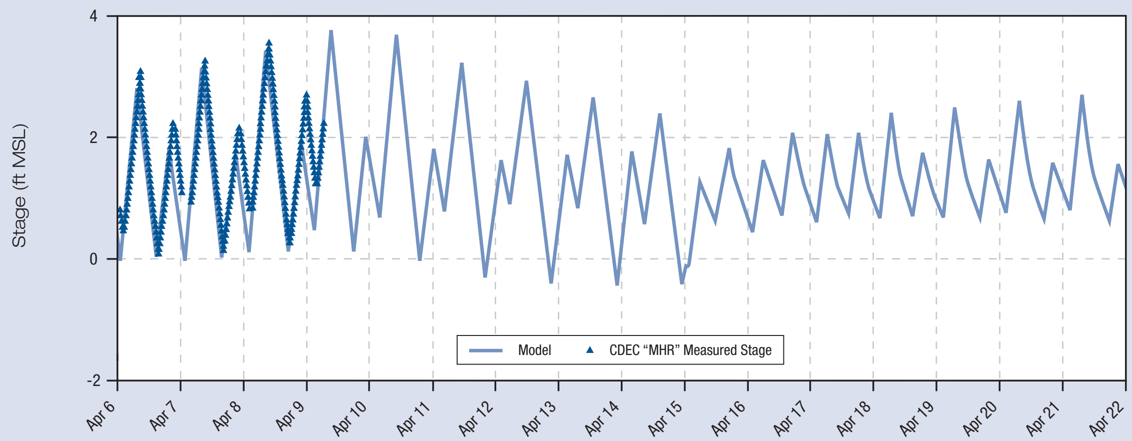
APPENDIX B

Head of Old River Barrier Operation

B–1. Forecasted Low-Low Tide Stage
Middle River at Howard Road

As of April 6, 2004

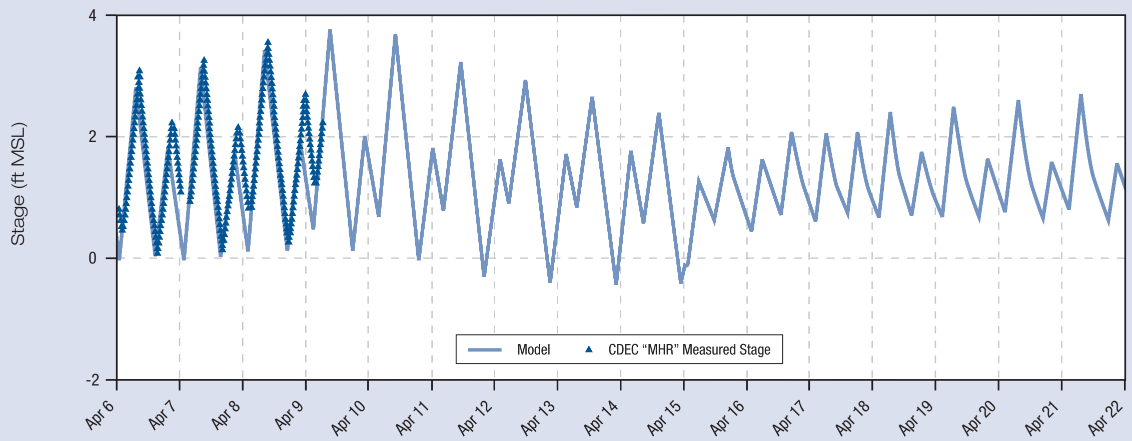
Note: 2 AG barriers tidally operated, GLC partial, ***All HORB culverts closed***



Notes:
All barriers closed on 4/15/04 except GLC.
The DMC and Middle River barriers modeled with culverts tidally operated
The GLC modeled partial barrier.

As of April 6, 2004

Note: 2 AG barriers tidally operated, GLC partial, ***3 HORB culverts open***

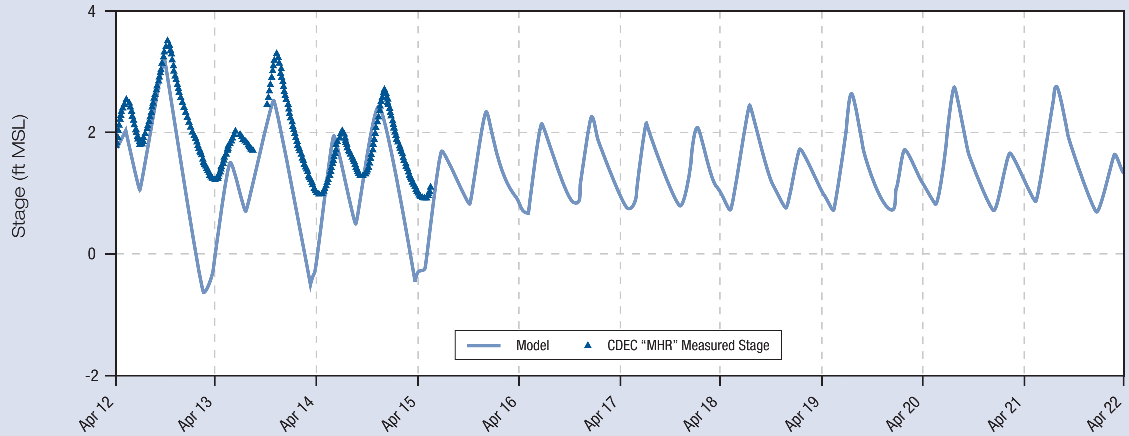


Notes:
GLC barrier partially closed 4/9/04, MR barrier closed 4/12/04, DMC and HORB barriers closed 4/15/04.
The DMC and Middle River barriers modeled with culverts tidally operated
The GLC modeled partial barrier.

B–1. Forecasted Low-Low Tide Stage
Middle River at Howard Road

As of April 12, 2004

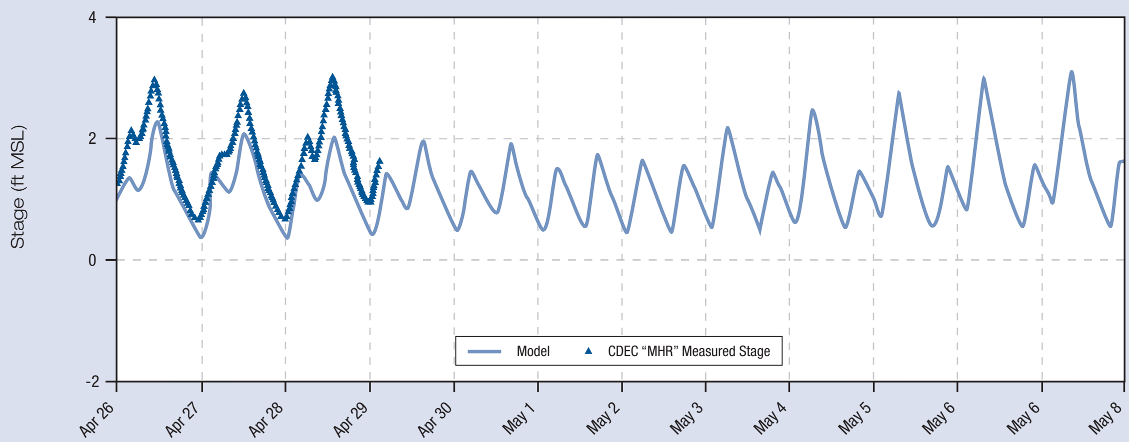
Note: 2 AG barriers tidally operated, GLC partial, ***HORB 3 culverts open***



Notes:
GLC barrier partially closed 4/9/04, MR barrier closed 4/12/04, DMC and HORB barriers closed 4/15/04.
The DMC and Middle River barriers modeled with culverts tidally operated
The GLC modeled partial barrier.

As of April 26, 2004

Note: 2 AG barriers tidally operated, GLC partial, ***HORB 6 culverts open***



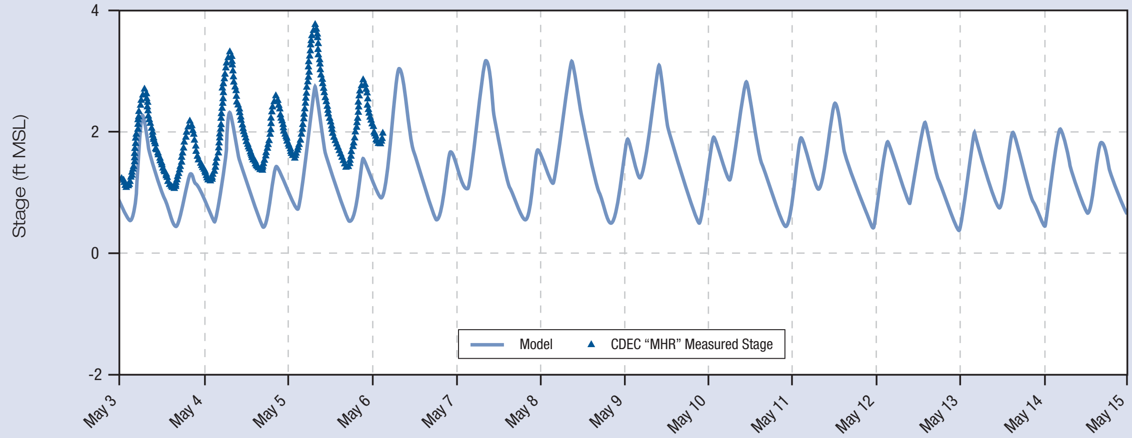
Notes:
GLC barrier partially closed 4/9/04, MR barrier closed 4/12/04, DMC and HORB barriers closed 4/15/04.
The DMC and Middle River barriers modeled with culverts tidally operated
The GLC modeled partial barrier.

APPENDIX B

B-1. Forecasted Low-Low Tide Stage
Middle River at Howard Road

As of May 3, 2004

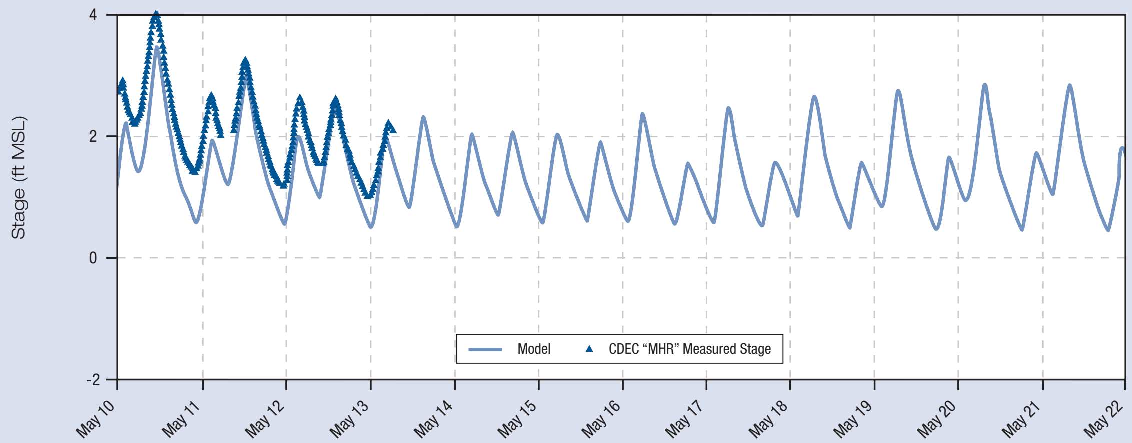
Note: 2 AG barriers tidally operated, GLC partial, HORB 6 culverts open



Notes:
GLC barrier partially closed 4/9/04, MR barrier closed 4/12/04, DMC and HORB barriers closed 4/15/04.
The DMC and Middle River barriers modeled with culverts tidally operated
The GLC modeled partial barrier.

As of May 10, 2004

Note: 2 AG barriers tidally operated, GLC partial, HORB 6 culverts open



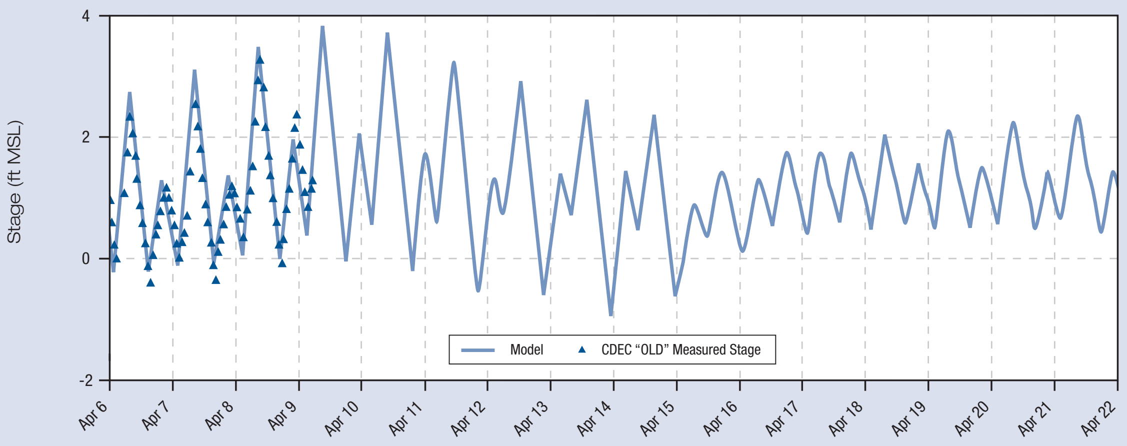
Notes:
GLC barrier partially closed 4/9/04, MR barrier closed 4/12/04, DMC and HORB barriers closed 4/15/04.
The DMC and Middle River barriers modeled with culverts tidally operated
The GLC modeled partial barrier.

APPENDIX B

B-2. Forecasted Low-Low Tide Stage
Old River near Tracy Road Bridge

As of April 6, 2004

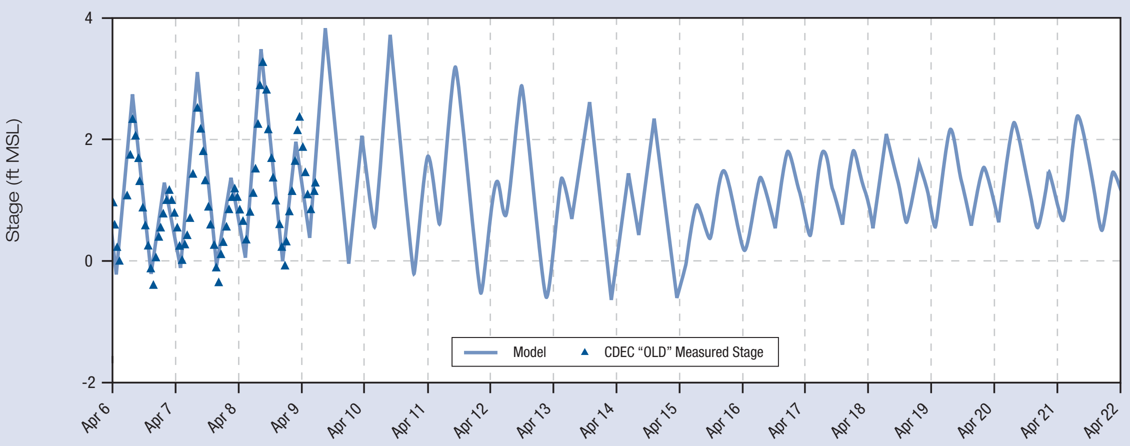
Note: 2 AG barriers tidally operated, GLC partial, ***All HORB culverts closed***



Notes:
All barriers closed on 4/15/04 except GLC.
The DMC and Middle River barriers modeled with culverts tidally operated
The GLC modeled partial barrier.

As of April 6, 2004

Note: 2 AG barriers tidally operated, GLC partial, ***3 HORB culverts open***

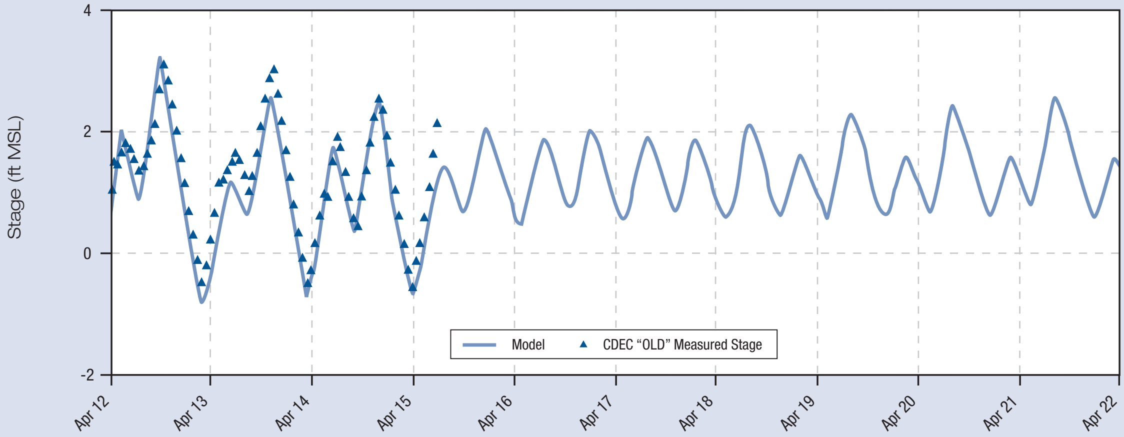


Notes:
GLC barrier partially closed 4/9/04, MR barrier closed 4/12/04, DMC and HORB barriers closed 4/15/04.
The DMC and Middle River barriers modeled with culverts tidally operated
The GLC modeled partial barrier.

B-2. Forecasted Low-Low Tide Stage
Old River near Tracy Road Bridge

As of April 12, 2004

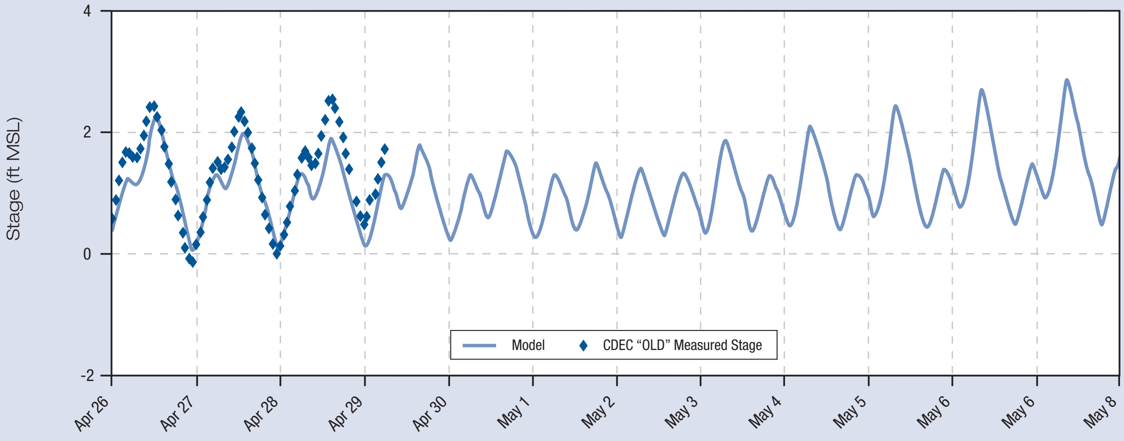
Note: 2 AG barriers tidally operated, GLC partial, ***HORB 3 culverts open***



Notes:
GLC barrier partially closed 4/9/04, MR barrier closed 4/12/04, DMC and HORB barriers closed 4/15/04.
The DMC and Middle River barriers modeled with culverts tidally operated
The GLC modeled partial barrier.

As of April 26, 2004

Note: 2 AG barriers tidally operated, GLC partial, ***HORB 6 culverts open***

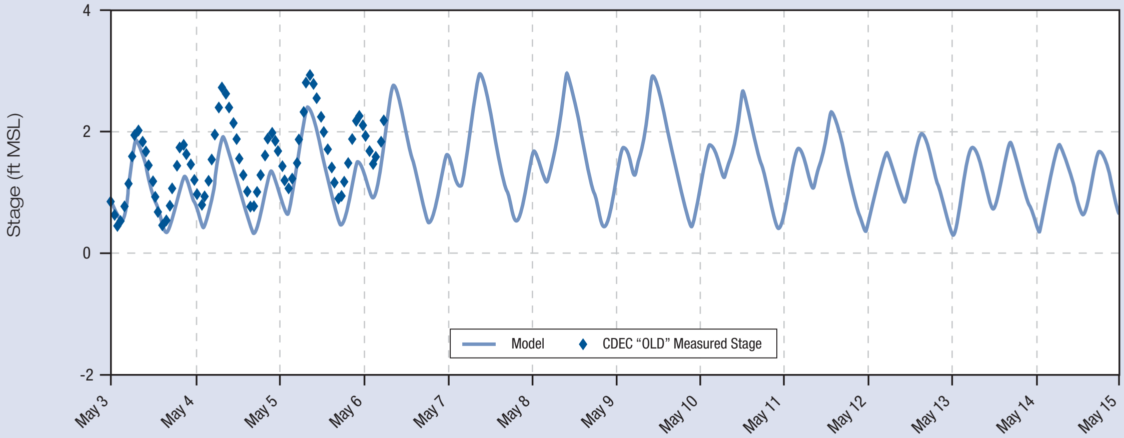


Notes:
GLC barrier partially closed 4/9/04, MR barrier closed 4/12/04, DMC and HORB barriers closed 4/15/04.
The DMC and Middle River barriers modeled with culverts tidally operated
The GLC modeled partial barrier.

B-2. Forecasted Low-Low Tide Stage Old River near Tracy Road Bridge

As of May 3, 2004

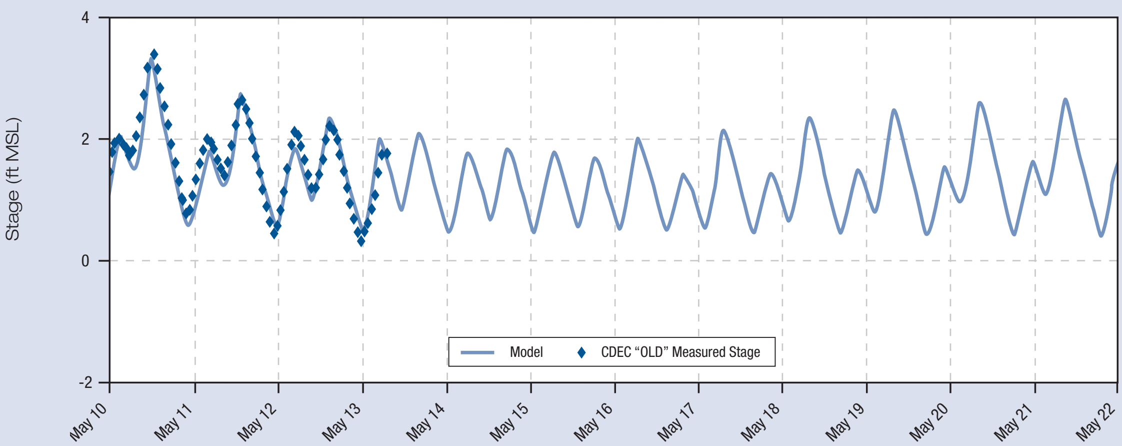
Note: 2 AG barriers tidally operated, GLC partial, ***HORB 6 culverts open***



Notes:
GLC barrier partially closed 4/9/04, MR barrier closed 4/12/04, DMC and HORB barriers closed 4/15/04.
The DMC and Middle River barriers modeled with culverts tidally operated
The GLC modeled partial barrier.

As of May 10, 2004

Note: 2 AG barriers tidally operated, GLC partial, ***HORB 6 culverts open***

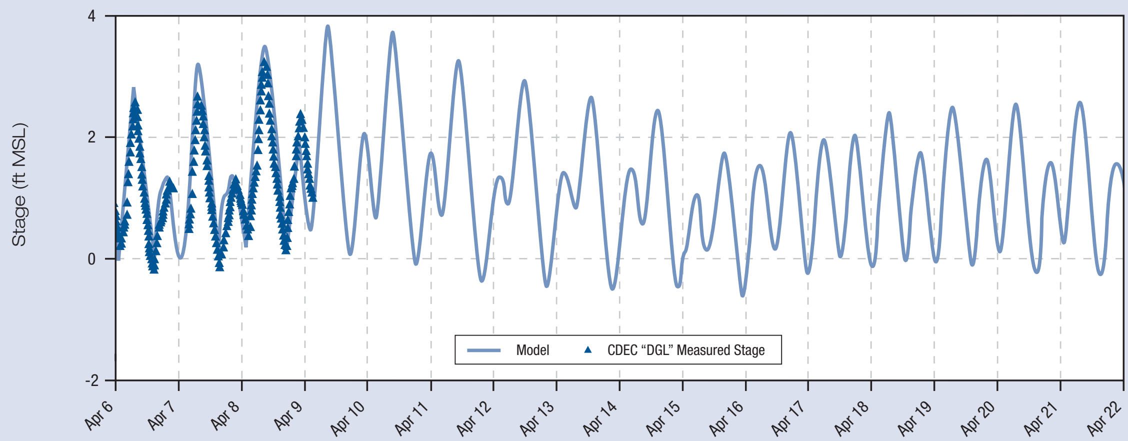


Notes:
GLC barrier partially closed 4/9/04, MR barrier closed 4/12/04, DMC and HORB barriers closed 4/15/04.
The DMC and Middle River barriers modeled with culverts tidally operated
The GLC modeled partial barrier.

B–3. Forecasted Low-Low Tide Stage Doughty Cut above GLC Barrier

As of April 6, 2004

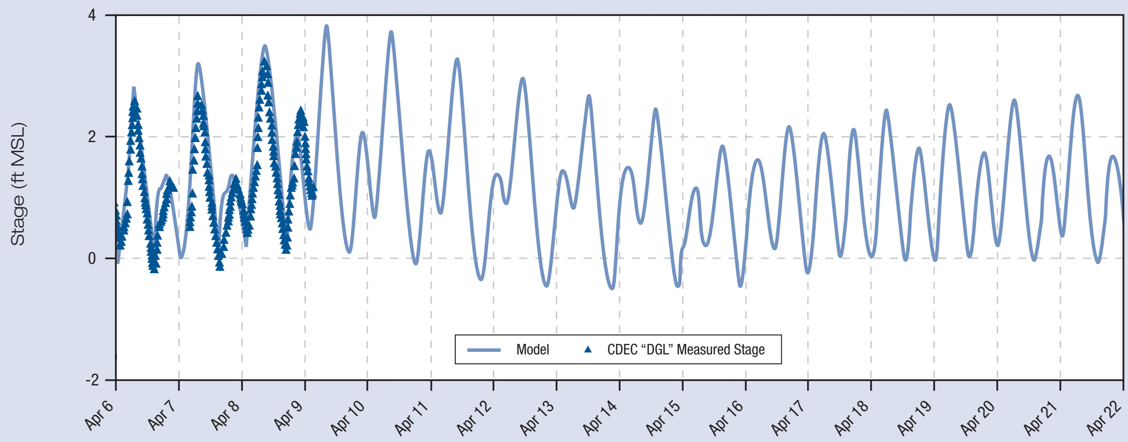
Note: 2 AG barriers tidally operated, GLC partial, ***All HORB culverts closed***



Notes:
All barriers closed on 4/15/04 except GLC.
The DMC and Middle River barriers modeled with culverts tidally operated
The GLC modeled partial barrier.

As of April 6, 2004

Note: 2 AG barriers tidally operated, GLC partial, ***3 HORB culverts open***



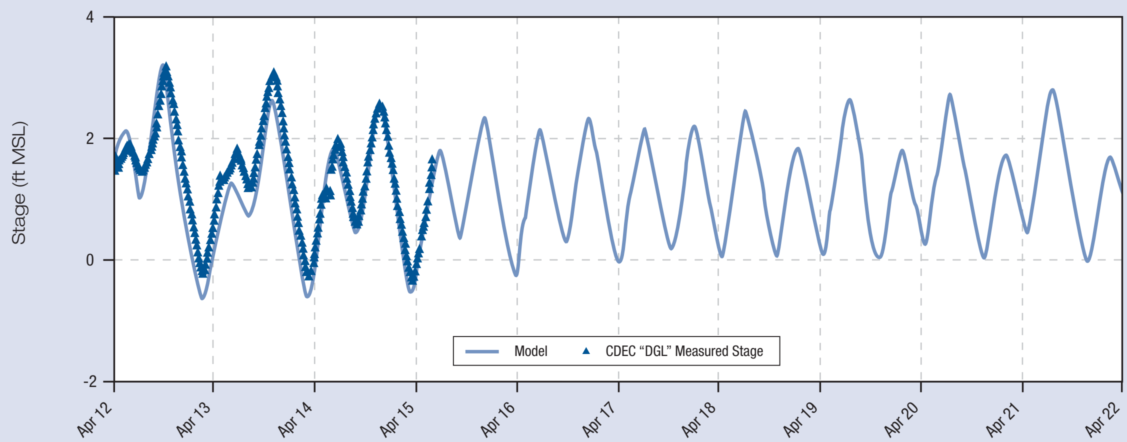
Notes:
GLC barrier partially closed 4/9/04, MR barrier closed 4/12/04, DMC and HORB barriers closed 4/15/04.
The DMC and Middle River barriers modeled with culverts tidally operated
The GLC modeled partial barrier.

APPENDIX B

B–3. Forecasted Low-Low Tide Stage
Doughty Cut above GLC Barrier

As of April 12, 2004

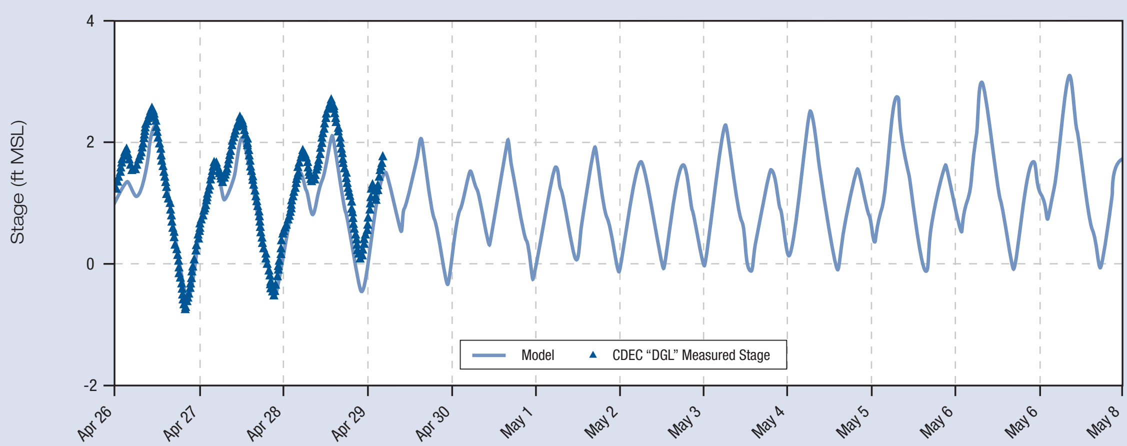
Note: 2 AG barriers tidally operated, GLC partial, ***HORB 3 culverts open***



Notes:
GLC barrier partially closed 4/9/04, MR barrier closed 4/12/04, DMC and HORB barriers closed 4/15/04.
The DMC and Middle River barriers modeled with culverts tidally operated
The GLC modeled partial barrier.

As of April 26, 2004

Note: 2 AG barriers tidally operated, GLC partial, ***HORB 6 culverts open***



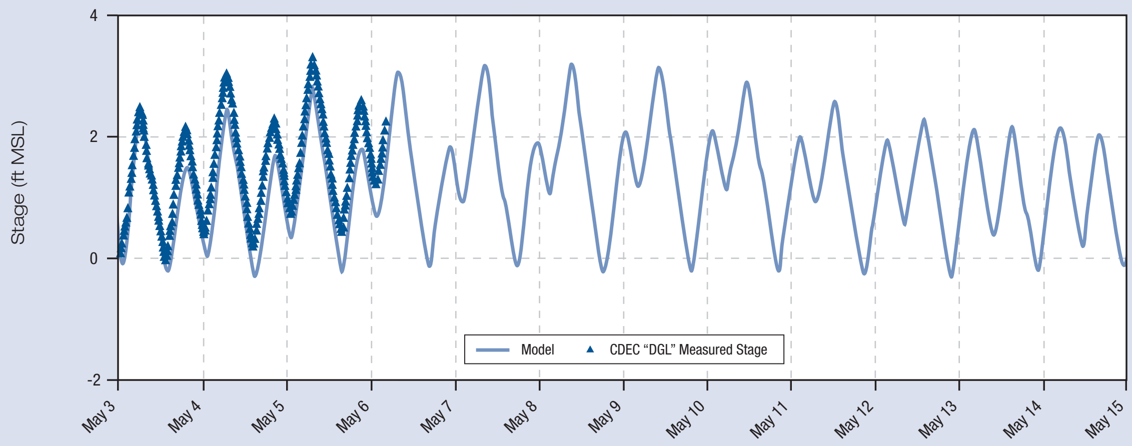
Notes:
GLC barrier partially closed 4/9/04, MR barrier closed 4/12/04, DMC and HORB barriers closed 4/15/04.
The DMC and Middle River barriers modeled with culverts tidally operated
The GLC modeled partial barrier.

APPENDIX B

B–3. Forecasted Low-Low Tide Stage
Doughty Cut above GLC Barrier

As of May 3, 2004

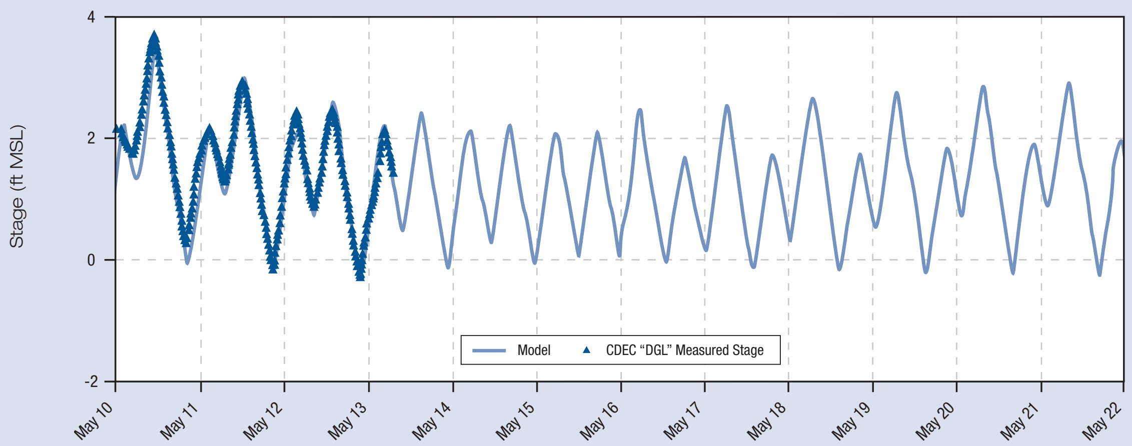
Note: 2 AG barriers tidally operated, GLC partial, ***HORB 6 culverts open***



Notes:
GLC barrier partially closed 4/9/04, MR barrier closed 4/12/04, DMC and HORB barriers closed 4/15/04.
The DMC and Middle River barriers modeled with culverts tidally operated
The GLC modeled partial barrier.

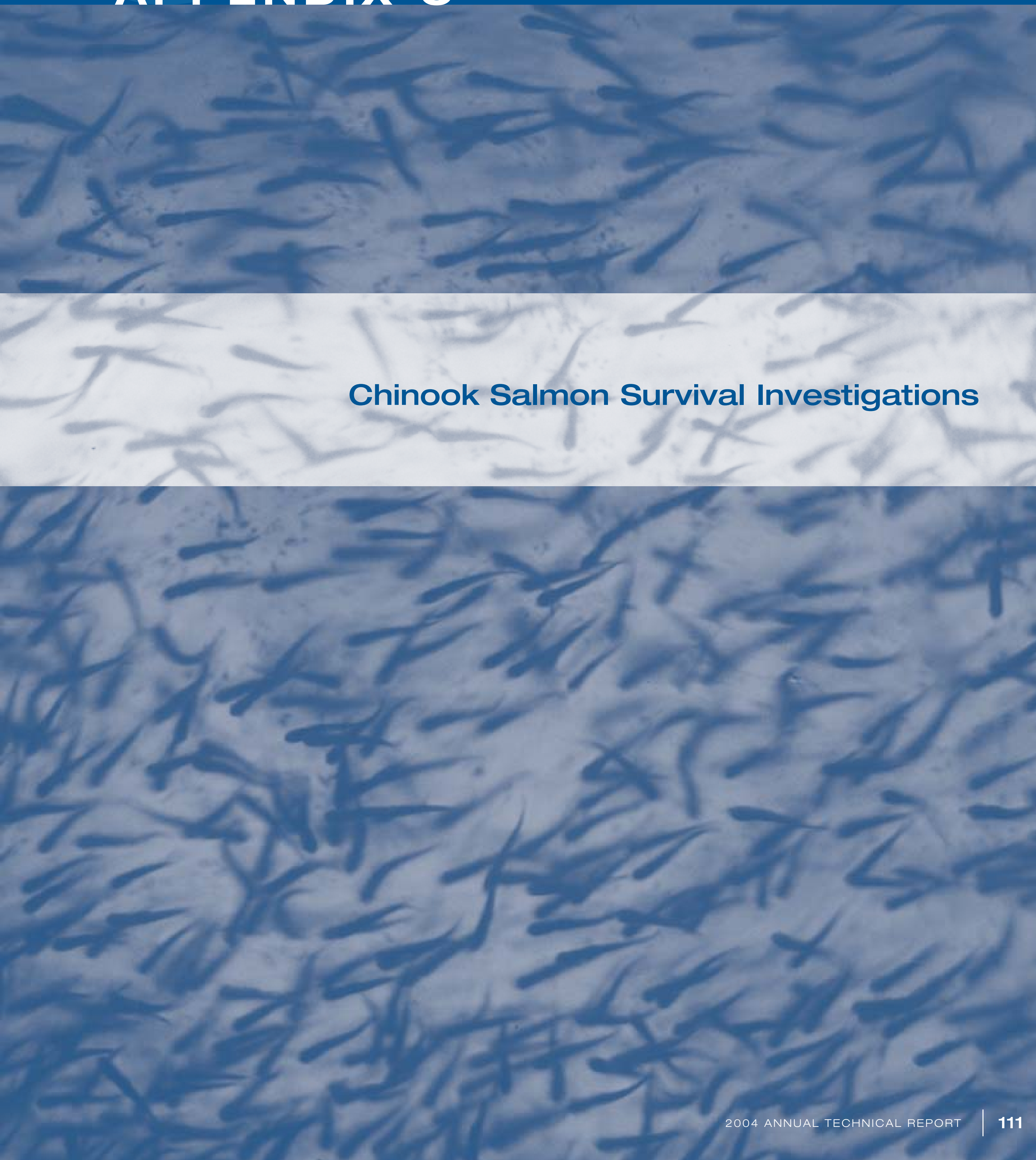
As of May 10, 2004

Note: 2 AG barriers tidally operated, GLC partial, ***HORB 6 culverts open***



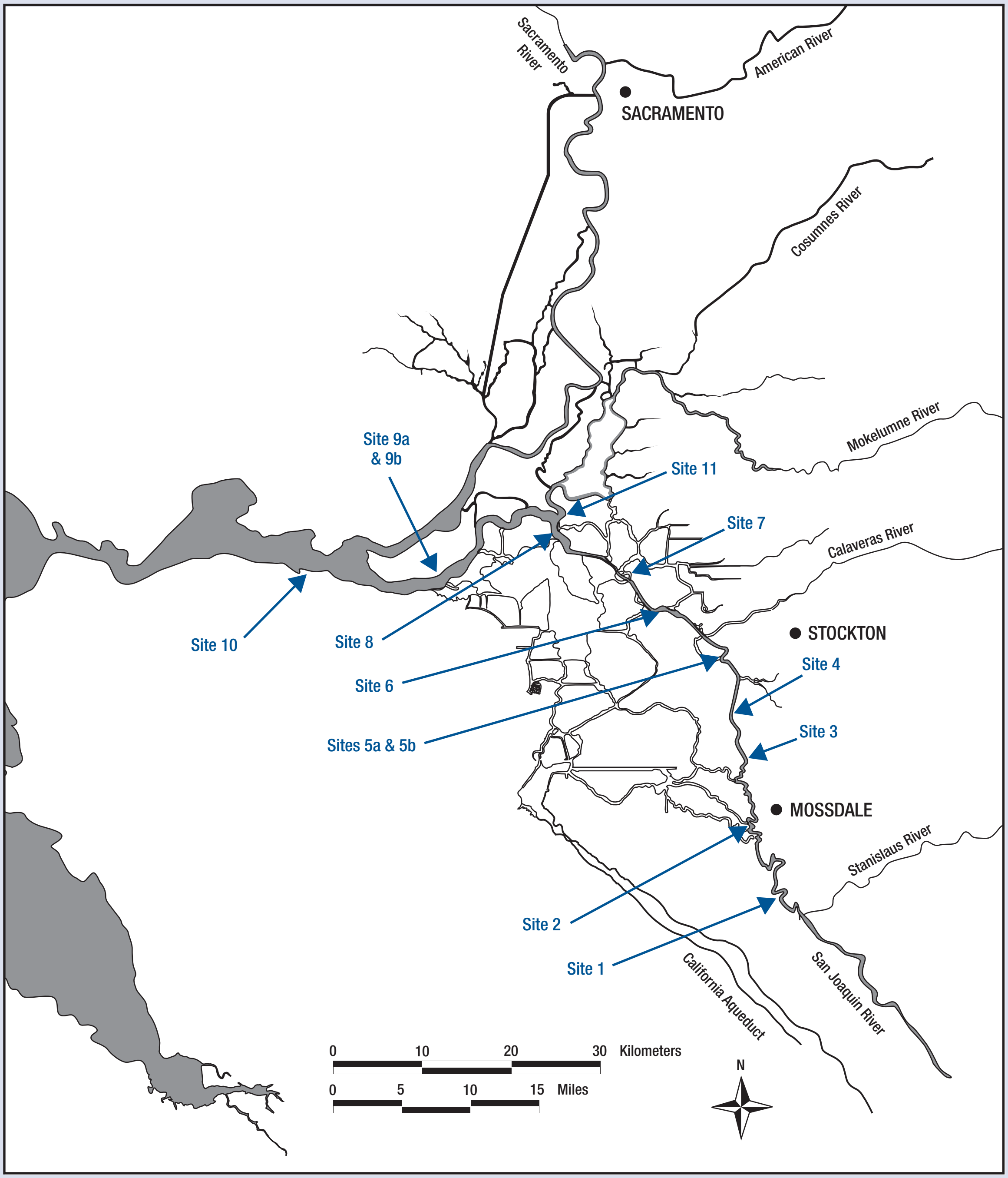
Notes:
GLC barrier partially closed 4/9/04, MR barrier closed 4/12/04, DMC and HORB barriers closed 4/15/04.
The DMC and Middle River barriers modeled with culverts tidally operated
The GLC modeled partial barrier.

APPENDIX C



Chinook Salmon Survival Investigations

C–1. Water Temperature Monitoring Locations

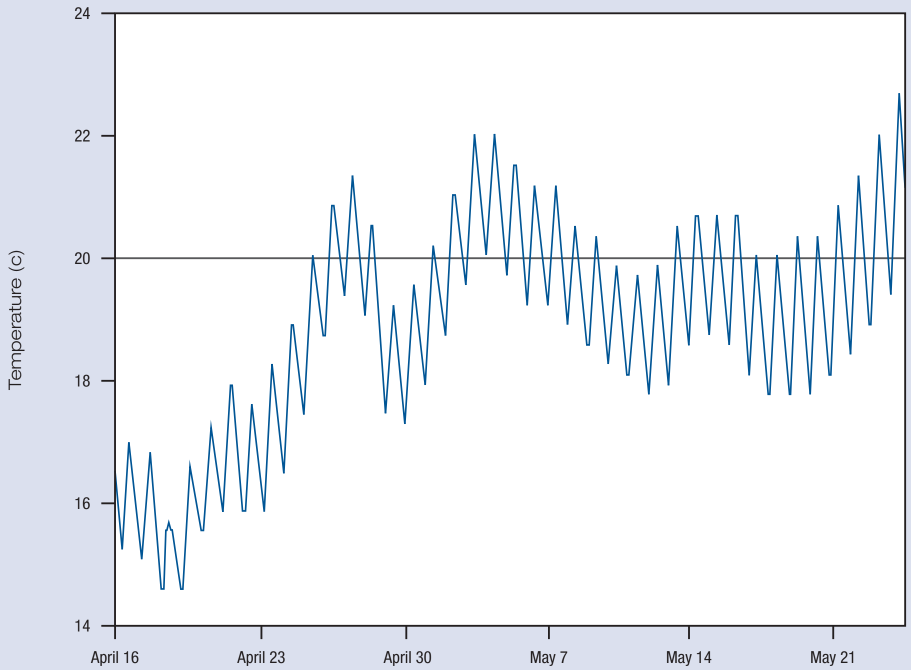


C-1. VAMP 2004 Water Temperature Monitoring

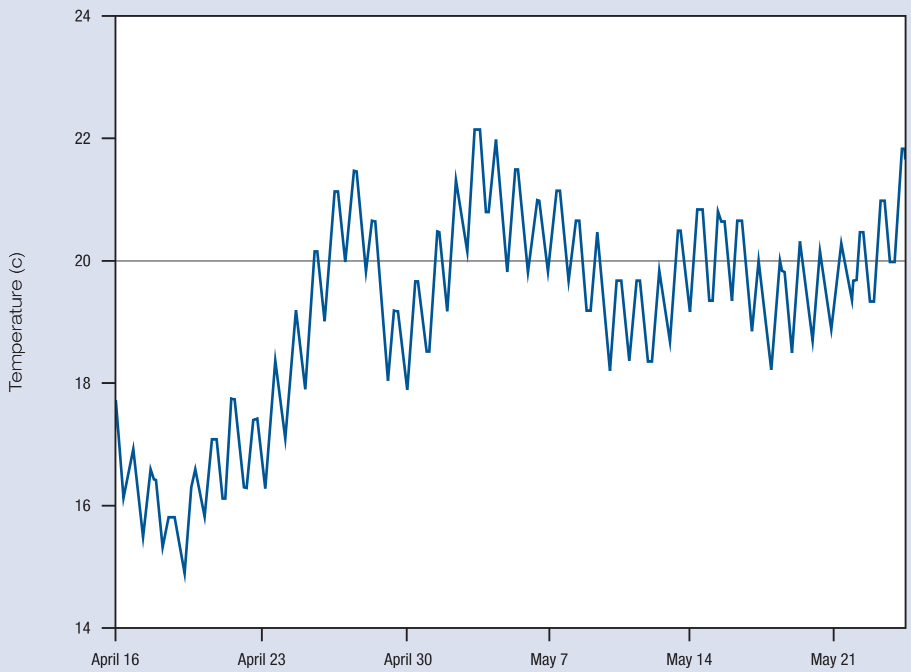
	Temperature Monitoring Location	Latitude	Longitude	Distance from Durham Ferry (mi)	Date Deployed	Date Retrieved	Notes
	Merced River Hatchery–1			n/a	March 18	April 24	In river April 22, 2004 at Durham Ferry
	Merced River Hatchery–2			n/a	March 18	April 25	In river April 23, 2004 at Mossdale
1	Durham Ferry	N 37 41.381	W 121 15.657	n/a	April 15	May 25	3 foot depth
2	Mossdale	N 37 47.180	W 121 18.425	11.2	April 15	May 25	3 feet below surface
3	Dos Reis	N 37 49.808	W 121 18.665	16.4	April 15	May 25	3 feet below surface
4	DWR Monitoring Station	N 37 51.869	W 121 19.376	19.4	April 15	May 25	3 feet below surface
5a	Confluence–Top	N 37 56.818	W 121 20.285	26.5	April 15	May 25	Logger Malfunction
5b	Confluence–Bottom	N 37 56.818	W 121 20.285	26.5	April 15	May 25	Located on bottom
6	Downstream of Channel Marker 30	N 37 59.776	W 121 25.569	33.3	April 15	May 25	3 feet below surface
7	½ mile Upstream of Channel Marker 13	N 38 01.940	W 121 28.769	37.3	April 15	May 25	3 feet below surface
8	Downstream of Channel Marker 36	N 38 04.522	W 121 34.413	44.7	April 15	May 25	3 feet below surface
9a	Jersey Point USGS Gauging Station–Top	N 38 03.172	W121 41.637	56.0	April 15	May 25	3 feet below surface
10	Chipps Island	N 38 03.084	W 121 55.463	71.5	April 15	May 25	4½ feet below surface
11	Mokelumne River-Lighthouse Marina	N 38 06.334	W 121 34.213	40.0	April 15	May 25	Logger malfunction

C–2. Water Temperature Monitoring

Site 1 · Durham Ferry

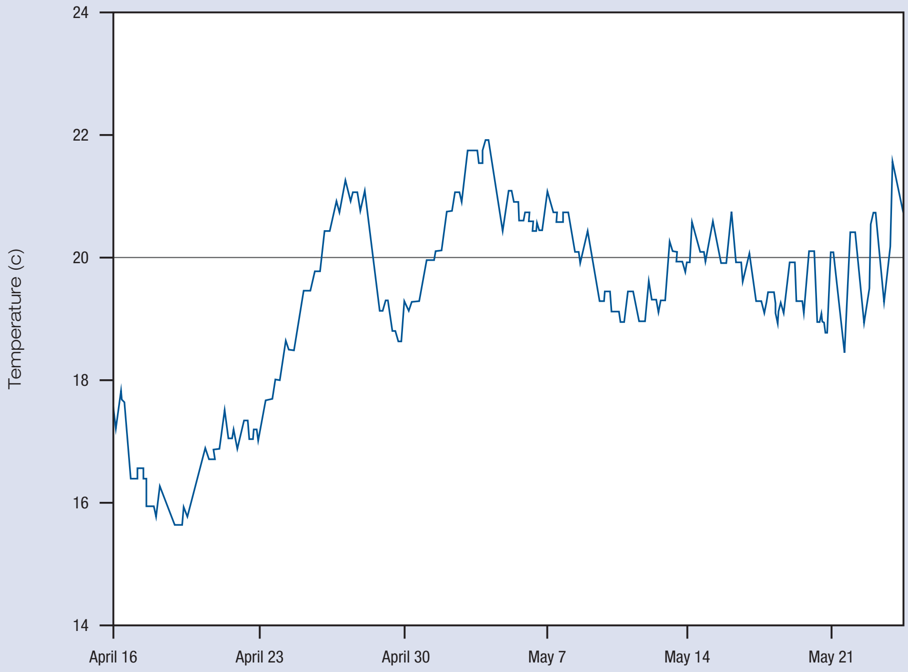


Site 2 · Mossdale

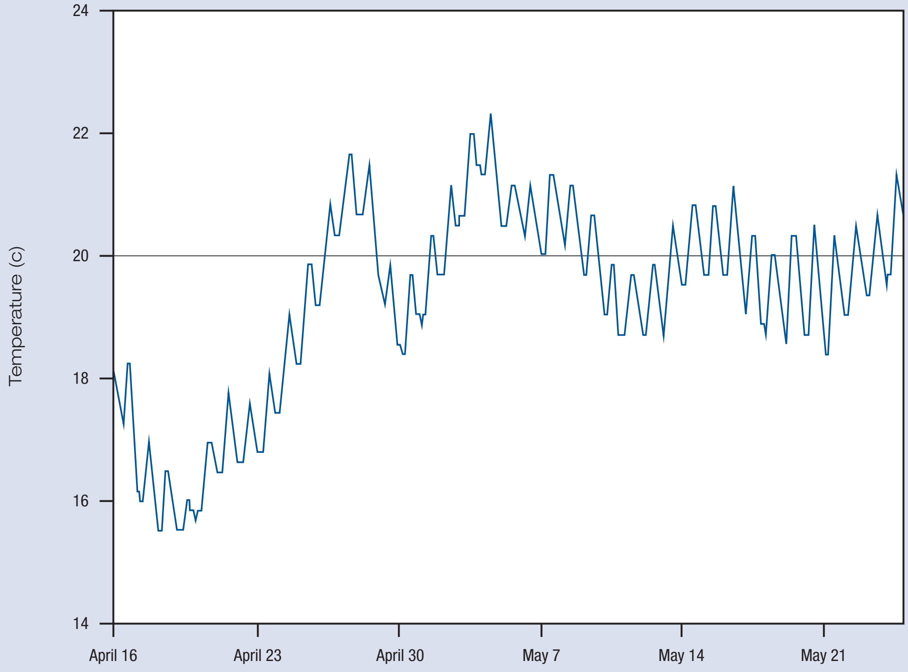


C–2. Water Temperature Monitoring

Site 3 · Dos Reis



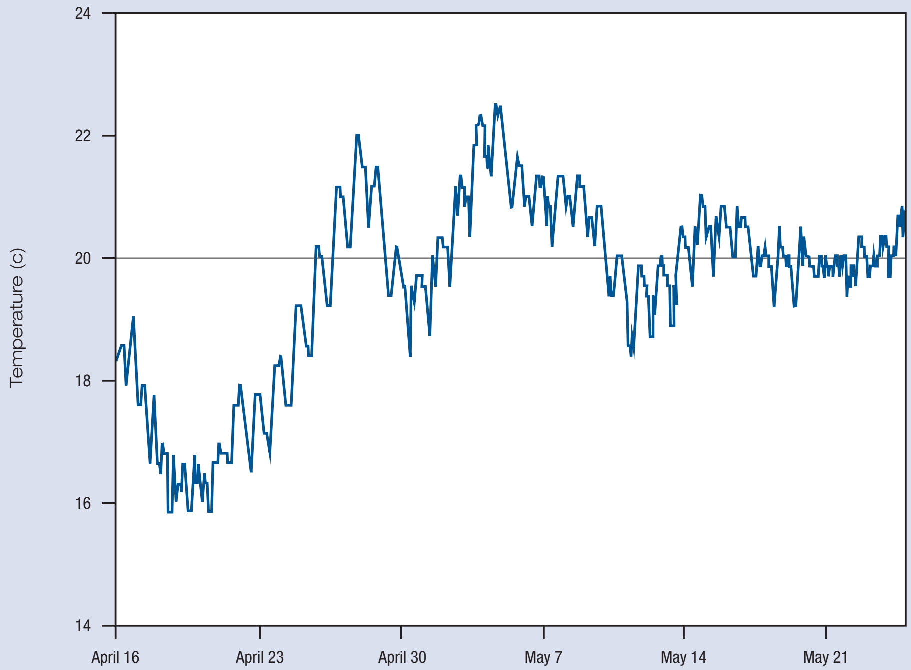
Site 4 · DWR Monitoring Station



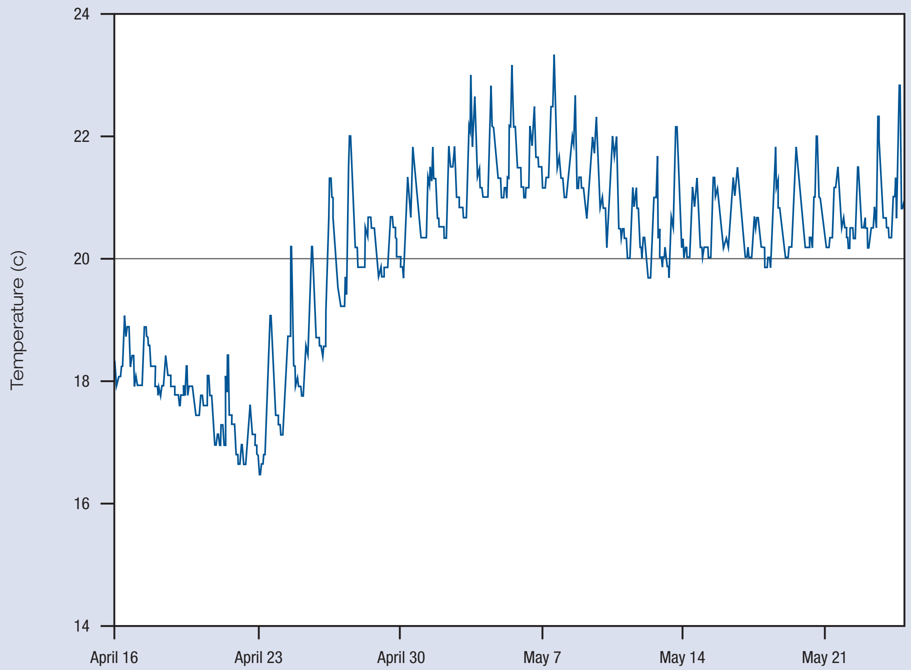
APPENDIX C

C–2. Water Temperature Monitoring

Site 5b · Confluence-Bottom



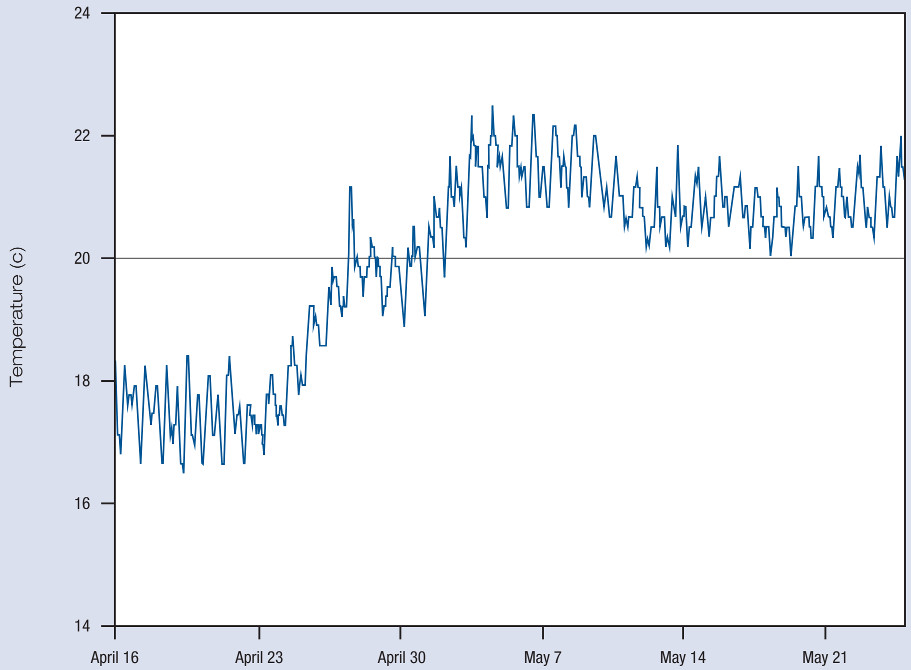
Site 6 · Downstream of Channel Marker 30



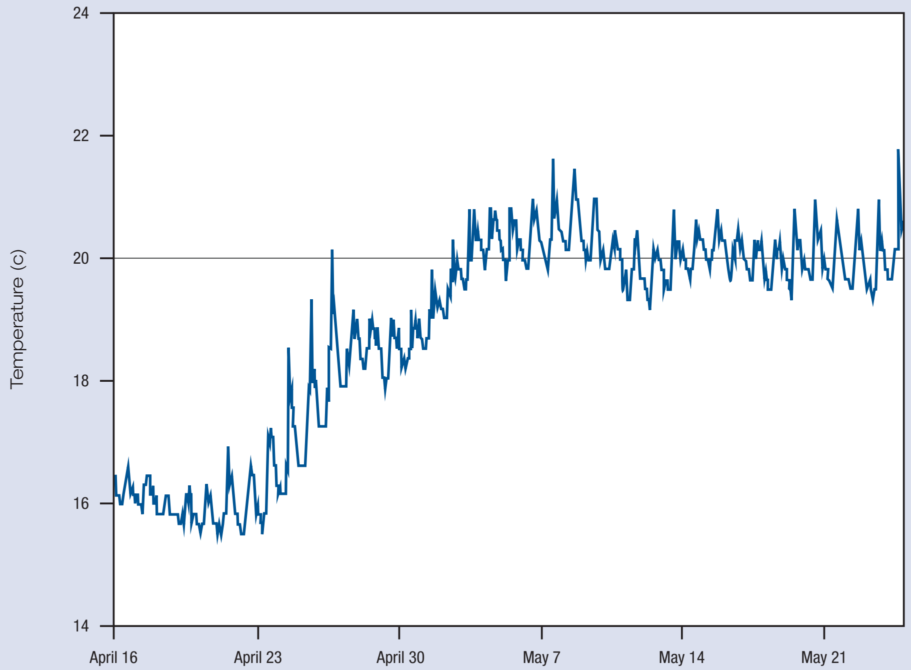
APPENDIX C

C-2. Water Temperature Monitoring

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



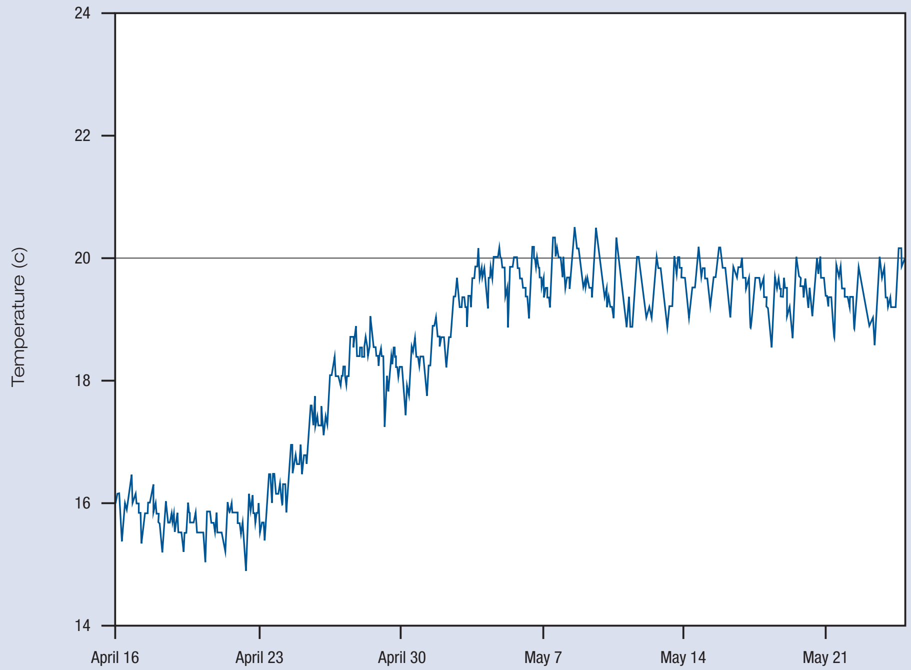
Site 8 · Downstream of Channel Marker 36



APPENDIX C

C–2. Water Temperature Monitoring

Site 9 · USGS Gauging Station at Jersey Point—Top

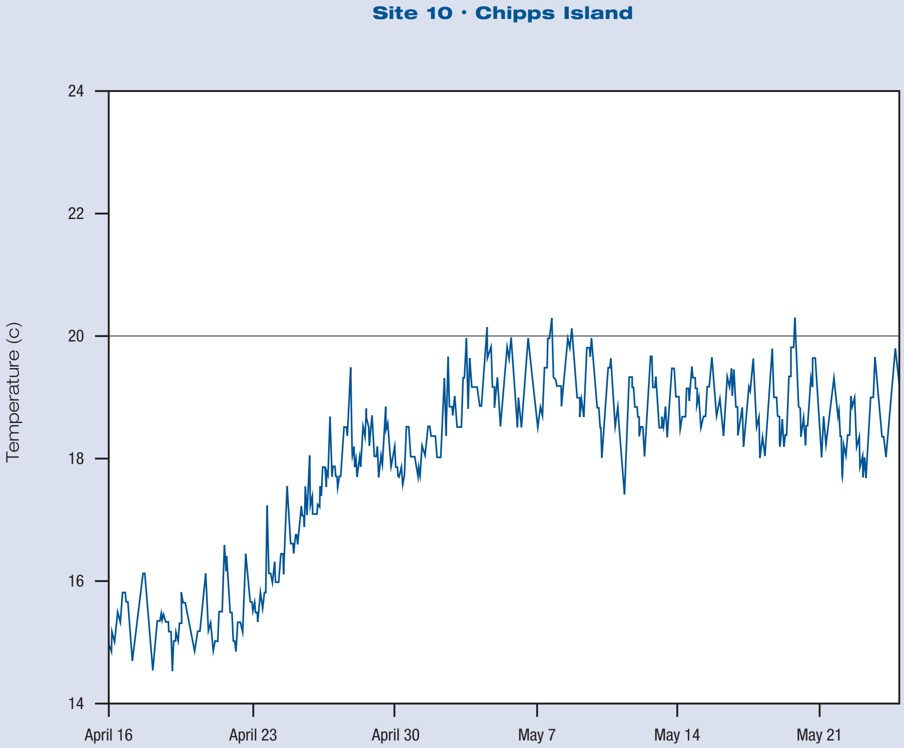


C–3. RESULTS OF NET PEN SAMPLING

a. Condition assessments immediately after release

Release Location	Coded-wire Tag Codes(s)	Number in Sample	Min FL	Max FL	Mean FL	Min Weight	Max Weight	Mean Weight	Min Scale Loss	Max scale loss	Mean scale loss
Durham Ferry I	06-27-52, 06-27-53, 06-27-54, 06-27-55	50	67	94	83.8	3.1	8.7	6.4	0.0	10.0	0.4
Mossdale I	06-46-70, 06-45-82, 06-45-83	75	71	91	83.8	3.4	7.8	6.1	2.0	12.0	5.1
Jersey Point I	06-45-80	25	76	96	89.5	4.5	9.4	7.6	1.0	8.0	3.2

C-2. Water Temperature Monitoring



Color (% normal)	Fin Hemorrhaging (% none)	Eyes (% normal)	Gill Color (% normal)	Partial Adipose Fin Clips (%)	Missing Adipose Fin Clips (%)	Number of Mortalities	Other Abnormalities and Comments
98	100.0	92	56	0	0	4	44% of fish had pale gills; possible ick. Appx. 150 fish (tag code 06-2-52) spilled onto boat ramp when hose disconnected from truck.
100	98.7	100	100	7	0	3	
100	100.0	100	100	4	0	1	

C–3. RESULTS OF NET PEN SAMPLING

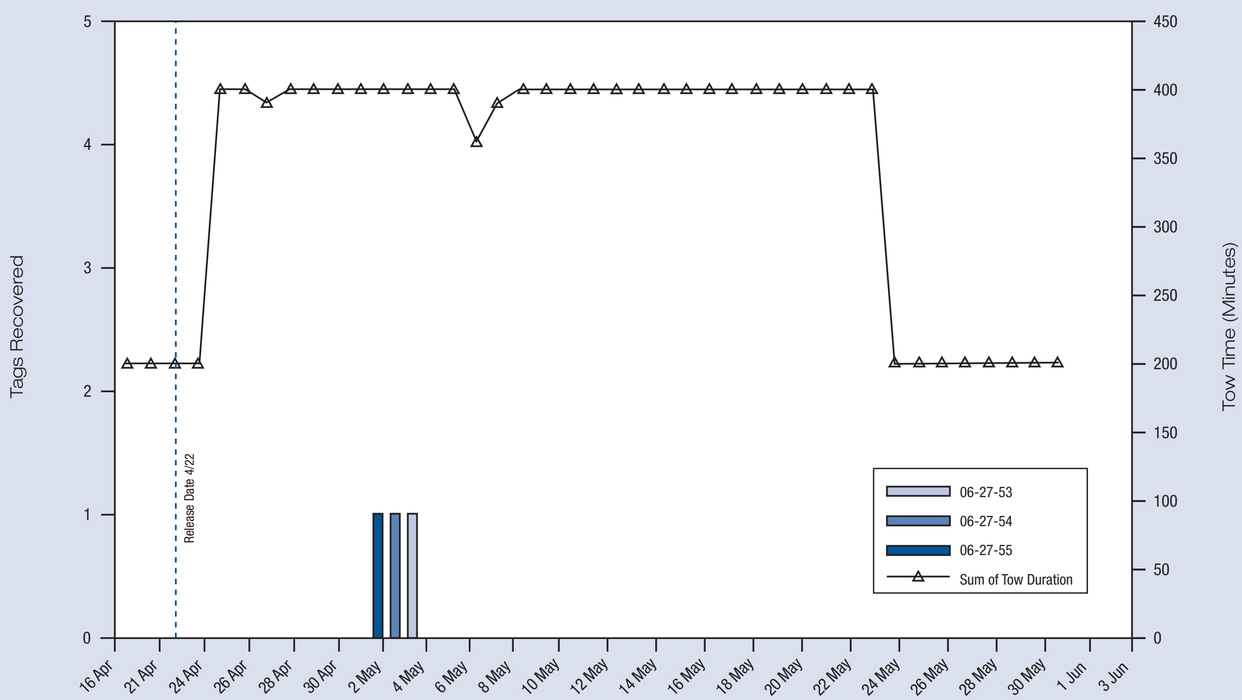
b. Condition assessments 48 hours after release (fish held in net pens)

Release Location	Coded-wire Tag Codes(s)	Number in Sample	Min FL	Max FL	Mean FL	Min Weight	Max Weight	Mean Weight	Min Scale Loss	Max scale loss	Mean scale loss
Durham Ferry I	06-27-52, 06-27-53, 06-27-54, 06-27-55	400	60	102	84.9	1.9	11.1	6.2	3.0	15.0	8.0
Mossdale I	06-46-70, 06-45-82, 06-45-83	400	62	100	83.9	2.0	10.4	5.9	0.5	15.0	4.3
Jersey Point I	06-45-80	200	74	100	86.8	4.4	11.1	6.9	4.4	11.1	6.9

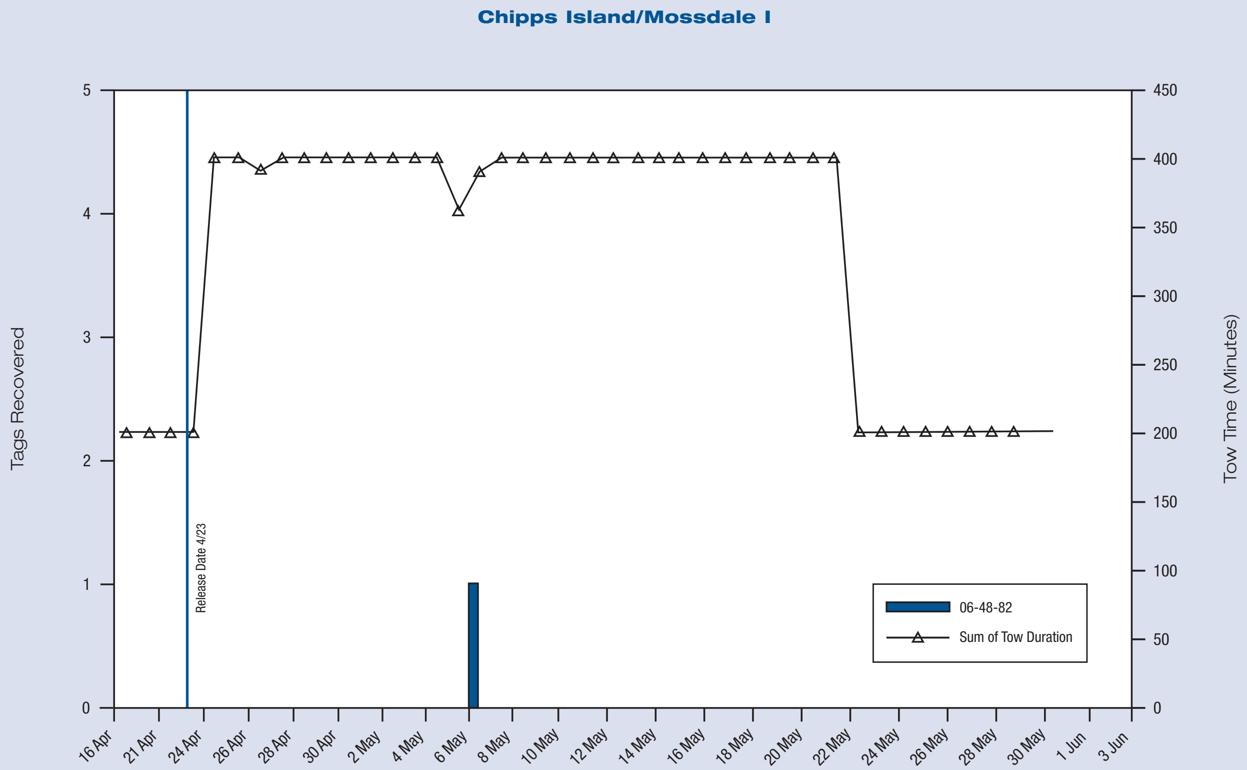
APPENDIX C

C–4. Coded Wire Tag Recovery Data (Recovery location/Release location)

Chipps Island/Durham Ferry I

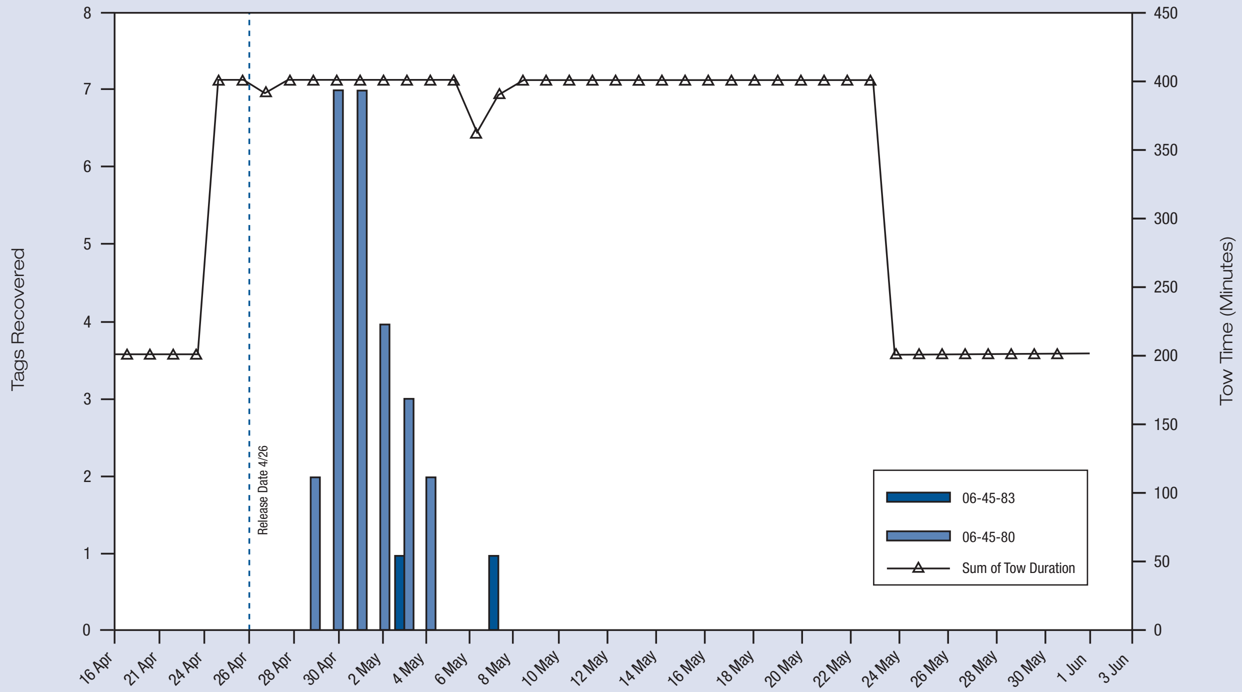


Color (% normal)	Fin Hemorrhaging (% none)	Eyes (% normal)	Gill Color (% normal)	Partial Adipose Fin Clips (%)	Missing Adipose Fin Clips (%)	Number of Mortalities	Other Abnormalities and Comments
100	196	100.0	100.0	6	1	4	1 fish with eroded caudal fin, 1 fish with deformed dorsal fin
100	100	97.3	98.7	3	1	0	1 fish had bulging eyes
100	100	100.0	100.0	2	0	2	2 fish had possible ick spots

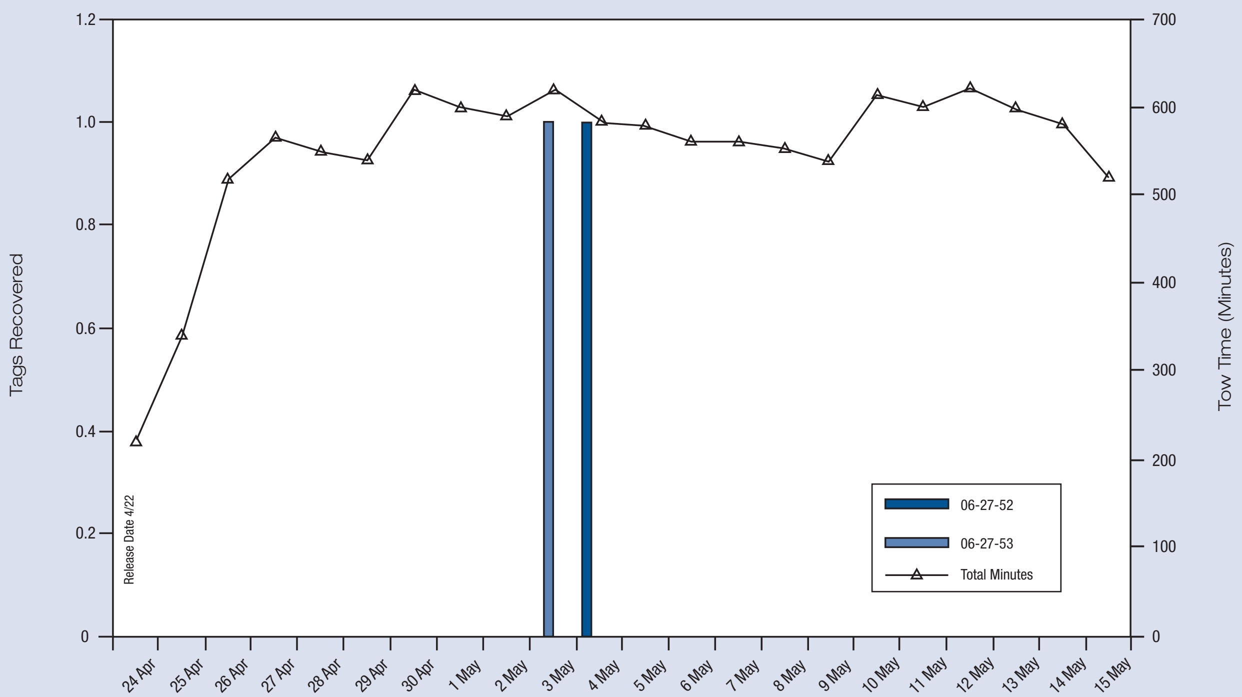


C–4. Coded Wire Tag Recovery Data

Chipps Island/Jersey Point I



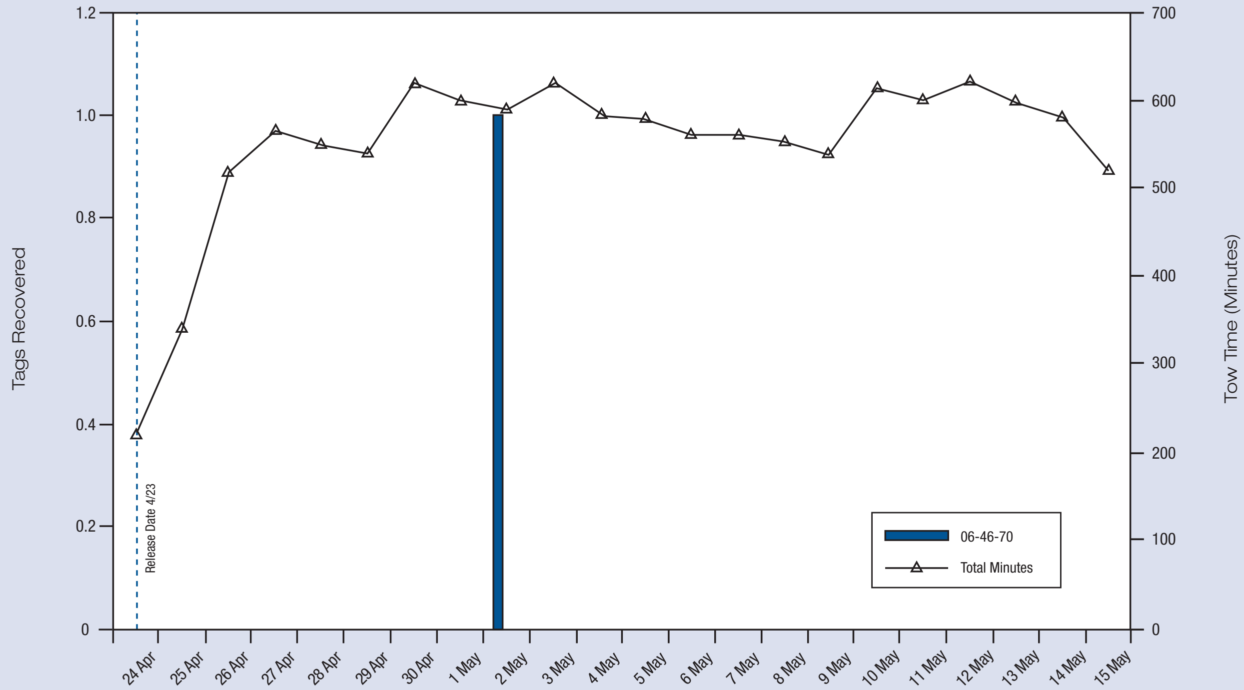
Antioch/Durham Ferry I



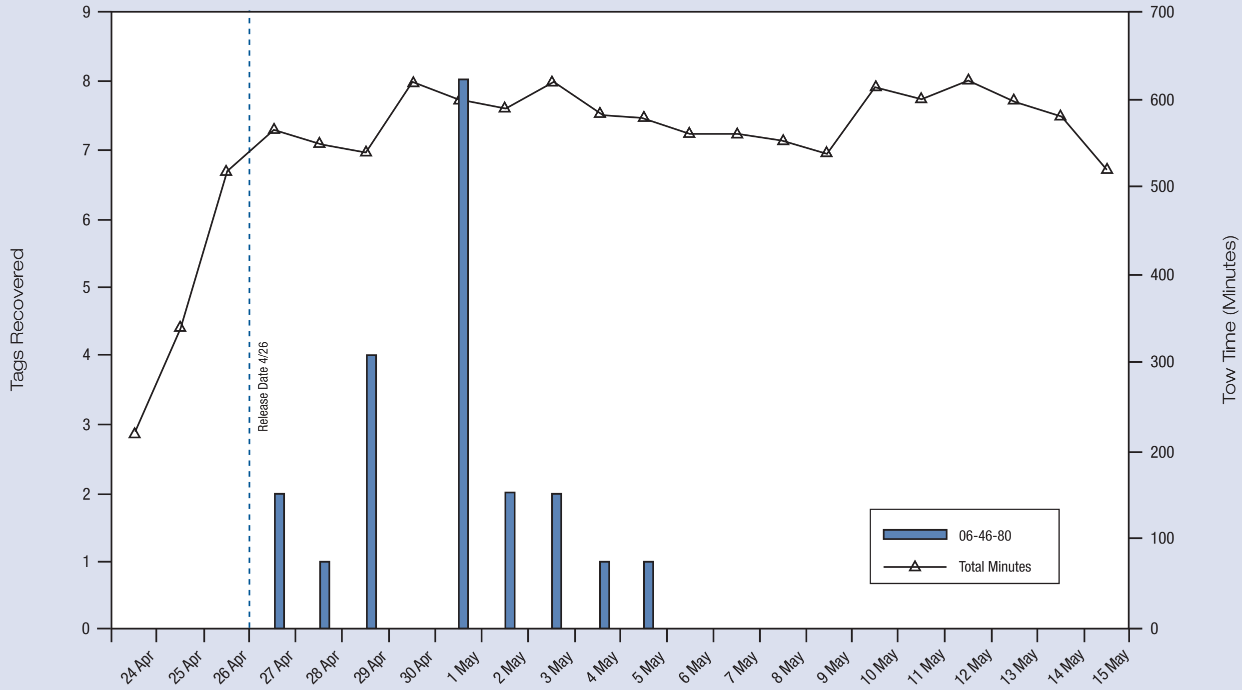
APPENDIX C

C–4. Coded Wire Tag Recovery Data

Antioch/Mossdale I



Antioch/Jersey Point I



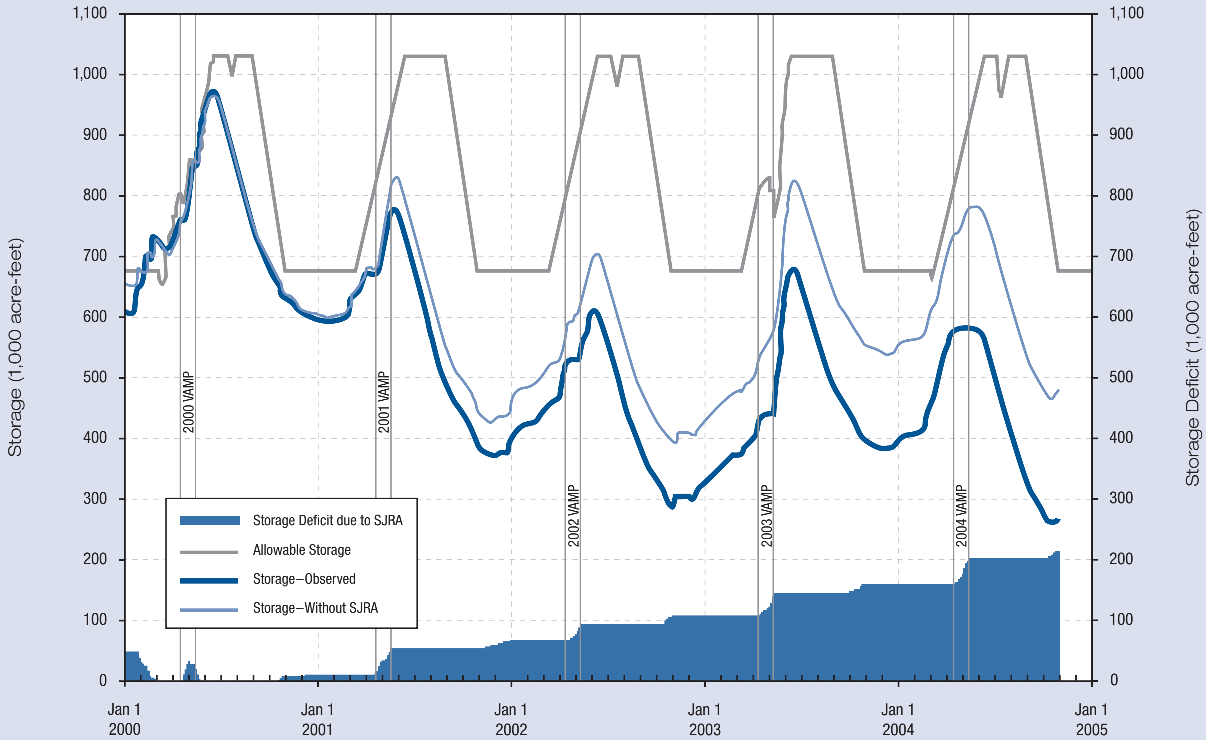
APPENDIX C

APPENDIX D

Historic Data

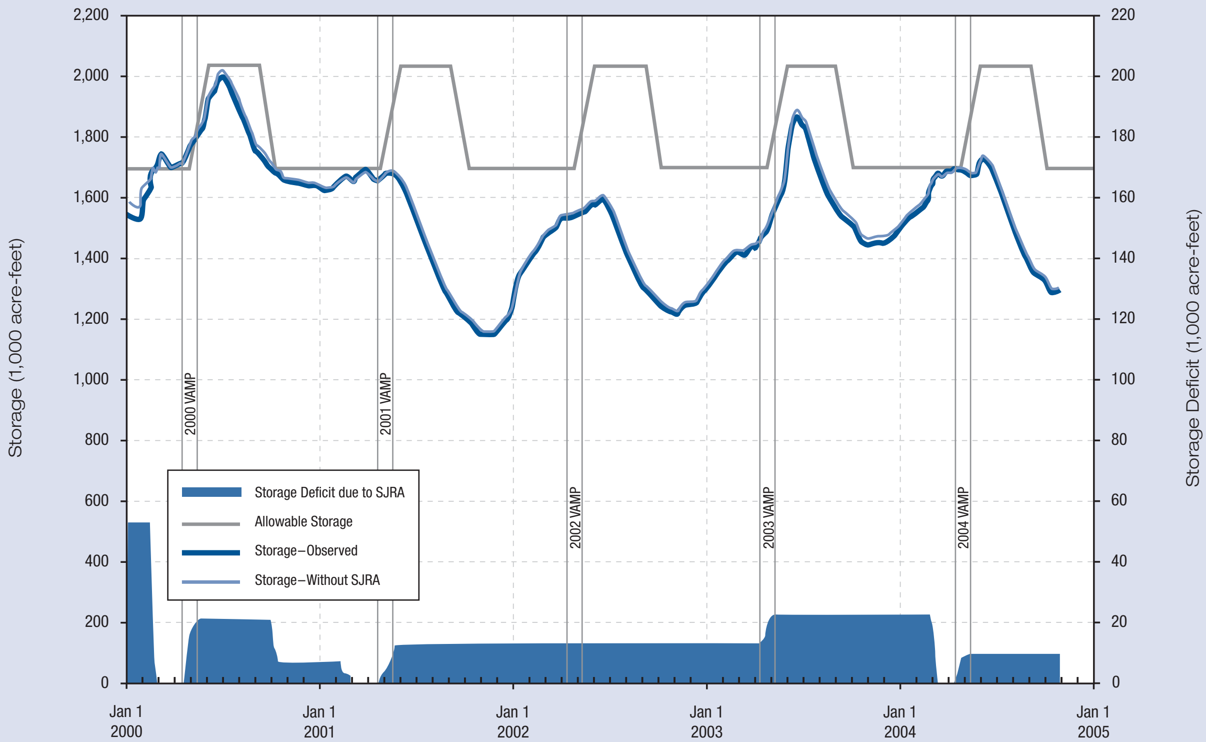
D-1. SJRA Storage Impacts, 2000–2004

Lake McClure (Merced River)



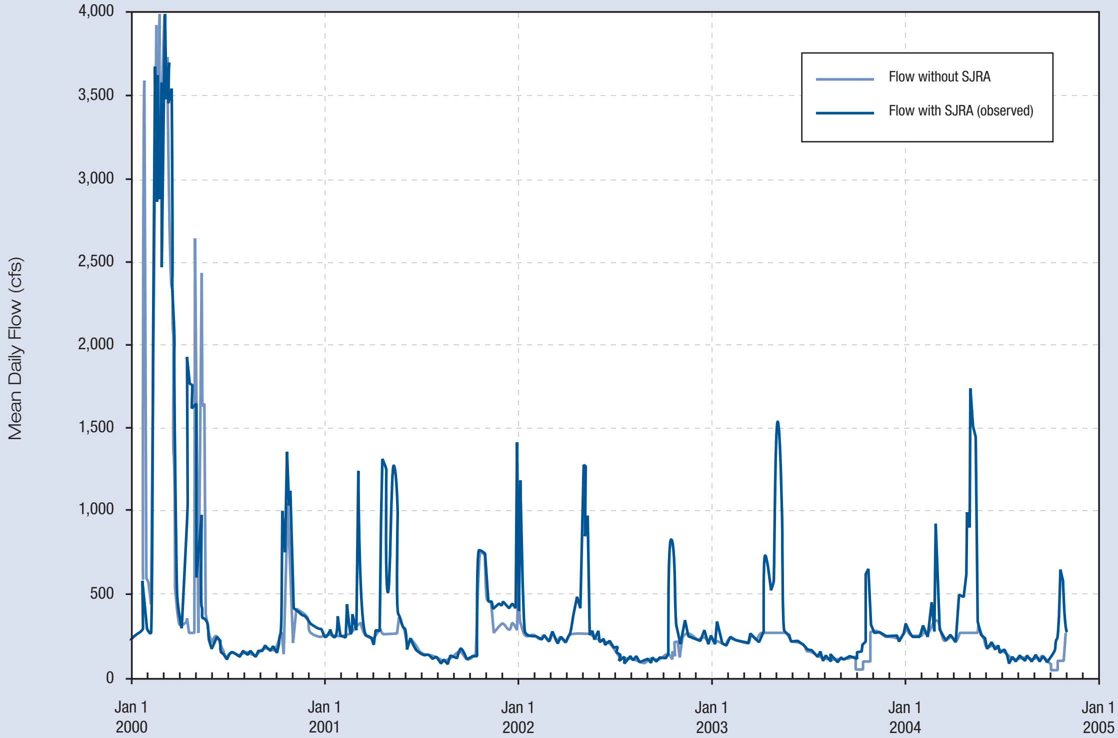
D-2. SJRA Storage Impacts, 2000–2004

New Don Pedro Reservoir (Tuolumne River)

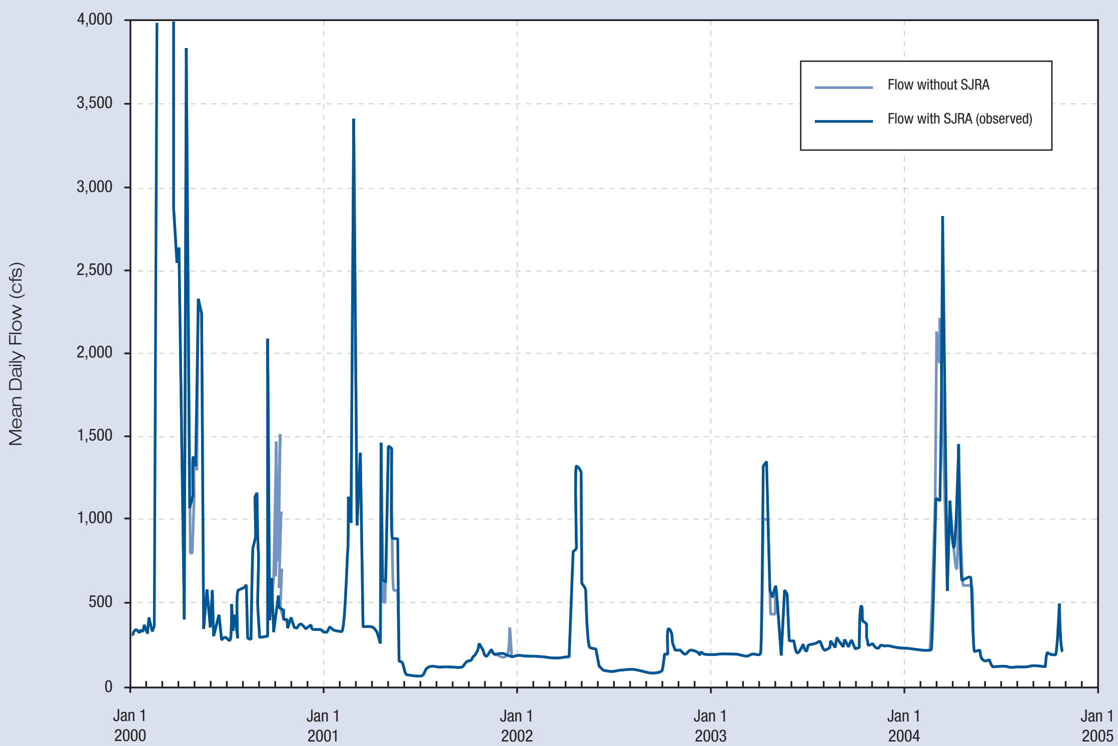


APPENDIX D

D-3. Merced River at Cressey, 2000–2004



D-4. Tuolumne River below LaGrange Dam, 2000–2004



APPENDIX D-5

2004 Vernalis Adaptive Management Plan (VAMP)

Comparison of Supplemental Water Contributions • Forecasted vs. Actual

A = Low Target   B = High Target

			EXISTING FLOW					VERNALIS					DIFFERENCE
Year	Operation Plan Date	Merced River	Tuolumne River	Stanislaus River	SJR up-stream of Merced R	Ungaged Flow at Vernalis	SJR at Vernalis	VAMP Target Flow	VAMP Forecast Flow	Observed Flow	VAMP Suppl. Flow	VAMP Suppl. Water Vol.	Suppl. Water Deviation: Decision Forecast to Actual
		(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	TAF	TAF
2004	Mar 17 A	250	694	681	255	300	2,185	3,200	3,200		1,015	62,400	
	B	250	1,000	1,191	538	800	3,779	4,450	4,450		671	41,280	
	Mar 30 A	250	650	681	255	300	2,135	3,200	3,200		1,065	65,460	
	B	250	1,000	1,191	538	800	3,778	4,450	4,450		671	41,280	
	Apr 9	250	702	647	254	500	2,352	3,200	3,200		847	52,070	
1/	Apr 13	250	700	647	254	500	2,352	3,200	3,199		847	52,170	
	Apr 20	250	700	647	252	365	2,213	3,200	3,186		972	59,780	
	May 3	250	700	647	260	281	2,137	3,200	3,172		1,035	63,620	
Final Acct.	Real-time	250	702	647	283	174	2,048	3,200		3,155	1,108	68,120	
	Provisional 2/	250	702	647	362	127	2,088	3,200		3,155	1,067	65,591	13,421
2003	Mar 12 A	250	467	750	304	300	2,071	3,200	3,201		1,130	69,480	
	B	250	732	924	472	600	2,978	3,200	3,200		222	13,670	
	Mar 26 A	250	730	750	248	300	2,278	3,200	3,200		922	56,710	
	B	250	730	924	435	500	2,839	3,200	3,200		361	22,210	
	Apr 4	250	730	750	435	400	2,565	3,200	3,200		635	39,060	
1/	Apr 9	250	652	750	388	300	2,340	3,200	3,200		860	52,900	
	Apr 22	250	652	750	360	319	2,331	3,200	3,199		868	53,340	
	Apr 30	250	652	750	339	331	2,322	3,200	3,189		884	54,350	
Final Acct.	Real-time	250	652	750	283	370	2,304	3,200		3,235	930	57,200	
	Provisional 2/	250	652	750	276	362	2,290	3,200		3,235	945	58,065	5,165
2002	Mar 13 A	250	650	654	201	400	2,154	3,200	3,200		1,046	64,300	
	B	250	851	798	435	800	3,133	3,200	3,200		67	4,120	
	Mar 22 A	250	945	654	201	400	2,449	3,200	3,200		751	46,160	
	B	250	945	654	435	600	2,883	3,200	3,200		317	19,470	
	Mar 28 A	250	945	735	201	400	2,531	3,200	3,200		669	41,160	
	B	250	945	1,295	435	600	3,525	4,450	4,450		925	56,910	
	Apr 8	250	945	999	248	400	2,842	3,200	3,200		358	22,040	
1/	Apr 9	250	845	999	248	400	2,742	3,200	3,200		459	28,190	
	Apr 16	250	845	999	247	294	2,645	3,200	3,199		554	34,060	
	Apr 19	250	845	1,000	245	283	2,623	3,200	3,200		577	35,470	
	Apr 25	250	845	1,000	246	292	2,636	3,200	3,199		563	34,640	
	May 9	250	845	1,002	201	446	2,747	3,200	3,295		548	33,700	
Final Acct.	Real-time	250	848	1,002	210	434	2,744	3,200		3,298	555	34,100	
	Provisional 2/	250	852	1,002	230	424	2,757	3,200		3,301	544	33,430	5,240
2001	Mar 14 A	250	1,145	1,500	348	700	3,943	4,450	4,450		507	31,170	
	B	250	1,148	1,500	348	1,000	4,246	4,450	4,450		204	12,520	
	Mar 20 A	250	769	766	348	700	2,833	3,200	3,200		367	22,570	
	B	250	769	766	348	1,000	3,133	3,200	3,200		67	4,130	
	Mar 23	250	769	766	348	500	2,633	3,200	3,200		567	34,870	
	Apr 3 A	250	769	769	348	500	2,636	3,200	3,200		564	34,660	
	Apr 3 B	250	769	769	348	1,000	3,136	3,200	3,200		64	3,910	
	Apr 10 A	250	735	1,103	332	500	2,920	3,200	3,200		280	17,190	
	Apr 10 B	250	736	1,103	332	800	3,221	4,450	4,450		1,229	75,550	
	Apr 12	250	736	1,205	375	650	3,216	4,450	4,450		939	57,720	
1/	Apr 16	250	736	1,205	375	650	3,216	4,450	4,450		1,189	73,090	
	Apr 23	250	736	1,205	353	686	3,230	4,450	4,441		1,173	72,150	
	May 2	250	736	1,205	357	664	3,211	4,450	4,450		1,203	73,980	
	May 4	250	736	1,205	353	483	3,026	4,450	4,317		1,276	78,440	
	May 7	250	736	1,205	345	469	3,004	4,450	4,291		1,249	76,800	
	May 14	250	736	1,205	309	450	2,950	4,450	4,247		1,261	77,510	
Final Acct.	Real-time	250	736	1,205	311	417	2,918	4,450		4,224	1,276	78,470	
	Provisional 2/	250	736	1,205	350	368	2,909	4,450		4,224	1,308	78,650	5,560
2000	Mar 15	250	1,760	1,500	1,937	1,000	6,447	7,000	7,015		567	34,890	
	Mar 23	250	1,719	1,500	465	1,000	4,934	7,000	7,000		2,066	127,030	
	Mar 29	250	1,719	1,500	465	1,000	4,934	7,000	7,002		2,068	127,140	
	Apr 5	250	1,694	1,500	506	1,000	4,949	7,000	7,044		2,095	128,830	
	Apr 11	250	1,763	1,500	506	1,000	5,018	7,000	7,048		2,029	124,770	
1/	Apr 13	250	1,763	1,439	395	565	4,412	5,700	5,813		1,400	86,100	
	Apr 14	250	1,761	1,441	363	500	4,320	5,700	5,776		1,456	89,530	
	Apr 17	250	1,761	1,439	364	437	4,265	5,700	5,721		1,456	89,500	
Final Acct.	Real-time	264	1,706	1,506	375	902	4,754	5,700		5,940	1,279	78,660	
	Provisional 2/	299	1,706	1,515	496	784	4,800	5,700		5,869	1,263	77,680	-8,420

1/ Operation plan forecast prepared prior to start of VAMP approved by SJRA Management Committee.
2/ Final accounting of supplemental water contributions.

APPENDIX D-6

Summary of VAMP Flows 2000–2004

Year	VAMP Pulse Period	Target Vernalis/Export Flows	Observed Vernalis/Export Flows	VAMP Supplemental Water	Test Fish Released	Combined Differential Recovery Rate
		(cfs)	(cfs)	(acre-feet)	(effective number)	
2000	April 15–May 15	5,700/2,250	5,869/2,155	77,680	294,388	0.187
2001	April 20–May 20	4,450/1,500	4,224/1,420	78,650	336,085	0.191
2002	April 15–May 15	3,200/1,500	3,301/1,430	33,430	392,186	0.151
2003	April 15–May 15	3,200/1,500	3,235/1,446	58,065	297,266	0.019
2004	April 15–May 15	3,200/1,500	3,155/1,331	65,591	188,884	0.026

APPENDIX D-7

Head of Old River Barrier

	INSTALLATION			REMOVAL		
Year	Started	Closed	Completed	Started	Breached	Completed
1992	April 15–boat port on		April 23@4 ft April 26@6 ft May 1	Jun 2		Jun 8
1993						
1994	April 21–boat port on		April 23@10 ft May 1	May 18		May 20
1995			(a)			
1996	May 6		May 11	May 16		Sept 3 (b)
1997	April 9		April 16	May 15		May 19
1998	(a)					
1999	(a)					
2000	April 5		April 16	May 19		Jun 2
2001	April 17		April 26	May 23		May 30
2002	April 2		April 18	May 22	May 24	Jun 7
2003	April 1	April 15	April 21	May 16	May 18	Jun 3
2004	April 1	April 15	April 21			

(a) Not installed due to high San Joaquin River flows.

(b) Barrier was breached on 5/16 on an emergency basis, but complete removal wasn't done until 9/3, after Corps demanded permit compliance of complete removal.

APPENDIX D-8

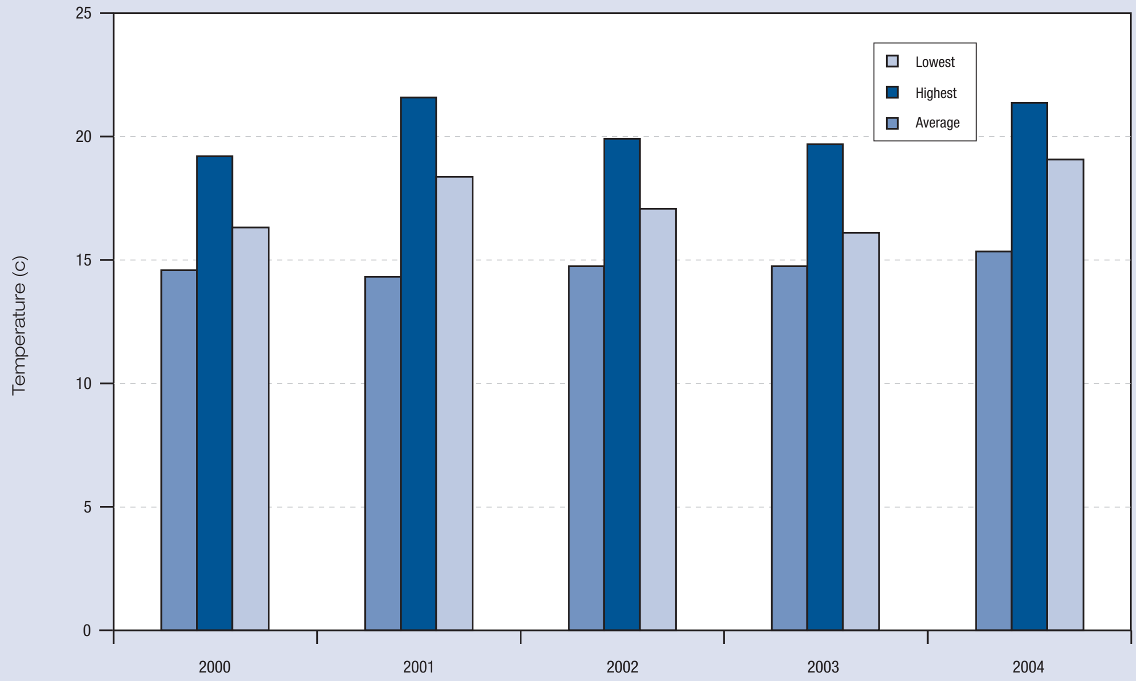
2004 Vernalis Adaptive Management Plan (VAMP)

Comparison of Water Temperatures (°C) Measured During the VAMP Sampling Period • April 16–May 16*

Year	Durham Ferry	Mossdale	Dos Reyes	DWR Monitoring Station	Confluence Top	Confluence bottom	Dwnstrm of Channel Mkr. 30	Dwnstrm of Channel Mkr. 13	Dwnstrm of Channel Mkr. 36	Jersey Point	Chipps Island	Mokelumne River	Average All Sites
2000*													
Lowest	13.07	13.32	logger	13.48	logger	13.97	14.65	15.22	15.97	logger	15.19	14.83	14.41
Highest	18.92	19.03	lost	19.04	dewatered	19.06	20.43	19.37	18.69	dewatered	18.54	18.82	19.10
Average	16.29	16.55		16.63		16.73	17.27	17.36	17.25		16.66	16.57	16.81
2001**													
Lowest	13.07	13.66	14.44	14.32	14.62	14.71	15.07	12.45	14.83	14.45	logger	no logger	14.16
Highest	21.87	22.32	21.85	22.04	22.52	21.63	23.33	22.91	21.93	21.34	lost	placed	22.17
Average	18.11	18.55	18.66	18.75	18.91	18.77	18.95	18.97	18.28	18.17			18.61
2002													
Lowest	13.08	13.33	14.21	14.21	14.39	14.79	15.22	16.18	15.70	15.35	14.41	15.35	14.69
Highest	20.05	20.15	19.79	20.27	20.33	19.91	20.99	20.52	19.38	18.70	19.03	19.84	19.91
Average	16.69	16.98	17.17	17.25	17.41	17.42	17.52	17.77	17.06	16.80	16.39	17.06	17.13
2003													
Lowest	14.31	14.67	15.43	15.07	logger	15.07	15.38	15.38	14.67	logger	13.81	13.20	14.70
Highest	21.03	20.93	20.73	21.02	dewatered	20.03	20.18	20.04	17.85	lost	17.43	17.93	19.72
Average	16.64	16.83	16.98	16.88		16.86	17.06	16.83	15.71		15.22	14.98	16.40
2004													
Lowest	14.60	14.83	15.59	15.52	logger	15.85	16.48	16.48	15.49	14.90	14.55	logger	15.43
Highest	22.01	22.09	21.89	22.32	dewatered	22.49	23.34	22.49	21.61	20.50	20.31	malfunction	21.91
Average	18.65	18.93	19.15	19.13		19.41	19.83	19.67	18.47	18.12	17.74		18.91

* 2000 Chipps Island temperature data begins April 17
** 2001 all temperature data begins April 20

D-8a. Comparison of Average Temperatures at All Sites during VAMP
April 16–May 16, 2000–2004



APPENDIX D

APPENDIX E

Errata

APPENDIX E

ERRATA FOR THE YEAR 2003 ANNUAL TECHNICAL REPORT

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

Page 44:

Survival indices using Antioch recoveries for the 06-27-44 Jersey Point group should be changed to 0.525 and the 06-27-51 group should be changed to 0.256.

Page 56:

The group survival index using Antioch recoveries should be changed for the Hatfield State Park group released on 4/16/03 to 0.031.