2003 ANNUAL TECHNICAL REPORT

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

Prepared by
San Joaquin River Group Authority

Prepared for the
California Water Resources Control Board

in compliance with D–1641

January 2004
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The San Joaquin River Agreement (SJRA) is the cornerstone of a history-making commitment to implement the State Water Resources Control Board (SWRCB) 1995 Water Quality Control Plan (WQCP) for the lower San Joaquin River and the San Francisco Bay—Delta Estuary (Bay—Delta). Using a consensus-based approach, the SJRA united a large and diverse group of agricultural, urban, environmental and governmental interests.

The 2003 Annual Technical Report comprises the consolidated annual SJRA Operations Report and Vernalis Adaptive Management Plan (VAMP) Monitoring Report. The VAMP 2003 program represents the fourth year of formal compliance with SWRCB Decision 1641 (D-1641). D-1641 requires the preparation of an annual report documenting the implementation and results of the VAMP program. Specifically, this report includes the following information on the implementation of the SJRA: the hydrologic chronicle; management of the additional SJRA water; installation, operation, and monitoring of the Head of Old River Barrier (HORB); results of the juvenile Chinook salmon smolt survival investigations; discussion of complementary investigations; and, conclusions and recommendations. Condition 4.b of D-1641 directs the Department of Water Resources (DWR) and the U.S. Bureau of Reclamation (USBR) to send the Executive Director of the State Board the results of the fishery monitoring studies on an annual basis and Condition 7 of D-1641 directs Merced, Modesto, Turlock, South San Joaquin and Oakdale irrigation districts to submit a report detailing district operations as a result of the SJRA. By letter dated September 8, 2000, the SWRCB approved combining these two reports into a single comprehensive report due the SWRCB on January 31 of each year.

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

VAMP employs an adaptive management strategy to use current knowledge of hydrology and environmental conditions to protect Chinook salmon smolt passage, while gathering information to allow more efficient protection in the future. In addition to providing improved protection for juvenile Chinook salmon emigrating from the San Joaquin River system, specific experimental objectives of VAMP 2003 included:

- Quantification of Chinook salmon smolt survival from Durham Ferry and Mossdale to 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 2003 with results from earlier survival studies where coded-wire tagged salmon releases occurred at Mossdale.

See Useful Web Pages
The VAMP 2002 Annual Technical Report presented a series of conclusions and recommended modifications to the VAMP experimental design and/or program implementation. The 2002 recommendations were used, in part, as the basis for developing the 2003 VAMP test program. For example, the 2002 report recommended weekly measurements of San Joaquin River flow at the Vernalis gage, continued hydrology investigations to estimate ungaged flows (accretions, depletions) to improve hydrologic predictions, and continued coordination among tributary operators to facilitate implementation of the VAMP test flow conditions. As part of the 2003 program, the hydrology technical committee, working in cooperation with tributary operators and USGS, was able to improve our understanding of San Joaquin River hydrology, provide measurements of Vernalis flow, and provide effective coordination of releases from upstream tributaries. The 2002 report also recommended modifications to the Head of Old River Barrier (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, measure flows within the culverts, continue monitoring to evaluate potential impacts of seepage, monitor fish entrainment at the culverts, and improve the experimental design of Head of Old River Barrier investigations. These recommendations were addressed as part of the 2003 VAMP program through delayed salmon releases at Durham Ferry and Mossdale after barrier closure, continued water level monitoring to refine the operational criteria for the culverts and evaluate potential seepage through groundwater well monitoring, and improved fisheries monitoring at the culverts to provide information on the percentage of VAMP CWT salmon released at Mossdale and Durham Ferry, in addition to unmarked salmon, subsequently entrained into the barrier culverts. The Department of Water Resources (DWR) was successful in securing all of the necessary permits and approvals for the installation of the Head of Old River Barrier over the next five years. However, landowner access remains to be negotiated annually.

A quality assurance/quality control program has been used as a routine part of VAMP tests. The 2003 CWT tagging at the Merced River Fish Facility included information useful in quantifying CWT retention and tag efficiency. During the 2003 program, coordination with the local landowner was continued to curtail operation of an agricultural diversion pump located immediately downstream of Durham Ferry, coincident with each of the two releases. In addition, the 2003 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. Additional measurements are needed of flow passing through the Head of Old River Barrier culverts and in the San Joaquin River downstream of the confluence with Old River. In the future measurements of San Joaquin River flow downstream of the Old River Barrier will be used in the relationship between San Joaquin River flow and juvenile Chinook salmon survival. Additional complimentary studies, including survival studies for juvenile Chinook salmon emigrating from San Joaquin River tributaries, were incorporated into the 2003 VAMP investigations.

The estimated survival of CWT salmon released from Durham Ferry and Mossdale was the lowest measured to date and the lowest since initiation of the VAMP. An elevated percentage of Proliferative Kidney Disease when combined with low flow conditions may have contributed to an increase in mortality but it is uncertain based on only the 2003 data. The 2002 report recommended that, to the extent possible, VAMP survival testing be conducted at flow and export extremes to improve the ability of the program to detect differences in juvenile Chinook salmon survival among target flow and export condi-
Hydrologic conditions within the San Joaquin River watershed did not provide conditions suitable for testing extreme target conditions as part of the VAMP 2003 program. These and other recommendations from the 2002 VAMP program were used to improve the overall experimental design and implementation of the 2003 VAMP investigations. Recommendations made based upon analyses of the VAMP 2003 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 2004 VAMP studies.

Based on data gathered during the experimental mark-recapture studies that occurred over a 31-day period in April and May 2003, a set of conclusions and recommendations has been developed. These conclusions and recommendations provide guidance and a foundation for design and implementation of future VAMP operations. Key conclusions and recommendations derived from VAMP 2003 include:

- **VAMP 2003** is the fourth year of full implementation of the program. Average Vernalis flow during the VAMP period was 3,235 cfs. SWP and CVP export rates averaged 1,446 cfs. The VAMP period was between April 15 and May 15, 2003.

- **Recovery rates** of the Durham Ferry and Mossdale groups relative to the Jersey Point groups using recaptures at Antioch and Chipps Island indicated that there was no statistical (p > 0.05) difference between the two replicates or release locations in 2003. The number of CWT salmon recovered from the second set of release groups, however, was lower than recoveries from the first release groups with no recoveries made for the second Durham Ferry release group at either Antioch or Chipps Island. The second set of release groups was found to have a significantly higher incidence of PKD infection, than the first set of releases.

- **The combined differential recovery rate of CWT salmon recovered** from Durham Ferry and Mossdale groups relative to the Jersey Point groups showed that the relative survival in 2003 was significantly lower than survival results from the 2002 VAMP although flow and export conditions (target flow 3200 cfs and exports of 1500 cfs in both years) were comparable for the two years. The factors contributing to the significantly lower survival in 2003 are unknown, although may be related to the combined effects of PKD infection and the lower flows.

- **The relationships between salmon survival, Vernalis flow, and SWP/CVP exports** are no longer statistically significant.

- **Streamflow data at Vernalis** were improved by weekly flow measurements and rating curve verification, however estimation of ungauged flow (accretions and depletions) requires further investigation for use in establishing annual VAMP target flows. Alternative methods of measuring flow at Vernalis and/or alternative measurement locations should also be investigated.

- **DWR installed a stage recorder and fixed acoustic Doppler velocity meter** in the San Joaquin River downstream of the confluence with Old River for use in measuring river flow. The monitoring station is being calibrated and is anticipated to be available for flow measurements associated with the VAMP 2004 studies.

- **The design, construction, and operation of the HORB were successful in 2003.** 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 assure the safety of personnel conducting fisheries sampling at the site. Operation of the HORB with three culverts open was successful in maintaining south Delta water levels.

- **The index of salmon entrainment at the HORB in 2003 with three culverts open was substantially greater then in 2001 and 2002 with all six culverts open.**

- **Construction of multiple barriers within the south Delta during the spring has the potential to delay completion of the construction of HORB, which may contribute to exposure of juvenile Chinook salmon to elevated water temperatures.** Due to the high risk of losing major salmon protection benefits and biasing experimental conditions, it is strongly recommended that construction of the HORB be completed on schedule to avoid delays in implementing survival investigations. The report also recommends that flow measurements be made to document flow through HORB culverts and the resultant flow within the San Joaquin River downstream of the confluence with Old River.

- **The variability inherent in measuring salmon smolt survival 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, conditions be tested at 7000 cfs flow and 1500 cfs export to improve ability to detect potential differences in salmon smolt survival among test conditions.
• Approximately 80 percent of the unmarked salmon migrating past Mossdale in 2003 migrated during the VAMP period (April 15 through May 15) and were, therefore protected by increased San Joaquin River flow, installation of the HORB and decreased export pumping.

• The selection and management of VAMP flow conditions should, if possible, minimize or avoid requiring upstream tributary flows that adversely affect potential habitat quality or survival of natural salmon produced within the tributaries. It is therefore recommended that upstream tributary and VAMP studies be coordinated as much as possible. Coordination during 2003 with upstream tributary operations was successful and coordination among tributary operators should continue in the future.

• The report encourages expansion of complementary studies to provide additional information on factors and mechanisms affecting salmon survival during migration from the lower San Joaquin River through the delta.

• Past data indicates that survival improves as flows increase and flows relative to exports increase. With the addition of the 2003 data the relationships between salmon survival rates and Vernalis flow and flow relative to SWP/CVP export conditions are no longer statistically significant. 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.
Actions associated with the Vernalis Adaptive Management Plan (VAMP) were implemented between April 15 and May 15, 2003 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 on the survival of marked juvenile Chinook salmon migrating through the Sacramento-San Joaquin Delta. Studies conducted in 2003, represent the fourth year of the VAMP experiment. Results from previous VAMP experiments are available in San Joaquin River Agreement 2000 Technical Report and San Joaquin River Group Authority, Technical Reports 2001 and 2002. Similar experiments were conducted prior to the official implementation of VAMP with results available in South Delta Temporary Barriers Annual Reports (DWR, 2001, 1999, 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 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. 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 and combined differential recovery rates were also calculated and used in relationships between survival and San Joaquin River flow and CVP and SWP exports.

The VAMP 2003 experimental design included both multiple release locations (Durham Ferry, Mossdale, and Jersey Point), and multiple recapture locations (Antioch, Chipps Island, SWP and CVP salvage operations, and in the ocean fisheries; Figure 1-1). Two sets of releases were made at Durham Ferry, Mossdale, and Jersey Point. The use of data from multiple release and recapture locations allows for a more thorough evaluation of juvenile Chinook salmon survival as compared to recapture data from only one sampling location and/or one series of releases. The VAMP coded-wire tag (CWT) releases (Durham Ferry, Mossdale, and Jersey Point) and recapture locations (Antioch and Chipps Island) 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). 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.

The added recovery numbers from recapturing marked fish at both Antioch and Chipps Island improves the precision associated with the individual survival estimates, and improves confidence in detecting differences in salmon smolt survival as a function of Vernalis flows and SWP/CVP exports.
A quality assurance/quality control program has been used as a routine part of VAMP tests, 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 each of the two Durham Ferry releases was continued in 2003. In addition, the 2003 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. Additional improvements are needed relative to measuring and reporting flow in San Joaquin River downstream of the confluence with Old River. Measurements of San Joaquin River flow downstream of the HORB will be used to evaluate the relationship between San Joaquin River flow and juvenile Chinook salmon survival in the future.

**Figure 1-1**
Sacramento—San Joaquin Estuary

Location of VAMP 2003
Release Sites (Durham Ferry, Mossdale and Jersey Point), Recovery Locations (Antioch and Chipps Island), and Head of Old River Barrier Location Within the Sacramento-San Joaquin River Delta/Estuary.