STATE OF CALIFORNIA – THE RESOURCES AGENCY

ARNOLD SCHWARZENEGGER, *Governor*

DEPARTMENT OF WATER RESOURCES
1416 NINTH STREET, P.O. BOX 942836
SACRAMENTO, CA 94236-0001
(916) 653-5791

January 8, 2007

Gita Kapahi, Chief
Bay Delta/Special Projects Unit
State Water Resources Control Board
P.O. Box 2000
Sacramento, CA 95812-2000

Via hand delivery to Division of Water Rights and electronic mail

Subject: Southern Delta Salinity Workshop

Dear Ms. Kapahi,

Please find enclosed 10 copies of the Department of Water Resources' final Comments to the State Water Resources Control Board Regarding Information on the Southern Delta Agricultural Salinity Objectives for the public workshop on January 16. The draft comments that DWR submitted to the Board on January 5 should be replaced with the enclosed comments. DWR has also submitted these documents to the State Water Board in electronic format to gwilson@waterboards.ca.gov.

Please contact Mark Holderman of the DWR Bay-Delta Office at (916) 653-7429 (email at markho@water.ca.gov), or me at (916) 653-5613 (email at crothers@water.ca.gov) if you have any questions regarding the comments.

Sincerely,

Cathy Crothers

Cathy Crothers
Senior Staff Counsel

Enclosures

Department of Water Resources Comments to the State Water Resources Control Board Regarding Information On the Southern Delta Agricultural Salinity Objectives and Program of Implementation

Table of Contents

Department of Water Resources Comments to the State Water Resources Control Board Regarding Information On the Southern Delta Agricultural Salinity Objectives and Program of Implementation

The State Water Resources Control Board (State Water Board) has asked for detailed information regarding the southern delta agricultural salinity objective in the Bay-Delta Water Quality Control Plan (WQCP).[1] In 1978, the State Water Board adopted the southern delta agricultural salinity objectives and the three compliance locations based on environmental conditions, crops, and irrigation practices at that time. In 2004, the State Water Board conducted a workshop on the salinity objective that provided information supporting a need to have additional review on the sources, concentrations, loads, effects, and methods of control of salinity in the southern Delta. At this 2007 workshop, the State Board requests that participants focus on the salinity objective, its corresponding program of implementation and provide information to evaluate whether additional studies should be undertaken that could support an amendment to the WQCP.

As requested in the October 13, 2006 Notice, the Department of Water Resources' (DWR) presentation will include information on the following:

- spatial and temporal variability of salinity in the southern Delta channels, at the three compliance points, and the salinity sources
- spatial and temporal variability of irrigation practices and cropping patterns
- actions to control salinity and effects of these actions
- reasonableness of existing salinity objectives
- recommendations for studies to obtain information needed to support possible changes to the WQCP.

At this time, DWR's presentation may not address all the questions that the State Water Board and its staff may have of DWR. Some of DWR's information may be considered as preliminary or as background on certain issues. In addition, DWR expects that the Board may request more information as a result of the workshops and meetings. Therefore, DWR intends to continue working, in cooperation with the Water Board and other parties, to provide any additional information the Board may need.

In review of information regarding the water quality objectives in the southern Delta, the State Water Board should consider what, in its judgment, is required to "ensure the reasonable protection of beneficial uses." (Water Code Section 13241). In addition, when reviewing information that would support a revised objective that is "reasonably protective" of the use, the State Water Board must consider information regarding:

[1] The Notice identifies the current plan as the 1995 WQCP. However, in December 2006 the Board adopted a 2006 WQCP replacing the 1995 WQCP. The southern Delta salinity objective was not changed in the 2006 WQCP, although some minor changes were made to the program of implementation. DWR comments apply to the 2006 WQCP.

- Past, present and probable future beneficial uses of water.
- Environmental characteristics of the hydrographic unit under consideration, including the quality of water available thereto.
- Water quality conditions that could reasonably be achieved through the coordinated control of all factors that affect water quality in the area.
- Economic considerations.

(Wat. Code Section 13241.).

During the upcoming workshops and any subsequent workshops and meetings, DWR looks forward to reviewing and discussing information provided by all the interested parties that may help the State Water Board determine a reasonable method of protection for southern Delta agriculture based on the above criteria.

DWR's comments include; A. Background on Development of Agricultural Salinity Objectives, and B. Specific Information on the following topic:

1. Overview of the Delta, SWP and CVP Facilities
2. Historic Salinity levels in the Southern Delta.
3. Salinity Variation
4. Effects on salinity from SWP and CVP operations as shown by historical data and modeling.
5. Monitoring Data and Maps of In-delta Discharges
6. Cropping patterns and irrigation intakes in the southern delta
7. Effects of the Temporary Barrier Program and the Proposed Permanent Operable Gates
8. Summary of information needed for further evaluation of south Delta objectives and methods of implementation
9. Scope of Work and funding for studies to determine reasonable water quality objectives and methods of implementation
10. Recommendations on changes to Program of Implementation.

A. Background on Development of Agricultural Salinity Objectives

About thirty years ago, during hearings to develop the 1978 Water Quality Control Plan and Decision 1485, parties presented information on irrigation needs of agricultural lands in the southern Delta. The objectives then established were based on the University of California "Guidelines for the Interpretation of Water Quality for Agriculture" (U.C. Guidelines). (1978 WQCP, at VI-19.) In the 1978 WQCP the State Water Board noted that "ongoing research by the U.C. Cooperative Extension in the southern Delta may produce information which will show a need for future revision of these water quality criteria." (Id.) Table VI-1 of the 1978 WQCP provided values for the southern Delta agricultural objectives of 0.7 mmhos/cm during April through August and 1.0 mmhos/cm from September through March, measured as a 30-day running average of mean daily electrical conductivity (EC). The Plan also indicated that the values were to become effective "only upon the completion of suitable circulation and water supply facilities." (1978 WQCP at VI-29.)

After litigation regarding D-1485, the State Water Board held workshops and hearings to prepare a new water quality control plan and water right decision. A Southern Delta Agriculture Work Group was formed to evaluate the irrigation water quality requirements for agriculture in the South Delta (See SDWA presentation at March 2005 Workshop, SDWA Exhibit No. 103 prepared for 1987 State Water Board water right hearings.). On January 4, 1982, the Committee submitted a final report, authored by Hoffman, Prichard and Meyer, to the State Water Board and interested parties. The report reviewed south Delta soil types, permeability of those soils, and water quality requirements for various crops grown in the area. The report provides data and graphs of water quality (in EC and mg/l of salt) applied to certain crops and the effects of leaching on crop yields. In general, the report shows that for a greater total amount of water passing, or leaching, through the crop root zone (the leaching fraction), crop yield can be maintained with a higher salt concentration in the applied irrigation water. (Hoffman, Prichard, and Meyer, "Water Quality Considerations for the South Delta Water Agency," Jan. 4, 1982, Figures 1 and 2.) The Committee report noted that some crops may be more sensitive during emergence than during later stages of growth. (Id. at 4.) The Committee made no recommendation as to an appropriate water quality value for the South Delta. It concluded that the "biggest uncertainty in this information is the leaching fractions which can reasonably be achieved for the various combinations of soils, crops, and management options suitable for the South Delta." (Id. at 10.) The Committee recommended "that the concerned parties sponsor a more extensive field study of the leaching fractions being achieved in the South Delta." At the time, the cost of the study was estimated at $15,000 and would require several months of work. (Id.) In the 1991 and 1995 WQCPs, the State Water Board made no changes to the southern Delta agricultural objectives.[2]

Although there have been recommendations over the years to investigate the relationship of leaching, applied water quality, and crop production in the southern Delta, such an investigation has not been done. Instead, the State Water Board, DWR, U.S. Bureau of Reclamation, and South Delta Water Agency (SDWA) have been relying on a physical solution of permanent operable gates installed in three channels of the southern Delta. The parties have studied this solution and agree that operable gates in the South Delta would improve circulation, water levels and water quality for agricultural uses. The gate program has been the preferred solution and there has not been an assessment of other methods that could help implement the objectives for protecting agricultural uses. Although the permanent gates may continue to be the preferred method of implementing the southern Delta agricultural objectives, information provided to the State Water Board during the Decision 1641 water rights hearings showed that the gates will not effectively control salinity under dry conditions of some years and will not have significant effect on water quality at the Brandt Bridge compliance location. Therefore, the State Water Board should consider including in the WQCP and its Program of Implementation additional methods other than the operable gates to achieve the objectives.

B. Specific Information

Below is a summary of the information that DWR has at this time to present to the State Water Board on southern Delta salinity. DWR anticipates that additional information will be developed and will be presented at subsequent workshops.

[2] In the 1991 WQCP, the State Water Board adopted the same southern Delta objectives because members of the Agricultural Workgroup did not reach consensus on a recommendation for revised objectives. (1991 WQCP at 5-12; 1991 WQCP Table 6-3 at 4.) In the 1995 WQCP, the Board did not revisit issues related to the southern Delta agricultural objectives, instead it focused on fish and wildlife issues, although it did extend the deadline for the effective date to December 31, 1997. (1995 WQCP at 2; 1995 WQCP Table 2 at 17.)

1. Overview of the Delta, SWP and CVP Facilities

Many water projects have been developed in the watershed of the Sacramento-San Joaquin Delta/San Francisco Bay. The two largest projects are the federally-owned Central Valley Project (CVP) and the state-owned State Water Project (SWP). Both projects have multiple purposes, but their chief purpose is to store excess runoff which occurs during the wet season and divert it to municipal and agricultural water agencies throughout California.

The CVP has three main storage facilities on tributaries north of the Delta. The principal storage facility is Lake Shasta on the Sacramento River north of Redding. The other storage facilities are Trinity Lake on the Trinity River and Folsom Lake on the American River. The main storage facilities on tributaries south of the Delta are New Melones Reservoir on the Stanislaus River and Millerton Lake on the San Joaquin River. The SWP has one main storage facility, Lake Oroville on the Feather River, north of the Delta. The projects jointly own and operate an off- stream storage facility called San Luis Reservoir for storage on the west side of the San Joaquin Valley. Both projects have major diversion facilities in the south Delta, the CVP's Tracy Pumping Plant and the SWP's Clifton Court Forebay/Banks Pumping Plant. The SWP has no on-stream storage facilities on the San Joaquin River System,

Both the SWP and CVP divert water from the Delta to serve the majority of their contracts with California water agencies located south of the Delta and the city of Tracy. The CVP's Tracy Pumping Plant has an estimated capacity of about 4,600 cubic feet per second (cfs) and it pumps directly from the Delta's southern waterways into the Delta-Mendota Canal (DMC). The SWP's Clifton Court Forebay/Banks Pumping Plant is operated in a different manner. Water is diverted from the Delta through five large operable radial gates at the entrance to the Forebay. The gates are open when water levels inside the Forebay are lower than those outside of the gates (typically during the high tide) and closed when water levels are lower outside of the Forebay (typically during low tides). Water stored in the Forebay is then pumped at Banks Pumping Plant which has a permitted capacity of 10,300 cfs into the California Aqueduct.

The diversion into the Forebay is generally limited to 6680 cfs over a three-day period. It may be increased above this limit by 500 cfs during July through September to transfer water for fishery purposes and from mid-December through mid-March when it can be increased by one-third of the flow amount of the San Joaquin River if that flow exceeds 1000 cfs. SWP diversions are usually minimized during low tide periods. CVP diversions are taken during both high and low tide periods. Because of the Forebay operations, the SWP diversions have less of an effect on south Delta low tide water levels than those of the CVP.

The service areas for both projects include water agencies located north of the Delta and south of the Delta. Many of the north-of-Delta contractors have pre-project rights to water and have negotiated settlement contracts that provide equivalent water supplies. Both projects also deliver the majority of their water supplies to south-of-Delta water agencies. The south-of-Delta service areas of both water projects are a combination of municipal/industrial water agencies and agricultural irrigation agencies. The CVP's south–of-Delta contractors are dominantly agricultural agencies, while the majority of the SWP's south-of-Delta contractors are municipal/industrial agencies. Many of the CVP contractors in the San Joaquin River Valley have surface or subsurface agricultural drainage that reaches the San Joaquin River either directly or indirectly. Oak Flat Water District with a relatively small contracted amount of 5,700 acre-feet per year is the only SWP water agency whose agricultural drainage flows into the San Joaquin River.

The CVP and SWP are operated in close coordination pursuant to the 1986 Coordinated Operations Agreement that spells out how the projects share water released from each project's storage facilities and excess waters which originate within the Delta's watershed. Joint point of diversion (JPOD) is the term which describes either projects ability to share in the use of Delta diversion facilities at Tracy and Banks Pumping Plants. The use of JPOD is dependent on the availability of unused or excess pumping capacity at a project's diversion facility by the project owning the facility. Because Banks Pumping Plant has a higher maximum pumping capability than the Tracy Pumping Plant, it is much more common for the CVP to use some of Banks capacity than it is for the SWP to use some of Tracy's capacity. The use of JPOD can be used to minimize the entrainment of fish if larger amounts of fish are being taken at one facility as opposed to the other facility.

One concept advocated by various interests over the last several years is to increase flow in the San Joaquin River at Vernalis through "recirculation" Recirculation, as defined herein, is the concept of diverting water at project Delta diversion facilities that is then released either simultaneously or, at some future time, into the San Joaquin River to augment existing San Joaquin River flows. The water could be released to the river via the CVP's Westley or Newman Wasteway. This water could be water stored in San Luis Reservoir or pumped from the Delta and released directly from the CVP's Delta-Mendota Canal.

2. Historic Salinity Levels in the Southern Delta[3]

Data on historic salinity levels in the southern Delta is fairly limited. Some data is available from the Sacramento-San Joaquin Water Supervisor Reports, and Bulletin 27, Variation and Control of Salinity in Sacramento-San Joaquin Delta and Upper San Francisco Bay, 1931 published by the Division of Water Resources (predecessor to the Department of Water Resources). The table in Appendix A attached to these Comments provides some of the data from these reports at various Delta stations. The first extensive investigation of Delta salinity was initiated in 1920 following the dry years of 1917 and 1919 which, combined with increased upstream diversion as a result of increased agricultural development, resulted in upstream invasion of salinity of a greater extent and magnitude than ever previously recorded (Bulletin 27, p. 22). Figure 1 below developed from Sacramento-San Joaquin Water Supervisor Reports shows the maximum seasonal salinity encroachment of 1000 ppm chlorine (about 3 to 4 times the current agricultural objective in the South Delta) during dry and critical years from 1920 through 1943 prior to the development of the Shasta and Friant elements of the Central Valley Project (1945) and State Water Project Delta pumping (1967). Available records show some level of degradation due to salinity in the southern Delta in certain critical years prior to the development of the projects. In addition, available flow reaching the Delta was insufficient to meet the consumptive use demands within the Delta. Crop losses in the Delta in 1931 from both saline irrigation water and lack of supply far exceeded those seen in any year since the development of the CVP or SWP, including those in the driest year of record, 1977. (DWR Bulletin 132-89, Appendix E, p xiii). Evidence of salinity intrusion and significant crop losses in critical years prior to development of the projects supports the consideration of flexible southern Delta salinity objectives during drier year types, as has been developed for other water quality objectives at other locations within the Delta.

[3] This report includes many different measures of salinity. Ocean salinity is about 35,000 pmm Total Dissolved Solids (TDS). A dominant ion in sea water is the chloride ion . Chloride in sea water is about 19,400 ppm. During the early 1900's a measure of ocean salinity was 1000 ppm which is about 5% seawater. More recently salinity in the Delta is measured in terms of Electrical Conductivity. This can be expressed as either mmhos/cm or µSiemens/cm (µS/cm). 1000 µS/cm is 1.0 mmhos/cm and 700 µS/cm is 0.7 mmhos/cm. The water quality objectives are expressed in mmhos/cm or mS/cm while many of the measurements are taken in µS/cm. 1000 ppm Chloride is about 2.8 mmhos/cm.

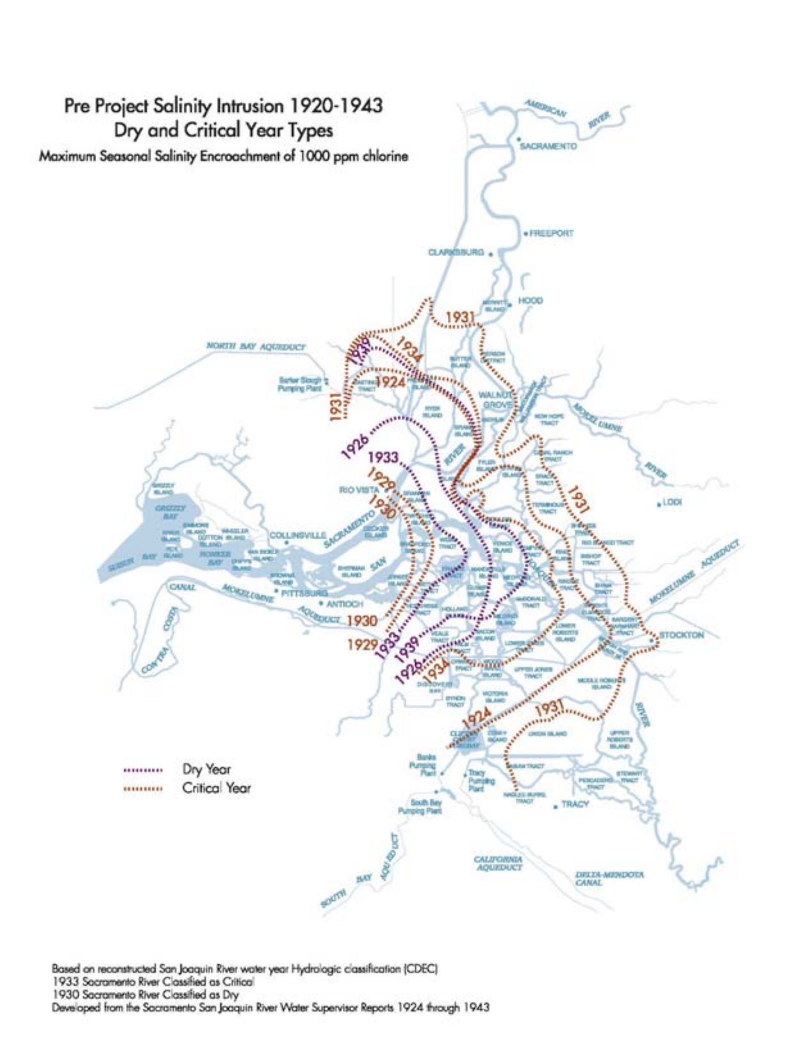

Figure 1. Historical Salinity Intrusion in Dry and Critical Year Types)

3. Salinity Variation

Salinity in the south Delta varies greatly dependent on the location, basin hydrology, tidal influences and inflows per diversions within the localized area. The principal inflow into the south Delta comes from the San Joaquin River at Vernalis. Water flowing from the northern part of the Delta is also conveyed into the south Delta by the Mokelumne River and flow through the CVP's Delta Cross Channel. Other, smaller tributaries also carry water into the south Delta region. The diversions in the south Delta include about 130 privately-owned agricultural diversions for irrigation of farmland, the CVP and SWP diversion facilities and the diversions by the Contra Costa Water District at Rock Slough and the intake to Los Vaqueros Reservoir. If the sum of diversions in the south Delta is greater than the inflow to the south Delta, the remaining flow is provided by the mixture of both fresh and salt water on the lower San Joaquin River near Jersey Point.

Therefore, predicting the salinity at any given location and time in the south Delta is very complicated because of the mixture of out-of basin land derived salts, local in-basin agricultural drainage return flows and ocean salts.

Salinities in the south Delta generally range from about 100 mmhos/cm EC (or 0.1 mmhos/cm EC) (virtually freshwater levels) to 1100 mmhos/cm EC (or 1.1 mmhos/cm EC). Salinities vary within the four south Delta locations or stations (e.g. Vernalis, Brandt Bridge, Old River near Middle River and Old River near Tracy Road Bridge) plus or minus 200-300 mmhos/cm EC. These differences reflect the direct impact that local drainage returns can has on one or more of the south Delta stations.. DWR Modeling described below provides some understanding of the effects of various sources of salinity on water quality in the south Delta.

Currently, compared to historical pre-CVP and SWP operations, southern Delta salinities are usually higher in the late fall and winter months and lower in the spring and summer months, reflecting both the natural occurrence of freshwater runoff from the melting snowpack as well as the overlying standards for fish protection (e.g. X2 and VAMP) and the requirements for lower salinity during the irrigation season, which are currently set at 700 mmhos/cm EC from April through August.

4. Effects on Salinity from SWP and CVP Operations Shown by Modeling

The Delta is a complex system and water quality can be affected very differently at different locations. To illustrate, the three water quality stations in the South Delta are affected by different influences than those stations in the Western Delta. For stations in the western Delta, water quality can be controlled by releasing fresher Sacramento flow or reducing exports. The reason is primarily because these stations are located downstream of the flows and the exports, and will respond to the changes in the system. By increasing the flow or reducing the exports, less ocean salinity makes its way into the Delta. In the South Delta, the natural flow, without exports, is the flow from the San Joaquin River making its way towards the ocean through the San Joaquin, Old and Middle Rivers. The agricultural water quality stations are upstream of Exports and do not naturally receive water from the Sacramento River. Exports pull water that contain a mixture of different sources of water, including the usually fresher Sacramento River, upstream towards the South Delta area but the exports are still downstream of the South Delta Water Quality locations and cannot control the salinity at those South Delta upstream stations. Some water can be “moved” upstream into the south Delta area by the use of the temporary agricultural barriers that work with the tides; however the water from the Sacramento side, during the majority of time is not transported far enough upstream to affect the three locations. Some improved movement upstream is achieved with the addition of the barrier in Old River where it diverges from the San Joaquin River (Head of Old River) and much greater circulation upstream can be provided with the permanent gates but with both the temporary barriers and the permanent gates, Brandt Bridge is not affected.

Historical and modified historical Delta Simulation Model 2 (DSM2) simulations were made to demonstrate how water quality is affected in the south Delta. Some of that work was presented in Exhibit 20 at the 2005 Cease and Desist Hearings and additional analysis is presented in the attached Appendix C of these comments. The work presented for the Cease and Desist hearings investigated the following areas:

- Degradation of water quality from Vernalis to Brandt Bridge (using observed data).
- Long term (1991 – 2005) historical simulation of flows and water quality in the Delta
- Long term (1991-2005) modified historical simulations, reduction and increase of State Water Project exports by 500 cfs (with barriers)
- Shorter term (2002, 2003) modified historical simulations, with a total elimination of State Water Project exports (with barriers)

These studies showed that the exports could affect, but could not control the water quality at the three agricultural objectives locations. When affected, the water quality sometimes improved and sometimes degraded with the reduction of exports. Of the three stations, Old River at Tracy was the only station that showed any significant effect.

The work presented in the Appendix C of these Comments focuses on the following areas:

- 2002 Historical DSM2 Simulation of flows and water quality in the south Delta
- 2002 modified historical simulations with no SWP exports from Jan – Aug and no South Delta Barriers installed
- 2002 modified historical simulations with no SWP and no CVP pumping from January through August and no South Delta Barriers installed
- Historical 2002 conditions with an additional 5000 cfs flow in the Sacramento River from April – August (decreasing Oroville down to minimum level by August)

These simulations validate the previous understanding of the system and provide additional information on the circulation in the South Delta with and without temporary barriers. The additional Sacramento flow does not significantly affect the water quality at the three locations and the elimination of exports demonstrates the natural flow pattern of the San Joaquin River through the Delta. Details on the modeling and the resulting data is provided in Appendix C.

To further illustrate how operations affect the salinity in the south Delta, particle tracking simulations were completed and animations of flow movement were made to aid in providing a better understanding. A description of the studies is provided in the following paragraphs and a link to our web site where you can download and view the animations is: ftp://ftpmodeling.water.ca.gov/pub/sdelta/SWRCB/. Copies on CD are available upon request.

PTM (Particle Tracking Model) Animations For South Delta Analysis. A set of four PTM animations have been assembled to show whether any changes in State operations (Sacramento River flow and/or pumping) or in CVP pumping affect the water quality in South Delta. In each PTM animation, two maps of the Delta are shown side by side. On the right side, the particles are released in San Joaquin River, and on the left side, the particles are released in Sacramento River. The particles basically represent the movement of the water in the two major rivers. The purpose of these animations is to increase the understanding of the mixing of water sources that take place in South Delta. All four animations are recorded in AVI format, and can be viewed via Windows Media Player, available on all Windows based Computers.

Table 1 has a summary of assumptions reflected in each scenario. The hydrology assumed in each scenario is generic, and does not represent an actual historical event. The Delta Cross Channel Gate and the barrier at the head of Old River (HOR Barrier) are assumed to be open for all four scenarios.

Table 1. Summary of Modeling Assumptions

PTM Animation	South Delta Gates	Sacramento River flow(cfs)	San Joaquin River flow (cfs)	SWP pumping (cfs)	CVP Pumping (cfs)
1	Temporary	15,000	1,500	6,680	4,600
2	Temporary	15,000	1,500	1,500	1,000
3	Temporary	20,000	1,500	0	0
4	Permanent	15,000	1,500	3,000	3,000

PTM Animation 1 (High Pumping). In this scenario, it is clearly shown that a big fraction of particles released in Sacramento River travel south toward the pumps, however, very few particles make it upstream of the temporary barriers to help dilute the water in the South Delta region. Based on the PTM animation, 0.5% of the particles released in Sacramento River make it upstream of the temporary barriers. To put that in perspective, this roughly means that under the conditions simulated, about 0.5% of Sacramento River flow (about 75 cfs) makes it upstream of the temporary barriers. This amount is clearly not enough to provide the dilution required at times when water quality in South Delta is poor. Basically, the particles in the South Delta region including main-stem of San Joaquin River are predominantly the ones which were released in San Joaquin River.

PTM Animation 2 (Low Pumping). In this scenario, pumping (both SWP and CVP) was curtailed dramatically. As expected, a much smaller fraction of Sacramento River particles reach the pumps, and in fact it takes them longer to reach there. However, similar to the first animation, few Sacramento River particles make it past the temporary barriers, to help dilute the water in the South Delta Region. Based on the PTM animation, 0.4% of the particles released in Sacramento River make it upstream of the temporary barriers.

PTM Animation 3 (Zero Pumping+Increase Sacramento River Flow by 5000 cfs). In this scenario, both pumps are turned off completely, and Sacramento River flow is increased by 5000 cfs. Again as expected, very few particles make it to South Delta. In fact, 0% of the particles released in Sacramento River make it upstream of the temporary barriers. The most noticeable difference here is that a bigger portion of the Delta is affected by the San Joaquin River.

The following are a few observations based on the results of the first three animations:

- The South Delta area (San Joaquin River to Turner Cut, and the area west of head of Old River extended to the temporary barriers) is predominantly affected by San Joaquin River.
- Reduction in pumping (CVP or SWP) or increasing Sacramento River flow has little influence on providing dilution in South Delta area (upstream of the barriers).
- In general, increasing pumping tends to bring a bigger portion of Sacramento River flow toward South. Although, it is not directly shown in the animations, one can conclude that assuming there is no salinity intrusion from the ocean, the water quality in the South (Downstream of the barriers) will usually be improved with increased pumping.

Based on the above observations, one can draw a general conclusion that the portion of the South Delta Shown in Figure 2 is predominantly dominated by San Joaquin River[4].

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[4] The Zone of influence(s) shown in the temporary barriers figure located in the main text are slightly different than the ones in Appendix C – due to different hydrology and different methods of assessing the zone. The main text's figure is a more general figure taken from where the particles moved to in the animation. Appendix C looked at several fingerprinting results at several locations and detailed contour lines were drawn showing the percentage of SJR water at the locations in the south Delta.

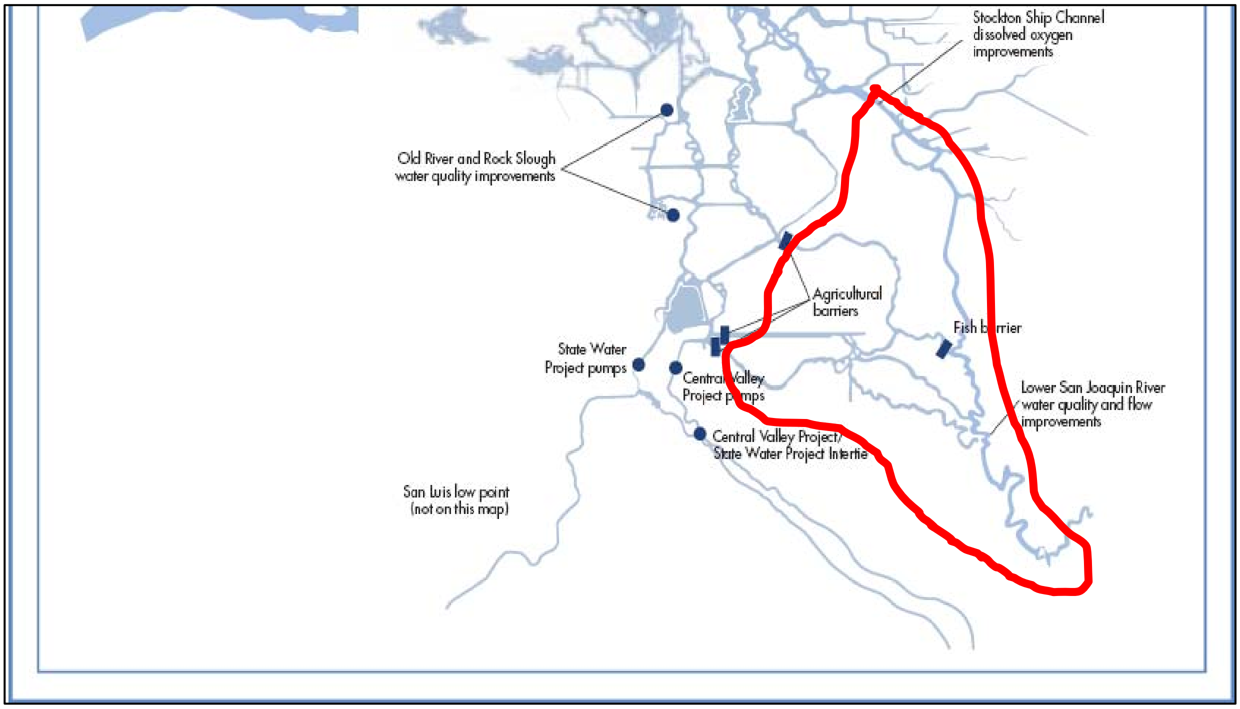


Figure 2. Zone of San Joaquin River Dominance Under Temporary Barriers

PTM Animation 4 (Medium Pumping + Permanent Gates). In this scenario, the temporary barriers are replaced with permanent gates, and a portion of Middle River is dredged (as described in the EIR/EIS for the South Delta Improvements Program (SDIP)). It is assumed that the gates operate according to "Modified Plan C" operation, consistent with the SDIP EIR/EIS studies. Basically, it is assumed that all the three gates are open during flood tide. During the ebb tide, the gates on Middle River and Old River are closed, forcing the water to circulate around and return toward the pumps via Grant Line Canal. These gates rely on the tidal energy to circulate a portion of the better quality water originating from Sacramento River water in the interior South Delta. This PTM animation illustrates the mechanics of how the permanent gates can be used to improve water quality in the interior South Delta. Based on this animation, 1.4% of the particles released in Sacramento River make it to the upstream of the permanent gate. This is about 1% higher than the amount corresponding to temporary barriers, which under the conditions simulated, translates to about 150 cfs of additional dilution provided for the interior South Delta. It should be noted that none of the particles released in Sacramento River made it to the main-stem of San Joaquin River (upstream of Turner Cut), illustrating that permanent gates will have little influence in solving the water quality problems at Brandt Bridge.

Based on the results from this animation, it can be concluded permanent gates have the potential to improve water quality in the interior South Delta, thus reducing the area of the South Delta that is predominantly affected by San Joaquin River, as shown in Figure 3.

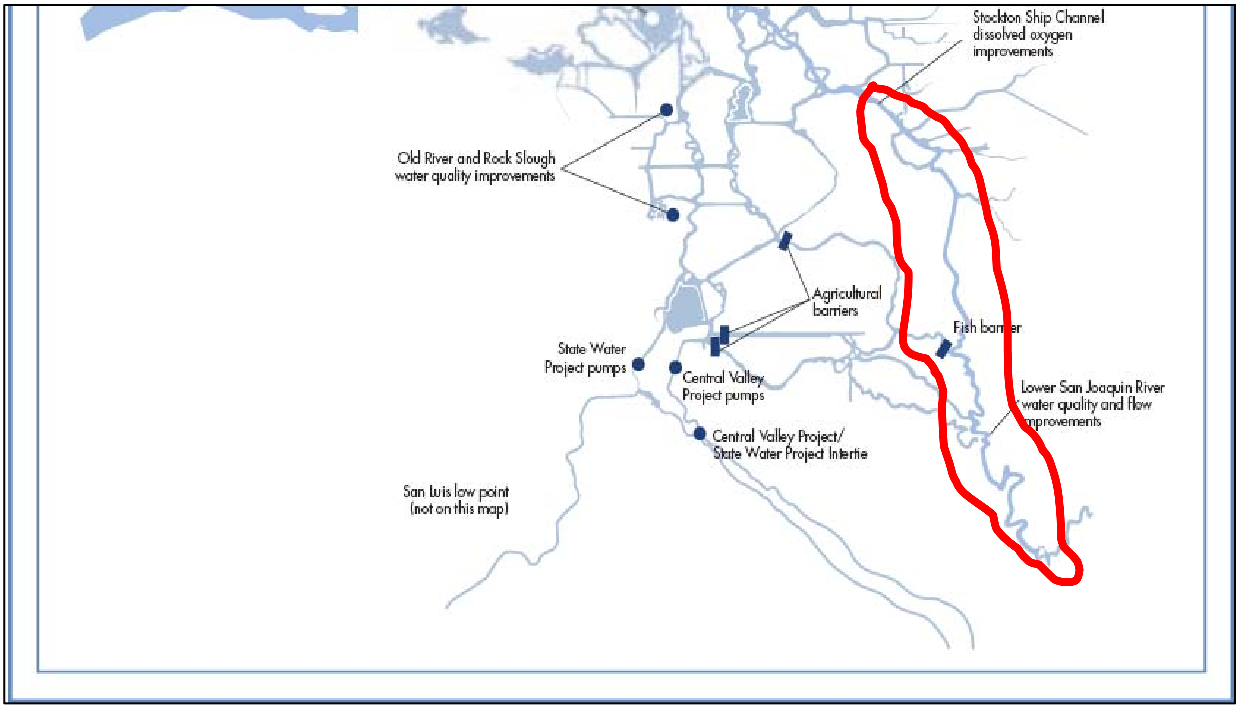


Figure 3. Zone of San Joaquin River Dominance Under Permanent Gates

5. Monitoring Data and Maps of In-delta Discharges

Monitoring Data and New Locations of Monitoring Stations

Beginning in the spring of 2006, the Department of Water Resources began installing additional EC gages in the south Delta. The new EC stations are not telemetered to CDEC yet, but the data are downloaded periodically. Evaluation of the information we obtain from the additional gaging is expected to identify areas where significant degradation is occurring. The Figure 4 below shows the location of existing and proposed EC gaging.

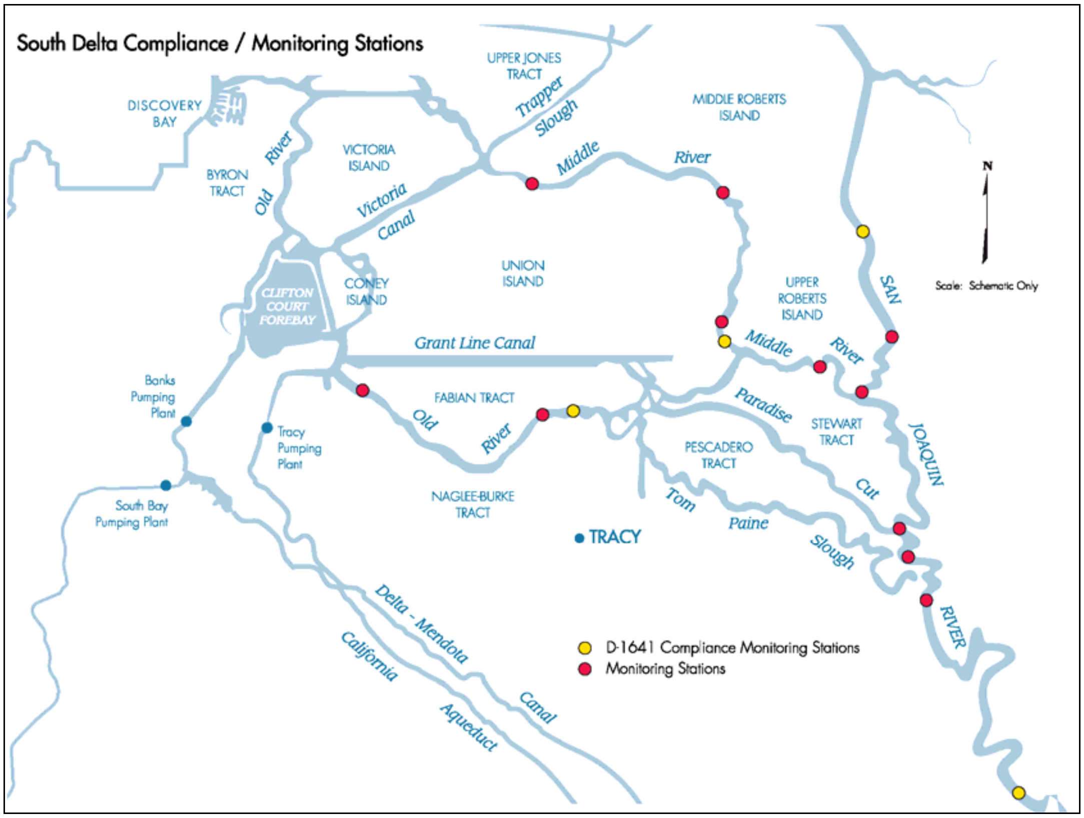


Figure 4. South Delta Compliance and Monitoring Sites

In-Delta Discharges

Local discharges from agricultural, municipal and industrial uses affect water quality available to the southern Delta. DWR has provided below some information on the salinity and flows from local discharges but more information is needed. DWR recommends that the SWRCB include as an element of its proposed salinity study an investigation of the contribution of municipal and irrigation discharges to the degradation of southern Delta water quality.

DWR's Environmental Assessment Branch has investigated sources of salinity in the southern Delta. The DWR report "Sources of Salinity in the South Sacramento-San Joaquin Delta" will be available in draft form prior to the January 16, 2007, SWRCB workshop on the southern delta water quality objective. DWR intends to submit a draft report to the SWRCB prior to the workshop. This investigation has identified approximately 74 discharge sites on waterways flowing to the State and federal export sites in the south Sacramento-San Joaquin Delta (Delta). Most are agricultural followed by treated sewage, urban runoff, and groundwater effluence. The waterways include south Old River, Grant Line Canal and the San Joaquin River between Vernalis and the head of Old River. The discharges are relatively saline and appear to be cumulatively raising the salinity of water approaching the export sites via these waterways. The report characterizes the discharges and their potential contribution to salinity between Vernalis and the export sites.

An upstream/downstream comparison of salinity was made between Vernalis on the San Joaquin River and Old River at Tracy Boulevard Bridge. Monthly average conductivity was consistently highest at the Old River station with the exception of a few relatively short duration periods. Differences in conductivity between stations were highest between April and November.

During this 8-month period, conductivity at the Old River station was often 100 to 185 µS/cm (median values) higher than at Vernalis. A similar comparison between the Vernalis and Grant Line Canal stations also showed increases, but to a lesser degree.

A number of factors have been provided to explain why conductivity consistently increases between the Vernalis and Old River stations. However, the sheer number of diversions and saline discharges situated between these two stations provides strong rational for causative effects. The Old River station appears to be especially influenced by saline outflows from Tom Payne Slough and possibly Paradise Cut as well as saline groundwater effluence to several urban/agricultural drainage channels. This is evidenced by a statistically higher conductivity in Old River versus Grant Line Canal during most of the year. Further, the intake of the Old River station appears to be located in the plume of a nearby saline discharge or discharges.

Agricultural Discharges. This section describes the potential contribution of agricultural drainage to the degradation of water quality throughout the Delta. Agricultural drainage is runoff water from agricultural fields. In different Delta areas, the drainage has different origins. Not only is the source water different, agricultural drainage quality is dependant on the soil types and the depth of the soil from which the drainage water is captured. Water quality of runoff water affects the water quality of Delta channels. In this way, discharges from farmers can affect water quality necessary for other farmers. At Figure 5 is a map showing agricultural discharge locations in the south Delta. This map is based on surveys done by DWR in 1999.

The following data is from two primary sources: the Central Valley Regional Water Board Agricultural Discharge Waiver Monitoring Program and the New Jerusalem Drain (NJD) automated monitoring station on California Data Exchange Center (CDEC). Figure 6 is a map showing the locations of the many sample sites referred to in this paper. Appendix D contains the data and charts from the Waiver monitoring program and Appendix E is a chart of the New Jerusalem Drainage CDEC data.

Data is limited in quantity and history. Some sites have very few reported sampling events. Because the agricultural waiver program is still rather new, the oldest data under this program dates back to 2003. Because both 2005 and 2006 water years were above normal, the water quality data from agricultural discharges is likely skewed in the lower Electrical Conductivity (EC) range compared to a longer history with drier year types.

In the more interior portions of the Delta, many of the islands are below mean sea level. Consequently, many of the fields have drain canals that serve to drain water below the root zone to prevent water logging of the roots. Water from these drain canals contain the salts in the irrigation water the plants will not use. Drainage canals from peat soils also contain organic material from the soils.

In upland areas and areas to the east of the San Joaquin River, agricultural runoff is predominantly surface water runoff and is not associated with dewatering root zones.

Because of the sporadic nature of the sampling, it is difficult to determine any specific trends across the Delta. Sampling is done for a year or two and is then stopped. Another drain nearby is then sampled, again, for a year or two. Even within any sampling period, it is rare to see data over a majority of months throughout the year, so an annual trend can not be discerned. No sampling of drainage water is reported in the problem areas of the south Delta, such as in Old River near Tracy Road Bridge, or near compliance stations for State Water Resources Control Board Decision 1641.

It is fairly clear that upland areas served by water coming from the eastern side do not contribute to any excursions above salinity goals within the Delta. And it is fairly clear that west side drains downstream of Vernalis and upstream of Old River have significant potential to degrade south Delta water quality.

If sampling were to stabilize, a pattern in south delta drains may show that leaching of agricultural lands occurs during the winter months which can contribute to excursions above salinity goals within the south Delta.

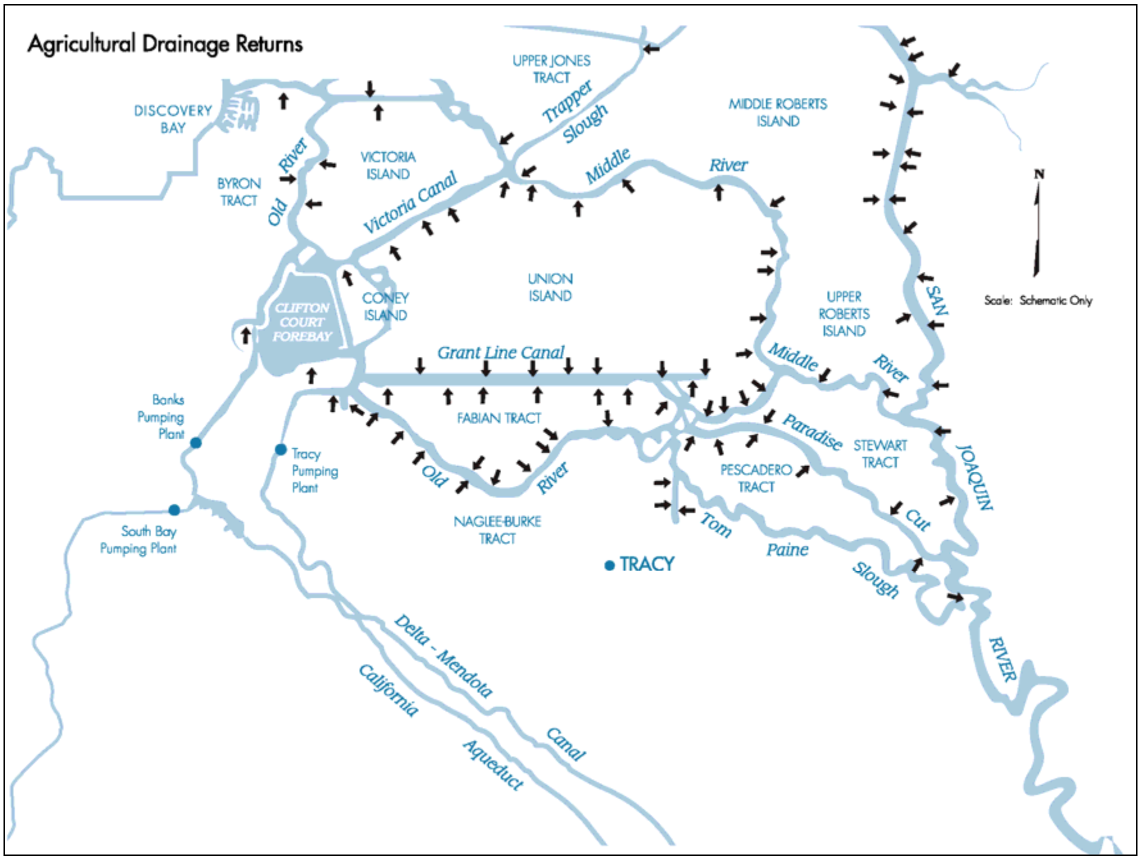


Figure 5. Agricultural Discharges in the South Delta

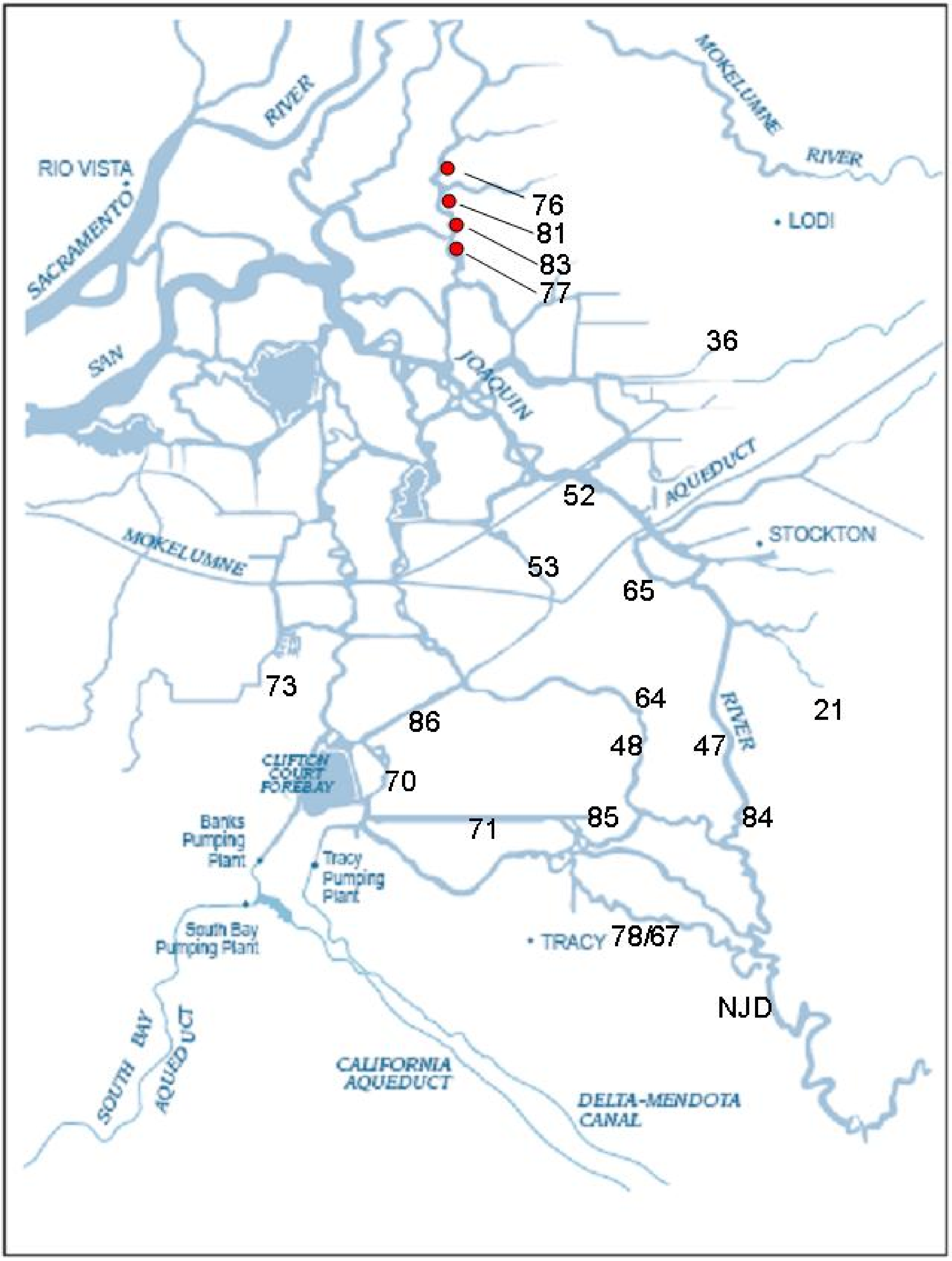


Figure 6. Map of the water quality sampling sites from the Agricultural Drainage Waiver Monitoring Program and the New Jerusalem Drain (NJD) CDEC Station.

Details of North Delta Data. Most north Delta drainage affects the Sacramento River water quality which affects water diverted in the central Delta and water diverted by the south Delta state and federal water projects. In the northern portions of the Delta, agricultural drain water quality is likely most affected by source water quality. The lower elevation drains may also contain water flushed from the root zone.

Agricultural Waiver Program monitoring indicates the water salinity levels in the north Delta are generally in the 500 – 1000 uS/cm range. Four sampling sites within two miles of each other were reported in the monitoring program. All four drains ultimately discharge to Potato Slough. One drain, Number 83, has EC levels up to 1800 uS/cm, while drain number 77 has EC levels more characteristic of East Side Drains. Drains 83 and 81 report drain water quality for 2005 and 2006. Drain 77, reports water quality for 2004 through 2006. Drain 76 only reports water quality for 2004. All water quality data used from the agricultural Drainage Waiver program is included in Appendix D. Figure 6 identifies the relative location of the drains.

East Side Tributaries. Although there are many East Side Tributaries that are sampled for the monitoring program, most of the monitoring locations were more than a few miles from the Delta channels. Two drains were selected to represent water quality of the irrigation return flow of east side agriculture. One station is on French Camp Slough near Lathrop (#21). The other station is on Pixley Slough near Bishop Tract (#36) south of Lodi. These drains are typically low in salinity averaging EC less than 200 uS/cm. The Pixley Slough discharge data spans 2004 and 2005 and is often less than 100 uS/cm. French Camp Slough data is from 2005 and 2006 and ranges from 100 to 250 uS/cm. Salinity this low indicates that these lands are probably irrigated with water captured outside of the Delta. Discharges at this salinity level are not a threat to exceeding Delta Salinity Criteria.

San Joaquin River. A total of four sites are discussed here to represent discharges to the San Joaquin River. Starting from the upstream location at the New Jerusalem Drain and proceeding downstream to a drain from Lower Roberts Island northwest of Stockton. The New Jerusalem Drain is monitored by a California Data Exchange Center station which started collecting information in 2005. The remainder of the data is gathered through the Agricultural Drainage Waiver monitoring program. These three sites, in downstream order, # 47, # 65, and # 52, are all on Roberts Island. The New Jerusalem Drainage (NJD) data is reported in 15 minute intervals. Daily averages of this data are reported on the New Jerusalem Drain chart (Attachment 3). The New Jerusalem Drain discharges to the San Joaquin River downstream of the Banta Carbona canal which is several miles downstream of the Vernalis water quality monitoring station. With the exception of about six weeks over the 18 month data set, the NJD is generally greater than 2000 uS/cm and is often very near or greater than 2500 uS/cm. Water quality criteria at Vernalis are 700 uS/cm during the irrigation season and 1000 uS/cm the remainder of the year. The water quality criteria is typically met at Vernalis, but the water quality is then degraded by this discharge of nearly 2500 uS/cm. Since this data history only reaches back to 2005, all of this history is during wet water year types when water quality in the source water has been typically much better than the water quality criteria. New Jerusalem Drain water may be significantly higher during an extended drought. However we do not yet have data regarding this possibility.

Drainage water quality data from the upper portion of Roberts Island, Station # 47, is from 2003 only. Four sampling events indicate water quality ranges between nearly 1300 uS/cm and nearly 4000 uS/cm. 2003 was an average water year. The 2005 and 2006 drainage from Middle Roberts, Station #65, and Lower Roberts Island, Station # 52, are much lower than the upper portion. Data for this area has typically been under 1000 uS/cm for the past couple of years.

South Delta. Drainage data from 2003 along Middle River averages around 900 uS/cm during much of the year, as seen in the data from Monitoring Station # 48. The drain monitored by station # 48 drains a portion of Union Island. Another drain monitored along Middle River is # 64 which drains a part of Roberts Island. The data for monitoring Station # 64 averages about 380 uS/cm for 2005, the only year of data on record. Further north on Middle River, in the Central Delta and also a Roberts Island drain, there are two data points in 2006. In Mid-May of 2006 Monitoring Station # 53 reported an EC of 736 uS/cm, whereas a month later the Drain EC was 1811 uS/cm.

West of the temporary barriers in the South Delta are two monitoring stations, # 86 along Victoria Canal and #70 at the west end of Union Island. The discharge into Victoria Canal was just under 1000 uS/cm in the summer of 2004 and increased to just under 2000 uS/cm during the next winter (January/February 2005). Over at the west end of the island, the discharge was at a similar level in February and March of 2005 (about 1700 uS/cm) which dropped off during the irrigation season to under 400 uS/cm. Between these two data sets, it is evident that winter discharges are higher than irrigation season discharges suggesting that the fields were being leached at this time.

More in the interior of the south delta, drains on Grant Line Canal and Tom Paine Slough show a variety of discharge patterns. The discharge into the east end of Grant Line Canal (Station # 85) was just over 1000 uS/cm in the summer of 2004 and increased to 2000 uS/cm during the next winter (January/February 2005), also suggesting leaching of the soils. But Monitoring Station # 71 on Grant Line Canal was much more varied, although still showing signs of leaching in February and March of 2005 and March and April of 2006. During the irrigation season of 2005 this drain averaged over 800 uS/cm. Drainage on Tom Paine Slough was sampled only in the irrigation season of 2003 and generally had EC above 1400 uS/cm. West Side Drainage, Station # 73, near Discovery Bay has a varied discharge pattern ranging from about 200 uS/cm to over 1400 uS/cm.

References. California Data Exchange Center Station NJD (New Jerusalem Drain), 2005 and 2006. Central Valley Regional Water Board Agricultural Discharge Waiver Monitoring Program, San Joaquin County & Delta Water Quality Coalition (SJCDWQC), data as of December 2006

Municipal and Industrial Discharges. DWR has obtained some information from the Regional Water Quality Control Boards of local municipal and industrial discharges. Some of these discharges flow into the San Joaquin River between Vernalis and Brandt Bridge. For example, the Central Valley Regional Quality Control Board issued a Waste Discharge Requirement to the City of Manteca requiring that the City not discharge greater than 1.0 EC to the San Joaquin River, at Highway 120 near Mossdale. (This location is upstream of the confluence of the San Joaquin River and Old River.) (CVRWQCB WDR Order R5-2004-0028.) Table 2 below shows the existing municipal dischargers within the southern Delta region. The discharge locations are shown on Figure 7. As can be seen from Table 2, each of the discharges exceeds the current WQCP salinity objectives of 1.0 EC (September through March) and 0.7 EC (April through August). At times, the Discovery Bay summer discharges exceed the summer objective by up to three times. Only one of the discharger's NPDES permits contains a limit for EC, the City of Manteca. Manteca's discharge exceeds the current objective but it has plans to change water supplies which will reduce the salinity level. Although the discharges may be small compared to total stream flow, the impact to water quality could be significant when the discharges are located near monitoring stations or within the vicinity of seasonal null zones. DWR recommends that the Regional Boards require that the dischargers' NPDES permit conditions be consistent with the Bay/Delta water quality objectives.

Table 2. Major Dischargers in the South Delta*

Discharger	Permitted Flow (mgd)	Permitted Flow (cfs)	Average EC (mmhos/cm)	Data Collection	Receiving Water	Outfall Location
City of Tracy	9	14	1.7	2002 - 2004	Old River	37.8047N, 121.4008W
Mountain House CSD	0 [2]	8	1.1	2004 - 2005	Old River	37.7977N, 121.5223W
City of Stockton	55	85	1.1	2002	San Joaquin River	37.9375N, 121.3347W
City of Manteca	8.11	12	1.1 [3]	2000 - 2002	San Joaquin River	37.7792N, 121.3000W
Discovery Bay CSD	2.1	3	1.9 - 2.3	2000 - 2002	Old River	37.8883N, 121.5750W

1. Information on NPDES dischargers in the South Delta area was provided to DWR by the Central Valley Regional Water Quality Control Board in December 2006.
2. Will begin discharging approx. 3 mgd in 2007. Permitted flow expected to be 5.4 mgd. CFS shown for permitted flow.
3. New permit includes monthly average effluent limitation of 1.0 EC (mmhos/cm). City of Manteca is changing water supplies to meet new limit.

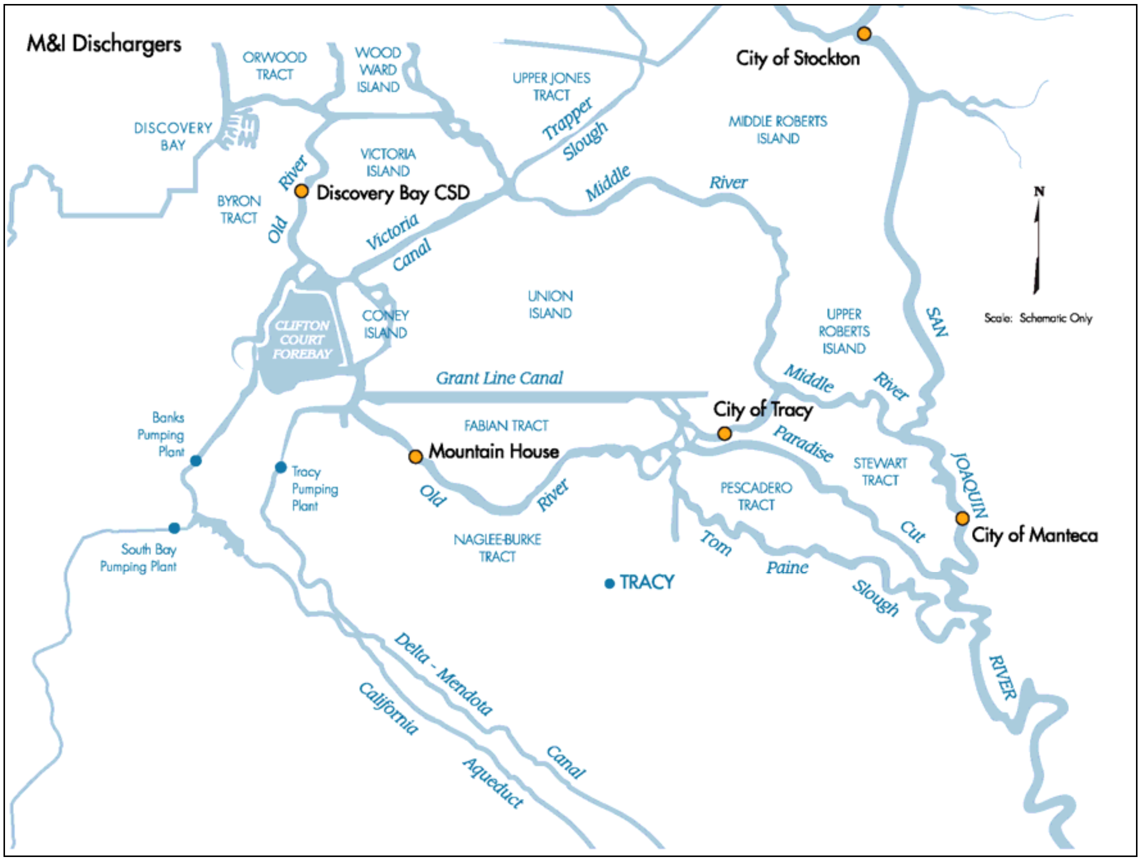


Figure 7. Municipal and Industrial NPDES Dischargers in the South Delta

6. Cropping Patterns and Irrigation Intakes in the Southern Delta

Cropping Patterns in the South Delta

DWR has surveyed locations of Delta crops in the past, and has provided a brief report to the SWRCB in October 2005, which is at Appendix F, DWR Exhibit 21 "Agriculture in the Southern Delta." DWR recommends the SWRCB obtain more detailed information on south Delta crops and soils.

Range of Channel Water Salinity Available for Irrigation

The State Water Resources Control Board currently mandates that salinity levels of 0.7 mmhos/cm EC or less be met from April through August and that 1.0 mmhos/cm EC or less be met from September through March for south Delta irrigation. From December 1999 to April 2005, the objective was 1.0 EC year-round. The objective was not in effect prior to December 1999. The salinity levels are specified at four south Delta compliance stations: (1) Vernalis, (2) Brandt Bridge, (3) Old River near Middle River, and (4) Old River near Tracy Road Bridge.

The Table shown below displays the maximum, minimum and average daily measurements of irrigation water quality at the four south Delta stations during the irrigation season (April through August) for years 2000 through 2006.

Over the seven-year period shown, the maximum salinity at Vernalis was 0.930 EC in both 2001 and 2002, the minimum was 0.100 EC and the average was about 0.500 EC. At Brandt Bridge, the maximum was 1.081 EC in 2003, the minimum was 0.081 EC in 2005 and the average was about 0.600 EC. At Old River near Middle River (Union Island), the maximum was

0.979 EC in 2002, the minimum was 0.099 EC in 2006 and the average was about 0.450 EC. At Old River near Tracy Road Bridge, the maximum was 1.050 EC in 2003, the minimum was 0.127 EC in 2006 and the average was about 0.600 EC.

Table 3. Salinity in South Delta Channels (mmhos/cm EC)

Year	Brandt Bridge			Union Island			Old River			Vernalis		
	Max	Min	AVG	Max	Min	AVG	Max	Min	AVG	Max	Min	AVG
2000	0.746	0.271	0.458	0.699	0.306	0.498	0.800	0.410	0.531	0.730	0.220	0.462
2001	0.889	0.279	0.619	0.914	0.328	0.614	0.990	0.420	0.785	0.930	0.250	0.577
2002	1.002	0.393	0.692	0.979	0.350	0.635	1.020	0.560	0.726	0.930	0.270	0.545
2003	1.081	0.406	0.608	0.962	0.399	0.573	1.050	0.480	0.650	0.900	0.360	0.544
2004	0.786	0.323	0.542	0.895	0.382	0.622	NA	NA	NA	0.780	0.290	0.558
2005	0.567	0.081	0.286	0.663	0.101	0.321	0.634	0.129	0.377	0.630	0.100	0.297
2006	0.502	0.102	0.245	0.471	0.099	0.225	0.580	0.127	0.307	0.480	0.100	0.205

7. Effects of Temporary Barriers Program and the Proposed Permanent Operable Gates

Temporary Barriers

Background. The TBP, initiated in 1990, provides for the seasonal installation of three flow control rock barriers and one fish control rock barrier in south Delta channels. The purpose of the Temporary Barriers Project is to improve water levels for the benefit of agriculture and at times improve water quality at some locations in the south Delta, and improve conditions for migrating San Joaquin River (SJR) Chinook salmon.

Three flow control barriers (agricultural barriers) are designed to help maintain water levels and improve circulation in South Delta channels during the irrigation season so that south Delta farmers can adequately divert water. These agricultural barriers mitigate for the adverse impacts to local water levels caused by State Water Project (SWP) and Central Valley Project (CVP) Delta exports. However, low water levels in the area are also influenced by low San Joaquin River (SJR) inflows, local agricultural channel depletions, natural tidal variations, fluctuating barometric pressure, local wind velocities and direction, and limited channel capacity.

The fourth barrier is a fish control rock barrier that helps improve migration conditions in the south Delta for chinook salmon smolts emigrating down the SJR in the spring and helps improve dissolved oxygen in the SJR for immigrating adults in the fall. The fish barrier is located at the Head of Old River (HOR), which is on Old River near the confluence with the San Joaquin River.

These barriers collectively have been installed to test the feasibility of the permanent operable gates (known also as operable barriers or flow control structures) now proposed by the Department of Water Resources (DWR) under its South Delta Improvements Program (SDIP).

Figure 8 shows the number of agricultural diversions in the south Delta area that are effected by the barriers. DWR surveyed the diversions in this area initially in early 1999. Diversions are mostly turbine pumps but there are a few siphons, especially at the west end of Union Island, where lower land elevations relative to the channel water levels make siphons workable.

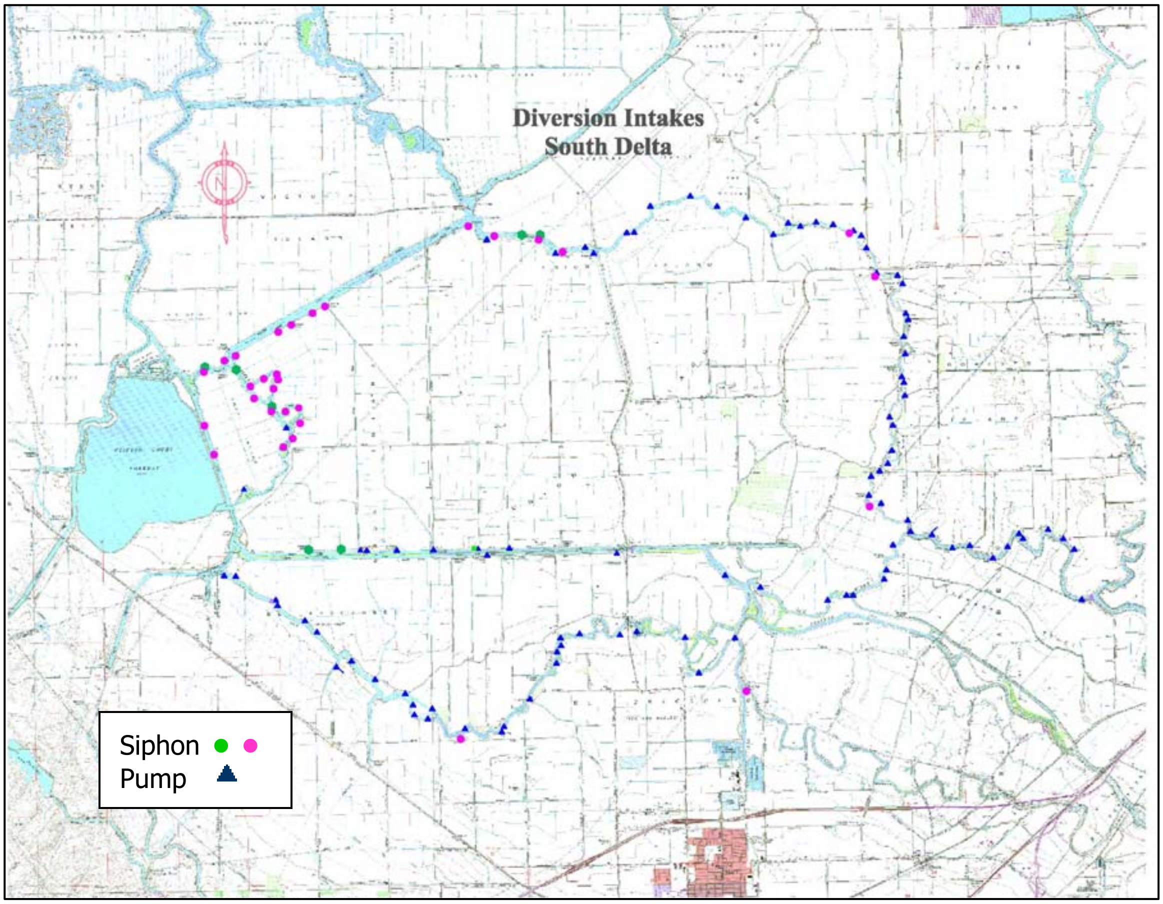


Figure 8. South Delta Agricultural Diversions

Figure 9 shows a map of the south Delta area with the temporary barrier sites shown in red. The three agricultural barriers are located in the Middle River, the Old River near Tracy Pumping Plant, and the east end of Grant Line Canal. The permanent operable gates that will be constructed under the SDIP will be at approximately the same locations except for the Grant Line Canal barrier. The location of the permanent gate on Grant Line Canal, indicated in green, is proposed to be on the west end of the canal instead of the east end.

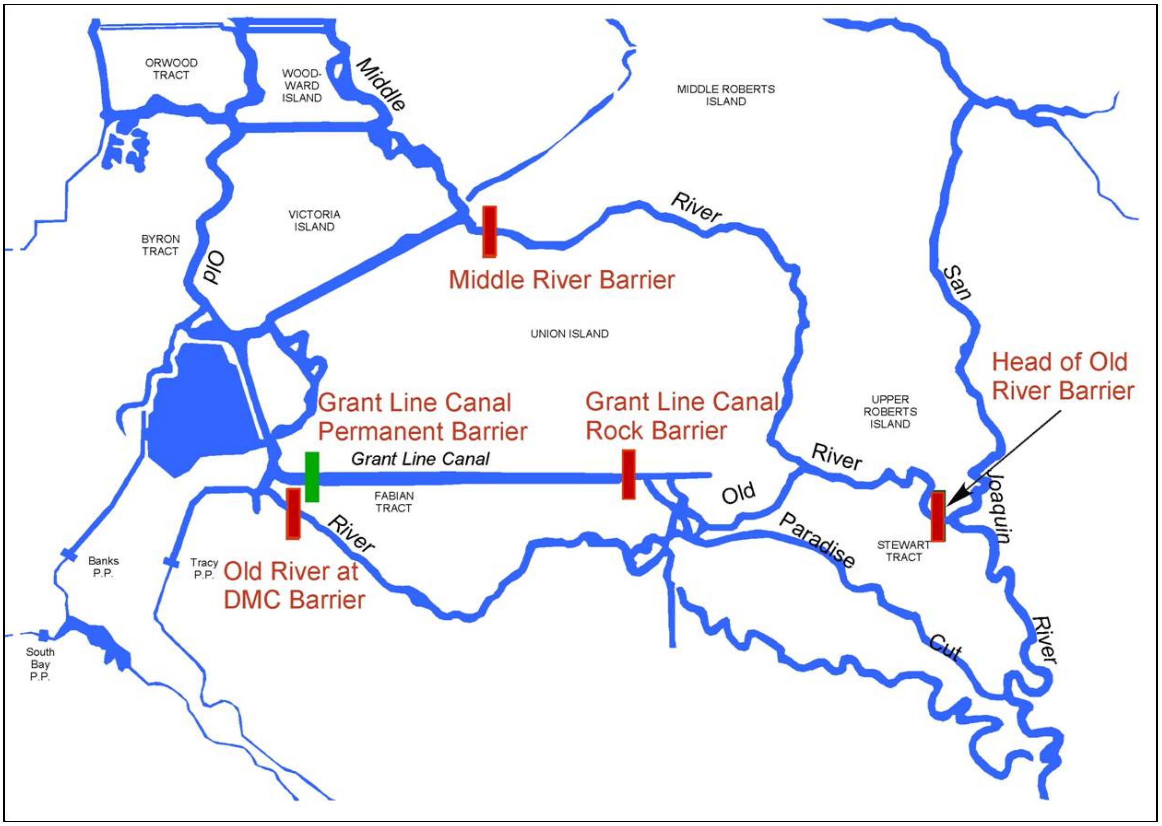


Figure 9. Temporary Barriers Location

Installation History. DWR has been installing and operating temporary barriers to assist diversions by farmers within the South Delta Water Agency in the south Delta since 1989. The fall Head of Old River barrier has been installed at the request of the Department of Fish and Game (DFG) since 1968 to benefit migrating adult Chinook salmon. The Spring HOR barrier has been installed since 1992 for the benefit of migrating salmon smolts to keep the smolts in the main channel of the San Joaquin River. The temporary barriers are rock structures placed across the channel with culverts placed through the rock near the low water levels. DWR is presently permitted to install and operate the barriers through the year 2007 and we are committed to continuing the temporary barriers program until such time as permanent, fully operable gates are constructed.

Operations. Typically each year, the barriers are installed from April 15 to about November 15. While the agricultural barriers operate partially or wholly throughout this time, the spring HOR barrier operates from April 15 to May 15, and sometimes until May 30 if requested by the fish agencies and then is removed for the summer. The fall HOR barrier is then installed about mid-September, when requested by DFG, and operates until mid-November. As required by our US Army Corps of Engineers Permit and biological opinions for constructing the barriers, all the barriers must be removed from the channels by November 30. This minimizes impacts to fish and prevents the barriers from being an impediment to higher river flows in the winter and spring.

Historical Water Quality Measurements. Water quality in the south Delta is influenced by many factors— the quality of incoming SJR flows, salt water intrusion from San Francisco Bay, local agricultural drainage, poor circulation in south Delta channels ("null zones"), and CVP and SWP Delta exports. Figure 10 shows water quality measurements taken in 2003 from three monitoring locations for the Temporary Barriers Project. These locations are along Old River from the Delta Mendota Canal to the HOR. This example shows how water quality generally improves when the temporary barriers are operating. There are a number of reasons why this improvement happens. One, the SJR river flows are much higher when the HOR barrier is operated in April/May in support of the Vernalis Adaptive Management Plan experiment. One, the SJR river flows are much higher in April/May in support of the Vernalis Adaptive Management Plan experiment. Although the HOR barrier was in place during this time, considerable flow from the San Joaquin River enters Old River via culverts in this barrier. Higher flows improve the water quality entering the south Delta area, which is generally SJR water during this time. Two, during the summer months, when the HOR barrier isn't operating and SJR flows are low and poorer quality; the three agricultural barriers reduce the amount of SJR flows entering the south Delta and change circulation dynamics. Three, the barriers hold a greater volume of water in the channels upstream of the barriers than would be present without them. Higher volumes provide greater dilution of salt from upstream and agricultural sources.

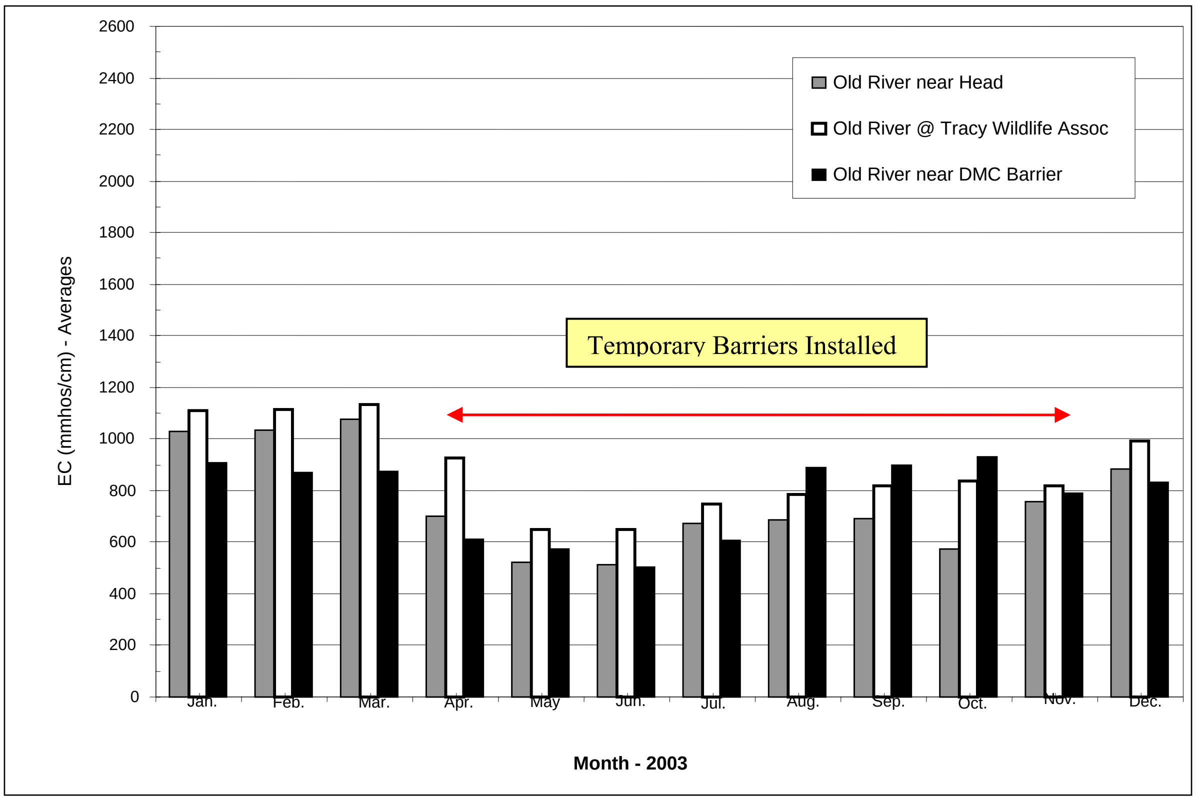


Figure 10. Water Quality Improvements During Temporary Barriers Installation

Permanent Operable Gates

On December 15, 2006, DWR and the U. S. Bureau of Reclamation certified the Final EIR/EIS on the proposed South Delta Improvements Project (SDIP). The Final EIR/EIS may be viewed at the DWR website: http://sdip.water.ca.gov/documents/final_eis_eir.cfm The SDIP includes two components: (1) a physical/structural component describing the construction and operation of the permanent gates, and (2) an operational component describing increased pumping at the State Water Project (SWP) Delta pumps. Because of uncertainties regarding recent declines in pelagic organisms in the Delta, including the endangered Delta Smelt, the second component of SDIP is not being considered for approval at this time. Therefore, DWR's comments herein summarize the physical/structural component involving the permanent operable gates. Additional details and analysis of this component is available in the FEIR/EIS at DWR's website cited above.

The summary of the permanent gates includes:

- description of the proposed permanent gate design and operations, and
- an explanation of how the gates will improve circulation in the south Delta which, most of the time, will result in improved water quality as measured by Electrical Conductivity (EC).

Design and Operation of the Permanent Operable Gates. DWR and Reclamation are proposing to install permanent operable gates to replace the four temporary rock barriers that have been installed seasonally since about 1990. The proposed gates are of a bottom hinge design (See Figure 11) as opposed to the radial gates described during the water rights hearings for Decision 1641. Bottom hinge gates have the following advantages:

- they lay flat on the river bottom during floods and do not cause an obstruction to flood water or debris
- because in-stream abutments are not necessary, the channel does not need to be widened to accommodate flood flow
- these gates provide the most flexibility in operation and for river traffic.

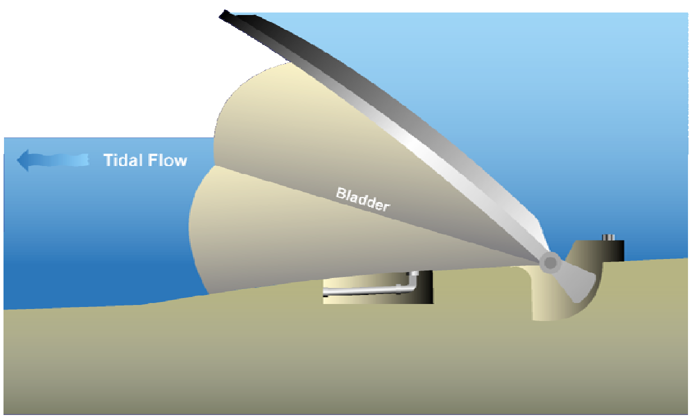


Figure 11. Depiction of a Bottom Hinged Gate

Improved Circulation / Improved Water Quality

Three of the permanent gates will operate to raise water levels and to induce circulation in the south Delta channels. The permanent gate will operate to achieve improvements in water levels and circulation by capturing tidal flows on the high tide. Figure 12 illustrates the potential average water quality improvements available by using the proposed permanent gate operations (Final SDIP EIS/EIR, December 2006).

The south Delta is influenced by tidal action and the raising and lowering of the gates use this tidal action to induce circulation in the south Delta. To capture tidal flow, the gate is positioned on the bottom of the channel during flood tide. As the tidal flow slows, the gate is raised to capture the high tide. When the gate is fully raised, the tide can ebb toward the Bay while the gate preserves stage on the upstream (or east) side of the gate.

Trapping the high tide on Middle River and Old River and setting the gate elevation in the Grant Line Canal at a lower water level results in water flowing from Middle River and Old River into Grant Line Canal, inducing circulation of water in the south Delta channels. During modeling of the gate operations, the height of the gate on Grant Line Canal is set at a 0.0 feet mean sea level so it operates as a weir, allowing high waters to flow over it. Under some conditions, it is best to slightly restrict San Joaquin River water to flow through Old River by slightly raising the gate to have it function as a weir.

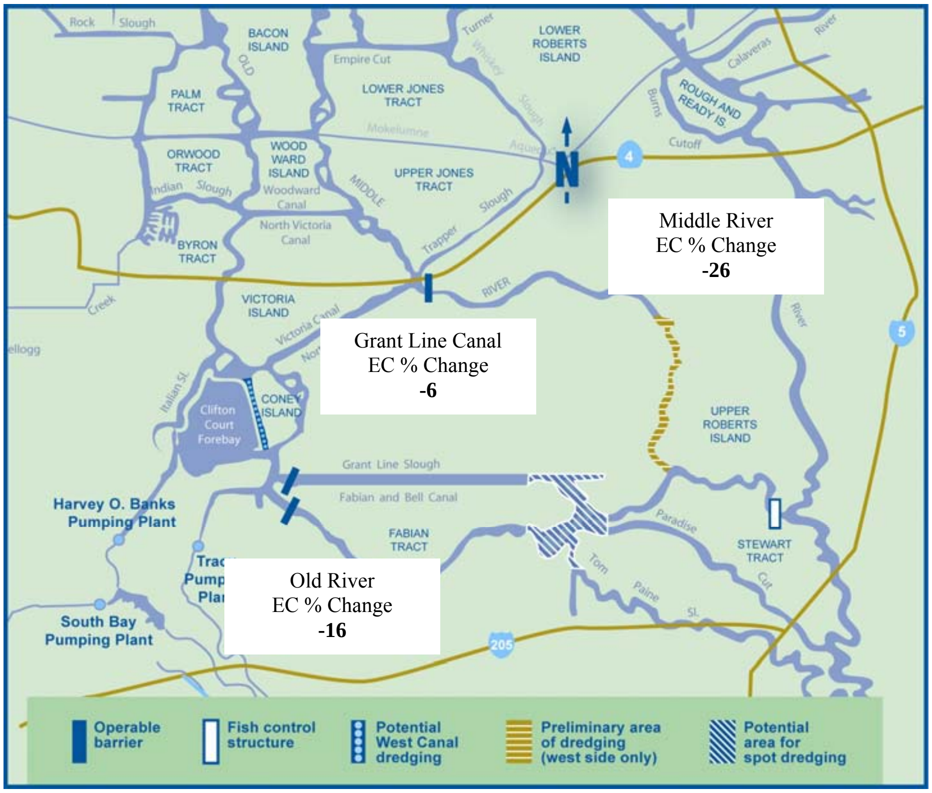


Figure 12. Average Reductions in Salinity Using Permanent Operable Gates

8. Summary of Information Needed for Further Evaluation of South Delta Objectives and Methods of Implementation

DWR recommends that the State Water Board hire a consultant(s) to further investigate factors affecting southern delta salinity to help determine reasonable methods to implement objectives that protect agricultural uses. Such an investigation has been suggested in the past by agronomists who have studied the southern Delta irrigation water quality issues. The State Water Board should commission new studies in furtherance of the work by Ayers and Westcot done for the Food and Agriculture Organization (FAO) (See 1985 FOA report). The new studies should obtain information specific to the southern Delta, such as leaching capabilities, cropping patterns, soil types, and irrigation practices. The analysis should address differences among conditions found in the interior Delta channels and on the San Joaquin River and differences in seasonal needs for agriculture.

Other factors that the State Water Board should consider are environmental characteristics of the hydrographic unit under consideration, including the quality of water available to the area. Factors affecting water quality in the area can be found from monitoring stations in the San Joaquin River upstream and downstream of the Vernalis. During the March 2005 State Water Board workshop on southern Delta objectives, the Department of Interior (DOI) and the San

Joaquin River Group Authority (SJRGA) indicated that hydrology on the San Joaquin River may be significantly different from what was presented to the Board during its last series of workshops and hearings on the 1995 WQCP and Decision 1641. This information should be more fully investigated by additional studies.

Recommendations for Further Studies to Evaluate Reasonable Objectives to Protect Southern Delta Agricultural Uses

The SWRCB established the salinity objective of 0.7 mmhos/cm EC to provide adequate water quality during the summer irrigation season (April-August) based on the salt sensitivity and growing season of beans; while the 1.0 mmhos/cm EC objective was established for the winter irrigation season based on alfalfa crop requirements. DWR believes that analyses of agricultural experts and others described in the reports listed below suggest that the 1.0 mmhos/cm objective in the southern delta may reasonably protect agricultural crop production during the summer season. This information would be useful in considering changes to the objectives or to methods of implementation. For example, if the SWRCB were to consider a summer objective of 1.0 EC during dryer year types, it might find this is a reasonable method of implementation as well as reasonably protective of the beneficial use because studies show the effects on crops to be minimal. DWR recommends that the SWRCB include in its studies on south Delta salinity a review of the following reports:

- "Establishing Water Standards that are Protective for Agricultural Crop Production," Report to DWR by Dr. John Letey, Oct. 14, 2005 (concluding that an EC standard of 1.0 mmhos/cm EC is protective of agricultural production in the south Delta).
- "An Approach to Develop Site-Specific Criteria for Electrical Conductivity to Protect Agricultural Beneficial Uses that Accounts for Rainfall," Dr. Isidoro Ramirez, and Dr. Steve Grattan, UC Davis Department of Land, Air and Water Resources, 2004 (concluding that an EC objective of 1.1 mmhos/cm EC is adequate to protect agricultural beneficial uses in the Delta).
- "Concerning Southern Delta Electrical Conductivity Water Quality Objectives," Mr. William Johnston, P.E., 2005. (discussing the evolution of the existing Southern Delta EC Objectives, research and crop changes that have taken place since the existing objectives were established, and recommendations on whether or not changes should be made to the existing objectives, based on updated research and current cropping patterns).
- Dr. James R. Brownell presentation for March 2005 SWRCB Workshop (concluding that there is no agricultural reason supporting the 0.7 mmhos/cm objective for Agricultural Water Quality Objective in the South Delta and recommending 1.1 mmhos/cm based on the more recent work of Hoffman, Grattan and his co-workers, and himself).

As part of future studies of southern delta water quality needs, DWR recommends that the SWRCB re-assess the analysis and information of the reports listed above as well as perform a technical review of all evidence presented on the irrigation water quality needs of the south delta. DWR recommends that the SWRCB conduct such review by contracting with a qualified, independent consultant. After a thorough review of the available information, the consultant should be prepared to make a recommendation to the SWRCB as to an appropriate value that would reasonably protect agricultural production in the southern Delta under various hydrologic conditions.

In addition, DWR recommends that the SWRCB retain a consultant to evaluate sources of water quality degradation within the south Delta. The purpose of such an evaluation would be to determine what sources may be a significant cause of increased salinity that degrades water quality in the area.

DWR obtained information of local salinity contributions by municipal discharges and permitted agricultural runoff drains, discussed below and in Section 4 above. Local groundwater accretions, and local agricultural surface discharges are more difficult to estimate due to the numerous points of discharges. A detailed study is needed to quantify these contributions. However, based on existing data, DWR estimates that such contributions are substantial, especially in terms of surface agricultural drainage discharges.

In 1987, DWR performed a land survey mapping over 1,800 agricultural irrigation diversions in the Sacramento-San Joaquin Delta (see figure 13).

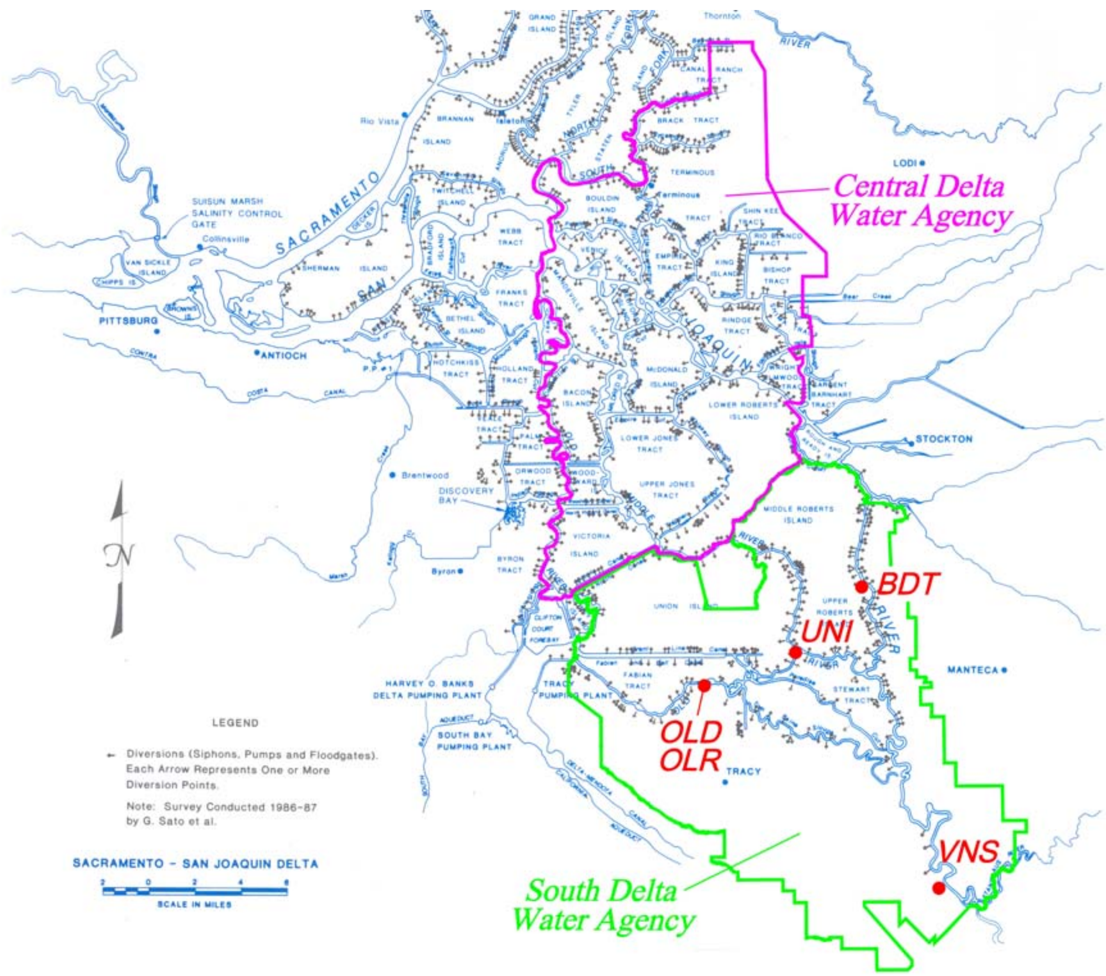


Figure 13. Agricultural Diversions in the Delta

At the time of this mapping effort, the principal crops grown were corn, sugarbeets, grains, alfalfa, tomatoes, asparagus, fruit, safflower, and nuts. The survey estimated that during the peak of the summer irrigation season, the diversions exceed 4,000 cfs. The survey also mapped the location of hundreds of agricultural drainage returns in the Delta (see Figure 14). The discharges from the drainage returns result from the natural evapotranspiration process of plants and run-off after irrigation, which leaves salts in the soils, and from the fact that most agricultural areas in the

Delta are near or below sea level. Drainage is needed to prevent plant root waterlogging and to remove excess salts from the soils. Typically irrigated agriculture in the Delta can produce a threefold increase in salt concentrations in the tailwater, compared to water that was pumped from the channel irrigation. In addition, salt concentrations from subsurface irrigation drains (tilewater) are much higher than agricultural surface drainage returns. Both types of discharges are pumped from the islands and discharged into Delta channels. These agricultural drainage returns often exceed salinity levels of 2 mmhos/cm EC, which, in turn, degrades water quality in the Delta channels. Total combined agricultural discharge flows into the Delta are estimated to range between 500 cfs and 1,000 cfs during the peak discharge season. Permitted municipal and agricultural dischargers (New Jerusalem Drain) may add as much as 165 cfs, with EC levels ranging from 0.7 to 2 mmhos/cm.

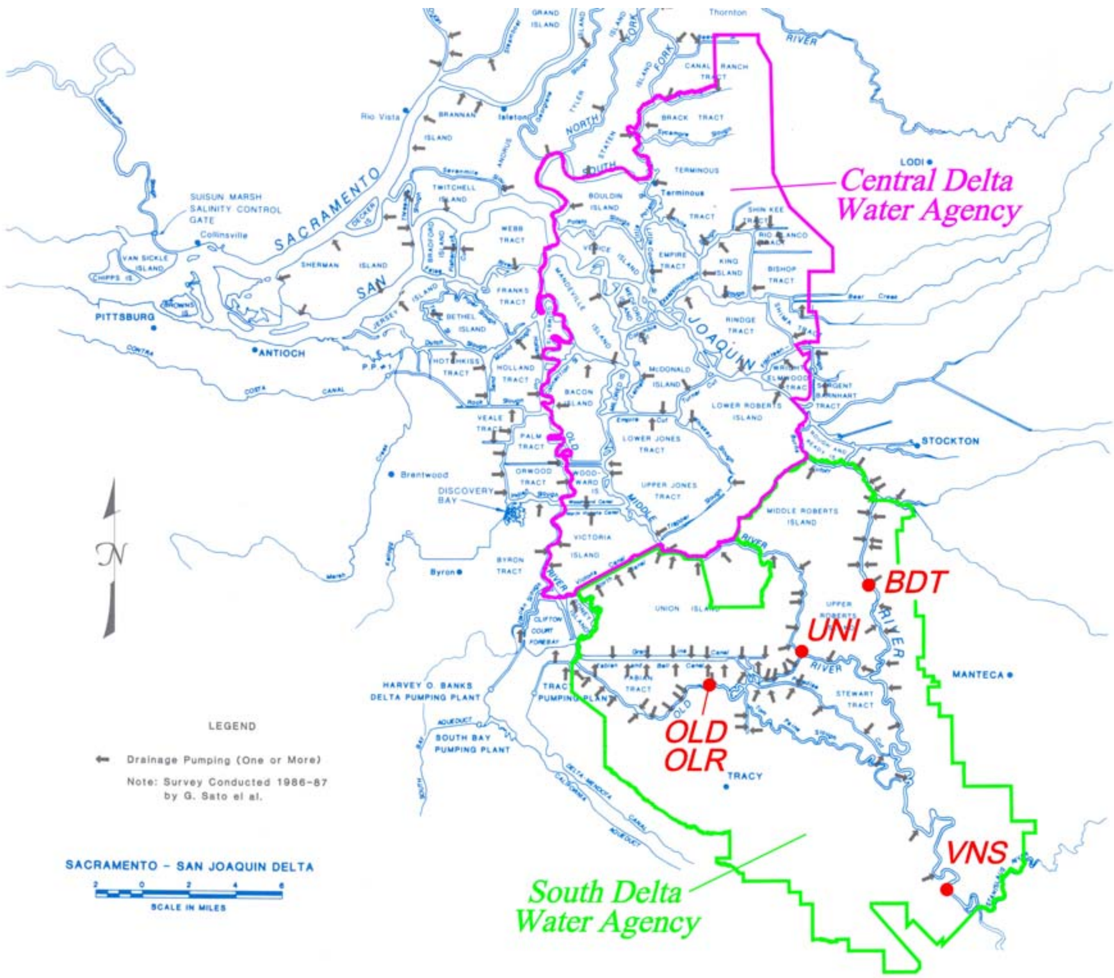


Figure 14. Agricultural Returns in the Delta

An example of the amount of water required for dilution flows needed in order to achieve the 0.7 mmhos/cm EC objective helps to show if such flows are reasonable. For example, to reduce the salt concentration in 100 cfs at 2 mmhos/cm EC (1240 mg/l) to 0.7 mmhos/cm EC, additional flows of 195 cfs of distilled water (25 ppm) would be needed. Or, using a more realistic water salinity of 0.5 mmhos/cm EC (320 ppm) would require an added 650 cfs. The

SWRCB should include in its south delta salinity studies, an investigation on requirements for dilution flows to help determine if such flows would be reasonable.

In addition, in order to reasonably achieve a summer water quality objective of 0.7 mS, DWR recommends that the SWRCB quantify the respective share of salt contributions from specific sources and determine if there are reasonable methods of reducing such contributions. A land use and irrigation survey similar to the one performed in 1987 by DWR is needed to provide updated information for the south Delta and locations of sources of salinity.

Investigating Effectiveness of Current and Future Salinity Controls on South Delta Salinity

The following is a summary of actions that DWR recommends the SWRCB investigate to control salinity in the southern Delta. These actions occur, or would occur, upstream and downstream of Vernalis, effecting salinity in the San Joaquin River and the southern Delta.

Actions Upstream of Vernalis Controlling Salinity in the San Joaquin River:

- Provide fresh water to dilute saline discharges and to increase flows upstream of Vernalis through flow releases from New Melones Reservoir, through the Vernalis Adaptive Management Program (VAMP) provided under the San Joaquin River Group Agreement, and through the release of water from the Central Valley Project via the Westley or Newman Wasteways; and
- Control discharge of saline water into the SJR upstream of Vernalis.

Measures Upstream of Vernalis Controlling Discharges In the San Joaquin River:

- On-farm management activities to reduce subsurface drainage,
- Real-time water quality management to maximize the assimilative capacity of the San Joaquin River,
- Efforts to improve water quality of wetlands discharges, and
- Implementation of TMDLs.

Specific information regarding methods to provide on-farm drainage management activities are discussed below.

On-farm Drainage Management Activities. Drainage management activities involving source control have proven to be effective in reducing salt loads in the San Joaquin River. These activities include:

- Irrigation Water Conservation such as use of improved irrigation systems; tiered block water pricing, shallow groundwater management, and best irrigation management practices.
- Agricultural tailwater and tilewater control and recycling.
- Agricultural subsurface drainage water reuse through the San Joaquin River Improvement Project.
- Development of integrated regional water quality management plans and operations through Proposition 50.

DWR additionally supports the recommendations of the San Joaquin River Management Group in its report for controlling salinity in the San Joaquin River. Recommendations include:

- fully implementing the West Side Regional Drainage Plan,

- further evaluating and pursuing managed wetland drainage management actions to mitigate impacts of February through April drainage releases, and
- developing a real-time water quality management coordination group involving Lower San Joaquin River (LSJR) tributaries, LSJR drainers and DWR to coordinate reservoir release and SWP/CVP Project operations (Head of Old River Barrier and New Melones operations) to realize opportunities to improve water quality and increase the utility of stored water releases.

The San Joaquin River Water Quality Management Group has merged into the Water Quality Subcommittee of the San Joaquin River Management Plan (SJRMP) with the purpose of implementing the above recommendations. DWR is a lead agency for the SJRMP.

DWR also refers the SWRCB to information in the Report on San Joaquin Drainage Programs prepared by Jose Faria for DWR in October 2005, which is attached as Appendix F. This report includes additional information on work done in the San Joaquin River upstream of Vernalis to reduce salinity and discharges. This work has reduced the amount of releases from New Melones reservoir required in the past to dilute salinity to achieve the 0.7 mmhos/cm EC at Vernalis.

9. Scope of Work and Funding for Studies to Determine Reasonable Water Quality Objective and Methods of Implementation

DWR has proposed a draft Scope of Work for studies that would help determine reasonable water quality objectives for the south delta agricultural uses and also methods to reasonably implement the objectives. The scope of work is focused on obtaining information that is not currently available. DWR's recommended draft Scope of Work is attached to these comments as Appendix B.

DWR will consider the use of Proposition 84 funds for work that SWRCB may determine is necessary for developing reasonable water quality objectives in the south Delta. Under Section 75029 of the Public Resources Code, DWR has available $130,000,000 for grants to local agencies to implement Delta water quality improvement projects that protect drinking water supplies. Local agencies are required to provide a share of the costs as part of the grant..

Eligible projects under this section include:

- Projects that reduce or eliminate discharges of salt, dissolved organic carbon, pesticides, pathogens and other pollutants to the San Joaquin River. Not less than forty million ($40,000,000) shall be available to implement projects to reduce or eliminate discharges of subsurface agricultural drain water from the west side of the San Joaquin Valley for the purpose of improving water quality in the San Joaquin River and the Delta.
- Projects that reduce or eliminate discharges of bromide, dissolved organic carbon, salt, pesticides and pathogens from discharges to the Sacramento River.
- Projects at Franks Tract and other locations in the Delta that will reduce salinity or other pollutants at agricultural and drinking water intakes.
- Projects identified in the June 2005 Delta Region Drinking Water Quality Management Plan, with a priority for design and construction of the relocation of drinking water intake facilities for in-delta water users.

10. Recommendations on changes to Objectives and the Program of Implementation

DWR believes that the State Water Board should investigate several alternatives that could be applied separately or in combination for implementing the southern delta objectives. At this time, DWR is providing a possible list of implementation methods, shown below. After the workshops and meetings, the methods could be more fully developed based on facts gathered by the SWRCB during these workshops.

- Varying the southern Delta salinity objective based on San Joaquin River water-year hydrologic classifications that are defined in Figure 3 of the 2006 WQCP. This method would be similar to variations in the salinity objectives based on the Sacramento River water-year classifications as shown for the Western Delta and Interior Delta on Table 2, footnote 3 of the 2006 WQCP.
- Assign the responsibility for achieving the objective among several entities shown to affect southern delta salinity.
- Implement the objectives in phases based on the schedule for constructing a physical solution, achieving waste discharge requirements, or other methods proposed for implementing the objectives.
- Provide protection of agricultural beneficial uses by a narrative objective instead of numeric objectives, similar to protection provided to brackish tidal marshes of Suisun Bay on Table 3 of the 2006 WQCP.

Summary

In summary, DWR's comments of modeling results showing effects of south Delta salinity by the SWP and CVP reaffirm prior modeling results presented to the SWRCB in October 2005. The modeling and particle tracking studies show that the SWP and CVP cannot effectively control salinity in the southern Delta through changes in their Delta exports or changes in flow from the Sacramento River. This modeling also shows the zone of influence of the San Joaquin River on the southern Delta under varying export conditions when the temporary barriers or permanent gates are operating. DWR has also provided information obtained from the Regional Water Quality Control Board on the locations and amounts of discharges by agricultural, municipal, and industrial water users in the area. DWR also reviewed information on the historic salinity patterns and cropping patterns in the southern Delta. The information, however, on specific agricultural practices and current crops in the south Delta is limited and the State Water Board may need to obtain additional information to better consider reasonable objectives for protecting the agricultural uses in the area.

DWR recommends that the State Water Board consider the information submitted for the 2007 salinity workshop, as well as any prior information on the southern Delta salinity that has been submitted to the Board, to assess a reasonable objective and methods to implement the objectives to protect southern Delta agriculture. Such an assessment could be done by an independent consultant who could provide recommendations to the Board. In addition, because information is probably lacking on details of types of agricultural lands and irrigation practices in the south Delta, the consultant should conduct scientific investigations to obtain such information. DWR has provided a draft Scope of Work with the understanding that the work needed by the State Water Board probably will be refined based on the information gathered at these, and any subsequent workshops.

APPENDICES

Appendix A. Historic Salinity Data from Bulletin 27

Appendix B. Draft Proposal for Scientific Investigation of South Delta Agriculture and Water Supply

Appendix C. Central Valley Project and State Water Project Operations' Effect on Variability of Salinity in the Southern Delta & Impact of SWP and CVP Operations on Delta-wide Circulation and South Delta Water Quality

Appendix D. Data and Charts from the Waiver Monitoring Program

Appendix E. New Jerusalem Drainage CDEC Data

Appendix F. DWR Exhibit 18A (Report on San Joaquin Drainage Programs), DWR 21 (Establishing Salinity Water Standards that are Protective for Ag Crops, Oct 7, 2005), DWR 22 (Salinity Water Values that are Protective for Agricultural Crop Production), DWR 20 (Investigation of the Factors affecting Water Quality at Brandt Bridge, Middle River at Union Point, and Old River at Tracy), DWR 20A (Fingerprinting Methodology), and DWR 20C (Description of historical DSM2 Particle Tracking Animation With Temporary Barriers Installed in South Delta) <u>are included as a separate file to this document</u>. They can also be found and downloaded at the SWRCB web site at: http://www.waterrights.ca.gov/Hearings/usbr_exhibits.html

APPENDIX A

HISTORIC DELTA SALINITY DATA (PPM CHLORIDE)

The data represented in the table below (above) was obtained from the Sacramento-San Joaquin Water Supervisor Reports, 1924-1943, and was expressed as parts of chloride per 100,000 part of water. The data was converted to ppm (mg/l) to be consistent with units used to express current water quality objectives (municipal). Conversion to EC is inexact and dependent on the composition of salts in the water source at a particular location. Based on analysis of chlorides vs EC at a location on Old River at Bacon Island (using water quality data from December 1998 through July 2003), DWR has estimated for previous hearings before the SWRCB that 150 mg/l chloride is approximately 0.7 EC, and 250 mg/l approximately 1.0 EC. Actual values at any particular location can vary.

Station	1924	1925	1926	1927	1928	1929	1930	1931	1932	1933	1934	1935	1936	1937	1938	1939	1940
Middle River	1860	130	690		210	170	130	270	120	180	1080	110	120	160	130	600	550
Mansion House	1480	110	690		160	160	110	240			900						
Victoria Island																350	
Stockton Country Club	1080		480			360	180	1220			440						
Clifton Court Ferry	800		240			230		130			400					190	
Stockton Country Club						2000	1200	1320	720	660	760					320	
Garwood Bridge								920			380						
Brandts Bridge								430			210						
Williams Bridge	420		180			120		1180			430						
Naglee Burke Pump																140	
Whitehall						150		310			120						
Mossdale Bridge	140					160	100	120	140	130	250	120	140	120	120	160	140
Durham Ferry Bridge								100									

Figures represent maximum recorded salinity at selected locations in southern Delta
Source: Sacramento-San Jaoquin Water Supervisor Reports 1924-1943

Middle River	Middle River, east bank, at Santa Fe RR crossing
Mansion House	Victoria Island, Old River, east bank, at junction with North Victoria Canal
Victoria Island	Old River at Borden Hwy crossing
Stockton	On Lindley Cut-off (San Joaquin R.), north bank, aobut 3/4 mi above Burns cut-off junction
Clifton Court Ferry	Old River just below junction with Grant Line Canal
Stockton	Near head of Stockton Channel at wharf of California Trans Co. (1931)
Garwood Bridge	San Joaquin River at drawbridge 1 mi above Santa Fe RR crossing
Brandts Bridge	San Joaquin River at drawbridge 6 mi above Santa Fe RR crossing
Williams Bridge	Middle River about 4 mi below Salmon Slough junction
Naglee Burke Pump	Old River at Naglee Burke pump (102.5 mi from GGB)
Whitehall	Old River west of junction of Salmon Slough & Paradise cut due north of Tracy (104.8 mi from GGB)
Mossdale Bridge	San Joaquin River at Lincoln Hwy crossing about 3 mi SW of Lathrop
Durham Ferry Bridge	San Joaquin River 1/2 mi below San Joaquin City

APPENDIX B

DWR DRAFT PROPOSAL FOR SCIENTIFIC INVESTIGATION OF SOUTH DELTA AGRICULTURE AND WATER QUALITY

SCOPE OF WORK

Introduction

In 1978, the SWRCB established water quality objectives for salinity of irrigation water for southern Delta agriculture. The SWRCB would like additional information regarding irrigation water quality to review the adequacy of these objectives and methods to achieve the objectives. DWR recommends that the SWRCB hire a consultant to conduct an independent scientific investigation that addresses in detail the issues raised during the SWRCB 2007 workshop on the southern Delta objectives, the result of which could assist the SWRCB in its determination of any changes to the water quality objectives or their implementation, if appropriate.

DWR also recommends as part of the investigation that the SWRCB involve interested stakeholders and conduct appropriate scientific review. Because of the statewide significance of the Delta, the public has an interest in the development of the study tasks. The SWRCB could include in its scope of work a process for public involvement and communication. Furthermore, the scope of work could also include scientific peer review to assure the quality and general acceptance of any findings and recommendations that may result from the scientific investigation. DWR's recommendation for the scope of work is prepared with the understanding that it could be modified to reflect the information obtained by the SWRCB during the upcoming workshops.

Study Objectives

A. Describe the nature, location and extent of salinity constituents in irrigation water applied to beans, alfalfa, and orchards in the south Delta during the growing season.

B. Identify the salt balance over short and long-term periods in the fields studied and the constituents involved.

C. Identify irrigation management, crop cultural practices, soil conditions, and drainage conditions that exist and/or develop in each crop investigation.

D. Characterize any actual impairment to crops from the beneficial uses of irrigation waters in the south Delta. Characterize any agronomic management or physical conditions that contribute to impairment of favorable crop growing conditions.

E. Consider in the study design the information needs identified by the SWRCB and its staff for development of a comprehensive salinity objective policy for the south Delta.

Study Tasks

Task 1. Refine General Scope of Work

The SWRCB will work with the Contractor to refine the general scope of work and study design. The overall and relative level of effort and timelines to complete the work described will be developed.

Task 2. Develop Final Study Design

The SWRCB and their consultant(s) will work with interested stakeholders to refine and modify the scope of work and final study design. The level of effort and timelines to complete the work described will be modified based on stakeholder comments. Milestones and specific interim work products will be identified, as well as the process for the review of tasks and work product by a scientific panel(s) identified by the SWRCB.

Task 3. Characterize Irrigation Water Quality Used in the South Delta

Review and synthesize available literature on south Delta water quality, sources of salt and salt disposition, including information from the following sources:

1. DWR Water Quality sampling records.
2. Irrigated agriculture studies in the south Delta.
3. Irrigation District water quality records throughout the watershed.
6. Other sources, including information on natural, background water quality levels.

Task 4. Characterize the history of each of the agricultural fields involved in the investigation and the prevailing agricultural practices

1. Review DWR land use surveys.
2. Review county Agricultural Commissioner pesticide use files.
3 Review all applicable, previous performed studies.
4. Assess prevailing crop and irrigation management/cultural practices in the area.
5. Review crop yield information.
6. Interview county Farm Advisors, consultants, and others.
7. Other sources.

Task 5. Identify and Quantify Agriculture in the south Delta

This Task includes conducting detailed field investigations based on the final study design. Conduct studies of agriculture in the south Delta, analyze beginning soil salt levels, volume and salt load of irrigation water, and disposition of the irrigation water and salt at the end of the growing season. Identify and document important physical and management factors influencing the soil salt balance in agriculture of the south Delta. Identify salt management practices in use and/or situations in which such practices should be used.

This task identifies and quantifies agricultural water use based on a study of leaching practices in the southern Delta, specific crop and soil types found in the southern Delta, and other factors related to hydrology and water quality in the area. This analysis should address differences in conditions found in the interior Delta channels and on the San Joaquin River and differences in seasonal needs for agriculture. Documentation and measurement of southern Delta agricultural site specific factors and actions are necessary and include:

1. Crop type.
2. Root zone depth.
3. Actual crop evapotranspiration.
4. Detailed soil properties and descriptions (soil profile, soil texture, horizons, hardpans or restricting layers).
5. Beginning and ending soil salt content and average root zone salinity.
6. Soil-water relationships of each soil type

7. Crop and irrigation management/cultural practices in each study area.
8. Quantity, distribution and effectiveness of precipitation.
9. Quality of water of each seasonal irrigation.
10. Soil moisture distribution in the root zone before, during and after the growing season.
11. Monitoring of available soil moisture levels, irrigation amounts and frequency, irrigation distribution uniformity and irrigation efficiency during the irrigation season.
12. Crop cultural practices (soil preparation, planting date and method, detailed plant development and growth, harvest date and yield).
13. Irrigation method, management, and performance.
14. Leaching fractions from irrigation and leaching from precipitation.
15. Water table depth, quality, behavior and management, and identify water table influence on the surrounding channel water levels or flows.
16. Runoff amount and quality (i.e. pumped out).
17. Soil profile salt distribution during the growing season and any influencing factors such as irrigation water quality, fertilizer, etc. Report average root zone salinity.
18. Tracking of soil permeability and percolation properties impacting irrigation performance and crop moisture needs.
19. Comparison of soils and water tables of native parcels of land adjacent to the fields investigated

Task 6. Identify and analyze data collected from each field

Determine the disposition of salts introduced from irrigation during the season and the adequacy of seasonal irrigations for meeting crop ET, soil moisture deficits and provide adequate leaching. Identify any factors contributing to increased soil salt content and possible management techniques that may affect these factors.

Task 7. Recommendations to the SWRCB on methods to implement salinity objectives.

Based on scientifically determined conclusions of the investigation, provide recommendations in a report to the SWRCB on potential methods to implement reasonable objectives for the southern delta agricultural beneficial uses.

Task 8. Other Tasks as Required

Perform other tasks as required by the SWRCB to help determine reasonable objectives for the southern delta agricultural beneficial uses..

APPENDIX C

Central Valley Project and State Water Project Operations' Effect on Variability of Salinity in the Southern Delta

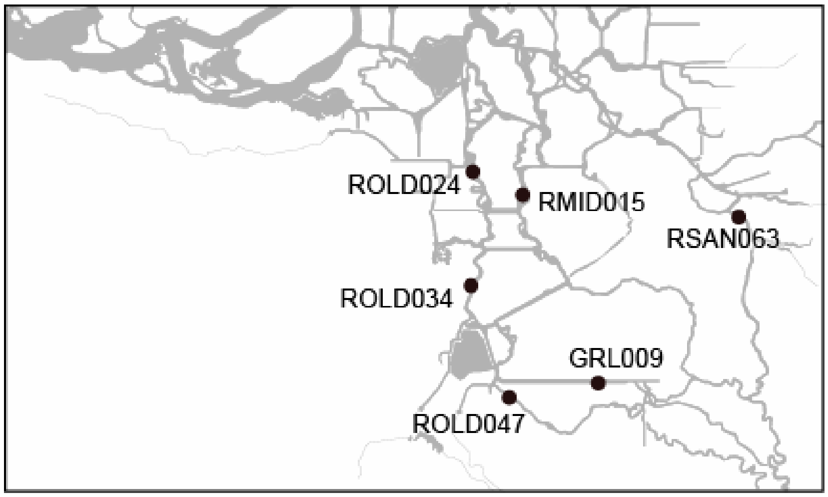
Salinity in south Delta channels is a result of the mixing of several sources of water with variable water quality. CVP and SWP operations affect Delta inflows, and these inflows, along with SWP and CVP exports, tides, and agriculture diversions, in turn affect general Delta circulation patterns. One important factor for determining salinity in south Delta channels is the relative contribution of the San Joaquin and Sacramento rivers as sources of water; the Sacramento River flowing into the Delta tends to be significantly less salty than the San Joaquin River. A second important determinant of salinity in the south Delta is the local circulation of water within the south Delta. South Delta channels at times receive significant amounts of agricultural drainage which can be two or three times more salty than the water in the receiving channels. Salt tends to buildup in channel reaches with relatively stagnant flow while salt from agricultural discharges tends to be flushed out with better circulation. This circulation in the south Delta, in part a result of Delta tides, inflows, exports, and agricultural activities, can also be significantly affected by the installation of temporary rock barriers. General Delta circulation patterns drive the relative contribution of the Sacramento and San Joaquin rivers as sources of water in the vicinity of the south Delta, and local circulation patterns determine how these sources are mixed and to what extent agricultural discharges are diluted. Thus, SWP and CVP operations which may affect salinity in the south Delta include SWP and CVP exports, Delta inflow, and the installation of temporary barriers.

In order to aid the understanding of the effects of SWP and CVP operations on south Delta salinity, Delta hydrodynamics and salinity have been simulated assuming modified historical 2002 Delta conditions. While San Joaquin River inflow and electrical conductivity (EC) were held fixed at historical levels, different CVP and SWP exports, Sacramento River inflow, and south Delta barrier installations were considered. CVP and SWP effects on south Delta salinity were evaluated using simulated Delta flows, EC, and 'fingerprints" of the Sacramento and San Joaquin rivers' contributions to the source of water throughout the Delta. Study results indicate that, when San Joaquin River flow into the Delta is fixed at historical values, changing localized circulation through different installations of south Delta barriers has more impact on salinity at the three compliance locations in the south Delta than does changing Delta-wide circulation patterns through changing SWP and CVP exports and Sacramento River inflow.

General Approach to Analysis

Simulated historical and modified 2002 Delta conditions were used as a basis for evaluating the effects of SWP and CVP operations on Delta circulation patterns and south Delta salinity. This year was selected to be consistent with the evidence provided by DWR in November of 2005 at SWRCB's hearing on draft Cease and Desist Order Nos. 262.31-16 and 262.31-17 (exhibit 20). The Delta simulation model, DSM2, was used to simulate Delta hydrodynamics and water quality. In order to show the model's ability to reproduce 2002 historical conditions, model and measured daily average flow at six locations in the Delta (Figure 1) are presented in Figure 2 and EC model and measured daily average EC are presented at the three compliance locations in Figure 3. At the time of this report, processed measured flow data from 2002 was immediately available only through June. Figure 3 indicates that DSM2 reproduces 2002 historical EC at the compliance locations fairly well with a tendency to underestimate, particularly at the Old River at Tracy Road Bridge site (ROLD047). Considering that the measured EC at the Old River at Tracy site in 2002 tended to be higher than the EC at the other two sites, the DSM2 simulation failed to account for a source of additional salt here. This underestimation is possibly due to failing to capture poorly circulating water and the build up of salt from agriculture drains or due to errors in the quality and quantity of local agricultural return flows estimated in DSM2.

Figure 1. Locations 2002 daily average measured and DSM2-simulated flow are compared.



Consistent with the presentation of historical simulations in DWR's South Delta Temporary Barriers reports, 15-minute Delta flows are averaged over periods for which Delta inflows and exports are fairly constant and the combined presence of south Delta barriers is fixed (Table 1). To accompany period-average flows, simulated Sacramento and San Joaquin rivers "fingerprints" and EC at the end of periods of time are presented. By using the fingerprinting method, relative contributions of water sources to the volume are estimated at any location. Volumetric fingerprinting can be thought of as taking a bucket of water at a particular location and being able to know what percentage of that water came from each inflow source. For this analysis, fingerprinting output is generated at several locations and from these results the fingerprints are displayed as contours delineating the extent 75% and 90% of Delta channel water originating from either the Sacramento or San Joaquin rivers. EC at the Old River near Middle River compliance location was not simulated for all alternatives in this study; EC at RMID041, approximately one mile downstream in Middle River from this site, is instead presented in order to be able to compare the effects of different SWP and CVP operations and different barrier configurations. Also presented is the EC in Old River just upstream of the temporary barrier location ("Old River near DMC") in order to better understand the different roles that Delta-wide circulation patterns and localized south Delta circulation patterns play in determining the salinity in the south Delta. The periods from 2002 that are presented for each simulation are: April 1-14, April 15-30, May 1-24, June 7-30, July 1-31, and August 1-31 (Table1).

A description of the results for the historical 2002 simulation is contained within the discussion of the results of variations from the historical conditions.

Figure 2. Comparison of measured daily average flow to DSM2-simulated daily average flow, 2002.

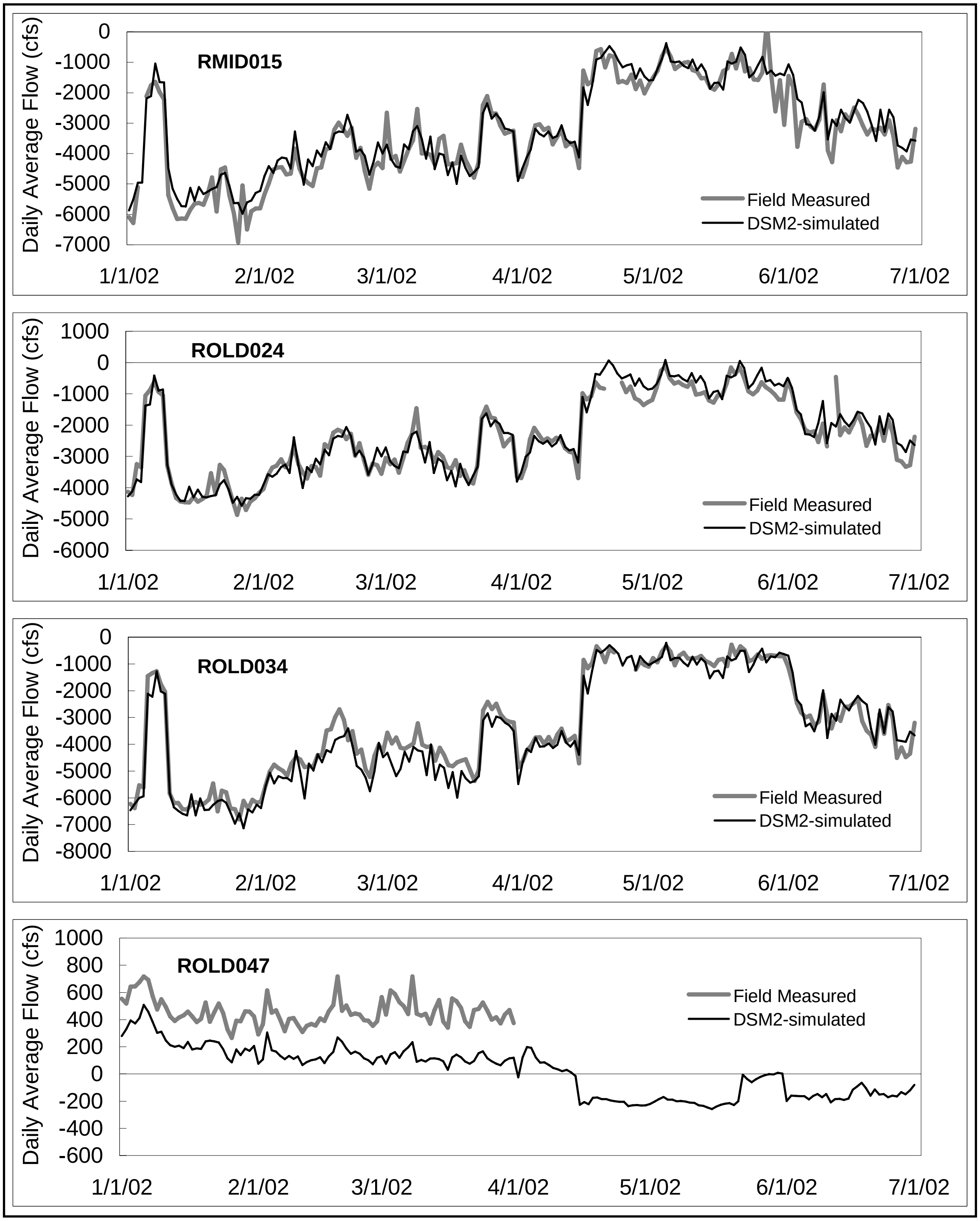


Figure 2 (cont.). Comparison of measured daily average flow to DSM2-simulated daily average flow, 2002.

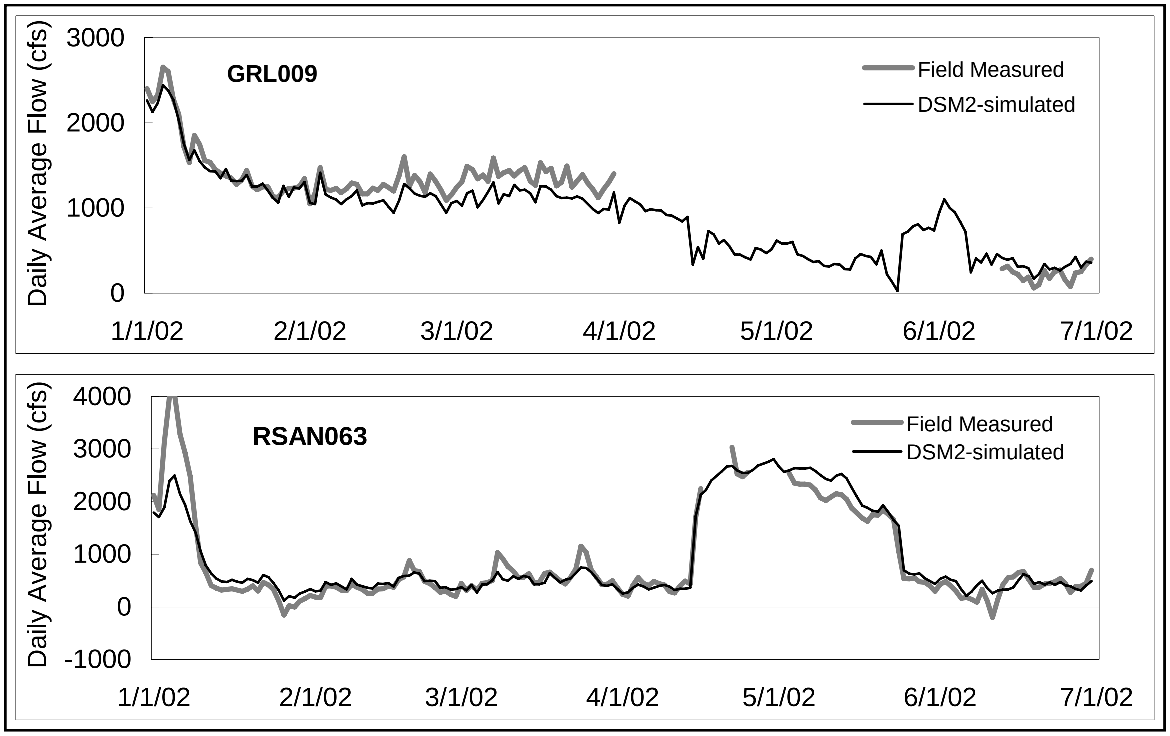
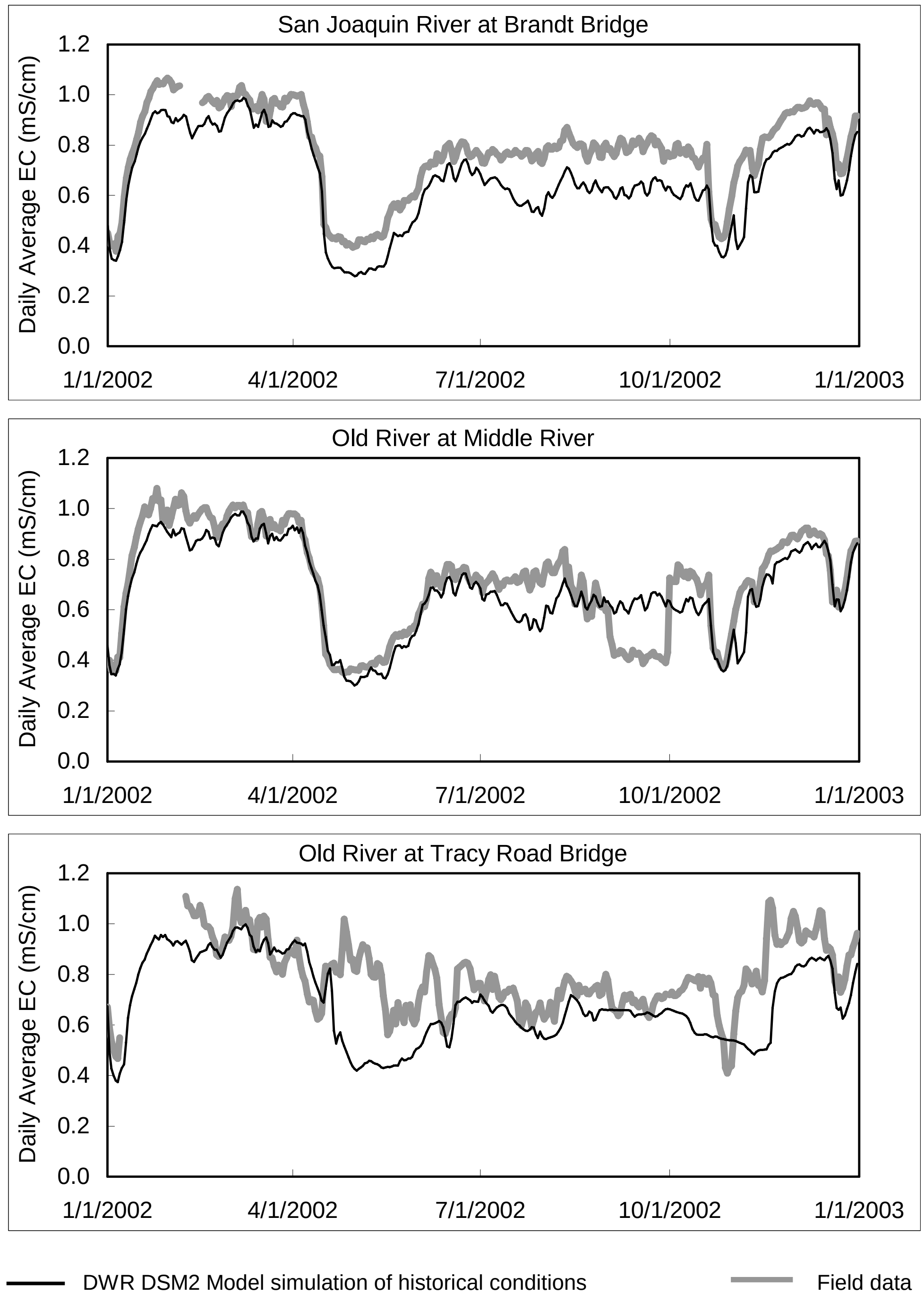


Figure 3. Comparison of DSM2-simulated and measured EC at the three south Delta agriculture compliance locations, 2002.



Source of field data: Interagency Ecological Program and DWR Central District

Table 1. Partitioning of historical 2002 simulation for presentation of results into periods of stable inflows and exports and constant south Delta barrier installation.

Period		Period Average Flows				Period Barrier Status			
		Sac River + Yolo Bypass (cfs)	San Joaquin River (cfs)	DMC Pumping (cfs)	SWP Pumping (cfs)	MR	OR	GLC	ORH
JAN	1 - 4	52,468	4,849	4,044	8,012	--	--	--	--
	5 - 10	83,533	3,839	4,117	2,581	--	--	--	--
	11 - 31	30,316	1,968	4,172	7,268	--	--	--	--
FEB	1 - 28	18,238	1,895	3,601	4,941	--	--	--	--
MAR	1 - 22	21,846	2,121	4,149	4,630	--	--	--	--
	23 - 31	20,139	2,157	4,209	2,091	--	--	--	--
APR	1 - 14	16,321	1,822	3,501	3,986	--	--	--	--
	15 - 30	13,355	3,218	1,097	693	IN	IN	--	IN
MAY	1 - 24	12,694	3,000	836	573	IN	IN	--	IN
	25 - 31	15,098	2,107	922	805	IN	IN	--	--
JUN	1 - 6	12,653	1,676	3,267	1,580	IN	IN	--	--
	7 - 30	14,105	1,368	2,427	2,331	IN	IN	IN	--
JUL	1 - 31	18,817	1,275	4,348	6,222	IN	IN	IN	--
AUG	1 - 31	16,959	1,150	4,329	6,733	IN	IN	IN	--
SEP	1 - 30	13,554	1,161	4,278	4,131	IN	IN	IN	--
OCT	1 - 3	11,707	1,176	4,321	2,202	IN	IN	IN	--
	4 - 20	9,772	1,306	4,286	1,039	IN	IN	IN	IN
	21 - 31	9,709	2,069	3,698	2,665	IN	IN	IN	IN
NOV	1 - 10	11,913	1,669	2,626	2,196	IN	IN	IN	IN
	11 - 20	13,245	1,712	4,114	4,703	IN	IN	IN	IN
	21 - 28	11,161	1,493	4,254	2,628	IN/--	IN/--	IN/--	--
	29 - 30	21,960	1,411	4,264	2,153	--	--	--	--
DEC	1 - 13	11,406	1,425	3,346	2,063	--	--	--	--
	14 - 31	44,904	2,379	3,312	5,844	--	--	--	--

Impact of SWP and CVP Operations on Delta-wide Circulation and South Delta Water Quality

To demonstrate the effect of SWP and CVP operations on Delta-wide circulation patterns and south Delta EC, three scenarios were simulated to compare to the historical 2002 simulation: 1) no SWP pumping from January through August and no south Delta barriers installed, 2) no SWP and no CVP pumping from January through August and no south Delta barriers installed, and 3) historical 2002 conditions including barrier installation with an additional 5,000 cfs in Sacramento River inflow. When SWP or CVP pumping was eliminated, Sacramento River was reduced the same amount to maintain the same Delta outflow. For the scenario with additional Sacramento River inflow, the downstream boundary EC was modified to reflect higher Delta outflow.

Figures 4a – 4f show for the historical 2002 simulation the Delta-wide period-average flow directions and the end-of-period volumetric fingerprints of the Sacramento River and San Joaquin rivers displayed as contours of 75% and 90% contribution. The daily average EC at the four locations in the south Delta on the last day of the period is also presented. These figures indicate that period-average flows in Old and Middle rivers downstream of the south Delta tend to be in the upstream direction towards the SWP and CVP pumps. When combined SWP and CVP pumping is low (April 15-30 and May 1-24), the area of high portion of Sacramento River water remained in the Sacramento River and lower San Joaquin River. However, when combined SWP and CVP pumping range from 7,400 cfs to 4,700 cfs (in the April 1-14 and June 7-30 periods), the region for which Sacramento River is an important source of water moves up Old River towards the pumps. In July and August, with combined SWP and CVP pumping exceeding 10,500 cfs, average flows in the lower San Joaquin River are upstream and the contour of 90% Sacramento River water by volume moves further upstream Old River and dominates Middle River. In July and August of 2002, Delta-wide circulation brings Sacramento River-source water into the vicinity of the south Delta barriers on Middle and Old rivers. This is reflected in the relatively low EC at Old River near the DMC (0.3 mS/cm) compared to the other sites which have a daily average EC of 0.6 mS/cm.

In contrast to the region of Sacramento River water influence, the area of influence of the San Joaquin River in 2002 varies far less over the study period. The source water at the three compliance stations usually exceeds 90% from the San Joaquin River. The exception for this is in July and August at Brandt Bridge because most of the San Joaquin River during these times flows down the head of Old River, allowing more Sacramento River-source water to move up the San Joaquin River. Still, the EC at the three compliance stations at the end of the periods is either equal to or greater than the EC at Vernalis, further demonstrating the dominance of the San Joaquin River as the source of water at the sites.

Figures 5a-5f present the results of simulating the scenario for no SWP pumping from January through August and no barriers installed. Without SWP pumping, period-average flow is in the downstream direction for Old and Middle rivers when CVP pumping is near or less than 1,000 cfs. As CVP pumping exceeds 2,000 cfs, net reverse flows in Old and Middle rivers are seen with an accompanying moving of Sacramento River-source water up Old and Middle rivers; however, Sacramento River-source water fails to penetrate into the south Delta to the extent that is seen in the historical simulation. The region dominated by the San Joaquin River tended to move further downstream the San Joaquin River than in the historical simulation, the three compliance locations once again falling within the 90% source contour and the EC here equal to or exceeding the EC at Vernalis.

Figures 6a-6f present the results of simulating the scenario of no SWP and CVP pumping from January through August and no barriers installed. Without the project exports in the south Delta, period-average flow direction in Old and Middle rivers is downstream with the exception of Middle River from June through August. From April through May, period-average San Joaquin River inflows exceeds 1,800 cfs and the region dominated by the San Joaquin River extends down the San Joaquin River and somewhat down Old River. From June through August, with San Joaquin River inflows below 1,400 cfs and Delta agricultural water use higher, the extent of San Joaquin River influence recedes to a region similar to the previous two scenarios. The compliance locations again fall within the region of dominance of the San Joaquin River and EC at these locations again equal or exceed the EC at Vernalis.

Figures 7a-7f present the results of simulating the scenarios of historical conditions with an additional 5,000 cfs flowing down the Sacramento River from April through August. The circulation patterns, regions of dominance by the Sacramento and San Joaquin rivers, and the EC at the compliance locations are all very similar to those from the historical simulation. The area for which the Sacramento River is the dominant source does tend to move down the Sacramento River somewhat when compared to the area from the historical simulation. In addition, some more Sacramento River-source water tends to move upstream Old River when compared to the historical simulation; however, the three compliance sites remain well within the dominance of the San Joaquin River.

Figure 8 presents the daily average EC at the four study sites for the four scenarios. The EC at the Old River near DMC site, which is downstream of the Old River at Tracy Road site, is substantially increased by eliminating SWP and CVP pumping and removing barriers. This is due to replacing some of the water originating from the Sacramento River with saltier water from the San Joaquin River, as is reflected in the area of San Joaquin River dominance moving downstream Old River. For the same reason, the EC at Old River near DMC decreases for additional Sacramento River flow in July and August because more of the water here at these times originates from the Sacramento River. At both Old River at Tracy Road and RMID040, some decrease in EC in April and May is shown for the scenarios of eliminating SWP pumping and both SWP and CVP pumping. Since, when compared to the historical simulation, the EC downstream at Old River near DMC either remained the same as the historical simulation (for the No SWP Pumping, No Barriers scenario) or increased (for the No SWP, CVP Pumping, No Barriers scenario), the improvement in EC isn’t attributable to Delta-wide circulation patterns. Instead, the south Delta barriers at times can reduce the circulation in Old River, allowing local agricultural drainage to accumulate and increasing salinity levels. More discussion of south Delta circulation patterns follows in the next analysis. Finally, the EC at Brandt Bridge remains essentially unchanged under the different scenarios. Overall, Figure 8 indicates that increasing Sacramento River flow by 5,000 cfs for the historical 2002 simulation does not dramatically change Delta-wide circulation patterns, the Delta regions dominated by the Sacramento and San Joaquin Rivers, or the EC at the compliance sites. Reducing or eliminating SWP and CVP pumping does significantly change general Delta circulation patterns, but these changes, in themselves, do not affect EC at the compliance sites.

The next section focuses on the impact on south Delta EC of inducing different circulation patterns within the south Delta by changing barrier installation strategies.

Figure 4a. DSM2-simulated period-average Delta-wide flow patterns and period-end fingerprints and EC, historical conditions, April 1-14, 2002.

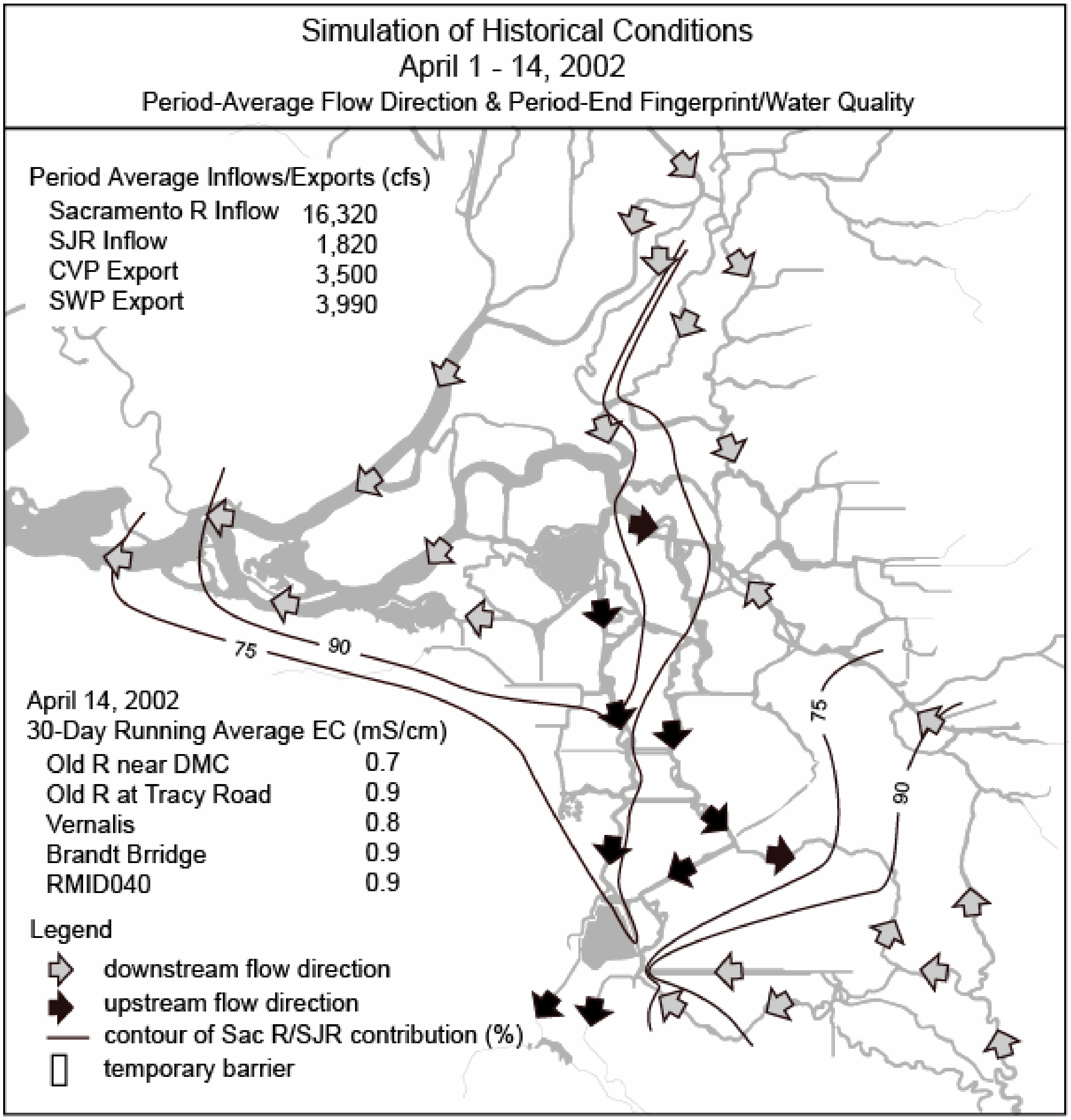


Figure 4b. DSM2-simulated period-average Delta-wide flow patterns and period-end fingerprints and EC, historical conditions, April 15-30, 2002.

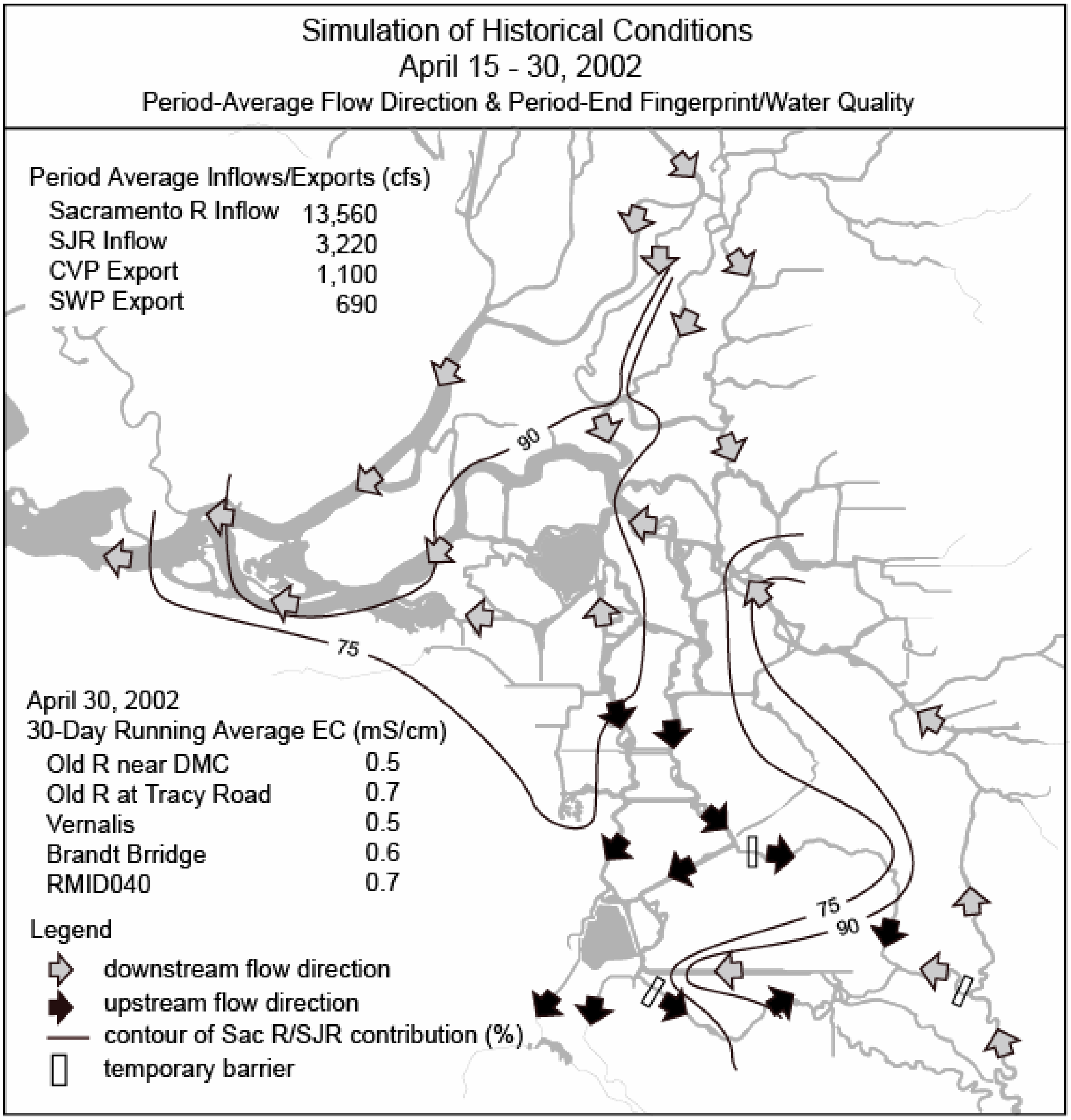


Figure 4c. DSM2-simulated period-average Delta-wide flow patterns and period-end fingerprints and EC, historical conditions, May 1-24, 2002.

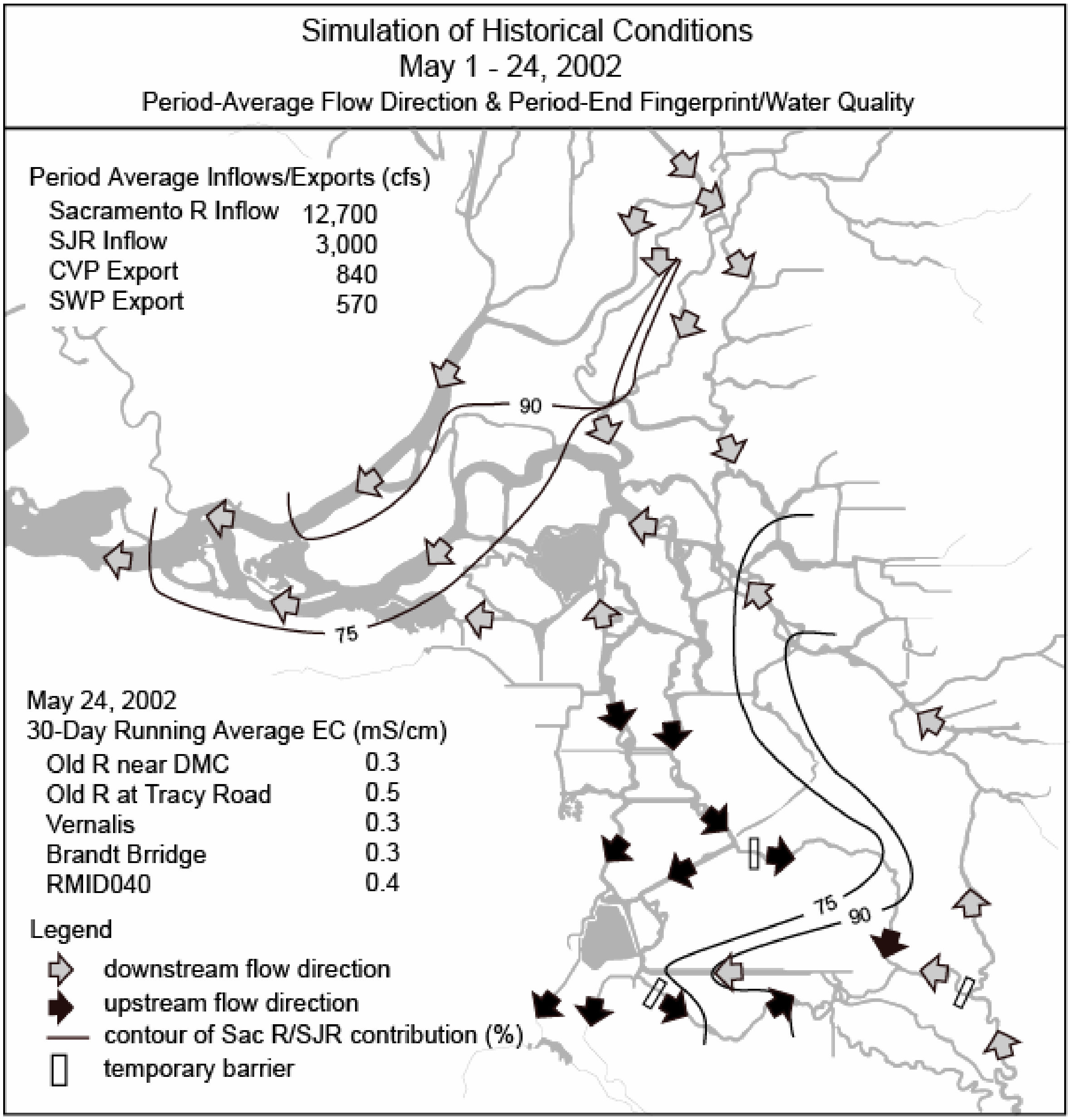


Figure 4d. DSM2-simulated period-average Delta-wide flow patterns and period-end fingerprints and EC, historical conditions, June 7-30, 2002.

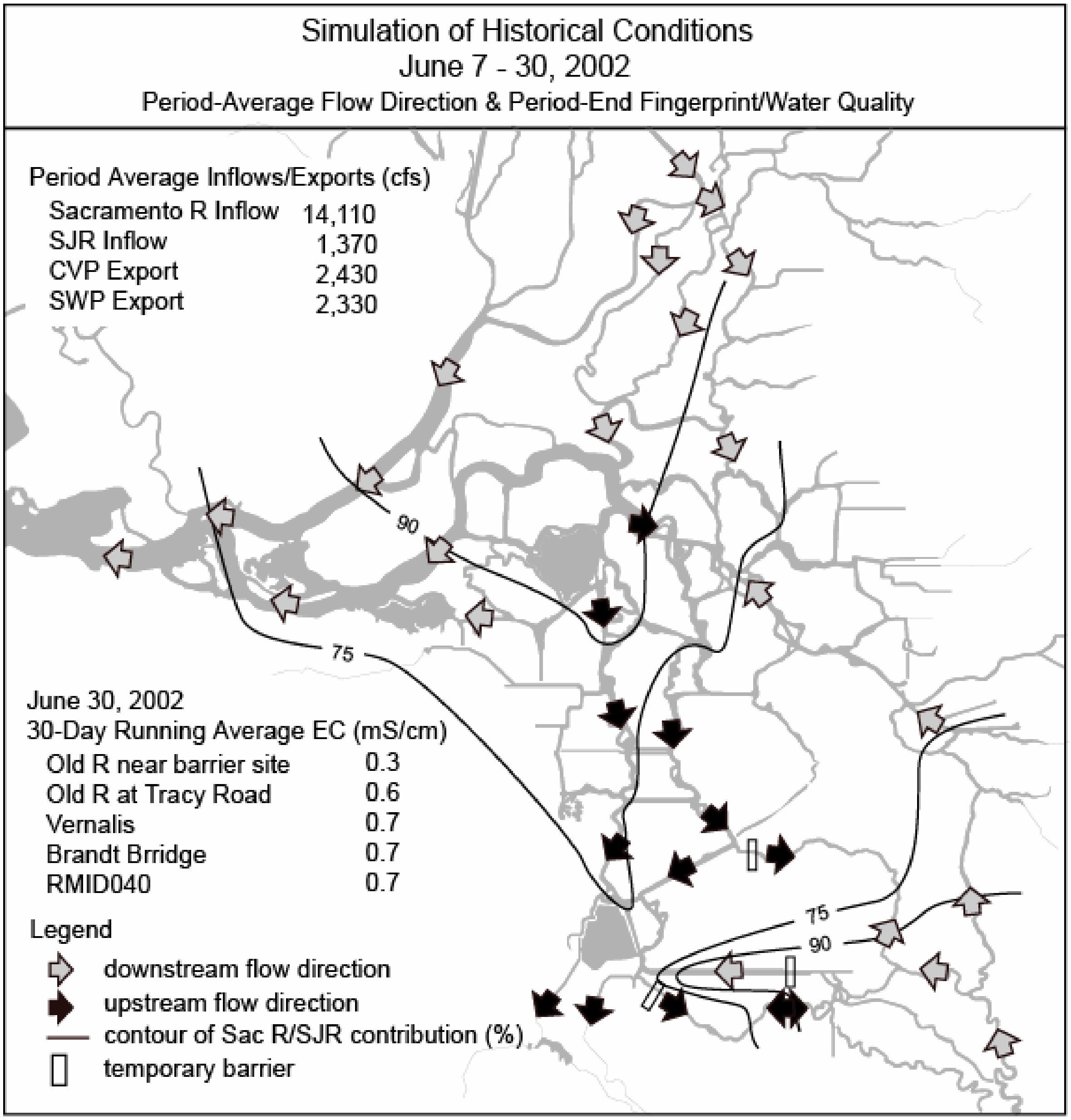


Figure 4e. DSM2-simulated period-average Delta-wide flow patterns and period-end fingerprints and EC, historical conditions, July 1-31, 2002.

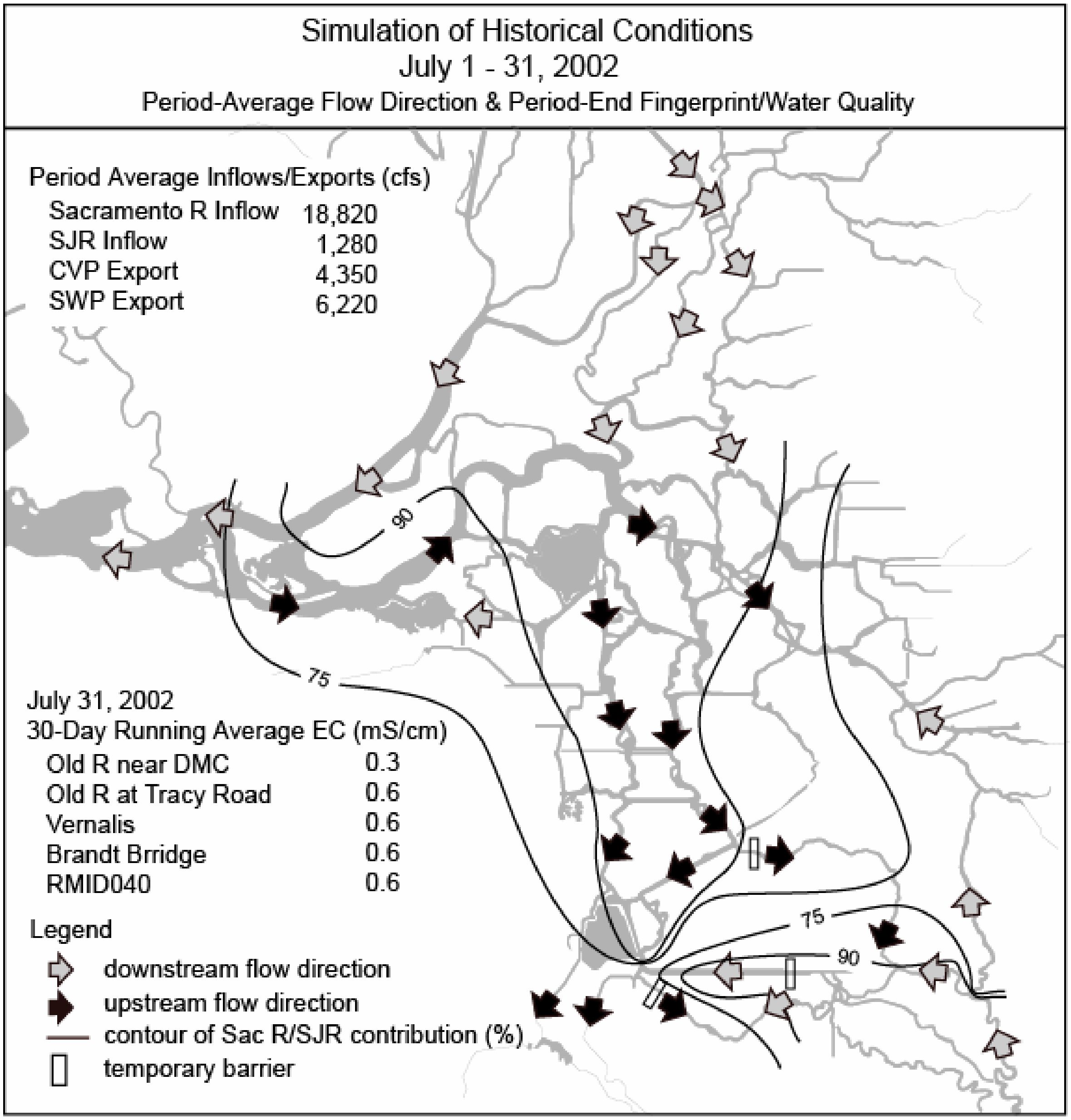


Figure 4f. DSM2-simulated period-average Delta-wide flow patterns and period-end fingerprints and EC, historical conditions, August 1-31, 2002.

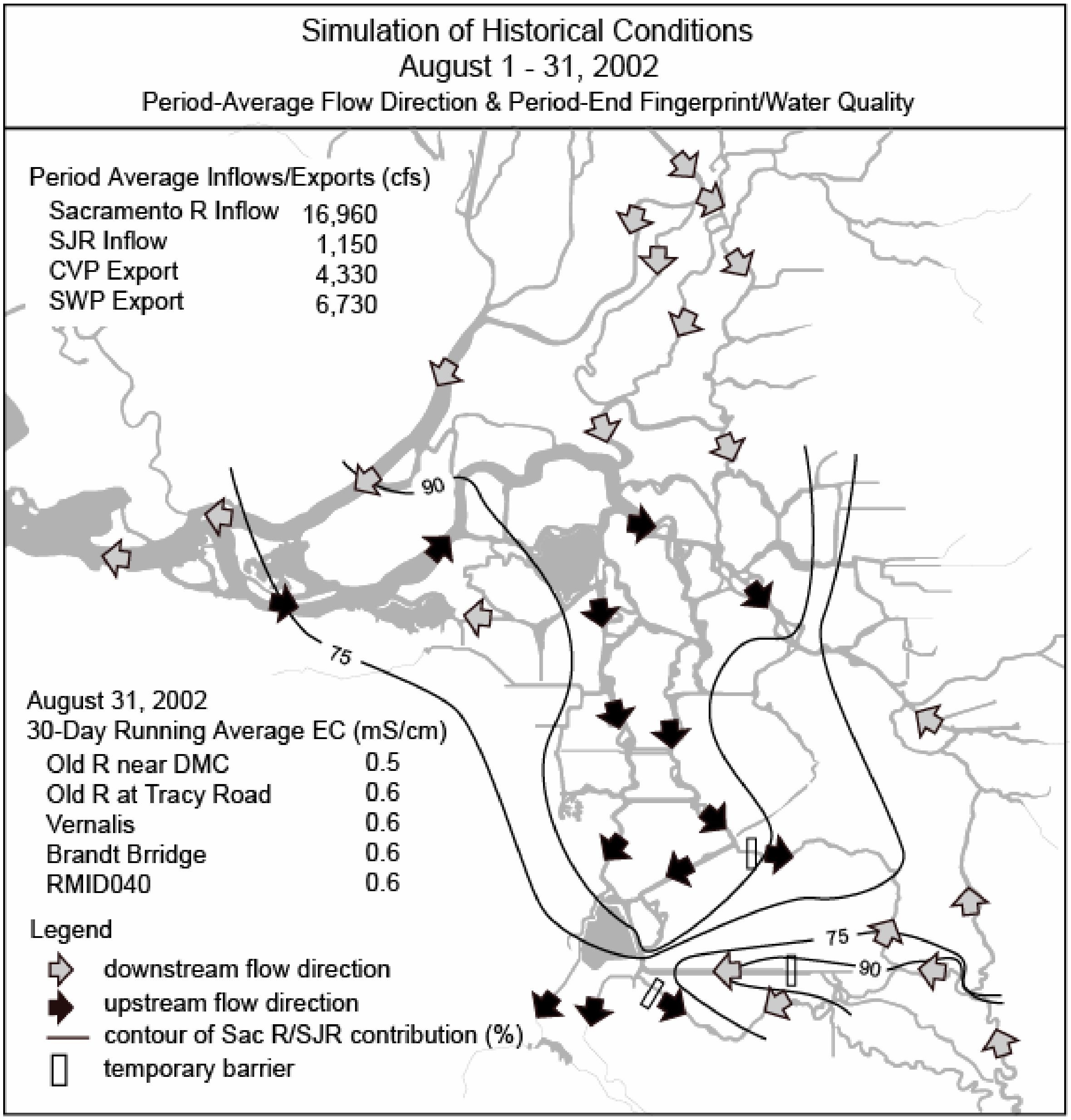


Figure 5a. DSM2-simulated period-average Delta-wide flow patterns and period-end fingerprints and EC, No SWP pumping and no barriers scenario, April 1-14, 2002.

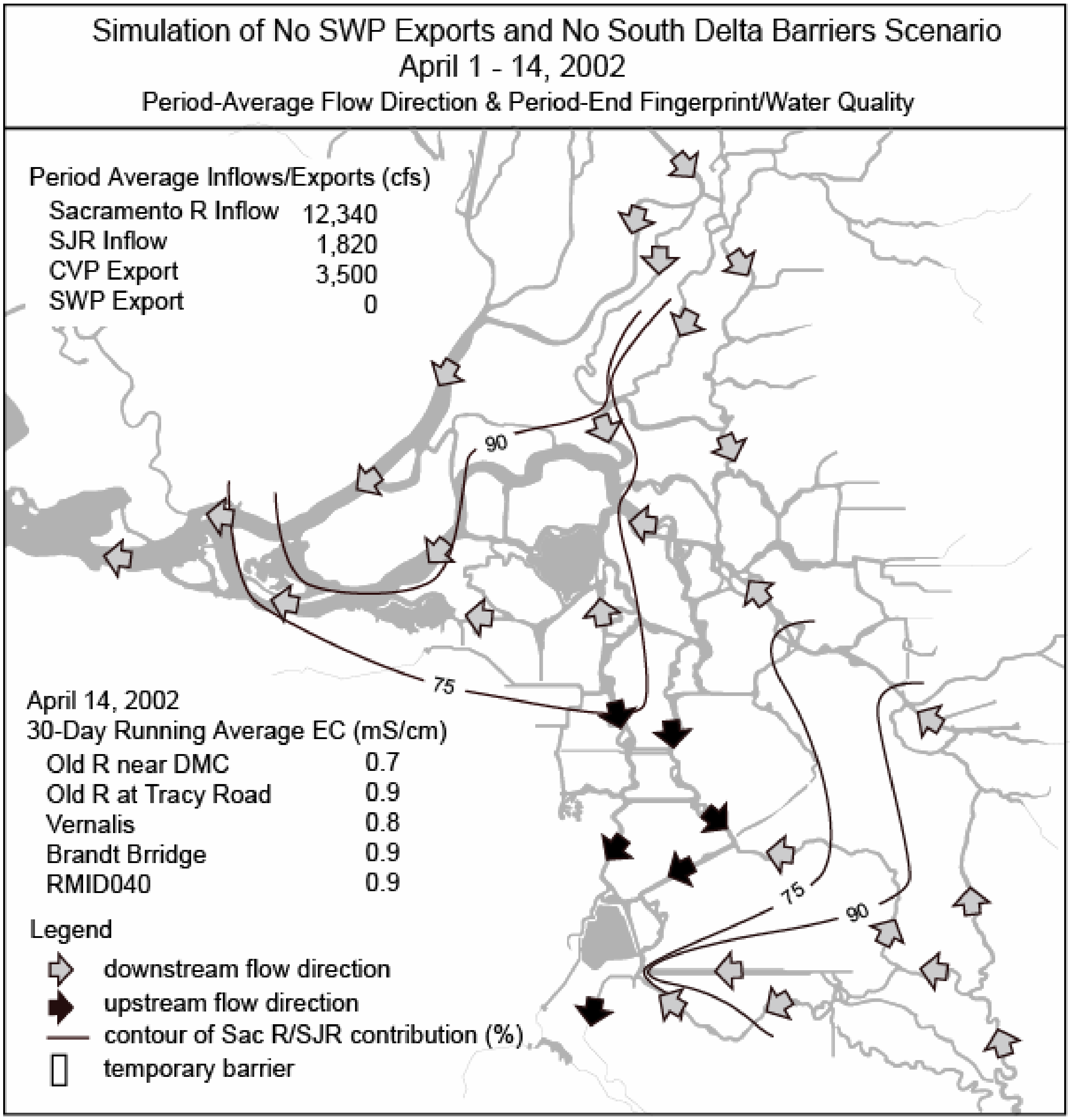


Figure 5b. DSM2-simulated period-average Delta-wide flow patterns and period-end fingerprints and EC, No SWP pumping and no barriers scenario, April 15-30, 2002.

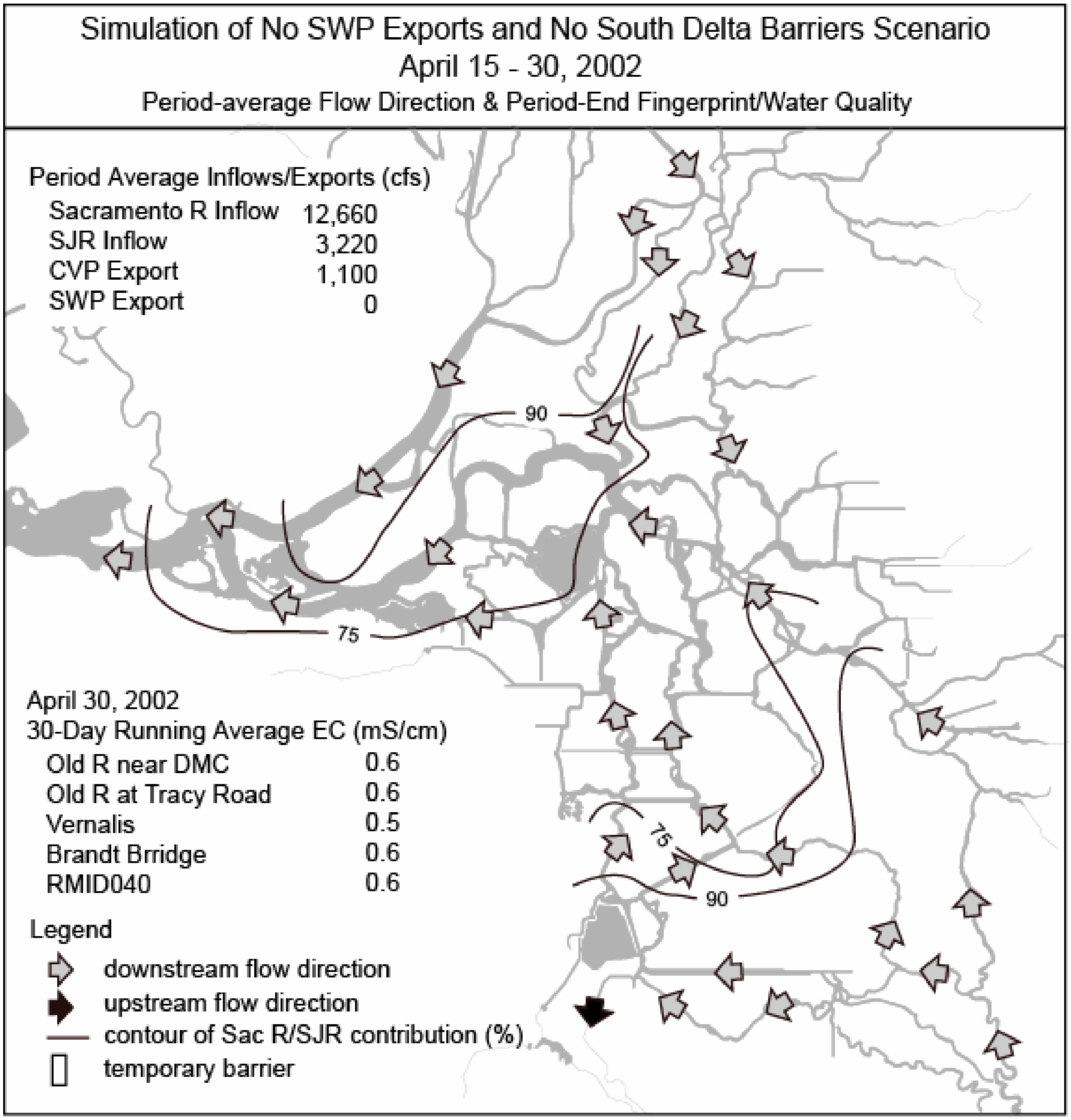


Figure 5c. DSM2-simulated period-average Delta-wide flow patterns and period- end fingerprints and EC, No SWP pumping and no barriers scenario, May 1-24, 2002.

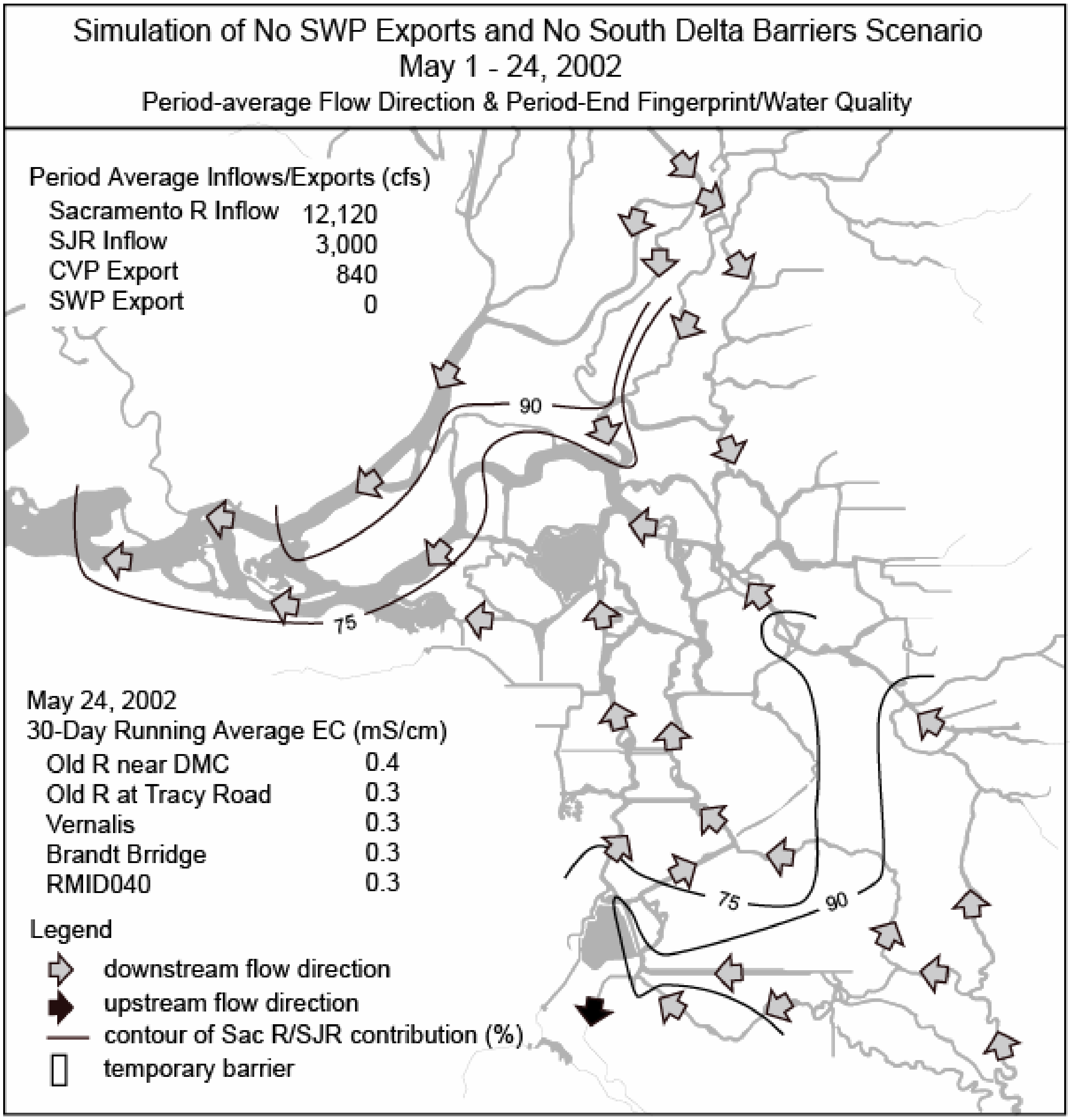


Figure 5d. DSM2-simulated period-average Delta-wide flow patterns and period-end fingerprints and EC, No SWP pumping and no barriers scenario, June 7-30, 2002.

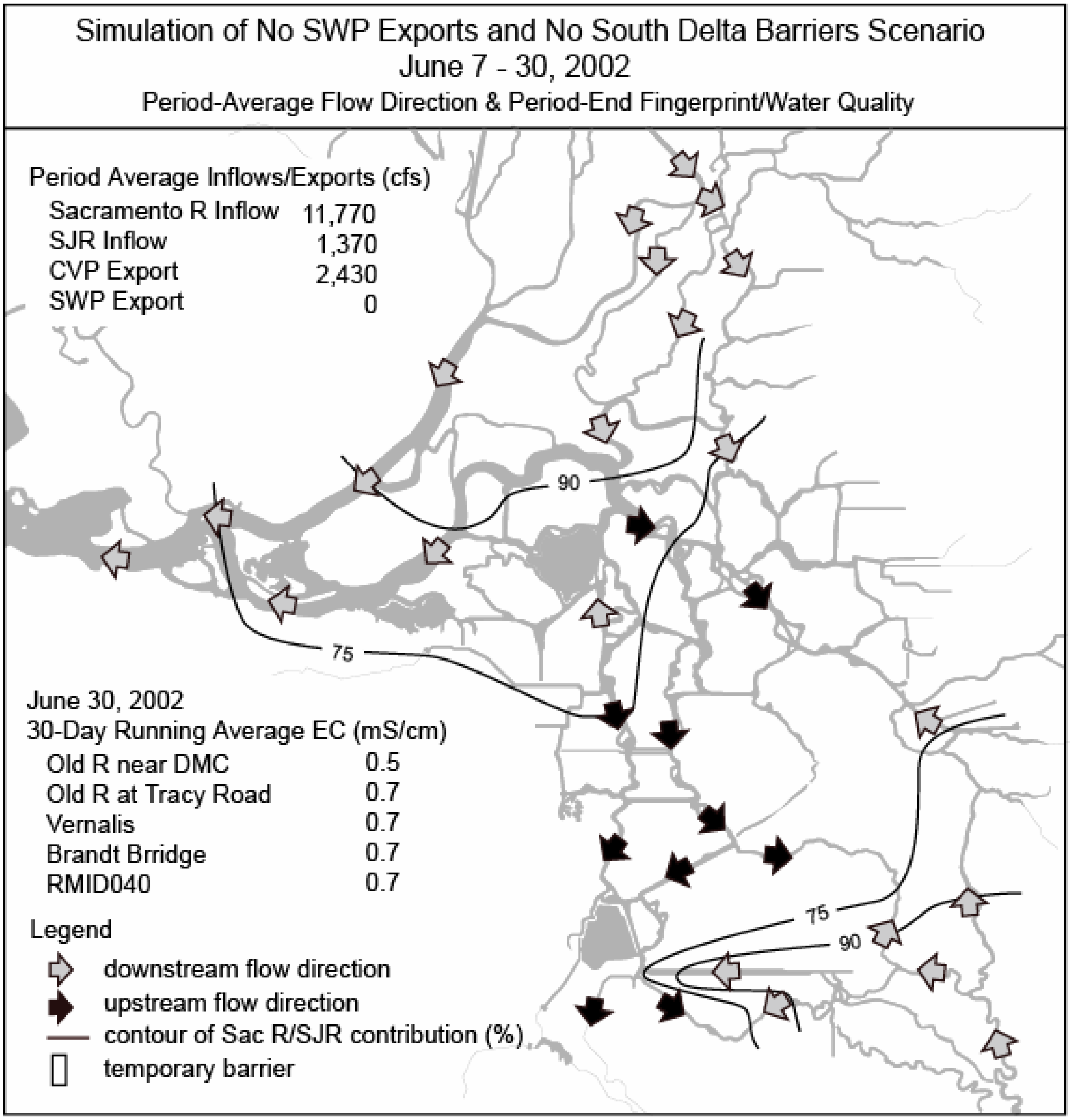


Figure 5e. DSM2-simulated period-average Delta-wide flow patterns and period-end fingerprints and EC, No SWP pumping and no barriers scenario, July 1-31, 2002.

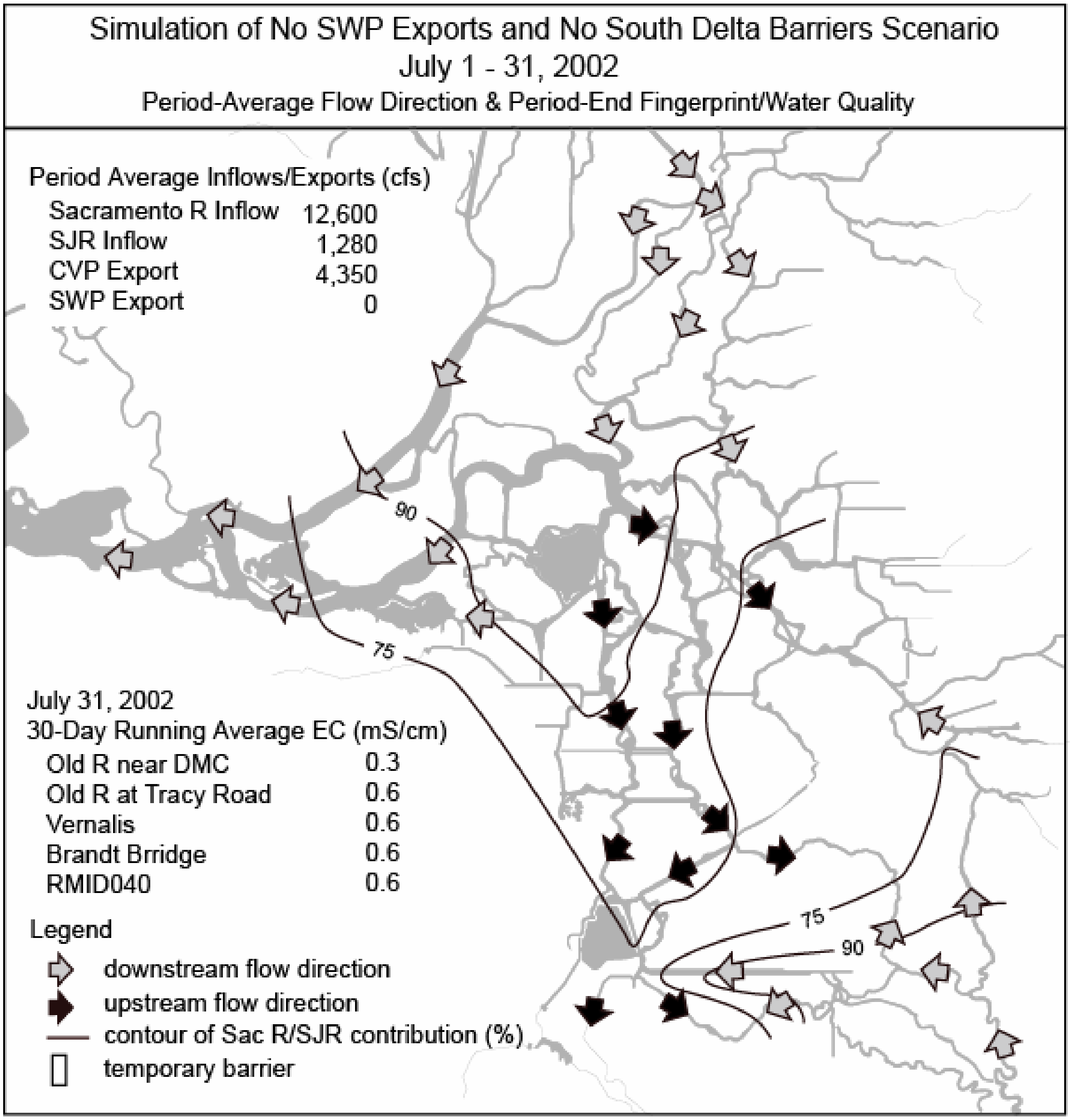


Figure 5f. DSM2-simulated period-average Delta-wide flow patterns and period-end fingerprints and EC, No SWP pumping and no barriers scenario, August 1-31, 2002.

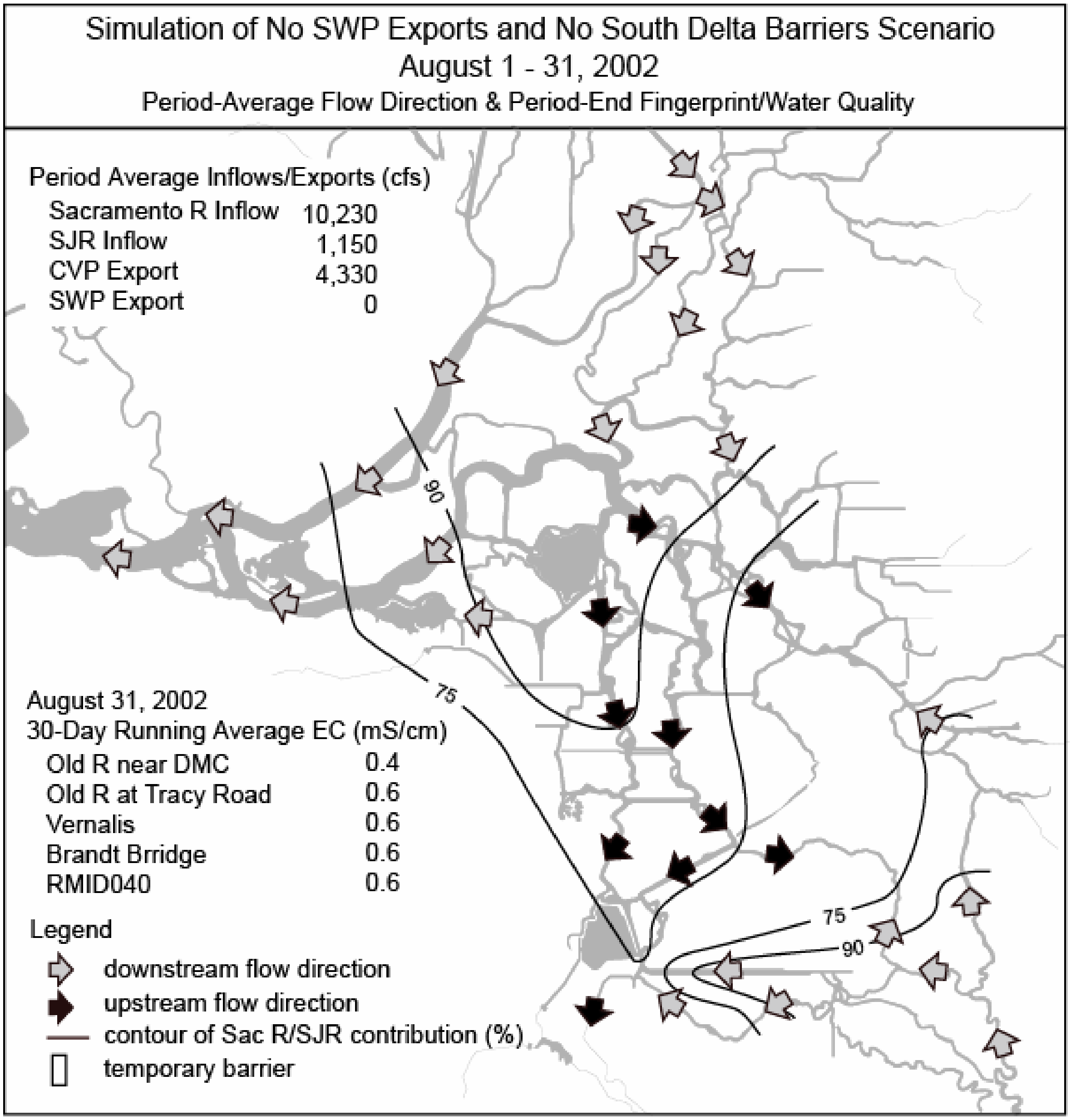


Figure 6a. DSM2-simulated period-average Delta-wide flow patterns and period-end fingerprints and EC, No SWP pumping, No CVP pumping, and no barriers scenario, April 1-14, 2002.

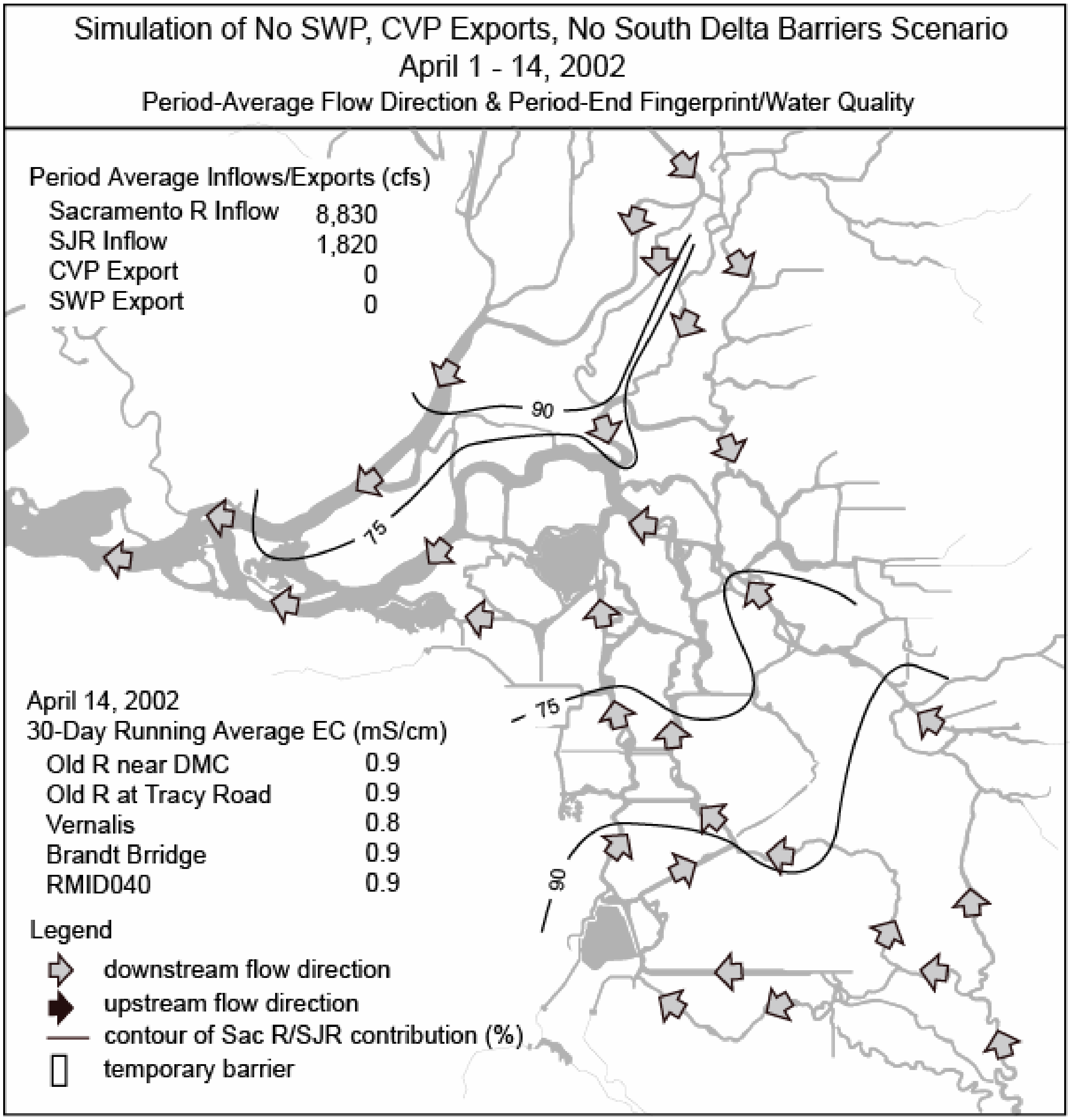


Figure 6b. DSM2-simulated period-average Delta-wide flow patterns and period-end fingerprints and EC, No SWP pumping, No CVP pumping, and no barriers scenario, April 15-30, 2002.

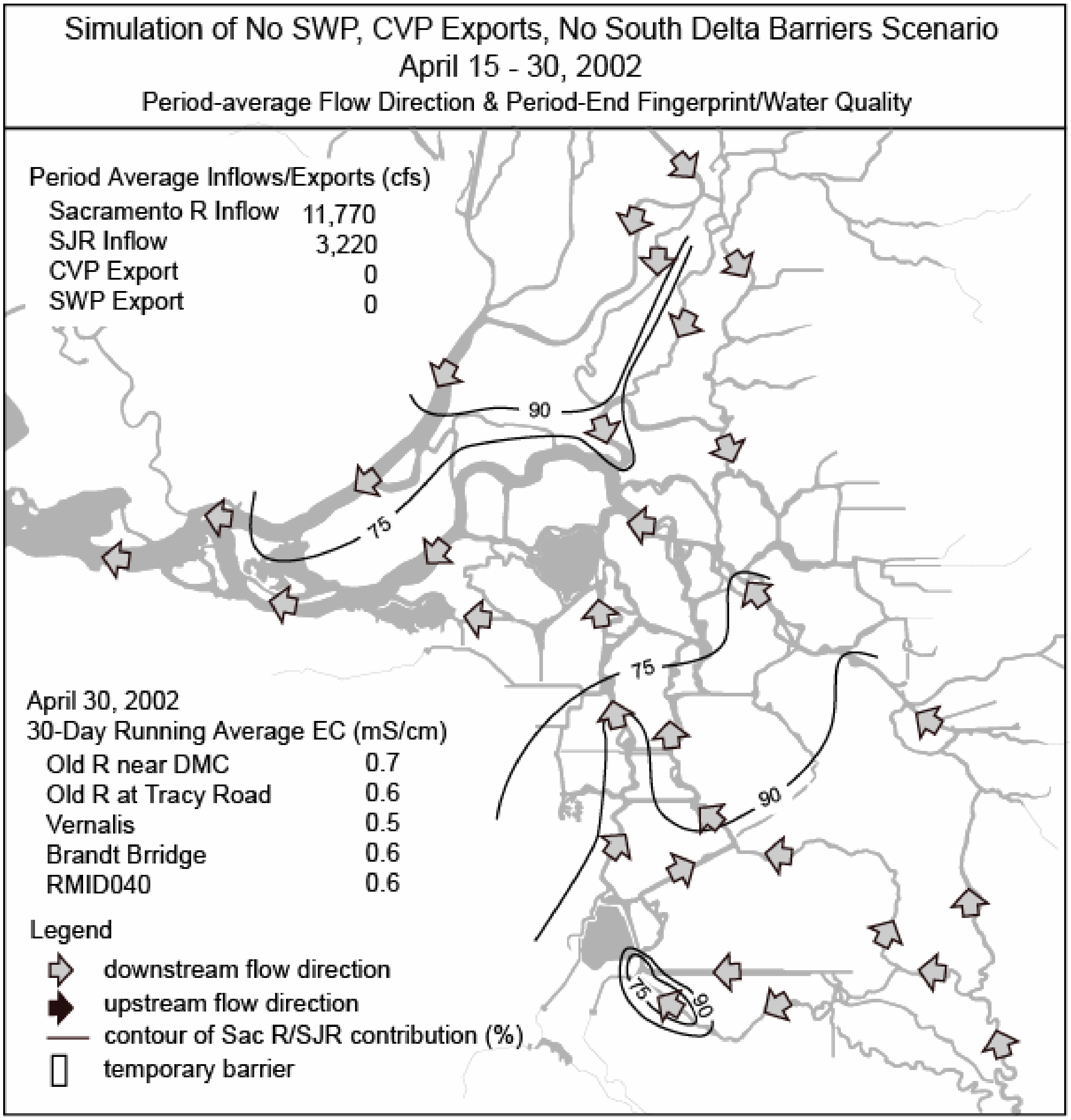


Figure 6c. DSM2-simulated period-average Delta-wide flow patterns and period-end fingerprints and EC, No SWP pumping, No CVP pumping, and no barriers scenario, May 1-24, 2002.

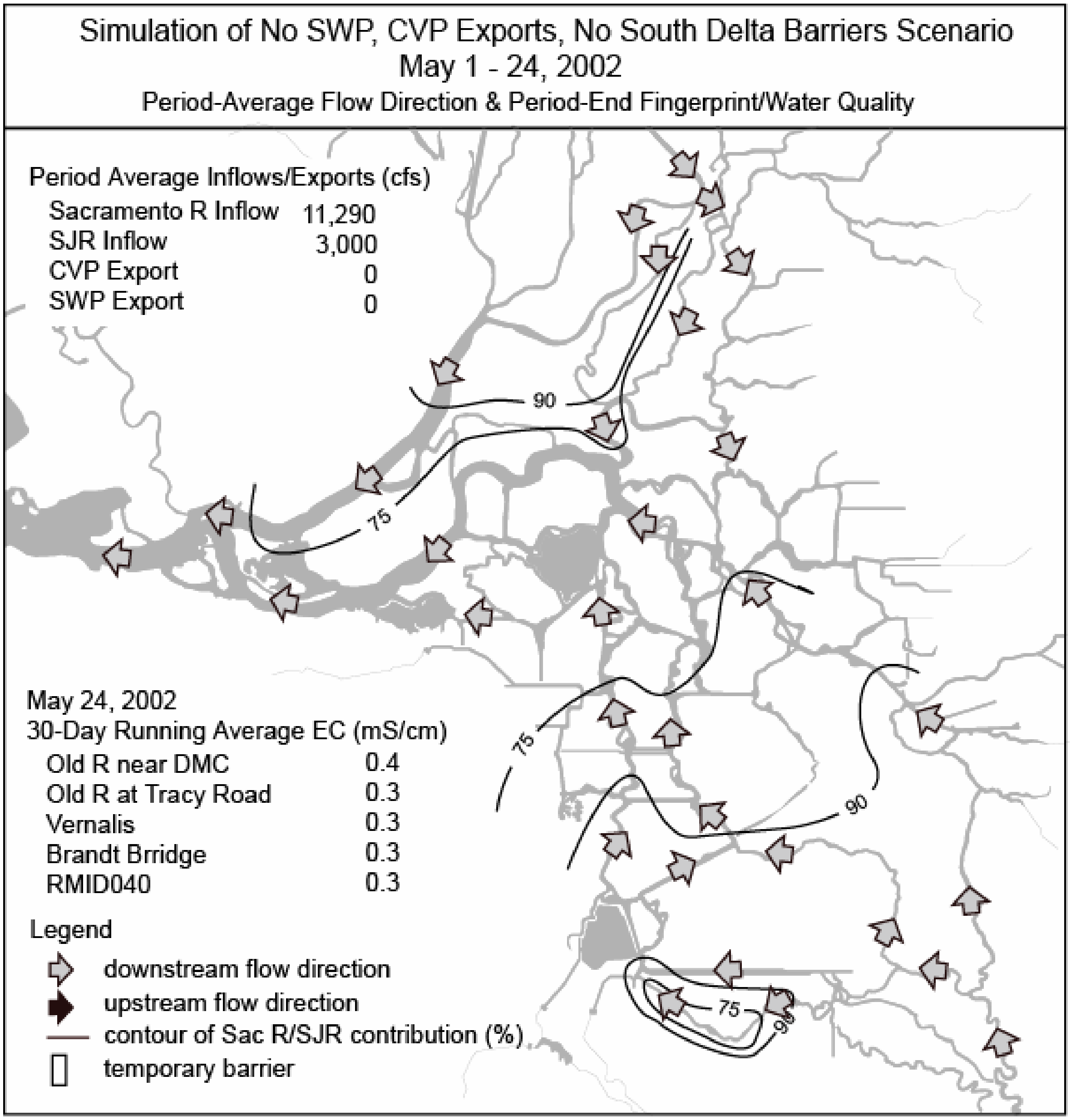


Figure 6d. DSM2-simulated period-average Delta-wide flow patterns and period-end fingerprints and EC, No SWP pumping, No CVP pumping, and no barriers scenario, June 7-30, 2002.

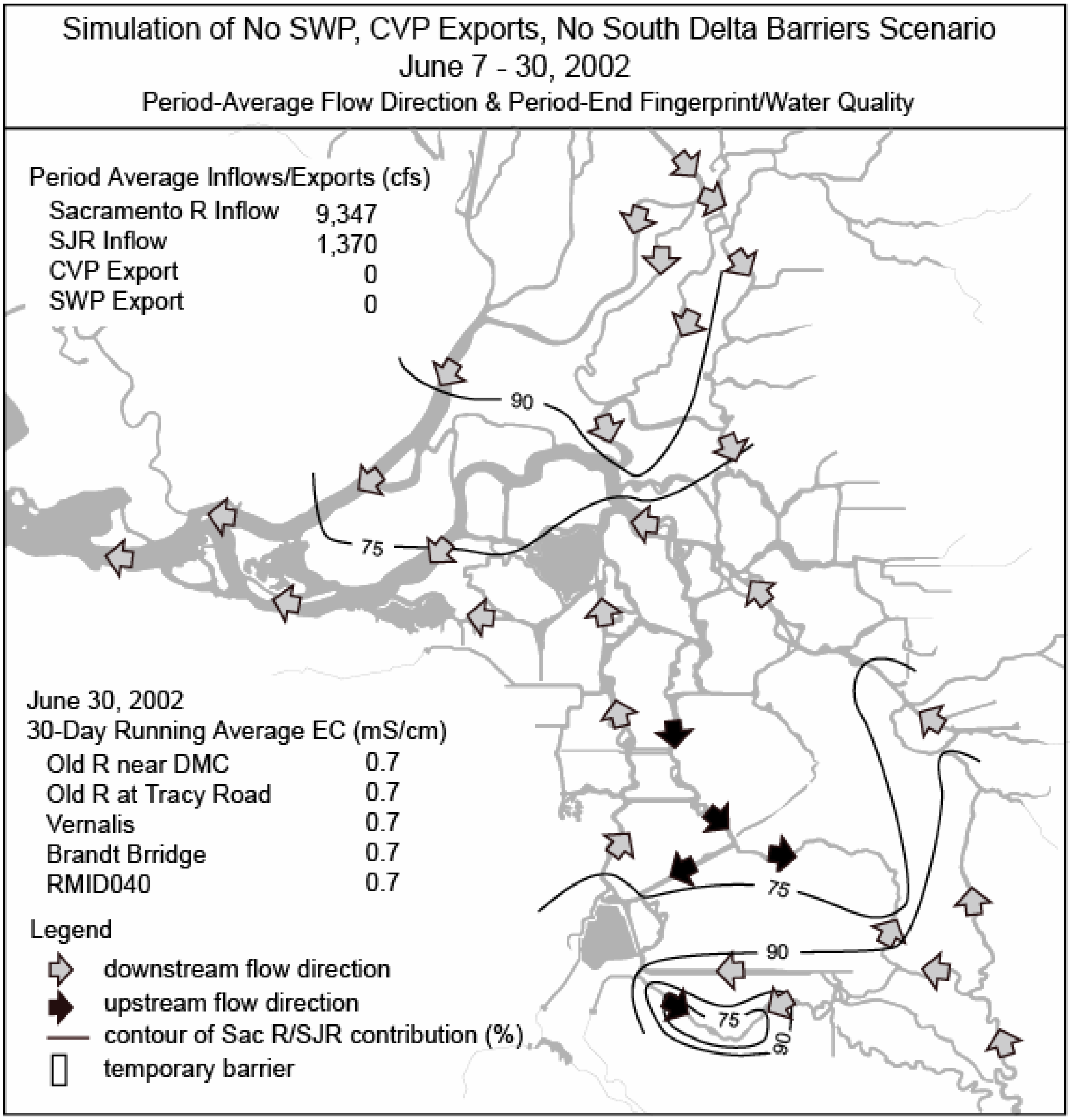


Figure 6e. DSM2-simulated period-average Delta-wide flow patterns and period-end fingerprints and EC, No SWP pumping, No CVP pumping, and no barriers scenario, July 1-31, 2002.

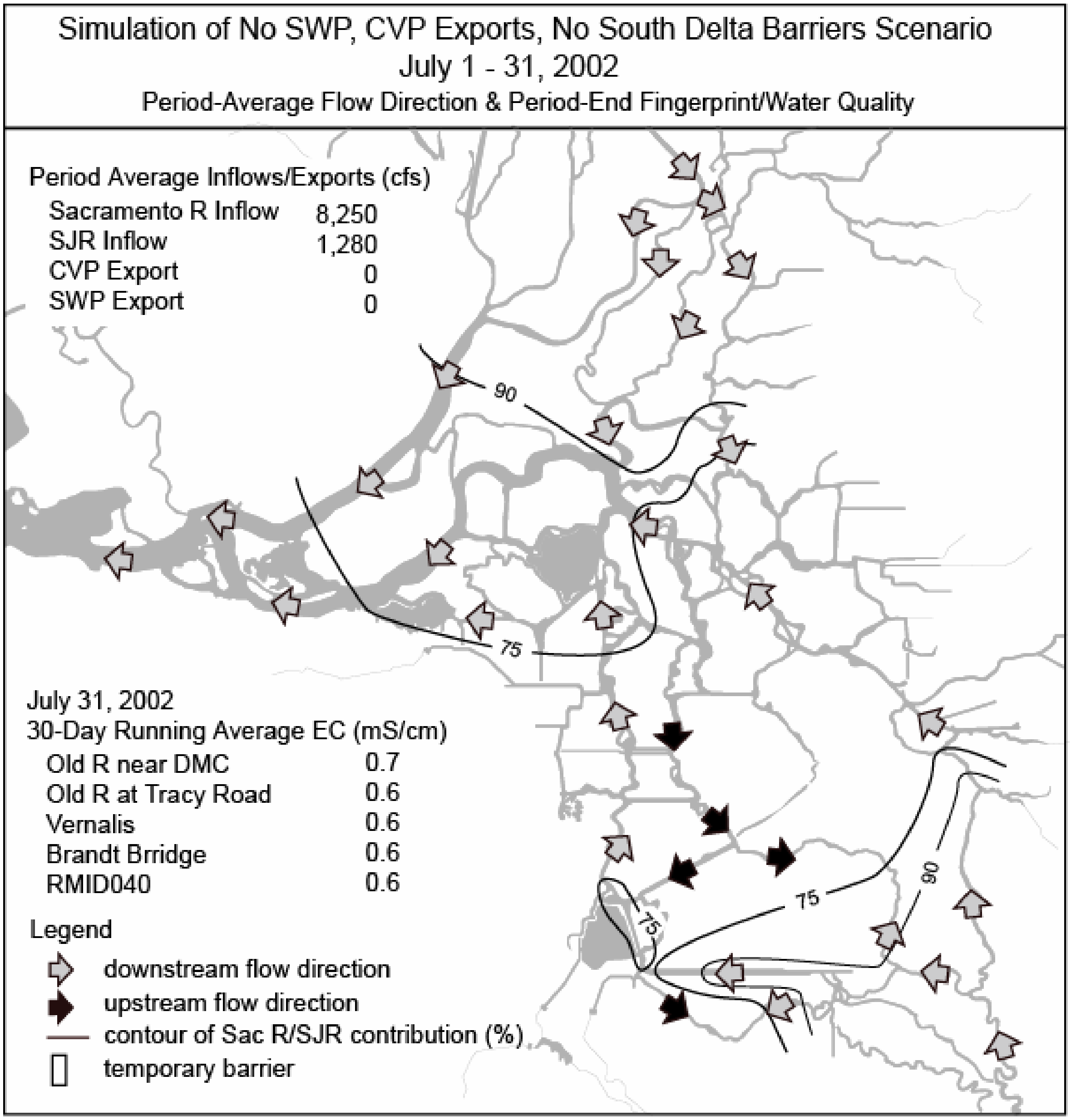


Figure 6f. DSM2-simulated period-average Delta-wide flow patterns and period-end fingerprints and EC, No SWP pumping, No CVP pumping, and no barriers scenario, August 1-31, 2002.

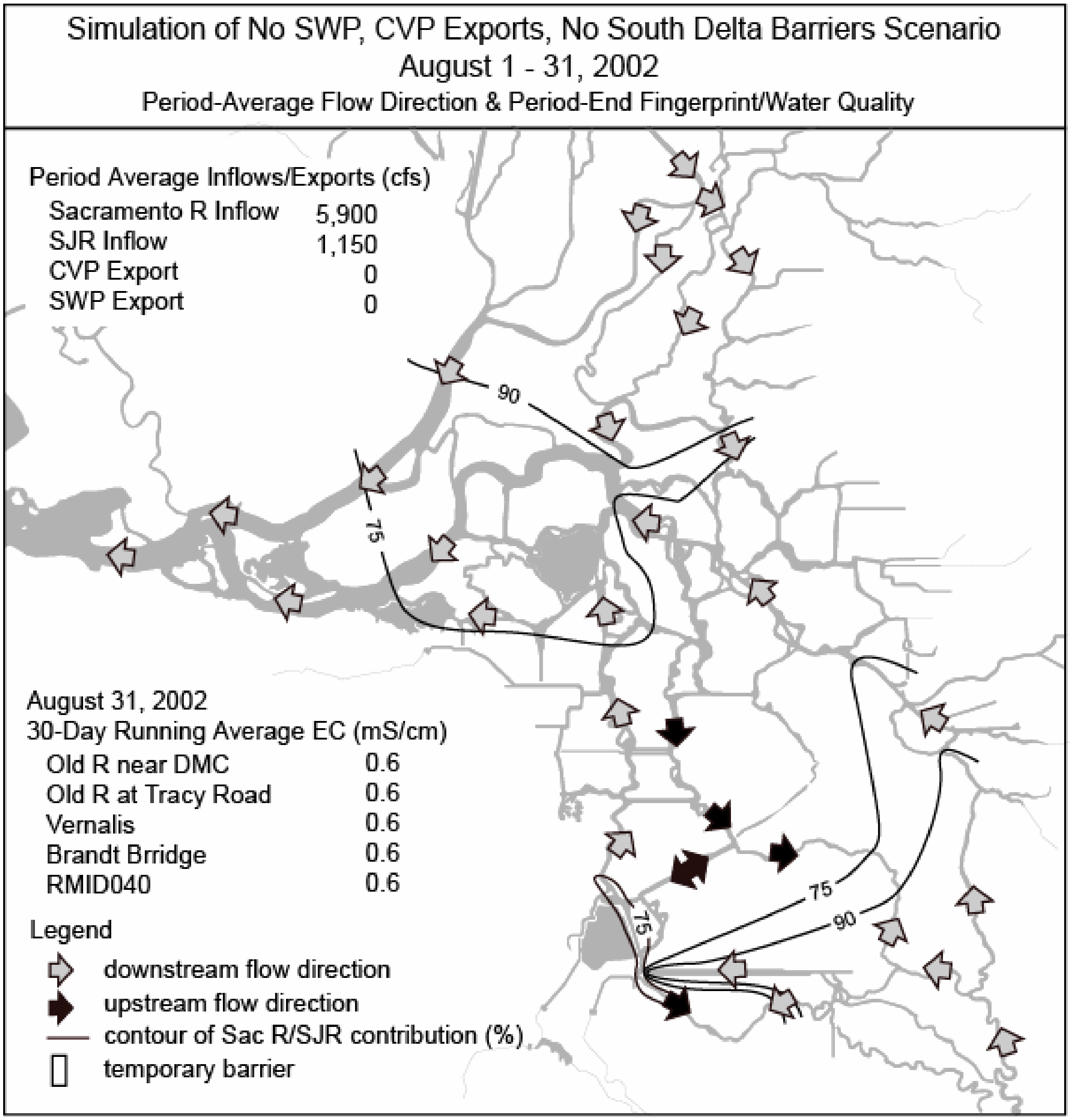


Figure 7a. DSM2-simulated period-average Delta-wide flow patterns and period-end fingerprints and EC, additional Sacramento River flows scenario, April 1-14, 2002.

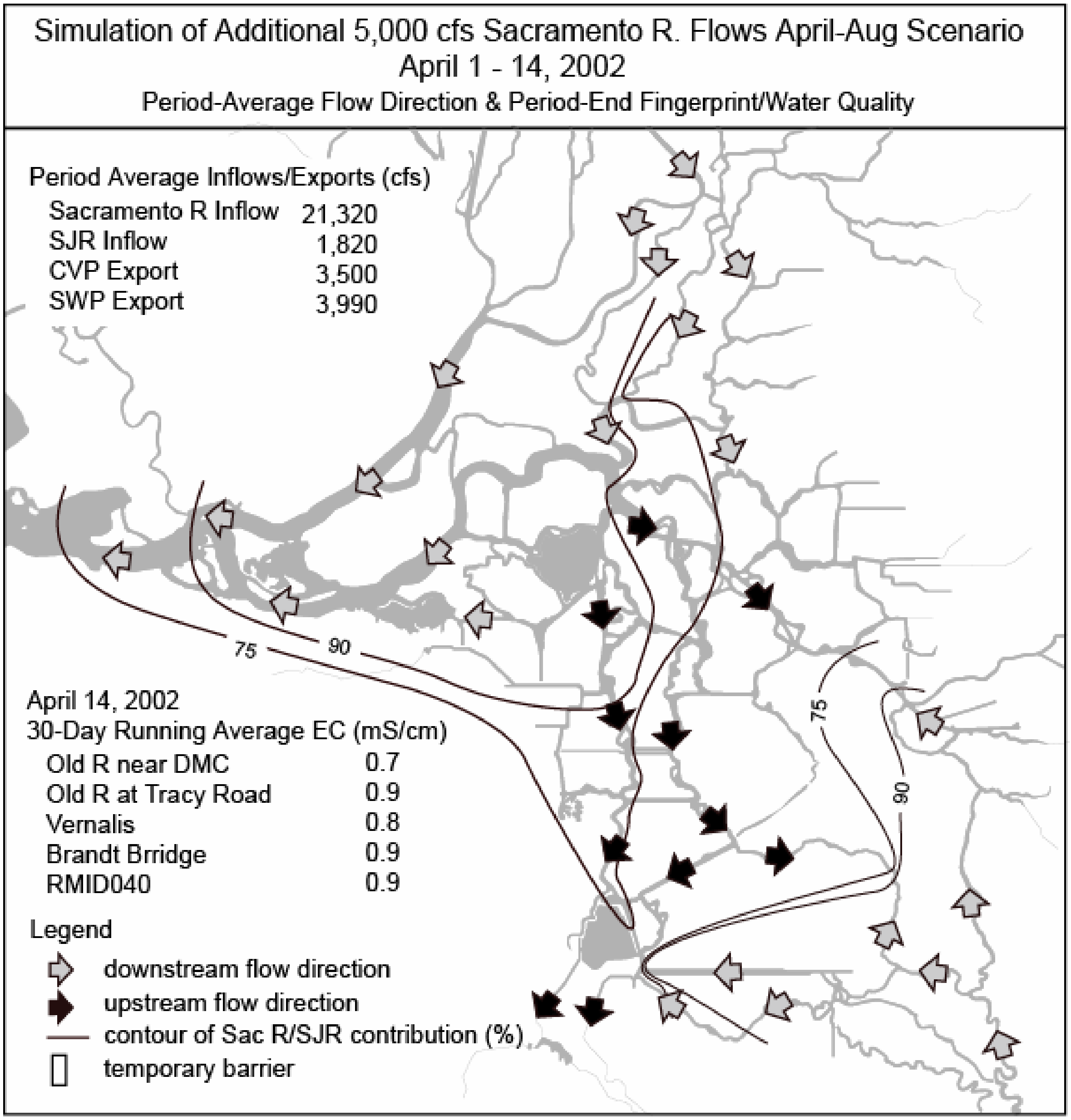


Figure 7b. DSM2-simulated period-average Delta-wide flow patterns and period-end fingerprints and EC, additional Sacramento River flows scenario, April 15-30, 2002.

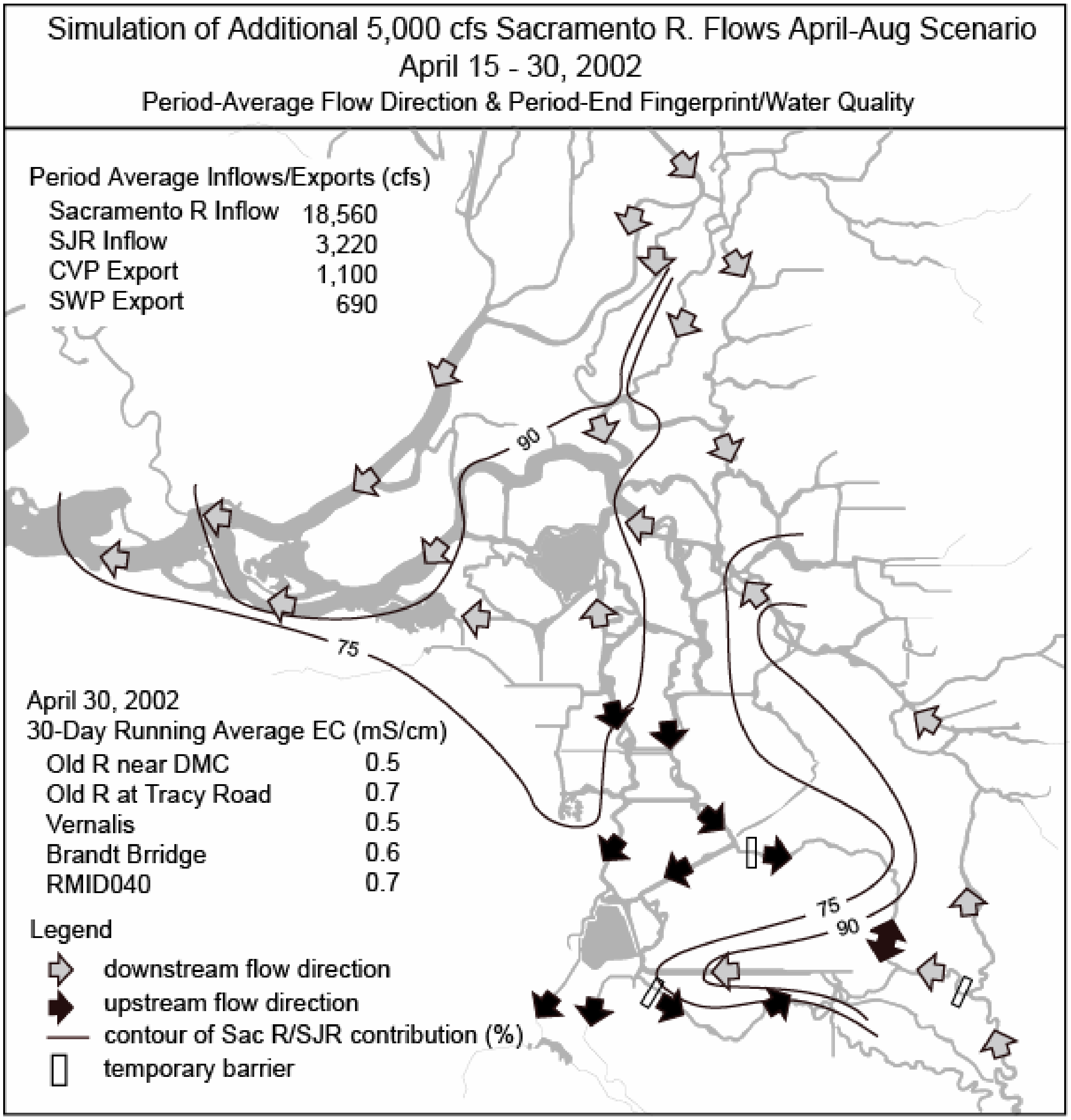


Figure 7c. DSM2-simulated period-average Delta-wide flow patterns and period-end fingerprints and EC, additional Sacramento River flows scenario, May 1-24, 2002.

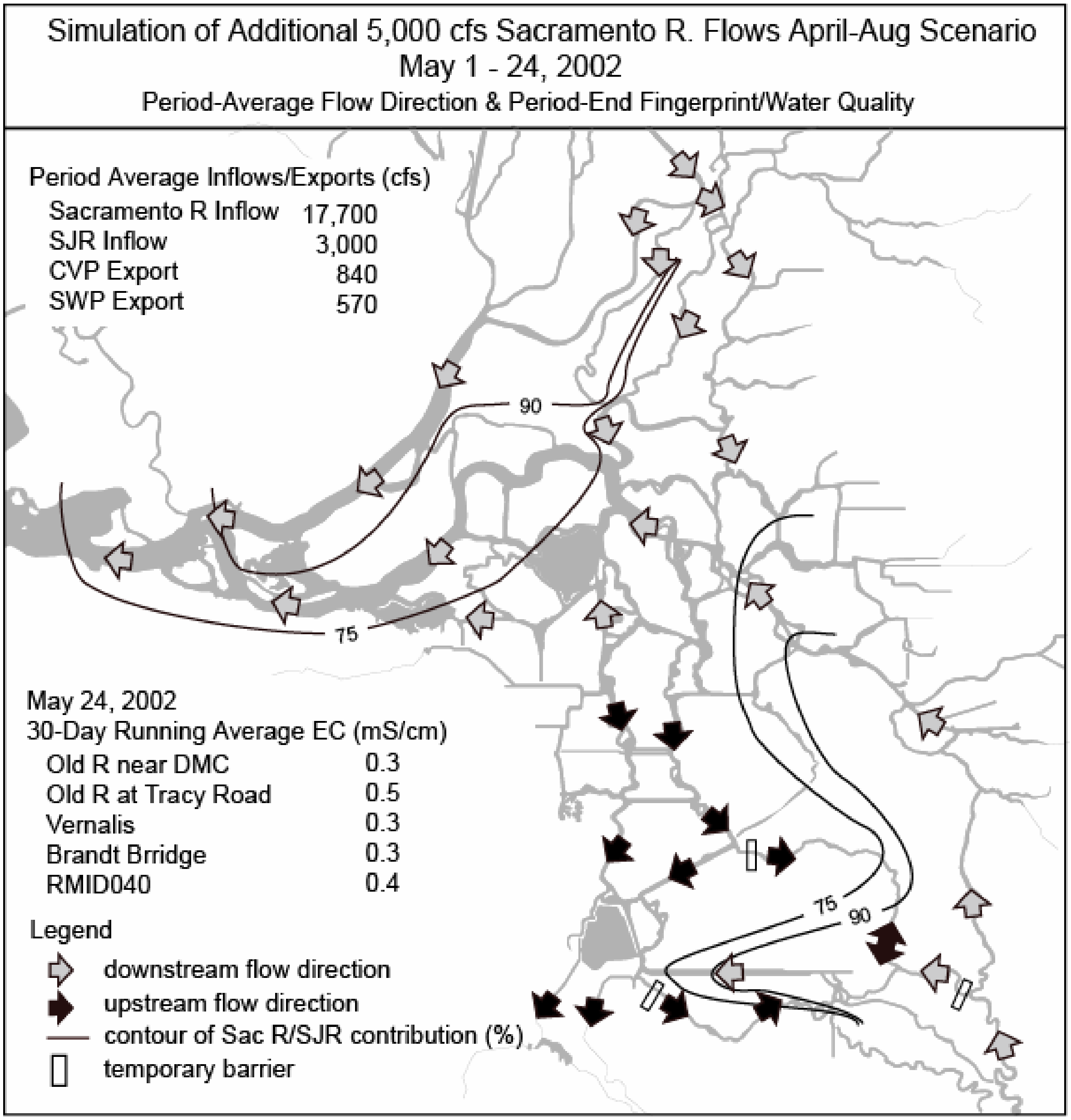


Figure 7d. DSM2-simulated period-average Delta-wide flow patterns and period-end fingerprints and EC, additional Sacramento River flows scenario, June 7-30, 2002.

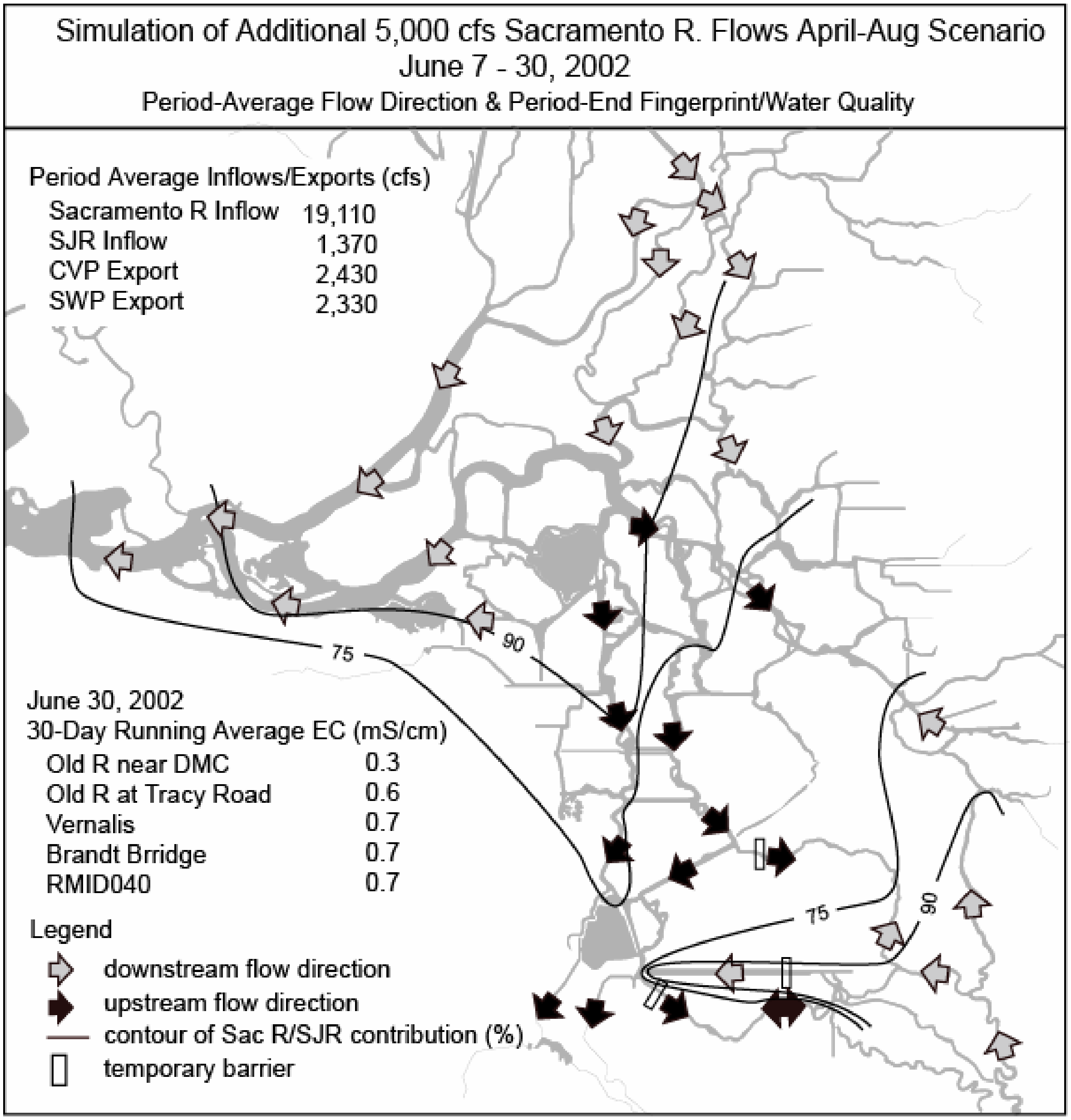


Figure 7e. DSM2-simulated period-average Delta-wide flow patterns and period-end fingerprints and EC, additional Sacramento River flows scenario, July 1-31, 2002.

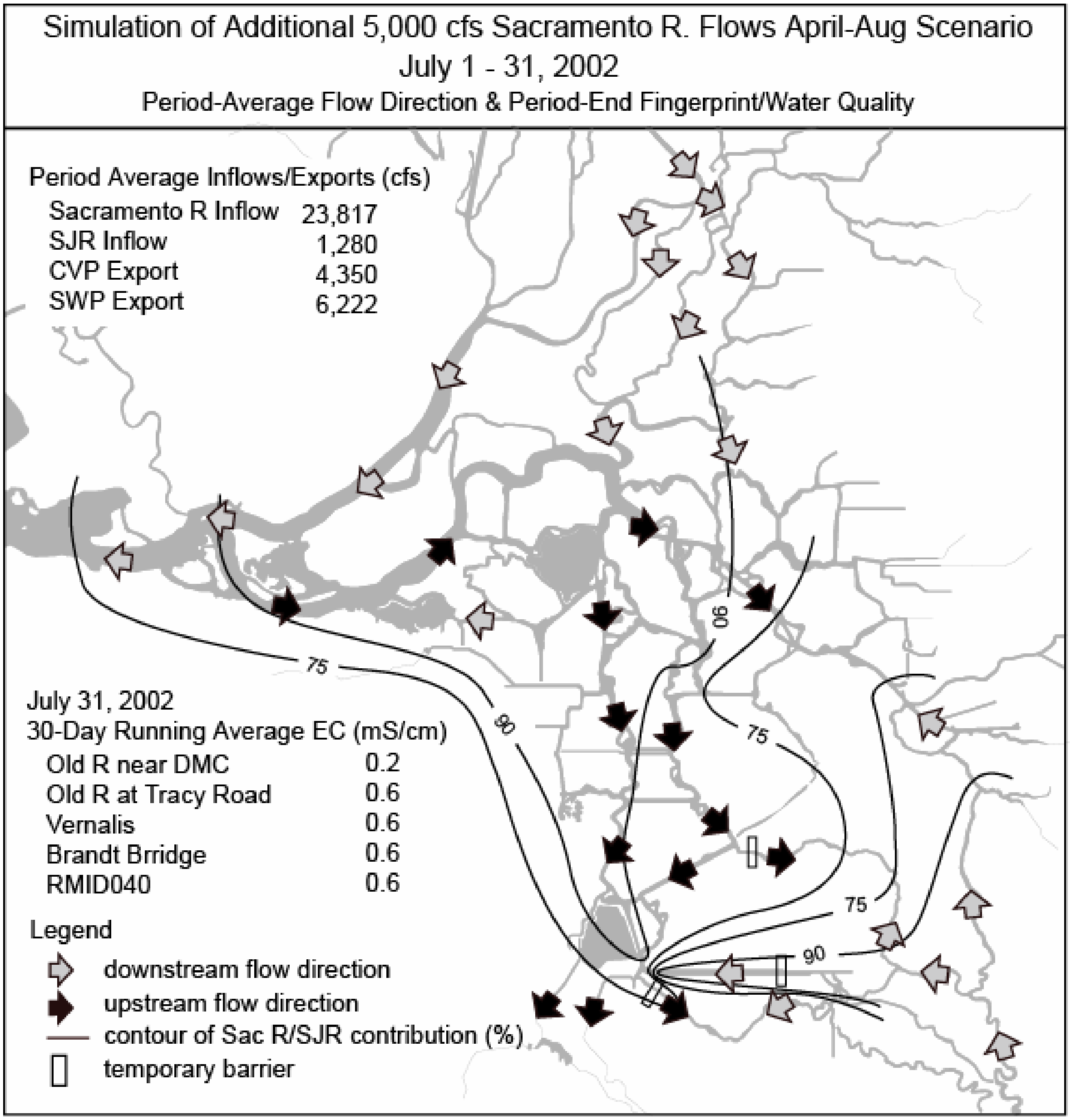


Figure 7f. DSM2-simulated period-average Delta-wide flow patterns and period-end fingerprints and EC, additional Sacramento River flows scenario, August 1-31, 2002.

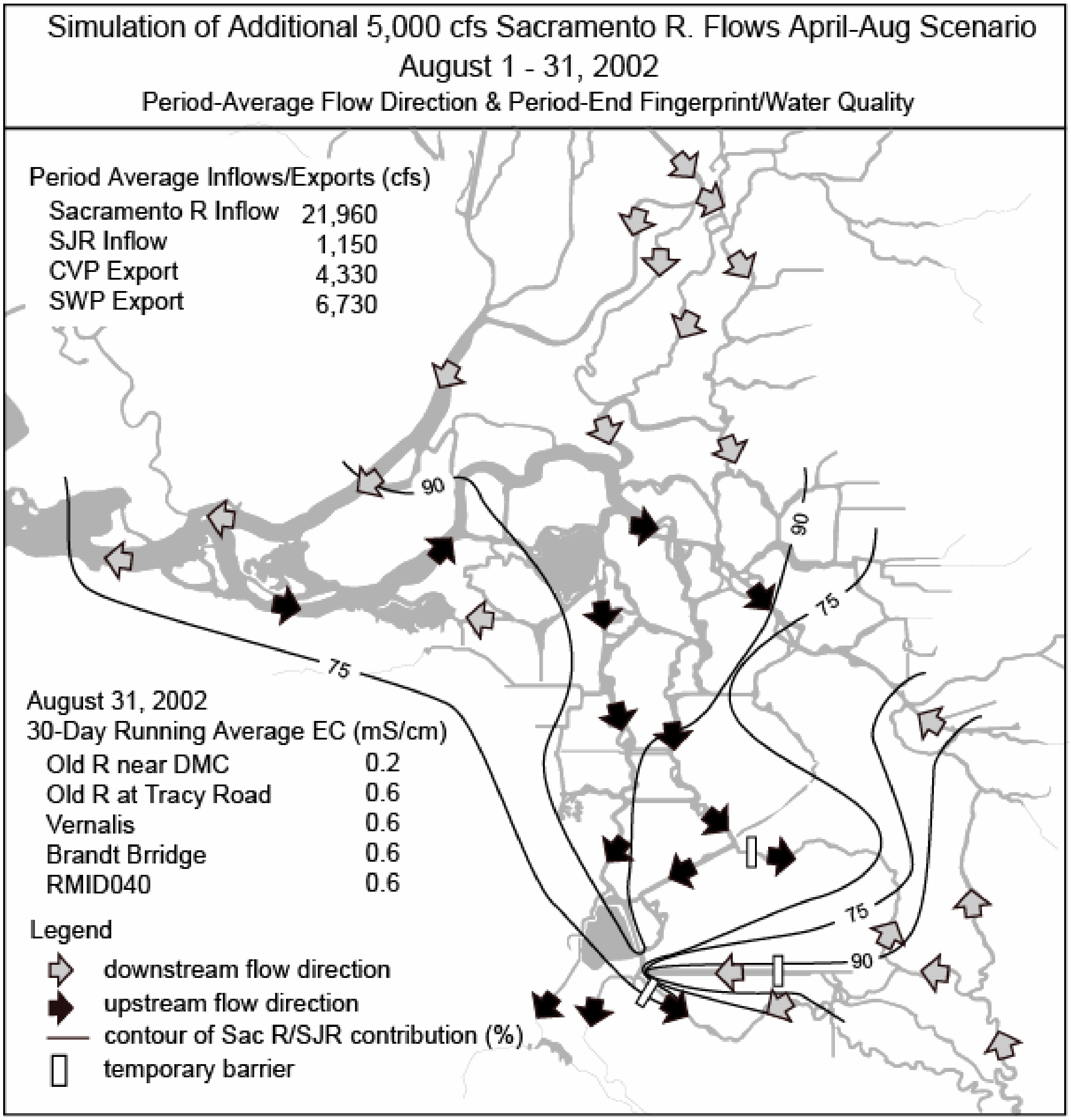
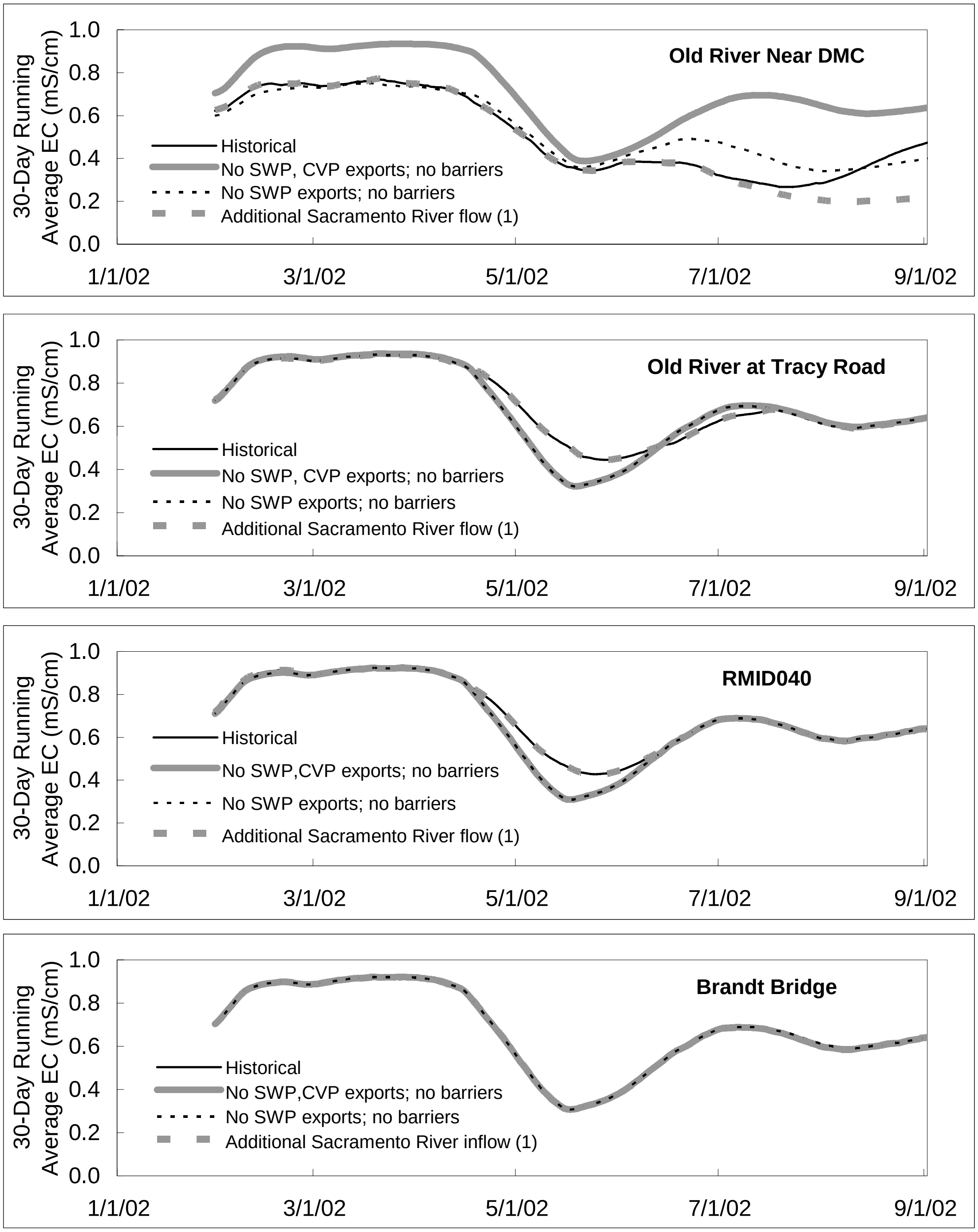


Figure 8. DSM2-simulated daily average EC under scenarios inducing significant changes in Delta-wide flow patterns.



(1) Sac River inflow increased 5,000 cfs over historical flow for April - Sep of 2002.

Impact of South Delta Barrier Installation on South Delta Circulation and Water Quality

To demonstrate the effect of south Delta barrier installation on south Delta circulation patterns and south Delta EC, two scenarios were simulated to compare to the historical 2002 simulation. The first scenario assumes no barriers installed. This scenario maximizes using San Joaquin River inflow to create favorable circulation in the south Delta. The second scenario assumes the installation of the barriers at Old River, Middle River, and Old River at Head during the entire April 1 – October 30 period. This scenario maximizes circulating water originating from the Sacramento River through the south Delta channels. Since SWP and CVP pumping and Sacramento River inflow in these simulations are the same as for the historical simulation, the focus of the analysis is more on EC and local circulation of water, specifically the direction and magnitude of period-average flows in the south Delta. When the barrier at the Head of Old River is installed in this analysis, it is assumed 6 culverts are open to allow some of the San Joaquin River to flow down Old River.

Figures 9a-9f shows the period-average flows with flow direction and end-of-period daily average EC at the study sites for the historical 2002 simulation and the scenarios maximizing circulation of San Joaquin River-source water and Sacramento River-source water. In general terms, when no barriers are installed in the south Delta, a large portion of the water entering the south Delta via the San Joaquin River flows down Grant Line Canal. When the water flowing down Old and Middle River are more than enough to meet local agricultural diversion along the rivers, period-average flows tend to be downstream. As agricultural demands along a river reach increase, period average flows on the boundary of the reach may converge. When period-average flow in Middle River near Old River compared to the flow in Middle River near the barrier site and in Old River near DMC compared the flow in Old River at the Tracy Road Bridge converge, relatively poor circulation is indicated and less salt from agricultural return flows is being flushed out of the reach. Installing the temporary rock barriers in the south Delta can greatly complicate circulation. The barriers in Old and Middle rivers allow water to move upstream with the flood tide and then restrict downstream flow during the ebb tide. This results in average flow immediately upstream of these two barriers being in the upstream direction. If the net flow is sufficiently high and there is no constraint of flow down Grant Line Canal, water can potentially circulate up Old and Middle rivers and down Grant Line Canal. However, the barriers can also induce poor circulation by restricting downstream flow, especially when the Grant Line Canal barrier is installed to restrict flow down this natural outlet.

For the 2002 historical simulation, the Old River, Middle River, and Old River at Head barriers are assumed installed from April 15 through May 24., and from June 7 through October, the Old River, Middle River, and Grant Line Canal barriers are assumed installed. Under historical conditions, circulation in Middle and Old rivers appears to be persistently unfavorable when the Old River, Middle River, and Grant Line Canal barriers are simultaneously installed. Significantly better circulation seems to occur when the Old River, Middle River, and Old River at Head barriers are all installed. However, because the flow and EC in the San Joaquin River and the SWP and CVP pumping is different under these different barrier configurations, comparing EC in the 2002 historical simulation between different periods is not informative. Therefore the results of the two other scenarios are presented.

Not installing south Delta barriers results in more San Joaquin River water flowing down the head of Old River. However unfavorable circulation patterns persist in Old and Middle Rivers from June through August due to channel characteristics and agricultural diversions. Water in the south Delta channels then can be expected to originate mostly from the San Joaquin River with some local agricultural drainage significantly contributing when circulation is particularly poor.

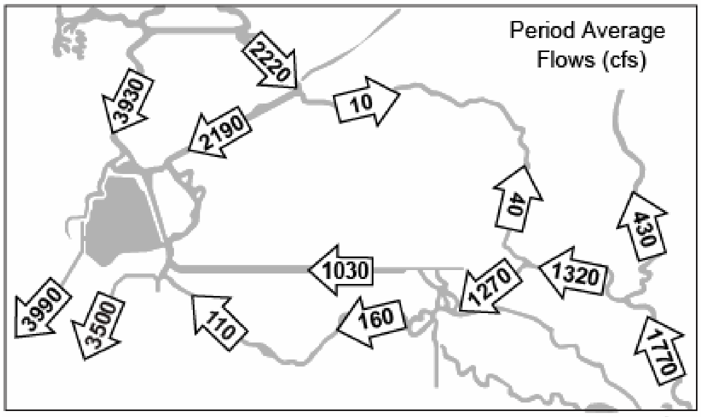
Installing the Old River, Middle River, and Old River at Head barriers results in desirable circulation in Old River from April through August and Middle River from April through May. The circulation pattern in Old River under this scenario indicates that water downstream of the Old River barrier, with at times a significant portion of water originating in the Sacramento River, can be significantly lower in EC than the San Joaquin River inflow. Thus, this barrier configuration has the potential of not only moving agricultural salts out of the south Delta channels, but this circulation is induced with better quality water than if the San Joaquin River is used to flush Old River.

Figure 10 compares the EC at the study sites under simulated historical 2002 conditions and the two scenarios. Maximizing San Joaquin River water circulating in south Delta channels increases the EC in Old River near DMC because without the Old River barrier, less Sacramento River-source water is retained in this vicinity. At Old River at Tracy Road and RMID040, maximizing San Joaquin River water circulating lowers the EC in May. This corresponds to the better circulation pattern mentioned above. The increase in EC from Vernalis to Old River at Tracy Road (0.2 mS/cm) and Vernalis to RMID040 (0.1mS/cm) seen in the historical 2002 simulation for May 24th, is absent when the barriers are removed. Removing the barriers also results in a significant decrease in EC at Brandt Bridge in July and August. This is due to inducing reverse flows in the upper San Joaquin River, bringing more water of Sacramento origin to the vicinity of Brandt Bridge. Figure 10 shows that installing the Old River, Middle River, and Old River at Head barriers on April 1 provides additional improvement to EC at Old River at Tracy Road and RMID040 on April 30 compared to waiting until April 15 as in the historical simulation. The EC at Old River at Tracy Road and RMID040 under the scenario maximizing Sacramento-source water circulation is significantly lower when than the historical simulation when the Grant Line Barrier is installed, which is consistent with the improved circulation discussed above.

Figure 9a. DSM2-simulated period-average south Delta flows and period-end EC, historical, maximizing San Joaquin River for circulation, and maximizing San Joaquin River circulation scenarios, April 1-14, 2002.

April 1-14, 2002

Historical Conditions



Key Simulation Information

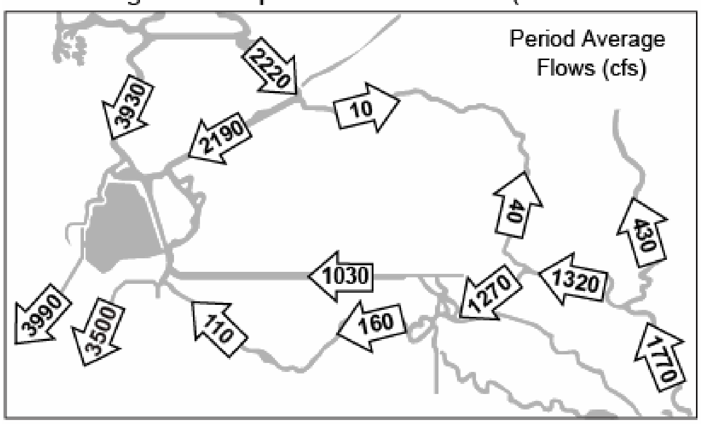
No barriers installed

SJR Inflow (avg)	1,820 cfs
CVP Export (avg)	3,500 cfs
SWP Export (avg)	3,990 cfs

30-Day Running Average EC at end of period (mS/cm)

Old R near DMC	0.7
Old R at Tracy Road	0.9
Vernalis	0.8
Brandt Brridge	0.9
RMID040	0.9

Maximizing San Joaquin River as Source (no barriers installed)



Key Simulation Information

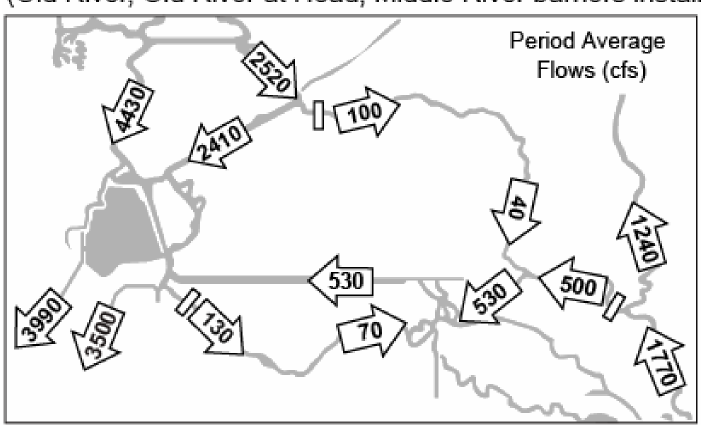
No barriers installed

SJR Inflow	1,820 cfs
CVP Export	3,500 cfs
SWP Export	3,990 cfs

30-Day Running Average EC at end of period (mS/cm)

Old R near DMC	0.7
Old R at Tracy Road	0.9
Vernalis	0.8
Brandt Brridge	0.9
RMID040	0.9

Maximizing Sacramento River as Source
(Old River, Old River at Head, Middle River barriers installed)



Key Simulation Information

Old River, Old River at Head, Middle River barriers in

SJR Inflow	1,820 cfs
CVP Export	3,500 cfs
SWP Export	3,990 cfs

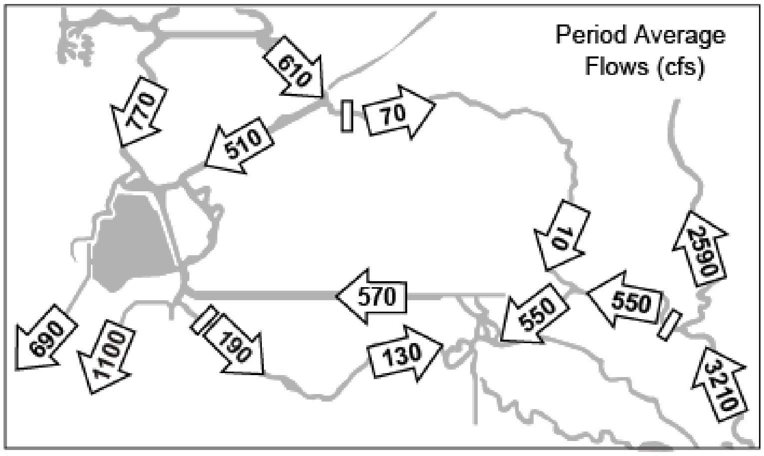
30-Day Running Average EC at end of period (mS/cm)

Old R near DMC	0.6
Old R at Tracy Road	0.8
Vernalis	0.8
Brandt Brridge	0.9
RMID040	0.8

Figure 9b. DSM2-simulated period-average south Delta flows and period-end EC, historical, maximizing San Joaquin River for circulation, and maximizing San Joaquin River circulation scenarios, April 15-30, 2002.

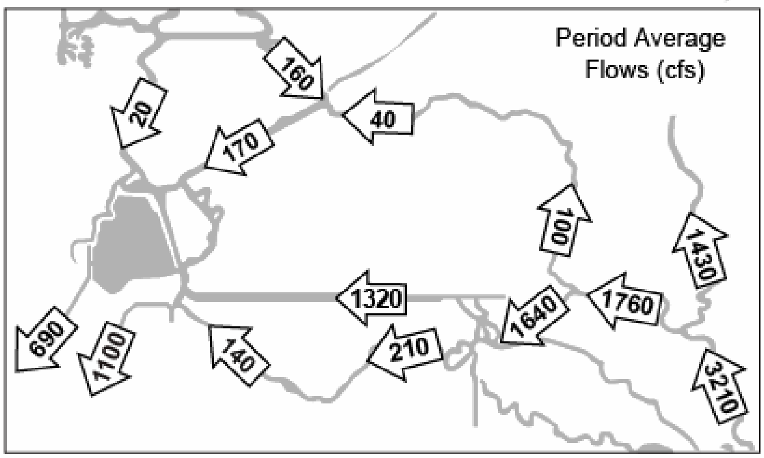
April 15-30, 2002

Historical Conditions



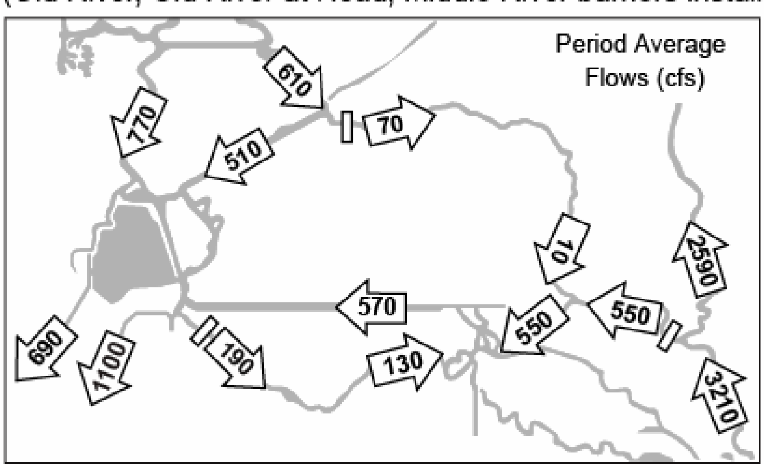
Key Simulation Information	
Old River, Old River at Head, Middle River barriers in	
SJR Inflow (avg)	3,220 cfs
CVP Export (avg)	1,100 cfs
SWP Export (avg)	690 cfs
30-Day Running Average EC at end of period (mS/cm)	
Old R near DMC	0.5
Old R at Tracy Road	0.7
Vernalis	0.5
Brandt Brridge	0.6
RMID040	0.7

Maximizing San Joaquin River as Source (no barriers installed)



Key Simulation Information	
No barriers installed	
SJR Inflow (avg)	3,220 cfs
CVP Export (avg)	1,100 cfs
SWP Export (avg)	690 cfs
30-Day Running Average EC at end of period (mS/cm)	
Old R near DMC	0.6
Old R at Tracy Road	0.6
Vernalis	0.5
Brandt Brridge	0.6
RMID040	0.6

Maximizing Sacramento River as Source
(Old River, Old River at Head, Middle River barriers installed)

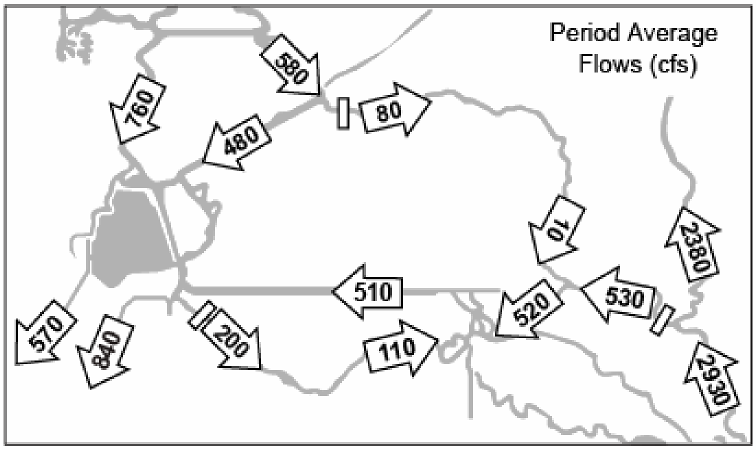


Key Simulation Information	
Old River, Old River at Head, Middle River barriers in	
SJR Inflow (avg)	3,220 cfs
CVP Export (avg)	1,100 cfs
SWP Export (avg)	690 cfs
30-Day Running Average EC at end of period (mS/cm)	
Old R near DMC	0.4
Old R at Tracy Road	0.6
Vernalis	0.5
Brandt Brridge	0.6
RMID040	0.5

Figure 9c. DSM2-simulated period-average south Delta flows and period-end EC, historical, maximizing San Joaquin River for circulation, and maximizing San Joaquin River circulation scenarios, May 1-24, 2002.

May 1-24, 2002

Historical Conditions



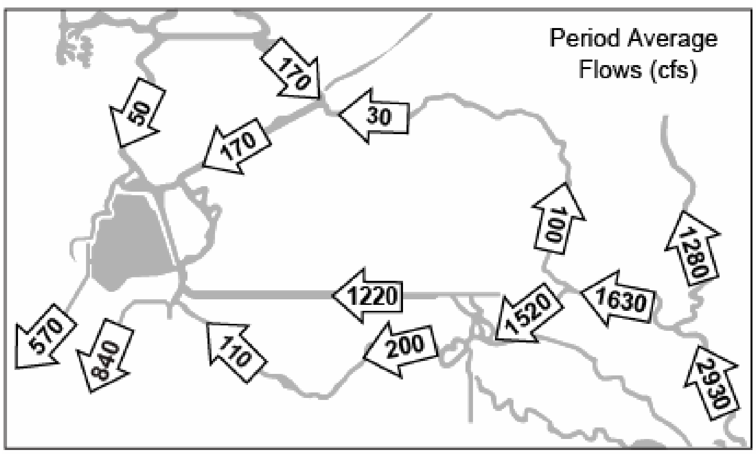
Key Simulation Information
Old River, Old River at Head, Middle River barriers in

SJR Inflow (avg)	3,000 cfs
CVP Export (avg)	840 cfs
SWP Export (avg)	570 cfs

30-Day Running Average EC at end of period (mS/cm)

Old R near DMC	0.3
Old R at Tracy Road	0.5
Vernalis	0.3
Brandt Brridge	0.3
RMID040	0.4

Maximizing San Joaquin River as Source (no barriers installed)



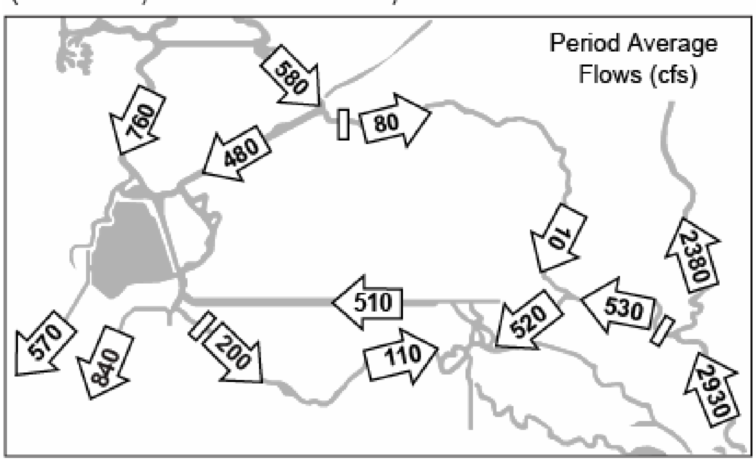
Key Simulation Information
No barriers installed

SJR Inflow (avg)	3,000 cfs
CVP Export (avg)	840 cfs
SWP Export (avg)	570 cfs

30-Day Running Average EC at end of period (mS/cm)

Old R near DMC	0.4
Old R at Tracy Road	0.3
Vernalis	0.3
Brandt Brridge	0.3
RMID040	0.3

Maximizing Sacramento River as Source
(Old River, Old River at Head, Middle River barriers installed)



Key Simulation Information
Old River, Old River at Head, Middle River barriers in

SJR Inflow (avg)	3,000 cfs
CVP Export (avg)	840 cfs
SWP Export (avg)	570 cfs

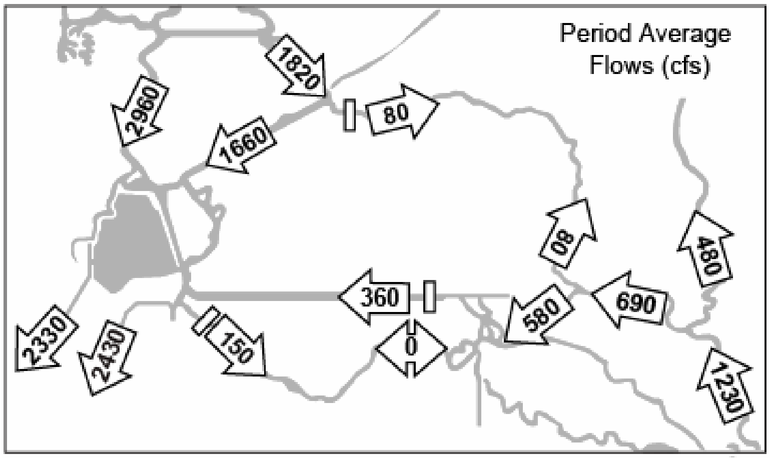
30-Day Running Average EC at end of period (mS/cm)

Old R near DMC	0.4
Old R at Tracy Road	0.5
Vernalis	0.3
Brandt Brridge	0.3
RMID040	0.5

Figure 9d. DSM2-simulated period-average south Delta flows and period-end EC, historical, maximizing San Joaquin River for circulation, and maximizing San Joaquin River circulation scenarios, June 7-30, 2002.

June 7-30, 2002

Historical Conditions



Key Simulation Information

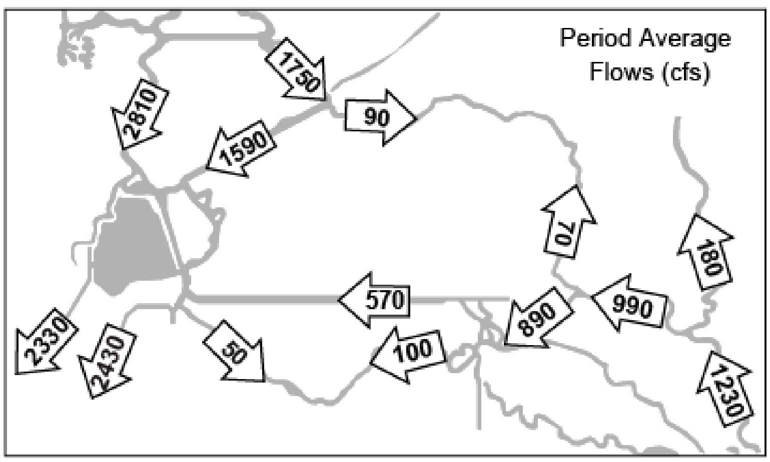
Old River, Grantline Canal, Middle River barriers in

SJR Inflow (avg)	1,370 cfs
CVP Export (avg)	2,430 cfs
SWP Export (avg)	2,330 cfs

30-Day Running Average EC at end of period (mS/cm)

Old R near DMC	0.3
Old R at Tracy Road	0.6
Vernalis	0.7
Brandt Brridge	0.7
RMID040	0.7

Maximizing San Joaquin River as Source (no barriers installed)



Key Simulation Information

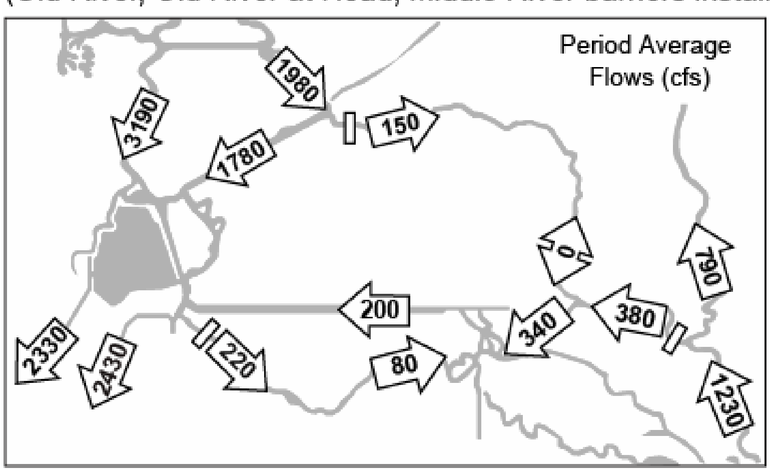
No barriers installed

SJR Inflow (avg)	1,370 cfs
CVP Export (avg)	2,430 cfs
SWP Export (avg)	2,330 cfs

30-Day Running Average EC at end of period (mS/cm)

Old R near DMC	0.5
Old R at Tracy Road	0.7
Vernalis	0.7
Brandt Brridge	0.7
RMID040	0.7

Maximizing Sacramento River as Source
(Old River, Old River at Head, Middle River barriers installed)



Key Simulation Information

Old River, Old River at Head, Middle River barriers in

SJR Inflow (avg)	1,370 cfs
CVP Export (avg)	2,430 cfs
SWP Export (avg)	2,330 cfs

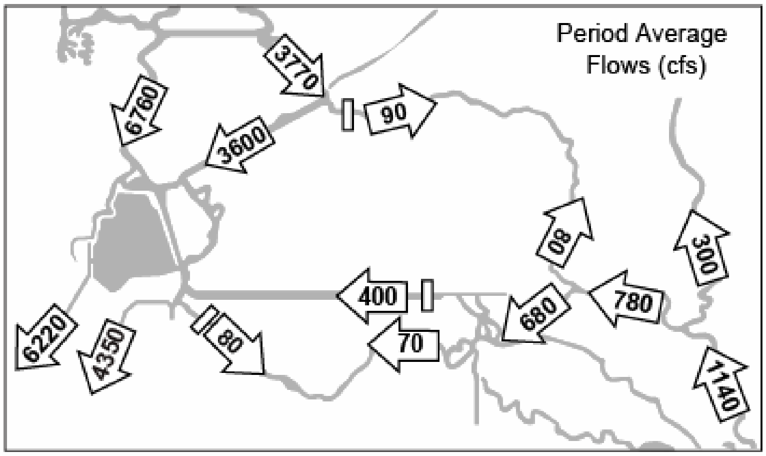
30-Day Running Average EC at end of period (mS/cm)

Old R near DMC	0.3
Old R at Tracy Road	0.5
Vernalis	0.7
Brandt Brridge	0.7
RMID040	0.6

Figure 9e. DSM2-simulated period-average south Delta flows and period-end EC, historical, maximizing San Joaquin River for circulation, and maximizing San Joaquin River circulation scenarios, July 1-31, 2002.

July 1-31, 2002

Historical Conditions



Key Simulation Information

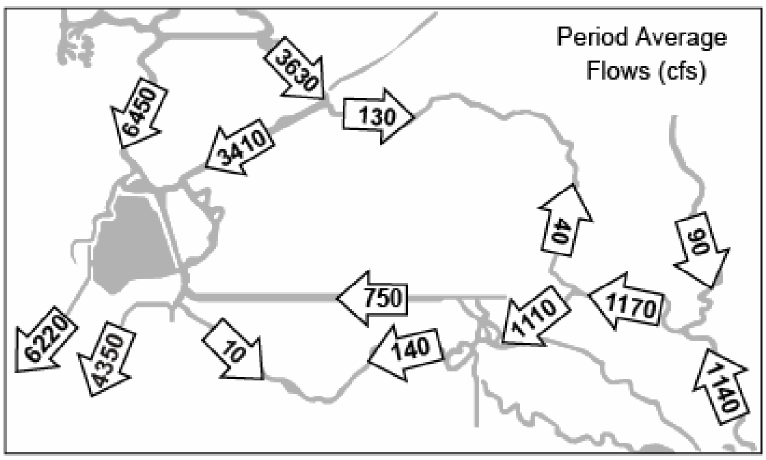
Old River, Grantline Canal, Middle River barriers in

SJR Inflow (avg)	1,280 cfs
CVP Export (avg)	4,350 cfs
SWP Export (avg)	6,220 cfs

30-Day Running Average EC at end of period (mS/cm)

Old R near DMC	0.3
Old R at Tracy Road	0.6
Vernalis	0.6
Brandt Brridge	0.6
RMID040	0.6

Maximizing San Joaquin River as Source (no barriers installed)



Key Simulation Information

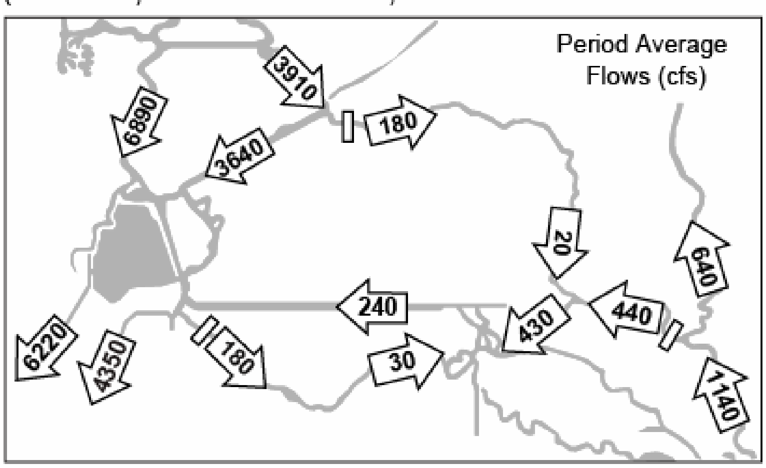
No barriers installed

SJR Inflow (avg)	1,280 cfs
CVP Export (avg)	4,350 cfs
SWP Export (avg)	6,220 cfs

30-Day Running Average EC at end of period (mS/cm)

Old R near DMC	0.4
Old R at Tracy Road	0.6
Vernalis	0.6
Brandt Brridge	0.6
RMID040	0.6

Maximizing Sacramento River as Source
(Old River, Old River at Head, Middle River barriers installed)



Key Simulation Information

Old River, Old River at Head, Middle River barriers installed

SJR Inflow (avg)	1,280 cfs
CVP Export (avg)	4,350 cfs
SWP Export (avg)	6,220 cfs

30-Day Running Average EC at end of period (mS/cm)

Old R near DMC	0.3
Old R at Tracy Road	0.4
Vernalis	0.6
Brandt Brridge	0.6
RMID040	0.4

Figure 9f. DSM2-simulated period-average south Delta flows and period-end EC, historical, maximizing San Joaquin River for circulation, and maximizing San Joaquin River circulation scenarios, August 1-31, 2002.

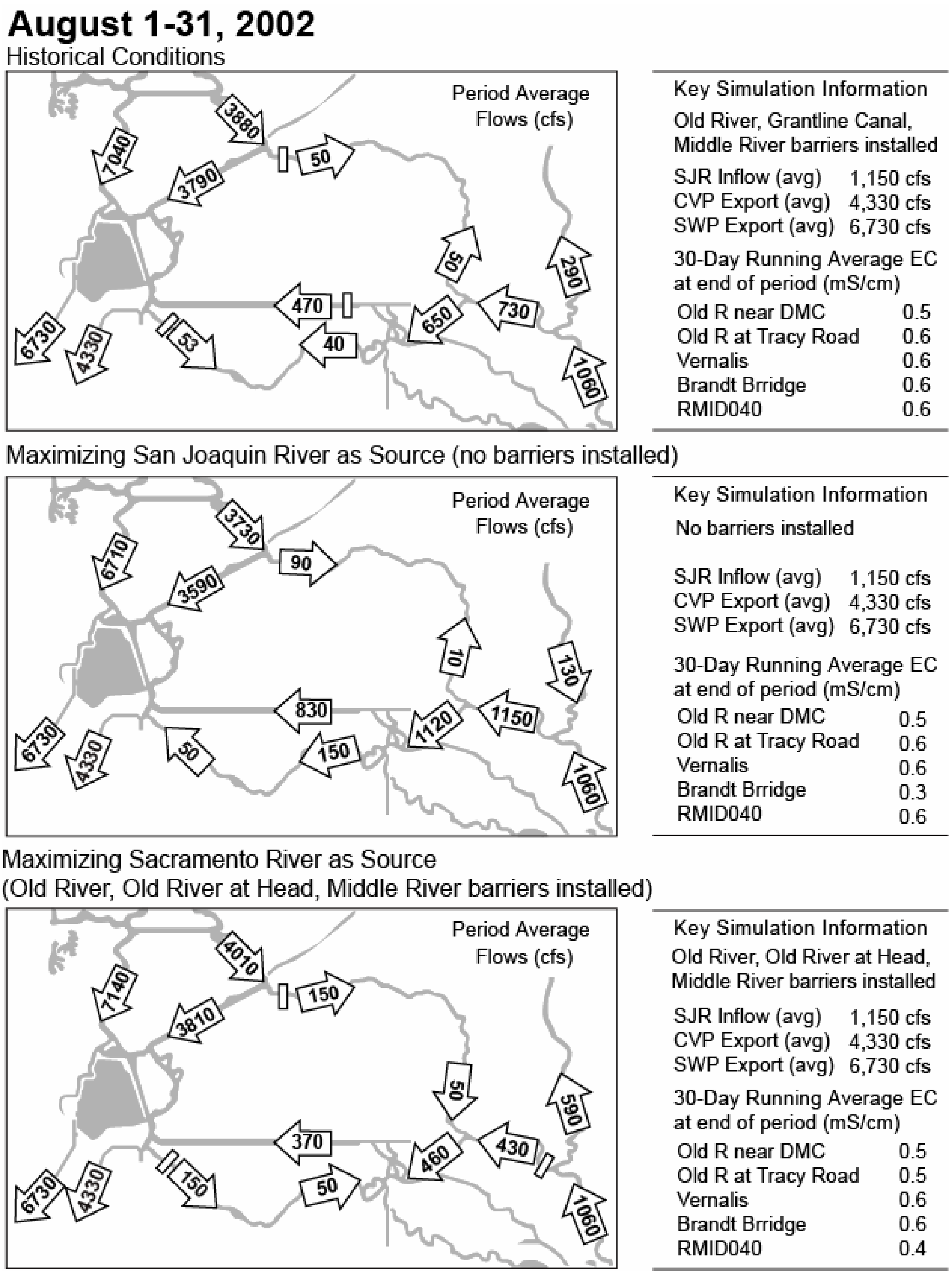
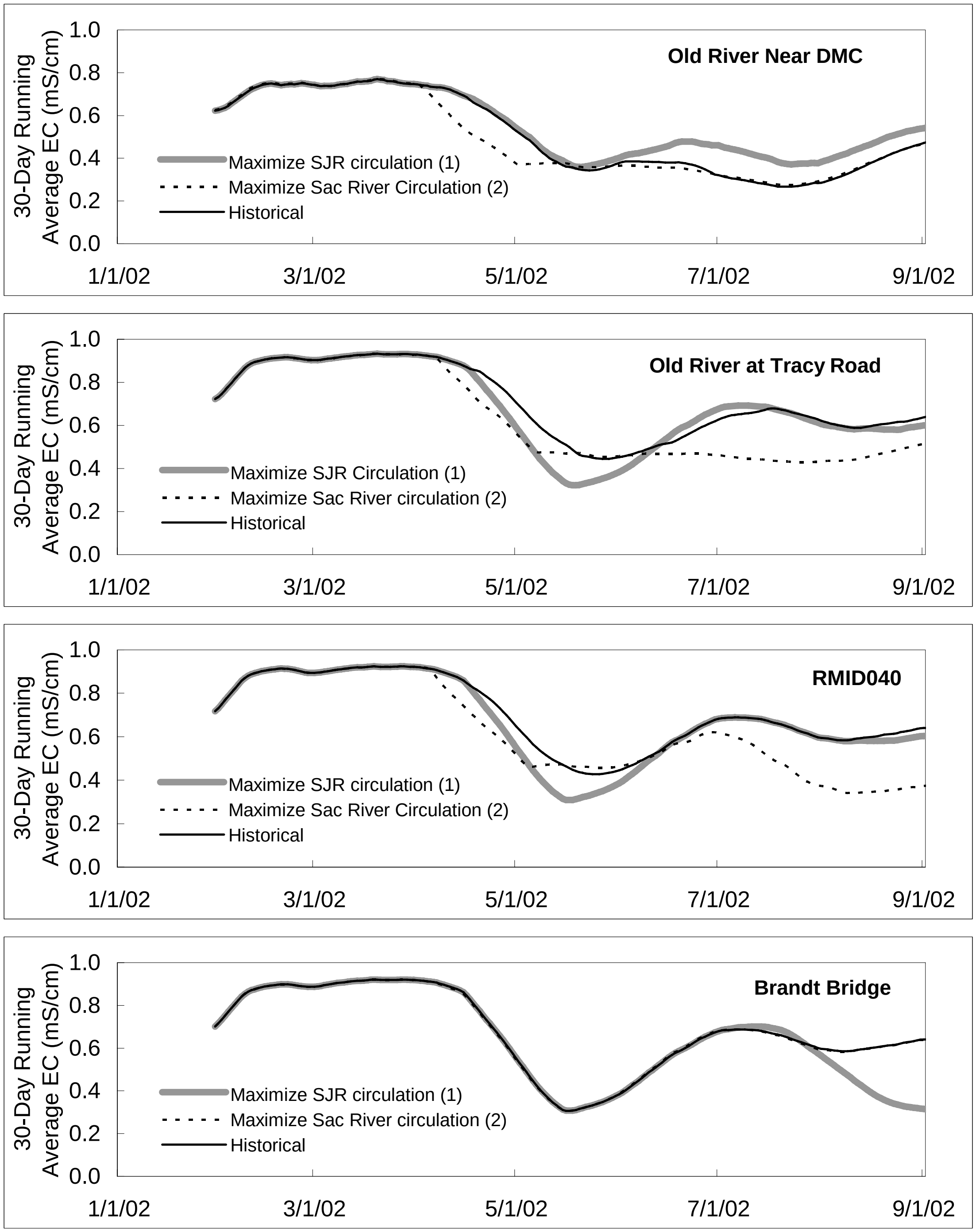


Figure 10. DSM2-simulated daily average EC under scenarios inducing significant changes in south Delta circulation.



(1) No barriers installed (2) Old River, Old River at Head, and Middle River barriers in Apr-Oct.

Summary of Study Results

Table 2 summarizes the changes in date-specific daily average EC with respect to the historical simulation at the four study sites. When the flow and EC in the San Joaquin River is held fixed compared to historical 2002 conditions, the most potential control over EC in the south Delta appears to be in varying the strategy of installing the south Delta barriers rather than in reductions in SWP or CVP pumping or increased Sacramento River inflows. This is due in part to the dominance of the San Joaquin River as the source of water in the south Delta regardless of SWP and CVP pumping and Sacramento River inflow. However, different barrier configurations in the south Delta have the potential of better circulating water locally thus reducing the concentrating of agricultural drainage with its higher salinity. Improvements are maximized when the water being circulated through south Delta channels has been captured by the Old and Middle River barriers.

Table 2. Summary of changes in EC from historical conditions for various scenarios of Delta-wide and south Delta circulation as simulated by DSM2.

RMID040						
	30-Day RA EC (mS/cm)	Change in 30-Day Running Average EC from Historical Simulation (mS/cm)				
		Modified General Delta Circulation			Modified Barrier Installation	
Date	Historical Simulation	No SWP & No Barriers	No SWP No CVP No Barriers	Additional Sac River Flows(1)	Maximize Sac River Circulation(2)	Maximize SJR Circulation(3)
Apr 14	0.87	0	0	0	**-0.1**	0
Apr 30	0.67	**-0.1**	**-0.1**	0	**-0.1**	**-0.1**
May 24	0.43	**-0.1**	**-0.1**	0	0	**-0.1**
Jun 30	0.68	0	0	0	**-0.1**	0
Jul 31	0.60	0	0	0	**-0.2**	0
Aug 31	0.64	0	0	0	**-0.3**	**0.0**

(1) Additional 5,000 cfs in April through September.
(2) Old River, Old River at Head, and Middle River barriers installed April through October.
(3) No barriers installed.

Table 2 (cont). Summary of changes in EC from historical conditions for various scenarios of Delta-wide and south Delta circulation as simulated by DSM2.

Old River at Tracy Road Bridge

Date	30-Day RA EC (mS/cm)	Change in 30-Day Running Average EC from Historical Simulation (mS/cm)				
		Modified General Delta Circulation			Modified Barrier Installation	
	Historical Simulation	No SWP & No Barriers	No SWP No CVP No Barriers	Additional Sac River Flows(1)	Maximize Sac River Circulation(2)	Maximize SJR Circulation(3)
Apr 14	0.9	0	0	0	**-0.1**	0
Apr 30	0.7	**-0.1**	**-0.1**	0	**-0.1**	**-0.1**
May 24	0.4	**-0.1**	**-0.1**	0	0	**-0.1**
Jun 30	0.6	0	0	0	**-0.2**	**0.1**
Jul 31	0.6	0	0	0	**-0.2**	0
Aug 31	0.6	0	0	0	**-0.1**	0

Brandt Bridge

Date	30-Day RA EC (mS/cm)	Change in 30-Day Running Average EC from Historical Simulation (mS/cm)				
		Modified General Delta Circulation			Modified Barrier Installation	
	Historical Simulation	No SWP & No Barriers	No SWP No CVP No Barriers	Additional Sac River Flows(1)	Maximize Sac River Circulation(2)	Maximize SJR Circulation(3)
Apr 14	0.9	0	0	0	0	0
Apr 30	0.6	0	0	0	0	0
May 24	0.3	0	0	0	0	0
Jun 30	0.7	0	0	0	0	0
Jul 31	0.6	0	0	0	0	0
Aug 31	0.6	0	0	0	0	**-0.3**

(1) Additional 5,000 cfs in April through September.
(2) Old River, Old River at Head, and Middle River barriers installed April through October.
(3) No barriers installed.

Table 2 (cont.). Summary of changes in EC from historical conditions for various scenarios of Delta-wide and south Delta circulation as simulated by DSM2.

Old River near DMC

Date	30-Day RA EC (mS/cm) Historical Simulation	Change in 30-Day Running Average EC from Historical Simulation (mS/cm) — Modified General Delta Circulation: No SWP & No Barriers	No SWP No CVP No Barriers	Additional Sac River Flows(1)	Modified Barrier Installation: Maximize Sac River Circulation(2)	Maximize SJR Circulation(3)
Apr 14	0.7	0	**0.2**	0	**-0.1**	0
Apr 30	0.5	0	**0.2**	0	**-0.2**	0
May 24	0.3	0	0	0	0	0
Jun 30	0.3	**0.2**	**0.3**	0	0	**0.1**
Jul 31	0.3	**0.1**	**0.4**	**-0.1**	0	**0.1**
Aug 31	0.5	**-0.1**	**0.2**	**-0.3**	0	**0.1**

(1) Additional 5,000 cfs in April through September.
(2) Old River, Old River at Head, and Middle River barriers installed April through October.
(3) No barriers installed.

APPENDIX D

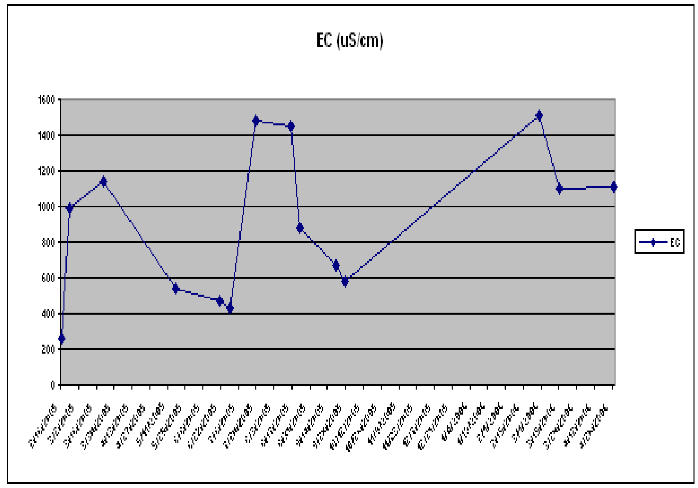
Data and Charts from the Waiver Monitoring Program

Data from the Agricultural Drainage Waiver Program

Kellogg Creek @ Hwy 4
544XKCHWF

73 West Side Drainage

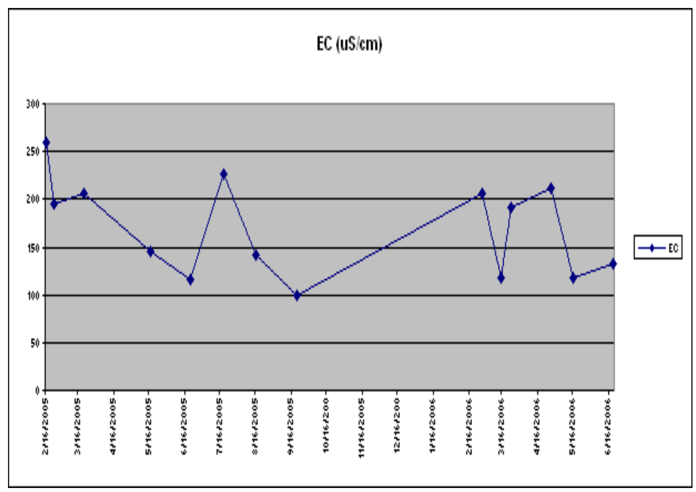
Date	EC	Time
16-Feb-05	259	12:40
23-Feb-05	990	13:40
21-Mar-05	1136	13:20
17-May-05	544	12:00
21-Jun-05	470	12:10
29-Jun-05	435	9:00
19-Jul-05	1485	11:00
16-Aug-05	1447	13:00
23-Aug-05	885	12:00
20-Sep-05	667	10:30
27-Sep-05	582	11:20
27-Feb-06	1512	11:20
15-Mar-06	1097	10:30
27-Apr-06	1112	9:40



French Camp Slough
531SJC504

21 East Side Drainage

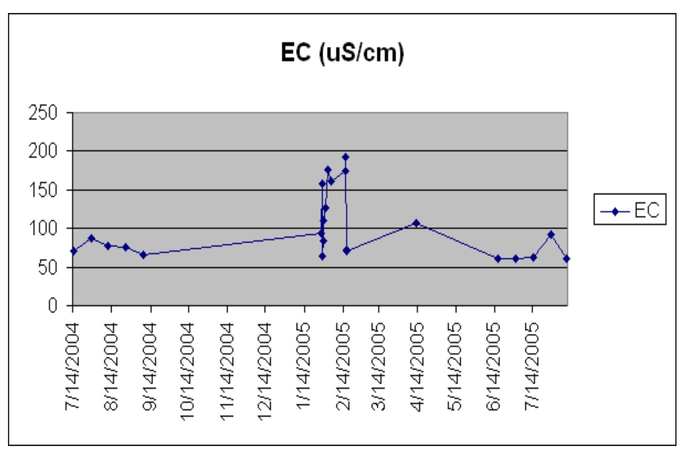
Date	EC	Time
16-Feb-05	259	16:00
23-Feb-05	195.4	11:30
21-Mar-05	207	16:50
17-May-05	145.5	15:00
21-Jun-05	116.2	13:40
19-Jul-05	226	13:40
16-Aug-05	142.1	15:20
20-Sep-05	99.4	14:10
27-Feb-06	206	15:00
15-Mar-06	118.6	13:40
24-Mar-06	192.3	9:40
27-Apr-06	211	11:50
16-May-06	118.6	16:10
20-Jun-06	131.8	17:00



Pixley Slough @ 8 Mile Road
531XNSJ28

#36 East Side Drainage

Date	EC	Time
14-Jul-04	70.1	10:20
28-Jul-04	87.9	10:30
11-Aug-04	77.1	10:00
25-Aug-04	75.4	9:30
8-Sep-04	66.2	9:30
27-Jan-05	93.5	19:10
27-Jan-05	93.7	13:00
28-Jan-05	157.1	10:00
28-Jan-05	64.2	15:00
29-Jan-05	83.3	17:00
29-Jan-05	109.9	11:00
30-Jan-05	126.4	16:00
30-Jan-05	127.3	10:00
1-Feb-05	175.7	13:00
4-Feb-05	161.2	9:50

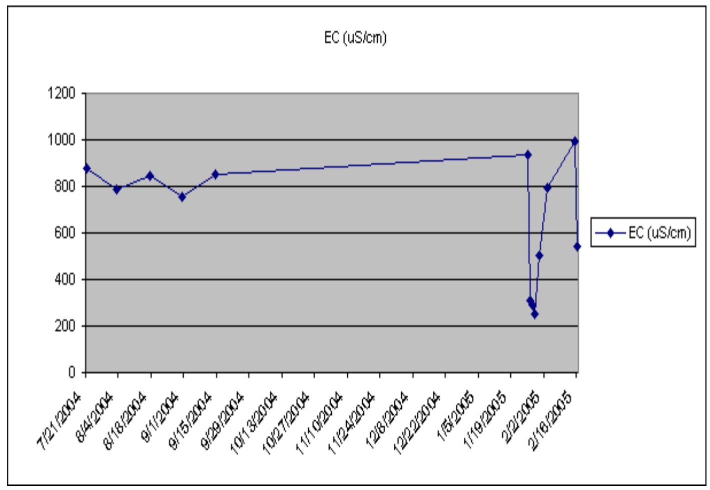


15-Feb-05	174.1	17:00
15-Feb-05	193	11:00
16-Feb-05	72.7	10:50
16-Feb-05	70.1	16:50
12-Apr-05	106.4	8:30
16-Jun-05	60.4	9:10
30-Jun-05	60.1	7:50
14-Jul-05	62	9:20
28-Jul-05	92	9:20
10-Aug-05	60.8	7:10

Drain to San Joaquin River
544XXXD01

84 San Joaquin River Drainage

Date	EC (uS/cm)	Time
21-Jul-04	878	8:40
3-Aug-04	786	9:00
17-Aug-04	845	9:30
31-Aug-04	757	10:00
14-Sep-04	853	10:50
26-Jan-05	938	17:50
27-Jan-05	311	10:30
28-Jan-05	290	10:40
29-Jan-05	252	11:00
31-Jan-05	505	10:10
3-Feb-05	791	11:00
15-Feb-05	991	10:10
16-Feb-05	543	10:00



Mid Roberts Island Drain
544SJC517

65 San Joaquin River Drainage

Date	EC	Time
14-Jul-05	852	8:20
28-Jul-05	-88	8:30
10-Aug-05	724	9:20

Roberts Island
544RIDAHR

52 San Joaquin River Drainage

Date	EC	Time
16-May-06	356	9:10
20-Jun-06	1060	8:50

San Joaquin at Bowman
544DABWMR

47 San Joaquin River Drainage

Date	EC	Time
1-Apr-03	3030	14:40
27-May-03	3971	13:30
12-Jun-03	2386	9:45
3-Jul-03	1289	10:00

544RIDAHT

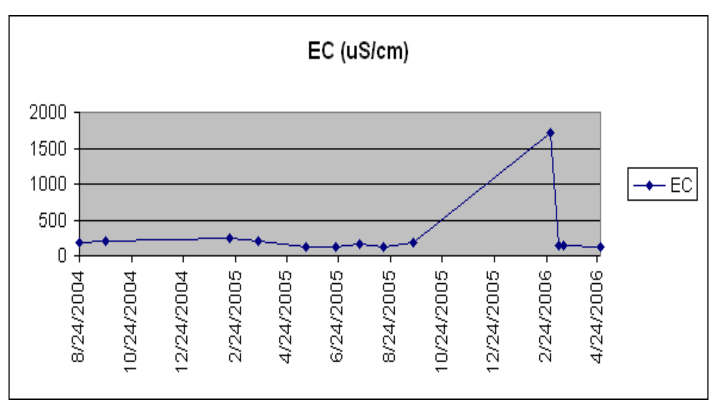
53 Central Delta Drainage

Date	EC	Time
16-May-06	736	8:00
20-Jun-06	1811	9:50

Potato Slough @ Hwy 12
544XPSAHT

77 North Delta Drainage

Date	EC	Time
24-Aug-04	191	9:00
23-Sep-04	196.1	9:30
16-Feb-05	243	8:00
21-Mar-05	195.5	8:00
17-May-05	124.8	7:30
21-Jun-05	121.5	7:50
19-Jul-05	160.5	7:20
16-Aug-05	125.9	8:50



20-Sep-05	174.1	8:00
27-Feb-06	1724	11:00
10-Mar-06	149.7	10:30
15-Mar-06	146.8	9:10
27-Apr-06	114.3	9:20

Potato Slough at WoodBridge
544XNSJ03

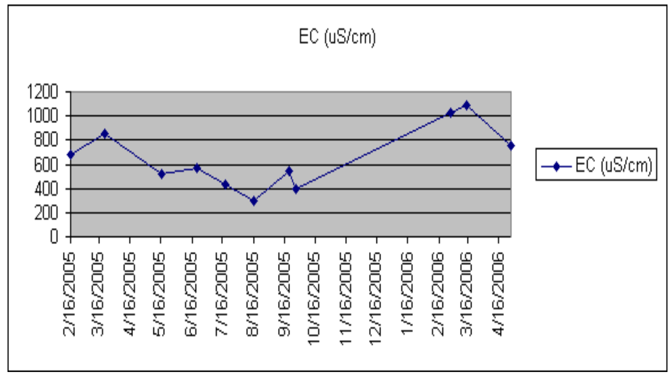
76 North Delta Drainage

Date	EC	Time
14-Jul-04	720	12:10
28-Jul-04	626	13:30
11-Aug-04	555	11:20
25-Aug-04	804	8:20
8-Sep-04	1060	8:30

Terminous Tract 544XTTGLR Delta Drain-

81 North Delta Drainage

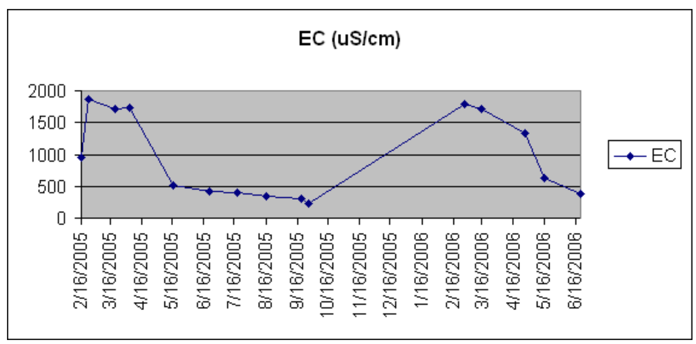
Date	EC (uS/cm)	Time
16-Feb-05	684	9:20
21-Mar-05	848	9:10
17-May-05	515	8:30
21-Jun-05	567	8:50
19-Jul-05	429	9:00
16-Aug-05	294	9:10
20-Sep-05	543	10:50
27-Sep-05	394	9:10
27-Feb-06	1030	8:20
15-Mar-06	1091	7:00
27-Apr-06	754	8:00



Terminous Tract
544XTTHWT

83 North Delta Drainage

Date	EC	Time
16-Feb-05	950	9:50
23-Feb-05	1868	9:50
21-Mar-05	1705	9:00
4-Apr-05	1742	8:30
17-May-05	515	9:00
21-Jun-05	411	8:40
19-Jul-05	398	8:00
16-Aug-05	348	9:40
20-Sep-05	314	9:00
27-Sep-05	235	10:10
27-Feb-06	1781	9:50
15-Mar-06	1720	8:20
27-Apr-06	1325	8:40
16-May-06	634	8:00
20-Jun-06	382	7:20

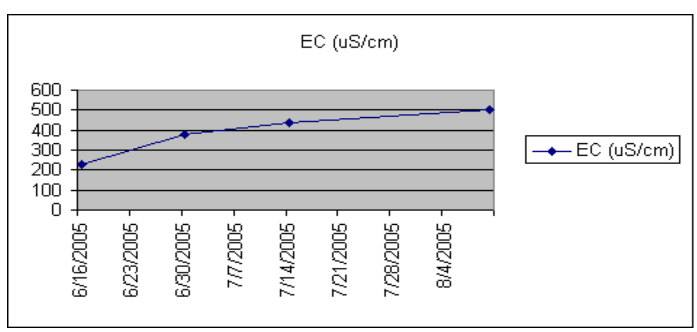


Interior South Delta

Howard Road
544SJC516 Unnamed Canal at Howard Road

64 South Delta Drainage

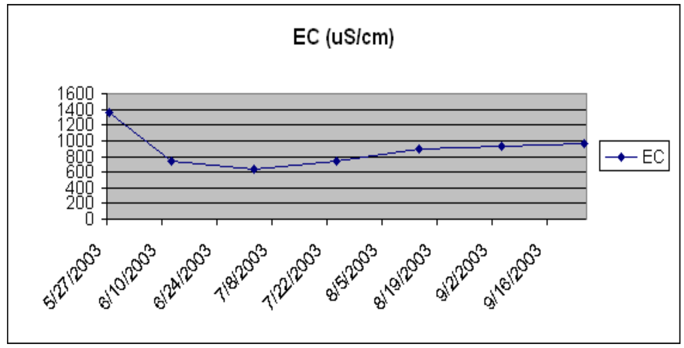
Date	EC (uS/cm)	Time
16-Jun-05	229	7:30:00
30-Jun-05	379	12:00:00
14-Jul-05	436	7:30:00
28-Jul-05	-88	7:40:00
10-Aug-05	500	9:50:00



Middle River Wing Levee
544DRAWLR

48 South Delta Drainage

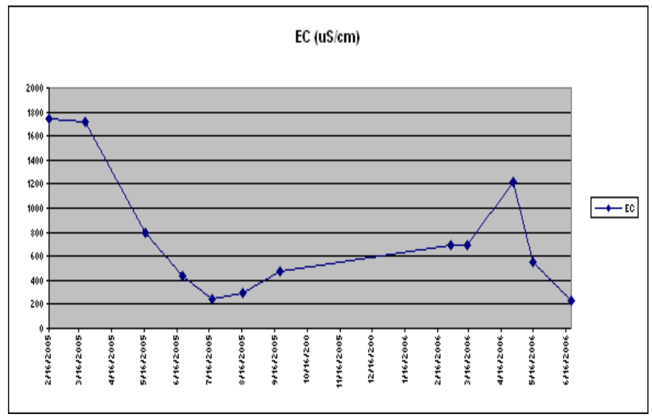
Date	EC	Time
27-May-03	1357	12:00
12-Jun-03	742	11:00
3-Jul-03	628	12:10
24-Jul-03	735	14:00
14-Aug-03	890	11:40
4-Sep-03	937	12:30
25-Sep-03	959	13:00



Grant Line at Clifton Court
544XGLCAA

70 South Delta Drainage

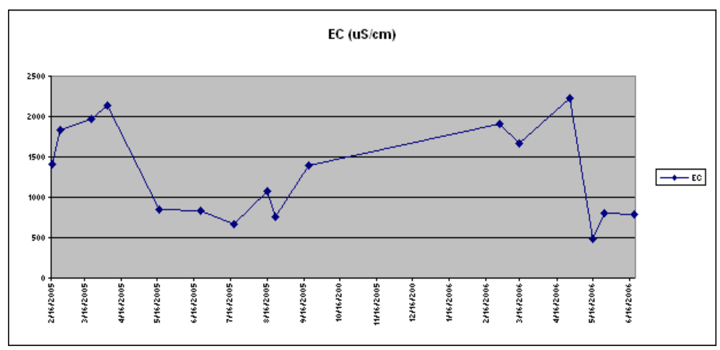
Date	EC	Time
16-Feb-05	1743	14:40
21-Mar-05	1715	16:10
17-May-05	801	15:30
21-Jun-05	442	14:30
19-Jul-05	243	13:20
16-Aug-05	290	15:20
20-Sep-05	477	13:00
27-Feb-06	693	13:50
15-Mar-06	693	12:40
27-Apr-06	1214	11:00
16-May-06	553	16:50
20-Jun-06	225	15:50



Grant Line at Calpack Rd
544XGLCCR

71 South Delta Drainage

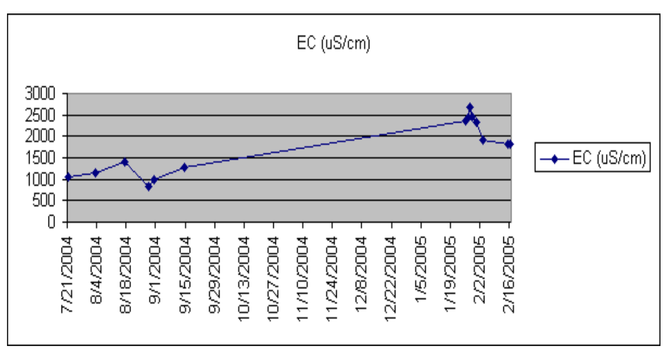
Date	EC	Time
16-Feb-05	1412	13:50
23-Feb-05	1834	12:30
21-Mar-05	1970	15:20
4-Apr-05	2140	11:30
17-May-05	847	14:10
21-Jun-05	835	13:40
19-Jul-05	673	12:40
16-Aug-05	1077	14:20
23-Aug-05	759	11:10
20-Sep-05	1390	12:00
27-Feb-06	1910	13:00
15-Mar-06	1660	12:00
27-Apr-06	2220	10:30
16-May-06	490	15:50
25-May-06	806	9:50
20-Jun-06	791	14:50



Grant Line Drainage
544XXXD02 Drain to Grant Line Canal off Wing

85 South Delta Drainage

Date	EC (uS/cm)	Time
21-Jul-04	1063	9:40:00
3-Aug-04	1153	10:30
17-Aug-04	1392	11:00
28-Aug-04	821	15:05
31-Aug-04	995	11:20
14-Sep-04	1265	11:30
26-Jan-05	2370	12:20
27-Jan-05	2410	12:50
28-Jan-05	2680	14:00
29-Jan-05	2470	12:30
31-Jan-05	2330	12:00
3-Feb-05	1916	11:30

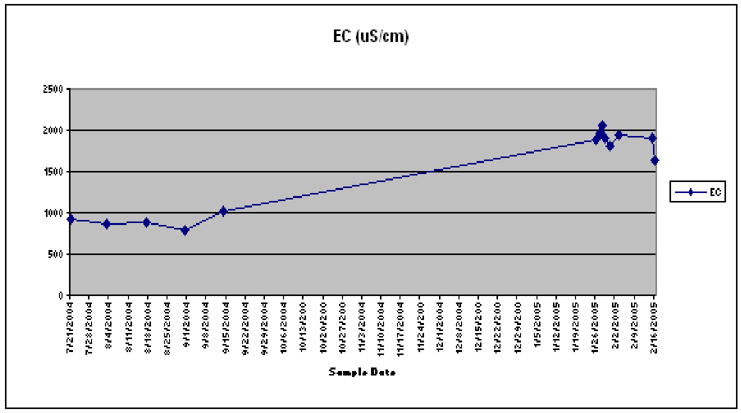


15-Feb-05	1805	12:00
16-Feb-05	1833	11:30

North Canal
544XXXD03

86 South Delta Drainage

Date	EC	Time
21-Jul-04	932	10:50
3-Aug-04	867	13:30
17-Aug-04	880	12:20
31-Aug-04	795	12:20
14-Sep-04	1010	12:50
26-Jan-05	1892	16:20
27-Jan-05	1962	14:20
28-Jan-05	2060	16:50
29-Jan-05	1913	14:30
31-Jan-05	1815	13:20
3-Feb-05	1939	12:30
15-Feb-05	1903	13:20
16-Feb-05	1627	12:50



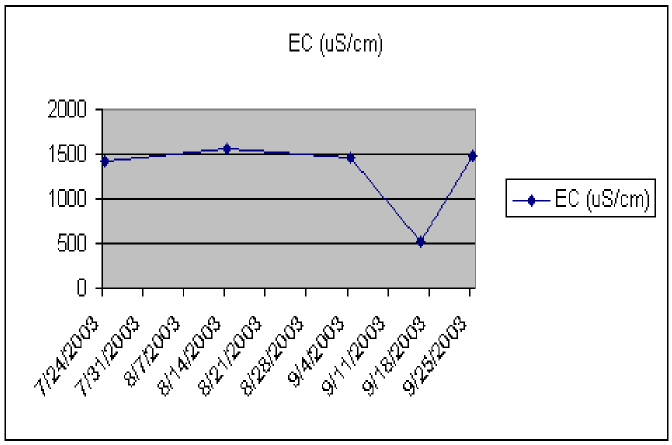
Tom Paine Slough
544XSED07

Date	EC	Time
27-Aug-04	607	18:30

544TPSELR

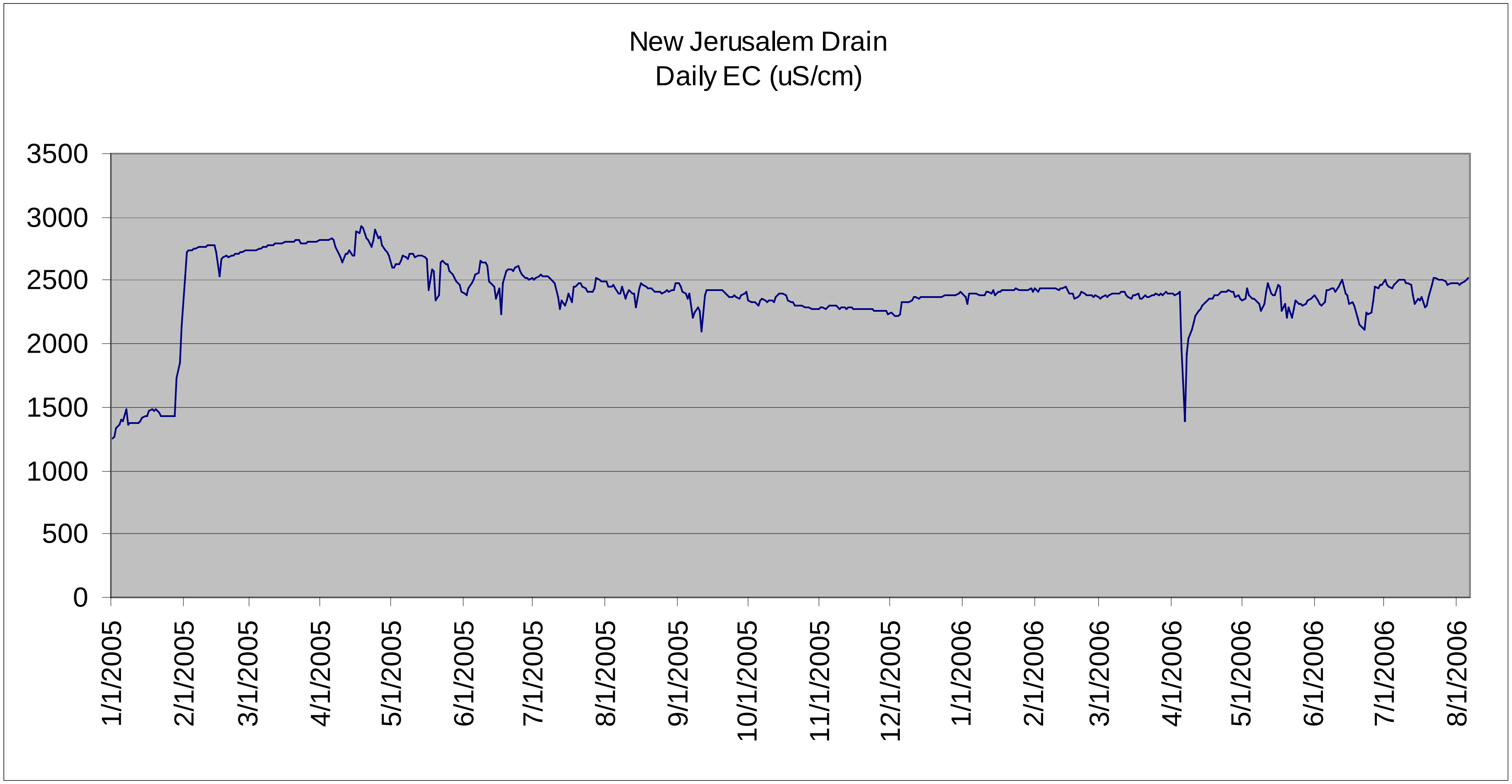
67 South Delta Drainage

Date	EC (uS/cm)	Time
24-Jul-03	1421	10:20
14-Aug-03	1558	10:00
4-Sep-03	1457	10:00
16-Sep-03	522	0:00
25-Sep-03	1475	10:30



APPENDIX E

New Jerusalem Drainage CDEC Data



APPENDIX F

DWR Exhibits from SWRCB 2005 Cease and Desist Order Hearings

DWR Exhibit 18A (Report on San Joaquin Drainage Programs), DWR 21 (Agriculture in the Southern Delta), DWR 22 (Salinity Water Values that are Protective for Agricultural Crop Production), DWR 20 (Investigation of the Factors affecting Water Quality at Brandt Bridge, Middle River at Union Point, and Old River at Tracy), DWR 20A (Fingerprinting Methodology), and DWR 20C (Description of historical DSM2 Particle Tracking Animation With Temporary Barriers Installed in South Delta) are included as a separate file to this document. They can also be found and downloaded at the SWRCB web site at: http://www.waterrights.ca.gov/Hearings/usbr_exhibits.html