Methodology for Flow and Salinity Estimates in the Sacramento-San Joaquin Delta and Suisun Marsh

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Chapter 4:
Using Volumetric Fingerprinting to Study Sources of Salinity in the South Delta

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4 Using Volumetric Fingerprinting to Study Sources of Salinity in the South Delta

4.1 Introduction

Using volumetric fingerprinting, the Department of Water Resources (DWR) investigated the sources of water at three of the four locations where southern Delta electrical conductivity (EC) objectives were established by the State Water Resources Control Board (SWRCB). The purpose of this investigation was to study the extent the San Joaquin River has historically been a source of water at these locations and how this contribution may be affected by State Water Project (SWP) operations and the installation of temporary barriers. This information, when viewed along with modeled EC at the three locations, can give insight into the reasons behind the degree of changes to EC after modifying SWP exports and barrier operations.

4.2 Background

Recent interest has been shown in understanding the role that San Joaquin River inflow plays in determining salinity, as expressed as EC, at the three 'interior' locations where southern Delta EC objectives were specified in the SWRCB's *Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary, 95-1 WR May 1995*. These locations, San Joaquin River at Brandt Bridge, Old River near Middle River, and Old River at Tracy Road are all downstream of the fourth objective location, San Joaquin River at Vernalis (Figure 4.1). The objectives at all four locations are the same: a 30-day running average EC of 0.7 mmhos/cm (700 µS/cm) between April and August and 1.0 mmhos/cm (1,000 µS/cm) between September and March for all year-types.

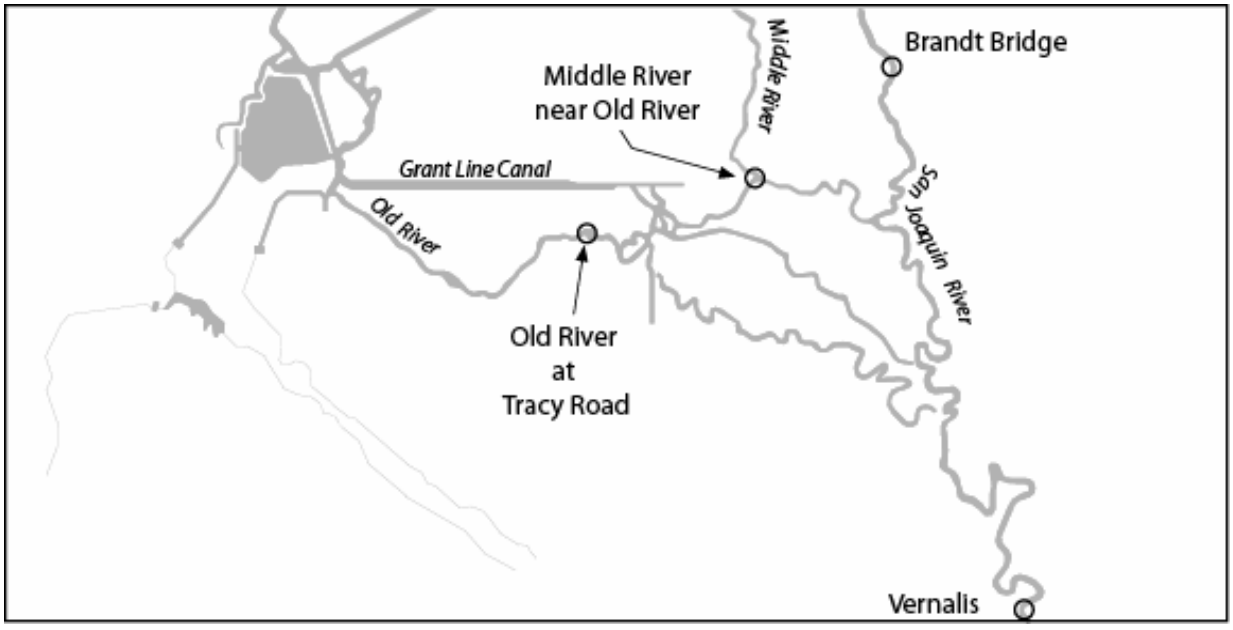
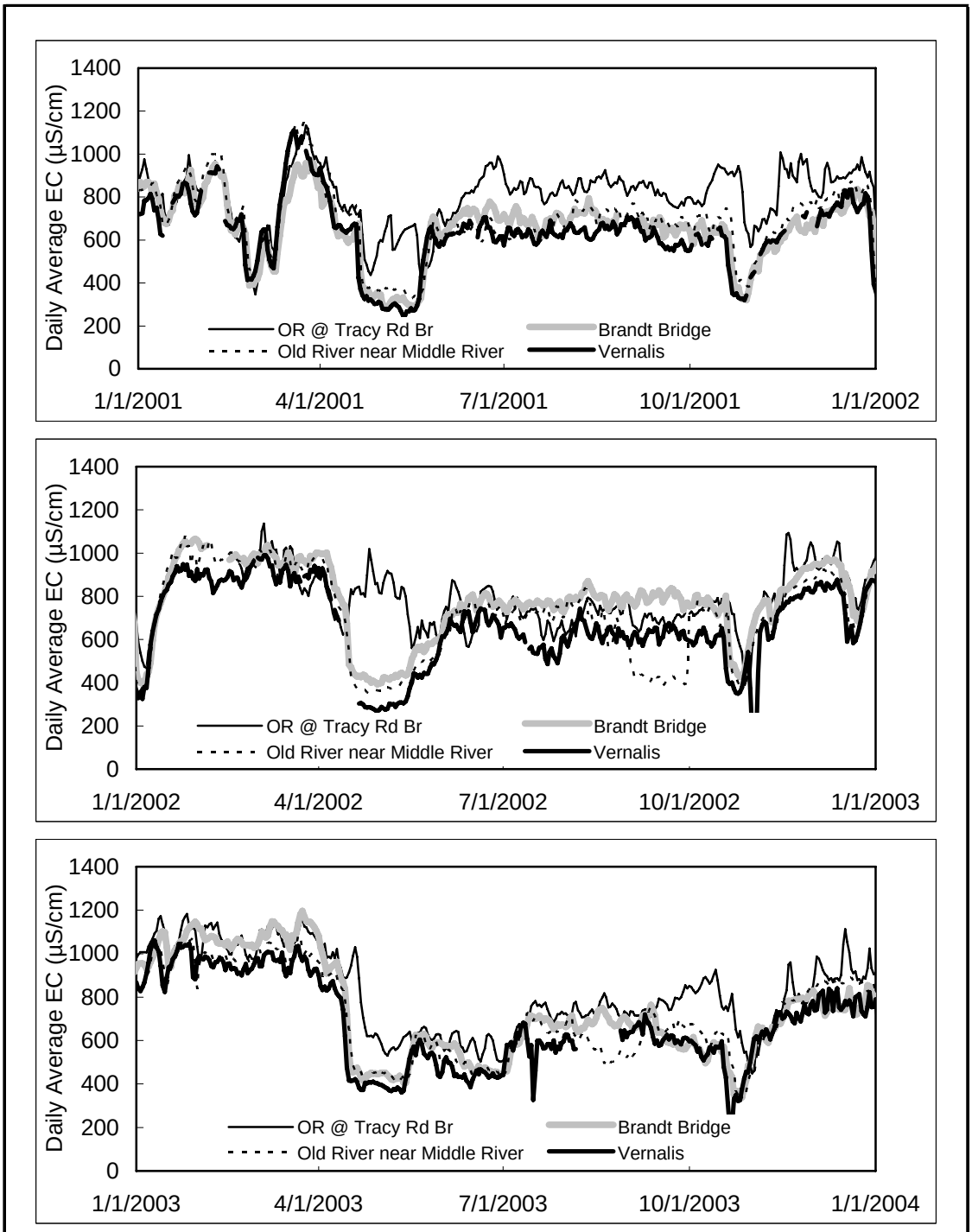


Figure 4.1: Locations of south Delta water quality objectives.

A plot of observed EC at these locations in 2001, 2002, and 2003 (Figure 4.2) shows that the EC at Vernalis during this period was consistently lower than the EC at the downstream locations. Thus, if Vernalis just meets its EC objective, the EC at the other locations may exceed the same objective. As Figure 4.2 shows, the relationship between EC at Vernalis and the other three locations is not constant; however, the San Joaquin River inflow does appear at times to strongly influence the EC in the south Delta. Better understanding was sought of the role San Joaquin River inflow has in determining salinity in the south Delta and the extent to which SWP pumping and temporary barrier operations may affect this role. In order to investigate these questions, volumetric fingerprinting of historical and modified conditions was done at the three interior EC objective locations.

Volumetric fingerprinting refers to the tracking of the relative volumetric contribution of various sources in a column of water at a specified location in the Delta. The methodology and applications of volumetric fingerprinting using DSM2 have been previously discussed (Anderson, 2002; Anderson and Wilde, 2005; Mierzwa and Wilde, 2004). Studies of volumetric fingerprinting in the Delta have tended to focus on Clifton Court Forebay in order to study the origin of the water exported by the State Water Project (SWP). DWR's Municipal and Industrial Water Quality Investigations (MWQI) program publishes a weekly report of current Delta water quality conditions. These reports include a volumetric fingerprint inside Clifton Court Forebay that is based on recent historical Delta hydrodynamic conditions as modeled by DSM2. A recent fingerprint appearing in MWQI's weekly report is shown in Figure 4.3 which shows that from the first of November 2005 through early January 2006 approximately 75% of the water being exported by the SWP originated in the Sacramento River. Then beginning in January 2006 and persisting at least through April 2006, most of the water in Clifton Court Forebay came from the San Joaquin River. This pattern of shifting between the Sacramento River and San Joaquin River as the main source of water in Clifton Court Forebay is repeated for most years and has been used to help explain observed variations in dissolved organic carbon and EC in the forebay.



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

Figure 4.2: Historical EC at locations of south Delta water quality objectives, 2001-2003.

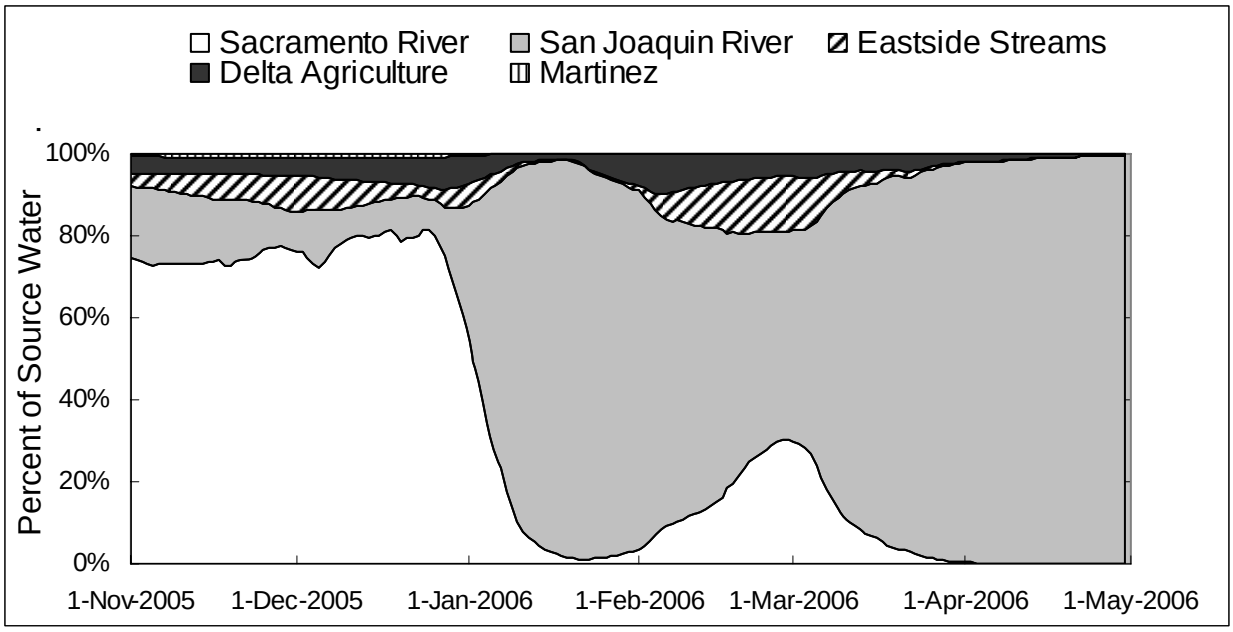


Figure 4.3: Volumetric fingerprint of historical conditions in Clifton Court Forebay (Source: DSM2 simulation of historical conditions).

4.3 Comparing Observed EC to Results of Modeled Fingerprinting

At the three south Delta locations, historically observed EC were plotted with the DSM2-generated fingerprint of the percent of water at the location that originated from the total of San Joaquin River inflow and Delta agricultural discharges (Figures 4.4, 4.5, and 4.6). These two sources were combined because they are usually considered outside the influence of DWR. In the figures below, the combination of San Joaquin River and Delta agricultural discharges frequently account for nearly all of the water at all three sites. When the combination of the two sources dips below 100%, other possible sources of water are Sacramento River inflow, Mokelumne River inflow, and water from the west Delta. Of these additional sources, Sacramento River inflow is predominant, most likely due to a combination of barrier operation and hydrology.

The figures below show that the predominance of the San Joaquin River and Delta agricultural drainage as the source of water varies at the three sites. Most strongly determined by the two sources of water is San Joaquin River at Brandt Bridge, next is Old River at Middle River, and least is Old River at Tracy Road. The figures below generally show no obvious relationships between fingerprints and EC. An important exception may be the fingerprint and EC at Old River at Tracy Road in 2003. Twice in that year sudden decreases in EC coincided with sudden decreases in the contribution of San Joaquin River water and agricultural drainage. In other words, twice in 2003 water originating from the Sacramento River reached the Old River at Tracy Road location, and both times the EC there decreased.

The results mentioned above for Old River at Tracy Road have created interest in studying what conditions cause water from the Sacramento River to reach the south Delta. Specifically, the

question arises as to how DWR operations in the Delta affect the origin of the water in the south Delta. DSM2 simulations of modified Delta conditions were performed to study this question.

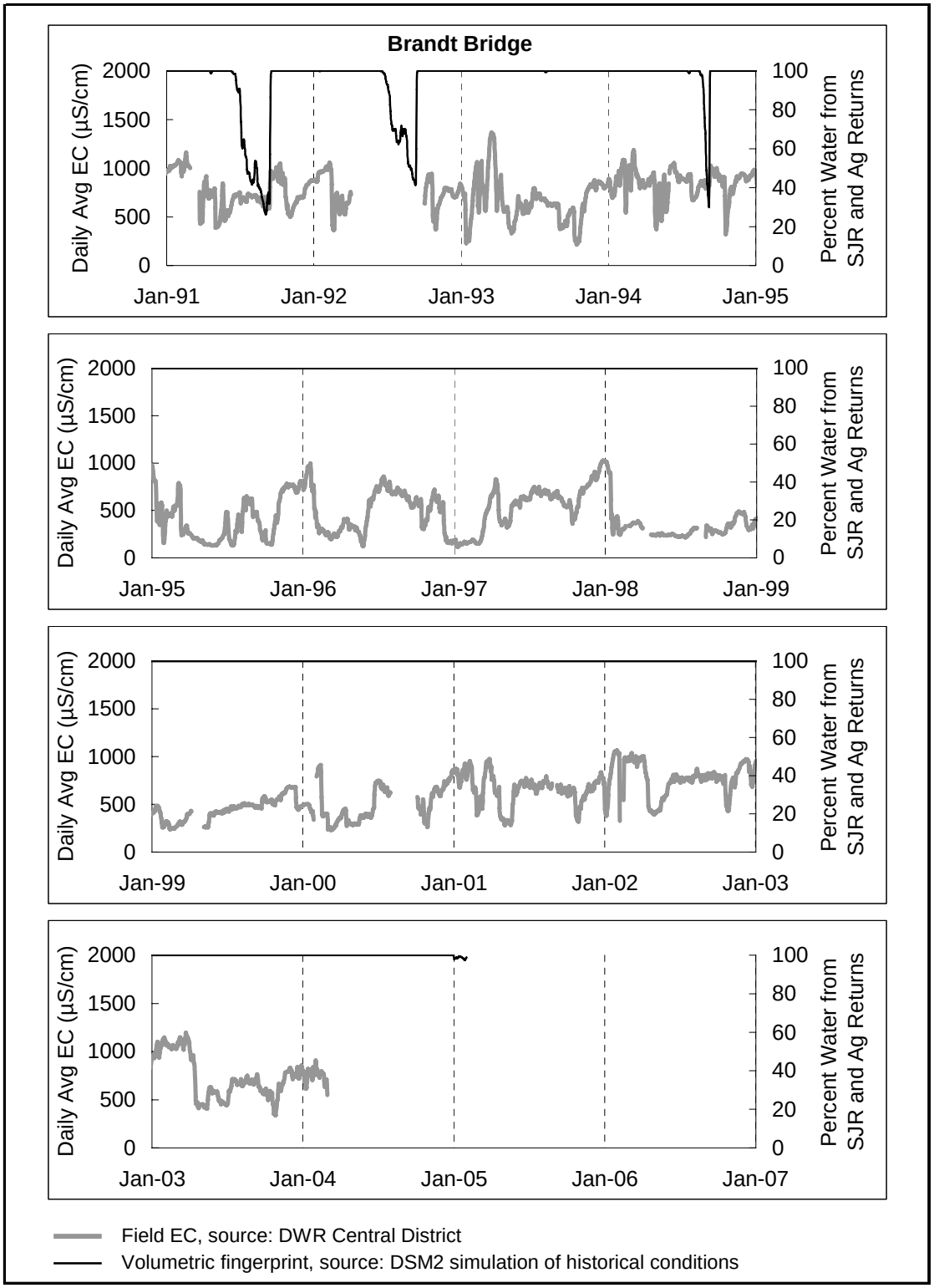


Figure 4.4 Observed EC and DSM2-generated volumetric fingerprint of historical conditions at Brandt Bridge.

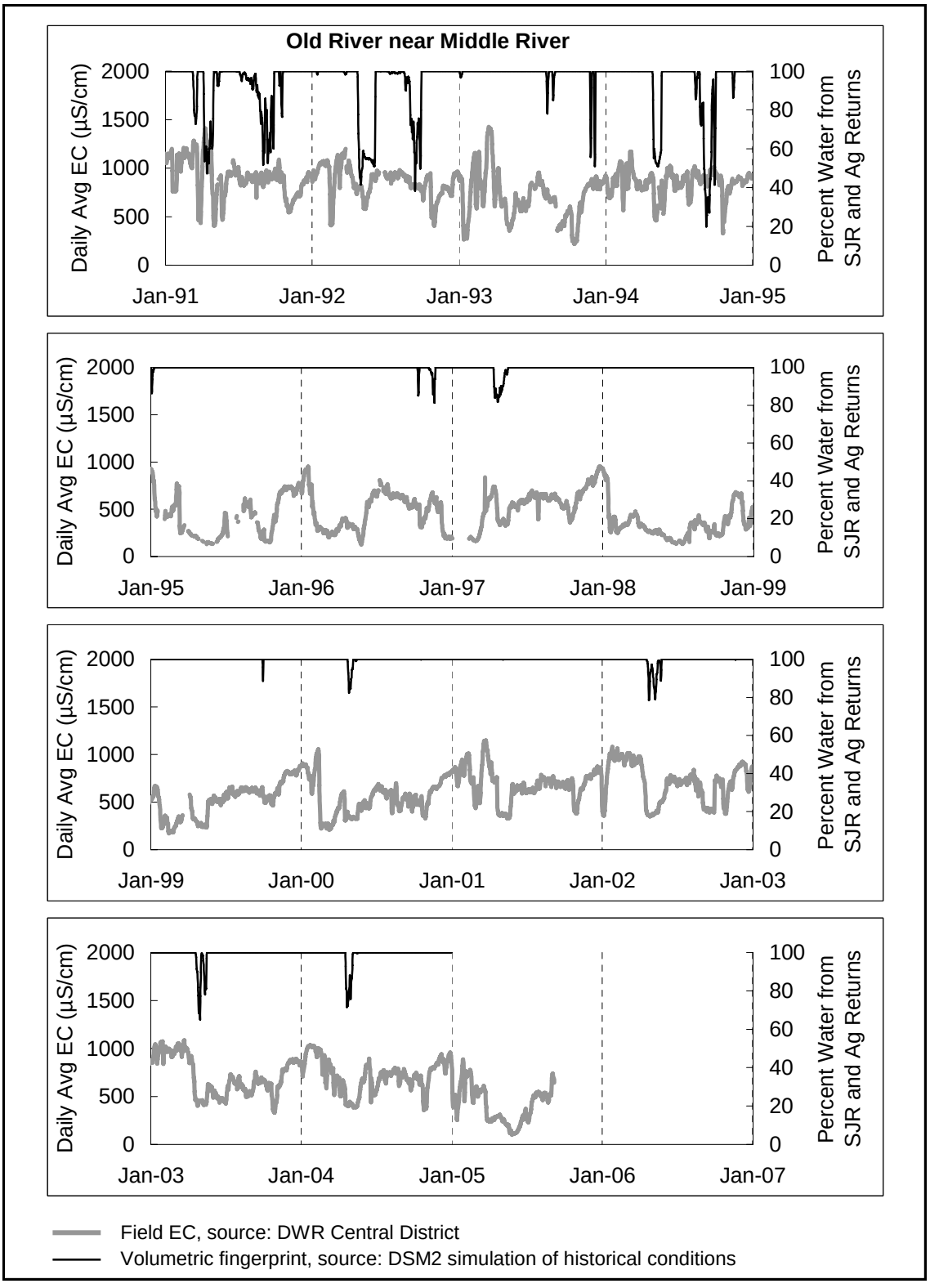


Figure 4.5 Observed EC and DSM2-generated volumetric fingerprint of historical conditions at Old River near Middle River.

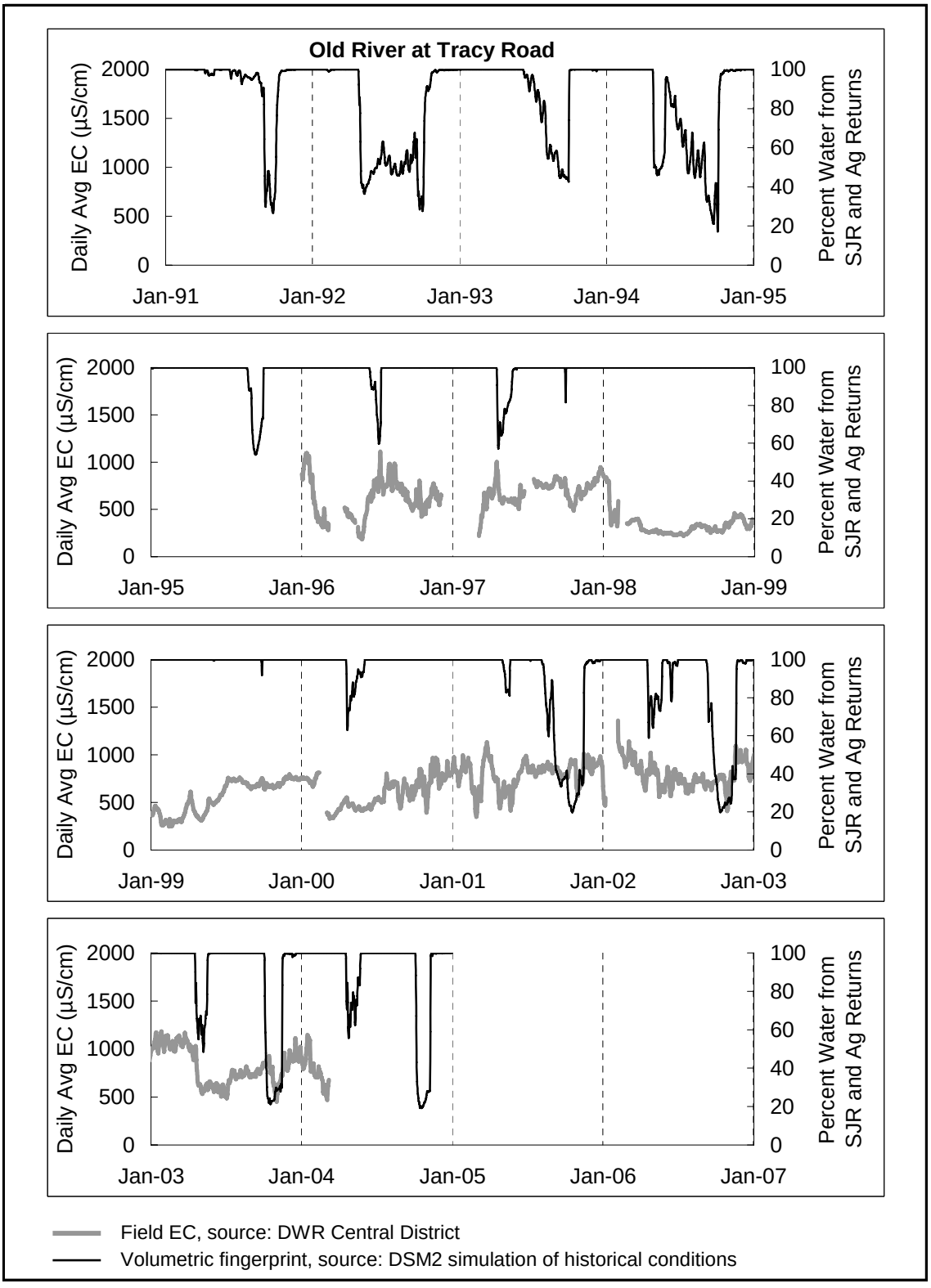


Figure 4.6 Observed EC and DSM2-generated volumetric fingerprint of historical conditions at Old River at Tracy Road.

4.4 Modeling Fingerprinting and EC for Modified SWP Pumping

EC and fingerprints of modified historical Delta conditions were simulated by DSM2 to determine how much SWP pumping and temporary barrier installation may have affected south Delta conditions in 2002 and 2003. Since the current validation of DSM2 does not include this period, an extended EC validation of DSM2 at the three locations of concern is first provided.

4.4.1 Validation of DSM2's Simulation of EC in the South Delta

Historical EC was simulated at the three interior locations for south Delta objectives in order to view the accuracy of DSM2's simulation of EC in the south Delta for years since 1999. The currently published validation of DSM2-QUAL (water quality module of DSM2) covers the time of April 1990 through September of 1999 and contains errors in the posted measured EC at Old River at Tracy Road. Figures 4.7, 4.8, and 4.9 compare DSM2-simulated to field-measured EC at the three locations over the period of 1990 through 2004. Vernalis EC is not presented because it is an input to DSM2 that is based on observed data.

The figures below show generally good agreement between DSM2-simulated and field-measured data. However, DSM2 does tend to underestimate EC at Old River at Tracy Road. As shown in Figure 4.2, the EC here can be substantially higher than what is seen in the San Joaquin River inflow at Vernalis. This implies that a source of salinity other than the San Joaquin River at times contributes to localized higher EC in Old River at Tracy Road. DSM2's tendency to underestimate EC here may mean that DSM2 fails to fully account for the phenomena occurring to raise the EC at this location in the south Delta.

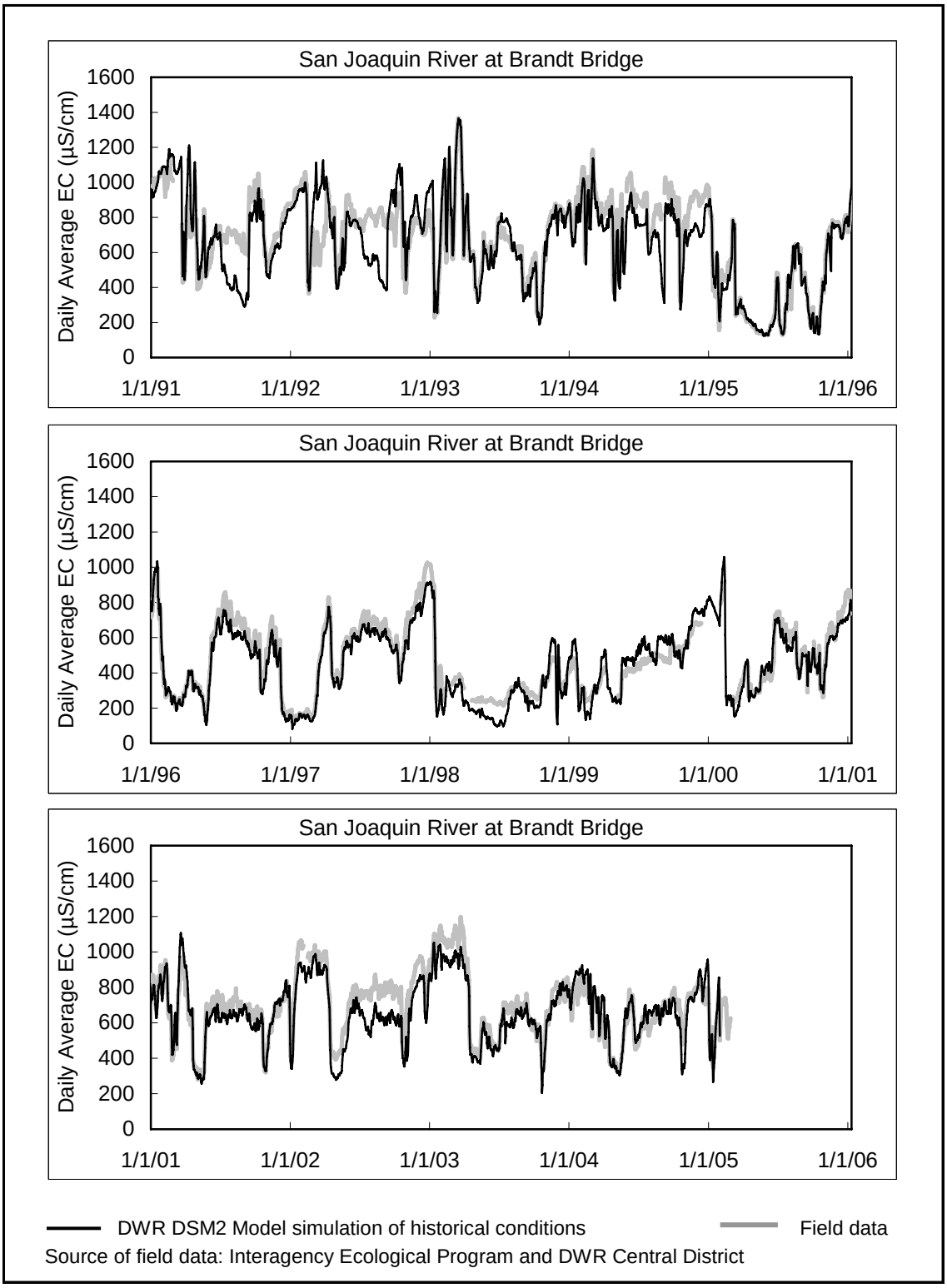


Figure 4.7: Observed and DSM2-simulated EC at Brandt Bridge, 1991-2004.

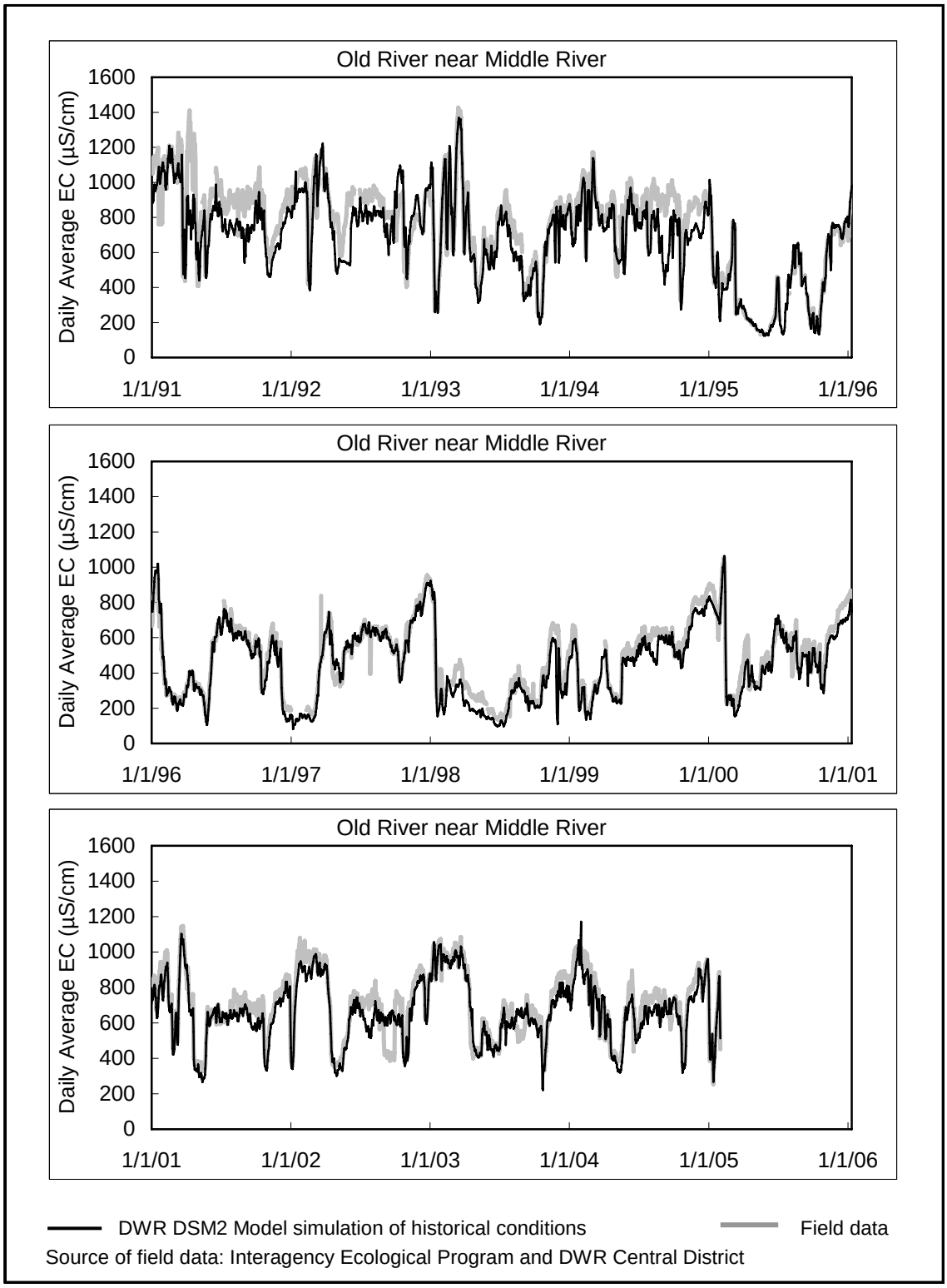


Figure 4.8: Observed and DSM2-simulated EC at Old River near Middle River, 1991-2004.

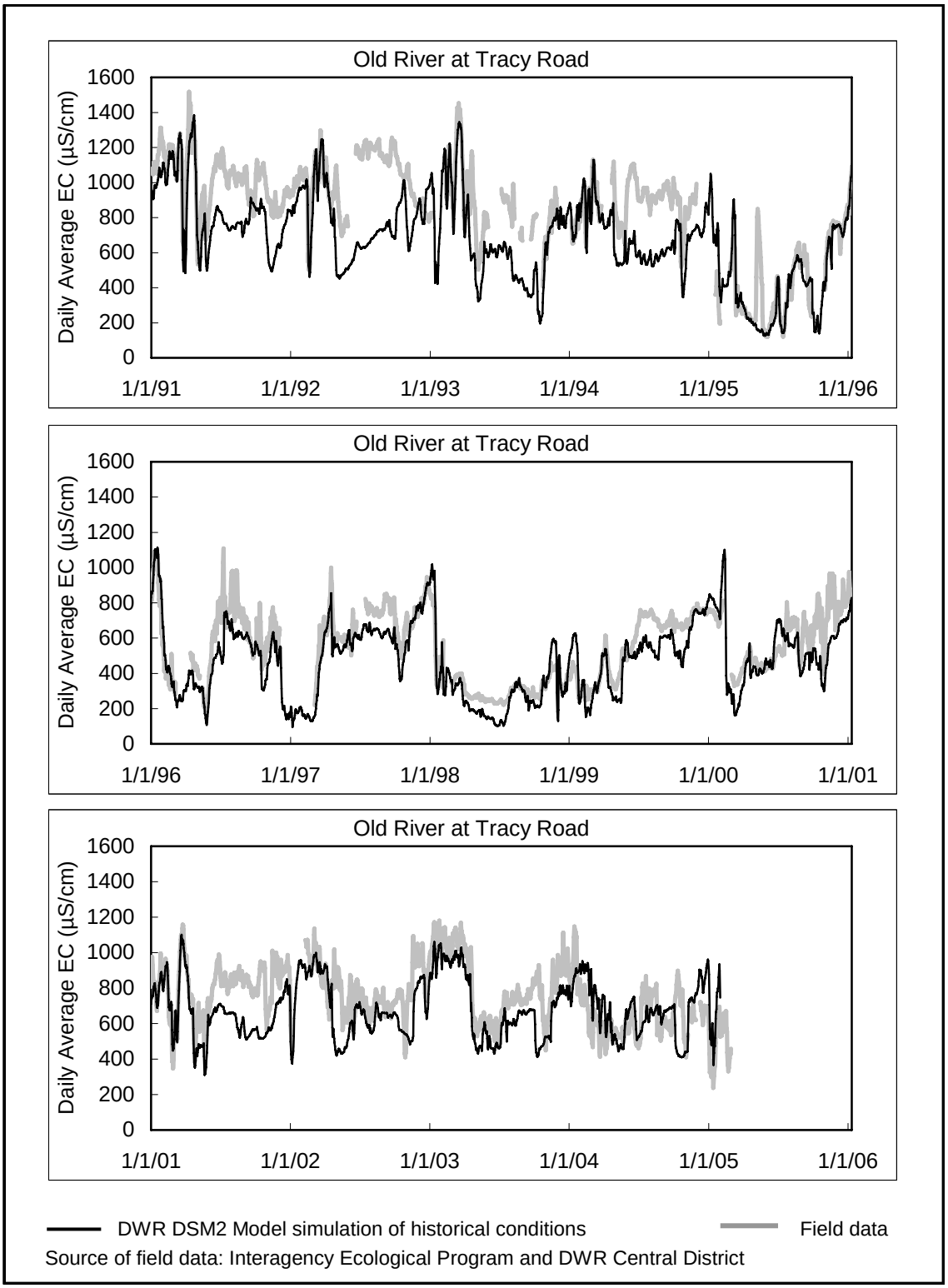


Figure 4.9: Observed and DSM2-simulated EC at Old River at Tracy Road, 1991-2004.

4.4.2 Delta Conditions with Modified SWP Pumping

Delta conditions were simulated for historical 2002 and 2003 conditions with SWP pumping eliminated for much of each year. These years were chosen because they are recent, SWP pumping was high at times, and 30-day running average of the historical EC at the three locations exceeded 0.7 mmhos/cm in the springtime.

Figures 4.10 and 4.11 show the SWP and Central Valley Project (CVP) pumping and the San Joaquin River inflow for 2002 and 2003. In the historical simulations, SWP pumping in both years exceeded 7,000 cfs for extended periods and the San Joaquin River inflow during the periods of interest ranged from 1,500 cfs to 3,000 cfs in both years (Figures 4.10 and 4.11). The periods of January 6, 2002 to September 9, 2002 and January 4, 2003 to May 30, 2003 were then selected as the times to eliminate SWP pumping.

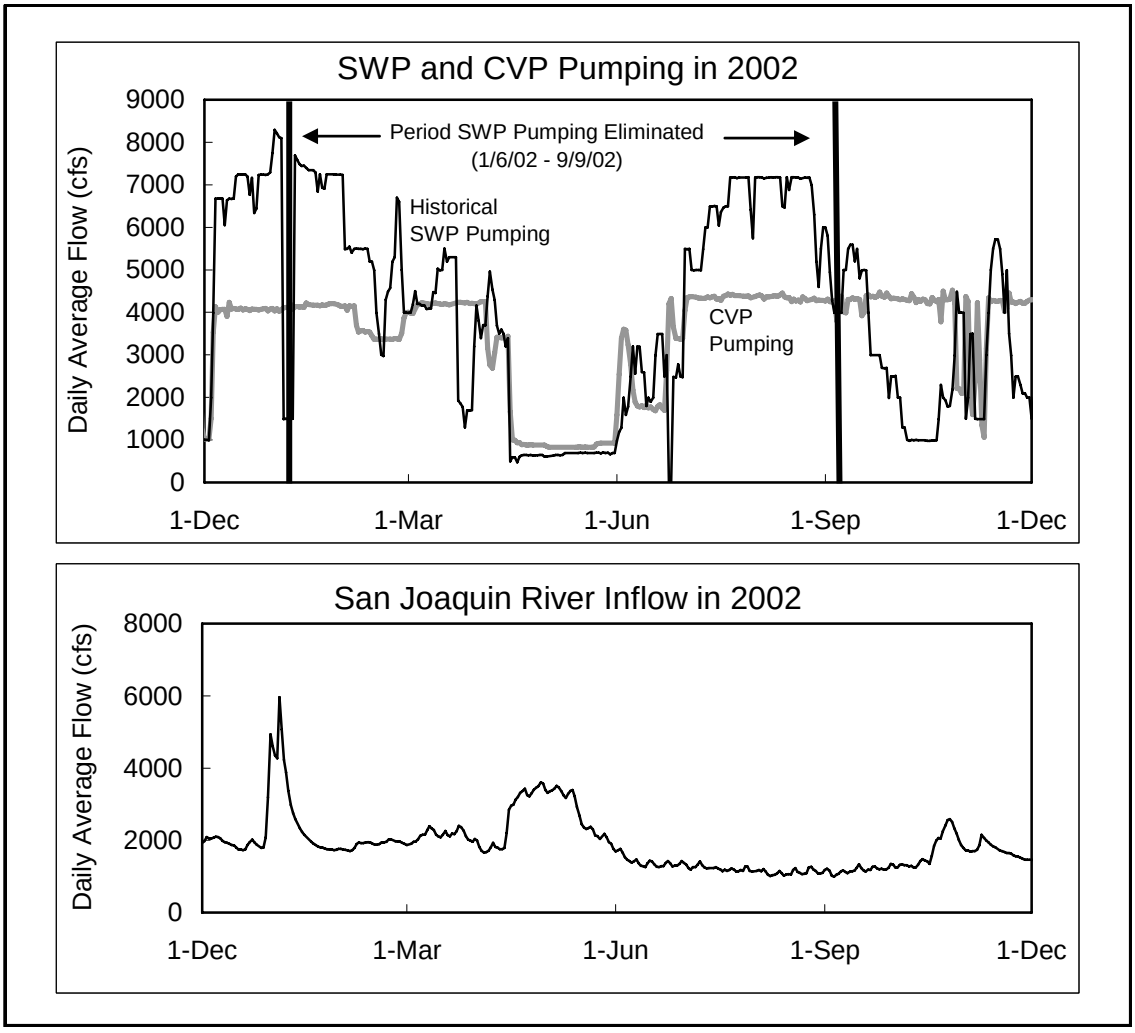


Figure 4.10: Historical SWP and CVP pumping and San Joaquin River inflow in 2002.

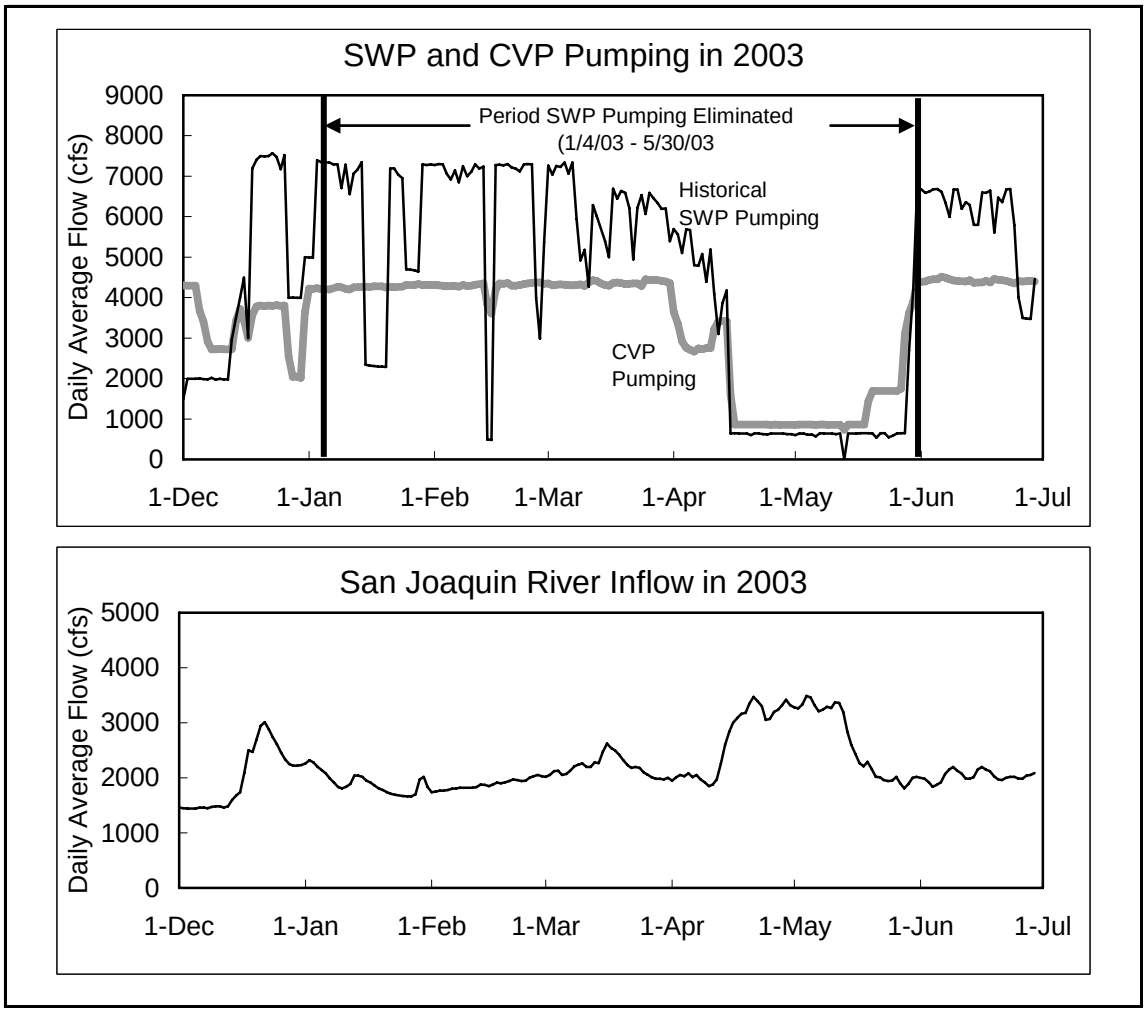


Figure 4.11: Historical SWP and CVP pumping and San Joaquin River inflow in 2003.

4.4.3 2002 Fingerprinting and EC

DSM2 simulations of both EC and fingerprinting were then performed for both the historical and modified Delta conditions. Figures 4.12, 4.13, and 4.14 show for Brandt Bridge, Old River near Middle River, and Old River at Tracy Road respectively the daily average EC and volumetric fingerprints for historical 2002 Delta conditions and when SWP pumping was eliminated during the January 6, 2002 through September 9, 2002 period. The fingerprints are broken down by the contribution of the combination of San Joaquin River inflow and agricultural drainage versus the contribution by the Sacramento River inflow. Figure 4.12 shows that eliminating SWP pumping in 2002 had very little if any impact on EC at Brandt Bridge. The source of water here, nearly always 100% from the San Joaquin River and agricultural drainage, only slightly changed after eliminating SWP pumping. At Old River near Middle River, a slight increase in EC in April and May was associated with a slight shift in source water from a combination of the San Joaquin River and agricultural drainage to mostly the Sacramento River (Figure 4.13). Some west Delta water may have also contributed to the increase in EC. Of the three sites, significant change in

EC due to eliminating SWP pumping was only seen at Old River at Tracy Road (Figure 4.14). A significant decrease in EC here from June through September was associated with a significant change in the source water, Sacramento River water replacing combined San Joaquin River and agricultural drainage. Interestingly, while the SWP pumping was eliminated beginning on January 6, 2002, these changes in EC and source water only became significant in June of 2002.

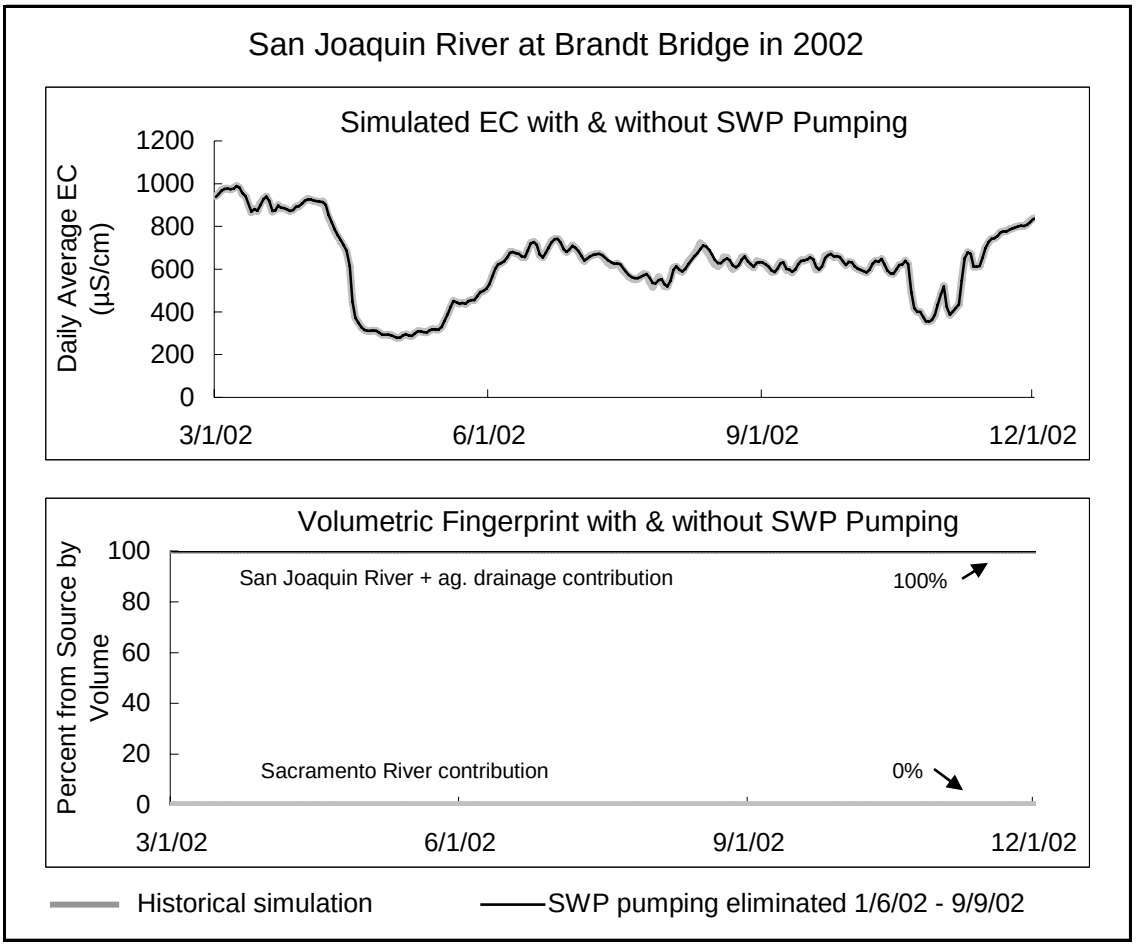


Figure 4.12: DSM2-modeled EC and volumetric fingerprint at Brandt Bridge for 2002 historical and modified conditions.

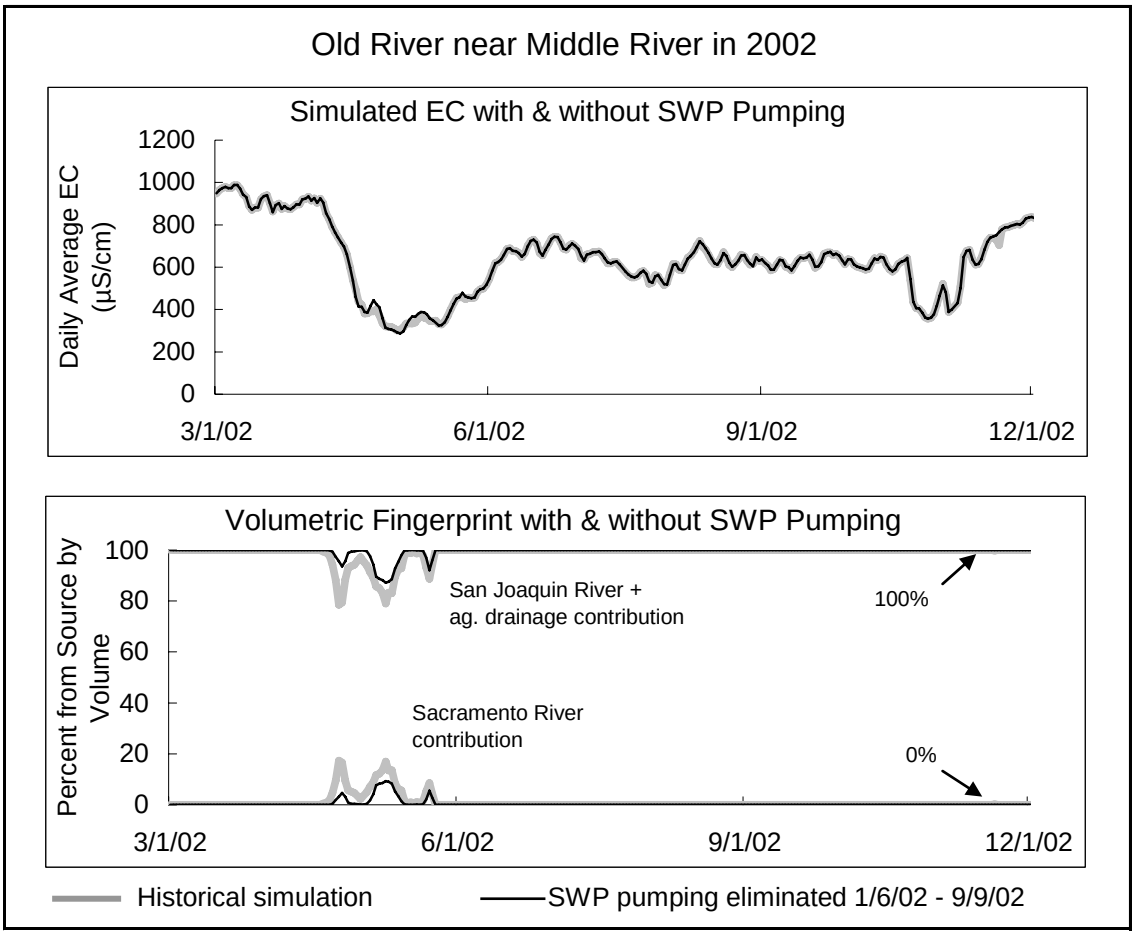


Figure 4.13: DSM2-modeled EC and volumetric fingerprint at Old River near Middle River for 2002 historical and modified conditions.

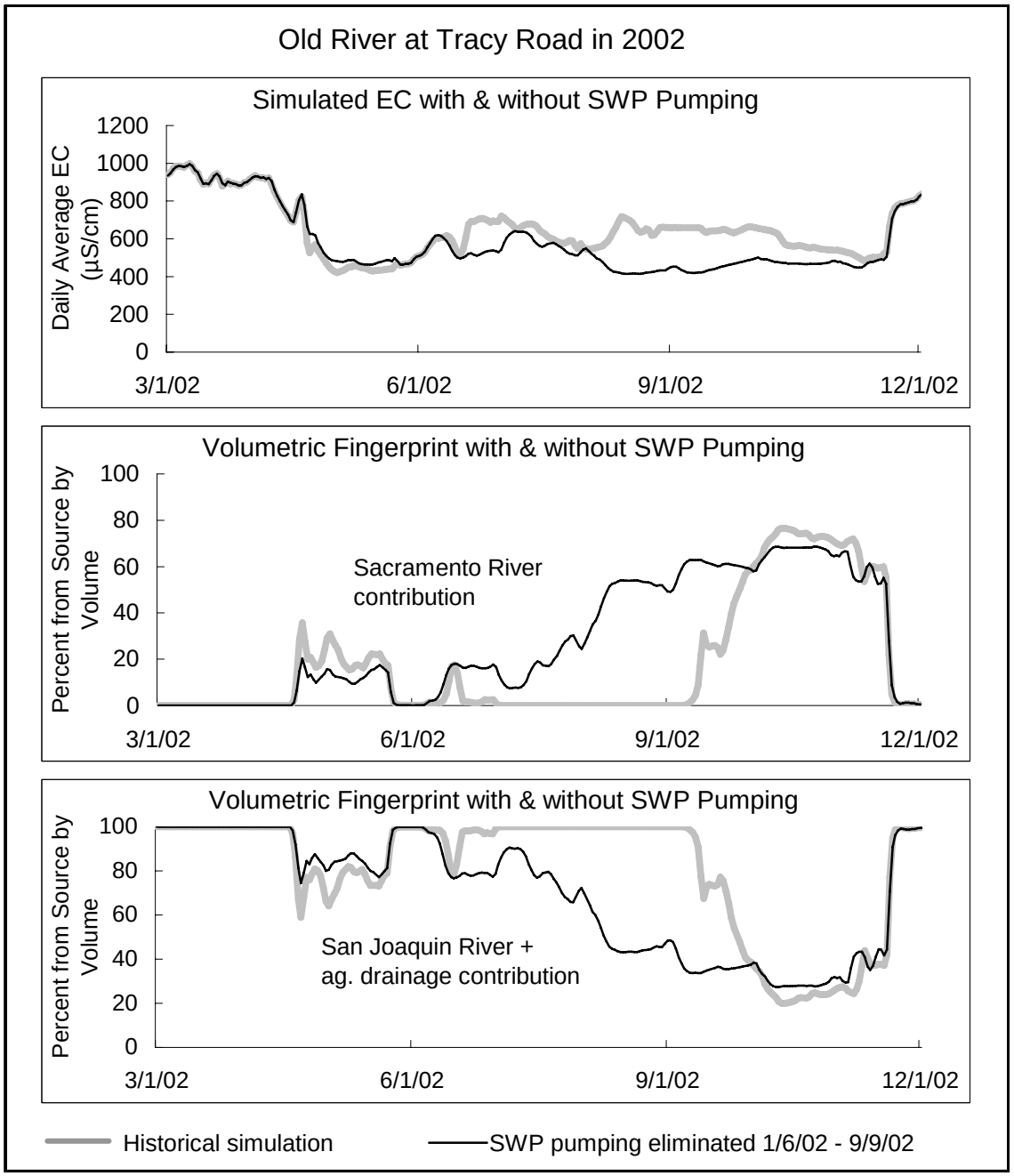


Figure 4.14: DSM2-modeled EC and volumetric fingerprint at Old River at Tracy Road for 2002 historical and modified conditions.

4.4.4 2003 Fingerprinting and EC

Figures 4.15, 4.16, and 4.17 present the EC and fingerprinting at the three locations for historical and modified 2003 conditions. At Brandt Bridge, the source of water in 2003 was again virtually entirely a combination of San Joaquin River and agricultural drainage and this did not significantly change when SWP pumping was eliminated (Figure 4.15). As a result, the EC here did not significantly change under the modified conditions. At Old River near Middle River, eliminating SWP pumping from 1/4/03 through 5/30/03 reduced the contribution of the Sacramento River as a source of water here and increased the combination of San Joaquin River and agricultural drainage (Figure 4.16). The result is a slight decrease then increase in EC here. At Old River at Tracy Road, eliminating SWP pumping shifted the source water here from Sacramento River to a combination of San Joaquin River and agricultural drainage and caused an increase in EC (Figure 4.17). As in 2002, eliminating SWP pumping did not have an effect on EC and the source of water until months later.

Comparing Figure 4.14 and Figure 4.17, eliminating SWP pumping can result in more or less Sacramento River reaching Old River at Tracy Road with the EC here either increasing or decreasing. In order to understand the conflicting results, more detailed analysis is needed of the historical hydrodynamic conditions and how these might change when SWP pumping is eliminated. In the 2002 simulation, the high SWP pumping combined with high CVP pumping induced a net downstream flow in Old River to Clifton Court Forebay despite the presence of the temporary Old River barrier. Eliminating SWP pumping allowed the Sacramento River water drawn to the south Delta by the CVP pumping and agricultural depletions to be moved upstream by the temporary barrier operation. In the 2003 simulation, eliminating SWP pumping reduced the amount of Sacramento River source water in the south Delta which meant less Sacramento River reaching Old River at Tracy Road and higher EC values here.

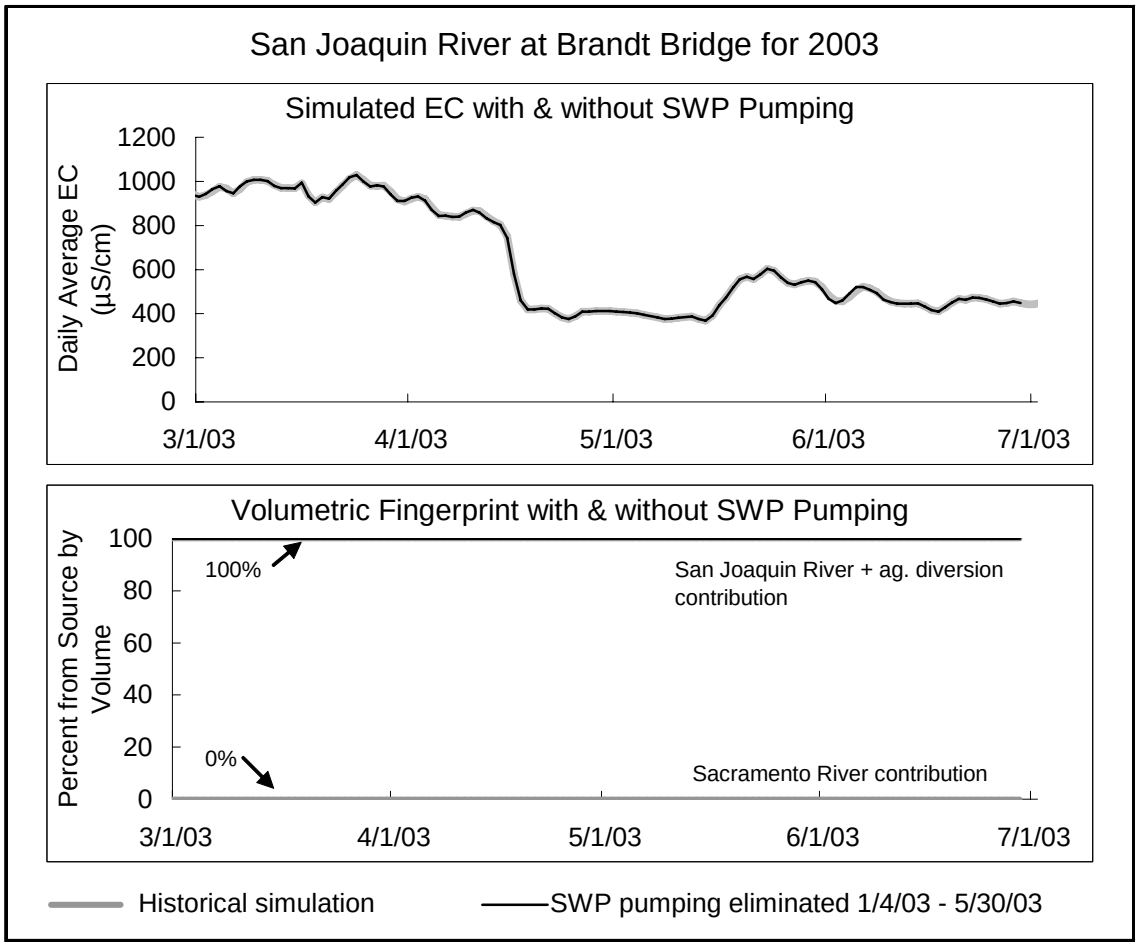


Figure 4.15: DSM2-modeled EC and volumetric fingerprint at Brandt Bridge for 2003 historical and modified conditions.

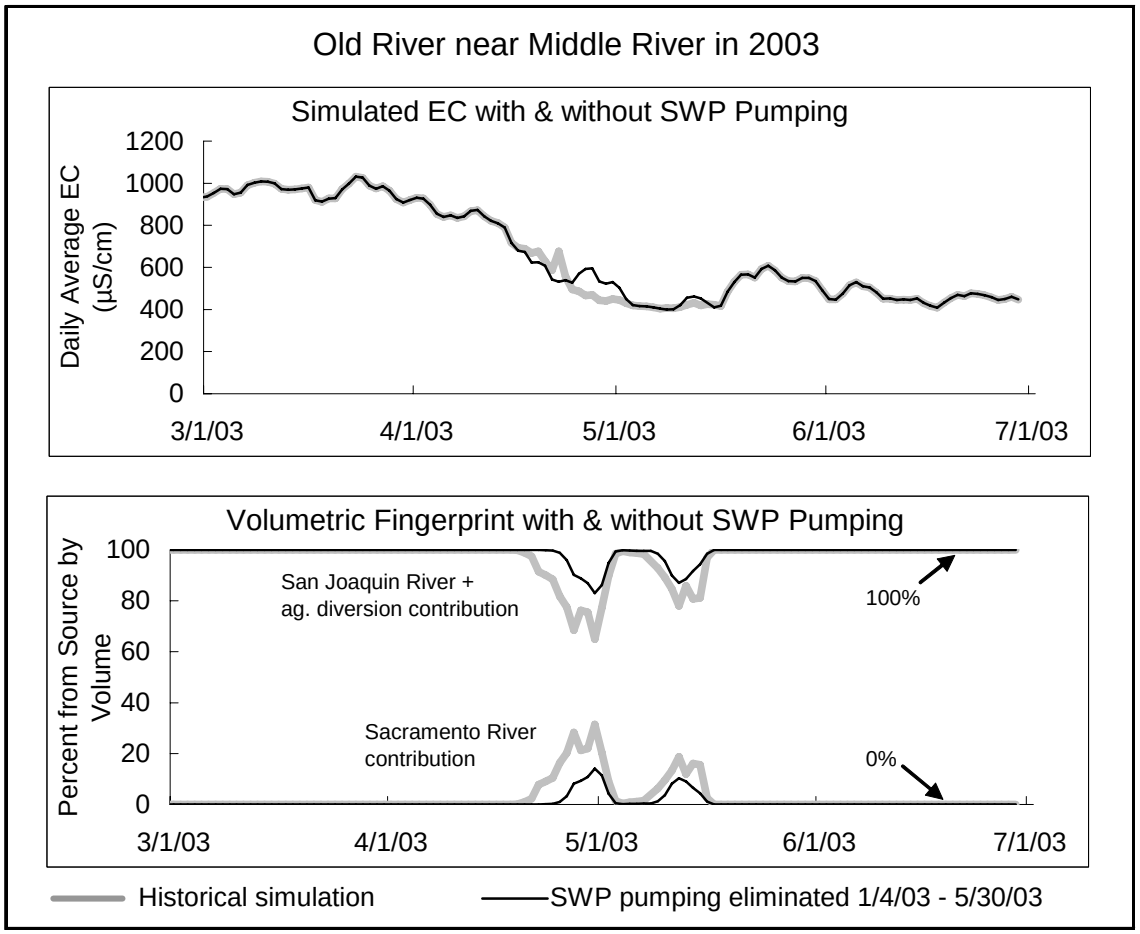


Figure 4.16: DSM2-modeled EC and volumetric fingerprint at Old River near Middle River for 2003 historical and modified conditions.

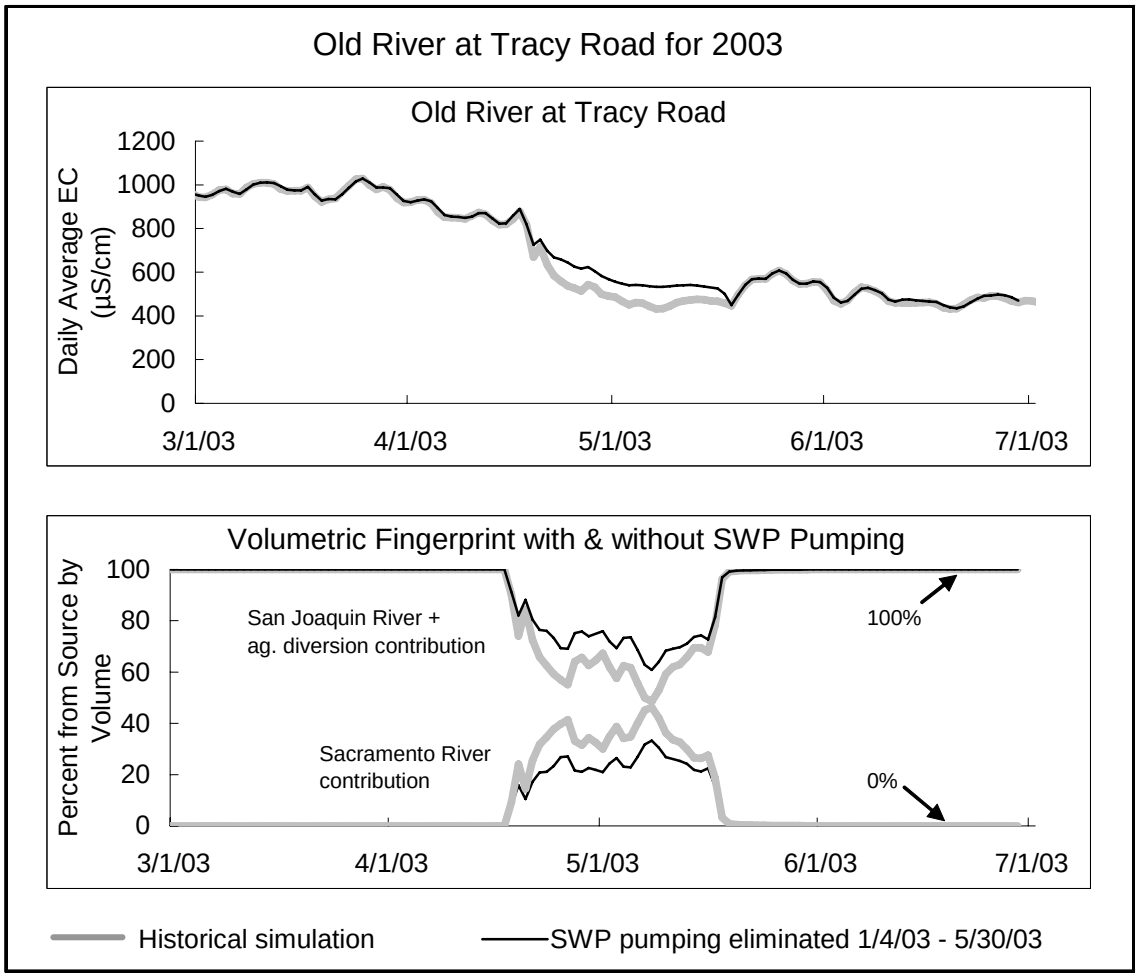


Figure 4.17: DSM2-modeled EC and volumetric fingerprint at Old River at Tracy Road for 2003 historical and modified conditions.

4.5 Summary and Conclusions

Modeled fingerprints of sources of water in the south Delta are valuable in interpreting changes in EC and explaining the movement of water due to hydrology, SWP pumping, and south Delta barrier operation. Water quality studies in the south Delta have tended to express results in terms of the extent operations of barriers or SWP pumping influence water quality. Underlying this information is an assumption that water in the Delta is being mixed differently. Fingerprinting allows direct analysis of how activities in the Delta affect mixing—in this case how SWP pumping affects the presence of water originating from the Sacramento River reaching the south Delta.

4.6 References

Anderson, J. (2002). "Chapter 14: DSM2 Fingerprinting Methodology." *Methodology for Flow and Salinity Estimates in the Sacramento-San Joaquin Delta and Suisun Marsh. 23rd Annual Progress Report to the State Water Resources Control Board.* California Department of Water Resources, Bay-Delta Office, Sacramento, CA. http://modeling.water.ca.gov/delta/reports/annrpt/2002/2002Ch14.pdf

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