CHAPTER VIII. ENVIRONMENTAL EFFECTS OF PREFERRED ALTERNATIVE

The purpose of this triennial review is to develop a set of objectives that increases protection for the aquatic resources in the Bay-Delta Estuary while retaining existing water quality protections for the agricultural, municipal, and industrial uses of Bay-Delta waters. Therefore, the preferred alternative should have no significant adverse environmental impacts in the Bay-Delta Estuary, but it will cause adverse environmental impacts both upstream of the Estuary and in export areas due to decreases in water supply.

The following discussion of environmental effects of the standards is largely theoretical because the SWRCB will not implement the objectives by allocating responsibility to meet the objectives until the water rights phase of the proceedings. This document need not explain in detail the as-yet unknown effects of implementing the objectives, since the SWRCB will conduct an appropriate environmental analysis of the effects of implementing the objectives before the implementation measures are imposed. (14 CCR §15145) When the SWRCB commences the water rights phase, the SWRCB will prepare appropriate environmental documentation for its action. For this analysis, the SWRCB is using the SWP and the CVP as surrogates for the water rights holders in the Central Valley that may be held responsible for meeting the standards.

The reference conditions for this environmental analysis are the actual conditions that existed from 1984 through 1992. This reference condition is different than the base case for the water supply impact analysis in Chapter VII, which is defined as D-1485 conditions at the 1995 demand level assuming a repetition of the 1922-1992 historical hydrology. The base case for the water supply impact analysis was selected because water supply demands increased over the recent past and historical operations do not reflect this increased demand. The base case for the water supply impact analysis, however, is not appropriate for the environmental analysis because the Bay-Delta environment never actually experienced those modeled conditions.

The recent historical period of 1984-1992 was chosen for this environmental analysis because it contains enough years to capture some of the biological and hydrological variability in the Estuary, including the extended drought of 1987 through 1992. Using the Sacramento River Valley hydrologic classification, which applies to the analyses of Delta inflow, outflow, and exports, as well as Sacramento River flow objectives, the historical reference period consists of two wet years (1984 and 1986), three dry years (1985, 1987, and 1989), and four critical years (1988, 1990, 1991, and 1992). Using the San Joaquin Valley hydrologic classification, which applies to the analyses of San Joaquin River flow objectives, the historical reference period consists of one wet year (1986), one above normal year (1984), one dry year (1985), and six critical years (1987 through 1992).

The discussion of the environmental effects of the preferred alternative is divided into three sections: effects in the Estuary, effects in upstream areas, and effects in export areas.

A. EFFECTS IN THE ESTUARY

This section discusses the effects of the preferred alternative on environmental conditions within the Bay-Delta Estuary. The analysis focuses on Delta outflow, Delta exports, salinity, aquatic resources, Suisun Marsh, agricultural water supply, municipal and industrial water supply, and recreation.

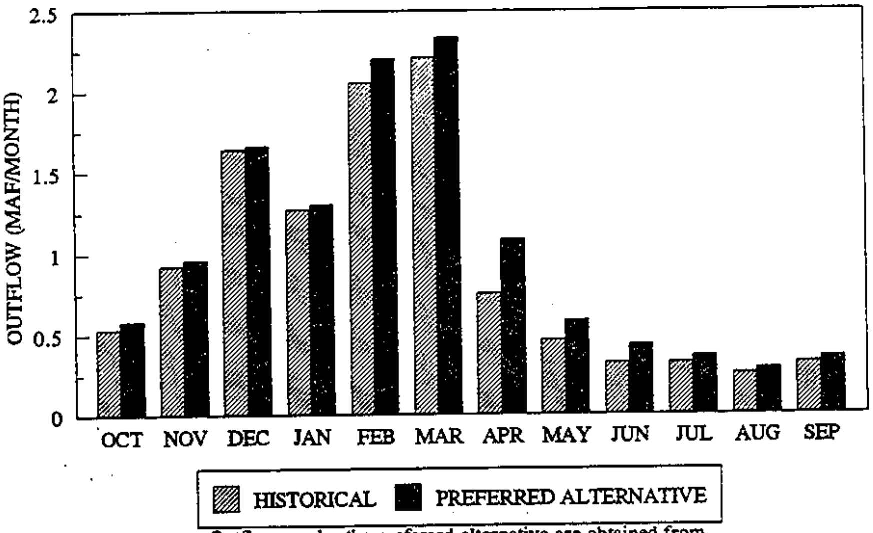
For some parameters, such as Delta outflow and salinity, the preferred alternative's potential effects are obtained by directly comparing the standards to historical conditions. For other parameters, such as exports, modeled conditions of the preferred alternative from a DWRSIM operation study or other applicable model are compared to actual historical operations or to conditions obtained from a DWRSIM base case study, as described in Chapter VII. The DWR, the agency that both developed DWRSIM and is its principal user, has cautioned the SWRCB not to compare historical data to DWRSIM outputs since the model uses monthly flows and fixed assumptions (e.g., demand, Trinity operations, in-basin depletions, etc.) which in actuality vary over the period for which the operation study is run (DWR 1993). The SWRCB recognizes these conditions and has avoided direct modeled-historical data comparisons in the water supply impact analysis (Chapter VII). Nevertheless, in some cases, DWRSIM is the only available tool to predict conditions under the preferred alternative for this environmental analysis. The modeled-historical data comparisons are necessary for this purpose, albeit results must be interpreted with care and full consideration of the modeled conditions.

1. Delta Outflow

Delta outflow is known to be positively correlated with the population sizes of numerous aquatic species. To analyze effects of the standards on Delta outflow, historical flows are compared with those under the preferred alternative. The preferred alternative flows are obtained from the additional outflow model developed by the CCWD and discussed in Chapter VI. The model starts with historical outflows and determines the additional flows necessary to meet requirements in the preferred alternative.

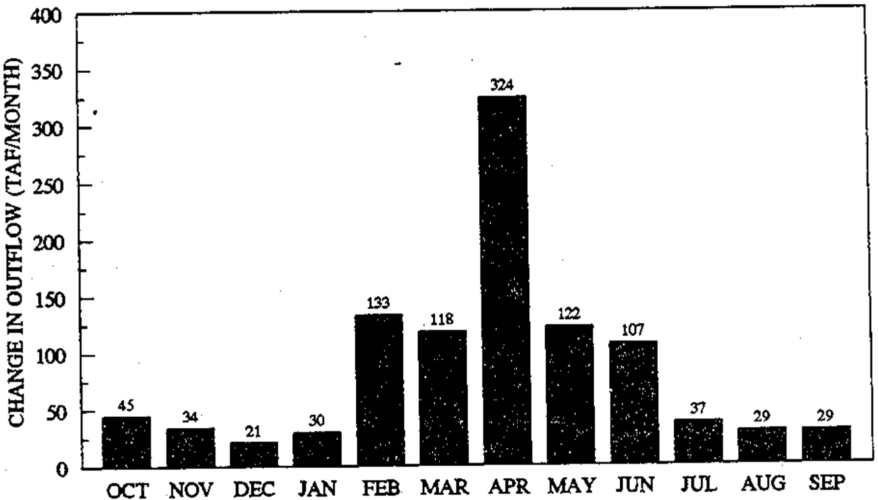
As shown in Figures VIII-1 through VIII-4, average Delta outflows increase under the preferred alternative for all months and all years in the 1984-1992 period. Figure VIII-1 shows historical average monthly Delta outflows and Delta outflows under the preferred alternative. The greatest effects of the preferred alternative are seen in the spring months of February through June when average monthly Delta outflows are increased by 133 TAF, 118 TAF, 324 TAF, 122 TAF, and 107 TAF, respectively (Figure VIII-2). Figures VIII-3 and VIII-4 show that, during the critical and dry years of 1985 and 1987 through 1992, average annual outflow increases range from 723 TAF in 1985 to 1,727 TAF in 1989 (both are dry years). Over the 1984-1992 period, the average annual Delta outflow is increased by 1,029 TAF under the preferred alternative. The effects of the Delta outflow objectives on aquatic resources in the Estuary are discussed under section A.5, below.

FIGURE VIII-1
AVERAGE MONTHLY DELTA OUTFLOW FROM WATER YEARS 1984-1992



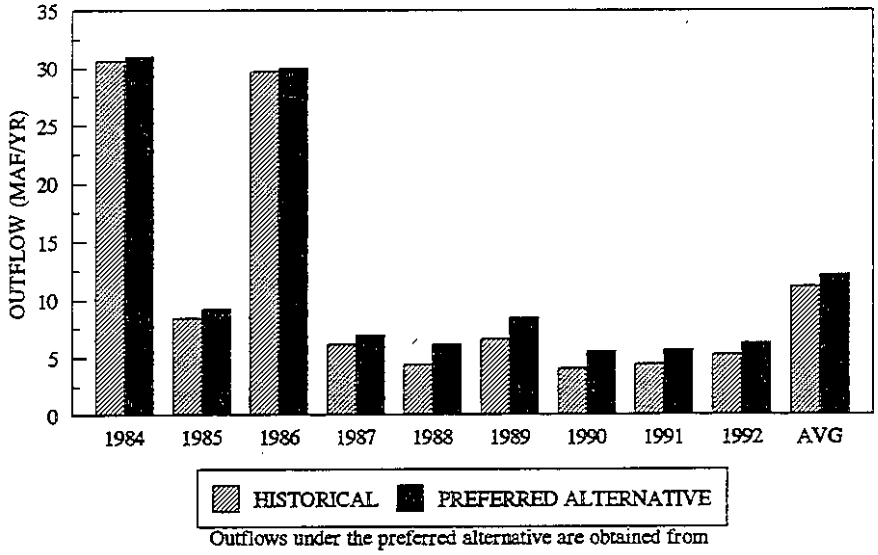
Outflows under the preferred alternative are obtained from the CCWD's additional outflow model.

FIGURE VIII-2
AVERAGE MONTHLY CHANGE IN DELTA OUTFLOW FROM WATER YEARS 1984-1992



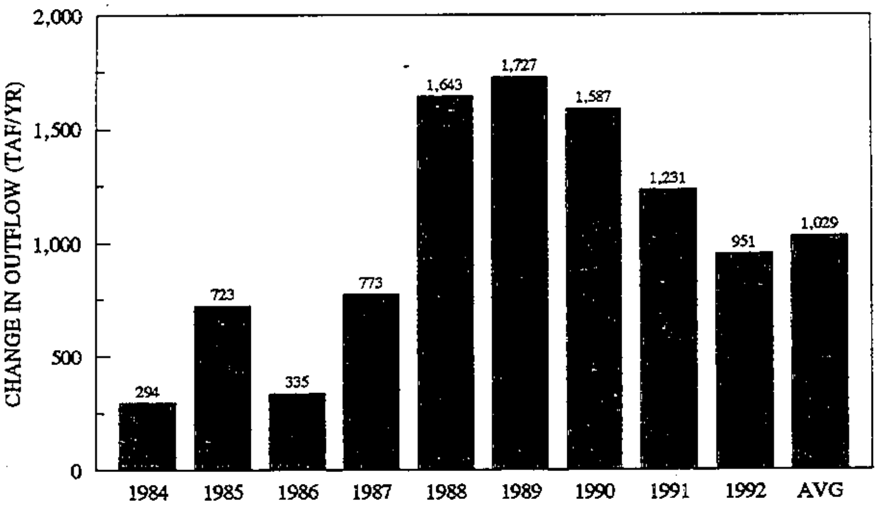
Outflows under the preferred alternative are obtained from the CCWD's additional outflow model.
Changes shown are for the preferred alternative from historical conditions.

FIGURE VIII-3
ANNUAL DELTA OUTFLOW
FROM WATER YEARS 1984-1992



Outflows under the preferred alternative are obtained from the CCWD's additional outflow model.

FIGURE VIII-4
ANNUAL CHANGE IN DELTA OUTFLOW
FROM WATER YEARS 1984-1992



Outflows under the preferred alternative are obtained from the CCWD's additional outflow model.
Changes shown are for the preferred alternative from historical conditions.

2. Delta Exports

Delta exports are known to affect aquatic resources adversely through entrainment by the export pumps, particularly in the spring. The preferred alternative includes restrictions on SWP and CVP pumping. These reduced exports should affect habitat conditions in the Delta and are, therefore, discussed in this chapter as well as in the water supply impact chapter (Chapter VII). Delta exports are defined in this section as exports from Banks and Tracy pumping plants. This narrow definition is used because the export restrictions in the preferred alternative apply only to these two diversions. The following discussion compares historical exports with DWRSIM-modeled exports for the preferred alternative.

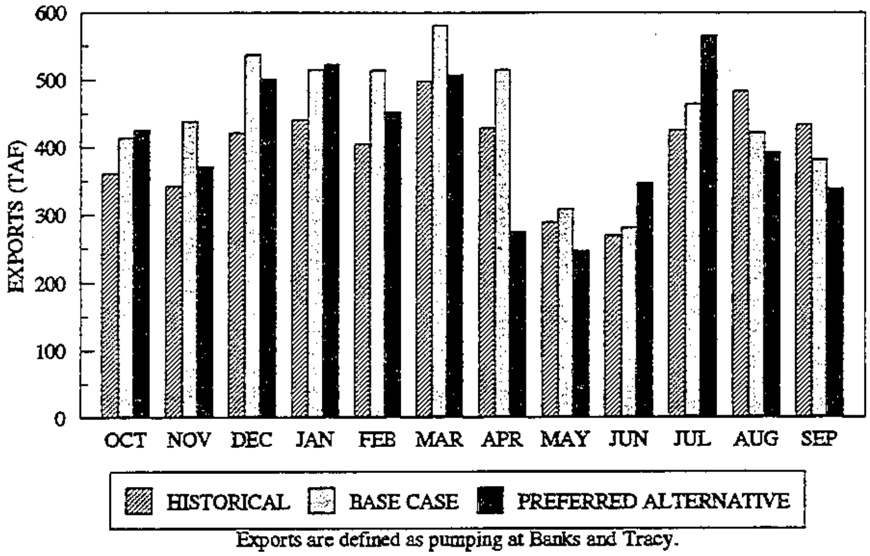
Figure VIII-5 shows average historical monthly Delta exports and those obtained from DWRSIM studies of the base case and preferred alternative; Figure VIII-6 shows the annual exports. In both figures, exports under the base case differ significantly from historical exports because of differences in demand, initial conditions, and operational rules.

Figure VIII-5 shows that average monthly exports under the preferred alternative are lower in April and May by 153 TAF and 43 TAF, respectively, and are lower in August and September by 92 TAF and 95 TAF, respectively. Reduced exports in April and May under the preferred alternative are consistent with restrictions on exports to 35 percent of Delta inflow, or 100 percent of the 3-day running average San Joaquin River flow at Vernalis, in these months. As shown in Figure VIII-6, during 1984 through 1992, exports are increased by an annual average of 147 TAF (from 4.79 MAF historically to 4.94 MAF under the preferred alternative). Annual exports are lower in 1988, 1989, and 1990 by 1.11 MAF, 695 TAF, and 1.77 MAF, respectively.

Due to fluctuations in demand, initial conditions, and operations during 1984 through 1992, this modeled-historical data comparison does not clearly illustrate the preferred alternative's impact on exports. Figures VIII-7 through VIII-10, discussed below, provide a more effective illustration of export impacts by comparing actual historical exports with the export limits in the plan. The preferred alternative includes export restrictions in terms of percent of Delta inflow exported. These types of objectives allow increased exports during periods when higher volumes of fresh water are flowing through the Delta. Correspondingly, exports are reduced as freshwater inflow to the Delta is lowered and susceptibility of fish to export losses increases.

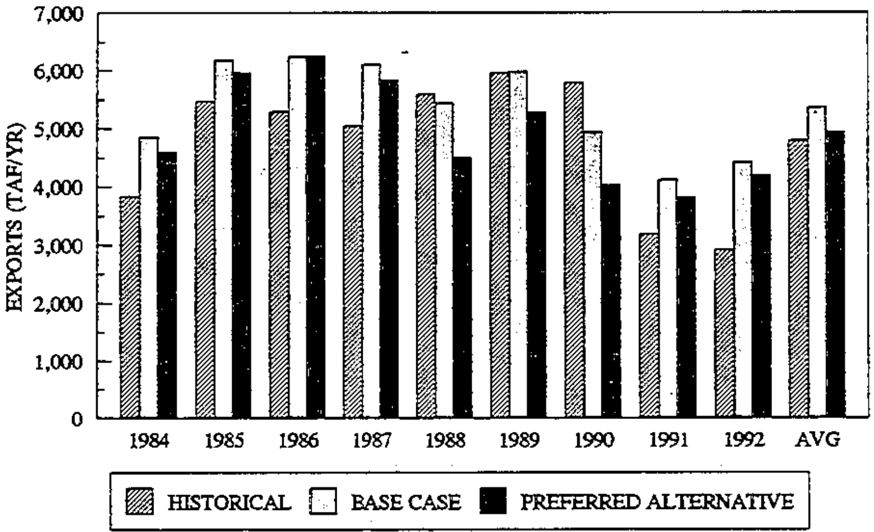
The export limit for February is based on the best available estimate of the Eight River Index for January. The Eight River Index refers to the sum of the unimpaired runoff as published in the DWR Bulletin 120 for the following locations: Sacramento River flow at Bend Bridge, near Red Bluff; Feather River, total inflow to Oroville Reservoir; Yuba River flow at Smartville; American River, total inflow to Folsom Reservoir; Stanislaus River, total inflow to New Melones Reservoir; Tuolumne River, total inflow to Don Pedro Reservoir; Merced River, total inflow to Exchequer Reservoir; and San Joaquin River, total inflow to Millerton Lake. If the best available estimate of the Eight River Index for January is less

FIGURE VIII-5
AVERAGE MONTHLY EXPORTS
FROM WATER YEARS 1984-1992



Exports are defined as pumping at Banks and Tracy.
Exports under base case and preferred alternative are from DWRSIM studies.

FIGURE VIII-6
ANNUAL DELTA EXPORTS
FROM WATER YEARS 1984-1992



Exports are defined as pumping at Banks and Tracy.
Exports under base case and preferred alternative are from DWRSIM studies.

than or equal to 1.0 MAF, the export limit for February is 45 percent of Delta inflow. If the best available estimate of the Eight River Index for January is greater than 1.5 MAF, the February export limit is 35 percent of Delta inflow. If the best available estimate of the Eight River Index for January is between 1.0 MAF and 1.5 MAF, the export limit for February will be within the range of 35 to 45 percent. For this analysis, it was assumed that when the index is between 1.0 MAF and 1.25 MAF, the export limit is set at 45 percent of Delta inflow; when the index is greater than 1.25 MAF and less than or equal to 1.5 MAF, the export limit was assumed to be 35 percent of Delta inflow.

Figure VIII-7 shows that, during the wet years in the reference period (1984 and 1986), the export restrictions would not have had any effect on exports due to low export demands and large inflows. In dry years, as shown in Figure VIII-8, exports would have been reduced (and outflows increased) in all years in April and May, with the greatest impact in April. The export limit in February in all dry water years (1985, 1987, and 1989) would have been 45 percent. (Exports would have also been reduced in March of 1985, June of 1985 and 1987, January and February of 1989, and September of 1987.) Historical exports as percent of Delta inflow for critical water years 1988 and 1990 through 1992 are shown in Figures VIII-9 and VIII-10 with the standards. The export limit in February in two of four critical water years (1991 and 1992) is 45 percent. Major impacts on exports would have occurred in the spring months, in particular February through April. In 1988, exports would have been reduced from February through June. The effects of the export limits on aquatic resources in the Estuary are discussed under section A.5, below.

Water transfers can be used to supplement exports in order to meet future water needs. Using the assumptions and methods discussed in section G of Chapter VII, the annual capacity for water transfers under the preferred alternative during the 1984-1992 period ranges from 165 TAF in 1989, a dry water year, to 624 TAF in 1991, a critical year. The average annual transfer during this period is 437 TAF. Thus, the combined average annual exports and potential water transfer under the preferred alternative is 5.4 MAF. The effects of water transfers on aquatic resources in the Estuary are discussed in section A.5, below.

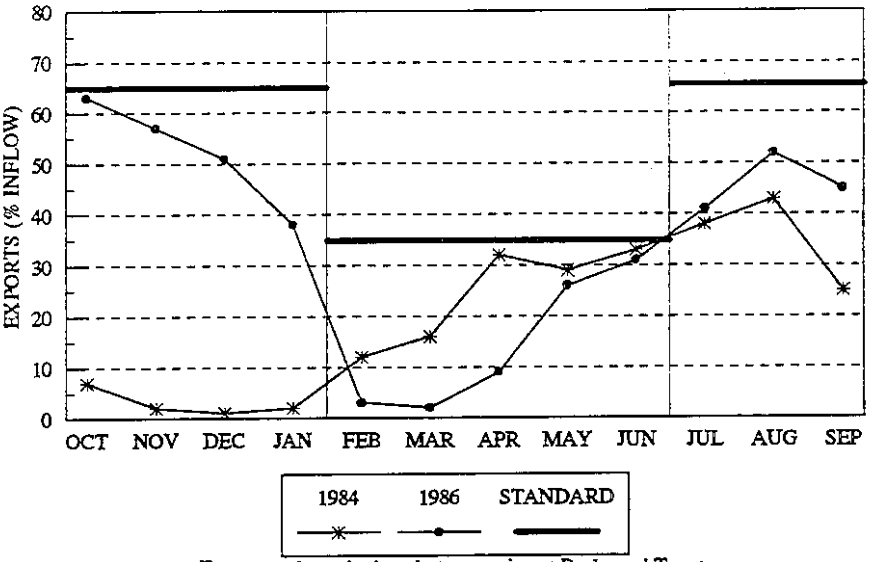
3. Salinity

Three analyses are discussed below to illustrate the preferred alternative's effect on salinity in the Estuary. The first two analyses compare the standards in the plan with historical X2 isohaline position and electrical conductivity (EC) at Vernalis, respectively. In the third analysis, EC conditions under the base case and the preferred alternative, as modeled by the DWR Delta Simulation Model (DWRDSM), are examined.

a. Comparison of Standards and Historical X2 Isohaline

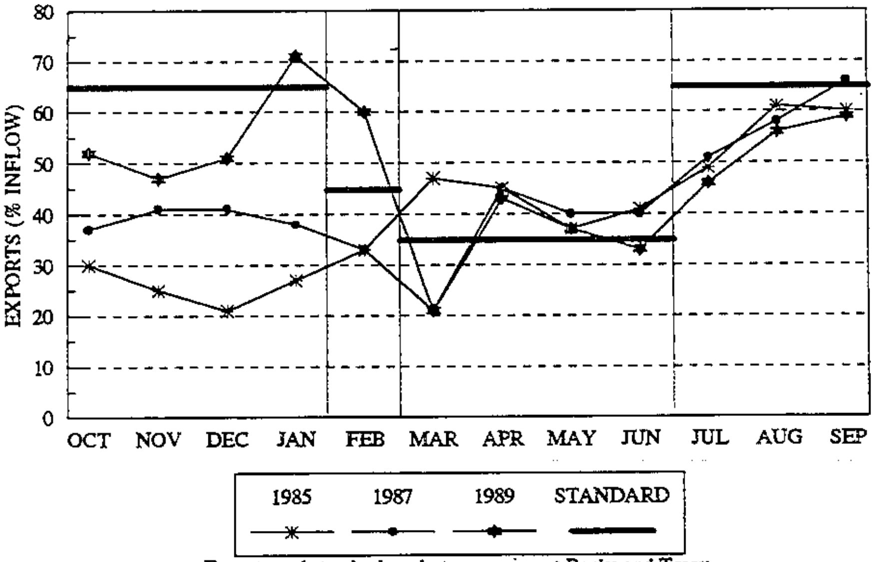
Figures VIII-11 through VIII-15 show the average X2 isohaline positions during February through June, respectively, under historical conditions and under the standards of the preferred alternative. The average X2 positions under the preferred alternative are obtained

FIGURE VIII-7
HISTORICAL EXPORT AS PERCENT OF DELTA INFLOW
WET WATER YEARS DURING 1984-1992



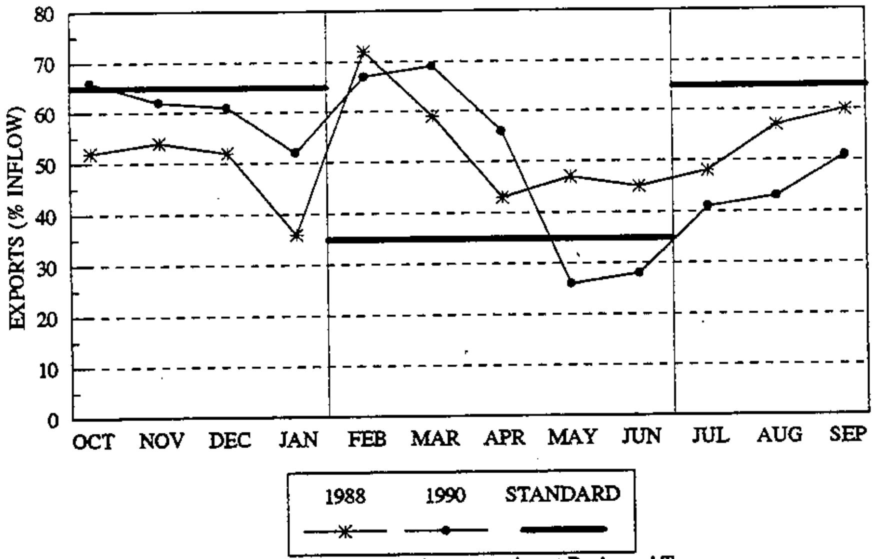
Exports and standard apply to pumping at Banks and Tracy.

FIGURE VIII-8
HISTORICAL EXPORT AS PERCENT OF DELTA INFLOW
DRY WATER YEARS DURING 1984-1992



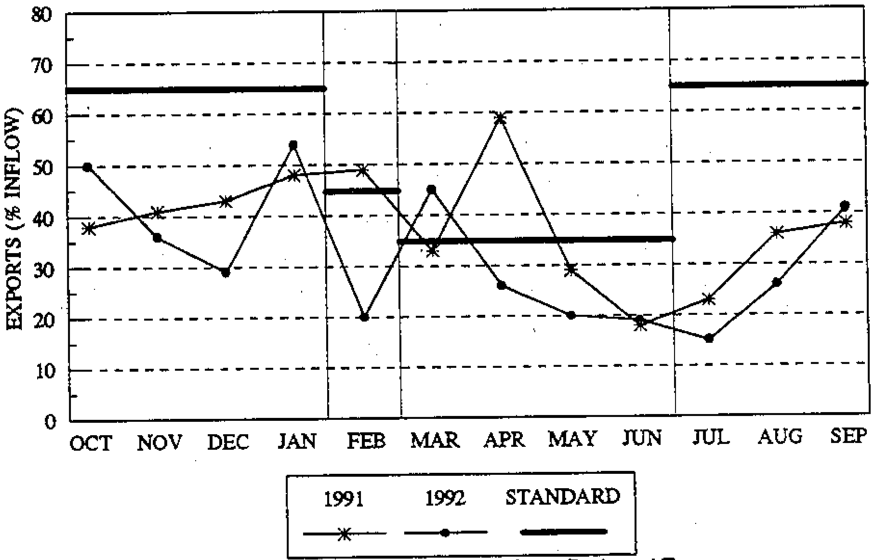
Exports and standard apply to pumping at Banks and Tracy.

FIGURE VIII-9
HISTORICAL EXPORT AS PERCENT OF DELTA INFLOW
CRITICAL WATER YEARS 1988 AND 1990



Exports and standard apply to pumping at Banks and Tracy.

FIGURE VIII-10
HISTORICAL EXPORT AS PERCENT OF DELTA INFLOW
CRITICAL WATER YEARS 1991 AND 1992



Exports and standard apply to pumping at Banks and Tracy.

from the outflow model developed by the CCWD. By applying the additional outflows required to meet the standards in the preferred alternative to the historical X2 positions, the CCWD model projects X2 positions for the preferred alternative. Results of the CCWD model, shown in Figures VIII-11 through VIII-15, indicate that in all months the average X2 isohaline position under the preferred alternative is further downstream than historical X2 positions. In March of all years, the average X2 position is maintained downstream of the confluence; in February, May, and June, the average X2 position is maintained downstream of or near the confluence; and in April, the X2 position is near or downstream of Chipps Island. The effects of the spring Delta outflow objectives on aquatic resources in the Estuary are discussed under section A.5, below.

b. <u>Comparison of Standards and Historical EC at Vernalis</u>

Pursuant to requirements in D-1422, during the 1984 through 1992 reference period, historical operation of New Melones Reservoir was being managed for salinity control at Vernalis. Figures VIII-16 through VIII-20 compare the average historical EC at Vernalis in 1984 through 1992 with the Vernalis agricultural salinity standards in the preferred alternative. EC standards at Vernalis are independent of water year type. For this analysis, the San Joaquin Valley 60-20-20 water year hydrologic classification index is used. The standards are not likely to have major impacts in wetter years. As shown in Figures VIII-16 and VIII-18, in 1984 (an above normal year) and 1986 (a wet year), historical salinity values measured at Vernalis are at or below the standards. Significant impacts are seen in drier years. In 1985, a dry water year, Figure VIII-17 shows that salinity levels in April through June exceeded the standard. The greatest impacts are seen in critical years 1987 through 1992, shown in Figures VIII-19 and VIII-20. In almost all critical years, salinity levels at Vernalis exceed the standards in April through August (the exceptions are April of 1987 and May of 1987, 1991, and 1992). In some critical years, the standards also require reduced salinity levels in January through March.

c. <u>Delta Salinity Under the Preferred Alternative</u> (DWR 1995)

Upon request by the SWRCB, the DWR has conducted hydrodynamics and water quality simulations using DWRDSM to determine the effect of the preferred alternative on water quality in the Delta. To estimate monthly average salinity in the Delta, DWRDSM (discussed in Chapter VI) uses the hydrology generated by DWRSIM studies of the base case and preferred alternative[1] as input. Thus, the modeling assumptions for DWRSIM, as discussed in Chapter VII, are also applicable to this salinity analysis. Of particular importance is the DWRSIM assumption that freshwater releases from New Melones Reservoir for salinity control would be limited to no more than 70 TAF annually. There is

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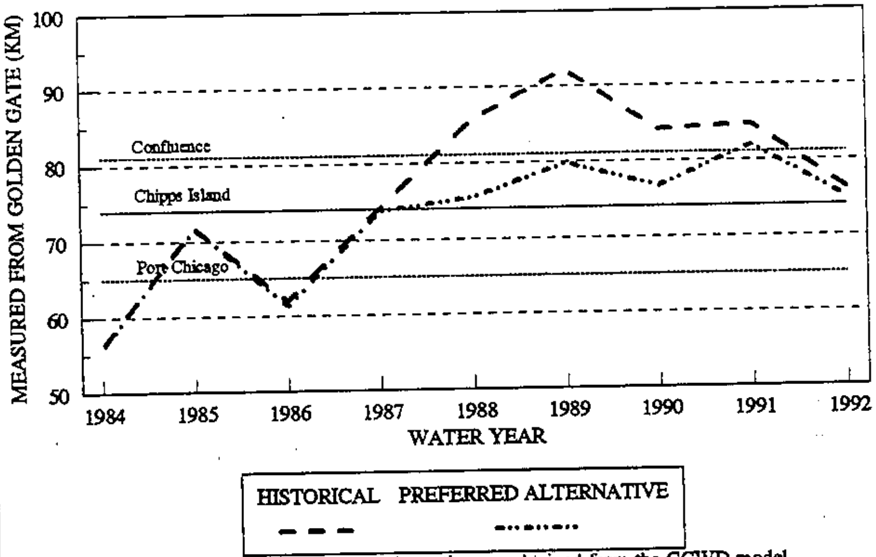
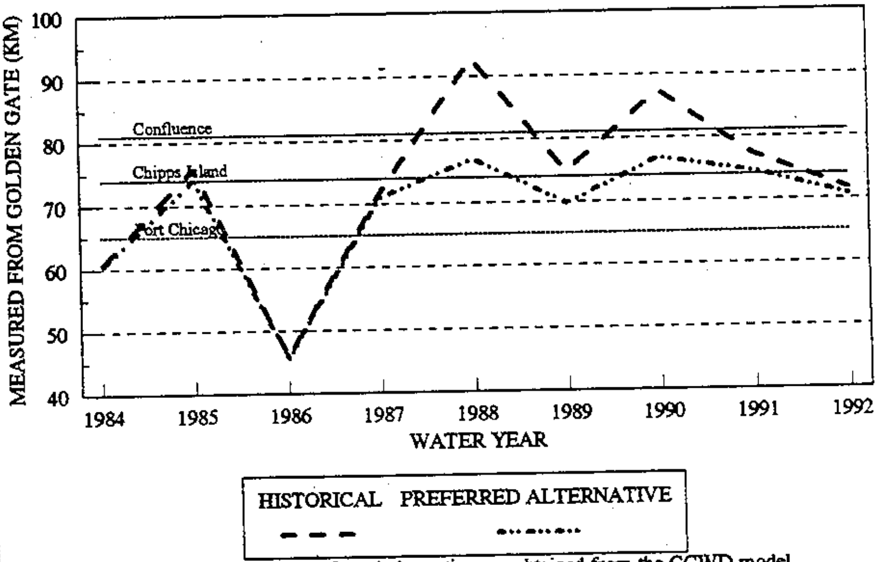
[1] Conditions under the base case and preferred alternative that were used as DWRDSM inputs are obtained from preliminary DWRSIM operation studies 1995c6b-MONTERY-412 and 1995c6b-SWRCB-409.MONT, respectively.

FIGURE VIII-11
AVERAGE X2 ISOHALINE POSITION
IN FEBRUARY OF 1984-1992



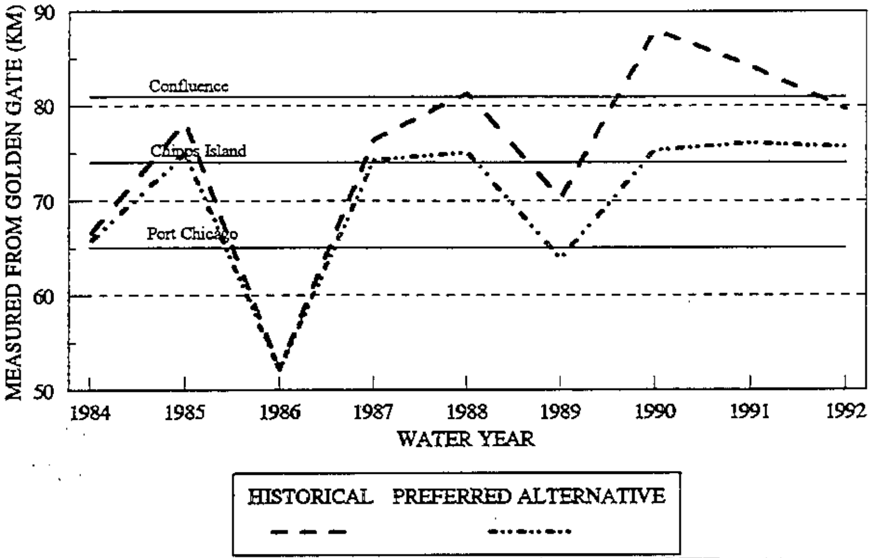
X2 positions under preferred alternative are obtained from the CCWD model.

FIGURE VIII-12
AVERAGE X2 ISOHALINE POSITION
IN MARCH OF 1984-1992



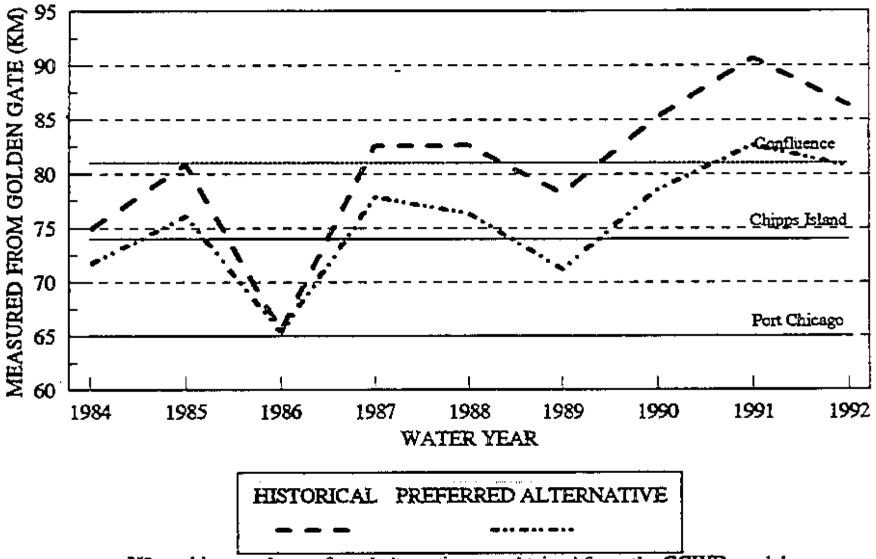
X2 positions under preferred alternative are obtained from the CCWD model.

FIGURE VIII-13
AVERAGE X2 ISOHALINE POSITION
IN APRIL OF 1984-1992



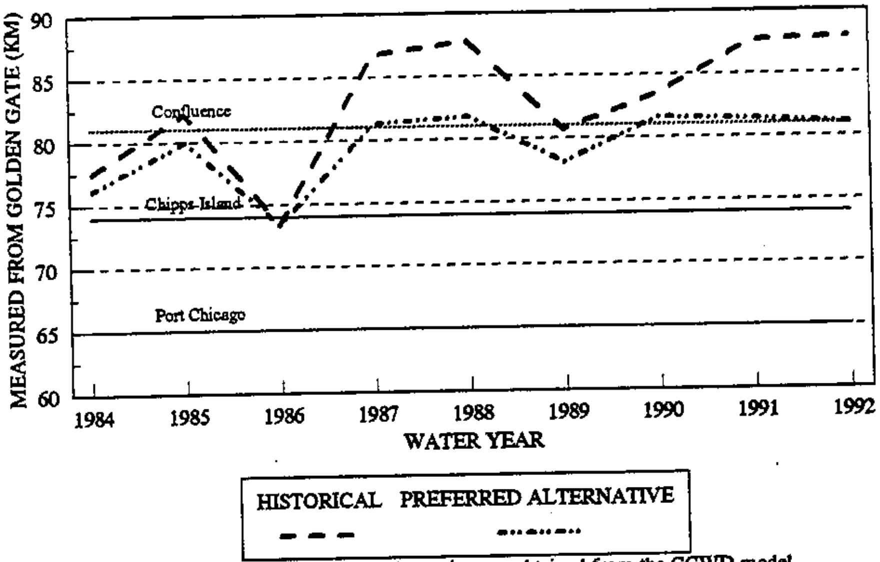
X2 positions under preferred alternative are obtained from the CCWD model.

FIGURE VIII-14
AVERAGE X2 ISOHALINE POSITION
IN MAY OF 1984-1992



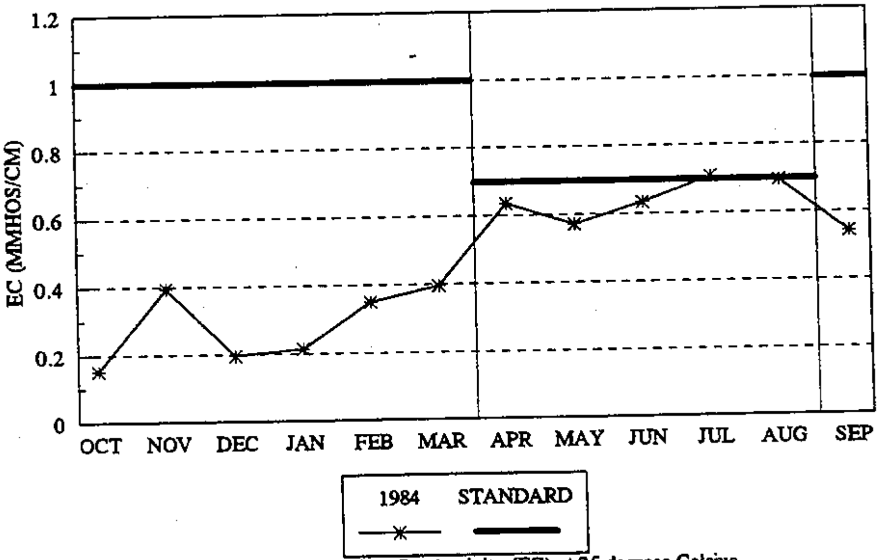
X2 positions under preferred alternative are obtained from the CCWD model.

FIGURE VIII-15
AVERAGE X2 ISOHALINE POSITION IN JUNE OF 1984-1992



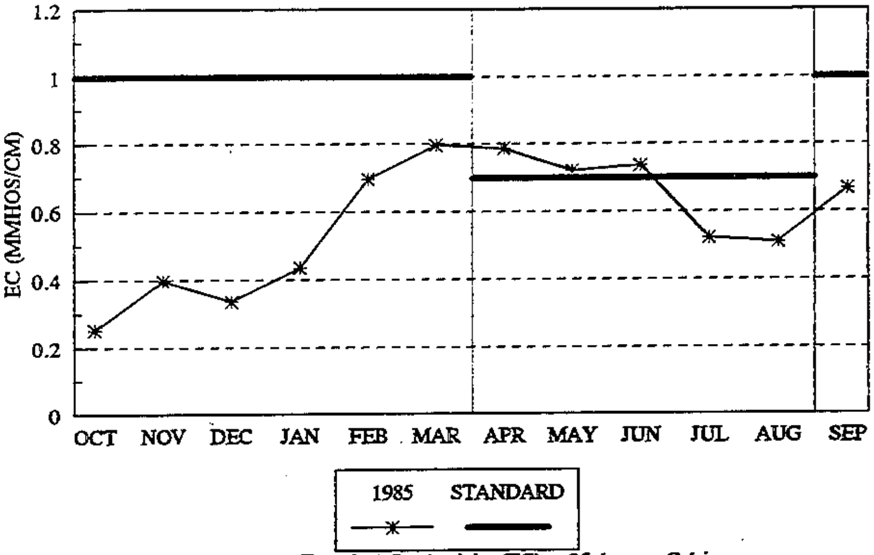
X2 positions under preferred alternative are obtained from the CCWD model.

FIGURE VIII-16
HISTORICAL SAN JOAQUIN RIVER SALINITY AT VERNALIS FROM ABOVE NORMAL WATER YEAR 1984



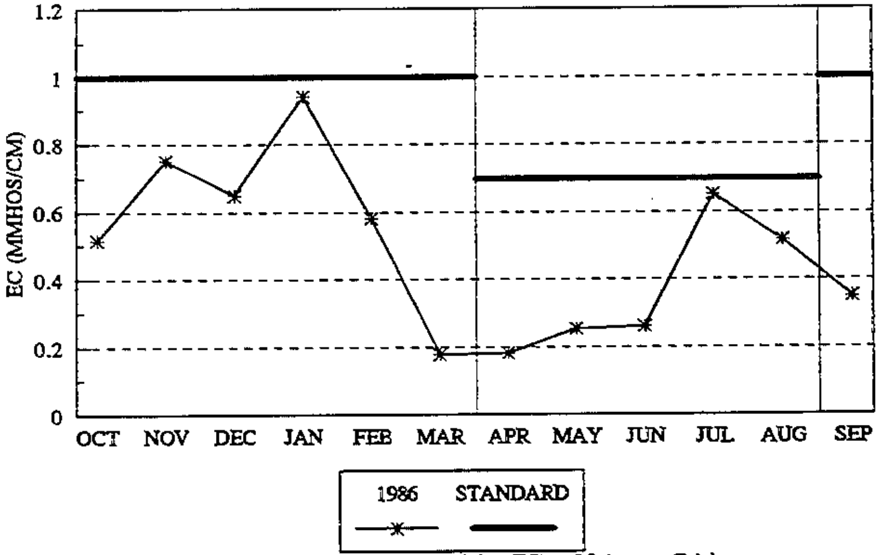
Measured as Electrical Conductivity (EC) at 25 degrees Celsius

FIGURE VIII-17
HISTORICAL SAN JOAQUIN RIVER SALINITY AT VERNALIS FROM DRY WATER YEAR 1985



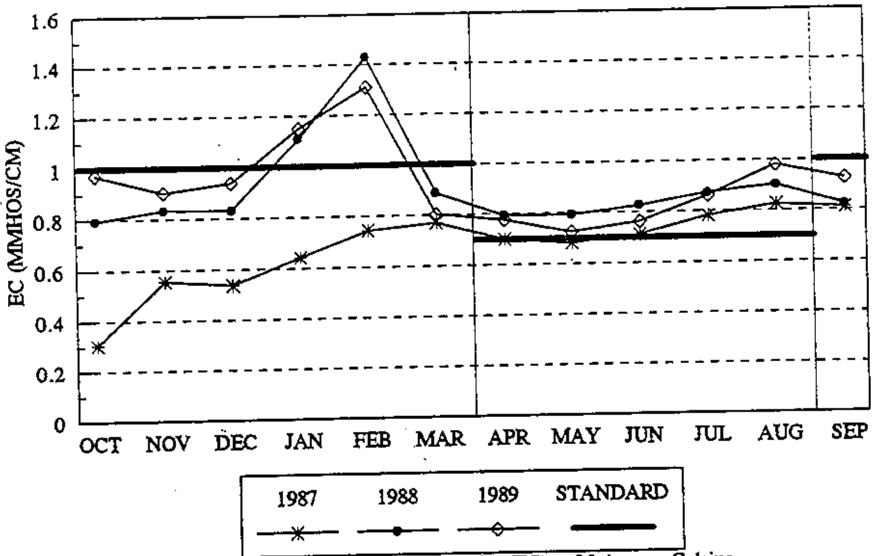
Measured as Electrical Conductivity (EC) at 25 degrees Celsius

FIGURE VIII-18
HISTORICAL SAN JOAQUIN RIVER SALINITY AT VERNALIS FROM WET WATER YEAR 1986



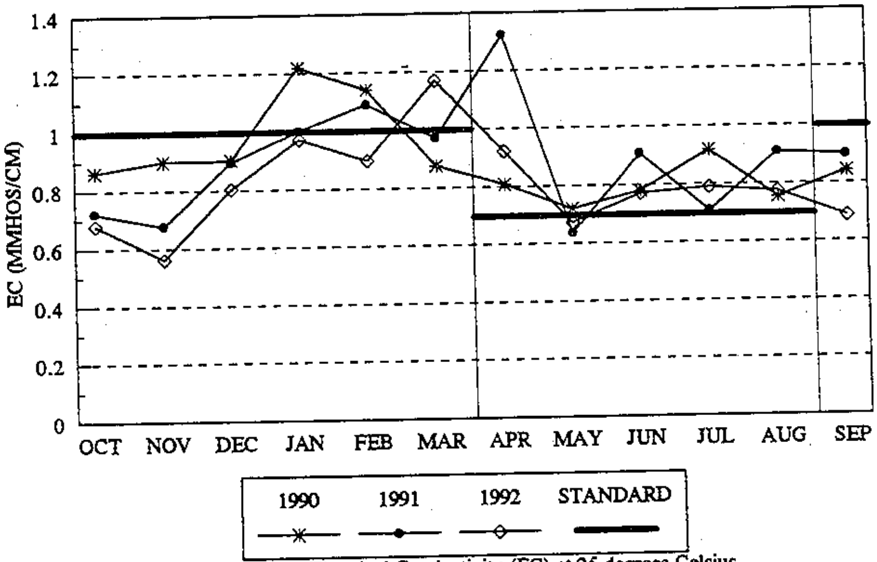
Measured as Electrical Conductivity (EC) at 25 degrees Celsius

FIGURE VIII-19
HISTORICAL SAN JOAQUIN RIVER SALINITY AT VERNALIS
FROM CRITICAL WATER YEARS 1987-1989



Measured as Electrical Conductivity (EC) at 25 degrees Celsius

FIGURE VIII-20
HISTORICAL SAN JOAQUIN RIVER SALINITY AT VERNALIS
FROM CRITICAL WATER YEARS 1990-1992



Measured as Electrical Conductivity (EC) at 25 degrees Celsius

actually no cap on the USBR responsibility to provide salinity control from New Melones, but a cap was used in the DWRSIM analysis because the SWRCB expects water quality control measures to reduce the dilution water required to meet the salinity standard. These water quality control measures are not modeled; therefore, the DWRSIM assumption represents a worst-case scenario.

The period from water years 1987 through 1992 was chosen for the salinity analysis because the greatest impacts are expected to occur in dry and critical years. Some of the modeling assumptions used to conduct the DWRDSM base case and preferred alternative simulations, and the resulting outputs, are discussed below. Additional assumptions and results are discussed in a report submitted to the SWRCB (DWR 1995).

Temporary Delta Barriers. Since 1987, three temporary rock barriers have been deployed in the Delta at the Old River head, Old River near DMC, and Middle River near Victoria Island. For planning purposes, a nominal installation and removal schedule representative of the historical pattern was devised. This installation and removal schedule was used identically in the base case and preferred alternative studies as follows:

Barrier	Installed	Removed
Middle River:	May 1	September 30
Old River head:	September 1	November 30
	May 1	May 30
Old River near DMC:	May 1	October 1

Clifton Court Forebay Operation Priority. Clifton Court Forebay is currently operated on a seasonal basis to protect water levels in the southern Delta. The priorities used by the DWR are summarized in a report submitted to the SWRCB (DWR 1995).

Delta Cross Channel Operation. The preferred alternative requires that the Delta Cross Channel be closed up to 45 days between November 1 and January 31, closed continuously between February 1 and May 20, and closed 14 days between May 21 and June 15.

Given the flexible nature of Delta Cross Channel operation under the preferred alternative in the November-January period, for modeling purposes the Delta Cross Channel was closed between November 1 and November 15, December 1 and December 15, and January 1 and January 15. The Delta Cross Channel was re-opened in the second half of each month. This nominal operation is somewhat conservative (i.e., it may over-emphasize the water quality impact of the Delta Cross Channel standard) because the preferred alternative requires the Delta Cross Channel to be closed "up to" 45 days. Presumably, the operations group will make these decisions on the basis of current water quality conditions and the presence of fish in the Sacramento River north of Walnut Grove. The May 21 through June 15 requirement, that the Delta Cross Channel be closed up to four days in a row, not including weekends, is modeled by leaving the Delta Cross Channel closed through May, and opening it thereafter.

Suisun Marsh Salinity Control Gates Operation. In recent years, the Suisun Marsh Salinity Control Gates (formerly known as the Montezuma Slough Control Structure) have been operated as a tidal pump between October and May in all water year types except wet years (Sacramento Valley 40-30-30 water year hydrologic classification). (The control gates are discussed in greater detail in section A.6 of this chapter.) Since only critical and dry years were modeled (water years 1987 through 1992), the control gates were operated in the model each year between October and May. When the control structure was not operating, all radial gates and flash boards were removed.

San Joaquin River Input Salinity. Vernalis is the upstream San Joaquin River (SJR) boundary condition of the model. As such, the boundary salinity must be provided at that location. Salinity is assumed to be an exponential function of flow by the following equation:

$$\ln EC = 10.0800014 - 0.48230 * \ln (\text{SJR flow in cfs})$$

TDS to EC conversion. Salinity output from DWRDSM was requested in EC units to be consistent with agricultural standards in the plan. The model computes salinity as TDS which, therefore, must be converted to EC. Location-specific conversion equations were used for this purpose.

Other Assumptions. The 19-year mean tide at Benicia was used; no duck club operation was simulated in Suisun Marsh; Benicia boundary salinity was calculated using the "Saldif4" program; maximum Clifton Court Forebay gate flow is 15,000 cfs; eastside stream boundary salinity was set constant at 85 ppm TDS; and Sacramento River salinity at the Sacramento boundary was set constant at 100 ppm TDS.

Salinity Output. Hydrodynamic inflows are constant within each month. Therefore, salinity approaches a steady-state condition as it is simulated within each month. For output purposes, the average monthly salinity is assumed to be the salinity on the last tidal day of the month.

Figures VIII-21 through VIII-30, prepared by the DWR, show time-series monthly average EC under the base case and the preferred alternative for water years 1987 through 1992 at the following ten standard locations, respectively: Sacramento River at Emmaton; San Joaquin River at Jersey Point; San Joaquin River at San Andreas Landing; San Joaquin River at Prisoners Point; South Fork of the Mokelumne River at Terminous; San Joaquin River at Buckley Cove; Old River near Tracy; Old River at Middle River; San Joaquin River at Brandt Bridge site; and San Joaquin River at Vernalis. Salinity output is shown in step form to emphasize that these are monthly average values resulting from steady, monthly average flow inputs. Half-month steps are shown in November, December, and January when the Delta Cross Channel is closed the first half and open the second half of the month. Solid and dashed lines at the bottom of each plot indicate the months, or portion of months, that the Delta Cross Channel is closed under the base case and the preferred alternative, respectively. Delta Cross Channel closure in the base case study only occurs for flood control when Sacramento River flow at Freeport is greater that 25,000 cfs.

The preferred alternative includes salinity standards for the western Delta from April through mid-August. As shown in Figures VIII-21 (Emmaton) and VIII-22 (Jersey Point), salinity in the western Delta is significantly reduced under the preferred alternative from the base case during these months. The average monthly salinity at Emmaton during 1987-1992 is reduced under the preferred alternative from the base case by 53 percent in April, 54 percent in May, 66 percent in June, 55 percent in July, and 15 percent in August. At Jersey Point, the average monthly salinity is reduced by 61 percent in April, 44 percent in May, 61 percent in June, 35 percent in July, and 18 percent in August.

Salinity conditions under the preferred alternative are generally in compliance with the western Delta agricultural standards. Figures VIII-21 and VIII-22 also show that: there are significant salinity decreases at Emmaton and Jersey Point in February and March; salinity at Emmaton increases in October under the preferred alternative (mainly due to reduced Sacramento River flows), and decreases during November through December (when the Delta Cross Channel closes and Sacramento River flows are increased); and salinity at Jersey Point increases in the November through January period when the Delta Cross Channel is closed the first half of the month.

The preferred alternative also includes agricultural salinity standards from April through mid-August for the interior Delta, specifically, the south fork of the Mokelumne River at Terminous, and the San Joaquin River at San Andreas Landing. Additionally, fish and wildlife objectives for salinity are established on the San Joaquin River between Jersey Point and Prisoners Point in April and May. Figures VIII-23 through VIII-25 show salinity under the preferred alternative and the base case for San Andreas, Prisoners Point, and Terminous, respectively. Salinities at San Andreas and Prisoners Point are generally lower under the preferred alternative than the base case from March through September, and are in compliance with the agricultural standards for the interior Delta. The salinity patterns at San Andreas and Prisoners Point tend to follow Jersey Point closely. However, there are greater incremental salinity increases in response to Delta Cross Channel closure. Like conditions at Jersey Point, salinity at these stations increases in the November through January period when the Delta Cross Channel is closed the first half of the month. The increase persists into February for San Andreas and Prisoners Point when the Delta Cross Channel is closed continuously. The Terminous station shows similar increases but tends to lag by one month.

Delta outflow is greater under the preferred alternative over the February through June period, resulting in generally lower spring and summer salinity at Jersey Point, San Andreas, and Prisoners Point. The increase in Delta outflow is attributable mainly to reductions in project exports. This lower salinity occurs despite continuous Delta Cross Channel closure between March and June under the preferred alternative. Salinity at Terminous remains generally higher in the spring despite higher flows under the preferred alternative, suggesting that the Delta Cross Channel has relatively greater effect there.

FIGURE VIII-21
EC FOR SACRAMENTO RIVER AT EMMATON

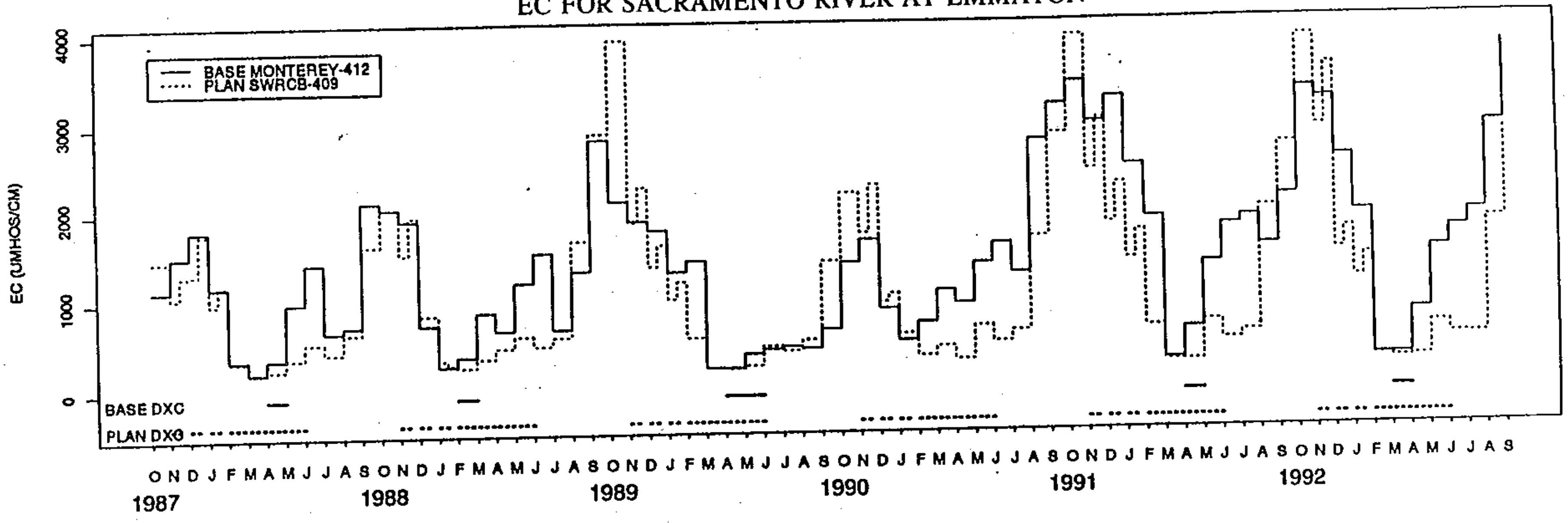
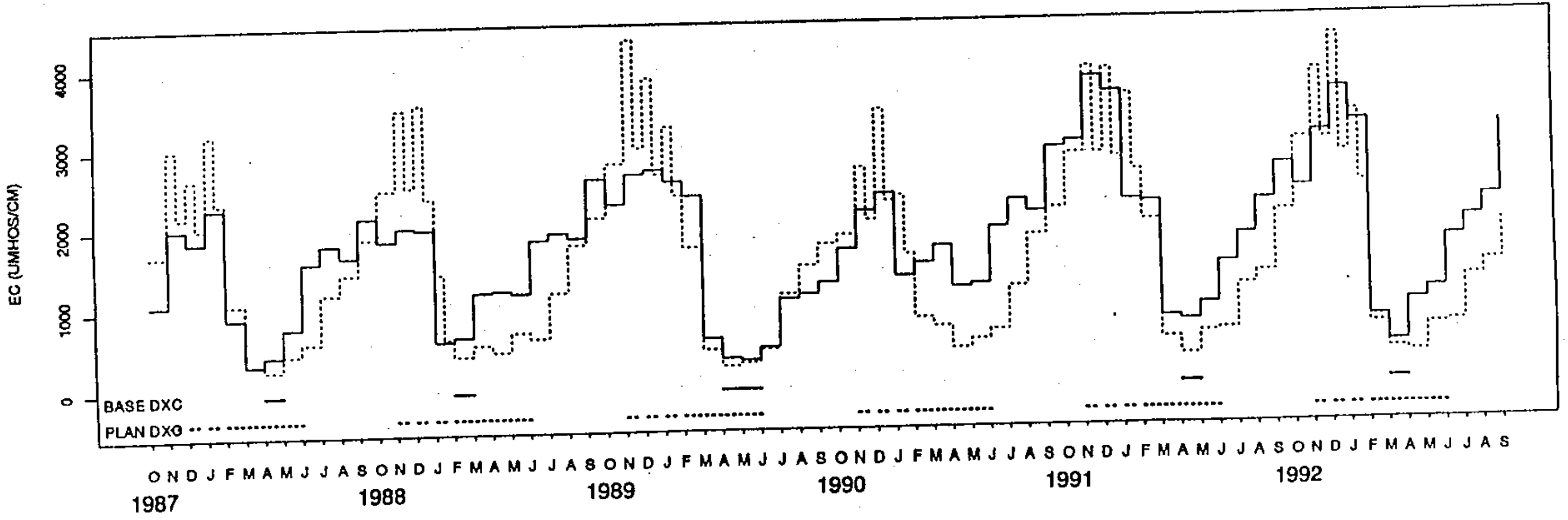


FIGURE VIII-22
EC FOR SAN JOAQUIN RIVER AT JERSEY POINT



SOURCE: DWR 1995

FIGURE VIII-23
EC FOR SAN JOAQUIN RIVER AT SAN ANDREAS LANDING

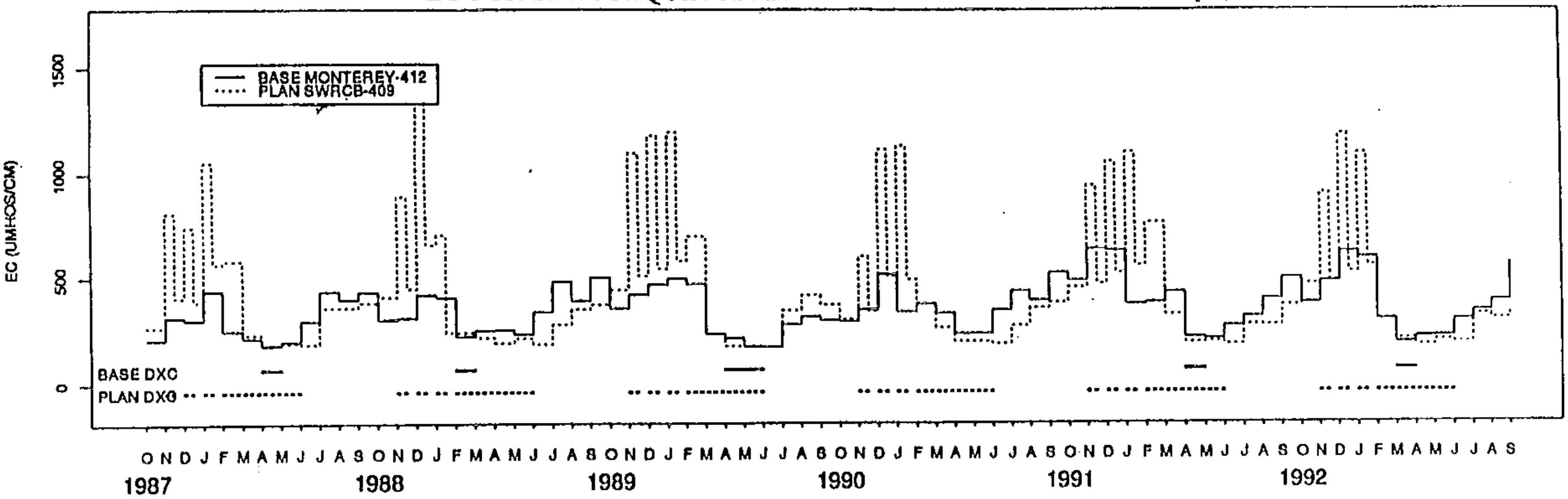
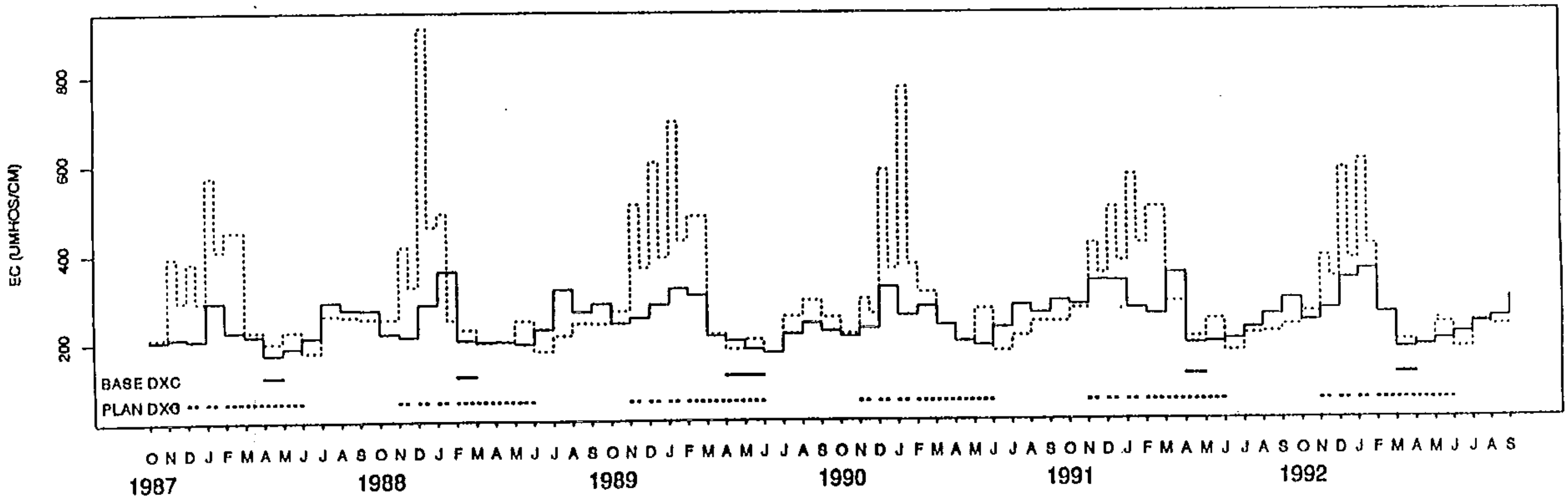


FIGURE VIII-24
EC FOR SAN JOAQUIN RIVER AT PRISONERS POINT



SOURCE: DWR 1995

FIGURE VIII-25
EC FOR SOUTH FORK OF THE MOKELUMNE RIVER AT TERMINOUS

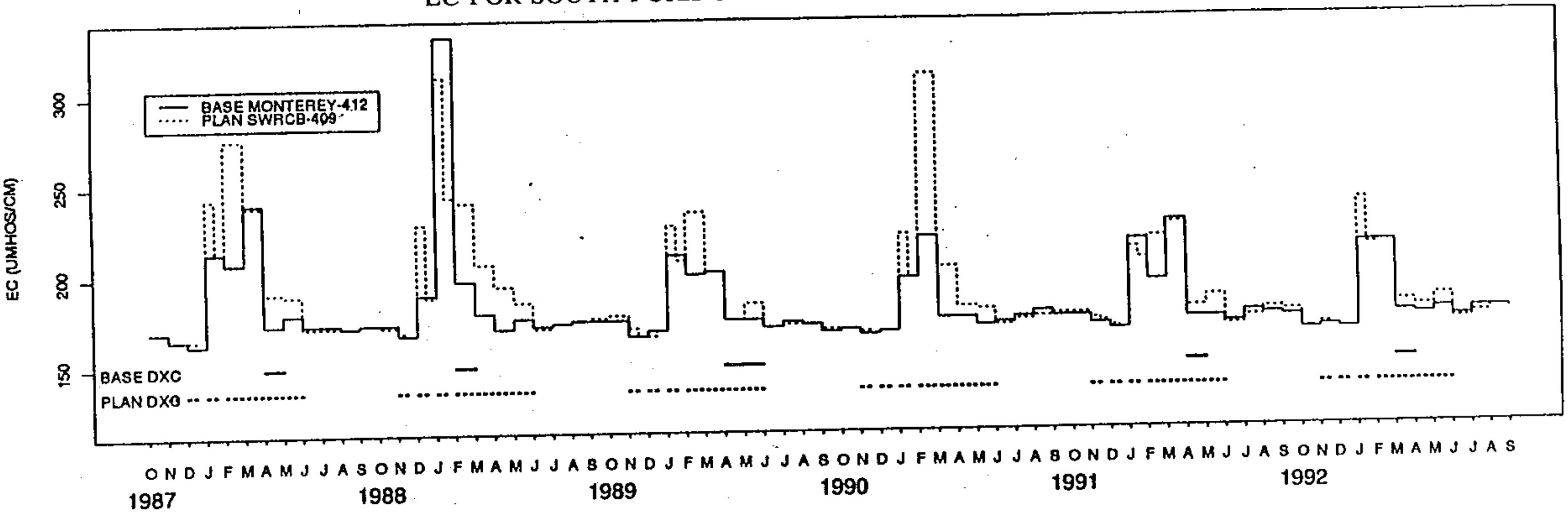
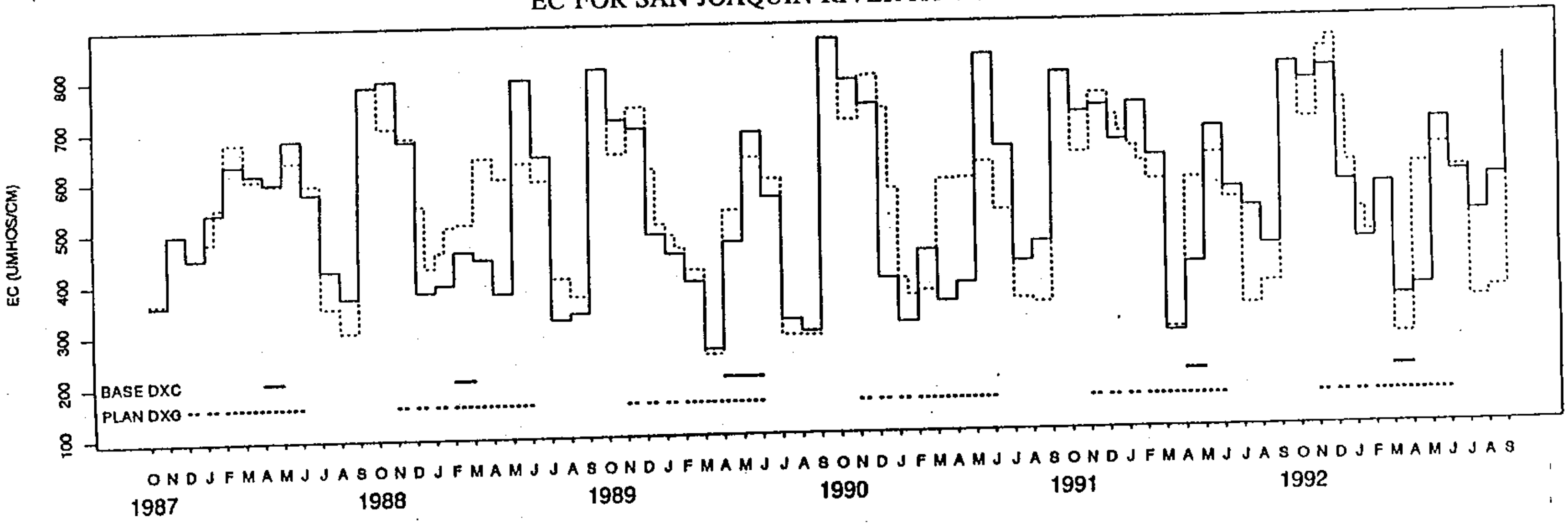


FIGURE VIII-26
EC FOR SAN JOAQUIN RIVER AT BUCKLEY COVE



SOURCE: DWR 1995

FIGURE VIII-27
EC FOR OLD RIVER NEAR TRACY

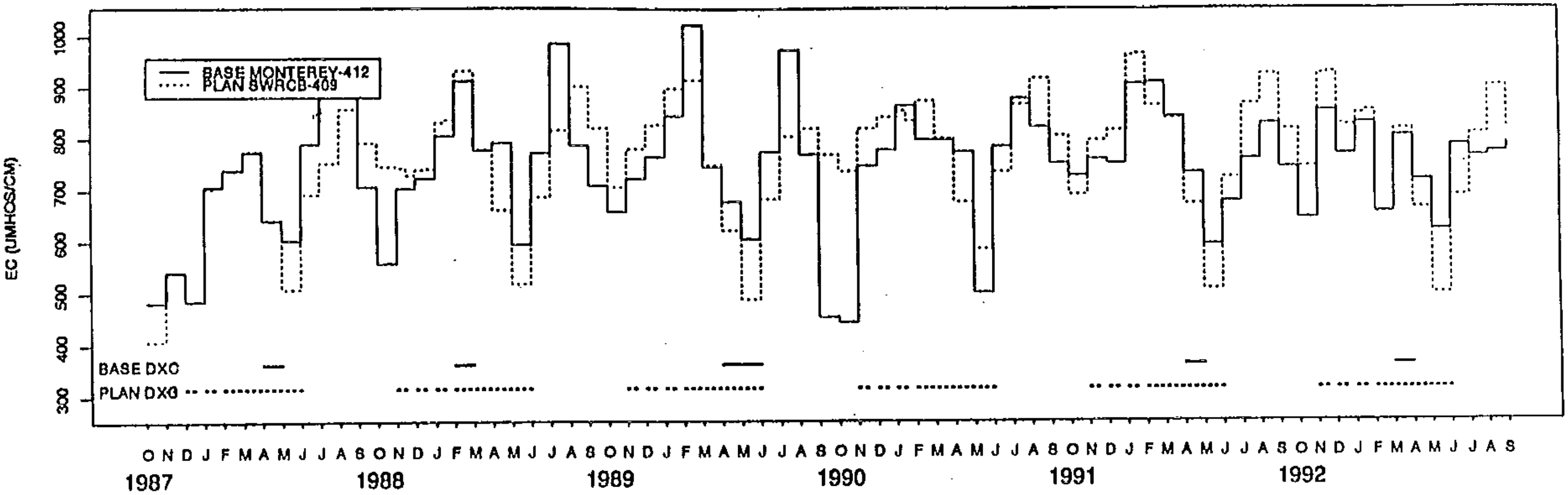
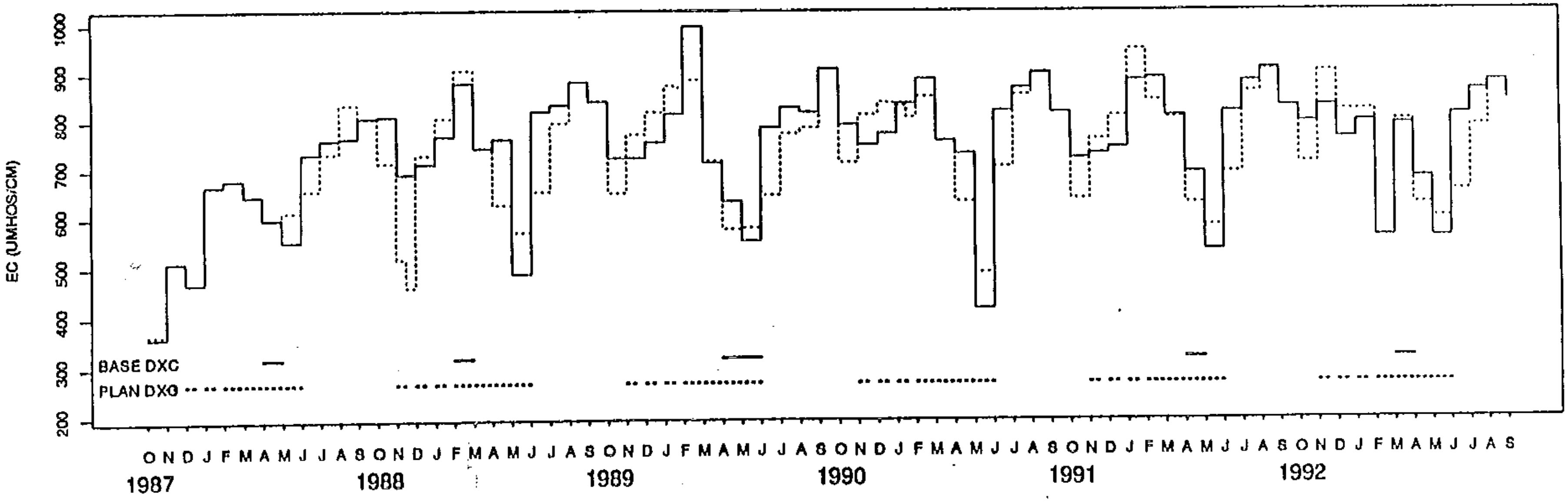


FIGURE VIII-28
EC FOR OLD RIVER AT MIDDLE RIVER



SOURCE: DWR 1995

FIGURE VIII-29
EC FOR SAN JOAQUIN RIVER AT BRANDT BRIDGE SITE

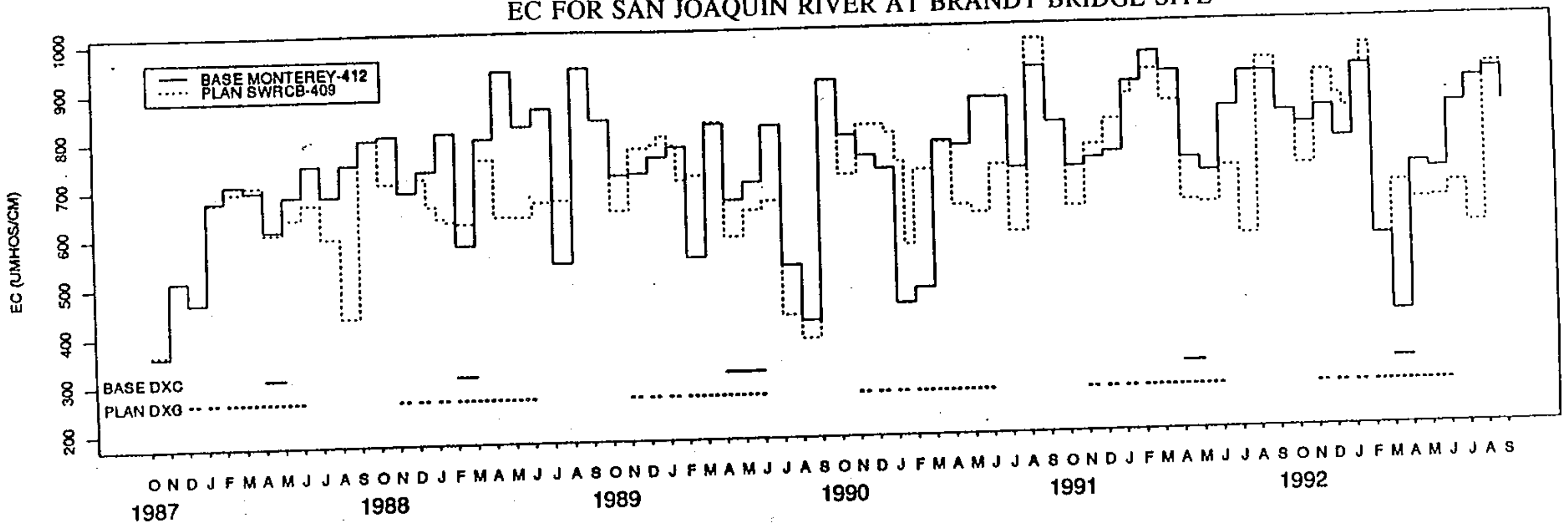
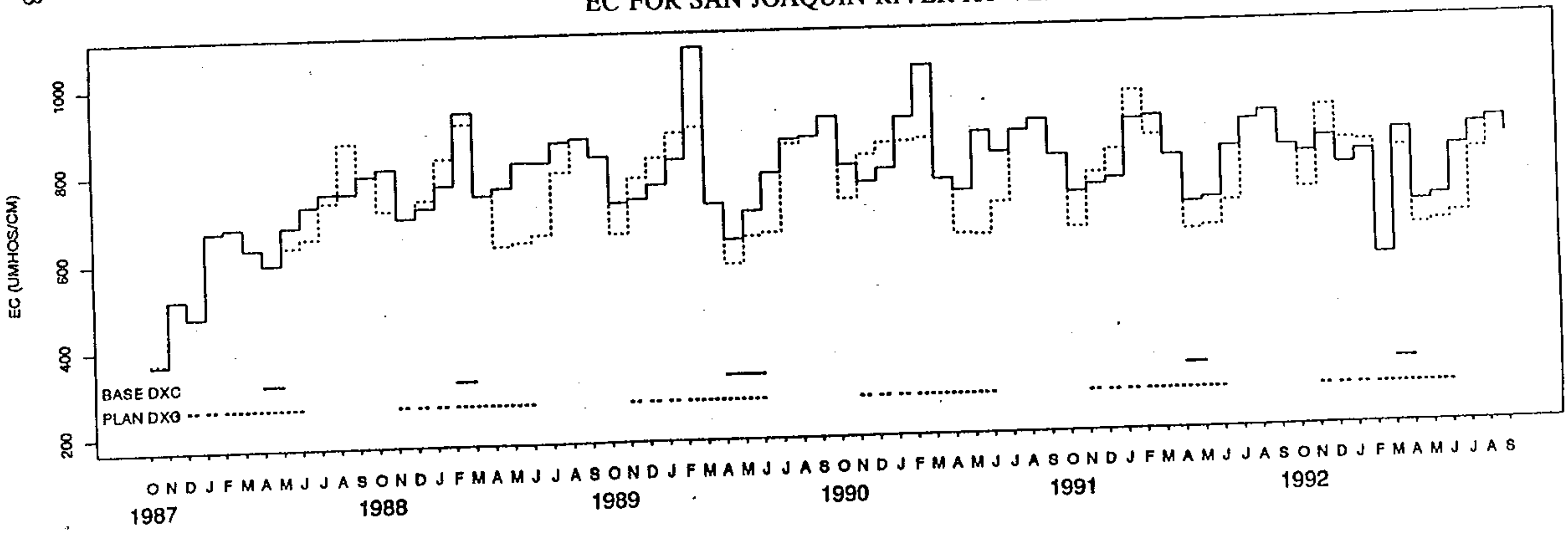


FIGURE VIII-30
EC FOR SAN JOAQUIN RIVER AT VERNALIS



SOURCE: DWR 1995

Figure VIII-26 shows salinity at Buckley Cove, on the San Joaquin River between Prisoners Point and Brandt Bridge site. Figures VIII-27 through VIII-30 show salinity under the preferred alternative and the base case at southern Delta stations for which the preferred alternative establishes year-round salinity objectives. Salinity changes in the southern Delta due to Delta Cross Channel closure are small. In general, salinity decreases under the preferred alternative from base conditions, especially from April through August. However, the 0.7 mmhos/cm standard for April through August is often exceeded in the later months (July and August) because of the 70 TAF cap on flows released from New Melones Reservoir to the San Joaquin River for water quality purposes.

Since salinity is an inverse function of flow at Vernalis, the base case versus preferred alternative differences in salinity shown in Figure VIII-30 directly reflect differences in flow. For example, November, December, and January flows are 0 to 14 percent less under the preferred alternative, resulting in 0 to 7 percent greater salinity. In general, the preferred alternative generates higher flows and lower salinities in October and April through July. Over the 1987-1992 period, average monthly salinity at Vernalis is reduced under the preferred alternative from the base case by 10 percent in April, 14 percent in May, 16 percent in June, and 3 percent in July.

Average monthly salinity at Brandt Bridge under the preferred alternative is reduced from the base case by 15 percent in April and May, 17 percent in June, 20 percent in July, and 8 percent in August. Buckley Cove generally has higher salinity in April under the preferred alternative despite higher San Joaquin River flow. This could reflect the influence of Delta Cross Channel closure. In May, larger San Joaquin River flows and reduced pumping improve salinity at Brandt Bridge and Buckley Cove under the preferred alternative. Salinity under the preferred alternative at Old River near Tracy is generally higher than the preferred alternative between September and January, and lower between March and August.

4. Water Levels

DWRDSM simulations of the base case and the preferred alternative, as discussed in section A.3, also provide means to address concerns regarding potential drawdown of water levels under the preferred alternative. According to DWRDSM modeling results (DWR 1995), significant increases in water levels are expected at Vernalis in October and April through June, as a result of the Vernalis flow requirements. On average over the 1987 through 1992 period, the average monthly Vernalis water level increases under the preferred alternative by 0.44 feet in October, by 0.71 feet in April, by 0.93 feet in May, and by 0.86 feet in June. Small decreases in water levels at Vernalis, ranging from 0.15 to 0.21 feet, are seen in November through January. Water levels also increase in February through April on the Old River near Middle River and at Tracy, and on the San Joaquin River at Brandt Bridge. DWRDSM results also show decreases in average monthly water level on the Old River near Tracy in May through October. The greatest average decrease in monthly water levels is 0.41 feet in July over the 1987 through 1992 period.

5. Aquatic Resources

The preferred alternative establishes new standards for controllable factors that both affect aquatic resources and are within the authority of the SWRCB. The preferred alternative also makes recommendations to other entities for factors within their control. The recommendations and their rationales are described in Chapter IX. The combination of new standards and recommendations to other agencies constitutes a comprehensive, multi-species management approach to the problems in the Bay-Delta Estuary. The entire package provides reasonable protection for all of the aquatic resources in the Estuary. However, not all species will receive the same level of protection, and monitoring will be needed to assess potential impacts on upstream fisheries resources.

The following discussion of the effects of the standards on aquatic resources is divided into two sections: summary of effects and aquatic resource model results.

a. Summary of Effects of Preferred Alternative on Aquatic Resources

The preferred alternative contains many of the elements found in a proposed set of standards titled, "Joint Proposal for Resolving San Francisco Bay-Delta Issues", prepared by a coalition of major agricultural and urban water users and submitted to the SWRCB at its October 1994 workshop. Consequently, much of the following description of the effects of the preferred alternative is extracted from a report prepared by this group titled, "Biological Explanation of the Joint Water Users Proposed Bay-Delta Standards" (JWU 1994).

The discussion of the effects of the preferred alternative is divided into four seasons, defined here as: spring (February through June), summer (July and August), fall (September and October), and winter (November through January).

SPRING (February-June). Spring is a critical time for most biological resources using the Estuary. During this time, many species are spawning, eggs are incubating, and juvenile fish, such as chinook salmon smolts, are emigrating through the Estuary. Because this time is so critical, a major focus of the standards is on the spring period. The greatest reduction in exports and the highest outflows are provided during this period.

Delta Outflow. The spring Delta outflow standard is complex. The standard consists of the number of days that three different flow levels are required from February through June. The flow levels are approximately the steady-state, 3-day running average flows necessary to maintain a 2 ppt isohaline (measured as 2.64 mmhos/cm EC) at: the confluence of the Sacramento and San Joaquin rivers, measured at Collinsville (7,100 cfs); Chipps Island (11,400 cfs); and Port Chicago (29,200 cfs). The number of days of a particular flow required by the standard can also be met if the daily average or 14-day average 2 ppt isohaline is at or west of the three locations specified above. The Port Chicago objectives apply only in months when the average EC at Port Chicago during the 14 days immediately prior to the first day of the month is less than or equal to 2.64 mmhos/cm.

The February through June Delta outflow standard approximately reproduces the number of days the 2 ppt isohaline would have been downstream of the three locations under various hydrologic conditions and year 1971.5 development levels. This level of development was selected since it is the mid-point of the time period, 1968-1975, that is believed to represent a reasonable level of protection. The confluence standard can be relaxed in March, upon the recommendation of the operations group established under the Framework Agreement, if the best available estimate of the Eight River Index for February is less than 500 TAF. Also, the confluence standard does not apply in May and June if the best available estimate of the Sacramento River Index for May is less than 8.1 MAF at the 90 percent exceedence level. Under this circumstance, a minimum 14-day average flow of 4,000 cfs is required in May and June.

The purpose of the Delta outflow standards are to increase outflow and restore some of the natural hydrologic patterns that historically occurred in the system and in which native fish and invertebrate species likely evolved and proliferated. The provision of late winter and spring river flow and Delta outflow promotes conditions conducive for spawning and dispersal of Delta smelt, longfin smelt, Sacramento splittail, and other estuarine and anadromous species.

As described in Chapters V and VI, a number of estuarine aquatic resources respond positively to increased spring outflow. The biological bases for this response are not well defined but are likely related to: (1) transport of eggs and larvae out of river and Delta areas and into downstream estuarine habitats; (2) nutrient transport into Suisun and Honker bays resulting in increased phytoplankton production; (3) mixing of salt and fresh water resulting in nutrient, egg, and larvae dispersal to shallow water habitats; (4) freshwater trapping in Grizzly Bay, an important nursery area; (5) reduced predation of juvenile fish due to increased dispersal to shallow water habitat and increased turbidity; and (6) intra- and inter-annual variation in outflow patterns which historically occurred in the system.

The geographic distribution of many planktonic fish eggs and larvae is influenced by the magnitude of freshwater outflow passing through the Delta. During periods of high spring freshwater outflow, the planktonic stages of these fish are distributed downstream in Suisun Bay, where their susceptibility to entrainment losses at the SWP and CVP diversions, and at other diversions within the Delta, is reduced. During years when spring outflow is low, a larger percentage of the planktonic larval fish is located within the Delta, where they are susceptible to entrainment losses and higher mortality rates (SWC 1992a).

The location of the entrapment zone downstream of the confluence of the San Joaquin and Sacramento rivers under higher outflow conditions may also be a factor causing improved survival during high outflow years. The entrapment zone is formed as fresh water flows over the more dense landward-flowing marine water, creating a circulation pattern that concentrates particles such as sediment and plankton (see section A.2.d of Chapter V). Production in the Estuary may be enhanced when the entrapment zone is located in the shallows of Suisun Bay rather than the comparatively narrow river channels upstream of the confluence.

Estuarine species respond to salinity as well as flow. Higher flows in the spring increase the volume of brackish water habitat available during a period when many euryhaline species are reproducing, which provides increased habitable space for certain species. Increased habitable space reduces densities, competition, and predation (DFG 1992).

Delta Cross Channel Gate Operation. The preferred alternative requires the Delta Cross Channel gates to be closed from February 1 through May 20 and closed for 14 days from May 21 through June 15. The purpose of this standard is to reduce the transport of emigrating salmon smolts, and eggs and larvae of other fish, into the central Delta.

The February through June period includes the peaks of both the migration season for winter- and fall-run chinook salmon smolts, and the spawning season for species such as Delta smelt, longfin smelt, Sacramento splittail, and striped bass on the Sacramento River. The diversion of smolts, eggs, and larvae out of the mainstem of the Sacramento River through the Delta Cross Channel and into the central Delta exposes them to numerous hazards, including entrainment in agricultural diversions and the export pumps, increased temperature, reduced food supply, and longer migration routes. Closing the Delta Cross Channel gates serves to reduce diversions of aquatic organisms into the central Delta, concentrate more flow in the mainstem Sacramento River, and help transport eggs, larvae, and smolts into Suisun Bay.

The Delta Cross Channel is but one of the two pathways by which salmon smolts can be diverted from the mainstem of the Sacramento River into the central Delta; the other pathway is Georgiana Slough. Georgiana Slough is a natural channel, and the Delta Cross Channel is a constructed channel. Smolts, eggs, and larvae diverted into the central Delta through Georgiana Slough encounter the same problems as smolts, eggs, and larvae diverted into the central Delta through the Delta Cross Channel. The SWRCB is not requiring installation of a barrier on Georgiana Slough, but the SWRCB recommends that the DWR and the USBR evaluate the use of a physical or acoustical barrier on Georgiana Slough. Recent prototype tests completed by Hanson Environmental, Inc. (1993) suggest that an acoustical barrier is a promising means for reducing the percentage of salmon smolts entering Georgiana Slough from the Sacramento River.

San Joaquin River Flow. The preferred alternative requires average flows ranging between 710 cfs and 3,420 cfs from February 1 through April 14 and May 16 through June 30, and average flows ranging between 3,110 and 8,620 cfs from April 15 through May 15. The required flow depends on water year type and location of the 2 ppt isohaline (a higher flow is required when 2 ppt is required to be at or west of Chipps Island). The purpose of these standards is to improve survival of salmon smolts emigrating down the San Joaquin River and to improve habitat conditions in the central and southern Delta for numerous aquatic species.

San Joaquin fall-run chinook salmon smolts migrate down the San Joaquin River principally in April and May, although some migration also occurs in June. The DFG has shown that increased flows in the San Joaquin River during the spring months is highly correlated with increased numbers of adult spawners returning two and a half years later (DFG 1987), which implies that smolt survival improves with increased spring flows. Since then, the USFWS has concluded from tagging studies in the San Joaquin River basin that smolt survival increases with increased flows and reduced exports (USFWS 1992). Results of experimental releases of tagged salmon smolts at various locations within the San Joaquin River (Dos Reis, Mossdale, Snelling, Lower Stanislaus, and Lower Tuolumne) between 1982 and 1993 suggest that smolt survival is related to the split of flows between Old River and the mainstem of the San Joaquin River. This flow split is affected by the flow at Vernalis, exports, and the status of the barrier at Old River. The likely mechanism for increased survival at higher flows is decreased migratory time through the central Delta and decreased chance of diversion off the mainstem of the San Joaquin River to the export pumps. The problem of diversion to the export pumps can also be partially addressed through construction of an Old River barrier. The SWRCB is recommending the evaluation and construction, if appropriate, of this barrier in the plan.

The volume of water required by the April 15 through May 15 pulse flow objective should be distributed over the 31-day period to coincide with fish migration, as determine by the operations group established under the Framework Agreement. Short-duration flow fluctuations, adequately separated in time, have shown to be effective in cuing smolts into outmigration. Effective planning and management of a combination of base flow and pulsed flow fluctuations can improve smolt survival efficiently.

The San Joaquin River spring flow objectives also coincide with the spawning season of a number of estuarine species, such as Delta smelt, Sacramento splittail, and striped bass. These higher flows will improve salinity conditions for spawning in the central and southern Delta, and provide transport flows out of the central Delta.

Direct Export Limits. The preferred alternative limits the maximum export rate from April 15 through May 15 to an amount equal to 100 percent of the 3-day running average Vernalis flow or 1,500 cfs, whichever is higher. The purpose of this standard is to limit entrainment and salvage losses of outmigrating smolts from the San Joaquin River.

A direct benefit of the standard is the reduction in numbers of species entrained into Clifton Court Forebay and into the screens, pumps, and salvage operations at SWP and CVP facilities. Spring is the period of reproduction of many aquatic vertebrates and invertebrates. Planktonic egg and larval stages are most susceptible to entrainment into the pumps because they can neither be screened nor salvaged. Spring is also the period of the outmigration of salmon smolts. The simultaneous reduction in exports with the increased flows in the San Joaquin River during the chinook salmon smolt outmigration period is especially important for improved survival of smolts from both the San Joaquin and Sacramento rivers; however, it is most critical for the San Joaquin smolts because the facilities entrain more salmon from the San Joaquin River (DWR 1992).

For the direct export limit standard to have its greatest benefit for outmigrating salmon, it should be coupled with construction of the Old River barrier. Results of coded wire tag studies indicate that outmigrating smolts are susceptible to entrainment at the pumps due to false attraction down the Old River channel near Mossdale (USFWS 1992).

Export/Inflow Ratio Limits. The preferred alternative limits export pumping to 35 percent of Delta inflow from February through June. Export pumping can be increased to 45 percent in February if the best available estimate of the Eight River Index for January is less than or equal to 1.0 MAF. If the best available estimate of the Eight River Index for January is between 1.0 MAF and 1.5 MAF, the export limit for February will be set by the operations group established under the Framework Agreement within the range of 35 percent and 45 percent. The purpose of these standards is to reduce fish, egg, and larvae entrainment and mortality at the pumps through export restrictions and intensive real-time monitoring designed to detect the presence of fish in areas adjacent to the pumps.

Relatively low export/inflow ratios are specified during the spring (≤ 35 percent) when fish, eggs, and larvae are especially vulnerable to entrainment at the pumps. The export/inflow limits during the summer, fall, and winter, which allow exports to 65 percent when fish are less vulnerable to diversion losses, were developed with consideration for balancing fish protection with water supply needs.

The development of the export/inflow concept was founded on two basic principles. First, exports may increase during periods when higher volumes of fresh water are flowing through the Delta without increasing the risk of adverse biological effects. Correspondingly, exports should decrease during those years when freshwater inflow to the Delta is decreased and a larger percentage of fish and other aquatic organisms are geographically distributed further upstream where their susceptibility to export losses is increased. Second, the percentage of water diverted in recent years, particularly during the spring, has increased substantially above diversion levels (expressed as a ratio of exports to inflow) during earlier years when aquatic resources inhabiting the Bay-Delta system were at higher population levels. The analysis in section A.2 of this chapter demonstrates that, in dry and critical years, the standard will result in lower export/inflow ratios than those which occurred in the reference period of 1984-1992, especially in the spring months.

SWP fish salvage records are available for use in evaluating the seasonal distribution in susceptibility and loss resulting from water project operations. Review of salvage data for 1980-1990 shows that the seasonal distribution of losses varies among species. Salvage data were compiled for striped bass, chinook salmon, American shad, Sacramento splittail, longfin smelt, and Delta smelt to characterize the seasonal distribution in fish losses. For these species, combined average monthly losses were greatest in April (10 percent), May

(23 percent), June (24 percent), and July (16 percent). Therefore, over 70 percent of the combined average losses for these species occurred between April and July. Average monthly losses ranged from 2 to 6 percent between August and March. In addition to salvage losses, relatively large numbers of fish eggs and larvae, which are not accounted for in salvage data, are susceptible to entrainment losses during April through June (JWU 1994). This summary of the salvage data by month does not, however, reflect the timing or loss of species of low abundance.

SUMMER (July and August). The occurrence of fish in the Bay-Delta Estuary during the summer is primarily limited to resident species, although some late spawning of striped bass, Delta smelt, and Sacramento splittail has been reported in some locations. A comparison of life stage periodicity data for several species indicates a window of inactivity during July and, in particular, August for these species. Standards for this period focus on maintenance of estuarine health and biological processes.

Delta Outflow. The preferred alternative requires the following minimum monthly average net Delta outflows for the summer period:

Table VIII-1. July and August Delta Outflow

Water Year Type	Delta Outflow (cfs)	
	July	August
Wet	8,000	4,000
Above Normal	8,000	4,000
Below Normal	6,500	4,000
Dry	5,000	3,500
Critical	4,000	3,000

The purpose of these standards is to provide outflow during summer months for maintenance of biological communities in preparation for the fall transition period, described below. The intended benefits are to sustain suitable habitat in the Delta for continued rearing of juvenile and maintenance of adult fish (Delta smelt, striped bass, and others) and to reduce seawater intrusions into the Estuary to prevent the colonization of undesirable organisms in the Delta (e.g., *Potamocorbula*, *Mya* sp., and others).

Although many of the important estuarine species of fish have spawned by June, several others, including striped bass, Delta smelt, and Sacramento splittail, have been reported to continue spawning into July. Additionally, larvae and early juveniles of Delta smelt and other species remain in the system and warrant conditions conducive to their survival. The derivation of the recommended flows is not based on the results of quantitative habitat or population studies, but rather on scientific judgment. No definitive studies have been completed to support this specific outflow proposal. The effectiveness of the recommended flows for benefitting the resource will be evaluated as part of the plan's monitoring program.

Export/Inflow Ratio Limits. The preferred alternative limits export pumping to 65 percent of Delta inflow in July and August. The purpose of this standard is to limit entrainment of organisms at the export pumps and to regulate pumping in conjunction with a real-time monitoring and response program at locations adjacent to the pumps.

July and August are a transition period during which Delta export/inflow ratios can increase, as biologically sensitive periods pass. The majority of spawning, and egg and larvae transport, is completed by July. As discussed above, review of salvage data indicates that, historically, the highest percentages of salvage occurred during the April-June period. No definitive studies or analyses were completed to support these export/inflow restrictions. The export/inflow ratios are based on shifting periods of high exports to less biologically sensitive periods.

FALL (September and October). The fall period marks the transition from the dry summer months to a period of increased rainfall with a corresponding decrease in water temperatures. Biologically, several species of fish, including fall-run chinook salmon, begin to migrate upstream into the Sacramento and San Joaquin rivers and tributaries in preparation for spawning. Adult and juvenile Delta smelt, striped bass, and adult Sacramento splittail continue to rear in portions of the Delta. Therefore, conditions promoting feeding and growth in preparation for spawning are important.

Delta Outflow. The preferred alternative requires a minimum monthly average net Delta outflow of 3,000 cfs in September and 4,000 cfs in October, except in October of critical years when the standard is 3,000 cfs. The purpose of this standard is to provide outflow for maintaining conditions conducive to growth and maintenance of resident and anadromous adult and juvenile fish populations utilizing the Bay-Delta Estuary during this period and to provide attraction flows for fall-run chinook salmon.

The intended benefits of this standard are to maintain a healthy ecosystem during this period by providing: (1) conditions which allow growth and maturation of adult fish in preparation for spawning; (2) conditions suitable for fall-run chinook salmon staging; and (3) velocity cues for upstream spawning migration of fall-run chinook salmon and longfin smelt. The standards are based on biological judgment of the life history and rearing requirements of species utilizing the Delta during this time period. No definitive studies have been conducted to determine flow magnitudes and durations.

Sacramento River Flow. The preferred alternative requires minimum monthly average flows on the Sacramento River at Rio Vista of 3,000 cfs in September and 4,000 cfs in October, except in October of critical years when the standard is 3,000 cfs. The purpose of this standard is to provide a minimum flow to attract adult salmon to the Sacramento River. Returning adult salmon rely on velocity cues for stimulating upstream migrations. Maintaining minimum Sacramento River flows will provide such cues for adult fall-run chinook salmon.

San Joaquin River Flow. The preferred alternative requires a minimum monthly average flow of 1,000 cfs in the San Joaquin River at Vernalis in October. A pulse flow of up to 28 TAF is also required in all water year types as needed to provide a monthly average flow of 2,000 cfs. The additional pulse flow is not required in a critical year following a critical year. The timing and duration of the pulse flow will be determined by the operations group established under the Framework Agreement.

The purpose of the pulse flow standard is to attract adult fall-run chinook salmon into the San Joaquin River; the purpose of the base flow standard is to provide adequate migratory conditions for adult fall-run salmon on the San Joaquin River. The pulse flow should also help to achieve the dissolved oxygen standard of 6.0 mg/l from September 1-November 30 between Stockton and Turner Cut on the San Joaquin River. The dissolved oxygen standard is intended to alleviate the dissolved oxygen sag that occurs every fall in that reach and which has been reported to block upstream migration of salmon.

Adult salmon returning to the San Joaquin River are faced with numerous channels on their migration to upstream natal spawning grounds. A pulse of water down the mainstem San Joaquin River will provide additional velocity and olfactory cues which should direct salmon to the main river and facilitate passage through the lower Delta. The month of October was chosen to coincide with the timing of adult chinook salmon arriving at the Merced River Hatchery prior to 1989, the beginning of the recent drought years (DFG 1992). Delays in upstream migration have occurred since then due to low fall flows upstream and poor water quality downstream. Migration and spawning delays constrict the time period available to produce salmon offspring. Narrowing the period can result in poor recruitment and further reduce the population (DFG 1992). Late or delayed spawning can result in poor egg quality and diminished survival to hatching. Delayed incubation and fry emergence resulting from late spawning can shift smolt outmigration further into May when water temperatures are higher and other mortality factors are greater.

The scientific basis for this standard is largely subjective, and based on biological judgment and knowledge of behavior patterns and requirements of migrating adult salmon. The amount of flow in the recommended standard represents an improvement over historical dry water year conditions.

Export/Inflow Ratio Limits. The plan limits exports to 65 percent of Delta inflow in September and October. The purpose of this standard is to limit entrainment of organisms at the export pumps, and to regulate pumping in conjunction with a real-time monitoring and response program at locations adjacent to the pumps.

The fall is a transition period during which export/inflow ratios can be higher because entrainment potential of fish is relatively low. Review of salvage data indicates that, historically, the highest percentages of salvage at the export pumps occur during the April-June period. The export/inflow ratios allow periods of higher exports during a biologically less sensitive period in exchange for lower exports during the April-June period.

WINTER (November-January). Winter is a less sensitive period for most estuarine biological resources. Certain fish species normally spawn during this period, including starry flounder and longfin smelt. While some migration occurs, this period is of lesser importance with respect to flow-related measures because the Estuary is at a natural production ebb and natural, unregulated flows through the system are sufficient for support of biological functions in most years.

Delta Outflow. The preferred alternative requires a minimum monthly average net Delta outflow in November and December of 3,500 cfs in critical years and 4,500 cfs in all other year types. In January, the minimum monthly average net Delta outflow standard is 4,500 cfs, except when the best available estimate of the Eight River Index for December is greater than 800 TAF, in which case the January standard is 6,000 cfs. The purpose of the standards are to provide net Delta outflow for continued rearing of juvenile and maintenance of adult fish, and to provide conditions conducive for maturation of adult fish in preparation for spring spawning.

There are no definitive scientific data to determine appropriate flow magnitudes and durations to produce intended benefits. The standard is based on professional judgment of the life history and rearing requirements of species utilizing the Delta during this time period. The higher flows in January, compared to those during November and December, are intended to provide conditions conducive to adult maturation and egg development, and represent a transition toward higher outflows that occur during the spring period (February-June).

Delta Cross Channel Gate Operation. The preferred alternative requires the Delta Cross Channel gates to be closed up to a total of 45 days based on real time monitoring (flows, turbidity, etc.) from November through January. Operating criteria for this standard will be developed by the operations group established under the Framework Agreement.

The purpose of this standard is to protect emigrating spring-run chinook salmon, and possibly winter-run chinook salmon, from diversion off of the mainstem of the Sacramento River and into the central Delta. The problems associated with such diversion are discussed under the spring period, above.

Sacramento River Flow. The preferred alternative requires minimum monthly average flows on the Sacramento River at Rio Vista in November and December of 3,500 cfs in critical years and 4,500 cfs in all other year types. The purpose of these standards is to contribute to the maintenance and continued rearing of resident juvenile and adult fish in the

Estuary, and to provide upstream migration cues for late fall- and winter-run adult chinook salmon and longfin smelt.

There are no definitive scientific data to determine appropriate flow magnitudes and durations to produce intended benefits. The standards are based on professional judgment and knowledge of the life history and rearing requirements of species utilizing the Delta during this time period.

Export/Inflow Ratio Limits. The preferred alternative limits export pumping to 65 percent of Delta inflow from November through January. The purpose of this standard is to limit entrainment of organisms at the export pumps.

Fish densities are typically low at the export pumps during the winter. The export/inflow ratios allow periods of higher exports during a biologically less sensitive period in exchange for lower exports during the April-June period.

b. Aquatic Resource Model Results. The previous section provides a biological rationale for, and a qualitative description of the expected benefits of, the standards in the preferred alternative. In this section, the aquatic resource models described in Chapter VI are used to provide quantitative descriptions of possible effects of certain standards in the preferred alternative. As discussed in Chapter VI, these regression equations have limited predictive capability. The regressions are only valid under the conditions in which they were derived, and conditions in the Delta are constantly changing. Nevertheless, the results are presented here for informational purposes.

The bar charts in Figures VIII-31 through VIII-41 summarize the results of the aquatic resource model calculations. Most of the figures have six bars. The six bars, in order, summarize the following information: (1) the actual monitoring aquatic resource data collected in the Delta during the historical reference period (1984-1992, except for POC and *Neomysis*, which are 1984-1989 and 1984-1990, respectively); (2) the calculated abundances (or survivals) in the reference period using actual hydrologic data; (3) the calculated abundance/survival in the reference period using DWRSIM-modeled hydrology under D-1485 conditions; (4) the calculated abundance/survival in the reference period using DWRSIM-modeled hydrology under the preferred alternative conditions; (5) the calculated abundance/survival over the 71-year DWRSIM-modeled hydrology under D-1485 conditions; and (6) the calculated abundance/survival over the 71-year (1922-1992) DWRSIM-modeled hydrology under the preferred alternative conditions. Figures VIII-39 through VIII-41 do not include the first bar described above because there are no historical wild salmon smolt survival data. (The salmon models were derived using tagged hatchery fish.) In addition, Figure VIII-39, which shows salmon survival with the Old River barrier, does not include the second bar because there was no barrier at the head of Old River during the reference period.

For purposes of discussion, the model results can be broken into three categories: (1) abundance/Delta outflow model results in Figures VIII-31 through VIII-36; (2) striped bass model results in Figures VIII-37 and VIII-38; and (3) salmon model results in Figures VIII-39 through VIII-41.

Under preferred alternative conditions, abundance/outflow model results predict that, at minimum, the existing abundances of the modeled aquatic resources would be maintained. In some cases, minor improvements may occur. A similar result is expected for most of the alternatives considered by the SWRCB, as discussed in Chapter XI. The abundance/outflow models indicate that substantial increases in abundances occur due to large storm-driven outflows, which are well outside the control of the CVP and the SWP. The additional outflow over the base case (as a result of the Delta outflow standards in the preferred and other alternatives) is adequate only to maintain existing populations of aquatic resources according to the models.

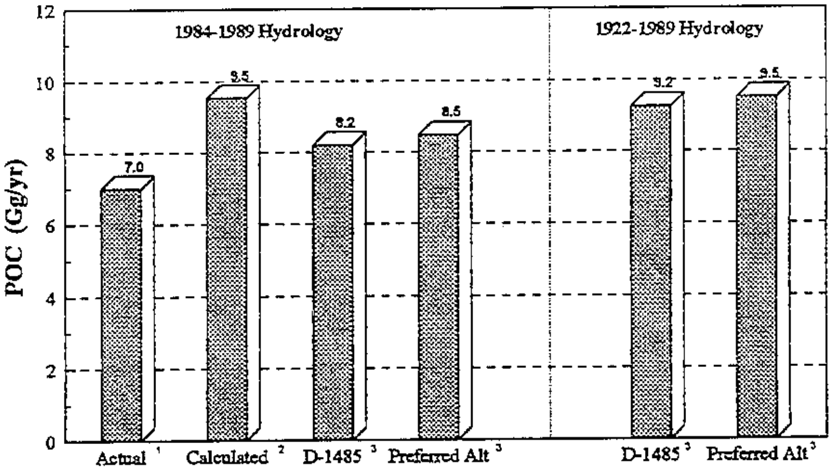
The results of the striped bass model are different than the abundance/outflow models. The striped bass model predicts that a substantial improvement in the young-of-the-year (YOY) will occur due to implementation of the standards. The YOY is principally dependent on the export and outflow conditions in the April through July period, and these months receive substantial protection in the plan. The model does not predict, however, a correspondingly substantial improvement in adult striped bass population. The adult striped bass population is principally dependent on the YOY, and on the export and outflow conditions from August through March. One of the effects of implementation of the standards will be to shift export pumping out of the spring period, which is considered most critical for estuarine protection, and into the fall and winter. The striped bass model indicates that this shift will result in the benefits of increased YOY to be largely lost, probably through increased entrainment in the fall and winter. Overall, the model results indicate that, if the plan had been in effect, with a 1995 demand level, during the reference period, striped bass populations would have declined more than they actually did. Over the 71 years of simulated hydrology, the long-term average population would have been similar to the existing population of about 600,000 striped bass.

The results of Figure VIII-38 should be viewed with caution. The figure shows that the population of adult striped bass would be greater under the 1984-1992 DWRSIM-modeled hydrology than under the 1922-1992 DWRSIM-modeled hydrology even though 1984-1992 was a dry period on average. This result is obtained because the modeled population in a particular year is dependent on the population from the previous seven years; and the actual striped bass population data from 1977-1983 were used in the 1984-1992 calculation, and the existing population of approximately 600,000 striped bass was used for the 1922-1992 calculation.

The salmon smolt survival models indicate that implementation of the standards will benefit Sacramento and San Joaquin fall-run chinook salmon smolts as they migrate through the Delta. However, as described in Chapter VI and illustrated in Figure VIII-39 through

Figure VIII-31

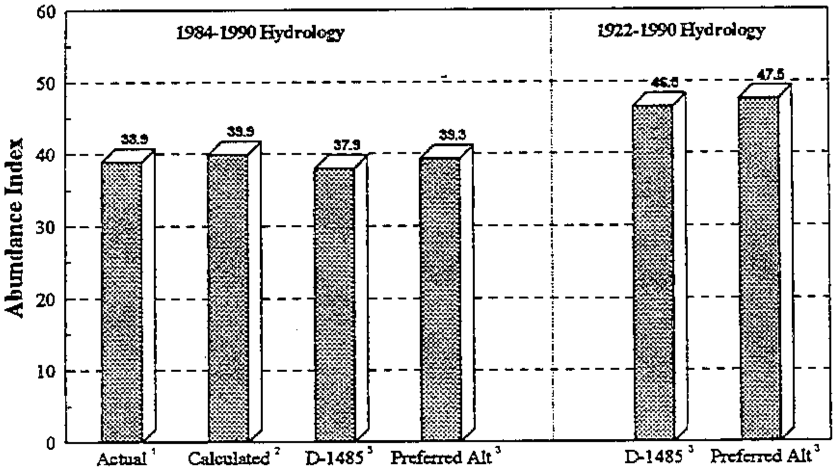
Particulate Organic Carbon (POC)



1 - Average index from empirical data provided by Jassby
2 - Average index from Jassby POC model using historical flows
3 - Average index from Jassby POC model using DWRSIM operation study flows

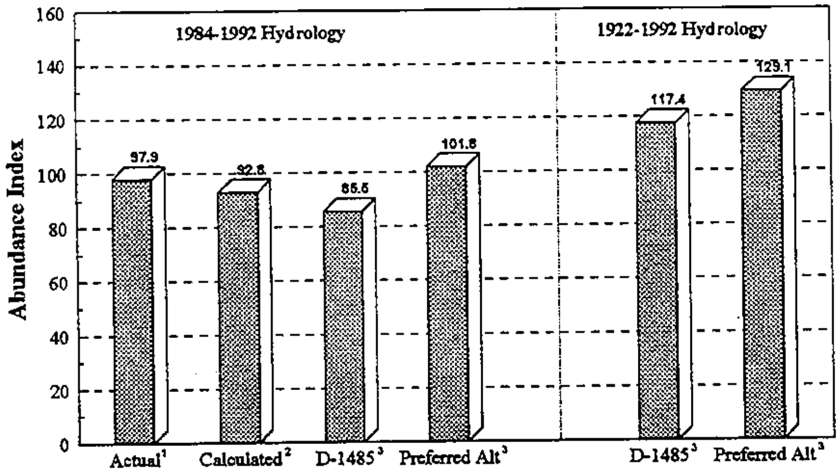
Figure VIII-32

Neomysis



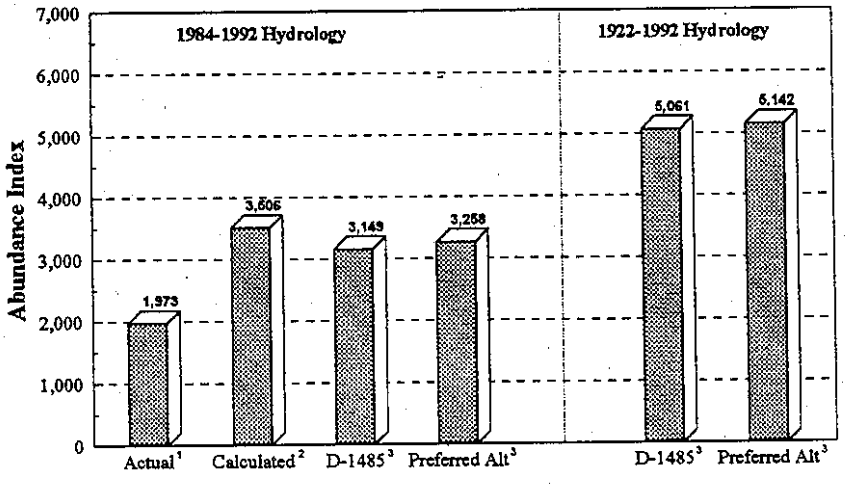
1 - Average index from empirical data provided by DFG
2 - Average index from Jassby *Neomysis* model using historical flows
3 - Average index from Jassby *Neomysis* model using DWRSIM operation study flows

Figure VIII-33
Immature *Crangon franciscorum*



1 - Average index from empirical data provided by DFG
2 - Average index from DFG *Crangon* model using historical flows
3 - Average index from DFG *Crangon* model using DWRSIM operation study flows

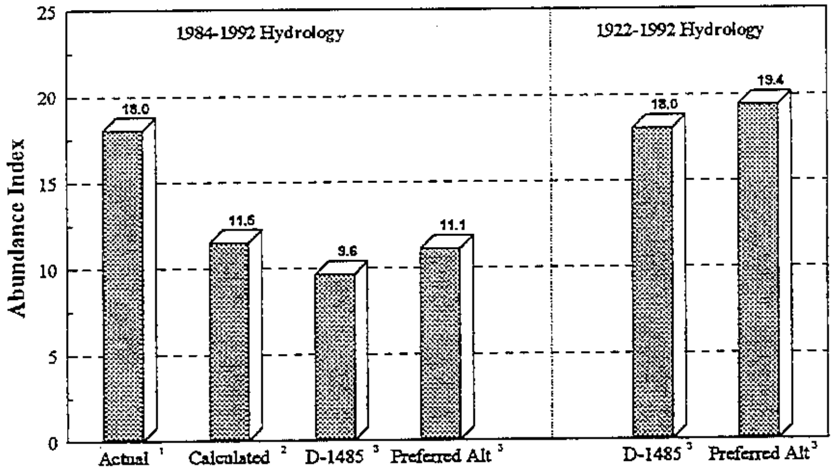
Figure VIII-34
Longfin Smelt



1 - Average index from empirical data provided by DFG
2 - Average index from DFG *Crangon* model using historical flows
3 - Average index from DFG *Crangon* model using DWRSIM operation study flows

Figure VIII-35

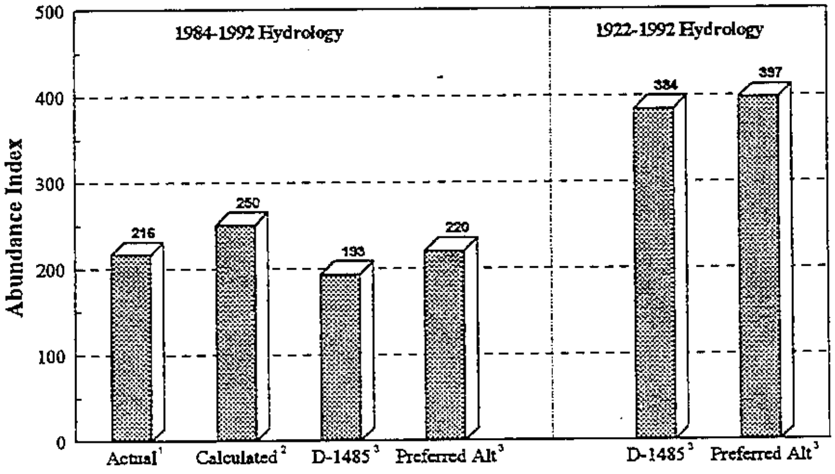
Sacramento Splittail



1 - Average index from empirical data provided by DFG
2 - Average index from DFG Sacramento splittail model using historical flows
3 - Average index from DFG Sacramento splittail model using DWRSIM operation study flows

Figure VIII-36

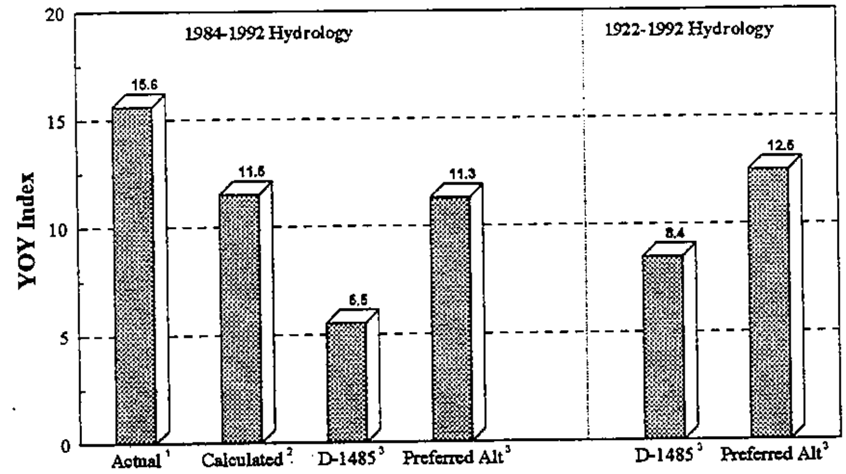
One-Year-Old Starry Flounder



1 - Average index from empirical data provided by DFG
2 - Average index from DFG starry flounder model using historical flows
3 - Average index from DFG starry flounder model using DWRSIM operation study flows

Figure VIII-37

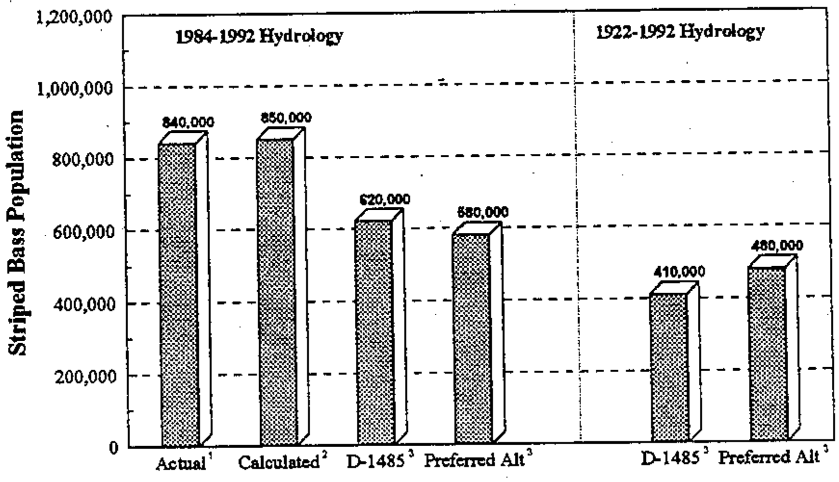
Striped Bass YOY Index



1 - Average index from empirical data provided by DFG
2 - Average index from DFG striped bass model using historical flows
3 - Average index from DFG striped bass model using DWRSIM operation study flows

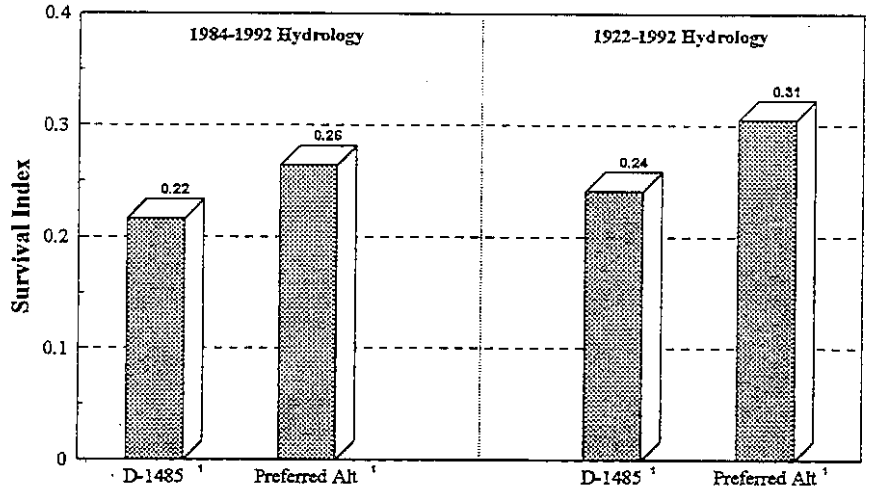
Figure VIII-38

Adult Striped Bass Population



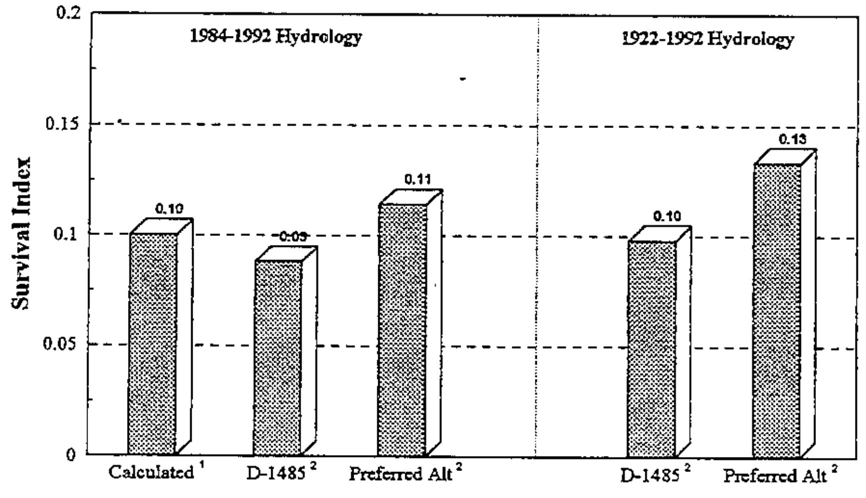
1 - Average index from empirical data provided by DFG
2 - Average index from DFG striped bass model using historical flows
3 - Average index from DFG striped bass model using DWRSIM operation study flows

Figure VIII-39
San Joaquin River Fall-Run Chinook Salmon Smolt Survival
with the Old River barrier



1 - Average index from USFWS salmon smolt model using DWRSIM operation study flows

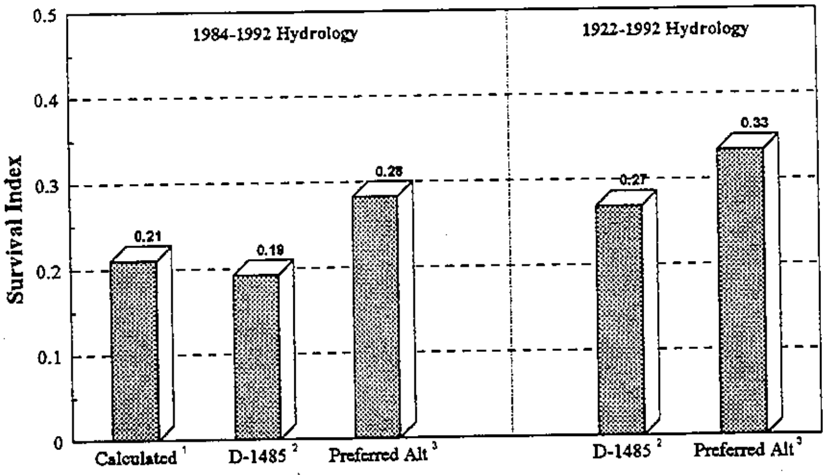
Figure VIII-40
San Joaquin River Fall-Run Chinook Salmon Smolt Survival
without the Old River barrier



1 - Average index from USFWS salmon smolt model using historical flows
2 - Average index from USFWS salmon smolt model using DWRSIM operation study flows

Figure VIII-41

Sacramento River Fall-Run Chinook Salmon Smolt Survival



[1] - Average index from USFWS salmon smolt model using historical flows; cross channel gates open in April, May, and June

[2] - Average index from USFWS salmon smolt model using DWRSIM operation study flows; cross channel gates open in April, May, and June

[3] - Average index from USFWS salmon smolt model using DWRSIM operation study flows; cross channel gates closed April thru May 20 and open May 21 thru June 30.

Figure VIII-41, the models indicate that the majority of the benefit is derived from closing the Delta Cross Channel gates on the Sacramento River and construction of a barrier at the head of Old River in the San Joaquin River basin. On the San Joaquin River, smolt survival is more than doubled by construction of the barrier.

In general, the models indicate that the survival or abundance indices of aquatic resources in the Delta would have been maintained or improved over the reference period conditions through implementation of the standards. The models' results do not predict dramatic improvements for any one species; however, the goal of the plan is to benefit many levels of the aquatic ecosystem so that conditions are improved for a broad range of species utilizing the Delta.

c. Impact of Water Transfers on Aquatic Resources

The SWRCB anticipates that requests for water transfers using the SWP and the CVP export facilities will occur in the future. In dry periods, the standards in the plan decrease export pumping from February through June, and water users in export areas are expected to respond by purchasing supplies and transferring them through the Delta in other times of the year. The capacity for water transfers in July through October under the standards in the plan is calculated in section G of Chapter VII, and an average annual transfer capacity of approximately 430 TAF is identified. The calculation of transfer capacity is limited to the July through October period because this is the period when transfers have historically been most common, and it is outside the most biologically sensitive period.

The impacts of increased export pumping in the late summer and early fall are generally less adverse to aquatic species than pumping in the spring. Salvage records from the SWP and CVP export facilities indicate that fish losses for striped bass, chinook salmon, American shad, Sacramento splittail, longfin smelt, and Delta smelt are considerably lower in the months from August through October than from April through July. Also, impacts to fish eggs and larvae due to entrainment at the export facilities should be minimal from July through October.

Three aquatic resource models, the POC, *Neomysis*, and striped bass models, indicate that these resources are sensitive to conditions in the July through October period. The models indicate that POC and *Neomysis* should not be adversely affected by water transfers because these models are abundance/outflow models, and outflow should not change significantly due to transfers. (Transfers are predicated on additional inflow to the Delta as necessary to meet the percent inflow export standards.) The striped bass model indicates that, with maximum transfers in July through October, the striped bass population over the 71 years of historical hydrology would decline from 480,000 to 381,000. This population is lower than the base case population of 410,000. Such a result is expected because the striped bass model is sensitive to exports throughout the year, and exports under the plan with maximum transfers from July through October exceed exports under the base case without transfers. Of course, if transfers from July through October were incorporated into the base case, the preferred alternative with transfers would provide a higher predicted striped bass population than the base case with transfers.

Even though transfers will increase exports, there are protection measures provided for aquatic resources from July through October. Limits on exports are fixed at 65 percent of inflow during this period. In addition, during this period, minimum Delta outflow objectives, varying by month and water year type, are in place, as described in section 5.a of this chapter. In September and October, there are minimum monthly average flows on the Sacramento River of 3,000 or 4,000 cfs. With cross-Delta transfers, flows in the Sacramento River would increase. There is a pulse flow requirement of up to 28 TAF on the San Joaquin River in October, as needed to provide a monthly average flow of 2,000 cfs (except in a critical year following a critical year). Transfers from the San Joaquin River basin would increase San Joaquin River flows, which would improve water quality conditions in the lower San Joaquin River.

6. Suisun Marsh

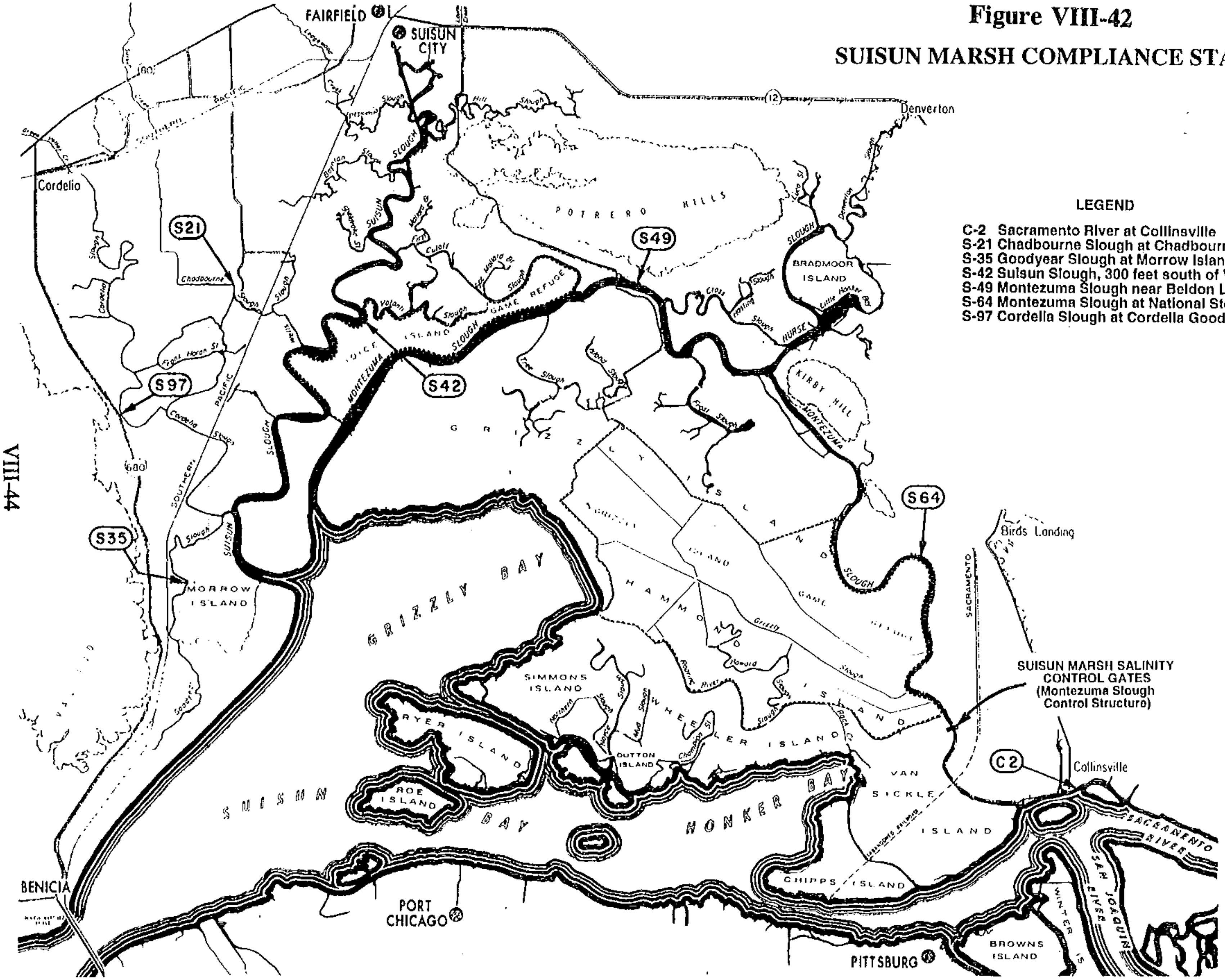
The preferred alternative includes: (1) 1978 Delta Plan standards in the eastern Suisun Marsh; (2) 1978 Delta Plan standards during normal hydrologic periods and SMPA deficiency standards in dry periods in the western marsh; and (3) a narrative standard for the tidal marshlands bordering Suisun Bay. The following discussion of the environmental effects of these standards on the Suisun Marsh is divided into three sections: background, standards, and salinity conditions.

a. Background. The 1978 Delta Plan set channel water salinity standards for the Suisun Marsh from October through May to preserve the area as a brackish water tidal marsh and to provide source water for waterfowl food plant production. Implementing the 1978 Delta Plan, D-1485 required the CVP and the SWP to develop and implement a plan, in cooperation with other agencies, which would meet all objectives by October 1, 1984. (Immediate compliance with the standards was not required because such compliance could be achieved only through large increases in outflow, then estimated at 2 MAF annually.) The USBR and the DWR later requested and received, in 1985, amendments to this requirement that changed some of the compliance locations and the compliance dates. The present compliance monitoring locations and the effective dates of compliance are listed below; the compliance monitoring stations are illustrated in Figure VIII-42.

Station ID	Location	Effective Date
C-2	Sacramento River at Collinsville	October 1, 1988
S-49	Montezuma Slough near Beldons Landing	October 1, 1988
S-64	Montezuma Slough at National Steel	October 1, 1988
S-21	Chadbourne Slough at Chadbourne Road	October 1, 1993
S-97	Cordelia Slough at Ibis Club	October 1, 1993
S-35	Goodyear Slough at Morrow Island Club	October 1, 1994
S-42	Suisun Slough at Volanti Club	October 1, 1997

Figure VIII-42

SUISUN MARSH COMPLIANCE STATIONS



LEGEND

C-2	Sacramento River at Collinsville
S-21	Chadbourne Slough at Chadbourne Road
S-35	Goodyear Slough at Morrow Island Clubhouse
S-42	Suisun Slough, 300 feet south of Volanti Slough
S-49	Montezuma Slough near Beldon Landing
S-64	Montezuma Slough at National Steel
S-97	Cordelia Slough at Cordelia Goodyear Ditch

The DWR, in cooperation with the USBR, DFG, USFWS, and SRCD, developed the "Plan of Protection for the Suisun Marsh including Environmental Impact Report" in 1984 to meet the D-1485 requirements. The Plan of Protection is a proposal for staged implementation of a combination of activities, including physical facilities, monitoring, a wetlands management program for marsh landowners, and supplemental releases from CVP and SWP reservoirs. The purpose of the staged implementation is to evaluate each action to determine the need for subsequent actions.

Phases I and II of the Plan of Protection are complete. These phases included construction of the Suisun Marsh Salinity Control Gates, which began operation in 1989. The primary goal of gate operation is to tidally pump lower salinity water through Montezuma Slough into the central marsh to reduce channel salinities during periods of low to moderate Delta outflow. Extended testing established that gate operation, in conjunction with reasonable outflow levels, results in compliance with the eastern marsh standards at stations C-2, S-49, and S-64; however, gate operation cannot consistently achieve compliance at the remaining stations in the western marsh. The planning and environmental review process to comply with the western marsh standards was initiated in June 1990. Present plans are to provide fresh water to the western marsh through augmented flow in Green Valley Creek, and possibly construction of ditches to improve flow distribution. The augmented flow would be obtained from either Lake Berryessa or the North Bay Aqueduct. The DWR and the USBR requested and received variances from the western marsh standards in the 1993-1994 and 1994-1995 control seasons to test the viability of the creek flow augmentation proposal. During the 1993-1994 control season, flow augmentation was not necessary because natural creek runoff, Delta outflow, and Suisun Marsh Salinity Control Gate operation were sufficient to meet standards. The 1994-1995 flow augmentation test is presently taking place. During the dry periods in 1984 through 1992, channel water salinities in the western Suisun Marsh exceeded the 1978 Delta Plan target salinity levels (standards were not in effect), as well as the deficiency standards defined in the SMPA.

In 1987, the DWR, USBR, DFG, and SRCD signed the SMPA. The SMPA is the contractual framework for achieving the objectives of the Plan of Protection, including controlling channel water salinity. The agreement includes normal period and deficiency period standards that are different than the standards in the 1978 Delta Plan and its required implementation, as amended. (The deficiency period is defined as either: (1) the second consecutive dry year following a critical year; (2) a dry year following a year in which the Four Basin Index was less than 11.35; or (3) a critical year following a dry or critical year.) A comparison of the SMPA-proposed standards with the 1978 Delta Plan standards is provided in Table VIII-2.

Table VIII-2. 1978 Delta Plan and SMPA Salinity Standards

Month	Mean Monthly High Tide Electrical Conductivity (mmhos/cm)		
	1978 Delta Plan	SMPA Normal	SMPA Deficiency
October	19.0	19.0	19.0
November	15.5	16.5	16.5
December	15.5	15.5	15.6
January	12.5	12.5	15.6
February	8.0	8.0	15.6
March	8.0	8.0	15.6
April	11.0	11.0	14.0
May	11.0	11.0	12.5

In 1987, the DWR, USBR, DFG, and SRCD requested that the water quality objectives in the SMPA be adopted as the marsh standards. The principal concern expressed regarding the 1978 Delta Plan standards is that they are not adjusted during dry periods. In response, the SWRCB requested, at the recommendation of the DFG, that the DWR and the USBR prepare a Biological Assessment to determine whether any flow and salinity changes that occur as a result of the actions taken pursuant to the SMPA would jeopardize any rare, threatened, or endangered species. Relevant portions of the Biological Assessment (i.e., those reflecting the current water management of the Estuary) were submitted to the SWRCB in December 1994. The SWRCB has requested the formation of a Suisun Marsh Ecological Work Group to evaluate beneficial uses and water quality objectives for the Suisun Marsh ecosystem.

During the SWRCB's current proceeding, the DWR, USBR, DFG, and SRCD again requested the SWRCB to adopt the SMPA standards (DWR 1994c, DFG 1994).

b. <u>Standards</u>. The 1978 Delta Plan Suisun Marsh standards, with the amended implementation under D-1485, include salinity standards at the seven compliance points listed above, and flow and salinity standards at Chipps Island from October through May. The plan changes the Suisun Marsh standards for the western marsh during year types when these standards have not yet been implemented. The discussion below describes the changes and provides the rationale for the standards in the plan.

First, the Chipps Island standards for protection of Suisun Marsh are replaced with the year-round outflow standards for general habitat protection. The outflow standards provide equivalent or better protection. Second, the eastern Suisun Marsh salinity standards (stations

C-2, S-64, and S-49) are not changed. These standards have been met since 1989, with minor exceptions, and operation of the Suisun Marsh Salinity Control gates, in combination with outflow conditions required by the plan, should be adequate to ensure continued compliance. Third, the western Suisun Marsh salinity standards (stations S-42, S-21, S-97, and S-35) are amended to include the SMPA deficiency standards. The 1978 Delta Plan standards have not been implemented in the western marsh; therefore, the implementation of the combination of 1978 Delta Plan standards in average hydrologic conditions and SMPA deficiency standards in dry conditions will provide lower salinity habitat than existing conditions. Also, there should be a natural gradient of increasing salinity from east to west which is not reflected in the existing standards, but is included in this plan when deficiency period standards are in effect. Fourth, a narrative standard for protection of tidal marshlands of Suisun Bay is added. This standard is expected to be achieved through compliance with the year-round outflow standards, but it is added to ensure that the tidal marshlands receive adequate protection.

Under the preferred alternative, there will be no decrease in protections for the Suisun Marsh beneficial uses compared with the 1984 through 1992 conditions and, as explained, there will be some improvements in protections. In the absence of any adverse effects, there is no need to wait for the DWR/USBR Biological Assessment before making these changes. If the DWR and the USBR want additional changes in the standards, their Biological Assessment will be required. Since the Suisun Marsh Biological Assessment study plan addresses implementation of SMPA standards under D-1485 conditions, a new study plan may be necessary for future standards.

c. Salinity Conditions. The following factors affected salinity in the Suisun Marsh from 1984 through 1992:

1. D-1485: the regulatory framework
2. SMPA: the contractual framework
3. Plan of Protection for the Suisun Marsh: facilities planning
4. Suisun Marsh Salinity Control Gates operation (beginning in 1989)
5. Delta outflow
6. Creek inflows
7. Managed wetland operations
8. Fairfield-Suisun Wastewater Treatment Plant effluent inflows
9. Precipitation/evaporation conditions
10. Tidal variations; influence of wind; barometric pressure

Of these factors, facilities planning, the operation of facilities in the marsh, and, to an extent, Delta outflow are controlled by the DWR and the USBR. Operations of the private managed wetlands in the marsh are controlled by 153 individual landowners, and the public areas are managed by the DFG. The ultimate destination and discharge of Fairfield-Suisun Wastewater Treatment Plant effluent is controlled by the Fairfield-Suisun Sewer District and the Solano Irrigation District, under permits issued by the San Francisco Bay RWQCB. Creek flows into northwestern Suisun Marsh are regulated by the management of reservoirs on Green Valley and Suisun Creek watersheds and are affected by urban development in the area. Precipitation, runoff, tidal variations, winds, barometric pressure, and evaporation are natural, uncontrollable factors.

In order to determine whether implementation of the standards will significantly change the salinity conditions in the marsh, the salinity conditions from 1984-1994 are compared to the standards (DWR 1994a). Mean monthly high tide salinity for water years 1984-1994 for eastern marsh compliance stations C-2, S-64, and S-49 and western marsh compliance stations S-21, S-97, and S-35 are presented in Figures VIII-43 and VIII-44, respectively (two pages each). Station S-42 is not included in this analysis, but the salinities at this station are very similar to the salinities at station S-21. In some cases, data are not shown for a station in a particular year because either the station was not established or the data did not meet quality assurance/quality control (QA/QC) criteria.

Mean monthly high tide salinities are presented on each bar chart, one bar per station as indicated on the legend in the upper left-hand corner of the figures. The monthly 1978 Delta Plan (solid line, indicated as D-1485) and SMPA deficiency (dashed line) standards lines are also shown on each of the six bar charts per page to facilitate comparison of the actual salinities with the 1978 Delta Plan and SMPA deficiency standards. Deficiency periods, as defined by the SMPA, occurred in 1988, 1989, 1990, 1991, and 1992.

The Suisun Marsh Salinity Control Gates began operating on October 31 of water year 1989. After gate operation began in water year 1989, salinity at the eastern marsh stations was generally below the 1978 Delta Plan standards and always below SMPA deficiency standards. Salinities at the western marsh stations were generally below 1978 Delta Plan standards and SMPA deficiency standards in wetter years or water years following wet periods, such as 1985, 1986, 1987, and 1994. However, during prolonged dry or critically dry periods, salinity in the western marsh is often above both 1978 Delta Plan standards and SMPA deficiency standards. Salinity in northwestern marsh sloughs (e.g., station S-97) is primarily affected by surface water inflows from local creeks and drainage water from the managed wetlands, and is relatively unaffected by Suisun Marsh Salinity Control Gates operations.

The DWR prepared Figures VIII-43 through VIII-51 (DWR 1994a). The bar charts in Figures VIII-43 and VIII-44 provide a graphical representation of the monthly occurrences of salinities above the standards, but they do not provide adequate information on how often and to what extent salinity at a particular station was either above or below the target salinities. Frequency-area plots are presented in Figures VIII-45 through VIII-51 for each marsh compliance station to provide an overall history of salinity with respect to the target standards. Figures VIII-45 through VIII-51 each include two plots, one for comparison with 1978 Delta Plan standards, indicated as D-1485 standards (top plot), and one for comparison with the SMPA standards (bottom plot).

Figure VIII-43

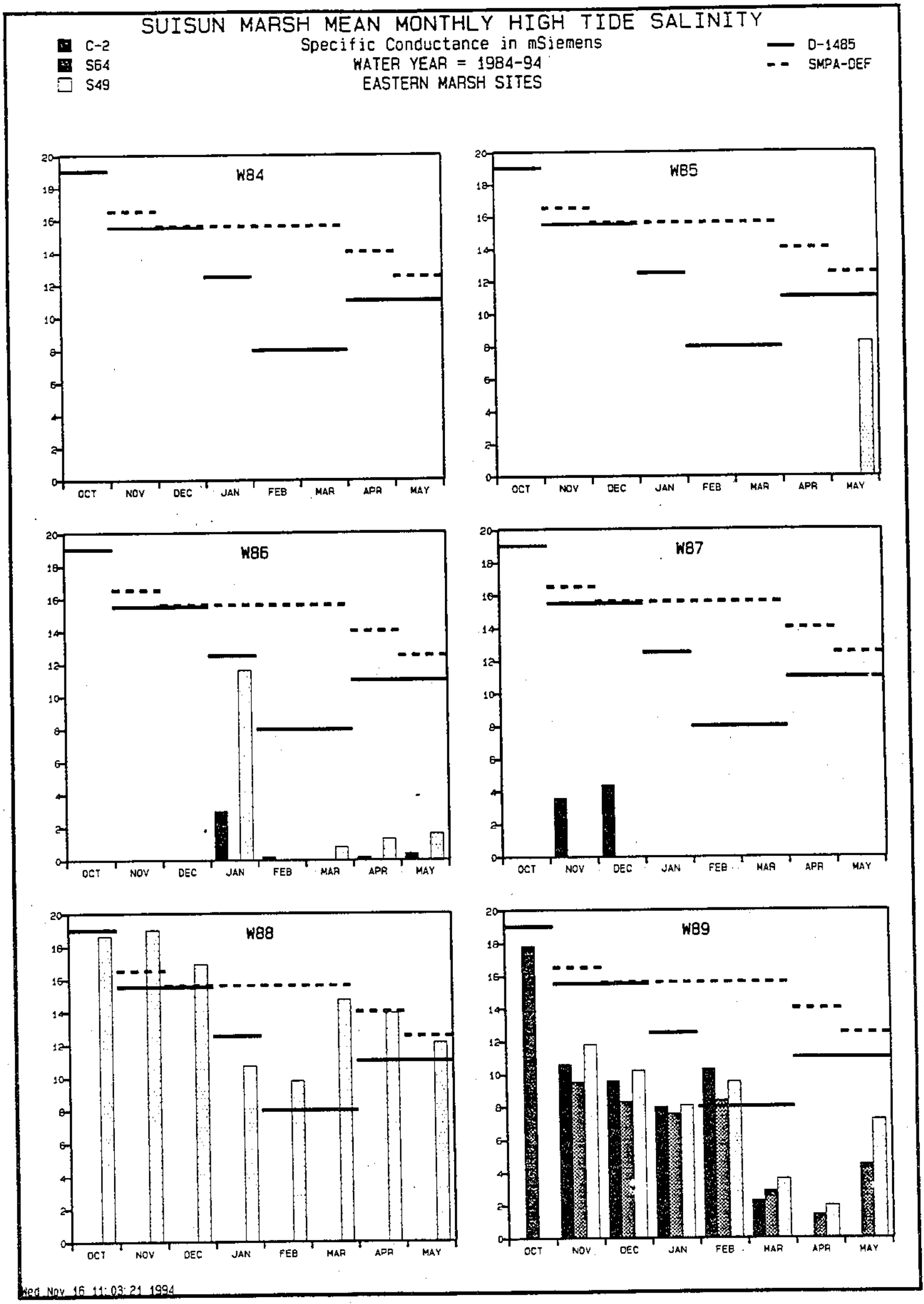


Figure VIII-43 continued

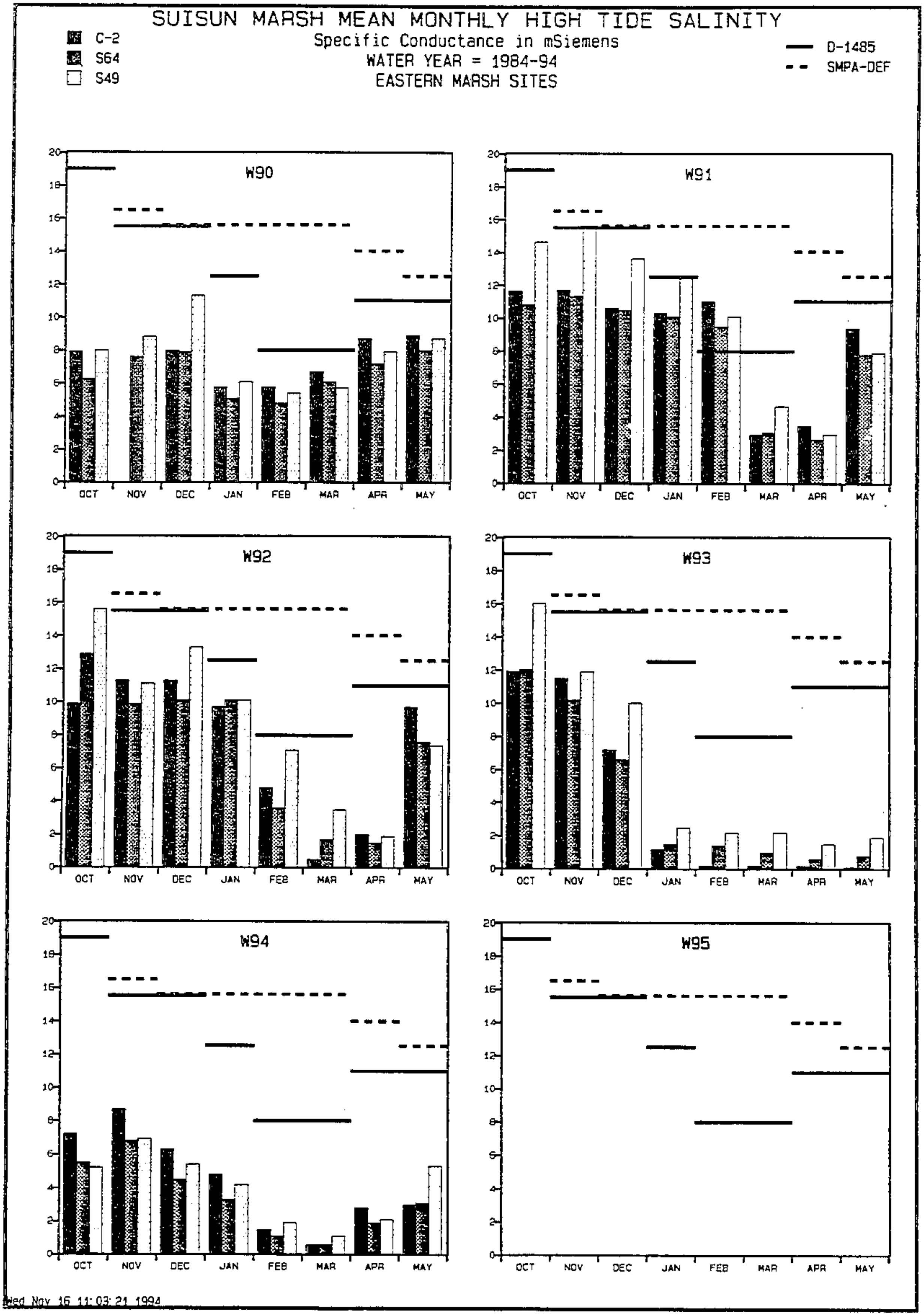


Figure VIII-44

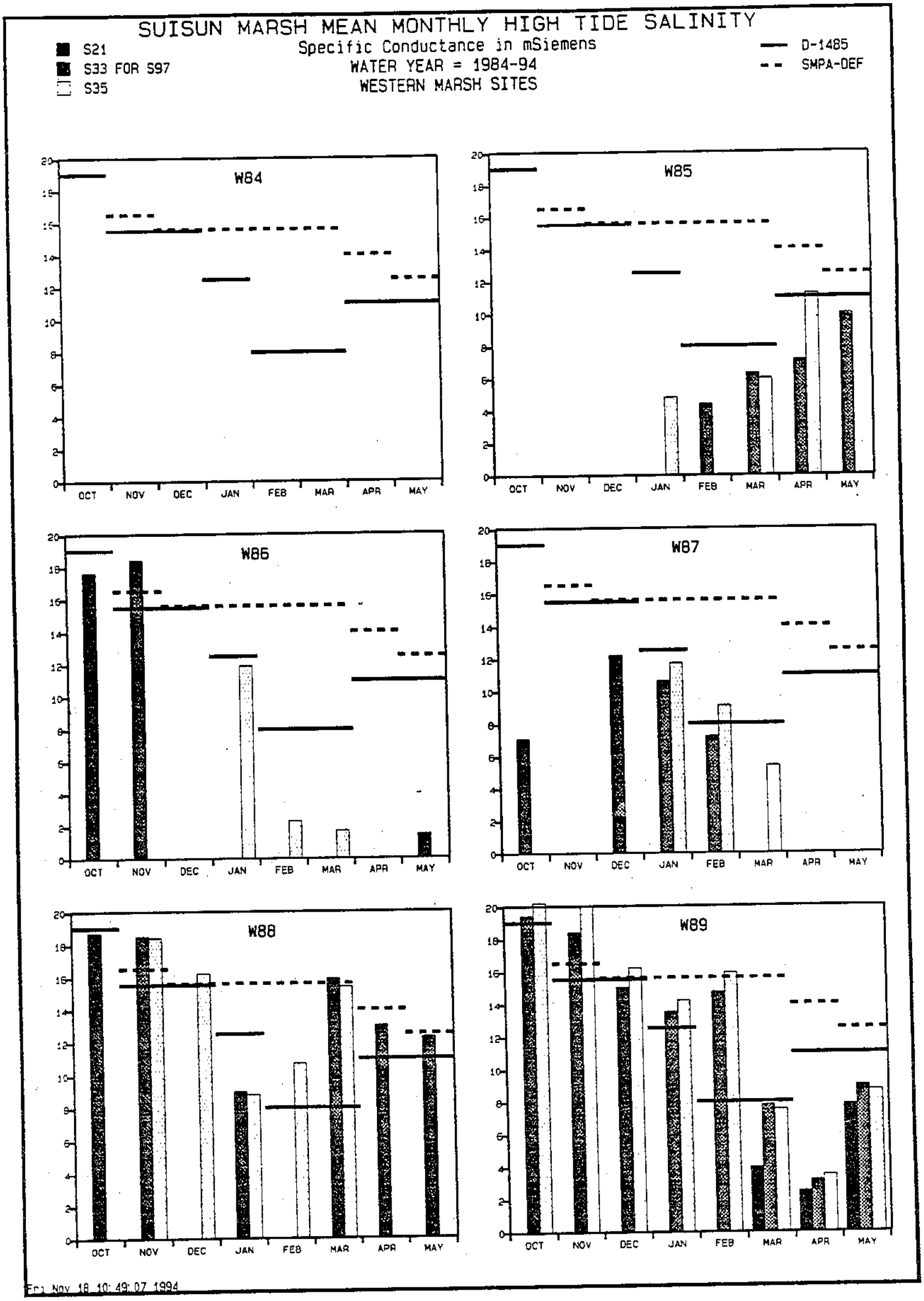


Figure VIII-44 continued

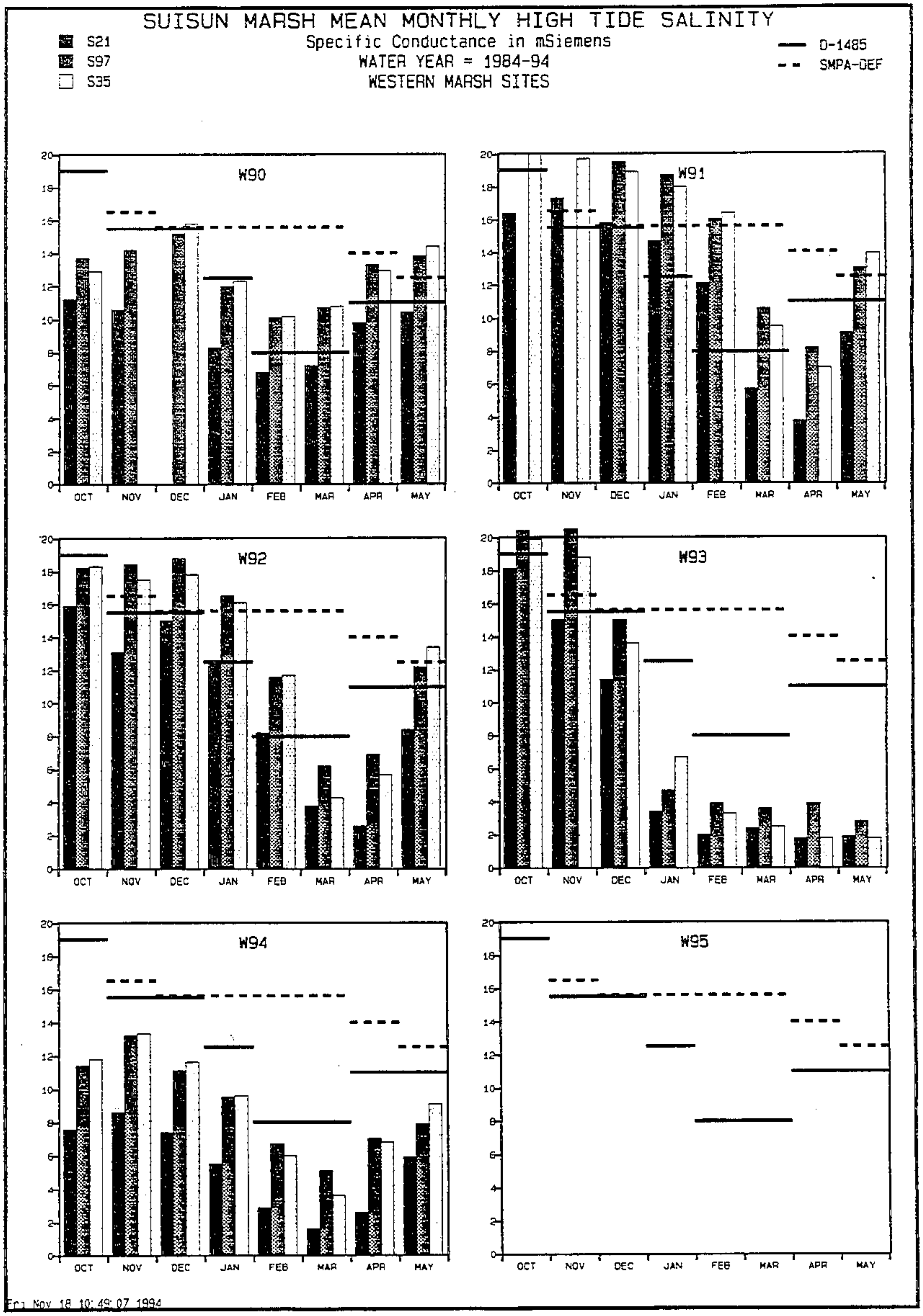
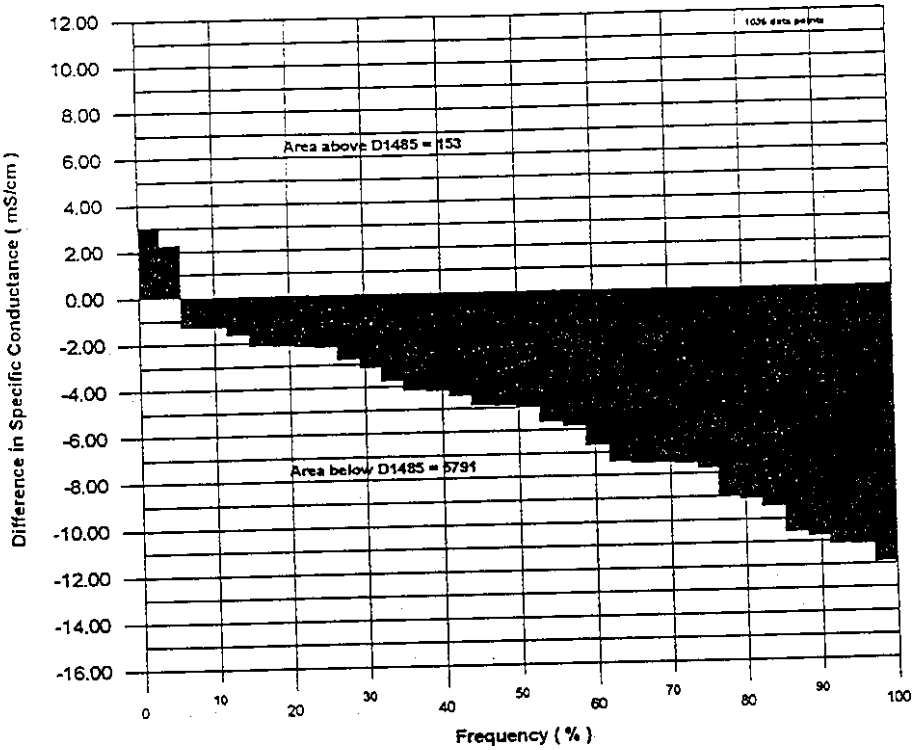


Figure VIII-45


C-2
MEASURED SALINITY MINUS D1485 STANDARD
For October through May of Water Years 1986-92

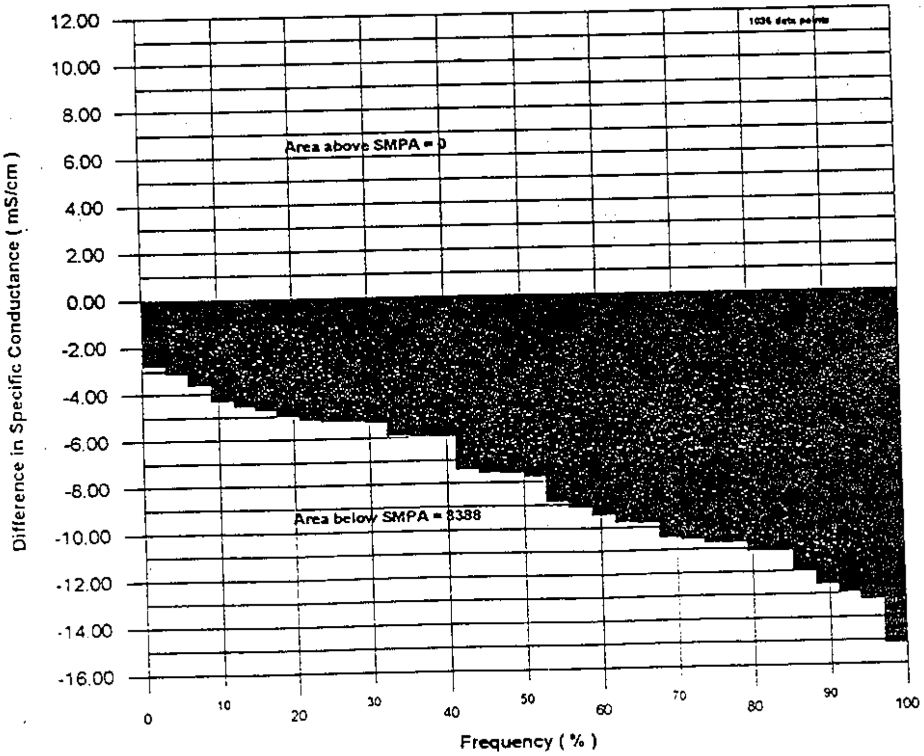
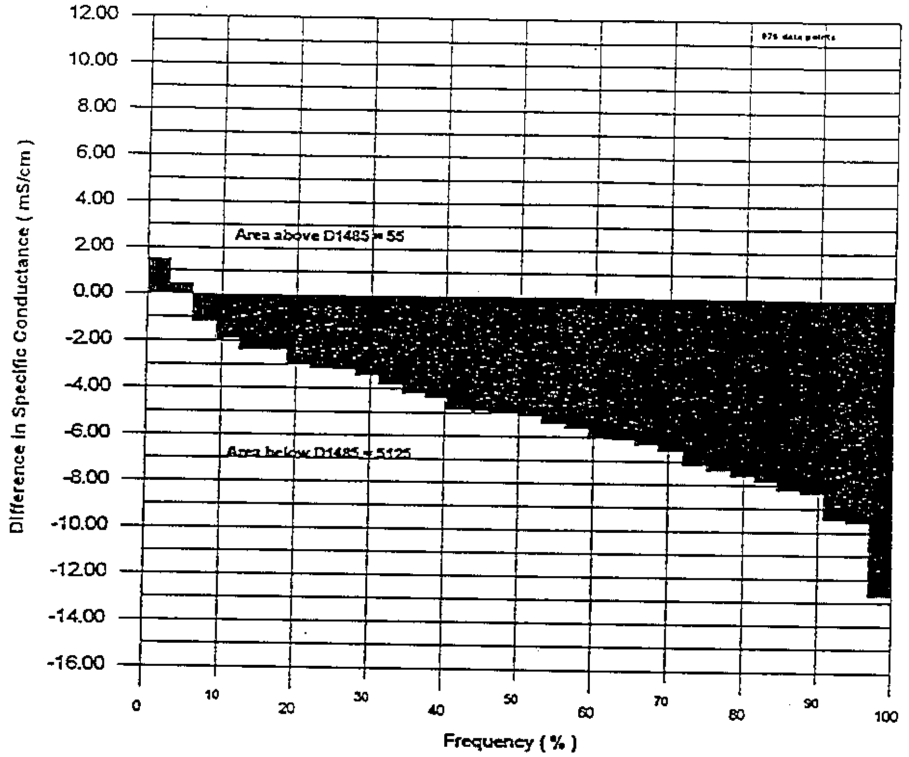

C-2
MEASURED SALINITY MINUS SMPA STANDARD
For October through May of Water Years 1986-92

Figure VIII-46

S-64
MEASURED SALINITY MINUS D1485 STANDARD
For October through May of Water Years 1989-92



S-64
MEASURED SALINITY MINUS SMPA STANDARD
For October through May of Water Year 1989-92

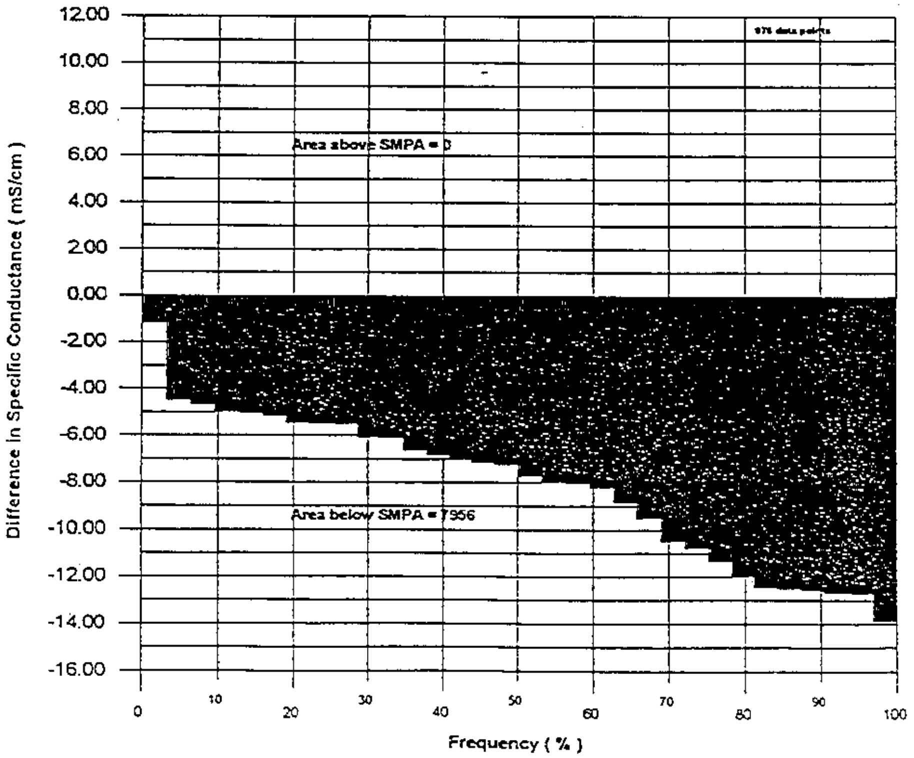
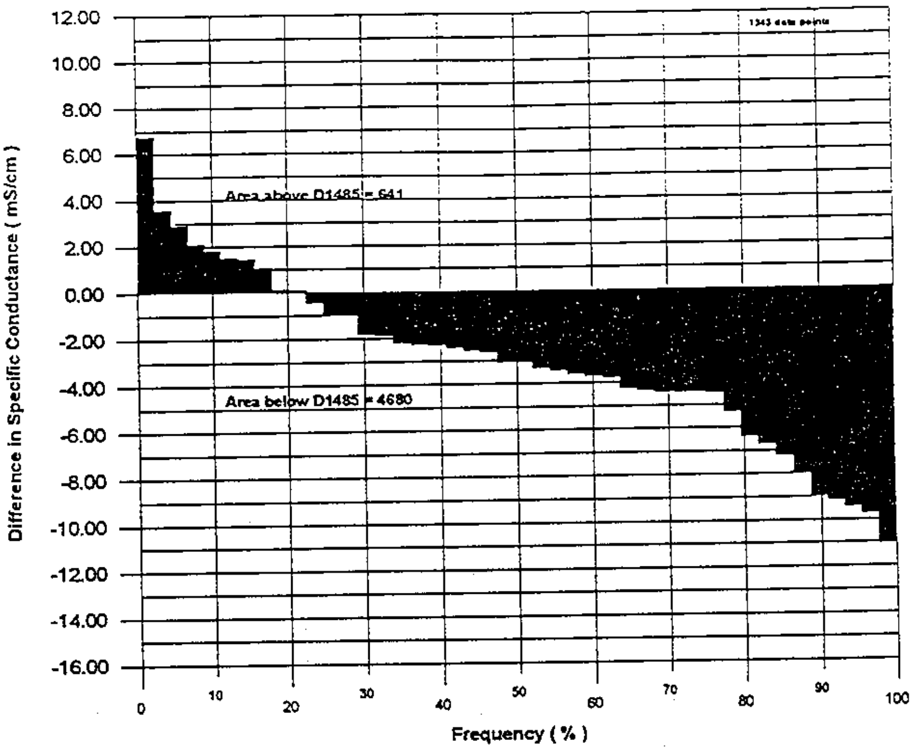


Figure VIII-47

S-49
MEASURED SALINITY MINUS D1485 STANDARD
For October through May of Water Years 1985-92



S-49
MEASURED SALINITY MINUS SMPA STANDARD
For October through May of Water Year 1985-92

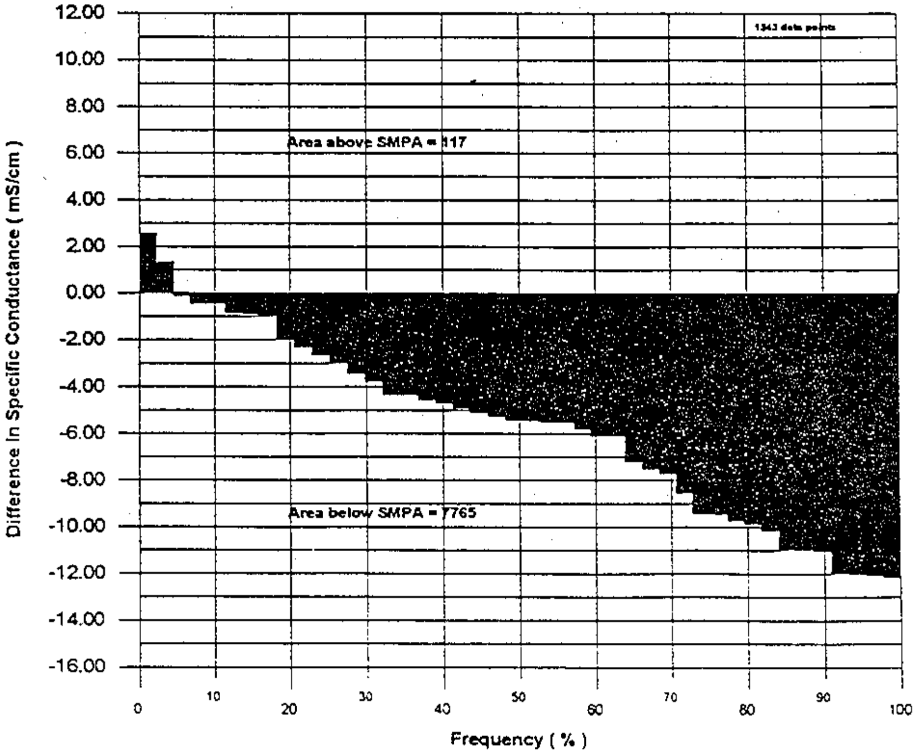
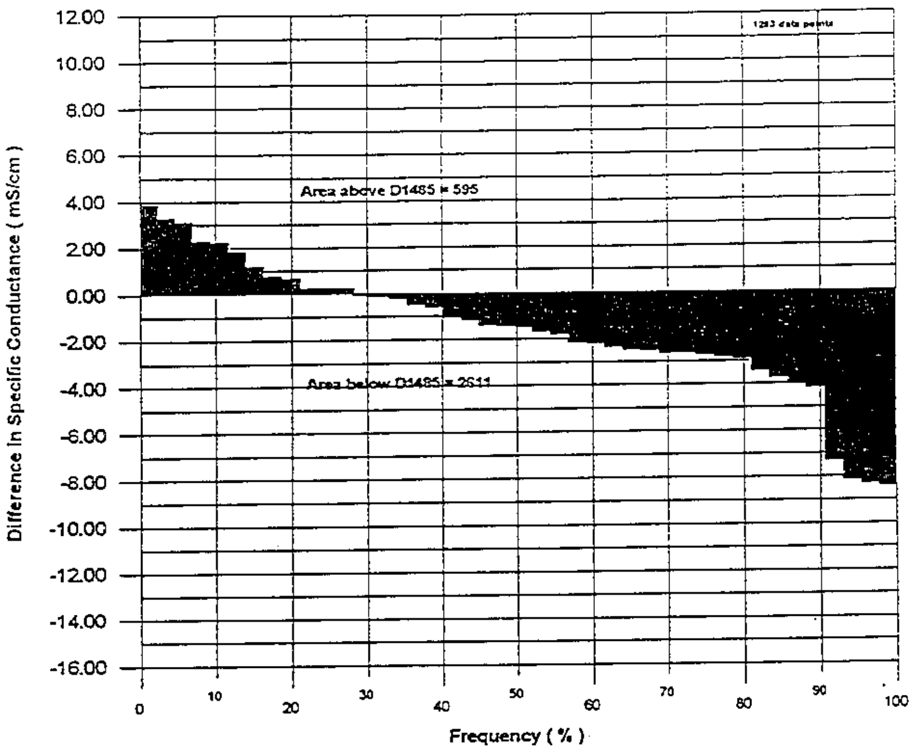


Figure VIII-48

S-42
MEASURED SALINITY MINUS D1485 STANDARD
For October through May of Water Years 1985-92



S-42
MEASURED SALINITY MINUS SMPA STANDARD
For October through May of Water Year 1985-92

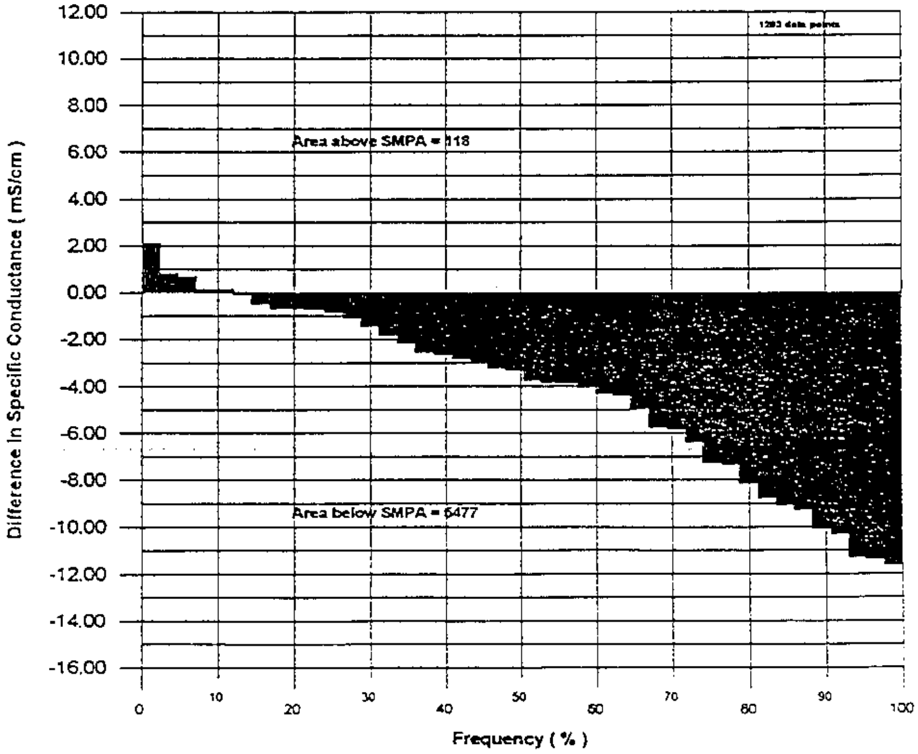
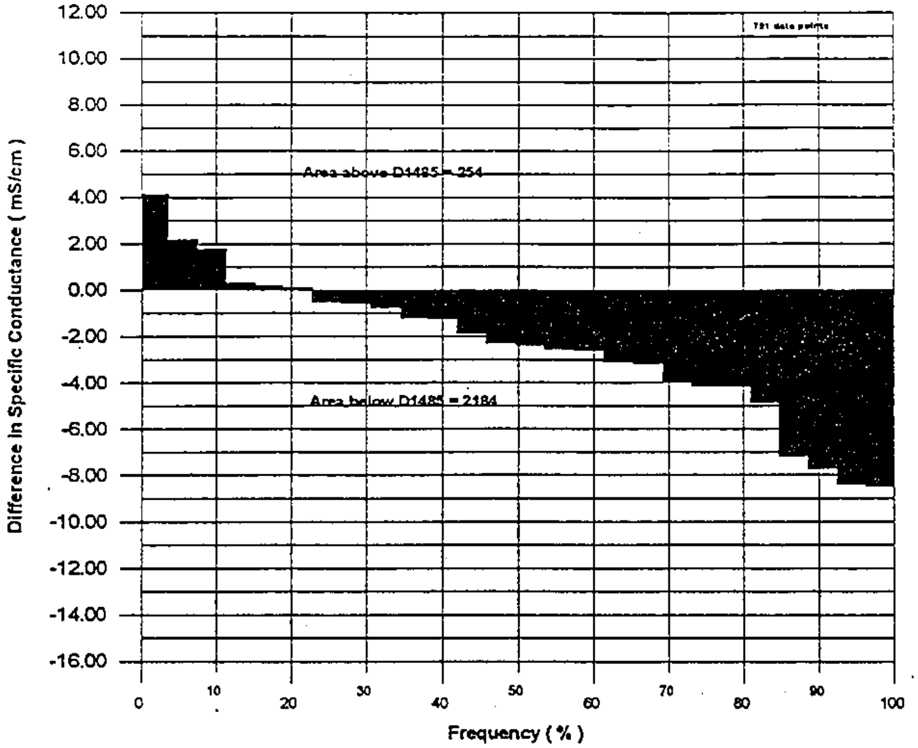


Figure VIII-49

S-21
MEASURED SALINITY MINUS D1485 STANDARD
For October through May of Water Years 1989-92



S-21
MEASURED SALINITY MINUS SMPA STANDARD
For October through May of Water Years 1989-92

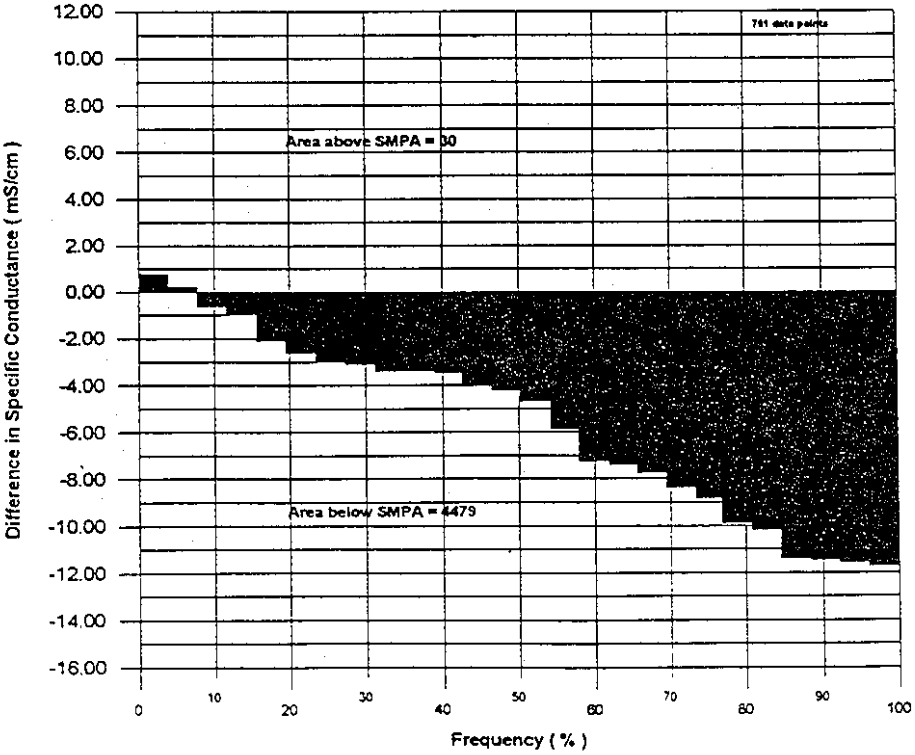
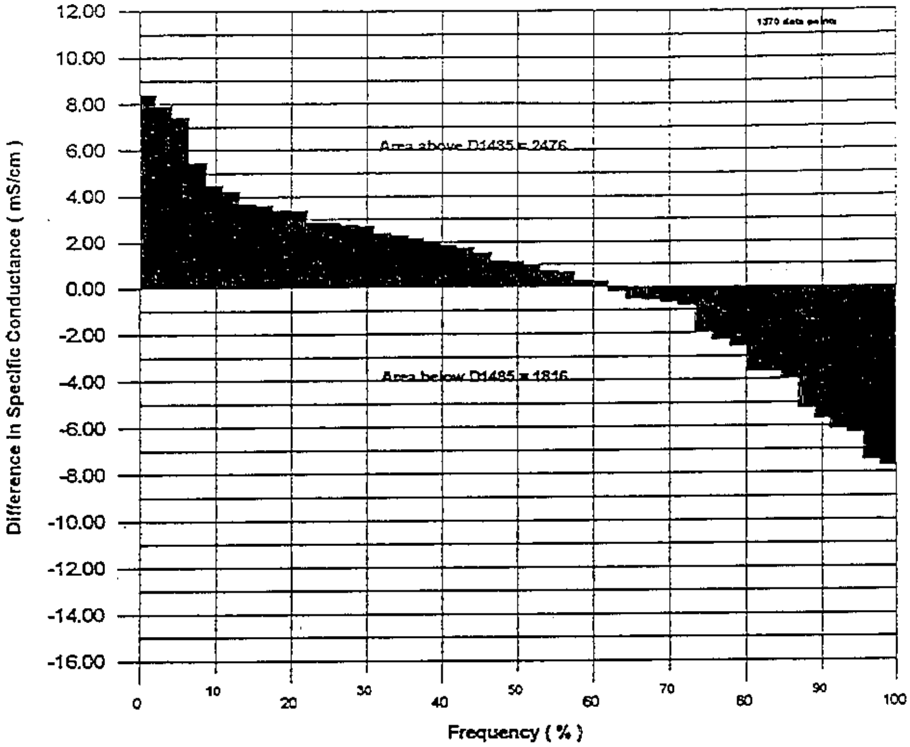


Figure VIII-50

S-35
MEASURED SALINITY MINUS D1485 STANDARD
For October through May of Water Years 1985-92



S-35
MEASURED SALINITY MINUS SMPA STANDARD
For October through May of Water Years 1985-92

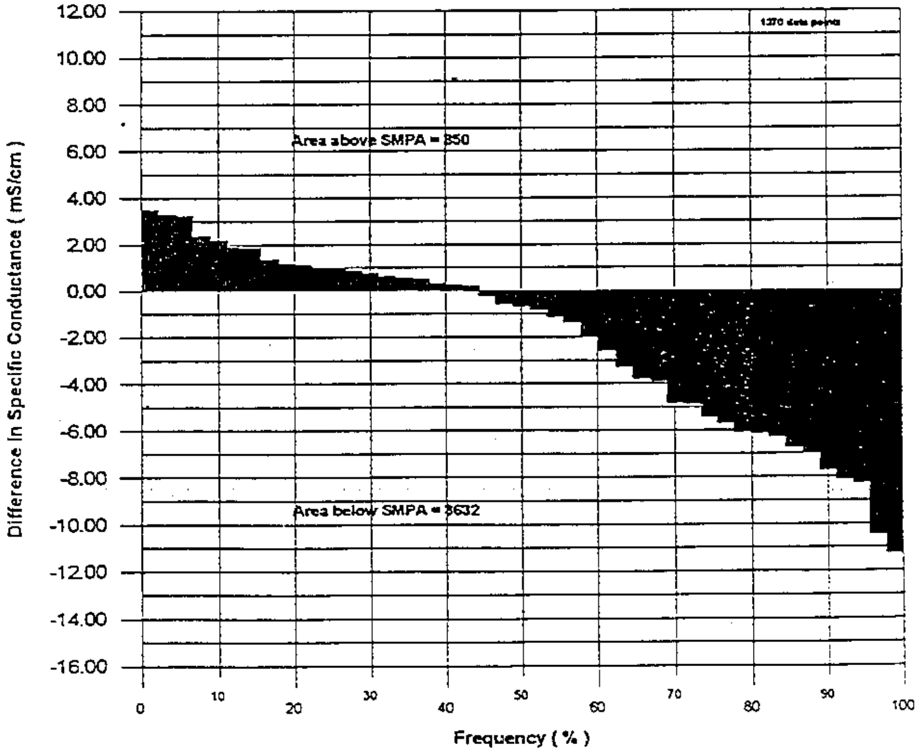
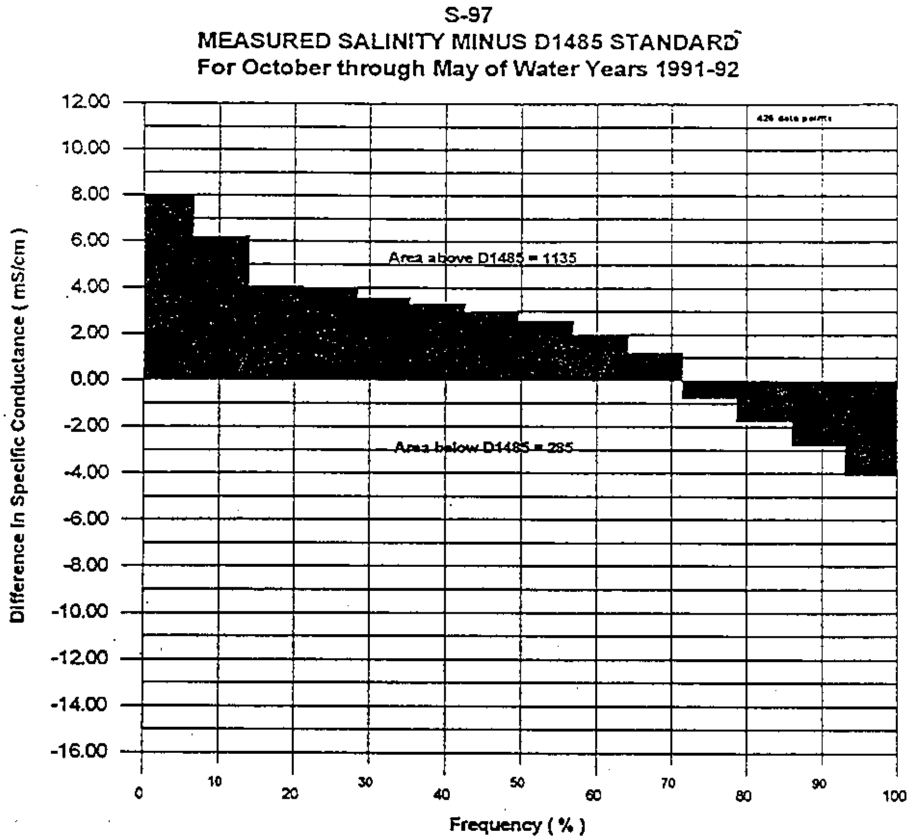
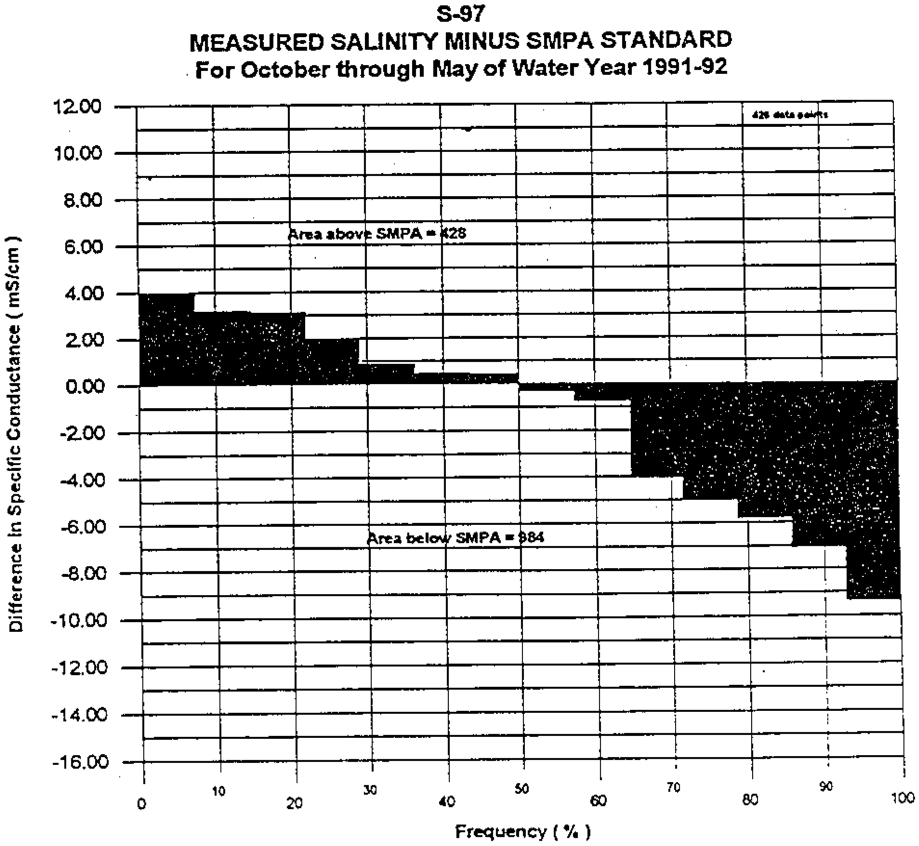


Figure VIII-51


S-97
MEASURED SALINITY MINUS D1485 STANDARD
For October through May of Water Years 1991-92


S-97
MEASURED SALINITY MINUS SMPA STANDARD
For October through May of Water Year 1991-92

To prepare the frequency-area plots for each location, the 1978 Delta Plan and appropriate SMPA (normal or deficiency) standards were subtracted from the respective mean monthly high tide salinity for the control season. The differences were then assigned to every day of the month and sorted from the largest positive difference (above the target standard) to the greatest negative difference (below the target standard). The sorted differences were then normalized from 1 to 100 percent and plotted. The areas above and below the zero line were calculated to indicate the relative duration and extent of salinity above and below the target standard. These areas are reported on the figures.

The areas below the target standards for eastern marsh compliance stations (C-2, S-64, and S-49) are significantly larger than the areas above. The areas for western marsh compliance stations (S-42, S-21, S-35, and S-97) below and above the target standard are either evenly balanced or greater above the target standards.

In conclusion, the implementation of the preferred alternative is expected to result in the maintenance of existing salinity conditions in the eastern marsh and result in a decrease in salinity in the western marsh. The principal environmental concern regarding the marsh is conversion of existing brackish marsh to salt marsh. Fish and wildlife agencies have also expressed concern with conversion of brackish marsh to freshwater marsh in efforts to meet internal Suisun Marsh standards. Therefore, implementation of the standards under the preferred alternative will not have a significant adverse effect on the Suisun Marsh.

7. Agricultural Supply

The SWRCB is not reviewing water quality standards for the protection of agricultural water supplies during this triennial review. Existing standards are adequate to protect the agricultural supply beneficial use.

The SWRCB has established water quality objectives in previous plans to protect Delta agriculture in three geographic areas: the western, interior, and southern Delta. The particular agricultural water quality needs in these areas were determined by analysis of predominant crops, soil type, and irrigation practices. The standards were designed to approximately replicate conditions in the Delta, with some adjustments, before the CVP and the SWP came on-line (without project conditions).

Corn is the predominant salt-sensitive crop in the western and interior portions of the Delta. In the 1978 Delta Plan, an agricultural water quality objective with a base level of 0.45 mmhos/cm EC was set based on evidence submitted by the University of California that this salinity level is necessary to maintain a 100 percent corn yield in this area. On varying dates during the irrigation season, depending on year type, this objective is adjusted to a lower quality. The adjustments, when weighted with the days at 0.45 EC, provide an average salinity throughout the irrigation season approximately equivalent to the average salinity over the irrigation season prior to construction of the projects. The agricultural water quality objectives for the interior Delta are different than the objectives in the western

Delta because water quality in the interior Delta was better during the irrigation season prior to the construction of the projects; therefore, water year type adjustments for the interior Delta are smaller.

During the time period between the 1978 Delta Plan and the 1991 Bay-Delta Plan, more information regarding the quality of water necessary to protect the agricultural beneficial use in the western and interior Delta was gathered. From 1979 to 1984, the SWRCB and the DWR cosponsored a 4-year study to establish the salt tolerance of corn grown in the Delta. The general conclusion of the study was that corn could be grown in the Delta with water supplies with a salinity level of up to 1.5 mmhos/cm EC with no loss in yield provided that controlled leaching was performed periodically to remove accumulated salts. This study did not provide information concerning the effectiveness or economics of leaching practices; therefore, the western and interior Delta standards for protection of agriculture were not changed in the 1991 Bay-Delta Plan. A study was initiated to determine the feasibility and effectiveness of leaching practices currently used in the Delta, but the full results of the study have not been submitted to the SWRCB.

For the southern Delta, the 1978 Delta Plan established objectives based on using beans and alfalfa as representative salt-sensitive crops. An objective of 0.7 mmhos/cm EC in the southern Delta protects beans during the summer irrigation season (April 1 through August 31) and an objective of 1.0 mmhos/cm EC protects alfalfa during the winter irrigation season (September 1 through March 31). Implementation of these objectives was deferred because the DWR, USBR, and SDWA were negotiating the construction of facilities to protect the agricultural productivity of the area. The negotiations were not completed, and the SWRCB proposed a staged implementation of the objectives in the 1991 Bay-Delta Plan, with final implementation to take place by 1996. The objectives in the plan do not change the objectives in the 1991 Bay-Delta Plan except the compliance date for the Old River objectives is extended by 2 years.

The new objectives for protection of fish and wildlife contained in the plan will cause a change in the salinity regime in the Estuary, as discussed in section A.3 of this chapter. During the spring, the increased outflow and San Joaquin River flows required by the plan will improve water quality throughout the Delta. These increased flows, however, may reduce the capacity to provide dilution water from New Melones Reservoir for salinity control purposes at Vernalis, as required by D-1422, depending on how the responsibility to meet the new fish and wildlife objectives are allocated. The SWRCB will address the issue of flow allocation, and its intention to implement the objectives, during the water right phase.

An assumption in the DWRSIM operation study for the preferred alternative is that only 70 TAF of water will be released from New Melones Reservoir on the Stanislaus River to control salinity at Vernalis. D-1422 contains no such limit. This constraint was incorporated into the study because the SWRCB intends to implement the Vernalis EC objective through a combination of agricultural drainage controls and freshwater releases.

The SWRCB believes that the plan will protect agricultural productivity throughout the Delta. Consequently, the plan will not have any significant environmental impact on agriculture in the Bay-Delta Estuary.

8. Municipal and Industrial Supply

The SWRCB is not reviewing water quality standards for the protection of municipal and industrial water supplies during this triennial review. Existing standards are adequate to protect the municipal and industrial supply beneficial uses.

Municipal and industrial uses are currently protected by standards that were originally adopted in the 1978 Delta Plan and were carried over unchanged into the 1991 Bay-Delta Plan. The 250 mg/l chlorides standard is based on the secondary standard for aesthetics (taste) and corrosion set by the California Department of Health Services (DHS). The 150 mg/l chlorides standard, which applies at the Contra Costa Canal Intake during a portion of the year, depending on year type, was established to protect industrial uses. Specifically, this standard was intended to protect the historical water supply of two paper manufacturers in the Antioch area. In adopting this standard, the SWRCB also recognized that the standard provides better water quality for municipal customers.

The new standards for protection of fish and wildlife contained in this plan will cause a change in the salinity regime in the Estuary, as discussed in section A.3 of this chapter. The increased outflow will improve water quality in the Delta, especially in the spring. Therefore, the municipal and industrial uses will continue to be protected by the existing standards. The plan does not have any significant environmental impact on municipal and industrial water supplies in the Estuary.

9. Recreation

The Delta supports year-round recreational uses because of its aesthetic beauty, wildlife, unique waterway system, and temperate climate. The Delta's close proximity to major population centers also contributes to its growing popularity. Recreation in the Delta, mostly water-oriented, exceeds 12 million user days annually (California Legislature 1982) and is expected to rise, particularly with increasing populations in the surrounding counties.

One of the principal recreational activities in the Delta is fishing. As discussed throughout this report, fish populations in the Delta have been declining for a number of reasons. The water quality standards, operational measures, and recommendations in the plan should stabilize or improve the fish populations in the Delta, as discussed earlier in this chapter. Recreational boating is another popular activity in the Delta. Closure of the Delta Cross Channel in some months, as required by the plan, may result in lower water levels (discussed in section A.4 of this chapter) and, thus, negatively impact recreational boating in some waterways. Overall, however, the SWRCB's action should improve recreational opportunities in the Delta, with the exception noted for closure of the Delta Cross Channel.

B. EFFECTS IN UPSTREAM AREAS

Upstream areas are defined in this analysis as the Sacramento Valley and the east side of the San Joaquin Valley. Increased outflow from the Bay-Delta Estuary will require either reduced direct diversions or releases from reservoirs in upstream areas. Therefore, significant adverse impacts are possible. The discussion below is divided into the following sections: (1) reservoir storage; (2) hydropower generation; (3) river flows; (4) land use; and (5) recreation.

1. Reservoir Storage

Section C in Chapter VII discussed in detail the preferred alternative's effect on reservoir storage in the Sacramento River basin, specifically on Clair Engle, Whiskeytown, Shasta, Folsom, and Oroville reservoirs. From 1984 through 1992, average carryover storage for these reservoirs under the preferred alternative is decreased from the base case by 150 TAF per year, as modeled by DWRSIM. This decrease is, on average, 2.7 percent of base case storage.

Section D.1 in Chapter VII discussed the preferred alternative's effect on storage in New Melones Reservoir in the San Joaquin River basin. The average reduction in New Melones carryover storage from 1984 through 1992 is 231 TAF compared to the base case, as modeled by DWRSIM. This reduction is, on average, 15 percent of base case storage.

2. Hydropower Generation

Hydropower impacts of the preferred alternative result both from shifting reservoir releases from the summer to the spring to meet higher spring outflow objectives and from reduced average storage levels. These changes reduce the ability of hydropower plants to meet peak summer loads and the plants' power generation capability (McCann et al. 1994). The preferred alternative's hydropower and cost impacts associated with reduced reservoir storage are discussed in Chapter XII.

Reduction in hydropower generation also leads to impacts on air quality due to the increased burning of fossil fuels. Common air pollutant emissions associated with the generation of electricity by fossil fuels include oxides of nitrogen (NOx), particulate matter of less than 10 microns in diameter (PM10), reactive organic gases (ROG), carbon emissions (Cx), and oxides of sulfur (SOx). Emission levels vary depending on the operating and efficiency levels of the plants (McCann et al. 1994), as well as reservoir storage and river flows. Air pollutant emission impacts of the preferred alternative have not been determined. An emission analysis was conducted for Alternative 1 (described in Chapter XI), which has greater water supply impacts than the preferred alternative. Table VIII-3 shows the net increase in emissions of NOx, SOx, PM10, ROG, and Cx under Alternative 1. Assuming a direct correlation between water supply and air quality impacts, these emissions are expected to be lower under the preferred alternative.

TABLE VIII-3
Net Increase in Air Emissions Under Alternative 1[1]
(tons per year, probability weighted[2])

YEAR	NOx	SOx	PM10	ROG	Cx
1995	231.61	80.57	7.84	5.57	42,427.35
1996	208.46	58.66	7.96	6.02	46,983.95
1997	119.35	65.03	9.29	6.83	50,543.40
1998	85.72	59.78	8.49	5.48	57,037.20
1999	103.57	40.10	8.83	6.72	52,048.45
2000	119.80	57.46	8.96	5.83	55,491.43
2001	73.60	35.42	8.69	6.37	59,980.98
2002	117.11	49.53	8.61	5.51	60,619.40
2003	90.10	46.65	9.46	6.27	65,079.93
2004	73.66	10.19	8.89	7.01	70,244.85
2005	121.24	49.17	7.80	4.47	64,360.98
2006	135.05	43.52	8.70	5.27	64,640.23
2007	234.80	62.76	11.14	4.36	57,399.48
2008	113.23	58.86	8.70	4.92	65,113.00
2009	126.14	58.42	9.15	5.01	66,983.68
2010	155.61	70.30	9.29	5.02	67,790.03
2011	129.68	52.80	8.10	3.99	66,503.55
AVG	131.69	52.90	8.82	5.57	59,602.81

[1] From Table F-1 of "Impact of Bay-Delta Water Quality Standards on California's Electric Utility Costs", prepared by Richard McCann, et al., for the Association of California Water Agencies, October 7, 1994.

[2] 20 percent dry, 55 percent normal, and 25 percent wet years.

3. River Flows

The preferred alternative includes minimum flow requirements in September through December for the Sacramento River. These requirements are not likely to have significant impacts in upstream areas since the required flows are similar to base river flows. However, the preferred alternative has other standards (e.g., export limits, salinity standards, outflow requirements, etc.) which indirectly affect flows on the Sacramento River. Overall, the preferred alternative's effects on Sacramento River flows are expected to be similar to those on Delta outflow, discussed in section A.1 of this chapter. As Delta outflows increase under the preferred alternative for all months during 1984 through 1992, with greatest increases in spring months, Sacramento River flows are expected to increase accordingly.

The preferred alternative's effects on historical San Joaquin River flows in spring months of water years 1984 through 1992 are shown in Figures VIII-52 through VIII-60, respectively. The applicable San Joaquin River flow standard, which is dependent on the location of the isohaline, was selected using the analysis described in section A.3 of this chapter. The figures illustrate the additional water required from historical conditions to meet the minimum San Joaquin River flow standards in the preferred alternative. The greatest impacts are in the April 15 through May 15 period when additional flows are required in all years except 1986, a wet water year. To meet the minimum flow standards in the preferred alternative, average April 15 through May 15 flows must be increased by 3,319 cfs in 1984 (an above normal year); by 1,548 cfs in 1985 (a dry water year); and by 705 cfs, 972 cfs, 1,448 cfs, 1,795 cfs, 2,075 cfs, and 1,901 cfs, in the critical years of 1987 through 1992, respectively. In critical years 1991 and 1992, additional flows are also required in June.

Figure VIII-61 compares average historical San Joaquin River flows at Vernalis in October with the minimum flow standard in the preferred alternative. Under the preferred alternative, additional average monthly flows of 7 cfs and 211 cfs are required in the two most recent critical years of 1991 and 1992, respectively, to bring average monthly flows up to 1,000 cfs. The 28 TAF pulse in October would not have been required in any year in the reference period.

4. Land Use

DWRSIM does not distribute the impacts of changes in regulatory conditions among all the water users in the Central Valley. Rather, the model assumes that upstream depletions in the Sacramento and east side San Joaquin valleys are set and shortages are borne by the exporters. In order to estimate any land use changes that might occur in upstream areas, assumptions regarding the allocation of shortages among all of the water users must be made. This issue is the subject of the water right phase of these proceedings which will commence upon adoption of the plan. The assumption used throughout this report is that the CVP and the SWP are surrogates for the entire water system, and these projects bear all shortages. For the purposes of this qualitative discussion on land use, this assumption is changed to the

FIGURE VIII-52
HISTORICAL SAN JOAQUIN RIVER SPRING FLOWS
AT VERNALIS FROM ABOVE NORMAL WATER YEAR 1984

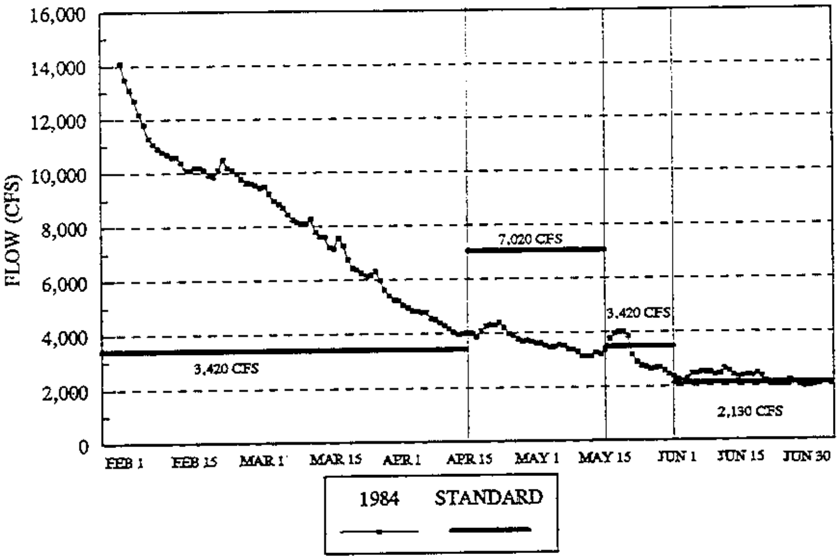


FIGURE VIII-53
HISTORICAL SAN JOAQUIN RIVER SPRING FLOWS
AT VERNALIS FROM DRY WATER YEAR 1985

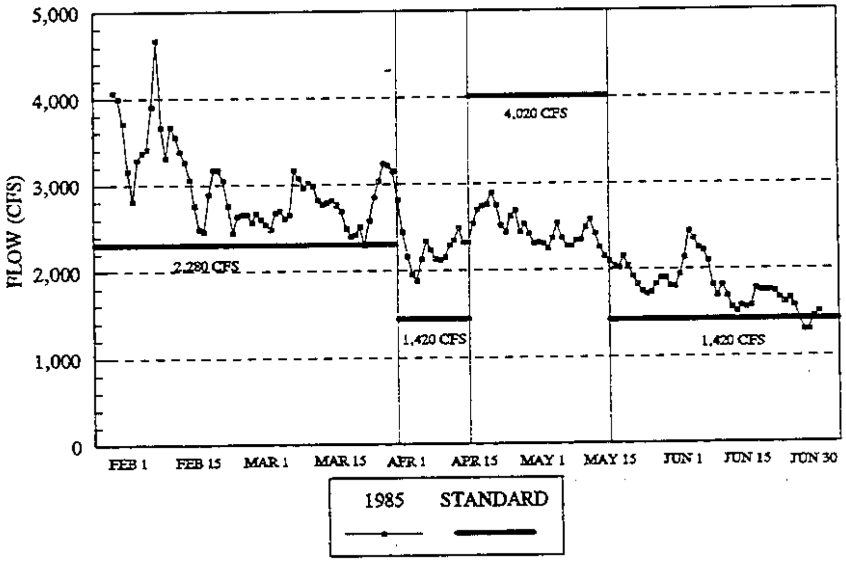


FIGURE VIII-54
HISTORICAL SAN JOAQUIN RIVER SPRING FLOWS AT VERNALIS FROM WET WATER YEAR 1986

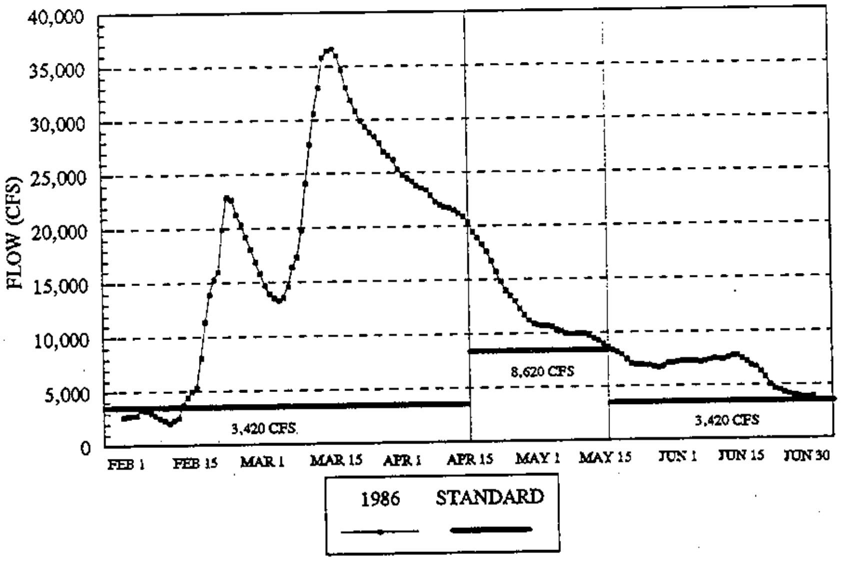


FIGURE VIII-55
HISTORICAL SAN JOAQUIN RIVER SPRING FLOWS AT VERNALIS FROM CRITICAL WATER YEAR 1987

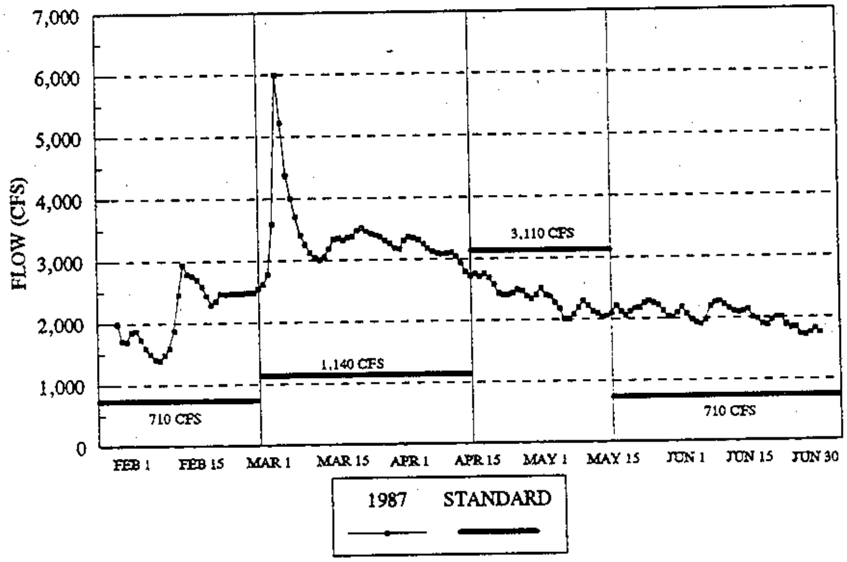


FIGURE VIII-56
HISTORICAL SAN JOAQUIN RIVER SPRING FLOWS AT VERNALIS FROM CRITICAL WATER YEAR 1988

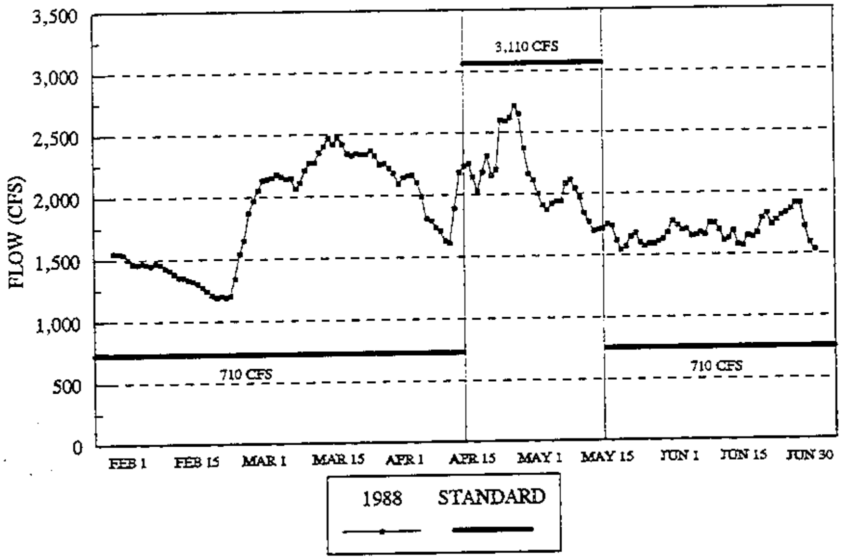


FIGURE VIII-57
HISTORICAL SAN JOAQUIN RIVER SPRING FLOWS AT VERNALIS FROM CRITICAL WATER YEAR 1989

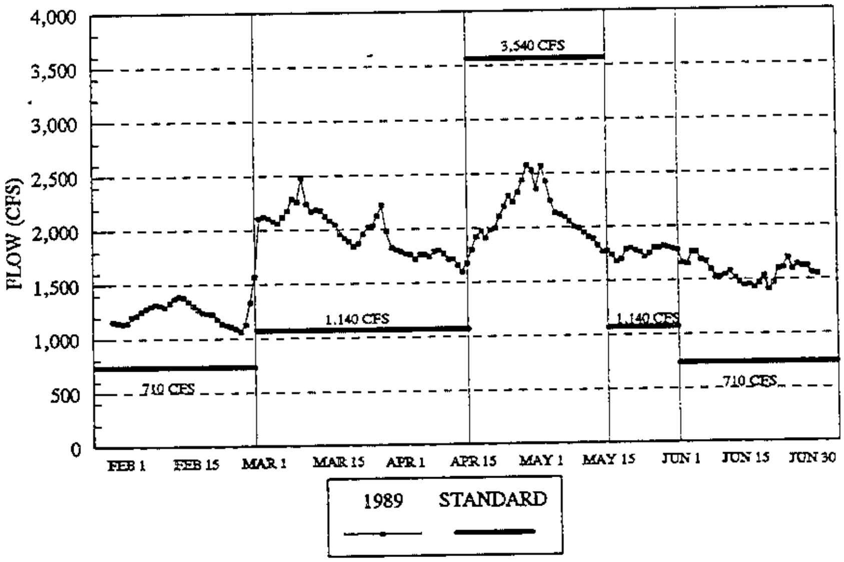


FIGURE VIII-58
HISTORICAL SAN JOAQUIN RIVER SPRING FLOWS AT VERNALIS FROM CRITICAL WATER YEAR 1990

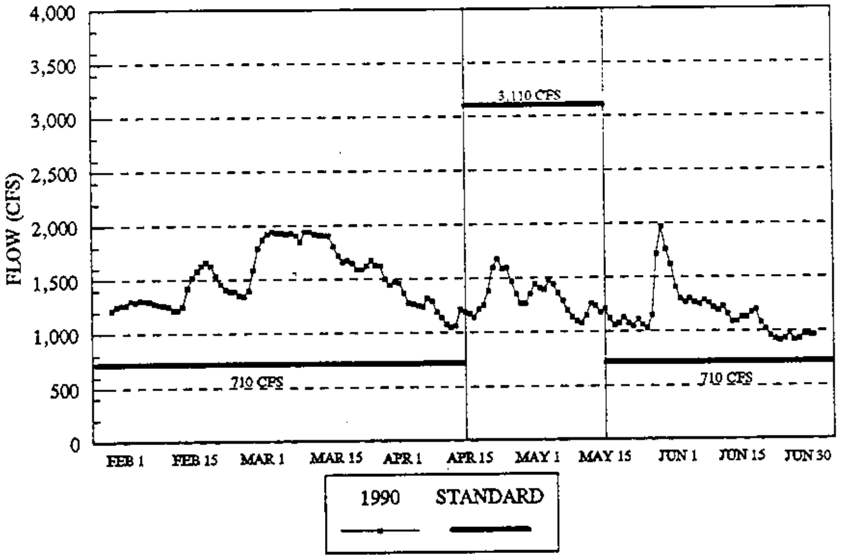


FIGURE VIII-59
HISTORICAL SAN JOAQUIN RIVER SPRING FLOWS AT VERNALIS FROM CRITICAL WATER YEAR 1991

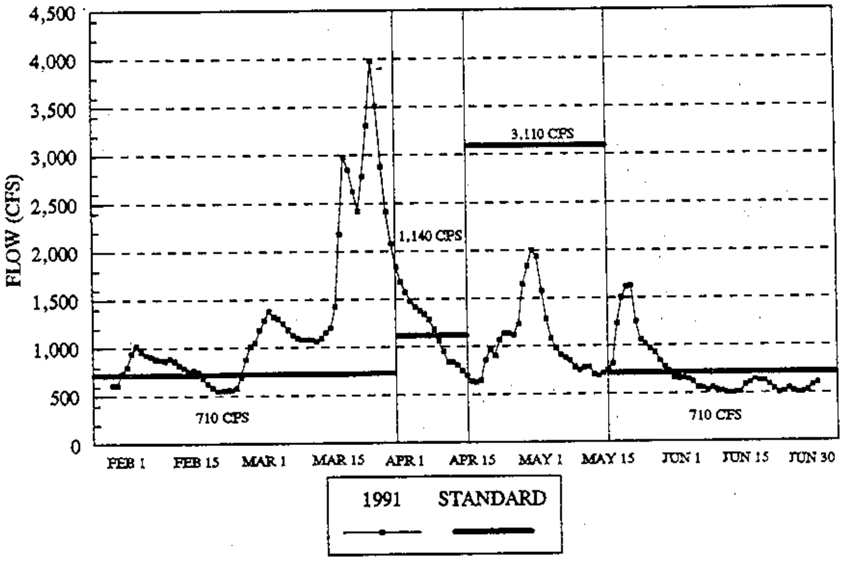


FIGURE VIII-60
HISTORICAL SAN JOAQUIN RIVER SPRING FLOWS
AT VERNALIS FROM CRITICAL WATER YEAR 1992

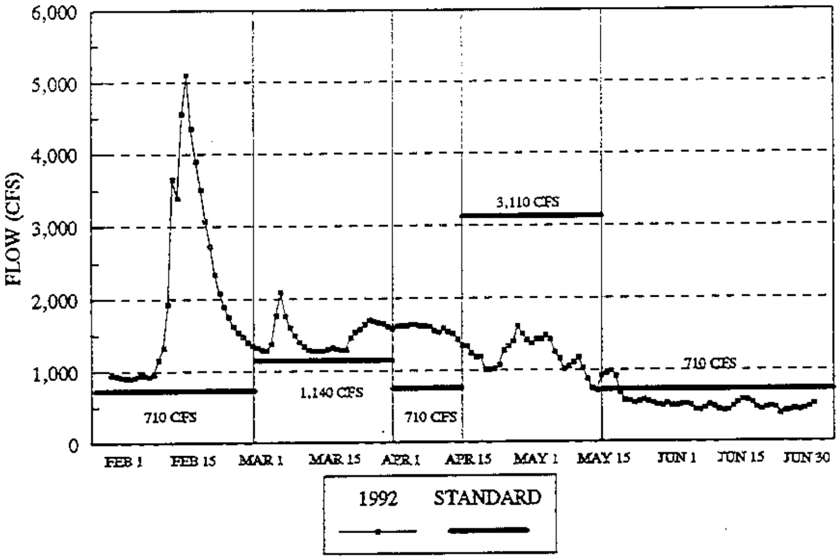
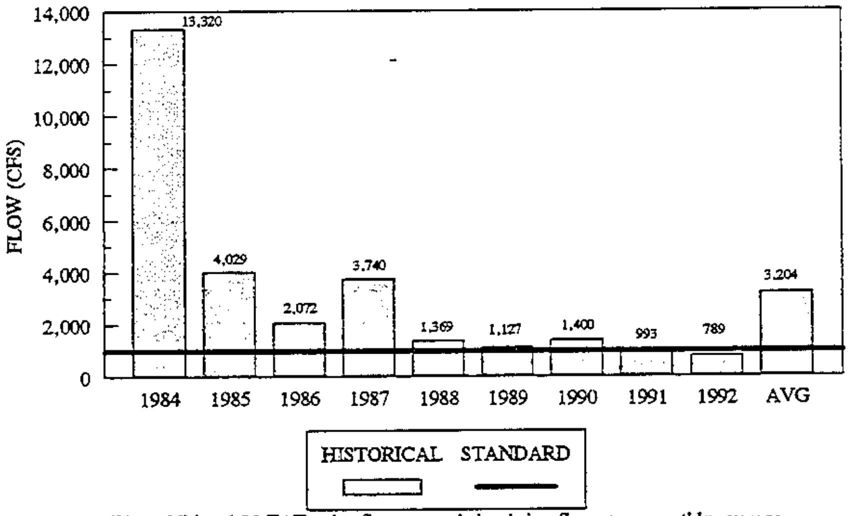


FIGURE VIII-61
AVERAGE HISTORICAL OCTOBER SAN JOAQUIN RIVER FLOWS
AT VERNALIS FROM WATER YEARS 1984-1992



Plus additional 28 TAF pulse flow as needed to bring flows to a monthly average of 2000 cfs except for a critical year following a critical year.

assumption that water users in upstream areas will be required to contribute an unknown amount of water to meet Bay-Delta Estuary standards.

Land use changes that may occur as a result of the plan cannot be predicted because such changes are the result of numerous decisions made by individuals, water districts, and governmental agencies. However, the most likely land use changes as a result of implementation of the plan are agricultural land retirement and crop shifts.

A study of the response of the agricultural community to reduced water supplies was recently completed (Archibald et al. 1992). This study concluded that agricultural producers will respond to decreased surface water supplies in one of three ways: (1) obtaining alternative sources of supply to supplement reduced surface water allocations; (2) increasing water use efficiency; and (3) matching land use and cropping patterns to available water supplies through a combination of fallowing and shifts in crop type. These responses can be further broken down into long- and short-term options. The third response is relevant to this section.

In general, agricultural producers expect that, if shortages continue, marginal land will be taken out of production. The extent of reductions will depend on the costs and feasibility of alternative water supplies. The option of land retirement can be high for producers in districts with high fixed costs as these costs must be spread over remaining acres if land cannot be sold or leased to other producers.

The case study approach used by Archibald et al. (1992) also indicated that cropping patterns can change as a result of water shortages. For example, between 1989 and 1991, drought years when water shortages occurred, cotton, rice, alfalfa, and vegetable (excluding tomatoes) acreage declined while tomato acreage increased and acreage in permanent crops remained stable. These shifts exceeded normal trends, but factors other than water reductions could be responsible for these shifts.

While crop shifts are possible, there are a wide range of constraints that limit producers' abilities to shift cropping patterns in response to water shortages. These constraints include: (1) federal commodity program regulations that can encourage or discourage shifts away from program commodities such as cotton and rice; (2) multi-year supply obligations to processors of such crops as garlic, onions, processing tomatoes, and rice; (3) concern about maintaining market share in a particular commodity; (4) producer ownership of processing operations; (5) agroclimatic constraints, including soil type, temperature ranges, and pest conditions; and (6) farm management expertise, and machinery and equipment complements, required to grow a particular crop.

If the SWRCB requires upstream water users to provide some of the water necessary to meet these new standards, both crop shifts and land retirement are likely.

5. Recreation

Lakes and rivers have always been a primary focus for outdoor recreational activities. The abundance of potential recreational sites limited the need for careful planning of recreational facility development. This situation changed as a rapidly growing population sought out recreational opportunities.

Most recreational facility developments are on streams, lakes, or reservoirs operated for other purposes. Recreational activity and resources generally do not consume significant amounts, no more than 3 percent of the statewide total, of water (DWR 1994d). Consumptive use occurs when water allocated specifically for recreation, with no other benefit, is not recaptured downstream or is evaporated from a larger than normal surface area.

In general, recreational uses that could be affected by the plan can be separated into three categories, as discussed below: reservoir recreation; river recreation; and wildland recreation. Conflicts among these categories can arise in water resource planning. Minimally fluctuating reservoir levels provide optimum reservoir recreational opportunities, but higher stream flows, which deplete reservoir levels, may provide more water for wildlife areas, healthy fisheries, and rafting opportunities.

a. Reservoir Recreation. Reservoir operations for water supply are usually adequate to support established recreational activities, particularly when surface runoff from precipitation is near normal. Alterations in operations, because of drought, regulatory changes, or increasing demand, can reduce both available recreational opportunities and per capita benefits. In general, reservoir recreational benefits decrease as receding water levels reduce water surface area because: (1) recreational facilities are farther from shorelines; (2) boat ramps are less accessible; (3) boating and swimming hazards are exposed; (4) swimming area beaches become unusable; (5) fishing conditions are degraded; and (6) the aesthetic qualities of the reservoirs decrease. Recreation attendance drops substantially when water levels fall. During the 1976-1977 drought, total attendance at State and federal reservoirs in California was reduced about 30 percent, with some reservoirs experiencing declines as much as 80 percent, while attendance at a few stable reservoirs increased. A similar pattern developed during the 1987-1992 drought although there were even fewer stable reservoirs (DWR 1994d).

As discussed in section B.1 of this chapter, reservoir levels in the Sacramento and San Joaquin river basins are likely to decline under the preferred alternative. Whether declines occur, and the magnitude of the declines, will depend on management decisions made by reservoir operators responsible for meeting the new flow standards. Lower reservoir levels can have a significant impact on recreational activities.

b. River Recreation. Riverine environments offer types of recreation not available from the large water surface impoundments. Some of the recreational opportunities associated with rivers and streams are fishing, swimming, and white-water sports such as rafting, kayaking, and canoeing. In some cases, these uses can conflict. For example, peak releases in the summer from the North Fork Stanislaus River project greatly increased white-water rafting but reduced opportunities for swimming (DWR 1994d).

The change in Sacramento River and San Joaquin River flows at Freeport and Vernalis, respectively, were discussed in section B.3 of this chapter. The conclusion in that discussion is that the only significant effect on river flows is an increase over historical flows at Vernalis during the spring and fall pulse flows. While this conclusion is true at this downstream point, it may not be true immediately below rim reservoirs that may be assigned responsibility to provide the required flows. The particulars of this change in upstream flow regime will be analyzed during the water right phase.

The change in the flow regime could have an impact on rivers below rim reservoirs. Higher flows in the spring could increase opportunities for rafting and decrease swimming opportunities. The overall flow regime is intended to improve conditions for anadromous fisheries, which have substantial recreational benefit. Overall, some aspects of river recreation may be adversely affected by implementation of the standards.

c. <u>Wildland Recreation</u>. Many designated wildlife refuges in California are dependent on water deliberately transported to the refuges. Seasonal wetland habitat at such refuges is integral to maintenance of local wildlife and migratory waterfowl populations along the Pacific Flyway. Historically, recreational values associated with such wildlife have focused primarily on hunting, but more recently bird watching has become a significant use.

The SWRCB does not believe, and does not intend, that the standards in the plan should affect the water supplies available for wildlife refuges. Therefore, the preferred alternative should not have any significant environmental effect on wildland recreation.

6. Ground Water Pumping

Since many upstream water users will replace reduced surface water supply with ground water, any such reduction in surface water supply caused by implementation of the preferred alternative will result in increased pumping of ground water and exacerbation of the overdraft problem in California. The impacts of the preferred alternative on ground water pumping are discussed in detail in section C.1 of this chapter. To the extent that upstream users experience reduced surface water supply as result of the standards in the plan, the impacts on ground water pumping are likely to be similar to those described in section C.1.

C. EFFECTS IN EXPORT AREAS

Reduced water deliveries in export areas as a result of implementation of the preferred alternative are expected to cause significant adverse impacts. The discussion below is divided into the following sections: (1) ground water pumping; (2) land use; (3) wildlife habitat; (4) urban landscape; and (5) recreation.

1. Ground Water Pumping

In a year of average precipitation and runoff, an estimated 15 MAF of ground water is extracted and applied for agricultural, municipal, and industrial use in California at the 1990 level of development. Under the same conditions, the ground water system is recharged with over 13.5 MAF of water from rainfall, streambed seepage, and deep percolation of applied water. Therefore, the average amount of ground water extracted in the State exceeds the average recharge by about 1.3 MAF (DWR 1994d).

The reduction in surface water deliveries caused by implementation of the standards will result in increased pumping of ground water because many water users will replace their reduced surface water supply with ground water. Ground water pumping is unregulated in much of California. Consequently, water users in most export areas can drill new wells or increase their pumping capacity without encountering legal, institutional, or governmental constraints (Archibald et al. 1992). However, substitution of ground water for surface water can cause environmental impacts, such as: (a) depletion of ground water resources; (b) permanent loss of aquifer capacity; (c) surface land subsidence; (d) seawater intrusion; (e) decreased agricultural productivity; (f) water quality deterioration; and (g) increased energy consumption. Because the magnitude of these effects (which depend on water users' responses to implementation of the preferred alternative) cannot be accurately predicted, a qualitative discussion of these impacts is provided below.

a. **Depletion of Ground Water Resources**. The reduction in surface water supplies that will result from implementation of the standards will exacerbate the overdraft problem in California. (Overdraft is defined as the amount of ground water extracted in excess of the perennial yield.) The present level of annual overdraft in some ground water basins affected by the plan, at the 1990 level of development and assuming D-1485 regulatory conditions, is provided in Table VIII-4 (DWR 1994d).

Table VIII-4. Ground Water Overdraft by Hydrologic Region at 1990 Level of Development

Region	TAF
Central Coast	250
South Coast	20
San Joaquin	210
Tulare Lake	340

An exact estimate of the magnitude of the increased overdraft that will occur as a result of the standards is not possible because of the uncertainty of the response of individual water users. However, the worst case estimate in the short-term is that all of the reduced surface water supplies from the Delta will be replaced by increased ground water pumping, and the overdraft will increase by the magnitude of the water supply impact of the plan (discussed in Chapter VII).

b. **Permanent Loss of Aquifer Capacity**. Permanent loss of aquifer capacity occurs when fine-grained beds of clay and silt, called aquitards, compress as water is extracted. Once the aquitards are compacted, they can never hold as much water again, resulting in a permanent loss of aquifer water storage capacity. This condition has occurred in the San Jacinto and San Joaquin valleys (SWC 1992b).

c. **Surface Land Subsidence**. Consolidation of water-bearing formations causes subsidence of the land surface. Land subsidence can change canal gradients, damage buildings, and require repair of other structures (DWR 1994d). Incidents of subsidence and major geologic hazards due to ground water withdrawal in San Joaquin, San Bernardino, Riverside, and Los Angeles counties have been documented. The lowering of the land surface in the San Joaquin Valley is a result of many geologic and hydrologic processes; however, one of the primary causes is ground water extraction. The U.S. Geological Survey (USGS) reports that, prior to 1977, 5,200 square miles of the San Joaquin Valley floor area subsided by at least 1 foot, and in some areas, subsidence has been as much as 30 feet. No recent land subsidence surveys have been made, but the DWR reports that subsidence has started again in western Fresno County and may be occurring elsewhere in the San Joaquin Valley (SWC 1992c). Data collected in Westlands Water District indicate that subsidence occurred in 1990, 1991, and 1992, with the highest amount of subsidence occurring in 1991 (DWR 1994d).

Accurate prediction of subsidence is generally not possible with our present level of knowledge or current data about the extent and properties of aquifer sediments in subsidence areas. In some areas, subsidence occurs when ground water levels decline below a certain level.

d. **Sea Water Intrusion**. Declining ground water levels along the coast causes seawater to intrude into freshwater aquifers. The resulting increase in ground water salinity eliminates many of the beneficial uses of the water. The response to seawater intrusion is to either reduce pumping, close wells, or construct a seawater intrusion barrier. The latter alternative is expensive and is employed only if the ground water storage capacity is critically needed.

Los Angeles County operates seawater intrusion barrier projects in West Basin and Dominguez Gap. Los Angeles and Orange counties jointly operate a seawater intrusion barrier in Los Alamitos Gap, which straddles the border between the two counties. In most of these barriers, water from wastewater recycling facilities is injected and flows down-gradient toward the ocean, as well as inland areas, where it mixes with ground water in the aquifer and can be extracted by irrigation and municipal wells.

e. Decreased Agricultural Productivity. Reduced surface water supplies may contribute to problems of salt buildup in agricultural soils because substitute ground water supplies have higher salinity levels. Excess salinity in the plant root zone negatively affects crop plants through a reduction in the growth rate and, hence, production. Scientists generally believe that plant growth is inhibited as plants expend more energy under high salt conditions to acquire water from the soil and to make biochemical adjustments necessary to survive (SWC 1992c).

f. Water Quality Deterioration. A change in ground water gradient may accelerate movement of point and nonpoint source contaminants toward water-producing wells. This accelerated movement of contaminants is exacerbated where ground water levels have been lowered significantly because of increased extraction (DWR 1994d).

g. Increase in Energy Consumption. Increased ground water pumping will result in higher pumping lifts due to lower ground water levels and, thus, increasing energy consumption.

2. Land Use

As discussed in section B.4 of this chapter, the most likely land use changes in the export areas as a result of implementation of the standards are agricultural land retirement and crop shifts. The discussion of this issue contained in section B.4 is also relevant to the export areas and is not repeated here.

The Zilberman Rationing Model used in the economic analysis of the plan (Chapter XII) provides an estimate of the quantity of land that will be fallowed in areas subject to water supply reductions due to implementation of the standards in the plan. Assuming worst case conditions of limited transfers and no crop shifts, this model estimates that approximately 48,000 acres and 57,000 acres will be fallowed over the 71-year average hydrology and the 7-year worst case hydrology, respectively. These acreage reductions would be distributed throughout the Central Valley if water supply impacts are distributed among all water users. However, if the CVP and the SWP are held largely responsible for meeting the standards, the majority of the reductions would be borne by the projects' contractors.

The agricultural acreage reductions and crop shifts that are likely to occur in export areas as a result of implementation of the preferred alternative are a significant impact.

3. Wildlife Habitat

Presently, export water from the Bay-Delta watershed supports wildlife habitat because of both planned deliveries of export water to wildlife refuges and other habitat areas, and incidental benefits during transport, use, and discharge.

Transport, use, and discharge of water in agricultural areas creates wetland, riparian, and fish habitats (SWC 1992b). Reductions in water supply will result in increased conservation and land fallowing, which will decrease both the water quality and water quantity available for these uses. The water quality issue arises because conservation and reuse of tail and tile water tend to increase the concentrations of salt and other pollutants in the water ultimately discharged. These pollutant increases reduce the value of the discharge water to wildlife habitat. Fallowed lands also can have an impact on the environment because pre-irrigation can provide wintering habitat for waterfowl and grain crops can provide food supply for wintering waterfowl (SWC 1992d). However, fallowed land can also provide beneficial habitat for dry land species.

Water from return flows and discharges is also important in urban areas. This water creates and supports wetland and riparian habitats by establishing live streams and creating prolonged soil moisture in the upper soils in spreading basins, natural creeks, and man-made flood control channels. These habitats support the growth of wetland and riparian plants such as cattails and willows. These types of habitat are highly valuable for wildlife because they support a wide variety and abundance of fish, insects, invertebrates, birds, amphibians, and mammals. Wetland and riparian habitats are particularly important to wildlife in Southern California due to the arid nature of most of the region.

An example of the importance of runoff from urban areas and the discharge of treated effluent in creating and maintaining significant wetland habitat can be found along the Santa Ana River and at Prado Basin in Orange and Riverside counties. Prado Basin is a major flood control facility in eastern Orange County along the Santa Ana River. It impounds water during the winter for flood control. As a consequence of this temporary impoundment, extensive wetland habitat has been created in the 9,000-acre basin. There is an abundance and diversity of wildlife in the basin, including migratory waterfowl, raptors, large mammals, and spring-breeding birds. There are numerous wastewater treatment plants in the Santa Ana River watershed above Prado Basin which discharge year-round into the river and its tributaries. In addition, the watershed has changed from a predominantly agricultural area to a highly urbanized area with substantial urban runoff. At this time, the summer base flow in the Santa Ana River at Prado Basin is due entirely to discharges from the upstream wastewater treatment plants. This artificial flow in the river creates wetland conditions in Prado Basin by increasing the duration and amount of surface water and increasing soil moisture available to plants through rising ground water. The reduction in the delivery of imported water to the region could result in lower levels of runoff and wastewater discharge. Natural and man-made wetland habitats reliant on this runoff could be adversely affected because live streams may be precluded, insufficient runoff could be available to saturate the upper soils to support wetland vegetation, and significant wetland habitat dependent on this runoff could be degraded and possibly destroyed as ground water elevations dropped.

Based on these considerations, the reduction in water exports expected as a result of implementation of the preferred alternative could adversely affect wildlife habitat, depending on the actions by water users in response to water shortages. Quantification of these impacts is speculative at this time.

4. Urban Landscape

Under the preferred alternative, urban areas will receive decreased water supplies from the Delta when the plan is implemented, which can result in environmental impacts. The State Water Contractors have identified the following uses and beneficial effects of urban landscapes (SWC 1992e): aesthetics and scenic design; embellishment of private dwellings and surroundings; creation of private, domestic space; community involvement activities, as in community gardens; public amenities such as public parks, parkways, greenways, and scenic reservations; wildlife habitat; reduction in use of fossil fuels for air conditioning and heating with a concomitant reduction in production of certain pollutants; absorption of certain pollutants; reduction of water pollution in wetlands; resistance to erosion, especially in areas of steep slopes, unstable soils, and variable rainfall; as aid in flood control; and in biological conservation, including conservation of endangered species.

Because urban landscape depends on an adequate water supply for its sustenance, a reduction in that supply could adversely affect some of the beneficial effects of an urban environment. During the 1987-1992 drought in Southern California, there was a well-documented loss of ornamental trees and landscaping in Santa Barbara County that resulted in wide-ranging economic and social effects.

In the long-term, lower water supplies are likely to result in locally-mandated, more efficient management of water resources. Most of the elements of such management are contained within the Memorandum of Understanding Regarding Urban Water Conservation in California, which is discussed under section A.1 in Chapter X. With respect to urban landscape, one element of more efficient management is implementation of xeroscape programs. Expanded use of xeroscape techniques will result in a change in the urban landscape over the long-term.

5. Recreation

The principal recreational facilities in southern California associated with exports from the Delta are reservoirs operated by the DWR and the Metropolitan Water District of Southern California (MWD). The reservoirs operated by the DWR provide opportunities for swimming, boating, fishing, picnicking, and sightseeing. Reservoirs operated by the MWD and local purveyors, with the exception of Lake Mathews where public use is prohibited, provide these same opportunities, excluding swimming. Extensive recreational facilities have been constructed at many of these reservoirs, including Lake Casitas, Lake Skinner, Castaic Lake, Lake Perris, and Pyramid Lake (SWC 1992b). Implementation of the standards will not have a substantial effect on these reservoirs and their recreational use because the reservoirs are operated, in part, to provide emergency storage in the event supplies into southern California are cut. Therefore, reservoir levels should not change significantly under the regulatory conditions in the plan.

In central California, the principal recreational feature of the SWP and the CVP is San Luis Reservoir and O'Neill Forebay. This facility provides storage for water diverted from the Delta for later delivery to the San Joaquin Valley and southern California. There are extensive recreational developments and three wildlife areas around the reservoir and at O'Neill Forebay which offer camping, picnicking, sail and power boating, water skiing, wind surfing, fishing, swimming, hiking, bicycling, and waterfowl hunting. San Luis Reservoir operation will change under the conditions in the plan, as described in Chapter VII. This change may affect recreational opportunities at the reservoir.

Recreational facilities have also been developed along the California Aqueduct. Fishing is permitted in canal reaches along nearly 400 miles of the California Aqueduct, beginning at Bethany Reservoir and extending to just north of Silverwood Lake. Fish from the Delta have spread throughout the aqueduct system. Fishing opportunities should not be significantly affected by implementation of the standards because aqueduct water levels should not fluctuate appreciably.

There are also recreational facilities in export areas that are not directly related to CVP and SWP facilities but could be affected by decreased water supplies. For example, the Orange County Water District owns approximately 2,100 acres in the Prado Basin in Riverside County. The acreage includes about 600 acres of constructed ponds fed by water diverted from the Santa Ana River. The land is leased to a duck hunting and dog training concession. These recreational facilities draw approximately 50,000 participants annually. Similarly, downstream of Prado, Orange County Water District owns approximately 1,100 acres used for spreading flows of Santa Ana River and imported water. Anaheim Lake and Santa Ana River Lakes are deep spreading basins that are also leased to a fishing concession for trout fishing (WACO 1992a). A reduction in SWP exports could reduce Santa Ana River flows, thereby making less water available for these and other recreational facilities dependent on imported water supplies.

D. NEED TO DEVELOP AND USE RECYCLED WATER

1. Background

Water reclamation and reuse in California has long been supported because of the arid and semi-arid condition in the State. Reclaimed water has been intentionally used as a nonpotable water supply source in California for nearly a century. Historically, its application generally has been motivated as a cost-effective means of wastewater treatment and disposal. However, due to drought and long-term water shortages, water reclamation as a means to augment fresh water supplies has received significant emphasis in recent years, both in State policy and local water supply planning (SWRCB 1990, SWCC/BDRSWG 1991).

In July 1991, the Porter-Cologne Water Quality Control Act was amended to include among the factors to be considered in establishing water quality objectives (Water Code §13241), "the need to develop and use recycled water". The amendment also applied the existing definition of "reclaimed water" to "recycled water" and declared reclaimed or recycled water as a valuable resource. The current definition (Water Code §13050) is: "'Reclaimed water' or 'recycled water' means water which, as a result of treatment of waste, is suitable for a direct beneficial use or a controlled use that would not otherwise occur and is therefor considered a valuable resource."

In addition, the 1991 legislation enacted the Water Recycling Act of 1991 (Water Code §13575), wherein the Legislature made the following findings and declarations:

> (a) The State of California is in a fifth year of drought, with three of the past four years being critically dry.
>
> (b) The development of traditional water resources in California has not kept pace with the state's population, which is growing at the rate of over 700,000 per year and which is anticipated to reach 36 million by the year 2010.
>
> (c) There is a need for a reliable source of water for uses not related to the supply of potable water to protect investments in agriculture, greenbelts, and recreation and to protect and enhance fisheries, wildlife habitat, and riparian areas.
>
> (d) The environmental benefits of recycled water include a reduced demand for water in the Sacramento-San Joaquin Delta which is otherwise needed to maintain water quality, reduced discharge of waste into the ocean, and the enhancement of recreation, fisheries, and wetlands.
>
> (e) The use of recycled water has proven to be safe from a public health standpoint, and the DHS is updating regulations for the use of recycled water.
>
> (f) The use of recycled water is a cost-effective, reliable method of helping to meet California's water supply needs.
>
> (g) The development of the infrastructure to distribute recycled water will provide jobs and enhance the economy of the state.

The Water Recycling Act of 1991 also established a statewide goal to recycle a total of 700 TAF of water per year by the year 2000 and 1.0 MAF of water per year by the year 2010.

In September 1991, the State Water Conservation Coalition Reclamation/Re-Use Task Force (formed by the Committee for Water Policy Consensus and the Southern California Water Committee) and the Bay-Delta Reclamation Sub-Work Group (formed by the SWRCB and chaired by the DWR) submitted a joint report to the SWRCB for consideration in its Bay-Delta Water Rights process. The report (SWCC/BDRSWG 1991), which presented the results of a study on water recycling, estimated the potential for reclamation by the year 2000, and addressed various issues which posed constraints to water reclamation.

Subsequently, in July 1993, Senate Concurrent Resolution 17 was passed which requested the DWR, in consultation with other appropriate agencies, to provide suggestions that will help the State meet or exceed the statewide recycling goals of the Water Recycling Act of 1991. In response to this request, the DWR, with the cooperation of the USEPA, USBR, Contra Costa Sanitary District, and San Diego County Water Authority, released a report titled, "Meeting the Goals of the Water Recycling Act of 1991: An Attainable Future", in May 1994.

Most recently, on June 1, 1994, the SWRCB, DWR, DHS, California Conference of Directors of Environmental Health, USEPA, USBR, and the WateReuse Association of California adopted a joint statement of support for water reclamation. In this statement, these agencies resolved that they will cooperate to develop specific policies and resource commitments that will enable the State to meet the Legislature's water reclamation goals and to help satisfy the State's overall water needs. This statement reported that the amount of water reclaimed in California had increased from 165 TAF per year in 1977 to over 380 TAF per year in 1993.

2. Potential for Reclaiming Water

In July 1993, the WateReuse Association of California released a report, based on a survey of California water and wastewater agencies, on the potential for future water recycling (WRAC 1993). The survey results indicated that water recycling projects being planned by water and sanitary districts and municipalities will substantially increase water reclamation in the State. While the WateReuse Association's 1993 survey report states that achieving the goals of the Water Recycling Act of 1991 are within reach and, in fact, the 2010 goal can be exceeded by over 30 percent if the survey respondents accomplish their own predictions, the SWRCB's Office of Water Recycling believes that this is an optimistic projection of water reclamation potential in light of limited funding for reclamation projects. The Office of Water Recycling concludes that, based on the survey report's projection of $2 billion to add 600 TAF per year, between $3 billion and $4 billion will be required for capital facilities to meet the 1.0 MAF per year goal for the year 2010. Therefore, to achieve the State's goals for water reclamation, substantial financial assistance will be needed (SWRCB 1994).

For purposes of assessing the potential of wastewater reclamation to reduce demands on other fresh water supplies, the quantities of fresh water displaced by reclamation should be considered rather than the quantities of reclaimed water deliveries. Fresh water displaced refers to the amount of fresh water that would otherwise be used to meet present or future non-potable demands if reclaimed water were not available. Reclaimed water deliveries include deliveries that serve all beneficial uses, including those that displace fresh water and other uses that would not, under most circumstances, have received fresh water if reclaimed water were not available (SWCC/BDRSWG 1991). Therefore, the amount of fresh water displaced by reclaimed water is considered the contribution of wastewater recycling to the State's future water supply (DWR 1994d).

While reclaimed water generally replaces fresh water, this replacement does not always result in an actual augmentation to the State's overall water supply. For example, wastewater discharged to streams or percolation ponds is available for indirect reuse through downstream diversions or groundwater pumping. Planned reuse directly from a wastewater treatment plant may be merely substituting for an unplanned reuse of the same effluent taking place downstream (SWRCB 1990).

The total annual fresh water that was or will be displaced by reclaimed water for the years 1990, 2000, 2010, and 2020 is estimated at 235, 453, 561, and 676 TAF, respectively. The source of most of this reclaimed water is wastewater discharged into the ocean from California's coastal cities. Smaller amounts could come from reclaiming brackish ground water and desalination of ocean water. Currently, most of the ground water reclamation programs under consideration (excluding contaminant remediation) are located in southern California. Ground water reclamation programs are designed to recover degraded ground water, which commonly has high TDS and nitrate levels. To be used, this water must either be treated, blended with higher quality water, or applied untreated for landscape irrigation. The total annual contribution of ground water reclamation by the year 2000 is likely to be about 90 TAF. Because of its high cost and uncertain success, desalting brackish agricultural water and ocean water currently is considered to be a minor possible option for augmenting the State's future water supply (DWR 1994d).

Numerous constraints to fully implementing all potential wastewater reclamation options exist, including: funding of reclamation facilities (as noted above), distances to potential applications, regulatory requirements, acceptance by health authorities and the public, and water quality, including salinity (DWR 1994d). The relatively poor quality of reclaimed water can significantly constrain water reclamation efforts and affect the quantity of fresh water displaced. For irrigation and industrial uses, the quantity of reclaimed water delivered will generally be greater than the quantity of fresh water displaced due to the differences in water quality between fresh water and reclaimed water. Reclaimed water contains higher concentrations of TDS, salts, and hardness than fresh water. Therefore, when irrigating, approximately 10 percent more reclaimed water needs to be applied to ensure that the salts are leached from the plants' root zones. In industrial applications, such as cooling tower supply, the greater hardness requires reclaimed water to be used for fewer cycles to prevent scaling and damage to the equipment (SWCC/BDRSWG 1991).

3. Relevance of Water Reclamation to Bay-Delta Standards

In testimony received by the SWRCB during Bay-Delta water rights hearings in 1992, the quality of reclaimed water and its source water was emphasized. To maximize the use of reclaimed water, the reclaimed water quality must be acceptable for its end use. Therefore, water reclamation is limited by the quality (i.e., salt content measured as TDS) of the fresh water supply and the intended market for the reclaimed water.

Most uses of reclaimed water can be served when the TDS is no greater than 800 mg/l. Certain types of salt-sensitive landscaping and agriculture are unable to tolerate irrigation with reclaimed water high in TDS. Normal urban water use generally adds about 300 mg/l TDS to the potable water supply (SDCWA 1992, MWD 1992). Therefore, to achieve an acceptable TDS level of 800 mg/l in reclaimed water, which will allow for a full range of beneficial uses that could be served with reclaimed water, a source water low in TDS (i.e., no more than 500 mg/l) is needed. For the urban areas of Southern California, where most water reclamation efforts in the State are taking place, this means that a reliable supply of imported water that is low in TDS is required.

Within the San Diego County Water Authority (SDCWA) service area, an average of 90 percent of the water supply is imported. This supply consists primarily of imported Colorado River water which typically has TDS levels of 600-750 mg/l. When Colorado River water is reclaimed, TDS increases to 900-1,050 mg/l after only one reuse. For example, during 1991, the SDCWA received 100 percent Colorado River water due to drought conditions. This imported water supply, which had a TDS level that reached 657 mg/l, resulted in reclaimed water from the Fallbrook Sanitary District Reclamation Facility that averaged 905 mg/l TDS and peaked at over 1,000 mg/l TDS (SDCWA 1992). These levels exceed the recommended and upper maximum contaminant levels for TDS of 500 mg/l and 1,000 mg/l, respectively, established as secondary drinking water standards by the DHS (CCR § 64473). TDS levels this high may restrict the use of reclaimed water for several purposes, including groundwater recharge to a drinking water supply and irrigated agriculture.

The Colorado River Basin Salinity Control Forum (CRBSCF), which is comprised of the seven states in the basin, recommended salinity criteria for three locations near key diversions on the Colorado River in its triennial review of Colorado River salinity criteria (CRSCF 1993). These criteria, which were first established in 1975, are 723, 747, and 879 mg/l flow-weighted annual salinity below Hoover Dam, below Parker Dam, and at Imperial Dam, respectively. These criteria were selected to maintain salinity levels to offset the effects of water resource development in the Colorado River basin since 1972. Periodic increases in salinity above the criteria as a result of reservoir conditions or natural variations in flow are considered to be in compliance with the criteria. Natural variations in runoff can cause a fluctuation in average annual salinity concentrations of about 450 mg/l at Imperial Dam. The CRBSCF report states that implementation of the criteria will prevent, by the year 2015, a salinity concentration increase of approximately 140 mg/l at Imperial Dam. In March 1993, the SWRCB approved the 1993 triennial review of the Colorado River salinity criteria and plan of implementation as presented in the CRBSCF report (SWRCB Resolution No. 94-28).

The SDCWA maintains that, if their water supply continues to consist primarily of Colorado River water, whose TDS levels are expected to increase unless salinity control measures are implemented, the TDS levels in reclaimed water will substantially limit the application of reclaimed water as a resource in San Diego County. To maximize the development of reclaimed water supplies in the county, a minimum amount of SWP water, which is relatively lower in TDS, is required for blending with Colorado River water supplies. The SDCWA has estimated that their future imported water supplies must contain 50 percent SWP water to meet their reclaimed water projections for the year 2000. A 50 percent blend of SWP water results in a TDS of 500 mg/l in the total imported water supply. Considering an increase of approximately 300 mg/l TDS due to normal municipal uses, the 50 percent SWP contribution to the imported water supply ultimately will achieve TDS levels of about 800 mg/l. Reclaimed water of this quality will serve a full range of uses for reclaimed water and, ultimately, reduce dependence on SWP water (SDCWA 1992).

The Water Advisory Committee of Orange County (WACO), which represents leaders in water reclamation and reuse in the State, and the MWD also testified that, to continue to operate wastewater reclamation projects effectively, a reliable imported supply of SWP water is needed. They also stated that the higher salt content Colorado River water is not suitable as a substitute for SWP supplies and, furthermore, may not be available in the future (WACO 1992b, MWD 1992). The WACO and the Santa Ana Watershed Project Authority (SAWPA) stated that the Santa Ana River watershed system in Orange County, and the SWP itself, were planned and built for the introduction of low salinity SWP supplies into the headwaters of the river system (WACO/SAWPA 1992). Like the SDCWA, the MWD testified that, to meet its projected total use of reclaimed water by the year 2010, adequate supplies of Delta water must be available (MWD 1992).

Although one might expect that reductions in imported water from the Delta should encourage water reclamation efforts in State and federal water project service areas, previous evidence brought before the SWRCB suggests that the poor quality of alternative water sources compared to Delta water may actually decrease the potential for water reclamation in certain areas of the State. Reductions in imported Delta water will probably encourage wastewater reclamation in some areas and impede it in others, depending on factors such as the quantity and quality of all water supply sources available, the level of treatment achieved, and the potential for various uses of reclaimed water.

The amount of water taken from the Delta may not be reduced by increases in water reclamation because the majority of reclamation projects are being built in areas experiencing increases in population and water demand. Reclaimed water will be used to offset future demand so that increased diversion from the Delta can be minimized; however, reclamation projects will probably not result in a substantial reduction in the need for imported water from the Delta (SWCC/BDRSWG 1991).

E. IRREVERSIBLE OR IRRETRIEVABLE COMMITMENT OF RESOURCES

Most of the environmental impacts identified in this report are reversible. The principal hydrologic effect of implementation of the preferred alternative will be to change Delta outflow, reservoir levels, and deliveries to export areas. These parameters presently fluctuate a great deal due to the variable hydrology in the Central Valley. If the standards are implemented and then rescinded at a future date, the hydrology will be dependent on the regulatory conditions in effect at that time. However, there are three irreversible impacts that might occur as a result of this situation: land use changes, fossil fuel combustion, and land subsidence. These irreversible changes are discussed below.

The most likely land use change that might occur as a result of the standards is accelerated agricultural land retirement. Without a firm agricultural water supply, the conversion of this land to some other use may occur, especially if the land is adjacent to an urban area. The extent to which this land use change will actually occur is dependent on decisions by local authorities.

The second irreversible impact is increased fossil fuel combustion. The dedication of additional water to the environment will decrease the availability of water in some upstream reservoirs for summer peak power generation, as discussed in both section B.1 of this chapter and in Chapter XII. In addition, the development of replacement water through ground water pumping and reclamation is power intensive. As discussed in section B.2 of this chapter, fossil fuel combustion will likely be an element in replacing lost power and meeting new power requirements as a result of the plan.

The third irreversible impact is land subsidence. As discussed in section C.1 of this chapter, implementation of the standards is likely to result in increased ground water pumping which can cause land subsidence. Land subsidence can damage surface structures, and it can result in permanent loss of aquifer capacity.

These commitments of resources are justified in light of the enhanced protection that the plan provides to aquatic habitat-related beneficial uses in the Estuary. If the plan is not adopted and implemented, there may be further declines in fresh- and brackish-water aquatic and terrestrial habitats in the Delta, resulting in the potential listing of additional species under the federal and State ESAs.

F. GROWTH-INDUCING EFFECTS

The preferred alternative will reduce the amount of water available to water utilities in areas served by the CVP, the SWP, and other parties charged by the SWRCB in the upcoming water rights proceeding with responsibility for meeting the requirements of the plan. To the extent that historic patterns are any indication of future trends, reduced water availability is unlikely to affect growth in these areas.

Growth patterns have historically been influenced by market conditions far more than by any other factor. Water shortages have rarely done more than slow the progress of adequately financed development proposals. Growth moratoriums have occasionally been imposed due to inadequate water supplies. El Dorado County, for example, imposed a building moratorium due to a temporary supply shortage (Rudy Limon, El Dorado County Counsel, pers. comm., October 19, 1994). But, in most cases, enough water has been found to sustain most economically viable growth. Because the costs of water supply augmentation projects can usually be spread over a large user base, the cost of new supplies has seldom been high enough to significantly reduce the profitability of new development projects.

Land fallowed in response to irrigation water cutbacks could become available for other uses, including development. The fact that fallowed farmland will probably drop in price could also increase its attractiveness for non-agricultural uses. Because development is primarily driven by demand, however, the availability of fallowed land is not expected to result in significant new growth. Without a tangible demand for new housing, an increase in the amount of available, affordable land will not stimulate the construction of new housing.

G. NEED FOR DEVELOPING HOUSING

The preferred alternative would have no direct effects on housing demand, but could alter demand indirectly by affecting economic conditions. One economic effect of implementation of the standards that could affect housing demand is job losses in agricultural areas where irrigation water supplies would be reduced. Demand would decrease in the affected areas, and increase in the regions to which displaced workers migrate.

Although the standards are expected to cause some job losses in the agricultural sector, the number of workers to be displaced will be too few to cause a significant change in the demand for housing. (The employment impacts of the standards are discussed in Chapter XII.) Nor are the standards expected to significantly affect the economy of the State as a whole (see Chapter XII). Decreased water supplies may increase costs for some businesses in some areas of the State. In most cases, however, these increases will be small relative to other factors affecting businesses. By providing a measure of certainty about future water supplies, Bay-Delta standards could have a stabilizing effect on the State's economy. Also offsetting the negative economic impacts of the standards on some businesses is a quality of life improvement that will result from improved water quality in the Bay-Delta Estuary (Sanders et al. 1990). This improvement could indirectly benefit the State's economy by, for example, keeping some trained, productive residents from moving to other states in pursuit of higher incomes.

H. RELATIONSHIP BETWEEN SHORT-TERM USES AND THE MAINTENANCE OF LONG-TERM PRODUCTIVITY

The principal issue associated with the relationship between short-term uses and the maintenance of long-term productivity is ground water overdraft. As discussed in sections B.6 and C.1 of this chapter, implementation of the standards will aggravate ground water overdraft problems. Additionally, changes in the use of water may well occur, from agricultural uses to municipal uses, or from one type of agricultural use or crop to another, in the short- and long-term.

The standards have the potential to affect water levels in reservoirs, flows in the rivers, water management operations, and the quantity of water deliveries to various districts in the short- and long-term. Surface water is, however, renewable from precipitation. Also, the plan will be reviewed every 3 years to evaluate the effectiveness of the standards and the water supply needs of the State.

The plan will provide better protection to aquatic habitat-related beneficial uses in the Estuary. Long-term increases in fresh- and brackish-water aquatic and terrestrial habitats in the Delta will result. If the plan does not go forward, there will probably be further declines in those resources and additional species may be listed under the federal and State ESAs.

I. CUMULATIVE IMPACTS

Cumulative impacts are defined in the CEQA Guidelines as two or more individual effects which, when considered together, are considerable or which compound or increase other environmental impacts. The individual effects may be changes resulting from a single project or a number of separate projects. The cumulative impact from several projects is the change in the environment which results from the incremental impact of the project when added to other closely related past, present, and reasonably foreseeable probable future projects. Cumulative impacts can result from individually minor but collectively significant impacts (CEQA Guidelines §15355).

In this case, the principal impacts of implementation of the standards can be traced to the loss of water to areas upstream of the Delta or in export areas. Therefore, significant cumulative impacts are impacts of other projects or activities that also reduce the water available to upstream and export areas. Such projects or activities include: (1) Mono Lake Water Right Decision 1631; (2) the CVPIA; (3) the federal ESA; (4) the reallocation of Colorado River water; (5) the proceedings of the Federal Energy Regulatory Commission (FERC); and (6) other SWRCB water right proceedings. These projects are discussed below.

1. Mono Lake Water Right Decision 1631

Mono Lake Water Right Decision 1631 was adopted by the SWRCB on September 28, 1994. The decision reallocates water in the Mono Lake Basin from consumptive use by the Los Angeles Department of Water and Power (LADWP) to protection of public trust resources.

LADWP diverts water in the Mono Basin from Lee Vining Creek, Walker Creek, Parker Creek, and Rush Creek. The water is then exported from the Mono Basin through the Mono Craters Tunnel approximately 11 miles to the upper Owens River. The Mono Basin water commingles with water in the upper Owens River and flows into the Los Angeles Aqueduct from which it is distributed for a variety of municipal uses in the City of Los Angeles.

Decision 1631 sets a target elevation of 6,391 feet for Mono Lake and it establishes minimum flow requirements for the creeks flowing into Mono Lake. The decision prohibits diversion from the basin until the lake level rises above 6,377 feet. Limited diversion is allowed after that event, and less restrictive diversions are allowed after the lake rises to the final target elevation, which is expected to occur in about 20 years. Hydrologic modeling of the standards in the decision project that Los Angeles will be able to divert an average annual amount of approximately 12.3 TAF over the next 20 years. The long-term average annual exports once the lake reaches an elevation of 6,391 feet are projected to increase to approximately 30.8 TAF. From 1974 to 1989, the City of Los Angeles diverted an average of 83 TAF annually from the Mono Basin.

2. CVPIA

The CVPIA reauthorizes the U.S. Department of the Interior's CVP. It includes fish and wildlife protection, restoration, and mitigation as project purposes having equal priority with irrigation and domestic uses, and fish and wildlife enhancement as a purpose equal to power generation. The CVPIA identifies the following three specific measures which are likely to reduce the amount of water available for irrigation and municipal use in the Central Valley and export areas:

1. The CVPIA dedicates 800 TAF of CVP yield in all normal years for the primary purpose of implementing the fish, wildlife, and habitat restoration purposes and measures authorized in the Act. Under dry year conditions, the dedication is reduced to 600 TAF.

2. The CVPIA requires the Secretary of the Interior to provide, either directly or through contractual agreements with appropriate parties, firm water supplies of suitable quality to maintain and improve wetland habitat areas on: units of the National Wildlife Refuge System in the Central Valley of California; the Gray Lodge, Los Banos, Volta, North Grasslands, and Mendota state wildlife management areas; and the Grasslands Resources Conservation District in the Central Valley of California. The amount of water that will be dedicated to this activity has not yet been firmly established.

3. The CVPIA provides that, by September 30, 1996, the Secretary of the Interior shall complete the Trinity River Flow Evaluation Study currently being conducted by the USFWS to develop recommendations regarding permanent instream flow requirements and Trinity River Division operating criteria and procedures for the restoration and maintenance of the Trinity River fishery. If the Secretary of the Interior and the Hoopa Valley tribe agree on these recommendations, they will be implemented; otherwise, the existing fishery releases of 340 TAF will remain in effect unless increased by an act of Congress, appropriate judicial decree, or agreement between the Secretary and the Hoopa Valley tribe.

3. Federal ESA

Requirements established under the federal ESA for protection of winter-run chinook salmon and Delta smelt, referred to as biological opinions, controlled many of the operational decisions of the CVP and the SWP in the Bay-Delta Estuary in the last 2 years. On December 15, 1994, federal and State agencies signed the Principles for Agreement in which the federal government agreed to accept the requirements in the preferred alternative for the next 3 years, after which the requirements may be revised. Accordingly, the biological opinion for Delta smelt has been redrafted and is largely consistent with the requirements in the plan. The biological opinion for winter-run chinook salmon has not been promulgated, but it is anticipated to also be consistent with the requirements in the plan.

Delta operations can be affected by the federal ESA in the future. If the requirements in the plan do not stabilize populations of endangered species in the Delta, more restrictive ESA requirements may be established after the 3-year agreement cited above has expired. Additional species could also be listed in the future. For example, the Sacramento splittail is being considered for listing, and discussions have been held on listings for other species such as the spring-run chinook salmon, sturgeon, longfin smelt, and steelhead trout. The agreement states that if additional water is required for protection of newly-listed species then water will be provided by the federal government on a willing seller basis. After the agreement expires, the ESA could have substantial, though unquantifiable, cumulative impacts on Delta water supplies.

4. Reallocation of Colorado River Water

During the past decade, the MWD has operated the Colorado River Aqueduct at or near capacity of about 1.2 MAF annually. Currently, however, the DWR estimates that the MWD's contractual supplies and firm rights to Colorado River water amount to only about 724 TAF (DWR 1994d). At the recent SWRCB Mono Lake hearings, the MWD testified that, notwithstanding the quantity of its firm water rights, the MWD intends to take all appropriate steps to maintain Colorado River deliveries at 1.2 MAF in the future (MWD 1993). The MWD believes that this can be accomplished through: (1) the use of water apportioned to, but unused by, Arizona and Nevada; (2) access to surplus water when available; and (3) implementation of water transfer programs in cooperation with the California agricultural districts which use Colorado River water and possibly with the other basin states.

The MWD cites its recent successful negotiations regarding water transfer programs as providing assurance that it will be able to rely on full deliveries of Colorado River water in the future. These negotiations have resulted in a major water conservation program in the service area of the Imperial Irrigation District and agreements with landowners and lessees in the Palo Verde Irrigation District on a land fallowing program.

If the MWD is required to reduce its diversions from the Colorado River, such reductions will exacerbate the effects of the water supply reductions caused by the plan in the MWD's service area.

5. FERC Proceedings

The FERC is evaluating and modifying existing terms for protection of fish and wildlife in licenses for hydroelectric generation projects. Pending FERC decisions on the Mokelumne and Tuolumne rivers may impose additional water supply impacts for water users in these systems.

6. SWRCB Water Right Proceedings

The SWRCB occasionally reopens water right permits to review flow requirements for protection of resources within the subject stream systems. As result of these water right proceedings, the SWRCB may require additional flows for protection of fish and wildlife. The implementation of these water right decisions in combination with the plan may impose additional water supply impacts for water users in these systems. The SWRCB is currently conducting water right proceedings on the Mokelumne and Yuba rivers.

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