# CHAPTER X. ALTERNATIVES FOR IMPLEMENTING THE DISSOLVED OXYGEN OBJECTIVE IN THE SAN JOAQUIN RIVER

The 1995 Bay/Delta Plan contains a dissolved oxygen (DO) objective of 6.0 mg/l from September through November in the lower San Joaquin River to protect fall-run chinook salmon. In addition, the Central Valley Regional Water Quality Control Board (CVRWQCB) Basin Plan includes a DO objective of 5.0 mg/l throughout the year. DO is required for the respiration of fish as well as for the respiration of the microorganisms that form their food web.

This chapter describes the environmental effects of the implementation of the alternatives to meet the 6.0 mg/l DO objective. The chapter is divided into three sections: (A) background, (B) alternatives for implementing the DO control objective, and (C) environmental effects of the alternatives.

## A. BACKGROUND

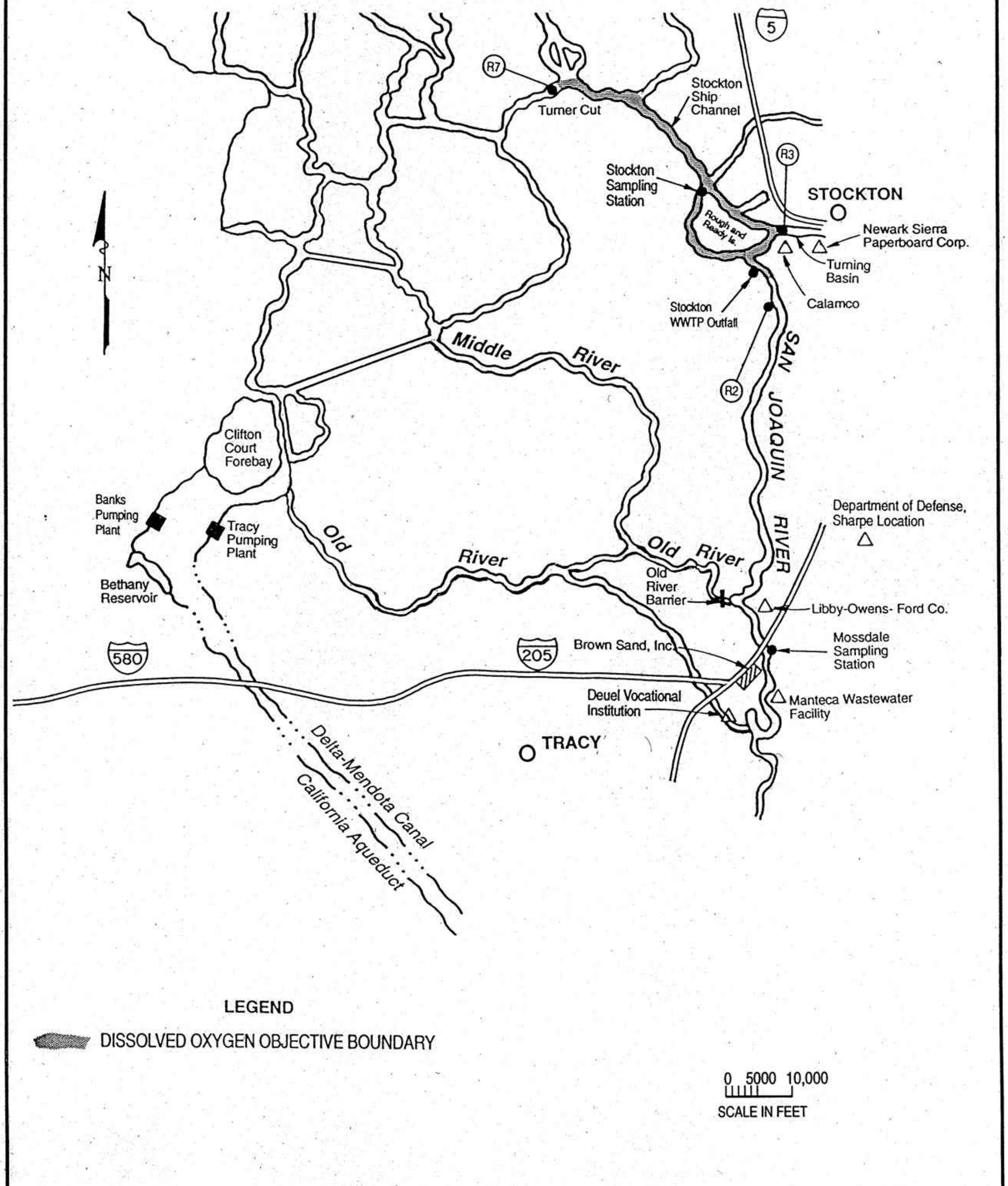
The background discussion is divided into four sections: (1) factors that affect DO levels in the San Joaquin River, (2) regulatory history, (3) historic DO conditions, and (4) current and proposed management actions to improve DO.

### 1. Factors that Affect DO Levels in the San Joaquin River

The fall-run chinook salmon pass through the Delta on their way to spawning areas in upstream tributaries. In order to migrate successfully to their natal streams, San Joaquin salmon must encounter favorable conditions in the Delta and the lower San Joaquin River. Water quality conditions in the reach of the San Joaquin River near the City of Stockton (Stockton), however, are often unfavorable, particularly in regard to temperature and DO levels. The reach of river (see Figure X-1) from Turner Cut to the head of Old River, which includes the Stockton ship channel, the Port of Stockton's turning basin, and the Stockton Wastewater Treatment Plant (Stockton WWTP) outfall has been identified as an area of concern because of low DO levels. DO levels below 5.0 mg/l create an "oxygen block" which impedes salmon migration upstream (Hallock 1970). DO levels as low as 1.5 mg/l have been recorded in the reach of the San Joaquin River from the turning basin to Turner Cut, and levels as low as 0 mg/l have been recorded in the turning basin. Reduced DO levels can cause physiological stress and increased mortality to fish in addition to delaying or blocking upstream migration (DFG 1995).

Water quality conditions in the San Joaquin River typically begin to deteriorate in the late spring, summer, and fall when flow in the river is low, water diversion rates are high, water temperature is high, and wastewater discharges into the river from upstream sources combine to increase the biochemical oxygen demand (BOD). The City of Stockton used a model to evaluate the sensitivity of DO to variations in river flow, temperature, sediment oxygen demand, algae, and waste loads. Each of the sensitivity analyses incorporated herein were prepared for the City of Stockton in a 1997 report entitled "Evaluation of Alternatives to Meet the Dissolved Oxygen Objectives of the Lower San Joaquin River." Descriptions of the San Joaquin River model, calibration and

**Figure X - 1**
**Location of Dissolved Oxygen Objective Boundary and NPDES Dischargers**



verification, Bay/Delta operations, and the sensitivity analyses can all be found in the aforementioned report.

Factors that contribute to low DO levels in the lower San Joaquin River include: (a) San Joaquin River flow, (b) San Joaquin River geometry, (c) water temperature, and (d) oxygen demand. Each of these factors is discussed below.

**a. San Joaquin River Flow**. Flow in the portion of the San Joaquin River that is subject to the 6.0 mg/l DO objective is influenced by upstream San Joaquin River flow, tidal fluctuations, pumping from the SWP and CVP facilities, and local diversions.

When evaluating the effects of flow in the lower San Joaquin River, both flow volume and flow direction are important to consider. Flow volume refers to the quantity of water moving through a river channel. Flow direction refers to whether the flow is moving upstream or downstream. Net positive flow means that the average flow is moving downstream, and net reverse flow means that the average flow is moving upstream. Sometimes a "slack water" condition occurs, where there is no significant net flow. A slack water condition significantly affects DO concentrations by reducing the assimilative capacity of the river (the ability of a waterway to dilute substances to a level where there are no deleterious effects on humans or the aquatic environment) and by promoting algae growth which results in increased oxygen demand as the algae die and decompose.

Positive flows do not always occur in the reach of the San Joaquin River near Stockton due, in part, to tidal effects. The Delta and its river systems are affected by four tides daily, two high tides and two low tides. These alternating tides can change the direction of the river several times a day during periods of low flow. The net effect at Stockton is poor circulation and a decreased assimilative capacity of the river.

The export operations of the SWP and the CVP also strongly influence flow in the San Joaquin River. The exports draw water from the San Joaquin River into the Old River, which decreases the flow of water past Stockton (Chen and Schanz 1993). Local diversions exacerbate this problem. Export pumping and local diversions also cause slack water conditions and net flow reversals in local channels.

**Sensitivity of DO to Flow**. San Joaquin River flow varies daily and seasonally. This analysis held flow constant at a given level throughout the year to eliminate the daily fluctuation of flow and its effects on DO. Waste loads from the WWTP are based on 1996 data. River flow was maintained at five constant levels of (1) -500 cfs, (2) 0 cfs, (3) 500 cfs, (4) 1,000 cfs, and (5) 2,000 cfs.

The modeling results contained in Table X-1 show seasonal trends of low DO in the summer even at high flow conditions, especially during July and August. This indicates that the historical low DO in the summer was not caused exclusively by the historical low flows, but low flow did accentuate the DO problem. The modeling shows that increasing river flow increases DO concentrations at

Stations R2 and R3 and decreases DO concentrations at station R7 as the oxygen demands are carried further downstream. Generally, zero net river flow (0 cfs) produced the lowest DO concentrations due to the lack of dilution.

**Table X-1**
**DO Concentrations (in mg/l) at Stations R2, R3 and R7 under Five Different River Flow Conditions**

| | River Flow = -500 cfs | | | River Flow = 0 cfs | | | River Flow = 500 cfs | | | River Flow = 1000 cfs | | | River Flow = 2000 cfs | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Date | R2 | R3 | R7 | R2 | R3 | R7 | R2 | R3 | R7 | R2 | R3 | R7 | R2 | R3 | R7 |
| Oct. 1995 | 6.8 | 6.9 | 8.0 | 5.9 | 5.8 | 7.8 | 7.5 | 6.2 | 7.3 | 8.0 | 6.9 | 7.0 | 8.3 | 7.7 | 7.0 |
| Nov. 1995 | 7.0 | 7.1 | 8.3 | 5.2 | 4.2 | 7.6 | 8.2 | 6.3 | 7.0 | 8.6 | 7.6 | 7.2 | 8.7 | 8.3 | 7.8 |
| Dec. 1995 | 7.9 | 7.8 | 8.8 | 6.4 | 5.1 | 8.1 | 9.1 | 7.6 | 7.9 | 9.2 | 8.6 | 8.2 | 9.2 | 9.0 | 8.7 |
| Jan. 1996 | 8.4 | 8.3 | 9.1 | 6.9 | 5.7 | 8.5 | 9.4 | 8.1 | 8.4 | 9.5 | 8.9 | 8.7 | 9.6 | 9.3 | 9.0 |
| Feb. 1996 | 8.0 | 8.2 | 9.2 | 5.6 | 4.4 | 8.3 | 9.2 | 7.5 | 8.1 | 9.3 | 8.6 | 8.5 | 9.4 | 9.1 | 8.9 |
| Mar. 1996 | 7.9 | 8.1 | 9.0 | 5.5 | 4.3 | 8.2 | 9.0 | 7.3 | 8.0 | 9.2 | 8.5 | 8.4 | 9.3 | 9.0 | 8.7 |
| Apr. 1996 | 7.7 | 7.8 | 8.5 | 6.0 | 5.2 | 8.1 | 8.2 | 7.0 | 7.8 | 8.5 | 7.8 | 7.9 | 8.6 | 8.3 | 8.1 |
| May 1996 | 7.0 | 7.1 | 8.0 | 5.9 | 5.5 | 7.7 | 7.5 | 6.5 | 7.4 | 7.9 | 7.2 | 7.4 | 8.0 | 7.7 | 7.5 |
| Jun. 1996 | 6.2 | 6.2 | 7.4 | 5.3 | 5.1 | 7.2 | 6.9 | 6.0 | 6.9 | 7.4 | 6.8 | 6.9 | 7.7 | 7.4 | 7.1 |
| Jul. 1996 | 5.5 | 5.6 | 6.8 | 4.7 | 4.5 | 6.6 | 5.7 | 4.9 | 6.2 | 6.4 | 5.6 | 6.0 | 6.9 | 6.3 | 6.0 |
| Aug. 1996 | 4.9 | 5.0 | 6.7 | 3.8 | 3.4 | 6.3 | 5.8 | 4.1 | 5.7 | 6.6 | 5.3 | 5.5 | 7.1 | 6.4 | 5.6 |
| Sep. 1996 | 5.0 | 5.2 | 7.1 | 3.1 | 2.4 | 6.5 | 6.9 | 4.4 | 5.8 | 7.7 | 6.2 | 5.9 | 8.0 | 7.4 | 6.6 |
| 12 month Avg: | 6.9 | 6.9 | 8.1 | 5.4 | 4.6 | 7.6 | 7.8 | 6.3 | 7.2 | 8.2 | 7.3 | 7.3 | 8.4 | 8.0 | 7.6 |

**b.** **San Joaquin River Geometry**. The geometry of the San Joaquin River is important because it controls many of the hydrodynamic conditions that affect water quality processes in the vicinity of Stockton. The San Joaquin River upstream of the Stockton ship channel is relatively shallow; between the head of Old River and the Stockton ship channel, the river has a mean depth of 7.5 feet. The San Joaquin River downstream of Stockton is much deeper because it is dredged to a depth of 35 feet to maintain the Stockton ship channel. The river has a mean depth of approximately 20 feet between Stockton and Turner Cut.

The mean depth of the San Joaquin River is a very important variable controlling the effects of surface reaeration and sediment oxygen demand on DO concentrations. The rate of reaeration per unit volume of water is reduced in deeper waters, which reduces the assimilative capacity of the waters.

The channel depth also affects algal photosynthesis and respiration. Because the turbidity of the San Joaquin River is relatively high, light penetration is limited and the fraction of the water column that supports photosynthesis and algae growth is less in the ship channel section of the river. Algal populations tend to grow in the upstream portion of the San Joaquin River and decline in the downstream portion of the river.

**c. Water Temperature**. Oxygen is only slightly soluble in water, and its solubility decreases as the temperature increases. For example, oxygen saturation is about 12.5 mg/l at 40°F and just over 8.0 mg/l at 80°F. When water is warm and complete saturation is in the range of 8.0 to 9.0 mg/l, a relatively low oxygen demand will bring the water below 6.0 mg/l or even 5.0 mg/l (Stockton 1996).

High temperatures also increase the rate of oxygen-consuming biological activity. Most biological processes speed up as the temperatures increase and slow down as the temperatures decrease. High temperatures stimulate the growth of aquatic organisms, such as algae, and increases the rate at which these organisms decompose and oxidize after they die.

**Sensitivity of DO to Temperature**. The effect of temperature on DO was evaluated by a constant addition or subtraction of temperature from the base case. The simulations were performed for constant flows of -500 cfs, 500 cfs, and 1,000 cfs.

The modeling results in Table X-2 show an uneven response of DO with respect to temperature. At a negative flow, a temperature decrease of 2°C led to an increase in DO by up to 1.0 mg/l. A temperature increase of 2°C led to a decrease of DO only by 0.1 mg/l. In other words, at the modeled conditions, more dissolved oxygen is gained by a reduction in temperature than is lost by an increase in temperature. The effects of reducing river temperature are more dramatic at lower flows.

**Table X-2**
**Sensitivity of Dissolved Oxygen to Change in Temperature**

| | Change in Dissolved Oxygen, mg/l | | | | | |
|---|---|---|---|---|---|---|
| | Flow -500 cfs | | Flow +500 cfs | | Flow +1,000 cfs | |
| Station | +2°C | -2°C | +2°C | -2°C | +2°C | -2°C |
| R2 | -0.1 | +1.0 | -0.2 | +0.2 | -0.2 | +0.1 |
| R3 | -0.1 | +1.0 | -0.2 | +0.5 | -0.2 | +0.2 |
| R7 | -0.1 | +0.1 | -0.1 | +0.3 | -0.2 | +0.2 |

**d. Oxygen Demand**. Sources of BOD loading along the San Joaquin River include point and nonpoint discharge sources, algae, and dredging activities. BOD includes carbonaceous oxygen demand (CBOD) and nitrogenous oxygen demand.

**Sensitivity of DO to Sediment Oxygen Demand**. The sensitivity analysis for sediment oxygen demands was performed by cutting the sediment oxygen demand by 50% and 100%. Sediment oxygen demands used in the model include all diffused sources of nonpoint source pollutants.

Table X-3 presents a summary of the sensitivity of DO to sediment oxygen demands. The modeling shows that reductions in sediment oxygen demands would significantly increase DO concentrations in the lower San Joaquin River.

**Table X-3**
**Sensitivity of Dissolved Oxygen to Sediment Oxygen Demand**

| | Change in Dissolved Oxygen, mg/l | | | | | |
|---|---|---|---|---|---|---|
| | Flow -500 cfs | | Flow +500 cfs | | Flow +1,000 cfs | |
| Station | 50% | 100% | 50% | 100% | 50% | 100% |
| R2 | +1.3 | +2.5 | +0.8 | +2.0 | +0.6 | +1.1 |
| R3 | +1.3 | +2.5 | +1.2 | +2.5 | +0.7 | +1.5 |
| R7 | +0.2 | +0.4 | +0.6 | +1.5 | +0.9 | +2.0 |

**Point Sources**. Point sources of oxygen demand include municipal and industrial discharges to the river. Point sources to navigable waterways are regulated by the federal Clean Water Act through the National Pollutant Discharge Elimination System (NPDES) permit program. NPDES permits specify discharge limits for various constituents and mandate monitoring water quality of effluent and receiving water. The purpose of the NPDES discharge limits is to protect identified beneficial uses of the river including recreation, water supply, fisheries, and wildlife. Important factors that determine discharge limits are the mixing characteristics of the receiving water, the chemical and biological reactions that transform constituents as they are transported in the river, and the sensitivity of the aquatic ecosystem. In California, the NPDES program is implemented by the RWQCBs.

The reach of the San Joaquin River near the Port of Stockton is the area of greatest concern in regard to DO. The turning basin at the port acts as an oxygen sink because there is relatively little water circulation or tidal activity in the basin. Dead or dying algae in the stagnant water produces an oxygen demand. The problem is exacerbated in the late summer and early fall months when water temperature is high. The point discharge from Stockton's WWTP has been identified as an important factor to water quality in the area (see Figure X-1).

A DO study prepared for Stockton identifies the most significant sources of oxygen demand in the San Joaquin River (Chen et al 1993). Near the WWTP's outfall, BOD and ammonia are the most significant sources of oxygen demand. Farther from the outfall, other BOD sources become the significant sources of oxygen demand. The study indicates that CBOD and ammonia discharged by the Stockton WWTP consume 16.8 percent and 25.8 percent, respectively, of the oxygen resources at the monitoring station located near the WWTP's outfall. Other BOD sources account for an estimated 57.4 percent of oxygen demand at this location; however, other BOD sources account for an estimated 78.1 percent of oxygen demand further away from the outfall (Chen et al 1993).

Other municipal and industrial discharges upstream of the Stockton WWTP include the Cities of Modesto, Turlock and Newman. There are other NPDES dischargers on the San Joaquin River that may also have impacts on dissolved oxygen. NPDES discharges located in the San Joaquin River and its tributaries between Mossdale and the Stockton WWTP are listed in Table X-4 and shown on Figure X-1.

**Table X-4**
**NPDES Dischargers in the San Joaquin River**
**Between Mossdale and Stockton**

| Discharger | Point of Discharge | Maximum Discharge Rate |
|---|---|---|
| Brown Sand, Inc. | San Joaquin River | 3.6 MGD |
| Calamco | Stockton Deep Water Channel | 1.7 MGD |
| Department of Defense-Sharpe Location | South San Joaquin Irrigation Canal | 1.2 MGD |
| Deuel Vocational Institution | Deuel Drain | 0.6 MGD |
| Libby-Owens-Ford Co. | San Joaquin River | 2.1 MGD |
| Manteca Wastewater Facility | San Joaquin River | 5.8 MGD |
| Newark Sierra Paperboard Corp. | McDougald Slough | 3.5 MGD |
| City of Stockton WWTP | San Joaquin River | 67.0 MGD |

**Sensitivity of DO to Waste Load**. Sensitivity of DO to waste load from Stockton's WWTP was evaluated by comparing DO concentrations under 1996 levels of waste load to a zero discharge condition, as shown in Table X-5. The simulations were performed for five hydrologic year types and the sensitivity of DO to waste load was measured by the DO increase in the critical summer months (June to August).

**Table X-5**
**Sensitivity of Dissolved Oxygen to Waste Loads from Stockton WWTP**

| | Maximum Change in Summer DO by Eliminating Stockton's WWTP Discharge, mg/l | | | | |
|---|---|---|---|---|---|
| Station | 1991 Critically Dry | 1981 Dry | 1966 Below Normal | 1957 Above Normal | 1982 Wet |
| R2 | +0.2 | +1.0 | +1.0 | +0.6 | +0.6 |
| R3 | +1.0 | +1.0 | +1.0 | +1.0 | +1.0 |
| R7 | +0.2 | +0.1 | +0.1 | +0.2 | +0.2 |

**Nonpoint Sources**. Nonpoint source discharges include agricultural drainage and urban runoff. The San Joaquin River carries substantial amounts of agricultural return water or drainage. Agricultural drainage contributes salts, nutrients, pesticides, trace elements, sediments, and other by-products that affect the water quality of the river and the Delta. In particular, nutrients contributed by irrigation runoff and livestock operations constitute significant sources of BOD, or promote the processes that consume oxygen. Urban runoff may contain metals, oil and grease, sediment, nutrients and trace amounts of various organic toxins. Urban runoff also contains organic materials that are an additional source of BOD. Urban runoff is generated primarily during storm events, when constituents are washed off of impervious surfaces into the storm drainage system.

**Algae**. Algal production can have considerable effects on DO in the San Joaquin River. Episodes of DO supersaturation in the San Joaquin River coincide with high chlorophyll concentrations at Mossdale and Vernalis and are thus almost certainly the results of algal photosynthesis. During most years, these periods of supersaturated conditions (high algal productions) at Mossdale are associated with extremely low DO levels in the Stockton ship channel. The diurnal variation of pH also indicates algal photosynthesis (Van Nieuwenhuyse, E., pers. Comm. 1997).

High levels of algal biomass prevail in the San Joaquin River at Vernalis and Mossdale because the river offers an abundant supply of phosphorus, nitrogen, light, and time for algal production. High phosphorus and nitrogen levels are due in part to natural fertility of basin soils, fertilization of row crops and orchards, runoff of manure from feedlots, and erosion from poorly managed land throughout the watershed. Light supply is generally adequate because the river is shallow and the water column is fully mixed. Thus, even though the water is moderately turbid, algae are frequently exposed to high light intensities during a given day because turbulent currents transport the algae through well-lit water near the surface. In addition, there is enough flow in the mainstem of the river during the summer to provide sufficient time for high biomass levels to develop.

The algae that prevail at Vernalis and Mossdale are generally a mixture of diatoms and, to a lesser extent, chlorophytes. Most of the diatoms are adapted to stream conditions in that they depend on the turbulence of stream flow to stay in suspension and are capable of surviving or even actively photosynthesizing if they temporally settle out onto shallow sediments. When these algae are transported to the deeper water (7.5 feet deep) of the San Joaquin River channel between Old River and Stockton or the Stockton ship channel (20 feet deep), they encounter conditions for which they are poorly adapted. Consequently, most of the algal biomass transported to this reach of the system dies, settles to the dark riverbed, and decomposes. Compliance monitoring has shown that late summer and fall phytoplankton blooms periodically occur within the Stockton turning basin (at the extreme eastern end of the Stockton ship channel). Dissolved oxygen levels can exceed 14.0 mg/L (supersaturation) in the surface bloom area, and approach 0.0 mg/l (total anoxia) near the bottom as dead or dying algae settle out of the water column and accumulate at the bottom. The decomposition of this algal biomass exerts a large DO demand.

**Sensitivity of DO to Algae**. This sensitivity analysis models the effects of increasing algal density at Vernalis and Mossdale from the base condition (1X) to assumed values of five times (5X) and ten times (10X) the base condition. There was no chlorophyll-a data for September 1991, therefore chlorophyll concentrations were assumed to be the same as in August.

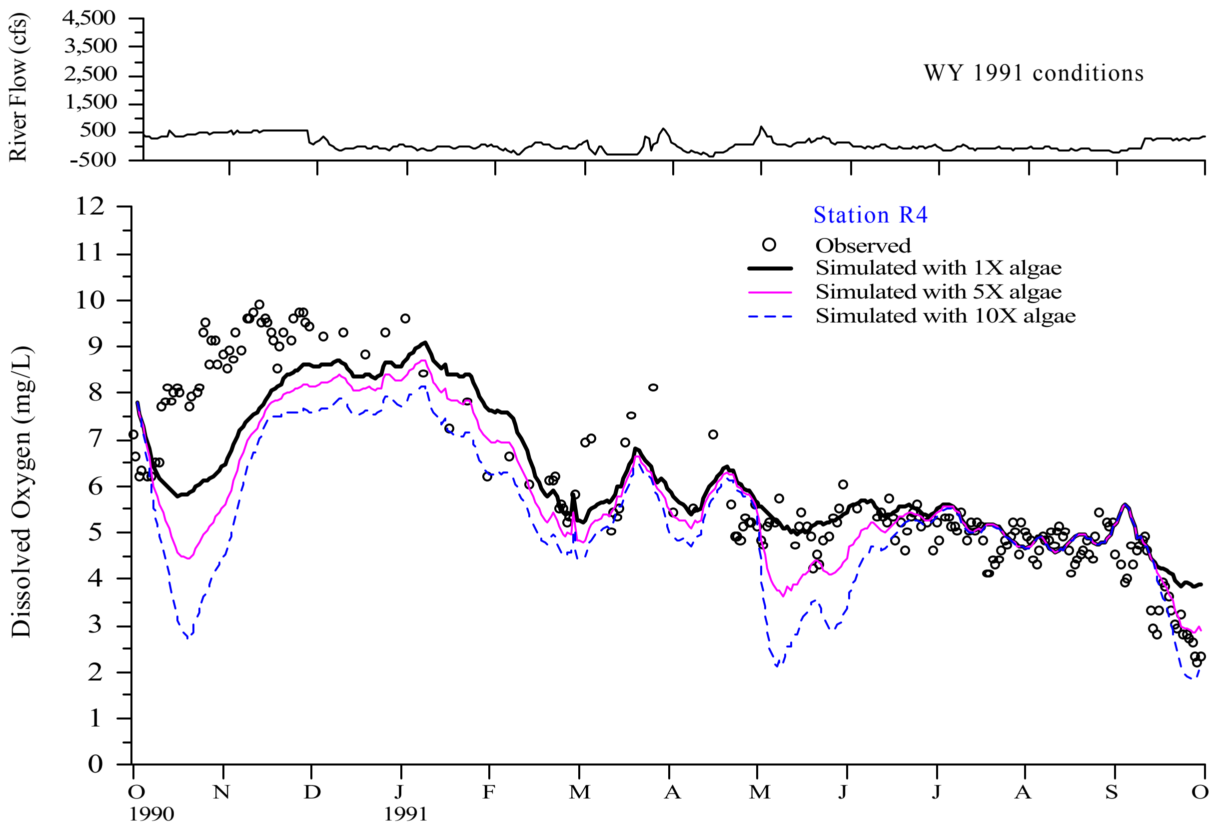
The sensitivity analysis results in Figure X-2 shows that algal blooms at Mossdale can depress DO in the San Joaquin River at Stockton. An increase of chlorophyll level by five times resulting from algal blooms at Mossdale coupled with a positive flow can cause a DO depression at Station R4 by as much as 3 mg/l.

**Dredging Activities**. Dredging activities in the ship channel have also been identified as a source of water quality problems. In the short term, dredging re-suspends solids and constituents containing BOD into the water column. In the long term, channel deepening decreases DO by reducing velocities and reaeration of the water column, and increasing oxygen demand by dying phytoplankton (Chen and Schanz 1993). A USCOE study found that dredging of the ship channel reduced DO levels in the area of the Port of Stockton up to approximately 0.2 mg/l (USCOE 1990). This reduction can be significant because DO concentrations are often already low during the important fall period when salmon migration is occurring.

## 2. Regulatory History

This section discusses the history of the SWRCB’s and the CVRWQCB's regulation of DO in the San Joaquin River and the Delta. Water quality objectives for the Delta are established by the SWRCB and the San Francisco Bay and the Central Valley RWQCBs through water quality control plans. These plans are implemented through water right decisions and through the RWQCB's NPDES and Waste Discharge Requirement permitting process. The SWRCB’s

**Figure X-2**
**Simulated Dissolved Oxygen under Three Algae Concentrations**




Delta water right decisions are summarized in Chapter I of this EIR and discussed here as they pertain to DO objectives. There are two DO water quality objectives that currently apply to the lower San Joaquin River: (1) the 1995 Bay/Delta Plan DO Objective, and (2) the CVRWQCB Basin Plan DO Objective.

A four-year study conducted from 1964 through 1967 indicated that salmon migration in the San Joaquin River is blocked when DO levels are below 4.5 mg/l and that "the run did not become steady until the dissolved oxygen levels were above 5.0 ppm" (Hallock 1970). To address the problem of low DO levels in the San Joaquin River, an agreement was reached in 1969 between the DWR, DFG, USBR, and USFWS to take specific actions "to maintain the dissolved oxygen content in the Stockton ship channel generally above 6.0 ppm when necessary." The study and resulting agreement formed the basis for the DO objectives that were subsequently adopted.

**a. 1967 Interim Water Quality Control Policy for the Sacramento-San Joaquin Delta**. The 1967 objectives were adopted to meet federal requirements for interstate waters for the Delta. Supplemental objectives were adopted in 1969. The 1967 objectives established a DO objective of 5.0 mg/l with two exceptions: (1) where the reduction occurs as a result of natural causes, and (2) in certain bodies of water which are constructed for special purposes and from which fish have been excluded.

**b. 1975 Basin Plan**. The 1975 CVRWQCB Basin Plan contains specific DO objectives for areas within and outside the legal boundaries of the Delta. The Basin Plan continues the 1967 DO objective of 5.0 mg/l with an exception for special purpose bodies of water which exclude fish. The objectives applied to all Delta waters except: (1) the Sacramento River below the I Street Bridge and in all Delta waters west of the Antioch bridge where the objective was 7.0 mg/l and (2) waters where the fishery is not important as a beneficial use.

**c. 1991 Bay/Delta Plan**. The Plan establishes a DO water quality objective of 6.0 mg/l for the segment of the San Joaquin River from Turner Cut to Stockton from September 1 through November 30.

**d. 1995 Basin Plan**. The 1995 CVRWQCB Basin Plan established a DO objective of 7.0 mg/l in the Sacramento River below the I Street Bridge and in all Delta waters west of the Antioch Bridge, a DO objective of 6.0 mg/l in the San Joaquin River between Turner Cut and Stockton from September 1 to November 30, and a DO objective of 5.0 mg/l in all other Delta waters.

**e. 1995 Bay/Delta Plan**. The 1991 Bay/Delta Plan was superseded by the 1995 Bay/Delta Plan. The DO objectives remained unchanged, with the exception of the addition of a provision that specifies that if it is infeasible for waste dischargers to meet the objective immediately, a time extension or schedule of compliance may be granted. The objectives, however, must be met by September 1, 2005.

### 3. Historic DO Conditions

Observations of low DO have been made in the lower San Joaquin River near Stockton since 1935. In 1963, however, the effect of low DO levels on fish was recognized as a result of a study conducted by the DFG, DWR, and the Central Valley Water Pollution Control Board. In 1961, salmon escapement declined from the previous year's run of 53,000 fish to 2,550 fish. During the following two years the escapement decreased even further to 320 fish by 1963. The 1963 study was designed to identify the causes of the decreased salmon runs and to determine possible solutions. As part of the study, DO observations were made throughout the lower San Joaquin River. The study area included the reach of river starting from a point near Turner Cut to a point approximately eight miles upstream from Stockton. These observations found DO levels less than 3.0 mg/l and as low as 0.4 mg/l throughout the study area. DO levels as low as 0.1 mg/l were observed in the Stockton ship channel (DFG 1964).

The 1963 study identified pollution originating at Stockton as a significant cause of the DO problem. Most of the pollution was the result of waste discharges from fruit and vegetable canneries. DO levels would decline as the weather warmed and cannery discharges increased. The oxygen block would eventually break in the fall when the cannery season ended, temperatures cooled, and flows increased.

In the fall of 1963, a barrier at the head of Old River was installed for the first time. At the same time, river flows were augmented by releases into the San Joaquin River through the Newman and Westly waterways. It was hoped that the barrier and flow augmentation would increase flows past Stockton thereby improving both flow conditions for fish and water quality conditions, including DO. The action had most of the desired effects (Hallock 1970).

In 1965, 1966 and 1967, DO concentration was identified as the factor that controlled the movement of salmon past Stockton. DO was typically lowest at the San Joaquin River at Turner Cut, but occasionally the lowest DO levels were found near the current Stockton WWTP outfall (Hallock 1970).

The critical area of concern regarding oxygen blocks affecting the migration of adult salmon continues to be the reach of river located from the head of Old River to Turner Cut. Recent monitoring data for DO in this area have been collected at several sampling stations. The data for two of the sampling stations are described in this report. The first sampling station (Mossdale sampling station) is located at the Mossdale crossing about 1.5 miles upstream of the head of Old River. The second station (Stockton sampling station) is located at the Stockton ship channel about 4.5 miles upstream of Turner Cut (see Figure X-1).

DO levels at the stations have been taken since 1984. Daily average DO readings are summarized in Figures X-3 and X-4 for the four-year period from 1990 through 1994. This time period includes three critically dry years and one wet year, based on the San Joaquin River Basin 60-20-20 hydrologic classification. DO levels at the Mossdale sampling station, shown in Figure X-3, appear to be adequate to support aquatic habitat. DO levels at the Stockton sampling station, shown in Figure X-4, are significantly lower than at Mossdale and the DO objectives were exceeded on numerous occasions.

## 4. Current and Proposed Management Actions to Improve DO

This section discusses the following current and proposed management actions to improve DO conditions: (a) U.S. Army Corps of Engineers (USCOE) aeration facility, (b) the barrier at the head of Old River, (c) Interim South Delta Program (ISDP), and (d) water quality regulatory actions by the CVRWQCB.

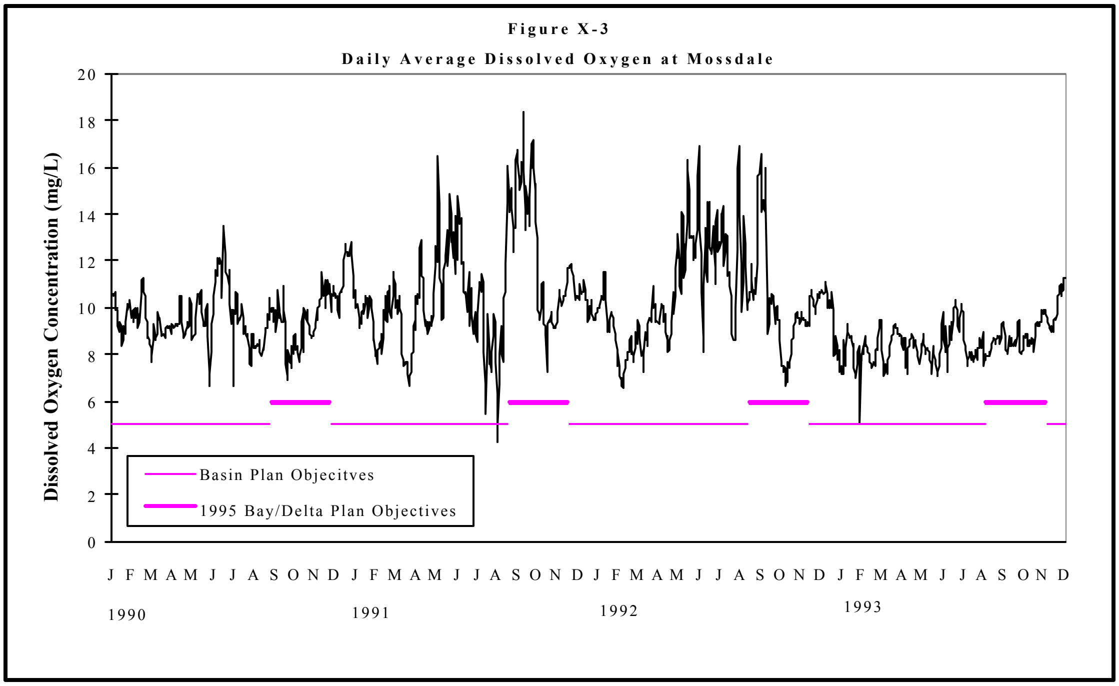


Figure X-3
Daily Average Dissolved Oxygen at Mossdale
Dissolved Oxygen Concentration (mg/L)
20
18
16
14
12
10
8
6
4
2
0
Basin Plan Objecitves
1995 Bay/Delta Plan Objectives
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
1990
1991
1992
1993

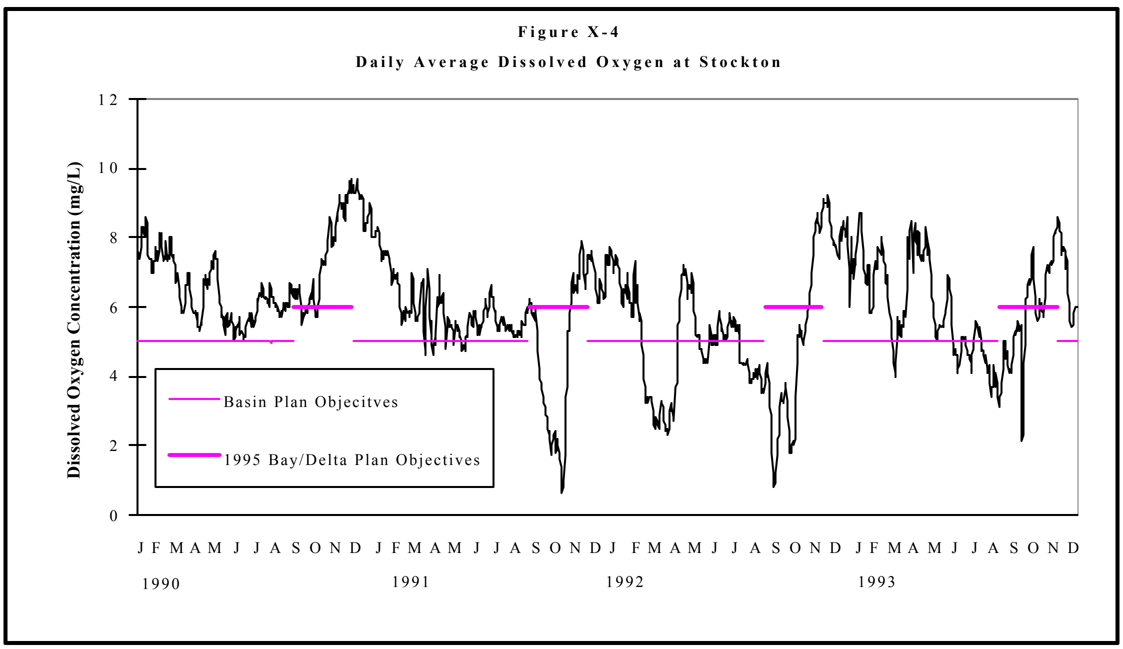


Figure X-4
Daily Average Dissolved Oxygen at Stockton
Dissolved Oxygen Concentration (mg/L)
12
10
8
6
4
2
0
Basin Plan Objecitves
1995 Bay/Delta Plan Objectives
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
1990
1991
1992
1993

**a. USCOE Aeration Facility**. The USCOE installed a jet aeration facility in the Stockton ship channel at the Port of Stockton in the vicinity of Rough and Ready Island. The purpose of the facility is to mitigate for the reduction of about 0.2 mg/l (approximately 2,000 lbs/day of oxygen at a flow of 2,000 cfs) in DO concentrations which occurs when the ship channel is dredged. The aeration facility consists of two manifolds with eight mixing nozzles each that introduce a jet of water mixed with air bubbles into the river. The aeration system is lowered to a depth of about 20-feet and is designed to inject about 2,000 lbs/day of DO into the river. The pump intake includes fish screens and is designed to achieve low intake velocities in order to prevent entrainment of fish (USCOE 1990).

The facility is operated by the USCOE in cooperation with the Port of Stockton and the City of Stockton. The USCOE is currently negotiating an agreement to transfer operational responsibilities to the Port of Stockton. The facility is operated whenever the DO levels at any of Stockton's eight river monitoring stations drop below 5.2 mg/l during the fall chinook salmon run (September through November).

**b. Barrier at Head of Old River**. Under a 1969 agreement between the DWR, DFG, USBR and U.S. Bureau of Sport Fisheries and Wildlife (predecessor to U.S. Fish and Wildlife Service), a temporary barrier is installed at the head of Old River from September through November in order to increase flow in the San Joaquin River past Stockton. When the barrier is in place, water flowing in the San Joaquin River is restricted from flowing down Old River and continues to flow downstream in the mainstem of the river. When the barrier is not in place, more than half of the San Joaquin River flow measured at Vernalis flows down Old River.

Monitoring data show that installation of the fall Head of Old River barrier usually improves DO concentrations in the lower San Joaquin River, especially in years with low San Joaquin river flows, although the rate of improvement has varied. The most pronounced beneficial effects of the barrier occur when its installation eliminates net negative flows in the San Joaquin River. Under these circumstances, adverse effects of slack water are avoided, and the turning basin is not a significant DO sink for the river (Stockton 1996).

The flow necessary to achieve the DO objectives in the absence of a barrier is not known. Low DO levels have been recorded even when San Joaquin River flows were relatively high.

**c. ISDP**. The ISDP is described in detail in Chapter IX. The ISDP is a proposed action to: (1) improve water quality and raise water levels in the southern Delta; (2) settle pending litigation by the South Delta Water Agency against the USBR and the DWR; (3) implement an element of the Central Valley Project Improvement Act (CVPIA); and (4) enhance the existing water delivery capability of the SWP. The ISDP includes five project components, one of which is the construction and seasonal operation of a permanent barrier at the head of Old River in spring and fall to improve fishery conditions for salmon migrating along the San Joaquin River. The permanent barrier would be operated to improve flow conditions past Stockton similar to the current temporary barrier operation.

**d. Water Quality Regulatory Actions by the CVRWQCB**. Oxygen levels in the San Joaquin River have improved as a result of incremental treatment of wastewater discharges required by the CVRWQCB. The pretreatment of cannery waste and its subsequent treatment at treatment plants has significantly reduced the BOD loading from this source.

The largest point source discharge of BOD in the southern Delta is the City of Stockton. In 1990, Stockton applied to renew its NPDES permit which would expire in 1991. During the application review, Stockton and the CVRWQCB staff agreed to develop new information to address permit renewal issues including the effects of the discharge on downstream DO concentrations (SWRCB 1996). As a result, Stockton developed a computer model that, among other things, simulates the effect of the WWTP and DO concentrations in the river in the immediate vicinity of the WWTP's outfall and Stockton shipping channel (Chen and Schanz 1993). The City's model showed that the treatment plant discharge was a significant contributor to the DO problem, even though the City complied with existing effluent limits. Consequently, the CVRWQCB staff proposed more stringent effluent limitations in the draft NPDES permit. The proposed effluent limitations are summarized in Table X-6.

**Table X-6**
**Proposed NPDES Limitations**

| Time Period | Carbonaceous BOD (mg/l) | | | $NH_3$ (mg/l) | | |
|---|---|---|---|---|---|---|
| | Monthly Avg. | Weekly Avg. | Daily Max. | Monthly Avg. | Weekly Avg. | Daily Max. |
| Dec. 1-<br>Mar. 31 | 20 | -- | -- | no nitrification required | -- | -- |
| Apr. 1-<br>Oct. 31 | 10 | 20 | 25 | 2 | 4 | 5 |
| Nov. 1-<br>Nov. 30 | 15 | 23 | 30 | 10 | 15 | - |

The City objected to the 2.0 mg/l monthly average ammonia limit during the April through October period. The City's objection was based on several grounds. First, it claimed that compliance with new effluent limitations would be unreasonably expensive. Stockton is in the process of designing and constructing improvements to its WWTP. The improvements are planned to achieve effluent quality of 10.0 mg/l CBOD and 7.0 mg/l ammonia. Stockton claimed that the cost of constructing the incremental improvement to achieve an effluent quality of 2.0 mg/l ammonia would be too expensive. Second, Stockton asserted that it could not complete improvements to comply with the effluent limitations during the five-year life of the NPDES permit, and it would be unfairly subject to enforcement actions. Finally, Stockton argued that even without its discharge, the DO levels in the area of its discharge would not consistently comply with current water quality objectives. Stockton claims that water quality impairments of the lower San Joaquin River are caused by man-made conditions, including Delta export pumping and other operations, which reduce and reverse flows in the San Joaquin River near Stockton (SWRCB 1996).

On October 28, 1994, the CVRWQCB adopted Waste Discharge Requirements for the Stockton WWTP, Order No. 94-324 (NPDES Permit No. CA0079138) which includes the effluent limitations recommended by staff. The order acknowledges that other causes contribute to the low DO levels, but finds that Stockton's discharge contributes to the violation of the DO water quality objectives and that more stringent effluent limitations for CBOD and ammonia would substantially reduce that contribution.

Stockton subsequently filed a petition with the SWRCB objecting to certain provisions of the NPDES permit. After review of the petition, the SWRCB adopted Order No. WQ 96-09 which remands the NPDES permit back to the CVRWQCB for review and revision. The SWRCB specified that the CVRWQCB should reconsider the CBOD and ammonia effluent limitations in the permit, taking into account new river flow conditions caused by implementation of the 1995 Bay/Delta Plan flow objectives. The CVRWQCB should also incorporate flexibility in the NPDES permit to revise the effluent limitations to accommodate both future improvements in receiving water DO levels and alternatives for reducing the discharger's impact to DO. The order requires the CVRWQCB to adopt a cease and desist order with a compliance schedule and to establish a compliance schedule in the NPDES permit to implement effluent limitations and receiving water limitations necessary to comply with DO objectives. The SWRCB continued a stay of the effluent limitations for ammonia and receiving water limitations for DO until the CVRWQCB completes the review and revision required in the order. In all other respects, the NPDES permit remains in full force and effect. The CVRWQCB and Stockton agreed to postpone action, including the adoption of a cease and desist order, until Stockton completes further modeling of the WWTP's effects on the river.

## B. ALTERNATIVES FOR IMPLEMENTING THE DO OBJECTIVE

DO conditions near Stockton are controlled by net flows past Stockton, BOD loading, water temperature, sediment oxygen demand, and algal blooms. The alternatives in this report evaluate two of the controlling factors, increased flows and BOD loading. Increased flows past Stockton can be provided either by increasing flows in the San Joaquin River entering the Delta or by placing a barrier at the head of Old River. Water temperatures, sediment oxygen demand, and algal blooms were not evaluated because there are no controllable mechanisms by which the SWRCB can significantly affect these parameters. The following four alternatives are evaluated in this report.

### 1. DO Control Alternative 1 - Base Case

The SWP and the CVP are responsible for meeting D-1485 flow objectives. The quantity and quality of effluent from the Stockton WWTP are at present levels. The Head of Old River temporary barrier is installed in September, October, and November. No further water right action is taken to implement the dissolved oxygen objective. This is the existing condition.

### 2. DO Control Alternative 2 - Bay/Delta Plan Flows

The 1995 Bay/Delta Plan flow objectives are met by implementation of one of the flow alternatives. Effluent quantity and quality from the Stockton WWTP are at present levels. The Head of Old River temporary barrier is installed in September, October, and November. No further action is taken to implement the dissolved oxygen objective.

### 3. DO Control Alternative 3 - ISDP Barriers Operation

The 1995 Bay/Delta Plan flow objectives are met by implementation of one of the flow alternatives. Effluent quantity and quality from the Stockton WWTP are at present levels. The permanent barriers proposed in the ISDP are constructed and operated and the barrier at the head of Old River is closed in September, October, and November.

### 4. DO Control Alternative 4 - Reduced BOD Loading from the Stockton WWTP

The 1995 Bay/Delta Plan flow objectives are met by implementation of one of the flow alternatives. The permanent barriers proposed in the ISDP are constructed and operated and the barrier at the head of Old River is closed in September, October, and November. The discharge quantity from the Stockton treatment plant is at the present levels; however, the effluent meets CBOD and ammonia effluent limits as specified in the NPDES permit issued by the CVRWQCB and shown in Table X-6. Stockton complies with the permit limits by constructing enhanced treatment facilities.

## C. ENVIRONMENTAL EFFECTS OF THE ALTERNATIVES

This section describes the environmental effects of implementing the DO control alternatives. The discussion is divided into eight sections: (1) Impacts to Water Quality in the San Joaquin River; (2) Impacts on Aquatic Resources; (3) Energy Effects; (4) Public Nuisance Considerations; (5) Use of Hazardous/Toxic Substances; (6) Socioeconomic, Fiscal and Secondary Effects; (7) Construction-Related Impacts; and (8) Summary. Section 1 discusses the water quality impacts in the San Joaquin River of the three DO alternatives and the base case. Sections 2 through 7 focus on impacts expected from implementation of Alternative 4. The information in these sections is summarized from an expanded initial study for the Stockton WWTP (Engineering-Science, Inc 1994) and an addendum to the expanded initial study (Stockton 1994). Other impacts expected to result from Alternative 2 are already described in Chapters V (water supply impacts), VI (environmental impacts) and XI (economic impacts) of this EIR. Other expected impacts of Alternative 3 are already discussed in Chapter IX of this EIR. Alternatives 3 and 4 include actions that would require subsequent project level evaluations pursuant to CEQA, and they will be evaluated as programmatic actions for the purpose of this EIR.

### 1. Impacts to Water Quality in the San Joaquin River

Stockton's San Joaquin River model was used to simulate DO levels in the San Joaquin River resulting from the DO control alternatives (Chen 1997). The DO model is described in Chapter IV of this EIR. The model was used to simulate five years; one year for each of the five year types as classified by the Sacramento Valley 40-30-30 Water Year Hydrologic Classification system described on page 23 of the 1995 Bay/Delta Plan. The selected years are: water year 1982 - wet; water year 1957 - above normal; water year 1966 - below normal; water year 1981 – dry, and; water year 1991- critically dry. These are the same years that were selected by the DWR in consultation with the DFG for the purposes of modeling the impacts to the Delta of implementing the ISDP (DWR 1996).

For each simulation, the river flows of the San Joaquin River at Stockton were obtained from the output of the DWR’s Delta Simulation Model (DWRDSM). The river flows reflect the upstream reservoir operations and Head of Old River barrier operations. For Alternatives 1 and 2, temporary barrier operation is assumed. Alternatives 3 and 4 assume operation of a permanent barrier. Barrier operations are described on Table IX-1.

Simulations for Alternatives 1, 2, and 3 assume CBOD and ammonia loading at Stockton's WWTP at 1996 levels. Alternative 4 reduces CBOD and ammonia loading through enhanced treatment. Stockton is in the process of expanding and rehabilitating its WWTP and the master plan is currently being updated to reflect the planned upgrade to 48 million gallons per day (mgd) capacity with an ultimate build-out of 55 mgd. The six-stage expansion project as planned, will meet the CBOD limits, with monthly average effluent quality of 10.0 mg/l CBOD. The designed effluent quality of 7.0 mg/l ammonia will not meet the proposed 2.0 mg/l ammonia monthly average limit. Stockton testified during the Bay/Delta water rights hearing that the cost of constructing nitrification facilities to achieve an effluent quality of 2.0 mg/l ammonia would be $61 million plus additional financial costs of $17 million. This analysis focuses on three of Stockton's monitoring stations: R2, R3, and R7 (see Figure X-1). Monitoring Station R2 is located just upstream of the WWTP outfall, monitoring Station R3 is located at the turning basin, and monitoring Station R7 is located at Turner Cut. These locations were chosen to show the simulated DO at approximately the upstream and downstream boundaries of the DO objective and where the lowest DO levels are often measured (the turning basin). Figures X-5 through X-19 show the minimum monthly DO levels for each objective at the three monitoring stations for each of the five years modeled.

Figures X-5 through X-9 show minimum monthly DO levels at Station R2, south of the WWTP. This station is normally upstream of the WWTP and the turning basin; however, during periods of reverse flow, the station is downstream. The figures show that minimum monthly DO levels at this station are consistently above the objectives for all year types from October through June, except during the critically dry year of 1991 when Alternatives 3 and 4 are slightly below the objective in June. Additionally, minimum monthly DO levels for the three alternatives during the time period of October through June generally are equal to or better than minimum monthly DO levels under the base case. Where minimum monthly DO is less than under the base case, the difference is either slight, or else the difference occurs in the winter when DO levels are not a problem. As the conditions become dryer in July and August, DO conditions worsen. Minimum monthly DO during July and August is generally better than the base case for Alternatives 3 and 4; however, minimum monthly DO levels for Alternative 2 are often worse than the base case in this period. By September, minimum monthly DO levels begin to recover. September minimum monthly DO levels are generally better for Alternatives 3 and 4 than for the base case.

Figures X-10 through X-14 show minimum monthly DO levels at Station R3, the turning basin. These figures show the same yearly trends as Figures X-5 through X-9, with the minimum monthly DO levels above the objectives through the winter and spring and DO levels declining through the summer until September when they start to recover. Alternative 3 generally provides the highest DO concentrations during June and July, while Alternative 4 is generally more beneficial to DO levels during the August through October time period. The effects of the barriers are also noticeable, especially in September and October, when the Head of Old River Barrier is in place. During the summer months, the barriers sometimes cause DO to worsen as compared to the base case, most notably during the dryer year types. Implementation of Alternative 2, the Bay/Delta Plan, improves DO conditions in April and May, the pulse flow period, but there is a corresponding drop in DO in the late summer for all year types.

Figures X-15 through X-19 show minimum monthly DO levels at Station R7, Turner Cut. DO levels follow the same yearly trends as the other figures. Minimum monthly DO levels at Turner Cut are generally higher than the minimum monthly DO for the same period at the turning basin. This is due, in part, to the greater mixing that occurs at this location.

All of the alternatives achieve the 5.0 mg/l objective for all year types. Even though DO levels improve from upstream stations, the 6.0 mg/l objective is often not met in September for Alternatives 1, 2, and 3. The objective is also not met in October for every alternative for every year type, except during the critically dry year of 1991, when every alternative met the October DO objective.

The flow in the lower San Joaquin River is highly regulated by the upstream reservoirs. For that reason, a wet year does not necessarily result in a higher stream flow during the critical summer months. The minimum DO for a dry year may be higher than the minimum DO for a wet year.

**Figure X-5**
**Simulated Minimum Monthly DO at Station R2 for Wet Year**

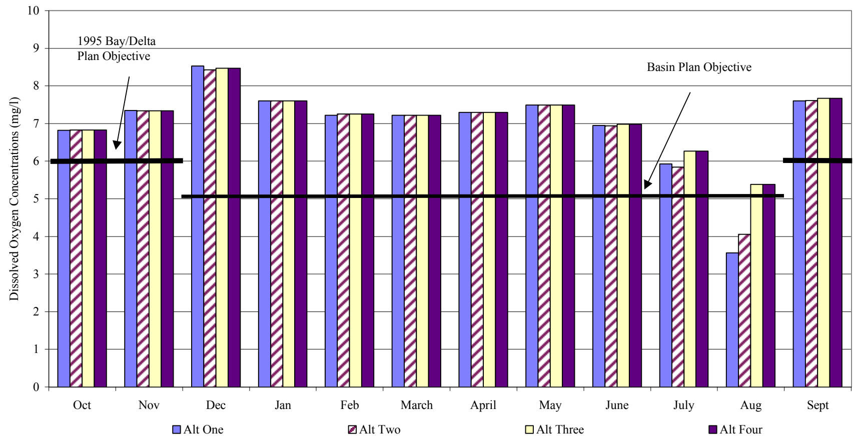



**Figure X-6**
**Simulated Minimum Monthly DO at Station R2 for Above Normal Year**

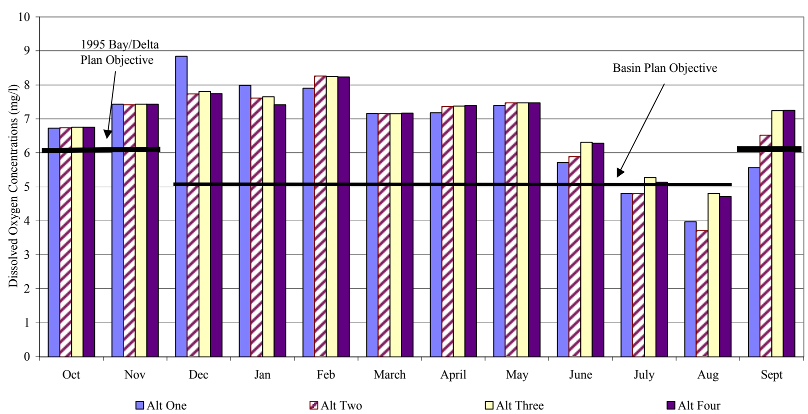



**Figure X-7**
**Simulated Minimum Monthly DO at Station R2 for Below Normal Year**

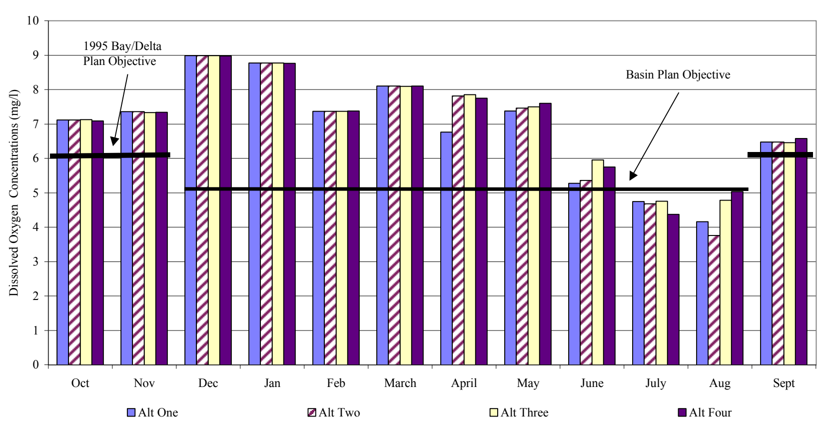


**Figure X-8**
**Simulated Minimum Monthly DO at Station R2 for Dry Year**

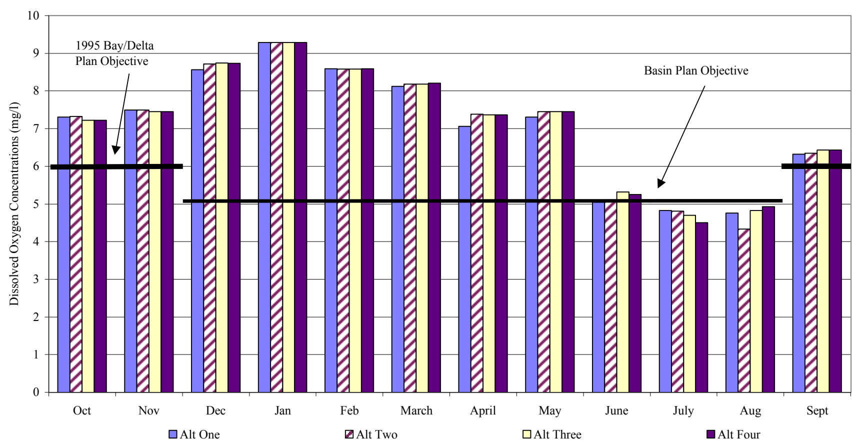



**Figure X-9**
**Simulated Minimum Monthly DO at Station R2 for Critically Dry Year**

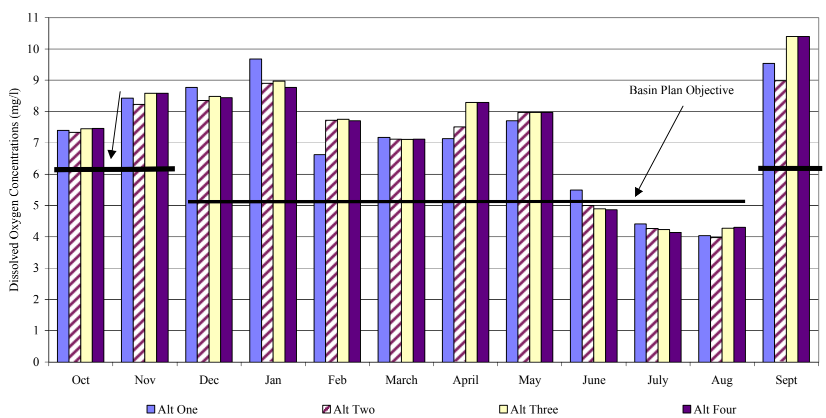


**Figure X-10**
**Simulated Minimum Monthly DO at Station R3 for Wet Year**

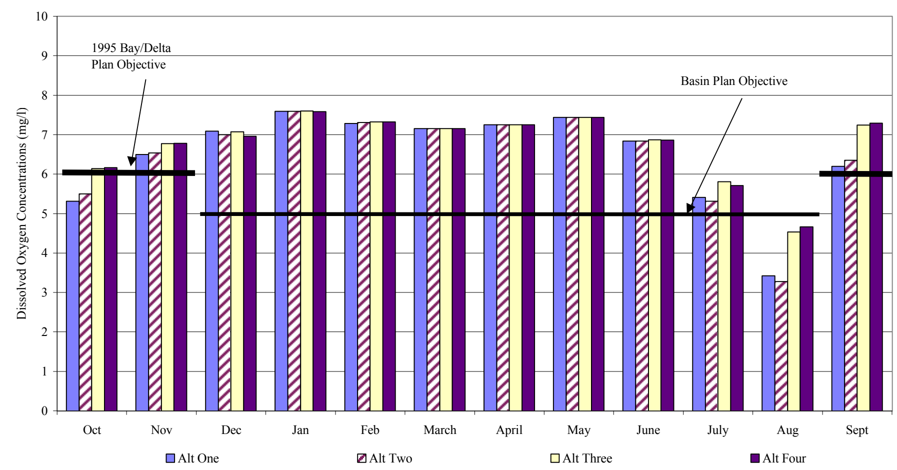



**Figure X-11**
**Simulated Minimum Monthly DO at Station R3 for Above Normal Year**

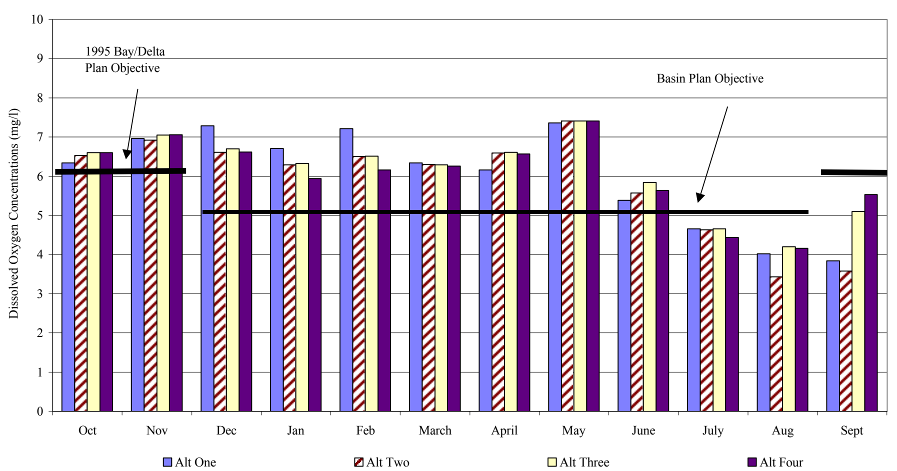



**Figure X-12**
**Simulated Minimum Monthly DO at Station R3 for Below Normal Year**

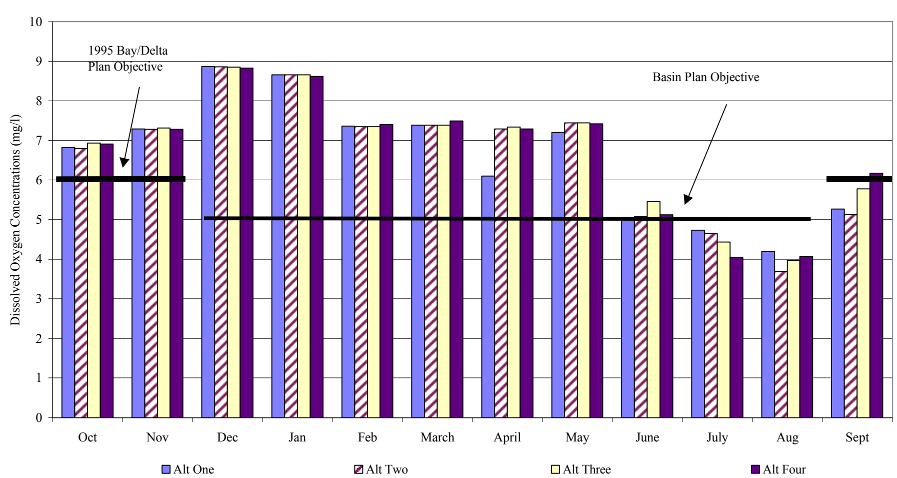


**Figure X-13**
**Simulated Minimum Monthly DO at Station R3 for Dry Year**

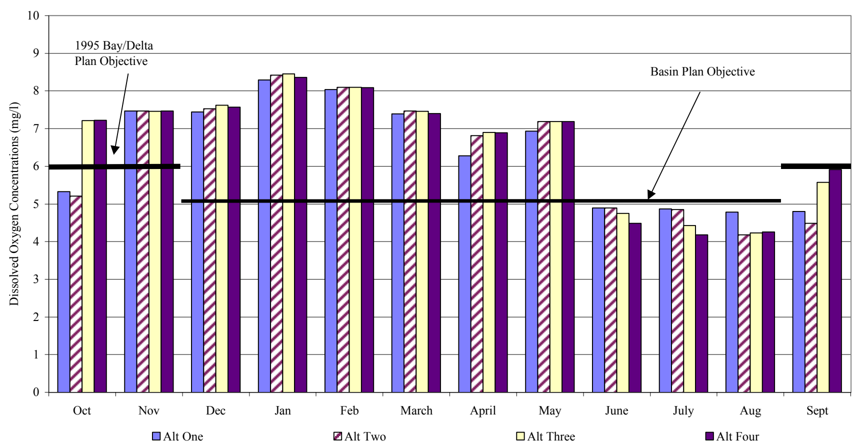



**Figure X-14**
**Simulated Minimum Monthly DO at Station R3 for Critically Dry Year**

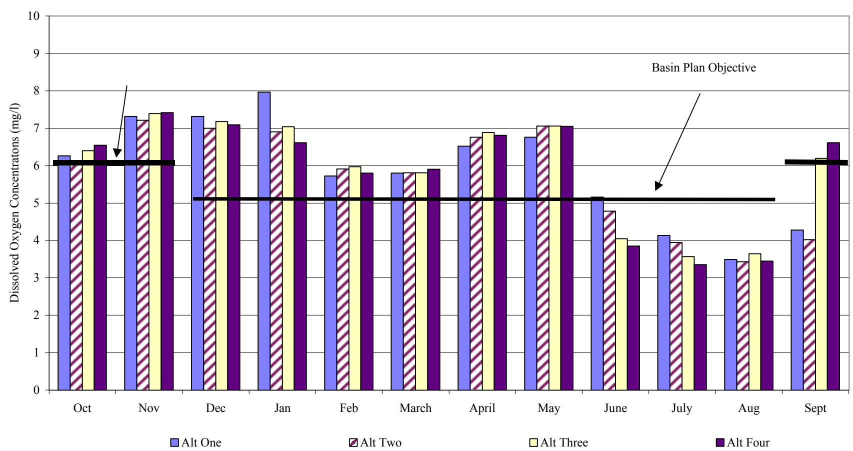


**Figure X-15**
**Simulated Minimum Monthly DO at Station R7 for Wet Year**

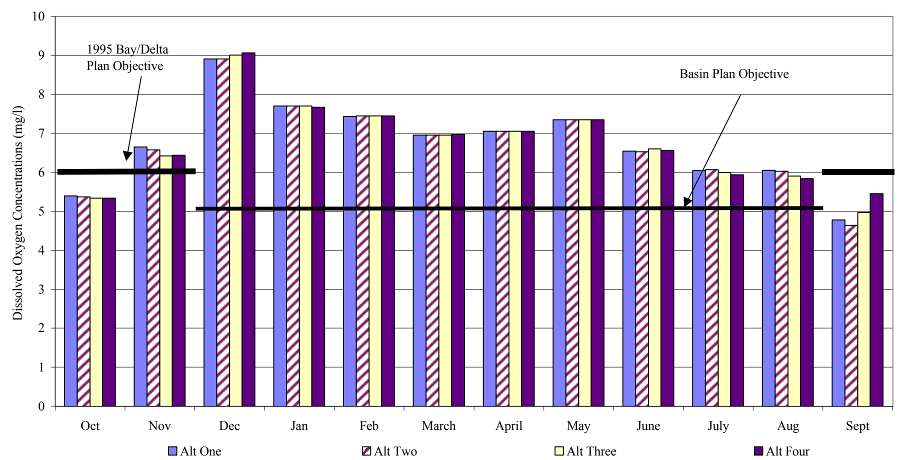



**Figure X-16**
**Simulated Minimum Monthly DO at Station R7 for Above Normal Year**

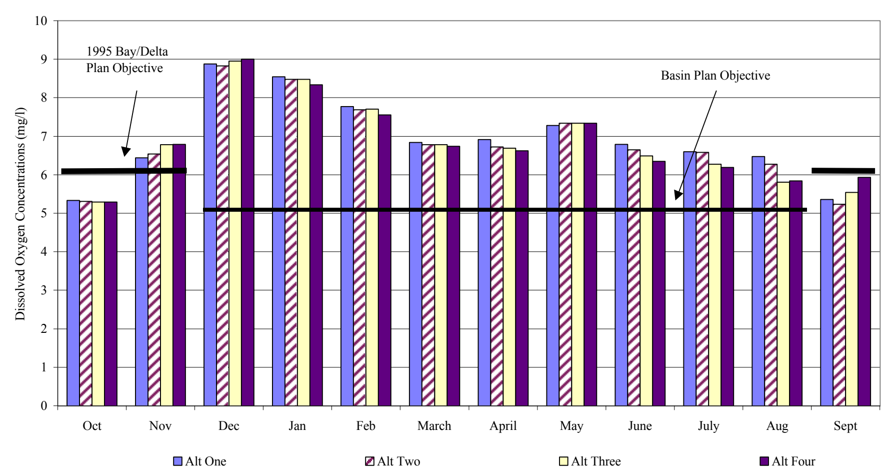



**Figure X-17**
**Simulated Minimum Monthly DO at Station R7 for Below Normal Year**

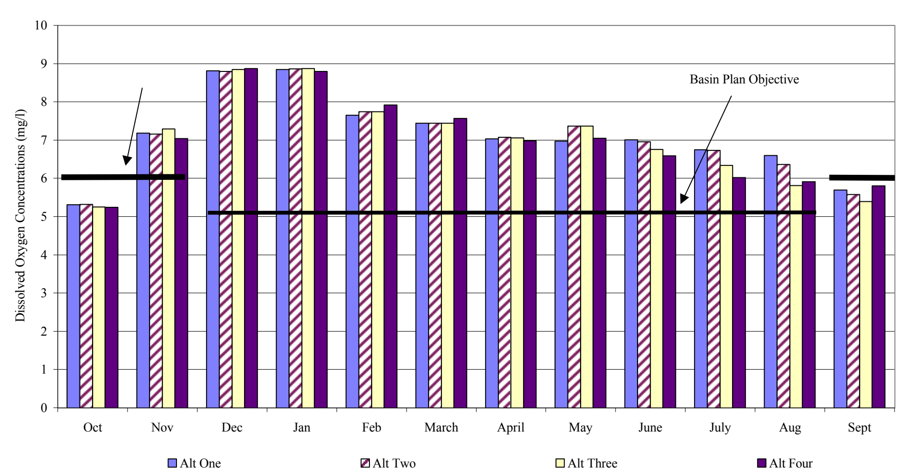


**Figure X-18**
**Simulated Minimum Monthly DO at Station R7 for Dry Year**

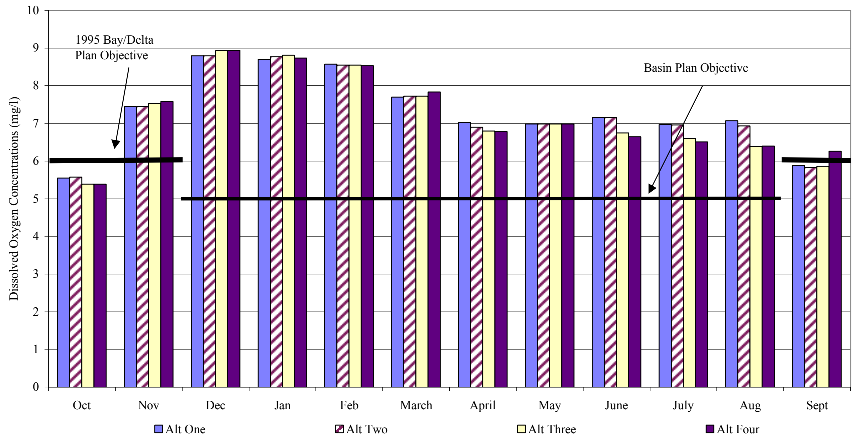
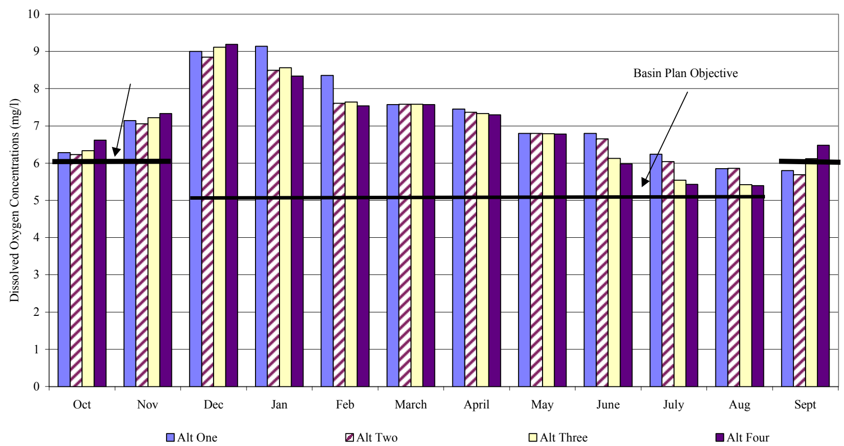



**Figure X-19**
**Simulated Minimum Monthly DO at Station R7 for Critically Dry Year**



Figures X-20 through X-29 show the frequency distribution of DO levels for each water-year type at monitoring Station R3. Historically, the lowest DO levels have been measured at Station R3. The first figure for each water year shows the period from September to November when the Bay/Delta Plan 6.0 mg/l DO objective is in effect, and the second figure for each water year shows the period from December to August when the CVRWQCB Basin Plan 5.0 mg/l objective is in effect. The objectives are also shown on the figures.

Figure X-20 shows that during the wet year of 1982, the DO levels vary little among the alternatives during the September through November period. Alternatives 3 and 4 provide slightly higher DO levels and meet the objective most of the time. The other alternatives fail to meet the objective only slightly less often. During the December to August period, shown on Figure X-21, Alternatives 3 and 4 meet the objective slightly more often than Alternatives 1 and 2. When the objective is not met, the DO under Alternatives 1 and 2 is up to 1.5 mg/l lower than the DO under Alternatives 3 and 4.

Figure X-22 shows that during the above normal year of 1957, all the alternatives result in similar DO levels in September through November. Alternatives 3 and 4 meet the objective slightly more often than Alternatives 1 and 2. Figure X-23 shows that during December through August, the alternatives provide similar DO levels, with Alternatives 3 and 4 providing slightly higher DO levels than Alternatives 1 and 2. When the objective is not being met, DO levels are up to 1.5 mg/l below the 5.0 mg/l objective.

Figure X-24 and X-25 show DO levels during the below normal year of 1966. During the September through November period Alternatives 1 and 2 do not meet the objective about 20 percent of the time. Alternative 3 meets the objective in all but about 10 percent of years and Alternative 4 always meets the DO objective during the months of September through November. During December through August, Alternatives 2, 3, and 4 meet the objective equally often and result in similar DO levels.

Figure X-26 shows that during the fall of the dry year 1981, Alternative 4 most often meets the DO objective. Figure X-27 shows that during December through August, DO levels are similar among the alternatives, with DO levels falling below the objective about 25 percent of the time. Alternatives 3 and 4 least often meet the objective and result in the lowest overall DO when the objective is not being met.

Figure X-28 shows that during the critically dry year of 1991, Alternatives 3 and 4 provide slightly higher DO levels and always meets the objective. Figure X-29 shows that during December through August, all alternatives result in similar DO levels. Alternative 1 meets the objectives most often, but the other alternatives meet the objectives only slightly less often than Alternative 1.

**Figure X-20**
**Frequency Distribution of Dissolved Oxygen Levels at Stockton in a Wet Year (Water Year 1982) for September - November**

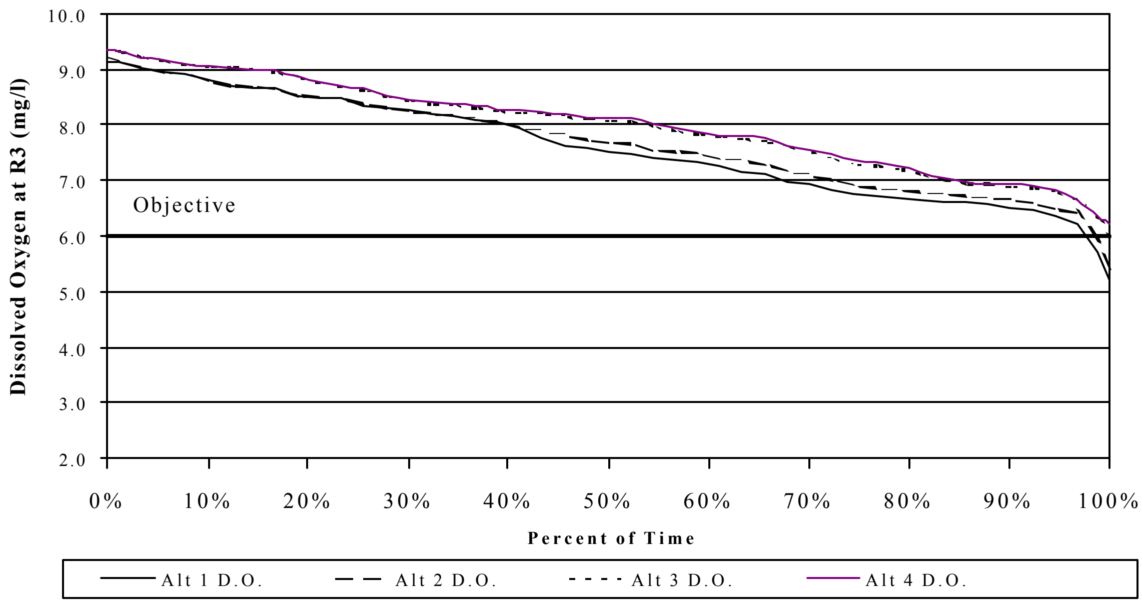



**Figure X-21**
**Frequency Distribution of Dissolved Oxygen Levels at Stockton in a Wet Year (Water Year 1982) for December - August**

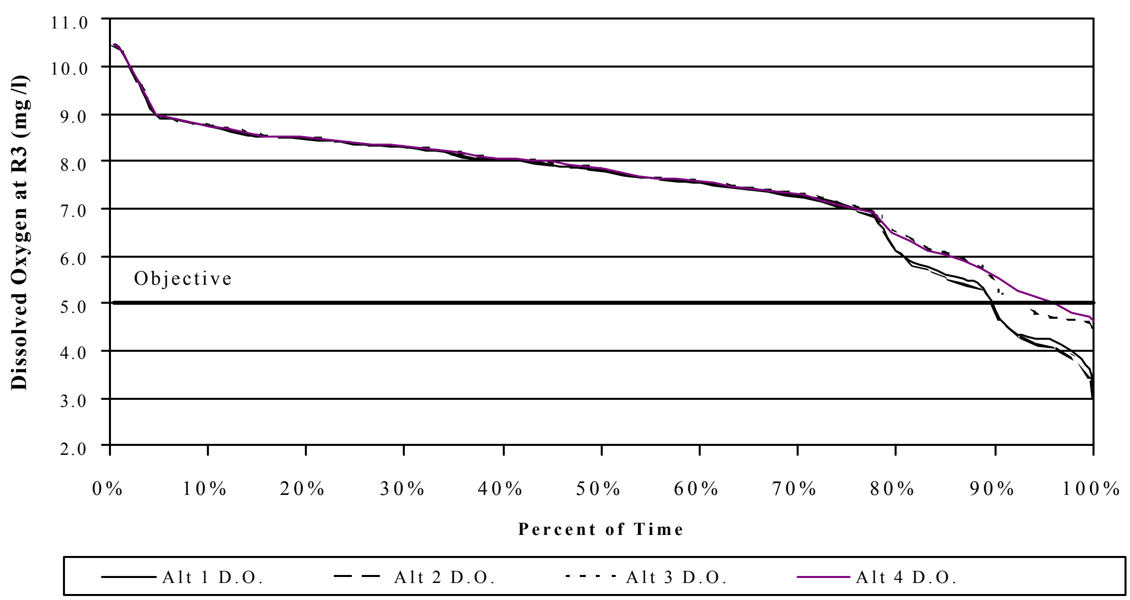


**Figure X-22**
**Frequency Distribution of Dissolved Oxygen Levels at Stockton in an Above Normal Year (Water Year 1957) for September - November**

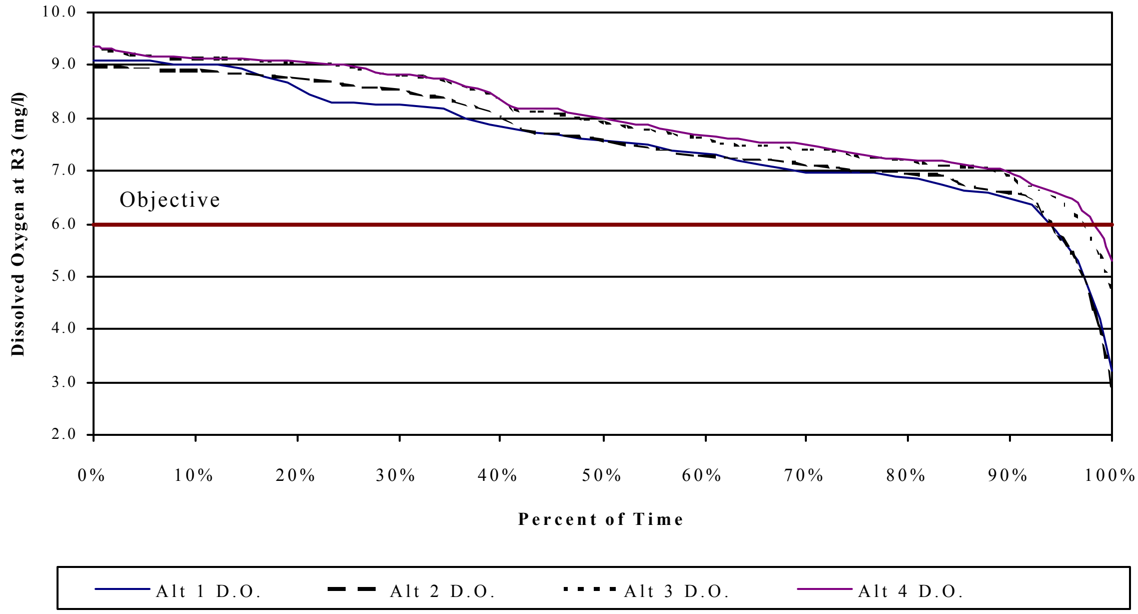



**Figure X-23**
**Frequency Distribution of Dissolved Oxygen Levels at Stockton in an Above Normal Year (Water Year 1957) for December - August**

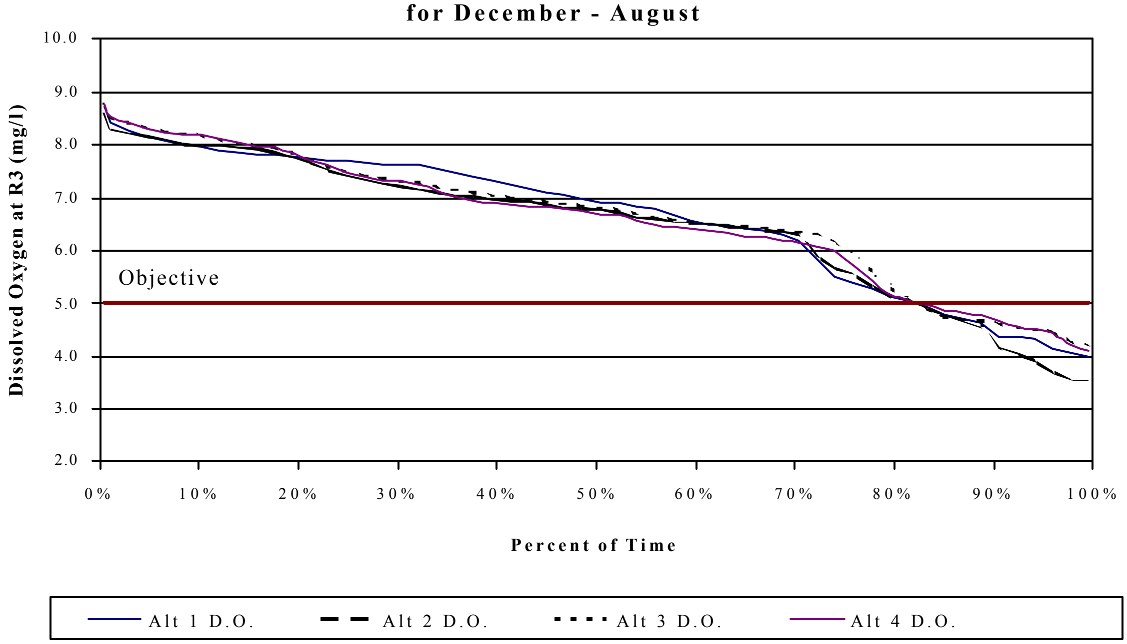


**Figure X-24**
**Frequency Distribution of Dissolved Oxygen Levels at Stockton in a Below Normal Year (Water Year 1966) for September - November**

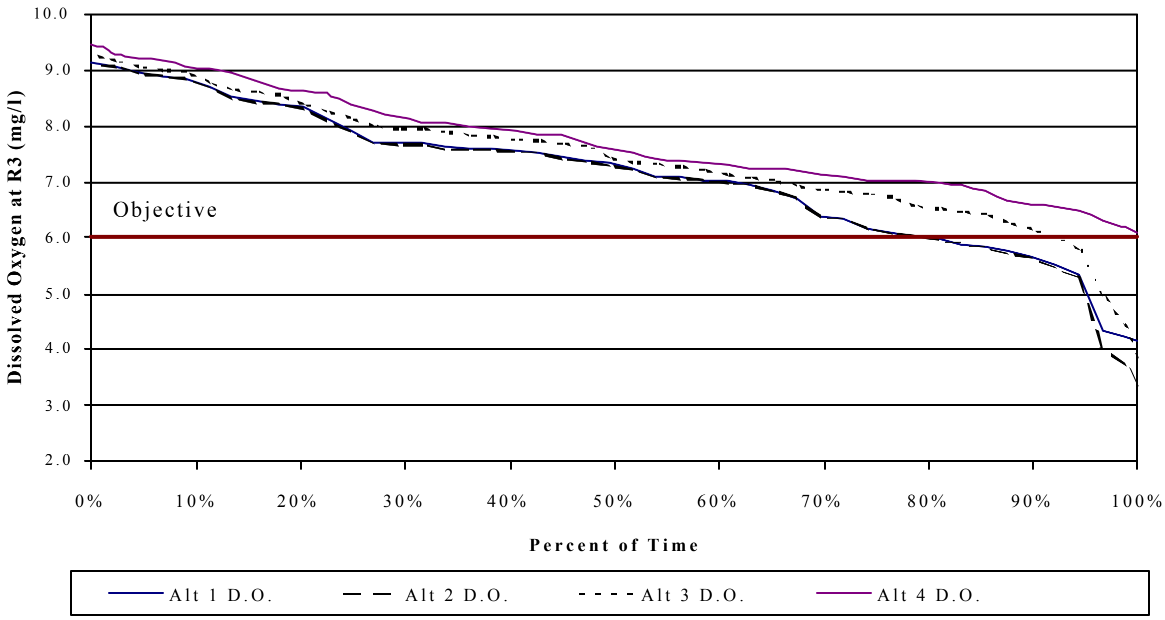



**Figure X-25**
**Frequency Distribution of Dissolved Oxygen Levels at Stockton in a Below Normal Year (Water Year 1966) for December - August**

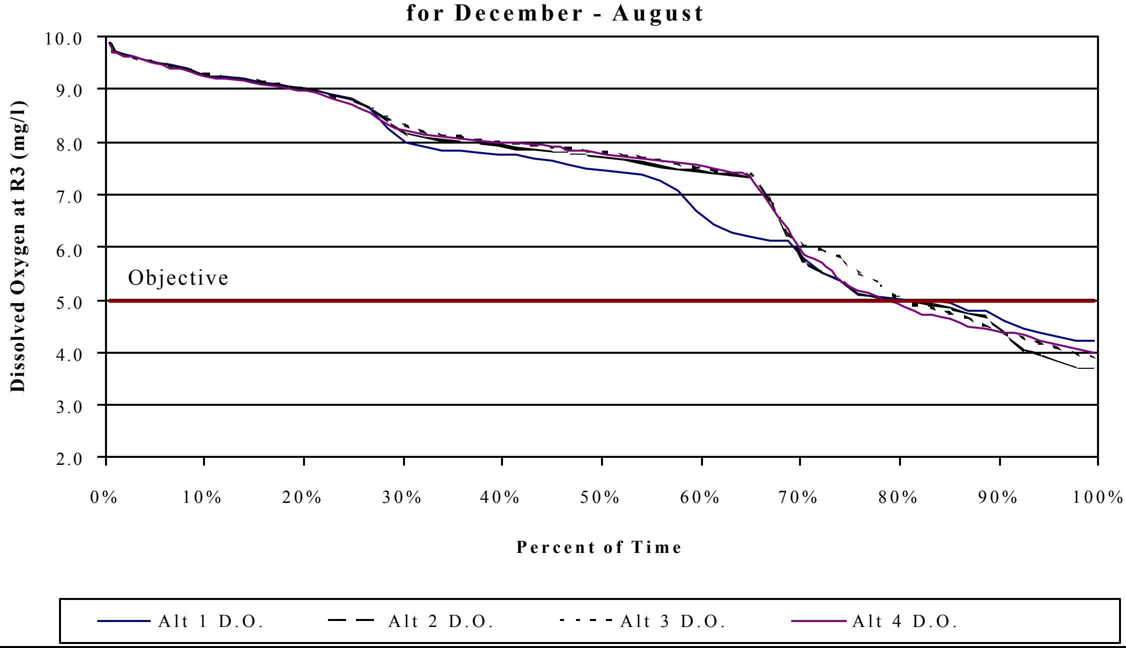


**Figure X-26**
**Frequency Distribution of Dissolved Oxygen Levels at Stockton in a Dry Year (Water Year 1981) for September - November**

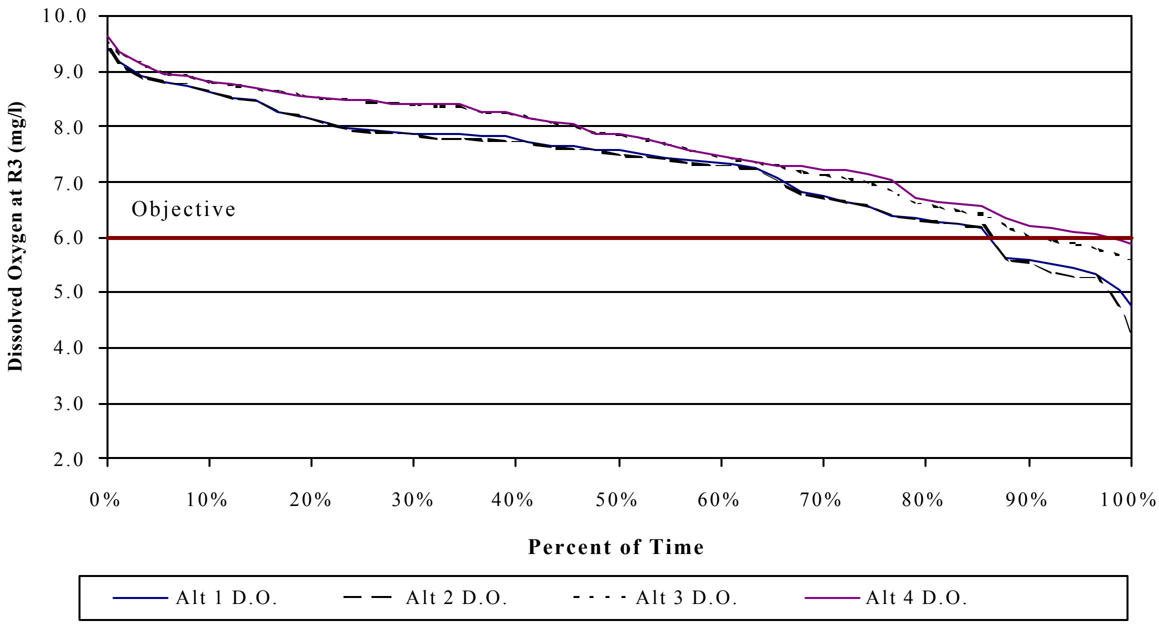



**Figure X-27**
**Frequency Distribution of Dissolved Oxygen Levels at Stockton in a Dry Year (Water Year 1981) for December - August**

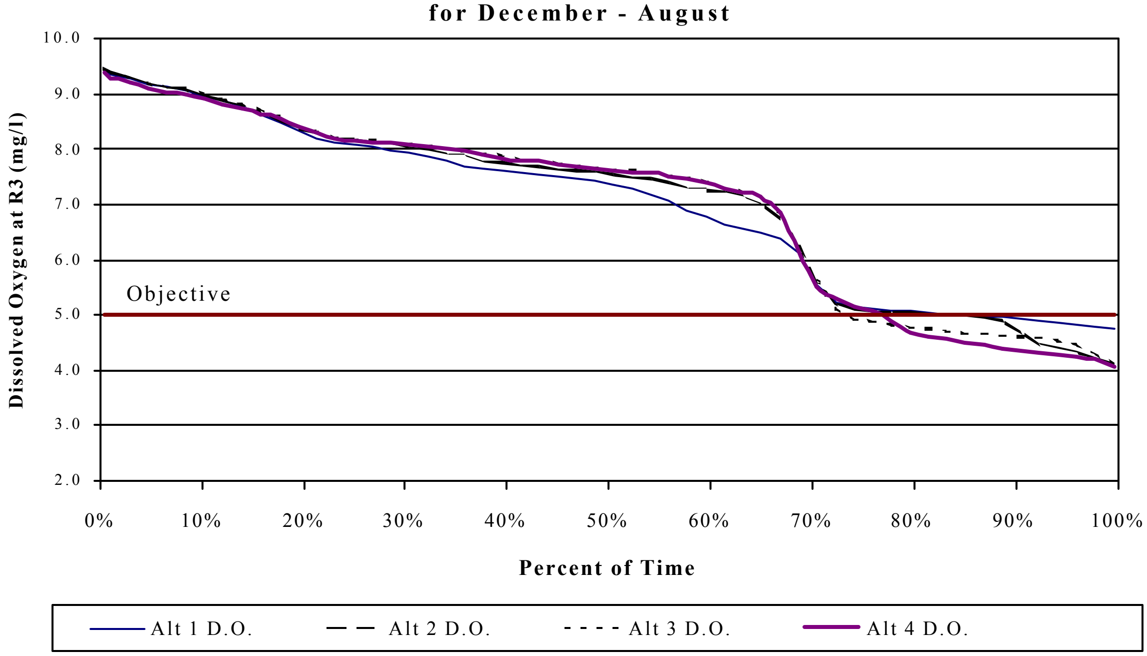


**Figure X-28**
**Frequency Distribution of Dissolved Oxygen Levels at Stockton in a Critically Dry Year (Water Year 1991) for September - November**

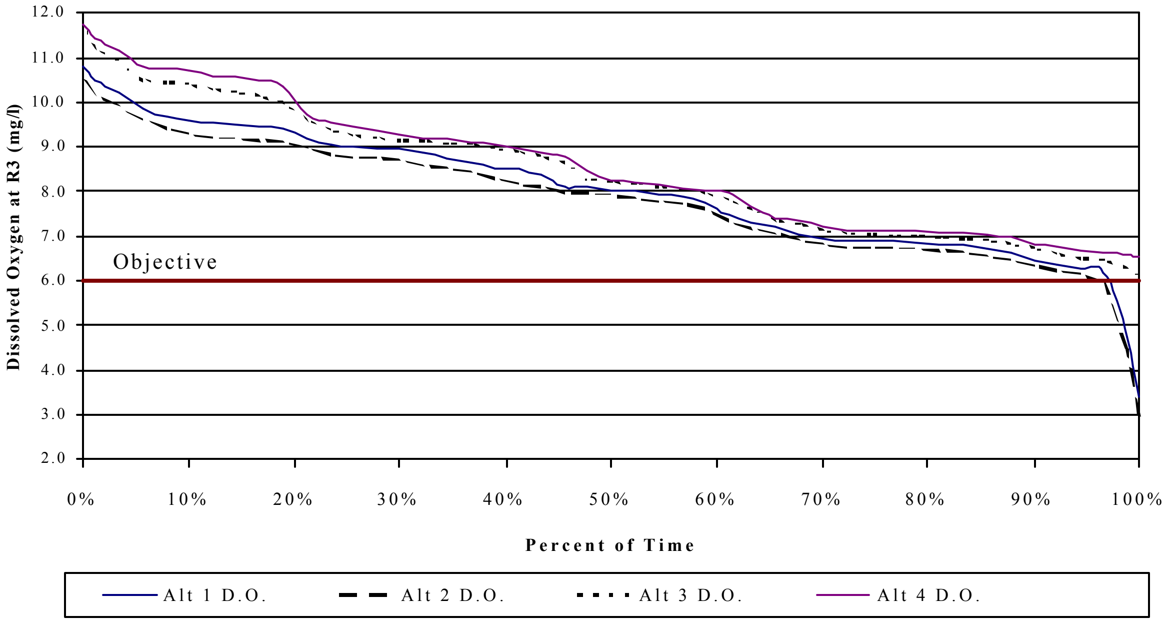
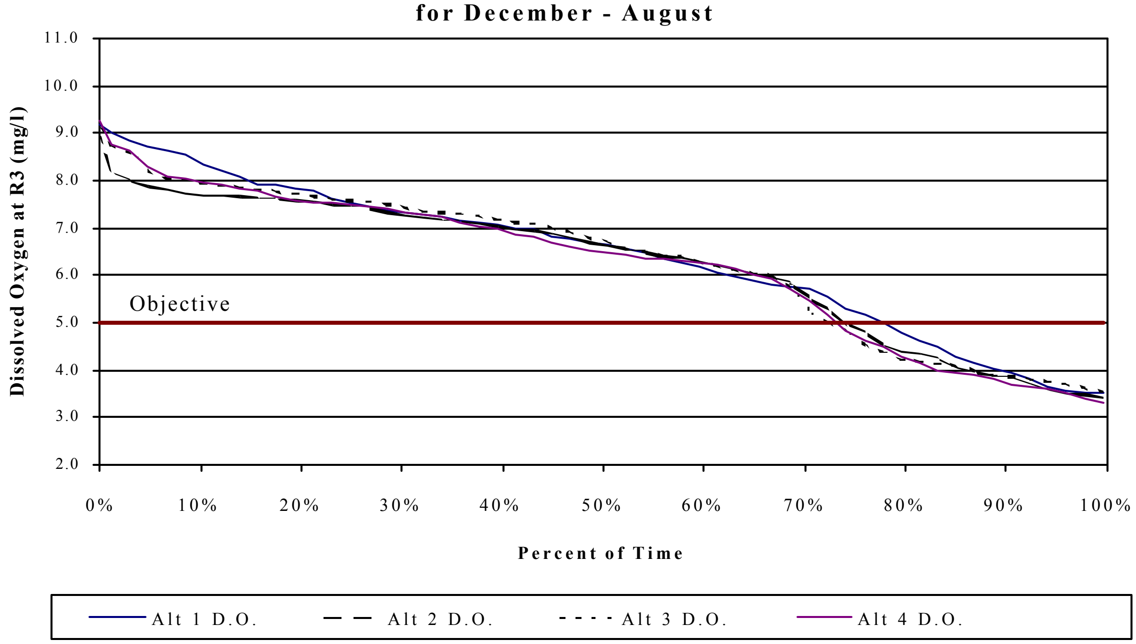



**Figure X-29**
**Frequency Distribution of Dissolved Oxygen Levels at Stockton in a Critically Dry Year (Water Year 1991) for December - August**



None of the alternatives will result in DO objectives being met in all water year types. During the period of November to May, the DO objective is met by all alternatives during each water year modeled. DO levels begin to subside at the downstream stations (R3 and R7) during June and July when Alternatives 1 and 2 often provide higher DO concentrations than Alternatives 3 and 4. During the month of August, DO levels are highest under Alternatives 3 and 4 at Stations R2 and R3, while Alternatives 1 and 2 produce higher DO levels at Station R7. During September and October, Alternatives 3 and 4 provide the highest DO levels and often meet the objective that is otherwise not met under Alternatives 1 and 2. Alternative 4 provides the greatest benefit to DO concentrations during September. Alternative 3, permanent barrier installation, meets the objectives almost as often as Alternative 4, as modeled, and sometimes provides higher DO levels, although not generally when DO levels are at their lowest. The modeling results also show that implementing the flow alternatives in the Bay/Delta Plan does not significantly affect DO.

### 2. Impacts on Aquatic Resources

Stockton's proposed expansion and rehabilitation project will consist of a six-stage construction project. Stages I and II will include rehabilitating existing wastewater treatment facilities and constructing new facilities. The purpose of Stages I and II is to correct existing process deficiencies, handle increased wastewater strengths and restore the rated capacity of the WWTP back to approximately its previously estimated capacity of 48 mgd. The entire expansion will take place on the existing plant site. Stages III through VI would expand the plant's rated capacity to 55 mgd. If required, nitrification facilities would be constructed during stages III through VI. Stockton has initiated the EIR process for this project.

Nitrogen in the form of ammonia exerts an oxygen demand in the receiving body of water and can be toxic to fish. When nitrification is needed to protect the receiving body of water, a nitrification facility is added to the end of the conventional treatment process to remove the nitrogen. Nitrification can be achieved by either biological or chemical processes. Both processes involve long detention times in plug-flow reactors or complete mix reactors followed by a clarifier to settle out solids.

### 3. Energy Effects

The expanded facility would not use a substantial amount of fuel or energy or substantially increase demand upon existing sources of energy, or require the development of new energy sources. The nitrification facility would impose a higher energy demand on the WWTP; however, it is not expected to alter the energy demand significantly.

### 4. Public Nuisance Considerations

Alternative 4 may have an impact on public nuisance, specifically aesthetics, lights and glare, and odor. The proposed project would increase the number of industrial structures at the WWTP site;

however, these would not be visible from any scenic road or major public viewing location. Boaters along the San Joaquin River may view some of the new structures, but these would be considered visually compatible with existing industrial buildings along this stretch of the river.

Lighting of the facility would be increased with the proposed project but would not result in significant impacts due to the location of the project site within an industrial area of Stockton. Outdoor lighting would be located on poles, with lighting directed downward onto paved areas and structures.

Normal treatment plant operations produce odors that may be considered objectionable by some people. The nitrification process produces carbon dioxide and nitrogen gas, neither of which are odiferous. The amount of emissions released by the nitrification process will depend on the type of nitrification process adopted by Stockton. Due to the additional process units, emissions from the WWTP would likely increase.

### 5. Use of Hazardous/Toxic Substances

After completion of the project facilities, the use of chemicals to facilitate the nitrification process would increase. The types of chemicals used would depend on the type of nitrification facility adopted by Stockton.

### 6. Socioeconomic, Fiscal, and Secondary Effects

If Stockton must meet the more stringent 2.0 mg/l ammonia standard, the cost of the six-staged expansion would increase to include the cost of the detention chambers and associated clarifiers. The cost to build the nitrification facility may cause an increase in sewage fees, and may affect Stockton's plans to build several reclamation facilities. The reclamation facilities are intended to provide needed water supply by reclamation and to preclude the need to add extensive additional treatment processes (Carollo 1992).

The cost of expanding the WWTP may also cause Stockton to change or reconsider the way it operates the WWTP. For example, it may preclude deliveries from industries whose discharges have high loads in terms of wastewater strength or volume. Increased costs may also result in a decision to discontinue discharge into the San Joaquin River. Lastly, costs may affect Stockton's plans to expand its service area.

### 7. Construction-Related Impacts

Although environmental documents prepared by Stockton do not specifically address construction of a nitrification facility, they do address construction of the other phases of the expansion. The impacts of those construction activities are assumed to be similar to the impacts of the nitrification facility. Impacts with respect to the following parameters are possible: (a) air, (b) noise, (c) population and housing, (d) traffic, (e) earth, (f) water, (g) terrestrial life, and (h) cultural resources.

**a.** **Air**. Construction-related emissions from Alternative 4 would be short-term and would not be significant. The project site is located in an industrial area of southwest Stockton where emissions would not immediately affect nearby receptors such as residential neighborhoods, schools or hospitals.

**b.** **Noise**. Construction noise resulting from the project would be short-term and would not be significant, given that surrounding land uses are industrial. Noise due to construction traffic associated with the project would be minimal, and traffic would use Charter Way, Navy Drive, and Fresno Avenue, which pass through industrial areas. No increase in noise due to operating the new completed facilities is expected.

**c.** **Population and Housing**. Construction activities could result in a temporary increase in employment but would not result in a need for new housing due to the available labor force in the Stockton area.

**d.** **Traffic**. Access roads to the project site would be adequate to serve the traffic associated with project construction. Charter Way, Navy Drive, and Fresno Avenue are all currently used by heavy trucks. There are no expected significant impacts.

**e.** **Earth**. During construction, the project site would be subject to some wind erosion of soils. These impacts are potentially significant without mitigation. Water erosion of soils is not considered a significant problem due to the level topography of the site, significant amounts of existing asphalt paving, the existing storm drainage system, and the presence of levees along the San Joaquin River.

**f.** **Water**. New construction would not affect the adjacent levee or the San Joaquin River. Surface runoff would increase slightly due to additional impervious surface area. This surface runoff is not expected to be significant and would be handled by the existing plant drainage system, which is discharged into the headworks for treatment with the raw sewage.

Groundwater volume at the project site could be affected by construction of the clarifiers associated with the nitrification facility. Construction of the clarifiers may involve dewatering of the site for excavation. There will not be any water quality impacts due to dewatering effluent because all groundwater pumped will discharge to the treatment plant and be processed along with the wastewater flow.

**g. Terrestrial Life**. Due to the presence of the levee along the San Joaquin River and the fact that any new construction would occur east of this levee, special-status taxa that may reside along the river are not expected to be affected.

**h. Cultural Resources**. Project construction could potentially affect a prehistoric site, although it is considered unlikely due to the previously disturbed conditions of the entire site.

### 8. Summary

As modeled, Alternatives 3 and 4 often meet the DO objective that otherwise would not be met under Alternatives 1 and 2, particularly during the months of September and October. Alternative 4 provides slightly higher DO levels than Alternative 3 during the months of August through October. Implementation of the proposed CVRWQCB permit and construction of the treatment plant improvements will certainly improve DO conditions in the river. Construction of permanent barriers also improves DO conditions if they are operated as modeled. Flow manipulations alone may not accomplish dissolved oxygen levels above 6.0 mg/L in the Stockton area under any conditions, however, modeling has shown treatment plant improvements and construction of permanent barriers would aid in achieving the DO objective.

## Literature Cited in Chapter X

Carollo, J. 1992. Supplement Report to the Wastewater Master Plan. Prepared for the City of Stockton by John Carollo Engineers, 4 chapters.

Chen, C., D. Leva, and R. Schanz. 1993. A Report on Dissolved Oxygen in the San Joaquin River near Stockton Outfall. Prepared for the City of Stockton by Systech Engineering, Inc., Lafayette, CA. 11 pp.

Chen, C. and Schanz. 1993. City of Stockton Water Quality Model, Volume 1: Model Development and Calibration. Prepared by Phillip William & Associates, Ltd., San Francisco, CA and Systech Engineering, Lafayette, CA. 38 pp. plus Figures, Tables, and Appendices.

Chen, C., Tsai, W. 1997. Evaluation of Alternatives to Meet the Dissolved Oxygen Objectives of the Lower San Joaquin River. Prepared for the California State Water Resources Control Board, Sacramento California by Systech Engineering, Inc., Lafayette, CA. 49 pp.

DFG. 1964. Problems of the Lower San Joaquin River Influencing the 1963 Salmon Run. Prepared by California Department of Fish and Game, Department of Water Resources, and Central Valley Water Pollution Control Board. 27 pp.

DFG. 1995. Statement at SWRCB Workshop on the Need for Physical Barriers in the Southern Delta of the San Francisco Bay/Sacramento-San Joaquin Delta Estuary to Protect Beneficial Uses of Water. Presented at the SWRCB Workshop, November 15, 1995. 15 pp.

DWR and USBR. 1996. Draft Environmental Report/Environmental Impact Statement on the Interim South Delta Program (Volume I). Prepared by Entrix, Inc. and Resource Insights for the Department of Water Resources and U.S. Bureau of Reclamation. Sacramento, California. July 1996. 700 pp.

Engineering-Science, Inc. 1994. Expanded Initial Study for the Stockton Regional Wastewater Control Facility: Staged Expansion Program Stages I and II Capacity Restoration. Prepared for the City of Stockton. 9 Sections.

Hallock, R., R. Eldwell, and D. Fry, Jr. 1970. Migration of Adult King Salmon, *Oncorhynchus Tshawytcha*, in the San Joaquin River Delta as Demonstrated by the Use of Sonic Tags. Department of Fish and Game, Fish Bulletin 151. 91 pp.

Stockton. 1994. Addendum to the Expanded Initial Study for the Stockton Regional Wastewater Control Facility: Staged Expansion Program Stages I and II Capacity Restoration. Prepared for the City of Stockton. 51 pp.

Stockton. 1996. Comments of the City of Stockton Regarding Alternatives to Achieve Dissolved Oxygen Objectives. Presented at the SWRCB Workshop, March 12-13 1996. 18 pp. plus exhibits 1-16.

SWRCB. 1996. Order No. WQ 96-09, In the Matter of the City of Stockton Requesting Review of Waste Discharge Requirements Order No. 94-324, NPDES Permit No. CA0079138 Issued by the California Regional Water Quality Control Board, Central Valley Region. 23 pp.

USCOE. 1990. Dissolved Oxygen Mitigation Plan: San Francisco Bay to Stockton Ship Channel. United States Army Corps of Engineers. 3 pp.

**Personal Communications**

Van Niuwenhuyse, Erwin. Jones and Stokes Associates, Inc., Sacramento, CA. October 9, 1997. Meeting and Draft Report.