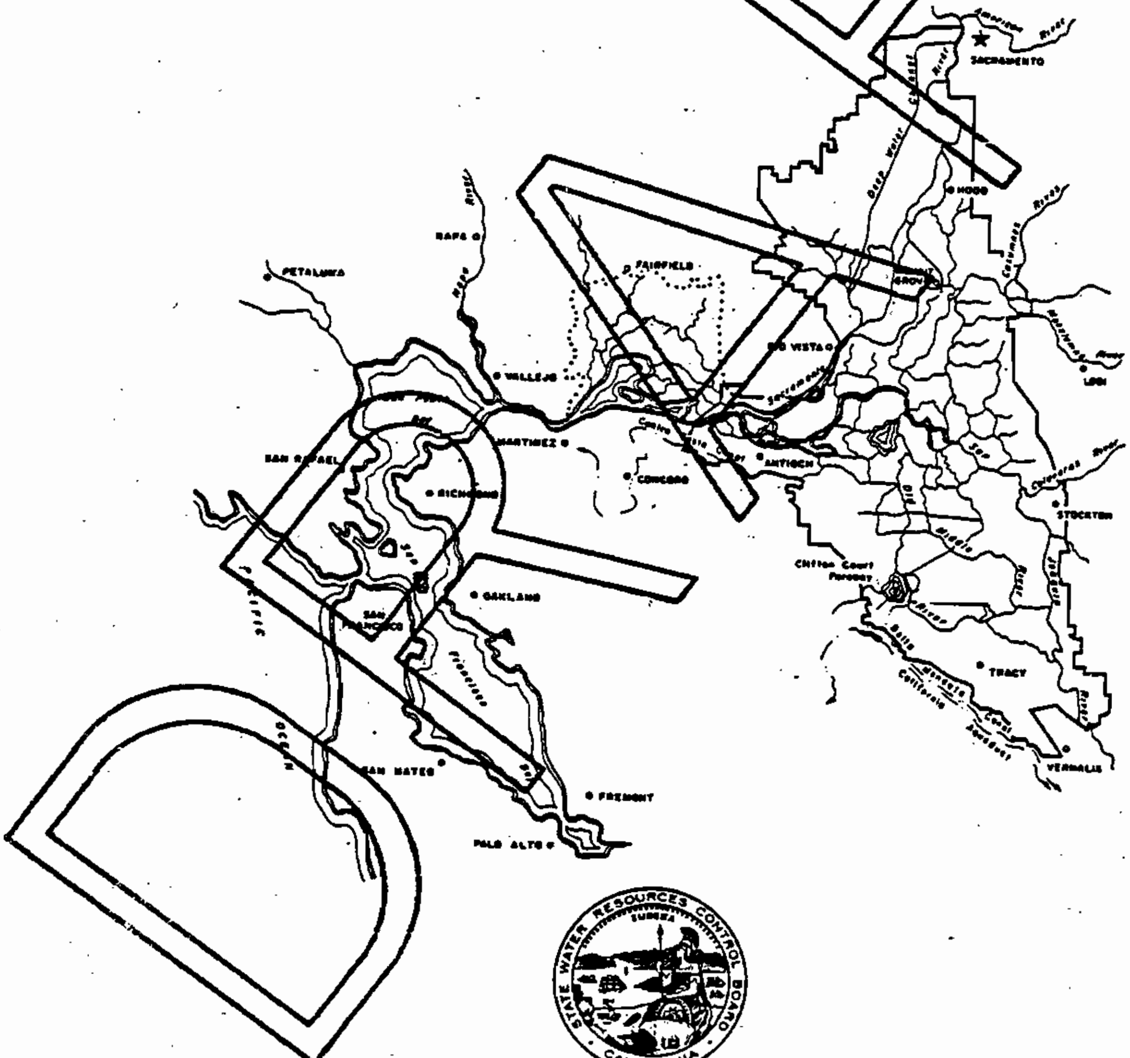
Water Quality Control Plan for Salinity

SAN FRANCISCO BAY/SACRAMENTO-SAN JOAQUIN DELTA ESTUARY



OCTOBER 1988

STATE WATER RESOURCES CONTROL BOARD

PREFACE

This draft document was prepared by technical staff of the State Water Resources Control Board (State Board) and is subject to the Board's review. The wording of this Plan is presented in a format for Board adoption, rather than being phrased as a staff recommendation to the Board. This Plan does not reflect a position by the Board. Board members have worked with staff in reviewing the contents of the Plan. However, the Board's decision will be based upon the public's comments on this Plan as presented in Phase II as well as the evidence already given in Phase I of the hearing.

Tim Stroshane
November 1988

CITING INFORMATION

When citing evidence in the hearing record, the following conventions have been adopted:

Information derived from the transcript:

T,XIX,123:09-125:20

- 125:20 — ending page and line number (can be same as the starting page) - may be omitted if a single line reference is used
- 123:09 — beginning page and line number
- XIX — volume number
- T — identifying abbreviation of the information source (T = Hearing Transcript)

Information derived from an exhibit:

SWRCB,25,45

- 45 — page number, table number, graph number
- 25 — exhibit number
- SWRCB — identifying abbreviation of the information source (see Appendix C, Abbreviations)

When citing references outside of the hearing record, the following conventions have been adopted:

Information derived from published documents,
(a) in the text of the Plan:

Denton, R.A.,1985

- 1985 — year of publication
- R.A. — author's name or agency abbreviation

(b) at the end of the appropriate Plan Chapter:

Denton, R.A., Currents in Suisun Bay, January 1985, pg. 4.

- 4 — page no.
- January 1985 — publication date
- Currents in Suisun Bay — title of document cited
- R.A. — author's name or agency abbreviation

CITING INFORMATION (Continued)

Information derived from Phase I closing briefs,
(a) in the text of the Plan:

RIC,Brief,8

- 8 — page number
- Brief — "Brief"
- RIC — identifying abbreviation of the information source

(b) at the end of the appropriate Plan Chapter:

Brief of the Rice Industry Committee on Pollutants in the Bay-Delta Estuary, pg. 8.

For a complete list of the abbreviations for information sources, citations and symbols used in this document, see Appendix C.

Appendix D is a Glossary of Terms.

WATER QUALITY CONTROL PLAN FOR SALINITY
SAN FRANCISCO BAY/SACRAMENTO-SAN JOAQUIN DELTA ESTUARY

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1.0 EXECUTIVE SUMMARY

1.1 Background

The San Francisco Bay and Sacramento-San Joaquin Delta Estuary (Bay-Delta Estuary) includes the Sacramento-San Joaquin Delta (Delta), Suisun Marsh and San Francisco Bay. The Delta is composed of about 738,000 acres, of which 48,000 acres are water surface area; Suisun Marsh comprises approximately 85,000 acres of marshland and waterways. San Francisco Bay includes around 300,000 acres of water surface area. The Delta and Suisun Marsh are located where California's two major river systems, the Sacramento and San Joaquinrivers, converge to flow westward where they meet seawater in the San Francisco Bay. The Bay-Delta Estuary is one of the largest, most important estuarine systems for fish and waterfowl production in the United States. The Delta is also one of the state's most fertile and important agricultural regions and is the location of a major industrial corridor in the vicinity of Antioch.

The watershed of the Bay-Delta Estuary provides about two-thirds of all the water used in California, including 40 percent of the state's drinking water. Two major water distribution systems export supplies from the Delta to areas of use: the State Water Project (SWP) operated by the California Department of Water Resources (DWR), and the Central Valley Project (CVP) operated by the U.S. Bureau of Reclamation (USBR). Numerous other water development projects also alter the river inflows into the Bay-Delta Estuary.

Salinity and flow objectives protect the beneficial uses of water in the Delta and Suisun Marsh. Existing objectives affect operations of the SWP and the CVP. New flow and salinity objectives for the entire Bay-Delta Estuary affecting the SWP, the CVP and other water diverters in the Bay-Delta watershed are being considered by the State Water Resources Control Board (State Board).

1.2 Hearing Process

In 1987 the State Board began a three-phase hearing process to receive and examine evidence on beneficial uses and water quality issues for the possible revision of existing water quality objectives in the Bay-Delta Estuary. The Water Quality Control Plan for Salinity for the San Francisco Bay and Sacramento-San Joaquin Delta Estuary (Plan), one of two documents prepared after the first hearing phase, addresses salinity levels and flow regimes necessary to protect the beneficial uses of Bay-Delta water. The second document, a Pollutant Policy Document (PPD), addresses other pollutants affecting beneficial uses of Bay-Delta water. This latter document will give guidance to the two Regional Water Quality Control Boards which have regulatory responsibility within the Bay-Delta Estuary. Both documents are being circulated for public review. Public comments from that review will be received during Phase II of the hearing process currently scheduled to begin in January 1989. Once these documents have been evaluated and revised by the State Board, they will be adopted. During Phase III, the State Board will conduct a water right hearing to consider implementation of the Plan by the appropriate water right holders.

1.3 Purpose and Current Context of the Plan

The draft Plan has been prepared by State Board staff after careful review and evaluation of the evidence presented during Phase I of the hearing. The Plan includes a description of a series of alternatives and recommendations for the flow and salinity levels needed to protect beneficial uses in the Bay-Delta Estuary; it is prepared under the authority of Water Code Section 13170.

1.4 Structure of the Plan

The draft Plan reflects the process by which the competing beneficial uses of Bay-Delta waters are balanced to provide reasonable protection for each beneficial use.

1.4.1 Chapter 1 -- Executive Summary

The Executive Summary serves as the first chapter of the Plan.

1.4.2 Chapter 2 -- Scope of the Plan

The Plan contains recommended flow and salinity objectives, as well as a program of implementation which will provide reasonable protection for beneficial uses of Bay-Delta Estuary water. In determining these levels of protection, all uses of water originating from and transferred into the Bay and Delta hydrologic basins are considered. The flow and salinity objectives for the Bay-Delta Estuary contained in this Plan supercede any conflicting objectives contained in the current Water Quality Control Plans of the San Francisco Bay and Central Valley Regional Water Quality Control Boards and other State Board plans.

- Board Authority

The State Board is responsible for formulating and adopting state policy for water quality control. Under its water right authorities, the State Board can condition rights for the diversion and use of water. The Board has continuing authority over all water rights to prevent waste and unreasonable use of water and to protect public trust uses. The Board also has authority under the Water Code to impose specific terms and conditions on new permits to protect the public interest, prior water rights, recreation, fish and wildlife, and other interests.

Recent court decisions, specifically, the Racannelli or Delta Water Cases Decision,[1] have directed the State Board to take a global perspective of water resources in developing water quality objectives. The State Board's duty in its water quality role is to provide reasonable protection for beneficial uses, considering all demands made on the water.

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[1] United States v. State Water Resources Control Board (1986) 182 Cal.App.3d 82, 227 Cal.Rptr 161.

The State Board's water quality function is related to but not coincident with protection of water rights. Water quality objectives are not to be limited to what the State Board can enforce under its water right authority. The court recognized, however, that an implementing program may be a lengthy and complex process that requires significant time intervals and action by entities over which the State Board has little or no control.

The contents of each Chapter are briefly described in Chapter 2 along with the geographic limits for the water quality objectives set in the Plan. The PPD is also identified as establishing state policy for pollutant regulation in the waters of the Bay-Delta Estuary.

1.4.3 Chapter 3 -- Basin Description

The Bay-Delta Estuary and its adjacent areas described in the Plan include the Delta; the Delta's tributary areas of the Sacramento River, the Central Sierra and the San Joaquin River basins; and the San Francisco Bay and itshydrologic basin. This chapter provides information on the physical description, hydrology, and unimpaired and current flow conditions for each of these areas.

- Water Year Classification

Under the Delta Plan adopted in 1978, water quality objectives were set for different water year classifications. Those classifications were wet, above normal, below normal, dry, and critically dry and were based on the four rivers of the Sacramento Basin. In this Plan the classification is still used (see Figure 1), but in addition, a separate water year classification has been established for the San Joaquin River Basin. The San Joaquin River Basin classification (see Figure 2) is based on the following four tributaries: the Stanislaus, Tuolumne, Merced, and San Joaquin rivers. An 82-year period, 1906 through 1987, is used to determine the classification boundaries for both river basins, instead of the 50-year period, 1922 through 1971, used in the 1978 Delta Plan. The current water year and the "year following critical year" designations are based on the April through July runoff, and apply to all objectives, not just those for fish and wildlife.

The San Joaquin River Basin water year classification is used for water quality objectives in the southern Delta and for the export objectives.

1.4.4 Chapter 4 -- Beneficial Uses

A clear understanding of each beneficial use builds a foundation for weighing and balancing appropriate levels of protection discussed in succeeding chapters. Beneficial uses include domestic, municipal, agricultural and industrial supply; recreation; esthetic enjoyment; navigation; and preservation and enhancement of fish, wildlife, and other aquatic resources. In summarizing issues addressed during Phase I of the Bay-Delta hearing, this chapter discusses what beneficial uses are, their flow requirements and their salt tolerances.

1.4.5 Chapter 5 -- Optimal Levels of Protection

The levels of flow and salinity considered to be optimal for the protection of each beneficial use without regard to others are presented in this chapter. Three alternatives for each beneficial use are discussed: (1) the no action alternative; (2) advocated levels of protection; and (3) the optimal level of protection.

1. The no action alternative is the existing level of flow and salinity protection for the beneficial use being discussed. This level complies with federal regulations protecting existing uses.

2. Advocated levels of protection are those recommended by the participants in Phase I of the hearing. Testimony or exhibits that recommend flow and salinity levels to protect a specific beneficial use are summarized.

3. The optimal level can be the same as one or both of the previous two if they provide optimal protection; it can also be a separate level based upon an independent evaluation of available data. In any case, the optimal level provides the ideal condition for a specific beneficial use and the background against which all alternatives developed in Chapter 7 can be measured.

1.4.6 Chapter 6 -- Reasonable Demands for Consumptive Use of Bay-Delta Waters

water ethic

This chapter offers a California water ethic (discussed subsequently) along with assumptions on water use that are consistent with this ethic. In order to preserve and distribute California's limited water resources equitably, there is a distinct need for a high degree of conservation, reclamation and conjunctive use of water.

simply not enough water for all B-uses

Since some beneficial uses have competing needs, an examination of optimal levels shows that full protection of all beneficial uses in all water years is impossible. There simply is not enough water. Also, protection of some uses can conflict with the needs of others. Some accommodation has to occur. An analysis of the reasonable consumptive needs for Bay-Delta water in areas upstream, within, and exported from the Estuary reveals that water can be managed differently to meet existing and reasonable future needs.

Water users offered projections of water needs to the year 2010. In these projections, some water savings were assumed. However, a more rigorous application of the California water ethic indicates that greater savings can be realized. Further, this chapter evaluates the ability to increase April through July Sacramento and San Joaquin river flows through the conjunctive use of surface and ground water and the changing of reservoir operations. The objectives in Chapter 7 are founded on the foregoing assumptions.

Estimates of agricultural water conservation savings are based on a more efficient, yet achievable, water application and reuse program.

The assumed water saving methods apply to all municipal and industrial needs, including upstream areas tributary to the Estuary, in-basin areas, downstream areas, and export areas. Estimates of savings are based on an agressive water conservation and reclamation program.

1.4.7 Chapter 7 -- The Development of Reasonable Alternative Water Quality Control Objectives

Reasonable water quality and instream flow needs for beneficial uses in the Estuary are discussed. These water quantity and water quality needs are compared in six sets of alternatives; the water supply impacts are summarized for three components: Sacramento and San Joaquin river inflows and Delta exports. To achieve equitable global balancing of protection for beneficial uses, the reasonable water quality and flow needs of the Estuary are weighed against the appropriateness of achieving those flows. Alternative five (5) is recommended (see Recommendation Section below).

1.4.8 Program of Implementation

Programs that reflect the need for the long range California water ethic are highlighted. They include water conservation and reclamation. The Plan anticipates that water projects other than the CVP and SWP will be modified as needed to protect beneficial uses in the Estuary. Additional water facilities such as ground water and offstream storage facilities are encouraged. The Central Valley Regional Water Quality Control Board is requested to adopt a salt load reduction policy. Various monitoring programs and legislative proposals are also suggested.

1.5 Concerns

During Phase I of the hearing, evidence was introduced about the need foradequate protection of water quality for agricultural, municipal, industrial and biological uses in the Estuary. The data show a prolonged decline in the natural salmon population and Delta fish as they related to water project operations (see Figure 3). The need for water to reduce salinity levels and for sufficient flows to protect the resources in the Estuary was presented. Considering the certainty of California's population and economic growth, representatives from several areas of the state testified that large amounts of additional water would be needed in the future.

Several witnesses testified about the availability of water. The evidence shows a greater need for water than the available supply. A broad balancing of that evidence has been made in recommending flow and salinity objectives.

In the balancing process, it should be recognized that biological resources have declined and are not experiencing the same degree of protection as other beneficial uses. Past balancing to protect biological resources has not been as effective as projected according to present evidence. This decline has beentaken into consideration in the balancing process.

1.6 California Water Ethic

All Californians must practice conservation, reclamation and conjunctive surface and ground water use in order to share responsibility for the reasonable use of water appropriately.

California's ground and surface waters are a precious, but limited resource. Water rights allow only the reasonable use of this resource. Water is vital to homes, industry, agriculture and public trust values. Supplies vary substantially from year to year. In the past, dams were built to control flooding and provide supplies during prolonged dry periods. Today, additional actions to promote the conservation, control and maximum utilization of water are required (Water Code Section 13000). All Californians must become involved in the reasonable use of water.

The California water ethic includes the coordination of several programs, each applicable in varying degrees to every region of the state. Best management practices related to the use of water are needed in all areas of the state. Careful water use decreases pollutant loadings as well as water demands.

The water ethic assumes:

- Conservation -- Municipal and industrial water users (residential, industrial and commercial) will be metered. With appropriate plumbing, leak detection, and landscaping techniques, per capita water use will be significantly reduced. Also, there are substantial opportunities for water savings by commercial and industrial water users. All agricultural users will use water as efficiently as feasible, particularly those who contribute drainage flows to salt sinks where reuse is impractical.

- Reclamation -- Where feasible, water reclamation and recycling consistent with state laws shall be required to reduce the demand on existing potable water supplies. Water reclamation includes the enhanced treatment of wastewater for reuse, the conversion of saline water to freshwater, and the treatment of ground water to a sufficient level to allow subsequent beneficial use.

- Conjunctive Use -- Ground water storage basins will be effectively utilized in conjunction with distribution of surface water.

- Sharing Responsibility -- Adequate flows for beneficial uses in the Estuary are the responsibility of all water users in the Bay-Delta watershed. In the past this obligation has been imposed largely on the CVP and SWP.

- Physical Facilities -- To better manage California's water resources, physical facilities are encouraged.

- Pollution Control -- Maximum practical pollution control at the source takes precedence over releases of freshwater for flushing flows.

1.7 Principles Guiding the Development of Water Quality Objectives

The following principles will assist in the conservation and equitable distribution of California's limited water resources. These principles are founded upon the foregoing water ethic, a careful review of the Phase I hearing evidence, an understanding of the Board's authority, and the appellate court's direction. Further, these principles also provide reasonable protection to each of the beneficial uses of the waters of the Bay-Delta Estuary under Water Code Section 13241.

- Municipal and industrial water users should receive salinity protection of at least the secondary public health standard of 250 mg/l chloride.

- Delta agricultural users should receive water quality that fully protects their needs assuming that they are employing best management practices and to the extent that such quality was available under unimpaired conditions with present day channel configurations (see Cal. Const., Art X, Sec.2).

- Aquatic life in the Estuary should receive the salinity and flows at an appropriate historic level. The appropriate historic level is established during the balancing process as subsequently explained. (See Water Code Section 1243; Public Resources Code Section 21000, et seq.; State Board Resolution 68-16). find this

- The formation of trihalomethane compounds from Delta waters cannot reasonably be resolved through the establishment of flow and salinity objectives.

- At this time, the use of Delta outflow solely to flush pollutants, other than ocean derived salts, out of the Estuary is not reasonable. The need for such flows may be considered in the future after all reasonable source control methods have been implemented and only if it is found to be in the public interest. forces pollution control upstream to users

- Increasing Delta inflows and decreasing Delta exports in the spring (which among other things will reduce reverse flows in the Old and Middle rivers) offers the best chance to obtain balanced protection of all beneficial uses dependent upon Bay-Delta water supplies. The Department of Water Resources should continue to investigate the potential for protecting beneficial uses and more efficient use of water through development of physical facilities.

The foregoing principles were used as assumptions in developing the water quality objectives contained in this Plan.

1.8 Recommendations

The Plan develops new water quality objectives for each beneficial use in the Estuary. The water quality objectives are shown in Table 1 and a summary of these objectives is presented below. Control stations for the objectives are depicted in the accompanying map (See Appendix D).

1. Municipal and industrial intakes are provided water quality protection for the secondary public health standard of 250 mg/l chloride. Actual water quality during most of the year will be considerably better than this due to the "umbrella" protection provided by other objectives.

   The 150 mg/l chloride objective at the Rock Slough intake of the Contra Costa Water District is deleted. The beneficial uses of water will be reasonably protected at 250 mg/l chloride. The users from this intake could relocate their intake, construct local reservoirs to capture winter time flows for blending in the summer, and take other actions to improve their water quality consistent with local desires for such quality and local economics.

2. Agricultural users in the Delta are provided water quality that fully protects their needs assuming that they are employing best management practices and to the extent such water quality was available under unimpaired flow with existing channel configurations. Evidence presented during the hearing indicates that the farmers on the Delta's organic soils can achieve full crop yields with saltier water than previously believed. The new objectives reflect these data.

   Agricultural pursuits on southern Delta mineral soils need better water quality than currently exists. The Plan will improve water quality so that these users are better protected.

3. Aquatic life in the Estuary has suffered losses in the recent past. The best data are for only two fish species--salmon and striped bass. Abundance of those species is affected by inflows into and exports from the Estuary, especially during the April through July period. The objectives for the Sacramento River salmon populations are established to attain the 1930-87 average monthly April through June flows (for each year type) which have been shown to be important to salmon. This represents all the data available for interior Delta stations important for salmon protection. The level of protection prescribed for the Sacramento River system was found to be unattainable on the San Joaquin River system without an unreasonable impact on upstream consumptive uses. An achievable and reasonable level of protection was the attainment of average flows that have existed since the current physical configuration of the Delta (1953-87). Also, minimum flows to protect striped bass

recommended by the State Department of Fish and Game (DFG) and supported by the U. S. Fish and Wildlife Service are incorporated in the recommended objectives. Export limits during the April through July period are made equivalent to the levels that existed before the decline of young fish survival in the Delta (1953-1967), but only to the extent that such reductions are needed to reduce the magnitude of reverse flows in Old and Middle rivers.

These levels reflect the average monthly exports that occurred during April through July for each year type in the period 1953-1967. One may note under Delta Fishery Export Limits in Table 1 that export limits for dry and critical years exceed those allowed in more water plentiful year types. The resilience of the fishery resource demonstrated in the past illustrates that the resource can withstand greater impacts of the magnitude shown for a short period of time (dry and critical years) and still recover.

These new objectives better protect aquatic resources than the previous objectives.

4. Suisun Marsh is provided protection generally consistent with the Four-Agency Agreement signed by the Suisun Resource Conservation District, DFG, State Department of Water Resources, and the U. S. Bureau of Reclamation. The only difference is that in water deficient years, year types are determined by using the median year runoff forecasts instead of the lower 20 percent forecasts as used in the agreement. This provides better protection than the Four-Agency Agreement. The Board is requesting DFG's advice during Phase II on the effects of the agreement on endangered species within tidal marshes in the Suisun Bay area.

SF Bay connection appeared tenuous

5. San Francisco Bay was discussed extensively during the Board's Phase I hearing. Information presented showed an insufficient connection between physical changes in the Bay due to inflows and the beneficial uses in the Bay. The evidence presented was judged insufficient as a basis for water quality objectives. The Board will require that further studies be performed to address these concerns and that such concerns will be addressed in the consideration of the water right permits of any large unconstructed water storage projects.

6. Analyses of the reasonable consumptive water needs of areas receiving exported water from the Delta indicates that the needs through the year 2010 can be met without increasing current annual exports. This assumes the California water ethic set forth previously is implemented. In Phase III the Board should consider the following in order to best conserve and utilize Bay-Delta waters:

skimming of floods OK

   a. The combined export quantity per water year from the USBR Tracy Pumping Plant and the SWP Banks Pumping Plant be limited, except that in wet and above normal years water above that required to meet objectives in the Bay-Delta Estuary may be pumped for conjunctive ground water storage and offstream surface storage; and

b. The amount of water pumped per water year at the SWP Edmonston Pumping Plant for use in the southern California portion of the SWP service area be limited, except that: (1) an increase above that amount equal to the quantity of water conserved through increased agricultural efficiency in the San Joaquin Valley would be allowed; and (2) in wet and above normal years water above that required to meet objectives in the Bay-Delta Estuary may be pumped for conjunctive ground water storage and offstream surface storage; and

c. Agricultural users who contribute drainage flows to salt sinks should achieve a high but reasonably attainable water use efficiency.

1.9 Implementation

Many of the recommendations contained in this water quality control plan will be attained through the Board's water right authority. During Phase III of the Bay-Delta hearing process, the Board will determine which water users will share in the responsibility of attaining the water quality objectives specified in the Plan and in achieving other provisions of the Plan. Implementation of all objectives is scheduled to occur over the next six years. A detailed time frame for implementing this Plan will be determined after the specific water users have been identified.

1.10 Water Supply Impacts

Alternative 5 best achieves the balanced levels of protection of beneficial uses described in the foregoing section. The impacts are depicted in Figures 4 and 5.

comparative bases

Two bases of comparison were used to develop an impact analysis. Impacts that could result from the objectives specified in the recommended alternative were compared to: (1) those of the 1978 Delta Water Quality Control Plan (currently in place) using a 1922-78 hydrologic cycle and a projected 1990 level of development as presented by DWR (Figure 4); and (2) actual values using the recent hydrologic period of 1972-87 (Figure 5). Two different analyses of impacts were performed to provide the public with an assessment of the effects of Alternative 5 objectives on planned water diversions in the near future and on historical conditions experienced in the recent past. Note that in the latter analysis, the 1983 water year data were disregarded because that year was the wettest year of record and tended to skew the average.

1983 disregarded

In both instances, the average impacts were analyzed on an annual basis and during the April through July period. The period April through July is particularly significant. Although the top bar graph in both figures depicts average impacts over the period of record, impacts for each year type (i.e., wet, above normal, etc.) were assessed to determine if the objectives were attainable and reasonable. A more detailed analysis of impacts is sought during the Phase II hearings.

1. The top bar graph of both figures reveals that there will be no change in average annual flows nor in the 1985-level of exports. Exports in 1985 are the highest to date, and 16 percent higher than the average amount of water exported since D-1485 standards went into effect in 1978. While Delta inflows from the Sacramento and San Joaquin rivers to meet the recommended Plan objectives increase over those required to meet the 1978 Plan objectives and increase over recent historic levels, annual flows do not. However, as shown in the bottom bar graphs, April through July flows do change. Our analysis shows that the reduction in flows during that period can be fully offset during other months of the year. This assumes partial utilization of existing water reserves on the Sacramento River system, conjunctive use of ground and surface waters in the San Joaquin River Basin, greater utilization of offstream storage south of the Delta, and a rescheduling of exports from the spring to winter months.

2. With regard to Figure 4, total Delta outflow in April through July to protect the Estuary will result in an increase over the long-term hydrologic period of 1922-78 of about 1,560 thousand acre-feet (TAF). If compared to recent historic information (Figure 5), the increase amounts to 1,080 TAF. The increase in April through July Delta outflow is achieved through an increase in river inflows into the Delta (Sacramento River -- 360 TAF and San Joaquin River -- 530 TAF; total of 890 TAF) and a decrease in water exported from the Delta (670 TAF). Correspondingly, Figure 5 illustrates that a total increase in river inflow of 880 TAF is needed with a decrease in exports, on the average, of 200 TAF.

   As stated previously, in order to meet the objectives of the recommended alternative and the additional water required, two major actions will be needed. First, a portion of the water reserves in the Sacramento and San Joaquin basins will be required for Estuary protection. According to DWR Bulletin 160-87, the Sacramento Basin currently has a 588 TAF reserve and the San Joaquin has a 157 TAF reserve. These reserves are projected to decrease to 549 and 128 TAF respectively by the year 2010. Second, conjunctive use of surface water and ground water supplies plus a different mode of operation of reservoirs may be needed to make up for water not available in the April through July period. On the San Joaquin River system, for instance, an analysis indicates that such programs could increase flows in the river during the April through July period from at least 170 TAF in critical years to almost 700 TAF in wet years. This change in operations would affect less than five percent of the combined ground water/surface water storage in the Basin.

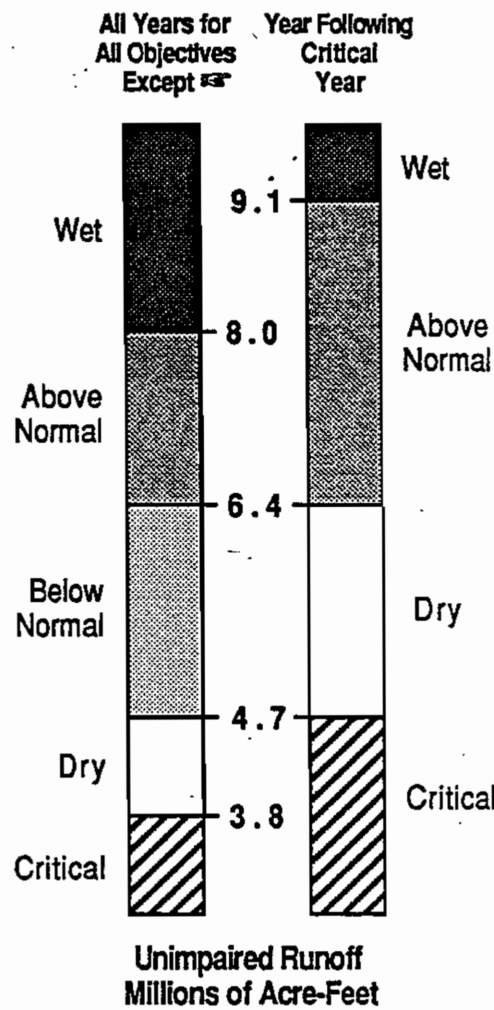
3. April through July exports from the Delta, projected from the 1990 operations study would be reduced by about 670 TAF under the recommended alternative Plan. A slightly greater reduction (about 680 TAF) would occur if the recommended Plan is compared to the recent high export values of 1985. On the other hand, if comparing to recent historic data, the reduction in exports would amount to 200 TAF on the average, or 540 TAF if compared to the 1985 level of exports. In either case, as demonstrated in the operations study, the capability to recover this deficit exists in the other seasons of the year, albeit a change in export operations would be required.

FIGURE 1
SACRAMENTO RIVER BASIN
APRIL THROUGH JULY HYDROLOGIC CLASSIFICATION

The Sacramento River Basin April through July hydrologic classification shall be determined by the forecast of Sacramento Valley unimpaired runoff for the year's April through July period as published in California Department of Water Resources Bulletin 120 for the sum of the following locations: Sacramento River above Bend Bridge, near Red Bluff; Feather River, total inflow to Oroville Reservoir; Yuba River at Smartville; American River, total inflow to Folsom Reservoir. Preliminary determinations of the classification shall be based on the April through July hydrologic conditions to date plus forecasts of future runoff assuming normal precipitation for the remainder of the April through July period.

CLASSIFICATION	UNIMPAIRED RUNOFF MILLIONS OF ACRE-FEET
Wet	Equal to or greater than 8.0 (except equal to or greater than 9.1 in an April through July period following a critical year).
Above Normal	Greater than 6.4 and less than 8.0 (except greater than 6.4 and less than 9.1 in an April through July period following a critical year).
Below Normal	Equal to or less than 6.4 and greater than 4.7 (except in an April through July period following a critical year).
Dry	Equal to or less than 4.7 and greater than 3.8 (except equal to or less than 6.4 and greater than 4.7 in an April through July period following a critical year).
Critical	Equal to or less than 3.8 (except equal to or less than 4.7 in an April through July period following a critical year).

APRIL THROUGH JULY CLASSIFICATION *



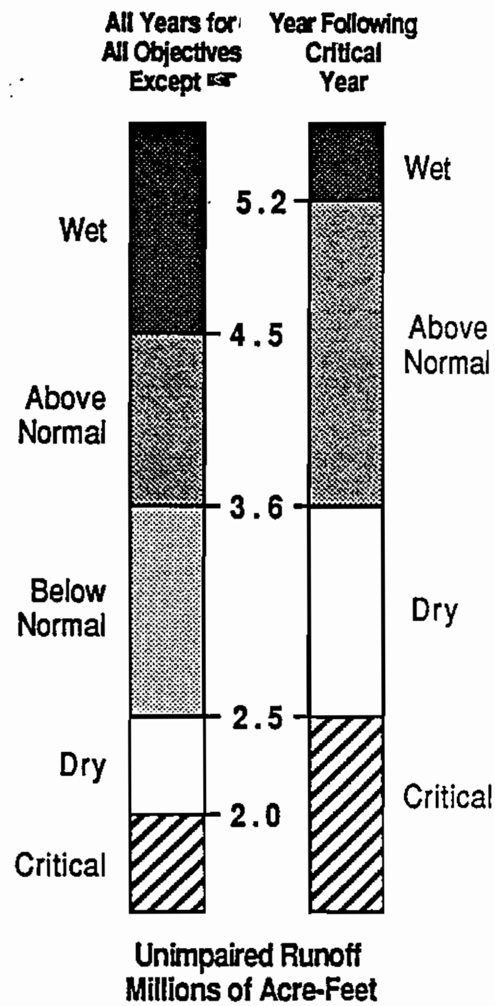
* The April through July classification for the preceding water year will remain in effect until the initial forecast of unimpaired runoff for the current water year's April through July classification is available.

FIGURE 2
SAN JOAQUIN RIVER BASIN
APRIL THROUGH JULY HYDROLOGIC CLASSIFICATION

The San Joaquin River Basin April through July hydrologic classification shall be determined by the forecast of San Joaquin Valley unimpaired runoff for the year's April through July period as published in California Department of Water Resources Bulletin 120 for the sum of the following locations: Stanislaus River, total inflow to New Melones Reservoir; Tuolumne River, total inflow to Don Pedro Reservoir; Merced River, total inflow to Exchequer Reservoir; San Joaquin River, total inflow to Millerton Lake. Preliminary determinations of the classification shall be based on the April through July hydrologic conditions to date plus forecasts of future runoff assuming normal precipitation for the remainder of the April through July period.

CLASSIFICATION	UNIMPAIRED RUNOFF MILLIONS OF ACRE-FEET
Wet	Equal to or greater than 4.5 (except equal to or greater than 5.2 in an April through July period following a critical year).
Above Normal	Greater than 3.6 and less than 4.5 (except greater than 3.6 and less than 5.2 in an April through July period following a critical year).
Below Normal	Equal to or less than 3.6 and greater than 2.5 (except in an April through July period following a critical year).
Dry	Equal to or less than 2.5 and greater than 2.0 (except equal to or less than 3.6 and greater than 2.5 in an April through July period following a critical year).
Critical	Equal to or less than 2.0 (except equal to or less than 2.5 in an April through July period following a critical year).

APRIL THROUGH JULY CLASSIFICATION *



* The April through July classification for the preceding water year will remain in effect until the initial forecast of unimpaired runoff for the current water year's April through July classification is available.

FIGURE 3

STRIPED BASS INDEX, SACRAMENTO/SAN JOAQUIN NATURAL SALMON POPULATION AND TOTAL DELTA EXPORTS

SBI: 1959 - 1988, EXCEPT 1966; POPULATION: SR 1953 - 1984, SJR 1953 - 1984; EXPORTS: AVERAGE APRIL - JULY EXPORTS, 1953 - 1987

(5 Year Running Average)

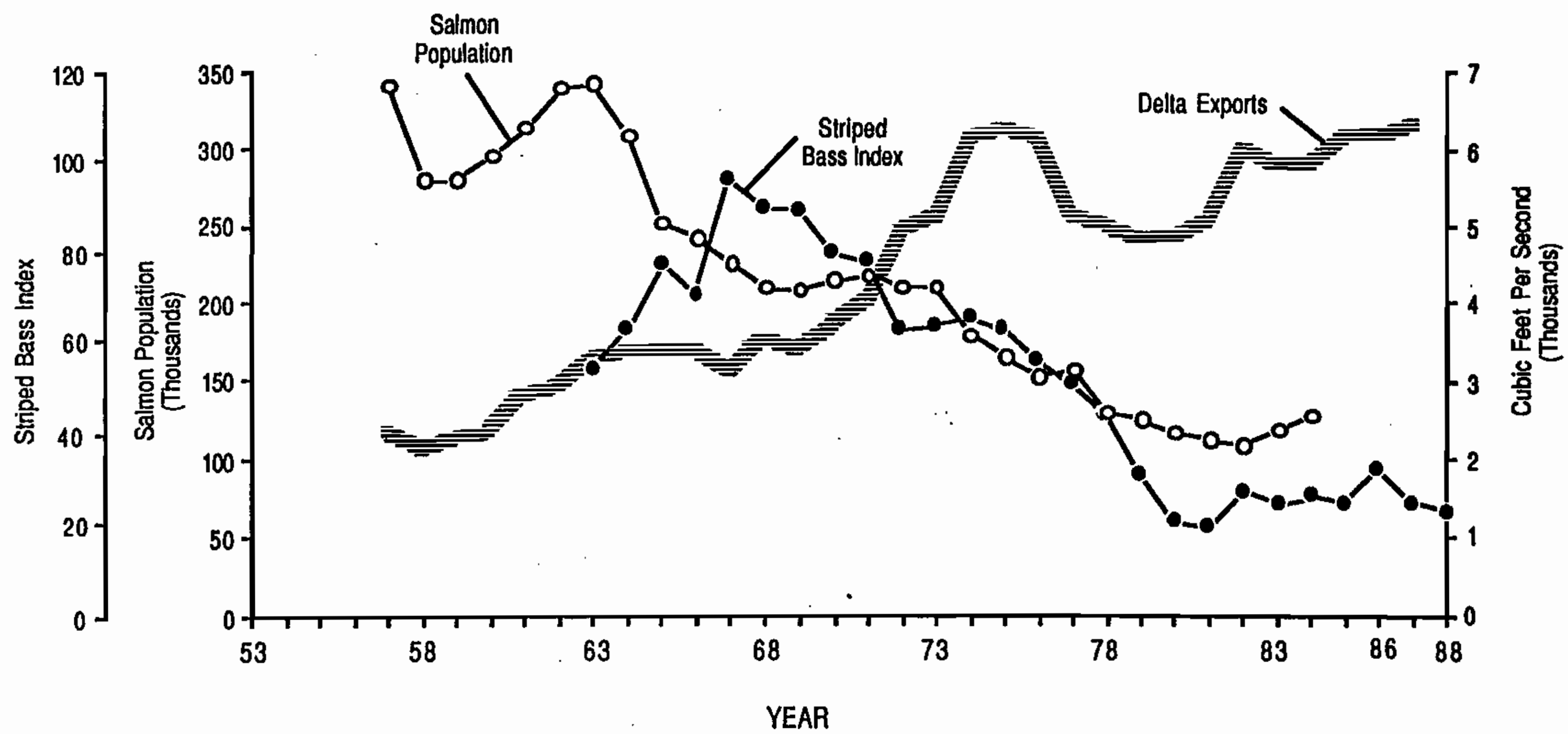
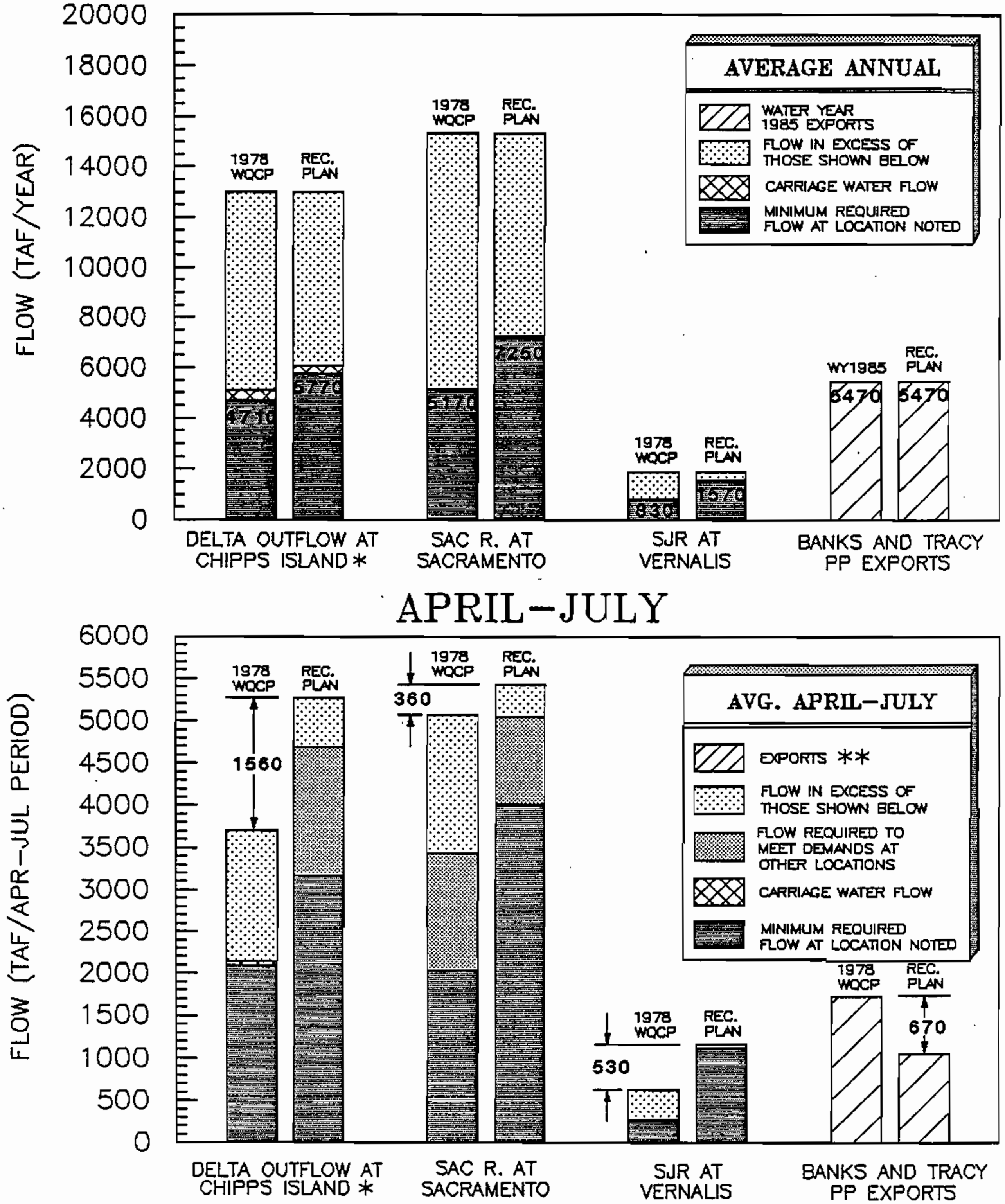


FIGURE 4

RECOMMENDED PLAN WATER SUPPLY IMPACTS

1922–78 HYDROLOGY UNDER THE PRESENT LEVEL–OF–DEVELOPMENT

AVERAGE ANNUAL

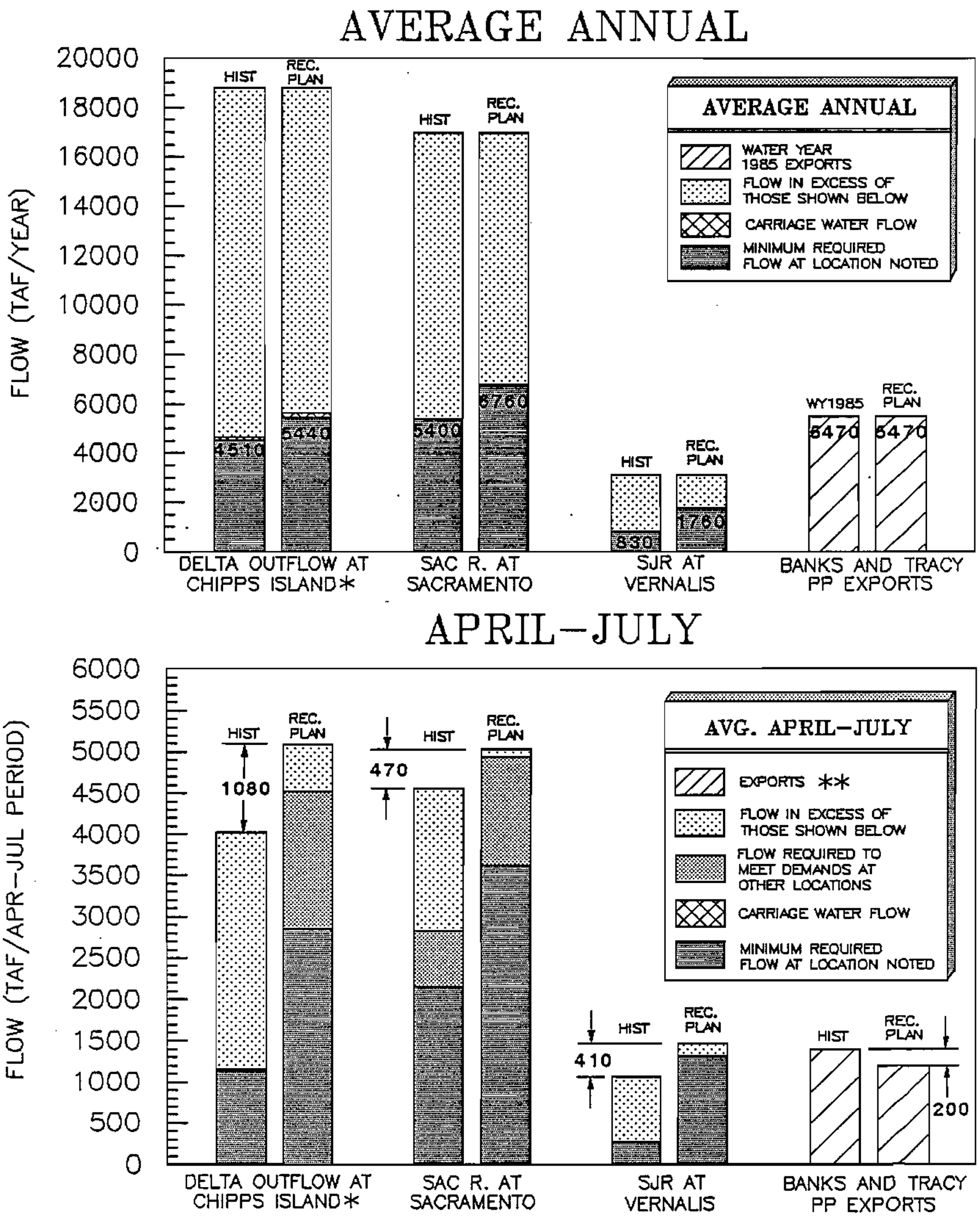


* INCLUDES YOLO BYPASS FLOW ** 1985 EXPORT IMPACT = 680 TAF

FIGURE 5

RECOMMENDED PLAN WATER SUPPLY IMPACTS

1972-1987 (W/O 1983) HISTORIC HYDROLOGY



* INCLUDES YOLO BYPASS FLOW   ** 1985 EXPORT IMPACT = 540 TAF

TABLE 1

RECOMMENDED WATER QUALITY OBJECTIVES

Beneficial Use Protected and Location		Sampling Site #	Parameter	Description	Year Type (Sacramento, unless * shows San Joaquin)	Dates	Values or Limits
MUNICIPAL and INDUSTRIAL							Cl-
City of Vallejo Intake (Footnote 1)		C19 (Footnote 2)	Chloride	Maximum Mean Daily Chloride, mg/l	All		250
Contra Costa Canal at Pumping Plant #1 (Footnote 3)		C5	"	"	"		"
Clifton Court Forebay Intake at West Canal		C9	"	"	All*		"
Delta Mendota Canal at Tracy Pumping Plant		DMC1	"	"	All*		"
North Bay Aqueduct at Barker Slough		NBA1	"	"	All		"
AGRICULTURE						Dates	EC
Western Delta Irrigation	Emmaton Jersey Pt.	D22 D15	Electrical Conductivity	Maximum 14-Day Running Average of Mean Daily EC, mmho/cm	All except Critical	4/1-8/15	1.5
					Critical	4/1-7/31 8/1-8/15	1.5 3.0
Interior Delta Irrigation	Cache Slough at Junction Pt. San Andreas Landing Terminous	CS1 C4 C13	Electrical Conductivity	Maximum 14-Day Running Average of Mean Daily EC, mmho/cm	All	4/1-8/15	1.5
South Delta Irrigation	Vernalis Brandt Bridge Tracy Road Br. Mossdale Howard Road Br. at Middle R. Old R. at Middle R.	C10 C6 P12 C7 HRM1 C8	Electrical Conductivity	Maximum 14-Day Running Average of Mean Daily EC, mmho/cm	All*	4/1-8/31 9/1-3/31	0.7 1.0
Delta Salinity Leaching	Emmaton Jersey Pt. Cache Slough San Andreas Landing Terminous	D22 D15 CS1 C4 C13	Electrical Conductivity	Winter pond leaching Maximum Monthly Ave. of Mean Daily EC, mmho/cm	All	12/1-2/28	1.7

See last page of table for Footnotes

TABLE 1 cont'd

RECOMMENDED WATER QUALITY OBJECTIVES

Beneficial Use Protected and Location		Sampling Site #	Parameter	Description	Year Type (Sacramento, unless * shows San Joaquin)	Dates	Values or Limits				
FISH and WILDLIFE							EC		Dates	EC	
Suisun Marsh Wildlife Habitat Interim objectives (Footnote 4)	Chipps Is.	D10	Electrical Conductivity	4-Agency Agreement Interim objective 28-day mean EC, mmhos/cm at Chipps Island	Wet	10/1-12/31	12.5		1/1-5/31	12.5	
					Ab. Normal	"	12.5		"	12.5	
					Bl. Normal	"	12.5		"	12.5	
					Dry (deficiency)	"	12.5 (15.6)		"	12.5	
					Critical(deficiency)	"	12.5 (15.6)		"	12.5	
Suisun Marsh Wildlife Habitat Interim objectives (Footnote 4)		D10	Delta Outflow Index (DOI) (Footnote 5)	4-Agency Agreement Interim objective Min mean mo. DOI with 2 of 3 reservoir flood env's encroached	All	All Year			Flow in CFS 6,600		
Suisun Marsh Wildlife Habitat Interim objectives (Footnote 4)		D10	Delta Outflow Index	4-Agency Agreement Interim objective Min 14-day mean DOI for 60 consec.days	Wet	2/1-5/31			10,000		
					Ab. Normal	1/1-4/30			12,000		
					Bl. Normal	"			12,000		
Suisun Marsh Wildlife Habitat Normal objectives		See Below	Control Sta. Electrical Conductivity	4-Agency Agreement Normal objective at station Mean mo. high tide EC, mmhos/cm	All (except in deficiency period)	Dates	EC		Deficiency Period EC		
Sacto. R. at Collinsville Road (C-2)						10/1-31	19.0		19.0		
Montezuma Slough at National Steel (S-64)						11/1-30	16.5		16.5		
Montezuma Slough near Beldon Landing (S-49)						12/1-31	15.5		15.6		
Suisun Slough 300 ft S. of Volanti Slough (S-42)						1/1-31	12.5		15.6		
Goodyear Sl. S. of proposed Goodyear Sl. Control Structure (proposed S-75)						2/1-28	8.0		15.6		
Cordelia Slough at Cordelia-Goodyear Ditch (proposed S-97)						3/1-31	8.0		15.6		
Chadbourne Slough at Chadbourne Rd.(proposed S-21)						4/1-30	11.0		14.0		
Goodyear Slough at Morrow Island Clubhouse (S-35)(Footnote 7)						5/1-31	11.0		12.5		
Cordelia Slough, 500 ft W. of Southern Pacific crossing at Cygnus (S-33)(Footnote 7)									(Footnote 6)		
						Flow in CFS 1/1-31	2/1-3/15	3/16-31	7/1-31	8/1-31	9/1-12/31
Sacramento Salmon Migration of Fall Run Adults	Rio Vista Bridge	D24	Flow	30-day Running Average of Mean Daily Flow,CFS	Wet	2,500	3,000	5,000	3,000	1,000	5,000
					Ab. Normal	2,500	2,000	3,000	2,000	1,000	2,500
					Bl. Normal	2,500	2,000	3,000	2,000	1,000	2,500
					Dry	1,500	1,000	2,000	1,000	1,000	1,500
					Critical	1,500	1,000	2,000	1,000	1,000	1,500
						4/1-30	5/1-31	6/1-30			
Outmigration of Smolts	Rio Vista Bridge	D24	Flow (Footnote 9)	Historic 1930-87 flows in CFS	Wet	22,500	22,000	18,500			
					Ab. Normal	22,500	21,000	10,500			
					Bl. Normal	16,500	14,500	7,500			
					Dry	12,500	10,000	6,500			
					Critical	8,500	5,000	2,500			
Salmon Fry Survival	Walnut Grove		Delta Cross Channel	Operation of gates	All when Delta Outflow Index over 12,000 CFS (Footnote 5)	1/1-3/31 closed					
San Joaquin Salmon Outmigration of Juveniles	Vernalis	C10	Flow (Footnote 9)	Historic 1953-87 flows in CFS	Wet *	14,000	13,500	11,000			
					Ab. Normal *	5,000	5,000	5,000			
					Bl. Normal *	2,500	3,500	3,000			
					Dry *	1,500	1,500	1,000			
					Critical *	1,000	1,000	500			
Migration of Fall Run Adult Salmon	Stockton to Turner Cut		Dissolved Oxygen	Minimum dissolved oxygen (DO) in mg/L	All*	Dates 7/1-11/30			DO 6.0		

See last page of table for Footnotes

TABLE 1 cont'd

RECOMMENDED WATER QUALITY OBJECTIVES

Beneficial Use Protected and Location		Sampling Site #	Parameter	Description	Year Type (Sacramento, unless * shows San Joaquin)	Dates	Values or Limits
FISH and WILDLIFE							
Delta Fishery Striped bass spawning	Prisoners Pt.	D29	Mean Daily Electrical Conductivity	Average for period not to exceed EC in mmhos/cm	All	4/1-5/5	EC 0.55
	Chipps Island	D10	Delta Outflow Index (DOI)	Average of the daily DOI, for the period, not less than	All	4/1-14	Flow in CFS 6,700
	Antioch Waterworks Intake on the San Joaquin River	D12 (near)	Electrical Conductivity	Average of the mean daily EC, mmhos/cm for the period, not more than	All	4/15-5/5	EC 1.5
	Antioch Waterworks	D12 (near)	Electrical Conductivity (Relaxation provision - replaces the above Antioch and Chipps Island objectives whenever the CVP and SWP impose deficiencies in firm supplies (Footnote 8)	Average of mean daily EC for the period, not more than the values corresponding to the deficiencies taken (linear interpolation to be used to determine values between those shown)	All - whenever the SWP and CVP impose deficiencies in firm supplies (Footnote 8)	see below	see below

Total Annual Imposed Deficiency (TAF)	4/1-5/5 EC
none	1.5
500	1.9
1,000	2.5
1,500	3.4
2,000	4.4
3,000	10.3
4,000 or more	25.2

Delta Fisheries — Egg and larvae survival — Chipps Is. — D10 — Mean Delta Outflow for Period (Footnote 9) — DFG and USF&WS outflow recommendations in CFS

Year Type	5/1-31	6/1-10	6/11-17	6/18-7/31
	Dates/Flow in CFS			
Wet	30,000	30,000	20,000	10,000
Ab. Normal	25,000	25,000	17,500	10,000
Bl. Normal	22,000	22,000	16,000	10,000
Dry	12,000	12,000	10,000	8,000
Critical	3,300	3,300	3,100	2,900

Delta Fishery — Export limit (Footnote 10) — Banks, Tracy, Contra Costa Delta Pumping Plants — Mean export for period (Footnote 11) — Historic 1953-67 exports from Delta, except wet years, in CFS (Footnote 12)

Year Type	4/1-30	5/1-31	6/1-30	7/1-15	7/15-31
Wet *	8,300	7,500	5,300	3,300	9,200
Ab. Normal *	2,000	2,900	3,700	4,200	9,200
Bl. Normal *	2,000	2,000	2,900	3,300	9,200
Dry *	3,000	3,300	4,000	4,600	9,200
Critical *	2,800	2,800	3,000	4,300	9,200

Delta Fishery — Flow control — Walnut Grove — Delta Cross Channel — Operation of Channel gates

Year Type	4/1-30	5/1-31	6/1-30	7/1-31
Wet	closed	closed	closed	open
Ab. Normal	closed	closed	c/ow	open
Bl. Normal	closed	closed	c/ow	open
Dry	closed	c/ow	open	open
Critical	open	c/ow	open	open

c/ow = gates closed, open weekends

See last page of table for Footnotes

TABLE 1 cont'd

RECOMMENDED WATER QUALITY OBJECTIVES

Footnotes

Footnote 1: Only used as a control station if City of Vallejo is taking water from this source in lieu of from North Bay Aqueduct.

Footnote 2: Sampling site numbers remain the same as in D-1485 for same sites. New sites are temporarily designated by their initials and a number.

Footnote 3: This objective will remain in effect until Contra Costa Water District moves its intake to Clifton Court Forebay. See accompanying map.

Footnote 4: Interim objective, superseded when parties agree facilities work. Water year types developed by State Board need no relaxation for subnormal snowmelt.

Footnote 5: DOI = Flows at Freeport + Vernalis - Channel Depletions + Byron Bethany Irrig. Dist. Diversions - Exports. All in CFS.

Footnote 6: Deficiency Period as defined in 4-Agency Agreement, except year type forecast shall be based on prediction of normal runoff instead of lowest 20 percentile of predicted runoff.

Footnote 7: Suisun Marsh control stations proposed to be replaced if objectives cannot be met with new facilities. New location and additional facilities to be developed and objectives are to be met with additional Delta outflows until facilities are adequate.

Footnote 8: Firm supplies of the USBR shall be any water the USBR is legally obligated to deliver under any CVP contract of 10 years or more duration, excluding the Friant Division of the CVP, subject only to dry and critical year deficiencies. Firm supplies of DWR shall be any water DWR would have delivered under Table A entitlements of water supply contracts and under prior right settlements had deficiencies not been imposed in that dry or critical year.

Footnote 9: Daily minimum to be not less than 80% of objective.

Footnote 10: Appropriate operating requirements to protect fish at the J. E. Skinner Fish Protective Facility and the CVP Tracy Fish Protective Facility should be presented to the State Board for incorporation in objectives during Phase III of these Bay-Delta Hearings.

Footnote 11: Daily maximum not to exceed 120% of objective.

Footnote 12: Exports above the values shown are permitted provided that positive downstream flows are maintained with a combined flow rate in Old and Middle rivers of at least 500 CFS.

2.0 SCOPE OF THE PLAN

2.1 Introduction

On July 7, 1987 the State Water Resources Control Board (State Board), pursuant to commitments in its 1978 Water Right Decision 1485 (D-1485) and Water Quality Control Plan (Delta Plan) for the Sacramento-San Joaquin Delta and Suisun Marsh, opened a public proceeding to receive evidence on beneficial uses and water quality issues for the San Francisco Bay and Sacramento-San Joaquin Delta Estuary (Estuary). Differing procedurally from that held for D-1485, the current hearing is to be conducted in three separate phases. To complete the first phase, this Water Quality Control Plan for Salinity for the San Francisco Bay and Sacramento-San Joaquin Delta Estuary (Plan) as well as a separate Pollutant Policy Document (PPD) have been prepared and are being distributed for review. After public comment, the Plan will be revised where necessary and adopted in the second phase, and will be considered for possible water right determinations in the third.

The scope of the Phase I proceedings covered:

- the beneficial uses being made of water flowing into, within, and from the Bay-Delta Estuary;
- the levels of protection, in terms of flow and salinity, which should be afforded these beneficial uses;
- reasonable consumptive uses made of Bay-Delta waters;
- the effects of pollutants on beneficial uses of Bay-Delta Estuary waters; and
- implementation measures to achieve the levels of protection afforded the beneficial uses.

2.2 Purpose of the Plan

This Plan establishes, where reliable data exist, numerical flow and salinity objectives[1/] as well as a program of implementation for the beneficial uses of Bay-Delta Estuary waters. In the 1978 Water Quality Control Plan and D-1485, the State Board set flow and salinity standards to protect only the Delta and Suisun Marsh against the effects of the SWP and the CVP (see Appendix A). This Plan takes a broader view in

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1/ For this Plan, "objectives" means the concept of enforceable numerical limits on water quality characteristics established to protect beneficial uses. The term is used in this Plan as it is used in the California Water Code, and not in the commonly understood sense of 'goals' or non-binding 'guidelines'. "Water quality objectives" in conjunction with an implementation schedule are the equivalent of EPA's "water quality standards". "objectives" defined setting water quality objectives. The entire Bay and Delta as well as waters that flow into and out of the Bay-Delta Estuary are considered when developing reasonable levels of protection for all beneficial uses. The flow and salinity objectives for the Bay-Delta Estuary contained in this Plan supersede any conflicting objectives contained in the current Water Quality Control Plans (Basin Plans) of the San Francisco Bay and Central Valley Regional Water Quality Control Boards, Regions 2 and 5, respectively.

A separate Pollutant Policy Document (PPD) prepared by the State Board addresses in detail the effects of pollutants on beneficial uses in the Bay-Delta Estuary; it contains water quality objectives to be used by Regions 2 and 5 as guidance when they update their Basin Plans (see 2.5).

Both the Plan and the PPD will be subjects of the Phase II hearing, during which the public will have the opportunity to comment on both before they are finalized and formally adopted by the State Board.

2.3 Authority for Regulation of Water Quality in the Bay-Delta Estuary

The State Board is responsible for formulating and adopting state policy for water quality control (Water Code {WC} Section 13140). The Water Code states that activities and factors which may affect the quality of waters of the state "...shall be regulated to attain the highest water quality which is reasonable considering all demands being made and to be made on those waters and the total values involved..."(WC Section 13000). Through the basin planning process, the State and Regional Boards formulate and adopt Basin Plans specifying water quality objectives to ensure reasonable protection for designated beneficial uses of water (WC Sections 13170, 13240). The federal Clean Water Act (Section 303(e)) also requires states to have a continuing planning process which contains water quality standards subject to review and approval by the Environmental Protection Agency (EPA).

Under its water right authorities, the State Board ensures the reasonable protection of beneficial uses of water by placing conditions on permits and licenses for the diversion and use of waters of the state (WC Sections 1253,1257,1258). The State Board has continuing authority over all water rights to:

- Prevent waste, unreasonable use, method of use, or unreasonable method of diversion of water;[1/] and to
- Protect public trust uses of water.[2/]

The State Board also has authority under the Water Code to impose specific terms and conditions on new permits to protect the public interest, prior water rights, recreation, fish and wildlife, and other interests.

1/ California Constitution Article X, Section 2; Imperial Irrigation District v. State Water Resources Control Board (1986) 183 Cal.App.3d 1160, 231 Cal.Rptr. 283; Water Code Sections 100,275,1050.

2/ National Audubon Society v. Superior Court (1983) 33 Cal.3d 419,189 Cal.Rptr. 346.

The Board may in addition reserve jurisdiction under Water Code Section 1394 to amend permits in anticipation of new information. For this reason, and "...recogniz(ing) the uncertainty associated with proposed project facilities to be constructed and the need for additional information on the Bay-Delta ecosystem," the Board limited the Delta Plan in 1978 to current and near term conditions in the Delta (Delta Plan, p. I-10). The Board stated it would review the 1978 Water Quality Control Plan in about ten years. This commitment as well as recent court decisions have called for the current hearing and have expanded the scope of its proceedings.

Specifically, in 1986, the State Court of Appeal, First District, issued a decision,[1] also known as the Racannelli or Delta Water Cases decision, addressing legal challenges to D-1485 and the Delta Plan. This decision directed the State Board to take a global perspective of water resources in developing water quality objectives: the State Board's duty in its water quality role is to provide reasonable protection for beneficial uses, considering all demands made on the water. The State Board's water quality function should not be equated with protection of existing water rights. Additionally, water quality objectives should not be limited to what the State Board can enforce under its water right authority. The decision recognized, however, that an implementing program may be a lengthy and complex process that requires significant time intervals and action by entities over which the State Board has little or no control.

Both the State Board's authority and the court's recent decision have guided the reassessment developed in this Plan.

2.4 Geographic Limits

The geographic limits for the water quality objectives set in the Plan include:

2.4.1 San Francisco Bay

San Francisco Bay (Bay), with its approximately 300,000 acres of water surface area, is located at the mouth of the Sacramento-San Joaquin Delta, the outlet for the Sacramento and San Joaquin rivers. These rivers drain about forty percent of the state. The Bay is composed of four primary embayments which are: (1) the south Bay, stretching from the Oakland Bay Bridge on the north to Mountain View on the southern edge; (2) the central Bay, the area between the Richmond-San Rafael Bay Bridge and the Oakland Bay Bridge; (3) the San Pablo Bay to the north, encompassing the area from the Richmond-San Rafael Bay Bridge on the south side to the Petaluma River on the north and the Carquinez Strait on the east; and (4) the area between the entrance to the Carquinez Strait and Chipps Island, encompassing the Carquinez Strait, Suisun Bay, Grizzly Bay, and Honker Bay.

1/ United States v. State Water Resources Control Board (1986) 182 Cal.App.3d 82, 227 Cal.Rptr. 161

2.4.2 Sacramento-San Joaquin Delta

The Delta, as defined in Water Code Section 12220, is roughly a triangular 738,000-acre area extending from Chipps Island near Pittsburg on the west to Sacramento on the north and to the Vernalis gaging station on the San Joaquin River in the south. Also included within the Delta boundary are the Harvey O. Banks Pumping Plant and the Tracy Pumping Plant, SWP and CVP facilities. Although water from the Delta is diverted for use in central and southern California, the water quality objectives for export uses are set at the pumping plants in the Delta. (The Tulare Lake Basin is not being considered tributary to the Estuary.)

2.4.3 Suisun Marsh

The 85,000-acre Suisun Marsh, located in southern Solano County south of the cities of Fairfield and Suisun City, is bordered on the south by Suisun Bay, Honker Bay, and the confluence of the Sacramento and San Joaquin Rivers; on the west by State Highway 21 running from Benecia to Cordelia; on the north by Cordelia Road to the city of Suisun; and on the east from Denverton along Shiloh Road to Collinsville.

2.5 Pollutants in the Bay-Delta Estuary

The information on pollutants received in Phase I of the hearing has been used in this Plan only to differentiate, where possible, the effects of flow and salinity on beneficial uses from those of pollutants. As noted, a separate Pollutant Policy Document (PPD) establishes state policy for pollutant regulation in the waters of the Bay-Delta Estuary, and will be used by Regions 2 and 5 in updating portions of their Basin Plans.

The PPD also identifies and characterizes pollutants with the greatest potential biological significance in the Bay-Delta Estuary. Point, nonpoint and riverine sources of pollutants presented during the hearing are discussed as well as the effects of these pollutants on public health and biological resources. The PPD recommends that water quality objectives be adopted for certain identified priority pollutants. Where information is insufficient to set water quality objectives, an approach is established for developing such objectives. Other related issues that the Regional Boards requested the State Board to resolve, such as dredging spoils, trihalomethanes, cumulative pesticide loads and database evaluation, are also addressed.

2.6 California Environmental Quality Act (CEQA)

Pursuant to Section 15251(g) Title 14, California Code of Regulations (C.C.R.), the State Board's Water Quality Control (Basin) Planning Program is a "certified program" by the Secretary for Resources. As a certified program it is exempt from the requirements of preparing Environmental Impact Reports (EIR). However, the Program remains subject to other provisions in CEQA, such as the policy of avoiding significant adverse effects on the environment when feasible.

The Draft Water Quality Control Plan "globally balances" the competing uses of Bay-Delta waters and provides reasonable protection to each use. It identifies alternatives and mitigation measures to avoid or reduce any significant or potentially significant effects thatthis Plan might have on the environment. Therefore, this Plan meets the requirements of a substitute for an EIR as set forth in 14 C.C.R. Section 15252.

3.0 BASIN DESCRIPTION

3.1 Introduction

The Estuary and adjacent areas described in this Plan include:

- The Delta (Figure 3.1-1);
- The Delta's tributary areas, that is, the Sacramento River, the Central Sierra, the San Joaquin River basins[1/] (Figure 3.1-2); and
- The San Francisco Bay and hydrologic Basin (Figure 3.1-3).

Together, the Estuary and tributary basins provide about two-thirds of all the water used in California, including 40 percent of the state's drinking water.

This chapter outlines the hydrologic conditions of the Estuary by providing a detailed description of each area's:

1. Physical Description--the geographical and legal dimensions;
2. Hydrology--the characteristics and nature of water movement;
3. Unimpaired Flow Conditions--the maximum amount of flow available in existent channels without consideration of diversions or storage (3.1.1); and
4. Current Flow Conditions--the water flow conditions as they now exist, or, where appropriate, as they have been affected by the Delta Plan (3.1.2).

3.1.1 Unimpaired Flow Conditions

Unimpaired flow conditions within the Estuary are the estimated amounts of water that would be available if there were no upstream impoundments or diversions of runoff but current upstream and Delta channel configurations existed (SWRCB,3,8). Unimpaired conditions could also be defined as the present day conditions if all storage and diversion were to cease on a short-term basis (T,II,114:2-15). "Natural" or "true natural flow" conditions, on the other hand, are defined as those existing in the late 1700's at the time of the first Spanish exploration of California (SWC,276,3). Unlike natural flow, it is assumed for unimpaired flow conditions that: (1) the present levees, bypasses and channel configuration are in place; (2) the natural flood basins and their marshes are drained; and (3) that only those riparian forests and tule marshes that currently exist are consuming water (SWC,262,6A2-21). Unimpaired flow conditions as well as current flow conditions are measured over a given period of time--the water year (see Section 3.1.3).

1/ The Tulare Lake Basin (Basin 5D), although part of the Central Valley, is not considered to be tributary to the Delta.

FIGURE 3.1.-1 Boundary of the Bay-Delta Estuary and locations of diversion points (from: SWRCB, 3, 5)

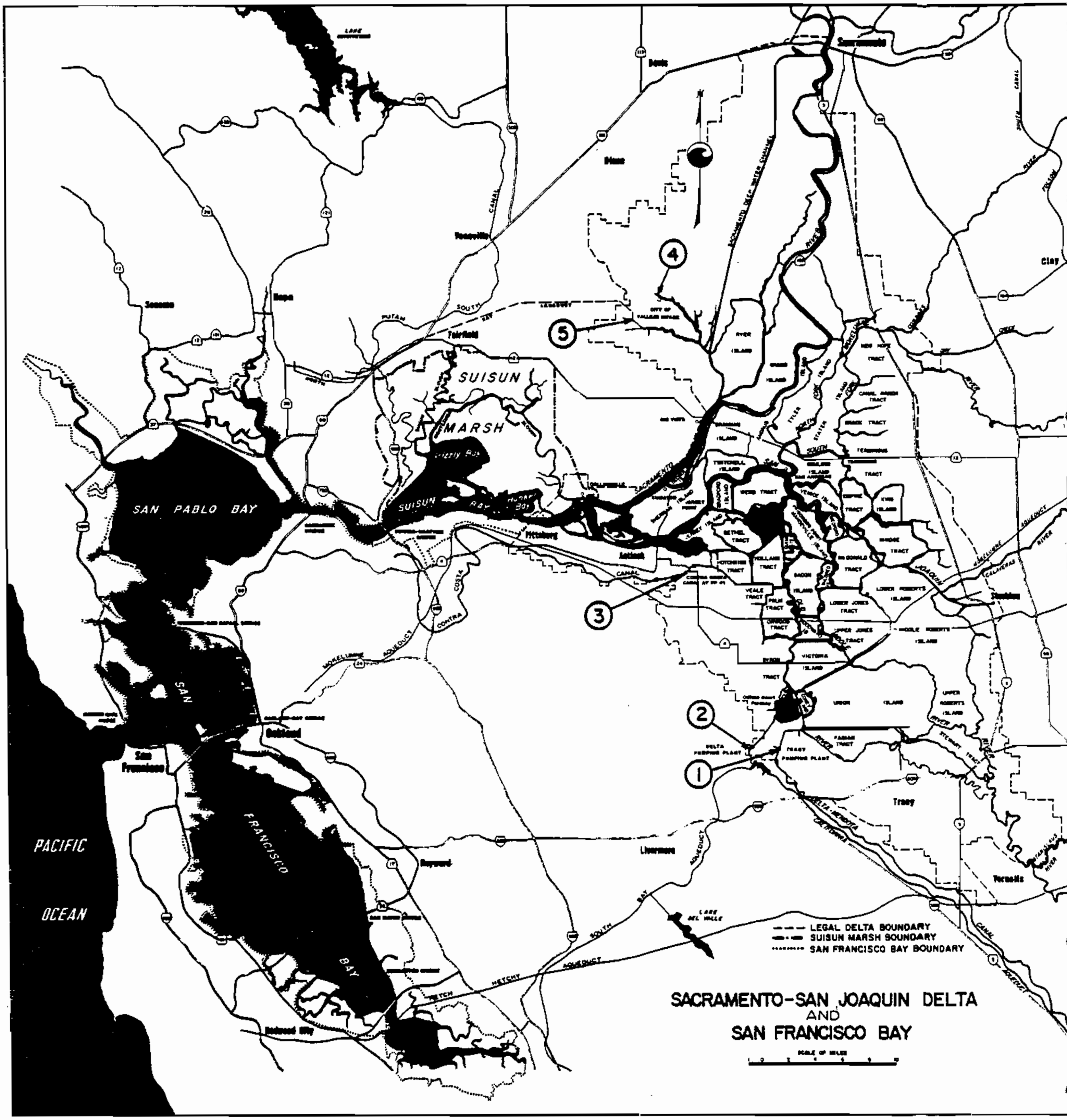
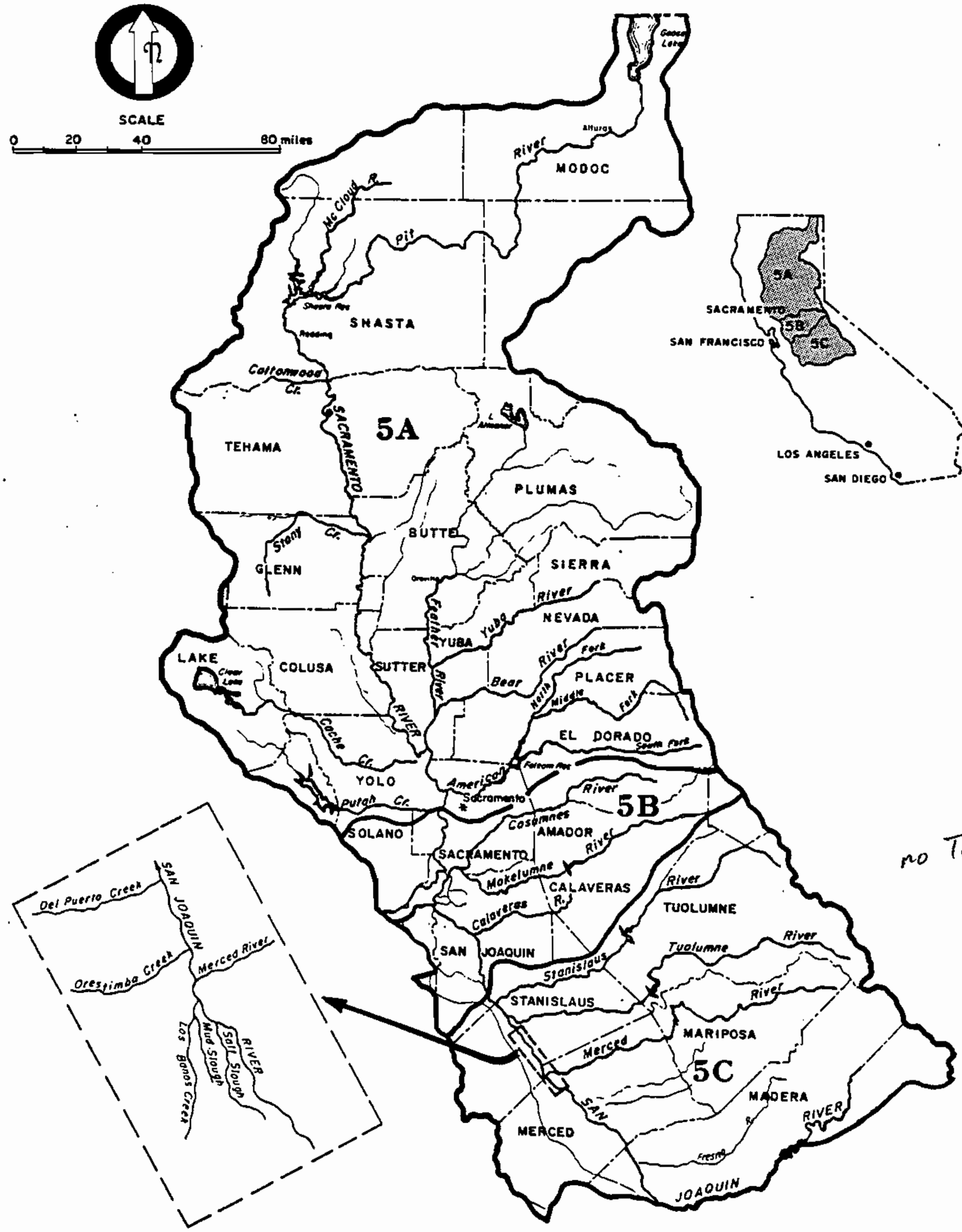


FIGURE 3.1-2 Boundaries of the Sacramento River (5A), Central Sierra and Delta (5B), and San Joaquin (5C) basins (From: RWQCB 5, 1975)



no Tulare Lake Basin

FIGURE 3.1-3 Boundary of the San Francisco Bay Basin
(From: SWRCB, 3, 12)

3.1.2 Current Flow Conditions

Current flow conditions are those estimated by DWR's 1990 level of development operations study which uses the unimpaired basin inflows for the hydrologic period 1922-1978 and modifies these based on reservoir operations and consumptive demands reflective of current conditions (1990). The operations study is run to meet the existing 1978 Delta Plan and D-1485 water quality objectives. Upstream storage releases, diversions and exports also depend, to some degree, on conditions established by the Delta Plan. To the extent, for example, that specified minimum outflows from the Delta are mandated by the Delta Plan and D-1485, the Sacramento River Basin is directly affected by the upstream storage releases that provide the required outflow amounts. The San Francisco Bay is likewise directly affected by Delta outflows not directly regulated even though its waters are. In discussing 'current flow conditions', it will therefore be necessary to describe the extent to which the Delta Plan influences water amounts available from storage releases and diversions in the Estuary.

At the end of this section a table comparing unimpaired flow and current flow conditions by water year type provides a summary of the actual amounts of water available in each basin.

3.1.3 Water Year Types

3.1.3.1 Classifying Water Years for a Basin

Water year (WY) classifications provide estimates of the amount of water in a basin that is available from precipitation and snowmelt runoff to meet the needs of beneficial uses. Most often, the classification means a water year of 12 months, but it can refer to a shorter period. The wetter classifications indicate the high probability that enough water will be available to meet the needs of all beneficial uses. Drier classifications indicate that, for at least part of the time, the demand could be greater than the natural supply of water needed to support beneficial uses fully.

3.1.3.2 1978 Delta Plan Water Year Classifications

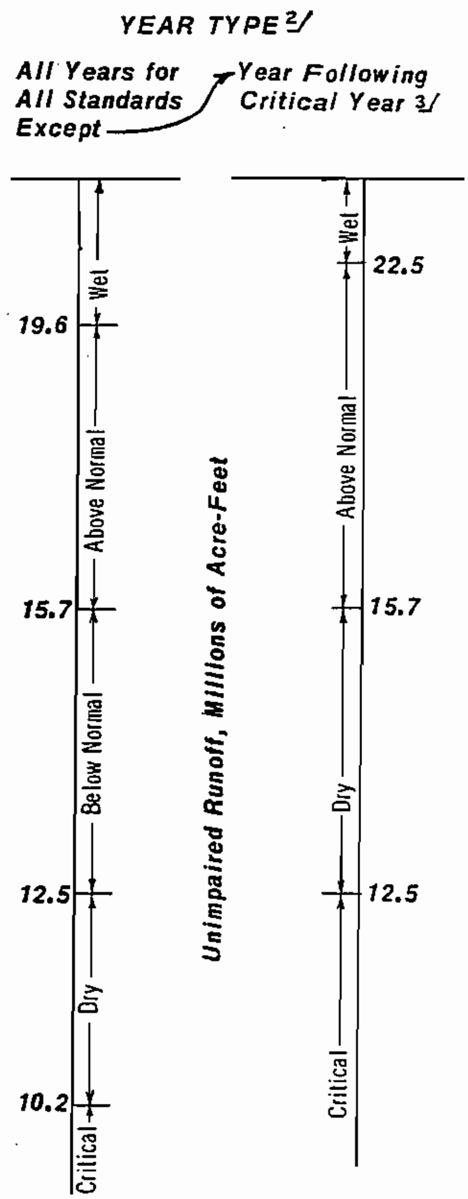
- Four River Index

The current hydrologic classification established by D-1485 is divided into five water year types: wet, above normal, below normal, dry, and critically dry (Figure 3.1.3.2-1) (SWRCB,13,III-10). This system is based on the "Four River Index"—the annual unimpaired runoff to the Sacramento Valley from its four principal tributaries, the Sacramento, Feather, Yuba, and American rivers.

FIGURE 3.1.3.2-1 Water Quality Control Plan Hydrologic Classification

Year classification shall be determined by the forecast of Sacramento Valley unimpaired runoff for the current water year *(October 1 of the preceding calendar year through September 30 of the current calendar year)* as published in California Department of Water Resources Bulletin 120 for the sum of the following locations: Sacramento River above Bend Bridge, near Red Bluff; Feather River, total inflow to Oroville Reservoir; Yuba River at Smartville; American River, total inflow to Folsom Reservoir. Preliminary determinations of year classification shall be made in February, March and April with final determination in May. These preliminary determinations shall be based on hydrologic conditions to date plus forecasts of future runoff assuming normal precipitation for the remainder of the water year.

YEAR TYPE	*RUNOFF, MILLIONS OF ACRE-FEET*
Wet [1]	equal to or greater than 19.6 (except equal to or greater than 22.5 in a year following a critical year). [3]
Above Normal [1]	greater than 15.7 and less than 19.6 (except greater than 15.7 and less than 22.5 in a year following a critical year). [3]
Below Normal [1]	equal to or less than 15.7 and greater than 12.5 (except in a year following a critical year). [3]
Dry	equal to or less than 12.5 and greater than 10.2 (except equal to or less than 15.7 and greater than 12.5 in a year following a critical year). [3]
Critical	equal to or less than 10.2 (except equal to or less than 12.5 in a year following a critical year). [3]



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[1] *Any otherwise wet, above normal, or below normal year may be designated a subnormal snowmelt year whenever the forecast of April through July unimpaired runoff reported in the May issue of Bulletin 120 is less than 5.9 million acre-feet.*

[2] *The year type for the preceding water year will remain in effect until the initial forecast of unimpaired runoff for the current water year is available.*

[3] *"Year following critical year" classification does not apply to Agricultural, Municipal and Industrial standards.*

This classification defines normal inflow, or the boundary between a below normal and an above normal water year, as the logarithmic mean of the Sacramento Basins Four River Index for the period of 1922 through 1971. The logarithmic mean is also the 50th percentile value. Half the years exceed this value and half the years are less than this value. In other words, there is a 50 percent chance that flows will exceed 15.7 million acre feet (MAF), the logarithmtic mean for the Sacramento Basin. The boundary between an above normal year and a wet year was set at the 70 percent probability, 19.7 MAF. In years following a critical year the 80 percent value, or 22.5 MAF, was used. The classifications of dry and critically dry years were developed by identifying the Four River Index values which had a potential for water supply shortages or critical water supply shortages. As a result of an analysis by DWR, it was determined that for the Four River Index the appropriate definition of dry and critically dry years should be 12.5 and 10.2 MAF, respectively (DWR, Exhibit 1).

3.1.3.3 Revised Water Year Types: An Index for Each Basin

The current hydrologic classification system does not provide an adequate indication of the quantity of water available in the Delta. The current water year measurements apply only to the Sacramento River Basin; the San Joaquin Basin needs to be included. The timing of seasonal flow also should be addressed. Two different water years, for instance, can have the same annual runoff; however, the runoff can come from separate seasons, that is, from winter flow or spring snowmelt. Planning for water supplies should account for these and other conditions.

In addressing these problems, the Department of Water Resources has suggested a revised hydrologic classification which forecasts unimpaired runoff during the period of April through July to determine the runoff classification for any particular year (T,I,99:13-20). South Delta Water Agency (SDWA) has also developed a separate classification for the San Joaquin River Basin (SDWA,4, 23-25).

The State Board has taken these and other recommendations and developed two new classification systems, one for each Basin (Figures 3.1.3.3-1 and 3.1.3.3-2)[1/]. The new classifications include the following:

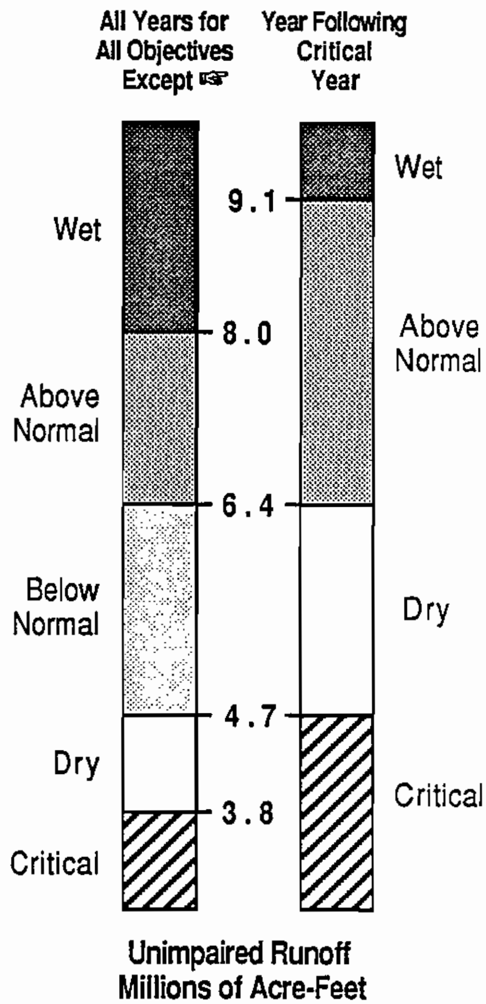
1/ The water year type designations for the Sacramento and San Joaquin River basins were developed by first determining the frequency an estimated unimpaired flow level occurred during April through July for the years 1906 through 1987 (Figure 3.1.3.3-3). Then, using the same percentage of occurrence as the Delta Plan, the water year types (i.e., wet, above normal, below normal, dry and critical for average years and for years following critical years) were classified for both basins.

FIGURE 3.1.3.3-1
SACRAMENTO RIVER BASIN
APRIL THROUGH JULY HYDROLOGIC CLASSIFICATION

The Sacramento River Basin April through July hydrologic classification shall be determined by the forecast of Sacramento Valley unimpaired runoff for the year's April through July period as published in California Department of Water Resources Bulletin 120 for the sum of the following locations: Sacramento River above Bend Bridge, near Red Bluff; Feather River, total inflow to Oroville Reservoir; Yuba River at Smartville; American River, total inflow to Folsom Reservoir. Preliminary determinations of the classification shall be based on the April through July hydrologic conditions to date plus forecasts of future runoff assuming normal precipitation for the remainder of the April through July period.

CLASSIFICATION	UNIMPAIRED RUNOFF MILLIONS OF ACRE-FEET
Wet	Equal to or greater than 8.0 (except equal to or greater than 9.1 in an April through July period following a critical year).
Above Normal	Greater than 6.4 and less than 8.0 (except greater than 6.4 and less than 9.1 in an April through July period following a critical year).
Below Normal	Equal to or less than 6.4 and greater than 4.7 (except in an April through July period following a critical year).
Dry	Equal to or less than 4.7 and greater than 3.8 (except equal to or less than 6.4 and greater than 4.7 in an April through July period following a critical year).
Critical	Equal to or less than 3.8 (except equal to or less than 4.7 in an April through July period following a critical year).

APRIL THROUGH JULY CLASSIFICATION *



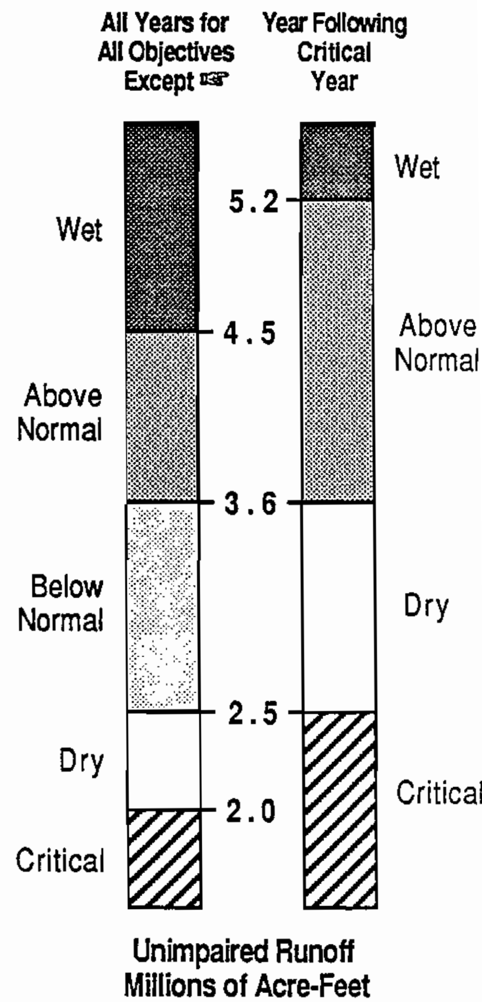
* The April through July classification for the preceding water year will remain in effect until the initial forecast of unimpaired runoff for the current water year's April through July classification is available.

FIGURE 3.1.3.3-2
SAN JOAQUIN RIVER BASIN
APRIL THROUGH JULY HYDROLOGIC CLASSIFICATION

The San Joaquin River Basin April through July hydrologic classification shall be determined by the forecast of San Joaquin Valley unimpaired runoff for the year's April through July period as published in California Department of Water Resources Bulletin 120 for the sum of the following locations: Stanislaus River, total inflow to New Melones Reservoir; Tuolumne River, total inflow to Don Pedro Reservoir; Merced River, total inflow to Exchequer Reservoir; San Joaquin River, total inflow to Millerton Lake. Preliminary determinations of the classification shall be based on the April through July hydrologic conditions to date plus forecasts of future runoff assuming normal precipitation for the remainder of the April through July period.

CLASSIFICATION	UNIMPAIRED RUNOFF MILLIONS OF ACRE-FEET
Wet	Equal to or greater than 4.5 (except equal to or greater than 5.2 in an April through July period following a critical year).
Above Normal	Greater than 3.6 and less than 4.5 (except greater than 3.6 and less than 5.2 in an April through July period following a critical year).
Below Normal	Equal to or less than 3.6 and greater than 2.5 (except in an April through July period following a critical year).
Dry	Equal to or less than 2.5 and greater than 2.0 (except equal to or less than 3.6 and greater than 2.5 in an April through July period following a critical year).
Critical	Equal to or less than 2.0 (except equal to or less than 2.5 in an April through July period following a critical year).

APRIL THROUGH JULY CLASSIFICATION *

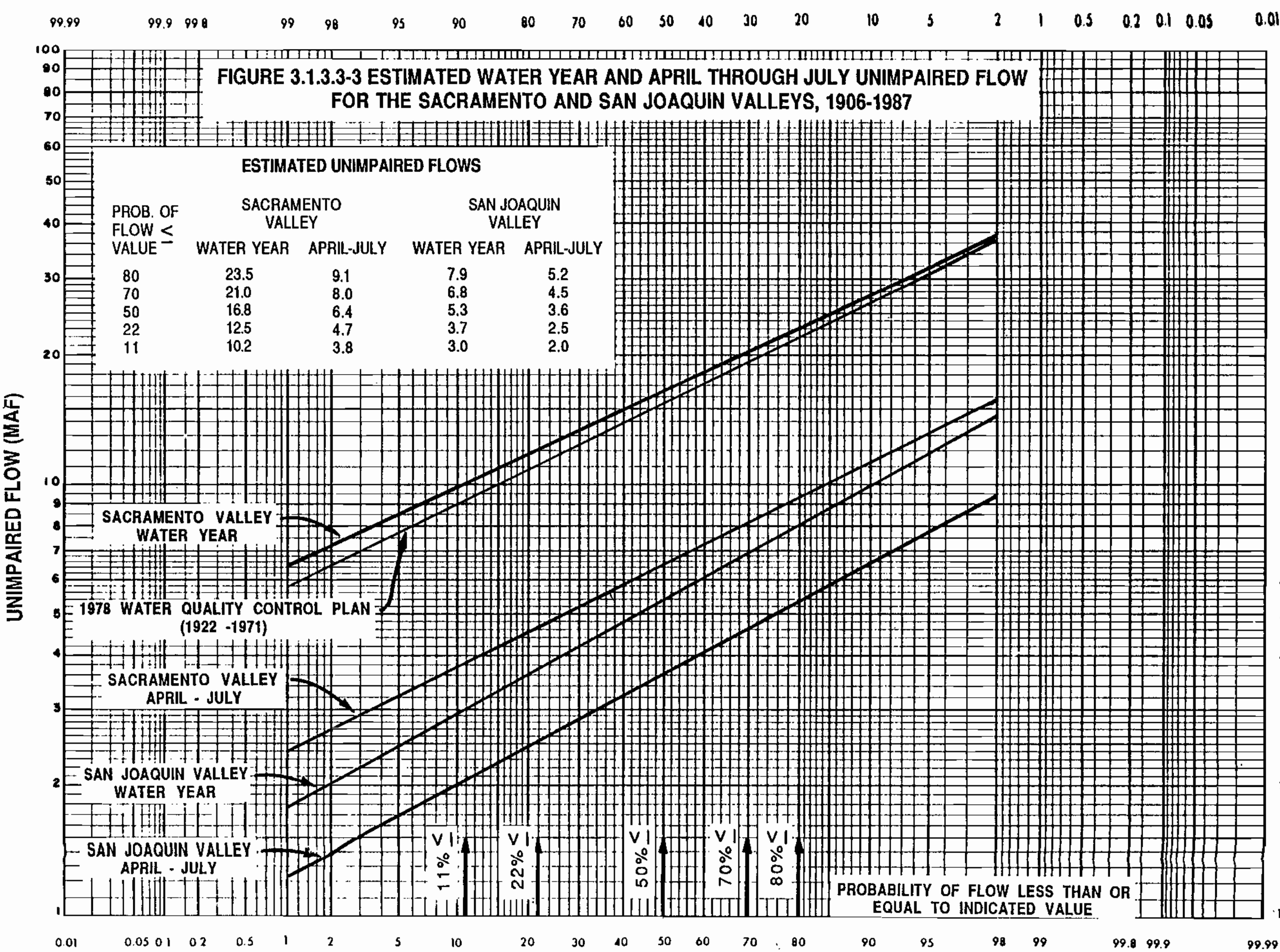


* The April through July classification for the preceding water year will remain in effect until the initial forecast of unimpaired runoff for the current water year's April through July classification is available.

FIGURE 3.1.3.3-3 ESTIMATED WATER YEAR AND APRIL THROUGH JULY UNIMPAIRED FLOW FOR THE SACRAMENTO AND SAN JOAQUIN VALLEYS, 1906-1987

ESTIMATED UNIMPAIRED FLOWS

PROB. OF FLOW ≤ VALUE	SACRAMENTO VALLEY		SAN JOAQUIN VALLEY	
	WATER YEAR	APRIL-JULY	WATER YEAR	APRIL-JULY
80	23.5	9.1	7.9	5.2
70	21.0	8.0	6.8	4.5
50	16.8	6.4	5.3	3.6
22	12.5	4.7	3.7	2.5
11	10.2	3.8	3.0	2.0



- The Sacramento Basin index incorporates its four principal tributaries--the Sacramento, Feather, Yuba, and the American Rivers.

- A separate classification system developed for the San Joaquin River Basin incorporates its four principal tributaries--the Stanislaus, Tuolumne, Merced, and San Joaquin rivers.

- The San Joaquin River Basin water year classification is used for water quality objectives in the southern Delta and for export objectives.

- An 82 year period, 1906 through 1987, is used to determine the classification boundaries for both river basins, instead of the 50 year period 1922 through 1971.

- The April through July unimpaired flows determine runoff classification systems for both the Sacramento and San Joaquin river systems. The subnormal snowmelt designation has been eliminated.

- The "year following critical year" designation is based on the previous year's April through July classification.

- The "year following critical year" designation applies to all objectives, not just those for fish and wildlife.

These revisions add information to, but do not greatly change, the conditions of hydrologic classification used in the 1978 Delta Plan.

3.1.3.4 Differences in Classification

Three possible classifications for the Sacramento and the San Joaquin River basins have been considered (see Tables 3.1.3.4-1 through -3):

1. The 1978 Delta Plan classification which is based on an entire water year, but only for the period of hydrologic record of 1922 through 1971.

2. A revised classification which is also based on an entire water year, but for the expanded period of 1906 through 1987.

3. The proposed classification which is based on the months of April to July, but also for the expanded period of 1906 through 1987.

There are only minor differences between the three. When, for example, the classification is expanded to include the period of 1906 to 1987, some relatively small changes in percentage of occurrence result (Table 3.1.3.4-3).

TABLE 3.1.3.4-1

SACRAMENTO RIVER BASIN FOUR RIVER INDEX AND HYDROLOGIC CLASSIFICATIONS *

	WATER YEAR			APRIL THROUGH JULY			D-1485 **
WATER YEAR	UNIMPAIRED RUNOFF (TAF)	PERCENT OF LOG MEAN	WATER YEAR CLASSI-FICATION	UNIMPAIRED RUNOFF (TAF)	PERCENT OF LOG MEAN	APRIL-JULY CLASSI-FICATION	D-1485 CLASSI-FICATION
1906	26709	159%	W	12924	202%	W	W
1907	33705	201%	W	13450	210%	W	W
1908	14773	88%	BN	5605	88%	BN	BN/SS
1909	30681	183%	W	8985	140%	W	W
1910	20122	120%	AN	6116	96%	BN	W
1911	26384	157%	W	13119	205%	W	W
1912	11410	68%	D	5646	88%	BN	D
1913	12847	76%	BN	6287	98%	BN	BN
1914	27812	166%	W	10077	157%	W	W
1915	23860	142%	W	11416	178%	W	W
1916	24143	144%	W	8886	139%	W	W
1917	17261	103%	AN	9138	143%	W	AN
1918	10997	65%	D	4888	76%	BN	D
1919	15657	93%	BN	6775	106%	AN	BN
1920	9200	55%	C	4910	77%	BN	C
1921	23801	142%	W	7523	118%	AN	W
1922	17982	107%	AN	10568	165%	W	AN
1923	13209	79%	BN	6271	98%	BN	BN
1924	5737	34%	C	1936	30%	C	C
1925	15994	95%	D	6511	102%	AN	AN
1926	11766	70%	D	4791	75%	BN	D
1927	23835	142%	W	8750	137%	W	W
1928	16763	100%	BN	5860	92%	BN	AN/SS
1929	8403	50%	C	3836	60%	D	C
1930	13516	80%	D	4652	73%	D	BN/D
1931	6095	36%	C	2088	33%	C	C
1932	13118	78%	D	6238	97%	D	BN/D
1933	8939	53%	C	4665	73%	D	C
1934	8631	51%	C	2452	38%	C	C
1935	16590	99%	D	9692	151%	W	AN
1936	17350	103%	AN	6407	100%	AN	AN
1937	13335	79%	BN	7238	113%	AN	BN
1938	31828	189%	W	12935	202%	W	W
1939	8183	49%	C	3039	47%	C	C
1940	22434	134%	AN	6927	108%	AN	W/AN
1941	27080	161%	W	9770	153%	W	W
1942	25237	150%	W	9931	155%	W	W
1943	21124	126%	W	6897	108%	AN	W
1944	10433	62%	D	4934	77%	BN	D
1945	15063	90%	BN	5919	92%	BN	BN
1946	17619	105%	AN	5971	93%	BN	AN
1947	10383	62%	D	3827	60%	D	D
1948	15752	94%	BN	9545	149%	W	AN

TABLE 3,1,3,4-1 (continued)

SACRAMENTO RIVER BASIN FOUR RIVER INDEX AND HYDROLOGIC CLASSIFICATIONS *

	WATER YEAR			APRIL THROUGH JULY			D-1485 **
WATER YEAR	UNIMPAIRED RUNOFF (TAF)	PERCENT OF LOG MEAN	WATER YEAR CLASSIFICATION	UNIMPAIRED RUNOFF (TAF)	PERCENT OF LOG MEAN	APRIL-JULY CLASSIFICATION	D-1485 CLASSIFICATION
1949	11969	71%	D	5587	87%	BN	D
1950	14442	86%	BN	6720	105%	AN	BN
1951	22945	137%	W	5418	85%	BN	W/SS
1952	28600	170%	W	13676	214%	W	W
1953	20086	120%	AN	8260	129%	W	W
1954	17427	104%	AN	6813	106%	AN	AN
1955	10986	65%	D	5067	79%	BN	D
1956	29890	178%	W	8604	134%	W	W
1957	14888	89%	BN	6294	98%	BN	BN
1958	29711	177%	W	12241	191%	W	W
1959	12055	72%	D	3837	60%	D	D
1960	13059	78%	BN	4651	73%	D	BN/SS
1961	11976	71%	D	4388	69%	D	D
1962	15116	90%	BN	6234	97%	BN	BN
1963	22993	137%	W	10091	158%	W	W
1964	10917	65%	D	4374	68%	D	D
1965	25665	153%	W	8134	127%	W	W
1966	12955	77%	BN	4836	76%	BN	BN/SS
1967	24060	143%	W	11016	172%	W	W
1968	13639	81%	BN	4114	64%	D	BN/SS
1969	26839	160%	W	10628	166%	W	W
1970	24060	143%	W	4356	68%	D	W/SS
1971	22775	136%	W	8914	139%	W	W
1972	13421	80%	BN	4991	78%	BN	BN/SS
1973	20029	119%	AN	6371	100%	BN	W
1974	32554	194%	W	9769	153%	W	W
1975	19227	114%	AN	8960	140%	W	AN
1976	8184	49%	C	2720	43%	C	C
1977	5105	30%	C	1925	30%	C	C
1978	23826	142%	W	8077	126%	AN	W
1979	12435	74%	D	5658	88%	BN	D
1980	22339	133%	W	6000	94%	BN	W
1981	11140	66%	D	3653	57%	C	D
1982	33338	198%	W	11745	184%	W	W
1983	37798	225%	W	13705	214%	W	W
1984	22352	133%	W	5518	86%	BN	W/SS
1985	11045	66%	D	4005	63%	D	D
1986	25735	153%	W	5358	84%	BN	W/SS
1987	9193	55%	C	2778	43%	C	C

* W - Wet; AN - Above Normal; BN - Below Normal; D - Dry; C - Critically Dry; SS - Subnormal Snowmelt

** In some cases a year will have a dual classification - one classification for fish and wildlife standards and the next wetter classification for agricultural and municipal and industrial standards

TABLE 3.1.3.4-2

SAN JOAQUIN RIVER BASIN FOUR RIVER INDEX AND HYDROLOGIC CLASSIFICATIONS *

	WATER YEAR			APRIL THROUGH JULY			D-1485 **
WATER YEAR	UNIMPAIRED RUNOFF (TAF)	PERCENT OF LOG MEAN	WATER YEAR CLASSI-FICATION	UNIMPAIRED RUNOFF (TAF)	PERCENT OF LOG MEAN	APRIL-JULY CLASSI-FICATION	D-1485 CLASSI-FICATION
1906	12427	234%	W	9238	257%	W	W
1907	11825	223%	W	7606	211%	W	W
1908	3327	63%	D	2167	60%	D	BN/SS
1909	8972	169%	W	5906	164%	W	W
1910	6645	125%	AN	3622	101%	AN	W
1911	11481	217%	W	7522	209%	W	W
1912	3211	61%	D	2572	71%	BN	D
1913	2995	57%	C	2340	65%	D	BN
1914	8691	164%	W	5672	158%	W	W
1915	6406	121%	AN	4949	137%	W	W
1916	8382	158%	W	5497	153%	W	W
1917	6663	126%	AN	4837	134%	W	AN
1918	4589	87%	BN	3397	94%	BN	D
1919	4097	77%	BN	2987	83%	BN	BN
1920	4096	77%	BN	3289	91%	BN	C
1921	5900	111%	AN	3840	107%	AN	W
1922	7677	145%	W	5996	167%	W	AN
1923	5512	104%	AN	3954	110%	AN	BN
1924	1500	28%	C	1034	29%	C	C
1925	5506	104%	AN	3926	109%	AN	AN
1926	3488	66%	D	2560	71%	BN	D
1927	6501	123%	AN	4564	127%	W	W
1928	4367	82%	BN	2639	73%	BN	AN/SS
1929	2844	54%	C	2292	64%	D	C
1930	3252	61%	C	2437	68%	D	BN/D
1931	1660	31%	C	1178	33%	C	C
1932	6630	125%	AN	4686	130%	AN	BN/D
1933	3341	63%	D	2767	77%	BN	C
1934	2286	43%	C	1259	35%	C	C
1935	6410	121%	AN	5025	140%	AN	AN
1936	6487	122%	AN	4379	122%	AN	AN
1937	6527	123%	AN	4655	129%	W	BN
1938	11268	213%	W	7358	204%	W	W
1939	2905	55%	C	1831	51%	C	C
1940	6589	124%	AN	4047	112%	AN	W/AN
1941	7932	150%	W	5515	153%	W	W
1942	7382	139%	W	5282	147%	W	W
1943	7266	137%	W	4273	119%	AN	W
1944	3919	74%	BN	2973	83%	BN	D
1945	6599	125%	AN	4371	121%	AN	BN
1946	5729	108%	AN	3645	101%	AN	AN
1947	3418	64%	D	2116	59%	D	D
1948	4210	79%	BN	3583	100%	BN	AN

TABLE 3.1.3.4-2 (continued)

SAN JOAQUIN RIVER BASIN FOUR RIVER INDEX AND HYDROLOGIC CLASSIFICATIONS *

	WATER YEAR			APRIL THROUGH JULY			D-1485 **
WATER YEAR	UNIMPAIRED RUNOFF (TAF)	PERCENT OF LOG MEAN	WATER YEAR CLASSIFICATION	UNIMPAIRED RUNOFF (TAF)	PERCENT OF LOG MEAN	APRIL-JULY CLASSIFICATION	D-1485 CLASSIFICATION
1949	3793	72%	BN	3113	86%	BN	D
1950	4652	88%	BN	3571	99%	BN	BN
1951	7251	137%	W	2829	79%	BN	W/SS
1952	9305	176%	W	6834	190%	W	W
1953	4354	82%	BN	3184	88%	BN	W
1954	4300	81%	BN	3161	88%	BN	AN
1955	3500	66%	D	2666	74%	BN	D
1956	9669	182%	W	5291	147%	W	W
1957	4288	81%	BN	3187	89%	BN	BN
1958	8356	158%	W	6396	178%	W	W
1959	2980	56%	C	1853	51%	C	D
1960	2958	56%	C	2072	58%	C	BN/SS
1961	2095	40%	C	1497	42%	C	D
1962	5612	106%	AN	4245	118%	AN	BN
1963	6237	118%	AN	4369	121%	AN	W
1964	3143	59%	D	2144	60%	D	D
1965	8120	153%	W	4549	126%	W	W
1966	3978	75%	BN	2422	67%	D	BN/SS
1967	9985	188%	W	7095	197%	W	W
1968	2935	55%	C	1850	51%	C	BN/SS
1969	12292	232%	W	8140	226%	W	W
1970	5613	106%	AN	2956	82%	BN	W/SS
1971	4907	93%	BN	3228	90%	BN	W
1972	3577	67%	D	2209	61%	D	BN/SS
1973	6475	122%	AN	4487	125%	AN	W
1974	7127	134%	W	4537	126%	W	W
1975	6156	116%	AN	4647	129%	W	AN
1976	1942	37%	C	1050	29%	C	C
1977	1016	19%	C	782	22%	C	C
1978	9425	178%	W	6363	177%	W	W
1979	5982	113%	AN	3991	111%	AN	D
1980	9453	178%	W	5389	150%	W	W
1981	3089	58%	D	2203	61%	D	D
1982	11259	212%	W	6951	193%	W	W
1983	14828	280%	W	8625	240%	W	W
1984	6843	129%	W	3479	97%	BN	W/SS
1985	3540	67%	D	2379	66%	D	D
1986	9293	175%	W	4584	127%	W	W/SS
1987	2029	38%	C	1453	40%	C	C

* W - Wet; AN - Above Normal; BN - Below Normal; D - Dry; C - Critically Dry; SS - Subnormal Snowmelt

** In some cases a year will have a dual classification - one classification for fish and wildlife standards and the next wetter classification for agricultural and municipal and industrial standards

This table is significant for historical reasons

TABLE 3.1.3.4-3
DECISION 1485 WATER YEAR CLASSIFICATION
FOR THE SACRAMENTO RIVER BASIN:
NUMBER AND PERCENTAGE OF OCCURENCES

	Hydrologic Period			
	1922 to 1971 [1/]		1906 to 1987	
Classification	No. of Years	Frequency of Occurrence	No. of Years	Percentage of Occurrence
Wet	16	32%	33	40%
Above Normal	9	18%	11	13%
Below Normal	9	18%	13	16%
Dry	10	20%	15	18%
Critical	6	12%	10	12%
TOTAL	50	100%	82	100%

[1/] Time period used in The Delta Plan to develop the original water year classification system.

Likewise, when the entire water year classification (1906 to 1987) is compared with the April through July classification for both the Sacramento and San Joaquin River basins, small changes in the percentage of occurrence also result (Tables 3.1.3.4-4 & -5). A comparison of the D-1485 classification with the April through July classification for the Sacramento River Basin over the 1906-87 period gives a difference in 35 years. In 18 of the 82 years, however, the April to July classification is wetter and in 17 years the classification is drier--a net real difference of one.

Finally, comparing the April to July classification for the San Joaquin River with the same classification for the Sacramento River, there is a difference in 31 years. In 15 of the 82 years, the San Joaquin classification is wetter, in 16 years drier--again, a net real difference of one. Where differences do exist between classifications and between basins, they are mainly due to the timing and magnitude of runoff as well as the boundaries of water year types.

Finally, when the classifications proposed in the Plan are compared with those in the Delta Plan, the total numbers of years in the extreme classifications, wet and critical, are reduced while the other, middle ranges are increased for both Basins (Table 3.1.3.4-6).

Why aren't these the same?

Probably because it's not the D-1485 scheme

TABLE 3.1.3.4-4
WATER YEAR AND APRIL THROUGH JULY CLASSIFICATION:
FREQUENCIES OF OCCURRENCE
FOR THE SACRAMENTO RIVER BASIN

	Classification System			
	Water Year		April-July	
Classification	No. of Years	Frequency of Occurrence	No. of Years[1/]	Frequency of Occurrence
Wet	30	37%	28	34%
Above Normal	10	12%	10	12%
Below Normal	15	18%	24	29%
Dry	17	21%	12	15%
Critical	10	12%	8	10%
TOTAL	82	100%	82	100%

1/ Year following critical year classification not included.

TABLE 3.1.3.4-5
WATER YEAR AND APRIL THROUGH JULY CLASSIFICATION:
FREQUENCIES OF OCCURRENCE
FOR THE SAN JOAQUIN RIVER BASIN

	Classification System			
	Water Year		April-July	
Classification	No. of Years	Frequency of Occurrence	No. of Years	Frequency of Occurrence
Wet	25	31%	27	33%
Above Normal	20	24%	15	18%
Below Normal	13	16%	19	23%
Dry	10	12%	10	12%
Critical	14	17	11	14
TOTAL	82	100%	82	100%

3.2 Sacramento River Basin

3.2.1 Physical Description

The Sacramento River Basin, Basin 5A in Figure 3.1-2, includes the westerly drainage of the Sierra Nevada and the Cascade ranges, the easterly drainage of the Coast Range, and the valley floor. The Basin covers about 26,500 square miles (16,960,000 acres) and extends from the Goose Lake Basin at the Oregon border to the American River Basin (RWQCB 5, 1975). The Basin includes the watersheds of the following major tributaries: McCloud, Pit, Feather, Yuba, Bear, and American rivers, and Cottonwood, Stony, Cache, and Putah creeks. In years of normal runoff, the Sacramento River Basin contributes about 70 percent of the total runoff to the Estuary (SWRCB,3,3).

TABLE 3.1.3.4-6

PROPOSED AND 1978 WQCP HYDROLOGIC CLASSIFICATIONS

NUMBER AND FREQUENCIES OF OCCURRENCE
(1906 THROUGH 1987)

SACRAMENTO RIVER BASIN

PROPOSED SALINITY CONTROL PLAN

April—July Classification	No. of Years	Frequency of Occurrence
Wet	28	34%
Above Normal	10	12%
Below Normal	24	29%
Dry	12	15%
Critical	8	10%
TOTAL	82	100%

1978 WATER QUALITY CONTROL PLAN *

Water Year Classification	No. of Years	Frequency of Occurrence
Wet	33	40%
Above Normal	11	13%
Below Normal	13	16%
Dry	15	18%
Critical	10	12%
TOTAL	82	100%

SAN JOAQUIN RIVER BASIN

PROPOSED SALINITY CONTROL PLAN

April—July Classification	No. of Years	Frequency of Occurrence
Wet	27	33%
Above Normal	15	18%
Below Normal	19	23%
Dry	10	12%
Critical	11	14%
TOTAL	82	100%

1978 WATER QUALITY CONTROL PLAN *

Water Year Classification	No. of Years	Frequency of Occurrence
Wet		
Above Normal		
Below Normal	SAME AS ABOVE	
Dry		
Critical		
TOTAL		

goes along w/ the perception of wide variability in California's climate.

* NOT INCLUDING SUB-NORMAL SNOWMELT CLASSIFICATION

The Sacramento Valley floor ranges from 30 to 45 miles wide in the central and southern parts, but narrows to five miles at its northern end; it slopes southward from about 300 feet above sea level at the north end near Red Bluff to sea level at Suisun Bay. The crestline of the Sierra Nevada generally ranges from 8,000 to 10,000 feet, while the crestline of the Coast Range extends from 2,000 to 8,000 feet. Due to the large snowpack at higher elevations in the Basin, the greatest volume of streamflow above the reservoirs occurs during snowmelt in the spring and early summer.

3.2.2 Hydrology

The Sacramento River Basin receives water transfers from other basins via the following projects:

Trinity River, Sly Park, Little Truckee Ditch, and Echo Lake Conduit.

The Basin exports water to other basins via the following projects:

Putah South Canal, Folsom South Canal, Tule Lake Diversion, North Fork Ditch, and Folsom Lake Diversion.

These and the amounts of other interbasin transfers are shown in Figure 3.2.2-1 (DWR,19). The basin boundaries in this figure differ somewhat from the boundaries defined in this Plan; however, it provides a good illustration of the magnitude of interbasin water transfers from the Sacramento River Basin to other areas in California.

3.2.3 Unimpaired Flow Conditions

The Sacramento River Basin inflow to the Delta comes from four major river systems—the Sacramento, Feather, Yuba, and American. The unimpaired flows from these river systems, often referred to as the Sacramento River Basin Four Rivers Index, represent approximately 47, 25, 13, and 15 percent, respectively, of the total flow from the Sacramento River Basin that make up this index. Figure 3.2.3-1 shows the average unimpaired and measured flows over the period of 1922 to 1978 ('1990 level' is the estimated flow for any year given current, or 1990, storage capacities, diversions and exports).

3.2.4 Current Flow Conditions

Delta inflow from the Sacramento River Basin comes from two major sources, the Sacramento River near Sacramento and the Yolo Bypass just west of Sacramento. The current annual flows, i.e., those estimated by DWR's 1990 level operations study, in the Sacramento River near Sacramento for 1922 through 1987 are also shown in Figure 3.2.3-1. In this time period, current flows are expected to decrease below unimpaired flows in wetter years due to upstream diversions and reservoir storage. Dry and critical year flows remain about the same principally due to river flow requirements needed to meet water quality objectives and export demands (Table 3.2.4-1).

FIGURE 3.2.2-1 Interbasin water transfers for a 1980 level of development
`and the annual amounts in AF/YR
(from: DWR, 19)

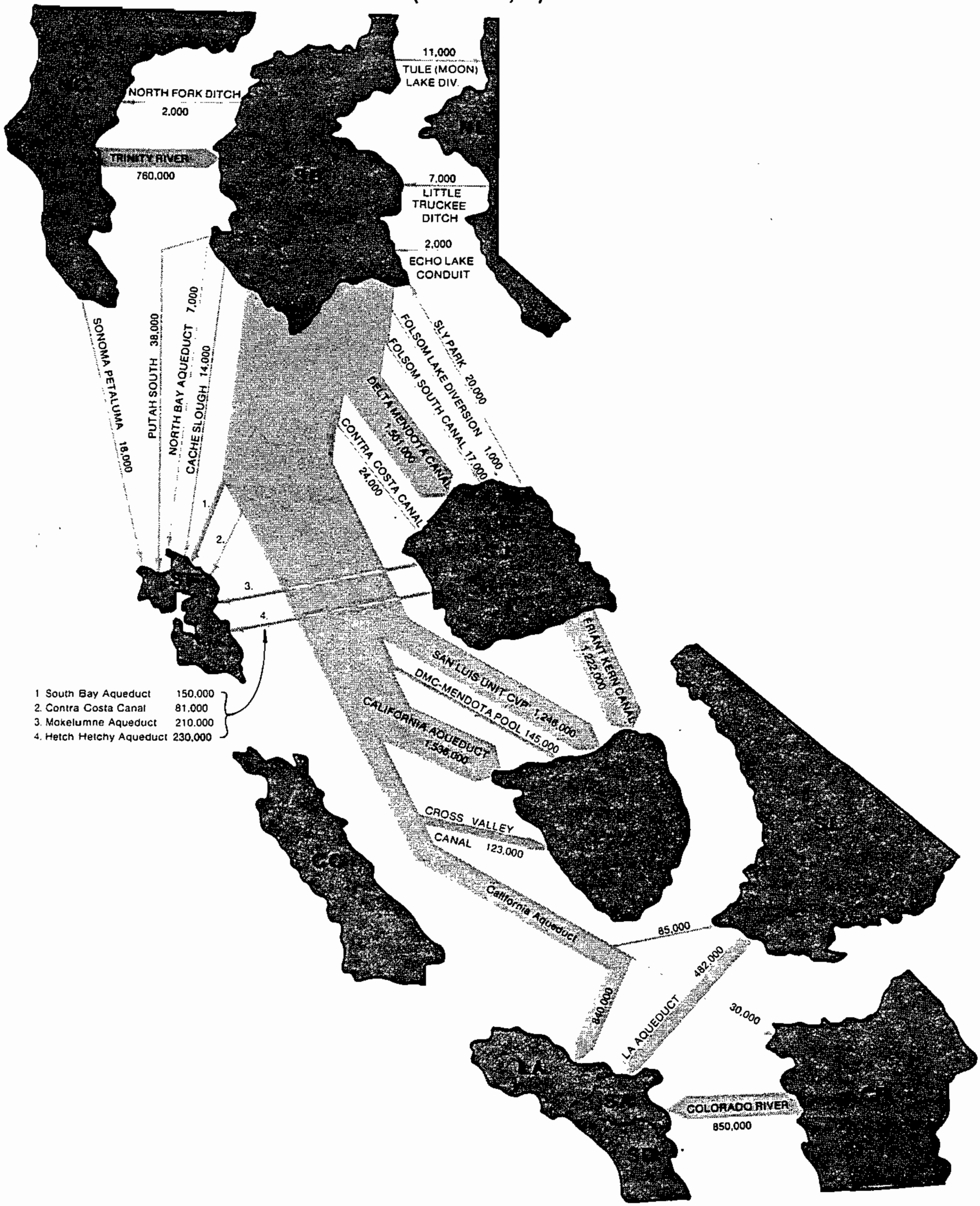


FIGURE 3.2.3-1

SACRAMENTO VALLEY AVERAGE MONTHLY FLOW

1922 THROUGH 1978

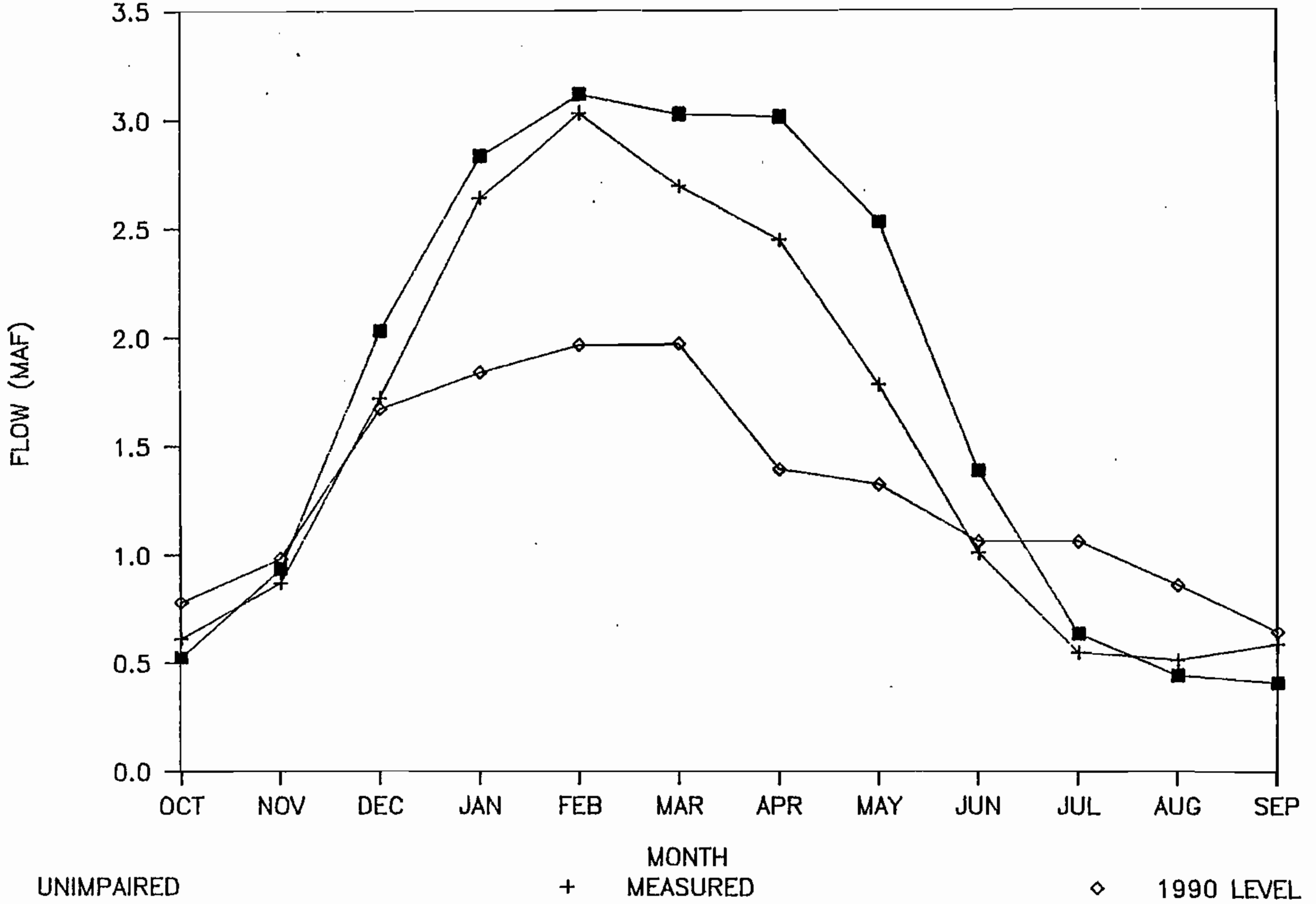


TABLE 3.2.4-1
SACRAMENTO RIVER BASIN:
UNIMPAIRED FLOW AND CURRENT FLOW CONDITIONS
BY WATER YEAR TYPE[1]

Water Year Type[2]	Unimpaired Flow (TAF)[3] Low	High	Current Flow[4] (TAF) (The Delta Plan Requirements) Low	High
Wet	24,456	40,639	19,711	36,003
Above Normal	18,284	23,673	12,682	20,698
Below Normal	15,063	18,061	8,923	15,768
Dry	12,014	14,231	10,597	14,089
Critical	5,557	10,103	7,092	10,737

1/ Using 1922 through 1978 hydrology.
2/ Using the wetter classification in dual classification years.
3/ Thousands of acre-feet.
4/ From DWR 1990 Level-of-Development Study.

During high flow periods (greater than 30,000 cfs), the Sacramento River overflows into the Yolo Bypass.

3.3 CENTRAL SIERRA BASIN

3.3.1 Physical Description

Basin 5B in Figure 3.1-2 is referred to as the Central Sierra Basin (SWRCB,3,4). This Basin includes the Delta and the watersheds of the Cosumnes, Mokelumne, and Calaveras rivers. Excluding the Delta, this Basin encompasses about 3,800 square miles (2,432,000 acres) of valley, foothills, and Sierra Nevada. In years of normal runoff, Basin 5B contributes about five percent of the total runoff to the Estuary (SWRCB,3,3).

3.3.2 Hydrology

The Central Sierra Basin inflow to the Delta comes from two river systems, the Mokelumne and Cosumnes, sometimes called the "Eastside Streams." The Basin also receives water from the Sacramento River Basin via the Folsom South Canal and the Folsom Lake Diversion. Water is exported from the Central Sierra Basin via the following projects:

Mokelumne Aqueduct, South Bay Aqueduct[1], and Sly Park.

1/ The South Bay Aqueduct diverts water just outside the legal boundaries of the Delta.

3.3.3 Unimpaired Flow Conditions

The Central Sierra Basin contributes about five percent of the average annual unimpaired inflow to the Delta. When unimpaired flows are reduced to current flow conditions, the percentage of the Central Sierra Basin's inflow to the Estuary remains five percent (see 3.3.4).

3.3.4 Current Flow Conditions

As of 1987, about 242,000 acre-feet of water or about one-third of the average annual Mokelumne River flow were diverted into the Mokelumne Aqueduct for use in the east San Francisco Bay area (EBMUD,1,9). Table 3.3.4-1 compares the amounts of water available in the Central Sierra Basin under unimpaired and current flow conditions.

The Delta Plan does not contain any flow or salinity standards at the Delta inflow points of the Central Sierra Basin.

TABLE 3.3.4-1
CENTRAL SIERRA BASIN:
UNIMPAIRED FLOW AND CURRENT FLOW CONDITIONS
BY WATER YEAR TYPE 1/

	Unimpaired Flow (TAF) 3/		Current Flow 4/	
Water Year Type 2/	Low	High	Low	High
Wet	1,176	3,329	669	2,534
Above Normal	954	2,343	358	1,377
Below Normal	722	1,940	319	1,092
Dry	361	1,030	240	505
Critical	162	593	163	366

1/ Using 1922 through 1978 hydrology. Individual water years measured as percentages of the Sacramento Basin's Four River Index have been used, resulting in some overlap of flow amounts for different water year types.
2/ Using the wetter classification in dual classification years.
3/ Thousands of acre-feet.
4/ From DWR 1990 Level-of-Development Operation Study; this Basin has no D-1485 requirements.

3.4 San Joaquin River Basin

3.4.1 Physical Description

The San Joaquin River Basin, Basin 5C in Figure 3.1-2, encompasses over 11,000 square miles (7,040,000 acres) between the crest of the Sierra Nevada Range and the crest of the Coast Range, and stretches southward from the Delta to the drainage divide between the San Joaquin and Kings rivers. The valley floor in the Basin measures about 50 miles wide by 100 miles long, and slopes from an elevation of about 250 feet at the southern end to near sea level at the northern end (RWQCB 5, 1975). In years of normal runoff, the San Joaquin River Basin now contributes about 15 percent of the total measured runoff to the Estuary (SWRCB,3,3).

The Kings River historically flowed into Fresno Slough and into the San Joaquin River. Due to upstream controls and diversions, this occurs now about once every three years (DWR,26,33). Due to this discontinuity, the Kings River is now considered to be part of the Tulare Lake Basin, Basin 5D, and not part of the San Joaquin River Basin.

3.4.2 Hydrology

The major tributaries in Basin 5C are the San Joaquin, Merced, Tuolumne, and Stanislaus rivers which originate in the Sierra Nevada. Peak streamflows above the reservoirs generally occur later in spring than the Sacramento Basin because the San Joaquin Basin mountain ranges are generally higher than those in the Sacramento Basin. Smaller tributaries, consisting of runoff from the Coast Range and/or argricultural drainage, include the following:

Salt and Mud sloughs, and Panoche, Little Panoche, Los Banos, Orestimba, and Del Puerto creeks.

Water is imported into the San Joaquin River Basin from the Delta via the Delta-Mendota Canal (DMC) of the CVP. Water is exported from the Basin via the following projects (see Figure 3.2.2-1):

Friant-Kern Canal (CVP), Hetch Hetchy Aqueduct, and San Felipe Unit (CVP).

About 77,000 acres in the San Joaquin River Basin have subsurface agricultural drainage systems which discharge to the San Joaquin River, primarily via Mud and Salt sloughs (EDF,11,I-1). During the irrigation season and occasionally following the flushing of agricultural drainage water from duck clubs in January and February, agricultural drainage makes up a significant portion of San Joaquin River flows and constituent loads (EDF,11,V-36--V-44,V-46&V-47). The San Joaquin River contains considerably higher concentrations of several constituents (including nitrates, selenium, arsenic, nickel and manganese) than the Sacramento River (AHI,302,219,231).

3.4.3 Unimpaired Flow Conditions

The unimpaired and measured annual flow of the four major rivers in the San Joaquin River Basin are shown in Figure 3.4.3-1 for WYs 1922 to 1978.

The completion of the Friant and Delta-Mendota Canal units of the CVP around 1950 altered the natural state of the San Joaquin River. A comparison of the pre-1950 and the post-1950 unimpaired versus measured flow relationship is shown in Figure 3.4.3-2 (EDF,11,II-30). The two regression lines in the figure are significantly different, indicating that the total amount of flow measured at Vernalis (the entry point of the San Joaquin River to the Delta) has decreased since 1950 (see 3.4.4).

FIGURE 3.4.3-1

SAN JOAQUIN VALLEY AVERAGE MONTHLY FLOW

1922 THROUGH 1978

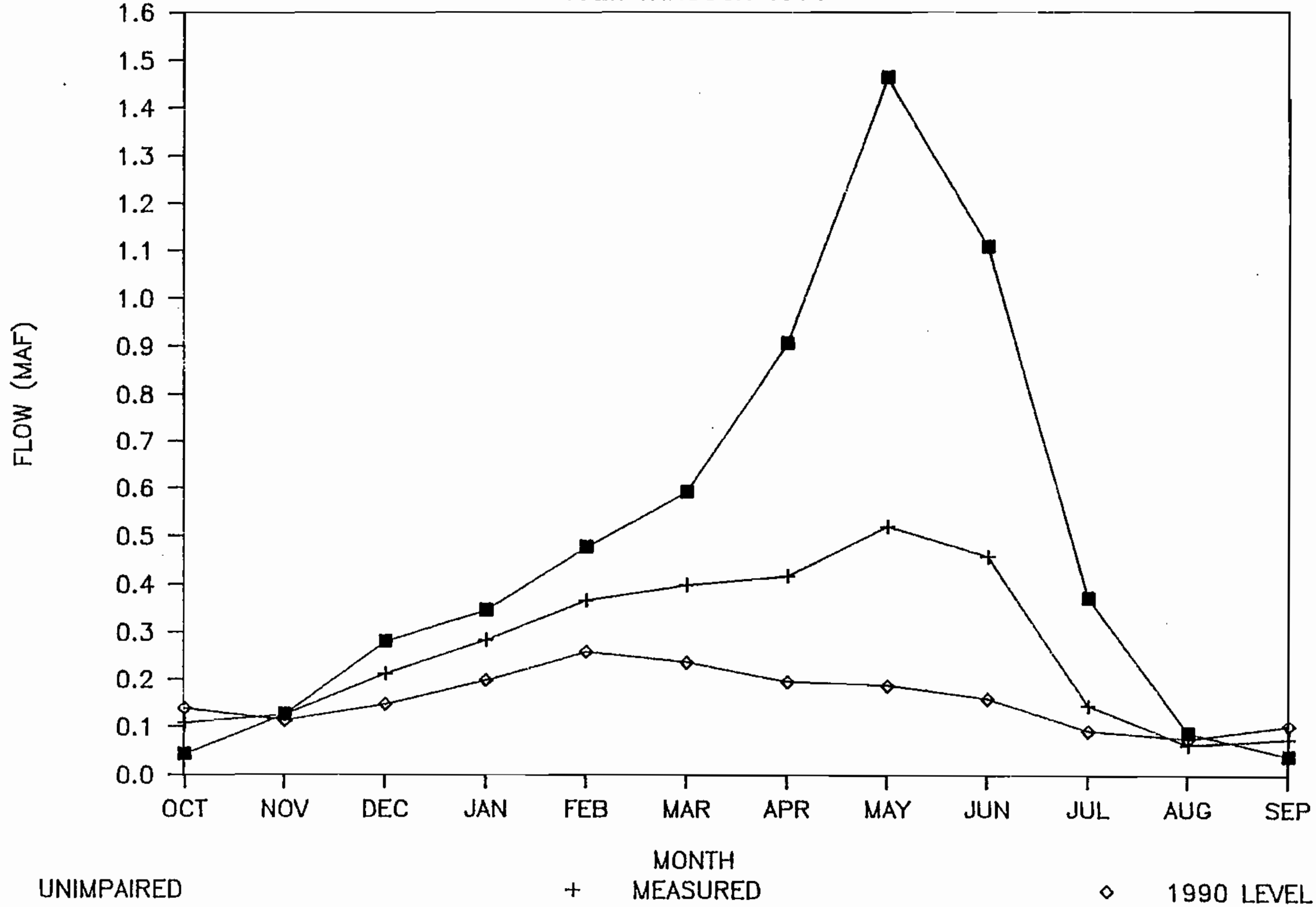
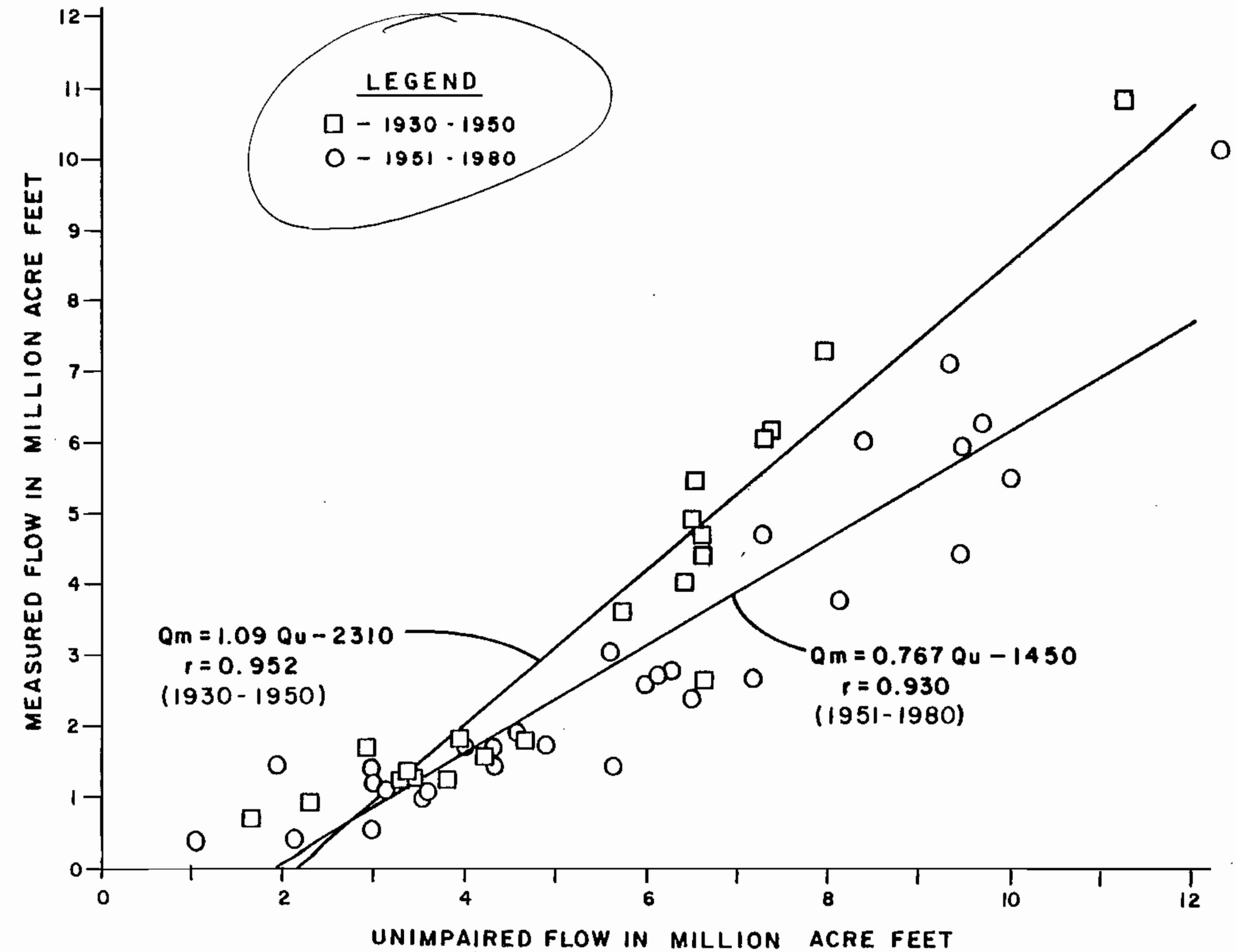


FIGURE 3.4.3-2 Unimpaired flows versus measured flows for the San Joaquin Basin



3.4.4 Current Flow Conditions

The annual measured flows in the San Joaquin River near Vernalis for WYs 1921 to 85 are also plotted in Figure 3.4.3-1 for comparison (flow data are not available for the 1906 to 20 and 1986 to 87 time periods). With the exception of the extremely wet WY 1983, the annual measured flows are less than the unimpaired flows[1/].

The main reason for the differences between annual unimpaired and measured flows is the consumptive water use by valley agriculture during the irrigation season, generally from April through September. Reservoirs on the four major rivers in the San Joaquin River Basin have also altered the timing of measured flows in relation to the unimpaired flows above the reservoirs, and have raised flows in September and October above unimpaired levels.

The current water quality objective set by The Delta Plan for the San Joaquin River Basin is a monthly mean of 500 ppm TDS for the San Joaquin River near Vernalis (RWQCB 5, 1975). For the period of 1975 through 1987, the 500 ppm TDS objective was met in all but two critically dry water years, 1976 and 1977, as well as the beginning of Water Year 1978. However, this 12-year period was dominated by wet years--six wet, two above normal, two dry, and two critical. Table 3.4.4-1 compares the amounts of water available in the San Joaquin River Basin under unimpaired and current flow conditions.

Figure 3.4.4-1, plotting annual salinity as TDS in the San Joaquin River near Vernalis for 1930-80 (Data from Orlob, 1982), shows that salinity concentrations have increased since 1930. The salt load has also increased since 1985, according to Dr. G. T. Orlob's analysis of USBR data measured at Vernalis (Orlob, 1988), probably because of the bypassing of agricultural drainage around the Grassland Water District directly to the San Joaquin River.

3.5 The Delta

3.5.1 Physical Description

The Delta is a roughly triangular area of approximately about 1,150 square miles (738,000 acres) extending from Chipps Island near Pittsburg on the west to Sacramento on the north and to the Vernalis gaging station on the south (see Figure 3.1-1) (California Water Code Section 12220). This area includes those waterways above the confluence of the Sacramento and San Joaquin rivers which are influenced by tidal action, and about 800 square miles (512,000 acres) of agricultural lands which derive their water supply from these waterways. The total surface area of these waterways is over 75 square miles (48,000 acres) with an aggregate navigable length of about 550 miles. Major tributaries to the Delta, besides the Sacramento and San Joaquin rivers, include the Cosumnes, Mokelumne, and Calaveras rivers, Dry Creek, and the Yolo Bypass.

1/ In WY 1983, flows from the Tulare Lake Basin contributed over two million acre-feet to the San Joaquin River flows near Vernalis, but were not included in the unimpaired flow of the four major rivers (DWR,26,33).

FIGURE 3.4.4.-1 Salinity, Flow and Salt Load in the San Joaquin River near Vernalis (5 year running Averages)
(adapted from Orlob, 1982 data)

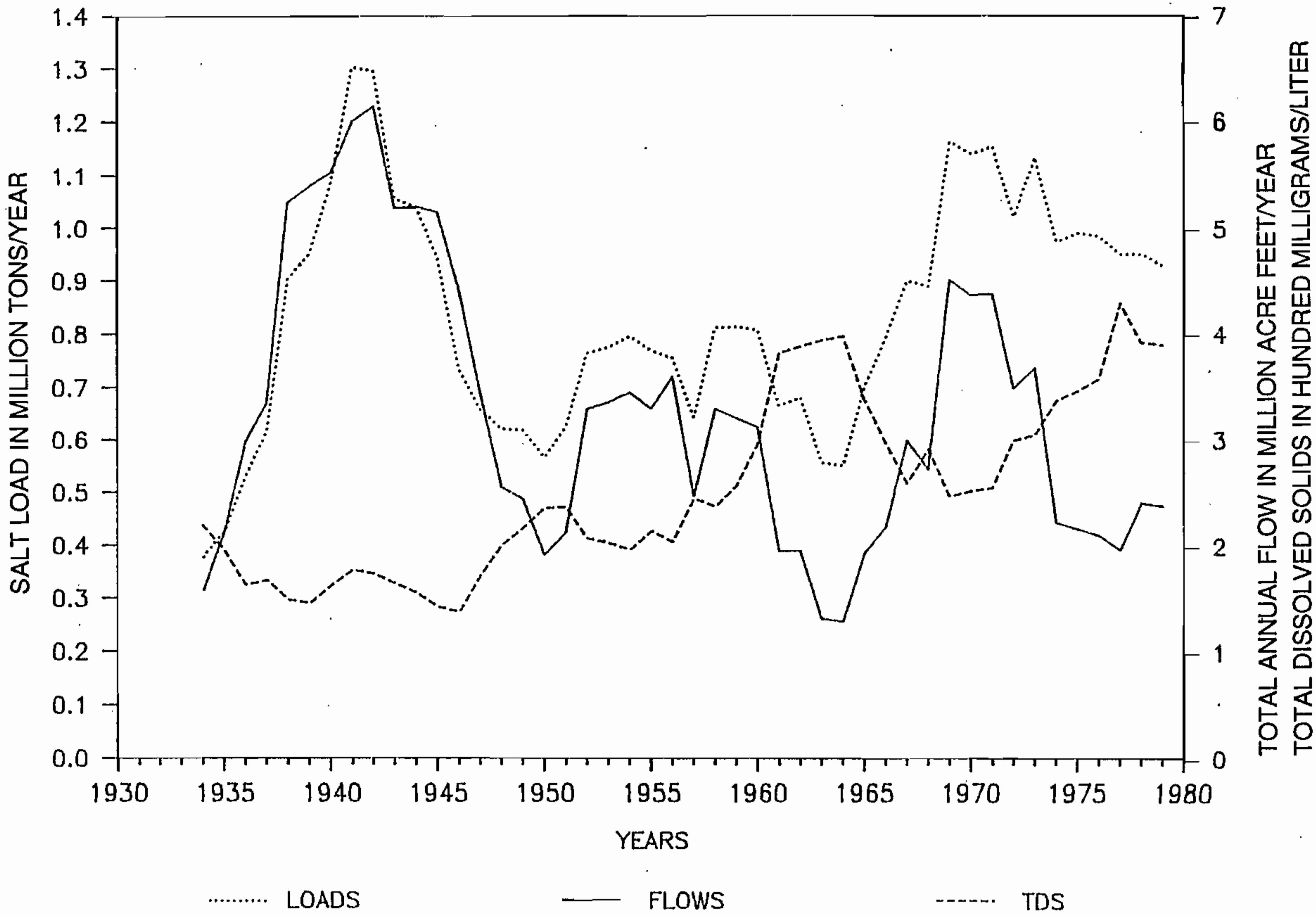


Table 3.4.4-1
SAN JOAQUIN RIVER BASIN:
UNIMPAIRED FLOW AND CURRENT FLOW CONDITIONS
BY WATER YEAR TYPE[1/]

Water Year Type	Unimpaired Flow (TAF)[2/] Low	High	Current Flow (The Delta Plan Requirements) Low	High
Wet	4,522	15,020	1,124	6,571
Above Normal	4,339	8,703	945	2,901
Below Normal	3,017	7,530	926	2,488
Dry	2,132	4,128	957	1,598
Critical	1,026	3,436	850	1,596

1/ Assuming 1922 through 1978 hydrology. Individual water years measured as percentages of the Sacramento Basin's Four River Index (see Chapter 4) have been used, resulting in some overlap of flow amounts for different water year types.

2/ Thousands of acre-feet.

Water is exported from the Delta at four major locations (identified by number on Figure 3.1-1):

Tracy Pumping Plant (1), Clifton Court Intake (2), Contra Costa Canal at Pumping Plant No. 1 (3), and the City of Vallejo intake at Cache Slough (4). The North Bay Aqueduct intake at Barker Slough (5) has recently replaced the City of Vallejo's intake (DWR,707,50).

3.5.2 Hydrology

3.5.2.1 Background

In its original condition, the Delta was a vast, flat marsh traversed by an ever changing network of channels and sloughs that divided the area into islands (SWC,262,A2-15). "During the flood season, the Delta became a great inland lake; when the floodwater receded, the network of sloughs and channels reappeared throughout the marsh" (DWR,707,67). In the 1860's reclamation began on low-lying areas, and local landowners undertook cooperative levee construction to allow the lands to be farmed. By the 1920's about 45,000 acres were completely reclaimed and in agricultural production (SWRCB,13,III-4); and "{m}any miles of entirely new channels had been dredged, and farmlands, small communities, highways and utilities were protected--often tenuously--by 1,100 miles of levees, many of them built on peat soils" (DWR,707,67).

The export of water directly from the Delta first took place in 1940 with the completion of the Contra Costa Canal, a unit of the CVP. In 1951, water supplying the Delta-Mendota Canal began to be exported at the CVP's Tracy Pumping Plant (DWR,707,67). In the same year the Delta Cross Channel and control gates were constructed near Walnut Grove to allow a more efficient transfer of water to the Tracy pumps (SWRCB,13,III-6). With the commencement of operation of the State Water Project's (SWP) Harvey O. Banks Pumping Plant in 1967, Delta exports were again increased. By 1975 the combined deliveries of waters exported by both the CVP and SWP totaled 4.8 million acre-feet per year--totals projected to reach 6.6 million acre-feet per year by the year 2000 (USBR,2,27).

3.5.2.2 Water Flow

- Inflow

Freshwater flow into the Delta comes primarily from the Sacramento and San Joaquin rivers, with small additional amounts contributed by the Mokelumne and Cosumnes rivers (SWRCB,13,III-7). Under present conditions, these river systems contributed 85, 10, and 5 percent, respectively, of the average annual Delta inflow during the water years 1922 to 1978 (DWR, 1987, from DWR 1990 'Level of Development Operation Model Output').

- In-channel Flow

  Flows in the Delta channels themselves result from a combination of Delta inflows, Delta agricultural use, export diversions, and the counteracting force of the tides from the Pacific Ocean through the San Francisco Bay. Many times when freshwater inflows are low, flows can change direction and move back upstream on incoming tides. The distance of the upstream movement, and the extent of saline intrusion, can vary depending on the quantities of water flowing in and the opposing force of tidal action (SWRCB,14,II-1). The total flow, however, is normally downstream, out of the Delta (SWRCB,13,III-11).

- Outflow

  The total outflow from the Delta is a combination of unimpaired runoff, Delta channel depletions, exports and upstream developments, which either reduce unimpaired runoff or change its time of occurrence.

  Delta outflow is highly seasonal and is characterized by large winter inflows from rainfall runoff generated by Pacific storms, and small, relatively steady inflows during the dry summers from reservoir releases. Delta outflow commonly exceeds 35,000 cfs from December through April, whereas it is usually less than 14,000 cfs from July through October (USGS,10,6).

3.5.2.3 Flow Measurement

Tidal movement, Delta channel depletions, and Delta exports (see 3.5.2.4) are not directly measured at present due to the complex effects of tidal fluctuation and flow patterns (SWRCB,14,IV-7). However, an estimate of net Delta outflow is important for purposes of water quality control and water resource management (SWRCB,13,III-16). The net Delta outflow at Chipps Island is usually estimated by performing a water balance at the boundary of the Delta, using Chipps Island as the western limit. The water balance involves adding the total Delta inflow and Delta precipitation runoff, then subtracting Delta channel depletions and exports (DWR,47,2).

DWR has estimated daily Delta outflow at Chipps Island for water years 1956 through 1985 using the flow accounting model, DAYFLOW. DAYFLOW is also used to estimate interior Delta flow at specified locations. (DWR,47) Figure 3.5.2.3-1 gives the means and standard deviations of Delta outflows computed by DAYFLOW for water years 1956 through 1985 (USGS,10,6).

Another commonly used estimate of Delta outflow, especially for the daily operation of the CVP and SWP, is the Delta Outflow Index (DOI). The DOI is similar to the DAYFLOW Delta outflow but does not include the smaller peripheral streams entering the Delta, such as the Mokelumne and Calaveras rivers, or the flows through the Yolo Bypass. Because of these differences, the DOI is considered to be less accurate than the DAYFLOW Delta outflow estimate (USBR,111,16).

FIGURE 3.5.2.3-1
(FROM USGS EXHIBIT 10, PAGE 6)

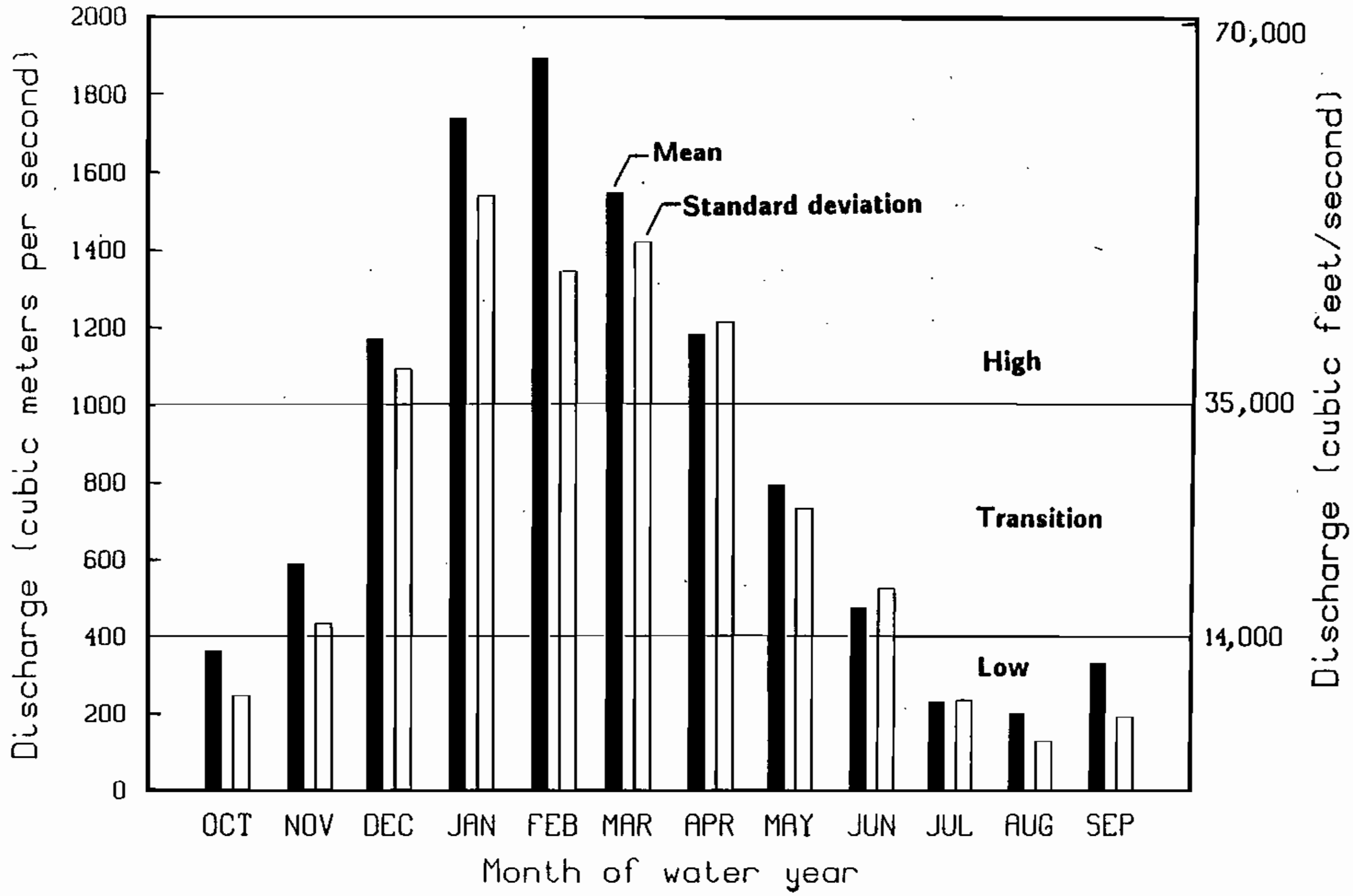


FIGURE 3.5.2.3-1 --Means and standard deviations of net monthly discharges of the Sacramento-San Joaquin Delta into San Francisco Bay at Chipps Island, 1956-85 from estimates of the State of California (1986). Also shown are arbitrary divisions of the months into high (>1,000 m^3/s [35,000 ft^3/s]), transition (400-1,000 m^3/s [14,000-35,000 ft^3/s]), and low (<400 m^3/s [14,000 ft^3/s]) delta discharges.

3.5.2.4 Channel Depletion, Exports and Reverse Flow

One of the critical factors in determining Delta outflow is Delta channel depletion, that is, "...the diversions of Delta channel waters via pumps, siphons, and subsurface seepage into the Delta uplands and lowlands for consumptive use by agriculture and native plants" (DWR,36,3-4)[1/]. The Delta channel depletions (not including precipitation) range from approximately 34 TAF inJanuary to 278 TAF in July (DWR,1988,Operation Study). Currently, over 1,600 diversion locations have been identified within the Delta (T,II,189:17). The location of agricultural irrigation diversion and drainage return points are shown in Figures 3.5.2.4-1 (DWR,49,1) and 3.5.2.4-2 (DWR,64,1).

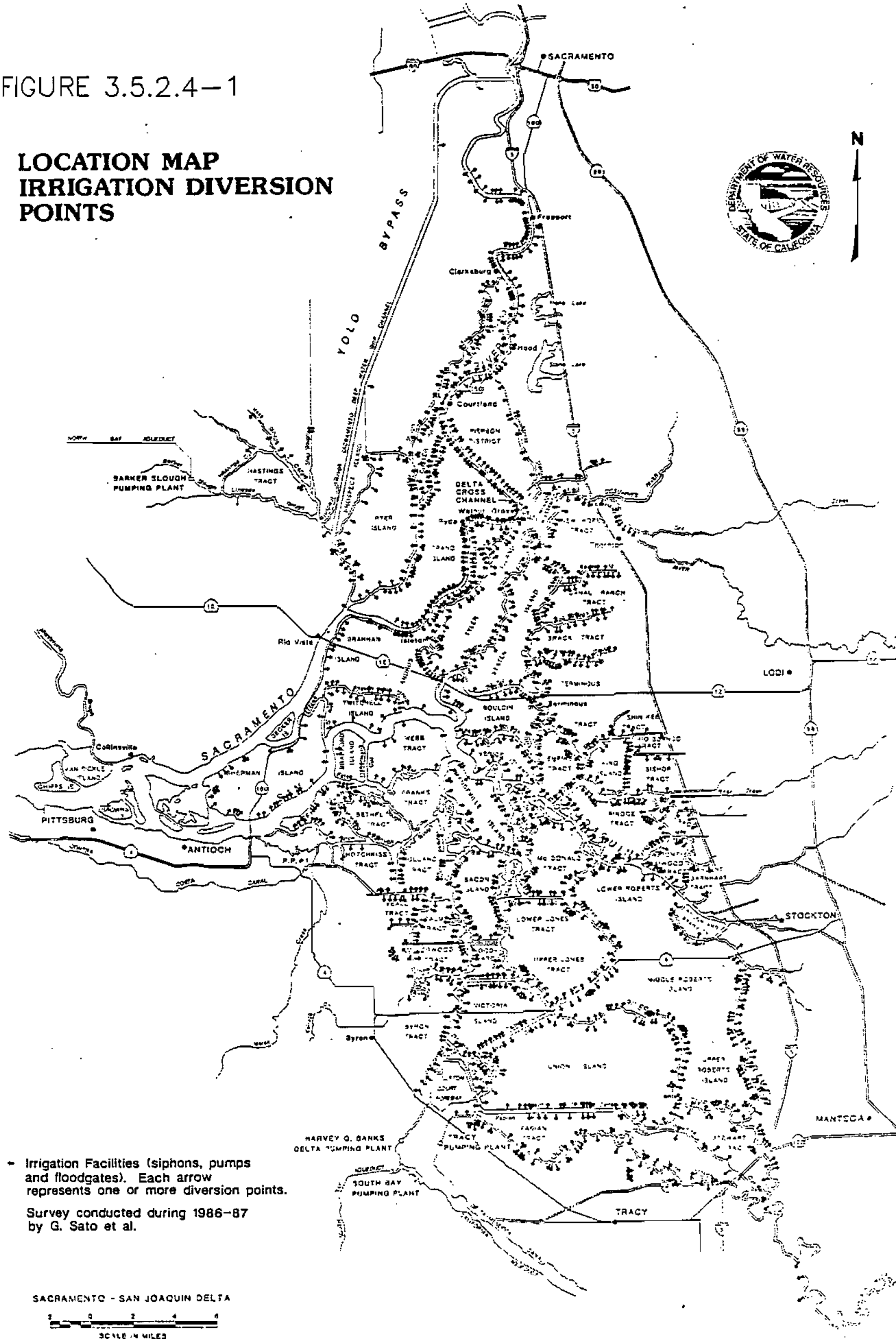
According to DWR, water supplies for export by the CVP and SWP are obtained from surplus Delta flows, and from upstream reservoir releases during low Delta inflow. Upstream reservoir releases from the Sacramento River Basin enter the Delta via the Sacramento River and then flow by various routes to the pumps in the southern Delta. Some of these releases are drawn to the CVP and SWP pumps through interior Delta channels facilitated in part by the CVP's Delta Cross Channel at Walnut Grove (DWR,707,69).

When export rates are high, the net flow of water can flow in an upstream direction and move toward the export pumps (SWRCB,13,III-II). This is known as reverse flows. During periods of high Delta inflow and high export, there is some reverse flow, but enough water is available from the San Joaquin River, eastern Delta tributaries (Central Sierra Basin) and from water transported out of the Sacramento River via the Delta Cross Channel to meet export demands (Figure 3.5.2.4-3). When there are high exports, low San Joaquin River inflows and high Delta consumptive uses, however, the normal water path changes, causing a reversal of flows around the lower (western) end of Sherman Island where the Sacramento River and the San Joaquin River meet (SWRCB,13,III-23) (Figure 3.5.2.4-4). As water travels around Sherman Island, it mixes with saltier ocean water entering as tidal inflow and is drawn upstream into the San Joaquin River and other channels that feed the CVP and SWP pumping plants (DWR,707,69). Figures 3.5.2.4-5 through 3.5.2.4-7 show other typical Delta flow patterns (DWR,51a-e).

1/ The consumptive use values used by the USBR and DWR to operate the CVP and SWP were fixed in the Federal-State Memorandum of Agreement dated April 9, 1969. The consumptive use values were based on: (1) a 1955 Delta land use survey; (2) estimates of consumptive use by identified crops; (3) changes in soil moisture; and (4) estimates of leaching requirements (SWRCB,13,III-16). Although the consumptive use values are adjusted seasonally, they are not adjusted between years; error can thereby be introduced into the Delta outflow calculations (USBR,111,16).

FIGURE 3.5.2.4-1

LOCATION MAP IRRIGATION DIVERSION POINTS



- Irrigation Facilities (siphons, pumps and floodgates). Each arrow represents one or more diversion points.

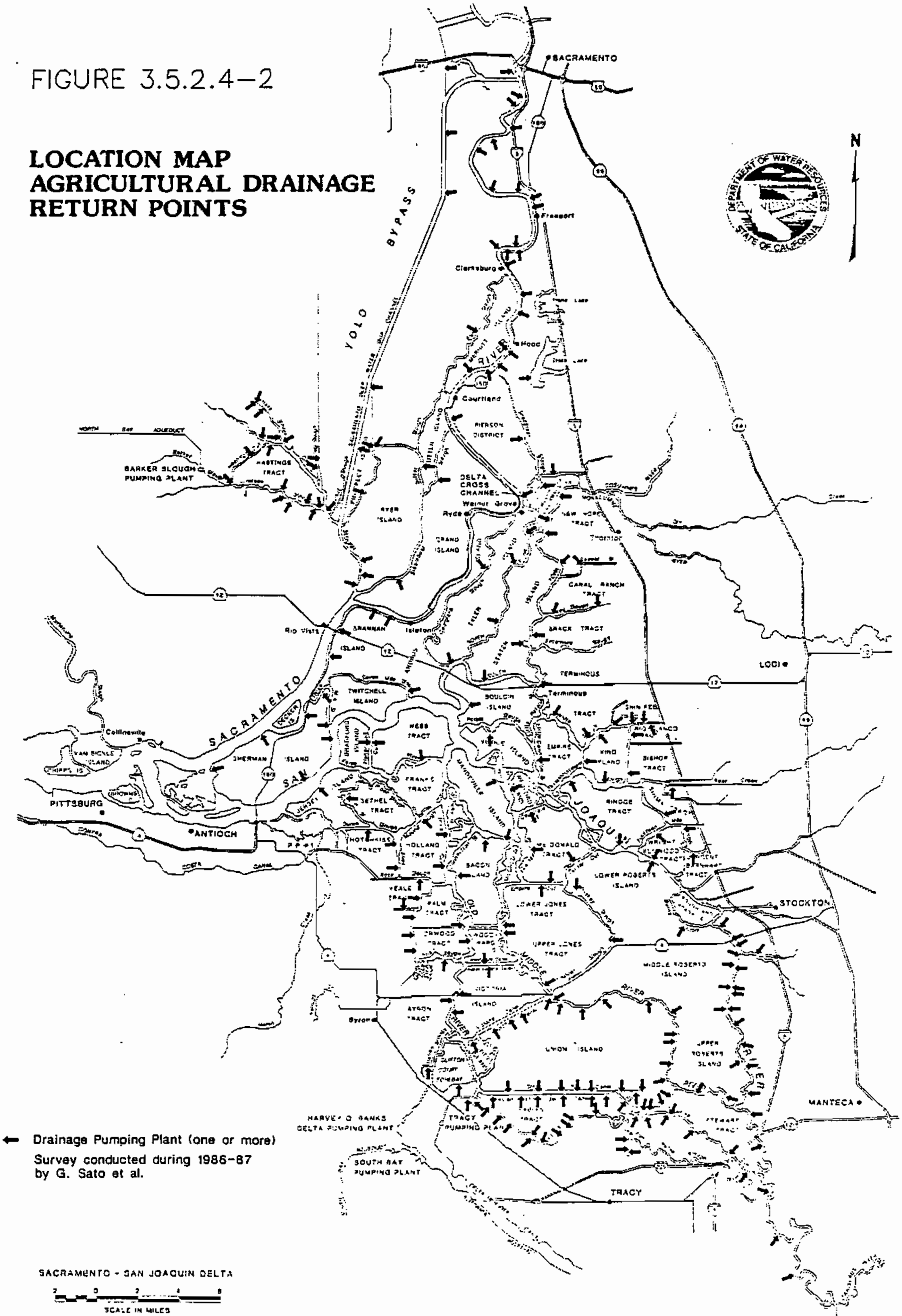
Survey conducted during 1986–87 by G. Sato et al.

SACRAMENTO - SAN JOAQUIN DELTA

SCALE IN MILES

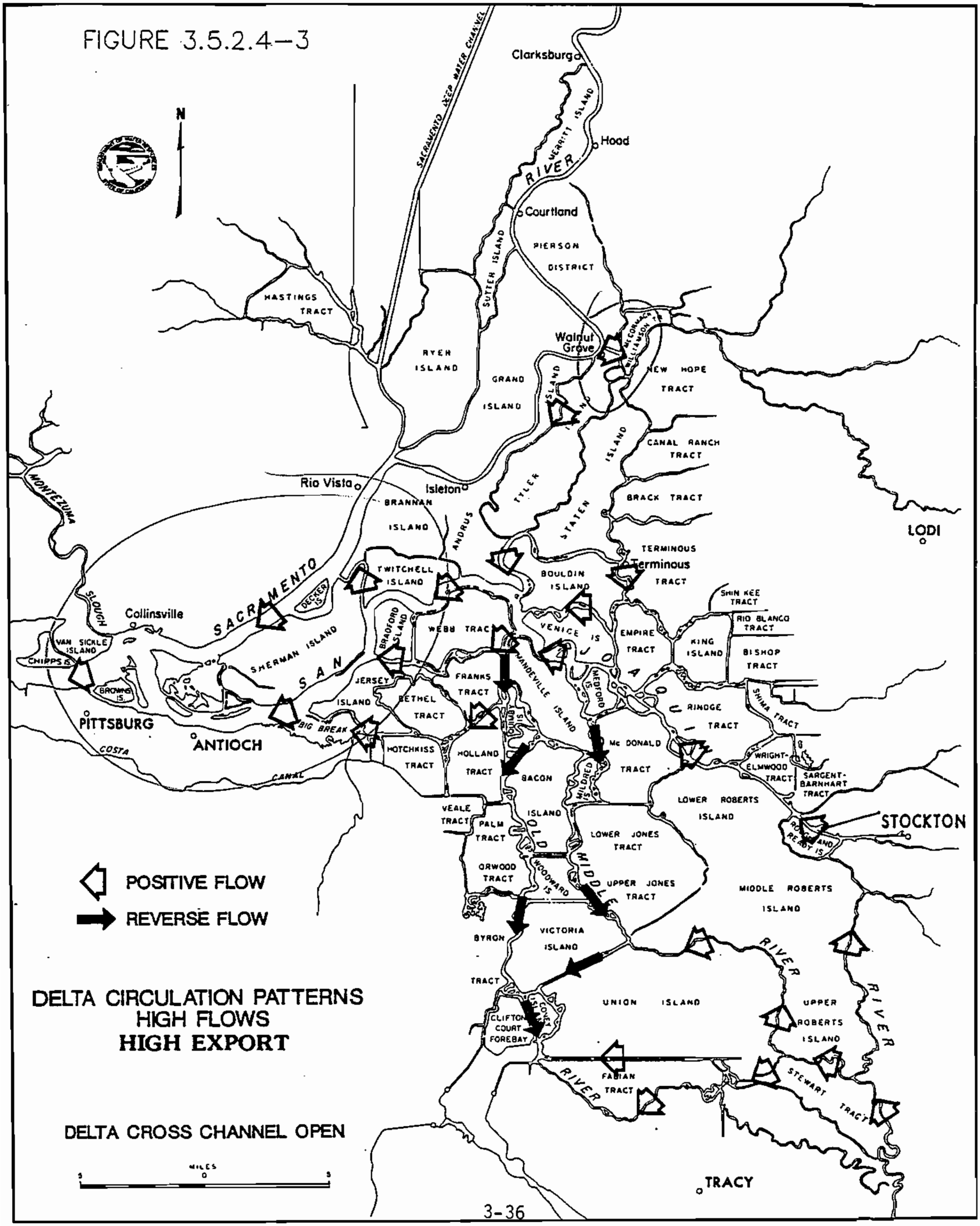
FIGURE 3.5.2.4-2

LOCATION MAP AGRICULTURAL DRAINAGE RETURN POINTS



← Drainage Pumping Plant (one or more)
Survey conducted during 1986-87 by G. Sato et al.

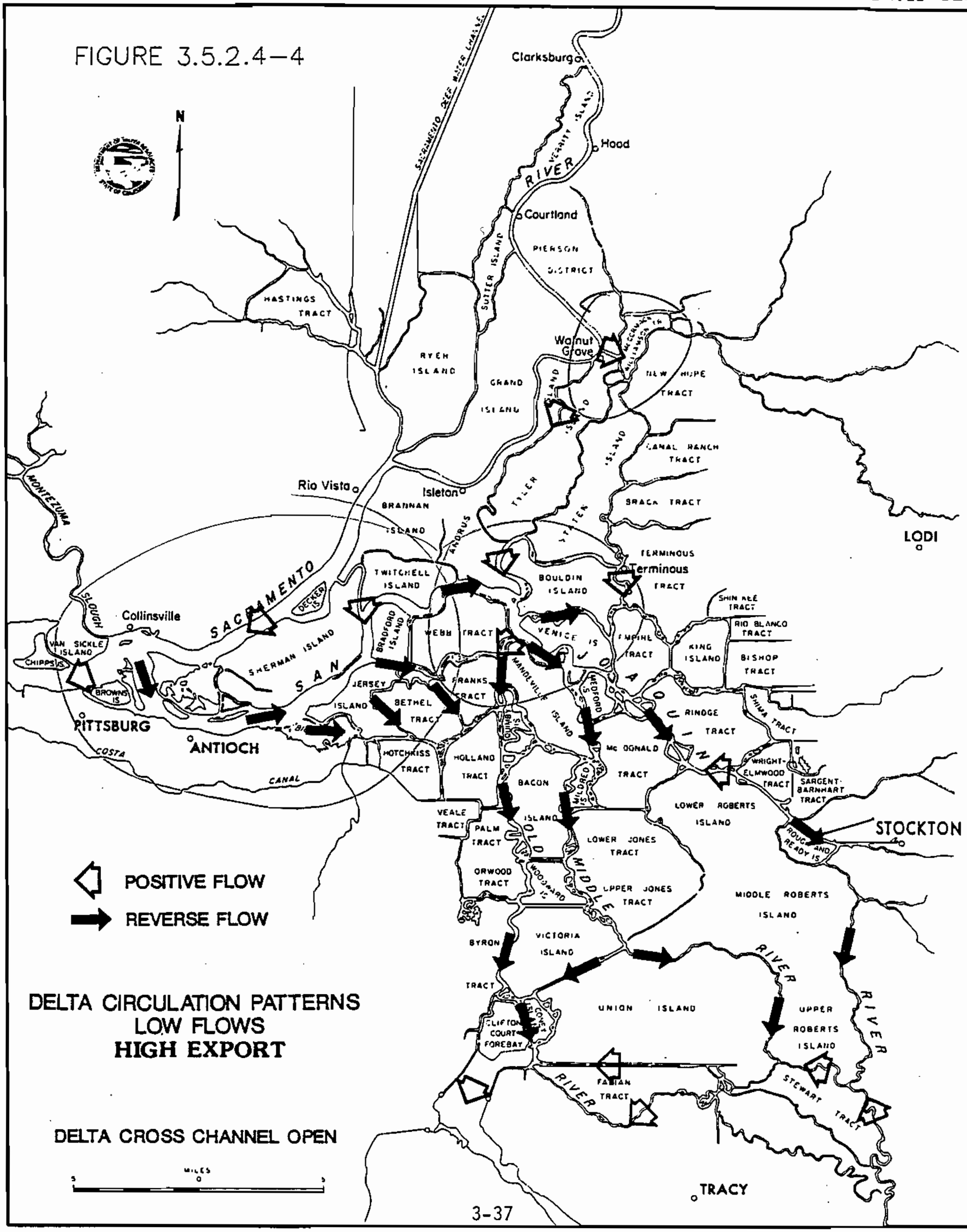
FIGURE 3.5.2.4-3



DELTA CIRCULATION PATTERNS
HIGH FLOWS
HIGH EXPORT

DELTA CROSS CHANNEL OPEN

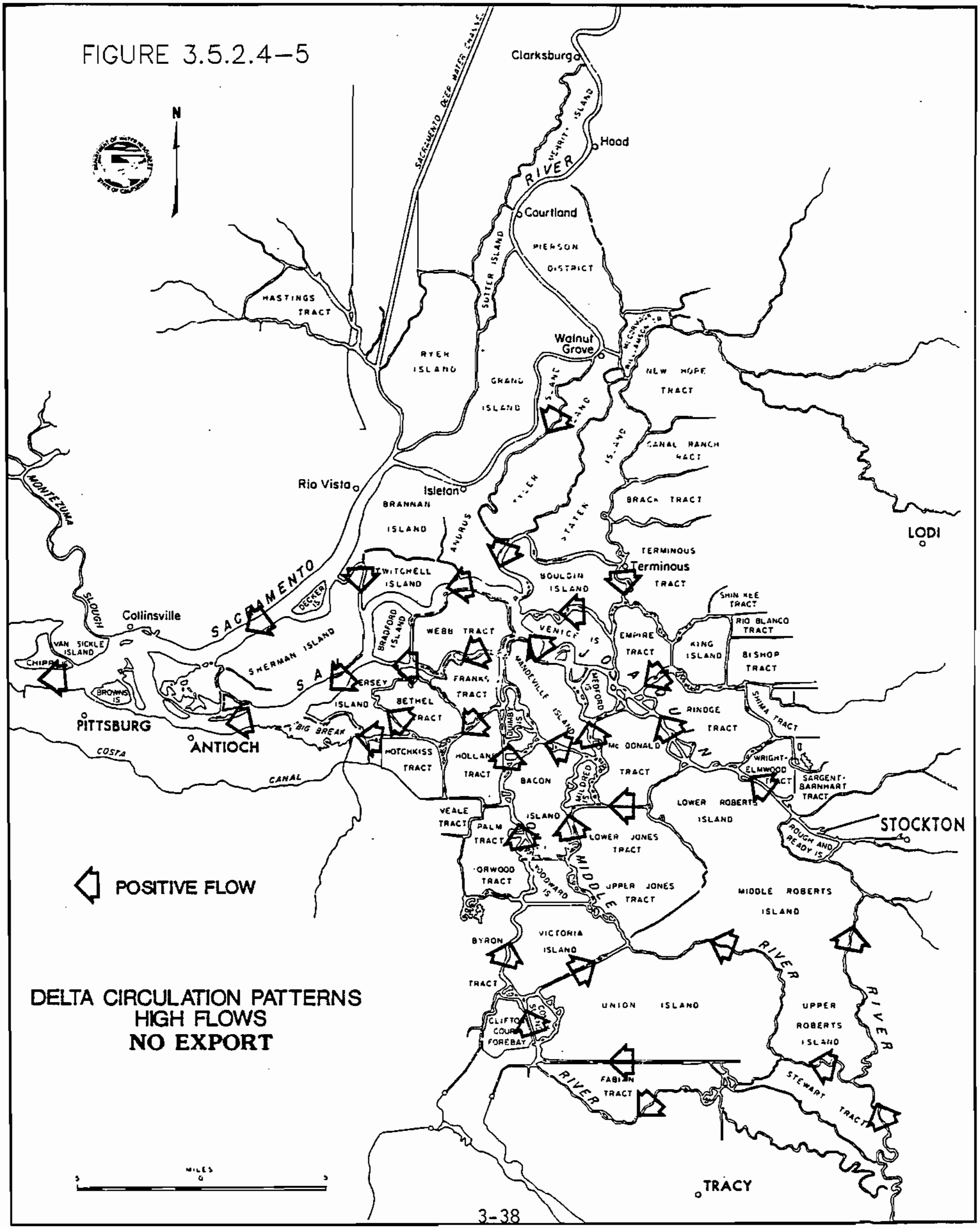
FIGURE 3.5.2.4-4



DELTA CIRCULATION PATTERNS
LOW FLOWS
HIGH EXPORT

DELTA CROSS CHANNEL OPEN

FIGURE 3.5.2.4-5



DELTA CIRCULATION PATTERNS
HIGH FLOWS
NO EXPORT

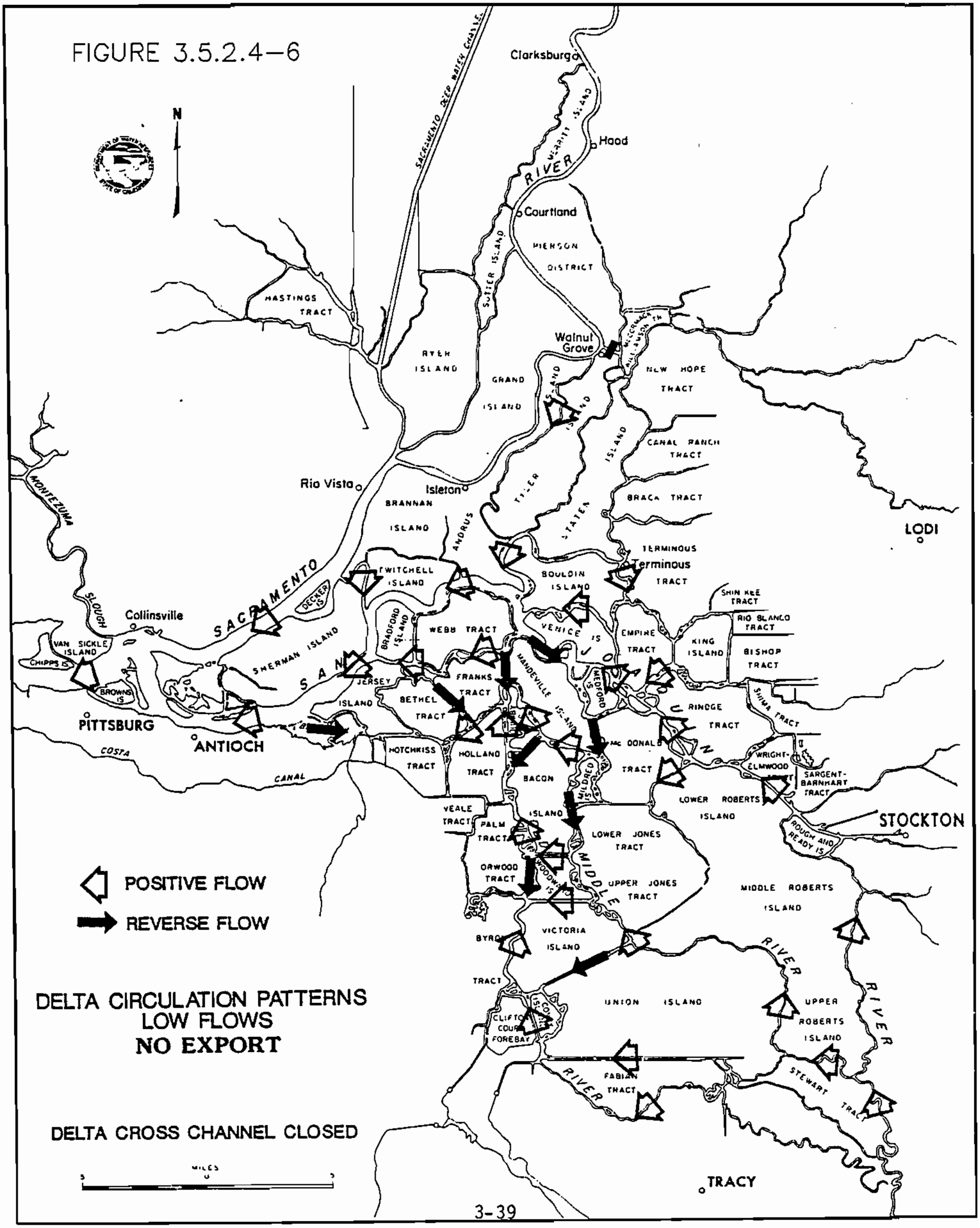
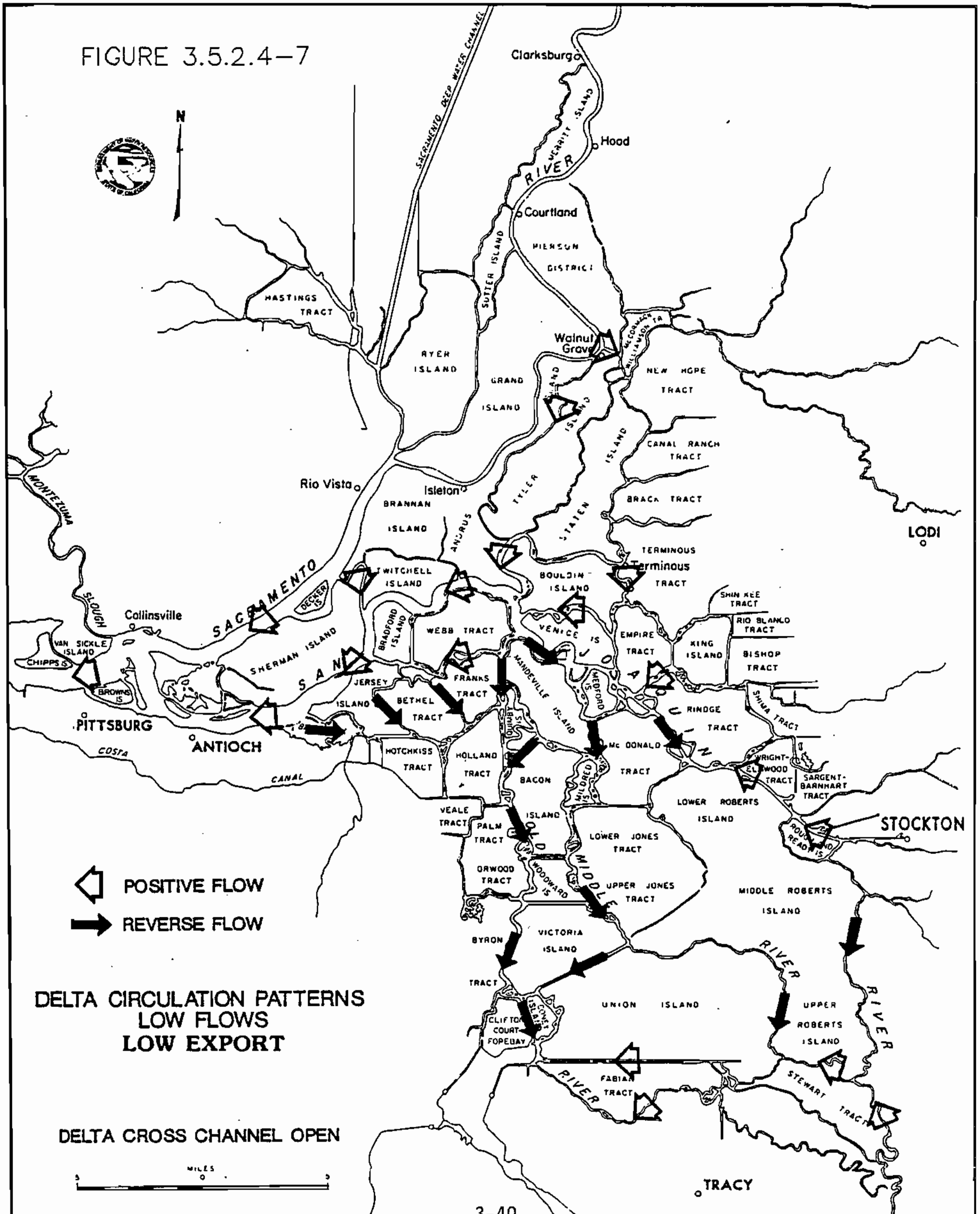


FIGURE 3.5.2.4-6

DELTA CIRCULATION PATTERNS
LOW FLOWS
NO EXPORT

DELTA CROSS CHANNEL CLOSED

FIGURE 3.5.2.4-7



DELTA CIRCULATION PATTERNS
LOW FLOWS
LOW EXPORT

DELTA CROSS CHANNEL OPEN

3.5.2.5 Salinity and Flow

Salinity is one of the major water quality factors affecting beneficial uses of Delta water supplies. Figure 3.5.2.5-1 shows that, as Delta outflows decrease, salinity increases[1/] (DWR,58,1). Changes in Delta outflow during low flow periods have greater effects on salinity than similar changes during high flow periods.

Upstream storage facilities, in-basin depletions and Delta exports, have reduced winter and spring Delta outflows. Releases from upstream storage facilities, on the other hand, have increased summer and fall Delta outflows (SWRCB,14, II-1). These changes in flows have correspondingly changed the extent of salinity intrusion into the Delta. Figure 3.5.2.5-2 shows the maximum annual salinity intrusion into the Delta for the period 1920 through 1977 (DWR,60). Flow modifications due to storage facilities since the 1940's have generally kept salinity intrusion, as indicated by the 1000 ppm chloride line in the Delta, at a point further west, or downstream, than had been the case before that period.

3.5.3 Unimpaired Flow Conditions

The State Water Contractors (SWC) estimated the average monthly Delta outflow under natural flow conditions (Case A & B) and compared these to DWR's estimated unimpaired and 1990 level of development outflows (Figure 3.5.3-1) (DWR,30,26;SWC,353,1). Compared to DWR's unimpaired flow, the Delta outflow that the SWC estimated to be natural is smaller due to the consumptive use by vegetation of natural marshes and riparian areas, and also due to the absence of existing man-made levees. David R. Dawdy also estimated the average monthly Delta outflow under natural flow conditions and arrived at values somewhat higher than the SWC estimate (DAWDY,3,5). The difference between these estimates results mainly from different estimates of tule acreage, which in turn causes different amounts of consumptive use via plant evapotranspiration. DWR's estimate of unimpaired Delta outflow (DWR,36,3) differs from the SWRCB's estimate (SWRCB,3,M-2) primarily due to different estimates of Delta consumptive use under unimpaired conditions.

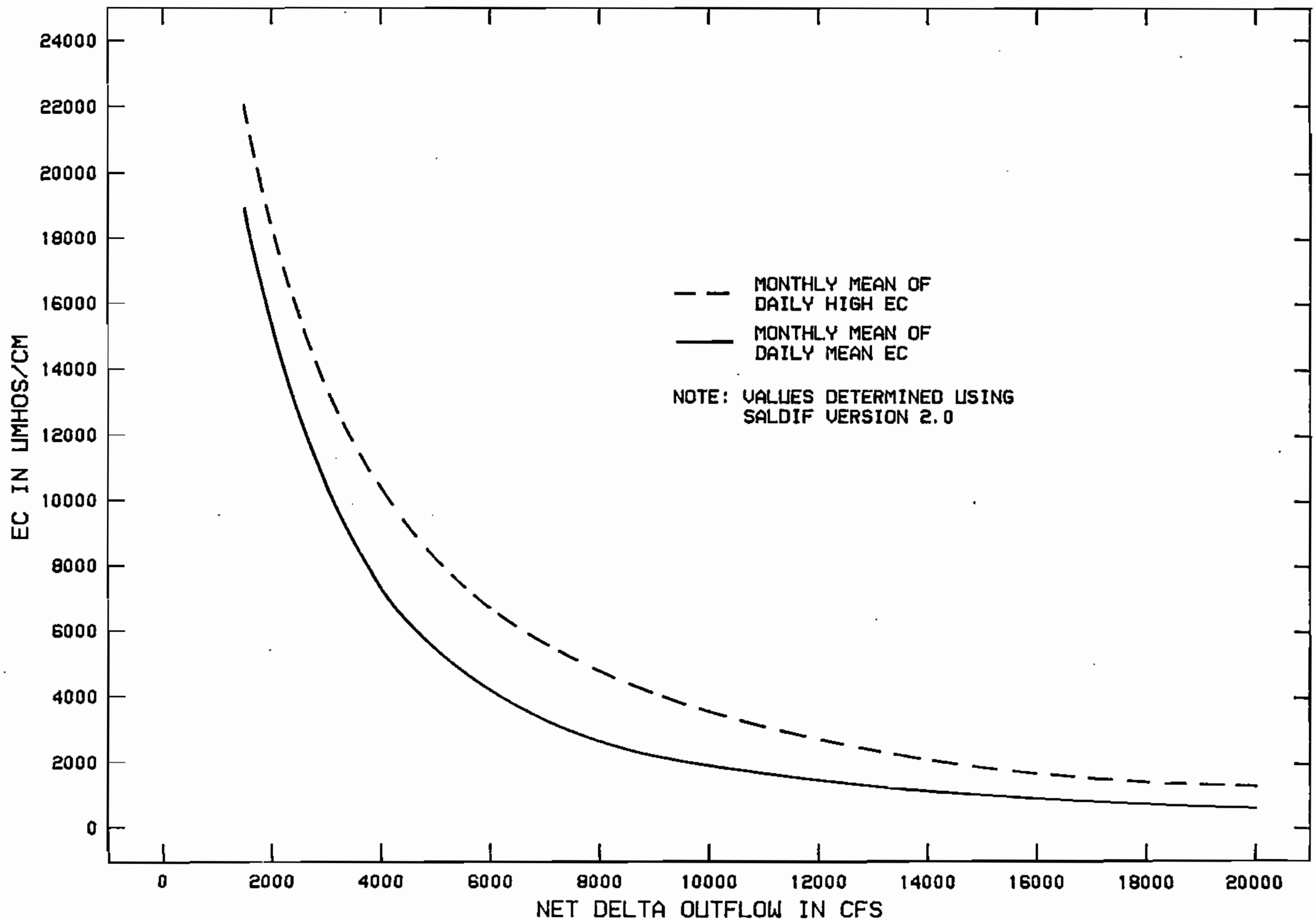
This Plan uses the unimpaired Delta inflows developed by both SWRCB and DWR to estimate unimpaired flows and salinities within the Estuary (SWRCB,3-5).

1/ In terms of EC at Collinsville in the western Delta. Historically, the salinity of waterways in the Delta has been expressed in chloride (Cl) or total dissolved solids (TDS) concentrations, and, more recently, in electrical conductivity (EC). However, sometimes it is necessary to convert one unit of salinity to another. Consequently, DWR has developed "Unit Conversion Equations" which are used to convert any one of the parameters to any of the others at various locations in the Delta using specific formulas for geographic location and water year type (DWR,61,1).

FIGURE 3.5.2.5-1

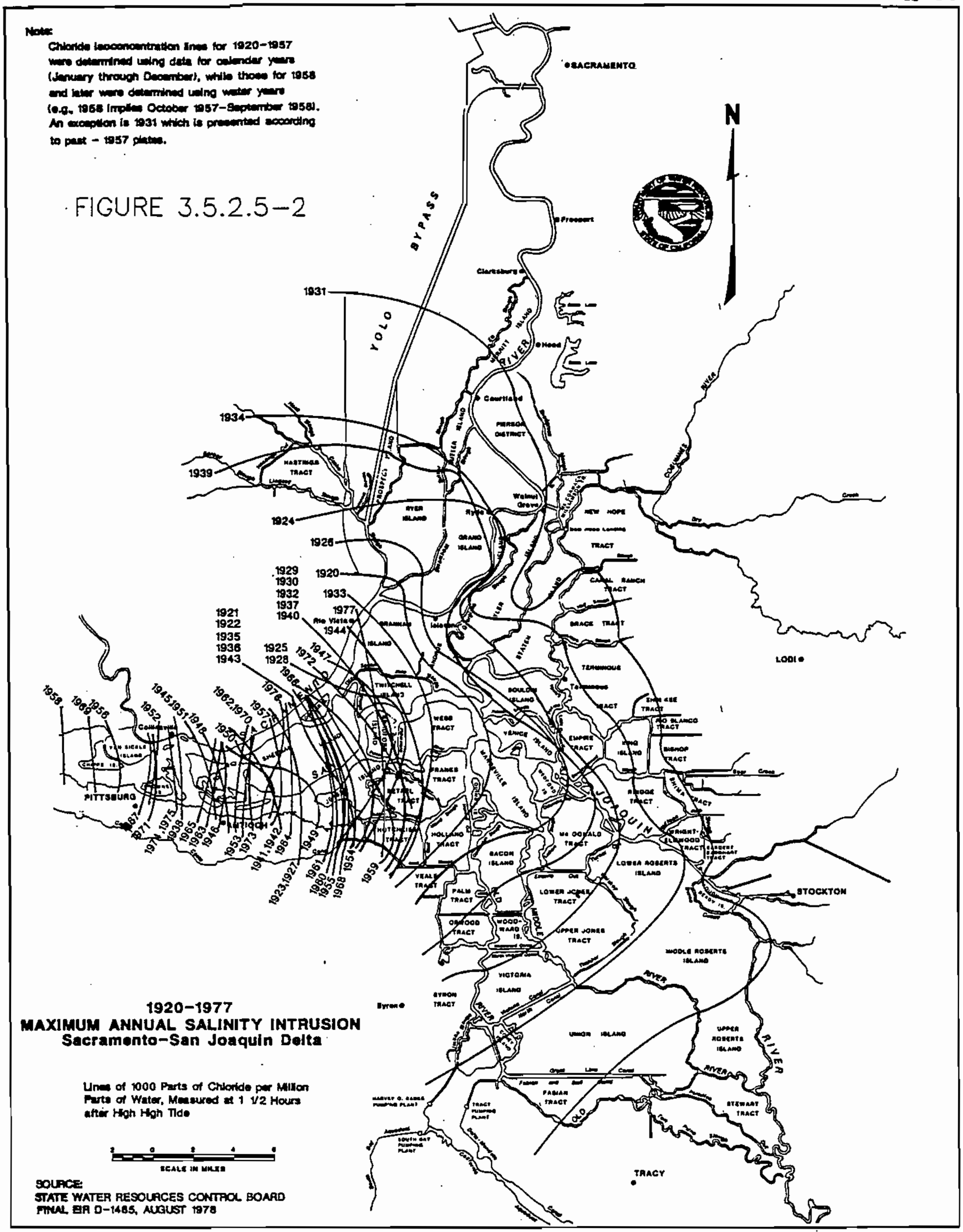
DWR-58

SALINITY-OUTFLOW RELATIONSHIP @ COLLINSVILLE
MONTHLY MEAN OF DAILY HIGH & DAILY MEAN EC



Note:
Chloride isoconcentration lines for 1920–1957 were determined using data for calendar years (January through December), while those for 1958 and later were determined using water years (e.g., 1958 implies October 1957–September 1958). An exception is 1931 which is presented according to past - 1957 plates.

FIGURE 3.5.2.5–2



1920–1977
MAXIMUM ANNUAL SALINITY INTRUSION
Sacramento–San Joaquin Delta

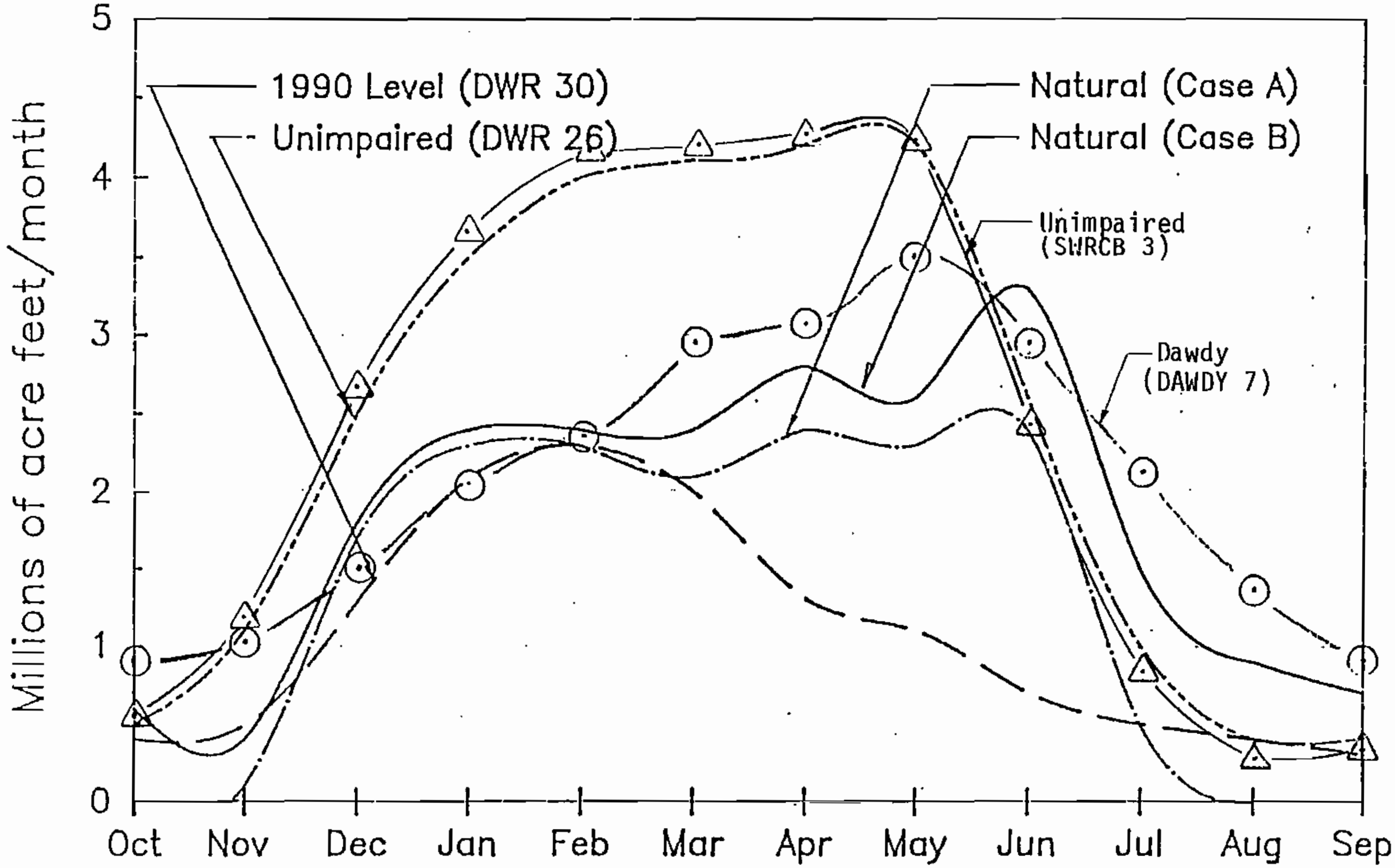
Lines of 1000 Parts of Chloride per Million Parts of Water, Measured at 1 1/2 Hours after High High Tide

SCALE IN MILES

SOURCE:
STATE WATER RESOURCES CONTROL BOARD
FINAL EIR D-1485, AUGUST 1978

FIGURE 3.5.3-1

Average Monthly Delta Outflow



(From SWC 353)

	DWR Unimpaired	SWRCB Unimpaired	SWC Natural	DAWDY Natural	DWR 1990 L.O.D.
ANNUAL FLOW (MAF/YR)	28	28	16-22	25	14

3.5.4 Current Flow Conditions

The Delta Plan currently requires the CVP and SWP to meet specified flow and salinity standards within the Delta and Suisun Marsh (SWRCB,15,5). Figures 3.5.4-1 through -3, and Table 3.5.4-1 compare unimpaired Delta outflows with minimum outflow requirements set by the Delta Plan objectives (DWR,1986,1). DWR has established (Table 3.5.4-2) the minimum outflow requirements to meet The Delta Plan objectives (DWR,1986,1). In some months such as August, Delta Plan flow requirements can actually be above the unimpaired amounts available(Figure 3.5.4-1).

TABLE 3.5.4-1
TOTAL ANNUAL DELTA OUTFLOWS:
UNIMPAIRED FLOW AND CURRENT FLOW CONDITIONS
BY WATER YEAR TYPE[1/]

	Unimpaired Flow (TAF)[2/]		Current Flow[3/]	
Water Year Type	Low	High	Low	High
Wet	29,441	56,686	16,034	34,715
Above Normal	22,997	32,368	6,554	16,145
Below Normal	18,428	26,110	4,684	11,021
Dry	15,334	18,133	4,785	8,707
Critical	5,793	13,279	3,273	4,848

1/ Assuming 1922 through 1978 hydrology.
2/ Thousands of acre-feet.
3/ Delta Plan requirements.

3.6 San Francisco Bay and Basin – includes Suisun Marsh

3.6.1 Physical Description: San Francisco Bay

The boundary of San Francisco Bay (SWRCB,3,3) extends from the Golden Gate Bridge on the west to the Delta on the east and includes:areas subject to tidal action up to mean high tide, areas 100 feet landward of the mean high tide shoreline, saltponds, and managed wetlands.

This definition includes the entire Suisun Marsh as part of San Francisco Bay. Suisun Marsh, as defined by Section 29101 of the Public Resources Code, includes the waterways north of Suisun, Grizzly, and Honker bays which are subject to tidal action and the adjacent lands whose management is dependent on tidal action of these waters. This definition generally follows the San Francisco Bay Conservation and Development Commission (BCDC) boundary as defined in Government Code Sections 66610 and 66611.

TABLE 3.5.4-2

ESTIMATED DELTA OUTFLOW REQUIREMENTS OF THE 1978 DELTA PLAN

Time Period	Delta Outflow Requirements in cfs (acre-feet)									
	Wet		Above Normal		Below Normal		Dry		Critical	
	Lower Requirements	Upper Requirements	Lower Requirements	Upper Requirements	Lower Requirements	Upper Requirements	Lower Requirements	Upper Requirements	Lower Requirements	Upper Requirements
January	4,500[2] (276,700)	6,600[1] (405,800)	4,500[2] (276,700)	6,600[1] (405,800)	4,500[2] (276,700)	6,600[1] (405,800)	4,500[2] (276,700)	6,600[1] (405,800)	4,500[2] (276,700)	6,600[1] (405,800)
February	10,000 (555,400)	10,000 (555,400)	4,500[2] (249,900)	12,000 (666,500)	4,500[2] (249,900)	12,000 (666,500)	4,500[2] (249,900)	6,600[1] (366,600)	4,500[2] (249,900)	6,600[1] (366,600)
March 1-17	10,000 (337,200)	10,000 (337,200)	4,500[2] (151,700)	12,000 (404,600)	4,500[2] (151,700)	12,000 (404,600)	4,500[2] (151,700)	6,600[1] (222,500)	4,500[2] (151,700)	6,600[1] (222,500)
March 18-31	10,000 (277,700)	10,000 (277,700)	4,500[2] (125,000)	12,000 (333,200)	4,500[2] (125,000)	12,000 (333,200)	4,500[2] (125,000)	6,600[1] (183,300)	4,500[2] (125,000)	6,600[1] (183,300)
April	10,000 (595,000)	10,000 (595,000)	7,600 (452,200)	7,600 (452,200)	7,600 (452,200)	7,600 (452,200)	7,600 (452,200)	7,600 (452,200)	4,500[3] (267,800)	6,700[3] (398,700)
May 1-5	10,000 (99,200)	10,000 (99,200)	7,600 (75,400)	7,600 (75,400)	7,600 (75,400)	7,600 (75,400)	7,600 (75,400)	7,600 (75,400)	4,500[3] (44,600)	6,700[3] (66,400)
May 6-31	7,600 (391,900)	14,000[4] (722,000)	7,600 (391,900)	14,000[4] (722,000)	7,600 (391,900)	11,400[4] (587,900)	7,600 (391,900)	7,600 (391,900)	3,900 (201,100)	3,900 (201,100)
June 1-15	7,600 (226,100)	14,000[4] (416,500)	7,600 (226,100)	10,700[4] (318,400)	7,600 (226,100)	9,500[4] (282,600)	7,600 (226,100)	7,600 (226,100)	3,900 (116,000)	3,900 (116,000)
June 16-20	7,600 (75,400)	14,000[4] (138,800)	7,600 (75,400)	10,700[4] (106,100)	7,600 (75,400)	9,500[4] (94,200)	4,700 (46,600)	4,700 (46,600)	3,900 (38,700)	3,900 (38,700)
June 21-30	7,600 (150,700)	14,000[4] (227,700)	7,600 (150,700)	10,700[4] (212,200)	5,400 (107,100)	9,500[4] (188,400)	4,700 (93,200)	4,700 (93,200)	3,900 (77,400)	3,900 (77,400)
July	7,600 (467,300)	10,000[4] (614,900)	6,700 (412,000)	7,700[4] (473,500)	5,400 (332,000)	6,500[4] (399,700)	4,700 (289,000)	4,700 (289,000)	3,900 (239,800)	3,900 (239,800)
August 1-15	7,600 (226,100)	7,600 (226,100)	6,700 (199,300)	6,700 (199,300)	5,400 (160,700)	5,400 (160,700)	4,700 (139,800)	4,700 (139,800)	3,900 (116,000)	3,900 (116,000)
August 16-31	2,500 (79,300)	2,500 (79,300)	2,500 (79,300)	2,500 (79,300)	2,500 (79,300)	2,500 (79,300)	2,500 (79,300)	2,500 (79,300)	2,500 (79,300)	2,500 (79,300)
September	2,500 (148,800)	2,500 (148,800)	2,500 (148,800)	2,500 (146,800)	2,500 (148,800)	2,500 (148,800)	2,500 (148,800)	2,500 (148,800)	2,500 (148,800)	2,500 (148,800)
October	4,500 (276,700)	4,500 (276,700)	4,500 (276,700)	4,500 (276,700)	4,500 (276,700)	4,500 (276,700)	3,500[5] (215,200)	4,500 (276,700)	3,500[5] (215,200)	4,500 (276,700)
November	4,500 (267,800)	4,500 (267,800)	4,500 (267,800)	4,500 (267,800)	4,500 (267,800)	4,500 (267,800)	3,500[5] (208,300)	4,500 (267,800)	3,500[5] (208,300)	4,500 (267,800)
December	4,500 (276,700)	4,500 (276,700)	4,500 (276,700)	4,500 (276,700)	4,500 (276,700)	4,500 (276,700)	3,500[5] (215,200)	4,500 (276,700)	3,500[5] (215,200)	4,500 (276,700)
Total in 1000s acre-feet	4,728	5,666	3,836	5,418	3,673	5,100	3,384	3,942	2,772	3,482

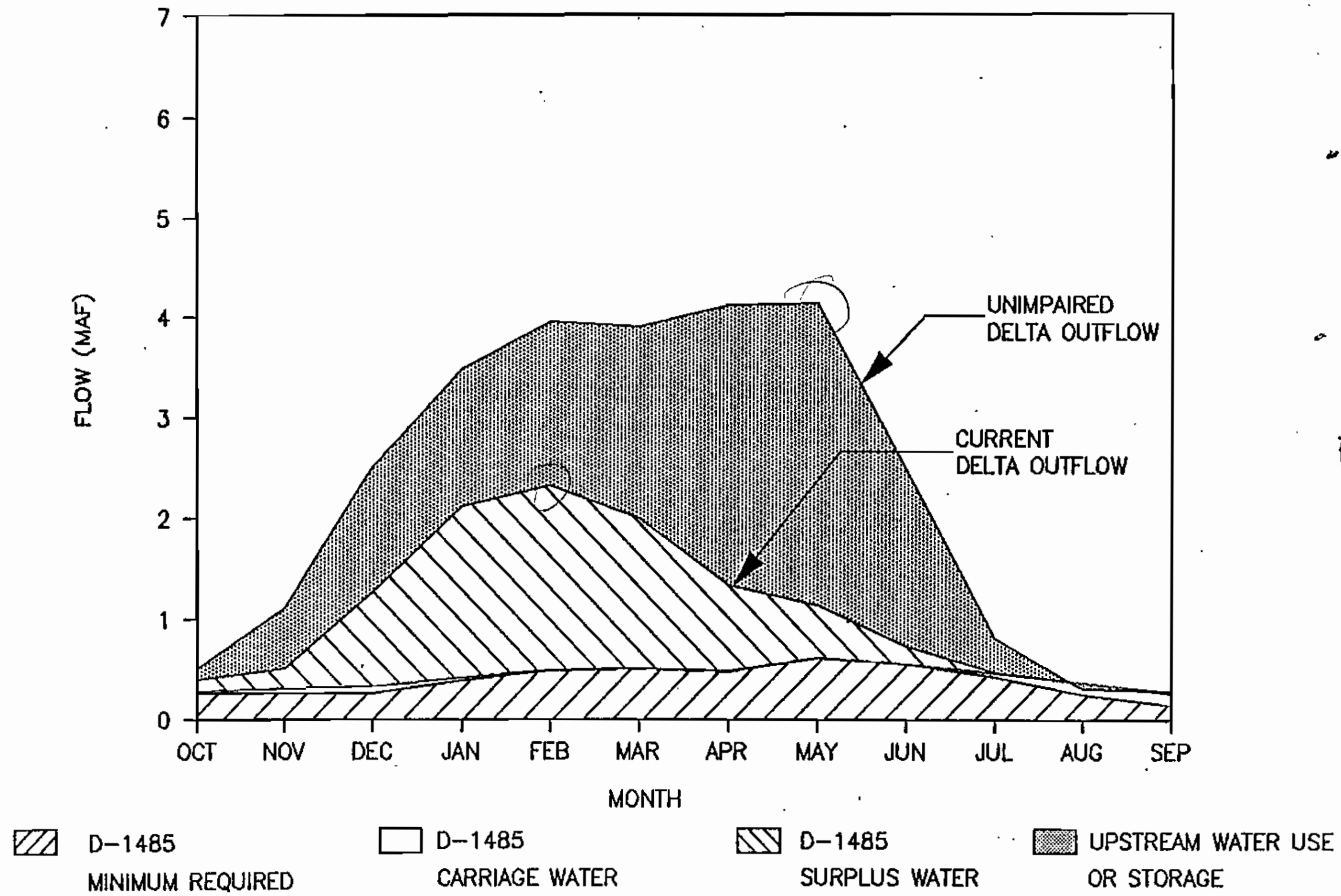
1 When the storages at any two of Shasta, Oroville and Folsom Reservoirs are encroached in their flood control reservation.
2 If storages are encroached (see No. 1) then 6,600.
3 If SWP and CVP users are taking deficiencies in firm supplies then 4,500 cfs for critical year.
4 If subnormal snowmelt then use lower limit.
5 When project users (CVP and SWP) are taking deficiencies, otherwise 4,500 cfs.

Department of Water Resources
Division of Operations and Maintenance
March 1986

FIGURE 3.5.4-1

CURRENT AND UNIMPAIRED DELTA OUTFLOW

USING 1922-1978 MONTHLY AVERAGE HYDROLOGY



- Unimpaired Flow hydrograph peaks in May
- Current Delta Outflow peaks in February!

FIGURE 3.5.4-2

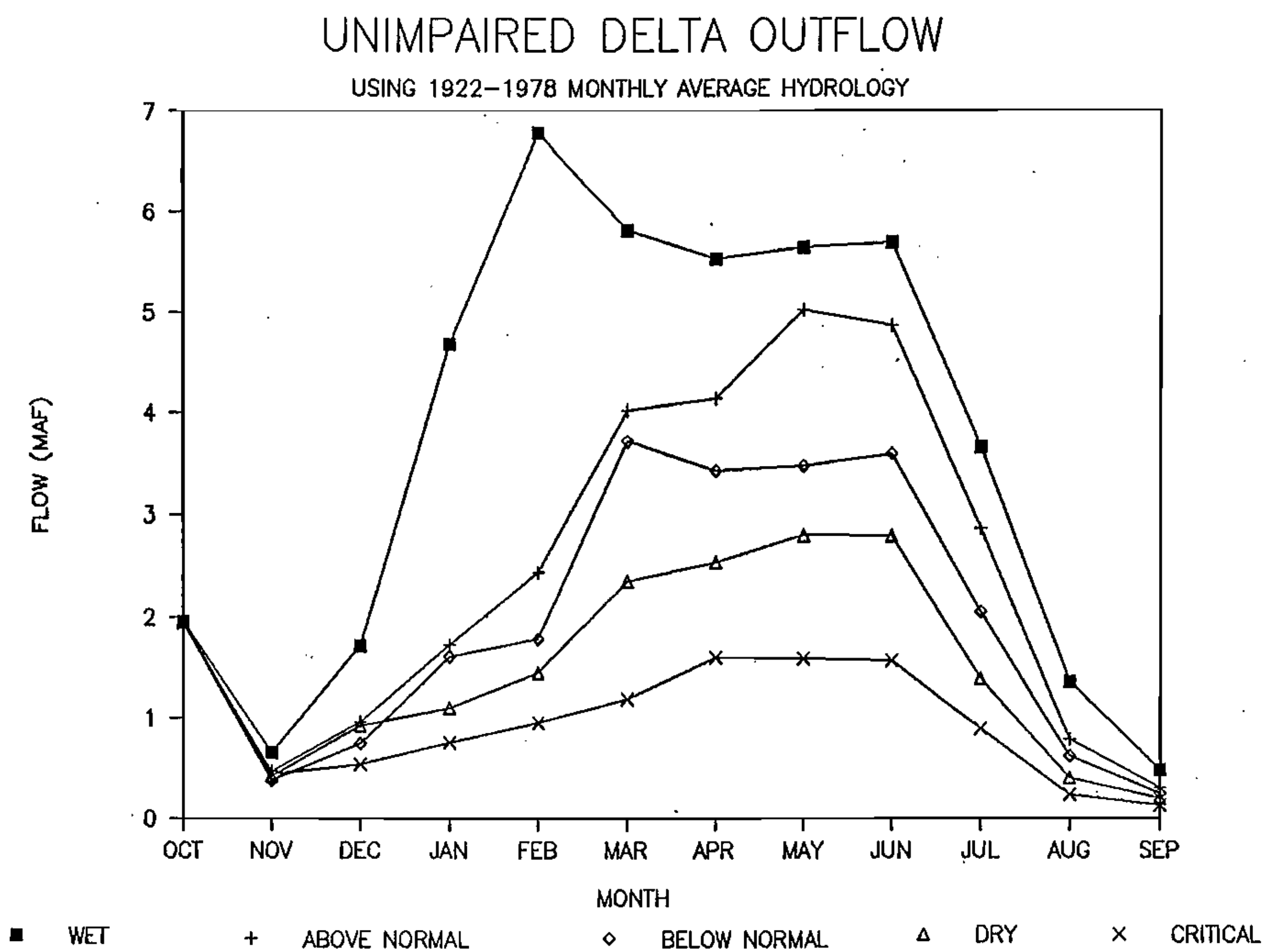
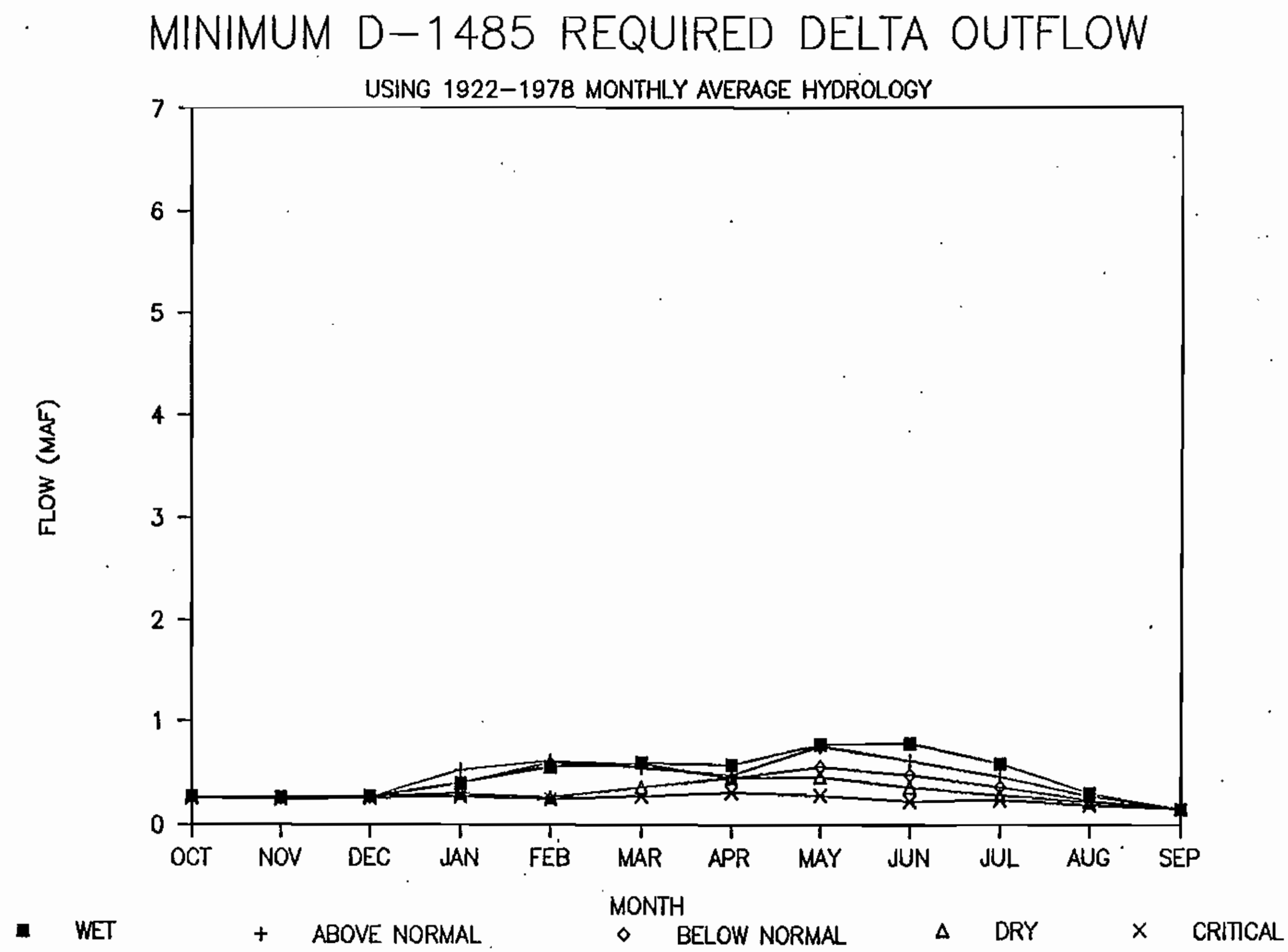

UNIMPAIRED DELTA OUTFLOW
USING 1922-1978 MONTHLY AVERAGE HYDROLOGY
FLOW (MAF)
0
1
2
3
4
5
6
7
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
MONTH
WET
ABOVE NORMAL
BELOW NORMAL
DRY
CRITICAL

FIGURE 3.5.4-3


MINIMUM D-1485 REQUIRED DELTA OUTFLOW
USING 1922-1978 MONTHLY AVERAGE HYDROLOGY
FLOW (MAF)
0
1
2
3
4
5
6
7
OCT NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEP
MONTH
WET
ABOVE NORMAL
BELOW NORMAL
DRY
CRITICAL

San Francisco Bay consists of about 805 square miles (515,000 acres) (BCDC,1982) including: 420 square miles (269,000 acres) of open water, 125 square miles (80,000 acres) of tidal marshes; 110 square miles (70,000 acres) of Suisun Marsh; 80 square miles (51,000 acres) of diked historic baylands, 70 square miles (45,000 acres) of saltponds and other managed wetlands.

3.6.2 Physical Description: San Francisco Bay Basin

The San Francisco Bay Basin, Figure 3.1-3, is the area contributing runoff to the Bay. This discription differs somewhat from the Basin Plan boundary of Region 2 (RWQCB,2,1975) which includes the entire San Francisco Bay Basin as well as coastal area from Dillon Beach to San Gregorio. The total area of the Basin is about 3,870 square miles, or 2,477,000 acres (SWRCB,3,Appendix F). The major streams contributing to local runoff to the Bay are Napa, Petaluma, and Guadalupe rivers, and Alameda, Coyote, Sonoma and Walnut creeks. Water is imported to the Basin via the following water projects (see Figure 3.1-3):

Mokelumne Aqueduct, Hetch Hetchy Aqueduct, South Bay Aqueduct, Contra Costa Canal, Putah South Canal, Sonoma Petaluma Aqueducts, North Bay Aqueduct (begun in 1988), and City of Vallejo intake at Cache Slough (ended when the North Bay Aqueduct began operation).

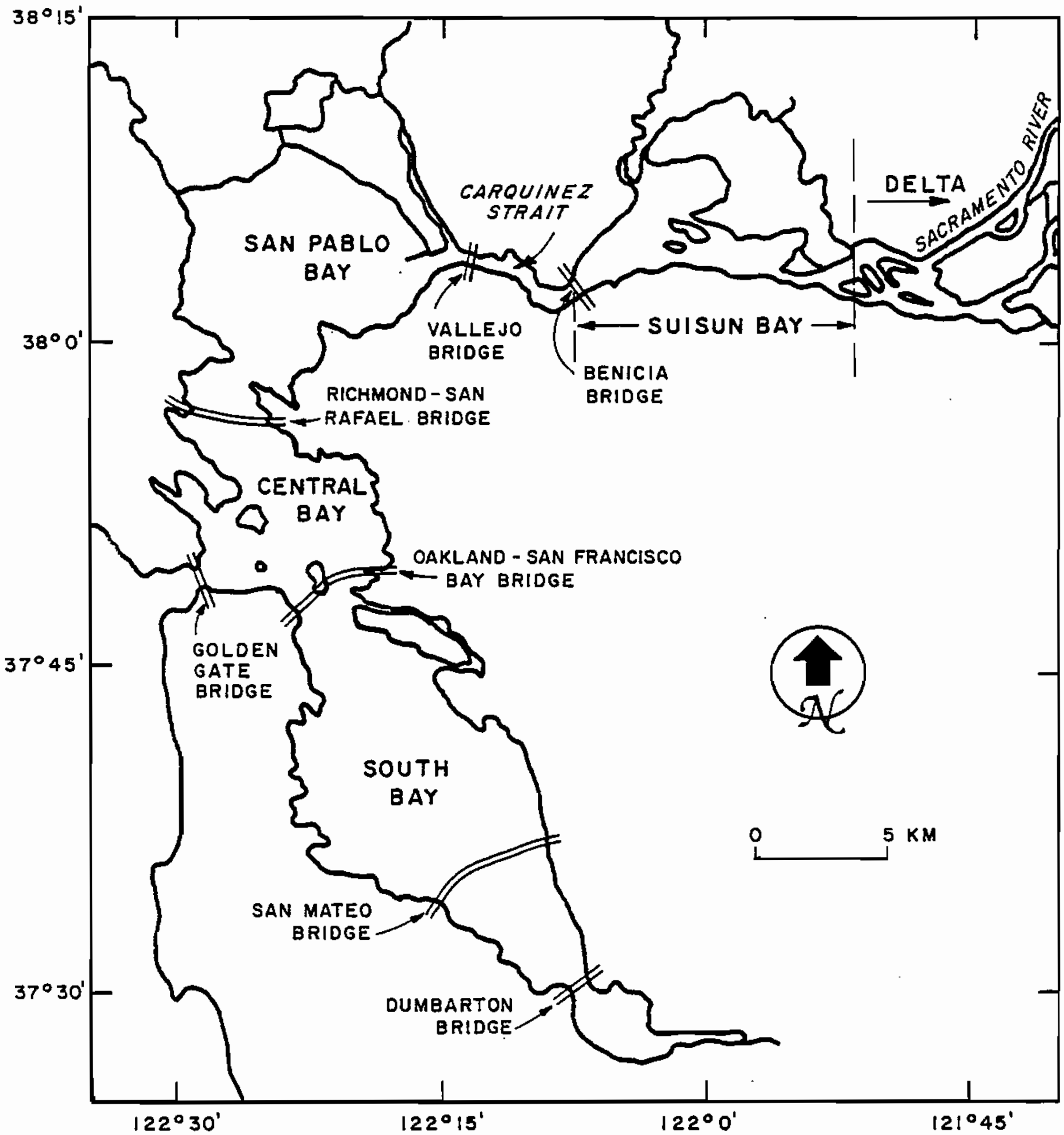
In years of normal runoff, the San Francisco Bay Basin contributes about ten percent of the total runoff to the Estuary (SWRCB,3,3). From 1970 to 1982, rainfall discharge averaged about 57 percent of the total runoff from the Bay Basin, with the rest being municipal and industrial discharges (SWRCB,3, Appendix R and 35).

3.6.3 Hydrology: San Francisco Bay

San Francisco Bay, excluding the Delta, but including saturated mudflats, has a total water surface area of approximately 300,000 acres or 470 square miles at mean lower low water (MLLW). The area, mean depth and volume of the subregions of the Bay are summarized in Table 3.6.2.1-1 (Cheng and Garner, 1984). The locations of the Bay's subregions are shown in Figure 3.6.2.1-1.

San Francisco Bay is unique among American estuaries in having two arms or reaches, the northern reach including San Pablo and Suisun bays, and the southern reach extending from the Oakland-Bay Bridge to Mountain View. The northern reach receives discharge from the Sacramento-San Joaquin Delta, approximately 90 percent of the freshwater inflow to San Francisco Bay. The southern reach receives only local runoff and is considered a tributary estuary. Between the two reaches is the central Bay bounded by the Richmond-San Rafael, Oakland-Bay, and Golden Gate bridges. The central Bay is deeper either of the two reaches, is more ocean-like in character and provides most of the inflow to the South Bay (SWRCB,431,18-19).

FIGURE 3.6.2.1-1 Location map of San Francisco Bay showing the four sub-regions and the Sacramento-San Joaquin Delta. (Source: Denton and Hunt, 1986)



- Freshwater Inflow

Excluding water from the Delta, freshwater inflows come into the Bay primarily via the Napa and Petaluma rivers which provide local drainage to the northern part of San Pablo Bay; via Walnut Creek and Suisun Slough which enter Suisun Bay; Pinole and Novato creeks which enter the San Pablo Bay; and San Lorenzo, Matadero and Coyote creeks which enter the south Bay. In addition, there are many municipal and industrial wastewater treatment plants and combined sewer overflows that contribute to inflows (SWRCB,3,11-16). Because these freshwater inflows into the Bay are small compared to Delta outflow, they are often ignored in calculations of total inflow to the Bay. In the southern portion of the south Bay, all tributary streams have intermittent, local runoff (excluding effluent) (BISF,6, 56-59).

- Tidal Exchange

Immense flows are exchanged between the bay and the ocean on tidal currents driven by the gravitational attraction between the earth, the sun and moon. Their exact size is not known (USGS,3 updated,5), but tidal flows entering San Francisco Bay at the Golden Gate Bridge have been estimated to average greater than 2.5 million cfs (BISF,6,51). Because of complex circulation eddies outside the entrance to the Bay, only a portion of the water flooding in from the ocean is "new" water, i.e., water which has not entered the Bay for at least several tidal cycles (Denton and Hunt, 1986).

  - Central Bay

    Flood tides first entering the central Bay pass on either side of Alcatraz Island, through Raccoon Strait between the Tiburon Peninsula and Angel Island; tides then flow northwards through San Pablo Strait into San Pablo Bay and southwards beneath the Oakland-Bay Bridge into south Bay (Figure 3.6.2.1-2).

  - San Pablo Bay

    The main tidal flows in San Pablo Bay pass along a natural channel between San Pablo Strait, across the shallow Pinole Shoal and through Carquinez Strait to the east (Figure 3.6.2. 1-3). The maximum depth in the two straits is about 83 feet, decreasing to about 20-25 feet over Pinole Shoal. A 600 foot wide shipping channel, dredged to a depth of 35 feet, across the shallow Pinole Shoal provides shipping access to the Mare Island Naval Shipyard and the ports of Sacramento and Stockton. The areas north and south of the shipping channel are very shallow; one half of the area of San Pablo Bay, for example, has a depth of less than six feet.

Table 3.6.2.1-1
BATHYMETRIC DATA FOR SAN FRANCISCO BAY
(Adapted from Cheng and Gardner, 1984)

Region	Surface Area at MLLW[1/] (sq mi)	Mean Depth[2/] (ft)	Mean Volume (AF)
Central Bay	103	35	2,307,000
San Pablo Bay	105	9	605,000
Carquinez Strait	12	29	223,000
Suisun Bay[3/]	36	14	323,000
South Bay	214	11	1,507,000
San Francisco Bay	470	17	4,965,000

1/ Excluding the Delta but including saturated mudflats
2/ These depths do not agree with those of Section 3.6.1 because of the inclusion of saturated mudflats.

FIGURE 3.6.2.1-2 Map of the Central Bay and the region immediately outside Golden Gate. The dotted line shows the 60 ft depth contour and the dashed line is the 18 ft contour. (Source: Denton and Hunt, 1986)

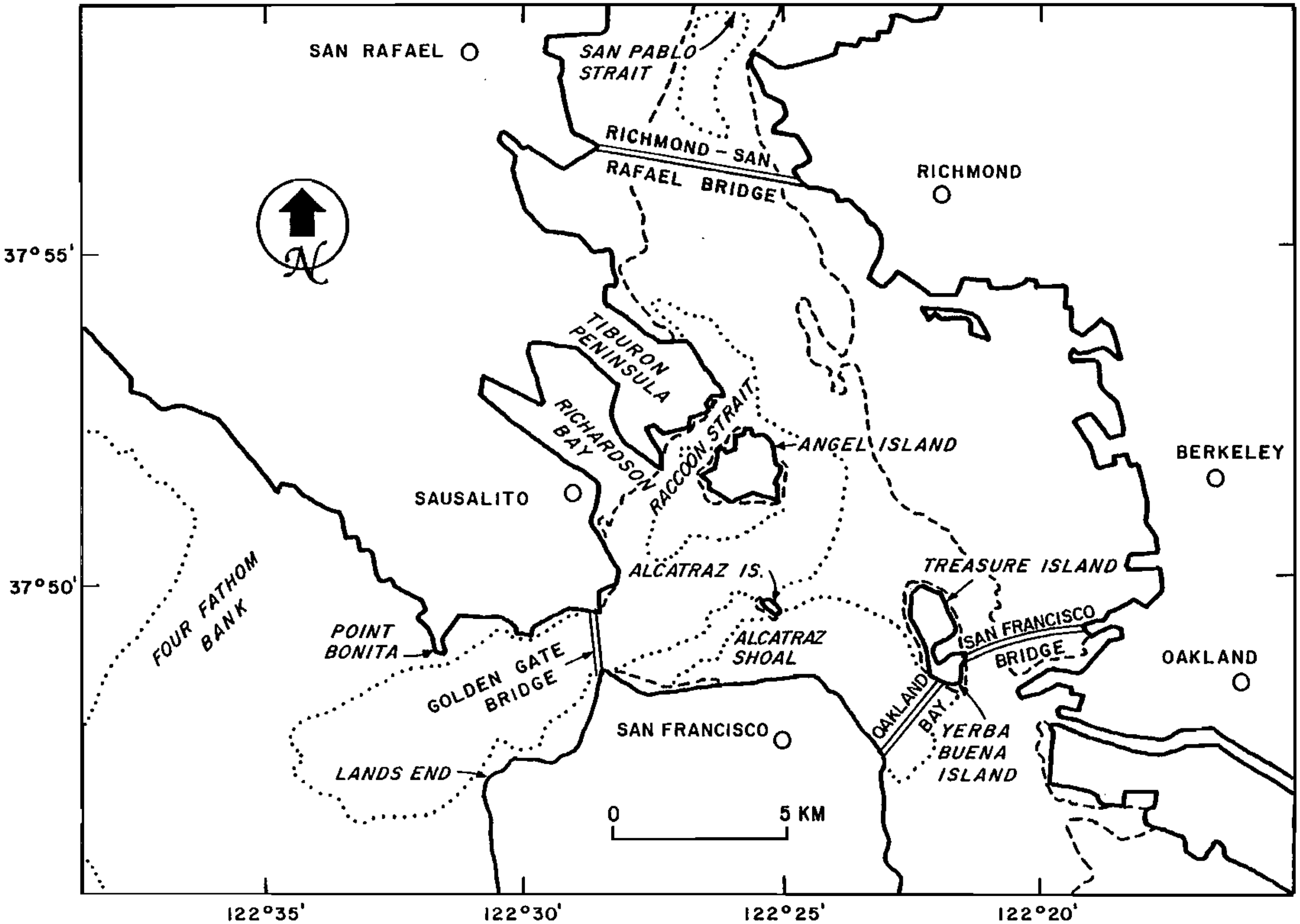
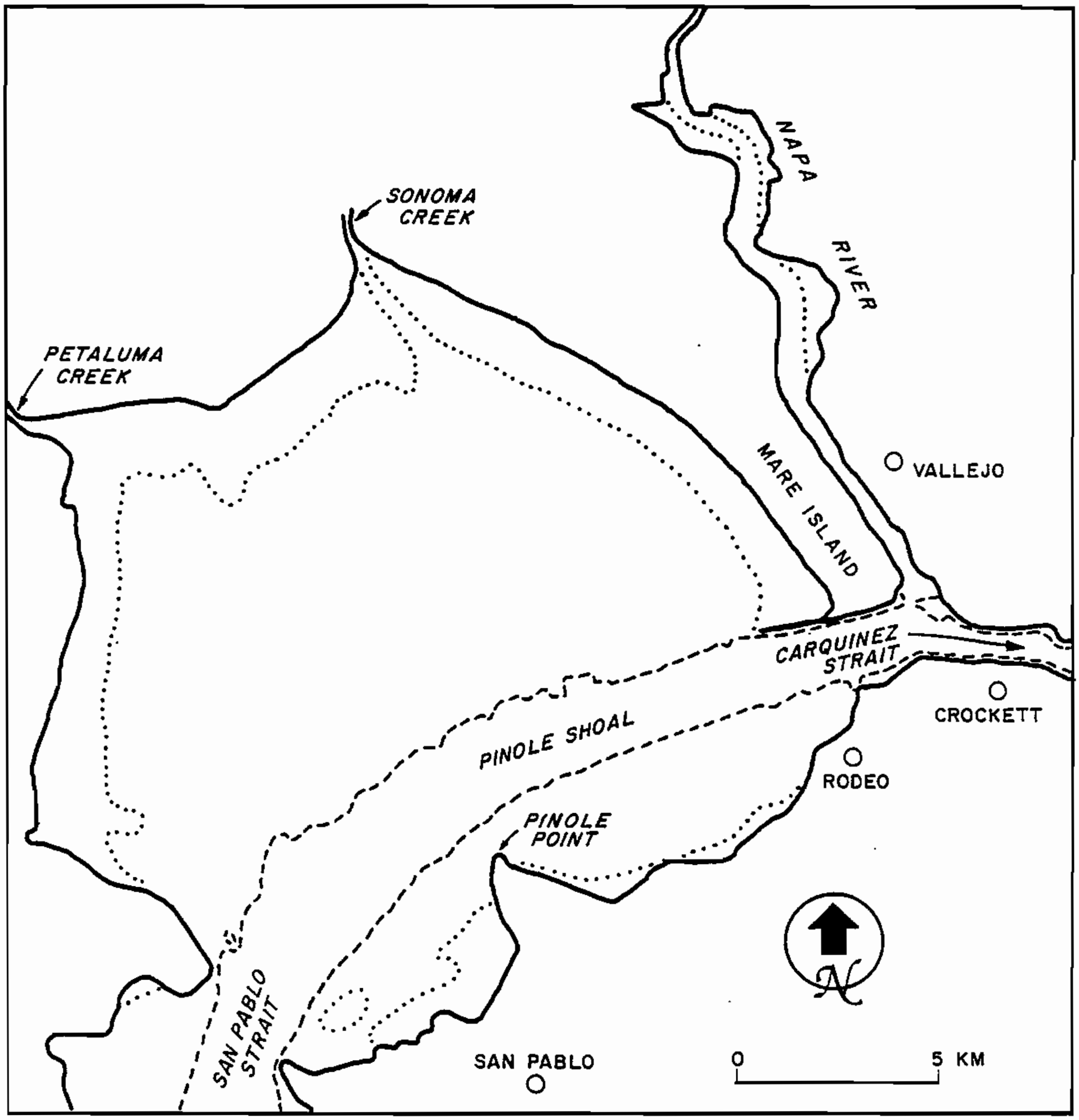


FIGURE 3.6.2.1-3 Map of San Pablo Bay. The 18 ft (5.5) depth contour is plotted as a dashed line and indicates the location of the main channel. The dotted line shows the extent of the mudflats around the bay.
(Source: Denton and Hunt, 1986



- Suisun Bay and Marsh

Having the smallest surface area of the four embayments, Suisun Bay is situated in the northeastern reach of San Francisco Bay between the cities of Benicia and Antioch (Figure 3.6.2.1-4). The entire Suisun Bay and Marsh area, including two subbays, Grizzly and Honker, consists of 84,190 acres, of which about 26,880 acres are bays and sloughs. The remaining 57,310 acres are diked and managed wetlands. (Approximately 45,710 acres of managed wetlands are privately owned and used primarily for duck hunting; 10,490 acres are owned by the State of California as a waterfowl management area, wildlife refuge and public recreation area; and 1,110 acres are controlled by the U.S. Navy {SWRCB,1978}).

The main tidal flows are along a few well-defined channels separated by islands and shallow gravel banks. During most periods of outflow from the Delta, Suisun Bay is the location of the estuary's 'null zone' (defined as the region in a partially or well-mixed estuary where the residual bottom currents are effectively zero). Upstream of this area there is a net downstream, or seaward, residual velocity along the bottom caused by river inflow. Seaward of the null zone, gravitational circulation produces a transport, for the most part toward land, of denser more saline water along the bottom. The null zone is significant because it is the theoretical upstream boundary of the entrapment zone, the area in the estuary where suspended materials, including biota, accumulate (USBR,112,407). Figure 3.6.2.1-5, a diagram of estuarine circulation for a partially mixed estuary such as Suisun Bay, illustrates the relationships between flows, salinities, and the null and entrapment zones (CCCWA/EDF,1,56).

The salinity of water within Suisun Bay varies seasonally with the freshwater outflow from the Delta. Salinities of the water in Montezuma Slough are lower than in Suisun Bay itself for a longer period of time each year because Slough lies further upstream and receives freshwater inflow from the Sacramento River and other tributary channels first. For the most part, low salinity water stays in the Suisun Marsh channels later in the spring and in early summer, but higher salinity water remains later in the fall before the Marsh channels are flushed by increasing Delta outflows (SWRCB,1978).

By most definitions, Suisun Bay includes Suisun Marsh, located to the north of the main body of the Bay. The Marsh was a natural brackish water marsh prior to widespread reclamation for agricultural purposes in the early 1900's. However, because the agricultural developments were largely unsuccessful in the 1930's, the reclaimed marsh lands were gradually converted to private duck clubs and state Wildlife Management Areas.

FIGURE 3.6.2.1-4 Map of Suisun Bay. The dashed line shows the 18 ft (5.5) depth contour.
(Source: Denton and Hunt, 1986)

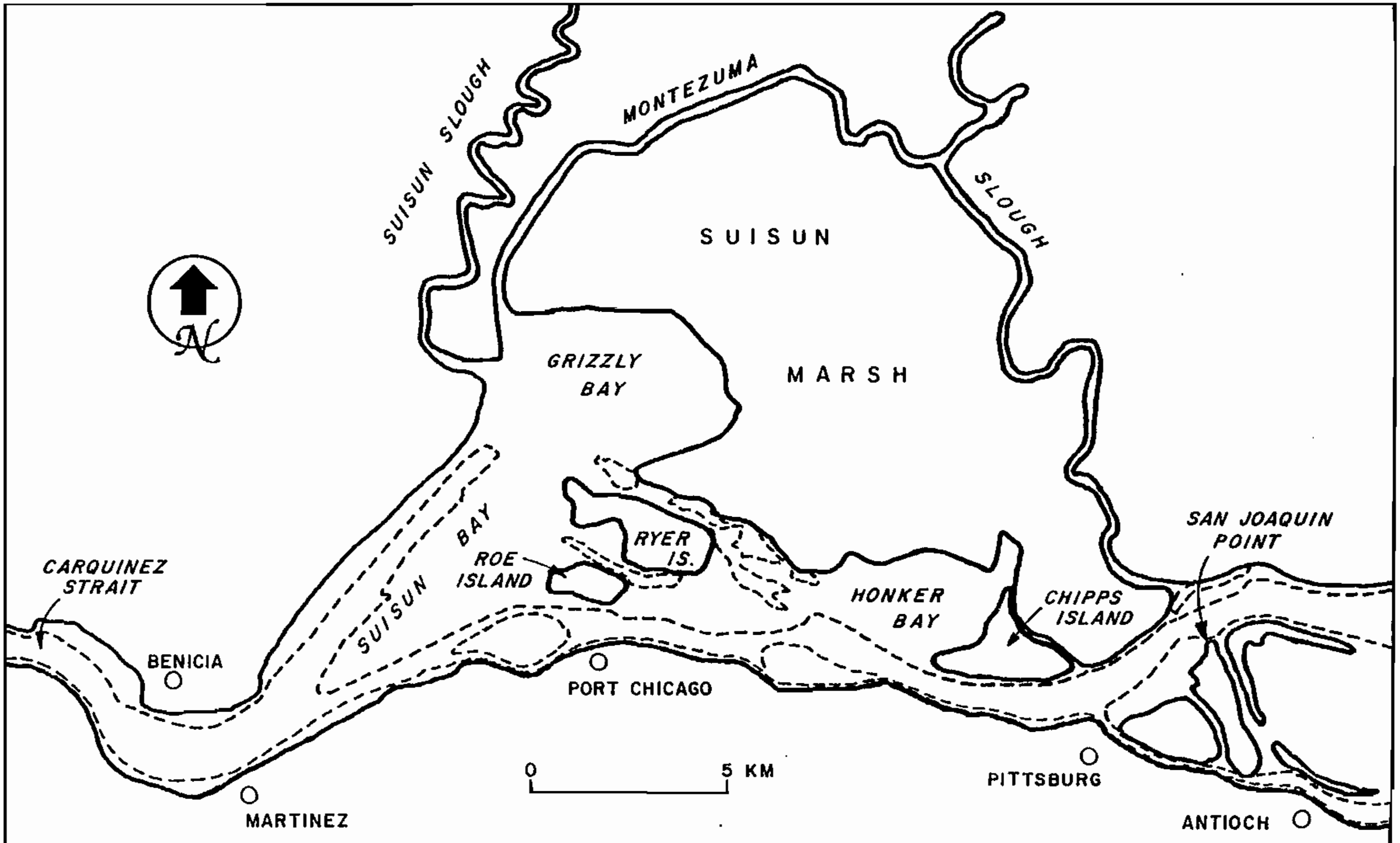
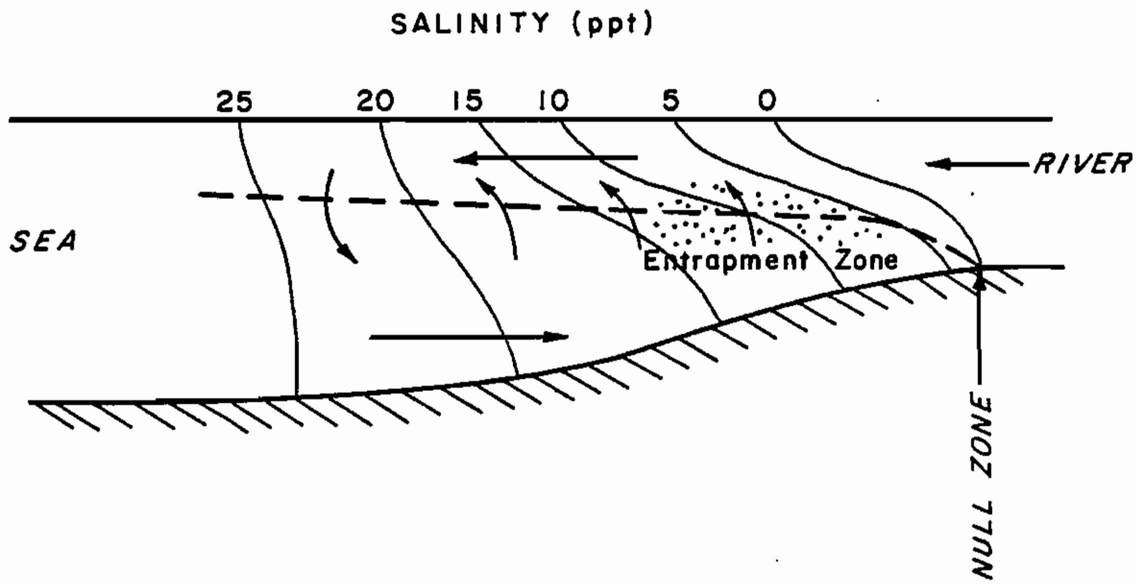


FIGURE 3.6.2.1-5 Diagram of Estuarine Circulation for a Partially Mixed Estuary (Source: CCCWA/EDF, 1, Figure 12)



- South Bay

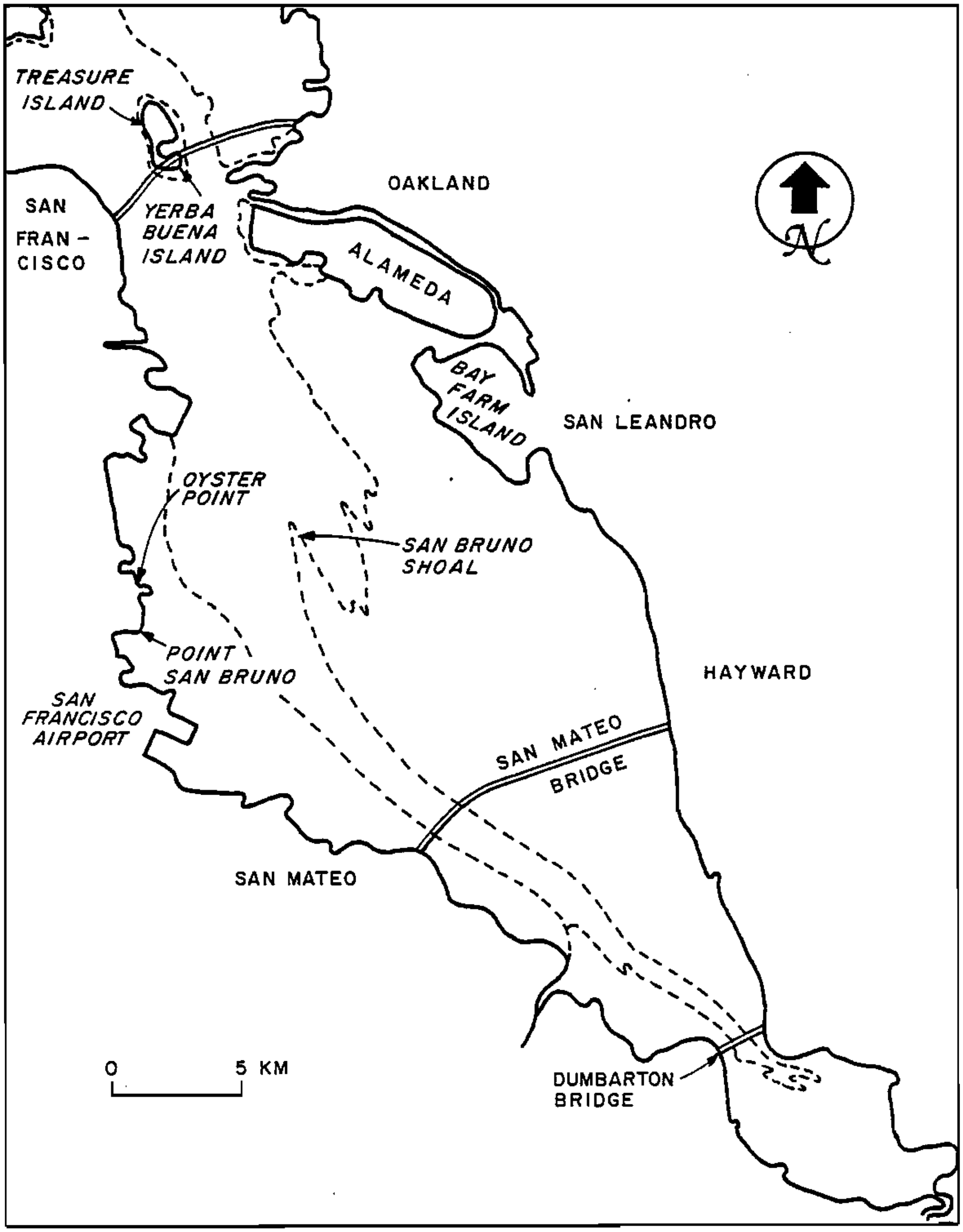
  The entrance to the south Bay from the central Bay is separated by Treasure and Yerba Buena islands into two passages, one to the east that is 30 to 35 feet deep and one to the west that is 70 feet deep at the Oakland-San Francisco Bay Bridge (Figure 3.6.2.1-6). Because the south Bay receives only minor amounts of local freshwater inflows, it is essentially a tidal lagoon. Tidal currents in south Bay are greatest along the main channel on the western side of the Bay. In the south Bay, evidence suggests three distinct mixing zones exist between: (1) the Oakland-San Francisco Bay Bridge and San Bruno Shoal, a relatively shallow area with water depths of about 11 to 26 feet between Bay Farm Island and Oyster Point; (2) San Bruno Shoal and the San Mateo Bridge; and (3) the area south of the San Mateo Bridge. A 500 foot wide, 29 feet deep navigation channel is maintained across the San Bruno Shoal. The salinity of the south Bay remains close to the level of the ocean (33 to 35 parts per thousand) throughout most of the year, except during periods of high Delta outflow. During particularly hot, dry periods when evaporation rates are high, the south Bay can act as a negative estuary where salinity levels actually increase in the southern extremities (Denton and Hunt, 1986).

  Currents differ in the south Bay according to Delta outflows. From analyses of current data for summer wind conditions and low Delta discharges, the USGS has concluded that net currents in south Bay north of San Bruno Shoal are southward along the eastern side and northward along the western side of the Bay (USGS,3 updated,25). During the season of high Delta outflows,a lens of fresher water can form on the surface of the northern reach of San Francisco Bay. This lens of fresher water eventually spreads southwards into the central and south Bays over more saline water that is flowing toward the ocean. This process, which provides the major source of freshwater for the South Bay, is known as gravitational overturn (Denton and Hunt, 1986). The significant density difference between the two flows acts to inhibit vertical mixing. When Delta outflow subsides, reintrusion of ocean water raises the salinities in central Bay above those in south Bay, and the direction of circulation reverses; that is, surface waters again flow seaward (USGS,3 updated,26).

3.6.4 Hydrology: San Francisco Bay Basin

In the San Francisco Bay Basin, most precipitation comes as rainfall that flows directly to the Bay, with some loss due to infiltration, evapotranspiration, and storage in natural impoundments. The timing and volume of inflows to the Bay from local runoff, for the most part, follow closely after precipitation in the Bay Basin.

FIGURE 3.6.2.1-6 Map of the South Bay. The dashed line shows the 18 ft. depth contour. (Source: Denton and Hunt, 1986)



3.6.5 Unimpaired Flow Conditions: San Francisco Bay

Throughout this section, the San Francisco Bay and San Francisco Bay Basin are described separately. Before this section, both a river and its basin are considered together, as integral parts of an area's total description. This is not the case with the Bay and its Basin. Whereas the San Francisco Bay Basin may be compared with other basins, the San Francisco Bay (the equivalent of this Basin's river) cannot be meaningfully compared with any river in the Estuary. There have been no sizeable impoundments or diversions of San Francisco Bay waters. Unimpaired inflows to the Bay from the San Francisco Bay Basin are small when compared to the volume of tidal exchange (see Table 3.6.3.2-1, Figures 3.6.3.2-1 and -2). Existent tidal and seasonal flows from the Pacific Ocean, the Delta and the San Francisco Bay Basin therefore constitute the closest estimate of unimpaired flow conditions for the Bay.

3.6.6 Unimpaired Flow Conditions: San Francisco Bay Basin

The unimpaired runoff for separate hydrologic areas in the Bay Basin was simulated by SWRCB for the period of water years 1921 through 1978 (SWRCB,3,Appendix F). Unimpaired flow to the Bay Basin includes local inflows but does not include inflow from the Delta. Table 3.6.3.2-1 includes estimated monthly and annual runoff values for the years 1921 through 1978 (SWRCB,3,17 {revised 11/5/87}).

Figure 3.6.3.2-1 shows that average unimpaired Bay Basin local runoff is small, about 3.3 percent of average unimpaired Delta inflow to the Bay (SWRCB,3). When tidal exchanges are compared, local runoff becomes insignificant (DWR,662,1) (Figure 3.6.3.2-2). However, local inflow may have an effect on subregions within the Bay, such as the Suisun Marsh, the marshes around Cuttings Wharf west of Vallejo, and the Petaluma Creek discharge area.

3.6.7 Current Flow Conditions: San Francisco Bay

The considerations in 3.6.3.1 are also valid for current flow conditions in the Bay, with some exceptions. Upstream storage and regulated releases required by the Delta Plan, for instance, have provided higher levels of inflow from the Delta in the summer months of dry and critically dry years. Significant amounts of effluent from industrial and municipal sources are discharged into the Bay, but the total effects of these additional flows are not known.

3.6.8 Current Flow Conditions: San Francisco Bay Basin

A variety of factors—upstream reservoirs, the change in land use patterns from native vegetation to agricultural vegetation, impermeable surfaces such as concrete or asphalt, and the effects of ground water pumping--have altered the effects of Bay Basin local runoff. For example, the extensive expansion of

TABLE
3.6.3.2-1

SAN FRANCISCO BAY BASIN LOCAL INFLOW STUDY - UNIMPAIRED FLOW CONDITIONS
TOTAL MONTHLY LOCAL RUNOFF INTO SAN FRANCISCO BAY
SUMMATION OF MONTHLY LOCAL RUNOFF FROM FSA'S 90 - 96 (TAF)

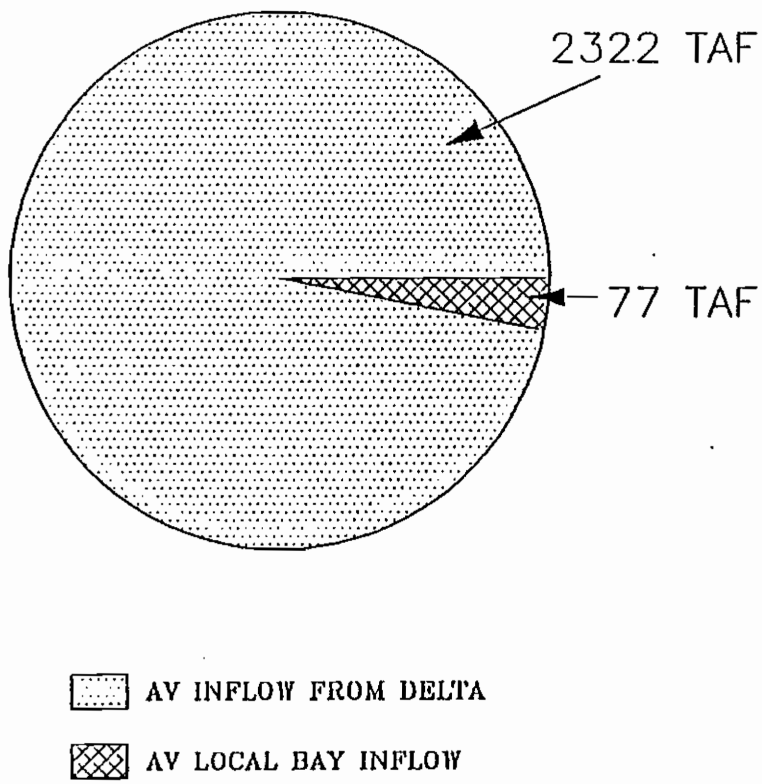
WATER YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JLY	AUG	SEP	AVERAGE MONTHLY	YEARLY TOTAL
21	2.4	14.9	356.7	378.1	127.7	68.1	83.8	20.2	8.0	2.7	2.8	0.9	88.8	1066.1
22	1.6	22.5	188.8	199.3	82.5	232.5	66.0	19.4	7.6	3.9	3.6	1.4	69.1	829.1
23	1.4	17.1	288.3	355.0	137.7	82.1	80.0	17.2	6.7	2.3	2.4	2.2	82.8	993.2
24	3.4	7.6	10.3	13.4	14.3	27.7	9.9	4.3	0.9	0.1	0.1	0.1	7.7	92.0
1925	5.4	228.0	241.8	375.4	124.8	401.1	195.9	25.6	10.1	5.3	3.0	2.7	134.9	1619.0
26	1.5	8.4	83.2	86.7	267.0	241.2	45.0	14.7	4.8	2.2	0.9	0.9	63.0	756.5
27	1.7	7.5	259.2	427.5	169.9	172.0	79.4	27.2	10.1	4.5	2.2	1.7	96.9	1163.0
28	2.5	2.8	82.5	83.4	210.7	197.2	36.6	15.5	5.6	2.8	1.2	0.9	53.5	641.8
29	1.1	1.9	5.1	88.8	42.8	78.3	27.1	11.9	2.8	0.5	0.3	0.5	21.8	261.2
1930	0.3	5.4	151.9	91.4	77.7	78.4	15.4	7.0	2.5	0.8	0.2	0.2	35.9	431.3
31	1.0	6.0	21.2	104.8	24.9	108.9	39.7	11.8	2.6	0.5	0.3	0.3	26.8	322.0
32	1.3	1.1	287.9	192.9	115.0	56.8	27.2	12.0	5.2	2.3	0.9	0.5	58.6	703.2
33	0.8	9.5	36.2	27.0	96.5	94.1	30.9	7.4	4.2	1.3	1.0	1.6	25.9	310.6
34	1.0	19.2	28.5	38.0	80.9	83.1	28.2	7.0	3.4	0.7	0.5	0.7	24.3	291.2
1935	2.0	32.4	128.5	499.6	152.0	173.2	62.3	21.4	8.7	4.2	2.0	1.5	90.7	1087.9
36	0.9	18.5	285.5	368.4	89.8	56.5	63.7	15.4	5.3	2.2	1.2	1.0	75.7	908.5
37	1.8	9.5	133.8	202.2	257.9	259.1	62.7	17.1	6.0	2.6	1.1	1.1	79.6	954.9
38	6.0	1.6	508.5	631.4	584.6	160.4	83.8	28.4	8.8	3.6	1.7	1.3	168.3	2020.0
39	9.5	13.9	18.8	18.4	24.0	23.4	23.5	7.7	2.5	0.1	0.0	0.6	11.9	142.5
1940	0.4	5.5	25.0	304.1	704.4	431.0	140.5	24.7	11.1	4.7	2.6	1.6	138.0	1655.6
41	0.9	4.8	387.8	718.7	572.4	366.1	416.9	56.2	16.4	7.3	5.0	4.0	213.0	2556.5
42	1.6	27.3	326.1	400.2	639.0	200.0	209.3	44.4	15.1	7.0	3.4	2.0	156.3	1875.6
43	1.9	19.0	111.5	464.8	167.0	140.9	41.2	19.7	8.2	4.2	1.9	1.0	81.8	981.4
44	0.8	5.7	14.9	28.2	183.2	212.2	26.7	14.2	7.2	2.8	1.2	0.5	41.5	497.6
1945	2.1	30.7	86.2	69.3	294.0	136.0	42.7	17.3	7.3	4.1	2.2	1.8	57.8	693.7
46	3.4	30.5	315.9	134.0	64.0	37.2	29.8	10.6	5.1	2.0	1.2	1.6	52.9	635.3
47	0.4	9.9	32.6	8.4	87.5	99.6	32.9	7.5	3.4	0.8	0.5	0.2	23.6	283.5
48	2.7	4.3	5.7	54.2	14.7	83.9	192.9	49.9	13.0	3.4	1.5	0.7	35.6	427.0
49	0.2	4.8	19.5	17.6	37.8	126.0	11.5	4.1	1.0	0.6	0.4	0.2	18.6	223.7
1950	1.9	1.8	2.3	117.8	215.7	55.1	30.0	10.1	3.9	0.9	0.6	0.3	36.7	440.5
51	1.9	113.4	407.7	376.8	219.1	172.2	41.4	23.6	8.1	3.9	2.0	1.4	114.3	1371.5
52	7.1	16.5	348.0	822.8	300.4	288.9	114.7	28.9	10.7	4.7	2.0	1.3	162.2	1946.1
53	1.2	2.6	323.9	438.0	43.8	82.4	40.2	25.1	9.1	3.2	1.6	1.1	81.7	980.2
54	0.9	5.4	4.7	114.9	135.5	93.0	75.3	10.6	3.3	1.0	0.6	1.6	37.3	447.7
1955	0.5	24.7	64.0	103.8	55.5	31.6	46.4	19.4	4.9	1.1	0.3	0.1	29.4	352.3
56	0.0	0.6	713.5	647.8	460.3	83.5	29.2	19.1	5.5	3.1	1.0	0.6	163.6	1963.4
57	5.5	5.4	4.9	26.7	195.1	118.7	33.6	61.8	13.1	2.3	0.7	0.5	39.0	468.4
58	13.7	8.9	54.4	276.0	910.2	424.0	570.9	35.1	14.6	5.6	2.2	1.2	193.1	2316.8
59	0.9	1.6	2.7	69.6	230.3	35.1	12.6	4.6	0.8	0.1	0.0	1.3	30.0	359.6
1960	0.3	0.4	1.4	16.6	222.5	85.8	18.0	6.5	1.8	0.4	0.1	0.2	29.5	354.1
61	0.4	6.8	22.5	64.9	128.4	99.3	34.7	11.5	3.3	0.5	0.3	0.4	31.1	373.0
62	0.1	3.1	19.2	17.6	312.3	149.3	18.7	6.2	1.7	0.6	0.4	0.1	44.1	529.4
63	234.5	13.5	111.9	364.3	411.4	171.6	369.3	54.2	16.7	5.7	3.8	2.3	146.6	1759.1
64	2.7	59.9	15.0	146.3	24.8	18.2	8.3	4.3	2.0	0.4	0.3	0.3	23.5	282.4
1965	1.0	20.0	420.6	453.8	51.0	31.0	112.6	20.6	7.6	3.1	3.2	1.3	93.8	1125.9
66	0.8	20.4	58.1	226.0	94.8	31.8	13.9	6.1	2.1	0.8	0.4	0.5	38.0	455.7
67	2.1	56.2	299.9	851.6	158.5	294.1	423.5	76.9	34.0	8.2	3.6	3.2	184.3	2211.8
68	1.5	3.5	17.2	150.8	141.9	119.7	20.5	6.8	2.1	0.7	0.9	0.8	38.9	466.4
69	1.4	4.6	126.9	648.9	544.1	174.0	51.5	16.8	8.0	3.1	3.0	2.5	132.1	1585.0
1970	3.5	3.2	170.6	712.7	119.2	101.3	15.3	7.4	4.1	2.3	1.4	1.1	95.2	1142.1
71	2.5	89.2	433.9	176.4	32.7	85.6	32.5	13.9	6.5	2.7	1.6	1.3	73.2	878.8
72	0.8	3.7	42.8	40.3	68.2	27.8	15.7	6.9	2.9	1.3	0.7	1.3	17.7	212.4
73	10.2	90.9	100.1	851.1	645.3	287.4	57.5	20.6	8.1	4.1	1.9	2.1	173.3	2079.3
74	8.1	247.2	251.3	368.2	104.7	450.4	223.1	29.2	11.9	6.7	4.1	3.6	142.4	1708.5
1975	5.1	4.1	11.9	16.5	270.6	339.5	80.0	20.7	7.3	4.0	2.0	1.7	63.6	763.4
76	10.8	14.1	12.0	12.2	13.7	21.9	21.6	7.0	2.4	0.1	0.1	0.5	9.7	116.2
77	2.1	7.1	10.3	16.9	17.0	31.8	7.8	4.3	0.8	0.1	0.0	0.0	8.2	98.5
78	0.3	33.7	133.9	863.9	470.9	391.7	117.6	35.8	12.0	4.7	2.7	3.1	172.6	2071.0
AVE	6.6	24.7	148.7	265.1	207.6	150.4	83.6	19.5	7.0	2.7	1.5	1.2	76.6	918.7

(SWRCB 3,27 Revised)

REVISED: 10-26-87

FIGURE 3.6.3.2-1

AVERAGE INFLOW FROM THE DELTA COMPARED WITH AVERAGE LOCAL BAY INFLOW

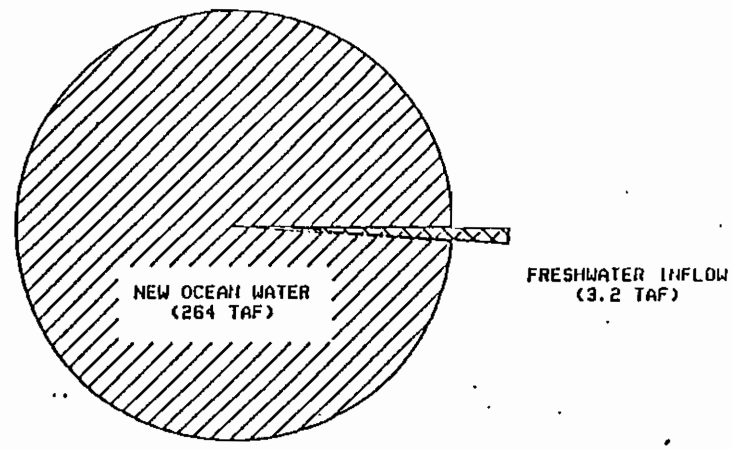


(From SWRCB, 3)

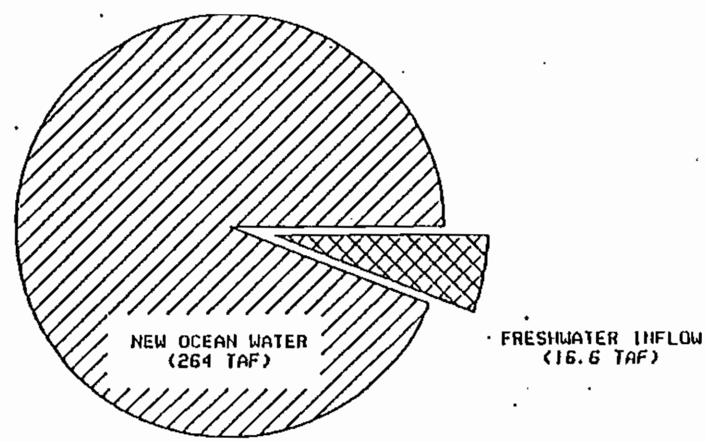
FIGURE 3.6.3.2-2

GOLDEN GATE TIDAL EXCHANGE VOLUME COMPARED WITH FRESHWATER INFLOW DURING A FLOOD TIDE WITH A 24% TIDAL EXCHANGE RATIO

SUMMER CONDITIONS (6,200 cfs FRESHWATER INFLOW)



WINTER CONDITIONS (32,300 cfs FRESHWATER INFLOW)



(DWR, 662)

streets, parking lots and drainage conduits have caused less rainfall to reach ground water and subsequently greater amounts to flow directly into the Bay. Wastewater treatment plant discharges and water imports into the Bay Basin have also changed the locations and greatly increased the quantity of local inflows to the Bay.

DWR developed a local runoff survey for separate Bay Basin hydrologic areas (Table 3.6.4.2-1) and a summary of wastewater discharge for the period of water years 1970 through 1982 (Table 3.6.4.2-2)(SWRCB,3,Appendix R). Listing the monthly, and yearly runoff totals, the tables indicate that effluent discharge can be as much as 70 percent less than local runoff (WY 81-82) and as much as 25 percent more (WY 76-77). Table 3.6.4.2-3 compares unimpaired and current flow conditions in the San Francisco Bay Basin.

TABLE 3.6.4.2-3
SAN FRANCISCO BAY BASIN:
UNIMPAIRED FLOW AND CURRENT FLOW CONDITIONS
BY WATER YEAR TYPE 1/

	Unimpaired Flow (TAF)		Current Flow	
Water Year Type	Low	High	Low	High
Wet	427.0	2556.5	157.2	301.3
Above Normal	440.5	2071.0	194.9 2/	
Below Normal	212.4	1079.3	112.3	231.6
Dry	261.2	1142.1	191.0 3/	
Critical	92.0	322	84.1	126.8

1/ Individual water years measured as percentages of the Sacramento Basin's Four River Index (see Chapter 4) have been used, resulting in some overlap of flow amounts for different water year types. Flows do not include inflows from the Delta.

2/ Only one reference point, Water Year 1969-70.

3/ Only one reference point, Water Year 1977-78

TABLE 3.6.4.2-1
SAN FRANCISCO BAY AREA LOCAL RUNOFF

(SUM OF DRAINAGE STUDY AREAS (DSA) 90 ---> 96) LESS (SUM OF DSAs 90 ---> 96) EFFLUENT DISCHARGE (ED) (TAF)

WTR YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL	AVG MO
6970	51	46	187	724	145	161	55	48	43	43	42	39	1584	132
7071	44	130	385	148	61	106	65	50	42	42	42	40	1155	96
7172	40	45	85	65	77	52	50	44	41	42	42	42	627	52
7273	64	132	100	595	506	264	85	63	55	47	45	44	2000	167
7374	52	225	229	322	112	387	247	63	50	49	45	43	1824	152
7475	46	44	58	59	277	347	104	55	44	43	43	41	1161	97
7576	52	43	44	41	44	50	43	39	37	38	40	38	509	42
7677	40	41	44	42	32	42	32	34	31	33	33	33	438	36
7778	32	63	113	517	294	301	130	53	42	41	41	40	1665	139
7879	41	46	43	187	225	124	66	50	40	40	40	39	942	78
7980	51	57	139	406	627	189	83	55	44	44	44	41	1780	148
8081	45	42	65	159	73	130	56	47	43	43	42	41	786	66
8182	51	171	370	584	330	385	659	73	54	49	46	47	2821	235
MO AVG	47	83	143	296	216	195	129	52	44	43	42	41	1330	111

(SUM OF DSAs 90 ---> 96) LESS (SUM OF DSAs 90 ---> 96) ED (CFS)

WTR YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL	AVG MO
6970	825	767	3035	11777	2614	2619	917	777	726	698	687	661	26102	2175
7071	711	2183	6257	2403	1102	1730	1093	809	710	688	686	665	19038	1587
7172	656	761	1388	1050	1338	847	844	715	690	687	685	713	10374	864
7273	1038	2215	1629	9683	9105	4300	1421	1026	919	757	732	746	33570	2798
7374	841	3782	3725	5238	2010	6293	4144	1032	835	801	737	722	30157	2513
7475	747	744	941	961	4989	5645	1748	900	744	700	691	683	19493	1624
7576	843	719	712	666	765	819	729	633	624	615	650	643	8417	701
7677	655	682	718	686	584	681	544	554	529	531	532	554	7252	604
7778	528	1051	1841	8402	5292	4890	2178	857	706	670	661	664	27739	2312
7879	661	778	699	3037	4057	2023	1102	816	676	658	650	650	15806	1317
7980	822	963	2266	6596	10895	3073	1398	895	743	719	712	692	29774	2481
8081	726	709	1053	2586	1311	2114	941	763	729	695	688	694	13010	1084
8182	835	2882	6024	9489	5934	6268	11080	1190	906	799	752	789	46949	3912
MO AVG	760	1403	2330	4813	3846	3177	2165	844	734	694	682	683	22129	1844

(SWCRB,3,APPENDIX R,pg. 17)

TABLE 3.6.4.2-2

SAN FRANCISCO BAY AREA LOCAL RUNOFF

EFFLUENT DISCHARGE (ED) FOR DRAINAGE STUDY AREA (DSA) 90 ---> 96 (MGD)

WTR YEAR	90 & 91	92 N	92 S	92	93	94	95	96	TOTAL	AVG MO
6970	93.0	28.2	79.6	107.8	33.5	120.9	51.2	116.4	630.6	52.6
7071	93.0	29.2	84.3	113.5	30.1	109.0	51.6	124.1	634.8	52.9
7172	89.2	30.2	82.7	112.9	29.6	114.5	52.0	135.3	646.4	53.9
7273	91.8	31.9	88.0	119.9	29.6	136.0	52.0	141.3	690.5	57.5
7374	89.5	28.7	83.7	112.4	26.9	129.9	47.6	140.0	658.7	54.9
7475	87.1	27.0	83.7	110.7	26.4	112.2	48.9	147.7	643.7	53.6
7576	66.6	24.0	73.4	97.4	24.8	104.5	42.4	147.4	580.5	48.4
7677	60.3	22.1	63.2	85.3	24.7	95.8	36.1	126.3	513.8	42.8
7778	68.1	25.3	68.5	93.8	27.0	110.6	41.8	162.5	597.6	49.8
7879	76.6	30.5	71.7	102.2	27.2	103.7	46.4	158.9	617.2	51.4
7980	79.0	34.7	75.2	109.9	27.7	116.2	45.0	163.8	651.5	54.3
8081	76.2	33.9	71.0	104.9	36.3	117.7	59.3	150.7	650.0	54.2
8182	98.5	39.1	81.5	120.6	42.9	140.8	30.4	154.6	708.4	59.0
AREA AVG	82.2	29.6	77.4	107.0	29.7	116.3	46.5	143.8	632.6	52.7

ED FOR DSAs 90 ---> 96 (CFS)

WTR YEAR	90 & 91	92 N	92 S	92	93	94	95	96	TOTAL	AVG MO
6970	144.2	43.7	123.4	167.1	51.9	187.4	79.4	180.4	977.4	81.5
7071	144.2	45.3	130.7	175.9	46.7	169.0	80.0	192.4	983.9	82.0
7172	138.3	46.8	128.2	175.0	45.9	177.5	80.6	209.7	1001.9	83.5
7273	142.3	49.4	136.4	185.8	45.9	210.8	80.6	219.0	1070.3	89.2
7374	138.7	44.5	129.7	174.2	41.7	201.3	73.8	217.0	1021.0	85.1
7475	135.0	41.9	129.7	171.6	40.9	173.9	75.8	228.9	997.7	83.1
7576	103.2	37.2	113.8	151.0	38.4	162.0	65.7	228.5	899.8	75.0
7677	93.5	34.3	98.0	132.2	38.3	148.5	56.0	195.8	796.4	66.4
7778	105.6	39.2	106.2	145.4	41.9	171.4	64.8	251.9	926.3	77.2
7879	118.7	47.3	111.1	158.4	42.2	160.7	71.9	246.3	956.7	79.7
7980	122.5	53.8	116.6	170.3	42.9	180.1	69.8	253.9	1009.8	84.2
8081	118.1	52.5	110.1	162.6	56.3	182.4	91.9	233.6	1007.5	84.0
8182	152.7	60.6	126.3	186.9	66.5	218.2	47.1	239.6	1098.0	91.5
AREA AVG	127.4	45.9	120.0	165.9	46.1	180.3	72.1	222.8	980.5	81.7

ED FOR DSAs 90 ---> 96 (TAF)

WTR YEAR	90 & 91	92 N	92 S	92	93	94	95	96	TOTAL	AVG MO
6970	104.4	31.7	89.3	121.0	37.6	135.7	57.5	130.6	707.8	59.0
7071	104.4	32.8	94.6	127.4	33.8	122.3	57.9	139.3	712.5	59.4
7172	99.8	33.8	92.6	126.4	33.1	128.1	58.2	151.4	723.4	60.3
7273	103.0	35.8	98.8	134.6	33.2	152.6	58.4	158.6	775.0	64.6
7374	100.5	32.2	93.9	126.2	30.2	145.8	53.4	157.1	739.3	61.6
7475	97.8	30.3	93.9	124.2	29.6	125.9	54.9	165.8	722.5	60.2
7576	74.5	26.9	82.1	109.0	27.8	116.9	47.5	165.0	649.7	54.1
7677	67.7	24.8	70.9	95.7	27.7	107.5	40.5	141.8	576.7	48.1
7778	76.4	28.4	76.9	105.3	30.3	124.1	46.9	182.4	670.7	55.9
7879	86.0	34.2	80.5	114.7	30.5	116.4	52.1	178.3	692.7	57.7
7980	88.4	38.8	84.2	123.0	31.0	130.0	50.4	183.3	729.1	60.8
8081	85.5	38.0	79.7	117.7	40.7	132.1	66.6	169.1	729.5	60.8
8182	110.6	43.9	91.5	135.4	48.1	158.0	34.1	173.5	795.1	66.3
AREA AVG	92.2	33.2	86.8	120.0	33.4	130.4	52.2	161.3	709.5	59.1

(SWCRB,3,Appendix R,pg. 14)

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4.0 BENEFICIAL USES OF BAY-DELTA ESTUARY WATER

4.1 Introduction

"'Beneficial uses' of the waters of the state that may be protected against quality degradation include, but are not necessarily limited to, domestic, municipal, agricultural and industrial supply; power generation; recreation; esthetic enjoyment; navigation; and preservation and enhancement of fish, wildlife, and other aquatic resources or preserves" (Porter-Cologne Water Quality Control Act, Water Code Section 13050(f)).

The establishment of beneficial uses of waters of the state is the first task of water quality control planning. Only after beneficial uses have been properly identified can appropriate water quality objectives and other control policies be established. A clear understanding of the service each beneficial use provides to the citizens of California also builds a foundation for weighing and balancing the levels of protection needed. In summarizing issues addressed during Phase I of the Bay-Delta hearing, this chapter discusses the beneficial uses, their water requirements, their salt tolerance, and, when available, their economic value.

4.2 Estuary Water for Municipal and Domestic Supply Purposes

Municipal and Domestic Supply (MUN) includes established uses in community or military water systems as well as domestic uses from private systems (RWQCB,1975). Common domestic uses of water include those for sanitation, direct consumption, food preparation, landscape watering, among others (RWQCB, 1975). Common municipal uses of water include those for light commercial businesses, restaurants, parks, etc. The two MUN needs are continuous and require a dependable water supply (SWC,3,1). It is state policy that domestic use is the highest use of water (Water Code {WC} Section 106).

Delta surface waters are used to supply MUN needs in both northern and southern California. The quality of these waters, and therefore MUN supplies, depends on complex flow and salinity relationships within the Estuary. When Delta outflow is insufficient to move the salinity gradient west of Chipps Island, there is a potential for ocean salinity to be drawn into the Delta's interior if reverse flows also occur (see 3.5.2.4). Saline waters may subsequently degrade supplies taken through the intakes of the Contra Costa Canal and Clifton Court (DWR,51D).

Locations of historic MUN use remain much the same, although there has been a change in the season and length of time that acceptable water occurs. Historically, to mitigate adverse salinity conditions prior to the existence of the state and federal projects, municipalities would fill storage reservoirs, "...when the water in the (San Joaquin River) was fresh to provide a supply to meet the demands during the period of saline invasion..." (DWR,1931). Prior to 1920, in the western Delta the MUN water source for Antioch became "...unfit for domestic consumption during part of the late summer or early fall months of most years and certainly during dry years as far back as the (eighteen) sixties and seventies." (DWR,1931). By 1920 Antioch had a significant decrease in the period of availability of municipal water supply from the San Joaquin River. Generally, as upstream development increased, the position of the salinity gradient moved upstream. In most areas in the Delta, operations of the federal and state water projects reversed this degradation by providing additional, sustained amounts of water during the summer months and prolonged dry periods (T,XIII,151:5-21;DWR, 84-87).

Present and projected MUN water use of Delta surface water is presented in Table 4.2-1. Delta cities that rely on this water are Antioch, Pittsburg, Tracy and Oakley. Pittsburg and Oakley obtain water supplies from Rock Slough via the Contra Costa Canal; Tracy obtains its supply from Old River via the Delta-Mendota Canal. Antioch diverts part of its water supply directly from the San Joaquin River and obtains part from the Contra Costa Canal. Sacramento maintains a standby diversion facility on the Sacramento River in the Upper Delta, but normally diverts from two other facilities on the American and Sacramento rivers upstream of the Delta. The cities of Stockton, Tracy, Rio Vista, and other Delta communities rely to various degrees on ground water for MUN water supplies (SWRCB,1978).

TABLE 4.2-1
MAJOR MUNICIPAL WATER DEMANDS

	Current 1986 Population	Current 1986 Water Demands (AF)
City of Tracy	25,300 1/	7,822 2/
Antioch	40,734 3/	9,073 4/ (1985)
Pittsburg	53,125 3/	7,729 4/ (1985)
Oakley County W.D.	8,436 3/	2,128 4/ (1985)
	Year 2000 Population	Year 2000 Water Demands (AF)
City of Tracy	33,000 1/ (1990)	10,400 2/ (1990)
Antioch	78,900 5/	14,338 4/
Pittsburg	59,100 5/	12,994 4/
Oakley County W.D.	N/A	5,153 4/

1/ City of Tracy (CT), Exhibit No. 2
2/ CT, Exhibit No.3
3/ Contra Costa Water District (CCWD), Exhibit No. 7
4/ CCWD, Exhibit No. 25
5/ CCWD, Exhibit No. 24

4.3 Industrial Beneficial Uses

4.3.1 Industrial Use Comprises Three Separate Beneficial Uses:

- Industrial Service Supply (IND) "includes uses which do not depend primarily on water quality such as mining, cooling water supply, hydraulic conveyance, gravel washing, fire protection, and oil well repressurization".

- Industrial Process Supply (PROC) "includes process water supply and all uses related to the manufacturing of products".

- Hydroelectric Power Generation (POW) "is that supply used for hydropower generation" (RWQCB,5,1975).

Very little information on Bay-Delta industrial use was presented in Phase I of the hearing. Two Bay-Delta industries, Fibreboard and Shell Oil Company, presented testimony, but no exhibits. Contra Costa Water District (CCWD) and DWR presented exhibits and testimony, but of a limited scope. SWRCB presented the "Environmental Impact Report for the Water Quality Control Plan and Water Right Decision, Sacramento-San Joaquin Delta and Suisun Marsh" (D-1485 EIR). This document was prepared for the D-1485 hearings and contains more extensive, but possibly out-of-date information on Bay-Delta industrial use.

Water use in 1975 of 11 major industries using at least 50,000 gallons per day is summarized in Table 4.3-1. Water delivered from the Contra Costa Canal to major industrial water users in the Delta totaled 22,733 acre-feet in 1985 and 15,519 acre-feet in 1986 (CCWD,26).

4.3.2 Antioch-Pittsburg Area

Most of the industries that depend upon Bay-Delta surface waters are in the Antioch-Pittsburg area. These industries depend almost exclusively for their water supplies on three possible sources:

- Water pumped by the industries directly from the San Joaquin River or New York Slough.

- Untreated water purchased from CCWD and conveyed from Rock Slough via the Contra Costa Canal or, in the Pittsburg area, pumped from Mallard Slough at the District's pumping plant.

- Treated water purchased from municipal purveyors who obtain their water from the Contra Costa Canal or, in the case of Antioch, from either Contra Costa Canal or a San Joaquin River diversion.

The Pacific Gas and Electric Company (PG&E) powerplants at both Antioch and Pittsburg use large quantities of water for once-through cooling. These uses are not affected substantially by salinity changes. PG&E did not provide information concerning Bay-Delta industrial water use in Phase I of the hearing, nor did they participate in the D-1485 hearing.

Table 4.3-1
Industrial Water Use Summary - 1975
(acre-feet per year)

Industrial Water User	Location	Product	Water Use	Water Source: Offshore Diversions	Ground Water	Costa Canal	Municipal Supply	Total
Crown Zellerbach Antioch (Now Gaylord Containers Inc.)	Antioch	Pulp and Paper Products	Boiler	(230)*		(90)	(40)	360
			Cooling	(620)				620
			Process	(11,000)				11,000
			Total	11,850	0	90	40	11,980
								17,422 (1986) a/
E.I DuPont	Oakley	Pigments, Petrochemicals, Fluorocarbons	Boiler				420	420
			Cooling				240	240
			Process				1,420	1,420
			Total	0	0	0	2,080	2,080
Fibreboard	Antioch	Pulp and Paper Products	Boiler		(780)	(230)		1,010
			Cooling	(1,770)				1,770
			Process	(14,020)		(320)		14,340
			Total	15,790	780	550	0	17,120
				13,783 (1986) b/				
Hickmott Canning	Antioch	Tomato Products	Boiler					
			Cooling				560	560
			Process				560	560
			Total	0	0	0	1,120	1,120
Kaiser Gypsum	Antioch	Wallboard	Boiler				(75)	75
			Cooling				(75)	75
			Process	0	0	0	150	150
			Total					
PG&E	Antioch	Electric Power	Boiler					
			Cooling	1,106,000				1,106,000
			Process					
			Total	1,106,000	0	0	0	1,106,000
Collier Carbon and Chemical	Pittsburg	Ammonium Phosphate Fertilizers	Boiler					
			Cooling	25		25		50
			Process			60		60
			Total	25	0	85	0	110
Dow Chemical	Pittsburg	Commercial Chemicals	Boiler			(1,300)		1,300
			Cooling	(1,310)				1,310
			Process	(1,110)		(200)		1,310
			Total	2,420	0	1,500	0	3,920
Johns-Manville	Pittsburg	Roofing Paper	Boiler				40	40
			Cooling	190				190
			Process	150			100	250
			Total	340	0	0	140	480
PG&E	Pittsburg	Electric	Boiler					
			Cooling	708,000				708,000
			Process					
			Total	708,000	0	0	0	708,000
U.S. Steel	Pittsburg	Steel Products	Boiler					
			Cooling			(10,000)		10,000
			Process				(1,500)	1,500
			Total	0	0	10,000	1,500	11,500

a) *DWR*,204
b) Ibid.
*Note: Parentheses indicate assumed breakdown of water use where industry could not furnish these data.
Source: Environmental Impact Report for the Water Quality Control Plan, August 1978 and Water Decision, Sacto-SanJoaquin Delta & Suisun Marsh, pg. III-149.

4.3.3 Other Industries

Shell

Heinz

Other Bay-Delta industries located outside the Antioch-Pittsburg area include: Shell Oil Company in Martinez which obtains most of its water supply from the Contra Costa Canal (T,IX,41:11-14); and three industries near Tracy, H. J. Heinz Company, Laprino Cheese and Laura Scudders, which obtain their water supply from the DMC or local ground water supplies (T,IX,11:4-12;T,IX,21:21-25).

Gaylord Container

Gaylord Containers Corporation recycles wastepaper at a mill on the south shore of the San Joaquin River. In 1975, approximately 12.5 million gallons per day (MGD) of water pumped directly from the San Joaquin River or purchased from CCWD were required for processing and cooling in the manufacture of several grades of paper that are converted into corrugated boxes, paper towels, etc.

Because canned goods can corrode when left in contact with linerboard of corrugated boxes containing more than 500 ppm sodium chloride, process water for the manufacture of boxes is kept below 150 ppm chloride (T,VI,92:25-93:6).

Lou-Pacific

Fibreboard Louisiana-Pacific, a large kraft paper mill located on the south shore of the San Joaquin River approximately five miles east of Antioch, produces linerboard, corrugating medium, and fiber board from wood chips (hearing for D-1485,RT,Vol.XVII,p.135). Unlike the nearby Gaylord Container Mill, Fibreboard's predominant raw material is pulp produced from wood chips. Fibreboard presented the only evidence supporting the need for process water with not more than 150 ppm chloride for the production of linerboard (T,IV,92:25-93:6;T,IX75:23,81:23). A witness for Contra Costa Water District, however, stated that a standard of 250 ppm chloride year-round would be adequate (T,VII,97:22,25).

Fibreboard

Fibreboard has two main sources of water, direct pumping from the San Joaquin River and CCWD. When the chlorinity in the San Joaquin River supply is higher than 150 ppm, a partial supply of water is purchased from CCWD; when the chlorinity level reaches 250 ppm, the entire supply is taken from the Contra Costa Canal (T,IX,77:23-78:6). A third, relatively minor source is ground water from two wells that provide between 500,000 and 800,000 gallons per day.

Dow

Dow Chemical Company did not present information on current water requirements during the hearing, but information was introduced in the D-1485 EIR. The Dow Chemical plant, located on New York Slough between the cities of Antioch and Pittsburg, diverts from New York Slough for cooling and process waters (hearing for D-1485, citing Decision 1379, RT Vol. XXXI, pp. 3292-3371; Dow Exhibit 502). An alternate water supply from the Contra Costa Canal was available for "critical water use" when the offshore supply exceeded a chloride concentration of 160 ppm.

U.S. Steel presented testimony in 1970 regarding water use at its steel processing facilities located on the south shore of New York Slough between Pittsburg and Antioch (hearing for D-1485, pg. III-160). Water was diverted from New York Slough for cooling uses and, seasonally, for process water in the Wire Mill. Contra Costa Canal water was used for process water in the Sheet and Tin Mill, the Morgan Rod Mill, the Pipe Mill, and for boiler feed water supply (hearing preceding D-1485; hearing preceding Decision 1379, RT, Vol. XXX, pp. 3175-3246). Table 4.3-1 shows that in 1975 U.S. Steel used 11,500 acre-feet of water from the Contra Costa Canal and city supplies.

Johns-Manville Products Corporation presented testimony in 1970 concerning water use at its plant located on New York Slough in the City of Pittsburg (hearing for D-1485, citing Decision 1379, RT Vol. 28, pp. 3098-3140). New York Slough provided the entire water supply until chlorinity limits were reached, at which point an alternate supply purchased from the City of Pittsburg was then used for the boiler feed water and paper mill (see Table 4.3-1).

Shell Oil Company operates an oil refinery on the south bank of Suisun Bay near Martinez, next to the Benicia Bridge. Though no water is incorporated directly in the refineries products, water is important in the refining process. Large quantities are used for cooling, steam generation, pumps and compressors, and to heat refining processes (T,IX,42:15-19). The refinery's main products are approximately five million gallons per day of gasoline, jet and diesel fuel (T,IX,41:22-25). The facility has 850 company employees and 300 contract employees, with a current annual company payroll of $38 million, and an annual contract payroll of $18 million (T,IX,42:3-5).

Shell Oil Company's source of water supply is the Contra Costa Canal terminating in Martinez. Annual water consumption in 1986 was approximately 10,000 acre-feet, with an average consumption rate of approximately 6,200 gallons per minute (gpm) and a peak consumption rate of approximately 9,060 gpm. Of the average use rate of 6,200 gpm, about 2,500 gpm is used for preparing boiler feed water, and 3,000 gpm for cooling water. The balance is used for pad and equipment washdown, landscape irrigation and other miscellaneous uses (T,IX,42:20-25;T,IX,43:1-10). Shell Oil Company's major concern is the reliability of their water supply (T,IX,46:12-13).

4.4 Estuary Agriculture Beneficial Uses

4.4.1 Delta Agriculture

About three-quarters of the Delta land area (515,000 acres) is farmed with water from the channels and sloughs adjacent to each individual island in the Delta (DWR,304). There is not a water supply problem in the agricultural waters affected by tidal actions. Most channels in the Delta have sufficient volume to supply agricultural water needs even at low tidal stages. However, water levels in some isolated channels in the southern Delta are affected by drawdown caused by the state and federal pumping plants (T,XIII,230:17-233:10).

Soils in the Delta fall generally into two categories, organic and mineral. Farmed organic soils constitute 68 percent of the total cropped area and mineral soils the remaining 32 percent. Organic soils are usually found in the Delta lowlands, that is, the land area below an elevation of +5 feet mean sea level. Delta uplands are those areas above +5 feet mean sea level. Mineral soils are found in both the Delta lowlands and uplands.

4.4.1.1 Delta Organic Soils - below +5' mean sea level

The Delta organic soils were formed through the biochemical breakdown of marsh plants and grasses that existed prior to the development of the present levee system. The amount of organic soils in the Delta is constantly being reduced because of continuing decomposition and oxidation from both natural processes and farm practices. As a result, the lowland Delta islands are sinking at the rate of one to three inches per year and the actual acreage of the organic soils is also being reduced (T,LV,82:20-25).

The high permeability of organic soils and their low surface elevation compared to surrounding waterways produces high ground water table conditions. The high ground water table, along with problems associated with uneven decomposition and settlement of organic soils,makes subirrigation the primary method of water application for crop production. Subirrigation is the delivery of water to plant roots by capillary action from the underlying saturated soil strata. This form of irrigation, however, must be tied to a winter leaching program to remove salts accumulated in the root zone. In the organic, sub-irrigated soils, the salts are brought into the soil column from beneath the plant roots. The shallow water table prevents downward leaching of these salts after the irrigation has been completed. To lower the high level of ground water and provide adequate drainage, water must be pumped from beneath the soil profile of the lowlying Delta islands and discharged into the adjoining waterways.

high water table → subirrigation

water must be removed from soil in Delta organics via pumping

4.4.1.2 Delta Mineral Soils - above +5' mean sea level

Delta mineral soils were formed through deposition of sands and minerals eroded from the Sierra Nevada by various streams tributary to the Delta. These soils are generally found in the Delta uplands. Since subirrigation is not practicable in the mineral soils, water is applied to the soil surface, usually through furrow, sprinkler, or flood irrigation. Leaching of the soils is also required along with occasional changes in cropping patterns. Unlike subirrigation of organic soils, in the mineral, surface-irrigated soils, the salts are brought into the soil column from above with the irrigation water. Excess salts are then removed at the end of the irrigation season by applying irrigation water to flush the salt into the lower ground water table. Some leaching may also be accomplished with winter rainfall.

4.4.1.3 Crop Production

Crop production information was presented by DWR for the Delta lowlands and uplands (DWR,304). Corn was the predominant crop grown in the Delta during the period 1977-84, accounting for 25.8 percent of the total acreage (Table 4.4.1.3-1). Grain is grown on an additional 21.5 percent of the acreage, followed by tomatoes, alfalfa and mixed pasture; other crops such as sugar beets, deciduous trees and safflower account for the majority of the remainder. Crops and livestock production in the Delta has a gross sale value of approximately $500 million (Table 4.4.1.3-2), with field and truck crops making up 57 percent of that total.

TABLE 4.4.1.3-2
ECONOMIC VALUE OF DELTA CROPS AND LIVESTOCK

	Gross Value Delta Area		
Agricultural Category	Lowland	Upland ($ Million)	Total
Field Crops	100.4	67.2	167.6
Truck Crops	76.9	34.6	111.5
Tree Fruit, Nut & Vine	25.1	18.2	43.2
Seed & Nursery	7.9	1.8	9.7
Livestock	9.9	144.5	154.5
TOTAL	$220.2	$266.3	$486.5

4.4.1.4 Salinity Tolerance

A major question to be addressed in setting salinity standards for agriculture is, "What is the salt tolerance of the crops grown in the Delta?" Several parties presented information on this topic (DWR,327,328; CCWD,50; SDWA,105,109,117; SWRCB,22,23,26). Table 4.4.1.4-1 presents selected information concerning salt threshold and yield levels for sensitive and moderately sensitive crops (DWR 328). The salt threshold for a particular crop is the level below which no loss in yield is experienced due to soil salt conditions.

TABLE 4.4.1.3-1
1977 to 1984 CROP ACREAGES AND PERCENTAGES*
FOR THE SACRAMENTO-SAN JOAQUIN DELTA
FROM DWR 304

Crop	Lowlands & Uplands		Lowlands		Uplands	
	ac.	%	ac.	%	ac.	%
Field Corn	132,770	25.8	107,480	30.6	25,290	15.6
Grain	110,900	21.5	81,960	23.4	28,940	17.8
Tomatoes	43,100	8.4	25,370	7.2	17,730	10.9
Alfalfa	39,770	7.7	24,350	6.9	15,420	9.5
Mixed Pasture	36,020	7.0	17,730	5.0	18,290	11.3
Sugar Beets	27,650	5.4	15,240	4.3	12,410	7.6
Deciduous	25,960	5.0	9,240	2.6	16,720	10.3
Safflower	23,530	4.6	21,060	6.0	2,470	1.5
Asparagus	23,400	4.5	21,840	6.2	1,560	1.0
Beans	17,580	3.4	4,690	1.3	12,890	7.9
Sunflower	6,630	1.3	6,050	1.7	580	0.4
Vineyard	4,870	1.0	4,150	1.2	720	0.5
Sorghum	4,580	0.9	3,600	1.0	980	0.6
Cole Crops	4,140	0.8	3,610	1.0	530	0.3
Melons	2,430	0.5	250	0.1	2,180	1.4
Sudan	2,180	0.4	710	0.2	1,470	0.9
Potatoes	2,160	0.4	2,160	0.6	0	0.0
Rice	1,810	0.4	480	0.1	1,330	0.8
Native Pasture	1,130	0.2	140	0.0	990	0.6
Misc. Truck	1,120	0.2	750	0.2	370	0.2
Lettuce	1,110	0.2	0	0.0	1,110	0.7
Onions	590	0.1	370	0.1	220	0.1
Misc. Field	510	0.1	460	0.1	50	0.0
Clover	450	0.1	440	0.1	10	0.0
Carrots	300	0.1	300	0.1	0	0.0
Peppers	250	0.0	50	0.0	200	0.1
Nursery	60	0.0	0	0.0	60	0.0
TOTAL	515,000	100.0	352,480	100.0	162,520	100.0

*Percentages computed by State Board staff

TABLE 4.4.1.4-1
DELTA SERVICE AREA
CROP SALT SENSITIVITY
(DWR,328)

Crop	Salt Sensitivity (Crop Salt Sensitivity) Threshold ECe[1/] ds/m	Loss in Yield per Unit Increase in ECe Beyond Threshold
Sensitive Crops		
Beans	1.0	19%
Onions	1.2	16%
Moderately Sensitive Crops		
Fruits & Nuts		
Almonds	1.5	19%
Apricots	1.6	24%
Peaches	1.7	21%
Grapes	1.5	9.%
Corn	1.7[2/]	12%
Corn (subirrigated, organic soil)	(2.1)	
Potatoes		
Miscellaneous		
Truck Crops		
Carrots	1.0	14%
Lettuce	1.3	13%
Cabbage	1.8	9.7%
Broccoli	2.8	9.2%
Alfalfa	2.0	7.3%
Tomatoes	2.5	9.9%
Sudan	2.8	4.3%
Rice	3.0	12%

1/ ECe means Electrical Conductance of the soil saturation extract, reported as deci Siemens per meter (ds/m).

2/ This tolerance of corn shown is for corn grown on a mineral soil using conventional methods of surface irrigation (furrow or sprinklers). The Delta corn trials (reported by Hoffman, et al., 1983) indicate a corn tolerance a little higher for corn grown on the Delta peat under subirrigation. It is reported to be ECe=2.1 ds/m, or 23% higher. This is probably due to the higher water content of the peat. The usual tolerance (for mineral soils) can be multiplied by a factor of 1.23 to obtain tolerance of similar crops grown on subirrigated soils.

4.4.2 Bay Agriculture

Very little information was presented in the hearing sessions on agriculture, as a beneficial use, outside of the legal limits of the Delta but within the boundary of San Francisco Bay. Contra Costa Water District presented records showing crop production for their district (CCWD,48) (Table 4.4.2-1).

TABLE 4.4.2-1--CROPS PRODUCED IN CONTRA COSTA WATER DISTRICT, 1986

Crop	Acres
Corn	10
Alfalfa	20
Irrigated Pasture	30
Other miscellaneous field crops	60
Apricots	10
Grapes*	500
Almonds*	700
Walnuts	10

* Not irrigated in 1986

4.5 Estuary Fishery Habitat Beneficial Uses

The fishery resources of the Estuary depend on its complex ecosystem for a variety of purposes during different life stages and in different seasons and water year types. The Estuary provides habitat for close to 150 fish species and a vast aquatic food web of invertebrates, including shellfish and crustacean, and planktonic organisms. The fishery provides valuable resources for many other terrestrial and aquatic wildlife species as well.

The relationship of fishery habitat requirements to water quality has been documented for relatively few species. Studies normally focus on important commercial and recreational species such as Bay shrimp, Dungeness crab, Chinook salmon, striped bass, and American shad, among others. There is still a great deal of debate about the relationship between water quality and quantity and the changes in fishery resources even for the well studied species.

Beneficial uses of the Estuary's fishery comprise four major categories in the current Water Quality Control Plans (Basin Plans) for the San Francisco and Central Valley Regional Water Quality Control Boards, Regions 2 and 5, respectively. These are:

- Freshwater Habitat -- which provides habitat to sustain aquatic resources for cold water (COLD) and warm water (WARM) species.
- Fish Migration (MIGR) -- which provides a migration route and temporary aquatic environment for anadromous and other fish species. This beneficial use is also subdivided for warm and cold water species.
- Fish Spawning (SPWN) -- which provides a high quality aquatic habitat suitable for fish spawning.

- Preservation of Rare and Endangered Species (RARE) -- which provides an aquatic habitat necessary, at least in part, for the survival of certain species established as being rare and endangered.

The following sections 4.5.1--4.5.2.3 summarize available information on the fishery beneficial uses of the Estuary, including invertebrates. There are two major subdivisions: Section 4.5.1 discusses fishery habitat beneficial uses for species mostly using freshwater habitat; Section 4.5.2 discusses those which mostly use estuarine habitat. The information presented in this chapter will be used in Chapters 5 and 7 to determine what levels of protection are optimal and reasonable for the fishery habitat in the Bay-Delta Estuary.

4.5.1 Delta Habitat

This section considers the habitat for species that primarily use the freshwater of the Delta. Suisun Bay and the other lower estuarine areas (San Pablo, San Francisco and South bays) are discussed in Section 4.5.2..

4.5.1.1 Phytoplankton and Zooplankton

The importance of phytoplankton and zooplankton (including the opossum shrimp, Neomysis mercedis) as the basis for the food chain of fish and larger invertebrates was discussed at length in Phase I of hearing record (see, for example, DFG,28,14; T,XXXIX,15:16-19,28:13-29:14,70:19-71:8;T,XLI,52:19-53:5,59:1-4). The young of striped bass and other game fish, and all life stages of forage fish, feed on zooplankton and Neomysis (DFG,28,1), which in turn feed on smaller zooplankton and phytoplankton (DFG,28,1-4). Phytoplankton abundance is itself dependent on light, flow, salinity and nutrients. The complex interactions of these components are discussed in the hearing record.

While phytoplankton and zooplankton in the Delta food chain are undoubtedly important, the evidence presented is not sufficiently definitive to develop specific objectives for the protection of phytoplankton or zooplankton. A variety of factors have led to this conclusion:

- Changes in the Delta

  There have been extensive changes in recent years in the Delta area, the effects of which are poorly understood. These changes include: (1) the introduction of the Asian copepod, Sinocalanus doerrii, and its apparent displacement of the native copepod, Eurytemora affinis from the central Delta area (DFG,28,25-28); (2) changes in phytoplankton bloom patterns in the Delta, with the appearance of dense blooms of the chain diatom, Melosira (DFG,28,14-19); (3) changes in Delta outflow, salinity and rate of exports (DFG,20,22-25); and (4) increases in releases of water from New Melones Reservoir for interim improvement of southern Delta water quality (T,XV,21:1-9).

- Limitations on Data and Analysis

  Limited available data precluded critical analyses needed to evaluate potential flow and salinity objectives to protect these beneficial uses. For example, almost no data were presented from the 1960's, prior to the operation of the SWP; thus the effects of increased export operations could not be analyzed. Data presented by DFG (Exhibit 28) tended to lump data into pre-drought (1969-1975) and post-drought (1978-1985) periods, even though they noted that some of the changes discussed in the post-drought period began to occur prior to the 1976-1977 drought (DFG,28,16,31). In addition, much of the data was presented as March-November averages, which tended to prohibit interpretation of the data during critical periods of the year, such as the spring spawning period for striped bass. Data averaged in this way reduced the usefulness of the evidence for the purpose of setting objectives.

- Absence of Definitive Relationships

  Limits on data collection design and data interpretation prevented development of definitive relationships among data sets. For example, USBR testified that the phytoplankton data they collected were not used to make connections with other parts of the food chain (T,LXII,109:7-18). The DFG presentations on the relationship between chlorophyll a levels and abundance of various zooplankton used the March-November average abundance levels for both factors (DFG,28,61-74). However, in most years, blooms occur for only a small portion of this nine-month period. Therefore, the effects of blooms on zooplankton abundance, an important concept in much of the discussion, is lost because the long-term average chlorophyll a is at background or non-bloom levels (<10 ug/l). Seasonal and geographic differences are also obscured because only one data point is presented for each year.

  For these reasons, no objectives are proposed specifically for the protection of phytoplankton or zooplankton in the Delta. It is anticipated, however, that the objectives proposed for the protection of other beneficial uses may provide substantial protection for these aquatic resources as well.

  Should additional evidence indicate that these aquatic resources are not being protected, and the evidence is sufficiently definitive to propose objectives, this issue may be reexamined at a later date.

4.5.1.2 Chinook Salmon

- Races and Migration

Chinook, or king salmon, Onchorhynchus tshawytscha, is a native, coldwater, anadromous species of major commercial and recreational importance in California. The total annual sport and commercial harvest of chinook salmon produced in the Central Valley since 1957 averages over 400,000 fish. The estuarine gill net fishery for salmon was outlawed in 1957. Since then the ocean commercial troll harvest of Central Valley salmon has averaged about 324,000 fish, approximately 57 percent of all Chinook harvested in California. The ocean recreational catch has averaged close to 60,000 fish and the inland sport harvest is estimated to be about 35,000 fish (USFWS,31,103,176-179;DWR,56,57-59).

Adult Chinook salmon migrate through the Estuary from the ocean to spawning areas in the upper Sacramento-San Joaquin River basins. Four races, all believed to be genetically distinct (USFWS,31,109), spawn in the upper Sacramento Basin (USFWS,29,4). Each race is named for the time of year when the upstream migration (run) occurs. There are fall, late-fall, winter and spring runs. Because the spawning runs of the four races overlap in the upper Sacramento River, all life stages may be found in all months (see Figure 4.5.1.2-1). The occurrence of four races of Chinook salmon in a single river basin is unique in the United States (T,XXXV,16:24-17:1).

The fall race, comprising 90 percent of all Chinook spawning in the Central Valley, migrates upstream from about late July through December (USFWS,29,5). Smaller populations of late-fall, winter, and spring run fish spawn in the upper Sacramento River (see Figure 4.5.1.2-2). The winter run was formerly the second largest but today is the smallest (T,XXXV,22:6-14); it is now under consideration as a candidate for endangered species status. The Sacramento River and its tributaries produce 80 percent of all Central Valley Chinook salmon (USFWS,31,1) with almost 20 percent contributed by the San Joaquin River Basin in some years (DFG,15,Appendix 1).

Prior to the closure of Friant dam on the San Joaquin River, there was a spring run in the upper river (DFG,15,8). Today, only the fall run spawns in the Merced, Tuolumne and Stanislaus rivers (DFG,15,4). There are also small runs in the Mokelumne and Cosumnes Rivers (SWRCB,435,35).

FIGURE 4.5.1.2-1 Timing of life history stages for the four races of Chinook salmon in the Sacramento River Basin (after USFWS, 29, 5, Figure 2)

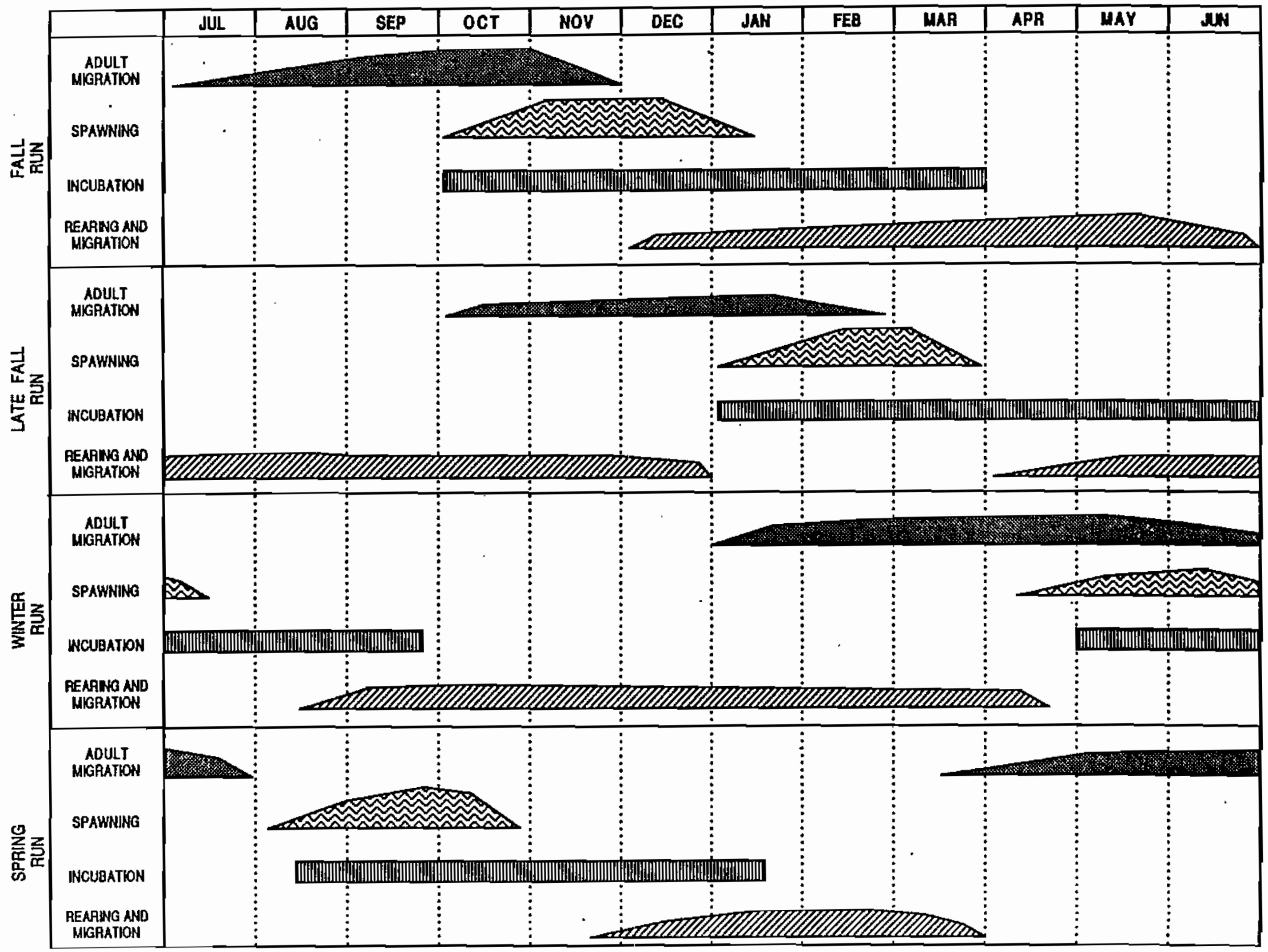
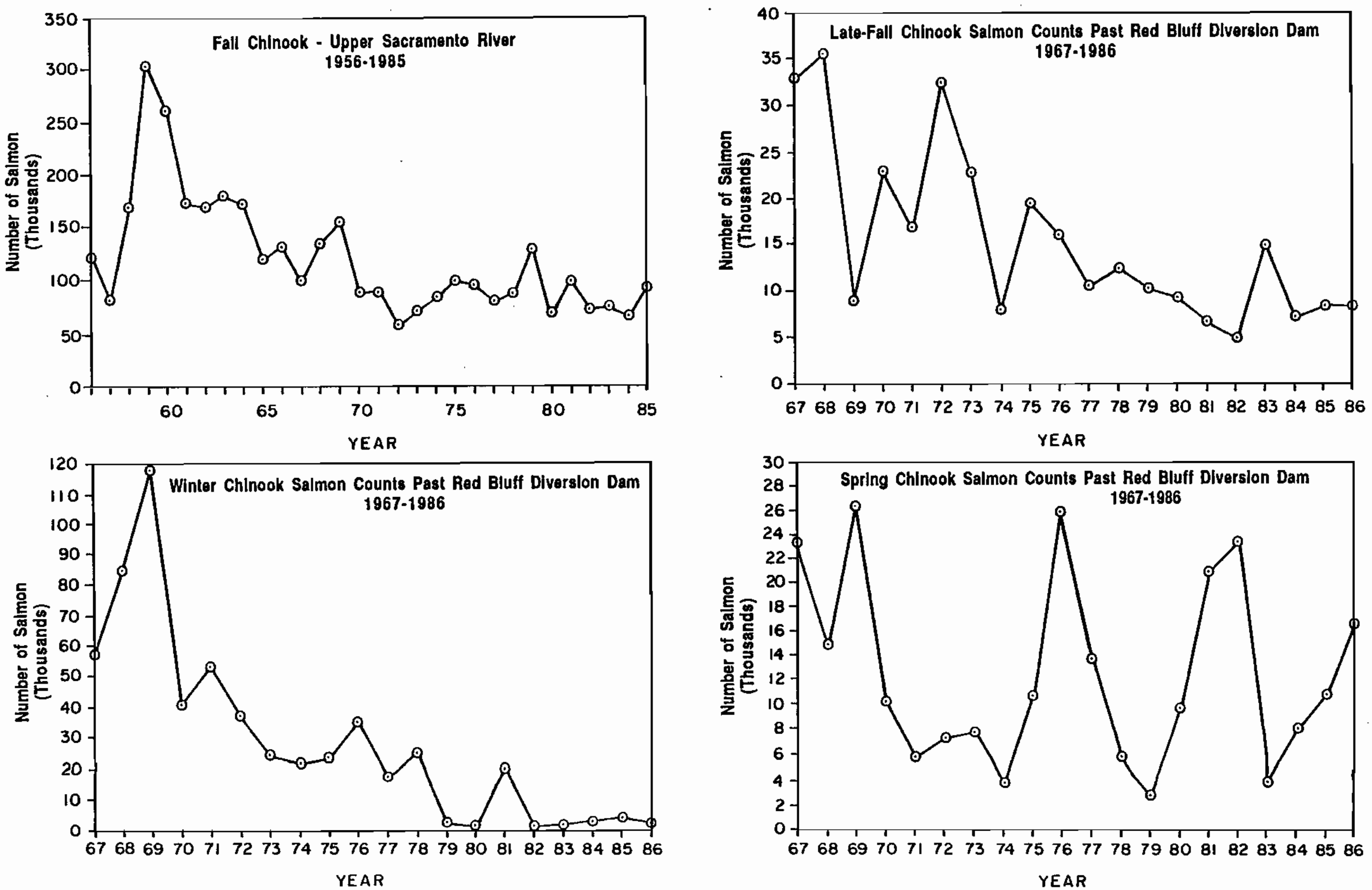


FIGURE 4.5.1. 2-2 Spawning escapement of the four races of Chinook salmon in the Upper Sacramento River Basin
(after USFWS, 29, 7-10, Figures 3-6)



- Development and Migration

The developmental stages and habitat requirements for each stage are generally the same for the four races of Chinook salmon in the Central Valley. However, the different life stages use different locations and require different habitat conditions as they develop within the Sacramento-San Joaquin River basins. The water quality and habitat requirements of each life stage, their location and duration are shown in Table 4.5.1.2-1.

Chinook salmon are a cold water species. Water temperatures below 60°F are required for spawning and the survival and growth of eggs and fry (USFWS,29,4; USFWS,31,4;T,XXXV,43:6-8). The virulence of many diseases affecting Chinook salmon is reduced when temperatures are below 60°F (USFWS,29,23). Juvenile emigrants (smolts) can tolerate water temperatures somewhat higher than 60°F but above about 65°F a variety of stress effects occur (DWR,562,3; DWR,563,1-3; USFWS,31,4; DFG,15,23-27). At temperatures of about 68°F or more, smolts are highly stressed (DFG,15,25-26); 76°F is lethal (USFWS,31,42).

Most naturally spawning Chinook salmon typically return to the stream where they hatched (home stream) at three years of age (DFG,15,18) (two and one-half years after their smolt migrating) or more. During the upstream migration, adults depend on sensing the chemical composition of the water for olfactory cues acquired during their juvenile emigration. Downstream flows of home stream water are necessary for successful spawning migration. If these flows are inadequate or have been diverted, migration delays can occur (USFWS, 31,94).

Adults follow the salinity gradient to the western Delta. Peak numbers of adult migrants, from the fall, late fall, and winter runs move through the Estuary from October to February (USFWS, 31, 93). However, because the spawning runs overlap, adults can be found in the Estuary during the entire year. In the western Delta, stocks from the two major river basins diverge. Most of the San Joaquin River fish follow the mainstem of the San Joaquin River into the tributaries although some use Old and Middle rivers (USFWS, 31, 93). Most Sacramento River Basin Chinook are thought to use the mainstem, though some travel through the Central Delta via the lower forks of the Mokelumne River (USFWS 31, 93).

Spawning, incubation and early rearing take place primarily upstream of the Delta. However, some fry also rear also takes place in the Estuary. While rearing, young salmon feed for about two months or more on a diet of aquatic and terrestrial insects and zooplankton (USFWS,29,4;USFWS,31,14; SWRCB,450,5-4). Peak fry abundance occurs in the Delta in February and March (USFWS,31,7). As they grow and move into the Estuary, <u>Neomysis</u> (opossum shrimp), <u>Corophium</u> (an amphipod) and <u>Crangon</u> (Bay shrimp) become important prey items (SWRCB,433,113).

Table 4.5.1.2-1--Chinook Salmon Environmental Requirements and Life History Stages

Life Stage	Location	Duration (race)	Flow	Water Quality	Other
Adult Migration	Pacific Ocean Bay-Delta to upstream	July-Dec (fall) Oct-Mar (late fall) Jan-June (winter) mid Mar-Aug (spring)	Adequate flow of home stream water to locate spawning grounds and cover redds	Temperature <68°F Dissolved oxygen >5mg/l marine to freshwater	
Spawning	Upper reaches of all major rivers and streams in Sacramento-San Joaquin River Basins below dams	Oct-mid Jan (fall) Jan-Apr (late fall) Apr-mid July (winter) Aug-Nov (spring)	Stable flow without extreme fluctuations sufficient to cover and aerate redds	Temperature <56°F Dissolved oxygen > 7mg/l freshwater	Clean gravel substrate with good circulation through redd
Incubation (Egg-Alevin)	Spawning grounds (see above)	Oct-Apr (fall) Jan-Jul (late fall) May-Oct (winter) mid Aug-mid Jan (spring)	same as above	same as above	
Rearing (Fry-Juvenile)	Upstream, Delta, and upper estuary	Dec-Mar (fall) Apr-Aug (late fall) mid Aug-Nov (winter) late Nov-Jan (spring)	Stable flow to prevent stranding Can tolerate greater flows and velocities as they mature and move into deeper water	Temperature optimum=54°F freshwater	Diet of aquatic and terrestrial insects, crustaceans
Smolt Migration	Bay-Delta Estuary to Pacific Ocean	Apr-June (fall) Aug-Jan (late fall) Nov-late Apr (winter) Feb-Apr (spring)	Tolerates higher flows typical of spring snow melt or rainy season. Helps move smolt downstream	Temperature <68°F Dissolved oxygen >5mg/l estuarine to marine	Diet of Neomysis Crangon, Corophium, and aquatic and terrestrial insects

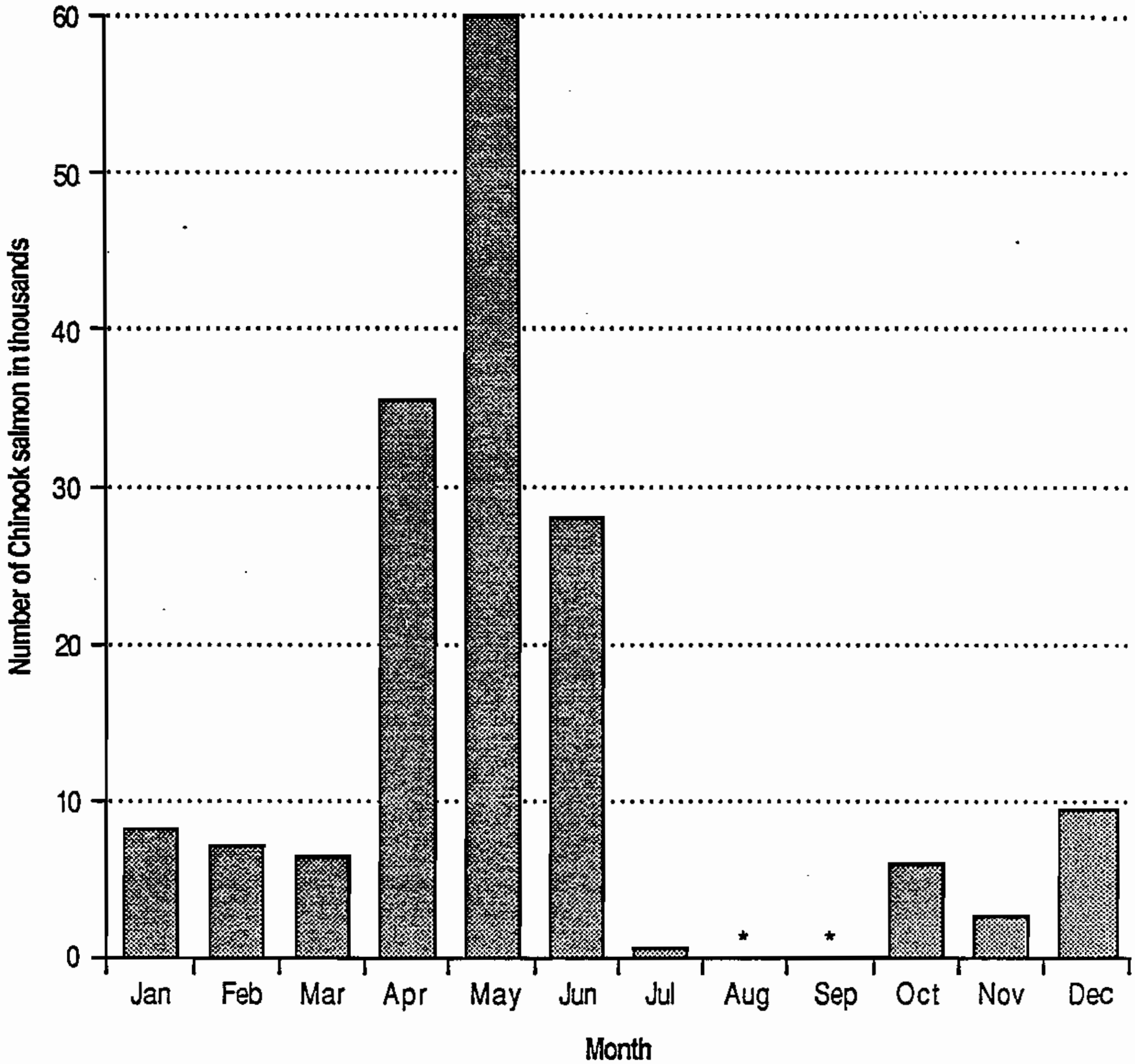
Salmon smolts migrate downstream through the Delta in all but the summer months when water temperatures reach lethal levels (USFWS,31,17-19). Including naturally produced fish and hatchery reared salmon released in or above the Delta (USFWS,31,27), the annual fall smolt run that passed Chipps Island between 1978 and 1985 was estimated to range from 10 to 50 million fish (USFWS,31,25). On the average, it takes an individual fall run smolt three weeks to emigrate from the upper Sacramento to the ocean, one week to reach the Delta and about two weeks to pass through the Delta and Bay (USFWS,31,32). Smolt emigration through the Delta usually peaks in May (Figure 4.5.1.2-3) (USFWS,31,22). However, smolts from different tributaries leave their natal streams and move into the Delta at different times and there are year to year variations in the timing of emigration (USFWS,31,23). The fall run emigration from April through June (USFWS,31,17) coincides with historical flow increases caused by snow melt (DWR,561,6). San Joaquin River Basin fall run smolts emigrate somewhat earlier during this period than Sacramento River Basin smolts (USFWS,31,23). The increase in Delta smolt abundance observed in October and November is probably the late fall race or yearling, fall run salmon. The winter or spring run emigrates from January through March. Peak abundance of salmon salvaged at the state's Delta pumping plant confirm this seasonal pattern of young salmon abundance in the Delta (see Figure 4.5.1.2-3).

- Survival and Abundance

Smolts migrate downstream to the ocean where they mature for two or more years. Recoveries of adults in the ocean, tagged as smolts and released in Suisun Bay, indicate that only about two percent survive. Thus, 10 to 50 million smolts would produce 200,000 to 1,000,000 fish available to the ocean fishery (USFWS,31,27). The number of fish escaping harvest and mortality and returning to the spawning grounds each year is known as annual escapement. Survival from eggs to returning adults in a stable population was reported to average 0.04 percent (DWR,561,3). No detailed evidence was presented regarding overall survival rates for Sacramento-San Joaquin Basin Chinook salmon.

The USFWS estimated that the abundance of naturally produced Chinook salmon has decreased by over 50 percent since the DFG began recording Central Valley escapement in the early 1950's when the population averaged over 400,000 fish (see Figure 4.5.1.2-4) (USFWS,31,1). From about 1955 until 1965, Sacramento Basin Chinook salmon escapement averaged above 250,000 fish. However, according to calculations by the DWR, over the last 20 years the total number of naturally produced adult salmon has declined to around 100,000 fish while escapement of hatchery reared fish has increased to about 90,000 fish (see Figure 4.5.1.2-4)(DWR,559,74). Escapement of nonhatchery salmon of all runs except the spring run have shown a consistent downward trend (see

FIGURE 4.5.1.2-3 Mean monthly salvage of Chinook salmon at the State Water Project fish protective facility, 1968 - 1986 (from DFG, 17, Appendix , Table 4)



* about 100 fish

FIGURE 4.5.1.2-4 Total Sacramento Basin fall run spawning Chinook salmon. Light bars are estimates of natural production, dark bars are estimates of production from Feather and American River hatcheries. Production from Coleman National hatchery is not included. (after DWR, 559,78, Figure VI-1)

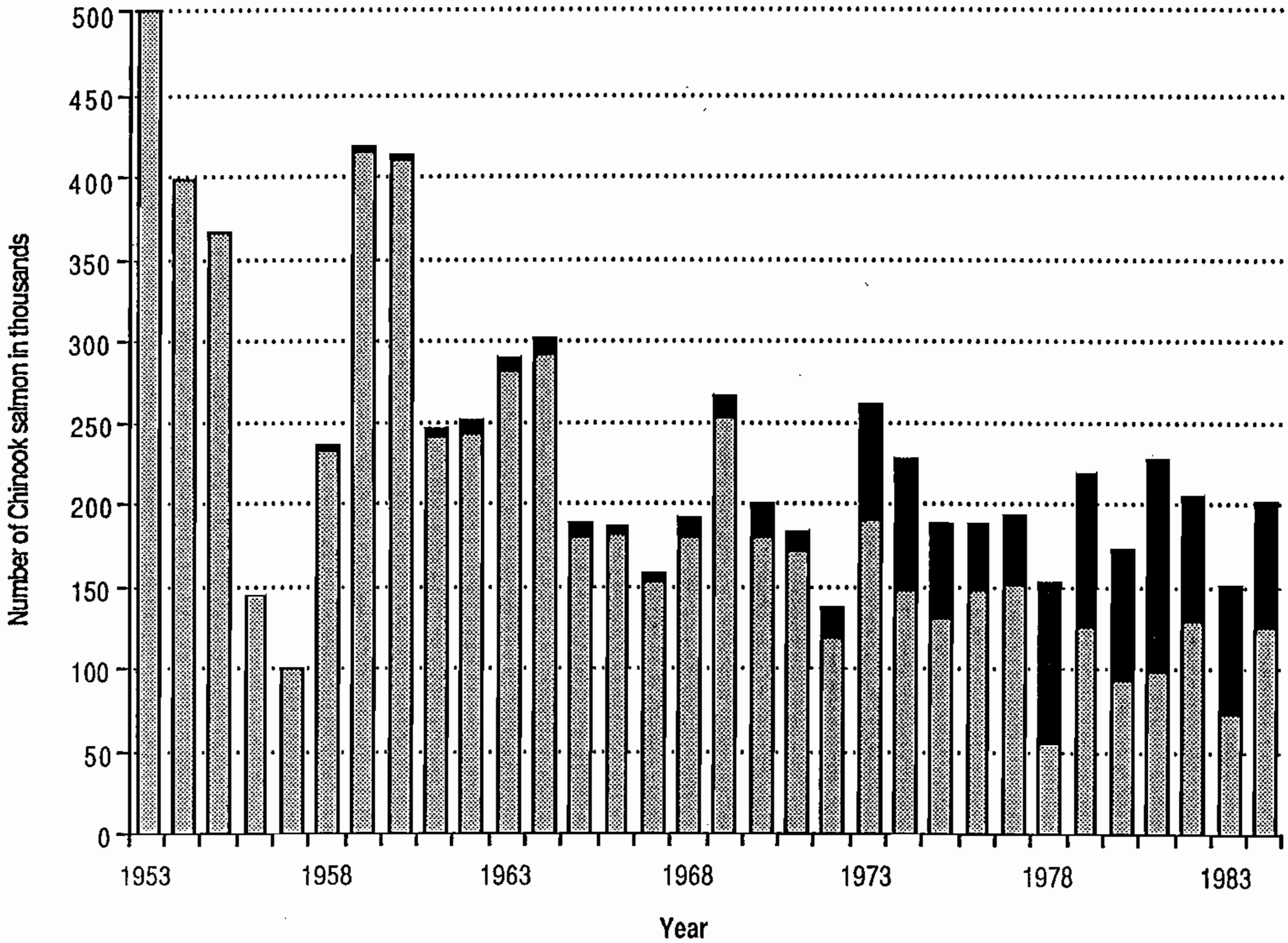


Figure 4.5.1.2-2). Upstream factors identified as contributing to the decline in natural salmon production include loss of habitat from construction and operation of dams and diversions (T,XXXV,25:20-23;DFG,15,8;T,XXXV,33:7-37:12). Stressful to lethal water temperatures, reduced or fluctuating flows, and harmful concentrations of toxins are also factors (USFWS,29;DWR,561)

Annual Sacramento Basin escapement and commercial ocean harvest have become relatively stable in the last 20 years due to the practice of taking immature Chinook salmon from the Feather and American River hatcheries and releasing them below the Delta (DWR,559,47-74; USFWS,31,2). Survival of these fish is six to eight times better than naturally or hatchery produced fish emigrating from upstream of the Delta (T,XXXVII,153: 2-154:1;T,XXXVII,161:22-162:1).

DWR's consultant reported that the Feather and American River hatcheries support. A significant proportion of spawning runs and the commercial catch (T,XXXVII,151:13-18, 14:1-14;T,XXXVI,140-10-21). Between 1978 and 1984, it has been estimated that hatcheries contributed an average of 87 and 78 percent to the American and Feather River runs, respectively (T,XXXVII,153:2-17), at least 16 percent or more to the upper Sacramento run, and an undetermined number to the Yuba River run (USFWS,29,12;T,XXXVII,152:6-22). DWR's consultant calculated that between 1978 and 1984 the Feather and American river hatcheries produced about 48 percent of total Sacramento Basin escapement and 44 percent of the ocean harvest of Central Valley Chinook salmon (T,XXXVII,151:22-152:5). This has enabled the commercial harvest of Central Valley Chinook to be maintained at around 350,000 to 450,000 fish and the catch to escapement ratio (harvest fraction) to double (T,XXXVIII,257:14-22) (see Figures 4.5.1.2-5 and 4.5.1.2-6).

San Joaquin Basin stocks, where the hatchery contribution to escapement is less than five percent (USFWS,31,107), still fluctuate widely (see Figure 4.5.1.2-7). Maximum adult escapement to the San Joaquin Basin appears to be correlated with high spring flow conditions two and one-half years earlier when young fish were produced and emigrating downstream (DFG,15,34-44;USFWS,31,64-66T,XXXVI,160:1-161:6). San Joaquin Basin escapement of 40,000 or more spawners is typical when spring outflows two and one-half years earlier are high (USFWS,31,65).

- Factors Contributing to Delta Survival

Delta conditions during smolt emigration have been identified as a major factor affecting salmon smolt survival and consequent adult escapement of hatchery and naturally produced Chinook (T,XXXVI,139:17-22). The primary changes identified by the USFWS, DFG and others to improve smolt survival in the Delta were: (1) higher spring flows, (2)

FIGURE 4.5.1.2-5 Estimated ocean harvest fraction for California Chinook salmon (illustrates the relative proportion of salmon harvested commercially to spawning escapement in the Central Valley) (T,XXXVIII, 251: 20-25 and 257: 19-22)
(adapted from DWR, 570)

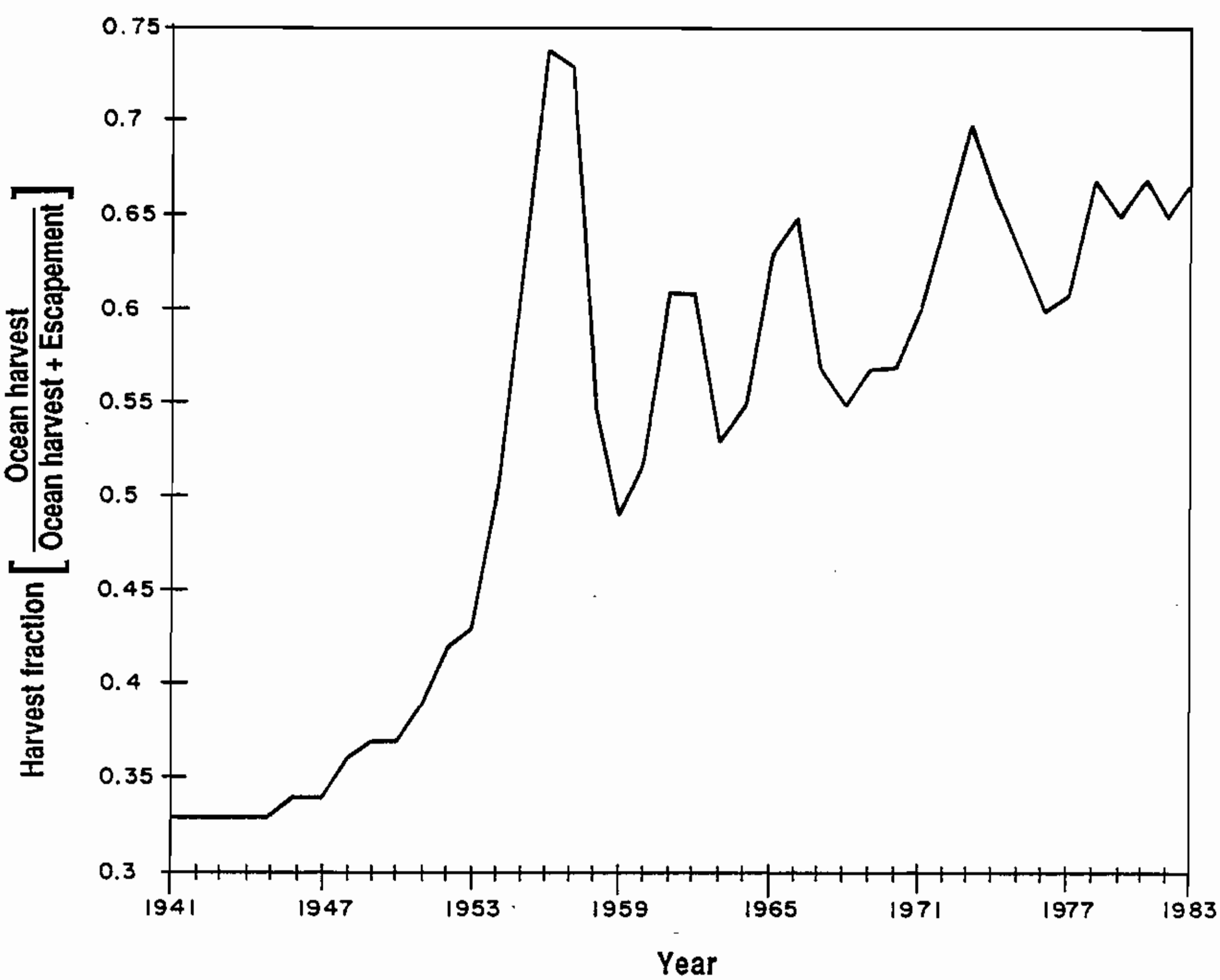


FIGURE 4.5.1.2-6 Estimates of annual ocean harvest of Central Valley Chinook salmon (after DWR, 561, 2, Figure III-3)

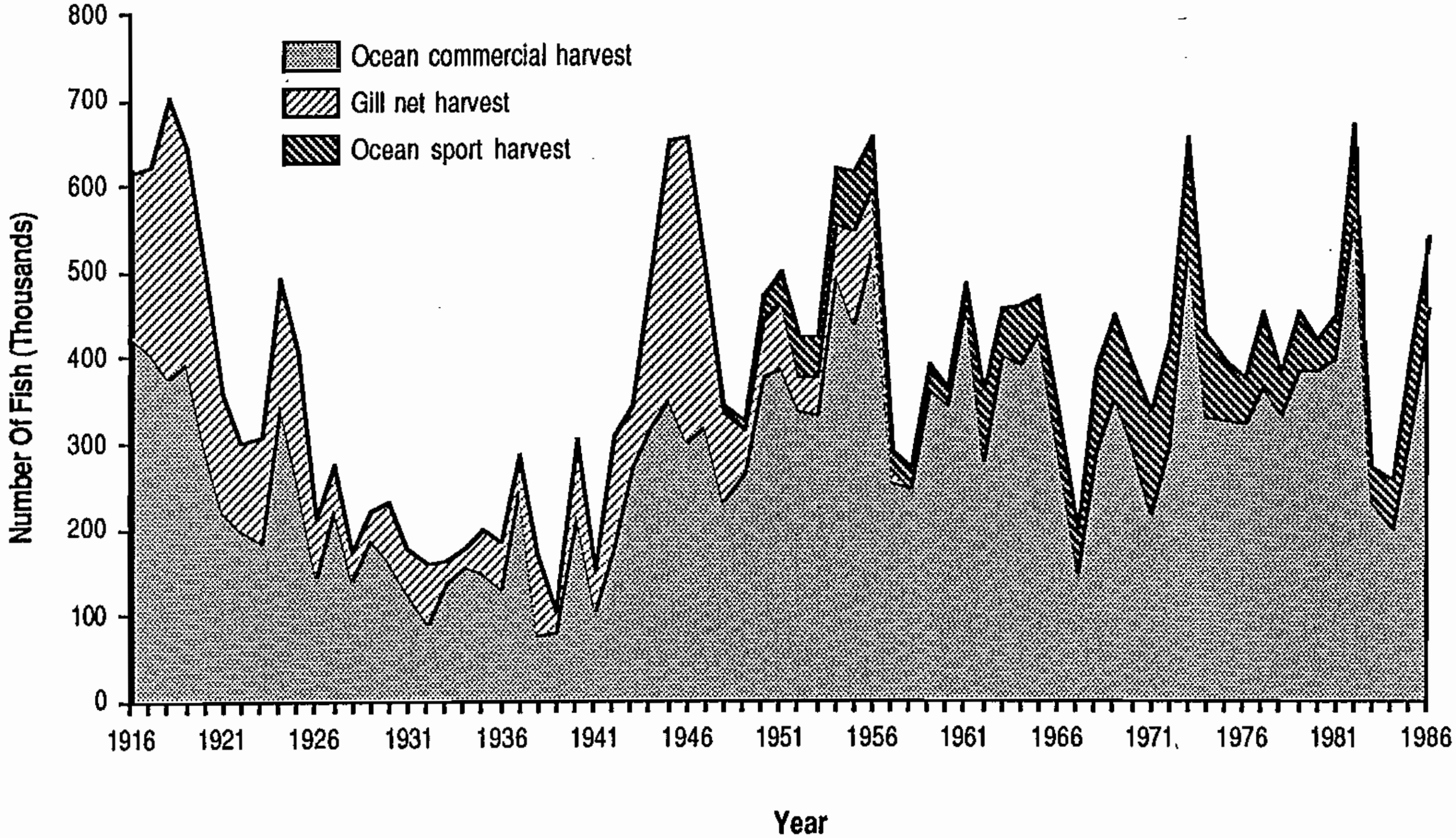
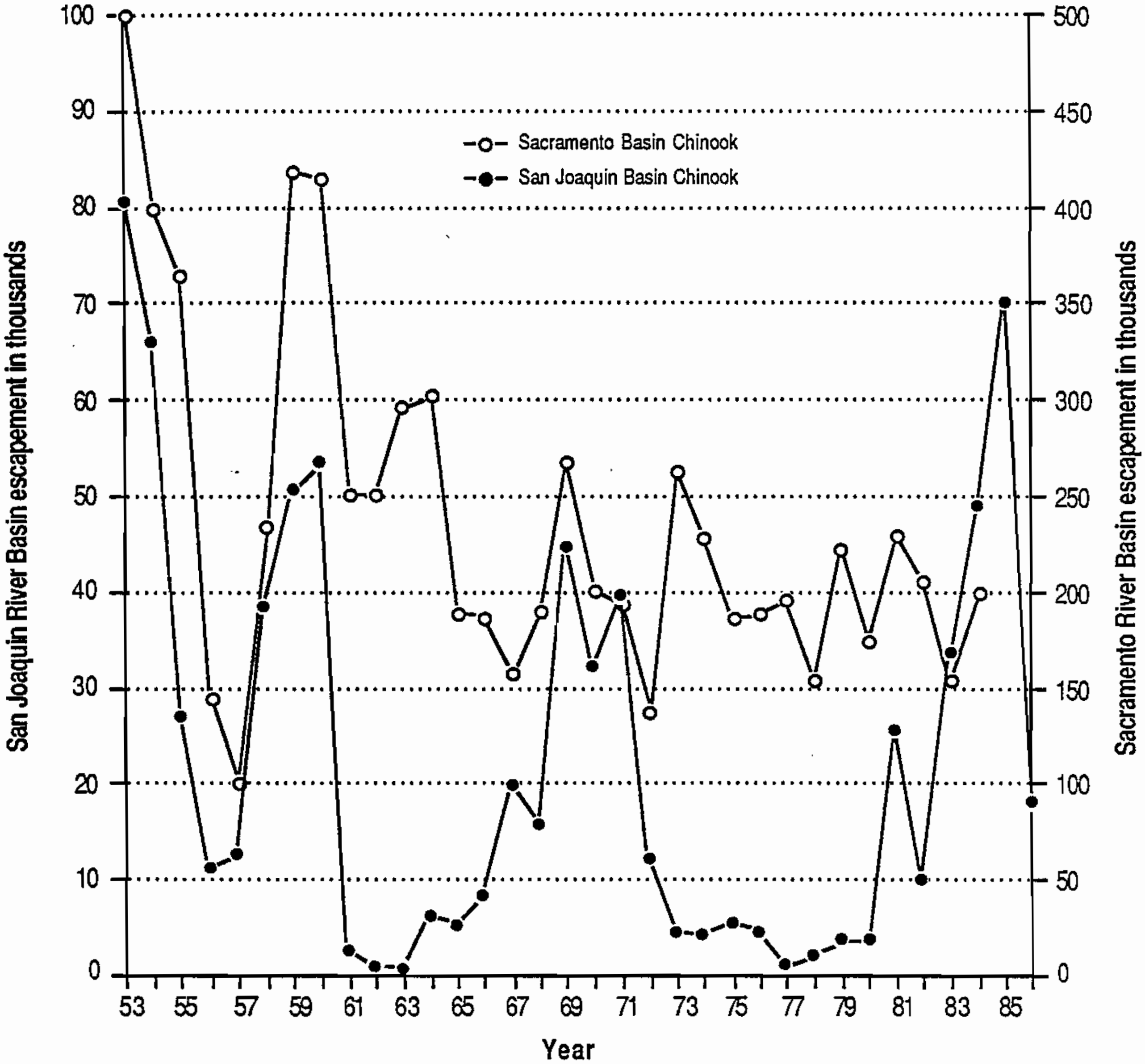


FIGURE 4.5.1.2-7 Comparison of total spawning escapement of Sacramento and San Joaquin River Basin Chinook salmon, 1953 - 1986 (from DFG, 15, Appendix 1)



temperatures below the stressful level of about 66 to 68°F, (3) "overcoming" the adverse impacts of water diversion that transport Sacramento Basin fish through the Delta Cross Channel, and (4) reverse flows in the lower San Joaquin that transport San Joaquin Basin fish away from their normal migration routes to CVP and SWP export pumps. (T,XXXVI,156:21-23; USFWS,31,62).

- Salmon Harvest and Economic Value

Table 4.5.1.2-2 shows the average estimated ocean commercial and sport catch of Central Valley Chinook salmon in California and an estimate of the proportion supported by hatchery production (DWR,559,45). The estimated 1977-1986 California commercial harvest of Chinook salmon from the Central Valley averaged well over 300,000 fish per year (USFWS,31,177,Appendix 32), representing almost 60 percent of the total ocean catch of Chinook salmon in California during this period. The five year average price per salmon purchased "off the boat" was estimated to be $26 in 1987. The average commercial catch for 1982-1986 was about 315,500 fish (USFWS,31,177), which translates to an average annual value of about $8.2 million per year for the commercial fishery. The ocean sport harvest averages about 60,000 fish per year (see Figure 4.5.1.2-6). It is estimated that $72 per day is spent for about 100,000 days of ocean recreational fishing, primarily party boat rentals, for an estimated annual value of $7.2 million (Thomson and Hupert, 1987). USFWS presented an estimate for the inland sport harvest of Chinook salmon of 35,000 fish (USFWS,31,103). However, Meyer Resources (1985) reported the inland catch to be ten percent of the ocean catch (BISF,40,15), or about 6,000 fish. At a catch rate of 0.2 fish per day represents a range of about 1,200 (for 6,000 fish) to 175,000 (for 35,000 fish) angler days each year. Based on cost estimates for shore fishing ($31 per day) to boat rental (about $48/day) the estimated annual value of the inland recreational Chinook fishery ranges from $37,300 to $57,500 for the lower catch estimate to $5.4 to $8.4 million for the upper catch estimate. The value of Central Valley Chinook salmon harvested in California's inland and coastal waters is estimated to range from a minimum of approximately $15.8 million to a maximum of approximately $23.8 million (see Table 4.5.1.2-3).

4.5.1.3. Striped Bass

Striped bass, Morone saxatilis, were successfully introduced into the Estuary at Martinez with the planting of about 140 fish from the Navesink River, New Jersey, on June 18, 1879. A second planting of 300 fish occurred in 1882 (BISF,58,2). The stock expanded quickly and before 1890 supported a commercial fishery that was terminated in 1935 due to a population decline (BISF,47,27). While important recreational fishery continues to the present, recent declines have caused concern.

Table 4.5.1.2-2. Estimated Average Annual Harvest of Chinook Salmon and the Hatchery Contribution to the Catch of Central Valley Salmon

Year	Ocean Commercial Catch 1/ (1)	Commercial Catch of Central Valley Chinook 1/ (2)	Percent of Ocean Catch from Central Valley Chinook (2/1) (3)
1952-1970	558,282	320,982	57
1971-1977	564,796	309,402	55
1978-1986	560,711	333,160	59

Year	Sport + Commercial Catch of Central Valley Chinook (2+4) (5)	Ocean Commercial + Sport Catch of Hatchery Chinook 3/ (6)	Percent Hatchery Chinook in Central Valley Catch (6/5) (7)
1952-1970	373,139	7,407	2.0
1971-1977	401,010	88,603	22.1
1978-1986	397,026	141,291	35.6

1/ from DWR,561,57, Appendix A-3
2/from DWR,561,58-60, Appendix A-4
3/from DWR,559,44-45, Table III-4. The period of time covers 1957-1970 for the American River hatchery alone. Subsequent years include the Feather River hatchery production through 1984. Contributions by other Central Valley hatcheries were not determined.

Table 4.5.1.2-3--Estimated Dollar Value of Chinook Salmon caught in California

Commercial Fishery (million $)	Sport Fishery[1] (million $)		Total (million $)
	Inland	Ocean	
	.373-.575	7.2	15.8-16.0
8.2	5.4-8.4		20.8-23.8

[1]Estimates of the size of the inland fishery vary widely from 6,000-35,000 fish. Therefore the estimated dollar value was calculated for both these estimates.

- Migration and Spawning

The striped bass is an anadromous fish. Most of its adult life is spent in San Francisco Bay and adjacent ocean areas (T,XLI,67:1-7). In the fall the adults migrate upstream and spend the winter in Suisun Bay and the western Delta. In spring the adults move farther upstream to spawn in the Sacramento River between Sacramento and Colusa and in the western and central Delta portion of the San Joaquin River between Antioch and Venice Island (T,XLI,67:1-16). The Delta spawning area is delimited by ocean salinity downstream and by land-derived salinity in excess of 0.550 mmhos/cm EC upstream, typically around Venice Island (T,XLI,68:11-20). Temperature is also important for spawning, with initiation of spawning typically occurring as water temperatures increase to above 61° F (SWC,203,13;SWRCB,450,24-1). Spawning typically occurs in the Delta from late April through May and in the Sacramento River from mid-May to mid-June (T,XLI,67:22-25). About one-half to two-thirds of the eggs that are spawned are produced in the Sacramento River, with the remainder in the Delta (T,XLI,67:20-22).

About 3 mm in diameter, striped bass eggs drift with the currents and hatch in two to three days (T,XLI,69:11-13). The larvae first feed on the remainder of their yolk sacs and oil droplets and continue to drift until they are about six mm in length when they start feeding (BISF,47,35) on zooplankton (copepods and cladocerans). They soon consume larger organisms, especially the opossum shrimp, Neomysis mercedis, which remains the dominant food organism through the first two years of life before the bass shift to larger food, including Bay shrimp and forage fish (T,XLI,70:1-8).

The majority of bass larvae tend to concentrate in the entrapment zone in Suisun Bay and the western Delta, although in very high flow years the larvae may be dispersed farther down the Estuary (T,XLI,69:15-24). The lower San Joaquin River appears to be a less desirable nursery area than in former years. Higher larval mortalities here appear to be the cause for the decline of the Delta portion of the Striped Bass Index (SBI)(T,XLIII,30:17-23;31:11-15).

Striped bass represent a substantial resource throughout the Estuary, upstream on the Sacramento River, in coastal waters and in export canals and reservoirs (see Sections 4.9.3 and 4.9.5). In the years 1983 to 1985, sales of striped bass stamps (required by law for fishing) have averaged over 560,000 per year (NOAA,1986). Annual recreational catches of striped bass (excluding reservoirs and aqueducts) vary from 100,000 to 400,000 fish (T,XLI,70:17-18) taken mainly from private boats or along the shoreline. Charter boats take 10-15 percent of the catch (T,XLI,70:25-71:17). Apart from the fishery, striped bass are also valuable in the food chain of the Estuary. Their eggs and small larvae also serve as food for other fish and invertebrates. Being principal predators in the river and estuarine food chains, larger bass contribute to the control of the size of forage fish populations.

Extensive, multi-year studies of the striped bass population have all indicated a substantial decline in the population since the 1950's (SWC,203,16-19; DFG,25,8-10,28-30,39-41). Estimates of adult population size have declined from about three million in the early 1960's to less than one million fish currently (T,XLI,72:3-7;SWRCB,500,1). The current two-fish, 18-inch minimum length bag limit was established in 1982 in response to this decline, and the striped bass stamp was instituted to provide additional funds for research on this fish. A variety of theories have been proposed to explain the reasons for the decline (see Chapter 5).

4.5.1.4 American Shad

American shad, Alosa sapidissima, is a warm water, anadromous fish species. Shad were introduced to the Delta from the east coast in the late 1800's and within ten years a commercial gill net fishery developed. Over one million pounds (lbs) per year were regularly harvested. It is estimated (at an average weight of three lbs per fish) that this represented a catch of about two million shad, with a total population of two to three times this number (DFG,23,16). By the late 1940's the fishery declined, and by 1957 commercial fishing of shad ended when gill netting was prohibited to protect other fisheries (DFG,23,1; SWRCB,405).

A popular shad sport fishery exists in the Sacramento, San Joaquin, American, Feather, and Yuba rivers and in the Delta. Surveys in the late 1970's indicate that between 35,000 and 55,000 angler days were spent in catching about 79,000 to 140,000 shad (DFG,23,1-2). Estimates from a 1976-1977 survey indicate a population of about three million shad (T,XXXIX,13:11-12;DFG,23,15). No specific data on the value of the shad fishery is available. However, if shore fishing expenditures average about $31 per angler day (Thomson and Huppert, 1987), the total annual value ranges from $2.4 to $4.3 million.

The life history stages and habitat requirements of American shad are shown in Table 4.5.1.4-1. Adult shad spend three to five years in the ocean before they reach maturity (SWRCB,450,3-3) and enter the lower Estuary in the fall; they migrate through the Delta from about March through May to upstream spawning grounds (T,XXXIX,13:23-24), actively feeding on copepods and cladocerans, as well as Neomysis and Corophium (DFG,23,12; SWRCB,433,100). Peak adult numbers occur in the upper Delta in May (DFG,23,5) at water temperatures ranging from about 57° to 75°F (DFG,23,4).

Historically, spawning occurred through the tidal fresh water reaches of the San Joaquin and Sacramento rivers and upstream (T,XXXIX,14:5-7) from about May through July. Today, the lower San Joaquin River no longer supports significant spawning activity because of poor water quality as well as low and reverse flows during the spawning season (T,XXXIX,14:23-24;SWRCB,450,3-3). Spawning occurs from May to June in the north Delta, the Sacramento River above Hood up to the Red Bluff diversion dam, and the major tributaries of the Sacramento River (DFG,23,2-4; SWRCB,450,3-3; DFG,13,21; SWRCB,405,41).

Table 4.5.1.4-1--American Shad Environmental Requirements and Life History Stages (from DFG,23;DFG,13;SWRCB,405;SWRCB,433)

Life Stage	Location	Period	Flow	Water Quality	Other
Adult Migration	from Pacific Ocean through Bay-Delta to upstream freshwater tributaries	March-May	low flows reduce size of run in tributaries	temperature 57-75° F	diet is *Neomysis* and other zooplankton
Spawning	upper Sacramento River to Red Bluff Diversion Dam and major tributaries, North Delta, Mokelumne and Old River. Formerly San Joaquin R.	April-early July	higher flows increase numbers spawning in tributaries	63-75° F optimum = 60-70° F	spawn over sand or gravel
Egg Incubation	lower Sacramento R. below Colusa, Feather and American Rivers, Delta	May-July	higher flows carry more eggs into Delta		
Rearing	same as above	June-Sept	more juveniles produced when flows are higher		feed on terrestrial insects, zooplankton
Juvenile Emigration	Delta-Estuary to Bay or Pacific Ocean	late June-December			diet is *Neomysis*, *Corophium*, larval fish, copepods

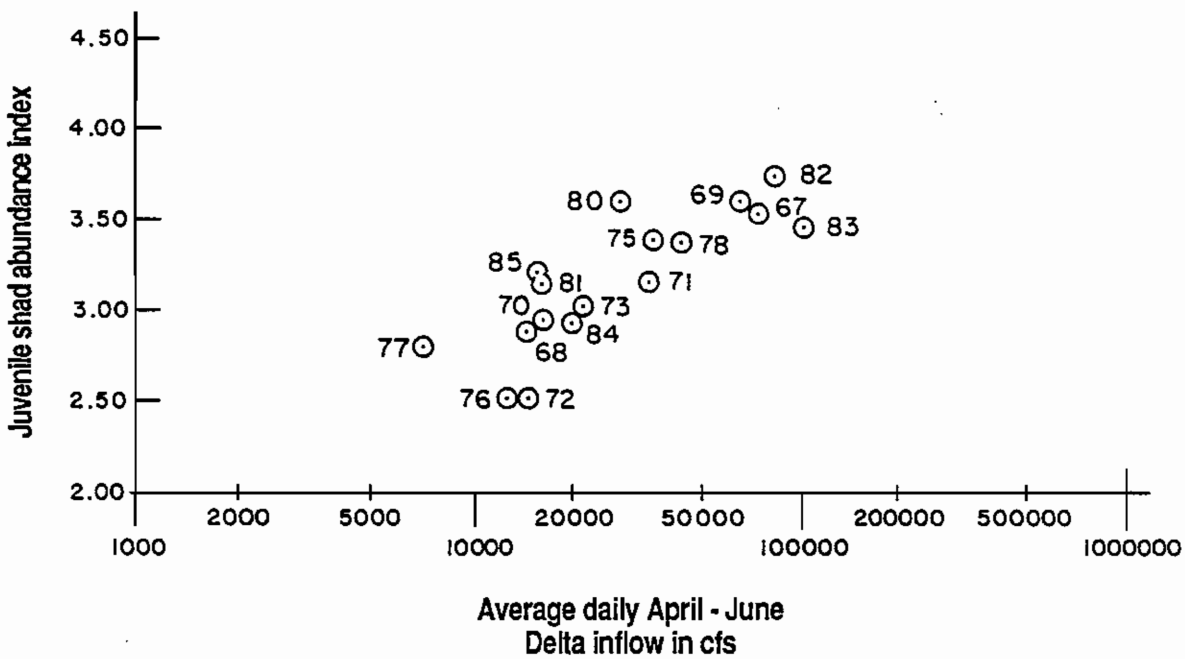
Shad spawn where there is a current, over gravel or sand at water temperatures of about 60°F to 75°F (DFG,13,21; DFG,23,3). The distribution and abundance of spawners is influenced by flow. When spring tributary flows are low, the bulk of the run spawns in the main stem of the Sacramento River while spawning in the tributaries decreases (T,XXXIX,14:12-14:22;DFG,13,22). Many shad die after spawning although some do survive to spawn again. It is believed these fish return to the tributary where they initially spawned (DFG,23,8).

After shad spawn, the fertilized eggs sink and drift with the current until hatching about 4-6 days later (SWRCB,405,41). When river flows are high, more shad eggs are carried further downstream and the importance of the Delta as rearing habitat increases (T,XXXIX,15:13-15). The major shad nursery areas are located in the Feather River below the mouth of the Yuba River, the lower American River, the Sacramento River from Colusa to Sacramento, and the north Delta (DFG,23,8;T,XXXIX,15:3-15:6). Shad nursery habitat is mostly upstream from striped bass nursery habitat (T,XXXIX,49:1-49:3) and overlaps with Chinook salmon rearing areas. In rearing areas upstream from the Delta, young shad concentrate near the water surface, feeding on terrestrial insects that drop into the water from riparian vegetation (SWRCB,433,101). From about June through August in the Delta, young shad feed on zooplankton before emigrating as juveniles during September to December (DFG,23,11; SWRCB,450, 3-3). Most shad emigrate by the end of their first year (DFG,23,10). However, some may remain in San Francisco, San Pablo, and Suisun bays and Suisun Marsh for a second year or not emigrate to the ocean at all (DFG,23,10-11). According to DFG relatively few yearling shad use the Suisun Marsh (T,XXXIX,46:1-5).

When Delta inflows are greater during the spawning and rearing seasons, shad production increases (Figure 4.5.1.4-1) (DFG,23,17). Higher flows during the spring to early summer may improve shad abundance by: (1) providing more spawning and rearing habitat with a consequent reduction in competition for food; (2) dispersing eggs and larvae over a larger area which also decreases competition; and (3) reducing the proportion of river flow diverted to the export pumps, thereby reducing the number of young shad entrained (T,XXXIX,16:2-17:16).

Millions of young shad, both those spawned in the Delta and migrants from the Sacramento River that have been transported through the Delta Cross Channel, are entrained by the CVP and SWP export pumps (DFG,23,20-21;TXXXIX;17:6-24). Fifty percent or more of the shad collected at the CVP and SWP fish protection facilities die during fish salvage operations (T,XXXIX,17:11-16-18:4;DFG,23,22). Numerous unscreened Delta agricultural diversions also contribute to the mortality of young shad (T,XXXIX,17:4-10). Water diversions during the spawning and rearing season may also reduce shad production by decreasing the abundance of their primary food, zooplankton (T,XXXIX,18:6-18).

FIGURE 4.5.1.4-1 Relationship between average daily April-June inflow to the Delta and fall abundance of juvenile American shad, 1967-1985 (except 1974 and 1979) (from DFG, 23, 19).



4.5.1.5 Other Resident and Anadromous Fish

There are over 30 species of resident, warmwater fishes in the Estuary (DFG,24,2), more than half of which were introduced. Most resident fish are members of one of three families: Centrachidae, sunfish; Cyprinidae, minnows; and Ictaluridae, catfish.

- Background

These families support popular recreational fisheries in the Delta. White catfish, Ictalurus catus, are the most commonly caught resident fish, followed by largemouth bass, Micropterus salmoides, and then other sunfish. Sunfish, catfish and largemouth bass are the second, third, and fourth most commonly caught gamefish statewide (DFG,24,5). Non-game resident fish are important components in the estuarine food web both as predators and prey (DFG, 24,6). An important introduced forage species, the threadfin shad, Dorosoma petenense, is consumed by striped bass, largemouth bass and other sunfish (SWRCB,450,3-10).

Relatively little is known about specific flow and water quality requirements of resident fishes of the Estuary (DFG,24,5). The results of a 1980 to 1983 survey by DFG were broadly descriptive but the habitat conditions controlling resident species populations could not be determined (DFG,24,41). Many of the native species were so rarely collected that they could not be statistically analyzed (DFG,24,2). Table 4.5.1.5-1 lists the resident species of the Estuary. Table 4.5.1.5-2 summarizes the regional water quality trends as measured during the DFG survey.

According to DFG, native species were generally associated with the "better water quality" of the northern and western Delta (DFG,24,41), but this could not be confirmed from the information presented. Species abundance and diversity was second highest in the northern Delta compared to the other regions (DFG,24,16). The abundance of several species--the native Sacramento sucker, Catostomas occidentalis; prickly sculpin, Cottus asper; tule perch, Hysterocarpus traski; Sacramento squawfish, Ptychocheilus grandis; and splittail, Pognichthys marolepidotus--was greatest where electrical conductivity (EC) was lowest, mainly in the northern and western Delta (DFG,24,19). However, it is known that the splittail, tule perch and prickly sculpin tolerate brackish conditions. It is therefore possible that other factors may be responsible for their distribution (DFG,24,21-22). The highest abundance and diversity of resident fish was observed in the eastern Delta (DFG,24,18) where introduced species predominated in the sluggish deadend sloughs (see Table 4.5.1.5-2).

According to DFG, Delta water temperatures are within the tolerance range of resident species (DFG,24,39). Warm water fish can tolerate temperatures as high as 86°F. Several native minnows are associated with the cooler temperatures

Table 4.5.1.5-1--Fishes of the Delta (from DFG 24 and SWRCB,450)

Cyprinidae - Minnows

Carassius, auratus, goldfish (I)* +

Cyprinus, carpio, common carp (I) +

Lavinia, exilicauda, hitch (N) +

Mylopharadon, conocephalus, hardhead (N) +

Notemigonus, crysoleucas, golden shiner (I) +

Orthodon, microlepidotus, Sacramento blackfish (N) +

Pimephales, promelas, fathead minnow (I)

Pogonichthys, macrolepidotus, splittail (N) + 2/

Ptychocheilus, grandis, Sacramento squawfish (N) +

Ictaluridae - Catfish

Ictalurus, catus, white catfish (I) +

Ictalurus, melas, black bullhead (I) +

Ictalurus, nebulosus, brown bullhead (I) +

Ictalurus, punctatus, channel catfish (I) +

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* I=introduced, N=native + indicates species collected in DFG's 1980-1983 electrofishing survey

1/ Species of special concern being considered for endangered species status

Table 4.5.1.5-1--contd.

Centrarchidae - Sunfish

<u>Lepomis, cyanellus</u>, green sunfish (I) +

<u>Lepomis, gibbosus</u>, pumpkinseed (I) +

<u>Lepomis, gulosus</u>, warmouth (I) +

<u>Lepomis, macrochirus</u>, bluegill (I) +

<u>Lepomis, microlophus</u>, redear sunfish (I) +

<u>Micropterus, dolomieui</u>, smallmouth bass (I) +

<u>Micropterus, punctulatus</u>, spotted bass (I) +

<u>Micropterus, salmoides</u>, largemouth bass (I) +

<u>Pomoxis, annularis</u>, white crappie (I) +

<u>Pomoxis,-nigromaculatus</u>, black crappie (I) +

Others

<u>Catostomus, occidentalis</u>, Sacramento sucker (N) +

<u>Hysterocarpus, traski</u>, tule perch (N) +

<u>Menidia, beryllina</u>, inland silversides (I) +

Table 4.5.1.5-1--condt.

Dorosoma, petenense, threadfin shad (I) +

Percina, macrolepida, bigscale logperch (I) +

Morone, saxatilis, striped bass (I) +

Alosa, sapidissima, American shad (I) +

Acanthogobius, flavimanus, yellowfin goby (I) +

Cottus, asper, prickly sculpin (N) +

Leptocottus, armatus Pacific staghorn sculpin (N) +

Oncorhynchus, tshawytscha, chinook salmon (N) +

Salmo gairdneri, gairdneri, steelhead (N) +

Gambusia, affinis, mosquitofish (I) +

Gastrosteus, aculeatus, three spine stickleback (N) +

Lampetra, tridentata, Pacific lamprey (N) +

Lampetra, ayresi, river lamprey (N)

Mugil, cephalus, striped mullet +

Hypomesus, transpacificus, Delta smelt (N) + 1/

Spirinchus, thaleichthys, longfin smelt (N) +

Platichthys, stellatus, starry flounder (N) +

Acipenser, transmontanus, white sturgeon (N)

Acipenser, medirostris, green sturgeon (N)

Table 4.5.1.5-2--Annual Average Water Quality Trends in the Delta (from DFG,24,15)

Delta Region	Water Temperature (°F)	Electrical Conductivity (mmho)	Dissolved Oxygen (ppm)	Transparency (cm)
Eastern	63.1	212	8.8	50.5
Northern	61.5	197	9.7	61.4
Western	61.7	353	9.6	46.6
Central	62.1	316	9.0	55.3
Southern	62.8	460	9.0	44.0

more typical of the northern and western Delta (DFG,24,39), (see Table 4.5.1.5-2). Except in localized areas, dissolved oxygen (DO) concentrations at or below the lethal level of 3 ppm were not observed (DFG,24,40-41). The DFG study concluded that resident fish abundance could not be correlated with Delta water temperatures or DO levels (DFG,24,39).

- Sunfish

Sunfish were most abundant in the eastern Delta in habitats with slow currents such as deadend sloughs, oxbows, and sheltered channels and embayments (DFG,24,29); with abundant riparian and/or aquatic vegetation (DFG,24,41-42); and with an abundance of zooplankton (DFG,24,22-23). Sunfish are carnivorous and eat everything from zooplankton to young-of-the-year striped bass (DFG,24,3;SWRCB, 433,145-152). They spawn in shallow water during the spring and summer when water temperatures range from 57° to 75°F (DFG,24,3). Aquatic vegetation is used as cover by all life stages (DFG,24,34).

The only native sunfish, the Sacramento perch, Archoplites interruptus, has disappeared from the Delta, probably due to competition with introduced species and habitat destruction (DFG,24,22). This species was once very widespread and abundant in the waters of the Central Valley floor but is now found only in artificial impoundments where it has been introduced (SWRCB,433,17).

- Minnows

Three species of introduced minnows--the carp, Cyprinus carpio; the goldfish, Carassius auratus; and the golden shiner, Notemigonus crysoleucus--have come to dominate the five species of native minnows (see Table 4.5.1.5-1)(DFG,24,4). The introduced minnows are abundant in the slow water of sloughs and sheltered channels, particularly in the eastern Delta (DFG,24,29).

In an earlier study (SWRCB,433,154), the introduced goldfish and carp, as well as the native Sacramento blackfish, Orthodon microlepidotus and Sacramento hitch, Lavinia exilicauda, were most numerous in the southern Delta at Mossdale on the San Joaquin River, and were also associated with high concentrations of dissolved solids, an indication of elevated salinity typical of areas receiving agricultural drainage. In the present study, goldfish, carp, and Sacramento blackfish were associated with higher salinity habitats in the Delta (DFG,24,28).

The native minnows have diverse feeding habits. The splittail eats Neomysis in the Estuary and amphipods and clams in the Delta (SWRCB,407,53); blackfish feed on phytoplankton and organic detritus; the hitch, zooplankton, and the squawfish, other fish (SWRCB,407,53). The introduced minnows eat small insects, zooplankton and plant material (SWRCB,450,10-4,10-6,10-15).

- Catfish

Of the four species of introduced catfish (see Table 4.5.1.5-1), the white catfish, by far the most numerous (DFG,24,4) supports a significant recreational fishery. In the southern Delta where EC and turbidity were greater, white catfish were the most numerous resident fish species (DFG,24,28). The breeding behavior of all four species is similar, spawning in the spring and summer when water temperatures reach or exceed 70°F (SWRCB,405,22-27). They are omnivorous (DFG,24,4), but the amphipod, Corophium, was found to be their primary food (SWRCB, 433,131-143). According to the DFG survey, white and channel catfish, Ictalurus punctatus, are abundant in the turbid riverine and open slough habitats of the south Delta where EC rises as agricultural runoff increases during the summer.

- Other Anadromous Species

Several other native, anadromous fish use the Delta as a migration corridor and nursery habitat. They are the green sturgeon, Acipenser medirostris; the white sturgeon, Acipenser transmontanus; and the steelhead rainbow trout, Salmo gairdneri gairdneri. Other than information presented in SWRCB exhibits, no testimony or recommendations were made in Phase I of the hearing regarding these species' use of the Delta.

Little is known about either the white or green sturgeon. Adults of both species migrate through the Bay-Delta to upstream spawning areas (SWRCB,405,38). White sturgeon migrate from the late winter through early spring. Most spawning occurs between February and May (SWRCB,407,46) in the Sacramento River upstream of its confluence with the Feather River. Larvae are present from late February to early June. Following spawning, adults return to the Bay and Delta where they remain, feeding on benthic invertebrates, Bay shrimp and herring. Green sturgeon are believed to spend more time offshore, traveling up and down the coast (SWRCB,430,452-453). Juvenile sturgeon live year round in the Delta, eating American shad, Corophium, Neomysis, and other species of benthic invertebrates and shrimp (SWRCB,433,120-122).

An intense commercial sturgeon fishery existed in the 1800's. It was closed in 1901 after the catch plummeted. The fishery reopened in 1910, was closed in 1917, and only reopened for recreational purposes in 1954 (SWRCB,430,453). Angling is popular in the Sacramento River up to Colusa, the Delta (SWRCB,405,35-36), and the bays. Sturgeon are taken in San Francisco Bay where they congregate to feed during the herring runs (SWRCB,430,454). Party boats reportedly harvested 2,400 sturgeon in 1967. There is no information on the recent magnitude of the recreational fishery.

Adult steelhead migrate upstream from the ocean during the spring through fall. Spawning occurs from December through April in tributaries above the Delta. Like salmon, steelhead return home to their natal stream; unlike salmon, not all adults die after spawning. Steelhead are known to have spawned up to four or more times (SWRCB,405,60; SWRCB,450, 5-7). There are several seasonal runs of steelhead migrating through the Delta (SWRCB,405,59-60;SWRCB,450,5-6). The size of the recreational fishery for steelhead adults and juveniles is unknown.

Juvenile steelhead rear in freshwater habitats for one to three years (DFG,13,21). Because they require flows to maintain adequate habitat during this period and much of their original upstream habitat is no longer available, natural steelhead populations have declined (SWRCB,407,48). Hatcheries in the upper Sacramento, Feather, American, and Mokelumne rivers now produce many of the steelhead occurring in the Bay-Delta (SWRCB,450,5-7;SWRCB,407,48). During their downstream migration through the Bay-Delta Estuary in the spring (April-May) and fall, juvenile steelhead feed on Corophium, terrestrial and aquatic insects, crustaceans, and fish (SWRCB,433,113; SWRCB,450,5-7).

- Species of Concern

The splittail is one of two species of special concern because its distribution is restricted to the Bay-Delta Estuary and it has recently declined in abundance (USFWS,35,1). The other, the Delta smelt, Hypomesus transpacificus, once abundant in Suisun Marsh and the Delta, has undergone a precipitious decline since the early 1970's (USFWS,35,20). Both fish have been recommended as candidate species by the USFWS to be studied to determine whether they should be added to the federal endangered and threatened list (USFWS,35,11).[1/]

Resident fish are subject to entrainment by the SWP and CVP Delta pumping plants. Between 1978 and 1985 an average of 330,000 white catfish and 810,000 threadfin shad were entrained annually at the SWP, with the highest numbers during the summer (DFG,24,35-36). Species inhabiting open

1/ Listing refers to a process established under state and federal Endangered Species Acts by which native species are identified. Those listed are determined to be in immediate jeopardy of extinction ("Endangered") or to be present in such small numbers throughout their range that they may become endangered if their present environment worsens (rare plant or threatened species) (California Fish and Game Code Sections 1901, 2062, 2067 and 2068; 16 USC.Section 1531, et seq.)

water or more riverine habitats are thought by DFG to be more vulnerable to diversion and entrainment than fish inhabiting dead end sloughs and other backwater areas. However, since the size of resident fish populations is unknown, it cannot be determined what effect losses caused by water diversions may have (DFG,24,36).

The information on resident freshwater species and other anadromous fish presented in the Phase I hearing was mostly descriptive. No quantitative data were presented on the relationship between population abundance and distribution and flow or salinity regimes. In the absence of such information no water quality objectives can be developed. Therefore, there will be no further discussion of these species in the following chapters of this report.

4.5.2 Bay Habitat

Suisun, San Pablo, San Francisco and south San Francisco (south) bays and consider here. Since, for this Plan, Suisun Bay is considered to be part of the Bay, it is included here for purposes of discussion (see Section 4.5.1.1).

4.5.2.1 Phytoplankton and Zooplankton

As in the freshwater portions of the Estuary (Section 4.5.1.1), phytoplankton and zooplankton form important parts of the food chain in the more saline portions of the Estuary. Extensive testimony was presented concerning three major issues. The first is the need for Delta outflows to position the entrapment zone in Suisun Bay in particular locations, and to stimulate growth of phytoplankton and zooplankton (including the opposum shrimp) to provide food for young striped bass and other fish species. As noted in the discussion of the Delta (Section 4.5.1.1), there have been numerous changes in the Bay in recent years. A second factor is the periodic intrusion of freshwater or estuarine benthic organisms into Suisun Bay under different outflow conditions (T,LXII,58:22-59:11;68:3-16), and their possible impacts on phytoplankton abundance. A third is the recently reported introduction of a new species of benthic bivalve (Potamocorbula amurensis, Family Corbulidae) which further complicates attempts to understand the biology of Suisun Bay.

Some Phase I hearing participants proposed objectives to maximize phytoplankton production, locate the entrapment zone in particular positions, and prevent intrusion of marine benthos into Suisun Bay (see, for example, CCCWA/EDF Exhibits 1 and 2). However, much of the evidence was challenged by other participants (see, for example, USBR rebuttal, T,LXII,65:18-75:9).

In the absence of definitive date to draw on, these positions cannot be resolved. However, it would appear that proposed Delta outflow objectives to protect other beneficial uses, especially outmigration of striped bass larvae and salmon smolt, are generally consistent with those outflows volumes required for protection of certain Suisun Bay aquatic resources. Some of the proposed objectives are also contradictory. Proposing, for instance, an objective to protect one food chain for striped bass, namely by stopping the intrusion of benthic organisms, has an immediate negative impact on the food chain of demersal (bottom-feeding) fish such as sturgeon. No evidence was presented that established there would not be negative impacts on these fish.

The second issue was the proposal to provide sufficient freshwater inflow to develop an entrapment zone in San Pablo Bay similar to that seen in Suisun Bay. The benefit of this second entrapment zone was intended to be additional production of phytoplankton, a concept proposed by witnesses for CCCWA/EDF based on their interpretation of USGS, USBR and other data. They presented evidence to suggest that, at Delta outflows of 10,000 to 20,000 cfs, an entrapment zone forms in Suisun Bay and an apparent second entrapment zone (or at least an area with "stratified flow...with a strong horizontal salinity gradient") forms in San Pablo Bay (CCCWA/EDF,3,23). This position was challenged by USBR in their rebuttal testimony and exhibits (T,LXII,75:10-87:12).

The evidence for the presence of a second entrapment zone is not conclusive. In addition, no compelling evidence was presented to demonstrate a benefit to populations of fish or invertebrates if such an entrapment zone did develop in San Pablo Bay.

The third major issue concerned the merits of setting objectives to cause a stratification of the South Bay by introduction of freshwater inflow, either by month-long periods of high winter or spring outflow or by short periods of large storage releases at specified times (i.e., pulse flows). It was proposed that these flows would enhance phytoplankton production in the South Bay (CCCWA/EDF,4). USGS testified that they have observed a correlation in South Bay among freshwater inflow, density stratification, and rapid development of phytoplankton blooms (T,LI,179:2-23). Their research also showed that the clam, *Macoma balthica*, tended to show increases in growth rates consistent with availability of microalgae, including phytoplankton (T,LI,181:20-182:15). These and other data were used as the basis for the CCCWA/EDF proposal. However, it was noted that the clams responded not just to increases in phytoplankton, but also to increases of *periphyton*, microalgae growing in the sediment (T,LI,238:1-22). In addition, these phytoplankton blooms have not been shown to have effects on zooplankton abundance. There is also no evidence to conclude that increases in zooplankton or benthos are likely to yield increases in fish populations in the South Bay. USGS noted that in other estuaries a relationship between phytoplankton production and fisheries production had been demonstrated, but to their knowledge, no such relationship has been demonstrated for San Francisco Bay (T,LI,180:9-181:11; 192:10-17).

Like that for the Delta, the evidence presented is not sufficiently definitive to develop specific objectives for the protection of phytoplankton and zooplankton in Suisun, San Pablo, San Francisco and South bays. It is anticipated that freshwater inflow resulting from flows to protect beneficial uses in these areas or upstream may also provide protection for estuarine phytoplankton and zooplankton. Should additional evidence indicate that these aquatic resources are not being protected, and the evidence is sufficiently definitive to propose objectives, this issue may be reexamined at a later date.

4.5.2.2 Benthic Invertebrates

"The 'benthos' is the community of invertebrate animals (worms, clams, shrimp, etc.) living on the bottom of aquatic environments. These animals consume organic matter that grows on, or settles to the bottom and in turn become food for fish and other consumers including humans" (TIBCEN,23,65). Benthic invertebrates in the Estuary tolerate a range of salinities; some prefer different flows and salinities at different life stages (DFG,59,14). There are species requiring only freshwater, species requiring a combination of salt and freshwater, and those surviving only in saltwater. For example, some species such as the commercially valuable starry flounder (Platichthys stellatus) prefer fresher water during early life stages and as juveniles are found in the upper reaches of the estuary, whereas adults prefer higher salinities and occupy the Bay (DFG,59,22). Adult shrimp occupy bottom areas in their preferred habitat, while shrimp larvae are found in less saline surface layers. These behavioral differences, combined with the effects of the two-layered flow in the Bay (see 3.6.2.1) result in different distributional patterns of young and old shrimp (USBR,110,15). For example, Crangon shrimp breed in the Bay, produce planktonic larvae which may be carried into the ocean near shore by surface water, drop down as benthic post-larvae and reenter the estuary carried by gravitational circulation (DFG,59,23). Gravitational circulation also strongly affects the distribution of bottom-dwelling species like speckled sanddab and English sole larvae (DFG,59,24).

The following benthic organisms found in the Estuary are part of the food chain which support popular sport or commercial fisheries and wintering waterfowl:

- mollusks, including clams (Macoma balthica, Mya arenaria, Tapes japonica, Gemma gemma, Corbicula spp.), mussels (Ischadium demissum, Mytilus edulis), oysters (Ostrea lurida), and snails (Nassarius obsoletus);

- arthropods, including amphipods (Corophium, spp. Grandidierella japonica, Ampelisca milleri), shrimp (Crangon spp.), and crabs (Cancer spp.); and

- worms (Limnodrilus spp., Boccardia ligerica, Streblospio benedicti) (Markmann, 1986).

There is a pronounced "faunal break" west of Suisun Bay, where freshwater and brackish water species give way to salt-tolerant species found in San Pablo Bay (DFG,59,12).

Densities of benthic organisms are highly variable in the Estuary. At any location their survival and growth can be affected by factors such as predation, disease, parasites, currents which carry them away, salinity regime and broodstock population size (DFG,60,57). Density estimates[1/] as high as 910 to 1153 grams per square meter (g/m^2) are reported in South Bay channels, to as low as 4 to 17 g/m^2 in the channels of San Pablo Bay; Suisun Bay has benthic invertebrate biomass ranging from 25 to 34 g/m^2 in channel substrates and from 6 to 30 g/m^2 in shoal areas (CCCWA/EDG,10,T2). The number of organisms varies much more than the biomass, with a few large animals sometimes equalling the biomass of many smaller ones. At the Carquinez Strait, this biomass was made up of about 160,000 and 40,000 $organisms/m^2$ in June and October of 1976; 25,000 $organisms/m^2$ in March of 1977; but by less than 1,000 $organisms/m^2$ in October 1977 and in 1978 (Markmann,1986,F8-F11). Organism numbers per m^2 at all stations were low in 1978; numbers appeared to recover to about 40,000 $organisms/m^2$ in the western Delta (Station D4) in 1979 and 1981, although Carquinez Strait stations were no longer sampled (Markmann, 1986, F8-F11). The brief peak in organism numbers in 1976 and 1977 during a major drought was due in part to an invasion of Suisun Bay by the filter-feeding clam, Mya arenaria, which replaced the usual deposit-feeding fauna (CCCWA/EDF,7,383).

The benthic grazing hypothesis was formed to explain the high numbers of these (e.g., Mya arenaria) more saline tolerant filter feeders (a ten-fold increase when compared to non-drought conditions) and the low phytoplankton and zooplankton populations during the 1976-1977 drought (CCWA,EDF,7,385). In Suisun Bay, the benthic salt-tolerant, filter-feeders apparently become large enough and sufficiently abundant to be capable of filtering the entire volume of the Suisun Bay in a day. With this amount of feeding, it is hypothesized that benthic filter-feeders consumed virtually all phytoplankton and nutrient material in the water column. The pelagic (open-water) food web, which is also based on phytoplankton, was therefore replaced by the benthic food web (CCCWA/EDF,7,386). However, it appears that marine benthic organisms which do invade during dry periods will be virtually wiped out during years of high flow. In the same way,

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1/ Abundance or density of benthic organisms measured by biomass per square meter freshwater filter-feeding organisms will be eliminated during drought. Under unimpaired rainfall and runoff conditions, the Suisun Bay normally receives enough fluctuation in salinity to prevent either marine or freshwater filter-feeding benthic organisms from surviving for more than a few months (SWRCB,105). This fluctuation in conditions provides a habitat which is uniquely suited to an open-water food web based on phytoplankton and zooplankton.

One of the consequences of water project operations under D-1485 is that salinity fluctuations in the Estuary are reduced under most flow conditions (SWRCB,102,A-K;SWRCB,103,A-C). Variability of habitat in the bays and estuaries normally increases the number of species (DFG,59,9-10). Under the more stable conditions of salinity which result from operations under D-1485, a reduction in habitat and species diversity can be expected. At present, with existing storage facilities and diversion capability operated according to D-1485, there are still a large number of pulses of freshwater outflow during above normal and wet years (LIII,199:13-17;DWR,654;DWR,655). DFG concluded that reductions in either annual outflows or pulse flow levels could result in more intraspecific competition and reduce recruitment into the adult population, but that more field observation than the six years of field sampling to date should be used to test whether their conclusion was correct (DFG,59,30).

Because substantial variation in freshwater outflow from the Delta will continue to occur with existing water project operations, and because of the lack of testimony or evidence linking the abundance of other fish and wildlife to the benthic organisms, no objectives are proposed specifically to control or enhance the benthic community. If data become available that relate freshwater outflow to changes in the benthos and other aquatic communities of organisms, may be reviewed.

4.5.2.3 Fish

Studies of San Francisco Bay fish required by the 1978 Delta Plan (T,LI,249:10-24) were initiated by DFG in January 1980 (T,LI,251:20-24) to "document the importance of flow to Bay resources...and determine...the ecological benefits of unregulated outflows and salinity gradients established by them". (DFG,59,29).

In reporting that "{s}port fishing is the most popular recreational activity in the San Francisco Bay and Delta area," DFG estimated that 4.4 million recreation days were used in this activity, with a much larger, as yet undeveloped potential demand existing (DFG,59,10). Striped bass, Chinook salmon, and halibut are the most popular species caught in the Bay; other sport species include brown rockfish, surf perch, lingcod, jacksmelt, topsmelt, white croaker, shark, ray and skate.

The commercial harvest of finfish in the Bay has been limited by legislation (T,LII,19:3-20), with only herring and anchovy being taken commercially today(DFG,59,11). The herring fishery is primarily for roe which is exported to Japan. English sole, which use the San Francisco Bay as a nursery, are an important offshore commercial species. Anchovy are harvested primarily for bait. DFG estimated the commercial harvest of herring roe and shrimp from San Francisco Bay landings to have a value of $11.6 million per year (H.Chadwick,pers.comm.,12/28/87).

DFG was unable to establish any relationship between freshwater outflow and the size of commercial catches because of significant problems with the data base, among which were: (1) inconsistent catch reports; (2) a commercial fishery with changing equipment, methods and territory; (3) catch reporting methods which make it difficult to determine catch location; (4) the species fished as well as the size of the catch being determined primarily by the market place rather than species abundance; and (5) life history information not being known for most commercially harvested species (DFG,60,318).

In Phase I of the hearing, DFG presented much new descriptive information about the effects of flow on individual fish species and the abundance and distribution of their life stages in the Bay. This is a necessary first step in describing the beneficial use of Bay fish. However, the information needed to establish numerical flow or salinity objectives for the protection of Bay finfish resources downstream of the entrapment zone was not presented. (Delta outflows needed to protect anadromous fish and/or the entrapment zone are discussed in Section 5.3.4.3). Numerical objectives cannot be set without considerable additional study (T,LII,25:17-24;T,LII,38:8-14;T,LII,45:12-24;T,LII,67:13-17;T,LII,74:6-13).

Patterns of Bay fish abundance and distribution, and their relationship to freshwater outflow were highly variable and were influenced by offshore as well as upstream processes. Studies from other estuaries confirm what the DFG studies indicated, that "{i}n some cases, the same flow changes favor some organisms, while negatively impacting others" (DFG,61,73). Also, "{t}here may be some level of [inflow] reduction that causes serious impacts in each system but certainly that level varies among systems and...species." (DFG,61,77). DFG postulated that the extreme variability of Bay conditions is normal and contributes to the productivity of the system (T,LII,4:13-25). Among the reasons for the diversity of responses observed by DFG are: (1) a constantly shifting community of fish species; (2) the hydrologic and biologic environment of the Bay not being isolated from oceanic influences; and (3) the very limited historical database on Bay finfish.

DFG collected 122 fish species and about 1,642,000 individual fish, including larvae, during a six-year study, from January 1980 through December 1985 (DFG,59). Most species were so rare they were not analyzed further. Bottom (demersal) habitats supported a more abundant, diverse fish community than open water (pelagic) or nearshore areas (DFG,59,6). Table 4.5.2.3-1 identifies the predominant species in each of these areas.

DFG analyzed the abundance of the 69 most common species in relation to DWR's water year classification system. During the study period there were four wet years (1980, 1982, 1983, and 1984) and two dry years (1981 and 1985) with a wide range of freshwater outflows (DFG,60,3)(see Figure 4.5.2.3-1). The abundance of 61 percent (42 species) showed no consistent change with water year type, 29 percent (20 species) increased in wet years and 10 percent (7 species) increased in dry years (DFG,59,19-20). This method of analysis produced only a very general idea of species' response to outflow since DFG did not relate fish numbers to monthly flows (T,LII,37:11-12).

Thirteen species occurred in numbers sufficient to warrant more detailed analysis (DFG,60) (see summaries in Tables 4.5.2.3-2 and 4.5.2.3-3). Of these, twelve were native species and one was introduced. All of the predominant species use the Bay during their life cycle (see Table 4.5.2.3-2)(DFG,59,10). Many of the species which are prey for other fish or birds are permanent residents of the Bay, including gobies, topsmelt, and Pacific staghorn sculpin. The Bay also provides nursery and rearing habitat for species which are harvested commercially and recreationally (see Table 4.5.2.3-2). For example, the English sole and starry flounder spawn off shore but their eggs or young are carried by gravational circulation into the Bay where they mature. Adults of other commercially important species such as Pacific herring and northern anchovy actively move into and spawn in the Bay where their young also mature (DFG,59,10).

DFG also examined fish abundance relative to salinities ranging from 0 to 35 ppt salinity. Nine species preferred more saline areas, among them Pacific herring, English sole, several gobies and northern anchovy. Four species, yellowfin goby, Pacific staghorn sculpin, longfin smelt, and starry flounder, tolerate a broader range of saline conditions (DFG,59,7-10;DFG,60,121,210, 280-283). Salinity preference appears to change with age in some species; for example, young starry flounder and Bay gobies prefer fresher water while older fish prefer more saline environments (DFG,59,22). The distribution of different life stages may change with shifts in salinity. For example, during wet years, juvenile English sole do not use San Pablo Bay but in dry years when salinity is higher they do (DFG,59,22). When marine waters penetrate upstream, marine fish species follow. During the drought (1976-77), freshwater species moved out of Suisun Marsh and marine species moved in (DFG,61,46).

No uniform response to Delta outflow was evident among the 13 most abundant species (DFG,59,13-28). DFG reported that some species or life stages increased in abundance and/or expanded their distribution during increased freshwater outflows while others did not (see Table 4.5.2.3-3). No consistent

Table 4.5.2.3-1 Most Common Bay Fin Fish Collected from Demersal, Pelagic, and Nearshore Areas by DFG, 1980-1986 (from DFG,59,6)

SHORE HABITAT	PELAGIC HABITAT	DEMERSAL HABITAT
Atherinops affinis	*Engraulis mordax*	*Spirinchus thaleichthys*
topsmelt	Northern anchovy	longfin smelt
Clupea harengus pallasi	*Sprinchus thaleichthys*	*Engraulis mordax*
Pacific herring	longfin smelt	Northern anchovy
Engraulis mordax	*Clupea harengus pallasi*	*Morone saxatilis*
Northern anchovy	Pacific herring	striped bass
Atherinopsis californiensis	*Morone saxatilis*	*Cymatogaster aggregata*
jacksmelt	striped bass	shiner perch
Morone saxatilis		*Parophrys vetulus*
striped bass		English sole
Leptocottus armatus		*Genyonemus lineatus*
Pacific staghorn sculpin		white croaker
Menidia beryllina		*Leptocottus armatus*
inland silversides		Pacific staghorn sculpin
Clevelandia ios		*Leptocottus lepidus*
arrow goby		Bay goby
Cymatogaster aggregata		*Citharichthys stigmaeus*
shiner perch		speckled sanddab
Micrometrus minimus		*Acanthogobius flavimanus*
dwarf perch		yellow fin goby
Acanthogobius flavimanus		*Platichthys stellatus*
yellow fin goby		starry flounder
		Clupea harengus pallasi
		Pacific herring

FIGURE 4.5.2.3.-1 Average monthly outflow at Chipps Island, 1980-1985 (DFG, 60, 3)

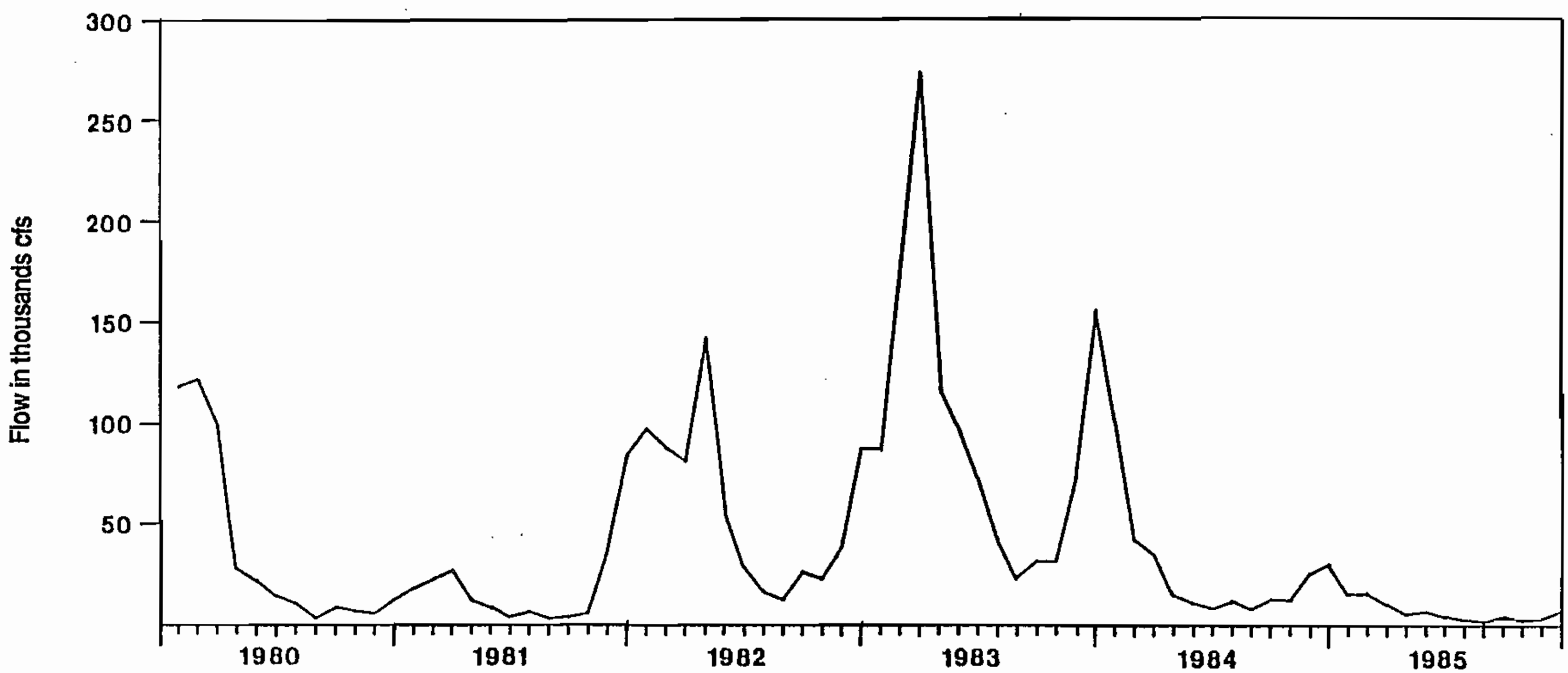


TABLE 4.5.2.3-2 Life history and descriptive information for the most abundant species of fish collected. (DFG, 59)

Species	Species origin	Species type	Life history			Center of population	Importance of species	Preferred habitat	Use of bay	Life stage major food source	
			Spawning time	Spawning location	Nursery area					Adult	Juvenile
Pacific herring	N	M	Fall-Winter	Bay	SSFB-SPB	Ocean	Commercial Forage	Pelagic	Spawning Nursery	P	P
Longfin smelt	N	E	Winter	Rivers	SPB	SPB	Forage	Pelagic	Nursery Residence	P	P
Pac. staghorn sculpin	N	E	Winter	Bay	Bay	CSFB-SPB	Forage	Demersal	Residence	F, B	B
Starry flounder	N	E	Winter	Ocean	SB-Delta	Ocean-Bay	Commercial Recreation	Demersal	Nursery Residence	B	B
Speckled sanddab	N	M	All Year	Ocean	Ocean-CSFB	Ocean	Forage	Demersal	Nursery Residence	B	B
English sole	N	M	Winter	Ocean	Ocean-Bay	Ocean	Commercial	Demersal	Nursery	B	B
California tonguefish	N	M	Summer - Fall	Ocean	Ocean-CSFB	Ocean	Forage	Demersal	Nursery	B	B
Yellowfin goby	I	E	Winter	Bay	SB-Delta	SPB-SB	Forage Commercial	Demersal	Residence	B	B
Arrow goby	N	M	Spring - Summer	Bay	SSFB-SPB	SSFB-SPB	Forage	Demersal	Residence	B	B
Bay goby	N	M	Summer - Fall	Bay	SSFB-SPB	CSFB	Forage	Demersal	Residence	B	B
Topsmelt	N	M	Summer	Bay	SSFB-CSFB	SSFB	Forage	Littoral / Pelagic	Residence	B	B
Jacksmelt	N	M	Spring - Summer	Bay - Ocean	SSFB-CSFB	Ocean	Recreation Forage	Pelagic	Spawning Nursery	F	P
Northern anchovy	N	M	Spring - Summer	Ocean	Ocean	Ocean	Commercial Forage	Pelagic	Spawning Nursery	P	P

N = native, I = introduced, E = estuarine, M = marine, SSFB = South San Francisco Bay, CSFB = Central San Francisco Bay, SPB = San Pablo Bay, SB = Suisun Bay, P = plankton, B = benthos, F = fish

TABLE 4.5.2.3-3 Relationship between freshwater outflow and abundance and distribution of various life stages of the most abudant fish. (DFG, 59)

SPECIES	LIFE STAGE	ABUDANCE CHANGES WITH INCREASING DELTA OUTFLOW				IN BAY DISTRIBUTION CHANGES WITH INCREASING DELTA OUTFLOW			
		Winter	Spring	Summer	Fall	Expand	Decrease	Shift	No change
Longfin smelt	larval					x			
	juvenile	+	+			x			
	adult					x			
Pacific herring	larval								x
	juvenile						x		
	adult						x		
Northern anchovy	larval								x
	juvenile						x		
	adult						x		
Pac. staghorn sculpin	larval	-					x		
	juvenile								x
	adult			+		x			
Starry flounder	juvenile		+	+		x			
	adult								
English sole	larval	+				x			
	juvenile		-				x		
Speckled sanddab	juvenile		+	+					x
	adult		+	+					x
California tonguefish	juvenile			+		x			
	adult		+	+		x			
Yellowfin goby	larval	-					x		
	juvenile					x			
	adult		+	+					x
Arrow goby	larval								
	juvenile								x
	adult								x
Bay goby	larval			-	-		x		
	juvenile	+	+						x
	adult	+	+						x
Topsmelt	larval						x		
	juvenile								x
	adult						x		
Jacksmelt	larval								x
	juvenile								x
	adult								x

relationship was observed between fish abundance and pulse flows (DFG,60,293). Monthly sampling was inadequate to determine the effects of short-term pulses (DFG,60,308). Freshwater pulses temporarily affected fish distribution, more widely dispersing estuarine species of the upper water column. The distribution of demersal species was less affected by pulse flows (DFG,60,296).

According to DFG, the juveniles of estuarine species (see Table 4.5.2.3-2) as well as the juveniles and adults of several flatfish species were generally more abundant during wetter conditions (DFG,59,15). Fish abundance appeared to be mostly associated with increases in Delta outflow for specific life stages of seven species during the spring or summer and three species during the winter (see Table 4.5.2.3-3). Increasing Delta outflows associated with increased abundance or distribution for a particular species in one season or life stage were often reversed in another period or life stage. For example, the abundance of larval English sole in the Bay increased during years of high Delta outflow and their range was broader; in contrast, the range of juvenile sole was limited to Central Bay in wetter years and expanded in drier years (DFG,60,248-251). Some life stages exhibited no detectable distributional shift with higher Delta outflows (DFG,59,16-17). The effect of increasing outflow had to be interpreted with respect to each species' life history because the location of a particular life stage influenced its response to changing hydrodynamics.

Winter-spring Delta outflows may play an important, but as yet poorly understood, role in the productivity and biological diversity of the Bay. Peak flow events and gravitational currents may transport nutrients into the Bay and disperse immature fish to estuarine nursery habitat species which DFG reported showed a positive response when Delta outflows increased (DFG,60) include Bay shrimp, several gobies, starry flounder, Pacific staghorn sculpin, longfin smelt, and English sole.

Future studies of Bay fish are needed to identify critical food chain relationships and the flow and water quality requirements of key species. Studies should concentrate on selected species within the Bay community identified as indicators of community viability and productivity.

Although the evidence presented by DFG in the Phase I hearing adds to knowledge of Bay fish, no specific salinity or outflow regimes were identified as being necessary to protect Bay fishery resources. From the available information, it would be premature to do so at this time. However, it should be noted that the Bay fish community appears well adapted to current variations in outflow and salinity and that potential future appropriations that reduce this variability may reduce the productivity of Bay fish and/or their adaptability. Unless it is determined that objectives proposed for the protection of other beneficial uses provide inadequate protection for Bay finfish, no specific objectives will be set for this beneficial use.

4.5.3 Ocean Habitat

Testimony concerning outflows from San Francisco Bay described two main effects on ocean habitat. The first is that the plume of freshwater in the Gulf of the Farallones provides for an abundant amount of marine life and thus serves as a concentrated feeding habitat for fish, marine mammals and birds (T,LIV,152:22-153:1). Two bird species which particularly use this plume area are the Brandt's cormorant and the common murre (T,LIV,154:3-13). The second effect of San Francisco Bay outflow is related to the movement of organisms, especially the larvae and juveniles of finfish and shellfish, into the Bay (T,LI,267:23-268:4). In certain cases, such as for bay shrimp, movement of larvae out of the Bay into the Gulf of the Farallones and their return later in the year is facilitated by higher Bay outflows (T,LI,272:6-19). In some circumstances, pulse flows, and their timing, were shown to be important in the determination of abundance of larvae (T,LI,289:5-25). The larvae or adults of English sole, Dungeness crab, Pacific herring and northern anchovy are transported back into the Bay on the bottom current inflows generated by the lighter, less saline freshwater flowing out of the Bay (see gravitational circulation; 3.6.2.1, south Bay) (T,LI,292:15-25).

The testimony presented general relationships between Bay outflow and the abundance of various species. However, there was no quantification of the relationship between specific levels of outflow and the effects on these species. Testimony from PRBO indicated that studies have not yet been done to relate the size of the plume to the volume of freshwater flowing from San Francisco Bay (T,LIV,155:15-156:6). No relationship has been established between the amount of freshwater outflow and the productivity of the plume (T,LIV,169:18-20;). Likewise, DFG has not yet been able to quantify the relationship between flows and their effects on various species (T,LI,300:5-8). No recommendations were given for any particular volume or timing of San Francisco Bay outflows, nor for any periodicity or volume of pulse flows to provide protection for beneficial uses in the ocean habitat. Any ocean outflows must be viewed in the context of the effects of water flows in the Estuary as a whole. As DFG pointed out, it is not appropriate to attempt to compartmentalize these effects for the ocean alone (T,LI,293:7-17;T,LIII,49:4-13).

Because of the lack of quantifiable data, and the absence of specific recommendations for flows to protect beneficial uses in the ocean habitat, no specific recommendations for flow or salinity will be made for the ocean habitat. If quantitative data become available that relate Bay outflow to ocean habitat, and if a determination can be made that objectives for the Estuary provide inadequate protection for the ocean habitat, this issue may be reviewed again.

4.6 Estuary Wildlife Habitat Beneficial Use

4.6.1 Delta

In the Delta there are 600,000 acres of agricultural land on the leveed islands and uplands, of which 515,000 acres are cultivated; about 7,000 acres are riparian woodland and scrub/shrub vegetation; 7,000 acres are freshwater marsh; 50,000 acres, water surface; 42,000 acres, grasslands and uplands; and about 32,000 acres of the Delta are urban—for a total of 706,000 acres (DFG,6,1). Freshwater marsh and riparian growth provide the habitats which support the greatest diversity of plant and animal species (DFG,6,4). The agricultural areas have supported from 450,000 to 600,000 migratory waterfowl during the winter, with thousands of shorebirds and wading birds making use of the shallows of seasonally flooded fields (DFG,6,4).

Over 230 species of birds and 43 species of mammals occur in the Delta (DFG,6,1). There are also 15 reptile species and eight amphibians reported or thought to occur in the Delta (Delta Wildlife Habitat Protection and Restoration Plan; DFG, USFWS, 1986). Many of these animals are so uncommon they have been identified on official lists of rare, threatened or endangered species by wildlife agencies. Seven bird species are listed by either the state or federal government as threatened or endangered. Two more bird species are candidates for federal listing (DFG,6,3;USFWS,19,20,21). The giant garter snake is a state-listed threatened species as well as a candidate for federal listing as either threatened or endangered (DFG,6,3; USFWS,22). Two mammals, the riparian brush rabbit and the riparian woodrat are candidates for federal listing as threatened or endangered; three invertebrates also are federally listed as threatened or endangered and thirteen plants are listed by federal and/or state agencies as rare, threatened or endangered (DFG,6,3).

In the Delta, wildlife habitat and wildlife are dependent upon water quality and flow in the channels and upon cropping patterns on the cultivated land. Migratory waterfowl in particular use spilled and unharvested corn and other grain crops, especially when Delta islands are allowed to be ponded or flooded for leaching purposes (DFG,6,4). The quality of water available in Delta channels can affect waterfowl and migratory bird use, as they are influenced by the crops planted and leaching frequencies. Fewer grain crops and less frequent flooding would reduce use by waterfowl such as Aleutian Canada geese, tule white-fronted geese, tricolored blackbirds, as wellas sandhill cranes which now depend on wet or flooded pasture and cultivated grains (DFG,6,4 and 7). The peregrine falcon may also be affected by changed waterfowl abundance because of the importance of waterfowl in their diet (USFWS,17,2).

Swainson's hawk, black rail, yellow-billed cuckoo, riparian brush rabbit, riparian woodrat and giant garter snake are species which would be affected by changes in water quality and flow to the degree that such changes lead to contamination of, or a reduction in, the natural habitat of the Delta (T,XXX,5:23-25). Vegetation changes which reduce the acreage of freshwater marsh and riparian forest or scrub/shrub would also have an adverse effect.

4.6.2 Suisun Marsh

Suisun Marsh, with an area of 116,000 acres, is the largest contiguous brackish water marsh in the United States (T,XXX,12;DFG,5,1). The major habitat types are managed marsh, subject to controlled inundation and drainage (generally for the enhancement of waterfowl habitat), and tidal marsh influenced by the water regime in the channels. There are also substantial areas of habitat consisting mostly of annual grasses and weedy growth, cropland and open ground. Between 54,000 acres (T,XXX,110:4-5) and 57,000 acres (DFG,5,3) are marshland, of which approximately 10,000 acres are tidal marsh (T,XXX,49:21,110:5). Estimates differ in regard to what proportion of the marsh acreage is managed and what is tidally influenced, depending on the definitions used and the areas examined. By all estimates the large majority (80 to 90 percent) of marshland is managed for plant species considered beneficial to wintering waterfowl (DFG,5,6).

The principal waterfowl species using Suisun Marsh in winter are pintail, mallard, shoveler, widgeon and green-winged teal; mallard, gadwall, and cinnamon teal breed here. The plants which are preferred food items for wintering waterfowl are alkali bulrush, brass buttons, and fat-hen (DFG,5,9). During the remainder of the year, invertebrates are important food for pre-nesting females and broods of ducklings (DFG,5,13).

Besides waterfowl, several state or federally listed animals and plants exist in the Marsh. Animals include salt marsh harvest mice, clapper rail, and black rail; plants include Mason's lilaeopsis, Suisun aster, Delta tule pea, and salt marsh bird's beak. These animals and plants are likely to be affected by changes in flow and salinity in the Marsh (T,XXX,68:24,136:3-25;BAAC,4). Increased salinity in tidally influenced channels will cause an increased physiological stress on plants, resulting in decreased reproduction and productivity, eventually leading to changes in the plant and dependent community (CNPS,1,5-8). Water quality standards lower than present levels, i.e., higher TDS levels (T,XXIX,210:9-12), will increase plant stress, decrease photosynthetic productivity of marsh plants, kill salt-sensitive species, retard growth of new plants, and reduce plant species diversity (CNPS,1,10).

4.6.3 Other Tidal Marshes

San Francisco Bay's tidal marshes, ranging from fresh to salt habitats, include 53 square miles of tidal marsh, 15 square miles of diked marsh and 55 square miles of diked ponds (DFG,7,1). Major areas of tidal wetland occur on the northeast shore of San Pablo Bay, specifically Tubbs Island, Napa and Petaluma Marsh. Diked marshes, ponds and mudflats are extensive in the south Bay (DFG,7,1).

Bay area wetlands and aquatic habitats support over half of the Pacific Flyway's wintering population of such waterfowl as canvasback ducks and are very important for scaup, scoters and redhead ducks. A variety of species of wildlife listed as threatened or endangered by state or federal wildlife agencies depend on Bay habitats for all or part of the year. Salt marsh harvest mice, California clapper rail, black rail, California brown pelican, and California least tern are listed (DFG,7,13). In Bay marshes, salt marsh bird's beak and Mason's lilaeopsis, are listed by the state as rare plants. Both plants are dependent on brackish or salt marsh conditions (T,XXX,70:19-23;T,XXX,76:5-22) and occur near the upper reaches of the Bay.

Aquatic habitat and aquatic invertebrates are important in their contribution to the food supply of higher forms of Bay wildlife. One of the most important food items for canvasback ducks is the clam Macoma balthica and two other molluscs, Mya arenaria and Musculus senhousia are also extensively eaten. These molluscs are also food for clapper rail, as are a variety of other invertebrates (DFG,7,9).

Although many Bay tidal marshes are relatively isolated from Delta outflow and salinity, the nearby Bay waters are affected by stratification, gravitational circulation, and flushing induced by outflow. To the degree that mollusc and fish species and aquatic habitat productivity changes in the Bay, the value of the adjacent marshes and beaches for sensitive wildlife, such as rails, terns, and pelicans, may change (DFG,7,10-12).

4.7 Estuary Recreation Beneficial Use

The waters of the Estuary are used for a variety of contact and non-contact forms of recreation, among them, swimming, boating, fishing, hunting, water skiing, and houseboating. The waters are also used for competitive events, marine parades and emerging activities, such as boardsailing and jetskiing (EBRPD,1-33). There are also a variety of water-oriented, non-contact activities such as sightseeing, whale-watching, bird watching and beachcombing, all of which depend on the esthetics or visual quality of the Estuary's waters to some degree (EBRPD,1-33).

4.7.1 Sacramento-San Joaquin Delta and Tributaries

Evidence was provided which projected user days and economic values for freshwater recreation in the Delta as compared to similar types of recreation at storage and export reservoirs and facilities (SWC,65,24). Freshwater-oriented recreation in the Delta was estimated to be 8.3 million user days in 1977-78, although this number includes some activities which do not depend entirely on the Delta's waters. Brackish water, ocean and estuary activities were not included in the total (SWC,66,5). Testimony and evidence were also provided which indicated that recreation visits to Estuary shoreline park facilities have been growing rapidly compared to the projections used by SWC, i.e., 122 percent in two years vs. 0.8 percent/year (EBRPD,24,T.1). Millions of user days and daily values of $20 or more for water use are calculated for recreational use of Estuary water (BISF,38,T4). Flow and salinity objectives which affect those uses, either in the area of origin or in the export area, will have an economic effect, but no testimony or evidence addressed quantitative effects of particular objectives on recreational uses. An extrapolation of old studies of Delta recreation has generated estimates in the range of 13 million recreation days annually (PICYA,2,51). Testimony by SWC suggested that these estimates were high and should be reduced to 6.95 million. However, no current information, based on recreation use studies, during this decade is available (T,LV,137:13-16).

There is also little evidence of the degree to which the Estuary's water recreation would be affected by flow or salinity. Submittals by SWC argued that recreation in the Delta depends on the surface acreage and has little or no relationship to changes in flow of freshwater (SWC,66,14). On the other hand, there was no evidence given as to the impacts of salinity on corrosion, growth of fouling organisms which might grow on boats moored in the Delta, or the costs of piling replacement if marine boring organisms penetrated further into the Delta as a result of higher salinity or more prolonged intrusion of marine water into the Delta.

4.7.2 Suisun Marsh and Carquinez Straits Area

Some evidence was submitted on the recreational use of the Suisun Marsh or Carquinez Straits area of the Bay-Delta Estuary. BAAC submitted evidence inferring that bird watching goes on in the Suisun Marsh (BAAC,20;26;27). From evidence submitted by EBRPD, estimated recreation at its Contra Costa shoreline facilities (Antioch and Martinez shoreline) has increased rapidly from 1981 to 1987, growing from 84,000 visitors to 287,000 visitors, or about 340 percent in six years (EBRPD,34,T1). Although there is little evidence linking the quantity of recreation in this reach to flow and salinity of the water, both BAAC and EBRPD expressed concern that visitors to these recreational areas would experience losses of the value they place on wildlife and fish resources which might be harmed if flow decreased and salinity increased (T,XXX,45:12-23;T,LV,184:15-25,185:1-2).

The rate of growth of recreational use in EBRPD units with water quality problems, Point Isabel and San Leandro Bay, increased from 71,000 to 487,000 users between 1981 and 1987, an increase of over 680 percent (EBRPD,34,T1). This occurred despite serious heavy metal contamination at these beaches. In comparison, the rate of growth at the nearby, unpolluted Hayward and Miller-Knox shorelines has moved from 21,000 users to 196,000, an increase of 930 percent in the same time. Without specific information on the features which prompt users to attend the various park units, or the measurement method by which use estimates were made, it is probably unrealistic to use these figures to show that visitation and recreational use would be harmed by changes in water flow or salinity. Moreover, it is noteworthy that users did not avoid contaminated sites, and it does not seem reasonable to suppose that a moderate change (of one or two parts per thousand) in salinity would substantially change future recreational use. This might not be true if the change were such as to convert a freshwater beach to saltwater; however, no data are in the record on this subject.

4.7.3 San Francisco Bay and Adjacent Ocean

The Basin Plan for Region 2, the San Francisco Bay Basin, identifies most of the same forms of recreation as the Delta. Recreational uses are also identified for the Pacific Ocean and the San Francisco Bay system and all other surface waters (RWQCB,2.1975). Water-oriented recreation in the San Francisco Bay area was estimated to total over 127 million user days (BISF,38,T3).

Evidence was presented that outflow to the Bay and Pacific Ocean and resultant salinity changes may affect recreation, but quantification was not made available. The Basin 2 Plan specifies a salinity standard in ocean waters requiring no significant variation beyond present natural background levels. A significant variation is "defined as any level of water quality which has an adverse and unreasonable effect on beneficial water uses or causes nuisance" (RWQCB 2,1975,3-3). Several participants presented testimony to the effect that past flow and salinity changes have impaired recreational beneficial uses, and that future flow and salinity changes could impair them further (BISF,38,40,41,46; EBRPD,34). Other parties submitted testimony and evidence which proposed that ecosystem changes in flow or salinity would also adversely affect recreational uses (BAAC,4;BCDC,1;BISF,50,51; PRBO,2;TIBCEN,1,2).

4.8 Other Beneficial Uses

4.8.1 Navigation

Navigation in the Estuary includes both commercial and recreational activities. There are seven major ports in the Estuary (San Francisco, Oakland, Alameda, Redwood City, Richmond, Stockton, and Sacramento), serving more than 5,000 ships annually (NOAA,1986,89); there arealso numerous oil transfer terminals located between Richmond and Suisun Bay. In 1984, imports at the Estuary's seven major ports were worth $10,419,000, while exports were worth $6,295,000 (NOAA,1986). Six million tons of cargo have been transported annually in Stockton and Sacramento deep-water ship channels (DWR,1987,60). In 1985 there were 143,646 recreational boats registered in the nine counties surrounding San Francisco Bay (NOAA,1986,74), and about 82,000 pleasure boats are registered in the Delta area (DWR,1987,60). These Delta area boaters are served by more than 8,500 berths, 119 docks and 27 launching facilities (DWR,1987,60).

Navigation is enhanced by a network of deepwater channels to the major ports. Extensive dredging is required to maintain these channels; in 1985, for example, nearly 8.6 million cubic yards of material were dredged in the Estuary at a cost of more than $17 million (NOAA,1986,97).

These channels have two major effects on the Estuary. The deeper channels allow increased salt water intrusion into the Estuary (T,LVI,176:9-178:8;DWR,709,1-2). This increased salinity may have impacts on other beneficial uses such as recreational boating which

Export

would see greater maintenance costs from hull fouling, corrosion of propellers and structures, and related problems (T,LV,158:1-7). The second effect is the impact of dredging and dredge spoils disposal on water quality (see, for example, T,XLVIII,71:20-102:9). This impact will be discussed in the Pollutant Policy Document.

On the other hand, water quality constraints to protect other beneficial uses may affect navigation. Objectives set for salinity and flow may, for example, influence the costs of maintaining or increasing the depths of existing channels (DFG & USFWS,1980,2-15). Closure of the Delta Cross Channel gates also prohibits recreational boaters from using the Cross Channel as a shortcut between the Sacramento and Mokelumne rivers.

Navigational requirements also have direct effects on the Sacramento River. The 5,000 cfs minimum at Wilkins Slough, just below Tisdale Wier, that the CVP is required to provide (T,I,43:15-21), sustains a minimum flow in the Sacramento River in the absence of other regulations.

The SWP and CVP export pumps currently operate under U.S. Army Corps of Engineers (COE) criteria. Maximum flow rates for Clifton Court Forebay are stipulated for various times of the year (DWR,708,10). Operations deviating from these criteria, such as additional export with the four new SWP pumps now under construction, will require a new permit from the COE (DWR,1982,7).

4.8.2 Dilution of Pollutants

Freshwater flows to dilute pollutant burdens in the Estuary and upstream was the subject of considerable testimony, much of which concerned "flushing flows" to reduce pollutant burdens in south San Francisco Bay. Burdens here tend to be higher because of limited exchange of water between South Bay and the ocean in the absence of substantial freshwater inflows to drive the exchange.

Evidence received on pollutants will be used by Regional Boards 2 and 5 to update their basin plans. The State Board will provide guidance to the Regional Boards in the development of pertinent provisions of these plans and will review and approve Regional Board updates. During the final phase of the hearing, the Board will evaluate whether the source control of pollutants proposed by the Regional Boards is sufficient to protect beneficial uses in the Estuary. The need for dilution or flushing flows through water right amendments may be considered only after all reasonable source control methods have been implemented.

4.9 Uses of Water Exported From the Bay-Delta Estuary

The following sections address water use in the areas of export, that is, the areas defined for purposes of this Plan as being outside the legal boundary of and receive water diverted from the Bay-Delta Estuary.

4.9.1 Municipal and Industrial Uses

The majority of California's population lives in semi-arid areas where population and industrial expansion have exceeded the ability of many communities to meet their water needs with local sources.

Local as well as distant communities have seen the Estuary's waters as a means to meet their needs. Municipal and Industrial (M&I) water exports to local areas outside the Estuary began in 1929 when EBMUD initiated the first export of Delta supplies by diverting Mokelumne River water through its Mokelumne Aqueduct to Alameda and Contra Costa counties. In 1934 San Francisco began diverting water from the Tuolumne River through the Hetch Hetchy Project for use in San Francisco, San Mateo, and Alameda Counties. In 1940 the Contra Costa Canal (CCC), the first unit of the CVP, was completed and began supplying water to the Antioch-Pittsburg area. The City of Vallejo began importing Delta surface water from Cache Slough in 1953. USBR began diverting Putah Creek water via the Putah South Canal to Fairfield and Benicia in 1957. In 1965 the South Bay Aqueduct of the SWP began exporting an interim supply of Delta water from the Delta-Mendota Canal (DMC) to Alameda and Santa Clara Counties. The North Bay Aqueduct Phase II facilities of the SWP divert Delta waters from Barker Slough tributary to Lindsey and Cache sloughs, and connect with the Phase I facilities just west of Cordelia. Water will be delivered to Solano and Napa counties (DWR,207,1-7).

The first non-local, statewide exports began in 1968 when the federal Central Valley Project began exporting water to the municipalities of Coalinga, Huron and Avenal through the DMC and San Luis Canal (DWR,204,1). In 1971 the SWP's California Aqueduct began exporting water to southern California through the Edmondston Pumping Plant over the Tehachapi Mountains (DWR,207,1-7).

CVP statewide M&I deliveries are approximately 430,000 AF/yr with a projected delivery in the year 2010 of 1,033,116 AF/yr (Table 4.9.1-1)(USBR,1987). In 1985, SWP statewide M&I deliveries were approximately 1,008,000 AF/yr (Table 4.9.1-2)(DWR,461,1). No estimate of SWP projected deliveries to southern California was presented. Table 4.9.1-3 lists state and federal water transfer facilities and the areas each serve.

Population and economic projections indicate growing M&I water demands. The Department of Finance has estimated that the state population will increase from 27,000,000 people in 1986 to 36,280,000 people in 2010 (DOF,1987). Of this, the population of the six most populated counties in southern California--Ventura, Los Angeles, Orange, Riverside, San Bernardino, and San Diego--are expected to increase from a 1986 level of 15,290,000 people to 20,220,000 in 2010 (SWC,6,7).

Table 4.9.1-1

Municipal and Industrial Water Contracts
Central Valley Project
(acre-feet)

SACRAMENTO VALLEY AND AMERICAN RIVER SERVICE AREAS c/

Contracting Entity	Contract Maximum a/	1986 Deliveries b/	Projected 2010
Bella Vista WD d/	7,000	2,060	7,000
City of Folsom d/	22,000	15,042	22,000
City of Redding d/	21,000	10,424	21,000
City/Redding(Buckeye)	6,140	2,320	6,140
City/Redding(Buckeye)	40	40	0
City of Roseville	32,000	11,591	32,000
City/Sacramento(AmRv) d/	326,000	71,331	227,500
City/Sacramento(SacRv) d	above	18,896	above
Clear Creek CSD	10,300	1,346	6,400
County of Colusa	40	40	40
Diamond International	510	0	510
Diamond International d/	425	425	425
East Bay MUD	150,000	0	20,000
East Yolo CSD	9,290	0	8,860
El Dorado ID	2,875	3,006	2,875
El Dorado ID	7,500	1,540	7,500
Elk Creek CSD d/	100	96	100
Folsom Prison d/	4,000	1,432	4,000
Foresthill PUD	2,500	1,084	2,500
G.W. Williams	130	0	130
Keswick SD	500	140	300
Lake CA (Rio Alto)	200	200	200
Louisiana Pacific d/	25	26	25
Mather AFB (temporary)	350	271	350
Mountain Gate	350	457	350
Napa Co. FCWCD	7,500	3,167	1,500 e/
Parks & Recreation d/	5,000	15	15
Placer Co. Water Ag. d/	150,000	4,921	75,000
Riverview Golf Club d/	280	280	280
San Juan Suburban WD	5,600	7,840	5,600
San Juan Suburban WD d/	33,000	23,100	33,000
Shasta County WA	5,000	162	2,800
Shasta CSD	1,000	602	1,000
Shasta Dam PUD	3,227	1,573	3,227
So. Cal. Water Co. d/	10,000	1,612	10,000
Sacramento MUD	7,500	3,167	1,500
Summit City PUD	1,170	300	1,170
U.S. Forest Service	10	10	10
Total Sacramento and American River	1,006,462	238,839	629,407

SAN JOAQUIN VALLEY SERVICE AREAS

Contracting Entity	Contract Maximum a/	1986 Deliveries b/	Projected 2010
Arvin Edison WSD	500	0	500
Arvin Edison (Cross Val.)	500	0	500
Broadview WD	20	23	20
City of Avenal	3,500	1,257	3,500
City of Coalinga	10,000	6,000	10,000
City of Fresno	60,000	45,000	60,000
City of Huron	3,000	828	3,000
City of Lindsay	2,500	2,021	2,500
City of Orange Cove	1,400	422	1,400
City of Tracy	10,000	5,734	10,000
Contra Costa WD	195,000	124,386	195,000
County of Madera	200	30	200
County of Tulare	1,345	1	1,345
Fresno County WW#18	150	59	150
Musco Olive Prod. (temp)	--	0	--
Pacheco WD	80	12	80
Panoche WD (DMC)	37	18	37
Panoche WD (SLC)	63	23	63
San Benito WD	8,250	0	6,680
Santa Clara WD	128,700	0	117,200
San Luis WD (DMC)	140	109	140
San Luis WD (SLC)	440	387	440
State of Calif.	10	10	10
Stockton-East WD	10,000	0	8,000
Tracy Golf Club-CA (temp)	--	451	--
Westlands WD	10,000	5,917	10,000
Total San Joaquin	418,779	192,690	403,709
Total Sacramento and San Joaquin	1,425,239	431,529	1,033,116

a/ Quantity is a contract maximum or is projected M&I use within a combination M&I/agricultural water service contract.
b/ Deliveries may include water transferred from other contractors or purchased under provisions of the contract and may therefore be higher than contract maximum.
c/ Includes Solano FCWCD and Napa Co. FCWCD of Solano Project.
d/ Contract includes water rights; no payment is made to the United States for water rights water.
e/ Present use includes City of Napa which will cease when North Bay Aqueduct completed.

Source: USBR, Factsheet: "Exhibits and Testimony before SWRCB, Bay-Delta Hearing, 1987", 1987.

Table 4.9.1-2

SWP WATER DELIVERIES FOR AGRICULTURE, MUNICIPAL AND INDUSTRIAL USES, RECREATION USE AT SWP FACILITIES AND HYDROELECTRIC ENERGY, 1962 to 1985.

	Water Delivered (Acre-Feet)								
	Entitlement Water			Other Deliveries					
Year	Municipal & Industrial Use	Agricultural Use	Total	Municipal & Industrial Use	Agricultural Use	Other Water a/	Total Delivery	Recreation Supported (Recreation Days) b/	Hydro-Electric Energy Generated (megawatt-hours) c/
1962						18,289	18,289	30,000	
1963						22,456	22,456	105,000	
1964						32,507	32,507	331,600	
1965						44,105	44,105	449,800	
1966						67,928	67,928	482,700	
1967	5,747	5,791	11,538	0	0	53,605	65,143	455,200	
1968	46,472	125,237	171,709	10,000	111,534	14,777	308,020	931,300	628,000
1969	34,434	158,586	193,020	0	72,397	18,829	284,246	1,554,800	2,614,000
1970	47,996	185,997	233,993	0	133,024	38,080	405,097	1,804,800	2,679,000
1971	85,286	272,054	357,340	2,400	293,619	44,127	697,486	2,085,900	3,302,000
1972	181,066	430,735	611,801	22,205	401,759	73,127	1,108,892	1,971,200	1,922,000
1973	293,824	400,564	694,388	3,161	293,255	43,666	1,034,470	2,502,000	3,298,000
1974	418,521	455,556	874,077	4,753	412,923	48,342	1,340,095	4,073,600	4,672,000
1975	641,621	582,369	1,223,990	21,043	601,859	67,170	1,914,062	4,189,300	3,159,000
1976	818,588	554,414	1,373,002	32,488	547,622	116,962	2,070,074	4,239,600	2,131,000
1977	280,919	293,236	574,155	0	0	390,176	964,331	3,951,900	958,000
1978	742,385	710,314	1,452,699	3,566	13,348	122,916	1,592,529	5,773,700	2,882,000
1979	690,659	969,237	1,659,896	66,081	582,308	189,396	2,497,681	5,298,700	2,485,000
1980	730,545	799,204	1,529,749	19,722	384,835	48,590	1,982,896	5,701,900	2,988,000
1981	1,057,273	852,289	1,909,562	12,000	896,428	283,849	3,101,839	6,017,800	3,358,000
1982	928,721 e/	821,303	1,750,024	0	215,873	155,820 e/	2,121,717	6,187,700	5,097,000
1983	483,499	701,370	1,184,869	0	13,019	188,596	1,386,484	5,838,200	5,419,000
1984	723,468 f/	865,043	865,043	3,663	259,254	387,505 f/	2,238,933	6,273,100	3,368,000
1985	998,138	1,002,915	2,001,053	9,638	292,372	414,566	2,717,629	6,639,800	3,227,000
Total d/	9,209,162	10,186,214	19,395,376	210,720	5,525,429	2,885,384	28,016,909	76,889,600	54,187,000

a/ Includes preconsolidation repayment water, emergency relief water, exchange water, regulated delivery of local supply, non-SWP water delivered to Napa County FC&WCD through SWP facilities, conveyance of CVP water (including Decision 1485 water), recreation water, and demonstration ground water fill withdrawal.
b/ A recreation day is the visit of one person to a recreation area for any part of one day.
c/ Includes SWP share of generation from Hyatt-Thermalito, San Luis, Devil Canyon, Warne, and Castaic Powerplants.
d/ In addition, SWP dams have prevented millions of dollars worth of flood damage.
e/ Revised and corrected from, Bulletin 132-85 to reflect 557 acre-feet of 1978 exchange water (MWDSC Basin) changed from other water to municipal and industrial use entitlement water.
f/ Revised and corrected from, Bulletin 132-85 to reflect 126 acre-feet of 1982 exchange water (MWDSC Basin) changed from other water to municipal and industrial use entitlement water.

(DWR,461)

TABLE 4.9.1-3
DELTA DRINKING WATER DIVERSIONS AND AREAS SERVED[1/]

Diversion Point	Area Served
State	
North Bay Aqueduct (Cache Slough)	Solano-Napa County Fairfield Vacaville Vallejo Benicia Napa American Canyon
South Bay Aqueduct (Clifton Court)	Livermore Valley Alameda CWD Santa Clara Valley WD
California Aqueduct	Avenal Coalinga Kern County WA Antelope Valley MWDSC San Diego CWA Crestline-Lake Arrowhead San Bernardino Valley Palm Springs Indio
Federal	
Contra Costa Canal (Clifton Court)	Concord Oakley Pittsburg Antioch Martinez Pleasant Hill Walnut Creek
Delta-Mendota Canal (Old River)	Tracy Huron Dos Palos

1/ SWC,76,6

The expected additional M&I demand for Bay-Delta water supply is a result both of the loss or degradation of alternative water supplies and of increases in population (SWC,4,6). Supreme Court decisions on the Colorado River have reduced MWD's supply of water by 692,000 AF/yr(SWC,3,2). Ground water pollution and overdraft have restricted the use of some ground water basins (SWC,3,9). Studies performed by DWR indicate a shortage of 1.4 MAF between existing dependable supplies and projected needs in southern California by 2010 (SWC,3,2; DWR,707,43). 17

Water loss by MWD

In the future the SWP and the CVP plan to expand deliveries to new areas and to areas experiencing increased need. SWP is studying a Coastal Branch which will supply water to Santa Barbara and San Luis Obispo counties, and an East Branch enlargement which will increase deliveries to the eastern part of the Metropolitan Water District's service area. CVP is studying an extended San Felipe Branch which will supply water to Monterey and Santa Cruz counties, as well as an American River Aqueduct which will increase deliveries to EBMUD's service area in the Bay Area. SWP is also planning transfer and storage facilities that will increase its water distribution capabilities at these locations: the Kern Water Bank, Los Banos Grandes Reservoir, the South Delta, and North Delta Facilities and additional pumps at the Delta Pumping Plant (DWR,707,42-53).

export expansion plans

1/ One of the assumptions of this study was that the maximum salinity level allowable at Clifton Court would be set at 100 ppm chlorides, a project goal. The SWRCB objective for export use at this location is 250 ppm chlorides. Using information from DWR studies, SWRCB staff estimated that the additional volume of water needed to meet the 100 ppm chloride level project goal at Clifton Court can be as much as 200,000 acre-feet per year.

WSSW

4.9.2 Agriculture

The CVP and SWP export water from the Estuary to support many farming and ranching operations (RWQCB 5, 1975). The main area of agricultural use of export waters is the San Joaquin Valley; three of its counties, Fresno, Kern, and Tulare, ranked first, second, and third in the nation in gross cash receipts from annual farm marketing in 1982 (CVAWU,41). The SWP exports water for agricultural use primarily in the Tulare Lake Basin, with smaller amounts exported to other areas. The CVP exports water for agricultural use as shown in Table 4.9.2-1.

TABLE 4.9.2-1
CVP EXPORT AREAS

Export Area	CVP Unit
San Joaquin Basin	Delta Mendota Canal San Luis Mendota Pool
Tulare Lake Basin	San Luis Cross Valley Canal
Contra Costa County	Contra Costa Canal

The recently completed San Felipe Unit of the CVP will soon make deliveries to Santa Clara and San Benito counties.

By 1970 the entitlement of agricultural contracts (including exchange contractors[1/]) to CVP export waters totaled over two million AF/yr (CVPWA,10-1). With the addition of the Cross Valley Canal Unit and expansion of the San Luis Unit, the 1980 total was almost 2 1/2 million AF/yr (CVPWA,10-1).

During the 1985 Water Year, the various units of the CVP exported a total of about 2,750,000 acre-feet of water to serve 1,220,000 acres (Table 4.9.2-2).

1/ Exchange contractors formerly diverted from the San Joaquin River, but exchanged their diversion rights for a contract that granted more consistent water supplies from the DMC. The maximum contractual entitlement of these users is 840,000 AF/yr (USBR,1987).

TABLE 4.9.2-2
AGRICULTURAL WATER EXPORTS AND SERVICE AREAS
BY CVP UNIT FOR THE 1985 WATER YEAR

CVP Unit	Water Exported (AF)	Area Served (ac)
Delta Mendota Canal (including exchange contractors)	1,050,000 (CVPWA,11;USBR, 1984;USBR,1985)	356,000 (T,XXVI,186:6-8,11-17)
San Luis	1,545,000 (CVPWA,11)	698,000 (T,XXVI,186a:24)
Mendota Pool	94,000 (CVPWA,11)	42,000 (T,XXVI,187:14)
Cross Valley Canal	64,000 (CVPWA,11(b)-3)	125,000 (CVPWA,11(b)-3)
Contra Costa Canal	895 (T,XXVI,185:16-21)	---
TOTAL	2,754,000	1,221,000

Although the recently completed San Felipe Unit began making deliveries in mid-1987, two contracts have been executed for a total of 68,600 AF/yr (T,XXVI,194:2-8). The projected water use by the existing CVP contractors is not expected to differ substantially from this 1985 Water Year level (T,XXVI,208:6-8). However, additional CVP supplies are needed to help solve ground water overdraft (T,XXVI, 209:6-13).

SWP export process

The SWP exports water for agricultural use via the California Aqueduct to Oak Flat WD in the San Joaquin Basin, to the Tulare Lake Basin and to southern California, and via the South Bay Aqueduct to Santa Clara and Alameda counties. The magnitude of SWP deliveries to the 13 southern California contractors for agricultural use was not identified in the hearing record. The annual SWP exports for agricultural use (excluding southern California) increased from about 237,000 AF in 1968 to about 1.3 million AF in 1985 (DWR,461). The future need for exported SWP water for agriculture should not change substantially from this 1985 amount (DWR,707,11). However, Kern County needs an additional 300,000 AF/yr to help solve its ground water overdraft problem (SWC,412,5).

The main change in agricultural production in the San Joaquin Valley since 1955 has been the increased acreage devoted to the production of vegetables, fruits and nuts (CVAWU,26). The acreage of vegetables increased from about 250,000 acres in 1955 to almost 400,000 in 1985. The acreage devoted to the production of fruits and nuts increased from about 550,000 acres in 1955 to about 1,300,000 acres in 1985 (CVAWU,26). The acreages of field crops and seeds in the San Joaquin Valley have remained relatively stable since 1955. Overall, the acreage devoted to these four major commodity groups (vegetables, fruits and nuts, field crops, and seeds) in the San Joaquin Valley has increased only about 25 percent from 1955 to 1985, from about 3.7 million acres to about 4.6 million acres (CVAWU,26).

In 1985, the CVP units listed in Table 4.9.2-2 delivered over 2.7 million AF of water to over 1.2 million acres in the export areas of the San Joaquin Valley to produce crops with a gross value of about $1.2 billion (CVPWA,12;EDF,11,G-148) (Table 4.9.2-3).

TABLE 4.9.2-3
MAJOR CROPS GROWN IN THE CVP EXPORT AREA
BY ACREAGE AND GROSS CASH VALUE

Crop	Acreage[1/] (thousands of acres)	Gross Cash Value[1/] (millions of dollars)
Cotton	450	360
Alfalfa	100	70
Wheat	90	22
Tomatoes	80	130
Melons	50	130
Barley	40	6
Almonds	30	NA[2/]
Table Grapes	NA[2/]	80
Apricots	NA[2/]	60
Lettuce	NA[2/]	60
TOTAL	1,221	1,200

1/ CVPWA,12;EDF,11,G-148
2/ Not available

In 1985, the SWP delivered over 1.3 million AF of water to about 445,000 acres in the export agricultural areas of the San Joaquin Valley to produce crops with a gross value of about $431 million (DWR,489h)(Table 4.9.2-4).

TABLE 4.9.2-4
MAJOR CROPS GROWN IN THE SWP EXPORT AREA
BY ACREAGE AND GROSS CASH VALUE

Crop	Acreage[1/] (thousands of acres)	Gross Cash Value[1/] (millions of dollars)
Cotton	210	154
Alfalfa	40	27
Almonds	35	26
Wheat	30	9
Pistachios	18	28
Wine grapes	18	13
Table Grapes	6	28
Oranges	4	19
Carrots	5	18
Other	79	109
TOTAL	445	431

1/ DWR,489h

Since water usage and acreage for livestock, poultry, and dairy production were not identified in the hearing record by CVP or SWP export areas, an accurate account of the effect of export water on the market values of these products cannot be given. In addition, project export areas often use supplemental water supplies from ground water and local sources; only a part of the value of agricultural production in the export area can therefore be directly attributed to project exports. Only an indirect indication can be made from the fact that the market value of livestock, poultry and dairy products for the entire San Joaquin Valley in 1982 was over half the value of all crops (CVAWU,28):

	1950	1969	1982
Crops	$455 million	$933 million	$4,039 million
Livestock, Poultry, Dairy	$199 million	$751 million	$2,053 million

The hearing record does not indicate any present or anticipated future problem of adequate water quality for agricultural production in the export areas. However, three main problems have affected and will continue to affect the agricultural uses in the export areas: (1) drainage; (2) ground water overdraft; and (3) urbanization. The drainage problems on the west side of the San Joaquin Valley have been well documented. The water quality problems associated with drainage disposal threatens agricultural production in many parts of the export areas, e.g., Westlands WD and entities draining to Grassland WD (EDF,11,I-2 and I-3). The amount of land with drainage problems will increase in the export area. The use of evaporation ponds for drainage disposal removes agricultural lands from production, especially in the Tulare Lake Basin; ground water overdraft causes lowered water tables and land subsidence and in turn causes higher pumping costs or increased demand for export water; subsidence creates problems of soil compaction and unlevel fields. The overdraft problem is particularly widespread in the Tulare Lake Basin. Encroaching urbanization continues to remove agricultural land from production in the export area.

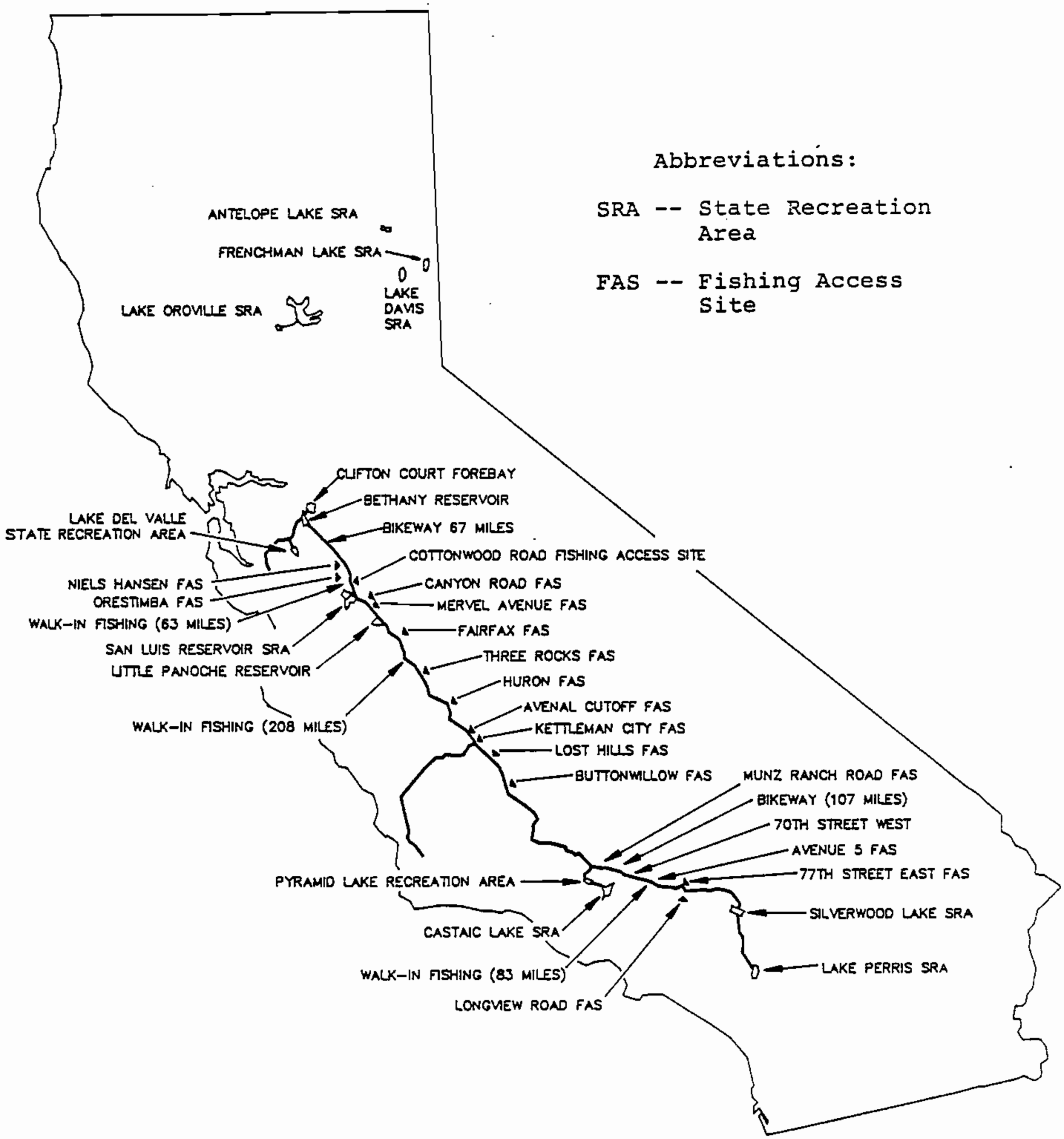
4.9.3 Fishery Habitat

Export fishery habitat consists primarily of the reservoirs and conveyance channels used for movement and storage of Bay-Delta water south of the Delta. In all cases this habitat may be classified as warm water fishery habitat. The major facilities discussed here and in Section 4.9.5 (Export Recreation) are:

- San Joaquin Valley and San Francisco Bay Area

  Delta-Mendota Canal, San Luis Canal, Edmund G. Brown California Aqueduct, Lake Del Valle, Bethany Reservoir, San Luis Reservoir (and O'Neill Forebay), and Los Banos Reservoir.

FIGURE 4.9.3-1 State Water Project Recreation Developments
(from: SWC, 65, 6)



SOURCE: DWR BULLETIN 132-86

o Southern California

West Branch California Aqueduct, East Branch California Aqueduct, Pyramid Lake, Castaic Lake, Silverwood Lake, and Lake Perris (SWC,65,6).

Recreational access at all SWP facilities is shown in Figure 4.9.3-1 (SWC,65,6). Expansion of this habitat will not occur unless additional facilities are built (e.g., Los Banos Grandes Reservoir) (DWR,707).

Some of the eggs and larvae of some fish entrained into the export pumps survive and develop in the aqueducts and some of the reservoirs such as Bethany Reservoir and San Luis Reservoir (and O'Neill Forebay) (SWC,65,45). The hearing record is unclear whether these populations are self-sustaining or are maintained by additional entrainment. In other reservoirs, the majority of fish are planted for recreational fishing (SWC,65,47) (see Section 4.9.5). (It was inferred from SWC,65,47 that DFG plants the fish in these reservoirs, but no direct evidence was presented.) No information was presented on which species are planted, or what percent of total statewide fish planting is dedicated to SWP facilities.

The aqueducts tend to provide a relatively stable habitat for fish because the export water quality is maintained for municipal and industrial standards, and because water depth in the aqueducts does not change. In some reservoirs such as San Luis, however, the habitat may change significantly due to either seasonal variation in temperature or drawdown to meet water demands. The San Luis Reservoir recreational storage objective for Labor Day is 6,900 acres of surface area, or approximately half the surface area of the full reservoir (DWR,708,14). However, this converts to an 83 percent reduction in storage and, therefore, in fishery habitat. Other reservoirs, especially the terminal SWP reservoirs in southern California, are operated to retain more stable water levels because of the level of recreational activity on them (T,39,122:2-9); DWR presented the specific operating criteria (DWR,708.)

4.9.4 Export Wildlife Use

Water exported from the Sacramento-San Joaquin watershed provides some wetland, aquatic, and riparian habitat wherever it is delivered. Examples of important wildlife uses may be found in a number of export areas (SWRCB,14,III-9). Water in SWP reservoirs and in wildlife areas in southern California provides aquatic habitat where there might formerly have been none or replaces wetland habitat which was damaged or destroyed by earlier urbanization or water development. Substantial waterfowl habitat for example is maintained with DMC water in the Grassland Water District, an area that formerly received water from San Joaquin River overflows and agricultural return flows which ceased when Friant Dam began operations (EDF,11,II-3). The quality of exported water generally meets the water quality needs of wildlife in the export areas, although supplies are unreliable (DFG,2,A-8). Attempts to develop more wildlife habitat by using agricultural drainage water have led to toxicity problems (EDF,11,II-11).

4.9.5 Export Recreation

The aqueducts and reservoirs in the SWP[1/] are used for recreation in both central and southern California. Fishing and bicycle riding are the main activities along the aqueducts, and numerous fishing access points are available along them (SWC,65,6)(see Figure 4.9.3-1). The reservoirs are used for a wide variety of water-contact and non-water-contact activities, including fishing, swimming, boating, waterskiing, camping, picnicking and bird watching (SWC,65,5). About five million visitors used the SWP facilities south of the Delta in 1985 and they spent an estimated $95 million to travel to and use these sites (SWC,65,7,14).More than one million game fish were stocked in 1985 (SWC,65,7) to support recreational fishing activity in the four southern California SWP reservoirs. No evidence was presented on alternative sites for freshwater recreation in southern California.

The water quality requirements for salinity and other constituents of SWP and CVP water to protect municipal and industrial uses also protect recreational uses. The aqueducts are usually full, and the southern California reservoirs are operated to minimize impacts on recreation during the peak recreation seasons (T,XXXIX, 122:2-9) primarily by limiting drawdown rates (DWR,708,15-18).

1/ Discussion is limited to recreational activities directly related to export facilities of the SWP. No information was provided on recreation at CVP export facilities other than those used jointly by the CVP and SWP, which are included in the SWP descriptions. These facilities are listed in Section 4.9.3 (Export Fishery Habitat).

References for Chapter 4

- Regional Water Quality Control Board #5, Water Quality Control Plan Report 5B, Volume I, 1975, pg. I-2-2.
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- Department of Water Resources, Bulletin 27 "Variation and Control of Salinity in the Sacramento-San Joaquin Delta and Upper San Francisco Bay", 1931, pgs. 21 and 47.
- State Water Resources Control Board, "Environmental Impact Report for the Water Quality Control Plan and Water Right Decision, Sacramento-San Joaquin Delta and Suisun Marsh", August 1978, pgs. 142,143.
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- Department of Water Resources. 1987. Sacramento-San Joaquin Delta Atlas.
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- RWQCB 5. 1975. Water Quality Control Plan Report, Sacramento River Basin (5A); Sacramento-San Joaquin Delta Basin (5B), San Joaquin Basin (5C). Volume I.
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CVAWD? CVPWA?

5.0 OPTIMAL LEVELS OF PROTECTION FOR BENEFICIAL USES OF BAY-DELTA ESTUARY WATER

5.1 INTRODUCTION

The levels of flow and salinity considered to be optimal for the protection of beneficial uses are presented in this chapter. The levels needed for protection are developed solely for the beneficial use being addressed; other beneficial uses are not considered. Three levels are addressed: (1) the no action alternative; (2) The advocated level(s); and (3) the optimal level of protection.

1. The no action alternative is considered to provide the minimum level of flow and salinity protection for the beneficial use being discussed. It is the level of protection currently existing at any particular site as a result of the Delta Plan, and the level considered to be in compliance with federal regulations protecting existing uses (40 CFR Section 131.3(e)and(f)[1/]. Those standards affecting South Delta Water Agency (SDWA) were held in abeyance, at their request, awaiting the results of negotiation among them, Department of Water Resources (DWR) and U.S. Bureau of Reclamation (USBR). Therefore, the existing 500 mg/l TDS standards for Vernalis contained in the New Melones water right permit is considered the "no action" value for this chapter. This standard would be in effect for this area if no further action occurred. Though water quality standards for San Francisco Bay were not explicitly addressed in the Delta Plan, the effects on the Bay were indirectly determined from Delta inflows regulated by the Delta Plan.

2. Advocated level(s) of protection are those recommended by witnesses during Phase I of the hearing. Testimony or exhibits that recommended flow and/or salinity levels to protect a specific beneficial use are summarized. (They are not given in any priority or ranking.)

3. The optimal level of protection can be considered the maximum level of protection possible for a beneficial use. This protection level is identified for a particular site when appropriate, and when data are available. The level can be the same as the two previous levels, if either provides optimal protection; or it can be a separate level based upon an independent evaluation of available data. The optimal level of protection will be used as a point of comparison for developing globally balanced objectives in chapter 6 and 7.

1/ The level of protection necessary to maintain the beneficial uses actually attained on or after November 28, 1975 level of protection. The level is mandated to the State Board by EPA regulations (40 CFR 131.12) and is considered to be the minimum protection which may be afforded a beneficial use.

5.2 Hydrologic Considerations

Flow and salinity at any particular location in the Delta is dependent upon Delta inflows, agricultural drainage return flows, consumptive uses, exports, and the placement of the Delta Cross-Channel gates. The major factors affecting the overall Delta flow and salinity are the magnitude and relative distribution of the Sacramento and San Joaquin river's inflows, since they are the major sources of water for the Delta. In the southern Delta, the flow and salinity is almost exclusively influenced by inflow and salt loading from the San Joaquin River due to its proximity to Vernalis. The internal Delta, on the other hand, is influenced to some degree by both river systems, especially when Delta exports are high. For the purpose of considering river effects on the beneficial uses discussed in this chapter, all of the Estuary locations were considered to be part of the hydrologic classification of the Sacramento River system except the following locations which were considered to receive water from the San Joaquin River system: San Joaquin River at Vernalis; San Joaquin River at Mossdale; San Joaquin River at the former location of Brandt Bridge; the bifurcation of Old and Middle River; Middle River at Howard Road Bridge; and Old River at Tracy Road Bridge.

5.3 DETERMINING THE OPTIMAL LEVEL OF PROTECTION FOR BENEFICIAL USES

5.3.1 Municipal and Industrial

5.3.1.1 No Action Alternative

Municipal and Industrial (M&I) use is currently protected by standards developed in the Delta Plan. These standards, listed in Table 5.3.1.1-1, cover both M&I categories of beneficial uses. The level of protection considered adequate to protect municipal uses was determined by the Delta Plan to be 250 mg/L chlorides. This level was not based on a primary health requirement, but on a secondary aesthetic requirement, set by the Department of Health Services (DHS).

The level set for the protection of industrial uses was determined to be 150 mg/L chlorides. This standard, intended to protect the historical water supply of two paper manufacturing industries provided a salinity necessary to maintain industry products.

5.3.1.2 Advocated Levels of Protection

The participating organizations making M&I recommendations have recommended that the Delta Plan be retained in total or in part to protect M&I use (DWR,280;T,LIX,189:1-7;T,VI,125:4-15). Modifications to the Delta Plan M&I standards were recommended by DWR, USBR, SWC, and CCWD. DWR and USBR are unified in their recommended modifications. SWC's recommended modifications fall within the recommendations made by DWR and USBR. The participants' recommendations are:

Table 5.3.1.1-1--Decision 1485
Water Quality Standards
For the Sacramento-San Joaquin Delta and Suisun Marsh 1/

Beneficial Use Protected and Location	Parameter	Description	Year Type 2/	Values
MUNICIPAL AND INDUSTRIAL				
Contra Costa Canal Intake at Pumping Plant No.1	Chloride	Maximum Mean Daily Cl^- in mg/l	All	250
Contra Costa Canal Intake at Pumping Plant No. 1 or Antioch Water Works Intake on San Joaquin River	Chloride	Maximum Mean Daily 150 mg/l Chloride for at least the number of days shown during the Calendar Year. Must be provided in intervals of not less than two weeks duration. (% of year shown in parenthesis)		Number of Days Each Calendar Year Less than 150 mg/l Chloride
			Wet	240 (66%)
			Ab. Normal	190 (52%)
			Bl. Normal	175 (48%)
			Dry	165 (45%)
			Critical	155 (42%)
City of Vallejo Intake at Cache Slough	Chloride	Maxium Mean Daily Cl^- in mg/l	All	250
Clifton Court Forebay Intake	Chloride	Maximum Mean Daily Cl^- in mg/l	All	250
Delta Mendota Canal	Chloride	Maximum Mean Daily Cl^- in mg/l	All	250

1/ All values for surface zone measurements. All mean daily values are based on at least hourly measurements. All dates are inclusive.

2/ The year for the preceding Water Year will remain in effect until the initial forecast of unimpaired runoff for the current Water Year is available.

- DWR, USBR, and SWC (where noted by reference)

  - Eliminate the 250 mg/l maximum mean daily chloride quality standard at Cache Slough. The City of Vallejo will divert water from the newly finished North Bay Aqueduct; the Cache Slough diversion point will only be used as a secondary M&I supply source (DWR,280).

  - Add a quality objective at the North Bay Aqueduct intake at Barker Slough. The recommended objective would be set at a maximum mean daily chloride level of 250 mg/l for all water year types. Barker Slough is an M&I diversion point for Napa, Vallejo, and Sonoma counties (DWR,280).

  - Eliminate the 150 mg/l chloride quality standard at both the Antioch Water Works Intake on the San Joaquin River and the Contra Costa Canal Intake at Rock Slough. This standard is set to protect industrial uses in the Antioch-Pittsburg area. The recommendation to eliminate this standard is based on the evidence indicating that diversion of water for industry of this quality at Antioch is not reasonable when considering the Delta outflow required to maintain it (DWR,280;T,LIX,149:12-20).

  - Add a quality objective at Old River near Rock Slough. The recommended objective would be set at a maximum mean daily chloride level of 250 mg/l for all water year types. This recommendation is based on the conclusion that an objective at Old River near Rock Slough will help in determining an "allocation of responsibility" for meeting the standard at the Contra Costa Canal Intake (DWR,280;T,VI,97:8-19;T,LIX,213:8-214,8).

- CCWD

  - Add a quality objective at the site of the future intake to the Kellogg/Los Vaqueros Reservoir. The location of the intake has not yet been determined. The recommended objective would be set at a maximum chloride level of 50 mg/l for the months of April through June (T,VII,57:13-19; T,VII,118:16-120,9).

5.3.1.3 Optimal Level of Protection

Retain the Delta Plan standards to protect M&I beneficial uses with the following changes:

o Retain the 250 mg/l maximum mean daily standard at Cache Slough as discussed in 5.3.1.2, under the condition that it would only be in effect when water is being diverted from there for M&I uses.

o Add a 250 mg/l maximum mean daily chloride objective at Barker Slough as discussed in 5.3.1.2. This objective will provide protection for M&I uses at this new point of diversion.

- Add a 250 mg/l maximum mean daily chloride objective, to become effective when the proposed facility begins operation, at the future intake to the proposed Kellogg/Los Vaqueros Reservoir. The objective will provide reasonable protection to the M&I uses supplied by the proposed facility.

- Retain the 150 mg/l maximum mean daily chloride objective at the Contra Costa Canal intake/Antioch water works intake. Extend the period of time that this objective is met to the full year. Industrial water quality within the Delta is protected in the Delta Plan by this standard. The amount of time this standard is in effect varies according to year type. Optimally, this objective would be met for the full year and is proposed as such under the optimal levels of protection.

The advocated addition of a 250 mg/l chloride objective at Old River near Rock Slough has been determined to be inappropriate. The current standard at the Contra Costa Canal Intake provides full protection for M&I diversions at that location. The advocated objective, located a distance away from the current point of diversion; does not represent the salinity at the point of diversion; it therefore does not protect the M&I beneficial uses served by the Contra Costa Canal as well as they are by the current standard. Also, the basis for the recommendation, i.e., that it would allow a "...later allocation of responsibilities..." for meeting the standard at the Contra Costa Canal does not justify the addition of a new standard.

The CCWD's proposal to add a 50 mg/l chloride objective at the intake of the proposed Kellogg/Los Vaqueros Reservoir should be rejected because the hearing evidence and testimony presented on M&I beneficial use needs do not justify it. The water quality standard for MUN use is 250 mg/l chlorides, which is a taste rather than a health consideration. Industries outside of the Delta, many of which are supplied from a diversion point other than the Contra Costa Canal, have not submitted evidence showing a need for water quality better than 250 mg/l chlorides. Based on this information, a level of protection better than 250 mg/l is not justified.

Table 5.3.1.3-1 is a list of averaged monthly salinities for each water year type. The source data are mean monthly hourly salinities over a tidal cycle simulated for an unimpaired condition over the Water Years 1922 through 1978. The data show that at no time do these average values exceed the 250 ppm chloride standard set forth in the Delta Plan. Table 5.3.1.3-2 lists the locations and optimal levels protection for M&I uses.

TABLE 5.3.1.3-1
UNIMPAIRED FLOW MEAN SALINITY
(mg/l chlorides)

WATER YEAR INDEX	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
CLIFTON COURT												
CRITICAL	190	154	119	77	64	102	137	154	146	176	199	196
DRY	145	105	80	56	40	52	107	144	160	163	195	182
B. NORMAL	114	85	63	45	29	44	91	130	158	189	162	127
A. NORMAL	100	53	45	32	21	34	74	114	139	182	200	167
WET	74	63	52	36	21	22	50	99	140	193	176	99
TRACY PUMPING PLANT												
CRITICAL	190	182	160	136	109	93	99	127	152	138	162	183
DRY	151	143	129	108	88	72	73	100	131	135	156	158
B. NORMAL	161	142	123	101	80	65	62	81	113	133	164	171
A. NORMAL	148	116	91	75	60	50	48	62	96	144	166	166
WET	124	93	72	58	47	39	37	47	75	142	169	166
CONTRA COSTA CANAL												
CRITICAL	142	146	157	132	84	74	100	101	146	119	137	145
DRY	131	137	130	93	56	50	66	90	92	135	139	133
B. NORMAL	60	59	57	48	33	30	39	54	55	56	58	59
A. NORMAL	69	68	66	49	29	26	36	52	54	71	71	71
WET	107	103	100	86	44	26	41	65	95	104	109	108
CACHE SLOUGH												
CRITICAL	16	16	16	16	17	18	20	21	22	19	18	17
DRY	16	16	16	16	16	17	18	19	19	20	19	16
B. NORMAL	18	18	18	18	18	18	20	21	22	21	19	18
A. NORMAL	18	18	18	18	18	18	19	21	22	22	20	19
WET	19	19	19	19	20	20	20	22	22	23	21	20
LINDSEY SLOUGH (BARKER SLOUGH)												
CRITICAL	16	16	16	16	16	17	17	19	23	17	16	16
DRY	16	16	16	16	16	16	17	17	17	18	17	16
B. NORMAL	18	18	18	18	18	18	19	19	19	19	18	18
A. NORMAL	18	18	18	18	18	18	19	19	19	19	19	18
WET	20	20	20	20	20	20	20	20	20	21	20	20

TABLE 5.3.1.3-2
OPTIMAL LEVEL OF PROTECTION FOR
MUNICIPAL AND INDUSTRIAL USES

Beneficial Use Protected and Location	Parameter	Description	Year Type	Values
MUNICIPAL				
Contra Costa Canal Intake[1/] at Pumping Plant #1	Chloride	Maximum Mean Daily Chloride in mg/l	All	250
Clifton Court Forebay Intake at West Canal	Chloride	Maximum Mean Daily Chloride in mg/l	All	250
Delta Mendota Canal at Tracy Pumping Plant	Chloride	Maximum Mean Daily Chloride in mg/l	All	250
North Bay Aqueduct at Barker Slough	Chloride	Maximum Mean Daily Chloride in mg/l	All	250
City of Vallejo Intake[2/] at Cache Slough	Chloride	Maximum Mean Daily Chloride in mg/l	All	250
INDUSTRIAL				
Contra Costa Canal Intake at Pumping Plant #1	Chloride	Maximum Mean Daily Chloride in mg/l	All	150
or				
Antioch Water Works Intake on San Joaquin River				

1/ This objective will remain in effect until Contra Costa Water District moves its intake to Clifton Court Forebay.

2/ Only used as a control station if City of Vallejo is taking water from this source.

5.3.2 (not used)

5.3.3 Agriculture

5.3.3.1 No Action Alternative

- Western Delta

  In the Delta Plan, the 0.45 millimhos/centimeter (mmhos/cm) electrical conductivity (EC) agricultural standards set for applied water in the western Delta were based upon the corn criterion which provided 100 percent corn yield in this region's subirrigated organic soil. These standards were relaxed in all water year types except wet years at Emmaton and Jersey Point, and in the above normal year at Jersey Point. The amount of relaxation was based on time weighted average of water quality over the period April 1 to August 15 for conditions that would exist without Central Valley Project (CVP) and the State Water Project (SWP) conditions (Without Project conditions). Adjustment of the standards for water year type was justified based on the water quality that would have occurred in the absence of the projects for such deliveries. Table 5.3.3.1-1 lists the numerical standards set for western Delta agriculture.

TABLE 5.3.3.1-1
WATER QUALITY STANDARDS FOR WESTERN DELTA AGRICULTURE[1/]

Location	Parameter	Description	Year Type[2/]	Values: 0.45 EC April 1 to Date Shown	Values: EC from Date Shown[3/] to August 15
Emmaton on the Sacramento River	EC	Max. 14-day Running Avg. of Mean Daily EC in mmhos/cm	Wet	August 15	—
			Ab. Norm	July 1	0.63
			Bl. Norm	June 20	1.14
			Dry	June 15	1.67
			Critical	--	2.78
Jersey Point on the San Joaquin River	EC	Max. 14-day Running Avg. of Mean Daily EC in mmhos/cm	Wet	August 15	—
			Ab. Norm	August 15	--
			Bl. Norm	June 20	0.74
			Dry	June 15	1.35
			Critical	--	2.20

1/ Water Quality Control Plan, August 1978
2/ The year type for the preceding water year will remain in effect until the initial forecast of unimpaired runoff for the current water year is available.
3/ When no data are shown EC limit continues from April 1.

- Interior Delta

The Delta Plan agricultural water quality standards for the interior Delta were set using the same corn criterion as in the western Delta. However, under Without Project conditions, water quality in the interior Delta during the irrigation season was better than in the western Delta. Therefore, water year type relaxations for the interior Delta were not as severe. Table 5.3.3.1-2 lists the interior Delta water quality standards set in the Delta Planhearing process.

TABLE 5.3.3.1-2
WATER QUALITY STANDARDS FOR INTERIOR DELTA AGRICULTURE 1/

Location	Parameter	Description	Year Type 2/	Values: 0.45 EC April 1 to Date Shown	Values: EC from Date Shown 3/ to August 15
Terminous on the Mokelumne River	EC	Max. 14-day Running Avg. of Mean Daily EC in mmhos/cm	Wet	August 15	--
			Ab. Norm	August 15	--
			Bl. Norm	August 15	--
			Dry	August 15	--
			Critical	--	0.54
San Andreas Landing on the San Joaquin River	EC	Max. 14-day Running Avg. of Mean Daily EC in mmhos/cm	Wet	August 15	--
			Ab. Norm	August 15	--
			Bl. Norm	August 15	--
			Dry	June 25	0.58
			Critical	--	0.87

1/ Water Quality Control Plan, August 1978.
2/ The year type for the preceding water year will remain in effect until the initial forecast of unimpaired runoff for the current water year is available.
3/ When no data are shown EC limit continues from April 1.

- Southern Delta

Water quality standards for the southern Delta in the Delta Plan were based on University of California guidelines for the quality requirements of two of the most predominant salt sensitive crops grown in the southern Delta, beans and alfalfa. They recommended an applied water quality for beans of 0.7 mmhos/cm EC from April through August, and 1.0 mmhos/cm EC for alfalfa the remainder of the year (WQCP,8/79; VI-18,19).

The standards were not implemented pending completion of New Melones Reservoir and an agreement among the South Delta Water Agency, the Department of Water Resources, and the Bureau of Reclamation to complete suitable circulation and water supply facilities. Upon completion of New Melones Reservoir in 1981, a 500 mg/l total dissolved solids (TDS) (770 mmhos/cm EC) standard at Vernalis came into effect. In the Delta Plan the Board stated that, if by January 1, 1980 facilities and water supplies were not in place, the Board would take appropriate enforcement action to prevent encroachment on riparian rights in the southern Delta. At South Delta Water Agency's request, this enforcement action was postponed awaiting results of continuing negotiations among the three agencies. For the purposes of the no action alternative these standards will be considered to have been in place. Table 5.3.3.1-3 lists the southern Delta water quality standards used as the no-action alternative objectives.

TABLE 5.3.3.1-3
WATER QUALITY STANDARDS FOR SOUTHERN DELTA AGRICULTURE[1/]

Location	Parameter	Description	Year Type	Values	
Vernalis near the San Joaquin River	TDS	Max. 30-day Running Avg. of Mean Daily TDS in mg/l	All[2/]	500	
				April 1 to August 31	September 1 to March 31
Tracy Road Bridge on Old River	EC	Max. 30-day Running Avg. of Mean Daily EC in mmhos/cm	All[3/]	0.7	1.0
Old River near Middle River					
Brandt Bridge on San Joaquin River					
Vernalis near the San Joaquin River					

1/ Water Quality Control Plan, August 1978
2/ After New Melones Reservoir becomes operational and until the standards below become effective.
3/ To become effective only upon the completion of suitable circulation and water supply facilities.

5.3.3.2 Advocated Levels of Protection

Central Delta Water Agency (CDWA):

- Water Quality Objectives

  The agricultural water quality objectives for the Delta should be set at a minimum water quality of 0.45 mmhos/cm EC year round except for adjustments in the drier months of drier years. The objective should not require a "leaching regimen" more rigorous than "winter flooding" or "fall sub-irrigation" more frequently than once in three years (CDWA,Brief,26-27). Delta leaching practices were defined in Section 4.4.1 of this Plan.

- Monitoring Locations

  The CDWA requests that monitoring stations be established at Old River near Holland Tract or Rancho Del Rio and on Turner Cut near McDonald Island Bridge, in addition to those previously established by the Delta Plan at Emmaton, Jersey Point, San Andreas Landing and Terminous (CDWA,Brief,27).

- Water Level Objectives

  CDWA stated that, "Water level objectives need to be established to prevent the operations of export diversions from depleting local channel volumes beyond the point that agricultural pumps and siphons are not adequately supplied" (CDWA,Brief, 27-28). No specific method of implementing this was recommended.

Central Valley Project Water Users Association (CVPWA):

- Water Quality Objectives

  Objectives should be established at 1.5 mmhoS/cm EC for the April 1 through August 15 period at Emmaton and Jersey Point. This objective should be adjusted to 3.0 mmhos/cm EC in critical Water Years (CVPWA,Brief,49). No objectives need be established for the areas of the Delta covered by contracts with the Department of Water Resources. DWR currently meets the Delta Plan standards in contracts with ECCID and NDWA (CVPWA,Brief,49).

- South Delta

  Meeting the existing 500 mg/l TDS standard at Vernalis must be the responsibility of all water right holders on the San Joaquin system (CVPWA,Brief,49).

Contra Costa County Water Agency (CCCWA):

- Water Quality Objectives

  The CCCWA recommends that the minimum water quality standard necessary to achieve a 100 percent yield of corn be set at 0.45 mmhos/cm EC for organic soils in the Delta (CCWA,Brief,17).

Delta Tributaries Agency Committee (DTAC):

- Water Quality Objectives

  DTAC recommends relaxation of the Delta Plan agricultural standard in the Central Delta, to the range of 1.5 to 2.5 deciSiemens/meter in all but critical years (One deciSiemen/meter is approximately equal to one mmho/cm EC). No objectives were suggested for critical years (DTAC,Brief,6).

- Leaching Objectives

  Water quality standards should be carefully established "to provide fall leaching water at the levels needed to leach a necessary minimum amount of salt from the crop root zone of Delta soils, but such leaching standard should be related to the quantity of water available for such leaching" (DTAC,BNIF,6-7).

- Southern Delta Objectives:

  DTAC recommends that the Board impose a short timetable for completion of the negotiations between SDWA, DWR, and USBR. Pending completion of such an agreement, the Board should require elimination of reverse flows in the San Joaquin River which are attributable to export pumping, and continuance of Delta plan standards (DTAC,Brief,6-7).

Department of Water Resources (DWR):

- Water Quality Objectives

  "Water quality objectives for the western and central Delta should be based upon the results and information derived from the Corn Study" (DWR,Brief,28). No specific numerical water quality criteria were recommended.

- Leaching Objectives

  An objective for post-harvest subirrigation leaching should be provided for a ten-day period between November 1 and December 20 at the Emmaton and Jersey Point stations. This objective should be in effect only when the upstream October 1 storage conditions are at or above the normal operating level which DWR defines as 11 million acre-feet for the following major Sacramento River system reservoirs: Shasta, Whiskey Town, Black Butte, Frenchman, Antelope, Grizzley Valley, Oroville, Almanor, New Bullards Bar, Engelbright, Folsom, Berryessa, and Trinity. Furthermore, a winter ponding objective should be provided at the Junction Point and San Andreas Landing stations for the months December through February (DWR,Brief,29-30).

- Monitoring Locations

  DWR recommends that specific Delta agricultural objectives for the irrigation season should be adopted for the following locations: (1) Sacramento River at Emmaton; (2) San Joaquin River at Jersey Point; (3) Mokelumne River at Terminous; (4) San Joaquin River at San Andreas Landing; and (5) Cache Slough near Junction Point (DWR,Brief, 30-31). Furthermore, the water quality objective at Emmaton should be eliminated when overland water supply facilities are developed for Sherman Island (DWR,Brief,32). The objective would be moved to the intake of the overland facilities.

- Southern Delta Objectives

  Negotiations should be completed among the DWR, USBR, SDWA to provide permanent solutions to the problems of local water level, water quality and circulation in the southern Delta (DWR,Brief,32).

North Delta Water Agency (NDWA) and East Contra Costa Irrigation District (ECCID):

- Water Quality Objectives

  NDWA and ECCID recommend that no change be made in Delta agricultural water objectives which would impair the contractual rights and obligations embodied in the contracts among NDWA, ECCID, and DWR (NDWA,Brief,2). These standards are outlined in summaries of testimony for ECCID and NDWA.

South Delta Water Agency (SDWA):

- Water Flow and Quality Objectives (Without Facilities)

  SWDA advocated two sets of recommendations. The first are recommendations with no south Delta facilities (SDWA,115, 1-2). The second are recommendations with south Delta facilities (SWDA,116,1-2). SDWA recommends that water quality at any monitoring points should not exceed an average of 400 mg/l TDS for the period March 1 through September 30 and must not exceed 400 mg/l TDS on a seven-day running average during March through June 30 and 500 mg/l TDS seven-day running average between July 1 and October 31. A TDS of 550 mg/l would be the maximum permissible seven-day running average between November 1 and February 28 (T,XV,31:15-31:23).

The minimum flow at Vernalis should comply with the following schedule to maintain the above water quality (the following figures relate to SDWA channel depletion, with a 500 cfs 5-day running average minimum flow. They do not include a flushing flow.):

October	696 cfs
November	583
December	500
January	500
February	500
March	600
April	900
May	900
June	1000
July	1300
August	1204
September	847

- Water Level Objectives (Without Facilities)

  Water levels at low tide should not be less than zero mean sea level at any point north of Vernalis at any time. Export pump drawdown must not contribute to violations of this objective (SDWA,115,1).

- Monitoring Locations (Without Facilities)

  SDWA proposes monitoring for water levels and water quality in the San Joaquin River near Vernalis, Mossdale, the bifurcation of Middle River and Old River, Middle River at Howard Road Bridge, San Joaquin River at, or near, the former location of Brandt Bridge, Old River at Tracy Boulevard, Old River at Westside Irrigation District intake; and water level only at the south end of Tom Paine Slough. The water flow should continue to be monitored in the San Joaquin River at Vernalis (SDWA,115,1).

- Water Flow and Quality Objectives (With Facilities)

  "Water quality required at the inflow points would be specified as a function of net daily inflow rate and of channel depletion by months for the channel reaches receiving water from each inflow point. The values would be initially determined by mathematical modeling of the system to give water quality equivalent to the no barrier standards" (SDWA,116,2).

  "The required net daily inflow rates at each inflow point would be in accordance with a monthly schedule sufficient to maintain the required undirectional net daily flow in each channel reach" (SDWA,116,2).

- Monitoring Locations (With Facilities)

  "Water levels would be monitored at Vernalis, on Old River at Middle Howard Road Bridge, on the San Joaquin River near Paradise Cut, on Old River at Tracy Boulevard, on Grantline Canal at Tracy Boulevard, and at Clifton Court" (SDWA,116,1).

  "Water quality would be monitored at Vernalis, on the downstream (intake) side of each barrier, at the former location of Brandt Bridge on the San Joaquin River north of Old River and Tracy Boulevard. On Grantline Canal, flow would be measured at Vernalis and through each barrier" (SDWA,116,172).

- Water Level Objectives (With Facilities)

  "Water level restraints at the monitoring points would be the same as for the no-barrier case except for an additional required level to be determined on the San Joaquin River south of Paradise Cut. Water level maintenance could also be assisted by seasonally functional flow restrictions in Grantline Canal and in the San Joaquin River Channel near Paradise Cut (SDWA,116,2).

State Water Contractors (SWC):

- Water Quality Objectives

  The SWC recommend changing existing standards to reflect the results of the corn study. Specific recommendations are 1.5 mmhos/cm EC from April 1 through August 15 for all water year types, and 3.0 mmhos/cm EC during critical years (SWC,Brief,I-43).

- Monitoring Locations

  The measuring station at Emmaton in the Sacramento River should be relocated to Three Mile Slough upon completion of overland water supply facilities to serve Sherman Island (SWC,Brief,I-43).

Bureau of Reclamation with Support from the U.S. Department of Interior:

- Water Quality Objectives

  The USBR presented testimony on the leaching requirements of the five most salt sensitive crops grown in the Delta uplands. These were beans, fruit and nuts, vineyards, corn and alfalfa (USBR,10 & A&B). From these leaching requirements, average irrigation season water quality objectives of 600 mg/l TDS in a normal year and 800 mg/l TDS in a dry year were developed for Delta agriculture (T,XV,139:15-139:21). The USBR, however, did not formalize these into recommendations (T,XV,140:3-140:9).

5.3.3.3 Optimal Level of Protection

Western and Interior Delta:

- Water Quality

  - Irrigation Water Quality

    Field corn, the most widely grown crop in the Delta, is grown on greater than 21 percent of the total Delta land area including greater than 26 percent of the Delta lowlands (DWR,304). The optimal level of protection for the western and interior Delta will be based on the protection of corn as it is the predominant crop and among the most salt sensitive crops grown in the area.

    The results of the corn study show that, with reasonable farm management practices, an irrigation water EC of 1.5 mmhos/cm will provide 100 percent corn crop yields in Delta organic soils that are subirrigated. An irrigation water salinity of up to 2.0 mmhos/cm EC would provide the same protection for corn on Delta mineral soils. In general, the quality level of 1.5 mmhos/cm EC is met under unimpaired flow conditions at all stations in all year types during the irrigation period of April 1 through August 15. Based on the need and the availability of this quality of water during unimpaired flow conditions, 1.5 mmhos/cm EC is proposed as the optimal level of protection. From information given in Phase I, it has been determined that, even with the adoption of these optimal objectives, Delta farmers will on occasion need to monitor field soil salinity conditions and provide effective leaching to bring the soil salinity to below the threshold value of 3.7 mmhos/cm EC (discussed below) before the start of each irrigation season. Results of the corn study also show that irrigation water salinity may be increased to as much as 6.0 mmhos/cm EC after the end of July without loss in crop yield for that irrigation season. The method or irrigation did not influence the salt tolerance relationship of corn but required increased leaching (SWRCB,22-24).

  - On-Farm

    Should the foregoing water quality objectives for irrigation water be adopted, then leaching to remove excess salt buildup will be required. Removal of salt from the crop root zone through leaching will be required when root zone salinity exceeds 3.7 mmhos/cm EC.

- Water Quality Objectives for Leaching

  DWR's proposal for a winter ponding objective is appropriate. DWR did not propose a particular level of water quality, but did propose that it be in the form of maximum monthly EC. To protect the Western Delta, this objective should be provided at the Western and interior Delta monitoring agricultural locations for December through February. A maximum monthly EC objective of 1.7 mmhos/cm is recommended for this purpose. This objective is sufficient to provide for the leaching needs throughout the Delta.

- Water Levels

  Insufficient information was presented on the negative impacts of water levels and possible solutions to set objectives in the western and interior Delta.

- Location of Objectives

  Water quality objectives for the western and interior Delta should be established at the following locations: Emmaton on the Sacramento River, Jersey Point on the San Joaquin River, Terminous on the Mokelumne River, San Andreas Landing on the San Joaquin River, and Cache Slough near Junction Point.

Southern Delta:

- Water Quality

  Beans, the most widely grown salt sensitive crop in the southern Delta, were chosen as a target crop for purposes of setting objectives. By setting objectives for this crop, the less salt sensitive crops would also be fully protected. Water quality standards were developed in the Plan for the southern Delta based on bean growth (Table 5.3.3.1-3). As New Melones Reservoir is now operational, the 500 TDS objective at Vernalis is not recommended. The remaining standards, along with a change in the description from a 30-day to a 14-day running average, should provide an optimal level of protection for the southern Delta.

- Water Levels

  The issue of protection from low water levels was raised in Phase I of the hearing. Maintaining adequate water levels in the southern Delta can be accomplished through increased flow releases through regulating export pumping, or through channel modifications. It is believed that structural alternatives combined with dredging and regulating export pumping operations are feasible water level solutions and that no flow objective be set for water levels in the southern Delta.

- Flows

  As discussed previously, SDWA requested a schedule of flows for protection of southern Delta agriculture, in addition to minimum water quality standards. Since water quality objectives that will sufficiently protect the crops grown in the southern Delta are being recommended, there is no need for an additional requirement for flows.

- Location for Setting Objectives

  The agricultural water quality objectives in the southern Delta should be set at the San Joaquin River near Vernalis and near Mossdale; at the bifurcation of Old and Middle rivers; in Middle River at Howard Road Bridge; in Old River at Tracy Road Bridge; and in the San Joaquin River at the former location of Brandt Bridge.

Bay Agriculture:

Insufficient information was presented in the hearings to set objectives for agriculture in the Bay region.

5.3.3.4 Consideration of Water Availability

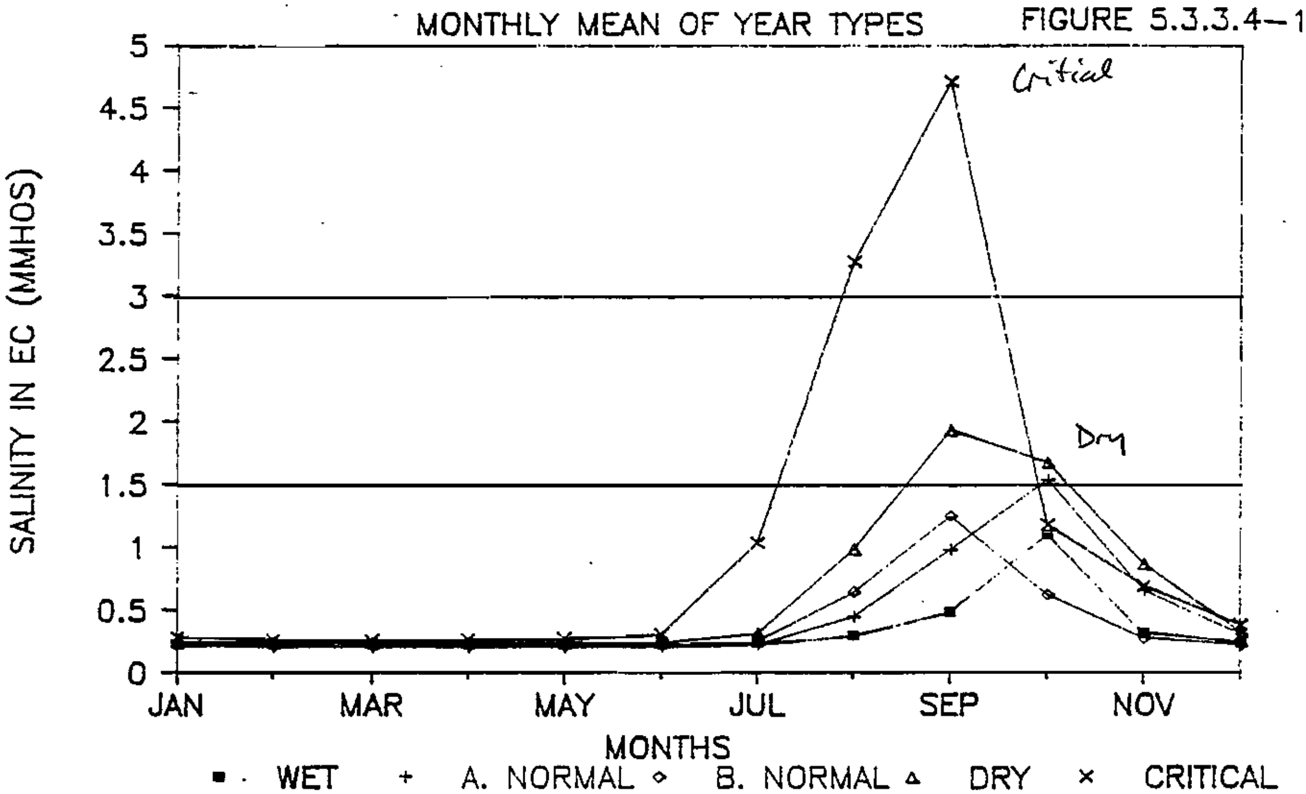
- Western and Interior Delta

  Figures 5.3.3.4-1 through 5 show the optimal objectives for the western and interior Delta superimposed over unimpaired water quality conditions for an average water year type at selected locations in the western and interior Delta. For the five stations in the western and interior Delta, the 1.5 mmhos/cm EC objective is exceeded at Emmaton only in dry and critical years and at Jersey Point only in critical years.

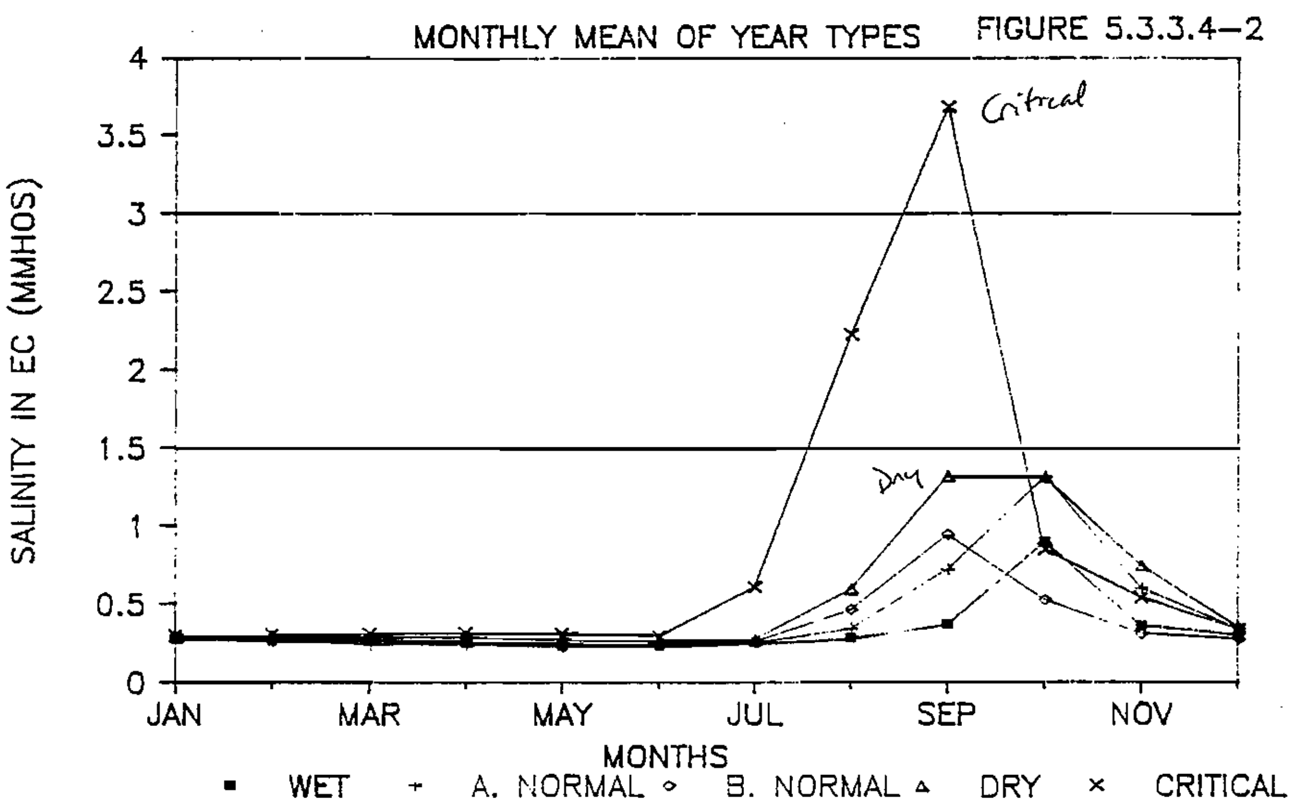
- South Delta

  Figures 5.3.3.4-6 through 11 show the optimal objectives for the southern Delta superimposed over average water year type of unimpaired water quality conditions for selected locations in the southern Delta. All stations in the southern Delta are below the objective of 0.7 mmhos/cm EC through the month of June in all year types. In all cases, July, only the critical years exceed the 0.7 mmhos/cm EC objective. In August through November for most year types, unimpaired water qualities are above the 0.7 mmhos/cm EC objective.

SACRAMENTO RIVER AT EMMATON

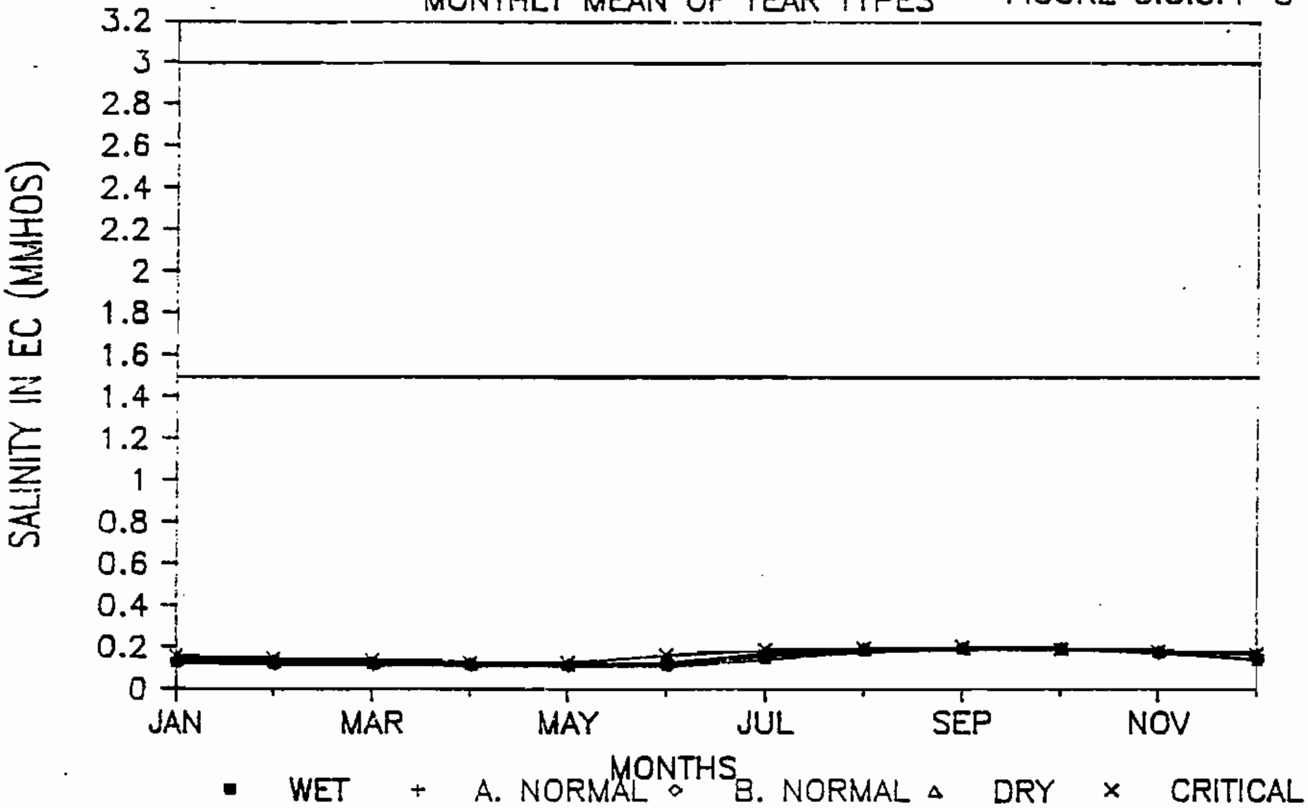


SAN JOAQUIN RIVER AT JERSEY POINT



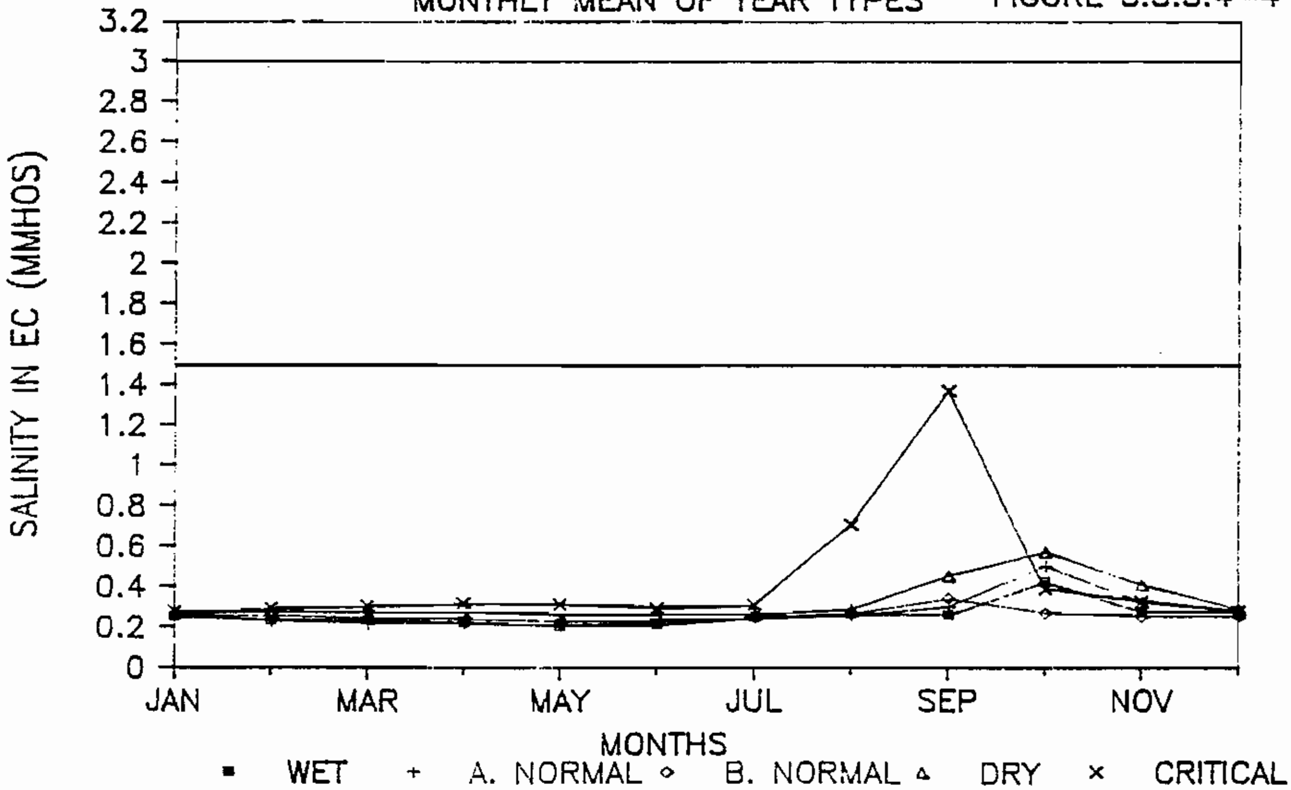
MOKELUMNE RIVER AT TERMINOUS

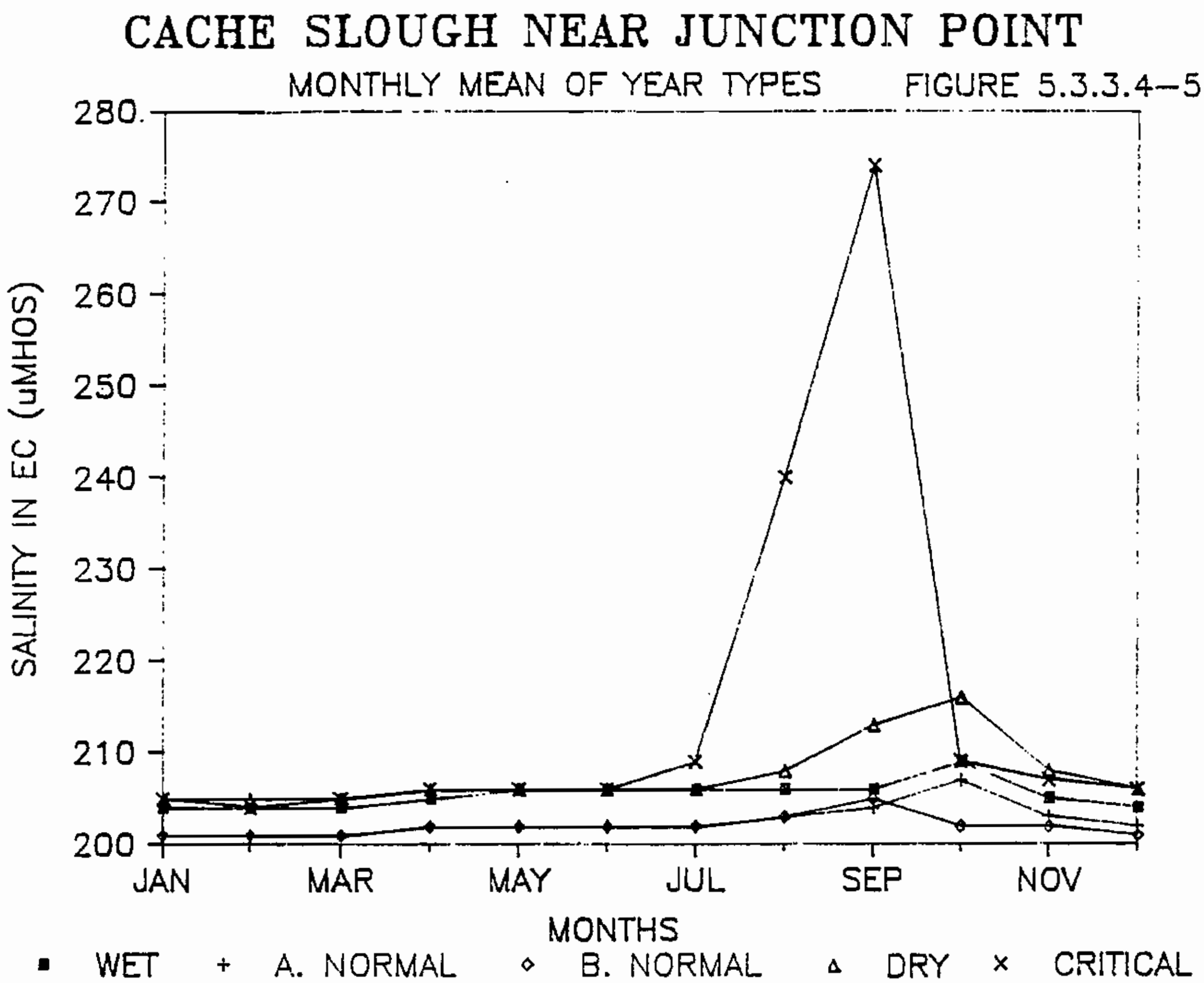
MONTHLY MEAN OF YEAR TYPES FIGURE 5.3.3.4-3

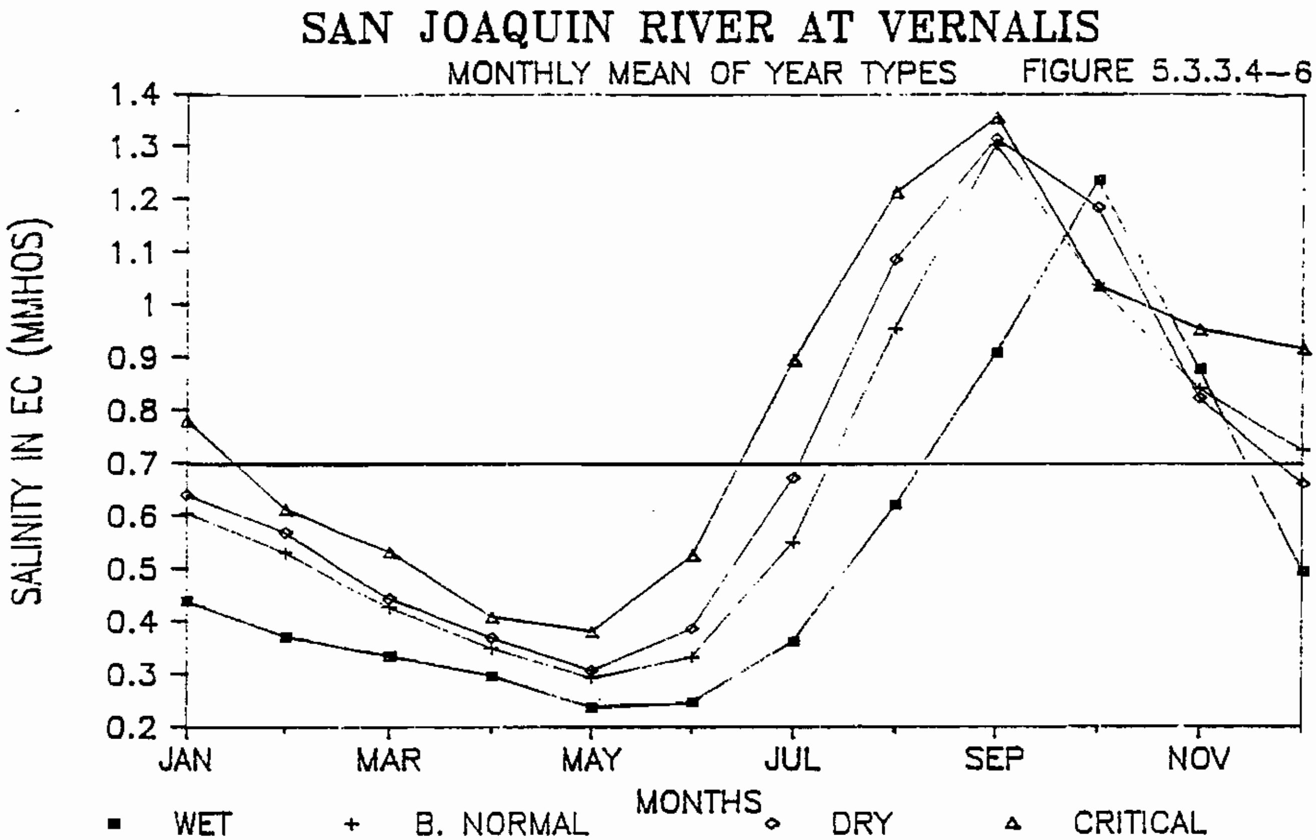


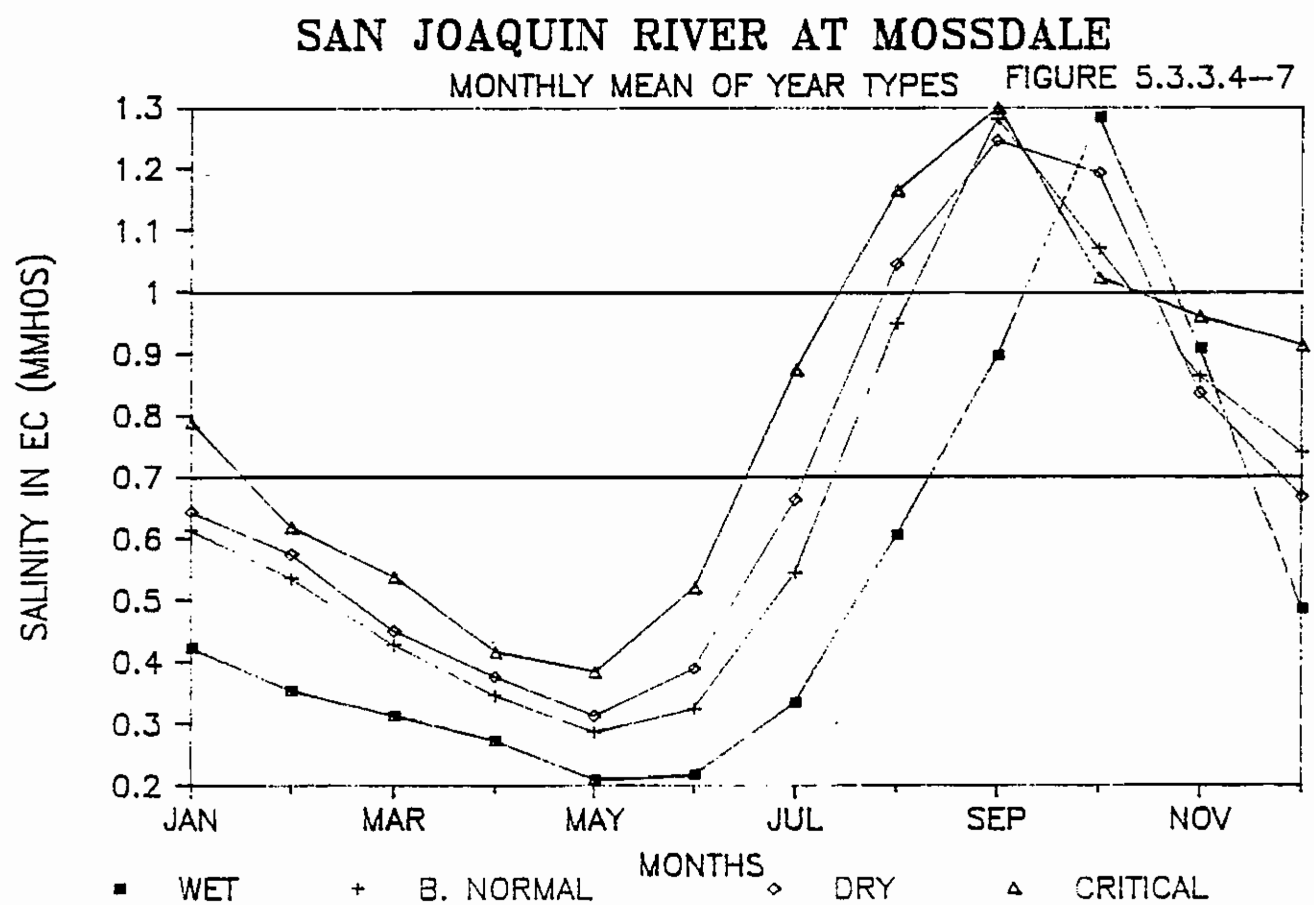
SAN JOAQUIN RIVER AT SAN ANDREAS

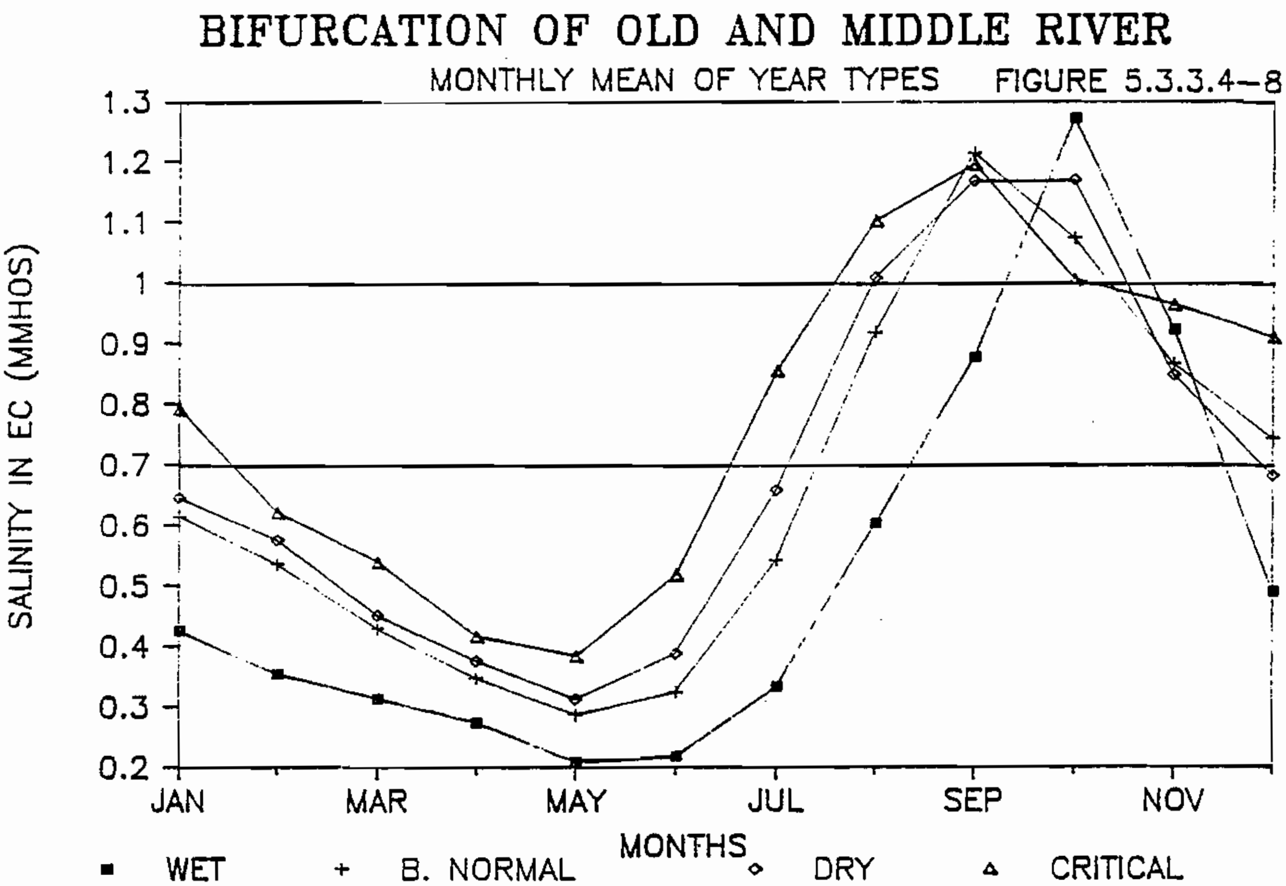
MONTHLY MEAN OF YEAR TYPES FIGURE 5.3.3.4-4

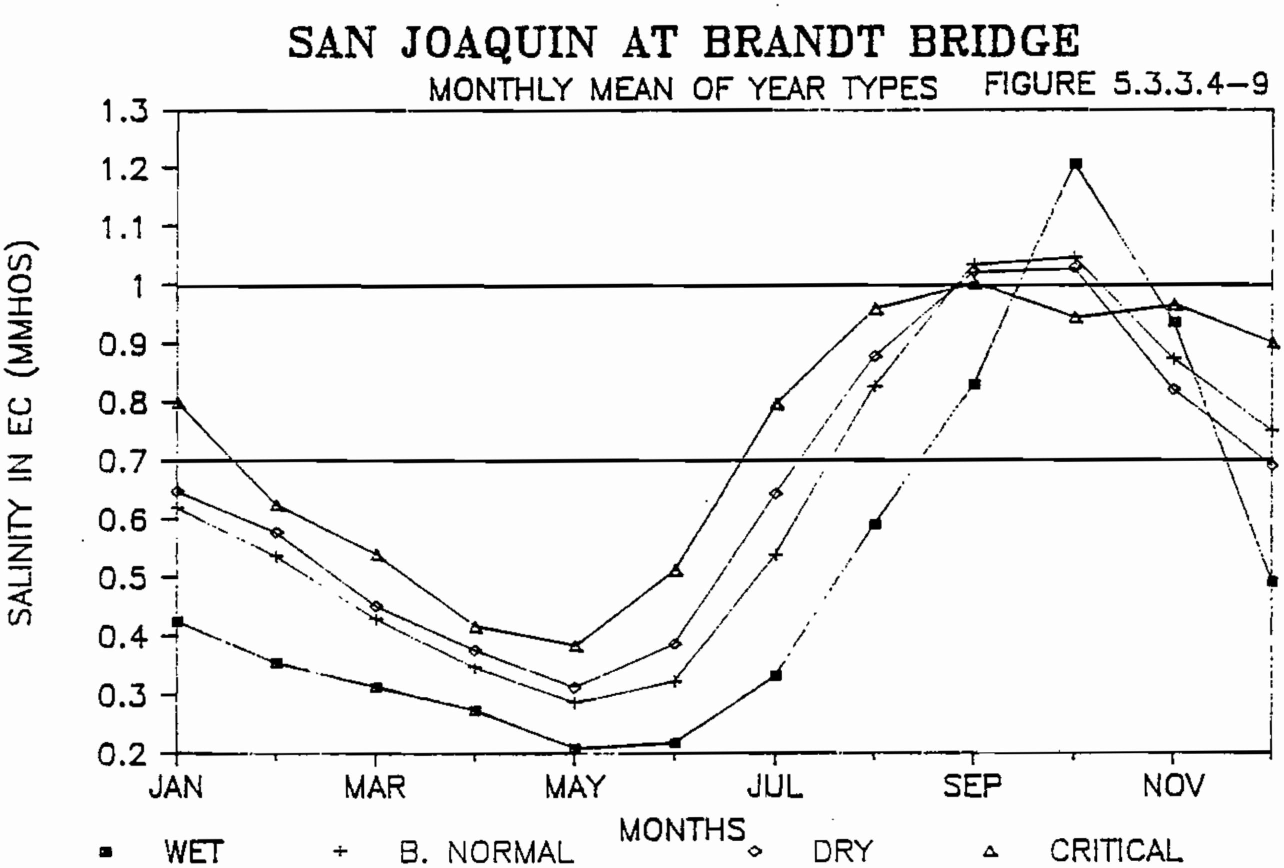



CACHE SLOUGH NEAR JUNCTION POINT
MONTHLY MEAN OF YEAR TYPES
FIGURE 5.3.3.4-5
SALINITY IN EC (uMHOS)
280.
270
260
250
240
230
220
210
200
JAN
MAR
MAY
JUL
SEP
NOV
MONTHS
WET
A. NORMAL
B. NORMAL
DRY
CRITICAL


SAN JOAQUIN RIVER AT VERNALIS
MONTHLY MEAN OF YEAR TYPES
FIGURE 5.3.3.4–6
SALINITY IN EC (MMHOS)
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
JAN
MAR
MAY
JUL
SEP
NOV
MONTHS
WET
B. NORMAL
DRY
CRITICAL

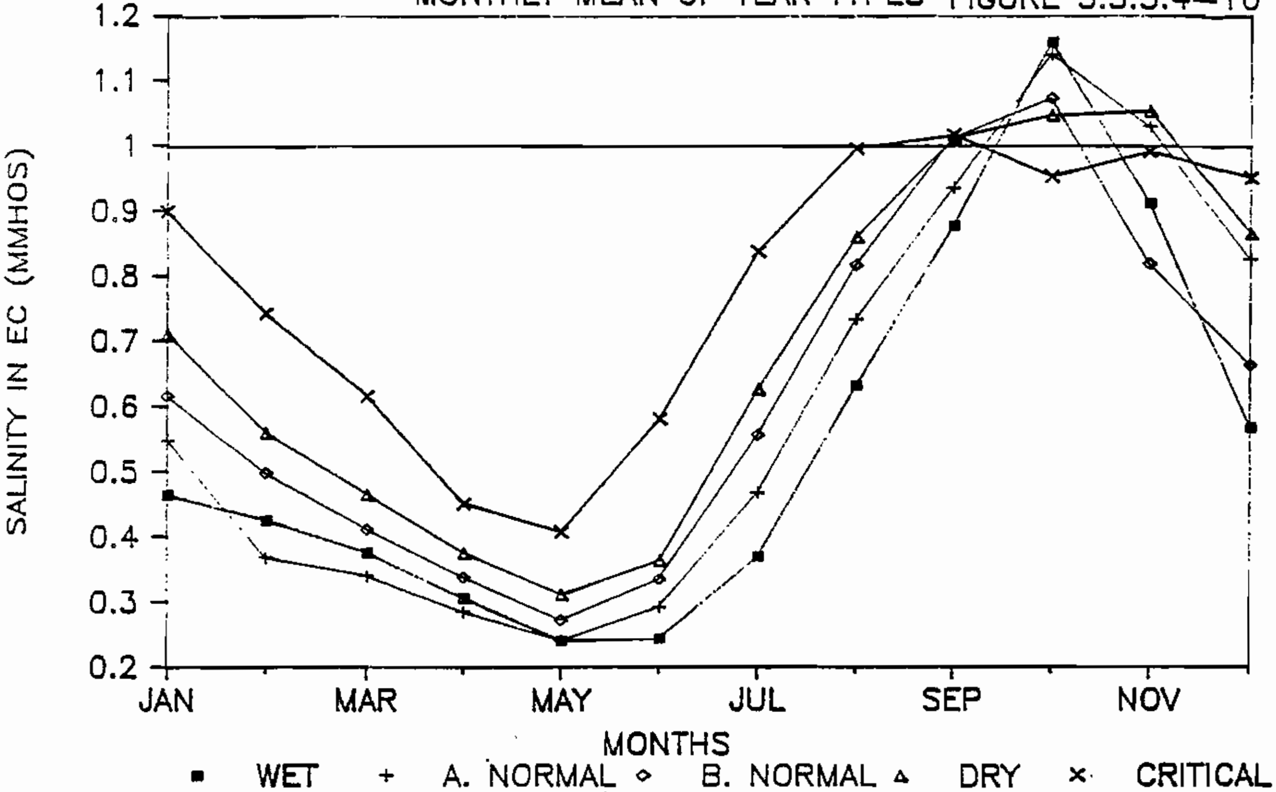

SAN JOAQUIN RIVER AT MOSSDALE
MONTHLY MEAN OF YEAR TYPES
FIGURE 5.3.3.4–7
SALINITY IN EC (MMHOS)
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
JAN
MAR
MAY
JUL
SEP
NOV
MONTHS
WET
B. NORMAL
DRY
CRITICAL


BIFURCATION OF OLD AND MIDDLE RIVER
MONTHLY MEAN OF YEAR TYPES
FIGURE 5.3.3.4–8
SALINITY IN EC (MMHOS)
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
JAN
MAR
MAY
JUL
SEP
NOV
MONTHS
WET
B. NORMAL
DRY
CRITICAL


SAN JOAQUIN AT BRANDT BRIDGE
MONTHLY MEAN OF YEAR TYPES
FIGURE 5.3.3.4–9
SALINITY IN EC (MMHOS)
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
JAN
MAR
MAY
JUL
SEP
NOV
MONTHS
WET
B. NORMAL
DRY
CRITICAL

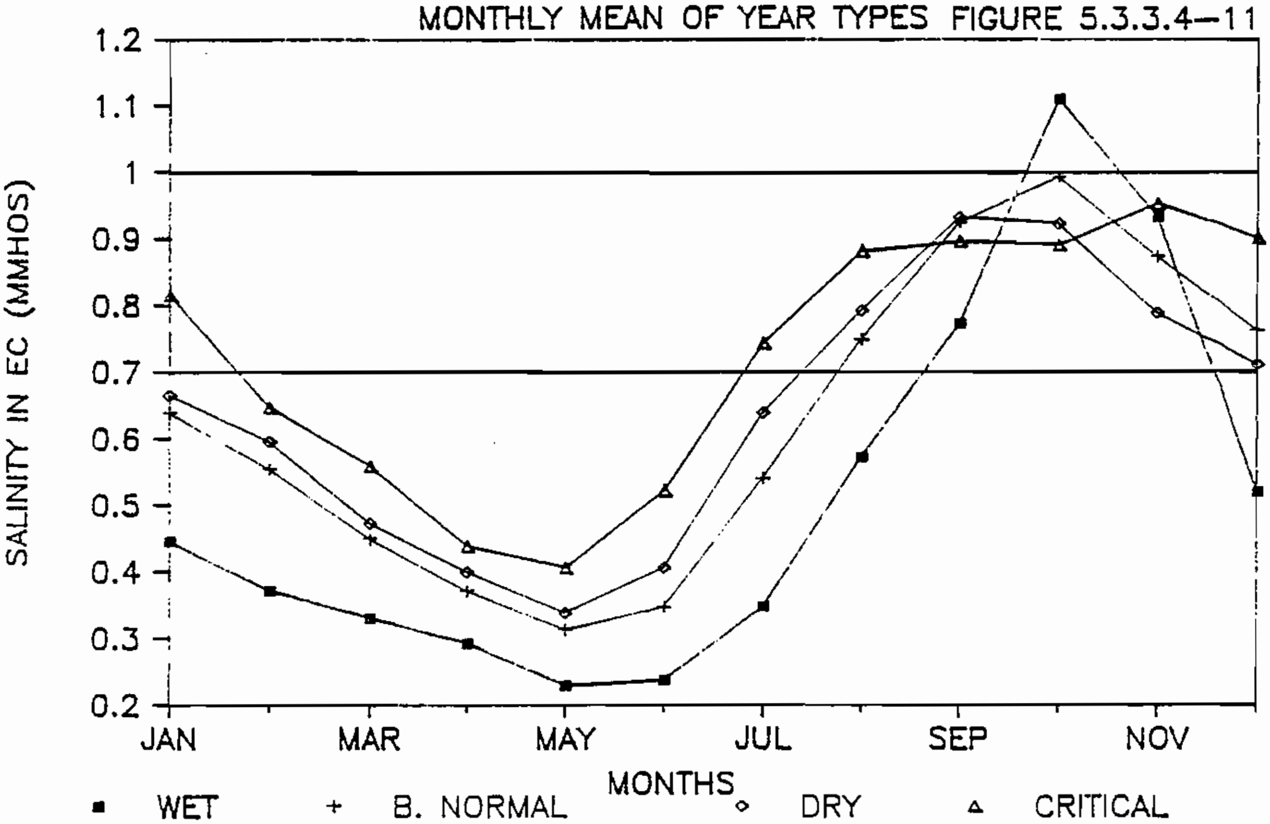
MIDDLE RIVER AT HOWARD ROAD BRIDGE

MONTHLY MEAN OF YEAR TYPES FIGURE 5.3.3.4-10



OLD RIVER AT TRACY ROAD BRIDGE

MONTHLY MEAN OF YEAR TYPES FIGURE 5.3.3.4-11



- San Francisco Bay Agriculture

  Until additional information is obtained that identifies the needs of Bay agriculture, no objectives can be set for Bay agriculture.

  The optimal level of protection for agricultural beneficial uses in the Delta is presented in Table 5.3.3.4.-1.

5.3.4 Chinook Salmon

5.3.4.1 No Action Alternative

The 1978 Delta Plan contains flow objectives for the protection of Chinook salmon migration throughout the year in the Estuary. These standards are 30 day running averages of daily flows at Rio Vista (see Table 5.3.4.1-1) which provide protection of Sacramento River Basin salmon. Special agreements, not included in the Delta Plan, which provide protection to salmon are discussed in Section 5.3.4.3. Figure 5.3.4.1-1 is a schematic representation of the location of sites, facilities and channels to be discussed.

The Delta Plan also requires the SWP and CVP, in all water year types, to close the Delta Cross Channel gates at Walnut Grove when the daily Delta Outflow Index at Chipps Island exceeds 12,000 cfs between January 1 and April 15. The intent is to minimize diverting fry, which rear in the north Delta, into the central or southern Delta. Under the Delta Plan's striped bass standards, DFG can request that the gates be closed between April 16 through May 31 for up to 20 days but not more than two out of four consecutive days. Such closures provide incidental protection for emigrating smolts.

The Delta Plan contains limitations and/or requirements for operation of SWP and CVP fish protective facilities at their respective Delta pumping plants and for maintenance of fish salvage records (SWRCB,1978,40). The Delta Plan operational criteria for the fish protection facilities, however, apply to the CVP secondary fish screening system only to the extent that they are compatible with water export rates.

The Delta Plan limits total Delta exports to 6,000 cfs for both the CVP and SWP (3,000 cfs each) in May and June for striped bass protection. However, the entire San Joaquin River flow may be diverted in May and June of most years (T,XXXVI,166:13-19) when exports exceed San Joaquin River inflows. As exports increase relative to inflows, more of this River's flow is drawn towards the CVP and SWP pumps via Old River (DFG,15,28; DWR,50) (see Figure 5.3.4.1-2) and flows in the lower reaches of Old, Middle, and the San Joaquin rivers may reverse and move upstream towards the export pumps.

TABLE 5.3.3.4-1

OPTIMAL LEVEL OF PROTECTION FOR AGRICULTURAL USES

Beneficial Use Protected and Location	Parameter	Description	Year Type	Dates	Values or Limit
AGRICULTURE					
Western and Interior Delta Irrigation Sacramento R. at Emmaton	Electrical Conductivity	Maximum 14-Day Running Average Mean Daily EC, mmhos/cm	All	Dates 4/1 - 8/15	EC 1.5
San Joaquin R. at Jersey Point					
Mokelumne R. at Terminous					
San Joaquin R. at San Andreas Ldg.					
Cache Sl. at Junction Pt.					
South Delta Irrigation San Joaquin R. near Vernalis	Electrical Conductivity	Maximum 14-Day Running Average Mean Daily EC, mmhos/cm	All	4/1 - 8/31 9/1 - 3/31	0.7 1.0
San Joaquin R. at Mossdale					
Bifurcation of Old and Middle rivers					
Middle R. at Howard Rd. Bridge					
Old R. at Tracy Rd. Bridge					
San Joaquin R. at former site of Brandt Bridge					
Delta Leaching (Ponding)					
Emmaton Jersey Point Cache Slough at Junction Point San Andreas Landing	Electrical Conductivity	Maximum monthly average of mean daily EC, mmho/cm	All	12/1-2/28	1.7

Table 5.3.4.1-1--1978 Delta Plan Salmon Standards

I. Salmon Migration-30 Day Running Average of Mean Daily Flow at Rio Vista in cfs

Time Period	Water Year Type: Wet	Above Normal	Below Normal	Dry	Critical
January	2,500	2,500	2,500	1,500	1,500
February 1-March 15	3,000	2,000	2,000	1,000	1,000
March 16-June 30	5,000	3,000	3,000	2,000	2,000
July	3,000	2,000	2,000	1,000	1,000
August	1,000	1,000	1,000	1,000	1,000
September 1-December 31	5,000	2,500	2,500	1,500	1,500

II. Cross Delta diversion of salmon fry

Jan 1-Apr 15 — Close Delta Cross Channel Gates at Delta Outflow Index > 12,000 cfs

III. CVP and SWP Delta pumping plant fish protective facilities

<u>SWP</u>
Nov 1-May 14

(a) approach velocity 3.0-3.5 fps
(b) bypass ratio-1.2:1.0 to 1.6:1.0 in primary and secondary channels
(c) primary bay-use Bay B as first choice
(d) velocity of water exiting the screened water system not to exceed secondary channel approach velocity

<u>CVP</u>
*Feb-May
**June-Aug 31[1/]

Secondary system to be operated as shown below to the extent compatible with export rates:
*(a) secondary velocity 3.0-3.5 fps
**(b) secondary velocity not to exceed 2.5 fps (preferably 1.5 fps). secondary velocity ratio not reduced below 1:1.0
(c) screened water discharge to lowest possible level consistent with its purpose
(d) bypass ratio in the seconday should prevent excessive velocities in the holding tanks but should not be less than the secondary approach velocity

[1/] Applies to all fish

FIGURE 5.3.4.1-1 Schematic representation of the Delta and experimental smolt release sites

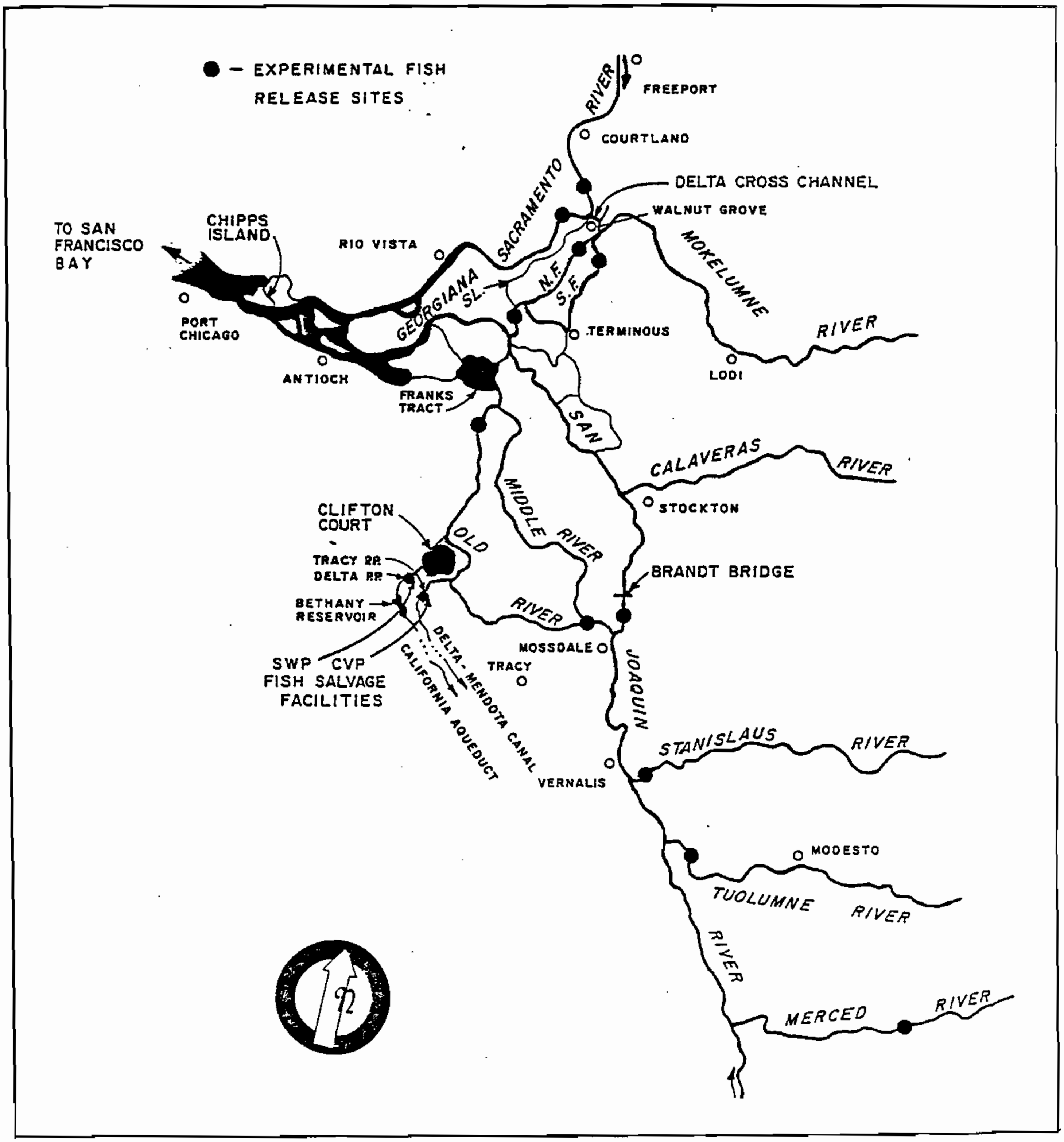
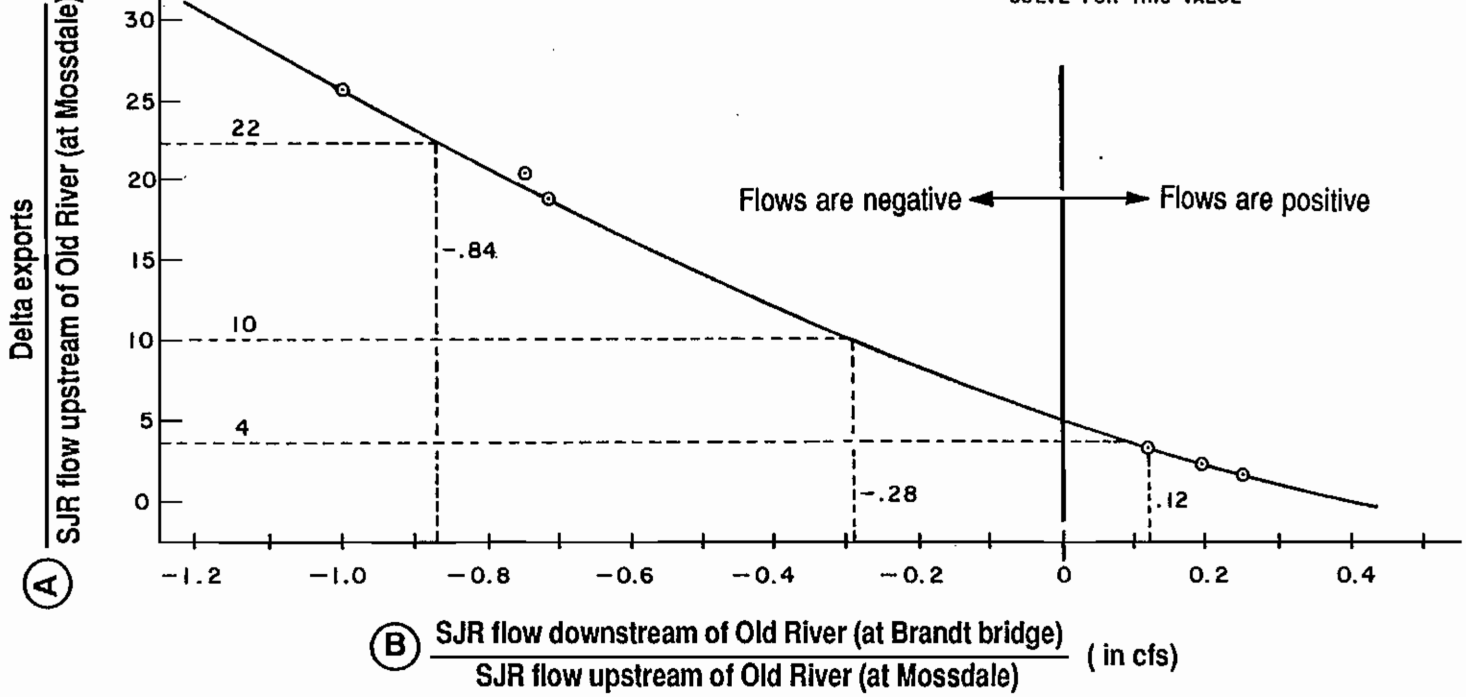


FIGURE 5.3.4.1-2 Relationship between Delta exports and flows in the San Joaquin River upstream and downstream of its confluence with Old River. This shows that as Delta exports increase relative to San Joaquin River inflows at Mossdale, flows downstream at Brandt Bridge will reverse and flow upstream (T, I I, 194:1-197:13) (from DWR 50)

EXAMPLE;	UPSTREAM FLOW (CFS)				STAGNANT	DOWNSTREAM FLOW (CFS)	
EXPORT Q=	11000	9000	5000	6000	6000	6000	6000
MOSSDALE Q=	500	500	500	1000	1200	1500	3000
RATIOS ON GRAPH (A) EXPORTS Q / MOSSDALE Q =	22	18	10	6	5	4	2
RATIOS ON GRAPH (B) * BRANDT BRIDGE Q / MOSSDALE Q =	−0.84	−0.68	−0.28	−0.05	0	0.12	0.32
** BRANDT BRIDGE Q =	−420	−340	−140	−50	0	180	960

* INTERCEPT POINT ON LINE
** SOLVE FOR THIS VALUE



Smolts of the four Chinook salmon races are emigrating through the Delta from about October through June, with the greatest abundance typically from April through June when the fall run emigrates. Average monthly salvage of Chinook salmon at the Harvey O. Banks Delta Pumping Plant reflects this seasonal abundance of young salmon in the Estuary (see Figure 4.5.1.2-3) (T,XXXVII,128:13-129:1).

Since the 1978 Delta Plan was approved, the survival of fall run smolts emigrating through the Estuary to the ocean has been identified as an issue of concern. Little information was available during the hearing for this plan. Since then, the USFWS on behalf of the Interagency Ecological Studies Program, carried out studies to evaluate the survival of fall run smolts during their emigration through the Estuary. These studies provide significant new information about relationships between smolt survival and Delta conditions under the 1978 Delta Plan, which are discussed in detail in section 5.3.4.3. USFWS has concentrated on Delta conditions affecting fall run smolts emigrating from the Sacramento River Basin. Generally they found that smolt survival improved with increasing flow, up to a maximum. Limited data from studies of San Joaquin Basin smolts show similar results. Evidence was not presented on the effects of existing estuarine conditions on the immature life stages of the other three races of Chinook salmon.

The recent evidence developed by USFWS indicates that, if the 1978 Delta Plan salmon migration flows were the controlling flow standard, fall run smolt survival would be minimal (see Table 5.3.4.1-2). However, under present conditions, other water quality standards and operational constraints on the SWP and CVP result in substantially higher flows during the April through June fall run smolt emigration period. Currently flow requirements to protect agricultural, fish and wildlife, and striped bass beneficial uses provide higher flows than those required for salmon migration (see Table 5.3.4.1-3). Uncontrolled flows during, and sometimes later than, April in wetter water years, also contribute to Rio Vista flows exceeding 1978 Delta Plan requirements (see Table 5.3.4.1-4).

Very little information is available about the effects of present conditions on salmon smolts migrating through the Bay. Information on Bay survival will not be available for several years.

5.3.4.2 Advocated Levels of Protection

Most of the parties presenting testimony on Chinook salmon agree that the 1978 Delta Plan salmon flow standards provide inadequate protection for fall run smolts, and that specific causes of salmon mortality upstream and in the Delta should be addressed to improve survival rates of immature fish. Most participants analysed the same data in preparing their testimony. The major differences dealth with: (1) when, where,

Table 5.3.4.1-2--Estimated Survival[1/] Index Values Under 1978 Delta Plan Salmon Migration Flow Standards during April-June

	Water Year Type									
	Wet		Above Normal		Below Normal		Dry		Critical	
Time Period	Flow (cfs)	Survival Index	Flow (cfs)	Survival Index	Flow (cfs)	Survival Index	Flow (cfs)	Survival Index	Flow (cfs)	Survival Index
April-June 30	5,000	0.02	3,000	0.0	3,000	0.0	2,000	0.0	2,000	0.0

[1/] Survival=0.000056Q-0.258 where Q=Rio Vista flows from 4,600-22,000 cfs (from USFWS,31)

Table 5.3.4.1-3--Estimated Controlling Delta Outflows[1/] Under the 1978 Delta Plan During Fall Run Smolt Migration Period. Values in parentheses are the estimated survival index values (from USFWS,31) if these flows occurred at Rio Vista

		Water year Type				
		Wet	Above Normal	Below Normal	Dry	Critical
Time Period	Flow in cfs	Flow in cfs	Flow in cfs	Flow in cfs	Flow in cfs	Mean Smolt Survival
April	10,000 (0.30)	7,600 (0.17)	7,600 (0.17)	7,600 (0.17)	4,500 - 6,700[3/] (0.0 - 0.12)	0.16-0.19
May 1-5	10,000 (0.30)	7,600 (0.17)	7,600 (0.17)	7,600 (0.17)	4,500 - 6,700[3/] (0.0 - 0.12)	0.16-0.19
May 6-31	7,600 - 14,000[2/] (0.17 - 0.53)	7,600 - 14,000[2/] (0.17 - 0.53)	7,600 - 11,400[2/] (0.17 - 0.38)	7,600 (0.17)	3,900 (0.0)	0.14-0.32
June 1-15	7,600 - 14,000[2/] (0.17 - 0.53)	7,600 - 10,700[2/] (0.17 - 0.34)	7,600 - 9,500[2/] (0.17 - 0.27)	7,600 (0.17)	3,900 (0.0)	0.14-0.26
June 16-20	7,600 - 14,000[2/] (0.17) - 0.53)	7,600 - 10,700[2/] (0.17 - 0.34)	7,600 - 9,500[2/] (0.17 - 0.27)	4,700 (0.01)	3,900 (0.0)	0.10-0.23
June 21-30	7,600 - 14,000[2/] (0.17 - 0.53)	7,600 - 10,700[2/] (0.17 - 0.34)	5,400 - 9,500[2/] (0.04 - 0.27)	4,700 (0.01)	3,900 (0.0)	0.08-0.23
Mean Survival	0.21-0.45	0.17-0.31	0.15-0.25	0.12	0-0.04	0.13-0.24

1/ Flow Estimates derived from DWR, personal communication, to R. Satkowski, SWRCB, dated 2/9/88.
2/ If subnormal snowmelt lower value applies.
3/ If SWP and CVP users are taking deficiencies in firm supplies lower value applies.

Table 5.3.4.1-4--Comparison of Mean Monthly Controlling Delta Outflows and Actual Delta Outflows in cfs (from DWR Dayflow).

Water Year	Year Type	April		May		June	
		Actual	Controlling[1/]	Actual	Controlling	Actual	Controlling
77-78	W	61,276	10,000	40,874	13,360	9,086	14,000
78-79	D	14,485	7,600	13,435	7,600	5,326	6,150
79-80	W	28,689	10,000	20,912	13,360	14,870	14,000
80-81	D	11,653	7,600	9,143	7,600	4,596	6,150
81-82	W	140,163	10,000	57,876	13,360	28,515	14,000
82-83	W	113,053	10,000	97,996	13,360	72,154	14,000
83-84	W	14,732	10,000	11,204	7,984	8,038	7,600
84-85	D	6,913	7,600[3/]	7,378	7,600	5,215	6,150
85-86	W	46,572	10,000	15,911	13,360	9,322	14,000
86-87	C	6,291	6,700	4,951	4,348	3,496	3,900

[1/] Controlling or minimum required Delta Outflow flows as shown on Table 5.3.4.1-3 from DWR tables revised March 1986 sent to R. Satkowski of SWRCB, 1/9/88. If controlling flow varies within the month each flow is weighted by the number of days in that month for which it applies. Carriage water is not included in these values.

[2/] Subnormal snowmelt criteria apply.

[3/] Differences due to imprecision in channel depletion estimates and correlations between flow and EC used to determine minimum required Delta Outflow. These do not represent violations of Delta Plan standards.

and what actions should be taken; and (2) which factors were considered the most influential on adult and/or young salmon survival and production. Only the fishery agencies and environmental groups advocated levels of protection essentially different from those of the 1978 Delta Plan.

The positions taken by the parties at Phase I of the hearing on Chinook salmon are summarized below and in Tables 5.3.4.2-1 through 5.3.4.2-4:

- SWC (SWC,201,22-27;T,LIX,170:7-173:13)

    - Existing Delta Plan striped bass flow standards should be maintained as the salmon flow objectives until adequate data are available to determine whether changes are required.

Table 5.3.4.2-1 shows what the striped bass flows would be from May 6 through June under the 1978 Delta Plan and represents an estimate of the levels of protection advocated by the SWC, USBR, and DWR. USFWS data were used to calculate the estimated smolt survival index under these flows to compare with levels of protection advocated by other parties. For comparison, Table 5.3.4.1-3 gives an estimate of controlling flows during the entire April through June smolt emigration period.

- DWR (T,XLIII,219:2-221:8)

    - The existing striped bass standards should be the salmon standards.

    - Recent historical levels of catch and escapement are already being maintained.

- USBR (T,LXI,120:24-131:6)

    - Natural salmon production should be increased.

    - A system-wide management plan that addresses conditions in all salmon habitats should be developed.

    - Structural solutions, such as screens, to improve Delta survival would be preferred to flow increases since they would minimize impacts on other beneficial uses.

    - Continue interagency studies and refine monitoring to determine effectiveness of new programs.

    - Allow operational flexibility to respond to recommendations of the five-agency salmon group, composed of the USFWS, DFG, NMFS, DWR and USBR, recently formed to reduce or solve salmon problems identified in the Phase I hearings.

Table 5.3.4.2-1--Recommended Salmon Flow Standards with present Delta Plan Delta Outflows for Striped Bass (SWC, USBR, DWR). (USFWS survival index values are shown in parentheses).

Period	Wet	Ab. Norm.	B. Norm.	Subnormal Snowmelt	Dry[1/]	Dry or Critical[2/]
			Water Year Type			
			Flow in cfs			
May 6-31	14,000	14,000	11,400	6,500	4,300	3,300
	(0.53)	(0.53)	(0.38)	(0.11)	(0.0)	(0.0)
June	14,000	10,700	9,500	5,400	3,600	3,100
	(0.53)	(0.34)	(0.27)	(0.04)	(0.0)	(0.0)

1/Dry year following a wet, above normal or below normal year, from D-1485 Table 2

2/Dry year following a dry or critical year

- Do not change existing standards until the recommendations of the five-agency salmon group can be evaluated.

- DTAC, TID/MID (TID/MID,Brief,9-14)

  - The smolt survival index should not be used as a standard.

- USFWS (USFWS,31,31d-j and 47)

  - Sacramento Basin fall run smolts should be protected April 1 through June 30 and San Joaquin Basin smolts from April 1 through June 15.

  - Sacramento River flows at Rio Vista, depending on water year type, should range from 21,500-10,000 cfs and provide smolt survival indices at the 1940's level, ranging from 0.95 in wet years to 0.30 in critical years.

  - San Joaquin River flows at Vernalis should range from 12,000-4,000 cfs, depending on water year type.

  - Eliminate reverse flows during smolt emigration.

  - Prevent delays to adult migrants, maintain unobstructed migration route, and maintain DO above 5 mg/l between Stockton and Turner Cut in the fall.

  - Survival goals could be achieved by a combination of flow, operational and physical modifications.

  Table 5.3.4.2-2 summarizes the protection levels recommended by USFWS and other fishery advocates.

- NMFS (T,LXI,22:24-28:4)

  - In the Sacramento River system, Delta smolt survival for all four races should be that which occurred under 1940 levels of water development (see Table 5.3.4.2-2).

  - The Water Quality Control Plan should contain a blend of physical and operational management measures as well as some increment of flow increase to improve smolt survival.

  - Interim standards should be established for the San Joaquin River system to improve salmon production.

- DFG (T,XLIII,76:24-80:24;DFG,64, and DFG,30)

  - Survival of each race in the Delta should be based on 1940 historical levels (see Table 5.3.4.2-2).

Table 5.3.4.2-2--Recommended Objectives for Chinook Salmon (USFWS,DFG,NMFS) (from USFWS,31d-i and 47)

	Sacramento Basin Smolts	
Water Year Type	April - June Survival Index	April - June Rio Vista Flow (CFS)
Wet	0.95	21,500
Above Normal	0.85	20,000
Below Normal	0.75	18,000
Dry	0.65	16,000
Critical	0.30	10,000

1. Keep smolts out of central Delta.
2. Keep temperatures below 66 degrees F.
3. Keep smolts out of upper Old River.
4. Positive net flow in the San Joaquin, Old, and Middle rivers.

San Joaquin Basin Smolts

1. Same survival levels as for the Sacramento Basin.
2. Vernalis in flows ranging from 12,000 cfs in wet water years to 4,000 in critical water years.

Central Valley Adults

1. Maintain unobstructed migration route.
2. Dissolved oxygen $\geq$ 5 mg/1 between Stockton and Turner Cut on the San Joaquin River.

- Survival rate for Sacramento Basin fall run salmon should based on the USFWS flow-to-survival relationship in Exhibit 31.

- Eliminate flow reversals by 1995 in the San Joaquin River and in Old and Middle rivers.

- Survival levels in the San Joaquin River should also be based on historical levels but these still need to be defined.

- Physical and operational measures should be considered to achieve protection.

- EDF (EDF,23)

  - USFWS flows recommended for Sacramento Basin smolt migration should be adopted.

  - Vernalis flows should range from 11,000-5,000 cfs depending on water year type.

  - Delta outflows should range from 31,000-10,000 cfs, depending on water year type.

  Table 5.3.4.2-3 summarizes the flow conditions recommended by EDF.

- BISF (BISF,Brief,85-86 and 93-98)

  - The spring Delta outflows at Chipps Island, measured as a combination of Sacramento and San Joaquin River flows, should not be less than 38,500 cfs averaged over three to five year periods.

  - Outflows could be reduced in dry years provided compensating flows are available in other years.

  - There should be objectives for wet, median and dry year spring flows at levels greater than D-1485.

  - Endorses other measures proposed by USFWS.

  Table 5.3.4.2-4 summarizes the standards recommended by BISF.

5.3.4.3 Optimal Levels of Protection

Evidence presented in Phase I of the hearing indicates that Delta Plan objectives do not fully protect all the different life stages of Chinook salmon using the Estuary. The parties presenting evidence at the hearing reviewed much of the same data and generally agreed that under existing conditions the Delta is a source of significant mortality for smolts emigrating from upstream areas. This section summarizes available information on the factors contributing to reduced

Table 5.3.4.2-3--Recommended April-June Salmon Smolt Migration Standards (EDF) (from EDF,23)

Water Year Type	Annual Survival Index Goal	Sacramento R. Rio Vista (cfs)	Sacramento R. Freeport (cfs)	Sacramento R. Diversion[1/] Above RV (cfs)	San Joaquin R. at Vernalis (cfs)	Total River (Freeport + Vernalis)	Estimated[4/] Export + Ch. Depl.- E. Side (cfs)	Estimated Delta Outflow (cfs)
Wet	0.95	22,000	26,000	4,000[2/]	11,000	37,000	6,000	31,000
Above N.	0.86	20,000	24,000	4,000[2/]	10,000	34,000	7,000	27,000
Below N.	0.75	18,000	22,000	4,000[2/]	9,000	31,000	8,000	23,000
Dry	0.65	16,000	20,000	4,000[2/]	8,000	28,000	9,000	19,000
Critical	0.30	10,000	15,000	5,000[3/]	5,000	20,000	10,000	10,000

1/ From DWR Exhibit 50
2/ Cross Channel closed, Georgiana Slough only
3/ Cross Channel and Georgiana Slough
4/ Based on recent historic DAYFLOW records

Table 5.3.4.2-4--Recommended Salmon Smolt Protection Levels (BISF)
(BISF, Brief, 85-86 and 93-98)

Controlling Year Type	Period	Protection Level (Delta Outflow in cfs)[1/]	Beneficial Use
Wet Years (wettest 10%)	Apr-Jun	38,500-42,000	salmon smolts, striped bass, shad
Median Years (years between wet and dry)	Apr-Jun	38,500-42,000	salmon smolts
Dry Years (driest 10%)	Apr-Jun	10,000	salmon smolts

1/ Combined Sacramento and San Joaquin River flows to meet outflow salmon production and hypothetical actions which would eliminate these mortality factors providing optimal protection for the salmon beneficial use in the Delta-Estuary. Much of the recent evidence was based on studies carried out since the 1978 Delta Plan went into effect. These study results were presented in terms of either: (1) correlations between fish survival and flow or other conditions in the Delta; or (2) descriptions of results for which only a few years' data were available and general, not always consistent, trends were apparent.

Evidence has been presented showing that natural populations of Sacramento salmon are declining and San Joaquin populations are undergoing extreme fluctuations. Also, Delta Plan salmon standards are not providing inadequate protection particularly with regard to conditions affecting the fall run smolts during their spring emigration.

Recent studies by the USFWS showed a significant positive correlation between April through June Rio Vista flows and survival of marked hatchery smolts migrating through the Delta (USFWS,31,33-41). Several years of data from the San Joaquin Basin suggest a similar relationship (USFWS,31,65-71). These studies also indicated a positive relationship between survival and keeping smolts in the main channels of the Sacramento and San Joaquin rivers (USFWS,31,72-73;T,XXXVI,152:6-155:23). Furthermore, survival in both basins may be reduced when spring water temperatures are above the stressful range of 66°to 70°F (T,XXXVI,159:17-20;DWR,562,60;TXXXVI,150:24-151:11; DFG,15,26-27).

The amount of flow is the major determinant of both the quantity and quality of fishery habitat. However, it is not feasible to try to establish or achieve precise numerical fish production goals since many factors, all of which may vary from year to year, influence the number of salmon returning to spawn. Instead, determination is made by fishery biologists as to the general habitat conditions needed to ensure the highest probability of reasonable or optimal fish production levels. This was the approach taken in the Interagency Delta salmon studies carried out by the USFWS. The point was made that correlation does not mean causation (T,XXXVIII,17:14-16) and that more study is needed before specific actions be taken to change beneficial use protection levels contained in the Delta Plan. However, as the SWC's consultant testified, the likelihood of being able to demonstrate causation when so many of the factors are interrelated (T,XXXVIII,17:17-24) is difficult (T,XXXVIII, 61:11-17).

In the following sections the factors affecting the salmon beneficial uses are discussed in detail. Recommendations are also made which would theoretically provide optimal protection to the fall run Chinook salmon in the Delta. No evidence regarding specific protection levels needed by smolts of the other three races was submitted, therefore, no discussion of them is presented.

- Problem 1: Decreased spring Delta inflows reduce fall run smolt survival.

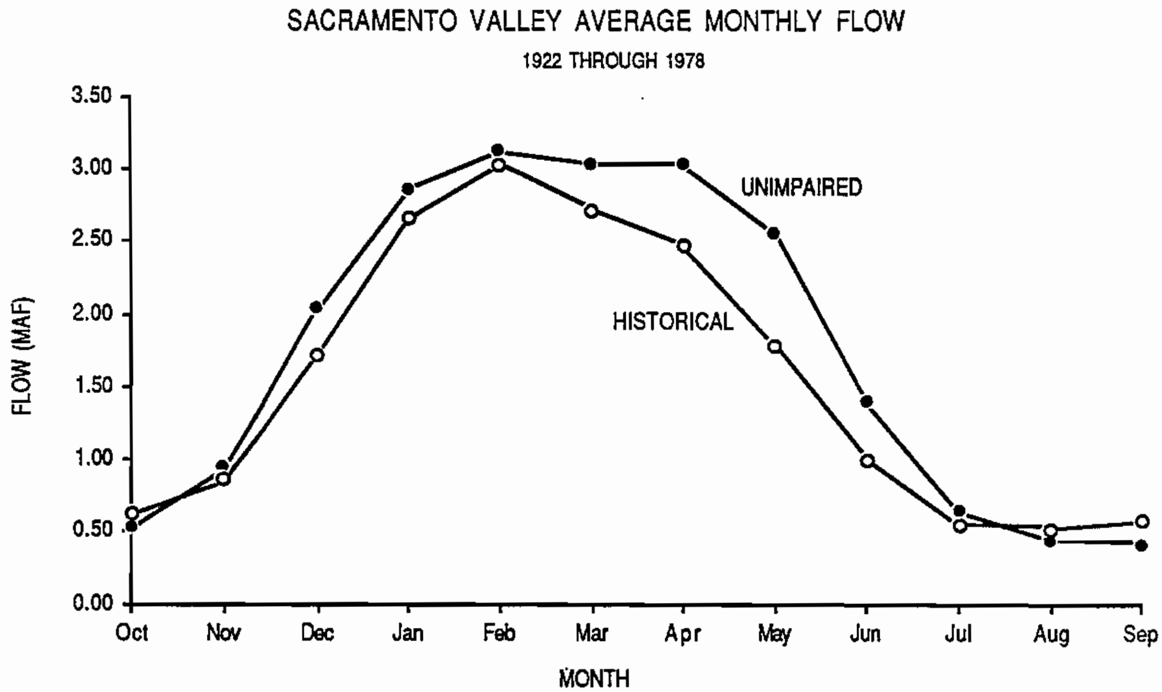
DFG testified that the primary factor limiting salmon survival in the Estuary is the survival rate for emigrants (T,XXXVII,66:11-14) and that "there are not substitute measures outside the Estuary that could compensate for all the potential harm that could result from decreased survival within the Estuary" (T,XXXVII,69:4-9).

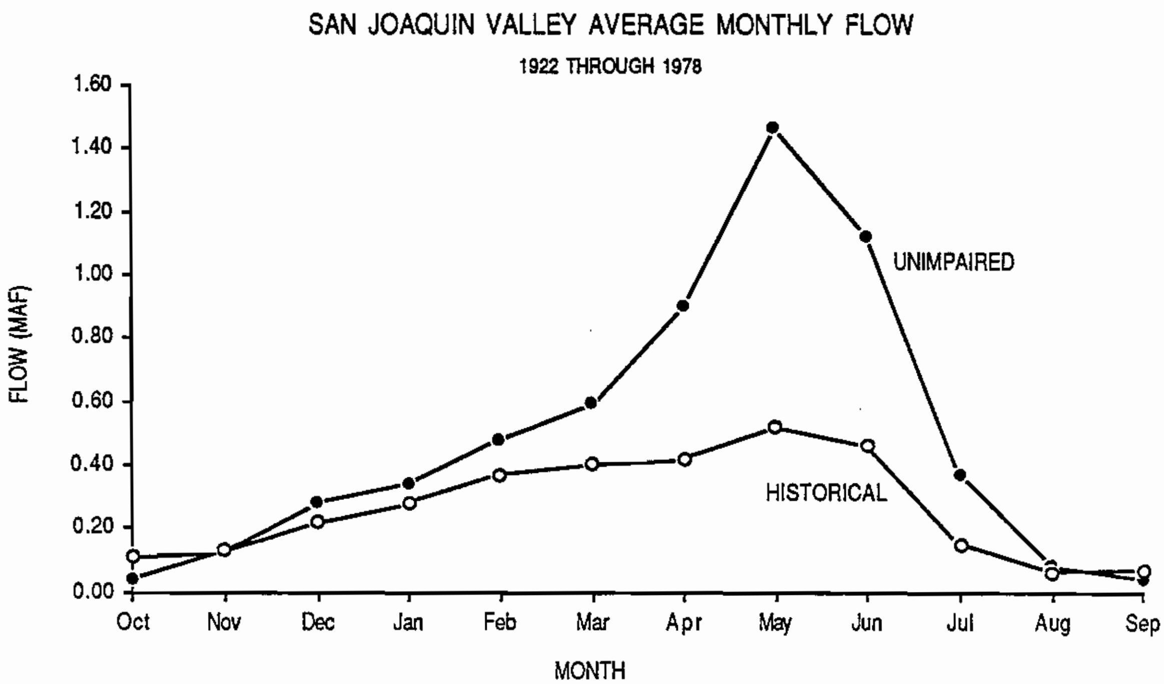
Since the 1940's upstream and in-Delta facilities have altered seasonal flow patterns. Reservoir operations and water diversions have decreased spring inflows to the Delta (see Figure 5.3.4.3-1).

Historically, the magnitude of spring flow during the fall run smolt emigration period has corresponded to the number of adults returning to spawn about two and one-half years later. In the Sacramento Basin before the improvement in hatchery production in the 1970's, spawning escapement fluctuated in relation to conditions during the smolt emigration period (DWR,561,17-20). An analysis performed by DWR's consultant indicated that prior to 1968, the two year moving average of monthly April-June Sacramento River flows during the smolt emigration period correlated significantly with the two year moving average of subsequent Sacramento Basin spawning escapement (monthly R ranging from 0.53-0.72,P<0.01 or <0.05 for April, May, and June). April through July Delta outflow also correlated significantly with spawning escapement (monthly R ranging from 0.52-0.77, P<0.01 or 0.05). After 1968 no significant correlation between smolt emigration flows and later adult escapement was found (DWR,561,34-48). Various events occurring after 1967 are thought to have eliminated this relationship, including, closure of the Red Bluff Diversion Dam on the upper Sacramento River (DWR,561,17-20;43-49), "an increase in Delta diversions by initiation of SWP exports, transfer of Trinity River water to the Sacramento Basin, and increased trucking of hatchery production around the Delta" (USFWS,31,77-79).

The practice of trucking and releasing hatchery reared smolts below the Delta has enabled the total adult Sacramento Basin fall run population to be stabilized despite the "persistent decline" of all races of naturally produced salmon and those hatchery reared fish which emigrate down the Sacramento River and through the Delta (T,XXXVII,153:-154:1). As discussed in section 4.5.1.2, survival of fish trucked around the Delta is established to be six to eight times greater than survival of hatchery produced smolts migrating through the Delta (T,XXXVII,161:22-162:1).

Figure 5.3.4.3-1 Change in Delta Inflows from Unimpaired Conditions



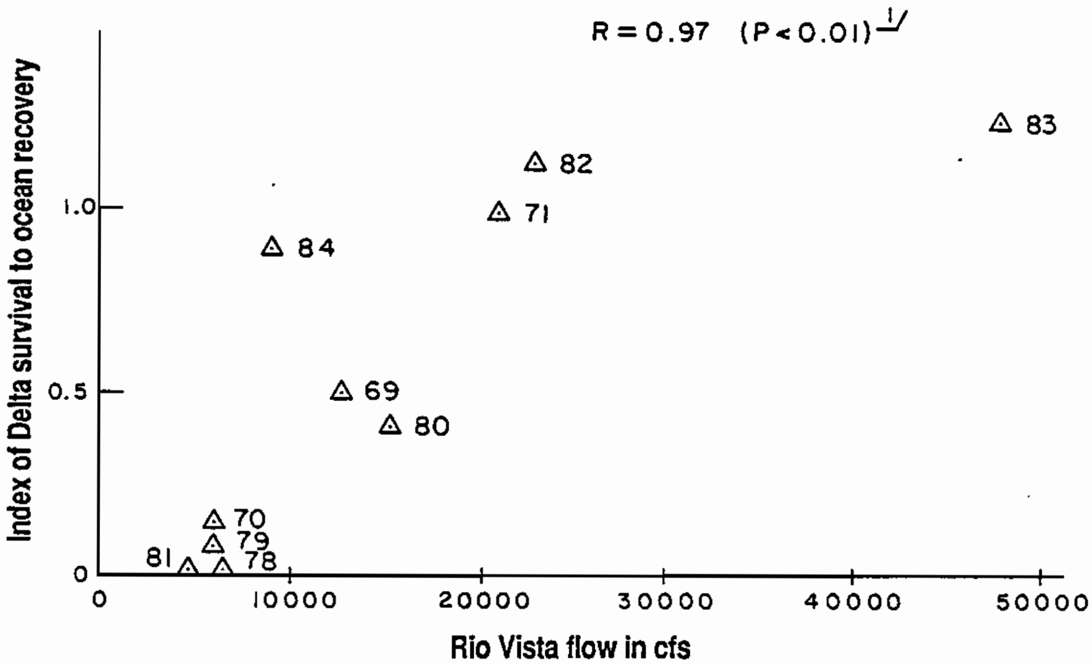


Salmon escapement to the Feather and American rivers has increased, even though reservoir storage has altered spring outflows, because hatchery rearing programs have replaced or augmented natural instream salmon production (DWR,561,49). Flows in the lower American River were reported to have no influence on escapement because the run is primarily maintained by planting smolts in the Estuary(DWR,561,49). Feather River escapement has continued to be significantly correlated with Sacramento River flows in June (R=0.75,P<0.01) and Delta outflow in July (R=0.74,P<0.01).Not all Feather River hatchery salmon are released in the Estuary which may account for the continued relationship between Sacramento River flows and escapement to the Feather River. Feather River escapement increases to about 50,000 fish when June flows in the Sacramento River range from about 16,000-25,000 cfs (DWR,561 40-50) and July Delta outflows range from about 6,000-12,000 cfs (DWR,561,41). Feather River escapement appears to have stabilized (DWR,561,25) and more escapement fish are produced at lower flows since hatchery production began in 1968 (DWR,561,49).

The support provided to the Sacramento Basin salmon fishery by hatchery production has hidden the decline of naturally produced fish migrating down the river (as shown in Figure 4.5.1.2-4). This practice has also counteracted the historical relationship between spring flow conditions and subsequent adult escapement. However, recent USFWS studies of spring inflow to the Delta and smolt survival through the Delta indicate there is still an important relationship between these factors.

USFWS found that Delta smolt survival, as calculated by ocean tag returns of adults marked and released as smolts in the Delta and harvested two to four years later, increases as mean daily flows measured from April through June at Rio Vista increased up to about 22,500 cfs (R=0.97,P<0.01) (USFWS,31,33-58) (see Figure 5.3.4.3-2). Based on the statistical relationship between Rio Vista flows and smolt survival, USFWS calculated that, under the 1978 Delta Plan salmon flow objectives, the spring smolt survival index would be less than 0.01 (USFWS,31,58). In other words, when the regression equation developed from the flow/survival relationship is used with the Delta Plan salmon flows, the resulting amount of salmn smolt expected to survive is less than one percent. The annual abundance of smolts at Chipps Island also increases up to a maximum Rio Vista flow of about 30,000 cfs (USFWS 31, 36-37). Smolt survival was negatively correlated with increasing water temperatures (R= -0.86,P<0.01) and percent of Sacramento

FIGURE 5.3.4.3-2 Relationship of smolt survival through the Delta to mean daily Rio Vista flow based on ocean recovery of tagged hatchery smolts. 1/
(from USFWS, 31, 35)



1/ The years 1982-1984 are not included in the regression equation because either fish were released downstream of Sacramento or survival was > 1.0.

2/ Survival = (0.000056 x Rio Vista flow) - 0.258

River flows diverted through the Delta Cross Channel at Walnut Grove during the fall run smolt emigration periodof April through June (R= -0.65,P<0.05). Sacramento River flow at Rio Vista was considered to be an index parameter representing the combined interaction of higher Sacramento River flows, lower water temperatures, and a decrease in the relative proportion of Sacramento River flows diverted through the Delta Cross Channel (USFWS,31,55; T,XXXVI,156: 15-23).

These experiments were carried out primarily under 1978 Delta Plan conditions, with normal exports and Cross Channel diversions. As discussed later in this section, these other factors also affect smolt survival.

In addition to calculating monthly survival indices under Delta Plan conditions, USFWS took this index and multiplied it by the percentage of fall run smolts passing Chipps Island in each month (as determined by annual trawl surveys) for 1978-1986 to derive an annual weighted survival index (USFWS,31,56-57) (see Table 5.3.4.3-1). As shown in Figure 5.3.4.3-3, annual weighted April through June smolt survival for all 1978-1986 appears to be much better, averaging 0.47, compared to expected survival under the controlling Delta Plan flow objectives which ranges from 0.13-0.24 (see Table 5.3.4.1-3 in section 5.3.4.1). The higher annual weighted survival values, ranging from 0.12-1.0 for any given year, reflect the fact that since 1978 six out of nine years have been wet. As mentioned previously, unregulated Delta flows in April and sometimes in May have been much higher than the controlling flow standards (see Table 5.3.4.1-4).

In order to estimate and compare salmon smolt survival for various historic periods, DWR Dayflow Rio Vista flows values from 1930 to 1987 were used in the USFWS smolt survival/Rio Vista flow equation. Smolt survival indices for mean unimpaired flows for each year type were also compared to the mean historical survivals as shown in Table 5.3.4.3-2. USFWS reported that estimated mean weighted smolt survival using DWRs 1940 level of development hydrology was 0.76 (USFWS,31e). The smolt survival index values based on selected historic periods indicate a declining trend, from an average of 0.75 under unimpaired conditions to 0.42 since 1968.

Several factors may have contributed some bias in the USFWS studies. Many of the experimental releases of smolts were made in May and June, although emigrating smolts are present throughout April. April conditions are thought to be more favorable to smolt survival (see Figure 5.3.4.3-3) so that the relationship observed between flow and survival may underestimate the mean April through June survival (USFWS,31,42-44). Recently planted hatchery fish may not survive as well as wild fish adapted to river conditions.

Table 5.3.4.3-1--Estimated Weighted Survival Indices Under Delta Plan Conditions[1/]
(Values in parentheses are the monthly percentage of smolts migrating past Chipps Island)

Year	Water Year Type	April[2/] Survival Index	(%)	May Survival Index	(%)	June Survival Index	(%)	Annual Estimated Survival Index[3/]
1978	W	1.0	(27)	0.69	(40)	0.07	(33)	0.57
1979	D	0.40	(19)	0.30	(52)	0.05	(29)	0.25
1980	W	0.74	(14)	0.40	(34)	0.33	(52)	0.41
1981	D	0.43	(34)	0.17	(50)	0.0	(16)	0.23
1982	W	1.0	(18)	1.0	(49)	0.80	(33)	0.93
1983	W	1.0	(19)	1.0	(49)	1.0	(32)	1.0
1984	W*	0.50	(11)	0.26	(66)	0.16	(23)	0.26
1985	D	0.09	(26)	0.14	(63)	0.13	(10)	0.12
1986	W	1.0	(37)	0.22	(55)	0.04	(08)	0.49
Mean		0.68	(23)	0.46	(51)	0.29	(26)	0.47

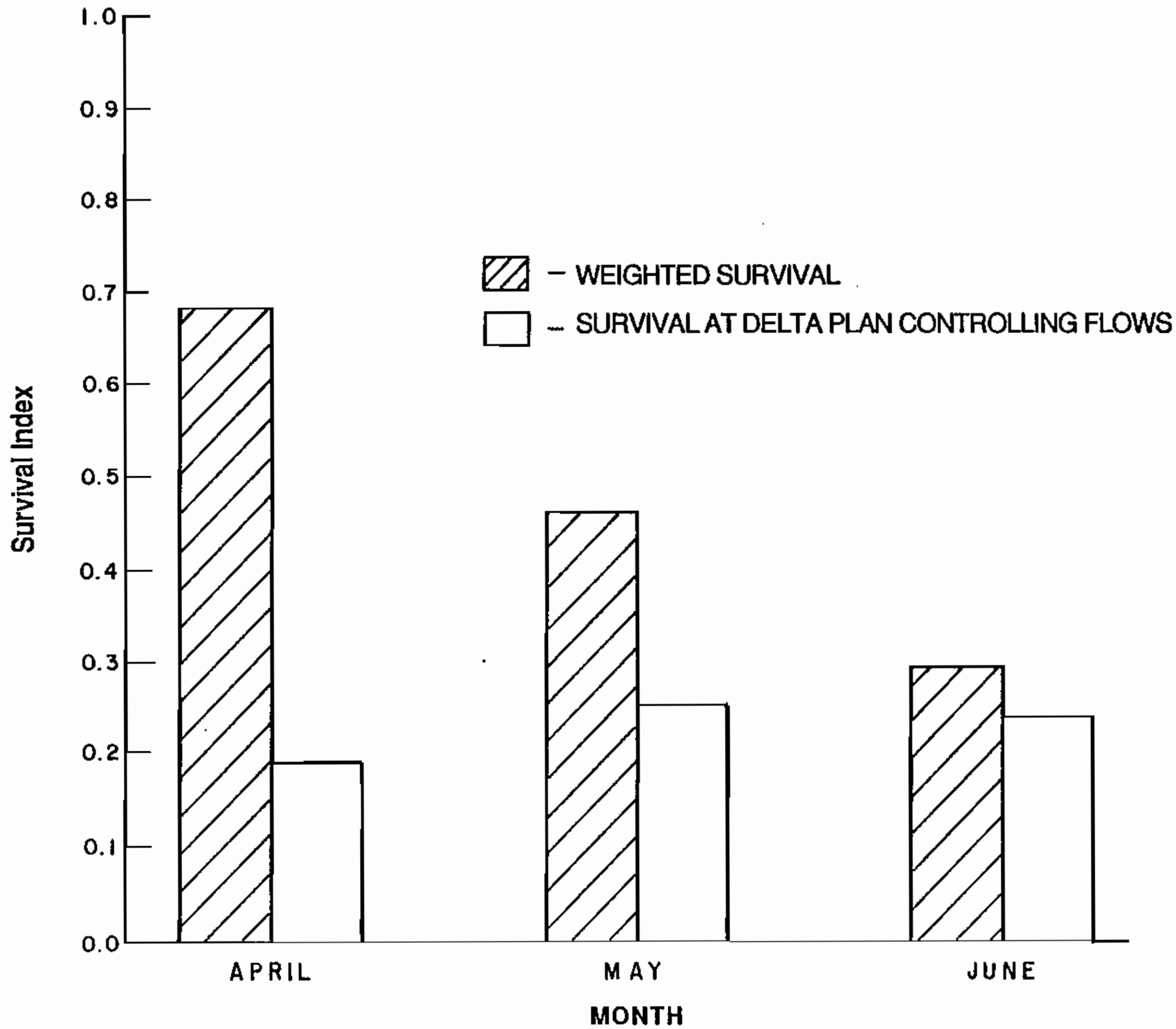
* Low spring flows due to subnormal snowmelt

1/ Numbers corrected from values in USFWS,31,57 Table 4-6, (P.Brandes pers. comm.)

2/ The monthly survival index is calculated using formula: $S=0.000056\ Q - 0.258$; where S=survival and Q=mean monthly Rio Vista flow in cfs for flows between 4,500 and 22,500 cfs

3/ The weighted annual survival index is the sum of each monthly survival index times the percentage of smolts migrating past Chipps Island in that month

FIGURE 5.3.4.3-3 Comparison of mean monthly smolt survival for 1978 Delta Plan controlling flows 1/ versus weighted monthly smolt survival based on actual Rio Vista flows and percent smolts passing Chipps Island, 1978 - 1986



1/ Assumes the controlling Delta outflow equivalent occurs upstream at Rio Vista. The upper flow values from Table 5.3.4.1-2 were used so that if the lower flows apply, survival would be reduced from the values shown.

Table 5.3.4.3-2 COMPARISON OF APRIL-JUNE RIO VISTA FLOWS FOR SELECTED HISTORICAL PERIODS 1/ AND CORRESPONDING SMOLT SURVIVAL INDICES

YEAR TYPE 2/	APRIL		MAY		JUNE		AVERAGE
	Flow	Survival	Flow	Survival	Flow	Survival	Survival
			UNIMPAIRED FLOWS 3/				
Wet	67,308	1.00	54,248	1.00	30,468	1.00	1.00
Above Normal	51,279	1.00	33,291	1.00	16,690	0.68	0.89
Below Normal	35,669	1.00	28,869	1.00	12,785	0.46	0.82
Dry	24,205	1.00	21,444	0.94	12,356	0.43	0.79
Critical	12,757	0.46	8,601	0.22	4,488	0.00	0.23
Average	38,244	0.89	29,291	0.83	15,357	0.51	0.75
			1930-1987 FLOWS				
Wet	61,845(22414)	1.00	41,769(22035)	0.97	24,408(18,580)	0.78	0.92
Above Normal	46,753(22500)	1.00	23,808(20875)	0.90	10,714(10714)	0.29	0.73
Below Normal	16,933(16333)	0.66	14,672(14554)	0.56	7,563(7563)	0.17	0.46
Dry	13,205(12673)	0.45	10,818(10203)	0.31	6,619(6619)	0.12	0.30
Critical	8,749(8749)	0.26	4936(4936)	0.04	2,531(2531)	0.00	0.10
Average 4/	32,775(17355)	0.72	22,278(15653)	0.62	12,385(10576)	0.35	0.56
Weighted Avg.5/							0.57
			1953-1987 FLOWS				
Wet	56,542(22371)	0.99	33,327(21,802)	0.96	20,456(17,152)	0.70	0.89
Above Normal	35,681(22500)	1.00	16,812(16812)	0.68	7,038(7038)	0.14	0.61
Below Normal	14,178(14163)	0.54	11,558(11381)	0.38	7,331(7331)	0.16	0.36
Dry	8,177(8177)	0.20	7,027(7027)	0.14	4,841(4841)	0.03	0.12
Critical	6,690(6690)	0.16	5,165(5165)	0.05	3,715(3715)	0.00	0.07
Average 4/	27,874(15,401)	0.61	17,685(13,683)	0.51	10,903(9770)	0.30	0.47
Weighted Avg.5/							0.47
			1930-1952 FLOWS				
Wet	72,452(22500)	1.00	58,653(22500)	1.00	32,313(21436)	0.94	0.98
Above Normal	51,182(22500)	1.00	26,606(22500)	1.00	12,184(12184)	0.42	0.81
Below Normal	22,443(20672)	0.90	20,901(20901)	0.91	8,027(8027)	0.19	0.67
Dry	22,015(20551)	0.89	17,456(15762)	0.62	9,731(9731)	0.29	0.60
Critical	11,494(11494)	0.39	4,630(4630)	0.03	952(952)	0.00	0.14
Average 4/	40,234(20328)	0.88	29,268(18650)	0.79	14640(11802)	0.43	0.70
Weighted Avg.5/							0.70
			1953-1967 FLOWS				
ALL	29,332(16436)	0.66	21,290(15876)	0.63	11,980(10582)	0.35	0.55
			1968-1978 FLOWS				
ALL	24,649(14292)	0.56	13,464(12381)	0.44	8,873(8873)	0.25	0.42
			1979-1987 FLOWS				
ALL	29,387(15031)	0.58	16,835(11619)	0.39	11,588(9513)	0.28	0.42

Footnote 1: Flows obtained from DWR DAYFLOW for Rio Vista flows, 1930-1987. 1930-1987 is the period of record. The flow on the left is the actual average flow for all months in that year type. The value in parentheses is the average of the monthly flows with with a cap of 22,500 cfs on all individual monthly flows exceeding this value. This is because USFWS data showed that 22,500 cfs produced a maximum survival index of 1.00. It is assumed that flows in excess of 22,500 cfs would not increase smolt survival. 1953-1987 is the period when the major water projects and Delta facilities were in their present configuration. 1930-1952 is the before the CVP and SWP began major Delta expots. 1953-1967 is the pre-SWP period, 1968-1978 is the pre-Delta Delta Plan period, and 1979-1987 is the post- Delta Plan period. Survival=(Rio Vista Flow)*.000056-.258.
Footnote 2: April-July year type index
Footnote 3: From Flowscience
Footnote 4: Average flow for that month over all year types,not the average of the year type values shown above.
Footnote 5: Weighted survival is the average April-June survival times the number of years of each year type, divided by the total number of years in the historical period.

However, trawl samples of the abundance of unmarked fish at Chipps Island underwent similar numerical changes with changes in flow, temperature, and diversion rate as were observed for marked fish (USFWS,31). Therefore, the survival of the tagged hatchery fish was assumed to be representative of the general effects of certain Delta conditions on all emigrating smolts and accurate enough to be used as an index (USFWS,31,41).

In the San Joaquin Basin, large annual fluctuations in the magnitude of spring flows during the smolt migration are followed by similar fluctuations in adult spawning escapement (T,XXXVI,15:10-23) (see Figure 5.3.4.3-4). The amount of spring flows during the smolt emigration period correlates significantly with subsequent adult escapement two and one half years later ($R=0.82, P<0.01$) (see Figure 5.3.4.3-5). Between 1955 and 1985 when mean April through June flows at Vernalis were around 20,000 cfs or more during smolt emigration, maximum adult escapement of around 40,000 or more fish occurred two and one half years later. Outflows around 5,000 cfs or less were generally associated with subsequent spawning escapement of less than 10,000 fish (USFWS,31,65) (see Figure 5.3.4.3-4). The fluctuating salmon escapement seen in the San Joaquin Basin is probably more typical of the historical response of salmon to varying water supply conditions and the resultant availability of fish habitat with a minimal hatchery contribution; this escapement is similar to what occurred in the Sacramento Basin prior to the increased hatchery contribution of the 1970's (DWR,561,17-20).

Recent USFWS studies of tagged smolts released in the San Joaquin River tributaries in two wet water years when inflows exceeded exports (1982 and 1986), and one critical water year when exports exceeded inflows (1987), showed that the highest survival indices, 0.58 and 0.62, occurred when flows measured at Vernalis were about 8,700 to 12,000 cfs (1982 and 1986). The survival index dropped to 0.17 when Vernalis flows were 2,100 cfs (1987) (USFWS,31,70-71; T,XXXVI,163:11-21) (see Figure 5.3.4.3-6). Based on this limited data, extending a line to intersect the 100 percent survival level suggests that a Vernalis flow of about 20,000 cfs would be needed (see Figure 5.3.4.3-6). DFG estimated that April through early June San Joaquin River inflows to the Delta of about 17,000 cfs would produce 70 percent of historical salmon escapement in the San Joaquin Basin (DFG,15,49). The estimates were based on (1) correlations between spring flows and adult escapement by that year class; and (2) estimates of the channel capacity of a particular river (T,XXXVI,22: 17-23:12). Thus, several different evaluations suggest that the greatest salmon smolt survival and/or subsequent adult production occurs when spring flows at Vernalis are around 17,000-20,000 cfs.

FIGURE 5.3.4.3-4 Mean April through June San Joaquin River flows at Vernalis during smolt emigration and subsequent adult escapement 2 1/2 years later. (from USFWS, 31, 66, Figure 4-8)

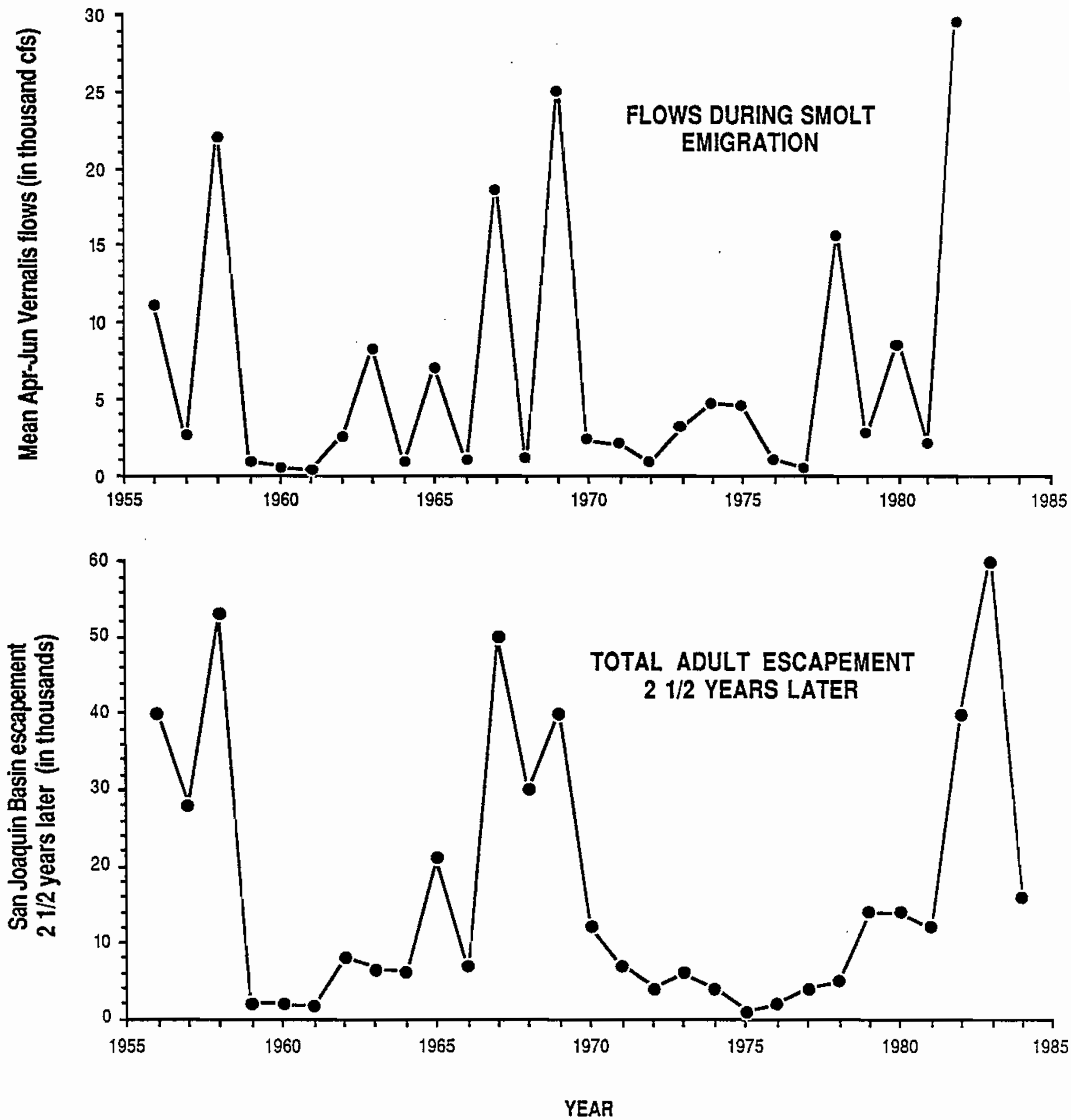


FIGURE 5.3.4.3-5 Relationship between mean April through June flows at Vernalis and adult spawning escapement 2 1/2 years later, 1956-1984 (USFWS, 31, 65)

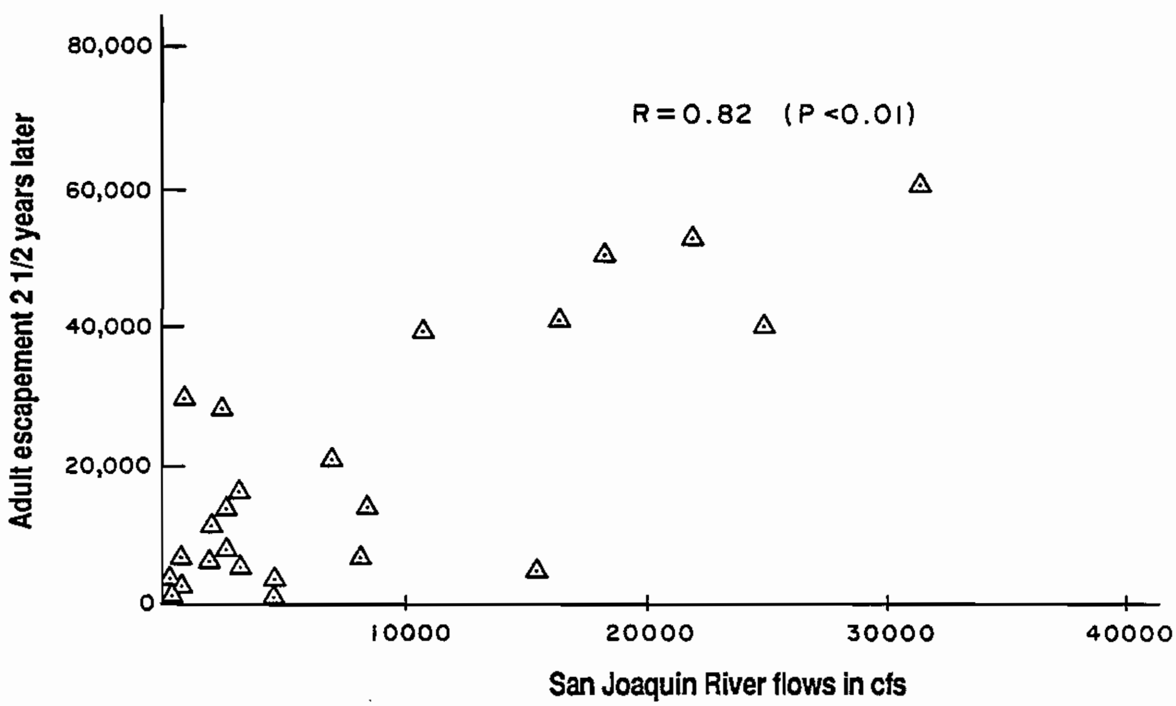
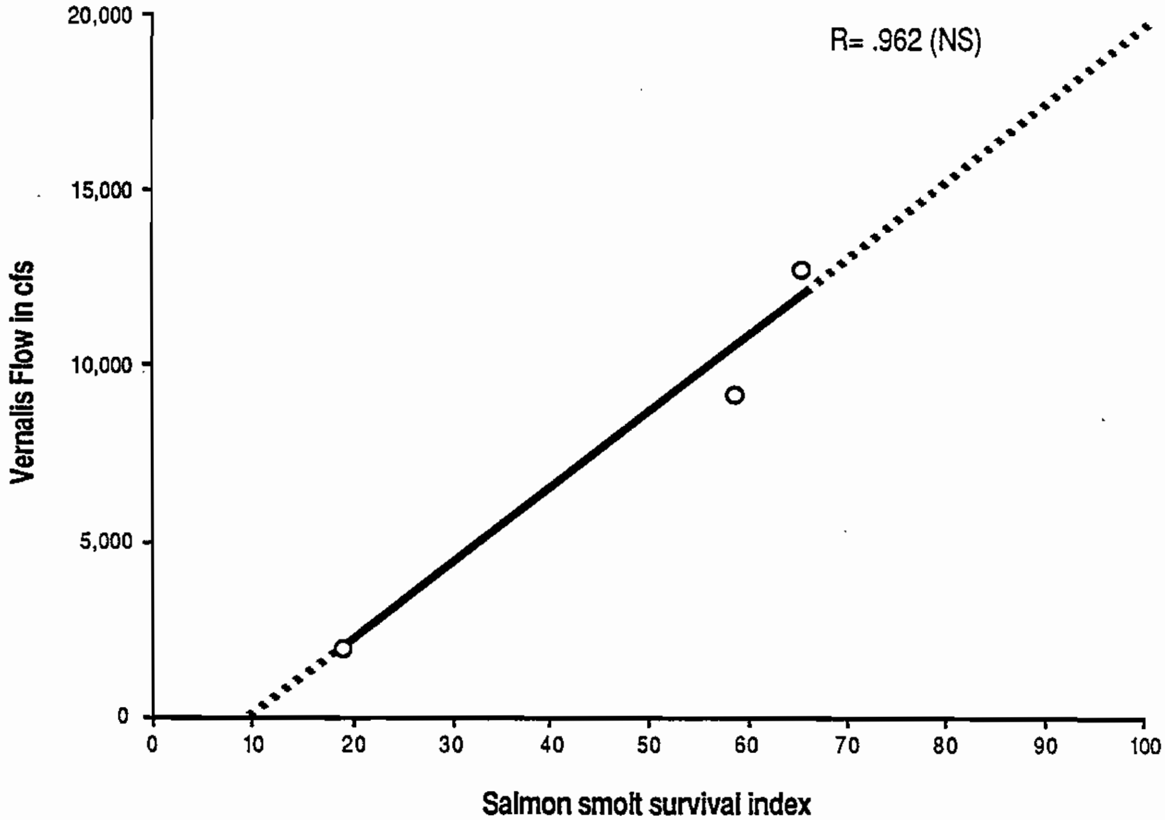


FIGURE 5.3.4.3-6 Mean April to June flows at Vernalis and the corresponding estimated smolt survival index[1] for marked smolt. Projected flows corresponding to maximum adult escapement 2 1/2 years later are shown by the dashed line. (from USFWS, 31,70) (This relationship is shown for informational purposes only since only 3 years of data are available and there is no significant correlation)



[1] Survival = 0.0046 (Mean Apr - Jun Vernalis flow) + 9.733

The optimal protection level described below is based on the flows that would, according to the available evidence, confer optimal habitat protection and facilitate maximum smolt survival without regard to other factors which may also influence Delta smolt survival. Reliance on hatcheries and trucking young fish around conditions shown to cause significant mortality in order to maintain adult production and harvest does not constitute optimal protection of this beneficial use.

- Recommendation: For optimal protection of fall run smolts emigrating down the Sacramento River, the April, May and June mean monthly flows at Rio Vista should be 22,500 cfs.

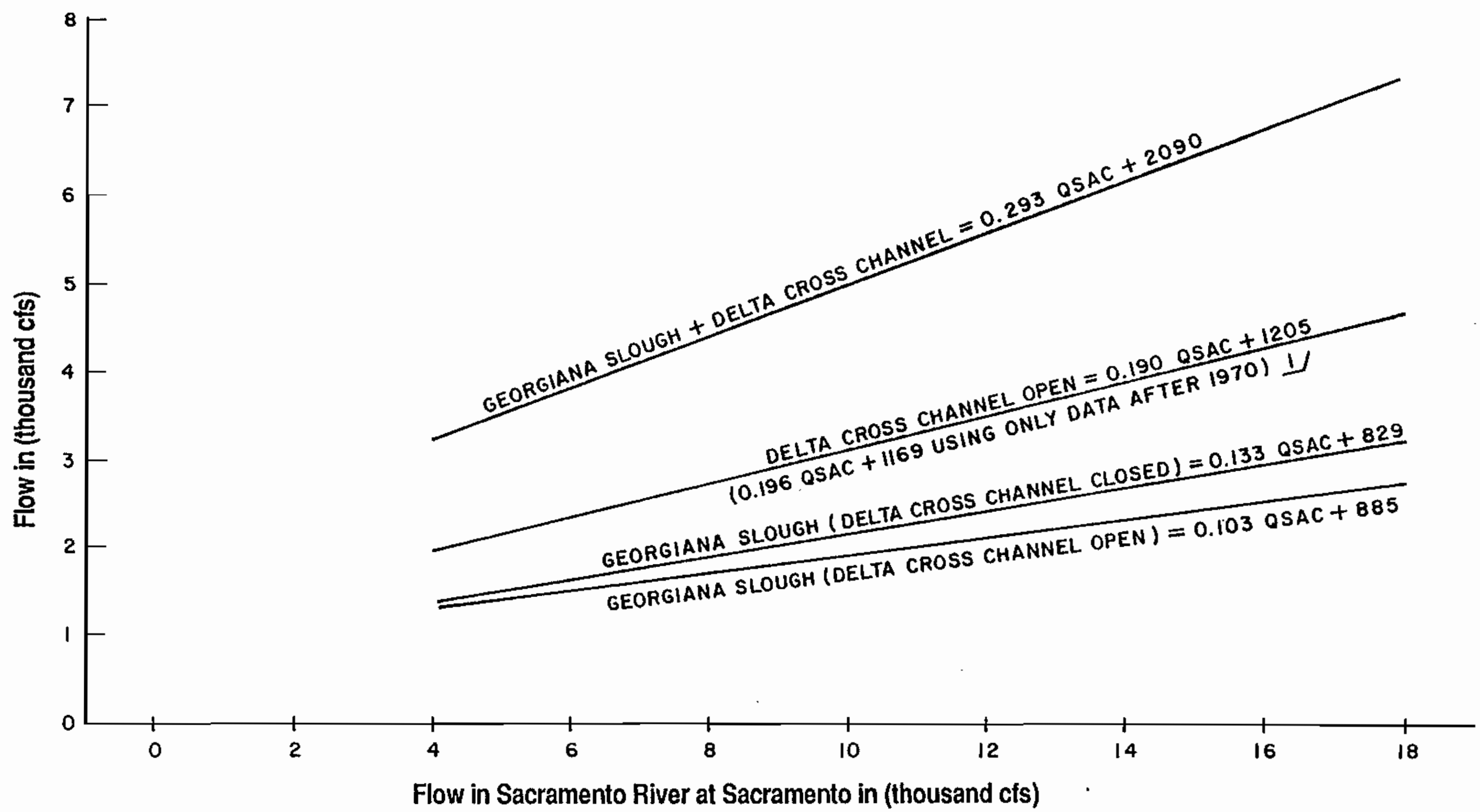
  For the protection of fall run smolts emigrating down the San Joaquin River, the mean April, May and June flow should be 20,000 cfs.

- Problem 2: Diversion of emigrating smolts from historical migration routes reduces their survival.

Tagging studies show that Delta survival decreases when smolts are diverted out of the main channels of the Sacramento and San Joaquin rivers during emigration. Central and southern Delta conditions believed to contribute to reduced smolt survival include: temperatures at stressful, to near lethal, levels during the late spring emigration period; possible poor food supplies; migration delays due to diversion from normal migration routes and reverse flows in Old, Middle, and the lower San Joaquin rivers carrying fish to the CVP and SWP export pumps; high predation rates near the SWP's Clifton Court Forebay; and the fish salvage process atthe CVP and SWP export pumps (USFWS,31,51-53).

The Delta Cross Channel, which began operating in 1950, splits the Sacramento River flow near Walnut Grove causing more young fish to be diverted into the central and southern Delta than would have passed via Georgiania Slough alone into these areas. Figure 5.3.4.3-7 shows the relationship between Sacramento River flows and flows in the Delta Cross Channel and Georgianna Slough (DWR,50). Even with the gates closed, a certain amount of Sacramento River flow still moves into the Mokelumne River and the interior Delta via Georgianna Slough (see Figure 5.3.4.1-1). At low flows, a greater proportion of the Sacramento River flow moves through the Cross Channel than at high flows. For example, at Sacramento River flows of 4,000 cfs, about 3,200 cfs or 75 percent is diverted while at flows of 16,000 cfs in the Sacramento River about 6,800 cfs or 42 percent is diverted through the Cross Channel.

FIGURE 5.3.4.3.-7 Empirical relationships between flows in Georgiana Slough, Delta Cross Channel and the Sacramento River
(from DWR,50)



1/ Flow split changed slightly after SWP went into operation but the two equations are not significantly different (T,IV, 45: 9-21).

The USFWS reported that one study showed the density of salmon above the Cross Channel to be similar to density in the Cross Channel itself when the gates are open suggesting that fish may be diverted in proportion to the flow split (USFWS,31,44). At lower river flows a greater relative proportion of fish as well as water may therefore be diverted.

If smolts enter the central Delta via Georgiana Slough or the Cross Channel, they can still emigrate successfully by moving down the Mokelumne River and turning west where it joins the San Joaquin River, then following the San Joaquin downstream (see Figure 5.3.4.1-1) (USFWS,31,49). However, smolts migrating to the Bay via the interior Delta travel a longer, more circuitous route and are exposed to increased predation, higher temperatures, and many unscreened agricultural diversions (USFWS,31,44). At the junction of the Mokelumne and San Joaquin rivers they may also encounter reverse flows moving southward toward the SWP and CVP pumping plants (USFWS,31,44-45).

Smolt survival, as measured by ocean tag recoveries, was negatively correlated with the percent of the Sacramento River flow diverted through the Delta Cross Channel ($R=-.65, P<0.05$) flow at Sacramento (USFWS,31,46) (see Figure 5.3.4.3-8). Evaluation of the survival of tagged smolts shows that, with the Cross Channel gates open, smolts released upstream of Walnut Grove survived approximately half as well as smolts released below the Cross Channel in three out of four years (See Table 5.3.4.3-3). Survival of smolts released above the Cross Channel with the gates closed (under low flow conditions and temperatures about 66° F) was about 68 percent greater than with the gates open. When the gates were closed, survival of fish released above the Cross Channel was similar to that of fish released below. Overall, these experiments showed that survival of Sacramento Basin smolts is greatest when they are not diverted into the Delta Cross Channel (T,XXXVI,152:10-155:23).

Studies were also carried out on smolts released at various locations in the central and southern Delta to test the survival of fish diverted from the main river channels via: (1) the Cross Channel; (2) export pumping from Old River; or (3) reverse flows. Although the results of studies in the central Delta are not as clear as those carried out in the Sacramento River, fish released into the central Delta exhibited somewhat lower survival in two out of three years compared to those migrating down the Sacramento River with the Cross Channel closed (T,XXXVI,155:10-17) (see Table 5.3.4.3-3 and Figure 5.3.4.3-8). Overall, survival of smolts released in Old River, where they would be subject to export pumping, was generally lower then the other groups studied except in 1985 (USFWS,31,48-51;T,XXXVI,155:1-23) (see Table 5.3.4.3-3 and Figure 5.3.4.3-9).

FIGURE 5.3.4.3-8 Delta smolt survival (based on ocean tag recoveries of marked salmon) versus percent diverted off the Sacramento River into the Cross Channel and Georgiana Slough at Walnut Grove during the time the marked fish were migrating downstream (USFWS, 31, 46)

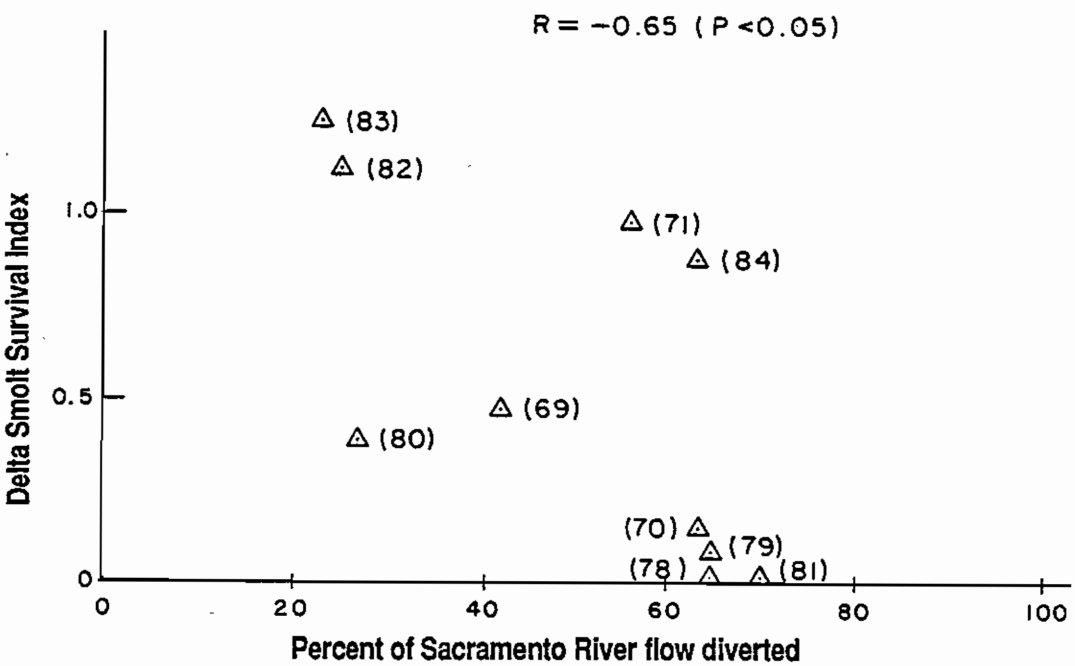


TABLE 5.3.4.3-3 Survival of marked smolts released at different locations in the Delta

SACRAMENTO[1] RIVER (Delta Cross Channel)

RELEASE LOCATION			Survival Index to Chipps Island		
	Year	% River Diverted	Gates Open	Gates Closed	Below Gates
SACRAMENTO[1] RIVER (Delta Cross Channel)	1983	23	-	1.06 [2]	1.33 [2]
	1984	62	0.61	-	1.05
	1985	65	0.34	-	0.77
	1986	64	0.35	-	0.68
	1987 (0)	69	0.40	-	0.88
	1987 (c)	29	-	0.67	0.85
	Mean =		0.42	0.83	0.86

CENTRAL DELTA[1] (Mokelumne River)

		Survival Index to Chipps Island		
	Year	North Fork	South Fork	Lower
CENTRAL DELTA[1] (Mokelumne River)	1983	-	-	1.13
	1984	0.51	0.86	-
	1985	0.28	0.23	-
	1986	0.36	0.26	-
	Mean =	0.38	0.45	

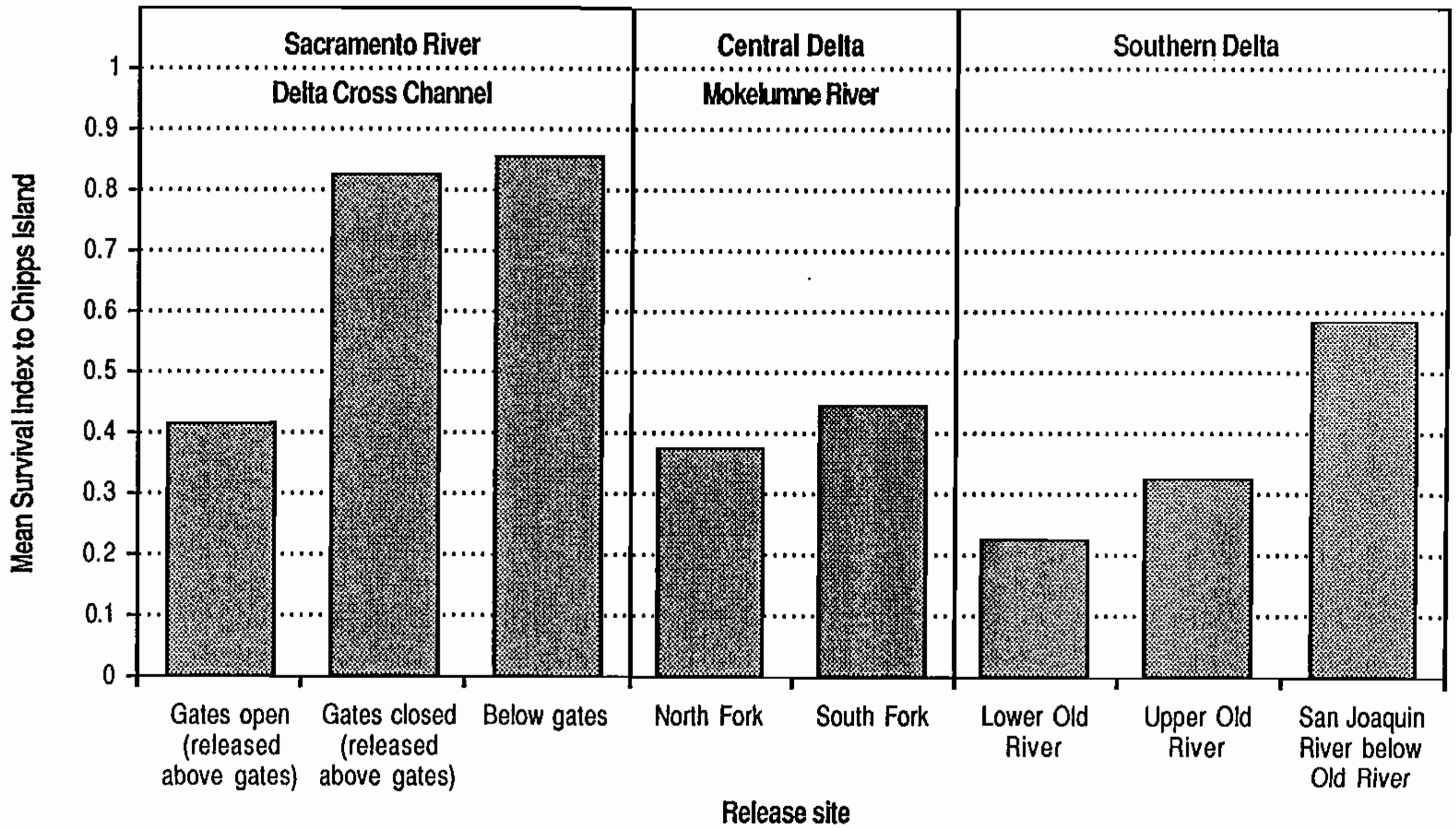
SOUTHERN DELTA

		Survival Index to Chipps Island		
	Year	Lower[1] Old River	Upper [3] Old River	San Joaquin R.[3] below Old River
SOUTHERN DELTA	1982	-	-	0.60
	1983	0.33	-	-
	1984	0.16	-	-
	1985	0.21	0.62	0.59
	1986	0.23	0.20	0.34
	1987	-	0.16	0.82
	Mean =	0.23	0.33	0.59

(1) from USFWS, 31, 48, Table 4-2
(2) values >1.0 suggest some sampling error and were reduced to 1.0 when calculating the mean
(3) from USFWS, 31, 70, Table 4-9

FIGURE 5.3.4.3-9 Mean Survival of tagged smolts released at different locations and recovered at Chipps Island

(after USFWS, 31, Tables 4-2 and 4-9)



Export pumping is a factor believed to contribute to reduced smolt survival (USFWS,31,44-51). As discussed in Section 5.3.4.1, export pumping in the spring frequently diverts the entire San Joaquin River inflow via Old River and can also reverse flows in the lower reaches of the San Joaquin, Old and MIddle rivers downstream of the pumps. Even when most of the San Joaquin River inflows were exported from Old River, smolts generally survived better if they remained in the main channel of the San Joaquin River (T,XXXVI,165: 17-23). To test this, groups of smolts were released in the San Joaquin River below its junction with Old River and in upper Old River enroute to the export pumps. Fish released in the San Joaquin River downstream of its junction with Old River had, on average, higher survival rates compared to smolts released in Old River (T,XXXVI,165:7-23) where they would be carried towards the export pumps (see Table 5.3.4.3-3 and Figure 5.3.4.3-9). Of smolts released in upper Old River (upstream of the export pumps) in 1985, 1986 and 1987, 25 percent, 74 percent and 27 percent, respectively, turned up at the pumping plant fish protective facilities compared to 3 percent, 3 percent and 8 percent of smolts released in the San Joaquin River below its junction with Old River (T,XXXVIII,47:10-15;USFWS,31,70). However, recovery of experimental smolts at Chipps Island is highest when smolts remain in the main channels of the Sacramento and San Joaquin Rivers (USFWS,3,45-49; Id.,74). Tagging studies show that, even though all flows may be diverted through the pumping plants, some smolts are able to find their way to Chipps Island (T,XXXVII,47:10-48:4).

Fry also rear in the Delta and, as was mentioned in Section 5.3.4.1, the 1978 Delta Plan provides for closure of the Cross Channel gates when Sacramento River flows exceed 12,000 cfs between January 1 and April 15. Fry are mostly present in the Delta from about January through April (T,XXXVI,169:8-10), with the highest abundance in the Delta in February or March (USFWS,31,82).As inflows to the Delta increase so do the number of fry.Also, their distribution extends further downstream, sometimes as far as San Francisco Bay (T,XXXVI,169:13-18). In wet years USFWS reported that fry survival in the central Delta was no different than that in the north Delta, but in dry years it was lower (USFWS,31,88). Ocean tag recoveries indicate that survival of fry in the northern Delta is better than that of fry released in the central Delta. Survival of Delta fry is better than that of fry released in San Francisco Bay (T,XXXVI,169:21-170:4). This evidence suggests that fry survival is improved if they are kept out of the central Delta in drier years but that their location in the Delta makes little difference in wet years; furthermore, fry carried into the Bay by very high flows may not survive well.

- Recommendations: Diversion of smolt or fry from their historical migration route or nursery areas can reduce survival. For optimal protection of fry rearing in the Delta, the Cross Channel gates should remain closed between January and April under below normal, dry, and critical water year conditions. For optimal protection of fall run smolt emigration, the Cross Channel gates should remain closed from April 1 through June 30.

- Problem 3: CVP and SWP export pumping from the Delta decreases salmon survival.

USFWS presented evidence, described in the previous section, suggesting that smolts subjected to reverse flows associated with export pumping do not survive as well as smolts which are not. Flows in the lower San Joaquin, Old and Middle river typically reverse when Delta exports exceed Vernalis inflows. In the 20 years, from 1968 to 1987, the mean April through June exports exceeded mean Vernalis inflows 15 times (see Figure 5.3.4.3-10). TID/MID's model of factors affecting salmon production also suggests that increasing spring Delta exports contribute significantly to decreases in the magnitude of subsequent adult escapement to the San Joaquin Basin (TID/MID,2,1-4). In addition to diverting emigrating smolts from their normal migration routes, there are direct losses of fish at the Delta pumping plants which increase with increasing export rates (see Figure5.3.4.3-11)

Salmon losses and salvage values are influenced by the timing, abundance and distribution of salmon in the Estuary, hydrologic conditions and project operations (DFG,17,28; T,XXXVII,35:11-15;T,XXXVII,124:5-22). DFG testified that losses reflect the amount of water going through the pumping plants when fish are present in the Delta (T,XXXVII,38:9-14). Monthly fish losses and salvage are highest during April through June and lowest during July through September (see Figure 4.5.1.2-3) (DFG,17,Appendix Table 4). There are year to year shifts in the peak of emigration through the Delta due to factors upstream of the Delta. In general, San Joaquin Basin smolts migrate somewhat earlier than Sacramento Basin smolts. Many Sacramento River Basin hatchery smolts released upstream of the Delta reach the Delta in June. Tagging studies show that Sacramento Basin smolts are mostly entrained at the SWP facilities while San Joaquin Basin smolts show up at the CVP fish screens (USFWS,31,53-55). The CVP exports averaged about 2,000-3,000 cfs from the Delta during the spring in the 1950's (see Figure 5.3.4.3-10). The SWP began exporting from the Delta in 1968, and, under the 1978 Delta Plan, combined CVP and SWP exports during the spring smolt migration period have increased to around 6,000 cfs (see Figure 5.3.4.3-10). While average salmon losses associated with CVP exports have remained similar since 1968, average losses associated with SWP operations have more than tripled since the 1978 Delta Plan became effective (see Table 5.3.4.3-4).

FIGURE 5.3.4.3-10 Comparison of mean April - June Delta exports and inflows at Vernalis, 1956 - 1987 (from DWR, Dayflow)

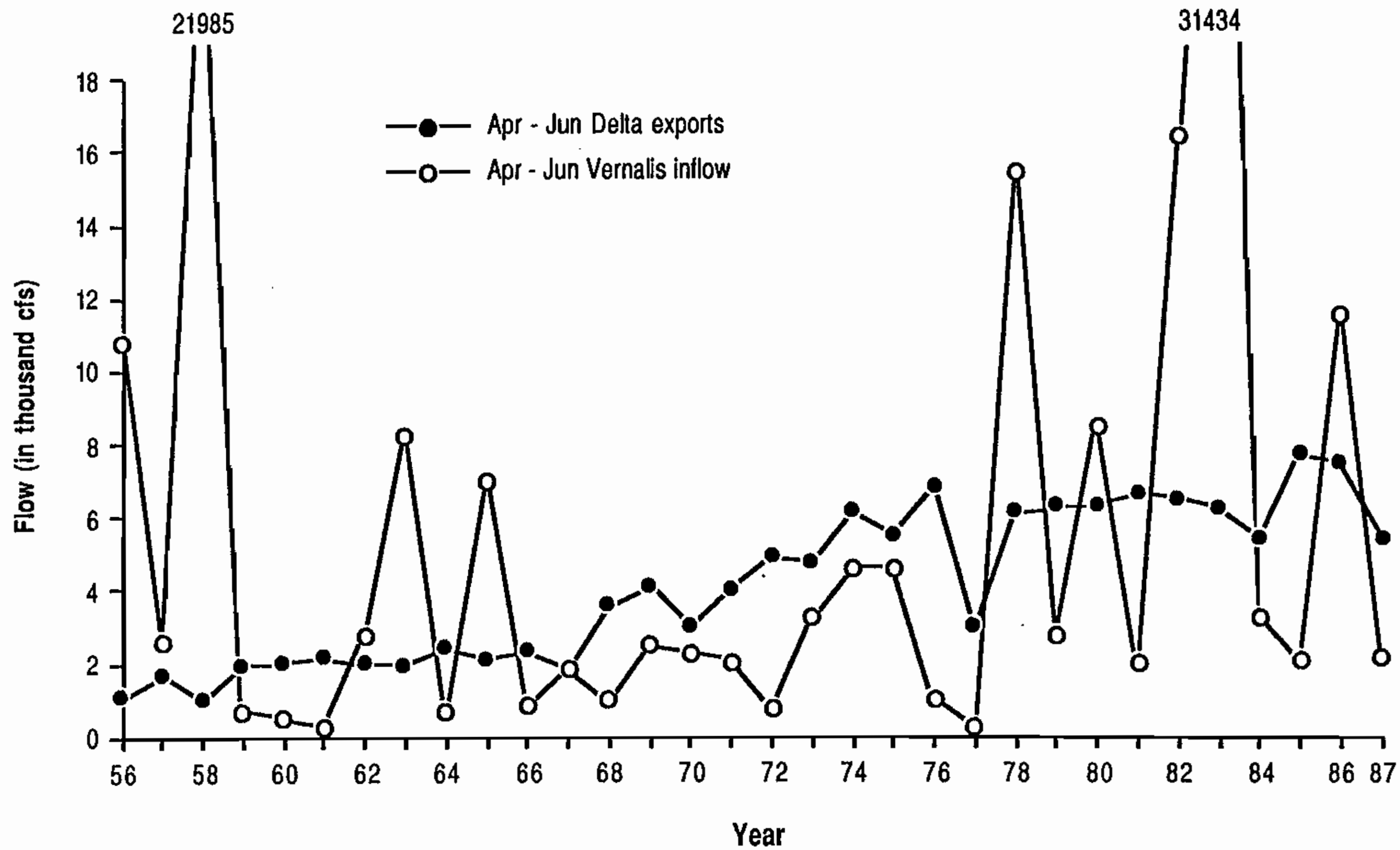


FIGURE 5.3.4.3-11 Change in mean monthly annual Delta exports and estimated Chinook salmon losses, 1956 - 1986 (from DWR, Dayflow, and DFG, 17)

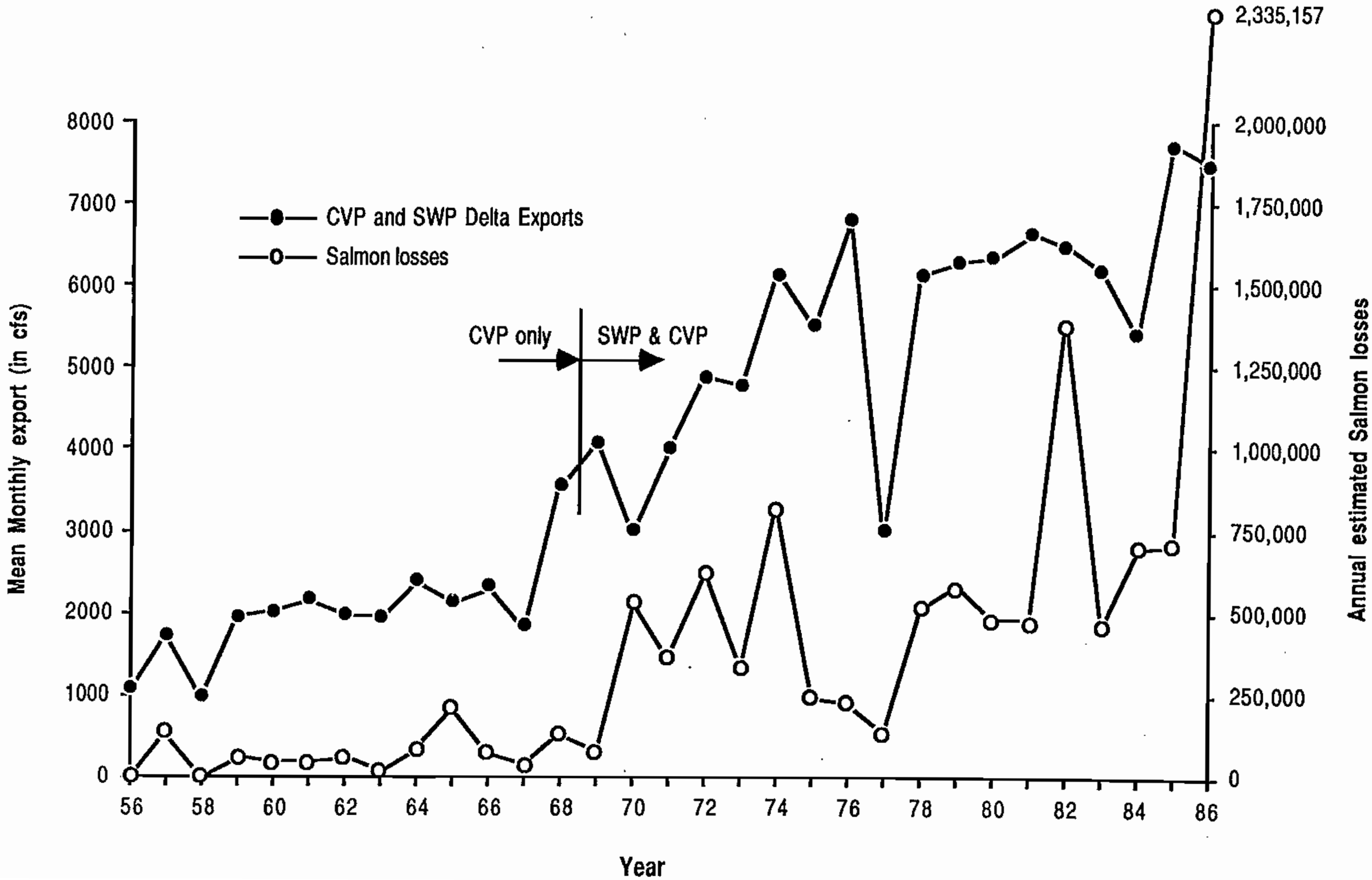


Table 5.3.4.3-4--Comparison of Mean Annual Estimated Chinook Salmon Losses and Monthly Exports at the CVP and SWP Fish Protection Facilities

1957-1986 (from DFG,17) and Mean Annual Exports in cfs (DWR,Dayflow)

	CVP		SWP		Total	
Period [1/]	Mean Annual Salmon Losses	Mean Annual Exports	Mean Annual Salmon Losses	Mean Annual Exports	Mean Total Losses	Mean Total Exports
1957-1967	68,886	1,843	0	0	68,886	1,843
1968-1977	136,865	2,865	108,540	1,592	345,405	4,446
1978-1986	129,442	3,314	719,275	3,133	848,717	6,447

[1/] Begins 1957 when fish losses calculated. Contra Costa Water District exports not included in total

The much higher losses at the SWP's Harvey O. Banks Delta Pumping Plant compared to the CVP's Tracy Pumping Plant may be related to several factors. Forebay conditions, including the presence of predators, contribute to this situation (DFG,17,16; DWR,560,2-3;DWR,560-6). Predation losses for salmon in Clifton Court average 75 percent (DFG,17,17). Prescreening mortality for salmon was estimated to average 75 percent at the SWP facilities as compared to 15 percent at the CVP facilities (DFG,17,14; T,XXXVII,38:4-8; T,XXXVII,35:22-36:8). The large increase in losses at the SWP facilities suggest that as exports of water from the Sacramento River Basin, which produces many more salmon, have increased so has the quantity of fish entrained. The USFWS testified that fish salvage operational criteria in D-1485 may provide some protection for fish at the CVP and SWP pumping plants (T,XXXVI,166:20-21). However, according to DFG, these criteria preclude the flexibility needed to alter operations in response to yearly shifts in the timing of peak fish abundance (T,XXXVII,134:1-19).

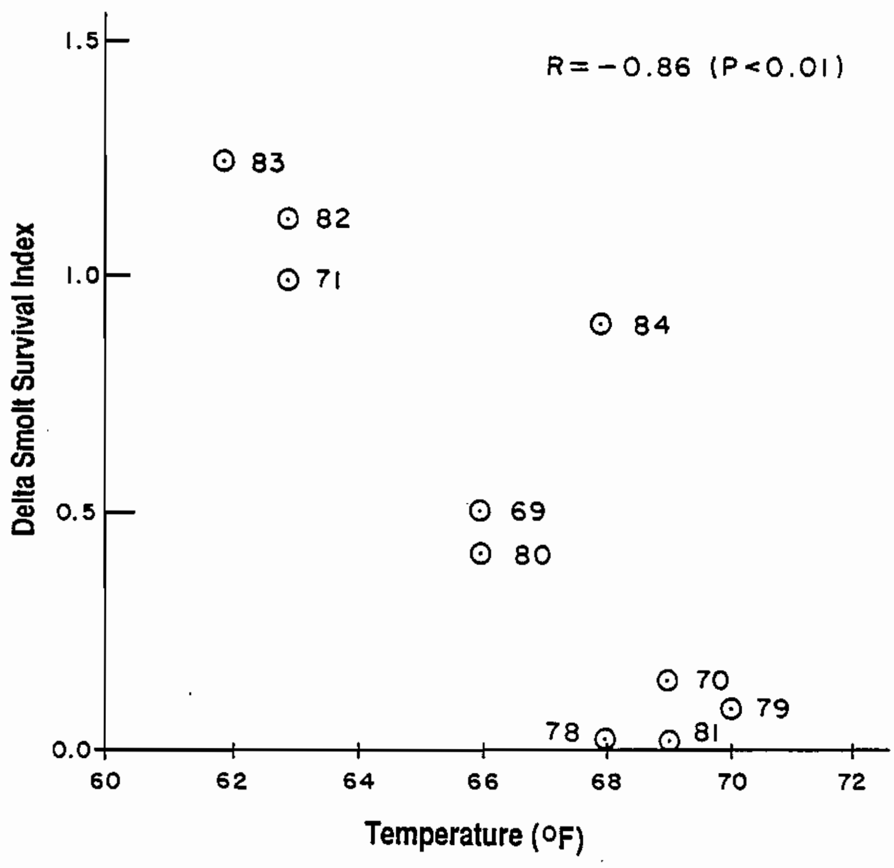
DFG and DWR entered into an agreement, which became effective in 1986, for a program to offset losses of salmon, steelhead, and striped bass at the Harvey O. Banks Delta Pumping Plant (DWR,569,1). According to the agreement, habitat restoration and other non-hatchery measures are to be given priority, and special emphasis is to be given to the San Joaquin River system for salmon habitat (DWR,560,6). No specific plans to reduce fish losses in Clifton Court forebay are contained in this agreement (DWR,560,9).

- Recommendation: Salmon survival is reduced during export of water from the Delta by the CVP and SWP. For optimal protection of fall run smolts, no water should be exported from the Delta by the CVP and SWP between April 1 and June 30.

- Problem 4: Water temperatures during the spring smolt emigration period reach levels that cause stress to fish.

Water temperature is another factor identified as affecting smolt survival in the Delta (see section 4.5.1.2). DWR's consultant testified that since 1978, temperatures at Sacramento have been two to three degrees centigrade (about four to six degrees Farenheit) higher (T,XXXVII,157:11-15). Consequently, smolts emigrating later in the season are likely to suffer higher mortalities (T,XXXVII,226:15-20). Sacramento Basin smolts would be affected, particularly hatchery reared fish which are released late in the spring, because the peak of emigration occurs somewhat later than in the San Joaquin Basin (T,XXXVII,215:17-22;T,XXXVII,225:23-226:7; DFG,15,17-23;USFWS,31,23). USFWS found that based on ocean tag recoveries, smolt survival decreased as water temperatures increased ($R=-0.86$ $P<0.01$) (see Figure 5.3.4.3-12). On the other hand, the survival index exceeded 50

FIGURE 5.3.4.3-12 Relationship between mean water temperatures and survival of marked smolts between Sacramento and Suisun Bay (based on ocean recoveries) (from USFWS, 31, 43)



percent when Sacramento River temperature at Freeport was 66°F or less (USFWS,31,43). Although temperature generally decreases as flow increases, there is a large temperature range at any given flow (T,XXXVII,157:4-8). In May, Sacramento River temperatures (at Freeport) are typically less than 66°F at flows between 25,000-30,000 cfs. San JoaquinRiver temperatures are generally less than 66°F atVernalis flows of 5,000 cfs or more (DWR,562,54; USFWS,31,148;DFG,15,26). When Sacramento River flows are below 20,000 cfs in June, the 5 day mean water temperature exceeds 66°F about half the time (T,XXXVII,156:24-157:2). By June temperatures do not drop below 66°F unless flows are about 30,000-40,000 cfs at Freeport (DWR,562,55; USFWS,31,148).

Laboratory studies have shown that a smolt's tolerance of elevated temperatures is improved when food supply is optimal (DWR,563,1-3). DWR's consultants testified that DFG's records indicate that the abundance of Neomysis, one of the primary foods of emigrating salmon (T,XXXVII,207:23-25), has decreased significantly in the last 20 years (T,XXXVII,207:25-208:1) and that upstream and estuarine food supplies may be poor. Taken together, these conditions could aggravate the effects of higher temperatures during emigration (T,XXXVII,207:3-9).

- Recommendation: The recommended flows for optimal protection of fall run smolts should significantly decrease May and June water temperatures in the Sacramento and San Joaquin rivers.

- Problem 5: Water quality conditions may block upstream migration in the San Joaquin River.

Within the Estuary, upstream migration of adult Chinook salmon occurs year round. The largest numbers of adult salmon are present in the Estuary from July through November (T,XXXVI,171:1-5) with the fall run predominating during much of this period. The fall run, which migrates upstream from July through November, is the only race in the San Joaquin Basin, while the late-fall, winter and spring runs migrate to spawning grounds in the upper Sacramento Basin from October to August (see Figure 4.5.1.2-1). As discussed in Section 4.5.1.2, adults follow olfactory cues contained in downstream flows of water from their homestream. The 1978 Delta Plan contained specific monthly Rio Vista flows for salmon migration ranging from 1,000 to 5,000 cfs (see Table 5.3.4.1-1). No minimum flows of homestream water have been identified for successful upstream migration, though it has been reported that salmon were able to migrate up the San Joaquin River when flows past Stockton were as low as 500 cfs (1978 Delta Plan draft EIR, p.III-80). It has been found that temperatures of about 65°F and DO levels below 5 mg/l in the fall have sometimes partially blocked adult migration in the San Joaquin River near Stockton (USFWS,31,94).

To address this problem in the San Joaquin River, an agreement was reached in 1969 among the USBR, DWR, and DFG (an agreement still in effect although not incorporated into the 1978 Delta Plan conditions) under which DWR monitors DO levels in the San Joaquin River between Stockton and Turner Cut (Stockton Ship Channel) during the fall migration. If DO drops below 6 mg/l, a temporary rock barrier is installed across the head of Old River to increase San Joaquin River flows past Stockton thus improving DO levels (T,XXXVII,85:4-22). Better treatment of cannery wastes since 1978 (reducing the biochemical oxygen demand) and improved flows and water quality from New Melones Reservoir operations were reported to have helped alleviate this problem (USFWS,31,94). Since then, the Old River barrier has been installed in the fall of 1979, 1981, 1984 and 1987 (H. Proctor,DWR,pers.comm).

- Recommendation: For the protection of adult Chinook salmon migration in the Estuary, there should be downstream flows in the Sacramento River equal to or greater than those required under the 1978 Delta Plan for salmon migration. Minimum flows in the San Joaquin River past Stockton should be 500 cfs from July through November for protection of fall run upstream migration. DO should not fall below 6 mg/l in the San Joaquin River between Stockton and Turner Cut during these months.

  The theoretical objectives which would provide optimal protection for salmon in the Estuary are summarized in Table 5.3.4.3-5.

5.3.5 Striped Bass

5.3.5.1 No Action Alternative:

Striped bass are included specifically in the beneficial uses protected under the Delta Plan (Table VI-1, pp. VI-31-33,35). Included are specific electrical conductivity and flow standards as well as certain operational constraints required of the SWP and CVP. These standards evolved out of negotiations conducted among DFG, DWR, USFWS, and USBR prior to the Delta Plan hearing as part of a draft Four-Agency agreement; this agreement was never implemented (DFG,25,133). These standards have not accomplished the intended goal of maintaining the actual Striped Bass Index (SBI) at a long-term average of 79 (the so called "Without Project" conditions). Based on a mathematical relationship (predicted SBI; see below) developed by DFG, the actual SBI under the Delta Plan (1979-1985) should have averaged about 65 (corrected from DFG,25,134-136 after consultation with DFG staff). In fact, during those years (excluding 1986, in which the index reached predicted levels), the actual SBI averaged 22.4, about one third of the predicted SBI (corrected from DFG,25,136). In 1988, the actual SBI reached an all-time low of 4.6.

Table 5.3.4.3-5--Optimal Levels of Protection for Salmon

Time Period	Location	Objective/Action	Use Protected
July 1- November 30	San Joaquin River between Stockton and Turner Cut	Maintain DO $\geq$ 6 mg/1	Adult Migration (fall run)
July 1- November 30	San Joaquin River at Stockton	500 cfs flow	(fall run)
All Year	Sacramento River	flows $\geq$ Delta Plan	(all runs)
January-1 April-30	Delta Cross Channel	Close gates under below normal, dry, and critical water years	Fry Rearing (fall run)
April-1 June-30	Delta Cross Channel	Close gates	Smolt Emigration (fall run)
April-1 June-30	Sacramento R. at Rio Vista	22,500 cfs flow	Smolt Emigration (fall run)
April-1 June-30	San Joaquin R. at Vernalis	20,00 cfs flow	Smolt Emigration (fall run)
April- June-30	Delta pumping plants	No exports	Emigration/ Rearing (fall run)

The actual SBI is a value obtained after extensive field sampling and measuring of larval striped bass each summer. This value is a measure of the relative abundance of young striped bass in the Estuary when their average length is 38 mm (1.5 inches). It is called an index because it is a relative value and is not directly translatable into an absolute value of the number of larvae in the Estuary. However, it is a legitimate and relatively sensitive measure of the change in abundance of larvae between years. The actual SBI tends to underestimate the larval abundance in very high outflow years (such as 1983) because many of the larvae are carried downstream beyond the DFG sampling stations. The actual SBI has been measured every year since 1959, except 1966.

The actual SBI is not the only measurement of striped bass populations. A variety of sampling programs are employed in monitoring various components of the striped bass population (Table 5.3.5.1-1). While the decline rates and patterns may vary somewhat, all programs measuring striped bass abundance show large declines from the levels measured in the 1960's (DFG,25,6:25,9).

Table 5.3.5.1-1--Methods to Assess Population Levels of Striped Bass

ADULTS

1. Petersen Estimate--Mark and recapture method; 1969 to present; in Delta and Sacramento River; statistical analysis of number of fish recaptured which were marked in previous years.

2. Catch Per Unit Effort (CPUE) Index--Index of population based on number of fish caught per standardized unit of time; same locations as for Petersen estimate; 1969 to present except 1977, 1978, and 1981; possibly more reliable than Petersen estimate (DFG,25,Appendix 1).

3. Tag Returns--1958 to present, except 1962-1964 and 1967-1968; analysis of tags returned by fisherman; provides basis for comparison of fishing vs. "natural" mortality.

4. Party Boat Census--Annual reports submitted by party boat operators; provides information on numbers of fish caught, number of angler-days, and related information.

5. Creel Census--Informal surveys of shorelines, piers and private boats to examine catch rates, fish sizes and other information for other than party boat operations; done sporadically, with reduced effort in recent years.

EGGS, LARVAE AND JUVENILES

1. Petersen Fecundity Estimate--Annual since 1977; combines Petersen population estimate with fecundity (egg number) data from Striped Bass Health Monitoring Program, with certain correction factors (age and number of fish spawning) to estimate total number of eggs produced.

2. CPUE Fecundity Index--Uses same procedure as above except that uses catch per unit effort (CPUE) index value for number of spawing females rather than Petersen estimate.

3. Egg and Larva Survey--Area sampled variable but standardized in recent years to Suisun Bay, central and western Delta, and Sacramento River to Colusa; 1966-1973, 1975, 1977, 1984-1986; intensive sampling at 75 stations in spring to monitor number, growth, movement and mortality of larvae up to about 14 mm in length; Sacramento River stations also monitor egg abundance and movement.

4. Tow Net Survey--1959 to present except 1966; Delta and Suisun Bay; biweekly sampling at 30-40 stations in summer until average length of larvae exceeds 38 mm length; provides index of abundance (actual Striped Bass Index, or SBI) and distributional information.

5. Midwater Trawl--Throughout Bay-Delta Estuary up to Rio Vista and Clifton Court Forebay; 1967 to present except 1974 and 1979; typically monthly tows between September and December at a variable number of stations; gives measure of young-of-the-year abundance; more variable than SBI.

Table 5.3.5.1-1 (Continued)

RELATED SURVEYS

1. Salvage Records--Provides numbers of fish salvaged from Skinner Fish Protective Facility in Clifton Court Forebay; annual from about 1970 to present; provides general estimate of population trends and densities based on number salvaged over time.

2. Striped Bass Health Monitoring Program--1978 to present, not all years; 1984 to present under consistent format; analysis of tissues of 40 prespawning adult female fish from Rio Vista and Antioch; provides samples for fecundity data.

3. Other--Various other special purpose studies which provide special information on striped bass (Export Curtailment Study, gut content analysis, spring die-off monitoring, etc.).

There has been considerable confusion in the testimony concerning whether the SBI in the Delta Plan has "worked" or "failed." This is because the Delta Plan set standards based on a predicted SBI, a mathematical formula based on the relationship of the historical record of larval abundance (actual SBI) to spring Delta outflow and exports. This formula provided a prediction of what the SBI ought to be, given certain flow and export conditions, and it was used to develop the export and outflow standards in the Delta Plan. The discrepancy between the actual and the predicted SBI is the reason that some participants stated that "the SBI has failed". However, the actual SBI has not failed. It continues to provide a comparative measure among years. In fact, the actual SBI simply reflects the fact that the Delta Plan standards have been inadequate to maintain striped bass at 1975 levels, much less restore them to "without project" levels.

The actual SBI is the sum of two separate indices: The Suisun Bay index and the Delta index (Table 5.3.5.1-2). Throughout the 1960's, the Delta index has been the major contributor to the overall actual SBI (Figure 5.3.5.1-1). Generally in the 1970's and 1980's the actual SBI declined, in large part because of the decline in the Delta index (Figure 5.3.5.1-2). As shown in Table 5.3.5.1-2, during the period 1959-1970 (except 1966) the Delta index was greater than 60 percent of the total actual SBI in five of eleven years, and was less than 40 percent of the total actual SBI in only one year (1967). By contrast, during the 18-year period 1971-1988, during which a significant increase in Delta exports had occurred (see section 5.3.5.3), the Delta index was greater than 60 percent of the total actual SBI in only two years (1977 and 1988, both critically dry years with very low outflow and low SBI's), and was less than 40 percent of the total actual SBI in 12 of 18 years. For the ten-year period in which the Delta Plan standards were in effect (1979-1988), the Delta index was greater than 60 percent of the total actual SBI only in 1988, and was less than 40 percent in seven of the ten years. These results indicate a substantial shift in the survival patterns of striped bass larvae in recent years. The probable reasons for this shift are discussed in Section 5.3.5.3.

5.3.5.2 Advocated Levels of Protection

The extensive testimony and exhibits presented on striped bass emphasize the point that, despite years of study, there is no consensus on the causes of the striped bass decline. As a result, two main and highly divergent approaches to the problem evolved during Phase I of the hearing. These approaches may be summarized as follows:

TABLE 5.3.5.1-2 STRIPED BASS INDEX DATA

YEAR	YEAR TYPE (1)	YEAR TYPE (2)	DATE SET	JULIAN DATE	DELTA INDEX	SUISUN INDEX	TOTAL INDEX	5-YEAR RUNNING AVERAGE	DELTA % OF TOTAL	PRED. INDEX	ACTUAL % OF PRED.
1959	D	D	JULY 12	193	30.7	3.0	33.7	-	91.1	34.1	98.8
1960	BN-SNSM	D	JULY 17	199	32.0	13.6	45.6	-	70.2	55.1	82.8
1961	D	D	JULY 21	202	25.2	6.4	31.6	-	79.7	45.5	69.5
1962	BN	BN	JULY 26	207	46.8	32.1	78.9	-	59.3	79.1	99.7
1963	W	W	AUG 03	215	38.2	43.5	81.7	54.3	46.8	87.3	93.6
1964	D	D	AUG 02	215	54.7	20.7	75.4	62.6	72.5	63.3	119.1
1965	W	W	JULY 31	212	49.4	67.8	117.2	77.0	42.2	87.7	133.6
1966	BN-SNSM	BN		NOT DETERMINED					NOT DETERMINED		
1967	W	W	AUG 12	224	35.1	73.6	108.7	95.8	32.3	92.7	117.3
1968	BN-SNSM	D	JULY 19	201	39.6	17.7	57.3	89.7	69.1	44.5	128.8
1969	W	W	AUG 09	221	33.6	40.2	73.8	89.3	45.5	92.7	79.6
1970	W-SNSM	D	JULY 18	199	36.6	41.9	78.5	79.6	46.6	66.8	117.5
1971	W	W	AUG 11	223	24.6	45.0	69.6	77.6	35.3	83.4	83.5
1972	BN-SNSM	BN	JULY 25	207	13.4	21.1	34.5	62.7	38.8	33.7	102.4
1973	W	BN	JULY 15	196	15.6	47.1	62.7	63.8	24.9	53.8	116.5
1974	W	W	JULY 22	203	17.4	63.4	80.8	65.2	21.5	63.1	128.1
1975	AN	W	JULY 30	211	23.4	42.1	65.5	62.6	35.7	83.8	78.2
1976	C	C	JULY 16	198	21.1	14.8	35.9	55.9	58.8	45.6	78.7
1977	C	C	JULY 24	205	8.3	0.7	9.0	50.8	92.2	47.5	18.9
1978	W	AN	JULY 23	204	16.5	13.1	29.6	44.2	55.7	65.1	45.5
1979	D	BN	JULY 19	200	5.4	11.5	16.9	31.4	32.0	54.9	30.8
1980	W	BN	JULY 15	197	2.8	11.2	14.0	21.1	20.0	80.5	17.4
1981	D	C	JULY 02	183	15.4	13.7	29.1	19.7	52.9	58.0	50.2
1982	W	W	JULY 30	211	9.5	39.2	48.7	27.7	19.5	79.3	61.4
1983	W	W	AUG 05	217	1.2	14.2	15.4	24.8	7.8	78.3	19.7
1984	W-SNSM	BN	JULY 13	195	6.3	20.0	26.3	26.7	24.0	68.6	38.3
1985	D	D	JULY 16	197	2.2	4.1	6.3	25.2	34.9	34.1	18.5
1986	W-SNSM	BN	JULY 09	190	23.8	41.1	64.9	32.3	36.7	65.1	99.7
1987	C	C	JUNE 22	173	7.3	5.3	12.6	25.1	57.9	43.5	29.0
1988	C	C	JULY 24	206	3.9	0.7	4.6	22.9	84.8	N.D.	N.D.

NOTES:

1. WATER YEAR TYPE (1) = BASED ON 1978 DELTA PLAN STANDARDS
2. WATER YEAR TYPE (2) = BASED ON PROPOSED SACRAMENTO VALLEY APRIL - JULY FORMAT
3. WATER YEAR TYPE CODE: W=WET; AN=ABOVE NORMAL; BN=BELOW NORMAL;
   D=DRY; C=CRITICAL; SNSM=SUBNORMAL SNOWMELT
4. 5 YEAR RUNNING AVERAGE INCLUDES 4 YEARS ONLY FOR 1967 - 1970
5. N.D. = NOT DETERMINED

FIGURE 5.3.5.1-1 STRIPED BASS INDEX

(NO SAMPLE IN 1966)

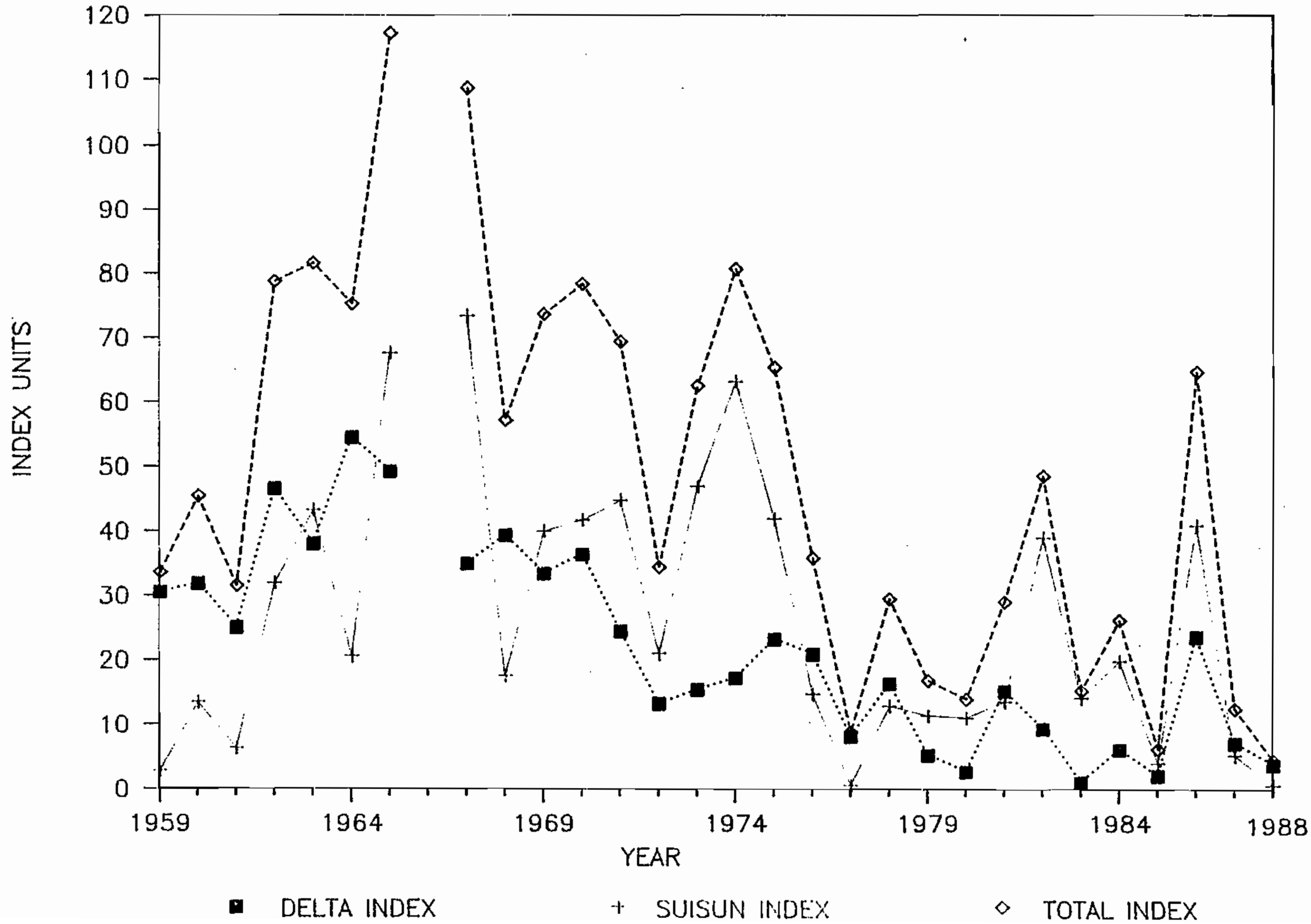
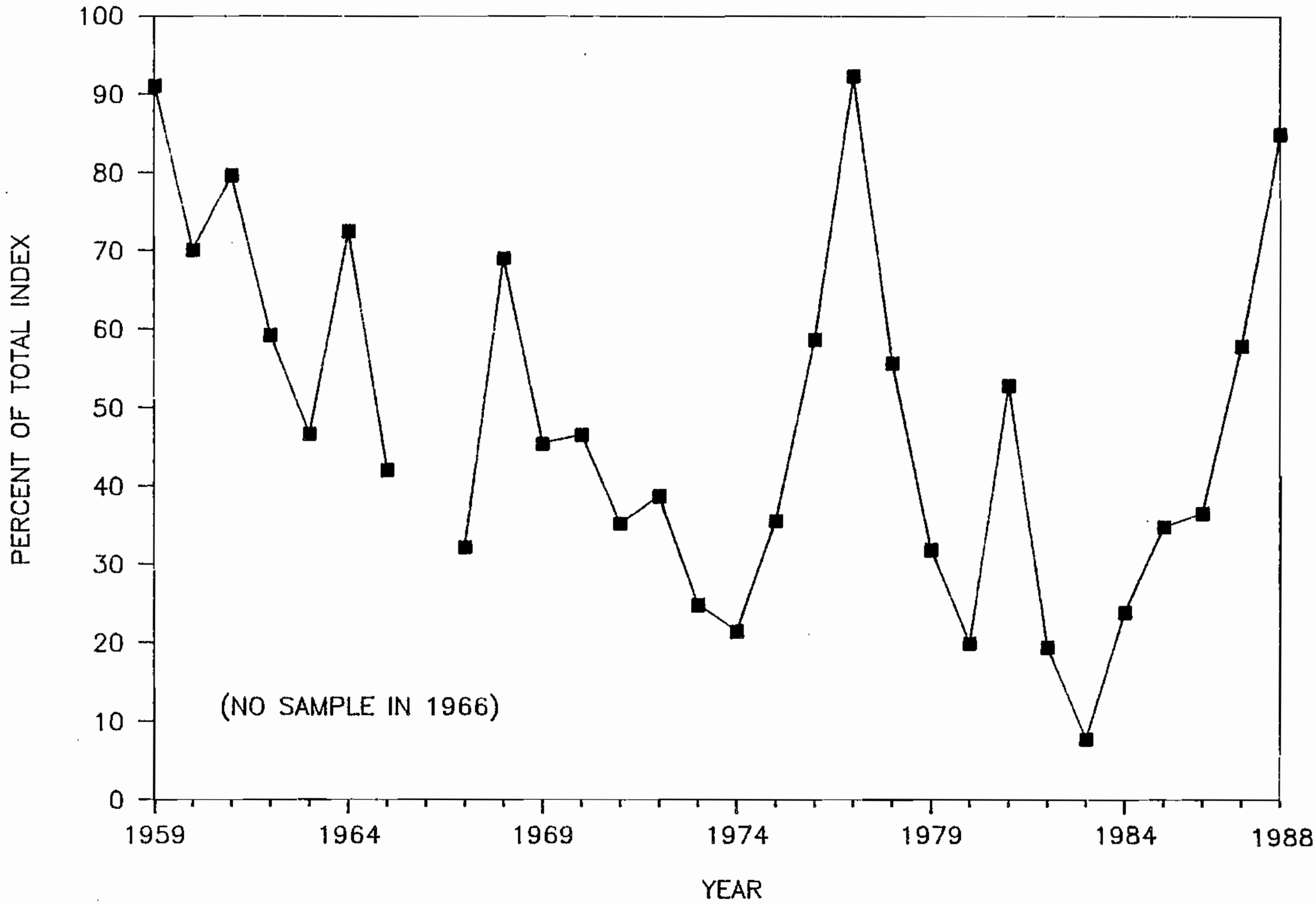


FIGURE 5.3.5.1-2 DELTA STRIPED BASS INDEX

AS PER CENT OF TOTAL ACTUAL STRIPED BASS INDEX



- Retain Present Standards

  Because there is no agreement on what to do about striped bass, it was suggested that the present Delta Plan standards be retained for the most part until "cause and effect" relationships have been determined. This position was advocated by SWC, DWR, and others (SWC,203,4;DWR,602,2). SWC proposed five major hypotheses for the possible decline of striped bass (SWC,203,22). Four of these involve the effects of water export either directly or indirectly. The SWC, among others, advocate an extensive series of experiments to test these various hypotheses; but in the meantime, the current standards should be retained except to facilitate performing these tests. This approach is discussed further in Section 5.3.5.3.

- Change the Delta Plan Standards to Attempt to Provide Additional Protection

  This position was advocated by DFG, USFWS, EDF and others. The main argument here is that striped bass are not being protected by the Delta Plan standards, and the population is in serious decline. Therefore, something must be done now, even if all the reasons for the decline are not known; enough is known to at least proceed in some areas.

  The major proposal for changed objectives was put forth by DFG (DFG,64,6-12) with support from USFWS in their own recommendations (USFWS,47,5-6). Both agencies called for short-term measures, primarily in the form of greatly increased outflow and changes in the operation of the Delta Cross Channel gates. Long-term proposals included recommendations for eliminating reverse flows in the San Joaquin River by 1995, examination of new Delta water transfer facilities, possible operational changes, and evaluation of current research and monitoring programs required by the Delta Plan (DFG,64,14-19).

  The overall goal of DFG was to achieve an annual production of young striped bass equal to a long-term average actual SBI of 106, which they determined was the "historical level" (DFG,64,6). DFG believes this is not a realistic objective in the near future (DFG,64,6) and cannot be achieved with their present state of knowledge about striped bass (T,LX,102:24-103:16). In fact, DFG estimated that their increased flow recommendations and other changes would, on average, increase the SBI only to 28, which is six points, i.e., 25 percent, higher than the average of the 1979-1985 period (T,LX,102:3-21). The proposed flow objectives do not call for increased flow beyond the levels presently required under the Delta Plan for critical years, or for dry years following dry or critical years (DFG,64,6; T,LX,82:2-4). No changes in exports are proposed except that a limit of 5,000 cfs total diversions would be imposed in May and June, rather than the present 6,000 cfs, when water is being withdrawn from storage for export (DFG,25,7;T,LX,82:11-15).

A larger percentage of total Delta inflow is exported under low flow conditions in the Delta; this provision would somewhat reduce impacts on striped bass larvae. DFG also proposed expansion of the provision for closure of the Delta Cross Channel gates to include the ability to request closures when the Delta Outflow Index is less than 12,000 cfs. Under the Delta Plan, DFG can request closure of the gates only when the Delta Outflow Index is greater than 12,000 cfs. DFG did not recommend any change in the length of the period during which such requests can be made (April 16--May 31 in all years). All other Delta Plan standards would remain in effect (DFG,25,7).

USFWS proposed flow objectives and operational changes similar to DFG as short-term measures, as well as similar long-term recommendations, such as elimination of reverse flows in the lower San Joaquin River (USFWS,47,5-6). However, they also proposed that outflow be not less than 10,000 cfs during the May through July period "to keep larvae and young-of-the-year [striped bass] in Suisun Bay and maintain the null zone (spring-summer) no further [upstream] than Honker Bay" (USFWS,47,5). This contradicts their own recommendation in support of the Delta Plan flow standards, per DFG, for critical years, and dry years following dry or critical years. No testimony was presented to resolve this contradiction.

EDF also proposed increased outflow standards (EDF,25). The recommendations are similar to, and are based on DFG recommendations, but include a multiplier factor of 1.5 in May, 1.0 in June, and 0.7 in July to the recommended May-June flow increases to adjust for the greater densities of eggs and larvae which are present in the earlier months (T,LVII,78:21-79:4). The recommended flow levels were expected to provide survival approaching "without project" levels. However, it was EDF's opinion that protection at "historic levels" would require higher levels than those recommended; EDF did not determine what those flow levels might be (T,LVII,79:5-18). In some years, the recommended flows would actually be greater than unimpaired flows (T,LVII,80:7-81:5).

5.3.5.3 Optimal Levels of Protection

The striped bass problem in the Estuary is very complicated, and there probably is no single answer to the problem. However, important steps could be taken to protect striped bass that are not being employed at present. Therefore, the recommendation by some participants that the present Delta Plan standards remain in effect is rejected. The striped bass population has declined too much (perhaps in excess of 70 percent since the 1950's) to take no definitive actions to provide additional protection. None of the participants disputed the fact that there is a problem with striped bass, even if they differed on what course to take. The record low 1988 SBI of 4.6 further emphasizes the need to take immediate action.

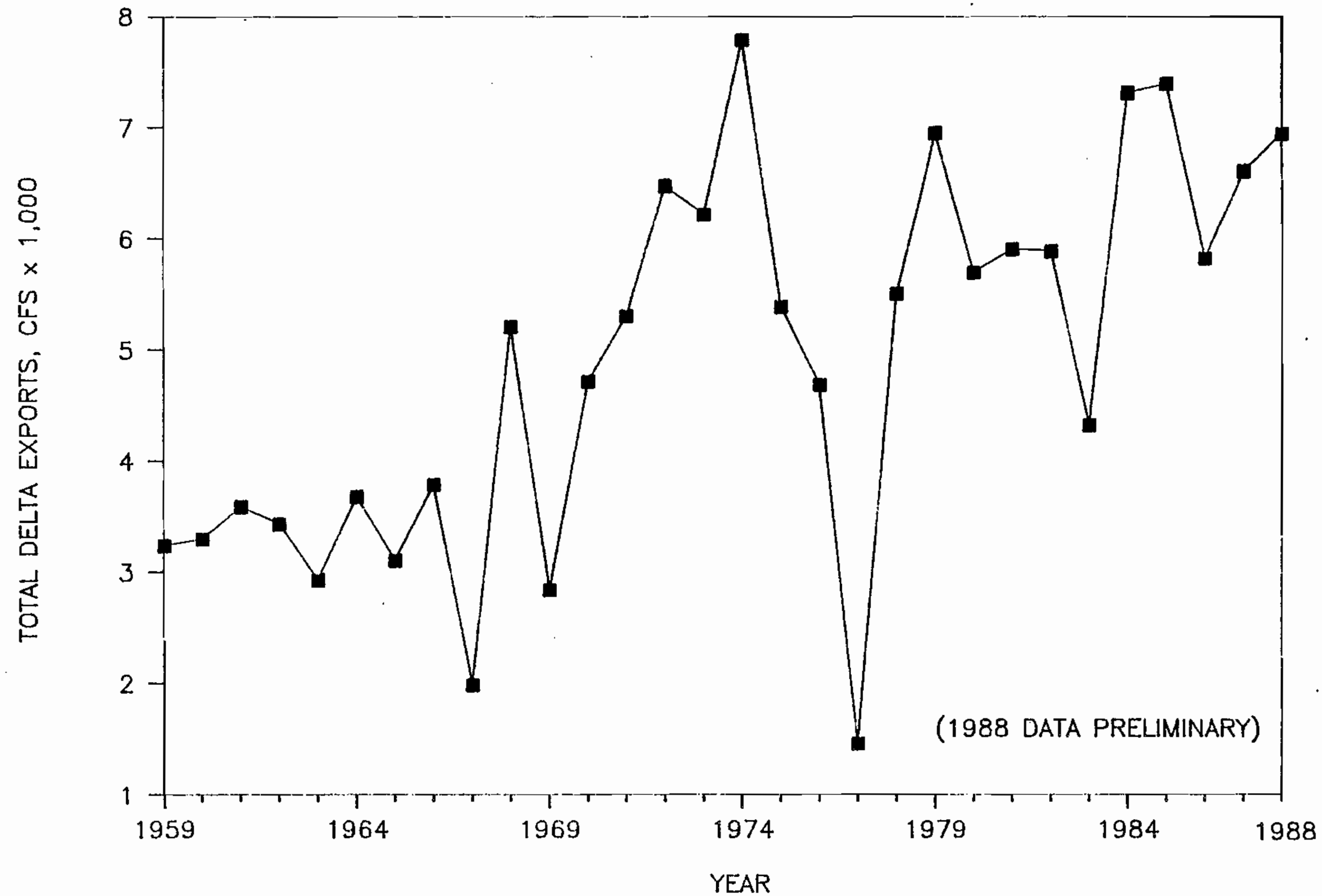
Changes in the Delta Plan are appropriate standards because they are not doing what they were intended to do i.e., provide reasonable protection for striped bass. This beneficial use is not being protected to the extent originally intended by the Board in the Delta Plan; therefore, steps must be taken to provide additional protection. Certain steps have been suggested which are not related to flow and salinity standards, or which are intended to provide "equivalent protection" for striped bass. In general, these proposed actions do not provide equivalent protection or are not relevant to actions included under this Plan. These alternative measures will be discussed in individual sections below as appropriate.

In rejecting continuation of the current Delta Plan standards, it is important to understand why those standards did not work. Spring flow and export standards have not worked because they were being applied to a situation in the Delta which was significantly different from the one under which the data used to develop the formulas for the predictive index were obtained. The original relationship among the predictive SBI, outflows and exports was based on data developed during the period 1959-1970. During this period, exports in the spring were primarily from the CVP, and certain major upstream storage projects (Oroville and New Melones) had not been completed or had not yet had a significant effect on the Delta. As shown in Figure 5.3.5.3-1, total Delta exports (SWP,CVP,and CCC) were relatively constant at about 3,500 cfs during the April through July period. However, during the 1971 through 1976 period, when the decline in the Delta portion of the SBI began to become apparent, total exports for the April through July period increased to an average of 6,000 cfs. When Delta Plan standards for striped bass were in effect (1979-1988), the average April through July total exports were about 6,300 cfs, or 80 percent higher than for the 1959-1970 period, and 45 percent higher than the 1959-1976 period (the period used for development of the predicted SBI in the Delta Plan).

The relationship for the May through July periods, on which the Delta Plan standards were set, shows a similar pattern. Average May through July total Delta exports for the period 1959-1970 were about 3,700 cfs. During the period 1971-1976, the average exports increased to 6,300 cfs. For the period that the Delta Plan standards were in effect (1979-1988), average May-July exports declined slightly from the 1971-1976 period to about 6,200 cfs, due to the export restrictions imposed by the Delta Plan. This restriction represents less than three percent reduction from the 1971-1976 period, when the Delta index was declining. In effect, the Delta Plan standards stabilized exports at post-1970 levels, but did nothing to provide protection comparable to that found under the original relationship from the 1959-1970 period. Under the Delta Plan, average total Delta exports in the months of May, June, and July are still 66 percent higher than the 1959-1970 period, and 34 percent higher than the 1959-1976 period (the period used as the basis for the predictive index).

FIGURE 5.3.5.3-1 TOTAL DELTA EXPORTS

COMBINED SWP, CVP, AND CCC; APRIL – JULY AVERAGE



The direct and indirect effects of these increased exports have most likely been the major factor in the recent decline of striped bass. As noted above, four of the five hypotheses proposed by the SWC are directly or indirectly related to flows and exports. All the participants acknowledge that exports and their attendant effects on flows in the Delta do have deleterious effects on striped bass. Below are presented the particular problems related to striped bass and the proposed recommendations to provide them optimal protection. These recommendations are summarized in Table 5.3.5.3-1. Acceptance or rejection of the proposed objectives of the participants will be discussed. As noted above, the proposal to retain the current standards is rejected.

TABLE 5.3.5.3-1
OPTIMAL LEVELS OF PROTECTION FOR STRIPED BASS

Time	Location	Recommendation	Protection
April 1--June 15 (all years)	San Joaquin R. Vernalis to Antioch Bridge	Maximum daily EC not to exceed 0.3 mmhos/cm	Adult striped bass migration and spawning
April 15--July 31 (all years)	Delta Cross Channel gates	Closed	Reduce trans-location of eggs and larvae
April 1--July 31 (all years)	Statutory Delta channels	No withdrawals or exports (except for emergency)	Reduce egg and larva entrain-ment
April 1--May 31 (all years)	Chipps Island	Daily Delta outflow at least 33,900cfs	Move larvae to Suisun Bay nursery area and keep null zone at Honker Bay or down-stream
June 1--June 30 (all years)	Chipps Island	Daily Delta outflow at least 32,400 cfs	Move larvae to Suisun Bay nursery area and keep null zone at Honker Bay or down-stream
July 1--July 31 (all years)	Chipps Island	Daily Delta outflow at least 29,100 cfs	Move larvae to Suisun Bay nursery area and keep null zone at Honker Bay or down-stream
April 1--July 31 (all years)	Vernalis	San Joaquin River component of Delta outflow equal to or greater than proportion under unimpaired flow	Maintain positive down-stream flow in all Delta channels

- Problem 1: Adult Striped Bass Spawning is Affected by Limitations on the Spawning Area.

  DFG has testified that the formation of a salinity barrier in the mainstem San Joaquin River above Venice Island tends to restrict spawning runs and spawning activity in that area (T,XLI,68:1-69:10). DFG also testified, and other evidence shows, that historically striped bass did spawn above the Delta in the San Joaquin River system. Striped bass are not able, under Delta Plan standards, to fully use the historical spawning habitat.

  Current Delta Plan standards provide for a maximum of 0.550 mmhos/cm EC at Prisoners Point, on the San Joaquin River from April 1 to May 5. DFG data (DFG,25,44-46) (shows that striped bass will not migrate through the eastern Delta into areas where EC is greater than 0.55 mmhos/cm. In addition, the majority of striped bass spawn in water with EC less than 0.3 mmhos/cm. Thus, the Delta Plan standard effectively blocks upstream migration of striped bass in the San Joaquin River beyond Prisoners Point in drier years, and may have an impact on spawning as well. The short period of time (35 days) which is covered by the Delta Plan standards may also be inadequate to provide full use of the San Joaquin River migration and spawning habitat.

  There are two aspects to the solution of this problem: Sufficient flows must be provided to break up this salinity barrier, and water quality in the San Joaquin River must be appropriate to promote migration and spawning upstream. Both can be accomplished by providing water of sufficient quality and quantity at Vernalis, provided that exports are not too large to prevent adequate flow down the mainstem San Joaquin River below Mossdale, and that the protection period is of sufficient length to utilize the habitat fully.

  None of the participants proposed any objectives to solve this problem, other than general proposals for greatly increased outflows for striped bass larvae. However, since San Joaquin River flows were not stipulated in these recommendations, it is assumed that this problem was not being specifically addressed.

  Based on evidence received, there appears to be no particular problem for adult striped bass, relative to habitat, in the Sacramento River, or to temperature regimes in either the Sacramento or San Joaquin rivers, since spawning tends to be initiated by increasing temperatures. The effects of warmer water in recent years is discussed below in relation to periods of time in which the objectives should apply.

  - Recommendation 1: Electrical conductivity in the mainstem San Joaquin River from Vernalis downstream to the Antioch Bridge should not exceed a daily maximum of 0.300 mmhos/cm from April 1 to June 15 in all water year types.

- Problem 2: Eggs and Larvae are Translocated into the Central Delta through the Delta Cross Channel and Georgiana Slough.

  Eggs and small larvae of striped bass are carried passively down the Sacramento River and are transported into the central Delta through the Delta Cross Channel and Georgiana Slough. Translocation to the central Delta exposes the eggs and larvae to increased mortality (DFG,25,54). The Delta area is less suitable as a nursery habitat than the Suisun Bay area. Screening is not effective for these small eggs and larvae.

  Existing Delta Plan standards call for closing of the Delta Cross Channel gates when the Delta outflow index (DOI) is above 12,000 cfs, but various conditions apply: DFG must request a closure, the potential closure period is only from April 16 through May 31, the maximum number of days available for closure within this period is 20, and no more than two out of four days may be consecutive. DFG has proposed expanding this standard to include closure when the DOI is less than 12,000 cfs, but for only a total of ten days in the period, and no more than one day out of four. Closure periods should be determined by real-time monitoring (DFG,64,7). The USFWS called for closure of the Delta Cross Channel gates and for modification of export operations "when densities [of eggs and larvae] are high" (USFWS,47,5). This recommendation is broader than the DFG recommendation, in that it appears to allow for more flexibility in the closure period to accommodate differences between years in striped bass spawning, but "high densities" is undefined. Neither recommendation provides optimal protection, however, since neither seeks to isolate Sacramento River eggs and larvae from the central Delta entirely.

  Georgiana Slough has no gates on it at present. Georgiana Slough intercepts little more than about 13 percent of the Sacramento River flow at Freeport (DAYFLOW documentation). Given the other recommendations proposed below to enhance downstream flows in the central Delta, no recommendation for protection of striped bass passing into Georgiana Slough appears to be warranted. However, losses through the Delta Cross Channel are larger, and protection can be provided with present facilities. In the absence of proven technology to provide real time monitoring, and because of the need to provide full protection, the following recommendation is made.

  - Recommendation 2: The Delta Cross Channel gates should remain closed for the period April 15 through July 31 in all water year types.

The above sets of recommendations are all inadequate to protect striped bass eggs and larvae fully because none provide flows sufficient to move all larvae out of the central Delta into Suisun Bay nursery areas in all year types. In addition, none call for curtailment of exports to reduce reverse flows and entrainment. On the other hand, the EDF, recommendation for 38,000 cfs seems excessive since DFG believes that 33,900 cfs will move 100 percent of the eggs and larvae past Collinsville. Since no recommendations for April flows were received, the DFG standard will be applied to April as well as May. April standards are needed because significant spawning occurs in the Delta in April, and these eggs and larvae also require protection.

The outflow recommendations proposed will still not assure positive downstream flows in all Delta channels. In particular, exports from the Delta by the SWP and CVP can induce reverse flows in Old and Middle rivers. Eggs and larvae in the central Delta can be drawn into these channels and entrained in the export facilities and agricultural diversions, or be carried to areas of the Delta which are unsuited for their survival. In addition, if, as a result of removal of the salinity barrier on the San Joaquin River, spawning returns to the area around and above Vernalis, eggs and larvae produced upstream will be pulled into Old River and entrained into the export facilities. These factors represent additional mortality for young striped bass.

Based on the above discussion, a series of recommendations to address these interrelated problems are proposed:

To prevent entrainment of striped bass eggs and larvae in municipal, industrial, and agricultural diversions and export facilities in the Delta:

- Recommendation 3-1: No withdrawals or exports of water from the statutory Delta for any purposes other than for emergency conditions should be permitted for the period April 1 through July 31 in any water year type.

To assure movement of striped bass eggs and larvae into the Suisun Bay nursery area and to keep the entrapment zone west of Collinsville:

- Recommendation 3-2: Daily Delta outflow should be no less than the following in all water year types:

April 1 through May 31------------33,900 cfs
June 1 through June 30------------32,400 cfs
July 1 through July 31------------29,100 cfs

- Problem 3: Striped Bass Eggs and Larvae in the Central Delta are Lost in Large Numbers.

Considerable evidence has been presented by DFG and USBR, among others, to demonstrate that the central Delta is not an appropriate environment for survival of eggs and larvae of striped bass. The primary causes of these losses are entrainment in agricultural diversions, export facilities and M&I intakes. In addition, the reverse flows and longer residence times induced by the export pumps result in increased starvation of and predation on eggs and larvae. Flows are required to move the eggs and larvae down stream of Collinsville on the Sacramento River and into the Suisun Bay nursery area. Calculations developed by DFG (DFG,64,8) based on egg and larva sampling programs have determined that a Delta outflow of 33,900 cfs in May will move 100 percent of six mm striped bass larvae into the Estuary west of Collinsville. Equal protection in June would require 32,400 cfs, and in July (for seven mm fish, the smallest size class still present in that month) 29,100 cfs. The exhibit does not specify what export levels were present when the data to develop these calculations were collected. Nor does the exhibit present any indication of how the flow should be proportioned between the Sacramento and San Joaquin rivers. Despite evidence that spawning in the central Delta and the San Joaquin River occurs in April (DFG,64,9), no flow requirements or recommendations were presented for the month of April.

USFWS recommendations (USFWS,47,5) basically support those of DFG, but also recommend that Delta outflow be not less than 10,000 cfs during the May through July period, and that reverse flows be eliminated in the lower San Joaquin River at Jersey Point. No recommendations for Delta outflow in April, for required flows in the San Joaquin River, or for elimination of reverse flows in Old and Middle rivers were presented.

As discussed above (see section 5.3.5.2), EDF proposed Delta outflows based on the DFG data but weighted for the abundance of larvae in different months (more larvae present in May, fewer in July). EDF Exhibit 25 calls for flows of 38,000 for the period May 6 through May 31 in wet years, decreasing to 21,000 cfs in critical years. Lesser flows are proposed for the months of June and July. As with DFG and USFWS, no flow is apportioned to the San Joaquin River.

To assure that positive downstream flows are maintained in all Delta channels and to move eggs and larvae downstream from the San Joaquin River system:

- Recommendation 3-3: The contribution of the San Joaquin River to the total Delta outflow should be at least equal to that proportion of flow which would be present under unimpaired flow conditions.

- Problem 4: Disruptions of the Striped Bass Food Chain have occurred

  Striped bass may be starving because of loss of food from the central Delta. DFG presented evidence to indicate that zooplankton are becoming depleted, or the species composition of zooplankton has changed in the central Delta. This may have detrimental effects on striped bass when they first begin feeding (DFG,25,95-102).

- Recommendation 4: The above recommendations to maintain downstream flows in all Delta channels and to move the larvae rapidly into the Suisun Bay nursery area, where food of the appropriate species composition is available and more plentiful, should provide appropriate resolution of this problem. Should the other recommendations not be fully implemented such that the zooplankton food problem needs to be addressed, separate recommendations will be developed at that time. However, for the present, no recommendation for the protection of striped bass food supply is made.

- Problem 5: Pollutant Burdens

  Adult striped bass are burdened with a variety of pollutants which may affect their survival and reproductive potential. DFG and other participants have introduced evidence to indicate that adult striped bass are burdened with various organic and inorganic pollutants, which may affect their survival and their ability to reproduce, particularly through resorption of eggs in the ovaries. In addition, certain of these contaminants may pose a health risk to humans if striped bass are consumed too often. DFG fishing regulations include a precaution against consumption of too much striped bass because of mercury levels in their flesh.

- Recommendation 5:

  This subject is not directly relevant to Water Quality Control Plan standards. Actions proposed in the Pollutant Policy Document may have beneficial effects for striped bass. Other related recommendations are discussed in Chapter 8.

- Problem 6: Attraction to Effluents

  Evidence presented by DFG indicates that some striped bass may be attracted to certain components of industrial effluent streams and suffer deterioration and starvation. Laboratory tests indicate that the fish are attracted even when these chemicals are extremely diluted. The fish tend to remain in the effluent streams even though little or no food is available, and they undergo fin rot.

- Recommendation 6: Additional study of this phenomenon is warranted (see Chapter 8). Actions proposed in the Pollutant Policy Document may also have beneficial effects for striped bass.

- Other Problems and Considerations

  The above recommendations represent those levels of flow, salinity, and operational constraints which will, in theory, provide optimal protection for the striped bass beneficial use. Certain aspects of the problem of the decline of striped bass, such as pollutants, the Suisun Bay spring die-off, and effects of upstream diversions on survival of eggs and larvae, are beyond the scope of this Plan, in that they are not directly related to flow and salinity considerations in the Estuary.

- Hatcheries

  Certain other corrective or mitigative measures, such as hatcheries or grow-out facilities for fish salvaged at the export pumps, may be capable of providing some protection for striped bass. The question of hatchery production should not be considered at this time. Although there has been some recent success in producing striped bass in the hatchery, the fate of those fish in the Estuary (and ocean) and their recruitment to the fishery have not yet been determined. In addition, and most critically,even if some hatchery fish are recruited to the fishery and produce viable eggs and larvae, the purpose of that recruitment is lost if those eggs and larvae are subsequently lost to the fishery because of the various problems discussed above. Likewise, the question of other facilities cannot be addressed at this time, since no specific facilities have been proposed.

- Relationship of Recommended Outflows to Unimpaired Delta Outflow

  The Delta outflow recommendations proposed in Recommendation 5 above are as follows: 33,900 for April 1 through May 31; 32,400 for June 1 through June 30; and 29,100 for July 1 through July 31 in all years. Based on data developed for SWRCB exhibits, for unimpaired flow at Chipps Island for the years 1922-1978, the objective will be met with unimpaired flows as shown below:

Year Type	April	May	June	July
Wet	A	A	A	S
Above Normal	A	A	M	N
Below Normal	A	A	S	N
Dry	M	N	N	N
Critical	S	N	N	N

A = recommended flow level met in all years
M = recommended flow level met on average; met in most years
S = recommended flow level met in some years; not met on average
N = recommended flow level not met in any year

5.3.6 American Shad--Protection of Beneficial Uses

5.3.6.1 No Action Alternative

Under the Delta Plan there are essentially no standards to protect American shad. While the impacts of the Delta Plan on shad could not be quantified, it noted that the recommended plan for striped bass protection was expected to provide shad protection as well in wet, above normal, and dry water years, with a "definite lessening of protection" in critical years (Plan,V-39,VI-9).

The only specific standards for shad proposed in the Delta Plan (Table VI-1, pg.VI-35) concerned operation of the CVP's Tracy Fish Protective Facility. Certain secondary velocities and bypass ratios are required "to the extent possible" between June 1 and August 31 to increase screening efficiency for shad and other species. However, these standards are to be met "to the extent that they are compatible with export rates." Thus, shad protection is incidental to the operation of the CVP export pumps. There are no standards addressing shad for the SWP pumps.

5.3.6.2 Advocate Recommended Levels of Protection:

- WACOC

  WACOC recommended continuing the current practice of relating flow requirements for the protection of fish and wildlife to the variation of each year's runoff and storage conditions. Specifically, flow requirements "should be relaxed proportionately in the drier years to meet the reasonable beneficial needs of people, while maintaining reasonable minimum water quality standards for fish and wildlife" (WACOC,4,8).

- BISF/SCLDF

  BISF and SCLDF discussed three "perturbations" and resulting adverse effects on shad (BISF-SCLDF, Brief,57-58). These perturbations were: reduced river flow, reduced food supply for young fish, and losses of fish entrained in water diversions. General statements on corrective measures were presented, but no specific objectives were proposed.

- DFG

  DFG discussed the present level of knowledge about shad (DFG,23). They made no specific recommendations for protection of shad (DFG,64,12) because they believe the recommendations for protection of striped bass will provide benefits to American shad as well (see discussion of striped bass recommendations in Section 5.3.5.3).

- USFWS

  USFWS proposed an overall goal of increasing young-of-the-year (YOY) production of shad. Two main mechanisms ("objectives") were proposed to accomplish this goal. The first is to increase Delta inflow from April to June according to striped bass and salmon flow needs. Though unstated, USFWS appears to support DFG's basic determination that recommended flows for salmon and striped bass will benefit shad as well. The second objective is to reduce fish translocations from the Sacramento River into the central Delta during July to September. This reduction would make the larvae less susceptible to entrainment in all Delta water diversion facilities, and specifically would reduce entrainment at CVP and SWP facilities. A variety of implementation measures are proposed (USFWS,47,6).

5.3.6.3 Optimal Levels of Protection:

The testimony and exhibits indicate that current standards do not fully protect American shad. Evidence for this conclusion comes from several areas:

- The abundance of adult shad appears to have declined from levels early in this century, and more specifically from about 1945 on, although specific population measurements from those years are not available (DFG,23,1;DFG,23,16;T,XXXIX,13:15-17).

- The range of spawning runs has declined, particularly in the San Joaquin River system, where runs in both the mainstem San Joaquin and its tributaries used to occur (DFG,23,2; T,XXXIX,14:5-11;31:5-11;47:7-25).

- Up to 4.4 million shad have been salvaged annually at the CVP and SWP export pumps, and about half of those salvaged do not survive; many more larvae and small fish are entrained and lost (DFG,23,20-22;T,XXXIX,17:4-18:4).

- Evidence was presented to indicate that a variety of factors may be involved in the current limited protection for shad. Each factor will be discussed in turn, followed by recommendations for optimal protection. The recommendations for optimal levels of protection are summarized in Table 5.3.6.3-1.

- Problem 1: Effects of Decreased River Flows on Spawning Runs.

  Decreased flows in the Sacramento and San Joaquin rivers and their tributary streams have reduced spawning runs or have limited the dispersion of adult shad into tributary streams (DFG,24,4;DFG,23;T,XXXIX,14:12-22;16:14-18;31:5-9; 33:12-34:14). According to DFG testimony, actual inflow to the Delta in the spring was 32 to 66 percent less than would have been available under unimpaired inflows for the years 1978-1982 (DFG,23,24). USFWS (USFWS,47,6) has recommended that Delta inflow should be increased in the April-June period according to levels demonstrated by DFG to have positive effects on shad YOY production. DFG's data (DFG,23,19) are shown in Figure 4.5.1.4-1. This relationship appears to have a decided break near the 20,000 cfs level; above this level of Delta inflow the relationship between YOY shad abundance and inflow does not appear to be statistically significant. However, since spawning continues into early July, the period of protection should extend beyond that recommended by USFWS (T,XXXIX,14:23-24).

- Recommendation 1

  Total daily Delta inflow in all year types should be a minimum of 20,000 cfs from April 15 to July 15. The contribution of the San Joaquin River to total Delta inflow should be at least equal to that proportion of flow which would be present under unimpaired flow conditions.

- Problem 2--Effects of Flow on Larval and YOY Shad.

  Variations in flows in the Sacramento and San Joaquin rivers and their tributaries may affect the distribution and outmigration of larval and YOY American shad (DFG,23,10; T,XXXIX,16:4-11;16:23-17:3). Lower flows may concentrate the larvae in limited areas, resulting in depletion of the food supply. Lower flows also lengthen the time required for larvae to get to suitable nursery habitat (DFG,23,23). Appropriate flows are required to disperse and transport the eggs, larvae and YOY down the tributary streams and through the Delta. Some young shad do not migrate through the Delta immediately but remain in summer nursery areas in the Sacramento and Feather rivers and the southern Delta. These shad begin their outmigration through the Delta later in the

TABLE 5.3.6.3-1
OPTIMAL LEVEL OF PROTECTION FOR
AMERICAN SHAD

Time	Location	Recommendation	Protection
April 15--July 15 (all years)	Delta	Minimum daily total Delta inflow cfs. San Joaquin R. component at least equal to proportion of total inflow present under unimpaired flow	Adult shad migration and spawning habitat
May 1--November 30	Delta	Same as Above	Egg and larval outmigration, nursery habitat, zooplankton
May 1--November 30 (all years)	Delta Cross Channel Gates	Closed	Reduce trans-location of eggs and larvae
May 1--November 30 (all years)	Statutory Delta Channels & SWP, CVP, CCC	No withdrawals or exports (except for emergencies)	Reduce egg, larval and YOY entrainment

year and continue to do so at least through November (DFG,23,10-11). Flows are required to facilitate this late outmigration as well as the spring and early summer outmigration (May to July). In order to restore runs in the San Joaquin River and its tributaries, total Delta inflow should be divided between the Sacramento River and the San Joaquin River in proportion to what would be present under unimpaired flow conditions.

- Recommendation 2

Total daily Delta inflow in all water year types should not be less than 20,000 cfs from May 1 to November 30. The contribution of the San Joaquin River to total Delta inflow should be at least equal to that proportion of flow which would be present under unimpaired flow conditions.

- Problem 3--Losses of Larval and YOY Shad to Diversions and Exports.

Shad larvae and YOY are subject to mortality from diversions and export facilities in the Delta. Shad originating in the Sacramento River system may be translocated into the central Delta, resulting in entrainment in local agricultural diversions (DFG,23,20;DFG,23,25) which are for the most part unscreened (T,XXXIX,17:9-10). These shad, plus those originating in the Delta or the San Joaquin River system, are also subject to entrainment at the CVP and SWP pumps (DFG,23,8-11;DFG,23,20-21). Although the export facilities have screens, they are ineffective for eggs and small larvae, and larger fish are subject to as much as 50 percent handling mortality because of their fragility (DFG,23,20-22;T,XXXIX,17:11-18:4).

Based on these findings, a series of recommendations is presented as follows:

To reduce translocation of shad eggs, larvae and YOY into the central Delta:

- Recommendation 3-1

The Delta Cross Channel gates should be closed from May 1 to November 30 in all water year types.

To reduce entrainment of shad eggs, larvae and YOY into municipal, industrial and agricultural diversions in the Delta and into the export pumps.

- Recommendation 3-2

No withdrawals or exports of water from the statutory Delta for any purpose other than emergencies should be permitted from May 1 to November 30 in all water year types.

- Problem 4--Disruption of Larval Shad Food Chain.

  Abundance of larval shad may be reduced because zooplankton on which they feed are reduced. This reduction in zooplankton abundance may result from direct entrainment in water diversion facilities, or from high net flows in Delta channels, due to export pumping, which provide a less stable environment for zooplankton, (T,XXXIX,18:6-18). The combination of the proposed recommendations and those proposed for protection of other beneficial uses in the Delta and Suisun Bay should provide adequate protection for the shad food chain. Should the proposed measures be determined to not provide adequate protection, separate recommendations specific to zooplankton will be addressed at that time. However, for the present, no recommendation for the protection of the American shad food chain is proposed.

- Problem 5--Loss Measurement and Mitigation.

  At present, American shad losses at the SWP export pumps are not covered under the Two-Agency Fish Mitigation Agreement, and there is no agreement for mitigation of losses at the CVP pumps (T,XXXIX,32:24-33:9). In addition, no evaluations of screening efficiency for American shad have been made (DFG,23,20). These factors will be discussed further in Chapter 8.

  When combined, recommendations 1 and 2 above require daily total Delta inflow to be at least 20,000 cfs from April 15 to November 30 in all year types, with proportions of San Joaquin River flow the same as would be present under unimpaired flow conditions. The approximate amount of San Joaquin River flow required in the April-November period in different year types, and the probability of meeting those flows under unimpaired flow conditions, are summarized in Tables 5.3.6.3-2--5.3.6.3-4.

  Table 5.3.6.3-2 is derived from data used to prepare SWRCB Exhibit 110, and it indicates the average percent of total inflow in the Delta which would originate from the San Joaquin River under unimpaired flow conditions. Table 5.3.6.3-3 converts the percentages to recommended flow values by multiplying each percentage by 20,000 cfs, the recommended level of total Delta inflow. Table 5.3.6.3-4 indicates the unipaired flow at Vernalis (based on model results used in SWRCB Exhibit 110) and indicates the probability of meeting the recommended level of San Joaquin River inflow.

TABLE 5.3.6.3-2 SAN JOAQUIN RIVER - PERCENT OF TOTAL DELTA INFLOW (UNIMPAIRED FLOW CONDITIONS; 1922 - 1978)

YEAR TYPE	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	# OF YEARS
WET	20	34	45	43	24	12	6	8	15
AB NRML	24	38	46	39	18	8	9	11	12
BL NRML	21	32	39	26	10	8	8	10	14
DRY	22	38	36	21	9	6	7	13	6
CRITICAL	27	35	29	13	7	7	10	9	10

TABLE 5.3.6.3-3 FLOW REQUIRED AT VERNALIS (IN CFS) TO MEET RECOMMENDED PERCENT OF 20,000 CFS TOTAL DELTA INFLOW

YEAR TYPE	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV
WET	4084	6824	8936	8657	4773	2468	1194	1606
AB NRML	4769	7511	9174	7710	3562	1578	1800	2181
BL NRML	4220	6418	7724	5280	2031	1582	1582	2026
DRY	4500	7506	7249	4112	1727	1260	1420	2523
CRITICAL	5356	6975	5825	2540	1400	1432	1920	1869

TABLE 5.3.6.3-4 ESTIMATED UNIMPAIRED FLOW AT VERNALIS (IN CFS) AND PROBABILITY OF MEETING RECOMMENDED FLOW UNDER UNIMPAIRED CONDITIONS

YEAR TYPE	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV
WET	21012	37369	33876	12847	3014	1249	509	1818
	A	A	A	A	S	N	N	N
AB NRML	18861	28015	20695	6604	1515	568	831	1928
	A	A	A	S	N	N	S	S
BL NRML	12889	19490	15059	3861	815	356	752	3134
	A	A	M	S	N	N	S	M
DRY	10499	16214	9373	1992	556	449	607	2828
	A	A	M	N	N	N	N	M
CRITICAL	8823	9773	4676	966	465	537	963	1021
	M	M	S	N	N	S	S	S

=========
A = MET IN ALL YEARS
M = MET ON AVERAGE; MET IN MOST YEARS
S = MET IN SOME YEARS; NOT MET ON AVERAGE
N= NOT MET IN ANY YEAR

5.3.7 Suisun Marsh Wildlife Habitat Beneficial Use Alternative

5.3.7.1 No Action Alternative

Absent any other action by the Board, operators of the SWP (DWR) and the CVP (USBR) will continue to be bound to meet the wildlife protection terms of the Delta Plan. These terms include measures to meet or exceed certain standards for water quality in the channels of the Delta and Suisun Marsh (SWRCB,1978,22). The terms for protection of wildlife were unchanged by the 1985 amendments, except for some changes in monitoring locations, and time for implementation. The original terms required permittees DWR and USBR, in cooperation with other agencies, to develop by July 1, 1979, a plan for protection of the Suisun Marsh (Marsh Plan). This Marsh Plan together with EIR/EIS documentation, was to provide a monitoring network, construction of physical facilities, operation and management procedures for the facilities and assurances by land managers to maintain the Marsh as a brackish water wetland (SWRCB,1978,26). The permittees were required to manage the Marsh to produce high quality feed and habitat for waterfowl and other wildlife and to implement the Marsh Plan for full protection of the Marsh by October 1, 1984 (SWRCB,1978,26-27). Subsequent extensions of time and modifications to monitoring locations were granted by the Board (DWR,505).

In the event the Board takes no action, the terms of the Delta Plan, as extended in 1985, remain in effect. These terms provide interim partial protection to Suisun Marsh wildlife in the managed wetland area as well as in part of the natural tidal brackish water marsh area (SWRCB,14,VII-4). Approximately 40 percent of the 10,000 acres of unmanaged tidal brackish marshes around Suisun Bay were originally protected by the Delta Plan BCDC,5,12;BAAC,4;USFWS,17; 18;19;20).

5.3.7.2 Advocated Levels of Protection

- DWR, USBR, DFG, SRCD--Four Party Agreement

  At the Phase I of the hearing that addressing wildlife, DWR provided testimony and exhibits describing the measures agreed upon by DWR, USBR, DFG and SRCD (hereafter referred to as Four Parties) to meet the the Delta Plan requirements (DWR,503; 504; 506A; 506B; 507A; 507B; 508A; 508B; 509; 510; 511; 512; 513; 514; 517 A-B; 518; 519; 520 & 521). The measures included a Suisun Marsh Preservation Agreement, a Mitigation Agreement, a Monitoring Agreement, and a Plan of Protection for the Suisun Marsh.

  There are differences between standards set in the Delta Plan and its extension (used herein as the No Action Alternative) and those agreed upon by the Four Parties. Principal differences are the addition of a dry year modification of water quality standards in the Suisun Marsh, changes in the Chipps Island EC standard and a lower minimum mean monthly Delta Outflow Index (DWR,506(B),5). The monitoring requirements in the Delta Plan for the Suisun Marsh (Terms 4 and 5) are silent on rare, threatened, or endangered species, although by inference the plan of protection (Marsh Plan) required in Order term 7(a) is intended to ensure protection of all Marsh wildlife. The monitoring agreement developed by the permittees calls for census and surveys of only the salt marsh harvest mouse, and these would only be done if changes in the general plant community are found (DWR,508 B,3). There are no provisions for monitoring other threatened or endangered plants or animals. The Board has not yet found that the plan of protection, which was required under the Delta Plan and prepared by DWR, DFG and USBR (DWR,511) is fully consistent with Term 7(a) of the Delta Plan. According to testimony, the Four Parties have an agreement to implement the plan of protection they have developed (T,XXIX,27,7-23), including the monitoring. The agreement binds the parties to petition the Board to find that the actions are appropriate to protect the Marsh and to substitute the proposed standards for Delta Plan standards (DWR 506A,14,15). There is nothing in the agreement which requires it to be approved by the Board. Thus, in the event of no action by the Board, the parties to the agreement would be obligated to continue to operate their projects under the D-1485 amended standards. These call for standards to be met at some locations on October 1, 1988; in the northwestern Suisun Marsh on October 1, 1991; in the southwestern Marsh on October 1, 1993; and in Suisun Slough at Volanti Slough and at Chipps Island and Van Sickle Island waterfowl management area water supply intakes on October 1, 1997 (DWR,505,1-2).

- BCDC

Experts testifying on behalf of BCDC proposed that the Board revoke its decision of December 5, 1985 amending the standards compliance schedule in the Delta Plan and changing the locations (BCDC,5,31;T,XXIX,238:22-25). The BCDC testimony also proposed an additional standard to protect tidal marshes adjacent to Suisun Bay (BCDC,5, T4;T,XXIX,239: 25-240:2). It is BCDC's position that the Board's 1985 amendments to the Delta Plan reduced protection for unmanaged tidal marshes as well as delaying the implementation of measures to protect water quality and beneficial uses in the managed wetlands of the Suisun Marsh (BCDC,5,5).

- BAAC

BAAC recommended a flow and salinity standard which provides greater protection for brackish water tidal marshes than does the Delta Plan (T,XXX,52:6-22). In addition, recommended salinity standards for water quality in tidal marshes (levels not specified) be set for summer rather than ending in May (T,XXX,54:10-21). The position of BAAC was that the brackish water marshes have already been degraded and they would like to see them improved and restored more toward their natural condition, which would require more stringent salinity standards (T,XXX,94:20-95:2). The BAAC testimony did not explicitly state what those freshwater flows or what salinity standards should be to adequately approach natural conditions.

- PRBO

PRBO advocated freshwater outflow through the Golden Gate as a means to provide a food supply to seabirds ten to 15 miles away in the Farallones National Marine Life Refuge (T,LIV,140:6-143:8). The San Francisco Bay plume of freshwater is an important foraging area in April and May (T,LIV,145:10-12,21-24). The salinity differential and nutrient input produce a concentration of food organisms for seabirds (T,LIV,150:17-23). Birds use the plume for feeding when the normal marine food web closer to the Farallon Islands fails to develop (T,LIV,154:21-23). According to PRBO testimony, during El Nino events, when upwelling of deep-coastal water is less than normal, marine food chains are less productive and seabirds are more dependent on the San Francisco Bay plume (T,LIV,155:10-14). El Nino events are possible during dry years (T,LIV,155:4-6). The PRBO position is that if the plume is less extensive or less frequently close to the Farallones during the breeding season, seabirds which feed there will decline in abundance (T,LIV,160:24-161:1). During cross-examination,it became clear that the linkage between bird populations and the size of the plume is not completely predictable, as populations have increased during some El Nino periods when there was little outflow, such as 1977 (T,LIV,164:8-23). In other years, El Nino events coincided with extraordinarily wet years (T,LIV,154:19-155:1). The plume is a primary foraging area from February through May, while birds resort to the plume if it is present and if upwellings fail during June and July (T,LIV,161:22-24; T,LIV,162:20-22). No testimony or evidence was provided to indicate how often El Nino years would coincide with low outflow under unimpaired conditions.

5.3.7.3 Optimal Level of Protection

Considerations which were not addressed in detail in prior hearings on the Bay-Delta Estuary include the beneficial uses of water by threatened and endangered species. Protection for these species is required by both the state and federal Endangered Species Acts. The Delta Plan did not weigh the obligation of non-project diverters to protect water quality for endangered species or other public trust beneficial uses. The Board has the authority, as the public trustee of water quality for fish and wildlife, to condition all water uses to reasonably protect fish and wildlife including threatened and endangered species.

The salinity of water provided to tidal wetlands of the Suisun Marsh influences the survival and reproduction of marsh plants. For example, the California Native Plant Society (CNPS) exhibit (CNPS,3) and testimony (T,XXX,66:11-25;T,XXX,67:2-13;T,XXX,76:15-23) identified five rare, threatened or endangered plant species, four of which would be less likely to survive, have reduced growth or seed production, or become less numerous because of changes in flow or salinity in the Suisun Marsh portion of the Bay-Delta. Some 50 additional species would be indirectly affected, becoming less abundant or widespread as a result of land use changes induced by newly available water supplies (T,XXX,110:25-111:23). The directly affected rare plant species occur in the tidal marshes. The CNPS testimony indicates that even during normal years, freshwater flow to the Suisun Marsh has been insufficient to prevent reductions in productivity (T,XXX,,79:18-20).

With rare species, once a population is eliminated, it is very unlikely to reinvade because of the scarcity of seed sources. Thus, although common species such as alkali bulrush may be adequately protected or or able to recover from higher salinity exposure during a critical dry year, rare species would be at risk (T,XXX,81:22-24). A salinity standard capable of preventing reductions in numbers and range of threatened or endangered species might therefore require a smaller dry year adjustment of the salinity standard. It would have to be set at a level at which the species were capable of sustaining normal survival, productivity and germination. The Suisun Marsh Preservation Agreement, proposed by the Four Parties, does not adequately address these needs in its proposed standards. It is therefore recommended that the Board retain jurisdiction to require additional protection for sensitive special status species rather than fully endorse the Agreement.

Suitable pore water salinity for five sensitive plants ranges from zero to minus two megapascals (comparable to a range of zero to four parts per thousand (ppt) salinity, or electrical conductivity of zero to 6.25 mmhos/cm) for freshwater plants in the Delta (California hibiscus, Delta tule pea) to minus two to minus three megapascals in Suisun Marsh (four ppt to six ppt, 6.25 to 9.36 mmhos/cm) for Mason's lilaeopsis and Suisun aster, which tolerate somewhat brackish conditions (T,XXX,76:5-23). On the other hand, salt marsh bird's beak which grows in saline areas could tolerate minus four to minus five megapascals (eight ppt to ten ppt, 12.5 to 15.6 mmhos/cm). These pore water potentials should not occur until after the growing season, which extends from March to July (T,XXX,79:12-14).

The DFG has proposed a method to produce certain salinities in the root zones of managed wetlands based on surface water quality and timing of applied water (DFG,5,T3). To protect the unmanaged vegetation along the channels of the adjacent tidal marsh, comparable application timing and water quality to that DFG proposed for managed wetlands may be needed. If this standard were set, it would require studies relating pore water salinities in the root zones of rare plants to flow and salinity in channels adjacent to those plants. There is little information in the exhibits or testimony which addresses the relationship between the salinity of applied water and the pore water salinity outside of managed wetlands. If studies showed pore water salinity remained suitable for sensitive plant species even when channel salinities reached high values, relatively little Delta outflow would be required. Conversely, if studies showed pore water salinities were at levels which cause stress or reduced productivity of threatened or endangered plants, improved water quality in adjacent channels would be needed to prevent a significant impact.

Water quality in Suisun Marsh tidal channels for protection of rare and threatened plant species should therefore conform to the dates and salinity levels specified in DFG's Table 3 (DFG,5,T3). Further, applied water salinity should remain at or below seven ppt (approximately 10.9 mmhos) through July to fully protect threatened and endangered plant species (T,XXX,79:12-14). The optimal objective for tidal channels within Suisun Marsh is set forth in Table 5.3.7.3-1. The optimal objective for tidal wetlands adjacent to Suisun Bay, but outside the Suisun Marsh is set forth in Table 5.3.7.3-2. It should be noticed that the likely soil water salinity based on DFG's Table 3 would be at nine ppt in March, April, and May, corresponding to the minus four to minus five megapascals tolerated by salt marsh bird's beak, but unsuitable for Mason's lilaeopsis and Suisun aster. The existing distribution of rare, threatened and endangered species is thought to reflect the availability of water meeting the optimal objectives in tidal marshes during recent years. These objectives specifically for plants in the Suisun Marsh, as set forth in Table 5.3.7.3-3, should be continued while the relationship between applied water quality and soil water salinity in the rare plant root zone along tidal channels is determined. Provision of water meeting these objectives to managed wetlands only would not guarantee protection threatened and endangered species on tidal channel wetlands.

TABLE 5.3.7.3-1

OPTIMAL LEVEL OF PROTECTION FOR WILDLIFE
(Including Rare, Threatened and Endangered)
USE IN SUISUN MARSH TIDAL CHANNEL WETLANDS

Time	Location Station, Name	Level of Protection (Section Proposed)	Species Protected
October-July	C2, Montezuma Slough at Collinsville	TABLE 5.3.7.3-3 soil water salinity no more than 9 parts per thousand (PPT) TDS during growing season, met by providing a schedule of lowering salinity in channels prior to growing season by maintaining 7 PPT TDS in channels through July of all year types. (Footnote 1)	Suisun aster(SA), Mason's Lilaeopsis (ML)
"	D7A, Grizzly Bay		salt marsh harvest mouse (SMHM),California clapper rail (CR)
"	D10, Chipps Island		CR, Delta tule pea (TP)
	S10, Suisun Slough at Boynton		CR, SA, slough thistle (ST)
"	S17, Cordelia Slough at Ibis		TP
"	S31, Suisun Slough at mouth		CR, SMHM
"	S94, Suisun Slough at Hunter's Cut		SA, TP
"	S42, Suisun Slough at Volanti Slough		CR, SMHM, ML
"	S48, Montezuma Slough at Cutoff Slough		TP, SMHM, soft bird's beak (SBB)
"	S63, Denverton Slough		SBB
"	S93, Hill Slough		CR, SMHM, SA, ML

Footnote 1: Objectives based on DFG,5,T3.

TABLE 5.3.7.3-2

OPTIMAL LEVEL OF PROTECTION FOR WILDLIFE
(Including Rare, Threatened and Endangered)
USE IN SUISUN BAY TIDAL CHANNEL WETLANDS
OUTSIDE SUISUN MARSH

Time	Location Station, Name	Level of Protection (Section Proposed)	Species Protected
Oct-May All Years	8, Point Edith	Same as original D-1485, Table II	black rail (BR), salt marsh harvest mouse (SMHM), least tern (LT)
"	D8b, Middle Point, Suisun	"	BR, SMHM, LT, California clapper rail (CR)
"	9, Port Chicago	"	SMHM, CR
"	D9a, Spoonbill Cut	"	CR, SMHM
"	D11a, Sherman Lake	"	Mason's Lilaeopsis (ML)
"	12, Brown's Is.	"	CR, ML, Suisun aster (SA) Delta tule pea (TP)
"	13, Antioch	"	SA, SMHM, ML
"	21, Point Sacramento	"	ML
"	f57, Suisun Bay at Roe Is.	"	CR
"	f59, Suisun Bay at Seal Island	"	CR

TABLE 5.3.7.3-3

OPTIMAL OBJECTIVES FOR SALINITY OF WATER IN SUISUN MARSH TIDAL CHANNELS TO MAINTAIN SENSITIVE PLANT SPECIES*

Month	Applied Water Salinity EC (mmho/cm)	Applied Water Salinity TDS (p/thous)	Pore Water Salinity EC (mmho/cm)	Pore Water Salinity TDS (p/thous)	Ratio, Pore Water Salinity to Applied Water Salinity
October	18.8	12 footnote 1	50.0	32	2:1
November	15.6	10 footnote 2	37.5	24	2:1
December	15.6	10	31.2	20	2:1
January	12.5	8	25.0	16	2:1
February	7.8	5	15.6	10	2:1
March	7.8	5	14.1	9	1.8:1
April	10.9	7	14.1	9	1.3:1
May	10.9	7	14.1	9	1.3:1
June	10.9	7 footnote 3	14.1	9	1.3:1
July	10.9	7	14.1	9	1.3:1

1/ The salinity of water applied in October (12 ppt) dissolves surface salts and is increased by 4 ppt (to 16 ppt), hence the 32 ppt TDS in the soil, which has a 2 to 1 ratio to applied water salinity (DFG,5,T3).

2/ The salinity of water applied in November is increased by 2 ppt TDS (to 12 ppt) due to residual surface salts, hence the 24 ppt TDS in soil (DFG,5,T3)

3/ The salinity of applied water and soil water in June and July is assumed to continue unchanged from May.

* Table adapted from DFG,5,22.

5.3.8 Other (i.e., Navigation/Recreation)

Other beneficial uses of the Estuary affected by flow and salinity are commercial navigation, and contact and non-contact-water recreation. Uses that are part of non-contact-water recreation include esthetic appreciation and educational and scientific study (RWQCB 5,1975,5B,I-2-2).

5.3.8.1 No Action Alternative

Under a no action situation, flow and water quality standards established by the Delta Plan would be continued and navigation uses and other beneficial uses would continue to receive the same level of protection they now have.

No explicit standards for the protection of the beneficial uses of navigation or recreation were addressed in the Delta Plan. Because both are among the uses generally considered to fall within the public trust purview, the Board must provide for the protection of these uses, even if no participant addressed the needs during Phase I of the hearing.

Because the existing water quality and fish populations are in large measure attributable to the standards set by the Delta Plan, a no action alternative would provide for continuation of current recreation, navigation and esthetic appreciation beneficial uses.

5.3.8.2 Advocated Levels of Protection

- PICYA/EBPRD

The PICYA prepared and submitted an exhibit regarding beneficial uses relating to recreational navigation, but their exhibit was never made part of the hearing record. The essence of the PICYA submittals was that swimmable, fishable waters which supported existing populations and runs of fish were an important part of their recreational boating experience (PICYA,1,3). In addition, the PICYA document proposed improvements for boat passage at the Delta Cross Channel, protection of existing unleveed Delta islands and maintenance of through navigation (PICYA,4).

EBRPD submitted testimony and exhibits which showed that rapid growth (122 percent increase in two years) in water-oriented recreation was taking place within their jurisdiction (EBRPD,34,1). These two parties emphasized their interest in providing abundant supplies of uncontaminated fish to provide boaters and fishers with an opportunity to experience successful fishing (PICYA,1,3; EBRPD,34,3).

- SWC

SWC presented testimony and exhibits which estimated the economic value of recreation at CVP and SWP reservoirs and proposed that flow reduction in the Delta would be of less economic harm than reduction in flows to reservoirs and canals in the export area (SWC,66,13). No explicit objectives for flow or salinity were proposed by SWC for the protection of recreational uses in the Bay-Delta. SWC argued instead that added diversions would have no effect on recreational fishing, and be to the state's economic advantage, because of higher recreational values in southern California (SWC,66,12).

- BISF

BISF submitted exhibits and testimony regarding recreational uses of the San Francisco Bay area (BISF,38,T2;T,XXX,174:2-9), and identified the values of a variety of water-oriented recreational activities from the California State Parks and Recreation Department's PARIS model (BISF,38,T3). Cross-examination indicated that some of the recreational activities added into the tabulation were such that they were clearly poorly related to the flow and salinity in the Bay-Delta Estuary (T,XXX,199:17-,200:19). Although BISF did not propose flow and salinity objectives during the session on recreation, they did so in a later session (T,LVIII,236:18-240:18). It was not clear that their recommendations for flow and salinity at the later session were fully keyed to the recreational values earlier described.

- Commercial Navigation

No advocate for commercial navigation presented any testimony on flow or water quality during Phase I of the hearing. A standard exists for protection of shallow draft commercial navigation; the requirement being 5,000 cfs year-round in the Sacramento River at Wilkins Slough near the Tisdale Weir. This standard reflects historical, rather than current uses.

5.3.8.3 Optimal Level of Protection

To protect navigation in the Bay-Delta Estuary, flows in the upper reaches of the system must be sufficient to maintain the draft in Delta channels (Table 5.3.8.3-1). Recent measures taken by DWR to control salinity in south Delta channels (DWR,349,3) and structural measures to control flows in the Suisun Marsh have been in potential conflict with navigation. Features such as boat locks have been included in some (e.g., Montezema Slough) but not all of these structures. The Montezuma Slough Control Structure includes a boat lock, but Roaring River Intake does not. If flow and salinity in the Estuary are to be controlled by structural facilities, the impacts on navigation will have to be considered, and the balance of public interest in flows, salinity and navigation addressed.

Based on a recent survey prepared for the California State Lands Commission (CSLC, May, 1986) of existing marina capacity in the general vicinity of Sacramento, 26 percent of moored boats were under 25 feet long, 65 percent were between 25 and 40 feet long, and 9 percent were over 40 feet long. This survey indicated that moored boats tended to be larger, as a class, than the entire class of boats registered in the area by the Department of Motor Vehicles. When considering total boat population, easily trailered boats (those under 21 feet long) made up about 87 percent of the total (CSLC,May,1986). The ability of Bay-Delta channels to serve recreation and navigation is partially related to the size and draft of the boats using the channels.

Boater activity data derived from DWR studies indicate about 59 percent of the boaters' time is spent fishing, 4 percent water skiing, 36 percent general pleasure boating, and less then 1 percent sailing or jet skiing (SRRS,1980). The season of use for boat fishing has a peak of 27.9 percent of year-round activity during April and 16.8 percent in May, and a lesser peak of 12.0 percent in October corresponding to striped bass (spring) and salmon (fall) runs. Water skiing, a year round activity, is concentrated during June, July and August, with about 85 percent of all such use occurring in these months. Cruising and general boating have nearly the same pattern. Reduced river flows and reduced channel width and depth during these seasons would affect navigation.

There is a relationship between river flow and the width of the channel, with the channel narrowing during low flow periods. During these lowered flows, there is less room to pass other boats and moored vessels, and traveling boats are required by federal law (33 USC Sec.1006) to slow down to avoid damaging vessels and docks with their wakes. The State has adopted the federal criteria (Title 14, California Administrative Code, Section 6615) and added specific speed constraints for vessels passing within 100 feet of swimmers or 200 feet of beaches, floats, lifelines or mooring areas (Harbors and Navigation Code, Section 655.2). At extreme low water in Sacramento (approximate elevation 4 feet), channel widths are as narrow as 300 feet at some locations, compared to widths of nearly 700 feet at extreme high water (elevation 29 feet). The result is that flow affects not only depths, which will conflict with navigation by larger boats, but if low flows or structures reduce the available channel width, below 200 feet in areas where people swim, boat speeds will be constrained as well.

The flow and water surface elevation needed to prevent adverse effects on navigation will differ in each channel. As a rule, to protect recreational boating beneficial use, channels must remain open to passage. Furthermore, the water in any channel must be sufficiently deep to permit passage by any boats which ordinarily use that channel. These effects must be considered on a case-by-case basis, rather than by adopting a uniform objective.

TABLE 5.3.8.3-1
OPTIMAL LEVEL OF PROTECTION FOR NAVIGATION USE

Time	Location	Level of Protection	Protected
All Year	Wilkins Slough near Tisdale Weir	5,000 cfs	Commercial shallow draft navigation
All Year	All Channels	Maintain open to navigation at existing speeds by recreational watercraft on a case-by-case basis.	Recreational boating
All Year	Channels affected by flow control or salinity control structures	Maintain existing channel widths where over 100 feet, and with no swimming use of bank side development. Maintain existing channel widths where over 200 feet and adjacent to beaches, floats, lifelines or mooring areas. Decision to be made on a case-by-case basis.	High speed boating water skiing

5.4 Summary

Table 5.4-1 was prepared to show the flows and water quality objectives needed in the Sacramento-San Joaquin Delta to provide optimal protection for beneficial uses such as municipal, industrial, agriculture, fish, wildlife, and wetland habitat.

Objectives for optimal protection of wetland habitat in the tidal channels of the Suisun Marsh appear in the form of electrical conductivity levels, which have been converted to approximate Delta outflows, based on a series of curves presented in DWR-57, Revised. For example, the electrical conductivity objective for February is 7.8 mmhos/cm which would be accomplised in Suisun Bay by a Delta outflow of about 17,000 cfs. Other flows and water quality objectives are introduced earlier in this chapter.

TABLE 5.4-1

OPTIMAL WATER QUALITY OBJECTIVES (Footnote 1)
FOR M & I, AGRICULTURAL, WILDLIFE, SALMON AND DELTA FISHERY USES

Beneficial Use Protected and Location	Parameter	Description	Year Type	Dates	Values or Limit
MUNICIPAL					Cl-
Contra Costa Canal at Pumping Plant #1	Chloride	Maximum Mean Daily Chloride, mg/l	All	1/1-12/31	250
Clifton Court Forebay Intake at West Canal	"	"	"	"	"
Delta Mendota Canal at Tracy Pumping Plant	"	"	"	"	"
North Bay Aqueduct at Barker Slough	"	"	"	"	"
City of Vallejo Intake at Cache Sl.	"	"	"	"	"
INDUSTRIAL					
Contra Costa Canal Intake at Pumping Plant #1 -or- Antioch Water Works Intake on San Joaquin R.	Chloride	Maximum Mean Daily Chloride, mg/l	All	1/1-12/31	150
AGRICULTURE				Dates	EC
Western and Interior Delta Irrigation Sacramento R. at Emmaton	Electrical Conductivity	Maximum 14-Day Running Average Mean Daily EC, mmhos/cm	All	4/1 - 8/15	1.5
San Joaquin R. at Jersey Point		"	"	"	"
Mokelumne R. at Terminous		"	"	"	"
San Joaquin R. at San Andreas Ldg.		"	"	"	"
Cache Sl. at Junction Pt.		"	"	"	"
South Delta Irrigation San Joaquin R. near Vernalis	Electrical Conductivity	Maximum 14-Day Running Average Mean Daily EC, mmhos/cm	All "	4/1 - 8/31 9/1 - 3/31	0.7 1.0
San Joaquin R. at Mossdale		"	"	"	"
Bifurcation of Old and Middle rivers		"	"	"	"
Middle R. at Howard Rd. Bridge		"	"	"	"
Old R. at Tracy Rd. Bridge		"	"	"	"
San Joaquin R. at former site of Brandt Bridge		"	"	"	"
Delta Leaching (Ponding)					
Emmaton Jersey Point Cache Slough at Junction Point San Andreas Landing	Electrical Conductivity	Maximum monthly average of mean daily EC, mmho/cm	All	12/1-2/28	1.7

Footnote 1: Optimal levels of protection designed to protect beneficial uses without consideration of impact on other beneficial uses or water needs.

TABLE 5.4-1 cont'd.

OPTIMAL WATER QUALITY OBJECTIVES (Footnote 1)
FOR M & I, AGRICULTURAL, WILDLIFE, SALMON AND DELTA FISHERY USES

Beneficial Use Protected and Location	Parameter	Description	Year Type	Dates	Values or Limit				
FISH and WILDLIFE									
Suisun Marsh Wildlife Habitat Channels adjacent to brackish tidal wetlands	Electrical Conductivity, Delta Outflow (Footnote 2)	Staff estimate of salinity and flow (mmho/cm, cfs) needed to optimally protect tidal marsh habitat around Suisun Bay	All		EC	cfs			
				10/1-31	18.8	6000			
				11/1-12/31	15.6	8000			
				1/1-31	12.5	10000			
				2/1-3/31	7.8	17000			
				4/1-7/31	10.9	12500			
Delta Fisheries (Sacramento R.)									
Salmon Migration Rio Vista	Flow (Footnote 3)	Minimum daily flow (cfs)		9/1-12/31	1/1-31	2/1-3/15	3/16-31	7/1-31	8/1-31
			Wet	5,000	2,500	3,000	5,000	3,000	1,000
			Ab. Normal	2,500	2,500	2,000	3,000	2,000	1,000
			Bl. Normal	2,500	2,500	2,000	3,000	2,000	1,000
			Dry	1,500	1,500	1,000	2,000	1,000	1,000
			Critical	1,500	1,500	1,000	2,000	1,000	1,000
Salmon Smolt Outmigration Rio Vista	Flow	Minimum daily flow (cfs)	All	4/1-6/30 22,500					
Outmigrant Survival salmon, shad striped bass Delta Cross Channel	Flow Constraint	Cross Channel Gates Status of both gates	All	4/1-11/30 closed					
Salmon Fry Rearing Delta Cross Channel	Flow Constraint	Cross Channel Gates Status of both gates	Below Normal, Dry, Critical	1/1-3/31 closed					
Delta Fisheries (San Joaquin R.)									
Adult Salmon Migration Stockton	Flow	Minimum daily flow (cfs)	All	7/1-11/30 500					
Between Stockton and Turner Cut	Dissolved Oxygen	Minimum daily value (mg/L)	All	7/1-11/30 6.0					
Salmon Smolt Outmigration San Joaquin R nr. Vernalis	Flow	Minimum daily flow (cfs)	All	4/1-6/30 20,000					
Striped Bass Adult Migration and Spawning San Joaquin R nr. Vernalis to Antioch Bridge	Electrical Conductivity	Mean daily value not to exceed (mmho/cm)	All	4/1-6/15 0.3					
Delta Fisheries									
Shad Migration, Spawning and Larval Outmigration									
Sacramento R at Freeport San Joaquin R nr. Vernalis	Combined Inflow Sacramento plus San Joaquin riv.	Sum of minimum daily flows not less than (cfs) (Footnote 4)	All	4/15-11/30 20,000					
Shad and Striped Bass Larvae, Salmon Smolt Survival Throughout Statutory Delta	Export and Diversion	Flow permitted except in emergencies (cfs)	All	4/1-11/30 0					
Striped Bass Larvae Movement to Suisun Bay Chipps Island	Delta Outflow	Minimum daily outflow (cfs)	All	4/1-5/31 33,900	6/1-6/30 32,400	7/1-7/31 29,100			

Footnote 1: Optimal levels of protection designed to protect beneficial uses without consideration of impact on other beneficial uses or water needs.

Footnote 2: Objective estimated to fully protect tidal wetlands of Suisun Bay including habitat of rare, threatened and endangered species.

Footnote 3: Retain Delta Plan conditions in the absence of evidence that these flows are not optimal.

Footnote 4: Proportion of San Joaquin River flow to total Delta inflow to be the same as would occur under unimpaired flow conditions (see Table 5.3.6.3-3).

References:

- California State Lands Commission, May 1986, River Marina Carrying Capacity Study, 160 pp. 5 appendices. Table 1, pg. 10, Table 14 and Appendix 1.

- California Department of Water Resources (Northern District), 1982. Sacramento River Recreation Study, 1980.

6.0 DETERMINATION OF REASONABLE NEEDS FOR CONSUMPTIVE USES OF BAY-DELTA WATERS

6.1 California Water Ethic

California's ground and surface waters are a precious, but limited resource. Water supplies, vital to homes, industry, agriculture, and fish and wildlife, while abundant in one year, can become critically limited in another. In the past, dams were built to control flooding and provide appropriate supplies during prolonged dry periods. Today the sum of water demands exceeds the reliable supply. Additional actions are required. All Californians must become involved in the reasonable use of water. All water users throughout the state will be required to participate in the task of sharing water.

6.1.1 Balancing

This Water Quality Control Plan balances the reasonable water quality and instream flow needs which protect the beneficial uses of Bay-Delta Estuary waters against the reasonable consumptive demands for Estuary water both in- and outside the watershed. These consumptive demands occur upstream in the Sacramento River Basin and San Joaquin River Basin and in export areas south and west of the Delta in the San Francisco Bay area, San Joaquin Valley and southern California. The beneficial uses in the Estuary include productive and valuable biological assets, over 1/2 million acres of fertile farm land in the Delta, and extensive wildlife habitats. The Estuary also provides water quality protection to those who divert water for use elsewhere. Because the entire state will be affected in some way by this Plan and its implementation, it has become necessary to develop a water ethic that involves all Californians.

The water ethic includes the coordination of several programs, in varying degrees, in every region of the state. Best management practices related to the use of water are needed throughout the state. Many benefits can be realized. Careful water use can decrease pollutant loadings as well as reduce water demands. The following are assumptions forming the basis of the California water ethic:

- Conservation--Municipal and industrial water users (residential, industrial and commercial) will be metered. With improved plumbing, appliances, leak detection, and landscape irrigation practices, per capita water use will be significantly reduced. All agricultural users will use water as efficiently as feasible, particularly those who contribute drainage flows to salt sinks which preclude recovery or reuse.

- Reclamation--Where feasible, water reclamation and recycling consistent with state laws shall be required to reduce the demand on existing potable water supplies. Water reclamation includes the enhanced treatment of wastewater for reuse, the conversion of saline water to freshwater, and the treatment of ground water to a sufficient level to allow subsequent beneficial use.

- Conjunctive Use--Ground water storage basins will be effectively utilized in conjunction with distribution of surface water.

- Sharing Responsibility--Adequate flows for beneficial uses in the Estuary are the responsibility of all water users in the Bay-Delta watershed.

- Physical Facilities--To better manage California's water resources, the development of physical facilities is encouraged.

- Pollution Control--Maximum practical pollution control takes precedence over releases of freshwater for flushing flows.

6.1.2 Actions Needed

All users of Estuary waters, persons north, south and within the Estuary must share in the responsibility of meeting objectives to protect Bay-Delta beneficial uses. Also, all users should pursue the reclamation and reuse of water to its maximum potential. Water conservation and reclamation will need to be practiced in all areas, not just those south of the Estuary. Water users in the areas of water origin will also need to participate in this new water ethic.

This new water ethic forms the basis for determining reasonable consumptive water needs upstream, within, and south of the Estuary as well as water project operations which affect water flows into and through the Estuary. These changes in use of water come with associated costs. Within the limits of the available data, these costs have been considered here; additional information on this subject should be received in Phase II.

6.2 Reasonable Needs for Consumptive Uses

A review of optimal levels described in Chapter 5 shows that full protection of all beneficial uses in all water years is impossible. There simply is not enough water. Some beneficial uses have competing needs for limited supplies, and some, as noted, conflict with each other. Some accommodation has to occur. Practical application of the principles developed from the California water ethic can help identify reasonable consumptive needs for Bay-Delta water in areas upstream, within, and exported from the Estuary. These reasonable needs show that current water supplies can be managed in ways that satisfy existing and future needs. In fact, a rigorous application of the California water ethic indicates that substantial savings can be realized.

Reasonable consumptive needs are projected 2010 agricultural, municipal and industrial demands minus those potential savings achieved through water conservation and reclamation practices. Following the California water ethic, water saving methods can be used which will decrease water needs yet provide adequate supplies to support the beneficial uses made of the water.

These reasonable consumptive needs and water saving methods are discussed below. The ability to increase April through July Sacramento and San Joaquin river flows through the conjunctive use of surface and ground water and the alteration of reservoir operations are also evaluated.

6.2.1 Reasonable Consumptive Agricultural Needs

Using projected changes in demand and potential savings due to more efficient water use, projected 2010 consumptive agriculture needs in areas receiving Bay-Delta water will be about 1,007 TAF/yr less than present needs (see Table 6.2.1-1). This overall savings could be used for other beneficial uses.

The water conservation potential identified in Table 6.2.1-1 for the San Joaquin and Tulare Lake basins is based on a modification of the methodology of the Central Valley Water Use Study Committee (CVWUSC) (CVAWU, 64A). CVWUSC's methodology defines water conservation as a reduction of deep percolation losses to saline sinks, an area of about 1.7 million acres in the San Joaquin Valley (0.37 million acres in the San Joaquin Basin and 1.34 million acres in the Tulare Lake Basin). For comparison, the total irrigated acreage in the San Joaquin Valley in 1980 was 5.37 million acres (2.06 million acres in the San Joaquin Basin and 3.31 million acres in the Tulare Lake Basin (DWR, 14, 29)). The area of saline sinks includes most of the west side of the San Joaquin Valley. The total water conservation savings for this area at an Irrigation Application Efficiency (IAE) of 80 percentwas considered to be about 230 TAF/yr by the CVWUSC. Instead, 550 TAF/yr is considered to be a reasonable water conservation goal at 80 percent IAE based upon the modifications to the CVWUSC methodology discussed below.

SWRCB changes

- Contribution of shallow ground water (SGC) toward meeting the evapotranspiration (ET) requirement of a crop. For areas of salt tolerant crops (only cotton and alfalfa are considered here) grown on land overlying shallow ground water, 20 percent of the ET is assumed to be satisfied by the ground water. Thus, for these areas the IAE is redefined as follows:

$$IAE = \frac{ET\text{-}SGC}{\text{Applied Water}}$$

- Analysis of net tailwater and ground water losses to the San Joaquin River, in areas draining to the San Joaquin River. The CVWUSC excluded all but 100,000 acres of the west side of the San Joaquin River from consideration for water conservation under the assumption that all losses returned to the San Joaquin River. Instead, lateral flow rates from recent studies of ground water on the west side were considered. These flow rates show that not all of the losses return to the San Joaquin River. Thus, the water conservation potential on all 345,200 acres of the west side of the San Joaquin River (DWR's Detailed Analysis Unit #216) which overlie a saline sink was evaluated.

- Assumption that the minimum leaching requirement is met by the 20 percent deep percolation which occurs at the IAE of 80 percent

TABLE 6.2.1-1

REASONABLE CONSUMPTIVE AGRICULTURAL NEEDS
(TAF/yr)

Basin	Present (1985)	Future (2010)	Water Cons. (2010)	Reasonable Needs (2010)
Upstream[1]				
o Sacramento	6,338[4]	6,505[4]	0	6,505
o SJ (w/o salt sinks)	4,505[4]	4,589[4]	0	4,589
Bay-Delta				
Delta[1]	935[5]	933[6]	0	933
S.F. Bay[2]	118[4]	94[4]	0	94
Export[2]				
SJ (w/salt sinks)	1,390[7]	1,390[7]	235[7]	1,155
Tulare Lake	10,680[4]	10,781[4]	315[7]	10,466
Central Coast[3]	388[8]	354[8]	0	354
S. California	1,405[7]	1,108[7]	452[7]	656
TOTALS	25,759	25,754	1,002	24,752

1/ Based on net water use
2/ Based on applied water use
3/ Santa Barbara and San Luis Obispo areas only
4/ From DWR, 707, Statistical Appendix; adjusted for Delta agricultural needs
5/ From DWR, 30b
6/ From DWR, 701b
7/ From staff analysis
8/ From T,XIX,166:9-14

(assuming recycling of all tailwater). Thus, in this analysis no additional water for leaching was added to the applied water needs, as was done by the CVWUSC.

By the CVWUSC definition, the areas in the Bay-Delta watershed outside of the 0.37 million acres in the San Joaquin Basin overlying saline sinks (i.e., the rest of the upstream areas and the Delta) do not have any potential for water conservation. The losses in these areas are all considered by the CVWUSC to be recoverable and contribute to net Delta outflow. However, in the case of losses to usable ground water, the recovery of the losses usually comes at the expense of water quality degradation and a time lag. The water quality degradation occurs by dissolution of soil minerals from percolating water which over time will lead to expansion of the area of saline sinks. The time lag involved in ground water flow means that the return of the water to a river system may come at a time when additional flows are not needed. Therefore, water conservation may provide real water savings in these areas. Unfortunately, they cannot be quantified at this time. Nevertheless, since these losses in the upstream areas and the Delta are considered generally recoverable, the consumptive agricultural needs are based on net water use (i.e., crop ET). In areas not contributing to net Delta outflow, the consumptive agricultural needs are based on applied water use.

The water conservation potential identified in Table 6.2.1-1 for southern California is based on hearing testimony by Imperial Irrigation District (IID) and SWRCB's analysis assuming a goal of 80 percent IAE for Coachella Valley Water District (CVWD). Losses from IID and CVWD both go to a saline sink, the Salton Sea, and are thus irrecoverable losses. Based on hearing testimony by IID, certain projects could be undertaken which would provide a water conservation potential of up to 368 TAF/yr in IID. A combined savings of 84 TAF/yr in the CVWD and the Desert Water Agency service areas is based on increasing their IAE to 80 percent.

Although this analysis of agricultural water conservation potential is focused on saline sink areas, the goal of 80 percent IAE should be applied to all agricultural areas in California. Excessive deep percolation in nonsaline sink areas will lead to other problems; e.g., contamination of ground water with pesticides, nitrates, heavy metals, and other constituents; high ground water problems; and expansion of saline sink area through dissolution of soil mineral salts. These problems could be reduced through improved irrigation management and achievement of a 80 percent IAE.

The annual costs associated with achieving an 80 percent IAE in the west side of the San Joaquin Valley have been estimated at $16 to $25 per acre (EDF, 11, Executive Summary; UC Committee of Consultants on Drainage Water Reduction, 1988). Based on an analysis for the west side of the San Joaquin Valley, these costs per acre translate to between $25 to $40/AF of water conserved. The cost estimates for IID water conservation projects range from MWD's estimate of $64/acre-foot of water conserved (SWRCB Order WR 88-20 p.22) to $160 - $275 of water conserved by IID (IID, 1987). The $160/AF figure only includes the program items with identified water savings, while the $275/AF includes several additional programs. These cost estimates are the subject of intense negotiations.

Much of the costs of agricultural water conservation would be incurred regardless of any decision by the SWRCB on water diversions from the Bay-Delta. For example, in September 1988 the SWRCB issued Water Rights Order WR 88-20, which requires IID to submit a written plan containing definite implementation measures designed to conserve at least 100,000 AF/yr by January 1994. It also states that the SWRCB finds the conservation of 367,900 AF/yr to be a reasonable long-term goal for IID, and it will retain jurisdiction to review future water conservation measures. The costs of water conservation in IID are not likely to be borne by IID or the farmers in IID because, as noted in WR 88-20, MWD (and possibly other agencies) have expressed an interest in purchasing the water saved by conservation from IID.

Agricultural water conservation savings on the west side of the San Joaquin River may be another example of savings which would occur regardless of a SWRCB decision on water diversions from the Bay-Delta. The level of these savings will depend on the water quality objectives set for the San Joaquin River by the California Regional Water Quality Control Board, Central Valley Region early next year. As with IID, there is the possibility of financing such conservation measures by selling conserved water to other water users. This possibility has been raised in several analyses of drainage problems in the San Joaquin Valley (e.g., San Joaquin Valley Drainage Program, 1987).

6.2.2 Reasonable Consumptive Municipal and Industrial Needs

The present (1985) and projected (2010) consumptive municipal and industrial needs in areas using Bay-Delta waters are summarized in Table 6.2.2-1.

assuming reasonable needs in 2010

The totals in Table 6.2.2-1 show that despite water conservation efforts an additional 1,076 TAF/yr will be needed by 2010 to satisfy municipal and industrial demand. Much of this increased demand could be satisfied by the savings from agriculture. As with the agricultural analysis, the municipal and industrial water conservation potential in the upstream areas and the Delta is considered to be unquantifiable at this time and therefore set to zero. This is because the losses can be recoverable and generally contribute to net Delta outflow. For the municipal and industrial analysis it is assumed that losses to saline sinks in the San Joaquin Basin are minimal due to the sparse population overlying these areas. Again, for areas where return flows do not contribute to net Delta outflow, the consumptive use is based on the applied water use; for other areas, the consumptive use is based on the net water use. For example, applied water use is used for Fresno and San Francisco, while net water use is used for Sacramento and Stockton. The projected water conservation savings in the San Francisco Bay Basin and export areas are based on an aggressive water conservation and reclamation program which includes the following assumptions for 2010:

aggressive conservation assumptions in SF Bay Basin

TABLE 6.2.2-1

REASONABLE CONSUMPTIVE MUNICIPAL AND INDUSTRIAL NEEDS
(TAF/yr)

Basin	Present (1985)	Future (2010)	Water Cons./ Recl. Savings (2010)	Reasonable Needs (2010)
Upstream 1/				
Sacramento	500 3/	679 3/	0	679
SJ River	248 3/	344 3/	0	344
Bay-Delta				
Delta 1/	27 4/	43 4/	0	43
S.F. Bay 2/	1,088 3/	1,222 3/	129 4/	1,093
Export 2/				
Tulare Lake	481 3/	729 3/	0	729
Central Coast	109 5/	136 6/	18 4/	118
S. California	3,609 4/	5,221 4/	1,089 4/	4,132
TOTALS	6,062	8,374	1,236	7,138

1/ Based on net water use
2/ Based on applied water use
3/ From DWR, 707, Statistical Appendix; adjusted for Delta M&I needs
4/ From staff analysis
5/ From T,XIX,166:9-14
6/ From SWC, 176, 3

SF Bay Basin conservation assumptions

- 95 percent compliance with the 1978 California Plumbing Code for all residences existing in 2010;
- About half of the water used by commercial and governmental/public customers is for outdoor irrigation or evaporative cooling; and
- As a result of improved irrigation efficiency and changes in landscaping practices, there will be a 20 percent reduction in existing outdoor residential, commercial and public water uses and a 40 percent reduction in new uses added between now and 2010.

Although the mix varies from agency to agency, in general the reasonable use analysis involves three areas of additional conservation: industrial use, indoor residential use, and outdoor use by residential, commercial, and public consumers. Additional conservation by industrial users is projected only for the MWD service area and the San Francisco Bay Basin, and is the smallest component of the proposed savings through conservation. This is because industrial water use in California has fallen by 50 percent or more over the past 15 years. This dramatic reduction in industrial water use is a nationwide trend that is attributable largely to enforcement of water pollution control laws. Because industrial use is now a relatively small component of total M&I use in California (about 10-13 percent), the gains from increased conservation in this component are relatively small.

The basis for the analysis of indoor residential conservation is the 1978 California Plumbing Code which mandated lower water-using toilets and showers in new construction. Typical indoor residential water use in a nonconserving home is about 77 gallons per capita per day (gpcd), and it has been estimated that the new standards contained in the 1978 Code would reduce this by about 15.2 gpcd if fully implemented. The appliances on sale in California now meet or exceed these standards, so the only lack of implementation can arise from existing toilets or shower heads that were installed before 1978 and meet the earlier standards. By 2010 all such shower heads, and many such toilets, are likely to have been replaced. For the purposes of analyzing reasonable use, it was assumed that there would be 95 percent compliance with the 1978 Code by the year 2010, which implies an average savings of about 14.5 gpcd. Some of the projections of 2010 M&I use presented during the Phase I hearing do not appear to incorporate any savings attributable to the 1978 Code at all, while others incorporate a smaller savings (for example, a savings of 11.5 gpcd, based on an assumption of 76 percent compliance). The incremental conservation in indoor residential use in 2010 that is implied by the reasonable use analysis is the difference between 95 percent compliance with the 1978 Code and the degree of compliance assumed in individual water agencies' projections -- i.e., the difference between 14.5 gpcd and, for example, 11.5 gpcd.

In the past, much of the effort aimed by California water agencies at conservation in M&I use has focused on industrial use and indoor residential use. However, 40 percent or more of all M&I use in California is outdoor use, primarily for lawn and garden irrigation by residential, commercial, and public-sector customers. This appears to have received relatively little attention. Whereas industrial water use has fallen by at least 50 percent over the past 15 years and indoor residential use is projected to fall by 15-25 percent by 2010 under existing conservation programs, no reduction is projected for outdoor uses. Indeed, there will probably be an increase in per-capita outdoor use by 2010 because of a trend to larger-sized lots, more development in the hotter, interior regions, and the growth of the commercial sector which appears to use significant quantities of water for outdoor irrigation and evaporative cooling. Because of the relative lack of attention, there are likely to be significant opportunities for conservation in outdoor use that have not yet been exploited. Accordingly, the third component of the reasonable use conservation analysis targets outdoor use by residential, commercial, and public consumers and proposed for 2010 reductions of 20 percent in currently existing uses and 40 percent in new uses developed between now and 2010. There is substantial evidence that such reductions are eminently feasible. DWR (1984), for example, asserts that improved irrigation practices on existing residential, commercial and governmental landscapes can reduce applied water by 20 percent, and changes in landscape design can reduce water use by 40-90 percent. Ferguson (1987) notes that even the cheapest and most primitive conservation measures can reduce urban irrigation use by 25 percent compared to a poorly designed or operated system, and argues that it is reasonable to shoot for 60-70 percent savings with more sophisticated planning and aggressive conservation measures.

In the San Francisco Bay Basin the present per capita water use is 190 gallons per capita per day (gpcd) and the 2010 water use is projected to be 179 gpcd. By applying the aggressive water conservation measures outlined above, the per capita water use in the San Francisco Bay Basin could be reduced by 19 gpcd to 160 gpcd, for a savings of 129 TAF/yr.

In the Central Coast Basin only the Santa Barbara and San Luis Obispo areas are considered in this analysis since they are the only areas planning to use Estuary water. In these areas, the aggressive water conservation and reclamation program outlined above could produce a municipal and industrial water savings of 18 TAF/yr in 2010. Based on these assumptions, M&I water use in the Santa Barbara and San Luis Obispo areas, which is currently 190 gpcd, could be reduced by 24 gpcd in 2010 from the State Water Contractors (SWC) projected level of 181 gpcd to 157 gpcd.

The major population centers in the Tulare Lake Basin, Fresno and Bakersfield, are outside of the designated saline sink area. Most of the wastewater produced in the basin is reclaimed for irrigation use. Thus, the only potential for water conservation in the Basin would be through reduced evaporation from regulating reservoirs (prior to irrigation). This amount is very small, and therefore the municipal and industrial water conservation potential is assumed to be zero.

The total water conservation and reclamation potential in the SWP service area of southern California shown in Table 6.2.2-1 is 1,089 TAF/yr in 2010. This value includes 924 TAF/yr of water conservation savings and 165 TAF/yr of increased reclamation. For Metropolitan Water District (MWD), total water conservation savings is 544 TAF/yr based on the aggressive water conservation assumptions shown earlier plus a small decrease in industrial water use. The present M&I water use in MWD is 207 gpcd. These conservation measures would reduce M&I use in the MWD service area from the 194 gpcd projected by the SWC for 2010 down to about 168 gpcd.

Water conservation savings in non-MWD areas of the SWP service area in southern California are estimated to be 380 TAF/yr. Of this total, 200 TAF/yr are based on the same reasonable use analysis as in MWD. As a result of that analysis, the non-golf course M&I use in these areas in 2010 is reduced from the level of 287 gpcd projected by SWC to about 222 gpcd. The other 180 TAF/yr represents potential savings in water use on golf courses. This savings is based on a 20 percent reduction in water usage on existing golf courses, plus an assumption that new golf course areas will increase by not more than 50 percent from 1985 to 2010, rather than the 300 percent increase assumed by the SWC.

Lastly, the increased reclamation of 165 TAF/yr is projected only for the MWD service area, and is based on data presented by MWD (SWC, 17, Table 2 and Figure 3; T, XVII, 3, 11, 69-71) identifying reclamation projects that could be developed by 2010 based on what MWD considers to be reasonable constraints on member agencies.

The primary motivating factor for additional water conservation by industry between now and 2010 will continue to be the enforcement of water pollution control regulations. This will occur regardless of any decision by the Board on water diversions from the Bay-Delta. Therefore, the incremental costs of such conservation should not be attributed to the aggressive water conservation plan described. The discussion here focuses specifically on the economic effects of conservation measures that are proposed in the analysis of reasonable use for 2010 and that go beyond those currently planned by M&I water agencies.

There are reasons to believe that the costs associated with indoor residential conservation are likely to be modest. For example, there have recently been proposals to revise the 1978 Code to require ultra-low flush toilets and shower heads in new construction, that have been made possible by newer technologies. If fully implemented, this could reduce indoor residential use in new units by an additional 11-15 gpcd as compared to the 1978 Code "at little or no cost to customers" (EBMUD, 1988). East Bay MUD has stated that, if the State Plumbing Code were revised in this way, it would consider requiring the replacement of existing toilets and shower heads in its service area with ultra-low flush units. Also, Monterey County has recently implemented a measure mandating the installation of ultra-low flush toilets on resale of residential units. MWD has recently announced a new program of Financial Incentives for Water Conservation under which it would subsidize part of the cost to member agencies of measures such as the installation of ultra-low flush toilet and shower head units. Such measures would more than meet the incremental indoor residential conservation implied by the reasonable use analysis.

The cost of outdoor water conservation would be greater for existing landscapes than for newly-developed landscapes. In smaller residential units without a sprinkler system, the costs of installing sprinklers or changing the landscaping can be substantial. In an efficient program, however, such users would be the last to be targeted; the initial focus would be on large commercial, public, and residential users of irrigation water. Moreover, significant savings may be obtained from existing users at relatively low cost through education and irrigation scheduling programs. Also, as noted in DWR 1984, replacing sprinkler heads and installing timers in existing sprinkler systems can be a cheap but effective way of reducing water use by 20 percent or more without harming the vegetation. Accordingly, while there will certainly be planning and management costs for water agencies administering an effective outdoor water conservation program, as well as retrofit or conversion costs for some existing users, it is believed that a well-designed program could achieve the outdoor conservation goals of the aggressive water conservation program at a reasonable cost and in an equitable manner.

The projections of increased reclamation are based on statements by the State Water Contractors about wastewater reuse projects which they intend to implement by 2010 (SWC, 17). There is no indication that the implementation of such projects would be attributable to specific actions by the SWRCB in connection with water diversions from the Bay-Delta. Therefore, these do not involve any additional economic impacts that are attributable to the aggressive water conservation and reclamation program discussed here.

It should be noted, lastly, that the reasonable use analysis assumes no reduction in population growth or new housing development from that projected for 2010 in the testimony presented during the Phase I hearing. New construction would have to incorporate more efficient plumbing fixtures and water-conserving landscaping, but all the available evidence suggests that these costs would be extremely small, both absolutely and in relation to the total price of the housing unit. Thus, no significant impacts on the housing industry are predicted as a consequence of the aggressive water conservation and reclamation program.

no pop or housing growth reduction assumed in the reasonableness analys

6.2.3 Southern California Water Balance

The present and future water supplies and demands in southern California are summarized in Table 6.2.3-1.

The decrease in total supply shown in Table 6.2.3-1 is due to two factors: (1) the projected decrease in Colorado River supply due to the Central Arizona Project, and (2) the reduced supply from the Los Angeles Aqueduct as a result of the Mono Lake litigation. The demands shown in Table 6.2.3-1 were discussed in Tables 6.2.1-1 and 6.2.2-1. With the conservation efforts outlined previously, the

TABLE 6.2.3-1

SUPPLY AND DEMAND FOR SOUTHERN CALIFORNIA AREAS WHICH RECEIVE STATE WATER PROJECT WATERS (IN MAF/YR)[1]

	Present[2]	Future[3]
Supply		
o Local surface and ground water	2.19[4]	2.19[4]
o Colorado River	1.47[5]	0.80[4]
o State Water Project	0.79[6]	0.79[6]
o Los Angeles Aqueduct	0.42[4]	0.40[7]
o Wastewater reuse	0.15[4]	0.34[8]
o Total Supply	5.02[9]	4.52
Demand		
o Agricultural w/o conservation	1.41[10]	1.11[10]
o Agricultural w/ conservation		1.03[11]
o M&I w/o conservation	3.61[12]	5.22[12]
o M&I w/ conservation		4.30[13]
o Total Demand w/o conservation	5.02	6.33
o Total Demand w/ conservation		5.33
Surplus/Deficit	0	-0.81
Transferable water supply from agricultural water conservation in IID		0.37[14]
Transferable water supply from agricultural water conservation in SJV		0.34 to 0.48[15]
Remaining Surplus/Deficit		-0.10 to 0.04

1/ - Area includes the following water districts: Antelope Valley-East Kern WA, Littlerock Creek ID, Palmdale WD, Coachella Valley WD, Desert WA, San Gorgonio Pass WA, Mojave WA, Crestline Lake Arrowhead WA, San Bernardino Valley WD, Castaic Lake WA, San Gabriel Valley MWD, Ventura County FCD, and Metropolitan Water District
2/ - 1985 level
3/ - 2010 level
4/ - From SWC, 4,3
5/ - By difference
6/ - 1985 deliveries; from DWR, 1987
7/ - Estimate of reduced supply due to Mono Lake litigation
8/ - From SWC, 4, 3 plus incremental reuse identified in SWC, 17, Table 2 and Figure 3
9/ - Set equal to demand for present
10/ - See Table 6.2.1-1
11/ - Includes conservation in CVWD only (0.08 MAF/yr)
12/ - See Table 6.2.2-1
13/ - Includes conservation only (reclamation of 0.17 MAF/yr was added to supply as wastewater reuse)

14/ Savings from the IID as discussed in Section 6.2.1

15/ 0.34 is agricultural water conservation and conveyance losses in areas supplied entirely with project water; 0.48 is agricultural water conservation and conveyance losses in areas supplied at least partially with project water (from staff analysis) projected future (2010) demand would increase slightly, from 5.02 MAF/yr to 5.33 MAF/yr.

Despite water conservation efforts in southern California, Table 6.2.3-1 indicates that there would be a deficit of 0.82 MAF/yr in 2010. However, this deficit could probably be satisfied by transferring water savings from conservation: (1) of project water in the San Joaquin Valley , and (2) of Colorado River water in IID. The first transfer would come from increased SWP supply, but would not affect the total project exports from the Estuary.

6.2.4 Methods to Increase April through July Net Delta Outflow

The net Delta outflow could be increased in April through July by redistributing the annual inflows and/or outflows to/from the Delta. Two methods for accomplishing this seasonal redistribution of flow were evaluated:

(1) conjunctive use of surface and ground waters; and

(2) reoperation of Central Valley reservoirs.

These methods could be applied separately or together to provide increased April through July flows. Conjunctive use could be practiced in several upstream areas in the Sacramento and San Joaquin basins. Reoperation of reservoirs in this study entails meeting all the specific demands of reservoir operations (flood control, irrigation, fish flows) except power production. Only those releases from reservoirs which are made solely for power would be affected, since most power could still be produced within the constraints of the other operations. For example, reservoirs in the Central Valley could increase storage during August through March, while decreasing downstream flows in those months, and subsequently increase April through July discharges. However, during wetter years, reservoirs commonly reach their flood control maximum storage by December and are required to release water to maintain flood control space for spring runoff. In these cases, conjunctive use could be coordinated with reservoir reoperation to store the excess water downstream of the reservoir.

The potential for shifting August through March flows to April through July was evaluated for the San Joaquin Basin. The range would probably be from 170 TAF/yr during critically dry years to almost 700 TAF/yr during wet years. The average for the 1972-87 period over which this analysis was performed was 490 TAF/yr. Based on a percolation rate of one-third foot/day (from Kern Water Bank estimates), a spreading basin area of about 20,000 to 30,000 acres would be required, depending on whether the spreading basins are operated throughout the year on unused land or whether they are operated only during the nonirrigation season on existing farmland. Suitable sites for conjunctive use could probably be located in both the San Joaquin and Sacramento basins and in export areas.

The cost of conjunctive use in the San Joaquin Basin depends, to a great extent, on whether the operation is planned to be year-round on land purchased for spreading basins, or whether it is to be operated only during the nonirrigation season on farmland leased for spreading purposes. In either case, the cost estimate of $60/AF for the Kern Water Bank probably represents a good upper estimate of the costs of conjunctive use (DWR, 1986). The costs in the San Joaquin Basin, however, would probably be somewhat less than the Kern Water Bank due to two advantages of the San Joaquin Basin location: (1) more extensive existing water distribution systems, and (2) shallower depth to ground water. The cost of reservoir reoperation, probably about $15/AF, would primarily be the lost power revenue created by shifting the time of reservoir releases from August through March to April through July.

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7.0 WATER QUALITY OBJECTIVES

7.1 Introduction

Chapter 5 identifies the optimal levels of protection for the beneficial uses of Bay-Delta waters. A review of these conflicting needs indicates that the watershed of the Bay-Delta Estuary does not possess enough water to satisfy all these demands except possibly in the wettest of years. Therefore, each of these demands must be reevaluated in light of the reasonableness to satisfy them. The concept of the California water ethic was presented in Chapter 6 to establish some ground rules to assess the reasonableness of water use. Chapter 6 also evaluates the reasonable needs of Bay-Delta water supplies for areas upstream and downstream of the Bay-Delta Estuary. Chapter 7 will present the information used to evaluate the reasonableness of instream flow and salinity objectives to protect the beneficial uses of Estuary water.

This chapter begins with an evaluation of each beneficial use and alternative levels of protection for each use. These alternatives were evaluated in light of the water ethic principles discussed in Chapter 6. The pertinent principles for this discussion are:

- Municipal and industrial water users should receive salinity protection of at least the secondary public health standard of 250 mg/l chloride.
- Delta agricultural users should receive water quality that fully protects their needs assuming that best management practices are being employed, to the extent that such quality was available under unimpaired conditions with present day channel configurations (see Cal. Const., Art X, Sec. 2).
- Aquatic life in the Estuary should receive salinity and flows at an appropriate historic level. The appropriate historic level is established during the balancing process as subsequently explained. (See Water Code Section 1243; Public Resources Code Section 21000, et seq.; State Board Resolution 68-16).

Once the alternative levels of protection for each beneficial use are determined, they are assembled into logical sets of alternative water quality objectives. Six alternative sets of objectives were developed and evaluated. The effects of each of these six sets of alternative water quality objectives on beneficial uses in the Estuary and the water supply and use community were assessed. Through the careful weighing of these effects a set of recommended water quality objectives is proposed.

7.2 Alternative Levels of Protection for Each Beneficial Use

This section presents the analysis of reasonable alternative levels of protection for each beneficial use in the Bay-Delta Estuary consistent with the water ethic (see Chapter 6).

7.2.1 Municipal and Industrial

As presented in Chapter 5, there are five major municipal and industrial water supply intakes in the Estuary. Water customers demand the best possible water quality they can obtain. However, what users would like to have and what is reasonable, when all competing demands are considered, are often very different.

Two major water quality issues were brought out during the Phase I hearing. The first deals with trihalomethanes and the second involves salinity.

7.2.1.1 Trihalomethanes

Trihalomethanes are known carcinogens that can be produced during some water treatment processes, such as chlorination, designed to purify water for drinking. Trihalomethanes are generated in higher concentrations when the source water contains high concentrations of two important precursors, organic compounds and halides, e.g., chlorides and bromides such as those found in sea water. Since the Delta contains significant amounts of organic soil formed when it was an inland marsh and since it is located near the ocean, the Delta contains ample quantities of both chlorides, bromides and organic materials.

Some hearing participants suggested that fresh water be used to flush chlorides and bromides away from municipal intakes. Others suggested that extensive agricultural drainage systems be installed to remove this unquantified portion of organic loading to locations far downstream of municipal intakes. Both of these proposals could reduce trihalomethane precursors. However, they will not guarantee that concerns over the formation of trihalomethanes will be resolved. Even water quality in the Sacramento River at the City of Sacramento will not attain the trihalomethane standard if it is lowered (from 100 mg/l to 50 mg/l or less as EPA is considering) and the water is treated through routine chlorination.

Based on the evidence presented during the Phase I of the hearing, the trihalomethane issue in the Delta is considered a water supply treatment issue. The establishment of reasonable water quality objectives in the Estuary will not resolve the issues surrounding the formation of trihalomethanes in the water supply treatment process. Technology curently exists for water purveyors who obtain water from the Estuary to treat their supplies (as does the Contra Costa Water District) without forming excessive trihalomethanes and other compounds.

7.2.1.2 Salinity

- Chlorides

Salinity in drinking water can cause two types of concerns: taste and increased industrial processing costs due to high chloride levels.

High chloride levels can impart an unpleasant taste to drinking water. All else being equal, most users would rather drink low salinity water than water with a slight salty taste. The Department of Health Services has recognized this and adopted a secondary drinking water standard of 250 mg/l for chlorides. This level of chlorides protects the public interest.

Groups of water users have expended funds to build projects to achieve water quality better than 250 mg/l chloride. These projects include diverting higher up on a water course, or the construction of storage facilities to store low saline water during the winter for dilution of saltier summer supplies. Such actions are local issues and are appropriate provided statewide interests are not unreasonably impaired.

In the 1978 Delta Plan, the Board developed water quality objectives for the Contra Costa Canal intake at Rock Slough for chloride levels of 150 mg/l for various times during the year, depending on the wetness of that year. This objective was intended to protect the historical water supply of two paper manufacturing industries.

Other industrial uses are reasonably protected at the 250 mg/l chloride objective. Some industries use special treatment processes to remove either salinity or other constituents that can affect their operations. However, such special processing is a matter for these industries to resolve with their water purveyor and not a matter of overriding statewide public interest. Therefore, the 150 mg/l chloride objective should be discontinued. The 250 mg/l chloride objective provides reasonable protection to municipal and industrial uses. It is used in each set of objectives presented in the next section to protect municipal and industrial beneficial uses.

- Sodium

A relatively new issue related to salinity involves the consumption of sodium. Diets high in sodium, especially for people with a history of heart problems, can contribute to heart problems. Some participants in the hearing suggested a sodium objective be adopted to protect against such concerns. Others were concerned about the effects of high sodium water on dialysis machines. The information presented to the Board shows that sodium contained in drinking water represents a very small portion of normal daily sodium intake. People on very restricted sodium diets should consult their physician and dietitian to revise their diet based on their local water supply or in very rare cases consider bottled water low in sodium. Concerns with dialysis machine operations can be resolved by switching to other lower saline sources when sodium levels become a problem.

Concerns raised, related to sodium, do not warrant the adoption of specific sodium water quality objectives. This concern can be reasonably resolved by achieving the 250 mg/l chloride objective in Delta waters or special actions by health professionals as they become more knowledgeable of the sodium levels in their water supply.

7.2.2 Agriculture

7.2.2.1 Western and Interior Delta Agriculture

Chapters 4 and 5 review the testimony presented during Phase I on the water quality needs of the mostly organic soils found in the western and interior Delta. Following the adoption of the 1978 Delta Plan, studies were designed to resolve concerns expressed by the Board on the lack of specific information about the needs of salt sensitive crops when grown using subirrigation on the Delta's rich organic soils. The results of this study show that corn (the most salt sensitive significant crop grown in the western and interior Delta) can be grown with no yield decrement in salinities that do not exceed 1.5 mmhos/cm EC during the growing season (April 1 through August 15). This assumes periodic leaching with water quality at least as good as 1.7 mmhos/cm EC during some winters.

One of the principles in the water ethic is that agricultural users should receive water quality to protect their reasonable needs as limited by the availability of this quality water under unimpaired water runoff conditions. Achievement of this level of water quality would protect this beneficial use to the extent it would have been protected if man's activities to modify river flows had not taken place. The level of salinities that would occur in these western Delta areas under these unimpaired water runoff conditions were reviewed. This review indicated that water qualities as good as 1.5 mmhos/cm EC occurred throughout the growing season except in the latter part of critically dry years. In order to reflect the water quality available under unimpaired conditions in critical years, values should be allowed to rise from 1.5 to 3.0 mmhos/cm EC beginning August 1 and remain no higher than that level through the end of the growing season (August 15). These salinity levels are appropriate to protect agriculture in the western and interior Delta. These proposed objectives along with leaching water requirements are used in each alternative set of objectives presented in the next section as the water quality objectives to protect western and interior Delta agriculture beneficial uses.

7.2.2.2 Southern Delta Agriculture

Water quality in the San Joaquin River as it enters the southern Delta near Vernalis has degraded in the last 50 years. Average salt concentrations have more than doubled during this period. This degradation is caused by a combination of two factors: increased salt loadings from upstream agricultural drainage and decreased flows, caused by upstream water development, that helped dilute high saline water.

In the 1978 Delta Plan, the Board adopted water quality objectives to protect southern Delta agriculture on the mineral soils in this area. These objectives differ from those set for the predominately organic soils found in the western and interior Delta. The Board delayed implementation of these objectives to allow interested parties time to negotiate a long-term agreement to achieve these objectives. While some progress has been made in this area, it has been too slow and decisive action is needed.

The 1978 Delta Plan objectives for the southern Delta have been reviewed in light of the testimony presented in the Phase I of the hearing. Beans, a salt sensitive crop, are grown in significant quantities in the southern Delta. With best management practices by the southern Delta farmers, the current Delta Plan objectives protect this and other crops grown during the primary irrigation season (April through August) and other less salt sensitive crops, e.g., alfalfa and sugar beets, grown during the remainder of the year.

However, two aspects of these objectives need review. First, the mean monthly monitoring frequency contained in the Delta Plan is too long, as explained by the South Delta Water Agency, and should be reduced to a 14-day running average consistent with western and interior Delta objectives. Second, the objectives need to be tested to see if they would be attained during unimpaired flow conditions. This analysis indicates that the 0.7 mmhos/cm EC set forth in the objectives during the primary irrigation season of April through August generally would be available under unimpaired runoff conditions during all water year types. This analysis used water quality to flow relationships for the San Joaquin River that existed prior to 1945 (SDWA Exhibit 123 and New Melones Hearing USBR Exhibit 43).

During the secondary irrigation season, September through March, the 1.0 mmhos/cm EC provides water quality sufficient to protect crops irrigated during this time of year, e.g., alfalfa, pasture and sugar beets. This quality protects the seedling stages of these crops and is sufficient for winter leaching. Also, analysis shows that 1.0 mmhos/cm EC generally would be achieved during these months under unimpaired runoff conditions. These objectives are used for each set of water quality objectives and are shown in detail in the recommended objectives presented later in this chapter.

7.2.2.3 Export Areas

Substantial quantities of water are exported from the Delta for use in areas outside the Delta. The locations of these diversions are the same as the municipal and industrial diversions discussed previously. The water quality objectives that protect drinking water supplies at these locations (250 mg/l chloride) also reasonably protect agricultural uses of water for irrigation of the crops grown in the Central Valley and southern California.

The SWP contractors have water supply contracts that have a goal of delivering water with a quality of 110 mg/l chloride. This delivered quality is achieved by blending good quality water diverted in the winter with the more saline water diverted during the summer. At times the SWP also allocates a portion of its water supply to improve water quality to approximately 100 mg/l chloride at Clifton Court. This "carriage water" requirement increases as exports increase during the summer. As much as one-third more water beyond that needed for export may be required to repulse sea water in some months. The water supply impact analysis discussed in Section 7.3.1 assumes a maximum 250 mg/l chloride level at SWP water supply intakes. The users may choose to allocate a portion of their limited supply to further improve the quality of exported water.

7.2.3 Delta Fisheries and Estuarine Habitat

There are two water project related effects on Delta fisheries. They are (1) River inflow and Delta outflow, which moves Delta fish downstream into the more biologically productive Suisun and San Pablo bays and away from the effects of the state and federal export pumps and other Delta diversions and (2) exports, which physically entrain fish, lead to increased predation, move fish into less biologically productive areas and generally decrease productivity of the Delta environment by increasing cross Delta flows.

7.2.3.1 Chinook Salmon

- Flow

As discussed in Chapters 4 and 5, evidence was presented showing that April through June inflows to the Delta affect the quality and quantity of fishery habitat, smolt survival during outmigration, and subsequent escapement of fall run Chinook salmon 2 1/2 years later. The Sacramento Basin produces up to 90 percent of Central Valley salmon. Since counts were first made in the 1950's, the natural salmon population has declined by an estimated 75 percent. In the last 20 years, although the natural population has continued to decline, an increase in hatchery produced fish has stabilized the total Sacramento Basin population (see Figure 4.5.1.2-4). This is achieved by releasing many hatchery reared fish downstream of the Delta, thus avoiding the poor environmental conditions in the Delta.

San Joaquin River salmon populations fluctuate markedly, partly in response to spring flow conditions, and range from less than one to 26 percent of the Central Valley salmon population. There are three other races of Chinook salmon in the Sacramento River, two of which have also experienced population declines since the late 1960's. One race was eliminated from the San Joaquin Basin by the construction of Friant Dam. Sufficient evidence was presented in the Phase I Hearing to determine Delta protections needed for the fall run salmon but not the other races of Chinook salmon on the San Joaquin or Sacramento River systems.

Available data indicate that river flows in April through June up to a certain limit (22,500 cfs on the Sacramento River at

Rio Vista and 20,000 cfs on the San Joaquin River at Vernalis) provide benefits to salmon migration. These benefits are linearly related to increasing Sacramento River flows. Limited data from the San Joaquin indicate a similar relationship.

In addition to the optimal level and the no action level, three alternative levels of salmon protection with different Delta inflow regimes were developed. One of the principles developed under the water ethic states that aquatic resources should receive protection equivalent to that received over some recent historical period. The alternatives presented below represent a range of historical periods and are evaluated later in this chapter to determine a reasonable level of protection for Chinook salmon. The alternatives are:

(1) Optimal protection - April through June average monthly flows of 22,500 cfs at Rio Vista on the Sacramento River and 20,000 cfs at Vernalis on the San Joaquin River.

(2) Average April through June flows in the Delta generally reflecting those prior to physical modifications to enhance water deliveries south of the Delta (1930-1952). The year 1930 represents the earliest year of flow data available for key interior Delta locations. Some modification to the actual historical value for each year type was made by decreasing wet year flows and increasing drier year flows as has been experienced in recent years.

(3) Average April through June flows for the entire period for which reliable data exist at key interior Delta locations (1930-1987).

(4) Average April through June flows which have occurred under the present physical configuration of the Delta (1953-1987).

(5) Flows as set forth in the 1978 Delta Plan for salmon.

The average April through June flows for the above alternatives are shown in Table 7.2.3.1-1. They are shown as averages for each month and are separated by water year type. These monthly average flows excluded flows that were above 22,500 on the Sacramento River at Rio Vista and 20,000 on the San Joaquin at Vernalis. Flows above these values were not included because there is no clear evidence that flows in excess of these amounts benefit salmon migration through the Delta. Figure 7.2.3.1-1 summarizes in graphic form how average April through June flows important to salmon have changed over various time periods and are expected to change in the future.

The USFWS and the DFG recommended the establishment of average Delta inflows generally reflective of conditions prior to 1950. The SWP contractors and others recommended maintenance of the 1978 Delta Plan fishery flows into the

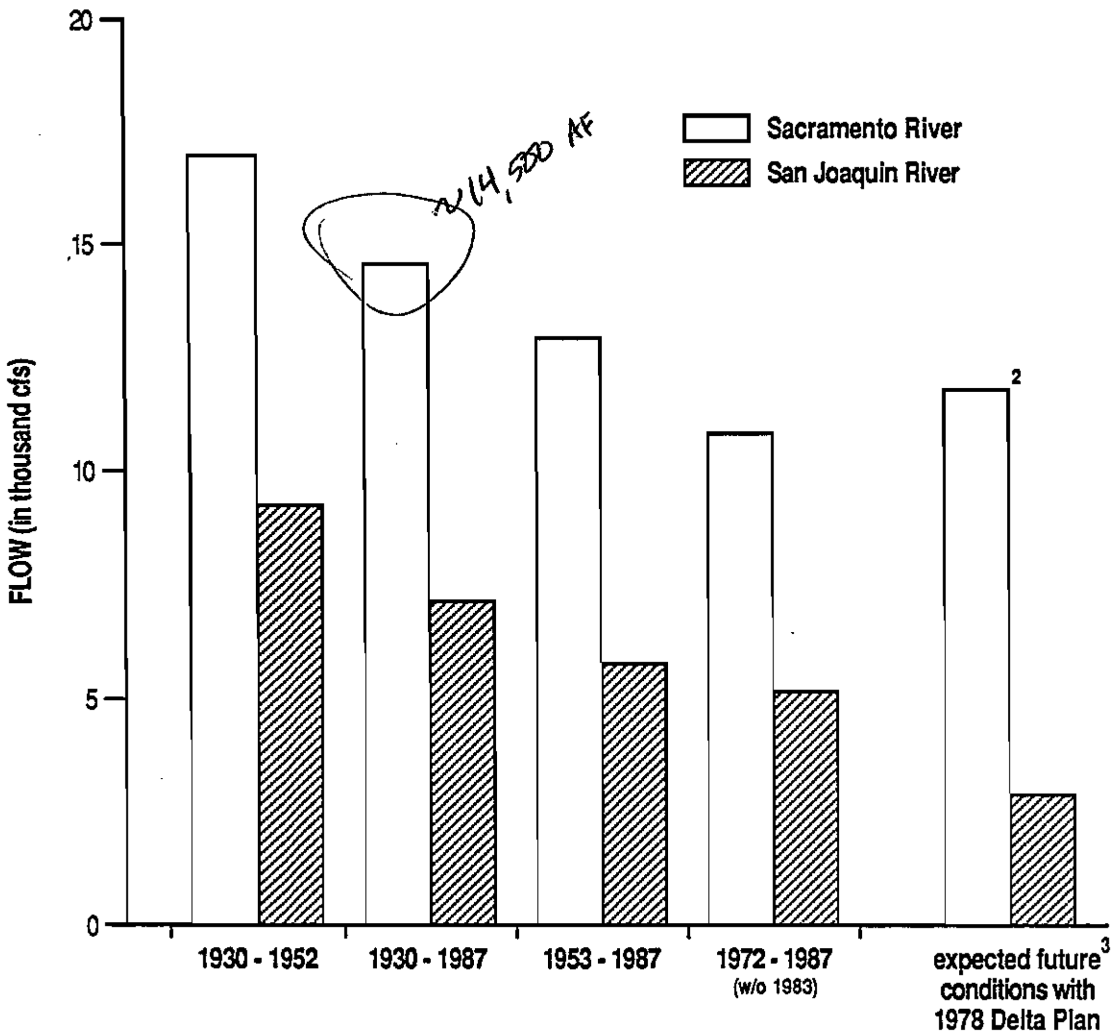
TABLE 7.2.3.1-1

ALTERNATIVE LEVELS OF PROTECTION
FOR SACRAMENTO AND SAN JOAQUIN SALMON OUTMIGRATION

Beneficial Use Protected and Location	Parameter	Description	Year Type	Values: Dates/ CFS 4/1-30	Cross Channel Status	Dates/ CFS 5/1-31	Cross Channel Status	Subnormal Snowmelt	Dates/ CFS 6/1-30	Cross Channel Status	Subnormal Snowmelt
FISH HABITAT											
o Sacramento Salmon Rio Vista 1930-1952	Flow at Rio Vista and Cross-Channel status. (see Footnote)	Flow pattern estimated to provide protection found from 1930-52, plus Cross-Channel closures to prevent smolt diversion	Wet	22,500	C	22,500	C		21,500	C	
			Ab. Normal	22,500	C	22,500	C		12,000	C	
			Bl. Normal	20,500	C	21,000	C		8,000	C	
			Dry	20,500	C	16,000	C		9,500	C	
			Critical	11,500	C	4,500	C		1,000	C	
o San Joaquin River Salmon Vernalis 1930-1952	Vernalis Flow	Flow pattern estimated to provide protection found from 1930-52	Wet	17,000		19,000			19,000		
			Ab. Normal	12,000		14,500			11,500		
			Bl. Normal	2,500		4,000			4,500		
			Dry	1,500		2,000			1,000		
			Critical	1,500		1,500			1,000		
o Sacramento Salmon Rio Vista 1930-1987	Flow at Rio Vista and Cross-Channel status .	Flow pattern estimated to provide protection found from 1930-87	Wet	22,500	C	22,000	C		17,000	C	
			Ab. Normal	22,500	C	21,000	C		7,000	C	
			Bl. Normal	16,500	C	14,500	C		7,500	C	
			Dry	12,500	C	10,000	C		5,000	C	
			Critical	8,500	C	5,000	C		4,000	C	
o San Joaquin River Salmon Vernalis 1930-1987	Vernalis Flow	Flow pattern estimated to provide protection found from 1930-87	Wet	15,000		15,500			13,500		
			Ab. Normal	9,000		11,000			9,000		
			Bl. Normal	2,500		3,500			3,500		
			Dry	1,500		1,500			1,000		
			Critical	1,500		1,000			1,000		
o Sacramento Salmon Rio Vista 1953-1987	Flow at Rio Vista and Cross-Channel status.	Flow pattern estimated to provide protection comparable to that from 1953 to 1987, plus Cross-Channel closures to prevent some smolt diversion	Wet	22,500	C	22,000	C		17,000	C	
			Ab. Normal	22,500	C	17,000	C		7,000	C1	
			Bl. Normal	14,000	C	11,500	C		7,500	C1	
			Dry	8,000	C	7,000	C1		5,000	C1	
			Critical	7,000	C	5,000	C1		4,000	O	
o San Joaquin River Salmon Vernalis 1953-1987	Vernalis Flow	Flow pattern estimated to provide protection comparable to that from 1953-87 @ Vernalis (During buildup of SWP & CVP)	Wet	14,000		13,500			11,000		
			Ab. Normal	5,000		5,000			5,000		
			Bl. Normal	2,500		3,500			3,000		
			Dry	1,500		1,500			1,000		
			Critical	1,000		1,000			1,000		
o Sacramento Salmon Rio Vista Delta Plan	Delta Outflow	Delta Plan had no specific protection for Salmon smolts but other standards provided protection as indicated	Wet	10,000	O	13,350	C	8,000	14,000	C	7,600
			Ab. Normal	7,600	O	12,950	C	7,600	10,700	O	7,600
			Bl. Normal	7,600	O	10,800	C	7,600	9,500	O	6,850
			Dry	7,600	O	7,600	O		6,150	O	
			Critical	6,700	O	4,350	O		3,900	O	
o San Joaquin River Salmon Vernalis Delta Plan	Vernalis Flow	Delta Plan had no specific protection for Salmon smolts									

Footnote: C = closed, C1 = closed, open weekends only, O = open

FIGURE 7.2.3.1-1 Average April-June flows[1] for selected historical periods providing different levels of protection for Salmon



[1] Average monthly flows calculated with a maximum Sacramento River flows at Rio Vista of 22,500 cfs and maximum San Joaquin River flows at Vernalis of 20,000 cfs because maximum salmon survival/production was shown by USFWS and DFG to occur at these flows. Therefore, it is assumed there is no additional benefit to fisheries at flows exceeding these values.

[2] The apparent increase in Sacramento River flows over the 1972 - 1987 period is due to the fact that the average April-July runoff for the 1922 - 1978 hydrology used to calculate the expected flows is 14% wetter than the 1972 - 1987 period for the Sacramento River Basin. Average unimpaired runoff for both time periods on the San Joaquin system are within 1% of each other.

[3] Expected future conditions with the 1978 Delta Plan are those shown in DWR's 1990 Level of Development operations study using 1922-78 hydrology (DWR, 30)

future. As can be seen from Figure 7.2.3.1-1, continuation of the existing flow objectives in the Delta Plan (which do not specifically protect salmon outmigration) will result in a relative decline in important salmon smolt flows on the San Joaquin River system when compared with flows experienced in the recent past. The apparent increase in Sacramento River flows under expected future conditions is due to the fact that the 1922-78 period used in this analysis is 14 percent wetter on the Sacramento system than the 1972-1987 period. The two hydrologic periods on the San Joaquin system, however, are essentially the same (less than one percent difference). Some hearing participants recommended that activities outside the Estuary be tried to resolve salmon survival concerns. Activities such as upstream habitat improvements might be successful on the Sacramento River system given the small expected decrease in spring flows under the no action alternative. However, it is unlikely that such actions would be successful on the San Joaquin River system with the decrease in April-June flows expected in the future.

Some parties suggested that additional fishery catch restrictions or other activities outside the scope of the Board's authority be pursued to address salmon concerns. While the option exists to take no action related to the further regulation of flows and exports, it is not reasonable to rely on "out of Estuary" measures to correct habitat concerns related to factors in the Estuary. To do so would be to have one segment of society mitigate for the effects not caused by their actions. Furthermore, fishery agencies testified that "out of Estuary" restrictions would have relatively little beneficial effect if smolts migrating through the Delta continued to experience poor conditions within the Delta.

Moderate flows are also needed for homing by adults during the upstream spawning migration from July-December. The 1978 Delta Plan contains minimum flow objectives for upstream salmon migration in the Sacramento River. These objectives were developed before the recent information on outmigrant smolts was known. In the absence of evidence to the contrary, these flows are assumed to be adequate and should be retained.

Currently there are no requirements for minimum upstream flows on the San Joaquin River for upstream salmon migration. Low dissolved oxygen at Stockton may also cause a blockage to upstream salmon passage. A 1969 agreement between DWR, USBR, and DFG provided for 1) installation of a temporary barrier across Old River when dissolved oxygen (DO) falls below 6 mg/l so that flows increase down the San Joaquin River, or 2) if that is not successful, increased flow releases. This objective should be incorporated in this Plan.

- Exports and Diversions

Salmon smolt migration through the Estuary is also affected directly by diversions and exports and indirectly by flow reversals caused by exports. Since 1967, export rates from the Estuary have increased over this same period while salmon populations have declined (see Figure 7.2.3.1-2). Alternatives to address these fishery impacts are discussed in the section below.

7.2.3.2 Striped Bass

- Outflow

Striped bass have undergone a decline in the numbers of young that survive their first summer. A gradual decline began soon after the start of operation of the SWP in 1967 and became precipitous in the late 1970's. This decline is shown on Figure 7.2.3.1-2. The exact cause for this decline is unknown. However, five causes have been postulated, of which four relate to water project operations and one relates to pollutants. The Board's Striped Bass Health Monitoring Program has indicated that the burdens of various pollutants in adult striped bass, and the percentage of egg resorption, have both improved in recent years. Yet the numbers of young striped bass, as measured by the striped bass index, continue to decline.

Outflows move the striped bass larvae (and young of American shad, salmon, etc.) out of the Delta and away from the influence of export pumps, diversions and power plants, and into the Suisun Bay nursery areas. A relationship of spring flow and exports to young bass populations in the summer was developed from data collected during the mid-1950's to the mid-1970's. However, in recent years, exports have increased beyond those for which this relationship was developed. Therefore, it is not surprising that this historic relationship no longer holds true. Higher outflows and reduced exports appear to be needed to help reverse this recent decline.

- Alternative Levels of Protection

New Delta outflow objectives for striped bass were recommended by DFG, USFWS and others. These agency recommendations are shown in Table 7.2.3.2-1. The dry water year following a dry or critical water year relaxation proposed by DFG has been deleted from that shown in Table 7.2.3.2-1 for the following reasons: (1) the year type definitions discussed previously now closely reflect April-July runoff conditions; (2) the year type definition already has a year after critical year relaxation built into it; and (3) recent project operations indicate that, while fishery standards are greatly relaxed in critical years, project operations are not modified commensurate to the fishery relaxation; operations, in fact, use the relaxation to

FIGURE 7.2.3.1-2

STRIPED BASS INDEX, SACRAMENTO/SAN JOAQUIN NATURAL SALMON POPULATION AND TOTAL DELTA EXPORTS

SBI: 1959 - 1988, EXCEPT 1966; POPULATION: SR 1953 - 1984, SJR 1953 - 1984; EXPORTS: AVERAGE APRIL - JULY EXPORTS, 1953 - 1987

(5 Year Running Average)

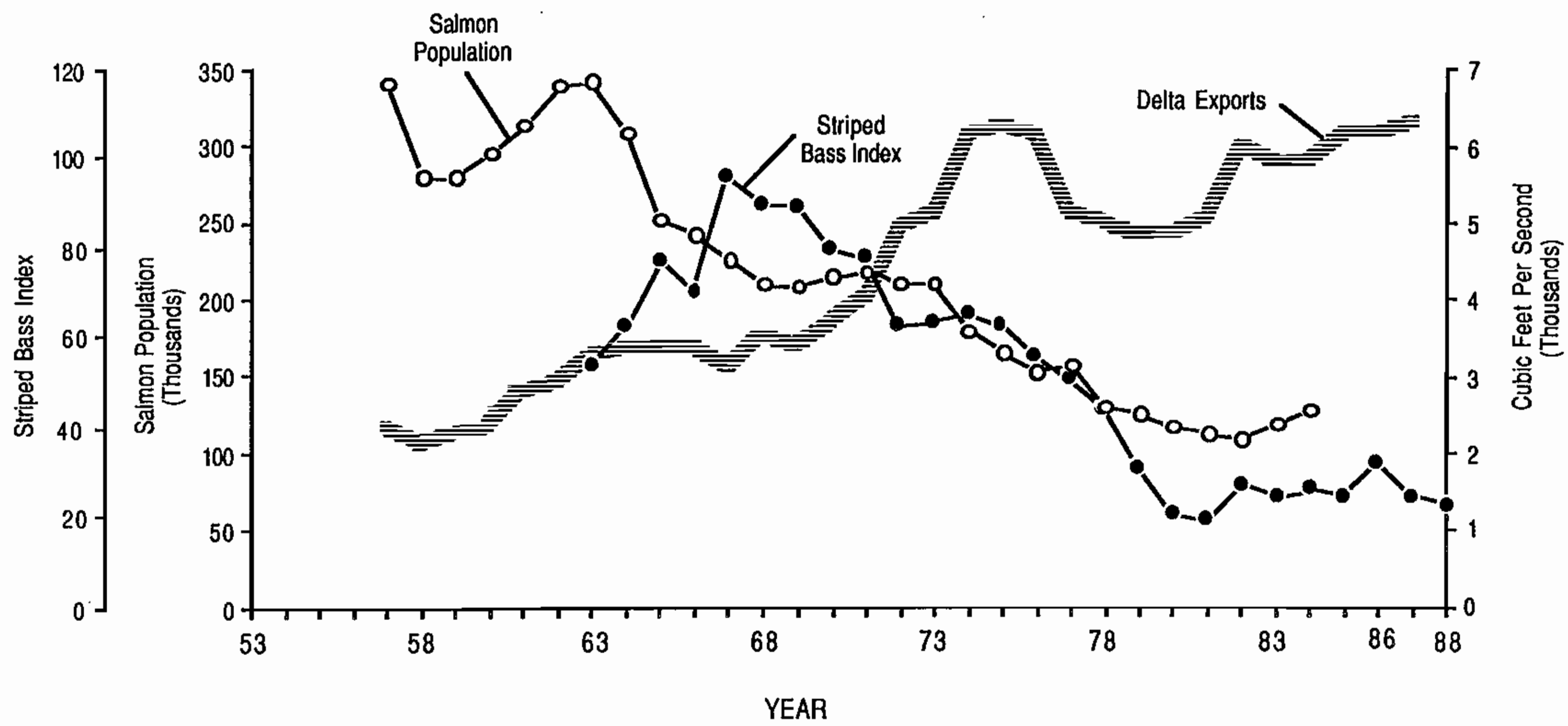


TABLE 7.2.3.2-1

ALTERNATIVE LEVELS OF PROTECTION
FOR DELTA FISHERIES (INCLUDING STRIPED BASS)
VIA DELTA OUTFLOW

Beneficial Use Protected and Method	Parameter	Description	Year Type	Values				
FISH HABITAT								
				4/1-30	5/1-31	6/1-30	7/1-15	7/16-31
o Delta Outflow Staff Recommendation	Mean Monthly Delta Outflow at Chipps Is.	Habitat quality to provide egg and larval transport through Delta and maintain suitable habitat for rearing in Suisun Bay.	Wet	32400	32400	32400	29000	29000
			Ab. Normal	26000	26000	20000	15000	15000
			Bl. Normal	22000	22000	16000	10000	NA
			Dry	12000	12000	12000	10000	NA
			Critical	9600	9600	9600	NA	NA
				4/1-30	5/1-31	6/1-10	6/11-17	6/18-7/31
o Delta Outflow DFG-USFWS Recommendation	Mean Monthly Delta Outflow at Chipps Is.	Habitat quality to provide egg and larval transport through Delta and maintain suitable habitat for rearing in Suisun Bay.	Wet	NA	30000	30000	20000	10000
			Ab. Normal	NA	25000	25000	17500	10000
			Bl. Normal	NA	22000	22000	16000	10000
			Dry	NA	12000	12000	10000	8000
			Critical	NA	3300	3300	3100	2900
				4/1-14	4/15-5/5	5/6-31	6/1-30	7/1-31
o Delta Outflow with limits from 1978 Delta Plan	Mean Monthly Delta Outflow at Chipps Is.	Habitat quality to provide egg and larval transport through Delta and maintain suitable habitat for rearing in Suisun Bay (includes EC at Antioch of 1.5 mmho/cm for spawning 4/15-5/5)	Wet	6700	7600	14000	14000	10000
			Ab. Normal	6700	7600	14000	10700	7700
			Bl. Normal	6700	7600	11400	9500	6500
			Dry	6700	7600	4300	3600	3200
			Critical	6700	7600	3300	3100	2900
			Dry & defic			3300	3100	2900

continue to meet full project demands. Therefore, such relaxation terms should be used only sparingly.

Upon review of the basic data presented on striped bass during the Phase I hearing, an alternative set of objectives has been proposed for consideration. This alternative set provides protection in April and increases critical year protection compared to DFG proposed levels. These values are shown in Table 7.2.3.2-1. Also shown in this Table are the 1978 Delta Plan flow objectives for striped bass.

- Export Flows

An integral factor affecting Delta fisheries is the exports from the CVP Tracy Pumping Plant and the SWP Banks Pumping Plant which can create flow reversals the lower San Joaquin, Old and Middle rivers. Appropriate limits on these large diversions are the subject of much debate. Fishery agencies and other interested parties recommended that, in the long term, improvement of the fisheries would result from positive downstream flows in Old and Middle rivers during the spring months. Such positive downstream flows result when San Joaquin River flows exceed exports and channel depletions in the southern Delta. Therefore, export rates that will achieve positive downstream flows must be matched month by month with the San Joaquin River inflows and channel depletions if the goal of positive downstream flows is to be achieved.

- Alternative Levels of Protection

Four alternative export water quality objectives have been developed for the April through July period. They are:

(1) Positive downstream flow in Old and Middle rivers by coordinating export levels with high San Joaquin River inflows resulting from the 1930-1952 flow objectives;

(2) Positive downstream flow in Old and Middle rivers by coordinating export levels with low San Joaquin River inflows resulting from 1953-1987 flow objectives;

(3) Average pre-SWP export conditions (1953-1967); and

(4) 1978 Delta Plan export limits.

All of these objectives are shown in Table 7.2.3.2-2. The first alternative evaluated the export rates that would allow positive downstream flows (about 500 cfs) in Old and Middle rivers in about 35 percent of the months assuming a San Joaquin River inflow generally equal to those that occurred during the period 1930-1952. The second alternative evaluated the export levels that were possible by using 1953-1987 San Joaquin River inflows, yet still maintaining approximately the same downstream flow pattern as in the first alternative.

TABLE 7.2.3.2-2

ALTERNATIVE LEVELS OF PROTECTION
FOR DELTA FISHERIES (INCLUDNG STRIPED BASS)
VIA EXPORT LIMITS

Beneficial Use Protected and Method	Parameter	Description	Year Type	Values in CFS			
FISH HABITAT							
				4/1-30	5/1-31	6/1-30	7/1-31
(1) Export Limits with Pre-1950 SJR inflows	Combined Exports by CVP and SWP	Export limits needed to help minimize loss of eggs, larval and young fish through export pumps and diversions by making flows positive (about 500 cfs) downstream in Old and Middle rivers.	Wet	7,000	7,000	6,000	7,000
			Ab. Normal	6,000	6,000	5,000	6,000
			Bl. Normal	5,000	5,000	4,000	6,500
			Dry	3,500	3,500	3,500	5,750
			Critical	3,500	3,500	3,500	NA
				4/1-30	5/1-31	6/1-30	7/1-31
(2) Export Limits with 1953-87 SJR Post-CVP inflows	Combined Exports by CVP and SWP	Export limits needed to help minimize loss of eggs, larval and young fish through export pumps and diversions by making flows positive (about 500 cfs) downstream in Old and Middle rivers.	Wet	10,000	8,000	6,000	4,000
			Ab. Normal	2,000	2,000	1,000	1,000
			Bl. Normal	1,000	1,000	1,000	1,000
			Dry	1,000	1,000	1,000	1,000
			Critical	1,000	1,000	1,000	NA
				4/1-30	5/1-31	6/1-30	7/1-15
(3) Export Limits with 1953-67 Pre-SWP Avg. exports	Combined Exports by CVP and SWP	Exports under recent historic conditions which restricted loss of egg and larval fish to pumps and diversions, flow in Old and Middle rivers generally downstream.	Wet	10,000	8,000	6,000	3,300
			Ab. Normal	2,000	2,900	3,700	4,200
			Bl. Normal	2,000	2,000	2,900	3,300
			Dry	3,000	3,300	4,000	4,600
			Critical	2,800	2,800	3,000	4,300
				4/1-30	5/1-31	6/1-30	7/1-31
(4) Export Limits Delta Plan	Combined Exports by CVP and SWP	Exports under Delta Plan conditions intended to reduce loss of egg and larval fish to pumps and diversions, no consideration for flow direction in San Joaquin, Old, or Middle rivers.	All	NA	6,000	6,000	9,200

3rd alternative pre-SWP export conditions 1953-67

The third alternative addresses the return to export conditions as they existed on the average after the start of substantial exports by the CVP and operation of the Delta Cross Channel gates (1953) but prior to the SWP operation in 1967. The export rates during April-July for the various water year types (based on the new San Joaquin River Basin definition) during this period were averaged to obtain these values. Exports were adjusted to be higher in wet years than those actually observed during the 1953-1967 period. Positive downstream flows in Old and Middle rivers would result with this alternative's high San Joaquin River inflows even at the elevated export rates.

During 1953-1967, exports were much lower than they are at present. Old and Middle river flows were not always positive, but the Delta fishery was less affected by the effects of exports than they are today. As discussed previously, of the five hypothesized causes for the recent striped bass decline, four relate to project operations. Returning to export rates reflective of a time when Delta fisheries (especially striped bass) were doing much better than they are today is no guarantee that the declines in these populations will be reversed. However, it does provide for improving spring Delta conditions which presumably will benefit the fishery. This alternative is a step toward achieving the fishery agencies' desired goal of positive downstream flow by reducing the magnitude of reverse flows. It is anticipated that the proposed conditions will also enhance overall salmon smolt survival through increased streamflow and reduced entrainment.

The fourth alternative would retain current export limitations for May, June and July contained in the 1978 Delta Plan, with no specific export limitations for April.

7.2.3.3 Other Beneficial Uses

- American Shad

As noted in Chapter 5, American shad have been impacted by the present Plan standards. The data presented by DFG do not provide an accurate picture of what these impacts are. In addition, much of the information developed on shad resulted as a by product of investigations of other species, rather than a detailed study of the particular needs of shad. In any case, DFG did not propose any specific objectives for shad, just as they did not in the 1978 Plan. Their belief, then as now, is that the striped bass objectives they proposed will benefit shad as well.

This concept of collateral protection for shad seems to be appropriate for the present Plan as well. An examination of the optimal needs for shad in Section 5.3.6 shows that, particularly during the spring, shad are quite similar to striped bass, in terms of the need for adequate flows, reduced translocation out of the Sacramento River into the central

Delta, and reduced entrainment by diversions and exports. The flows, export limitations and Delta Cross Channel gate operations discussed for salmon and striped bass should provide shad substantial increases in protection compared to the 1978 Plan.

The major difference between the shad and striped bass is that some young shad remain in the Delta or in tributary streams into the summer and fall, while the young striped bass tend to be largely out of the Delta by the end of July. These late summer and fall outmigrating shad will not receive specific protection under the proposed Plan. The proportion of the population which are late outmigrants is not known, but it is assumed that increased protection for striped bass provided in the April-July period will accomplish three things: 1) provide better migration and spawning habitat for adult shad; 2) provide increased protection for the earlier migrants; and 3) perhaps increase the proportion of early migrants because of the increasd flows in tributary streams during the April-July period to meet Delta inflow and outflow requirements. Better documentation of the population dynamics and needs of American shad need to be provided before definitive objectives can be considered for that species. As noted, the non-1978 Delta Plan levels of protection presented for striped bass should provide additional protection for shad, compared to present conditions.

- Migratory Fish Food Chains

The Phase I of the hearing included considerable discussion of the food chains in the Bay and Delta, particularly the food requirements of young outmigrating striped bass and shad. Limited information was presented on the requirements of salmon smolts. All three species begin feeding on very small invertebrates, such as copepods (and small insects in the case of salmon and shad), and then progress to larger invertebrate species, particularly Neomysis. The data presented indicate that the food chain of the Estuary, particularly the Delta, is in a very dynamic state at present. Delta phytoplankton blooms, presumed to be a major component of the base of the food chain, have been dominated by the chain diatom Melosira in recent years. The value of this species as food for copepods and Neomysis is unclear. In addition, the traditionally dominant copepod Eurytemora, a preferred food source for young striped bass, has been at least partially replaced by the introduced copepod, Sinocalanus. The recent appearances of the clam Potamocorbula amurensis, and the benthic amphipod Lagunogammarus, both recently introduced and rapidly expanding in range and numbers, further complicate our limited understanding of the food chain dynamics of young striped bass and shad. Attempting to set objectives in such a changing environment is not possible at present.

In general, the proposed increased spring flows and reduced exports may result in a Delta and Suisun Bay habitat more conducive to the propagation of those species which have been beneficial to species in food chains of young anadromous fish in the past, since the habitat will approximate those earlier conditions more closely. However, there is no guarantee that this will occur. In any case, the understanding of the dynamics and interactions of the food chains in the Estuary must be greatly increased before proposed objectives for protection of the food chains can be considered. Indeed, there has not been demonstrated at present solid evidence that the changes in the food chains are having a deleterious effect on young striped bass, salmon, shad, or other Estuary species. Considerable additional effort in this area is warranted.

- Striped Bass Migration Up the San Joaquin River

As discussed in Chapter 5, striped bass generally do not migrate upstream into water with an electrical conductivity (EC) in excess of about 0.550 mmhos/cm, and appear to prefer spawning in water fresher than about 0.300 mmhos/cm. The Delta Plan objectives call for a maximum of 0.550 mmhos/cm at Prisoners Point for the period April 1 to May 5. While this objective may still impose a migration limit on striped bass, the other proposed objectives may somewhat compensate for this limitation. Increased outflows and reduced exports during the April-July period should result in greater outmigration of larvae produced in the San Joaquin River spawning area than at present, with presumably greater survival. In addition, increased flows in the San Joaquin River in wet and above normal years, combined with the reduced exports, may result in water quality better than that provided by the proposed objective. This may result in removal of, or at least a reduction in, this upstream barrier in wetter years. Additional monitoring of salinity in the mainstem San Joaquin, combined with better sampling for striped bass eggs and larvae in the eastern Delta, will provide additional information on the effects of the proposed objectives and the potential use of the San Joaquin River by striped bass in wetter year types. Available data are not adequate to attempt to propose a lower EC objective in the San Joaquin River.

- Races of Chinook Salmon Other Than Fall Run

Very little information is available on the other three races of Chinook salmon using the Estuary. What was presented in the Phase I of the hearing was not sufficient to identify flow or water quality needs, nor to develop water quality objectives. Additional studies are needed to develop such information.

- Other Aquatic Resources

A variety of other aquatic resources considered in the Phase I of the hearing, including: phytoplankton and zooplankton in San Francisco Bay, Bay outflow and offshore habitat, freshwater and estuarine benthic organisms, bay fish, Delta resident and other anadromous fish, pollutant flushing flows, upstream uses, export fishery habitat, export recreation, and Estuary recreation. After due consideration, no specific flow or salinity objectives is proposed for any of these aquatic resources. In most cases, the absence of specific objectives is due to lack of sufficient information upon which to base objectives, or because the aquatic resources are already protected under another objective. For example, no specific objectives are proposed for export fishery habitat or export recreation because the Municipal and Industrial objectives discussed previously for export water provides adequate protection for these aquatic resources as well. The specific reasons for the absence of proposed objectives for these resources is discussed in Chapter 4.

7.2.3.4 Suisun Marsh

- Managed Wetlands

The Suisun Marsh consists of about 50,000 acres of managed wetlands and 7,000 acres of tidal marsh. DFG, Suisun Resource Conservation District, DWR and USBR have entered into an agreement to protect these managed wetlands and mitigate for the loss of about 900 acres of managed wetland and tidal marsh impacted by facility construction and reduced outflows. This agreement allows water quality relaxation beyond the water quality objectives contained in the 1978 Delta Plan, Water Right Decision 1485 and State Board Order of December 5, 1985. The only major difference between the objectives being considered and those in the agreement is in the determination of water year types. For consistency with the other objectives, compliance with these objectives will be determined by using the water year types set forth in Chapter 3. This includes the use of the 50th percentile forecast of future runoff conditions instead of the 20th percentile as set forth in the agreement.

- Tidal Marshes

One concern left unresolved in the testimony presented in Phase I is the protection of rare and endangered species that inhabit the tidal marsh in Suisun Bay and the Suisun Marsh areas outside the managed wetlands. The provision of flows specifically to protect these areas could result in an additional 600,000 acre-feet to be released on the average each year during dry periods. This amount is above and beyond that required under the alternatives discussed in the following section. The DFG, the agency responsible for the protection of rare and endangered species, is requested to provide the Board in Phase II with its recommendations on how rare and endangered species in the tidal marsh areas of Suisun Bay and Suisun Marsh should be protected via this Water Quality Control Plan.

7.2.3.5 San Francisco Bay

San Francisco Bay was discussed extensively during the Board's Phase I of the hearing. This information was addressed in detail in Chapters 4 and 5. The information presented did not provide an adequate connection between physical changes in the Bay due to inflows and the beneficial uses in the Bay. The evidence presented was judged not sufficient as a basis for water quality objectives. Further studies should be performed to address these concerns. The concerns regarding protection of San Francisco Bay should also be addressed during consideration of the water right permits of any large unconstructed water storage projects.

7.3 Development of Alternative Objectives

There are many possible alternative sets of water quality objectives that can be developed from the water quality and flow needs for Bay-Delta Estuary uses presented in the previous section. Six logical alternatives that span this range of needs have been selected. The alternatives and the level of protection provided each beneficial use are presented in Table 7.3-1.

This section discusses the global balancing of the various beneficial uses of Bay-Delta waters. This global process builds upon all the information presented thus far, especially the California water ethic, to produce a recommended set of water quality objectives that reasonably protect the beneficial uses of Bay-Delta Estuary waters.

In the balancing process, one must recognize that biological resources have declined and currently are not experiencing the same degree of protection as other beneficial uses. In light of the evidence submitted during the Phase I hearing, past attempts to protect biological resources in the Estuary have not achieved the level of protection sought. Declines in biological resources of the Estuary need to be taken into consideration in the current balancing process.

7.3.1 Effects on Water Availability

To develop balanced water quality objectives, assessment must be made of the impacts resulting from the objectives under consideration. This is done by determining the controlling flow and salinity objectives, i.e., those which require the most water to attain, for each alternative and comparing the water requirements against a base condition. Two base conditions were used to provide a range of impacts: (1) a 1990 level of development operations study which uses the water quality standards of the 1978 Delta Plan as a constraint and (2) the actual historical conditions that existed between 1972-1987, excluding the wettest year of record, 1983. (Excluding this year, the wettest of record that shows the average, makes the average San Joaquin River Basin April through July unimpaired flows for these two hydrologic periods almost identical.) The differences between the alternative and the base are then calculated for each month and summarized by water year type.

TABLE 7.3-1

ALTERNATIVE SETS OF WATER QUALITY OBJECTIVES

Alternatives	(1)	(2)	(3)	(4)	(5)	(6)
Description of key provisions	Optimal Level	High SJR Flows High Exports	Moderate SJR Flows Low Exports	Moderate SJR Flows Delta Plan Exports	Recommended Plan	No Action
Beneficial Use						
Municip. & Indust. (Footnote 1)	150 mg/l Chloride (Contra Costa Canal) 250 mg/l Chloride elsewhere	250 mg/l Chloride	250 mg/l Chloride	250 mg/l Chloride	250 mg/l Chloride	Delta Plan
West Delta Ag. (Footnote 2)	1.5 mmho/cm EC	1.5 mmho/cm EC 3.0 mmho/cm EC	1.5 mmho/cm EC 3.0 mmho/cm EC	1.5 mmho/cm EC 3.0 mmho/cm EC	1.5 mmho/cm EC 3.0 mmho/cm EC	Delta Plan
South Delta Ag. (Footnote 3)	Delta Plan	Delta Plan	Delta Plan	Delta Plan	Delta Plan	New Melones
Sacto. Salmon (Footnote 4)	22,500 cfs	1930-1952	1930-1987	1930-1987	1930-1987	Delta Plan
SJR Salmon (Footnote 4)	20,000 cfs	1930-1952	1953-1987	1953-1987	1953-1987	Delta Plan
Delta Fishery Outflow object. (Footnote 5)	Optimal Flows	Staff	Staff	DFG	DFG p.7-13	Delta Plan
Delta Fishery Export limit (Footnote 5)	No exports May-Nov	Pos. Dwnstream Flow High SJR	Pos. Dwnstream Flow Low SJR	Delta Plan Exports	1953-1967 exports	Delta Plan
Suisun Marsh (Footnote 6)	Optimal Salinities	4-Agency Agreement	4-Agency Agreement	Delta Plan	4-Agency Agreement	Delta Plan
San Francisco Bay (Footnote 7)	Further Study	Further Study	Further Study	Further Study	Further Study	

see pp. 7-7 & Table 7.2.3.1-1 p. 7-8

p. 7-16, 7-15 data table combined CVP & SWP.

Footnote 1: See Section 7.2.1 for further description.

Footnote 2: See Section 7.2.2.1 for further description.

Footnote 3: See Section 7.2.2.2 for further description.

Footnote 4: See Section 7.2.3.1 for further description.

Footnote 5: See Section 7.2.3.2 for further description.

Footnote 6: See Section 7.2.3.4 for further description.

Footnote 7: See Chapter 4 under San Francisco Bay for further description.

7.3.1.1 The 1990 Level of Development Operations Study

The Operations Study used is that which was presented as DWR Exhibit 30 during the Phase I of the hearing, except that a carriage water requirement to meet a 250 mg/l chloride objective was used. This study uses the 1978 Delta Plan and New Melones criteria for the southern Delta as the controlling Delta objectives. The operation study uses the hydrological runoff conditions experienced from 1922 through 1978.

There are certain peculiarities about this study that must be emphasized. First, the average annual exports are about 6.1 million acre-feet for the entire study, whereas the maximum export for any water year to date has been the 1985 level of approximately 5.5 million acre-feet. Apparently the 1990 operation study has a built-in expansion of exports of about 0.6 million acre-feet beyond that seen in any year since the CVP and SWP have been operating. Review of the data indicates that virtually all this increase occurs in the months of October-April. This factor is important when comparing the impacts of these studies to the reasonable consumptive needs discussed in Chapter 6.

DWR includes an export expansion factor in its study

Second, the operations study somewhat overstates DWR's 1987 estimates of current agricultural net use in the Sacramento and San Joaquin basins. This is important when comparing alternatives to present or expected future conditions. The 1990 operation has enough agricultural demand built into it to satisfy in-basin growth through the year 2010 and beyond.

Also, one must keep in mind that operations studies are estimates, not reality. They are, in effect, a set of common rules by which alternatives can be compared; they are not intended to reflect how projects will actually operate. The results here are presented only to compare alternatives.

The output of the 1990 operations study presented by DWR was used to perform the analysis of alternatives. By changing the controlling Delta inflow and outflow objectives or export limits and keeping all other aspects of the study the same, we can compare the increases, or decreases, in flow required each month for the alternative in question beyond that of the 1978 Delta Plan. Care must be taken when determining the flows required to meet the controlling objectives to evaluate controlling objectives separately for the San Joaquin River, Sacramento River, as well as Delta outflow. By carefully evaluating months with surpluses, one can determine if water is saved under the new alternative or is needed to satisfy the new objectives. The process is simple in concept but is complicated in practice. Only summaries of the results of these studies will be presented here.

7.3.1.2 The 1972-87 Historical Base

The second base from which water supply impacts of the various alternative plans are compared is the 1972-87 actual historical conditions. As stated previously, the year 1983 was not used in this analysis. During most of the 1972-87 period the 1978 Delta Plan was in effect. During the time prior to 1978, the objectives of the Delta Plan were generally met with extra flows in the Delta beyond water project needs. The base flows for each month in this period were compared with those needed to meet the flows of each of the alternatives based on year type. The historical base flows were obtained from the DWR DAYFLOW data set, except for Delta outflow which was estimated using DWR consumptive use planning values (SWRCB, 1, Q-4). The process of comparison used is the same as that discussed for the 1990 operations study.

7.3.1.3 Assumptions Used in the Evaluation of Alternatives

A schematic showing the Delta's hydrologic scheme used in the water supply impact analysis is illustrated in Figure 7.3.1.3-1. The following are the assumptions used to evaluate the water supply impacts of alternative water quality objectives. These assumptions apply to both the 1990 operations study and the 1972-1987 historical period:

(1) All of the Estuary water quality objective locations were assigned to the Sacramento River system April through July hydrologic classification, except the following locations, which were assigned to the San Joaquin River system April through July hydrologic classification:

- San Joaquin River near Vernalis
- San Joaquin River at Mossdale
- San Joaquin River at the former location of Brandt Br.
- Bifurcation of Old and Middle River
- Middle River at Howard Road Bridge
- Old River at Tracy Road Bridge
- Delta Mendota Canal at Tracy Pumping Plant
- Clifton Court Forebay Intake at West Canal

(2) The Delta flow and salinity conditions necessary to meet objectives can be achieved through control of flows, exports, or gate operations at the Delta "control points." If the control point flows, exports, or gate operations are adequate to meet the local controlling objective, the other (noncontrolling) objectives within local influence of the control points are assumed to be met. The Delta control points are as follows:

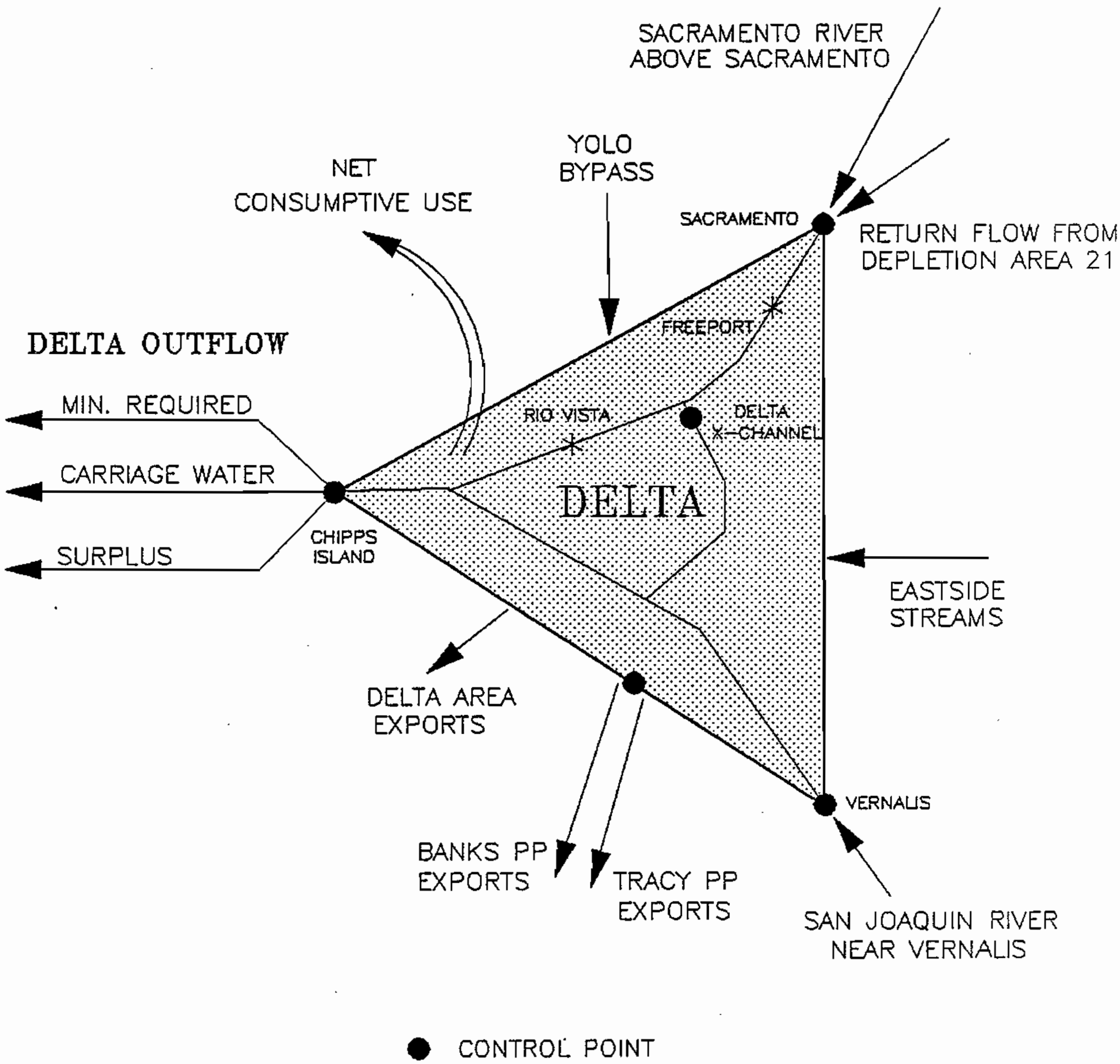
- Chipps Island
- San Joaquin River at Vernalis
- Sacramento River at Sacramento
- The Banks and Tracy Pumping Plants
- The Delta Cross-Channel near Walnut Grove

These control points are illustrated in Figure 7.3.1.3-1.

(3) The following basic equations apply for each of the hydrologic bases:

FIGURE 7.3.1.3-1

DELTA HYDROLOGIC SCHEME USED IN THE WATER SUPPLY IMPACT ANALYSIS



- The Delta outflow at Chipps Island, DO is defined as follows:

DO = DI - NETCU - AREADIV - B&TEXP (1)

where: DI = Delta inflow
NETCU = Net Delta consumptive use
AREADIV = Delta area diversions
B&TEXP = Banks and Tracy Pumping Plan exports

- The Delta inflow, DI, is defined as follows:

DI = SAC + YOLO + RF21 + SJR + EAST (2)

where: SAC = Sacramento River flow above Sacramento
YOLO = Yolo Bypass flow
RF21 = Return flow from depletion ares 21
SJR = San Joaquin River near Vernalis flow
EAST = East side tributaries flow (Mokelumne, Cosumnes and Calaveras rivers)

- The net consumptive use, NETCU, is defined as follows:

NETCU = CU - PREC (3)

where: CU = Delta consumptive use
PREC = Delta precipitation

- The Delta area diversions, AREADIV, is defined as follows:

AREADIV = VALL + NBA + CCC + MDIV (4)

where: VALL = City of Vallejo Diversions
NBA = North Bay Aqueduct Diversions
CCC = Contra Costa Canal Diversions
MDIV = Miscellaneous Delta Diversions (MDIV = 0 for the 1990 level-of-development runs)

- The Banks and Tracy Pumping Plants' exports, B&TEXP, is defined as follows:

B&TEXP = BANKS + TRACY (5)

where: BANKS = Total Banks Pumping Plant exports
TRACY = Tracy Pumping Plant exports

- The Delta outflow, DO, can also be divided into three components:

DO = MINRQDO + CWDO + SURPDO (6)

where: MINRQDO = Minimum required Delta outflow at Chipps Island
CWDO = Carriage water requirement at Chipps Island
SURPDO = Surplus Delta outflow at Chipps Island

- The carriage water requirements can be adequately estimated using the method described in DWR Exhibit 30 and the effective export, EFFEXP. The effective export, EFFEXP, is defined as follows:

  EFFEXP = BANKS + TRACY - SJR - EAST - CCC (7)
  (see note below)

  Note: the CCC "export" was not included in DWR's 1990 level of development (LOD) analysis, even though the carriage water curves were developed using the "export" of the CCC; consequently, the alternative carriage water was estimated without the CCC to conform with the 1990 LOD analysis.

- The carriage water requirements for the alternatives were estimated using DWR's Carriage Water Table 5, which assumes the following objectives:

  - 250 mg/l chlorides at Clifton Court and Rock Slough in all years. (DWR assumed a Rock Slough "operational" objective of 225 mg/l chloride to provide an operational buffer to the 250 mg/l chloride objective.)

  - 1.5 mmhos/cm EC at Jersey Point from April 1 through August 15 in all years except EC critical; 1.5 mmhos/cm EC at Jersey Point from April 1 through June 30 and 3.0 mmhos/cm EC from July 1 through August 15 in critical water years.

If 1978 Delta Plan surplus Delta outflows occur, then projected reductions in minimum flow requirements in the San Joaquin River near Vernalis and the Sacramento River at Sacramento are considered water that could not be saved; conversely, if 1978 Delta Plan surpluses are zero, then projected reductions in minimum flow requirements are considered "savable" and are applied to offset water requirements in other months.

To the extent that surplus Delta outflow under the 1978 Delta Plan is available, it is used to reduce the impacts of the alternatives. The surplus Delta outflow is adjusted depending on the change in 1) Chipps Island minimum flow requirements, 2) carriage water requirements, and 3) Banks and Tracy exports. If the 1978 Delta Plan surplus is zero, the alternative surplus is also zero.

The YOLO, RF21, EAST, NETCU, and AREADIV alternative flows remain the same as in the 1978 Delta Plan.

Additional water needed to meet Delta objectives, exports or consumptive uses is obtained from the Sacramento River Basin through the Sacramento River at Sacramento.

7.3.2 Evaluation of Alternative Plans

In order to evaluate these alternative sets of water quality objectives, a determination had to be made as to whether the flow requirements of each could be achieved through implementation of the new California water ethic discussed previously or whether existing uses would need to be curtailed. The present and future reasonable water needs are discussed in Chapter 6. Important findings for San Joaquin River Basin, Sacramento River Basin, and export areas are discussed below:

In the San Joaquin River Basin April-July flows to the Delta can be increased through (1) an aggressive conjunctive use of surface and ground waters, and (2) a reoperation of existing reservoirs in the Basin. An analysis for the San Joaquin River Basin indicated that the potential increase in April through July flows would probably range from about 0.17 MAF/yr during critically dry years to almost 0.7 MAF/yr during wet years. The average between 1972-87 was estimated at about 0.49 MAF/yr.

In the Sacramento River Basin about 0.550 MAF of water supply reserves exist through the year 2010 (DWR Bulletin 160-87). This reserve supply could be used to meet additional flow requirements in the Bay-Delta Estuary.

For the entire State reasonable consumptive agricultural needs will decrease by about 1.0 MAF/yr from 1985 to 2010. However, reasonable consumptive municipal and industrial needs will increase by about 1.1 MAF/yr from 1985 to 2010.

The south Coastal Area can provide adequate water supplies to expected populations through the year 2010 at existing Bay-Delta export levels provided (1) aggressive water conservation and reclamation measures are pursued, and (2) water saved through agricultural water conservation in the Coachella and Imperial and San Joaquin Valleys is made available to augment expected decreases in water supplies to the south Coastal Area from the Colorado River Basin area.

An analysis has been made of the CVP and SWP ability to make up in other months, exports which are foregone in April through July. If exports are curtailed during the April-July period, about 0.7 to 0.8 MAF on the average can be made up annually by utilizing currently available pumping capacity in other months (up to the Corps of Engineers pumping criteria) provided (1) water supplies from the Sacramento River system are available to satisfy this demand and its carriage water requirements, (2) reservoir storage south of the Delta is more fully utilized during the spring and summer, and (3) municipal water users utilize alternative water sources during the spring and early summer rather than relying on Delta Supplies. These users could then switch to Delta supplies during the late fall and winter. This analysis utilized 1985 export rates (the highest to date and 16 percent higher than the 1979-1987 average) and compared them to exports expected in the fall and winter months under the 1990 operations study. The 1990 operations study shows that its average April through July exports are slightly higher than those experienced in 1985. However, it also shows higher pumping in the late fall and winter than currently exists under actual 1985 conditions by about 0.7 MAF per year. The 1990 operations study uses existing project facilities. Decreases in export pumping in April-July of around 0.7 MAF can be recouped in other periods.

Each alternative set of water quality objectives and their water supply impacts are discussed below. Table 7.3.2-1 tabulates the impacts of the alternatives compared to the 1990 level of development and Table 7.3.2-2 does the same but uses the historic base.

7.3.2.1 Alternative 1

Alternative 1 provides optimal protection to each beneficial use in the Estuary. This alternative was developed to provide a starting point for the analysis of the various other alternatives presented below. Each beneficial use in the Estuary for which adequate data are available was evaluated to determine what would be the ideal set of conditions for protection of that beneficial use. Each use was evaluated without regard for any other competing or complementary beneficial use. The purpose of this exercise was to indicate where different beneficial uses had similar needs, so that a single or few objectives could provide a measure of protection for several beneficial uses. For example, reductions in export levels in the spring months may provide benefit to the young of shad, salmon, and striped bass, as well as for western Delta agriculture. This knowledge provided greater flexibility in developing the other alternatives. Table 7.3.2-1 illustrates that April-July exports would be eliminated and average Delta outflow would increase by more than 7 million acre-feet. Large segments of California's population would no longer receive a water supply. The impacts of this alternative clearly are not reasonable.

7.3.2.2 Alternative 2

Alternative 2 provides the next highest level of protection of the beneficial uses for the Bay-Delta Estuary. Salmon fisheries are protected at the historical levels that existed generally prior to the 1950's. Flows for striped bass are set at levels initially proposed by State Board staff. The DFG and the USFWS recommended achievement of positive downstream flow in Old and Middle rivers during April-July. This alternative constrains exports in April-July to provide these flows about 38 percent of the time. Since striped bass and salmon have declined in the recent past, actions may be needed to prevent further decline and allow a reasonable recovery. Alternative 2 attempts to do this by increasing San Joaquin River flows on the average by about 1.0 to 1.3 million acre-feet during April-July (see Tables 7.3.2-1 and 7.3.2-2). This is an increase of about 200 percent. As stated previously, average flows in the San Joaquin can be increased by only about 0.5 MAF with an aggressive conjunctive use and reservoir reoperation program. Increases beyond this 0.5

TABLE 7.3.2-1

APRIL - JULY WATER SUPPLY IMPACTS
OF ALTERNATIVE SETS OF WATER QUALITY OBJECTIVES

1990 LEVEL OF DEVELOPMENT OPERATIONS STUDY (DWR 30)
AS THE BASE

Base Conditions (Millions of Acre Feet)		Change in Base Flows Needed to Meet Alternative (Millions of Acre-Feet)					
		Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Alternative 6
Average (Based on 57-year record)							
Sacramento *	5.074	2.2	0.402	0.579	0.689	0.358	0.000
San Joaquin	0.636	3.3	1.308	0.528	0.528	0.528	0.000
Exports(-)	1.735	-1.7	-0.465	-1.074	0.000	-0.676	0.000
Other Flows **	-0.268	-0-	-0-	-0-	-0-	-0-	-0-
Total Delta Outflow	3.707	7.2	2.175	2.181	1.217	1.562	0.000
Wet (18 years out of 57-year record)***							
Sacramento	7.354	0.8	1.238	1.480	0.402	0.132	0.000
San Joaquin	1.102	3.0	1.525	0.979	0.979	0.979	0.000
Exports(-)	1.794	-1.7	-0.297	-0.539	0.000	-0.406	0.000
Other Flows	0.366	-0-	-0-	-0-	-0-	-0-	-0-
Total Delta Outflow	7.028	5.5	3.060	2.998	1.381	1.517	0.000
Above Normal (8 years out of 57) ***							
Sacramento	5.129	1.8	0.323	0.715	0.939	0.613	0.000
San Joaquin	0.654	3.4	1.635	0.621	0.621	0.621	0.000
Exports(-)	1.817	-1.8	-0.446	-1.200	0.000	-0.781	0.000
Other Flows	-0.187	-0-	-0-	-0-	-0-	-0-	-0-
Total Delta Outflow	3.779	7.0	2.404	2.536	1.560	2.015	0.000
Below Normal (14 years out of 57)***							
Sacramento	4.190	2.5	-0.074	0.040	1.253	0.689	0.000
San Joaquin	0.399	3.6	1.531	0.347	0.347	0.347	0.000
Exports(-)	1.842	-1.8	-0.621	-1.604	0.000	-1.004	0.000
Other Flows	-0.596	-0-	-0-	-0-	-0-	-0-	-0-
Total Delta Outflow	2.151	7.9	2.078	1.991	1.600	2.040	0.000
Dry (11 years out of 57)***							
Sacramento	3.717	3.1	-0.267	-0.214	0.473	0.098	0.000
San Joaquin	0.337	3.5	0.914	0.182	0.182	0.182	0.000
Exports(-)	1.729	-1.7	-0.633	-1.349	0.000	-0.823	0.000
Other Flows	-0.687	-0-	-0-	-0-	-0-	-0-	-0-
Total Delta Outflow	1.638	8.3	1.280	1.317	0.655	1.103	0.000
Critical (6 years out of 57)***							
Sacramento	2.714	4.3	0.335	0.404	0.300	0.177	0.000
San Joaquin	0.320	3.4	0.419	0.104	0.104	0.104	0.000
Exports(-)	1.205	-1.2	-0.324	-0.775	0.000	-0.316	0.000
Other Flows	-0.728	-0-	-0-	-0-	-0-	-0-	-0-
Total Delta Outflow	1.101	8.9	1.078	1.283	0.404	0.597	0.000
1928-34 Dry Period (7 years)							
Sacramento	3.218	3.6	0.095	0.157	0.651	0.482	0.000
San Joaquin	0.346	3.5	1.070	0.226	0.226	0.226	0.000
Exports(-)	1.451	-1.5	-0.416	-1.197	0.000	-0.568	0.000
Other Flows	-0.67	-0-	-0-	-0-	-0-	-0-	-0-
Total Delta Outflow	1.443	8.6	1.581	1.580	0.877	1.276	0.000

* Includes return flows from Hydrologic Study Area 21.
** Banks and Tracy Pumping Plants only.
*** Alternatives are summarized based on Sacramento Basin year types. However objectives for San Joaquin River and exports were always based on San Joaquin Basin year types, even when different from Sacramento Basin year type.

TABLE 7.3.2-2

APRIL - JULY WATER SUPPLY IMPACTS
OF ALTERNATIVE SETS OF WATER QUALITY OBJECTIVES

HISTORICAL LEVEL OF DEVELOPMENT USING VALUES FROM
YEARS 1972-87 (EXCEPT 1983) AS BASE

Base Conditions (Millions of Acre Feet)		Change in Base Flows Needed to Meet Alternative (Millions of Acre-Feet)					
		Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Alternative 6
Average (Based on 15 years of record)							
Sacramento	4.558	2.671	0.401	0.525	0.687	0.474	0.000
San Joaquin	1.066	2.936	0.995	0.406	0.406	0.406	0.000
Exports(-) *	1.397	-1.397	-0.132	-0.556	-0-	-0.201	0.000
Other Flows	-0.202	-0-	-0-	-0-	-0-	-0-	-0-
Total Delta Outflow	4.025	7.004	1.528	1.487	1.093	1.081	0.000
Wet (3 of 15 years) **							
Sacramento	8.231	0.516	0.928	1.159	0.026	-0.064	0.000
San Joaquin	1.733	2.471	1.340	1.066	1.066	1.066	0.000
Exports(-)	1.506	-1.506	0.096	0.151	-0-	-0.118	0.000
Other Flows	1.541	-0-	-0-	-0-	-0-	-0-	-0-
Total Delta Outflow	9.999	4.493	2.172	2.074	1.092	1.12	0.000
Above Normal (1 of 15 years)							
Sacramento	5.495	1.748	0.605	0.826	0.671	-0.449	0.000
San Joaquin	2.905	1.241	0.730	0.224	0.224	0.224	0.000
Exports(-)	1.304	-1.304	0.302	0.357	-0-	-0.324	0.000
Other Flows	-0.233	-0-	-0-	-0-	-0-	-0-	-0-
Total Delta Outflow	6.863	4.293	1.033	0.693	0.895	0.099	0.000
Below Normal (6 of 15 years)							
Sacramento	3.995	2.669	0.117	0.243	1.137	0.787	0.000
San Joaquin	1.018	3.025	1.229	0.379	0.379	0.379	0.000
Exports(-)	1.510	-1.510	-0.168	-0.787	-0-	-0.380	0.000
Other Flows	-0.511	-0-	-0-	-0-	-0-	-0-	-0-
Total Delta Outflow	2.992	7.204	1.514	1.409	1.516	1.546	0.000
Dry (1 of 15 years)							
Sacramento	3.347	3.584	0.063	0.110	1.171	0.690	0.000
San Joaquin	0.539	3.323	0.643	-0.115	-0.115	-0.115	0.000
Exports(-)	1.738	-1.738	-0.790	-1.544	-0-	-0.740	0.000
Other Flows	-0.813	-0-	-0-	-0-	-0-	-0-	-0-
Total Delta Outflow	1.335	8.645	1.496	1.539	1.056	1.315	0.000
Critical (4 of 15 years)							
Sacramento	2.715	4.291	0.466	0.501	0.398	0.360	0.000
San Joaquin	0.309	3.480	0.541	0.127	0.127	0.127	0.000
Exports(-)	1.085	-1.085	-0.195	-0.722	-0-	-0.168	0.000
Other Flows	-0.882	-0-	-0-	-0-	-0-	-0-	-0-
Total Delta Outflow	1.057	8.856	1.202	1.350	0.525	0.655	0.000

* Banks and Tracy Pumping Plants only.
** Alternatives are summarized based on Sacramento Basin year types. However objectives for San Joaquin River and exports were always based on San Joaquin Basin year types, even when different from Sacramento Basin year type.

MAF level would likely require a curtailment of existing uses in the Basin. This alternative would provide greatly enhanced protection to Estuary uses over those existing levels while having a significant impact on upstream users. This does not appear to be reasonable.

7.3.2.3 Alternative 3

Alternative 3 provides protection to the salmon resources in the Sacramento River system by preserving the April-June flows (shown to be important to salmon) at levels that have existed on the average over the period of record (1930-1987). However, on the San Joaquin River system a more modest level of protection is sought. It represents a more recent period of flows reflective of the current Delta physical condition (1953-87). This level of protection is more achievable on the San Joaquin system than that provided under Alternative 2. This level of protection is better than that provided under the no action alternative. It would prevent the important spring flows in the San Joaquin River from dropping any lower in the future as would be expected under the no action alternative. Since the level of protection sought is an average over a 35-year period, and reflects a level that generally occurred before these two fishery resources were showing a dramatic decline, it actually provides some increase over present day flows.

Striped bass protection is at levels initially proposed by State Board staff. Exports are decreased to allow for positive net downstream flows in April-July about 35 percent of the time in Old and Middle Rivers.

As shown in Tables 7.3.2-1 and 7.3.2-2, Alternative 3 reduces the average April-July water flow demands on the San Joaquin River system between 0.53 and 0.41 MAF above the base flows. This is a more achievable level. However, in so doing, it also calls for reductions in spring exports over those planned in the future by about 1.1 MAF. This represents about a 65 percent decrease in April-July exports. Some of this decrease may be able to be regained through increased exports in other months at the cost of building addition storage south of the Delta. However, this entire amount could not be regained without additional facilities in the Delta.

7.3.2.4 Alternative 4

Alternative 4 is the same as Alternative 3 except it retains the export limitations set forth in the current Delta Plan and the Delta outflows for striped bass as recommended by DFG and the USFWS. This means that the only mechanism used to address the concerns raised regarding the status of the salmon and striped bass fisheries is to increase flows. Exporters are not asked to shoulder any of the burden even though export operations are known to have effects on internal Delta flows and physically remove milions of young fish each year. The water supply impacts are shown in Table 7.3.2-1 and 7.3.2-2. Although this alternative has the least overall impact on water users, it too does not provide an equitable sharing of responsibilities to protect beneficial uses in the Bay-Delta Estuary.

7.3.2.5 Alternative 5

Alternative 5 offers the level of flows for protection of salmon as set forth under Alternative 3. However, outflow protection provided to striped bass is commensurate with that recommended by the DFG and the USFWS. Both the DFG and the USFWS recommended that some reduction in spring exports be achieved. However, neither made specific recommendations. Under this alternative, in April-July exports are established to reflect the conditions that occurred during a time when both striped bass and salmon populations were in much healthier conditions, prior to the increased export of the SWP (1953-1967 - see Figure 4.5.1.2-4). Reducing exports to the period before the SWP does not always provide the positive downstream flow in Old and Middle rivers sought by many fishery groups. Under this alternative, positive flows occur only about 20 percent of the time during April-July. It does reduce the magnitude of reverse flows compared to present conditions. A safe level of exports is not known. However, pre-SWP spring export rates appears to be a reasonable interim goal until a safe level of exports is found.

670,000 AF impact on exports in spring

The average impact on existing and planned spring exports is a decrease of about 0.67 MAF. Compared to the last 15 years of spring exports, they would be reduced by about 0.2 MAF. In order to make up for this decrease in spring exports the CVP and SWP could increase exports in fall and winter months above today's levels as planned in their 1990 operations study. This is possible with existing facilities as shown in DWR's 1990 operations study. These actions would in effect freeze existing total annual exports at about the 1985 levels. The 1985 level of exports is the highest to date and 16 percent higher than the average level of exports since implementation of the 1978 Delta Plan. However, as shown in Chapter 6, this level of Delta supply is sufficient to meet reasonable water demands south and west of the Delta through the year 2010.

7.3.2.6 Alternative 6

Alternative 6 is the no action alternative. As stated previously, continuation of this alternative is expected to result in a decrease in April-June flows in both the San Joaquin River and the Sacramento River at Rio Vista. Exports in the October-April period will increase by at least 0.6 MAF above the highest levels experienced to date. All this will take place while the natural population of salmon continues to decline and the index of young striped bass is at its lowest levels ever recorded. In addition, the southern Delta will continue to receive inadequate protection.

In the face of these decreases in Estuary beneficial use protection and the benefits received by the water use community, the no action alternative appears to be inequitable.

7.3.2.7 Recommended Alternative

In light of this review, Alternative 5 is the recommended alternative.

Figure 7.3.2.7-1 and Figure 7.3.2.7-2 show in bar chart form the water supply impacts of the recommended alternative using the 1990 operations study as a base and the 1972-87 historical period as a base, respectively. The April-July data shown in these bar charts are from Tables 7.3.2-1 and 7.3.2-2. The figures allow the comparison of recommended changes to the average base condition for each control point in the Delta, i.e., Delta outflow, Sacramento River, San Joaquin River and Tracy and Banks exports.

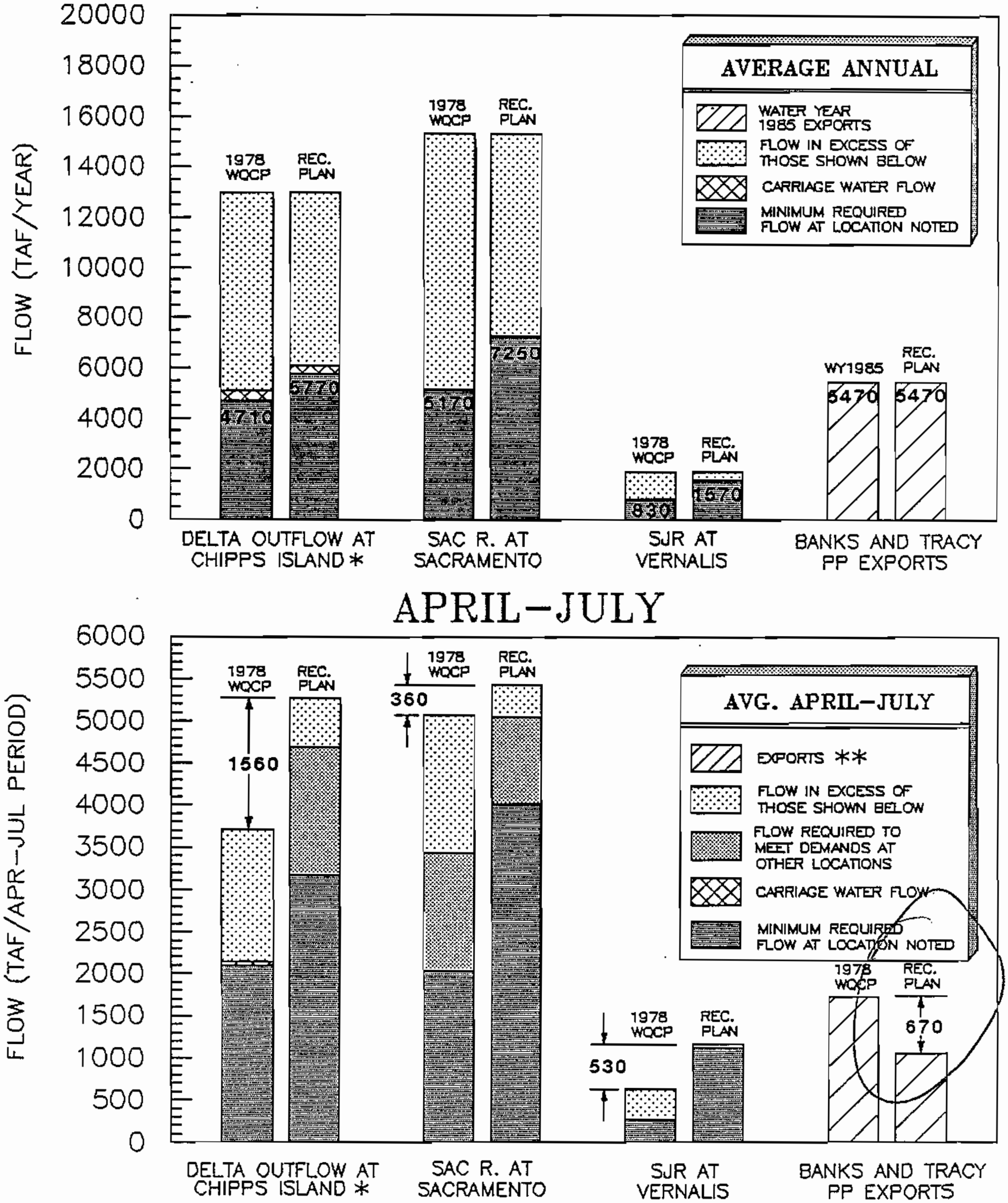
The water quality objectives derived from the recommended alternative are shown in Table 1 (see Chapter 1, Executive Summary).

FIGURE 7.3.2.7-1

RECOMMENDED PLAN WATER SUPPLY IMPACTS

1922-78 HYDROLOGY UNDER THE PRESENT LEVEL-OF-DEVELOPMENT

AVERAGE ANNUAL

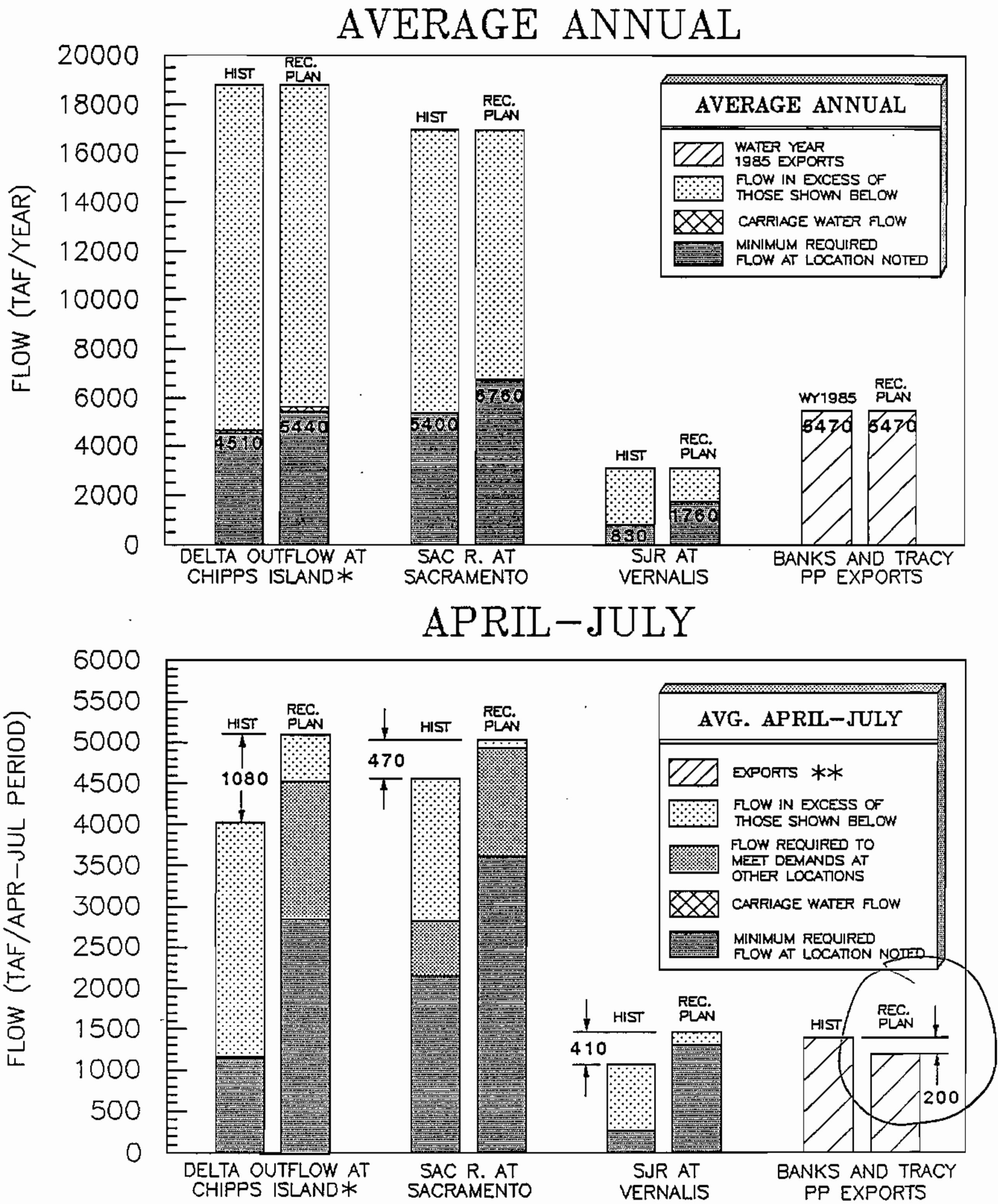


* INCLUDES YOLO BYPASS FLOW ** 1985 EXPORT IMPACT = 680 TAF

FIGURE 7.3.2.7-2

RECOMMENDED PLAN WATER SUPPLY IMPACTS

1972-1987 (W/O 1983) HISTORIC HYDROLOGY



* INCLUDES YOLO BYPASS FLOW

** 1985 EXPORT IMPACT = 540 TAF

8.0 PROGRAM OF IMPLEMENTATION

8.1 Introduction and Discussion of Issues

A Program of Implementation is required in all water quality control plans (WC Section 13242). This chapter provides the program of implementation, and includes: a discussion of how and when the water quality objectives set forth in this Plan are to be implemented; sampling and studies to be performed; and a time schedule.

The Board will use both its water quality and water right authorities to implement the objectives in this Plan. The most controversial aspects of this Plan are related to water rights. Water right issues will actually be determined by the Board during Phase III of the hearing process for the San Francisco Bay/Sacramento-San Joaquin Bay Delta Estuary. To help provide interested parties with an idea of some of the issues that will be discussed fully during Phase III, presented below are some of the concepts and conditions addressed in this Plan as they relate to water right aspects.

8.1.1 Water Right Issues

8.1.1.1 California Water Ethic

The California water ethic is fully discussed in Chapter 6 of this Plan (see 6.1). The principles developed from this ethic are discussed in sections of chapters 6 and 7 as they relate to determining reasonableness of consumptive use needs (chapter 6) and to determine appropriately balanced objectives for specific beneficial uses (Chapter 7). The Board can consider placing appropriate terms in water right licenses and permits to ensure more efficient use of the state's limited water supply consistent with the California water ethic. In Phase III the Board should consider the following in order to best conserve and utilize Bay-Delta waters:

- The annual combined export quantity per water year from the USBR Tracy Pumping Plant and the SWP Banks Pumping Plant be limited, except that in wet and above normal years, water above that required to meet objectives in the Bay-Delta may be pumped for conjunctive ground water storage and offstream surface storage; and

- The annual amount of water pumped per water year at the SWP Edmonston Pumping Plant for use in the southern California portion of the SWP service area be limited, except that: (1) an increase above that amount equal to the quantity of water conserved through increased agricultural efficiency in the San Joaquin Valley would be allowed; and (2) in wet and above normal years, water above that required to meet objectives in the Bay-Delta may be pumped for conjunctive ground water storage and offstream surface storage; and

- Agricultural users who contribute drainage flows to salt sinks should achieve a high but reasonably attainable water use efficiency.

8.1.1.2 Sharing the Obligation to Meet Water Quality Objectives in the Estuary

Currently, only certain permits of the CVP and SWP facilities are required to meet Bay-Delta Estuary water quality and flow objectives. These projects represent only about one-half of the almost 30 million acre-feet of water stored within the watershed. The Board will consider an equitable sharing of this responsibility among all users of Bay-Delta Estuary waters during Phase III. One possibility the Board may consider, to create a more equitable sharing, would be to expand the responsibility to maintain Estuary water quality to all reservoirs larger than 100,000 acre-feet. This action would add 31 reservoirs to the list of those assigned this responsibility. Almost 90 percent of the water stored in the watershed would then be operated to help maintain Estuary objectives.

In Water Right Decision 1594, the Board set forth the policy that all new water right permittees should not reduce flows needed to meet Bay-Delta water quality objectives by placing water right terms 91 and 93 into their permits. The Board determined that water for appropriation is no longer available when terms 91 and 93 are in effect. When this occurs new water users must cease diverting. If appropriators use water during this period, they must show the Board evidence that they have another water source being available to them and that they are using that alternaive source of supply. Terms 91 and 93 estimate on a real time basis when the CVP and SWP release their stored water to maintain Bay-Delta objectives. During Phase III, the Board may decide if similar terms should be placed in the permits and licenses of existing projects that are not currently operated to maintain water quality objectives in the Estuary. Such actions by the Board would redefine the water right rules upon which the water yield of not only these existing projects but also the water yield of the CVP and SWP are defined. Taking this action may require the phased implementation of the objectives contained in this Plan.

8.1.2 Water Quality Issues

In addition to the concerns, concepts, and analyses discussed in previous chapters which led up to the water quality objectives presented in Chapter 7, an additional issue not addressed heretofore is discussed below.

8.1.2.1 Salt Load Reduction Policy

Two occurrences have degraded water quality in the southern Delta. They are decreases in San Joaquin River flow and increases in salt loads to the river from irrigated agriculture. In this Plan, these flow issues and others are addressed. Upon adoption of this Plan, the State Board should consider requesting the Central Valley Regional Water Quality

Control Board to adopt a salt load reduction policy. The goals of this policy should be to stabilize and to reduce the salt loads discharged into the San Joaquin River. The policy should be achieved through amending existing and new waste discharge requirements, adopting nonpoint source controls, and amending the Basin Plan. The policy should reduce salinity levels to protect beneficial uses.

8.2 Monitoring and Special Studies

A monitoring program is necessary to assess compliance with the water quality objectives of the Water Quality Control Plan and to develop information to refine the water quality objectives in the future. Very little information was presented in Phase I regarding an appropriate monitoring program to be contained in the Water Quality Control Plan. The components of such a monitoring program should include:

- program coordination/data management and reporting
- compliance monitoring
- baseline studies and special studies

Concerns have been raised about the coordination and guidance provided by existing programs and the proper role of the State and Regional Boards in interagency efforts to study various aspects of the Estuary. Specifically, concern has been expressed that the Board's water quality monitoring programs which assess pollutant loads and effects need to be more closely integrated into other interagency studies of the Estuary. Also some groups believe the baseline studies required in D-1485 need to be better integrated into interagency study efforts and made more flexible.

Prior to the 1978 Delta Plan the State and Regional Board's had very little involvement in the interagency study efforts of the Estuary. In D-1485 the State Board required specific new studies of San Francisco Bay be performed. The Board has participated in studies of the Bay by sharing funding of the hydrodynamic element of the San Francisco Bay Program with the Interagency Study Program and by initiating the Aquatic Habitat Program to evaluate pollutant affects on the Bay. However, as discussed in the Pollutant Policy Document, better coordination of State and Regional Board studies on pollutant effects both in and upstream of the Estuary is needed. Consideration should be given for the Board to become a signatory to the Interagency Study Program so that the Board may better coordinate its studies in and upstream of the Estuary with the other agencies. This would include data manageent and reporting of this information.

This draft plan does not contain a specific baseline study program. The existing program as set forth in the 1978 Delta Plan has not been altered significantly since it was adopted. Baseline studies are necessary to identify long-term trends but they should also be continuously reevaluated and appropriate changes made as required in the 1978 Delta Plan and D-1485. This baseline study program should be reevaluated in Phase II and consideration should be given to merging it more closely with other interagency studies to make it more responsive to special study needs of these programs while still providing an appropriate long-term trend analysis on important parameters.

8.2.1 Compliance Monitoring

A compliance monitoring program will be established during Phase III to assess compliance with the water quality objectives contained in this Plan. The program will include continuous monitoring electrical conductivity recorders at each control station shown on Table 7.3.2.7-1 or a demonstration, to the satisfaction of the Board, that monitoring at a nearby location ensures demonstration of compliance. Funding of this program may be more complex since more parties may be required to help maintain these objectives. In Phase III the cost allocations for such a program will be decided.

8.2.2 Baseline and Special Studies

As stated earlier the baseline program in the 1978 Delta Plan needs to be reevaluated and made more flexible. Information regarding this reevaluation should be presented by the parties in Phase II.

Special studies are a more complex subject. In the 1978 Delta Plan the Board set forth specific special studies to be performed. The goal of these studies were to develop a better understanding of the hydrodynamics, water quality, productivity and significant ecological interactions in the Estuary so that more accurate predictions of the effects of water project operations on beneficial uses could be made. The most significant of these new studies were those in San Francisco and Suisun Bay. Unfortunately, while these studies provided information on the physical effects of flow changes on salinity gradients, phytoplankton production, and fish movement, they did not clearly address how these changes effect beneficial uses like fish and wildlife. Special studies in the San Francisco Bay, Suisun Bay and the Delta should continue to attempt to address this critical information link needed to develop water quality objectives.

Existing studies on the effects on water project operations or salmon and striped bass should continue and new studies to refine our knowledge in this area should be performed. Studies which quantify the effects of water project operations on shad and resident fish should also be performed.

If the State Board were a full member of the interagency study team it could provide more guidance to this group on the type of special studies that are most useful to the Board in setting water quality objectives. After going through the voluminous Phase I hearing record, the Board has identified information gaps that when filled should provide a firmer base upon which to set standards. The Board can help study teams formulate their study plans to gather this missing information.

Funding of baseline and special studies programs in the Estuary should be evaluated in Phase III.

8.3 Legislative Proposals

Although legislation is not required for the implementation of the water quality objectives in this Plan, there are specific areas in which new legislation may be helpful. They are:

- Legislation assisting the Board in implementing the new California water ethic through incentives to increase water conservation, reclamation, and conjunctive ground water and surface water use;

- Legislation to assure the Board's ability to enforce the foregoing recommendations.

New objectives must be implemented in large measure through regulation of water rights. In keeping with the appellate court decision, a much greater universe of water right holders will need to modify their water project operations to help achieve Bay-Delta water quality objectives. These changes in operations will have to be evaluated on a real-time basis in order to assess compliance. As demonstrated during the drought in 1988, the Board has minimal ability to assure compliance by even a small percentage of diverters. Also, increased monitoring and research will be needed to further refine the water quality objectives discussed in preceding sections. In order to achieve an equitable sharing of these responsibilities, the following changes are needed: (1) the water rights administration process should be streamlined to decrease requirements for small projects which have little potential for causing regional or statewide impacts; (2) compliance monitoring of larger projects needs to be automated; and (3) annual users fees should be imposed on permittees and licensees. These fees would be used to help fund the cost of continuing baseline and special studies on the water quality and instream flow needs of the Estuary, and to fund the compliance studies discussed in this Plan.

8.4 Time Schedule

The detailed time schedule for implementation of this Plan will be prepared at the conclusion of Phase III of the hearing process. An appropriate schedule cannot be prepared sooner because the responsibility for implementing various aspects of the Plan will not be addressed until Phase III. However, phased implementation of the objectives should be considered in no more than six years after adoption of this Water Quality Control Plan.

APPENDIX A

Past Proceedings Related to Flow and Salinity
Objectives for the Bay-Dleta Estuary

APPENDIX A -- Past Proceedings Related to Flow and Salinity Objectives for the Bay-Delta Estuary

Water quality objectives were first proposed for the Delta on November 19, 1965. Water Right Decision 1275 (D-1275) and Decision 1291 adopted in 1967, incorporated these objectives and other terms into the permits issued for the SWP. The State Boards' predecessor agency, the State Water Rights Board, issued a Water Quality Control Policy for the Delta and Suisun Marsh in 1967. This was amended in 1968. Pursuant to commitments made when D-1275 was issued, hearings regarding a salinity standard were initiated in July 1969. Following these hearings, Decision 1379 (D-1379), containing new water quality objectives for the Delta and Suisun Marsh, was issued in July 1971. However, subsequent litigation and court action stayed the implementation of D-1379 so that the requirements of D-1275 remained in effect. Regions 2 and 5 developed interim Basin Plans for their respective parts of the Estuary which were approved by the State Board in 1971. In 1973, in response to EPA concerns regarding the above mentioned 1967 Water Quality Control Policy, the State Board held a hearing and adopted a plan to supplement the 1967 policies. Comprehensive Basin Plans for the Sacramento-San Joaquin Delta Basin (Basin 5B) and the San Francisco Bay Basin (Basin 2), containing long-term water quality objectives, were approved by the State Board in 1975. Most of the water quality objectives incorporated into the Basin Plan for Basin 5B were similar to those of D-1379. In 1976 the State Board initiated a joint water quality and water right hearing to coordinate salinity objectives for the Delta and Suisun Marsh. This resulted, in 1978, in adoption by the State Board of the Water Quality Control Plan for the Sacramento-San Joaquin Delta and Suisun Marsh (Delta Plan) and Water Right Decision 1485 (D-1485). The Delta Plan contained flow and salinity objectives superseding those in the 5B Basin Plan. D-1485 placed permit conditions on the SWP and CVP to achieve salinity objectives in the Delta and Suisun Marsh through regulation of flows and operational constraints. In November 1983, the State Board adopted Water Right Decision 1594 pursuant to its reserved jurisdiction over more than 500 permittees in the Sacramento-San Joaquin Delta watershed. This decision placed conditions on permits issued since 1965, other than SWP and CVP, generally prohibiting diversions when natural and abandoned flows are insufficient to meet the D-1485 Delta water quality objectives. Under insufficient flow conditions the SWP and CVP have to release stored water to meet the objectives contained in D-1485.

APPENDIX B

DAYFLOW and Salmon Survival Data Sets

The following tables, B1 - B12, provide the flow data from DWR's DAYFLOW program which were used to calculate fishery protection levels and average historical conditions. Also included is the Sacramento River (Rio Vista) Estimated Salmon Survival Index. Year type classifications are the proposed April - July water year types as defined in the Draft Plan. Sacramento Valley year types are used throughout except for Delta exports and Vernalis (San Joaquin River) inflow, which use San Joaquin Valley year types. The effects of Delta island flooding and dewatering are discounted from the export values.

List of Tables

SACRAMENTO VALLEY HISTORIC FLOWS - CFS 1953-1987
(SACRAMENTO RIVER PLUS YOLO BYPASS) FROM DAYFLOW

WATER YR.	YR. TYPE	APR	MAY	JUN	JUL	AVG
1953	W	30,093	36,809	31,637	11,193	27,433
1954	AN	52,972	25,086	11,508	8,100	24,417
1955	BN	13,446	20,947	12,054	9,145	13,898
1956	W	32,506	43,788	25,660	12,413	28,592
1957	BN	20,040	31,856	16,871	9,353	19,530
1958	W	109,618	54,717	35,825	14,502	53,666
1959	D	13,964	11,435	8,030	10,562	10,998
1960	D	19,331	16,123	10,900	10,428	14,196
1961	D	17,037	13,160	10,965	10,558	12,930
1962	BN	28,359	19,823	13,066	10,262	17,878
1963	W	87,081	43,835	17,736	12,183	40,209
1964	D	12,538	13,970	11,166	11,639	12,328
1965	W	44,476	30,249	16,085	12,155	25,741
1966	BN	21,778	14,237	9,608	11,588	14,303
1967	W	55,513	53,324	44,511	19,520	43,217
1968	D	14,719	13,367	11,380	12,597	13,016
1969	W	46,420	41,299	23,271	14,248	31,310
1970	D	14,743	14,312	11,820	13,190	13,516
1971	W	39,121	29,779	27,734	20,995	29,407
1972	BN	13,126	12,856	13,854	15,002	13,710
1973	BN	21,338	16,505	14,974	15,182	17,000
1974	W	103,780	29,351	24,464	21,776	44,843
1975	W	34,889	30,551	23,738	18,297	26,869
1976	C	12,724	10,950	10,936	12,077	11,672
1977	C	5,962	7,598	6,866	8,249	7,169
1978	AN	40,261	25,215	12,677	14,317	23,118
1979	BN	16,577	18,015	12,225	16,428	15,811
1980	BN	22,643	15,930	17,842	17,753	18,542
1981	C	17,256	13,802	10,747	15,311	14,279
1982	W	114,798	42,674	26,126	17,662	50,315
1983	W	78,419	65,822	49,486	31,040	56,192
1984	BN	18,266	15,470	15,028	21,653	17,604
1985	D	12,495	13,432	13,310	16,035	13,818
1986	BN	26,978	12,804	11,863	16,924	17,142
1987	C	11,872	10,039	10,110	15,185	11,802

SACRAMENTO VALLEY FLOWS (SACRAMENTO R. + YOLO BYPASS) - CFS
YEAR TYPE SUMMARY FROM DAYFLOW

1953-1967

WATER YR.	YR. TYPE	APR	MAY	JUN	JUL	AVG
AVERAGE	W(6)	59,881	43,787	28,576	13,661	36,476
1954	AN(1)	52,972	25,086	11,508	8,100	24,417
AVERAGE	BN(4)	20,906	21,716	12,900	10,087	16,402
AVERAGE	D(4)	15,718	13,672	10,265	10,797	12,613
-	C(0)	-	-	-	-	-
GRND MEAN	15	37,369	26,065	15,812	10,661	22,477
WTDGNDMN	15	37,250	28,624	18,375	11,573	23,956

1968-1987

WATER YR.	YR. TYPE	APR	MAY	JUN	JUL	AVG
AVERAGE	W(6)	69,571	39,913	29,137	20,670	39,823
1978	AN(1)	40,261	25,215	12,677	14,317	23,118
AVERAGE	BN(6)	19,821	15,263	14,298	17,157	16,635
AVERAGE	D(3)	13,986	13,704	12,170	13,941	13,450
AVERAGE	C(4)	11,954	10,597	9,665	12,706	11,230
GRND MEAN	20	31,119	20,938	15,589	15,758	20,851
WGTGNDMN	20	33,319	21,989	17,423	16,696	22,357

1979-1987

WATER YR.	YR. TYPE	APR	MAY	JUN	JUL	AVERAGE
AVERAGE	W(2)	96,609	54,248	37,806	24,351	53,253
-	AN(0)	-	-	-	-	-
AVERAGE	BN(4)	21,116	15,555	14,240	18,190	17,275
1985	D(1)	12,495	13,432	13,310	16,035	13,818
AVERAGE	C(2)	14,564	11,921	10,429	15,248	13,040
GRND MEAN	9	36,196	23,789	18,946	18,456	24,347
WTDGNDMN	9	35,478	23,110	18,526	18,666	23,945

1953-1987

WATER YR.	YR. TYPE	APR	MAY	JUN	JUL	AVG
AVERAGE	W(12)	64,726	41,850	28,856	17,165	38,149
AVERAGE	AN(2)	46,617	25,151	12,093	11,209	23,767
AVERAGE	BN(10)	20,255	17,844	13,739	14,329	16,542
AVERAGE	D(7)	14,975	13,686	11,082	12,144	12,972
AVERAGE	C(4)	11,954	10,597	9,665	12,706	11,230
GRND MEAN	35	31,705	21,825	15,087	13,510	20,532
WTDGNDMN	35	35,004	24,832	17,831	14,501	23,042

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GRND MEAN = AVERAGE OF ALL YEARS IN GROUP
WTDGNDMN = AVERAGE OF ALL YEARS IN GROUP WEIGHTED BY FREQUENCY OF EACH YEAR TYPE IN GROUP

RIO VISTA FLOWS, 1930-1987
(From DWR DAYFLOW)

YEAR	YR TYPE	APR Q	MAY Q	JUNE Q	AVG Q
1930	D	27171	16841	6392	16801
1931	C	6070	3068	349	3162
1932	D	23686	29274	14925	22628
1933	D	18694	16171	12255	15707
1934	C	13762	5155	1590	6836
1935	W	79218	40679	16114	45337
1936	AN	38447	24393	14512	25784
1937	AN	46085	33492	12217	30598
1938	W	83013	72068	37227	64103
1939	C	14650	5668	916	7078
1940	AN	94517	25834	8923	43091
1941	W	92744	84952	50901	76199
1942	W	64020	46344	29054	46473
1943	AN	46645	25534	12415	28198
1944	BN	14454	19045	6689	13396
1945	BN	22542	21745	11063	18450
1946	BN	27988	22276	8786	19683
1947	D	18509	7536	5350	10465
1948	W	46700	44333	26828	39287
1949	BN	25825	19262	6574	17220
1950	AN	30215	23779	12852	22282
1951	BN	21406	22176	7023	16868
1952	W	69015	63542	33756	55438
1953	W	20947	25223	20307	22159
1954	AN	36875	16927	8247	20683
1955	BN	11231	17076	8597	12301
1956	W	27375	36915	20392	28227
1957	BN	12753	24266	10880	15966
1958	W	100201	46283	29308	58597
1959	D	7569	5319	2542	5143
1960	D	11337	8768	4577	8227
1961	D	9677	6598	4645	6973
1962	BN	17544	11366	6115	11675
1963	W	78676	36897	10514	42029
1964	D	6344	7205	4999	6183
1965	W	36728	24180	8253	23054
1966	BN	14142	7387	3667	8399
1967	W	48585	44945	36663	43398
1968	D	7988	6733	4914	6545
1969	W	39290	34409	15475	29725
1970	D	7979	7368	5265	6871
1971	W	32692	21483	16533	23569
1972	BN	6915	6345	6710	6657
1973	BN	13397	9454	8589	10480
1974	W	94216	18732	14241	42396
1975	W	25744	18912	13658	19438
1976	C	6814	4981	4602	5466
1977	C	1615	2990	1791	2132
1978	AN	34486	16697	5829	19004
1979	BN	11738	9996	5509	9081
1980	BN	17896	11775	10488	13386
1981	C	12321	7718	4464	8168
1982	W	104470	35529	18953	52984
1983	W	69581	56419	41173	55724
1984	BN	13515	9305	7497	10106
1985	D	6303	7197	6946	6815
1986	BN	22650	8605	5261	12172
1987	C	6008	4972	4002	4994
AVG 30-52		40234	29268	14640	28047
AVG 53-87		27874	17685	10903	18821
AVG 30-87		32775	22278	12385	22480
AVG 53-67		29332	21290	11980	20868
AVG 68-78		24649	13464	8873	15662
AVG 79-87		29387	16835	11588	19270
AVG 72-87		27979	14352	9982	17438
AVG 72-87(-83)		25206	11547	7903	14885

AVERAGE MONTHLY RIO VISTA FLOW, 1930-1987
(Maximum set to 22,500 cfs)
(from,DWR,DAYFLOW)

YEAR	YR TYPE	APR Q	MAY Q	JUNE Q	AVG Q
1930	D	22500	16841	6392	15244
1931	C	6070	3068	349	3162
1932	D	22500	22500	14925	19975
1933	D	18694	16171	12255	15707
1934	C	13762	5155	1590	6836
1935	W	22500	22500	16114	20371
1936	AN	22500	22500	14512	19837
1937	AN	22500	22500	12217	19072
1938	W	22500	22500	22500	22500
1939	C	14650	5668	916	7078
1940	AN	22500	22500	8923	17974
1941	W	22500	22500	22500	22500
1942	W	22500	22500	22500	22500
1943	AN	22500	22500	12415	19138
1944	BN	14454	19045	6689	13396
1945	BN	22500	21745	11063	18436
1946	BN	22500	22276	8786	17854
1947	D	18509	7536	5350	10465
1948	W	22500	22500	22500	22500
1949	BN	22500	19262	6574	16112
1950	AN	22500	22500	12852	19284
1951	BN	21406	22176	7023	16868
1952	W	22500	22500	22500	22500
1953	W	20947	22500	20307	21251
1954	AN	22500	16927	8247	15891
1955	BN	11231	17076	8597	12301
1956	W	22500	22500	20392	21797
1957	BN	12753	22500	10880	15378
1958	W	22500	22500	22500	22500
1959	D	7569	5319	2542	5143
1960	D	11337	8768	4577	8227
1961	D	9677	6598	4645	6973
1962	BN	17544	11366	6115	11675
1963	W	22500	22500	10514	18505
1964	D	6344	7205	4999	6183
1965	W	22500	22500	8253	17751
1966	BN	14142	7387	3667	8399
1967	W	22500	22500	22500	22500
1968	D	7988	6733	4914	6545
1969	W	22500	22500	15475	20158
1970	D	7979	7368	5265	6871
1971	W	22500	21483	16533	20172
1972	BN	6915	6345	6710	6657
1973	BN	13397	9454	8589	10480
1974	W	22500	18732	14241	18491
1975	W	22500	18912	13658	18357
1976	C	6814	4981	4602	5466
1977	C	1615	2990	1791	2132
1978	AN	22500	16697	5829	15009
1979	BN	11738	9996	5509	9081
1980	BN	17896	11775	10488	13386
1981	C	12321	7718	4464	8168
1982	W	22500	22500	18953	21318
1983	W	22500	22500	22500	22500
1984	BN	13515	9305	7497	10106
1985	D	6303	7197	6946	6815
1986	BN	22500	8605	5261	12122
1987	C	6008	4972	4002	4994
AVG 30-52		20328	18650	11802	16927
AVG 53-87		15401	13683	9770	12951
AVG 30-87		17355	15653	10576	14528
AVG 53-67		16436	15876	10582	14298
AVG 68-78		14292	12381	8873	11849
AVG 79-87		15031	11619	9513	12054
AVG 72-87		14470	11417	8815	11568
AVG 72-87(-83)		13935	10679	7903	10839

RIO VISTA FLOWS, 1930-1987
(From DWR DAYFLOW)
(Maximum flow = 22,500cfs)

SALMON SMOLT SURVIVAL 1/

YEAR	YR TYPE	APR Q	MAY Q	JUN Q	YEAR	YR TYPE	APR S	MAY S	JUN S	AVG S	WEIGHTED SURVIVAL
1935	W	22500	22500	16114	1935	W	1.00	1.00	0.64	0.88	Survival=average
1938	W	22500	22500	22500	1938	W	1.00	1.00	1.00	1.00	Apr.-Jun survival
1941	W	22500	22500	22500	1941	W	1.00	1.00	1.00	1.00	* year type
1942	W	22500	22500	22500	1942	W	1.00	1.00	1.00	1.00	frequency
1948	W	22500	22500	22500	1948	W	1.00	1.00	1.00	1.00	
1952	W	22500	22500	22500	1952	W	1.00	1.00	1.00	1.00	
1953	W	20947	22500	20307	1953	W	0.92	1.00	0.88	0.93	
1956	W	22500	22500	20392	1956	W	1.00	1.00	0.88	0.96	
1958	W	22500	22500	22500	1958	W	1.00	1.00	1.00	1.00	
1963	W	22500	22500	10514	1963	W	1.00	1.00	0.33	0.78	
1965	W	22500	22500	8253	1965	W	1.00	1.00	0.20	0.74	
1967	W	22500	22500	22500	1967	W	1.00	1.00	1.00	1.00	
1969	W	22500	22500	15475	1969	W	1.00	1.00	0.61	0.87	
1971	W	22500	21483	16533	1971	W	1.00	0.95	0.67	0.87	
1974	W	22500	18732	14241	1974	W	1.00	0.79	0.54	0.78	
1975	W	22500	18912	13658	1975	W	1.00	0.80	0.51	0.77	
1982	W	22500	22500	18953	1982	W	1.00	1.00	0.80	0.94	
1983	W	22500	22500	22500	1983	W	1.00	1.00	1.00	1.00	
30-87 AVG		22414	22035	18580	30-87 AVG		1.00	0.98	0.78	0.92	0.29
53-87 AVG		22371	21802	17152	53-87 AVG		0.99	0.96	0.70	0.89	0.30
30-52 AVG		22500	22500	21436	30-52 AVG		1.00	1.00	0.94	0.98	0.25
1936	AN	22500	22500	14512	1936	AN	1.00	1.00	0.55	0.85	
1937	AN	22500	22500	12217	1937	AN	1.00	1.00	0.43	0.81	
1940	AN	22500	22500	8923	1940	AN	1.00	1.00	0.24	0.75	
1943	AN	22500	22500	12415	1943	AN	1.00	1.00	0.44	0.81	
1950	AN	22500	22500	12852	1950	AN	1.00	1.00	0.46	0.82	
1954	AN	22500	16927	8247	1954	AN	1.00	0.69	0.20	0.63	
1978	AN	22500	16697	5829	1978	AN	1.00	0.68	0.07	0.58	
30-87 AVG		22500	20875	10714	30-87 AVG		1.00	0.91	0.34	0.75	0.09
53-87 AVG		22500	16812	7038	53-87 AVG		1.00	0.68	0.14	0.61	0.04
30-52 AVG		22500	22500	12184	30-52 AVG		1.00	1.00	0.42	0.81	0.18

1944 BN	14454	19045	6689	1944 BN	0.55	0.81	0.12	0.49	
1945 BN	22500	21745	11063	1945 BN	1.00	0.96	0.36	0.77	
1946 BN	22500	22276	8786	1946 BN	1.00	0.99	0.23	0.74	
1949 BN	22500	19262	6574	1949 BN	1.00	0.82	0.11	0.64	
1951 BN	21406	22176	7023	1951 BN	0.94	0.98	0.14	0.69	
1955 BN	11231	17076	8597	1955 BN	0.37	0.70	0.22	0.43	
1957 BN	12753	22500	10880	1957 BN	0.46	1.00	0.35	0.60	
1962 BN	17544	11366	6115	1962 BN	0.72	0.38	0.08	0.40	
1966 BN	14142	7387	3667	1966 BN	0.53	0.16	0.00	0.23	
1972 BN	6915	6345	6710	1972 BN	0.13	0.10	0.12	0.11	
1973 BN	13397	9454	8589	1973 BN	0.49	0.27	0.22	0.33	
1979 BN	11738	9996	5509	1979 BN	0.40	0.30	0.05	0.25	
1980 BN	17896	11775	10488	1980 BN	0.74	0.40	0.33	0.49	
1984 BN	13515	9305	7497	1984 BN	0.50	0.26	0.16	0.31	
1986 BN	22500	8605	5261	1986 BN	1.00	0.22	0.04	0.42	
30-87 AVG	16333	14554	7563	30-87 AVG	0.66	0.56	0.17	0.46	0.12
53-87 AVG	14163	11381	7331	53-87 AVG	0.54	0.38	0.16	0.36	0.10
30-52 AVG	20672	20901	8027	30-52 AVG	0.90	0.91	0.19	0.67	0.15
1930 D	22500	16841	6392	1930 D	1.00	0.69	0.10	0.60	
1932 D	22500	22500	14925	1932 D	1.00	1.00	0.58	0.86	
1933 D	18694	16171	12255	1933 D	0.79	0.65	0.43	0.62	
1947 D	18509	7536	5350	1947 D	0.78	0.16	0.04	0.33	
1959 D	7569	5319	2542	1959 D	0.17	0.04	0.00	0.07	
1960 D	11337	8768	4577	1960 D	0.38	0.23	0.00	0.20	
1961 D	9677	6598	4645	1961 D	0.28	0.11	0.00	0.13	
1964 D	6344	7205	4999	1964 D	0.10	0.15	0.02	0.09	
1968 D	7988	6733	4914	1968 D	0.19	0.12	0.02	0.11	
1970 D	7979	7368	5265	1970 D	0.19	0.15	0.04	0.13	
1985 D	6303	7197	6946	1985 D	0.09	0.15	0.13	0.12	
30-87 AVG	12673	10203	6619	30-87 AVG	0.45	0.31	0.12	0.30	0.06
53-87 AVG	8171	7027	4841	53-87 AVG	0.20	0.14	0.03	0.12	0.02
30-52 AVG	20551	15762	9731	30-52 AVG	0.89	0.62	0.29	0.60	0.10

1931 C	6070	3068	349	1931 C	0.08	0.00	0.00	0.03	
1934 C	13762	5155	1590	1934 C	0.51	0.03	0.00	0.18	
1939 C	14650	5668	916	1939 C	0.56	0.06	0.00	0.21	
1976 C	6814	4981	4602	1976 C	0.12	0.02	0.00	0.05	
1977 C	1615	2990	1791	1977 C	0.00	0.00	0.00	0.00	
1981 C	12321	7718	4464	1981 C	0.43	0.17	0.00	0.20	
1987 C	6008	4972	4002	1987 C	0.08	0.02	0.00	0.03	
30-87 AVG	8749	4936	2531	30-87 AVG	0.26	0.04	0.00	0.10	0.01
53-87 AVG	6690	5165	3715	53-87 AVG	0.16	0.05	0.00	0.07	0.01
30-52 AVG	11494	4630	952	30-52 AVG	0.39	0.03	0.00	0.14	0.02

TOTAL WEIGHTED SURVIVAL, 1930-1987: 0.57
TOTAL WEIGHTED SURVIVAL, 1953-1987: 0.47
TOTAL WEIGHTED SURVIVAL, 1930-1952: 0.70

1/ Survival=(Rio Vista flow * .000056)-.258. From USFWS,31.

AVERAGE SURVIVAL,1930-1987: 0.51
AVERAGE SURVIVAL,1953-1987: 0.41
AVERAGE SURVIVAL,1930-1952: 0.64

RIO VISTA FLOWS, 1930-1987
(From DWR DAYFLOW)

YEAR	YR TYPE	APR Q	MAY Q	JUNE Q
1935	W	79218	40679	16114
1938	W	83013	72068	37227
1941	W	92744	84952	50901
1942	W	64020	46344	29054
1948	W	46700	44333	26828
1952	W	69015	63542	33756
1953	W	20947	25223	20307
1956	W	27375	36915	20392
1958	W	100201	46283	29308
1963	W	78676	36897	10514
1965	W	36728	24180	8253
1967	W	48585	44945	36663
1969	W	39290	34409	15475
1971	W	32692	21483	16533
1974	W	94216	18732	14241
1975	W	25744	18912	13658
1982	W	104470	35529	18953
1983	W	69581	56419	41173
30-87 AVG		61845	41769	24408
53-87 AVG		56542	33327	20456
30-52 AVG		72452	58653	32313
53-67 AVG		52085	35741	20906
68-78 AVG		47986	23384	14977
79-87 AVG		87026	45974	30063
1936	AN	38447	24393	14512
1937	AN	46085	33492	12217
1940	AN	94517	25834	8923
1943	AN	46645	25534	12415
1950	AN	30215	23779	12852
1954	AN	36875	16927	8247
1978	AN	34486	16697	5829
30-87 AVG		46753	23808	10714
53-87 AVG		35681	16812	7038
30-52 AVG		51182	26606	12184
53-67 AVG		35681	16812	7038
68-78 AVG		34486	16697	5829
79-87 AVG		34486	16697	5829
1944	BN	14454	19045	6689
1945	BN	22542	21745	11063
1946	BN	27988	22276	8786
1949	BN	25825	19262	6574
1951	BN	21406	22176	7023
1955	BN	11231	17076	8597
1957	BN	12753	24266	10880
1962	BN	17544	11366	6115
1966	BN	14142	7387	3667
1972	BN	6915	6345	6710
1973	BN	13397	9454	8589
1979	BN	11738	9996	5509
1980	BN	17896	11775	10488
1984	BN	13515	9305	7497
1986	BN	22650	8605	5261
30-87 AVG		16933	14672	7563
53-87 AVG		14178	11558	7331
30-52 AVG		22443	20901	8027
53-67 AVG		13918	15024	7315
68-78 AVG		10156	7900	7650
79-87 AVG		16450	9920	7189

YEAR	YR TYPE	APR Q	MAY Q
1930	D	27171	16841
1932	D	23686	29274
1933	D	18694	16171
1947	D	18509	7536
1959	D	7569	5319
1960	D	11337	8768
1961	D	9677	6598
1964	D	6344	7205
1968	D	7988	6733
1970	D	7979	7368
1985	D	6303	7197
30-87 AVG		10214	8719
53-87 AVG		6680	5934
30-52 AVG		22015	17456
53-67 AVG		8732	6973
68-78 AVG		7984	7051
79-87 AVG			
1931	C	6070	3068
1934	C	13762	5155
1939	C	14650	5668
1976	C	6814	4981
1977	C	1615	2990
1981	C	12321	7718
1987	C	6008	4972
30-87 AVG		8749	4936
53-87 AVG		6690	5165
30-52 AVG		11494	4630
53-67 AVG			
68-78 AVG		4215	3986
79-87 AVG		9165	6345

VERNALIS FLOWS,1930-1987
(from DWR,DAYFLOW)

YEAR	YEAR TYPE	APR Q	MAY Q	JUNE Q	AVG Q
1930	D	2581	2214	2754	2516
1931	C	389	444	392	408
1932	AN	4814	11594	15100	10503
1933	BN	1147	1384	5308	2613
1934	C	702	639	627	656
1935	AN	14758	16384	15776	15639
1936	AN	13022	16784	11119	13642
1937	W	14463	20052	15558	16691
1938	W	22410	28345	36650	29135
1939	C	2467	2036	991	1831
1940	AN	16907	14300	10850	14019
1941	W	17087	21284	22303	20225
1942	W	13414	16532	22240	17395
1943	AN	18060	14973	11653	14895
1944	BN	2300	3827	3384	3170
1945	AN	8987	13915	11323	11408
1946	AN	6015	13058	5783	8285
1947	D	1488	2046	942	1492
1948	BN	1393	5001	8606	5000
1949	BN	2058	3530	2003	2530
1950	BN	5367	5012	5014	5131
1951	BN	2652	6525	3338	4172
1952	W	20197	27639	23340	23725
1953	BN	1520	3059	4914	3164
1954	BN	5059	6716	1286	4354
1955	BN	917	1150	1496	1188
1956	W	6261	13911	12251	10808
1957	BN	1326	2582	3759	2556
1958	W	27920	22419	15617	21985
1959	C	812	791	533	712
1960	C	517	618	293	476
1961	C	200	380	207	262
1962	AN	2085	2621	3497	2734
1963	AN	8616	9339	6663	8206
1964	D	764	703	650	706
1965	W	9859	5296	5650	6935
1966	D	982	863	570	805
1967	W	14495	20365	20000	18287
1968	C	1435	891	592	973
1969	W	22117	24613	27887	24872
1970	BN	1673	2393	2737	2268
1971	BN	1961	1833	2322	2039
1972	D	1037	744	587	789
1973	AN	4203	2937	2576	3239
1974	W	5850	4106	3860	4605
1975	W	3957	3972	5708	4546
1976	C	1293	939	798	1010
1977	C	212	400	118	243
1978	W	20030	19119	7069	15406
1979	AN	3506	2524	2254	2761
1980	W	10249	9912	5305	8489
1981	D	2532	1967	1499	1999
1982	W	22963	18654	7584	16400
1983	W	36447	31771	26083	31434
1984	BN	4285	3240	2297	3274
1985	D	2445	2134	1751	2110
1986	W	19590	8764	6233	11529
1987	C	2867	2178	1990	2345
30-87 AVG		7632	8300	7271	7734
30-52 AVG		8377	10762	10220	9786
53-87 AVG		7142	6683	5332	6386
72-87 AVG		8842	7085	4732	6886
72-87 AVG(-83)		7001	5439	3309	5250

VERNALIS FLOW,1930-1987
(Maximum flow = 20,000 cfs)

YEAR	YEAR TYPE	APR Q	MAY Q	JUNE Q	AVG S
1930	D	2581	2214	2754	2516
1931	C	389	444	392	408
1932	AN	4814	11594	15100	10503
1933	BN	1147	1384	5308	2613
1934	C	702	639	627	656
1935	AN	14758	16384	15776	15639
1936	AN	13022	16784	11119	13642
1937	W	14463	20000	15558	16674
1938	W	20000	20000	20000	20000
1939	C	2467	2036	991	1831
1940	AN	16907	14300	10850	14019
1941	W	17087	20000	20000	19029
1942	W	13414	16532	20000	16649
1943	AN	18060	14973	11653	14895
1944	BN	2300	3827	3384	3170
1945	AN	8987	13915	11323	11408
1946	AN	6015	13058	5783	8285
1947	D	1488	2046	942	1492
1948	BN	1393	5001	8606	5000
1949	BN	2058	3530	2003	2530
1950	BN	5367	5012	5014	5131
1951	BN	2652	6525	3338	4172
1952	W	20000	20000	20000	20000
1953	BN	1520	3059	4914	3164
1954	BN	5059	6716	1286	4354
1955	BN	917	1150	1496	1188
1956	W	6261	13911	12251	10808
1957	BN	1326	2582	3759	2556
1958	W	20000	20000	15617	18539
1959	C	812	791	533	712
1960	C	517	618	293	476
1961	C	200	380	207	262
1962	AN	2085	2621	3497	2734
1963	AN	8616	9339	6663	8206
1964	D	764	703	650	706
1965	W	9859	5296	5650	6935
1966	D	982	863	570	805
1967	W	14495	20000	20000	18165
1968	C	1435	891	592	973
1969	W	20000	20000	20000	20000
1970	BN	1673	2393	2737	2268
1971	BN	1961	1833	2322	2039
1972	D	1037	744	587	789
1973	AN	4203	2937	2576	3239
1974	W	5850	4106	3860	4605
1975	W	3957	3972	5708	4546
1976	C	1293	939	798	1010
1977	C	212	400	118	243
1978	W	20000	19119	7069	15396
1979	AN	3506	2524	2254	2761
1980	W	10249	9912	5305	8489
1981	D	2532	1967	1499	1999
1982	W	20000	18654	7584	15413
1983	W	20000	20000	20000	20000
1984	BN	4285	3240	2297	3274
1985	D	2445	2134	1751	2110
1986	W	19590	8764	6233	11529
1987	C	2867	2178	1990	2345
30-87 AVG		7079	7671	6607	7119
30-52 AVG		8264	10009	9153	9142
53-87 AVG		6300	6135	4933	5790
72-87 AVG		7627	6349	4352	6109
72-87 AVG(-83)		6802	5439	3309	5183

VERNALIS FLOWS,1930-1987
(DWR,DAYFLOW by Year Type)

YEAR	YEAR TYPE	APR Q	MAY Q	JUNE Q	AVG Q
1937	W	14463	20052	15558	16691
1938	W	22410	28345	36650	29135
1941	W	17087	21284	22303	20225
1942	W	13414	16532	22240	17395
1952	W	20197	27639	23340	23725
1956	W	6261	13911	12251	10808
1958	W	27920	22419	15617	21985
1965	W	9859	5296	5650	6935
1967	W	14495	20365	20000	18287
1969	W	22117	24613	27887	24872
1974	W	5850	4106	3860	4605
1975	W	3957	3972	5708	4546
1978	W	20030	19119	7069	15406
1980	W	10249	9912	5305	8489
1982	W	22963	18654	7584	16400
1983	W	36447	31771	26083	31434
1986	W	19590	8764	6233	11529
30-87 AVG		16901	17456	15490	16616
53-87 AVG		16645	15242	11937	14608
30-52 AVG		17514	22770	24018	21434
1932	AN	4814	11594	15100	10503
1935	AN	14758	16384	15776	15639
1936	AN	13022	16784	11119	13642
1940	AN	16907	14300	10850	14019
1943	AN	18060	14973	11653	14895
1945	AN	8987	13915	11323	11408
1946	AN	6015	13058	5783	8285
1962	AN	2085	2621	3497	2734
1963	AN	8616	9339	6663	8206
1973	AN	4203	2937	2576	3239
1979	AN	3506	2524	2254	2761
30-87 AVG		9179	10766	8781	9576
53-87 AVG		4603	4355	3748	4235
30-52 AVG		11795	14430	11658	12627
1933	BN	1147	1384	5308	2613
1944	BN	2300	3827	3384	3170
1948	BN	1393	5001	8606	5000
1949	BN	2058	3530	2003	2530
1950	BN	5367	5012	5014	5131
1951	BN	2652	6525	3338	4172
1953	BN	1520	3059	4914	3164
1954	BN	5059	6716	1286	4354
1955	BN	917	1150	1496	1188
1957	BN	1326	2582	3759	2556
1970	BN	1673	2393	2737	2268
1971	BN	1961	1833	2322	2039
1984	BN	4285	3240	2297	3274
30-87 AVG		2435	3558	3574	3189
53-87 AVG		2392	2996	2687	2692
30-52 AVG		2486	4213	4609	3769
1930	D	2581	2214	2754	2516
1947	D	1488	2046	942	1492
1964	D	764	703	650	706
1966	D	982	863	570	805
1972	D	1037	744	587	789
1981	D	2532	1967	1499	1999
1985	D	2445	2134	1751	2110
30-87 AVG		1690	1524	1250	1488
53-87 AVG		1552	1282	1011	1282
30-52 AVG		2035	2130	1848	2004
1931	C	389	444	392	408
1934	C	702	639	627	656
1939	C	2467	2036	991	1831
1959	C	812	791	533	712
1960	C	517	618	293	476
1961	C	200	380	207	262
1968	C	1435	891	592	973
1976	C	1293	939	798	1010
1977	C	212	400	118	243
1987	C	2867	2178	1990	2345
30-87 AVG		1089	932	654	892
53-87 AVG		1048	885	647	860
30-52 AVG		1186	1040	670	965

VERNALIS FLOW,1930-1987
(Maximum flow = 20,000 cfs)

YEAR	YEAR TYPE	APR Q	MAY Q	JUNE Q	AVG Q
1937	W	14463	20000	15558	16674
1938	W	20000	20000	20000	20000
1941	W	17087	20000	20000	19029
1942	W	13414	16532	20000	16649
1952	W	20000	20000	20000	20000
1956	W	6261	13911	12251	10808
1958	W	20000	20000	15617	18539
1965	W	9859	5296	5650	6935
1967	W	14495	20000	20000	18165
1969	W	20000	20000	20000	20000
1974	W	5850	4106	3860	4605
1975	W	3957	3972	5708	4546
1978	W	20000	19119	7069	15396
1980	W	10249	9912	5305	8489
1982	W	20000	18654	7584	15413
1983	W	20000	20000	20000	20000
1986	W	19590	8764	6233	11529
30-87 AVG		15013	15310	13226	14516
53-87 AVG		14188	13645	10773	12869
30-52 AVG		16993	19306	19112	18470
1932	AN	4814	11594	15100	10503
1935	AN	14758	16384	15776	15639
1936	AN	13022	16784	11119	13642
1940	AN	16907	14300	10850	14019
1943	AN	18060	14973	11653	14895
1945	AN	8987	13915	11323	11408
1946	AN	6015	13058	5783	8285
1962	AN	2085	2621	3497	2734
1963	AN	8616	9339	6663	8206
1973	AN	4203	2937	2576	3239
1979	AN	3506	2524	2254	2761
30-87 AVG		9179	10766	8781	9576
53-87 AVG		4603	4355	3748	4235
30-52 AVG		11795	14430	11658	12627
1933	BN	1147	1384	5308	2613
1944	BN	2300	3827	3384	3170
1948	BN	1393	5001	8606	5000
1949	BN	2058	3530	2003	2530
1950	BN	5367	5012	5014	5131
1951	BN	2652	6525	3338	4172
1953	BN	1520	3059	4914	3164
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1955	BN	917	1150	1496	1188
1957	BN	1326	2582	3759	2556
1970	BN	1673	2393	2737	2268
1971	BN	1961	1833	2322	2039
1984	BN	4285	3240	2297	3274
30-87 AVG		2435	3558	3574	3189
53-87 AVG		2392	2996	2687	2692
30-52 AVG		2486	4213	4609	3769
1930	D	2581	2214	2754	2516
1947	D	1488	2046	942	1492
1964	D	764	703	650	706
1966	D	982	863	570	805
1972	D	1037	744	587	789
1981	D	2532	1967	1499	1999
1985	D	2445	2134	1751	2110
30-87 AVG		1690	1524	1250	1488
53-87 AVG		1552	1282	1011	
30-52 AVG		2035	2130	1848	2004
1931	C	389	444	392	408
1934	C	702	639	627	656
1939	C	2467	2036	991	1831
1959	C	812	791	533	712
1960	C	517	618	293	476
1961	C	200	380	207	262
1968	C	1435	891	592	973
1976	C	1293	939	798	1010
1977	C	212	400	118	243
1987	C	2867	2178	1990	2345
30-87 AVG		1089	932	654	892
53-87 AVG		1048	885	647	860
30-52 AVG		1186	1040	670	965

TOTAL EXPORTS FROM THE DELTA, 1951 - 1987
AVERAGE DAILY FLOWS, CFS; YEARLY TOTALS, ACRE-FEET; FROM DAYFLOW

WATER YEAR	CVP	SWP /1/	CONTRA COSTA CANAL	TOTAL EXPORTS CFS /1/		TOTAL EXPORTS AC-FT	TOTAL CVP+SWP AC-FT
1950	0	0	30	30		21,719	0
1951	224	0	41	265		191,851	162,169
1952	228	0	41	269		195,281	1,657,428
1953	1,076	0	48	1,124		813,739	778,988
1954	1,386	0	58	1,444		1,045,408	1,003,418
1955	1,555	0	66	1,621		1,173,550	1,125,769
1956	994	0	61	1,055		765,878	721,595
1957	1,629	0	74	1,703		1,232,916	1,179,342
1958	907	0	66	973		704,420	656,638
1959	1,844	0	95	1,939		1,403,772	1,334,995
1960	1,910	0	105	2,015		1,462,790	1,386,565
1961	2,048	0	108	2,156		1,560,873	1,482,684
1962	1,864	0	99	1,963		1,421,147	1,349,474
1963	1,847	0	86	1,933		1,399,428	1,337,167
1964	2,266	0	113	2,379		1,727,036	1,645,004
1965	2,026	0	100	2,126		1,539,154	1,466,757
1966	2,200	0	116	2,316		1,676,707	1,592,727
1967	1,729	0	99	1,828		1,323,412	1,251,739
1968	2,749	653	133	3,535		2,566,235	2,469,683
1969	2,546	1,424	107	4,077	/2/	2,951,613	2,874,149
1970	2,281	574	130	2,985		2,161,041	2,066,926
1971	2,647	1,261	104	4,012		2,904,555	2,829,263
1972	3,232	1,508	143	4,883	/3/	3,544,816	3,441,005
1973	2,549	2,096	128	4,773	/3/	3,455,494	3,362,826
1974	3,376	2,645	109	6,130		4,437,917	4,359,005
1975	3,249	2,143	109	5,501		3,982,542	3,903,630
1976	4,146	2,513	153	6,812		4,945,174	4,834,104
1977	1,769	1,101	137	3,016	/4/	2,183,484	2,077,785
1978	3,134	2,872	106	6,138	/4/	4,443,709	4,348,145
1979	3,158	3,013	126	6,297		4,558,820	4,467,600
1980	2,764	3,463	120	6,347		4,607,607	4,520,493
1981	3,602	2,908	145	6,655		4,818,000	4,713,025
1982	2,729	3,651	104	6,484		4,694,201	4,618,909
1983	3,459	2,616	110	6,185		4,477,735	4,398,099
1984	3,018	2,268	135	5,421		3,935,377	3,837,374
1985	3,854	3,700	156	7,710		5,581,785	5,468,846
1986	3,616	3,683	152	7,451	/5/	5,394,277	5,284,235
1987	3,811	3,152	180	7,143		5,171,296	5,040,982

NOTES

/1/ Does NOT include diversions from Byron-Bethany Irrigation District; DAYFLOW includes BBID in channel depletions.

/2/ Total export value different from DAYFLOW; effects of Sherman Island flooding and dewatering (MISC) NOT included.

/3/ Total export value different from DAYFLOW; effects of Andrus and Brannon islands flooding and dewatering (MISC) NOT included.

/4/ Total export value INCLUDES export (MISC) to Mokelumne Aqueduct from Middle River (9/1/77 - 1/14/88), averaged over water years (1977 = 9 CFS; 1978 = 26 CFS).

/5/ Total export value different from DAYFLOW; effects of Delta island flooding and dewatering (MISC) NOT included.

AVERAGE EXPORTS (ACRE-FEET)

YEARS	TOTAL	CVP+SWP
1950-1987	2,644,073	2,606,541
1953-1967	1,283,349	1,220,857
1953-1987	2,859,026	2,777,970
1968-1987	4,040,784	3,945,804
1979-1987	4,804,344	4,705,507

TOTAL DELTA EXPORTS (CVP, SWP, AND CCC) - CFS
1953-1987 FROM DAYFLOW

WATER YR.	YR.TYPE	APRIL	MAY	JUNE	JULY	AVG
1953	BN	1,421	2,109	2,311	2,905	2,187
1954	BN	2,052	1,371	3,001	3,293	2,429
1955	BN	2,283	2,447	3,194	3,206	2,783
1956	W	704	423	1,179	3,248	1,389
1957	BN	2,353	2,186	3,277	3,591	2,852
1958	W	152	599	772	2,931	1,114
1959	C	2,757	2,661	3,564	4,005	3,247
1960	C	2,605	2,688	3,825	4,095	3,303
1961	C	2,900	2,837	3,992	4,656	3,596
1962	AN	2,761	2,963	3,799	4,229	3,438
1963	AN	1,231	2,774	3,543	4,198	2,937
1964	D	3,065	3,261	3,795	4,619	3,685
1965	W	1,204	3,193	3,694	4,361	3,113
1966	D	3,108	3,381	4,075	4,597	3,790
1967	W	1,207	1,921	2,162	2,697	1,997
1968	C	5,380	5,611	4,708	5,168	5,217
*1969	W	3,212	3,270	2,494	3,382	3,090
1970	BN	4,653	4,012	4,997	5,227	4,722
1971	BN	4,431	4,549	5,768	6,509	5,314
*1972	D	6,356	6,495	5,350	5,074	5,819
1973	AN	3,352	6,501	7,355	7,693	6,225
1974	W	4,203	7,130	9,130	10,691	7,789
1975	W	6,304	5,583	4,520	5,184	5,398
1976	C	5,037	5,488	4,152	4,109	4,697
1977	C	1,295	2,987	739	845	1,467
1978	W	3,271	3,058	7,621	8,088	5,510
1979	AN	5,882	6,245	6,341	9,339	6,952
1980	W	5,343	4,630	5,961	6,869	5,701
1981	D	8,090	4,478	4,032	7,046	5,912
1982	W	9,603	5,994	3,935	4,032	5,891
1983	W	3,814	3,293	5,010	5,207	4,331
1984	BN	7,685	5,929	6,165	9,457	7,309
1985	D	7,342	6,215	6,530	9,465	7,388
*1986	W	4,696	6,260	6,177	8,607	6,435
1987	C	7,021	5,313	5,183	8,952	6,617

*VALUES DIFFERENT FROM DAYFLOW; DO NOT INCLUDE EFFECTS OF DELTA FLOODING AND DEWATERING

TOTAL DELTA EXPORTS (CVP, SWP, AND CCC) - CFS
YEAR TYPE SUMMARY FROM DAYFLOW

1953-1967

WATER YR.	YR.TYPE	APRIL	MAY	JUNE	JULY	AVG
AVERAGE	W(4)	817	1,534	1,952	3,309	1,903
AVERAGE	AN(2)	1,996	2,869	3,671	4,214	3,187
AVERAGE	BN(4)	2,027	2,028	2,946	3,249	2,563
AVERAGE	D(2)	3,087	3,321	3,935	4,608	3,738
AVERAGE	C(3)	2,754	2,729	3,794	4,252	3,382
GRND MEAN	15	2,136	2,496	3,259	3,926	2,954
WTDGNDMN	15	1,987	2,321	3,079	3,775	2,791

1968-1987*

WATER YR.	YR. TYPE	APRIL	MAY	JUNE	JULY	AVG
AVERAGE	W(8)	5,056	4,902	5,606	6,508	5,518
AVERAGE	AN(2)	4,617	6,373	6,848	8,516	6,589
AVERAGE	BN(3)	5,590	4,830	5,643	7,064	5,782
AVERAGE	D(3)	7,263	5,729	5,304	7,195	6,373
AVERAGE	C(4)	4,683	4,850	3,696	4,769	4,499
GRND MEAN	20	5,442	5,337	5,419	6,810	5,752
WTDGNDMN	20	5,349	5,152	5,308	6,547	5,589

1979-1987*

WATER YR.	YR. TYPE	APR	MAY	JUN	JUL	AVG
AVERAGE	W(4)	5864	5044	5271	6179	5,589
1979	AN(1)	5882	6245	6341	9339	6,952
1984	BN(1)	7685	5929	6165	9457	7,309
AVERAGE	D(2)	7716	5347	5281	8256	6,650
1987	C(1)	7021	5313	5183	8952	6,617
GRND MEAN	9	6,834	5,576	5,648	8,436	6,623
WTDGNDMN	9	6,608	5,373	5,482	7,664	6,282

1953-1987*

WATER YR.	YR.TYPE	APRIL	MAY	JUNE	JULY	AVG
AVERAGE	W(12)	3,643	3,780	4,388	5,441	4,313
AVERAGE	AN(4)	3,307	4,621	5,260	6,365	4,888
AVERAGE	BN(7)	3,554	3,229	4,102	4,884	3,942
AVERAGE	D(5)	5,592	4,766	4,756	6,160	5,319
AVERAGE	C(7)	3,856	3,941	3,738	4,547	4,020
GRND MEAN	35	3,990	4,067	4,449	5,480	4,496
WTDGNDMN	35	3,908	3,939	4,353	5,359	4,390

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GRND MEAN = AVERAGE OF ALL YEARS IN GROUP
WTDGNDMN = AVERAGE OF ALL YEARS IN GROUP WEIGHTED BY FREQUENCY OF EACH YEAR TYPE IN GROUP
* = VALUES DIFFERENT FROM DAYFLOW; DO NOT INCLUDE EFFECTS OF DELTA FLOODING AND DEWATERING IN 1969, 1972 AND 1986

CHIPPS ISLAND OUTFLOWS - CFS
1953-1987 FROM DAYFLOW

WATER YR.	YR. TYPE	APRIL	MAY	JUNE	JULY	AVG
1953	W	31,143	37,831	33,076	6,109	27,040
1954	AN	58,670	30,223	6,865	1,314	24,268
1955	BN	13,343	19,156	6,999	2,280	10,445
1956	W	40,217	59,667	35,498	8,795	36,044
1957	BN	20,480	32,732	15,581	2,427	17,805
1958	W	153,782	78,859	50,529	12,009	73,795
1959	D	11,607	7,303	1,322	2,561	5,698
1960	D	16,878	12,407	3,847	2,244	8,844
1961	D	13,397	8,580	3,541	1,672	6,798
1962	BN	27,385	18,173	10,317	2,795	14,668
1963	W	102,776	53,124	19,180	5,639	45,180
1964	D	9,187	9,784	5,302	3,185	6,865
1965	W	56,912	32,370	16,990	5,865	28,034
1966	BN	18,946	9,835	2,460	3,155	8,599
1967	W	77,685	74,550	61,265	23,864	59,341
1968	D	9,932	6,737	3,666	3,684	6,005
1969	W	69,375	64,564	46,596	13,143	48,420
1970	D	11,027	10,761	6,214	5,256	8,315
1971	W	36,983	26,406	21,218	11,654	24,065
1972	BN	7,542	5,140	2,891	6,211	5,446
1973	BN	22,191	11,699	7,211	4,599	11,425
1974	W	109,547	25,544	16,943	9,365	40,350
1975	W	34,519	28,796	22,508	11,129	24,238
1976	C	8,833	4,066	3,915	4,343	5,289
1977	C	3,083	3,999	2,521	3,212	3,204
1978	AN	61,276	40,874	9,086	3,974	28,803
1979	BN	14,485	13,435	5,326	5,384	9,658
1980	BN	28,689	20,912	14,870	11,191	18,916
1981	C	11,653	9,143	4,596	5,296	7,672
1982	W	142,203	57,876	28,515	16,849	61,361
1983	W	118,109	98,707	71,038	43,860	82,929
1984	BN	14,732	11,204	8,038	10,252	11,057
1985	D	6,913	7,378	5,215	4,934	6,110
1986	BN	46,572	15,911	9,322	7,384	19,797
1987	C	6,291	4,951	3,496	3,829	4,642

CHIPPS ISLAND OUTFLOWS - CFS
YEAR TYPE SUMMARY FROM DAYFLOW
1953-1967

WATER YR.	YR. TYPE	APRIL	MAY	JUNE	JULY	AVG
AVERAGE	W(6)	77,086	56,067	36,090	10,380	44,906
1954	AN(1)	58,670	30,223	6,865	1,314	24,268
AVERAGE	BN(4)	20,039	19,974	8,839	2,664	12,879
AVERAGE	D(4)	12,767	9,519	3,503	2,416	7,051
-	C(0)	-	-	-	-	-
GRND MEAN	15	42,140	28,946	13,824	4,193	22,276
WTDGNDMN	15	43,494	32,306	18,185	5,594	24,895

1968-1987

WATER YR.	YR. TYPE	APRIL	MAY	JUNE	JULY	AVG.
AVERAGE	W(6)	85,123	50,316	34,470	17,667	46,894
1978	AN(1)	61,276	40,874	9,086	3,974	28,803
AVERAGE	BN(6)	22,369	13,050	7,943	7,504	12,716
AVERAGE	D(3)	9,291	8,292	5,032	4,625	6,810
AVERAGE	C(4)	7,465	5,540	3,632	4,170	5,202
GRND MEAN	20	37,105	23,614	12,032	7,588	20,085
WTDGNDMN	20	38,198	23,405	14,659	9,277	21,385

1979-1987

WATER YR.	YR. TYPE	APR	MAY	JUN	JUL	AVE
AVERAGE	W(2)	129,108	77,936	50,335	30,365	71,936
-	AN(0)	-	-	-	-	-
AVERAGE	BN(4)	26,120	15,366	9,389	8,553	14,857
1985	D(1)	6,913	7,378	5,215	4,934	6,110
AVERAGE	C(2)	9,131	6,994	3,981	4,201	6,077
GRND MEAN	9	42,818	26,918	17,230	12,013	24,745
WTDGNDMN	9	43,097	26,522	16,822	12,031	24,618

1953-1987

WATER YR.	YR. TYPE	APRIL	MAY	JUNE	JULY	AVG.
AVERAGE	W(12)	81,104	53,191	35,280	14,023	45,900
AVERAGE	AN(2)	59,973	35,549	7,976	2,644	26,535
AVERAGE	BN(10)	21,437	15,820	8,302	5,568	12,781
AVERAGE	D(7)	11,277	8,993	4,158	3,362	6,948
AVERAGE	C(4)	7,465	5,540	3,632	4,170	5,202
GRND MEAN	35	36,251	23,818	11,869	5,954	19,473
WTDGNDMN	35	40,468	27,220	16,170	7,699	22,889

****
GRND MEAN = AVERAGE OF ALL YEARS IN GROUP
WTDGNDMN = AVERAGE OF ALL YEARS IN GROUP WEIGHTED BY FREQUENCY OF EACH YEAR TYPE IN GROUP

APPENDIX C

Terms, Symbols and Abbreviations

BAY-DELTA HEARING
WATER QUALITY CONTROL PLAN

GLOSSARY

WORD/PHRASE	DEFINITION
1-in-20 dry year	A statistical term refering to a water year with a total annual runoff exceeded by 95% of the water years which are likely to occur.
Acre-Foot (AF)	The quantity of water which will cover an acre of land to a depth of one foot (i.e. 43,560 cubic feet or 325,900 gallons).
Algae	Simple rootless plants that grow in bodies of water at rates in relative proportion to the amounts of nutrients available in the water or, in the case of nitrogen, in the atmosphere overlying the water body.
Anadromous	Pertaining to fish that spend part of their life cycle in the ocean and return to freshwater streams to spawn (SWRCB Order no. WQ 85-1).
Arsenic (As)	A highly poisonous metallic element. Arsenic and its compounds are used in insecticides, weed killers and industrial processes (SWRCB Order no. W.Q. 85-1).
Banks, Harvey O. Pumping Plant	The Department of Water Resources' State Water Project main deltapumping plant located West of Tracy. The source of the water in the California Aquaduct.
Basin plan	A plan for the protection of water quality prepared by a Regional Water Quality Control Board in response to the federal Clean Water Act (SWRCB Order no. W.Q. 85-1).
Bathymetry	Measurements of the differences in depth between mean lower low water and the bottom of the bay.
Beneficial uses	"Beneficial uses" of the waters of the state that may be protected against quality degradation include but are not limited to, domestic, municipal, agricultural and industrial supply; power generation; recreation; esthetic enjoyment; navigation; and preservation and enhancement of fish, wildlife, and other aquatic resources or preserves. [Cal. Water Code Sec. 13050(f)]
Benthos	The whole assemblage of plants or animals living on the bottom of a water body: distinguished from plankton.
Best management practices	A practice, or combination of practices, that is determined after ...problem assessment, examination of alternative practices, and appropriate public participation to be the most effective, practicable (including technological, economic, and institutional considerations) means of

WORD/PHRASE	DEFINITION
	preventing or reducing the amount of pollution generated by nonpoint sources to a level compatible with water quality goals. [40 CFR]
Biota	All living organisms that exist in an area.
Bloom	A proliferation of algae and/or higher aquatic plants in a body of water.
Carriage Water	The amount of Delta outflow needed to meet all of the water quality requirements of D-1485 less (minus) that needed to meet the requirements excluding those for Contra Costa Canal at Pumping Plant No. 1 (D5) and Clifton Court Forebay Intake at West Canal (C9). The quantity of additional Delta outflow (carriage water) is a function of Delta export pumping and south Delta inflow rates. It is necessary to reduce the effects of sea water intrusion into the Delta around the south side of Sherman Island (reverse flows up the San Joaquin River). This definition differs from that used by others in that it does not include additional Delta outflow which may be needed to meet certain contractual obligations of the Department of Water Resources.
Chloride (Cl)	The ionic form of the gaseous element chlorine, usually found as a metallic salt with potassium or sodium (SWRCB Order no. W.Q. 85-1).
Coagulation	A clumping of particles in water or wastewater which may result in the settling out of suspended materials. often induced by the addition of chemicals such as lime or alum, or a change in the dissolved ions in a water body such as that which occurs in an estuary when the fresh water inflow mixes with intruding seawater (i.e., in the entrapment zone).
Conservative constituent (or property)	A constituent (or property) the concentration of which is not effected by chemical or biological processes. [T,XLV,5:16-5:25]
Current flow conditions	Flow conditions as they exist at present. The factors considered when defining flow conditions include: land and water use patterns, reservoir capacities and operating rules, channel configurations, diversion point locations aand capacities, etc. Hydrologic investigations typically impose various sets of flow conditions upon the available "hydrologic record" and analyze the resultant effects. Within this Plan current flow conditions are those used by

GLOSSARY

WORD/PHRASE	DEFINITION
	the Department of Water Resources to produce the results from their 1990 level of development Operations Study (e.g., DWR Exhibit 30). The DWR Operations Study used the hydrologic record for WY 1922 through 1978.
DAYFLOW	A Department of Water Resources flow accounting model used to calculate daily Delta outflow at Chipps Island. It also estimates interior Delta flows at specified locations, and fish-related parameters and indices.
Delta	The Sacramento-San Joaquin rivers delta as defined in the California Water Code Section 12220.
Delta Channel Depletion	The diversions of Delta channel waters via pumps, siphons, and subsurface seepage onto the Delta uplands and lowlands for consumptive use by agriculture and native plants.
Dissolved oxygen (DO)	A measure of the amount of oxygen available for biochemical activity in a given amount of water. Adequate levels of DO are needed to support aquatic life. Low dissolved oxygen concentrations can result from inadequate waste treatment (Environmental Glossary 4th ed.).
Edmonston, A.D. Pumping Plant	The Department of Water Resources State Water Project (SWP) pumping plant located at the south end of the San Joaquin Valley. The prime mover for all SWP water used south of the Tehachapi Mountains, in Southern California.
Electrical Conductivity (EC)	Measures in milli- or micro- mhos, or milliSiemens per centimeter (mmhos/cm, umhos/cm or dS/cm, resp.). The ability of a particular parcel of water to conduct electricity. The EC of a water sample is an indirect measure of the total dissolved solids (TDS) or salinity levels of a water sample (i.e., the higher the EC the greater the TDS).
Entrainment	Direct entrainment occurs when fish are actually pulled along with water into a diversion structure because of strong currents created by pumps. Indirect entrainment is caused by the transport of eggs or larve into less desirable areas because of induced flows in channels surrounding diversion structures.
Entrapment Zone	An area in an estuary where suspended materials (including certain biota) accumulate. Net upstream transport of the particulate materials that settle into the bottom density current is nullified by the net downstream transport of materials in the river inflow. As a result, certain suspended materials concentrate in the area where the bottom currents are nullified (see Null Zone). [USBR,112,xi]

GLOSSARY

WORD/PHRASE	DEFINITION
Escapement	The number of adult salmon escaping harvest and returning to the spawning grounds.
Estuary	The mouth of a stream which serves as a mixing zone for fresh and ocean water. Mouths of streams which are temporarily separated from the ocean by sandbars are considered as estuaries by the SWRCB. Estuarine waters are generally considered to extend from a bay or the open ocean to a point upstream where there is no significant mixing of fresh water and seawater. Estuarine waters are considered to extend seaward if significant mixing of fresh and seawater occurs in the open coastal waters (SWRCB, Water Quality Control Policy for the Enclosed Bays and Estuaries of California, May 1974).
Evapotranspiration	The quantity of water transpired (given off) and evaporated from plant tissue and surronding soil surfaces.
Flushing	The process by which contaminant concentrations in a body of water are diluted by river inflow and, where applicable, tidal exchange of "new" uncontaminated water combined with the net advection of the contaminants away from their source by residual currents.
Food chain	The pyramidal relationship of producers (plants) and consumers (animals) by which solar energy is converted through photosynthesis to plant tissue which is consumed by animals which are in turn consumed. At each step up the food chain consumers are usually larger but fewer in number.
Fry	The stage in the life of a fish between the hatching of the egg and the absorption of the yolk sac (same as sac fry or alevin). From this stage until they attain a length of one inch the young fish are considered advanced fry. (Bell, M.C., Fisheries Handbook of Engineering Requirements and Biological Criteria, U.S. COE, 1986)
Geometric Mean	The antilogarithm of the mean of a group of logarithms of a measured variable. The geometric mean is used to transform logarithmically distributed numbers for statistical purposes. (See definitions for Logarithm and Logarithmic Distribution.)
Grab sample	A single sample taken at an instant in time to represent the conditions at that instant.
Gravitational Circulation	Net internal motions caused by horizontal density gradients. The denser fluid flows along the bottom and lighter fluid

GLOSSARY

WORD/PHRASE	DEFINITION
	along the surface in an attempt to restore a stable vertical stratification. In the case of a longitudinal salinity gradient, this produces a net landward bottom current and compensating seaward current of fresher water at the surface. Also refered to as Baroclinic Circulation. (Also see Null Zone.)
Gravitational Overturn	The formation of a lens of fresh water on the surface of an estuary during a period of high runoff. Also refered to as Gravitational Overflow. This surface layer can spread beyond the mouth of the estuary into the ocean.
Grow-out facilities	Ponds at a hatchery or pumping facility where fish are kept until they are large enough to survive on their own.
Gyre	A circular or spiral motion: whirl: revolution.
Habitat	The sum of environmental conditions in a specific place that is occupied by an organism, population, or community.
Historic Flows	Depending on the context used can mean either (i) those flows before man began influencing river flows (i.e., the Natural Flow), or (ii) the actual flows recorded during a specific period of time in the past.
Hydraulics	The branch of physics having to do with the mechanical properties of water and other liquids and with the application of these properties in engineering.
Hydrodynamics	The motion and action of water and other liquids, i.e., the dynamics of liquids, and the study thereof.
Hydrology	The science of water in nature: its properties, distribution, and behavior.
Leaching	The flushing of salts from the soil by the downward percolation of water.
Logarithm (Log)	The exponent expressing the power to which a fixed number (the base) must be raised in order to produce a given number (the antilogarithm). The most common logarithms are for the base 10. For example, 3 is the base 10 logarithm of 1,000 -- 100 is the base 10 antilogarithm of 2.
Logarithmic Distribution	The distribution of a set of observations of a variable which is limited at its lower end by zero (i.e., cannot have a value of less than zero) but is otherwise unrestrained. The logarithms of the observations of a logarithmically distributed variable are symmetrical about (i.e., 50% above

WORD/PHRASE	DEFINITION
	and 50% below) the logarithm of the geometric mean of the variable.
Logarithmic Mean (or Log Mean)	See definition of geometric mean.
Lunar Day	The time of rotation of the moon about the earth, 24.84 hours.
Manganese (Mn)	A hard, brittle, grayish white metallic element, oxidizing readily and forming an important component of certain alloys, as manganese steel. (Funk & Wagnalls Standard College Dictionary, 1973)
Marsh or marshland	A tract of low, wet, soft land; swamp; bog; morass; fen.
Natural or True Natural Flow	The embayment and channel flows which existed at the time of the first Spanish exploration of California, i.e., before the Gold Rush.
Nickel (Ni)	A hard, ductile, mallable, silver-white metallic element of the iron-cobalt group.
Nitrate	An ion composed of one atom of nitrogen bound to three atoms of oxygen. An important plant nutrient. In high concentrations, it can bind to hemoglobin resulting in methemoglobinemia. also refers to salts of the nitrate ion with other ionic substances, usually metals. (SWRCB Order No. WQ 85-1)
Non-point Source	SWRCB Definition: Any source of discharge to a surface water body that is not from a point source. [CCWD,58A,G10] EPA Definition: Causes of water pollution that are not associated with point sources, such as agricultural fertilizer runoff, or sediment from construction. Examples include (i) Agriculturally related non-point sources of pollution including runoff from manure disposal areas, and from land used for livestock and crop production; (ii) Siviculturally related non-point sources of pollution; (iii) Mine-related sources of pollution including new, current and abandoned surface and underground mine runoff; (iv) Construction activity related sources of pollution; (v) Sources of pollution from disposal on land, in wells or in subsurface excavations that affect ground and surface water quality; (vi) Salt water intrusion into rivers, lakes, estuaries and ground water resulting from reduction of fresh water flow from any cause, including

GLOSSARY

WORD/PHRASE	DEFINITION
	irrigation, obstruction, ground water extraction, and diversion; and (vii) Sources of pollution related to hydrologic modifications, including those caused by changes in the movement, flow, or circulation of any navigable waters or ground waters due to construction and operation of dams, levees, channels, or flow diversion facilities. [40 CFR]
Null Zone	The region in a partially- or well-mixed estuary where the residual bottom currents are effectively zero. Landward of this point there is a net seaward residual velocity along the bottom caused by river inflow and seaward of the null zone, gravitational circulation produces a net landward transport of denser more saline water along the bottom. The null zone is the theoretical upstream boundary of the entrapment zone.
Partially-Mixed Estuary	An estuary in which vertical mixing due to tidal currents is large enough to prevent a distinct vertical density stratification between fresh and seawater but not strong enough to completely remove any vertical variation in density. The northern reach of San Francisco Bay is typical of a partially-mixed estuary.
Piscivore	Fish eater.
Point source	SWRCB Definition: Any discernible, confined and discrete conveyance, including but not limited to any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, or vessel or other floating craft, from which pollutants are or may be discharged. [CCWD,58A,G11] EPA Definition: The same wording as the SWRCB definition with the addition of an exclusion for return flows from irrigated agriculture. [40 CFR]
Potable water	Suitable for drinking (Funk & Wagnalls Standard College Dictionary, 1973).
Progressive Wave	A tidally-driven wave which travels along an estuary. This type of wave occurs in long shallow estuaries where there is a significant frictional resistance to the tidal flow and only weak wave reflection at the head of the estuary. The tide in the northern reach of San Francisco Bay travels upstream as a progressive wave.

GLOSSARY

WORD/PHRASE	DEFINITION
Pulse Flow	A substantial increase in the flow of water followed by a decrease within a relatively short period of time.
Quality of Water	Chemical, physical, biological, bacteriological, radiological, and other properties and characteristics of water which affect its use. [Cal. Water Code Sec. 13050(h)]
Recruitment	Addition by reproduction of new individuals to a population.
Residual Current	The net transport of a particle averaged over a complete tidal cycle.
Riparian	Pertaining to the banks and other terrestial environs adjacent to water bodies, watercourses, and surface-emergent aquifers (e.g. springs, seeps, oases), whose waters provide soil moisture significantly in excess of that otherwise available through local precipitation. Vegetation typical of this environment is dependent on the availability of excess water.
Riparian wetland	A zone which may be periodically inundated by water, characterized by moist soil and associated vegetation; typically bounded on one border by a drier upland and on the other by a freshwater body (SWRCB Order no. W.Q. 85-1).
Run	To migrate, especially to move in a shoal in order to spawn (American Heritage Dictionary 4th ed.).
Salinity	The total concentration of dissolved ions in water, a conservative property (T,XLV,5:12-5:25). The salt content of a water (SWRCB Order no. W.Q. 85-1). Usually expressed as ppt (g/l), or ppm (mg/l).
Salvage	Those fish diverted away from or removed from screens at intakes to diversion structures and subsequently returned to a water body.
San Francisco Bay-Delta Estuary (the Estuary)	San Francisco Bay, the Sacramento-San Joaquin Delta and Suisun Marsh, as defined in Section 29101 of the Cal. Public Resources Code, Sections 6610 and 66611 of the Cal. Government Code, and Section 12220 of the Cal. Water Code, respectively.
Selenium (Se)	A non-metallic element chemically resembling sulfur. Essential for animals at trace concentrations, selenium is toxic to animals in deficient or excesseive dietary exposure (SWRCB Order no. W.Q. 85-1).

GLOSSARY

WORD/PHRASE	DEFINITION
Semidiurnal Tide	A tidal variation consisting of two high and two low tides per lunar day (24.84 hrs). In San Francisco Bay, the cycle typically consists of a high high followed by a low low, a low high, a high low and back to a high high tide.
Shoal	A shallow place in any body of water, or an assemblage or multitude; throng (i.e., a school of fish (Funk & Wagnalls Standard College dictionary, 1973).
Smolt	An anadromous fish that is physiologically ready to undergo the transition from fresh to salt water; age varies depending on species and environmental conditions. (Bell, M.C., 1986).
Standing Wave	A wave which does not travel so the point of maximum amplitude (crest to trough) remains fixed in space. Standing waves occur in an estuary when the resistance to the flow is small. The tide in South Bay is an example of a standing wave.
Striped bass index (SBI)	An index of the number of young bass which have survived through their first summer. Young bass are sampled with nets which are most efficient for fish about 1.5 inches in length. Sampling methods are consistent (with respect to location, frequency, technique, etc) so that the number of young striped bass caught may be compared with the catch at various locations year to year. The number of young bass caught by the standard sampling methods allows statistical treatment of data to estimate the abundance of young striped bass and to correlate changes in the number caught with changes in environmental factors. (SWRCB, Final EIR for the 1978 WQCP and D-1485, August 1978)
Subsurface agricultural drainage system	A set of tile drains, collectors and, in most cases, one or more sump pumps which are installed in a field to remove water from the root zone of any crops which may be planted. Generally installed in areas with shallow perched water tables.
Tidal Prism	The increase in water volume landward of a given cross-section from low tide to high tide. Related to the tidal volume on the ebb and flood tide and the cumulative upstream inflows.
Tile drains	A System of clay pipes installed beneath irrigated lands to artificially remove water saturating the soil of the crop root zone by gravity flow.

GLOSSARY

WORD/PHRASE	DEFINITION
Total dissolved solids (TDS)	A measure of the salinity equal to the amount of material remaining after evaporating a water sample at 103 to 105 degrees Celsius (formerly centigrade) for one hour (SWRCB Order no. W.Q. 85-1).
Tracy Pumping Plant	The U.S. Bureau of Reclamation Central Valley Project pumping plant in the Delta west of Tracy. The source of the water in the Delta-Mendota Canal.
Unimpaired Flow	The embayment and channel flows which would exist in the absence of upstream impoundments and diversions of rainfall or snowmelt runoff, but in the presence of existing channel configurations, both upstream and in the Delta.
Water Quality Control Plan	A designation or establishment for the waters within a specified area of (1) beneficial uses to be protected, (2) water quality objectives, and (3) a program of implementation needed for achieving water quality objectives. [Cal. Water Code Sec. 13050(j)]
Water Quality Objective	The measureable limits or levels of water quality constituents or characteristics which are established for the reasonable protection of beneficial uses of water or the prevention of nuisance within a specific area and time frame. Factors to be considered in establishing water quality objectives shall include, but not be limited to all of the following: (a) past, present, and probable future beneficial uses of water, (b) environmental characteristics of the hydrographic unit under consideration, including the quality of water available thereto, (c) water quality conditions that could reasonably be achieved through the coordinated control of all factors which affect water quality in the area, (d) economic considerations, and (e) the need for developing housing within the region. (California Water Code Section 13050 et seq.)
Water Quality Standard	A term used in connection with the federal Clean Water Act which is roughly equivalent to water quality objective, except that a water quality standard also includes a plan of implementation to achieve the standard.
Water rights	A form of property rights which give their holder the right to use public waters. During the history of California, a variety of procedures have been in effect by which a person could acquire a water right A summary follows:

GLOSSARY

WORD/PHRASE	DEFINITION
	Appropriative rights initiated prior to December 19, 1914 - prior to the 1914 statutes which established the present system for appropriating water (taking water and putting it to a use removed from property adjoining the water source) two methods of appropriation existed. Prior to 1872, appropriative rights could be acquired simply by taking water and putting it to beneficial use. In 1872, Sections 1410 through 1422 of the California Civil Code enacted a permissive procedure by which priority of rights could be established as of the date of posting of notice of intention to appropriate water, subject to a show of diligence in carrying out construction of diversion works and actual use of water. Appropriators who did not follow the permissive procedure had priority from the date of actually putting the water to use. Because in an appropriative water rights system, first in priority means first served by available water, considerable advantage attaches to an earlier date of appropriation.
	Appropriative rights initiated after December 19, 1914 - an appropriation of water must now comply with provisions of Part Two, Division Two of the California Water Code. The right to use water appropriated under earlier procedures as well as under the current procedure maybe lost by abandonment or non-use.
	Riparian rights - an owner of land adjoining a water source has, under common law, the right to use a share of the water available from the source. Only those parcels of land adjoining the source may be served by it under riparian right, unless a nonadjoining parcel was at one time part of a riparian parcel and the riparian right was transferred when the parcel was sold. No priority is established for riparian rights, and all riparian users must share the available supply. Riparian owners have priority of use over all appropriators.
	Prescriptive rights - rights obtained when water is taken and put to use for five years even though other rightholders' interests are damaged, if the injured parties take no action in their own defense. California Water Code Section 1225 and State Water Resources Control Board policies have made obtaining secure prescriptive rights essentially impossible since 1914 (SWRCB Order no. W.Q. 85-1).
Watershed	The land area that drains into a body of water (Environmental Glossary 4th ed.).

GLOSSARY

WORD/PHRASE	DEFINITION
Yearling	An organism that is one year old but has not completed its second year.
Young-of-year (YOY)	Fish of other organisms less than one (1) year old.

ABBREVIATIONS FOR INFORMATION SOURCES AND CITATIONS

ABBREVIATION	NAME
ACH	THE CITIES OF AVENAL, COALINGA & HURON
ACWA	AMADOR COUNTY WATER AGENCY
AHI	AQUATIC HABITAT INSTITUTE
ANTIOCH	THE CITY OF ANTIOCH
AWWA	AMERICAN WATER WORKS ASSOCIATION: CALIF.-NEV. SECTION
BAAC	BAY AREA AUDUBON COUNCIL
BADA	BAY AREA DISCHARGERS ASSOCIATION
BALIA	BAY AREA LEAGUE OF INDUSTRIAL ASSOCIATIONS
BCDC	SAN FRANCISCO BAY CONSERVATION AND DEVELOPMENT COMMISSION
BCF	BUTTE CREEK FARMS
BISF	THE BAY INSTITUTE OF SAN FRANCISCO
CBE	CITIZENS FOR A BETTER ENVIRONMENT
CCCWA	CONTRA COSTA COUNTY WATER AGENCY
CCWD	CONTRA COSTA WATER DISTRICT
CDWA	CENTRAL DELTA WATER AGENCY
CFBF	CALIFORNIA FARM BUREAU FEDERATION
CNPS	CALIFORNIA NATIVE PLANT SOCIETY
CNRF	CALIFORNIA NATURAL RESOURCES FEDERATION
COE	U. S. ARMY CORPS OF ENGINEERS
CSPA	CALIFORNIA SPORTFISHING PROTECTION ALLIANCE
CVAWU	CENTRAL VALLEY AGRICULTURAL WATER USERS
CVPWA	CENTRAL VALLEY PROJECT WATER ASSOCIATION
CWA	CALIFORNIA WATERFOWL ASSOCIATION
DAWDY	DAVID R. DAWDY
DFG	CALIFORNIA DEPARTMENT OF FISH AND GAME
DHS	CALIFORNIA DEPARTMENT OF HEALTH SERVICES
DTAC	DELTA TRIBUTARY AGENCIES COMMITTEE
DWR	CALIFORNIA DEPARTMENT OF WATER RESOURCES
EA	EA ENGINEERING, SCIENCE AND TECHNOLOGY, INC.
EBMUD	EAST BAY MUNICIPAL UTILITY DISTRICT
EBRPD	EAST BAY REGIONAL PARK DISTRICT
ECCID	EAST CONTRA COSTA IRRIGATION DISTRICT
EDF	ENVIRONMENTAL DEFENSE FUND
EPA	U.S. ENVIRONMENTAL PROTECTION AGENCY
FAO	FOOD AND AGRICULTURAL ORGANIZATION OF THE UNITED NATIONS
FDA	U.S. FOOD AND DRUG ADMINISTRATION
GDPUD	GEORGETOWN DIVIDE PUBLIC UTILITY DISTRICT
HASTINGS	HASTINGS COLLEGE OF THE LAW
JOHNSON	PETER JOHNSON
KCWA	KERN COUNTY WATER AGENCY
KINGS	KINGS COUNTY STATE WATER PROJECT AGRICULTURAL CONTRACTORS
MET	THE METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA
MID	MODESTO IRRIGATION DISTRICT
NAPA	THE CITY OF NAPA
NAS	NATIONAL ACADEMY OF SCIENCES
NDWA	NORTH DELTA WATER AGENCY
NMFS	U.S. NATIONAL MARINE FISHERIES SERVICE

NOAA	U.S. NATIONAL OCEANOGRAPHIC AND ATMOSPHERIC ADMINISTRATION
NRDC	NATURAL RESOURCES DEFENSE COUNCIL
OWD	OAKLEY WATER DISTRICT
PALMDALE	PALMDALE WATER DISTRICT
PG&E	PACIFIC GAS & ELECTRIC
PICYA	PACIFIC INTER-CLUB YACHT ASSOCIATION
PRBO	POINT REYES BIRD OBSERVATORY
QED	QED RESEARCH, INC.
RD2068	RECLAMATION DISTRICT NO. 2068
RIC	RICE INDUSTRY COMMITTEE
RWQCB_2	SAN FRANCISCO BAY REGIONAL WATER QUALITY CONTROL BOARD (REGION 2)
RWQCB_4	LOS ANGELES REGIONAL WATER QUALITY CONTROL BOARD (REGION 4)
RWQCB_5	CENTRAL VALLEY REGIONAL WATER QUALITY CONTROL BOARD (REGION 5)
RWQCB_7	COLORADO RIVER BASIN REGIONAL WATER QUALITY CONTROL BOARD (REGION 7)
RWQCB_8	SANTA ANA REGIONAL WATER QUALITY CONTROL BOARD (REGION 8)
RWQCB_9	SAN DIEGO REGIONAL WATER QUALITY CONTROL BOARD (REGION 9)
SACTO	THE CITY OF SACRAMENTO
SACTOCO	THE COUNTY OF SACRAMENTO
SAWPA	SANTA ANA WATERSHED PROJECT AUTHORITY
SCLDF	THE SIERRA CLUB LEGAL DEFENSE FUND
SDIEGO	SAN DIEGO COUNTY WATER AGENCY AND THE CITY OF
SDWA	SOUTH DELTA WATER AGENCY
SEHC	SACRAMENTO ENVIRONMENTAL HEALTH COALITION
SFBAWUA	SAN FRANCISCO BAY AREA WATER USERS ASSOCIATION
SFCC	SAN FRANCISCO COMMONWEALTH CLUB
SFEP	EPA's SAN FRANCISCO ESTUARINE PROJECT
SFRISCO	THE CITY AND COUNTY OF SAN FRANCISCO
SHELL	SHELL OIL COMPANY
SMUD	SACRAMENTO MUNICIPAL UTILITY DISTRICT
SRCD	SUISUN RESOURCE CONSERVATION DISTRICT
SRWCA	SACRAMENTO RIVER WATER CONTRACTORS ASSOCIATION
SWC	STATE WATER CONTRACTORS
SWRCB	STATE WATER RESOURCES CONTROL BOARD (STATE BOARD)
TIBCEN	THE ROMBERG TIBURON CENTER FOR ENVIRONMENTAL STUDIES
TID	TURLOCK IRRIGATION DISTRICT
TLBWSD	TULARE LAKE BASIN WATER STORAGE DISTRICT
TRACY	THE CITY OF TRACY
UAC	UNITED ANGLERS OF CALIFORNIA
USBR	U.S. BUREAU OF RECLAMATION
USDA-SCS	U.S. DEPARTMENT OF AGRICULTURE - SOIL CONSERVATION SERVICE
USFDA	U.S. FOOD AND DRUG ADMINISTRATION
USFWS	U.S. FISH AND WILDLIFE SERVICE
USGS	U.S. GEOLOGICAL SURVEY
WACOC	WATER ADVISORY COMMITTEE OF ORANGE COUNTY
WESTERN	WESTERN CONSORTIUM FOR THE HEALTH PROFESSIONS, INC.

MONITORING STATIONS

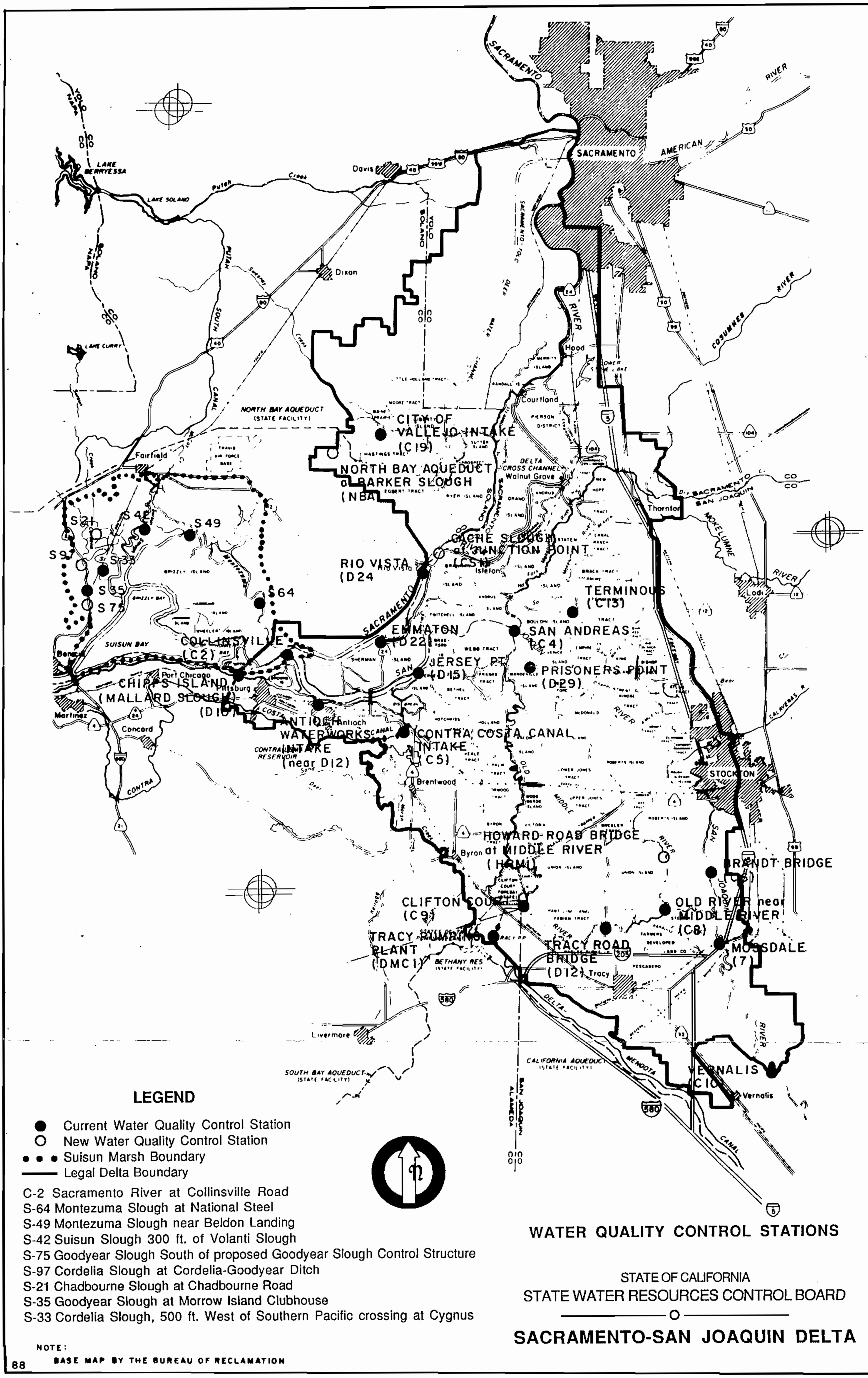
MONITORING SITE #	STATION NAME
C10	San Joaquin River near Vernalis
C13	Little Potato Slough at Terminous
C19	City of Vallejo Intake
C2	Sacramento River at Collinsville Road
C4	San Joaquin River at San Andreas Landing
C5	Contra Costa Canal at Pumping Plant #1
C6	San Joaquin River at Brandt Bridge
C7	San Joaquin River at Mossdale Bridge
C8	Old River at Middle River
C9	Clifton Court Forebay Intake at West Canal
CS1	Cache Slough at Junction Point
D10	Sacramento River @ Chipps Island
D12 (near)	Antioch Waterworks Intake on the San Joaquin River
D15	San Joaquin River at Jersey Point
D22	Sacramento River at Emmaton
D24	Sacramento River at Rio Vista Bridge
D29	San Joaquin River at Prisoner's Point
DMC1	Delta Mendota Canal @ Tracy Pumping Plant
HRM1	Middle River at Howard Road Bridge
NBA1	North Bay Aquaduct at Barker Slough
P12	Old River at Tracy Road Bridge (near Tracy)
S21 prop.	Chadbourne Slough @ Chadbourne Road (proposed)
S33	Cordelia Slough 500 ft West of Southern Pacific Crossing at Cygnus
S35	Goodyear Slough at Morrow Island Clubhouse
S42	Suisun Slough 300 ft South of Volanti Slough
S49	Montezuma Slough near Beldon Landing
S64	Montezuma Slough at National Steel
S75 prop.	Goodyear Slough South of Goodyear Slough Control Structure (proposed)
S97 prop.	Cordelia Slough at Cordelia-Goodyear Ditch (proposed)

LIST OF SYMBOLS AND ABBREVIATIONS

SYMBOL/ ABBREVIATION	DEFINITION
AF	Acre-Foot = 43,560 cubic feet = 325,900 gallons
As	Arsenic
BOD	Biochemical oxygen demand
CFR	U.S. Code of Federal Regulations
COD	Chemical oxygen demand
CVP	Central Valley Project
Cl-	Chloride ion
D-1485	SWRCB Water Rights Decision 1485
DMC	Delta-Mendota Canal
DO	Dissolved oxygen
DOI	Delta outflow index
EC	Electrical conductivity
Estuary	San Francisco Bay-Delta Estuary
FSA(s)	Flow study area(s)
MAF	Million acre feet
MGD	Million(s of) gallons per day
MLLW	Mean lower low water
Mn	Manganese
Ni	Nickel
PPD	Pollutant Policy Document
SBI	Striped bass index
SWP	State Water Project
Se	Selenium
TAF	Thousand acre feet
TDS	Total dissolved (filterable) solids
THM	Trihalomethane
WQCP	Water Quality Control Plan
WY	Water year (October 1 through September 30)
YOY	Young-of-year
ac	Acre = 43,560 square feet
cfs	Cubic feet per second = 448.8 gallons per minute = 1.983 acre-feet per day
ft	Foot or feet
g/l	Grams per liter
gpcd	Gallons per capita per day
hr(s)	Hour(s)
lb	Pound
m	Meter or meters = 3.28 feet
mg/l	Milligrams per liter
mmhos/cm	Millimhos per centimeter (a measure of electrical conductivity)
ppb	Parts per billion (approximately equal to ug/l)
ppm	Parts per million (approximately equal to mg/l)
ppt	Parts per thousand (approximately equal to g/l)
sq. ft.	Square foot or feet
sq. mi.	Square mile = 640 acres = 259 hectares
ug/l	Micrograms per liter
umhos/cm	Micromhos per centimeter

APPENDIX D

Map of Water Quality Control Stations



LEGEND

- ● Current Water Quality Control Station
- ○ New Water Quality Control Station
- • • • Suisun Marsh Boundary
- —— Legal Delta Boundary

C-2 Sacramento River at Collinsville Road
S-64 Montezuma Slough at National Steel
S-49 Montezuma Slough near Beldon Landing
S-42 Suisun Slough 300 ft. of Volanti Slough
S-75 Goodyear Slough South of proposed Goodyear Slough Control Structure
S-97 Cordelia Slough at Cordelia-Goodyear Ditch
S-21 Chadbourne Slough at Chadbourne Road
S-35 Goodyear Slough at Morrow Island Clubhouse
S-33 Cordelia Slough, 500 ft. West of Southern Pacific crossing at Cygnus

NOTE:
BASE MAP BY THE BUREAU OF RECLAMATION

WATER QUALITY CONTROL STATIONS

STATE OF CALIFORNIA
STATE WATER RESOURCES CONTROL BOARD

SACRAMENTO-SAN JOAQUIN DELTA