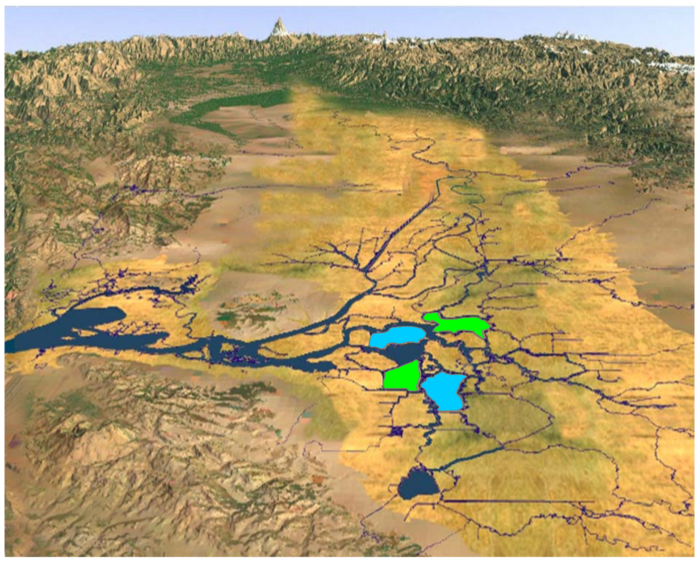
INTEGRATED STORAGE INVESTIGATIONS

IN-DELTA STORAGE PROGRAM
STATE FEASIBILITY STUDY
DRAFT REPORT ON WATER QUALITY



CALIFORNIA BAY-DELTA AUTHORITY

DEPARTMENT OF WATER RESOURCES STATE OF CALIFORNIA

Division of Planning and Local Assistance
Department of Water Resources

December 2003

ORGANIZATION

FOREWORD

We acknowledge the technical assistance provided by Reclamation in carrying out the role of federal lead agency for the CALFED Integrated Storage Investigations. Reclamation will continue to provide technical assistance through the review of the State Feasibility Study reports and DWR will work with Reclamation to incorporate comments and recommendations in the final reports.

State of California
Arnold Schwarzenegger, Governor

The Resources Agency
Mike Chrisman, Secretary for Resources

California Bay-Delta Authority	**Department of Water Resources**	
Patrick Wright, Director	Linda Adams, Director	Stephen Verigin, Acting Chief Deputy Director
Wendy Halverson-Martin, Chief Deputy Director	Jonas Minton, Deputy Director	Tom Glover, Deputy Director
	Lucinda Chipponeri, Deputy Director	Peggy Bernardy, Chief Counsel
	Mark Cowin, Chief, Division of Planning and Local Assistance	

This report was prepared under the direction of

Division of Planning and Local Assistance
Stephen S. Roberts, Chief
Surface Storage Investigations Branch
Tirath Pal Sandhu, Project Manager
In-Delta Storage Program

With Major Contributions from

Engineering Investigations Team
Jeremy Arrich, Senior Engineer, WR
Ganesh Pandey, Engineer WR
Amarjot Bindra, Engineer WR
Dainny Nguyen, Engineer WR
Cosme Diaz, Supervising Engineer WR
Mike Driller, Senior Engineer WR
Jasmine Doan, Engineer WR
John Meininger, Engineer Mechanical

Environmental Evaluations Team
Leslie Pierce, Senior Environmental Scientist
Robert DuVall, Environmental Scientist
John Robles, Environmental Scientist
Russell Stein, Senior Environmental Scientist
Jerry Ripperda, Senior Environmental Scientist
Derrick Adachi, Senior Environmental Scientist
Janis Offermann, Senior Environmental Planner
Laura Patterson, Environmental Scientist

Robert Moore, Engineer Electrical
Brent Lamkin, Engineering Geologist
Frank Dubar, Retired Annuitant
McDonald, Chief Contracts Section

Mike Bradbury, Staff Environmental Scientist
James Gleim, Environmental Scientist
Beth Hedrickson, Environmental Scientist
Harry Spanglet, Environmental Scientist
Chuck Vogelsang, Senior Env. Scientist

Operation Studies Team
Sushil Arora, Chief, Hydrology & Operations
Dan Easton, Engineer WR
Amarjot Bindra, Engineer WR
Jeremy Arrich, Senior Engineer WR
Sean Sou, Supervising Engineer WR
Ryan Wilbur, Engineer WR
Mike Moncrief, Engineer WR
Ganesh Pandey, Engineer WR

Water Quality Investigations Team
Tara Smith, Chief, Delta Modeling Section
Parviz Nader-Tehrani, Senior Engineer WR
Robert DuVall, Environmental Scientist
Ganesh Pandey, Engineer WR
Michael Mierzwa, Engineer WR
Hari Rajbhandari, Senior Engineer WR
Richard S. Breuer, Senior Env. Specialist
Philip Wendt, Chief Water Quality
Dan Otis, Environmental Program Manager
Bob Suits, Senior Engineer WR

Economic Analyses Team
Ray Hoagland, Chief, Economic Analysis
Farhad Farnam, Research Program Specialist II
Jim Rich, Research Program Specialist
Richard Le, Retired Annuitant
Amarjot Bindra, Engineer WR
Leslie Pierce, Senior Environmental Scientist

Policy and Legal
Cathy Crothers, Legal Counsel

Consultants
URS Corporation   CH2M HILL   MBK Engineers   Saracino-Kirby-Snow   Flow Science Inc.

***Additional Technical Assistance Provided by**

U.S. Fish and Wildlife Service
Ryan Olah, Environmental

California Department of Fish and Game
Jim Starr, Senior Biologist
Laurie Briden, Senior Biologist
Julie Niceswanger, Biologist

Table of Contents

List of Tables

List of Figures

List of Plates

Chapter 1: GENERAL

1.1 Introduction

The CALFED Record of Decision (ROD) identifies five surface water storage projects: Enlarged Shasta, Los Vaqueros, Sites Reservoir, 250 to 700 TAF of additional storage in the upper San Joaquin River watershed and In-Delta Storage. The purposes of new storage in the Delta are to increase operational flexibility for the Central Valley Project (CVP) and the State Water Project (SWP) and to provide ecosystem benefits in the Delta. The ROD includes an option to explore the lease or purchase of the Delta Wetlands (DW) Project, a private, In-Delta storage proposal by DW Properties. The ROD also provides the option to initiate a new project, in the event that the DW Project proves cost prohibitive or infeasible.

In 2001, the California Department of Water Resources, Bay-Delta Agencies (formerly CALFED agencies) and the U.S Bureau of Reclamation began a joint planning study to evaluate the DW Project and other In-Delta storage options. The joint planning study, completed in May 2002, concluded that the project concepts proposed by DW were generally well planned. However, project modifications and evaluations were needed to make the project acceptable for public ownership. The DW project has since been revised and studied as the In-Delta Storage Project. Additional information on In-Delta Storage are available at http://www.isi.water.ca.gov/ssi/indelta/index.shtml

The In-Delta Storage Project consists of developing Webb Tract and Bacon Island as reservoir islands. To mitigate the environmental impacts caused by the proposed project, Holland Tract and Bouldin Island will be developed as habitat islands. The locations of the project and habitat islands in the San Joaquin-Sacramento Island Delta are shown in Figure 1.1. Water will be diverted to the In-Delta Storage reservoirs during the winter months when flows are high and released back to Delta channels during the summer months when demand is high and flows are low.

The project islands soil is predominantly from carbon-rich peat and during the storage period it is expected that leaching of organic carbon (OC) from this soil together with biological productivity could increase OC loads in the reservoirs. Because of the proximity of the project to urban intakes, total organic carbon (TOC) and other water quality standards like Chloride, Bromate, Trihalomethane and Water Temperature could be impacted by reservoir releases. Thus, estimates for OC concentrations and other water quality measures of the stored water and the impacts of the released water at the urban intakes and Delta channels are keys to assessing the viability of the project. This report summarizes the findings of a series of numerical and experimental studies intended to assess the impacts of In-Delta Storage projects in the Delta water quality.

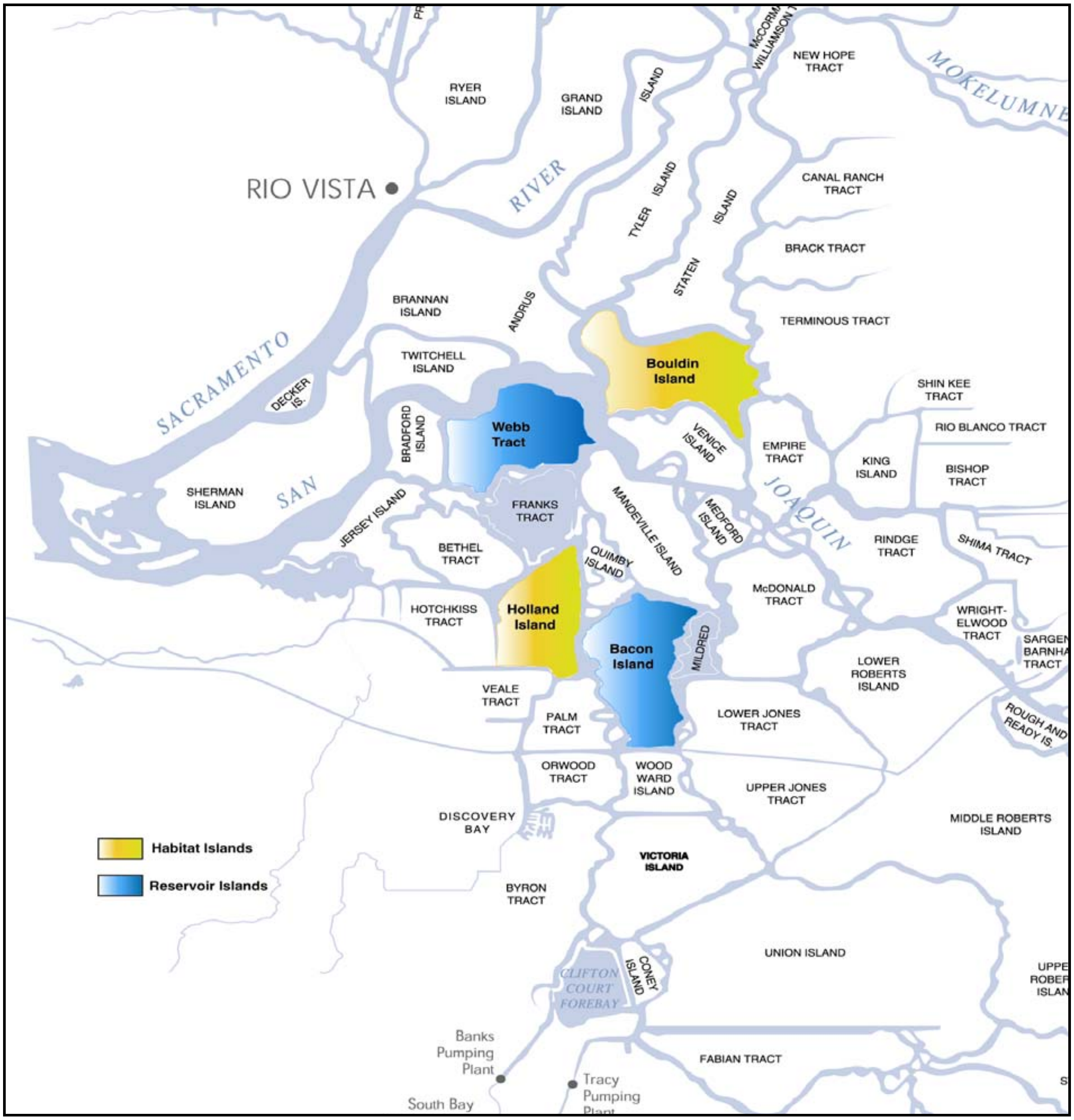


Figure 1.1: Proposed Habitat and Reservoir Islands for In-Delta Storage Project

1.2 Water Quality Requirements

The water quality requirements for the DW Project are set forth in SWRCB Decision 1643 (D1643) as agreed by DW Properties and the California Urban Water Agencies (CUWA). The ISI operations must be carried out such that the guidelines outlined in Water Quality Management Plan (D1641) and D1643 are not violated.

1.2.1 General Requirements

Discharges of water from the project shall not cause: (1) an exceedance of any applicable water quality objective in a water quality control plan adopted by the SWRCB or by the RWQCB; (2) any recipient water treatment plant to exceed the maximum contaminant levels for disinfection byproducts as set forth by EPA in Title 40, Section 141.12 & 141.30. The regulated classes of disinfection byproducts are trihalomethanes, haloacetic acids, chloride, and bromate (SWRCB, condition 14.a.). For the purpose of determining that the Project has caused an exceedance of one or more of the operational screen criteria, an uncertainty of ±5% of the screening criteria will be assumed.

1.2.2 Long-Term Requirement

The Project is required to mitigate 150% of the net increase in TOC and salt (i.e. TDS, bromide and chloride) loading greater than 5% in the urban diversions due to Project operations.

1.2.3 Total Organic Carbon

The project operation shall not cause or contribute to total organic carbon (TOC) concentrations that will violate either criterion:

- Increase in TOC concentration at a SWP, CVP, CCWD pumping plant, or at a receiving water treatment plant that will cause the limit of 4.0 mg/L to be exceeded;
- Incremental increase in TOC concentration at a SWP, CVP, or CCWD pumping plant of greater than 1.0 mg/L (14-day average) (SWRCB, condition 14.b).

In this study DOC was used as a surrogate for TOC.

1.2.4 Chloride

Chloride concentration shall not:

- Increase more than 10 mg/L chloride concentration at any of CCWD's intakes
- Cause any increase in salinity of more than 10 mg/L chloride (14-day running average salinity) at any urban intake in the Delta
- Cause or contribute to any salinity increase at one or more urban intake in the Delta if the intake is exceeding 90% of an adopted salinity standard (Rock Slough chlorine standard defined in SWRCB Decision 1641) (SWRCB, condition 14.c.)

1.2.5 Disinfection Byproducts

The Project operations will be curtailed, rescheduled, or constrained to prevent impacts on drinking water quality at any water treatment plant receiving water from the Delta based on the following WQMP screening criteria:

- Modeled or predicted Total Trihalomethanes (TTHM) concentrations in drinking water in excess of 64 µg/L as calculated in the raw water of an urban intake in the Delta or at the outlet of a water treatment plant.
- Modeled or predicted Bromate concentrations in drinking water in excess of 8 µg/L as calculated in the raw water of an urban intake in the Delta or at the outlet of a water treatment plant.

1.2.6 Dissolved Oxygen (DO)

No discharge of stored water would be allowed if the DO of stored water:

- Is less than 6.0 mg/L, or
- Causes the level of DO in the adjacent Delta channel to be depressed to less than 5.0 mg/L, or
- Depresses the DO in the San Joaquin River between Turner Cut and Stockton to less than 6.0 mg/L September through November. (SWRCB, condition 19.a.)

1.2.7 Temperature

No discharge of stored water would be allowed if:

- The temperature differential between the discharged water and receiving water is greater than 20º F,
- If the discharged water causes an increase in the temperature of channel water by more than:
  - 4º F when the temperature of channel water ranges from 55º F to 66º F
  - 2º F when the temperature of channel water ranges from 66º F to 77º F
  - 1º F when the temperature of channel water is 77º F or higher (SWRCB, 20.b)

1.3 Scope of Work

1.3.1 Modeling Studies

The Delta Simulation Model (DSM2) was used to assess the impacts of the In-Delta Storage reservoirs on Delta water quality in channels and at urban intakes. The following work was done as part of the modeling studies.

- Revise the organic carbon growth algorithm in DSM2 to address carbon loading from peat soils and biological productivity.
- Revise estimates for likely organic carbon concentrations in storage water in comparison to the base No Action condition.
- Create dispersion rules for CALSIM II recirculation studies and check final reservoir DOC at the urban intakes for the final CALSIM II run.
- Compare water quality constituents under base No Action conditions with In-Delta Storage Project operations under D1643 and WQMP.
- Provide input to Reservoir Stratification studies.

1.3.2 Water Quality Field Investigations

The following work was done as part of the field investigations to estimate the organic carbon loading from peat soils and biological productivity on the reservoir islands.

- Review literature on organic carbon loading in the Delta for information that may be applicable to In-Delta Storage project.
- Evaluate likely DOC concentrations and loads expected in the stored water using mesocosms or physical models of the proposed reservoir islands.
- Integrate results from filed studies with mathematical models of the proposed reservoir islands.

1.3.3 Temperature and Stratification Modeling

The DYRSEM model study was conducted by the Flow Science Inc., and the study period covered three representative years (dry, normal and wet) for different project operation scenarios. The DYRSEM model study focused on the following issues.

- Develop meteorological data sets for the reservoir islands.
- Determine if the reservoir islands will stratify using the one-dimensional DYRESM model.
- Quantify likely water temperatures for the reservoir islands and discuss potential changes in channel temperature resulting from reservoir discharge.

A report by Flow Science Inc. outlining the detailed methodology, assumptions and results of the DYRSEM model studies of the In-Delta storage islands is given in Appendix C.

1.4 Organization of Report

This report has four sections and one appendix. This section is organized to present general information including the overview of the project and scope of the work. Methodology and findings of the DSM2 model studies of water quality parameters are given in Chapter 2. Chapter 3 provides the details of the Water Quality Field Investigations. DO and temperature modeling study results are given in Chapter 4. Conclusions of the study and recommendations are given at the end of each chapter. Consultant's report on stratification of the reservoir islands are given in the appendix.

Chapter 2: WATER QUALITY MODELING STUDIES

2.1 Overview

Three DSM2 daily time step 16-year planning studies were run in HYDRO and QUAL based on the proposed operations for the IDS project islands: Webb Tract and Bacon Island. The Delta inflows, exports and island operations used in these studies were provided from the CALSIM II Daily Operations Model (DOM). A basic description of the DSM2 / CALSIM II scenarios is listed in Table 2.1.1.

Table 2.1.1: Summary of DSM2 Studies.

Study	*Basic Study Objective*	*CALSIM II Operational Constraints*
Study 1	No Action Base	D1641
Study 4[1]	Water Supply / EWA / ERP	D1641 / D1643 / EWA & ERP
Study 4b	DOC Resolution Through Circulation	Study 4 with DOC Constraints

1. Study 4 was used to develop fingerprinting results, but no water quality results from study 4 will be presented.

All three studies were based on separate CALSIM II runs. However, CALSIM II's study 4b includes information from DSM2's study 1 and study 4. The interaction between CALSIM II and DSM2 is illustrated in Figure 2.1.1. Study 1 provided the base line DOC concentrations at the urban intakes. Study 4 used fingerprinting information to provide the project island volume - flow relationships that were integrated into CALSIM II in order to constrain project releases to meet the DOC standards consistent with the State Water Resources Control Board (SWRCB) water rights decision D1643. Due to time constraints, study 4 was not used to analyze DOC or EC based on the study 4 CALSIM II operations.

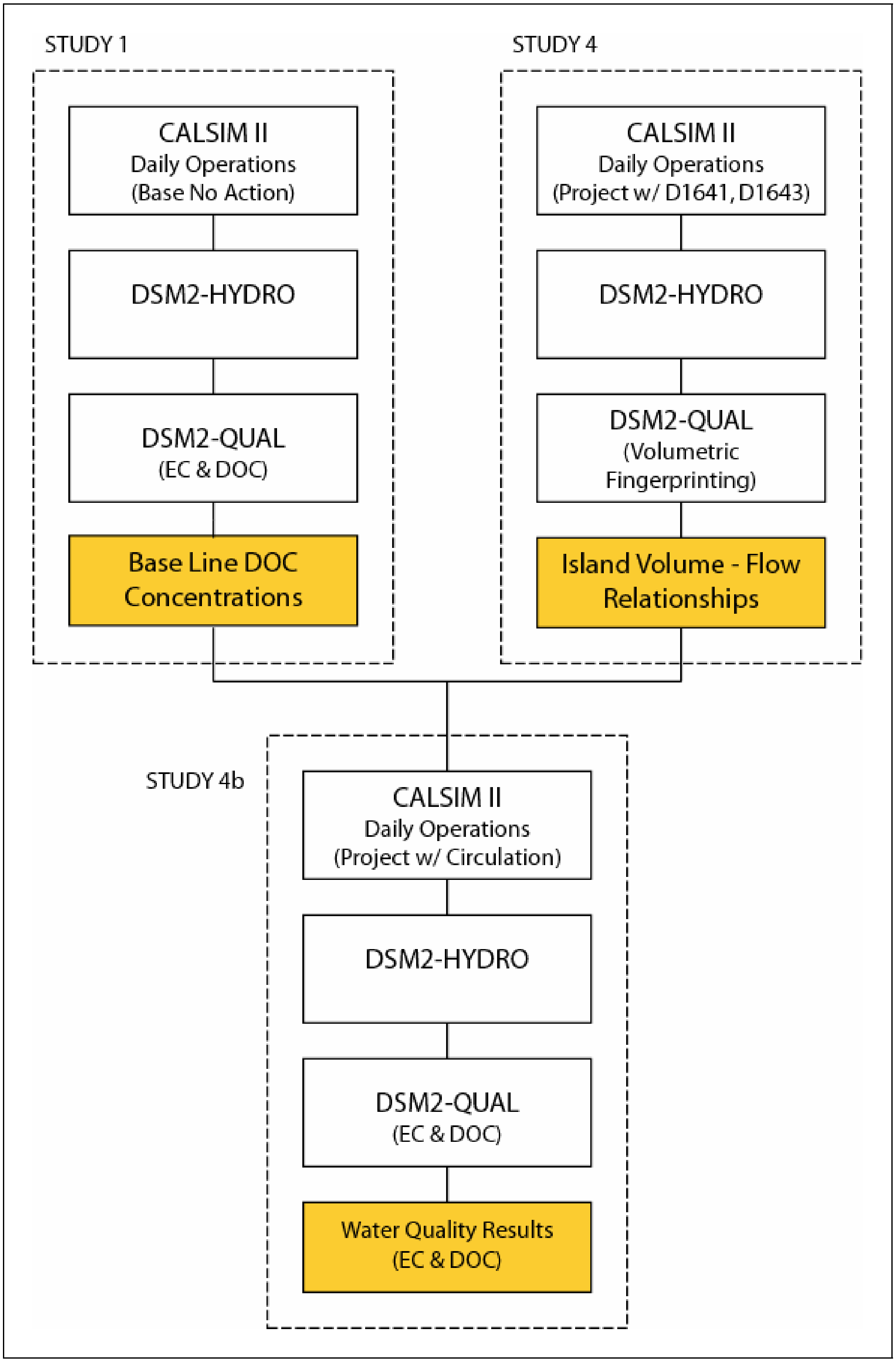


Figure 2.1.1: Study Methodology.

2.2 Delta Hydrodynamics

The major tributary flows, exports, diversions, and operations of the gates and barriers in the Delta affect the hydrodynamics in the Delta. Understanding these hydrodynamics is essential when examining the water quality for any Delta location. The Delta hydrodynamics for all three studies are summarized below. (NOTE: for information related to the operation of the project islands in study 4 and study 4b, see *Section 2.4*.)

2.2.1 Sacramento River and San Joaquin River Inflows

Time series illustrating both the daily average and change in daily average flows (alternative – study 1) for the Sacramento and San Joaquin rivers are shown below. All of the CALSIM II simulations were based on the same hydrology and 2020 level of development demands. The difference between the base and alternative flows and exports was based on how CALSIM II chose to operate the entire system.

For both rivers, the change in daily average flow was calculated as the difference of the base case flow from the alternative. Positive values correspond to periods when the alternative flow was higher than the base case flow. Negative values correspond to periods when the base case flow was higher.

2.2.1.1 Sacramento River

The monthly average difference in Sacramento River Flows for both alternatives (study 4 and study 4b) is shown in Figure 2.2.1. The largest changes in Sacramento flow in April (an increase in Sacramento River flows in the alternatives) and July (a decrease in Sacramento River flows in the alternatives). Since July is a typical project island release month (see *Section 2.4.2.1* for more information about project releases and diversions), this change in Sacramento inflows to the Delta is likely the result of the availability of IDS water to meet SWP and CVP demands.

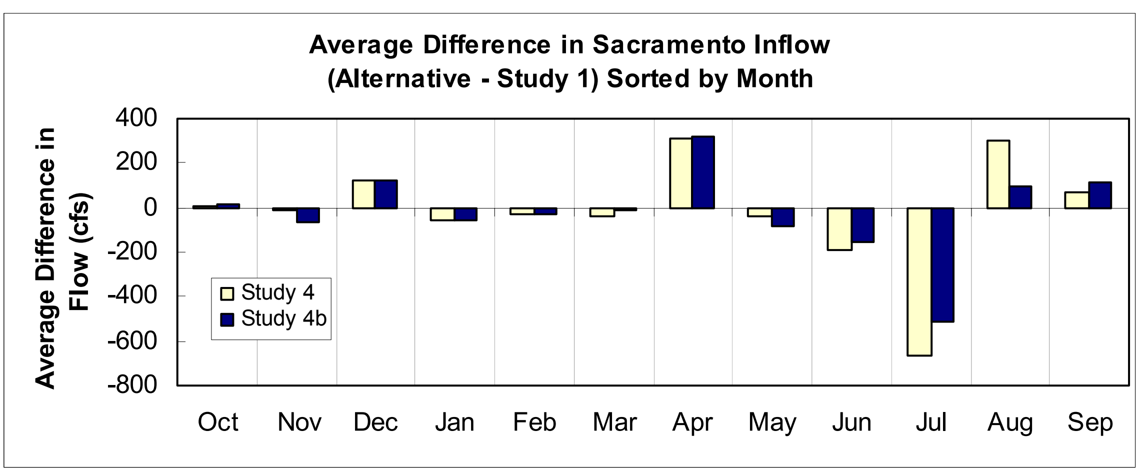


Figure 2.2.1: Difference in Sacramento River Flows (Alternative – Study 1) Stored By Month.

The daily average flows on the Sacramento River (Figure 2.2.2) are highly varied over the course of the 16-year study. The changes in these daily flows due to the operation of the IDS project is illustrated in Figure 2.2.3.

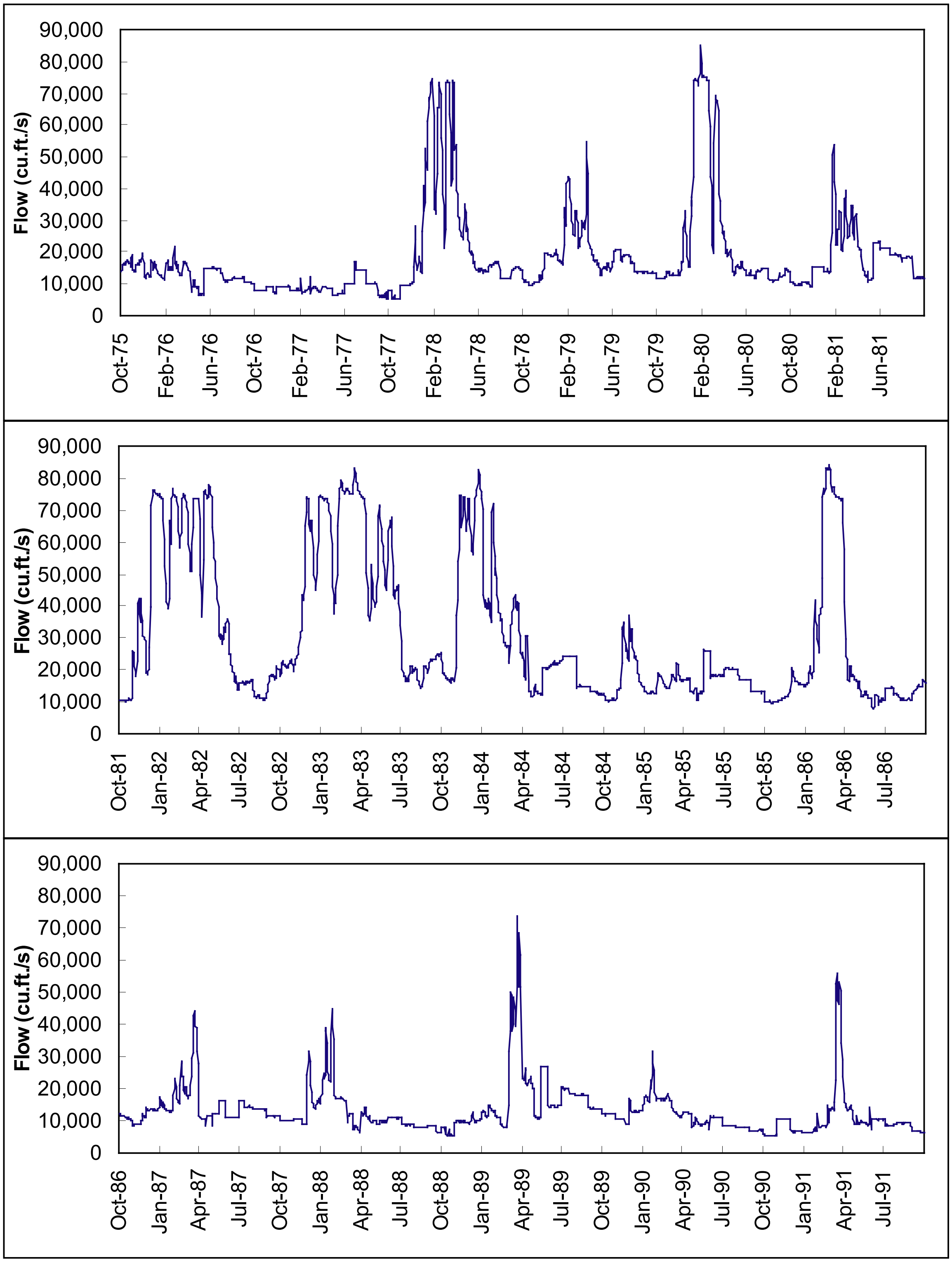


Figure 2.2.2: Daily Average Flow on the Sacramento River for Study 1 (Base).

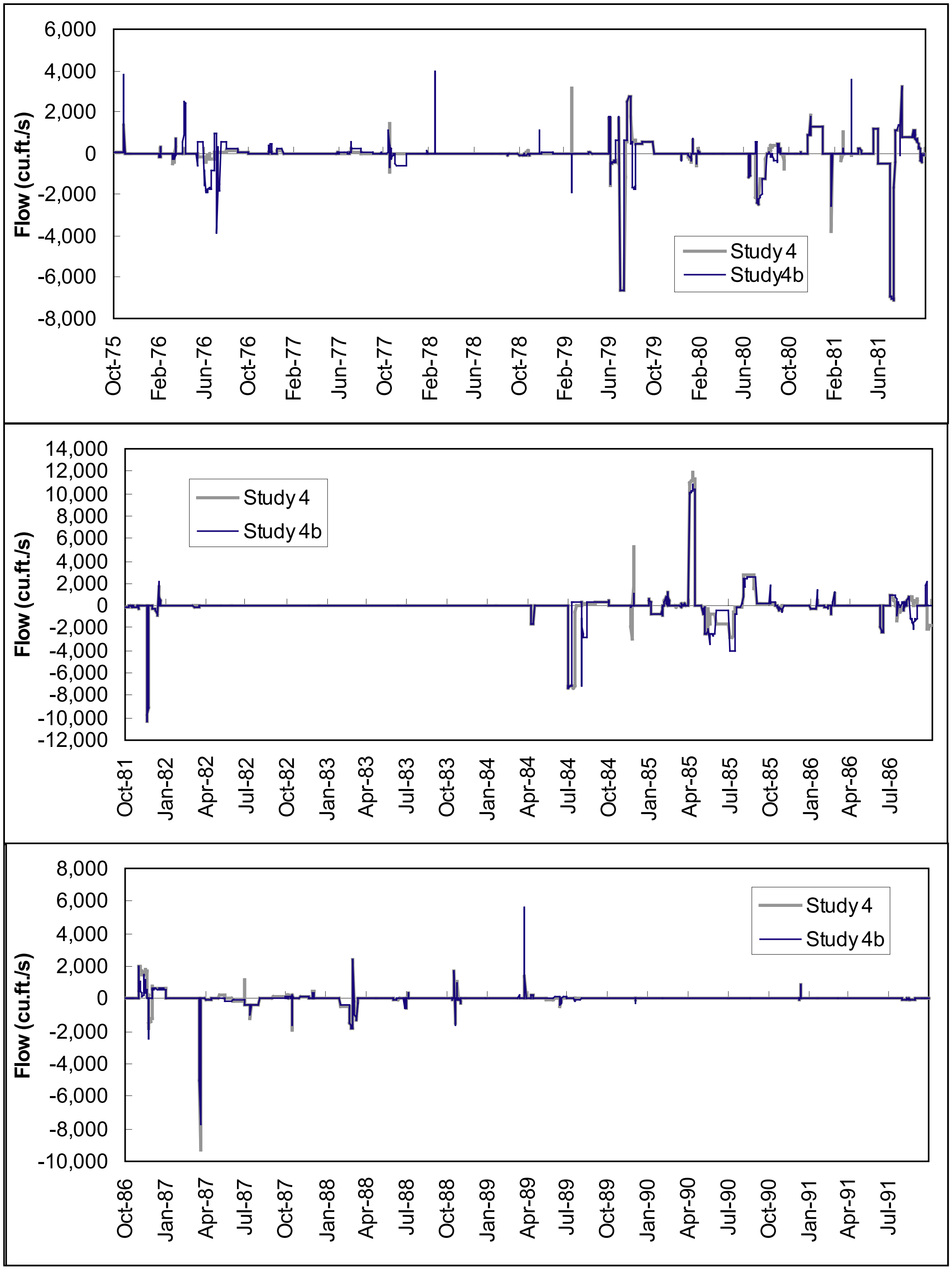


Figure 2.2.3: Change in Daily Average Flow on the Sacramento River due to Study 4 and Study 4b.

2.2.1.2 San Joaquin River

The daily San Joaquin River flows were used to determine the operation of the South Delta barriers (see *Section 2.2.4*). The daily average flows provided by CALSIM II's DOM were calculated by distributing the CALSIM II monthly average flows to a daily pattern based on historical observations.

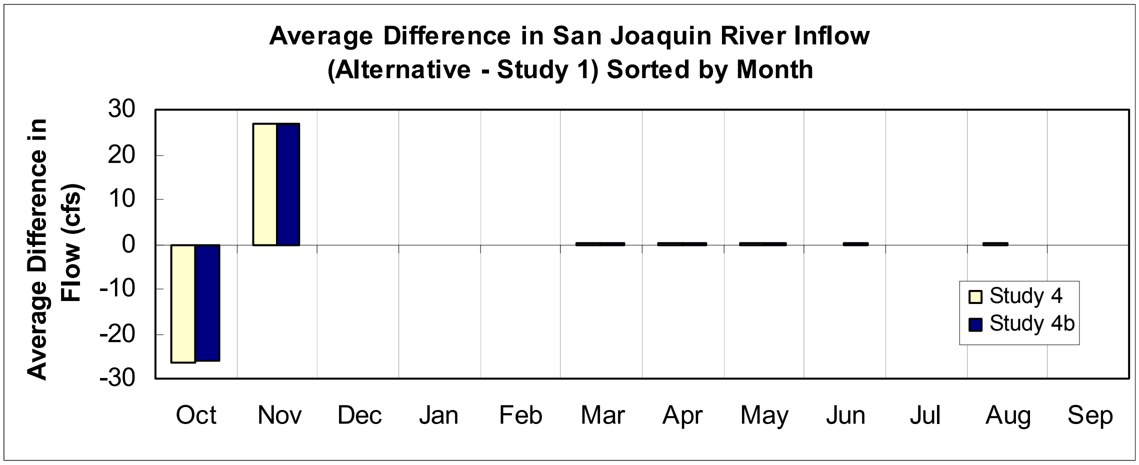


Figure 2.2.4: Difference in San Joaquin River Flows (Alternative – Study 1) Stored By Month.

The daily average flows on the San Joaquin (Figure 2.2.5) are seasonally varied over the course of the 16-year study. As shown in Figure 2.2.6, the changes in the San Joaquin flows by either alternative (study 4 or study 4b) from the base case flows are relatively insignificant. The only major change, a 400 cfs change, occurred in the Fall of 1982, and was consistent between both studies.

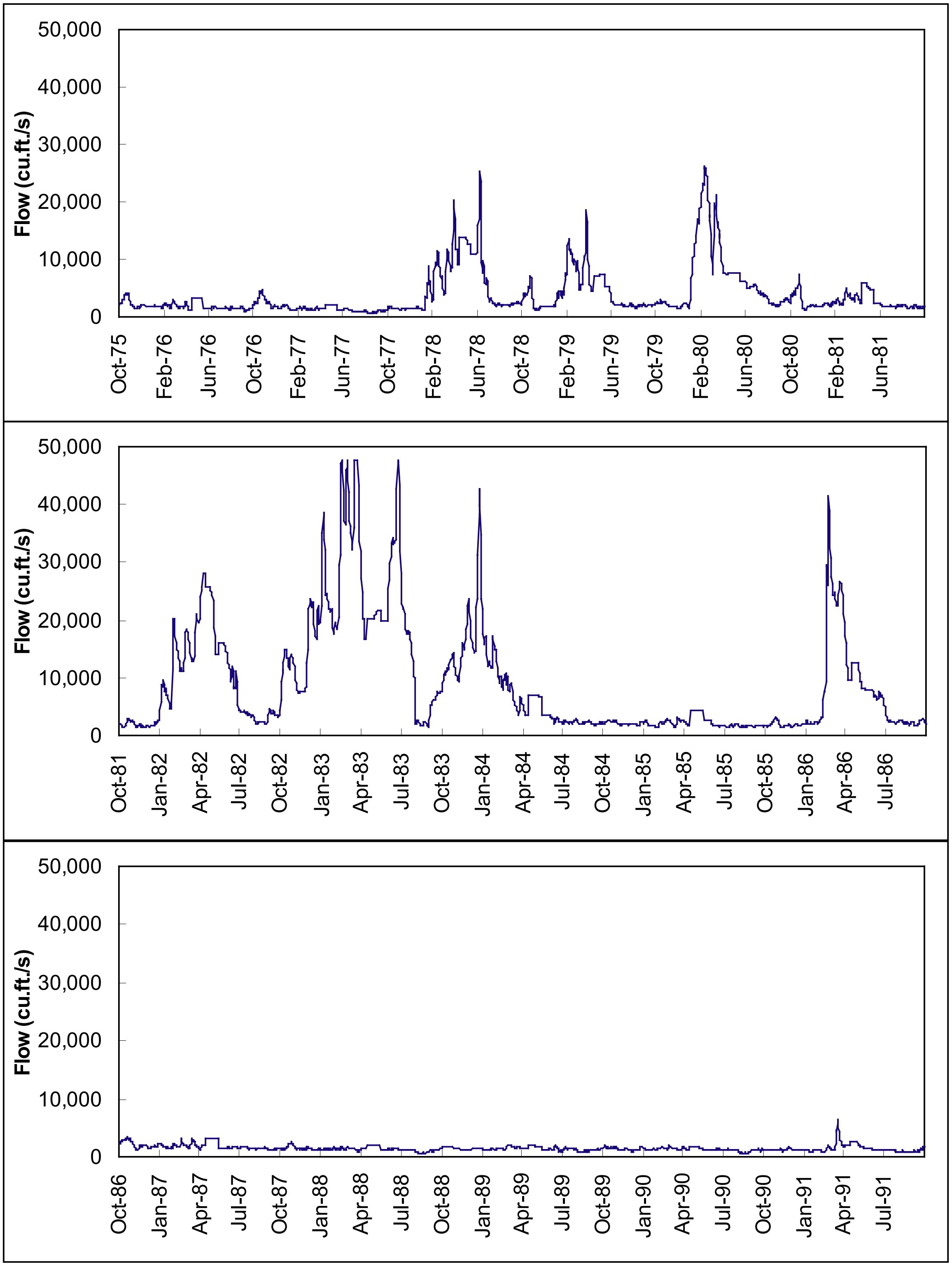


Figure 2.2.5: Daily Average Flow on the San Joaquin River for Study 1 (Base).

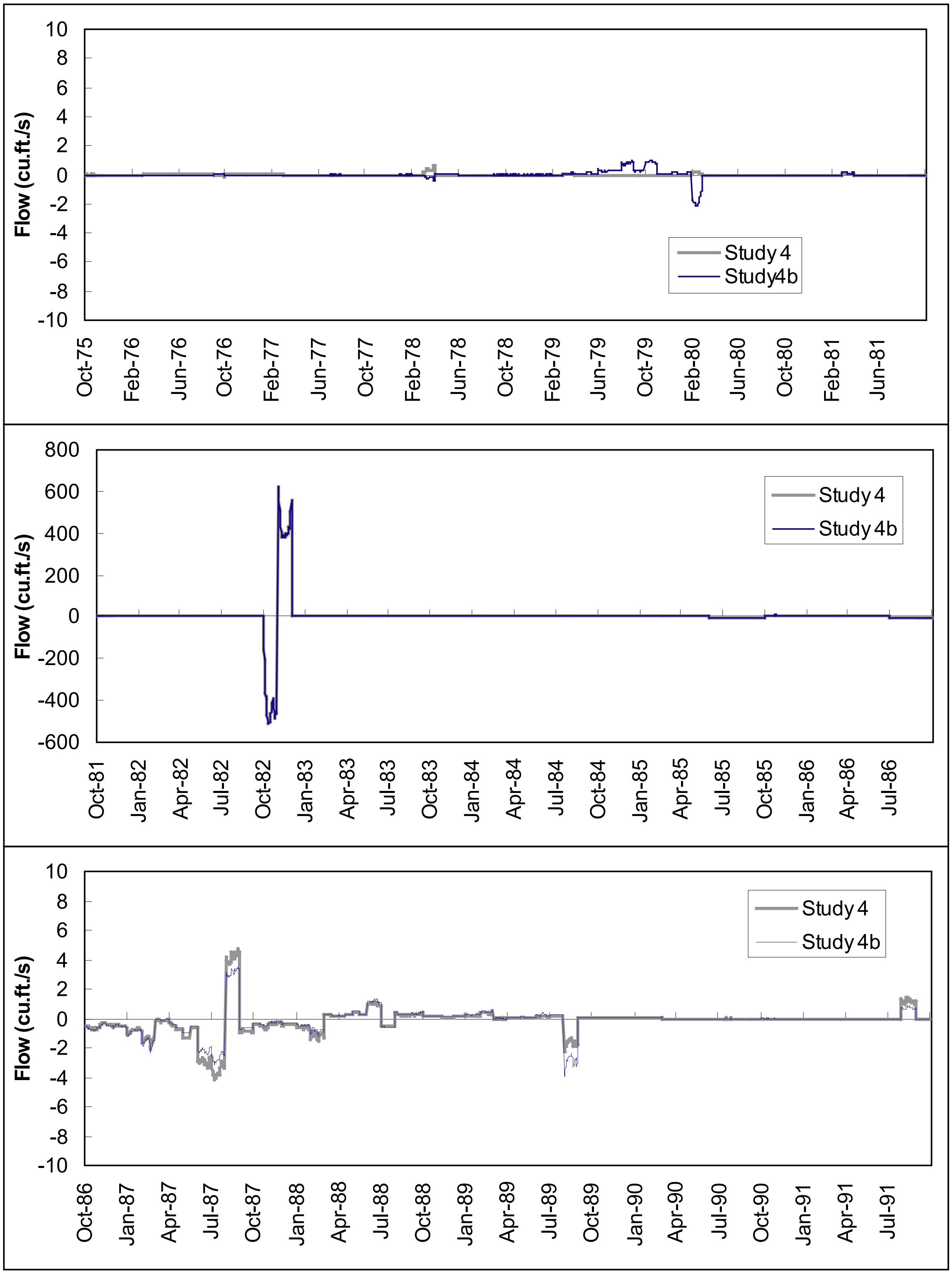


Figure 2.2.6: Change in Daily Average Flow on the San Joaquin River due to Study 4 and Study 4b.

2.2.2 Combined Exports

In addition to diversions and releases from the IDS islands (see *Section 2.4.2*), changes in the amount and timing of both the SWP and CVP exports have a significant impact on the flow patterns in the Delta. A net increase in SWP and CVP exports was expected, since the primary objective of the project was to increase SWP and CVP project storage. As shown below in Figure 2.2.7, the most significant increases in the exports occurred in July and August.

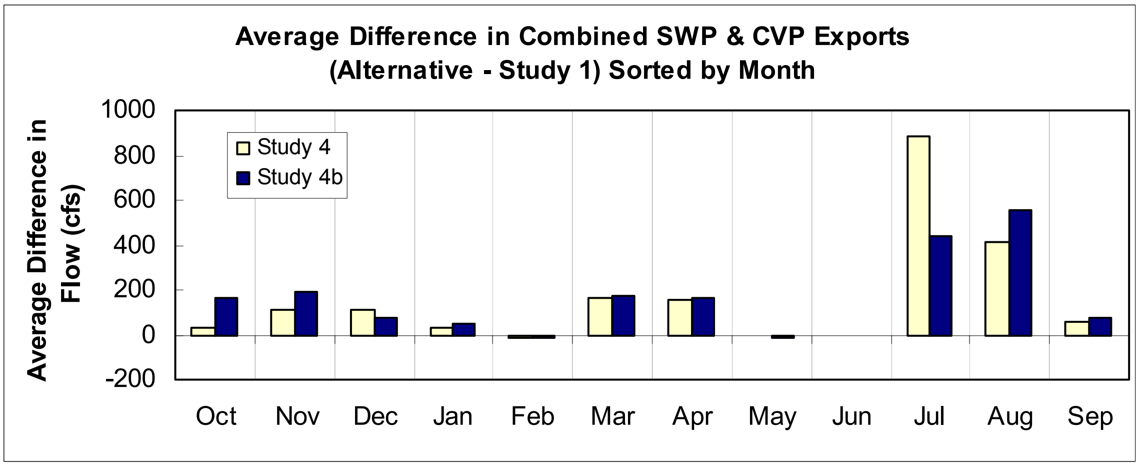


Figure 2.2.7: Difference in Combined SWP and CVP Exports (Alternative – Study 1) Stored By Month.

The daily averaged combined SWP and CVP exports for study 1 during the entire 16-year simulation are shown in Figure 2.2.8. The time series of the change in the combined SWP and CVP exports due to the operation of the project in both alternatives is shown in Figure 2.2.9.

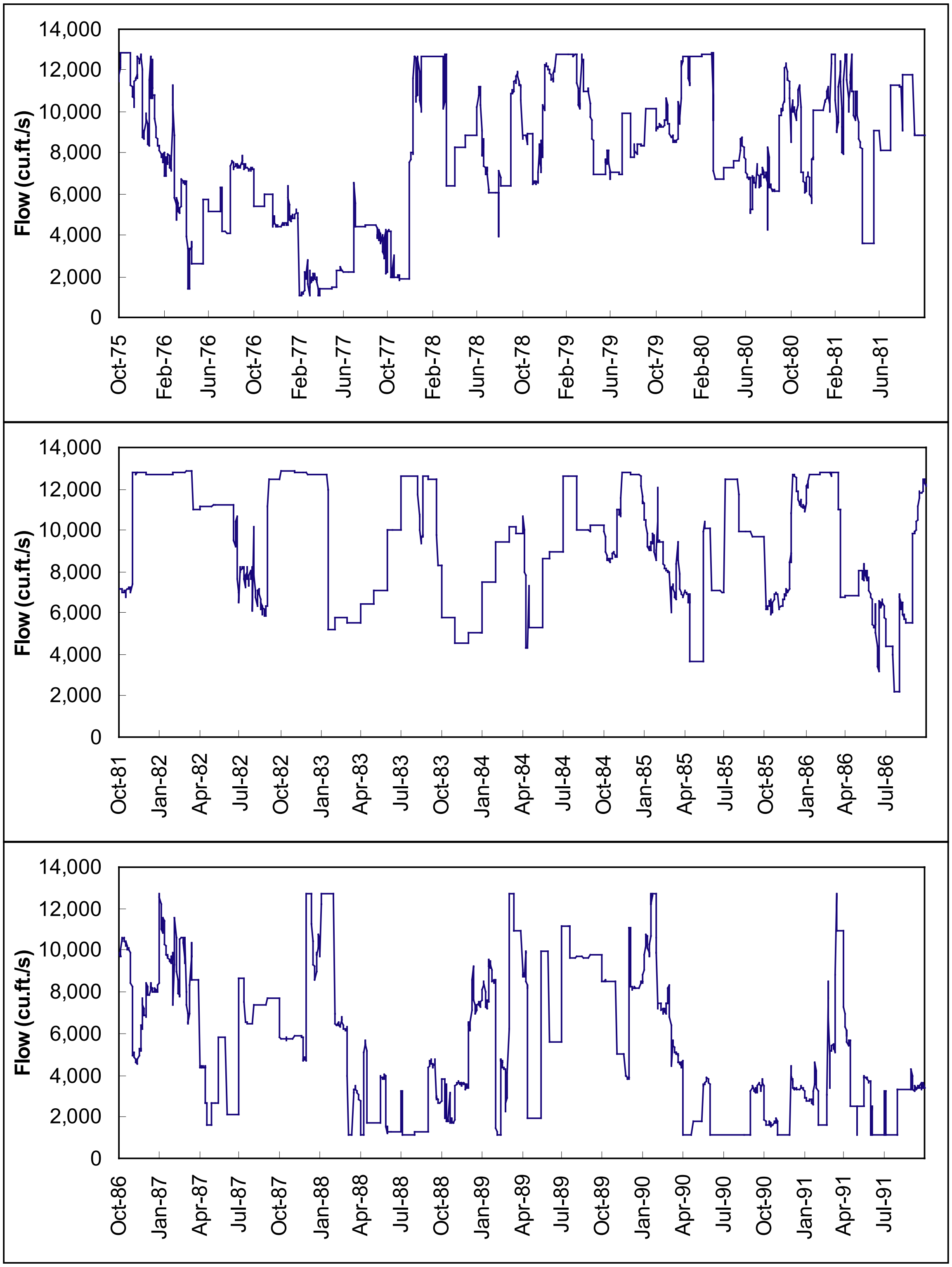


Figure 2.2.8: Daily Average Combined SWP and CVP Exports for Study 1 (Base).

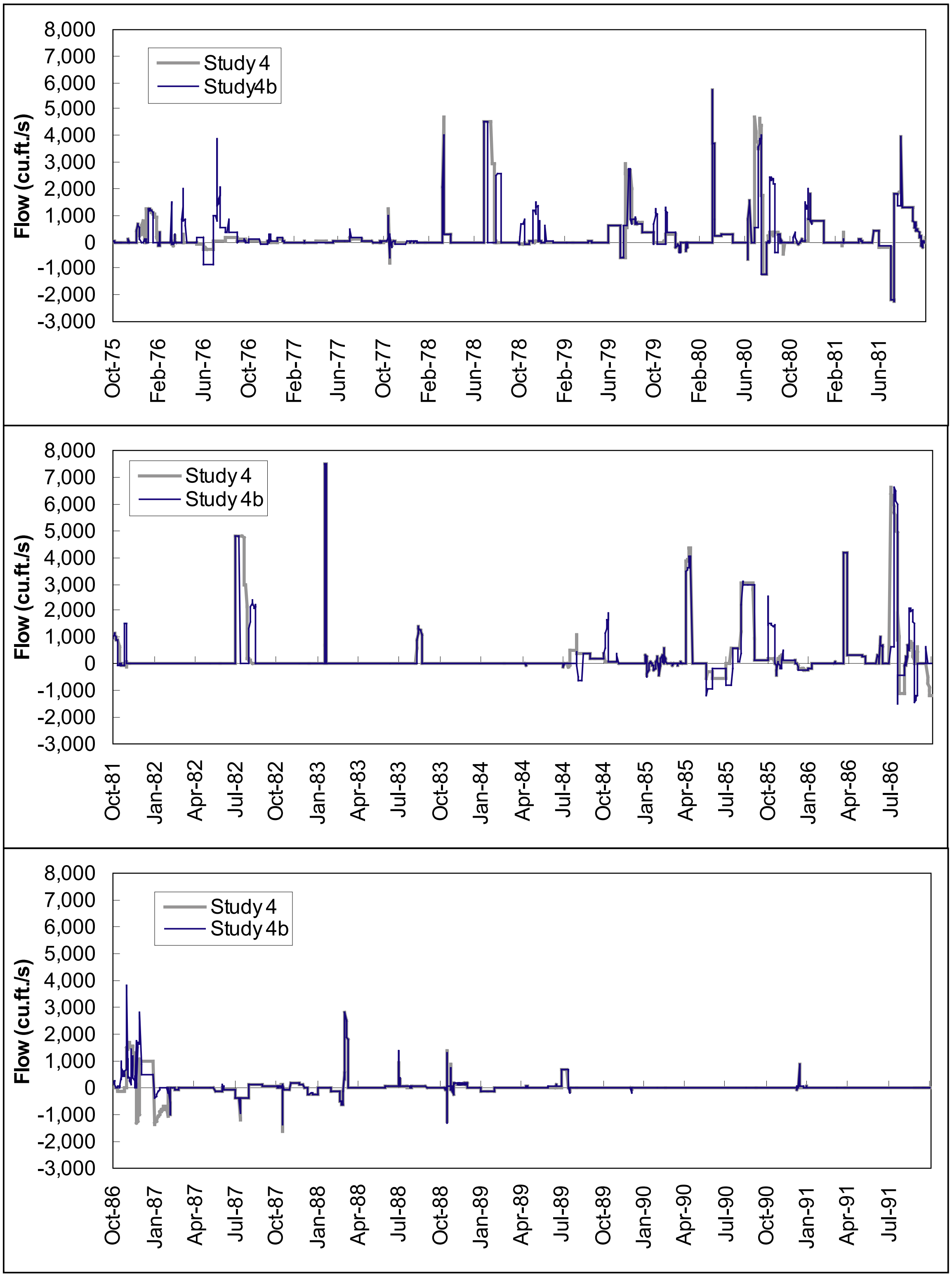


Figure 2.2.9: Change in Daily Average Combined SWP and CVP Exports due to Study 4 and Study 4b.

2.2.3 Contra Costa Water District Diversions / Exports

CALSIM II calculates CCWD's combined Rock Slough and Los Vaqueros Reservoir diversions and exports at a single point. Though DSM2's grid would make it possible to simulate the two urban intakes independently, it would be necessary to develop a series of rules to emulate the CCWD operation. DSM2 assumed that all of the CALSIM II CCWD diversions were from Rock Slough.

The significance of this assumption has not been tested, but the location of the CCWD diversions and exports may also be sensitive to the type of water quality constituent being simulated. For example, by assuming all CCWD diversions take place at Rock Slough, water quality results at Rock Slough are more likely to include a higher percentage of ocean water, while water in the Old River is more likely to include a lower percentage of ocean water. Since ocean water is a significant source of chlorides, this assumption could result in higher Rock Slough chloride concentrations and lower Los Vaqueros Reservoir intake (and possibly SWP and CVP) chloride concentrations.

2.2.4 Gates and Barriers

The operation of the Delta Cross Channel was taken directly from CALSIM II. As described by Easton (2003), the DCC can be opened only on specific days per month, as specified in input to CALSIM II. However, the DCC will be closed on any day when:

- Sacramento River Delta inflow exceeds 25,000 cfs,
- Mokelumne River Delta inflow exceeds 8,700 cfs, or
- The Rio Vista minimum instream flow requirement constrains Delta operations and the flow in Georgiana Slough if the DCC is closed will be sufficient to meet the necessary Delta exports.

Though the monthly average of percentage of time the DCC was opened is nearly the same for all the scenarios, the daily operation of the DCC was much more varied between different scenarios.

Table 2.2.1: Monthly Average of Percentage of Time DCC Open.

Scenario	*Oct*	*Nov*	*Dec*	*Jan*	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sep*
Study 1	86%	54%	38%	25%	0%	0%	0%	0%	81%	99%	100%	94%
Study 4	86%	56%	38%	25%	0%	0%	0%	0%	81%	99%	100%	94%
Study 4b	86%	55%	38%	25%	0%	0%	0%	0%	81%	99%	100%	94%

The four South Delta barriers, Middle River, Old River, Grant Line Canal (west), and Head of Old River at the San Joaquin River, were modeled as permanent barriers. The purpose of the first three barriers is to improve the water levels in the South Delta. The Head of Old River at the San Joaquin River barrier is designed to prevent fish from swimming down the Old River and ending up at the SWP and CVP pumps.

All four barriers were treated as gated weirs. Flow could pass in either direction of the barriers when the gates in the barriers were not operating. When the gates were operating, the barriers restricted flow downstream through the barrier.

The locations of all four barriers are shown below (Figure 2.2.10). The operations for all four barriers are listed in Tables 2.2.2, 2.2.3, and 2.2.4. The same operations were used in the base and alternative simulations. Although the Old River and Middle River barriers used the same schedule of operations, the physical configuration of the two barriers was different. This schedule of operations was based on a CALSIM II D1641 monthly study.

San Joaquin River flows were used to determine when the gates in the barriers should not be operated. When the flow in San Joaquin River exceeded 8,600 cfs (such as it did in 1982 and 1983), the Head of Old River at San Joaquin River fish barrier was not operated. Similarly, when the flow in the San Joaquin River exceeded 20,000 cfs, the remaining three barriers were not operated.[1]

[1] Although this study was based on daily average CALSIM II flows, the schedules of barrier operations were based on SJR flows from an older D1641 monthly CALSIM II study. Though the daily average CALSIM II flows were based on monthly CALSIM II results, in June 1978, some of the daily average flows exceeded the SJR flow removal criteria listed above.

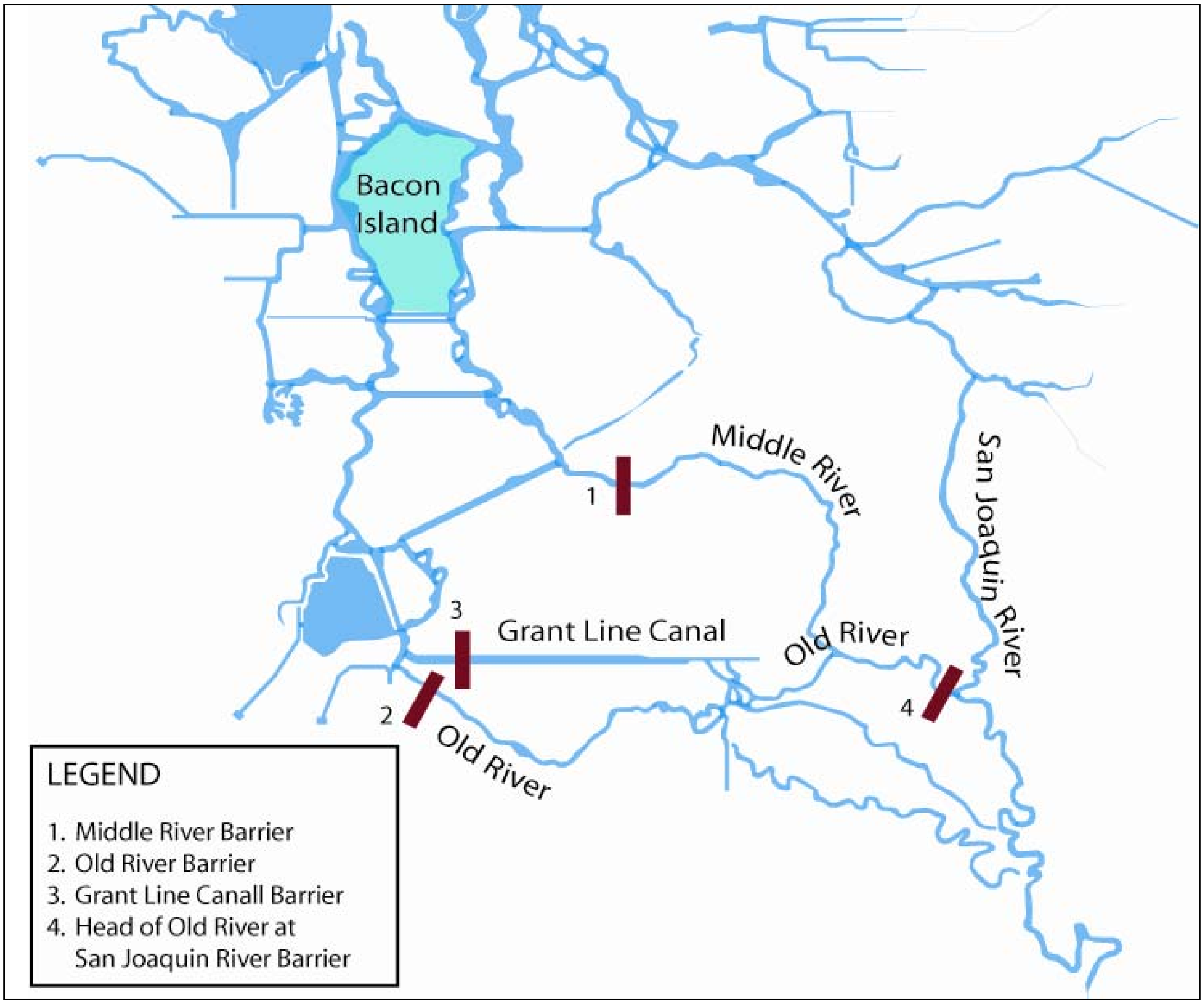


Figure 2.2.10: South Delta Permanent Barrier Locations.

Table 2.2.2: Old River and Middle River Barrier Operation.

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1975												
1976												
1977												
1978												
1979												
1980												
1981												
1982												
1983												
1984												
1985												
1986												
1987												
1988												
1989												
1990												
1991												

Legend
- Gates are not operating, i.e. open
- Gates are operating, i.e. closed (restricts downstream flow)

Table 2.2.3: Grant Line Canal Barrier Operation.

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1975												
1976												
1977												
1978												
1979												
1980												
1981												
1982												
1983												
1984												
1985												
1986												
1987												
1988												
1989												
1990												
1991												

Legend
- Gates are not operating, i.e. open
- Gates are operating, i.e. tidal operations (restricts downstream flow)

Table 2.2.4: Head Old River at San Joaquin River Barrier Operation.

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1975												
1976												
1977												
1978												
1979												
1980												
1981												
1982												
1983												
1984												
1985												
1986												
1987												
1988												
1989												
1990												
1991												

Legend

Barrier not installed

Barrier installed (restricts flow downstream when stage < 11 ft)

2.2.5 Delta Island Consumptive Use

Though originally used to calculate Delta wide consumptive use for the original Delta Simulation Model (DWRDSM) as described by Mahadevan (1995), the DICU model has been modified to calculate the historical consumptive use in the Delta for DSM2. In order to remain consistent with the level of development used in the CALSIM simulations, a 2020-Level of Development was used to adjust the historical Delta Island consumptive use using the department's ADICU model. The adjusted consumptive use was then applied to 257 locations (model nodes) in the Delta to represent agricultural diversions and returns to and from Delta islands and the seepage from Delta channels to the islands.

The scope of this study is not to account for the impact of the operation of the project islands on the entire Delta, but rather to focus on quantifying the water quality impacts at the four major urban intakes. Thus, the same consumptive use patterns were used in both the base (study 1) and alternative (study 4 and 4b) simulations. Even though the land use associated with the two project islands would be different for the alternatives based on the real operation of the project, it was decided to not rerun the DICU and ADICU models to account for the changes in land use. Previous DSM2 studies (Mierzwa, 2001) have shown that the change in base case simulated DOC at the State Water Project (SWP) and Rock Slough (RS) intakes due to removing the return flows (and hence the water quality associated with those follows) from Bacon Island and Webb Tract is small.

2.3 Delta Water Quality

Water quality inputs, EC and DOC, were applied in DSM2-QUAL to the flows generated in DSM2-HYDRO at the river and ocean Delta boundaries and at interior Delta locations. With the exception of EC at Martinez, the water quality concentrations for both EC and DOC at all of the flow inputs into the Delta were based on standard monthly varying DSM2 planning studies concentrations (i.e. the concentrations themselves did not change between studies). However, the relative amount of each constituent brought into the Delta is variable between studies. The amount at each boundary input is the product of the concentration assumed for that boundary and the volume of water that enters at the boundary.

EC and DOC were simulated as a conservative constituent while in the Delta channels. DSM2 has been calibrated and validated for EC and validated for DOC (insert reference to EC and DOC calibration and validations). However, DOC was treated as a non-conservative constituent inside the project islands (see *Section 2.4.4*). The mixing of Delta water with island water is discussed in *Sections 2.4.3 and 2.4.4*.

2.3.1 EC

Martinez EC was generated using Net Delta Outflow from the CALSIM II daily results and an updated G-model (Ateljevich, 2001). By incorporating tidal information into the process of estimating EC at Martinez, data was generated for a 15-minute time step. Since Sacramento inflow is an important component to Net Delta Outflow, the 15-minute Martinez EC was different in all of the simulations.

Monthly CALSIM II Vernalis EC was smoothed to a 1-hour time step using a mass conservative tension spline.[2] The hourly EC at Vernalis was virtually identically for all of the simulations.

Lack of adequate EC – flow relationships made it necessary to assume fixed concentrations to assign to the flows at the other major inflow boundaries to the Delta (see Table 2.3.1). These values are the standard values used to represent the quality associated with these inflow boundaries. The concentrations were used in study 1 and study 4b (EC was not simulated in study 4).

Table 2.3.1: EC at Delta Inflow Boundaries.

Boundary Inflow	**EC (umhos/cm)**
Sacramento River	160
Yolo Bypass	175
Eastside Streams (Mokelumne and Cosumnes Rivers)	150
City of Stockton Waste Water Treatment Plant Releases	0

[2] This mass conservative tension spline is a specific type of spline that preserves the monthly average value when creating hourly values.

The monthly varying EC concentrations assigned to the agricultural return flows are based on field observations that have been prepared for use in DSM2 by the Delta Island Consumptive Use (DICU) model (DWR, 1995). This report divided EC return concentrations into three sub regions: north, west, and southwest, based on Bulletin 123 and Municipal Water Quality Investigations (MWQI) data. The same monthly varying time series was used each year for each sub region (i.e. every October for the north sub region assigned the same concentration to agricultural return flows in the north sub region). However, as discussed in Section 2.2.5, the agricultural return flows changed from year to year, thus an individual island's EC contribution to the Delta would change at the product of its return flow and repeating monthly concentration. The same concentrations were used in study 1 and study 4b.

2.3.2 DOC

DOC from the ocean boundary at Martinez and Stockton Waste Water Treatment Plant releases were considered negligible (i.e. 0 mg/L). The standard monthly varying DSM2 16-year planning study DOC concentrations applied at the remaining DSM2 flow input boundaries were generated based on historical DOC – flow relationships (Suits, 2002). The DOC concentrations associated with agricultural return flows are based on DICU model results (Jung, 2000). The Delta was divided into three sub regions based on observed DOC return quality concentrations: low-, mid-, and high-range DOC. These sub regions are different than those associated with EC.

2.4 Project Islands

The principle difference between study 1 (no action base) and the two alternatives (study 4 and study 4b) was the addition and operation of the IDS project island reservoirs: Bacon Island and Webb Tract. The location of the two project islands is shown in Figure 2.4.1. In the two DSM2 alternative simulations, the project islands were modeled as isolated reservoirs. The representation of the project islands in DSM2 is described below in *Section 2.4.1*.

In addition to isolating the reservoirs from the Delta channels, several additional processes unique to operating the IDS project island as short-term reservoirs were addressed. The processes related to hydrodynamics include: diversion and release schedules (at two integrated facilities per island), evaporation losses, and seepage returns (see Figure 2.4.2). The island processes related to hydrodynamics are described in *Section 2.4.2*.

Water quality in each project island is related to the concentration of the inflows and the concentration already in the island. EC in the project islands is treated as a conservative constituent. A complete description of mixing conservative constituents is discussed in *Section 2.4.3*. As shown in Figure 2.4.2, several important organic carbon sources, representing the interaction of the island water with the organic carbon rich peat soils and the bioproductivity of carbon from aquatic plants and algae, provide additional organic