CALFED Directed Action Proposal

For

Monitoring and Investigations of the San Joaquin River and Tributaries Related to Dissolved Oxygen

March 13, 2003

San Joaquin Valley Drainage Authority

SAN JOAQUIN VALLEY DRAINAGE AUTHORITY

P O Box 2157 Los Banos, CA 93635
209 826 9696 Phone 209 826 9698 Fax

March 13, 2003

Dan Castleberry, Chief
Ecosystem Restoration Program
1416 9th Street, Room 1155
Sacramento, CA 95815

Sam Luoma, Lead Scientist
CALFED Science Program
1416 9th Street
Sacramento, CA 95815

Subject: Dissolved Oxygen TMDL Directed Action Proposal For The San Joaquin River

Dear Dan and Sam,

The San Joaquin Valley Drainage Authority has been an active participant in the Dissolved Oxygen TMDL Steering Committee for the last several years. The Steering Committee, as part of their work plan, requested that a monitoring program be developed for the upstream part of the San Joaquin River between Stockton and Mendota Dam as a directed action effort to be funded by CALFED. Work began on the monitoring program by a group who had previously worked on the dissolved oxygen issue, including scientists from Lawrence Berkeley National Lab, University of the Pacific, University of California Davis, US Geological Survey and others. Public meetings were held to develop the proposal by the Technical Advisory Committee (TAC) within the westside of the watershed on September 19, 2002 and on the eastside on October 3, 2002. Additional TAC meetings to develop the proposal were held on October 15, November 15 and December 18, 2002. A draft of the proposal was distributed prior to the Steering Committee meeting on January 30, 2003. Written comments received prior to that meeting and verbal comments were discussed at the January 30th meeting. The notes for these meetings are on the SJR TMDL website at http://www.sjrtmdl.org/. Written comments received on the January draft of the monitoring program are also posted on the above website. All comments were considered in preparation of the final plan.

The San Joaquin Valley Drainage Authority has always considered the development of this plan as a cooperative effort between the Regional Board, CALFED and the stakeholders. Any number of entities could have been the sponsor of the directed

action proposal. However, when no entity was available, the Drainage Authority agreed to be the sponsor and submit the grant application. With this cooperative effort in mind we request an on-going dialogue on any suggested changes or modifications to the upstream monitoring program resulting from the peer review or agency review process.

Attached is a copy of the proposal that we are submitting for your consideration.

Sincerely,

Daniel G. Nelson
Executive Director

cc: Barbara Marcotte, CALFED
Tom Pinkos, Regional Water Quality Control Board
Chris Foe, Regional Water Quality Control Board
Mark Gowdy, Regional Water Quality Control Board

PART A – COVER PAGE

STATE WATER RESOURCES CONTROL BOARD
CALFED Drinking Water Quality Program

PROJECT TITLE: CALFED Directed Action Proposal For Monitoring and Investigation of the San Joaquin River and Tributaries Related to Dissolved Oxygen

Project Region: SJR Drainage — Indicate RWQCB #: 5

Multi-regional Project: ______ — Indicate RWQCB #s: ______

Statewide Project: ______

PROJECT DIRECTOR (one name only) (Ms., Mr., Dr.): Mr. Joseph C. McGahan — 3/13/03
PRINT — DATE

LEAD APPLICANT OR ORGANIZATION: San Joaquin Valley Drainage Authority

TYPE OF AGENCY:

Municipality ______ Local Agency X *Nonprofit (non-landowner) ______

Nonprofit (landowner) ______ Local Public Agency ______

STREET ADDRESS: 842 6th Street, Suite 7

CITY: Los Banos — Zip Code: 93635

P.O. BOX: 2157 — Zip Code: 93635

COUNTY: Merced

STATE: California

PHONE NO.: (209) 826-9696 — FAX NO.: (209) 826-9698

E-MAIL ADDRESS: jmcgahan@summerseng.com — FEDERAL TAX ID. NO.: 77-0518862

PROJECT TYPE	Data collection and analysis

LEGISLATIVE INFORMATION	Senate District	5, 12, 14, 16	Assembly District	5, 9, 17, 26, 25
			United States Congressional District	5, 11, 18

CALFED, RWQCB or SWRCB STAFF CONTACTED REGARDING THIS PROPOSAL:

Contact:	Chris Foe (CVRWQCB)	Contact:	Barbara Marcotte (CALFED)
Phone No.:	916-255-3113	Phone No.:	916-651-6476
Dates contacted:	10/1/02 to present	Dates contacted:	10/1/02 to present

COOPERATING ENTITIES:

Entity Name:	Lawrence Berkeley National Laboratory		
Role/Contribution to Project:	Lead Investigator/ Scientific Research		
Contact Person:	Dr. William Stringfellow	Phone No.:	510-486-7903
E-mail address:	wstringfellow@lbl.gov		

Entity Name:	U.C. Davis		
Role/Contribution to Project:	Scientific Research		
Contact Person:	Randy A. Dahlgren	Phone No.:	530-752-2814
E-mail address:	radahlgren@ucdavis.edu		

Entity Name:	University of the Pacific		
Role/Contribution to Project:	Scientific Research		
Contact Person:	Gary M. Litton	Phone No.:	209-946-3070
E-mail address:	glitton@uop.edu		

WATERBODY/WATERSHED (Include Catalog Number in Section 4 of the Application Reference Document (ARD)):	The San Joaquin River and tributaries from the Mendota Dam to Channel Point at Stockton including the following watersheds: Middle San Joaquin – Lower Chowchilla (18040001), Middle San Joaquin – Lower Merced/Lower Stanislaus (18040002) San Joaquin Delta (18040003) Panoche-San Luis Reservoir (18040014)

GPS COORDINATES FOR PROJECT LOCATION, IF AVAILABLE: 38º00'N, 121º22'W to 36º47'N, 120º22W

FISCAL SUMMARY:

CALFED Directed Action Funds Requested	$**6,886,960**
Other Project Funds	$**1,083,463**
Total Project Budget	$**7,970,424**

CERTIFICATION

Please read before signing.

I certify under penalty of perjury that the information I have entered on this application is true and complete to the best of my knowledge and that I am entitled to submit the application on behalf of the applicant (if the applicant is an entity/organization). I further understand that any false, incomplete, or incorrect statements may result in the disqualification of this application. By signing this application, I waive any and all rights to privacy and confidentiality of the proposal on behalf of the applicant, to the extent provided in this RFP.

March 13, 2003

Applicant Signature Date

Dan Nelson, Executive Director, San Joaquin Valley Drainage Authority

Printed Name of Applicant

Table A-1: List of Acronyms

Acronyms/Abbreviations	Description
ARD	Application Reference Document, State Water Resources Control Board, Nonpoint Source Pollution Control and Watershed Programs
BOD	Biochemical oxygen demand
CBOD	Carbonaceous biochemical oxygen demand
CDEC	California Data Exchange Center
CEQA	California Environmental Quality Act
CVRWQCB	Central Valley Regional Water Quality Control Board
CWI	California Water Institute
DO	Dissolved oxygen
DOC	Dissolved organic carbon
DOM	Dissolved organic matter
DWR	California Department of Water Resources
DWSC	Deep water ship channel
EC	Electrical Conductivity
GPS	Global Positioning System
ID	Irrigation District
IEP	Interagency Ecological Program
NEPA	National Environmental Policy Act
NPDES	National Pollutant Discharge Elimination System
ODS	Oxygen-depleting substance
PI	Principal Investigator
POM	Particulate organic matter
ppb	Parts per billion
PRR	Peer Review Recommendation
QA/QC	Quality Assurance/Quality Control
QAPP	Quality Assurance Project Plan
RWQCB	Regional Water Quality Control Board
SCADA	Supervisory Control and Data Acquisition
SCUFA	Self-Contained Underwater Fluorescence Apparatus
SJR	San Joaquin River
SJRGA	San Joaquin River Group Authority
SJVDA	San Joaquin Valley Drainage Authority
SM	Standard Method
SR	Stakeholder Recommendation
TAC	Technical Advisory Committee
TMDL	Total maximum daily load
TOC	Total organic carbon
TSS	Total suspended solids
UCD	University of California, Davis
UCB	University of California, Berkeley
UOP	University of the Pacific
USGS	U.S. Geological Survey
VSS	Volatile suspended solids
WWTP	Wastewater treatment plant

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PART B: PROPOSED SCOPE OF WORK

Background and Goals

Introduction

For many years, the Deep Water Ship Channel (DWSC) on the San Joaquin River (SJR) has had intermittent low dissolved oxygen (DO) conditions. The DO sag is most acute during the late summer and early fall, but low DO incidences occur year-round. The low DO conditions are impacting critical fish habitat and a total maximum daily load (TMDL) Implementation Plan for oxygen-demanding substances is currently being developed.

In support of the development of a scientific DO TMDL allocation, 13 research and monitoring projects examining various aspects of DO demand in the SJR were conducted in the summers of 1999, 2000, and 2001. Additionally, the Central Valley Regional Water Quality Control Board (CVRWQCB) generated a "strawman" allocation of responsibility report (Strawman Report). The Strawman Report represents a process by which responsibility for the low DO conditions can be assigned and a plan for remediation of the DO sag in the SJR can be implemented. The final reports for these projects can be found on the SJR DO TMDL website.

Studies conducted in the summers of 1999, 2000 and 2001 identified four major factors contributing the formation of a DO sag in the DWSC: the deepening of the ship channel, ammonia discharges from the Stockton Wastewater Treatment Plant (WWTP), transport of oxygen-consuming materials from the upper SJR into the DWSC, and production of oxygen-consuming organic matter in the channel. The actual impact of these factors is dependent on flow and temperature, where lower flows and higher temperatures allow a DO deficit to accumulate if the other factors are present.

This proposed study is focused on understanding the sources of oxygen-consuming materials in the SJR upstream of the DWSC. The purpose of this study is to provide a comprehensive understanding of the sources and fate of oxygen-consuming materials in the SJR watershed between Channel Point and Lander Avenue. This study will provide the stakeholders an understanding of the baseline conditions of the basin, provide input for an allocation decision, and provide the stakeholders with a tool for measuring the impact of any water quality management program that may be implemented in response to the DO-TMDL requirements.

Previous studies have identified algal biomass as the most significant oxygen-demanding substance in the SJR upstream of the DWSC. Algal biomass is not a conserved substance, but grows and decays in the SJR; hence, characterization of oxygen-demanding substances in the SJR is inherently complicated and will require an integrated effort of extensive monitoring, scientific study, and modeling. This study includes a coherent and comprehensive study of algal growth dynamics in the SJR and will identify sources of algal nutrients to the SJR.

Other oxygen-demanding substances found in the SJR above the DWSC include ammonia and organic carbon from sources other than algae. The upper SJR watershed contains municipalities, dairies, wetlands, and agricultural industries that could potentially contribute biochemical oxygen demand (BOD) to the SJR. This study is designed to discriminate between algal BOD and other sources of BOD throughout the entire SJR watershed.

This study is directed at resolving outstanding scientific issues, identified by external and internal peer review, and from prior studies. This project is an important step in the establishment and management of a comprehensive DO TMDL in the upstream SJR. This effort is an integral part of the proposed DO TMDL Implementation Plan requested from the SJR DO TMDL Steering Committee by the CVRWQCB. The Steering Committee is a stakeholder group organized at the CVRWQCB's behest to develop a plan to implement the DO TMDL and remediate the DO sag in the DWSC. The effort in this proposal will be integrated with studies conducted in the DWSC and with SJR modeling projects. Integration with other projects will be coordinated by the Steering Committee through the agency of the Long Term Coordinator and the Technical Advisory Committee (TAC).

Peer Review Recommendations

CALFED-funded studies conducted between 1999 and 2001 and the Strawman Report were subject to extensive internal and external peer review. The internal peer review was conducted in open meetings of the TAC, which consists of scientists and engineers from industry, municipalities, farm organizations, universities, and government organizations. The external peer review committee consisted of six scientists from university and government. The peer review panel consisted of James Cloern, United States Geological Survey; Steven Chapra, Tufts University; William Ritter, University of Delaware; David Beasley, North Carolina State University; Alex Horne, University of California Berkeley; and Alan Jassby, University of California Davis. The peer review panel examined the final reports from the CALFED studies conducted in 1999 and 2001 and met on June 11 and 12, 2002, in Sacramento, CA, to hear presentations from each Principal Investigator (PI) on their individual projects, ask questions, and engage in a discussion with the TAC concerning the DO deficit in the DWSC.

The conclusions and recommendation of the peer review were published in a "Peer Review Report" (PRR) dated July 1, 2002, which can also be found on the SJR DO TMDL website. The PRR praised the progress made to date on understanding the causes and nature of the DO deficit and recommended continued funding for DO-related monitoring and research. The PRR made specific recommendations for future work. Comments and recommendations from the PRR related to the SJR above the DWSC are summarized and organized for reference as follows:

Peer Review Recommendation 1: Improve and Expand DO TMDL-Related Monitoring in the Upper SJR

The SJR upstream of the DWSC needs to be better characterized. A better understanding of the origin of algal loads in Mud and Salt Sloughs and upstream of Lander Avenue on the SJR is needed. The measurements of flow and water quality parameters upstream of the DWSC need to be expanded. The monitoring currently being conducted needs to be continued and the monitoring effort should be extended upstream. Data collection needs to be continued and expanded to include more stations. Monitoring should be conducted year-round and the loadings of oxygen-demanding substances in the winter need to be examined to gain additional information as to causes of DO deficits. Continuous monitoring of flow and other constituents should be applied where practical. Fluorescence should be used to monitor chlorophyll continuously. Specific parameters to measure include phytoplankton, zooplankton, and nutrients. Data sharing and data exchange should be improved. More integrated data analysis is desirable.

Peer Review Recommendation 2: The Growth and Mass Balance of Algae in the Upper SJR is Not Well Understood and Needs to be Further Investigated

Reducing algal loads from Mud and Salt sloughs has been suggested as a possible approach for reducing DO demand in the DWSC. The value of reducing algal loads from these watersheds needs to be evaluated more thoroughly. The link between the upper watershed algal sources and the algal load entering the DWSC needs to be better established. Independent rate constants, to be used in river models, need to be developed for algal growth and nitrification. Plankton species composition should be measured at different locations along the SJR, as it would help establish if a link exists between the algal from the upper and lower reaches. Investigate if upstream algae inputs act as a seed to the lower river. Synoptic studies need to be continued and expanded.

Peer Review Recommendation 3: River Modeling Needs to be Expanded and Directly Integrated with the Data Collection and Scientific Effort

Data collection needs to be coordinated with modeling needs. Information gathered in this study should be coordinated with Hydroqual and other modeling efforts. The Chen and Tsai (Systech) model is the best model currently available. The local modeling effort should be supported, at least until the 3D modeling effort (Hydroqual) matures. Modelers and scientists need to work together more closely.

Peer Review Recommendation 4: Characterization of BOD in the SJR is Incomplete and Needs Further Investigation.

More research is needed to accurately delineate sources of DO-demanding material in the SJR. The relationship between pigment concentration and BOD needs to be more carefully evaluated and established. The importance of ammonia to river BOD loading needs to be more thoroughly evaluated. The exact nature of the BOD in Salt Slough is unknown, as it cannot be fully attributed to algal biomass or ammonia. Salt Slough needs to be better characterized. Resolving the relative importance of different BOD fractions to the SJR loading should be a research priority.

Peer Review Recommendation 5: The Section of the SJR between Vernalis and the DWSC is Poorly Understood and Needs Further Investigation

The section of river between the Mossdale sampling station and the entry to the DWSC (Channel Point) is a key region that is not well understood. Algal growth dynamics between Mossdale and the DWSC need to be better characterized, especially as it relates to algal biomass losses in this region. A new station between Mossdale and Channel Point should be established, directly above the zone of tidal influence. The apparent loss of algal biomass in this region needs to be explained. The impact of primary consumers on algal biomass in this reach should be investigated.

Stakeholder Recommendations

The development of a comprehensive DO TMDL plan for the upper SJR and the allocation of responsibility through the Strawman process were presented to stakeholder groups at special meetings held on September 19 and October 3, 2002. Additionally, ongoing stakeholder review of prior and planned studies from the DO Steering Committee and stakeholder attendance at the TAC meetings has occurred. Minutes of these meetings are posted on the SJR DO TMDL website.

The stakeholders made a number of recommendations concerning the development of an upstream DO TMDL program that are summarized as follows:

Stakeholder Recommendation 1: Assumptions Concerning Algal Dynamics Used in the Strawman Need to be Verified

The link between algae produced in the upper river and the algae entering the DWSC was questioned. Stakeholders expressed concern about the scientific basis for algal growth rates used in the Strawman Report. These algal growth rates are key for linking algae produced in Mud and Salt sloughs to algae entering the DWSC. The stakeholders felt that the understanding of algal growth dynamics was insufficient to assign responsibility for DO deficits in the DWSC to algal produced a hundred miles upstream. Further study was requested to address this specific issue.

Stakeholder Recommendation 2: Monitoring Should be More Comprehensive

The scope and thoroughness of the monitoring used to develop the Strawman Report was questioned. Stakeholders felt the monitoring conducted in prior years was not comprehensive enough to be considered a basis for development of the Strawman allocation of responsibility. Specific recommendations included monitoring at flow diversions to give credit for algae removed with river water used for irrigation and to develop more balance between the number of eastside and westside monitoring sites. Support was expressed for the development of a more comprehensive program that approached the study and management of the watershed as a complete unit.

Stakeholder Recommendation 3: Monitoring Should Include Internal Watershed Sites as Well as River Sites

The source of algae in the sub-watersheds was questioned. Stakeholders wanted to determine whether the algae found in drainage originated in their regions or was pass-through from other sources. The quality of source water flowing into a specific region should be monitored to build confidence that the water users are responsible for algae that develop in that region. Additionally, they wanted TMDL monitoring and studies to provide information useful for development of management options, if a scientific basis is determined to allocate responsibility to specific SJR sub-watersheds.

Stakeholder Recommendation 4: The DO TMDL Should be Integrated with Other TMDLs as Much as Possible

Stakeholders expressed concern that the DO TMDL would be implemented without consideration for the requirements of the salt and boron TMDL. A concern was raised that the stakeholders would soon be faced with new TMDLs for pesticides and perhaps nutrients. It was questioned whether salt management programs (which typically involve flow reduction) would be compatible with DO management programs. Stakeholders wanted input on the selection of sampling sites, which should be chosen to correspond with existing monitoring programs where possible to economize sampling and analytical costs.

Stakeholder Recommendation 5: Confidence in the Fairness of the DO TMDL Allocation Process Should be Increased

Stakeholders have expressed a general concern that the DO TMDL allocation process (Strawman) should be transparent, scientifically based, and equitable. All data used in development of the allocation should be publicly available. Meeting Stakeholder Recommendations 1 to 4 would increase the level of confidence in the Strawman process. The Strawman process should be led by local stakeholder groups, rather than imposed by the CVRWQCB, to ensure that all parties are treated fairly.

Project Goals and Objectives

This project will address the recommendations of the peer review panel and those put forth by the stakeholders to provide answers to many of the key data gaps identified in previous studies. Along with related activities of the DO-TMDL Steering Committee, this study will be an integral part in evaluating the linkage between what happens in the watershed above the DWSC and the DO problem in the DWSC. The monitoring, data interpretation, and studies will lay the framework for evaluation of other non-aeration alternatives.

Based on the peer review, stakeholder recommendations, and input from the TAC, the Steering Committee, and members of the CVRWQCB, the following objectives have been set for this study:

Objective 1: Establish a comprehensive monitoring program to characterize the loading of algae, other oxygen-demanding materials, and nutrients from individual tributaries and sub-watersheds of the upstream SJR.

Objective 2: Characterize the transformation and fate of algae and other oxygen-demanding materials between their sources in the watershed and the DWSC.

Objective 3: Characterize the fate of nutrients and the impact of nutrients on algal growth between their sources in the watershed and the DWSC.

Objective 4: Characterize the temporal variability of water quality parameters on a daily and seasonal basis.

Objective 5: Provide input and calibration data for water quality modeling associated with the low DO problems in the SJR watershed, including modeling on the linkage among nutrients, algae, and low DO.

Objective 6: Provide stakeholder confidence in the information that will be used to support the DO TMDL allocation and implementation process.

Research Questions

Research questions addressed in this study include the following:

What are the sources of algal inoculum in the watershed?

What are the sources of nutrients in the watershed?

What is the relative importance of inoculant size and nutrient sources in determining the algal biomass load reaching Channel Point?

What would be the impact of reducing either inoculum or nutrients or both on algal biomass loads at Channel Point?

What other sources of BOD (besides algae) are in the San Joaquin River watershed and are these sources important to the SJR BOD load to the DWSC?

Organization and Implementation of the DO TMDL Directed Action Project

Joseph McGahan of the San Joaquin Valley Drainage Authority (SJVDA) is the Project Director and Principal Investigator (PI) on Tasks 2 and 3. The SJVDA will administer the grants in co-operation with the San Joaquin River Group Authority (SJRGA). Lowell Ploss is the Project Director for the SJRGA involvement with this project. William Stringfellow of Lawrence Berkeley National Laboratory (LBNL) is the Scientific Leader for the overall project and the PI on Tasks 4 and 9. Randy Dahlgren of the University of California Davis (UCD) and Sharon Borglin of LBNL are co-PIs for Task 5. Russ Brown of Jones & Stokes Associates, Inc. (Jones & Stokes) and Carl Chen of Systech Engineering, Inc. (Systech) will be co-PIs for Task 6. Carol Kendall of the United States Geological Survey (USGS) will be PI for Task 7. Gary Litton of the University of the Pacific (UOP) and Nigel Quinn of the University of California, Berkeley (UCB) are co-PIs on Task 8. Other investigators and organizations included in this project include Parviz Nader and Hari Rajbhandari of the Delta Modeling Section, Department of Water Resources (DWR), who are subcontracted on Task 6; Karl Jacobs, Brian Hale and Kris Lightsey of the Interagency Ecological Program (IEP) who are subcontracted on Task 4; William Oswald of UCB will serve as an advisor on Task 5; Theresa Sebasto and Tim Jacobsen of the California Water Institute (CWI) are sub-contracted to organize training and outreach under Task 4; Steven Silva, Brian Bemis, and Brian Bergamaschi are scientists from USGS working on Task 7; Chris Linneman from SJVDA is assisting in collection of hydrologic data on Task 4; and Donna Smith from LBNL is an analytical chemist and quality control expert participating in Task 4. Qualifications of participants are given in Part H.

Each task described in this proposal is an interdisciplinary and inter-institutional effort. This represents a departure from previous DO studies, where individual institutions were given individual tasks and little synergy or interaction occurred between research groups. Also unlike previous studies, each effort includes a commitment by the PIs to participate in the TAC, the major mechanism for transferring technical knowledge to the stakeholders. Local stakeholder involvement occurs at all levels of effort envisioned in this document.

Project oversight and management is provided by two local stakeholder groups: the San Joaquin Valley Drainage Authority (SJVDA) and the San Joaquin River Group Authority (SJRGA). Each task has a designated PI who is responsible for the overall task and providing all deliverables, including quarterly and annual reports. The PI is responsible for organizing the execution of the task, ensuring that data are collected in a scientific manner and compiled, reports are written on schedule, and results of each task are made available to the TAC in a timely manner. Each PI is from a single institution or organization, but the resources applied in each task are from multiple organizations, including federal, state, and private institutions. All investigators participating in this proposal have committed to participating in a collaborative and cooperative research effort.

All tasks will be implemented under a structured adaptive management plan. The overall adaptive management strategy is to reorganize and focus resources each succeeding year of the project, based on the previous years results. The most intensive field effort will take place in summer months (June to October) and the most intensive analytical effort will take place in winter months. In the winter months, the TAC will review data collected the previous season and set priorities for the coming summer. In this manner, the adaptive management plan will be instituted to narrow the focus of effort to the most critical areas in the watershed and, thereby, provide the local stakeholders the information most needed to institute a basin management plan.

Study Area

The study area included in this proposal is the SJR watershed upstream of the DWSC. The study area includes the full length of the SJR that extends from Channel Point, at the head of the DWSC, to Lander Avenue, approximately 100 miles south of the DWSC. The study area is shown on Figure B-1.

Figure B-1 Study Area and Sampling Locations

TASK 1: PROJECT ADMINISTRATION

This project will be managed by the SJVDA. The SJVDA will be responsible for administering the contract. Joseph C. McGahan, consultant to the SJVDA, will be project manager to provide administration and technical oversight. The proposed project schedule accounts for the time that will be required to complete the subcontracts with all project participants once CALFED has awarded funds.

Informational and technical presentations on this research will be made in cooperation with educational programs organized by the CWI and the Center for Irrigation Technology at Fresno State University. UCD and Fresno State University students will be trained in water sampling protocols and employed on this project. Employees of participating agencies will also be trained and employed to conduct water quality sampling and operate and maintain equipment.

Task 1 Budget Justification:

The San Luis & Delta-Mendota Water Authority (Water Authority) acting on behalf of the SJVDA will undertake administration for the project. Work will be performed by staff of the Water Authority and by outside legal and engineering consultants. Work will include reviewing and executing the contract with CALFED, developing the subcontracts for the various tasks, finalizing and executing subcontracts, setting up and maintaining financial accounts for this project, reviewing and approving subcontractor invoices, processing payments, quarterly and annual financial progress reports, technical oversight (with the lead scientist funded in other tasks), preparation of quarterly and annual progress reports, attend meetings of technical and steering committees, and periodic meetings of the Regional board and other related groups. Funding for this work has been set at 7% of the Directed Action funds.

TASK 2: CEQA/NEPA DOCUMENTATION

This proposed project involves only monitoring and research, and, in accordance with Section 15306 of the California Public Resources Code, has been determined to not result in serious or major disturbance to any environmental resource. A Categorical Exemption will be filed with the California State Clearinghouse to comply with CEQA. The lead agency for this project is not a Federal Agency and NEPA does not apply.

Task 2 Budget Justification:

The cost to complete and file the CEQA Categorical Exemption for this project is $7,383. This includes the cost to complete the Categorical Exemption form and develop related documentation, duplicate and submit the documentation to the California State Clearinghouse and other agencies, and respond to comments as necessary.

TASK 3: QUALITY ASSURANCE PROJECT PLAN

Past monitoring efforts for the SJR have been undertaken by a number of different agencies and investigators, using a variety of data collection and analytical methods. As a result, historical data from multiple studies are often difficult to compare and evaluate. One of the goals of the proposed monitoring is to ensure that methods are consistent and data collected throughout the study area will be comparable. In addition, because data may be collected by different entities, it is essential that consistent quality control procedures are followed and a thorough quality assurance program is developed and carried out. The Quality Assurance Project Plan (QAPP) will establish the procedures and methods by which data will be collected and analyzed through the three years of the project. The QAPP for this monitoring program will be based on the most recent QAPP for the Compliance Monitoring Program for Use and Operation of the Grasslands Bypass Project (Bureau of Reclamation 2002). The following elements will be revised as appropriate:

List of parameters

Data quality objectives

Reporting limits

Project team organization

Sampling procedures

Chain-of-custody procedures

Equipment and calibration procedures

Data reduction, validation, and reporting procedures

Internal and external quality control

Laboratory performance evaluations

Maintenance of equipment

Comparison of data from multiple laboratories

The QAPP will be reviewed, finalized, and approved by the project team, the Steering Committee, the CVRWQCB, and CALFED before data collection activities are undertaken.

Task 3 Budget Justification:

Because it will be necessary to set the QA/QC requirements, the QAPP will be completed early in the first year of the project, and will not require any funding after that. The cost to implement the QAPP will be included under each separate task. The total cost for the development of the QAPP is $35,074, which includes time for the PI's to meet and establish their methods and procedural requirements; time for the document to be written and reviewed; and supplies for the duplication and distribution of the final document to the PI's of each task and their staff.

TASK 4: MONITORING PROGRAM

Task 4 Objectives

In Task 4 we will collect sufficient hydrologic and water quality data to characterize the loading of algae, other oxygen-demanding materials, and nutrients from individual tributaries and sub-watersheds of the upstream SJR between Channel Point and Lander Avenue (Objective 1, see Introduction). Task 4 will identify sub-watersheds that are the most significant sources of algal biomass, nutrients, and BOD to the river (Objective 1). These sub-watersheds will be fully characterized with the objective of providing basic information that will be needed by stakeholders to plan a DO TMDL management program. The final deliverable will include a recommendation of what monitoring stations and parameters should be considered for continued sampling under the DO TMDL Long-Term Implementation Plan.

The data collected in this task will be used to characterize the transformation and fate of algae and other oxygen-demanding materials between their sources in the watershed and the DWSC (Objective 2), characterize the fate of nutrients and the impact of nutrients on algal growth between their sources in the watershed and the DWSC (Objective 3), and characterize the temporal variability of water quality parameters on a daily and seasonal basis (Objective 4). To meet Objectives 1, 2, and 4, data will be analyzed for a mass balance and statistical relationships (as part of Task 4) and algal growth rate estimates will be made from this data (in Task 5). The data collected in Task 4 will also be used in Task 6 to model and predict the transformation and fate of algae in the river (Objective 2). Objective 3 will be met by combining a mass balance and statistical analysis from Task 4 with algal growth potential experiments described in Task 5 and carbon and nitrogen isotope analysis described in Task 7.

Task 4 will provide input and calibration data for water quality modeling associated with the low DO problems in the SJR watershed, including modeling on the linkage among nutrients, algae, and low DO (Objective 5). This objective will be met by providing a higher volume of high quality and coherent data to the modeling team than was available in the past for the upstream SJR (PRR1 and PRR3). The coherent data set will be provided by collecting a comprehensive data set of all significant hydrologic input and outputs in the upstream study area (Task 4.1), an expanded grab sampling program that will collect a year-round data set on 21 key points in the watershed (Task 4.2), and the installation of continuous monitoring for chlorophyll at 7 locations on the SJR (Task 4.4). In addition, the modeling team (see Task 6 Organization section) has requested the installation and maintenance of three continuous DO and pH monitoring stations on the mainstem of the SJR. These stations are needed to calibrate the river model and provide coherency for linking the upstream portion of the model to the DWSC models under developments as part of other State funded projects.

Task 4 will improve stakeholder confidence in the information that will be used to support the DO TMDL allocation and Implementation Plan (Objective 6). This objective will be achieved by conducting this research project in cooperation with local water and irrigation districts through the SJRGA and the SJVDA. Stakeholders have been instrumental in the selection of the water quality stations included in this plan and are willing to participate because the plan is structured so as to be equitably distributed across the watershed and is not biased against any one drainage, tributary, or sub-watershed. The research will be conducted in an open and transparent fashion, including outreach and training programs coordinated by the California Water Institute at Fresno State University (Task 4.7) and attendance at the TAC meetings by principal investigators funded on this project. The TAC meetings provide a ready forum for the stakeholders to discuss the project directly with principal investigators from each task. The confidence of the stakeholders in the DO monitoring effort will also be increased by training qualified personnel from local stakeholder organizations in water quality sampling procedures so that the local districts can take over the responsibility of any monitoring that may be needed after the third year of this project (Task 4.7).

Task 4 Conceptual Model

The conceptual model for Task 4, and the project as a whole, is that a directed, coherent, and complete study is needed to understand the transport and fate of non-conserved substances, such as algal biomass and other oxygen demanding materials, in the SJR. This conceptual model is an advancement from the approach taken in the previous directed action studies, which relied on "synthesizing" a comprehensive picture of the transformation and fate of oxygen demanding materials in the SJR and DWSC by compiling and comparing information from independent studies. This integrated approach is taken in direct response to Peer Review suggestions (Cloern et al. 2002), many of which are summarized in the introduction (PRR1 to PRR5).

Task 4 builds upon the structure of the Strawman proposed by Foe et al. (2002). Dr. R. Dahlgren at UCD, who collected and analyzed samples for the Strawman Report (Foe et al. 2003), is funded as part of this project to insure continuity between this study and prior data sets. The program is expanded to include all significant flows entering the SJR and the number of grab samples increased to fill data gaps identified in PRR1, PRR4, PRR5, SR2, SR3, SR4, and SR5. Task 4 will also utilize continuous fluorescence monitoring to fill data gaps between grab sampling events (see Grab Sampling Frequency, below, for full explanation) as recommended in PRR1.

This project proposes to take a complete "snap-shot" of the upstream SJR between Channel Point and Lander Avenue to allow a comprehensive understanding of the watershed to be developed. The proposed monitoring will also identify specific tributaries and sub-watershed areas that contribute significant portions of the upstream load, as well as provide information on the transformation processes that lead to oxygen depletion downstream. The results can be used to help identify the most effective and efficient methods for implementing the DO TMDL plan.

Task 4 Hypothesis

The fundamental hypothesis of Task 4 is that the mass balance of algae and other oxygen-demanding materials in the upper SJR can be modeled, understood, and ultimately managed, if sufficient flow and water quality data are collected in an organized and systematic fashion from the region. It is our hypothesis that a combined program of grab sampling and fluorescent monitoring is the most direct method to fill the data gaps concerning the sources and fate of algae in the upstream SJR.

Task 4 Justification

The current model of the DO impairment in the DWSC suggests that the magnitude and timing of loads of oxygen-demanding materials from the SJR upstream of Channel Point is a significant cause of low DO conditions near Stockton (Foe et al. 2002, Chen and Tasi 2000, Lee and Jones-Lee 2002). Algal biomass is the most important oxygen demanding material entering the DWSC from the upstream SJR (Lehman 2001). The region of the SJR upstream of the DWSC will be included in the DO TMDL Implementation Plan currently being developed by the RWQCB. Information on the sources, transport, and transformation of oxygen demanding materials in the upstream SJR is needed by both the stakeholders and the RWQCB for the DO TMDL Implementation Plan.

Studies were sponsored by CalFed and the RWQCB between 1999 and 2001 to identify and investigate sources of BOD, algae, and nutrients in the SJR upstream of Channel Point (Foe et al. 2002, Stringfellow and Quinn 2002). These studies determined that there were significant sources of algal biomass and BOD entering the river from above Lander Avenue on the SJR and from the Salt Slough and Mud Slough tributaries, approximately 100 river miles above the DWSC (Stringfellow and Quinn 2002, Foe et al. 2002). The Peer Review evaluated these reports, along with the reports from all of the other DO TMDL studies conducted between 1999 and 2001. It was determined that there was not sufficient information available from the upstream region of the SJR to determine the source of algae entering the DWSC (Cloern et al. 2002). Task 4 was developed in response to the need for a more comprehensive study of the upstream SJR between Channel Point and Lander Avenue, which was identified as the necessary next step in the development of a scientifically based DO TMDL plan, if the upstream SJR was to be included in the DO TMDL (Cloern et al. 2002).

Task 4 is the core program for the development of a DO TMDL for the SJR. Task 4 will provide the baseline or reference data by which to measure the impact of the DO TMDL Implementation Plan or any other management program instituted as part of the Implementation Plan. Task 4 is a more comprehensive, integrated, and organized monitoring program than was attempted in prior years. This approach is justified to respond to recommendations PRR1, SR2, and SR3.

Task 4 will provide a well-organized and integrated analysis of a coherent data set. In previous DO TMDL studies, scientists have conducted statistical and mass balance analysis in an independent fashion without any central coordination of effort. Additionally, it has not been clear in the past that all analyses were conducted on the same data set. The lack of coordination and differences in data sets could explain how previous DO TMDL studies reached disparate conclusions on key issues, such as the relative impact of ammonia and algal biomass on the DO demand in the DWSC (Lehman 2001, Lee and Jones-Lee 2002).

Task 4 will resolve stakeholder questions concerning the scientific validity of the DO TMDL process (SR1, SR2, SR3, SR5). Task 4 is a stakeholder-led monitoring effort, built on an adaptive management strategy, which balances the various interests of regulators and stakeholders. Task 4 is scientifically based and was developed with advice from scientists and engineers from government, universities, and the private sector. Academic institutions, in close cooperation with stakeholder groups and the RWQCB, will execute Task 4.
Data collected in Task 4 will be used in Task 5 to calculate apparent algal growth rates for use in the Strawman Process. Data from this task will be used in Task 6 for model calibration. Samples collected, as part of Task 4 will be analyzed in Task 7 for characterization of BOD sources.

In summary, the comprehensive upstream monitoring program proposed in Task 4 will fill data gaps identified in PRR1, SR2, SR3, SR4, and SR5. This Task will reduce uncertainties in the

TMDL analysis for DO. Currently, the effects of various upstream loads of oxygen-demanding materials on downstream DO conditions have not been quantified adequately to determine the role of upstream sources on oxygen depletion. The proposed monitoring program will collect data to support all of the overall project objectives and research questions described in Part B: Background and Goals. The investigations and analyses conducted in Tasks 5–8 will supplement the data collected under Task 4 to ensure that these objectives are met and sufficient information is available to answer the study questions.

Task 4 Approach and Methods

Selection of Monitoring Locations and Parameters

The selection of the monitoring locations and the parameters to be measured as part of this project was conducted in a public process that lasted several months. Consultants, academics, water district personnel, wetland mangers, and individuals from the CVRWQCB, DWR, and USGS were asked to suggest potential monitoring stations and water quality data that should be collected at these sites. Information was solicited on existing monitoring stations and the history of monitoring at existing or previous monitoring stations. An initial comprehensive list of 120 potential monitoring sites for the DO TMDL monitoring program was assembled and presented at public TAC and Steering Committee Meetings for review.

Each of the 120 suggested monitoring stations was categorized as a river (SJR), tributary, drain, canal spill, diversion, municipality, or source. Stations were further categorized by proximity to the SJR and the number of other stations between the station and the SJR. Stations located on the main stem of the SJR were classified as 0^o stations. Primary (1^o) stations represent flows that are not included in other monitoring stations before they reach the SJR. Secondary (2^o), tertiary (3^o), and quaternary (4^o) stations represent flows that pass through one, two, or three other monitoring points before they reach the SJR, respectively.

From the initial list of 120 potential monitoring locations, stations were selected for inclusion in this program based on the following criteria:

1) Importance to the establishment of a comprehensive monitoring program that would allow a complete algal, BOD and nutrient mass balance (Objectives 1, 2, and 3).

2) Importance and relevance to the modeling effort (Objective 5).

3) Flow monitoring was already being collected at the site.

4) The station was included in other water quality studies or monitoring programs.

5) Was the station necessary to the development of stakeholder confidence in the TMDL process (Objective 6).

6) Cost

7) Site access

8) Safety

One additional overarching objective in this process was the need for the plan to include all stations needed for calibration of the existing DSM2 model of the upstream SJR between Lander Avenue and the DWSC. Using the model as a monitoring template was considered useful since DSM2 defines the major hydrologic (flow) inputs and withdrawals from the SJR and allows quantification of their relative importance in terms of flow volume.

In the final analysis, 56 monitoring stations were selected for inclusion in this project (Table B-1). Thirty-five of these stations are river (0^o) or primary (1^o) stations and 4 stations are irrigation diversions taken directly from the SJR (Table B-1). These 39 stations are believed to represent all of the significant surface inflows and diversions from the upstream SJR in our study area. The remaining 17 sites were selected to allow the characterization of specific sub-watersheds contributing flows to the SJR.

A similar process was followed for selection of the water quality parameters to measure. There was good agreement among most parties concerning what parameters were necessary. The final list of parameters is given in Tables B-2 and B-3. These water quality constituents were chosen because of their importance to understanding oxygen demand and to maintain continuity with other past or existing monitoring effort in the upstream SJR.

Grab Sampling Frequency

The selection of sampling frequency for the grab sampling conducted as part of this project (Task 4.2 and 4.3) has been the subject of considerable debate. The original sampling frequency suggested by the PI's on this project was every week on a year round basis. Public comments on drafts of this proposal have made a variety of recommendations, from 2 times per week sampling to a recommendation that we conduct summer sampling only. The final selection of grab sampling frequency was a compromise between cost and the desire for more information. The selected sampling frequency is compatible with peer review and stakeholder recommendations.

Year round sampling was selected, because low DO conditions can occur during all months of the year, even thought low DO conditions are most frequent in the summer. Winter sampling was recommended in PRR1 as an important component needed to determine root causes of DO deficits in the ship channel. Winter sampling was also requested by stakeholders to document the quality of their water on a year round basis and to insure the fairness of the TMDL process (SR2 and SR5). However it was agreed that winter grab sampling was less critical and could be made at a lesser frequency than summer sampling.

It was determined that weekly sampling would be very expensive. Analytical cost alone for the weekly sampling of the river and primary (1^o) sites alone was estimated to be greater than $460,000 per year. This did not including the costs of collection and transport; cost associated with data analysis; or cost for sampling any sites that had not been sampled in the past. PRR1 and PRR4 identified the need to sample more stations in the SJR in addition to the stations that were sampled in previous studies. Stakeholders agreed that the number of stations included in previous studies was inadequate to characterize the basin (SR2 and SR3). Limiting this project to conducting weekly sampling at the same stations as sampled in previous studies was incompatible with the scientific goals of the project.

The most fundamental problem addressed in determining the sampling frequency is the inherent limits of grab sampling.   It is not obvious if more frequent grab sampling would really reduce uncertainty in the measurements being made. For example, all grab samples would be made during daylight hours, hence even bi-weekly sampling would not correct for any bias associated with daylight sampling. The normal approach to eliminate grab sample bias is to deploy composite samplers. Unfortunately, algae and BOD cannot be preserved in a manner compatible with composite sampling technology.

In this proposal, it has been decided to supplement grab sampling with the use of continuous fluorescent chlorophyll monitors (Tasks 4.3 and 4.5). This approach was recommended by the peer review panel (PRR1) and has been successfully instituted by the DWR at several locations on the SJR. It is a basic hypothesis of this project that we will be able to fill the data gaps between grab-sample events using continuous fluorescence monitoring.

In this project it is proposed to sample key sites every two weeks during the months of June to October and once per month between November and May (Task 4.2) for three years. In addition, Task 4.3 includes an additional 144 sampling events spread out over the remaining 35 stations in the first year. In year two and three, the sampling events in Task 4.3 will be directed toward the characterization of sources in watersheds identified as having significant BOD sources. These grab sampling events will be closely integrated with the continuous monitoring programs described in Tasks 4.4 and 4.5. This combined grab and continuous monitoring program is believed to be the most reasonable and rational approach possible for meeting the key proposal objectives in a cost-efficient manner.

Table B-1: Monitoring Program Summary

Station Name	Station Number (corresponds with Figure B-1)	Station Type (Relation to SJR)[1]	Stations Associated with Task 4.1: Flow Data Collection	Stations Associated with Task 4.2: Year-Round Grab Sampling Program	Stations Associated with Task 4.3: Intermittent Grab Sampling Program	Stations Associated with Task 4.4: Permanent Chlorophyll Monitoring Station	Stations Associated with Task 4.5: Moveable Chlorophyll Monitoring Station
SJR at Channel Point	1	River (0^o)	X	X		X	
SJR at Lathrop	2	River (0^o)	X		X		
SJR at Old River	3	River (0^o)	X		X		
SJR at Mossdale	4	River (0^o)	X	X			
SJR at Vernalis	5	River (0^o)	X	X		X	
SJR at Maze	6	River (0^o)	X	X			
SJR at Patterson	7	River (0^o)	X	X		X	
SJR at Crows Landing	8	River (0^o)	X	X		X	
SJR at Fremont Ford	9	River (0^o)	X		X		
SJR at Lander Avenue	10	River (0^o)	X	X		X	
French Camp Slough	11	Tributary (1^o)	X		X		
Stanislaus River at Caswell Park	12	Tributary (1^o)	X (from Ripon)	X			
Stanislaus River at Ripon	13	Tributary (2^o)	X		X		
Tuolumne River at Shiloh Bridge	14	Tributary (1^o)	X (from Modesto)	X			
Tuolumne River at Modesto	15	Tributary (2^o)	X		X		

Table B-1 (continued)

Station Name	Station Number (corresponds with map numbers)	Station Type (Relation to SJR)[1]	Stations Associated with Task 4.1: Flow Data Collection	Stations Associated with Task 4.2: Year-Round Grab Sampling Program	Stations Associated with Task 4.3: Intermittent Grab Sampling Program	Stations Associated with Task 4.4: Permanent Chlorophyll Monitoring Station	Stations Associated with Task 4.5: Moveable Chlorophyll Monitoring Station
Merced River at River Road	16	Tributary (1^{o})	X (from Stevenson)	X			
Merced River near Stevinson	17	Tributary (2^{o})	X		X		
Mud Slough near Gustine	18	Tributary (1^{o})	X	X		X	
Salt Slough at Lander Avenue	19	Tributary (1^{o})	X	X		X	
Los Banos Creek at Highway 140	20	Tributary (1^{o})	X	X			X
Orestimba Creek at River Road	21	Tributary (1^{o})	X	X			X
Modesto ID Lateral 4 to SJR	22	Drain/Spill[2] (1^{o})	X		X		
Modesto ID Lateral 5 to Tuolumne	23	Drain/Spill (1^{o})	X	X			
Modesto ID Lateral 6 to Stanislaus River	24	Drain/Spill (2^{o})	X				
Modesto ID Main Drain to Stan. R. via Miller Lake	25	Drain/Spill (1^{o})	X	X	X		
Turlock ID Highline Spill	26	Drain/Spill (1^{o})	X		X		
Turlock ID Lateral 2 to SJR	27	Drain/Spill (1^{o})	X		X		

Table B-1 (continued)

Station Name	Station Number (corresponds with map numbers)	Station Type (Relation to SJR)[1]	Stations Associated with Task 4.1: Flow Data Collection	Stations Associated with Task 4.2: Year-Round Grab Sampling Program	Stations Associated with Task 4.3: Intermittent Grab Sampling Program	Stations Associated with Task 4.4: Permanent Chlorophyll Monitoring Station	Stations Associated with Task 4.5: Moveable Chlorophyll Monitoring Station
Turlock ID Westport Drain to SJR	28	Drain/Spill (1^o)	X	X			
Turlock ID Harding Drain to SJR	29	Drain/Spill (1^o)	X	X			
Turlock ID Lateral 6 & 7 to SJR	30	Drain/Spill (1^o)	X		X		
New Jerusalem Drain	31	Drain (1^o)	X		X		
Grayson Drain	32	Drain (1^o)	X		X		
Hospital Creek	33	Drain (1^o)	X		X		
Ingram Creek	34	Drain (1^o)	X		X		
Westley Wasteway	35	Drain (1^o)	X		X		
Del Puerto Creek	36	Drain (1^o)	X	X			
Newman Wasteway	37	Drain (1^o)	X		X		
Marshall Road Drain	38	Drain (1^o)	X		X		
Salado Creek	39	Drain (1^o)	X		X		
Patterson Irrigation District	40	Diversion (1^o)	X		X		X
West Stanislaus Irrigation District	41	Diversion (1^o)	X		X		
Banta Carbona Irrigation District	42	Diversion (1^o)	X		X		

Table B-1 (concluded)

Station Name	Station Number (corresponds with map numbers)	Station Type (Relation to SJR)[1]	Stations Associated with Task 4.1: Flow Data Collection	Stations Associated with Task 4.2: Year-Round Grab Sampling Program	Stations Associated with Task 4.3: Intermittent Grab Sampling Program	Stations Associated with Task 4.4: Permanent Chlorophyll Monitoring Station	Stations Associated with Task 4.5: Moveable Chlorophyll Monitoring Station
El Solyo Water District	43	Diversion (1°)	X		X		
San Luis Drain Site B	44	Drain (2°)	X	X			X
Volta Wasteway	45	Inlet (3°)	X		X		X
Mud Slough at Gun Club Road	46	Tributary (2°)	X	X			X
Delta-Mendota Canal inlet to the Mendota Pool	47	Inlet (3°)	X		X		X
Sump 1 – Grasslands Area Farmers	48	Drain (5°)	X		X		X
PE-14 – Grasslands Area Farmers	49	Drain (4°)	X		X		X
San Luis Drain Site A	50	Drain (3°)	X		X		X
Arroyo Canal	51	Inlet (3°)	X		X		X
Salt Slough at Sand Dam	52	Drain (2°)	X		X		
Salt Slough at Wolfsen Road	53	Tributary (2°)	X		X		X
Los Banos Creek at Ingomar Grade	54	Tributary (2°)	X		X		X
Modesto WWTP	55	Municipality (2°)	X				
Turlock WWTP	56	Municipality (2°)	X				

[1] Stations located on the SJR's main stem were classified as 0° stations. Primary (1°) stations represent flows that are not included in other monitoring stations before they reach the SJR. Secondary (2°), tertiary (3°), and quaternary (4°) stations represent flows that pass through one, two, or three other monitoring points before they reach the SJR, respectively.
2 Drain/Spill designations for stations on channels that carry drainage and irrigation spill water.

Adaptive Management Approach for Monitoring

An innovative and flexible adaptive management approach was developed for Task 4 due to the large number of monitoring sites required to characterize an entire watershed. The use of an adaptive management plan is necessary to balances costs with the need for comprehensive information and to allow for sampling intensity and location to be altered in years two and three as information from prior years becomes available.

All 56 sites included in Table B-1 will be monitored for flow (Task 4.1). Gathering flow data at all sites will ensure that all significant flow contributions to the SJR are identified and included in the water quality sampling program and the model. Most of the monitoring sites identified currently have flow measuring stations and data is available but has not been compiled in a manner useful for DO TMDL studies. Low flow stations with good water quality can be documented in the first year and eliminated from the sampling program in the second and third year. In this way, it will be apparent to stakeholders why one watershed is considered more important than another in the DO TMDL implementation process (SR2, SR3, SR4, and SR5).

Twenty-one sites have been chosen for year-round water quality sampling (Task 4.2). These stations will be sampled monthly in the winter (November to May) and twice a month in summer (June to October) for a total of 17 sampling events at each station per year (357 samples). Water samples from these stations will be analyzed for the constituents listed in Table B-2 (laboratory) and Table B-3 (field measurements). These sites were chosen because of their importance to river modeling efforts and the presence of year-round flow. It is expected that these stations will be sampled at this frequency for the entire three-year period. However, stations may be eliminated under this adaptive management plan if it is determined that stations are redundant in terms of flow or water quality measurements. At the end of the project it will be recommended what stations should be continued to support the DO TMDL Implementation Plan.

Thirty-three stations will be subject to water quality sampling less frequently (Task 4.3). These sites were chosen based on the need to develop a comprehensive understanding BOD sources in the SJR watershed and to increase stakeholder confidence in the TMDL process. In year 1, all 33 stations will be sampled at least once per quarter (132 samples). In the second and third years, stations having high water quality or insignificant loading of nutrients, algae, or BOD will be eliminated from the sampling program and the sampling effort will be directed more toward sub-watersheds identified as important sources of BOD. This approach is consistent with peer recommendations PRR1, PRR2, PRR4, and PRR5 and stakeholder recommendations SR2, SR3, SR4, and SR5. Task 4.3 is a key component of the adaptive management strategy for Task 4.

Seven river stations have been selected for permanent continuous chlorophyll and turbidity monitoring and three stations have been selected for continuous DO and pH monitoring (Task 4.4). These sites were selected for permanent installations because of their importance to calibration of the algae growth component of the SJR quality models (Task 6). Permanent stations will be integrated into existing real-time data collection systems over the course of the study. The stations will be operated for the full three years, but stations may be eliminated under the adaptive management plan if they are determined to be redundant with other stations in the plan or stations operated by other agencies. Operation of the stations will be turned over to DWR or USGS at the end of the three-year period if the stations are needed to support implementation of the DO TMDL plan and continued monitoring of algal growth in the SJR watershed is justified.

Movable continuous chlorophyll and turbidity monitoring stations (Task 4.5) will be deployed to fill specific data gaps identified in previous studies and by the Peer Review (Cloern et al. 2002). In the first year, the moveable continuous fluorescence monitoring stations will be deployed to characterize algal sources and growth patterns in sub-watersheds identified in previous studies as sources of algal biomass to the SJR. In the second and third years, similar studies will be conducted in other regions identified in the first year of monitoring as needing more characterization. These deployments will be made to answer specific data gaps identified in PRR1, PRR2, PRR4, SR1, SR2, and SR3. Under our adaptive management plan, the movable monitors will also be deployed to assist stakeholders in evaluating the impact of changing management practices on algal growth patterns (SR4). These monitors will be deployed for 2 or 4 weeks at a time to capture information concerning the variability of algal loading that occurs between grab sampling events. The information will be used to refine the grab sampling program and identify stations that could warrant the installation of permanent continuous monitoring stations.

Table B-2: Water Quality Parameters to be Measured in the Discrete Sampling Programs (Task 4.2 and 4.3), Not Including Field Measurements

Analyte	Abbreviation	Rationale
10-Day Biochemical Oxygen Demand	BOD_{10}	BOD_{10} is widely used in scientific and regulatory studies as a fundamental and direct measurement of oxygen-demanding materials.
10-Day Carbonaceous and Nitrogenous Biochemical Oxygen Demand	$CBOD_{10}$/ $NBOD_{10}$	$CBOD_{10}$/$NBOD_{10}$ will be measured for approximately 10% of the BOD samples to further characterize BOD at selected sites (PRR4). Examining relationships between $CBOD_{10}$ and $NBOD_{10}$ are useful for developing DO management strategies.
10-Day Soluble Biochemical Oxygen Demand	$SBOD_{10}$	$SBOD_{10}$ will be measured for approximately 10% of the BOD samples to further characterize BOD at selected sites (PRR4).
Chlorophyll *a*	Chl-*a*	Chl-*a* is a major algal pigment that is measured as an indicator of algal biomass concentration.
Phaeophytin *a*	Pha-*a*	Pha-*a* is a degradation product of Chl-*a*. Pha-*a* is typically interpreted as an indicator of dead or inactive algal biomass and can be added to Chl-*a* to give a measure of total algal pigments.
Total Organic Carbon	TOC	TOC is a major component contributing to oxygen demand (BOD). Examining relationships between TOC and BOD are useful for developing DO management strategies.
Dissolved Organic Carbon	DOC	DOC is typically low in most areas of the SJR. DOC is measured to maintain continuity with existing databases and to identify areas with significant amount of TOC that are not algal biomass.
Volatile Suspended Solids	VSS	VSS is direct measure of organic detritus and is a surrogate measure for algal biomass.
Total Suspended Solids	TSS	TSS measurement is necessary to measure in order to measure VSS. TSS is also an important determinant in light-limited algal growth.
Total Kjeldahl Nitrogen	TKN	TKN is an important component of BOD and another surrogate measure for algal biomass.
Nitrate and Nitrite Nitrogen	NO_3/NO_2-N	NO_3/NO_2-N is a basic water quality parameter and an important algal nutrient.
Ammonia Nitrogen	NH_4-N	NH_4-N is an important component of BOD and an algal nutrient.
Orthophosphate, soluble	o-PO_4	o-PO_4 is a key algal nutrient that may control algal growth potential in some sub-watersheds.
Total Phosphate	TPO_4	TPO_4 is a basic water quality parameter that will be measured to insure continuity with historical databases.

Table B-3: Field Parameters

Parameter	Instrument	Rationale
Fluorescence	SCUFA or YSI 6600	Fluorescence provides a direct, *in-situ* measurement of chlorophyll *a* concentrations.
Turbidity	SCUFA or YSI 6600	Turbidity is automatically measured with fluorescence and used to correct for instrument interference. Turbidity also is an important parameter influencing light-limited algal growth.
Temperature	YSI 6600	Temperature is a basic water quality parameter that directly influence algal growth rate.
Electrical conductivity (EC)	YSI 6600	EC is a basic water quality parameter that is a surrogate measure for salt concentration. EC measurements will be used in algal mass balance calculations as a conservative reference.
Dissolved oxygen (DO)	YSI 6600	DO is a basic water quality parameter that can be used in combination with pH to estimate algal growth condition.
pH	YSI 6600	pH is a basic water quality parameter that can be used in combination with DO to estimate algal growth condition.

Task 4.1: Flow Data Collection

Task 4.1.1: Collection of Flow Data From Existing Monitoring Stations

Existing flow monitoring stations on the SJR have been developed for a number of different purposes including:

Flood management

Environmental compliance

Water district operations

National and state data acquisition programs

Scientific research

Most SJR stations are maintained and supported by the Bureau of Reclamation, DWR, and USGS. The USGS funds some of its own flow stations but typically serves as a contractor to one of the water agencies. These stations are typically permanent installations that collect data on a 15 minute or hourly frequency and use a variety of techniques for data acquisition ranging from punch tapes and charts to phone and satellite telemetry. Acquisition of data from these stations may be as simple as accessing a real-time website or online computer or as complex as requesting published data from an agency after it has been transcribed from a chart, hand entered into a spreadsheet, error checked, collated, and certified. All of the proposed SJR monitoring stations are operated by either the DWR or the USGS. Flow data from stations at Crows Landing, Patterson, and Vernalis are available on a real-time basis through the California Data Exchange Center (CDEC). Lander Avenue, Lathrop, and Old River flow data must be requested from the DWR. Flow data from the major tributary stations along the Merced and Tuolumne rivers are also available either via CDEC or from published district records. At least one station on each tributary is part of the flood early warning system and, therefore, accessible on a real-time basis through CDEC.

Flow data from east- and west-side water districts also differs in its accessibility. On the east side most of the major drainage ditches and canal spills have flow telemetry that is accessible to the water districts through their custom Supervisory Control and Data Acquisition (SCADA) systems. SCADA is a computer network that provides real-time monitoring as well as the remote control of pumps, valves, and other control devices. On the west side of the San Joaquin Basin only Mud and Salt sloughs, Orestimba Creek, and Del Puerto Creek have continuous flow monitoring. All other stations are checked daily, weekly, or monthly using a flow measurement device and a stage sensor. Eastside and Westside water district data will be accessed through cooperative arrangements with the water districts.

Diversion flow rates from major SJR diverters such as West Stanislaus Irrigation District (ID), Patterson ID, and Banta Carbona ID are recorded on ID SCADA systems and relayed into the ID office. West Stanislaus ID has a real-time, web-accessible flow-monitoring site that is maintained by LBNL. Diversions for El Solyo ID are estimated based on the number of pumps that are operating. All other riparian diversions are not monitored or poorly monitored by individual landowners.

Fifty-six sample stations have been identified for the collection of flow data under Task 4. Data will be organized and made available in a database as described in Task 4.6. For each station, all available data will be compiled to maintain a complete record of minimum, maximum, and average daily flow for the entire study period. These data will be made available for use in Tasks 5–8.

Task 4.1.2: Improvement of Flow Monitoring Stations

A total of 17 sites have been identified as needing some sort of flow measurement improvements, varying from the installation of real-time Sontec velocity meters (as is the case for the SJR at Lander Avenue) to continuous stage recording equipment. Additionally, 25 monitoring stations will have EC and temperature probes installed and five stations will have telemetry equipment installed to allow off-site access to the data. Because flow data is the core element to the monitoring program of this project, all of these upgrades will occur in the first year of the project. Table B-4 summarizes the stations requiring upgrades (and their associated costs) in the first year of the project.

As the flow data is collected, it will be evaluated for accuracy and precision and compiled in the database developed for this project. The flow and EC data will be used for the calculation of algal biomass and BOD mass loading and for the prioritization of stations under the project's adaptive management approach. High flow or high loading stations with poor quality data will be targeted for improvement in the second and third years of the project. It is not anticipated that a significant number of sites will need improvements beyond those completed in the first year.

Table B-4: Budget Justification for Task 4.1 and F.3 Flow and Water Quality Continuous Monitoring Stations

Rev. Site Number	Site Description	New installation (equipment + labor)	Agency upgrade (equipment + labor)	Stage / flow	EC-Temp	SCUFA Chl-a, Turb[1]	YSI Sonde DO, pH	Tele-metry	Labor (2 man days)	Labor (match)
1	SJR at Channel Pt			e	e	$9,300	$15,000	e		
2	SJR at Lathrop			e	e			e		
3	SJR at Old River			e	e			e		
4	SJR at Mossdale			e	e			e		
5	SJR at Vernalis			e	e	$9,300		e		
6	SJR at Maze			e	$2,500		$15,000	e	$2,000	
7	SJR at Patterson			e	e	$9,300		e		
8	SJR at Crows Landing	$3,000		e	e	$9,300	$15,000	e		
9	SJR at Fremont Ford	$3,000		e	$2,500			e		
10	SJR at Lander Ave			$7,500	e	$9,300		$4,000	$2,000	
11	French Camp Slough			e	$3,500			e	$2,000	
12	Stanislaus River at Caswell Park			e	e			e	e	
13	Stanislaus R at Ripon			e	e			e		
14	Tuolumne R at Shiloh Bridge			e	e			e	e	
15	Tuolumne R at Modesto			e	e			e		
16	Merced R at River Road			$5,000	$2,500			e	$2,000	
17	Merced R near Stevinson			e	e			e		
18	Mud Sl near Gustine	$3,000		e	e	$9,300		e		
19	Salt Sl at Lander Ave			e	e	$9,300		e		
20	Los Banos Cr at Hwy 140			e	e			e		$2,000
21	Orestimba Cr at River Road	$3,000		e	e			e		
22	Modesto ID Lat 4 to SJR			$5,000	$3,500			e		$2,000
23	Modesto ID lat 5 to Tuolumne			e	$3,500			e		$2,000
24	Modesto ID Lat 6 to Stanislaus R			e	$3,500			e		$2,000
25	Modesto ID Main Drain to Stan R. via. Miller Lake			$5,000	$3,500			e		$2,000
26	Turlock ID Highline Spill			$5,000	$3,500			e		$2,000
27	Turlock ID Lateral 2 to SJR			e	$3,500			e		$2,000
28	Turlock ID Westport Drain to SJR			$5,000	$3,500			e		$2,000
29	Turlock ID Harding Drain to SJR			e	$3,500			e		$2,000
30	Turlock ID Lat 6 & 7 to SJR			e	$3,500			e		$2,000
31	New Jerusalem Drain			$5,000	$3,500			$4,000		$2,000
32	Grayson Drain			e	e			e		
33	Hospital Cr			$5,000	$2,500			e		$2,000
34	Ingram Cr			$5,000	$2,500			e		$2,000
35	Westley Wasteway			$5,000	$2,500			e		$2,000
36	Del Puerto Cr			$5,000	$2,500			e		$2,000
37	Newman Wasteway			$5,000	$2,500			e		$2,000
38	Marshall Rd Drain			$5,000	$2,500			e		$2,000
39	Salado Cr			$5,000	$2,500			e		$2,000
40	Patterson ID			e	e			e		
41	West Stanislaus ID			e	e			e		
42	Banta Carbona ID			e	$2,500			e	$2,000	
43	El Solyo WD			$5,000	$2,500			e		$2,000
44	SLD Site B		$3,000	e	e			e		
45	Volta Wasteway			e	e			$4,000	$2,000	
46	Mud Sl at Gun Club Rd			e	e			e		
47	DMC inlet to Mendota Pool			e	e			e		
48	Sump 1 (DP 25)			e	e			e		
49	PE-14			e	e			e		
50	SLD Site A			e	e			e		
51	Arroyo Canal			e	e			e		
52	Salt Sl at Sand Dam			e	e			e		
53	Salt Sl at Wolfsen Rd			e	e			e		
54	Los Banos Cr at Ingomar Grade			e	e			e		
55	Modesto WWTP			$5,000	$3,500			$4,000	$2,000	
56	Turlock WWTP			$5,000	$3,500			$4,000	$2,000	
Totals:		$12,000	$3,000	$87,500	$75,500	$130,000	$45,000	$20,000	$16,000	$38,000

e Existing Site, no upgrade necessary

[1] Includes 7 mobile monitoring units.

Task 4.2: Collection and Analysis of Discrete Water Quality Data at Year-Round Sites

Task 4.2.1: Collection of Discrete Water Quality Samples

Twenty-one stations were selected for inclusion in a year-round sampling program. These stations will be sampled every 2 weeks between June and October and once per month between November and May, for a total of 17 visits per site per year. The sites included in the year-round program were selected based on their importance as determined by prior studies and the requirements of the modeling program (see Selection of Monitoring Stations, above).

Depth-integrated grab samples will be collected in appropriate containers and volumes as required for analysis. Samples will be both depth and laterally integrated where possible and practical. When grab samples are collected, field measurements will be made of water temperature, electrical conductivity (EC), DO, fluorescence, turbidity, and pH using a field portable meter. Field measurement will be made using an YSI 6600 equipped with appropriate probes (Yellow Springs Instruments, OH). Samples will be immediately iced down or otherwise properly preserved and transported directly to the appropriate laboratory for analysis. In year 1, LBNL research personnel will collect samples. During the course of years 1, 2, and 3, local water and drainage agency personnel will be trained in uniform sample collection procedures (Task 4.7). At the end of year 3, the sampling program can be turned over to local stakeholders if further monitoring is required.

Task 4.2.2: Analysis of Samples Collected in Task 4.2.1

Samples collected in the field will be transported to LBNL and UCD for analysis. Samples will be analyzed for the constituents listed in Table B-2. UCD will conduct analysis for TKN, NO_3/NO_2-N, NH4-N, o-PO_4, and TPO_4. LBNL will conduct analysis for BOD_{10}, Chl-*a*, Pha-*a*, TOC, DOC, VSS, and TSS. Approximately 10% of the samples will also be analyzed for $CBOD_{10}/NBOD_{10}$, to provide data for BOD characterization analysis described in Tasks 5 and 7. All analyses will be run within the allowed holding time applicable to the preservation method used. All analyses will be conducted using procedures described in *Standard Methods for the Examination of Water and Wastewater* (APHA 1998) unless otherwise noted. Quality Assurance/Quality Control (QA/QC) protocols established as part of Task 3 will ensure consistency between the laboratories. BOD will be measured by Standard Method (SM) 5210B. Total organic carbon (TOC) and dissolved organic carbon (DOC) will be measured by SM 5310 A, the Combustion InfraRed Method, using an Apollo 9000-HS TOC analyzer (Teckmar-Dohrmann, Cincinnati, OH). Nitrate and nitrite will be analyzed by the Cadmium Reduction Method (adapted from SM 4500-NO3-E). Ammonia will be quantified by the Nessler Method. *Ortho*-phosphate and total phosphorous will be quantified by the Ascorbic Acid Method (adapted from SM 4500-P-E). Ammonia, nitrate, nitrite, total phosphorous and *o*-phosphate will be analyzed using reagents purchased from HACH Co. (Loveland, CO). Total suspended solids (TSS) and volatile suspended solids (VSS) will be analyzed by SM 2540 D and E, respectively. Chlorophyll-*a* (chl-*a*) and phaeophytin-*a* (pha-*a*) will be extracted and analyzed using UV absorption (SM 10200H).

An additional 1-liter composite water sample from site will be filtered through pre-combusted glass fibers for isotope analysis as part of Task 7. Filters will be wrapped in foil, frozen, and sent to the USGS stable isotope lab in Menlo Park for isotopic analysis of the particulates. The filtered water sample will be divided into smaller bottles, chilled or frozen (as needed), and sent to the USGS lab for other isotopic analyses.

In addition to field samples, up to 20% of the number of field samples will be analyzed for quality control standards, blanks, and duplicates. The exact number of samples will be determined during the development of the QA/QC plan (Task 2).

Task 4.3: Collection and Analysis of Discrete Water Quality Data at Sites Not Included in Task 4.2

Task 4.3.1: Collection of Discrete Water Quality Samples

Thirty-five stations included in this study were not included in the year-round sampling program due to economic and other considerations (see above). Thirty-three of these stations will be sampled in Task 4.3. The two exceptions are the Modesto WWTP and Turlock WWTP. WWTPs submit water quality data to the public record as part of a National Pollutant Discharge Elimination System (NPDES) permit. NPDES data will be examined for all WWTPs discharging into the SJR and this data will be included in the evaluation under this study. Additional sampling at these sites will not be conducted under Task 4.3 unless a need is identified after evaluation of NPDES data.

The 33 stations sampled under this task will be sampled on an adaptive management schedule. The initial sampling schedule will consist of a rotation through the sites with up to 23 sites sampled at one time on a single rotation. All stations will be sampled at least once per quarter in year 1, with the exception of the Modesto WWTP and Turlock WWTP.

Up to 144 samples per year will be collected under this task per year. After a comprehensive survey is completed in the first year, the resources allocated to this task will be concentrated and directed specifically at the characterization of sub-watersheds that are sources of algae and nutrients as identified in the first year study and prior studies. Sampling will be conducted as described in Task 4.2.1. By the end of year 3, all 33 stations included in this task will have been evaluated for their importance in terms of flow and loading of water quality parameters. Based on the information gathered in this task, recommendations will be made concerning which stations included in this Task would be appropriate for inclusion in any monitoring proposed as part of the DO TMDL Implementation Plan.

Task 4.3.2: Analysis of Samples Collected in Task 4.3.1

Samples collected in the field will be transported to LBNL and UCD for analysis as described in Task 4.2.2. Up to 144 samples per year will be analyzed under this task.

Task 4.4: Installation and Operation of Permanent Continuous Chlorophyll and Turbidity Monitoring Stations

Task 4.4.1: Installation, Operation, and Maintenance of Permanent Continuous Chlorophyll and Turbidity Monitoring Stations

A 15-minute to 1-hour time interval is used for SJR models. To calibrate these models, data must be collected at similar intervals at key locations in the SJR. Sample locations that are critical for model inputs and calibration will be monitored continuously. Seven stations have been identified as most critical for model calibration (Table B-1). Most of these stations occur on the mainstem of the SJR, but two are on tributaries (Salt Slough and Mud Slough) identified as being important sources of algae and nutrients in previous studies. These stations are already equipped with infrastructure for the continuous monitoring of flow. Most of the stations are also equipped with instruments for other continuous water quality measurements (typically temperature and EC) and data telemetry.

In year 1, a combination fluorometer and turbidometer manufactured by Turner Designs (Sunnyvale, California) will be installed at each of the seven stations identified as part of this task in Table 4-1. The SCUFA is an accurate, simple-to-use, and versatile submersible fluorometer for chlorophyll applications (Figure B-2). The SCUFA can be programmed for user-defined sampling rates and times. The SCUFA can be configured to log data independently of external devices with the purchase of the Internal Data Logging Package. Alternatively, the SCUFA can generate 0-5V and RS-232 signal outputs that can be mated to data collection devices already existing at stations. This feature allows the SCUFA to be deployed independently at the monitoring stations or fully integrated into existing flow monitoring station infrastructure.

Maintenance of the SCUFA consists of visits every two weeks to clean the optics and casing, check calibration using a solid calibration standard, inspect parts and connections, replace battery (if SCUFA is not on local power source), and re-deploy the device. If the device does not pass calibration, the device will be removed from service and replaced with a calibrated device. The calibration criteria and replacement protocols will be established as part of the QA/QC plan.

The maintenance and operation of the SCUFA continuous monitoring devices will be conducted by LBNL staff until operation of the units is turned over to other agencies. SCUFA units will be integrated into existing continuous monitoring infrastructure where possible. It is expected that responsibility for maintenance and operation of the SCUFA devices will be transferred fully to the DWR, USGS, and other responsible agencies by the second or third year of the project. Oversight of the operation of the units will continue under the QA/QC plan for the entire 3-year period of this study (Task 3).

DWR and the USGS have agreed to allow integration of the DO TMDL fluorescence monitoring with their existing networks. However, the success of this task is not dependent on the timely action of those agencies. The SCUFA units can and will be deployed and maintained independently until the agencies are prepared to fully integrate the chlorophyll monitoring into their continuous, telemetered monitoring programs.

Budgets for this task will be transferred from LBNL to DWR or USGS as those agencies take responsibility for the stations.

(a) SCUFA disassembled

(b) SCUFA in protective housing

Figure B-2 Self-Contained Underwater Fluorescence Apparatus (SCUFA)

Task 4.4.3: Installation, Operation, and Maintenance of Permanent Continuous DO and pH Monitoring Stations

DWR operates two continuous 15-minute interval pump sampling stations for temperature, EC, DO, pH, and algal fluorescence at Mossdale and Vernalis on the SJR. Additionally, they operate similar stations at Rough and Ready Island in the DWSC and three continuous 15-minute interval, submerged monitors (Hydroloab or YSI) at three south Delta locations. We propose to sub-contract DWR to install and maintain an additional three submerged monitors at Maze, Crows Landing, and Fremont Ford (Table B-1). This will give a total of five continuous DO and pH monitoring stations on the SJR in our study area.

The submerged monitors for DO and pH will be installed and operated for the 6-month period of May through October to record the pattern of algal growth at the five main river stations that are upstream of Mossdale. These data will be integrated with the permanent fluorescence and turbidity instruments (SCUFA) at these same stations, and with the existing flow, EC, and temperature measurements at these same main river locations. These data will provide a continuous hourly record of the amount of algae biomass and the resulting magnitude of algal photosynthesis that converts atmospheric CO_2 into algae biomass and DO. The nighttime decline in DO indicates the net effect of surface aeration and respiration. The daytime increase indicates the amount of algal growth.

The data collected is very useful to model calibration and validation (Task 6.3). The data will also be used to provide independent estimate of photosynthesis and respiration as a function of time and river length. This task supports efforts recommended in PRR2 and PRR3 as well as PRR5 and SR1.

Task 4.5: Deployment and Operation of Mobile Continuous Chlorophyll and Turbidity Monitoring Devices

In Task 4.5, mobile (stand-alone) SCUFA continuous chlorophyll and turbidity monitoring devices will be deployed for temporary periods at different locations in the SJR watershed to:

1) Determine temporal and total variability of algal concentrations at individual sites between grab sample collection events, for the purpose of validating the grab sampling program and providing information need for the adaptive management of Tasks 4.2, 4.3, and 4.4.

2) Identify changes in algal biomass concentrations and loadings between specific stations in the watershed with the purpose of identifying sources of algae and the development of management plans for particular sub-watersheds.

3) Provide information concerning temporal variability in water quality.

4) Fill data gaps as requested for model calibration.

5) Provide support to experiments described in Tasks 5 through 8.

Other deployments may be implemented under the adaptive management strategy based on monitoring results over the course of the 3-year study.

The SCUFA has been successfully tested for application as a mobile, continuous monitoring device by LBNL researchers and is well suited for use in this application. The stability and the reliability of the fluorescent measurement was evaluated over a 3-month period in 2002. The SCUFA unit successfully logged chlorophyll data for 2 weeks between maintenance visits. If the maintenance schedule was extended to longer than 2 weeks, sensor fouling could result in signal degradation. The sensor maintained calibration against chl-*a* for the entire 3-month test period and calibration could be checked in the field using a solid calibration standard.

Data from a 2-week deployment at two of the stations listed in Table B-1 is presented on Figure B-3. The data show that chl-*a* concentration can vary by a factor of greater than two within a short time (hours). This type of rapid change cannot be evaluated by grab sampling. These preliminary results illustrate that information collected with SCUFA units can help fill data gaps concerning the magnitude and frequency of algal blooms. Combining mobile, SCUFA-based, continuous monitoring with judicious grab sampling will also help establish whether the grab sample program is developing a representative description of the watershed.

In this task, SCUFA units containing batteries and data loggers for independent deployment (Figure B-2 and description in Task 4.4.1) will be deployed from bridges, docks, or other structures associated with the monitoring stations listed in Table B-1. Units will be typically deployed for a 2- or 4-week period, returned to the laboratory for cleaning and recalibration, and then redeployed at another site.

The units will be deployed to answer specific questions at specific areas within the watershed. Deployments will be deployed in coordination with activities planned in Tasks 6 and 8 whenever possible. The mobile units will be deployed at strategic locations in the watershed in coordination with bimonthly grab sampling events conducted as part of Tasks 4.2 and 4.4. Data collected from the SCUFA will be combined with data collected in the grab sampling program to establish the site-specific variability in chlorophyll that occurs between sample events. The data collected as part of this task will be used to establish the validity of using grab samples to characterize algal loading in the region. Data collected under this task may suggest that some stations need a higher or lower sampling frequency and changes can be implemented under the adaptive management plan.

The mobile continuous monitoring program (Task 4.5) will be used to identify problem areas for algal biomass accumulation within specific reaches or sub-watersheds. For example, the data in Figure B-3 show a consistent increase in algal biomass between the two sample stations, suggesting that not all the algae seen at the 2^{o} station (Site B) come from the upstream 3^{o} station (Site A). This information is useful for designing a management plan for this area.

In year 2 and 3, mobile SCUFA units will be deployed in response to requests by the modeling team for additional calibration data at specific sites. Temporary deployments would be made at key flow stations or in areas where model results are not consistent with grab sample data. Any proposed installations for new permanent stations in years 2 and 3 will be evaluated under this task (as described under the adaptive management program sections).

Eight SCUFA units will be purchased for use in Task 4.5 in year 1 and up to six more units will be purchased in years 2 and 3 as needed to replace damaged units or to expand the effort on this task if it is especially successful. Protective housings will be manufactured at LBNL (as shown on Figure B-2).

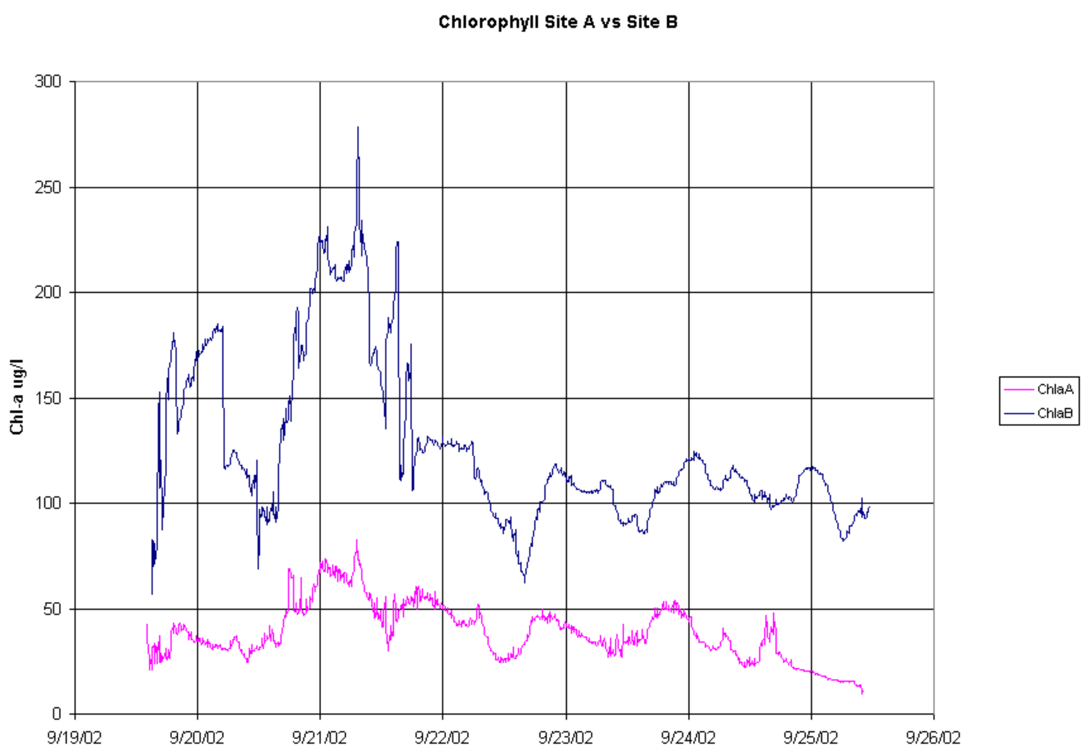

Figure B-3 Example of Data From a 2-Week Experimental Deployment of a SCUFA Unit at Site A and Site B (Table B-1).

Task 4.6: Data Management

Task 4.6.1: Management of Discrete Data Collected in Tasks 4.1, 4.2, and 4.3

Data collected in this study will be validated according to procedures established in the QA/QC plan developed in Task 3. Validated data will be entered into a local Access Database at LBNL and directly transferred to the DWR Interagency Ecological Program (IEP) database using a database program expressly designed for this project by Karl Jacobs and Brian Hale of the IEP database project. Data from the local databases will be synchronized with a comprehensive object relational databases that contains data from several of the monitoring programs in the San Francisco Bay and its tributaries. Data collected from this project will be made available independently and comprehensively to those who would like use the data as an independent data set or those who would like to use it along with the other data collected in the region. The collected data will be available on the Internet through several query and viewing tools. In addition, discrete data can be transferred to Excel files and made available to individual project PIs, TAC members, river modelers, and other interested parties for independent evaluation.

The data will be stored on a local hard-drive and backed up nightly on a remote data storage system (Connected Inc., Cambridge, MA). Hard copies of data and calculations will be made on a regular basis. All data will be made available to the SJR DO TAC as requested. Data will be provided to modelers (Task 6) for use in the TMDL model in the format they request. Discrete data collected in Task 4 will be compiled in a single database available for individual analysis by TAC members. The use of a compiled database is expected to help resolve differences in interpretation that may arise as the result of different analyses conducted by TAC members with expertise in different areas of water resources.

Task 4.6.2: Management of Continuous Data Collected in Tasks 4.1 and 4.4

The data management techniques employed for continuous monitoring data will depend largely on the source of the data collection and the maintenance of the field sensors. In the case of the USGS, Bureau of Reclamation, and DWR stations located along the SJR and its major tributaries, data will be downloaded from websites or arrangements will be made to have access to the data once it is reviewed, error checked, and approved. The CDEC polls a variety of state, federal, and local stations either by phone modem, cellular phone, radio, or satellite. Many of the SJR stations in the monitoring plan are currently accessible through the CDEC. Important sites such as Mud Slough, Salt Slough, and Crows Landing whose maintenance is covered under USGS contract are currently relying on phone modem for data telemetry but are in the process of converting to a GOES satellite-based system. The advantage of GOES satellite technology, besides its minimal maintenance cost after installation, is that it lends itself to data retrieval automation. Computer programs or UNIX scripts can be written to retrieve the data, error check it, and parse it into formats that models such as DSM2 require for input. Other west-side continuous sites are accessible through cellular or LAN line modem. Software is now available to automate the retrieval and processing of data from these sites also. In some cases such as Los Banos Creek and some internal Grassland Water District sites where satellite telemetry has been installed but is not yet working and phone telemetry is unavailable, continuous data retrieval is accomplished by downloading data on to a laptop or similar storage device during field visits.

Local database systems will be implemented by a staff of five developers from the IEP. The principal developer will be Brian Hale with assistance from Karl Jacobs and Kris Lightsey. Data from the local databases will be synchronized with a comprehensive object relational databases that contains data from several of the monitoring programs in the San Francisco Bay and its tributaries. Data collected from this project will be made available independently and comprehensively to those who would like use the data as an independent data set or those who would like to use it along with the other data collected in the region. The Collected data will be available on the Internet through several query and viewing tools.   Overall management for this component will be provided by Karl Jacobs.

Task 4.7: Training and Outreach

The California Water Institute (CWI) will organize outreach and technical training sessions for individuals and organizations involved in the DO TMDL process. Outreach will involve organizing technical seminars and information seminars. In the second and third year, interested stakeholders will be trained in the technical aspects of the monitoring program so that local stakeholders will be prepared to take over the monitoring program if it is continued after the third year as part of the DO TMDL Implementation Plan.

Qualified individuals who can conduct the training will be identified and scheduled as instructors. Stakeholders will be trained in conducting sampling activities in compliance with the sampling and analysis plan and QAPP. The training will include proper operation and maintenance of continual monitoring stations and proper procedures for collecting and handling grab samples. The training will include a “dry-run” water quality monitoring and sample collection event. The “dry-run” will include instrument calibration, water quality parameter measurement and recording, preparation and handling of sample containers, completing chain-of-custody documents, and actual sample collection.

CWI will develop and maintain a contact list of those who could be involved in training. Individuals and organizations on the list will receive information on upcoming training sessions. CWI will also identify and secure appropriate local venues for training activities.

Additional outreach efforts will include the employment of Fresno State, UCD, UOP, and UCB students on this project. Principal investigators will attend TAC and Steering Committee meetings and give public presentations at CWI organized DO TMDL science conferences.

Task 4.8 Interpretation of Results

Data collected in Task 4 will be compiled and organized at LBNL (Task 4.6). The data will receive extensive QA/QC as detailed in the QA/QC plan developed in Task 3. The validated data will then be directly distributed to scientists, engineers, and modelers on the project. Data will also be provided to members of the TAC for additional analysis and review at the TAC's request.

A series of graphs and summary tables of measurements will be prepared for rapid distribution and review by the TAC, stakeholders, and other interested parties. An example of this type of exploratory data display is shown on Figure B-4. This figure shows the annual Vernalis flow and the daily DO record from Mossdale, compared with the weekly measurements of VSS and algae (chlorophyll and phaeophytin). These graphs will be updated each quarter so that the seasonal trends and longitudinal river patterns can be tracked. These graphics will correspond to the model calibration graphs that will be prepared in Task 6.3 so that the methods for display will be familiar and consistent (see PRR3). The distribution of the data in this manner is consistent with recommendations made by the stakeholders relating to improving the availability of the data collected in this study (SR2, SR4, and SR5).

In addition, the data will be made available to the public through the IEP database. The objective of disseminating the data in this manner is to better integrate the modeling with the monitoring effort (PRR3), increase stakeholder confidence in the fairness of the TMDL process (SR5), and provide data to the public for use in co-ordination of SJR TMDL efforts (SR4).

In this project, data analysis by individual scientists and engineers will be coordinated. All analysis will involve evaluation of both spatial and temporal trends (Objective 4). Data collected in this study will be reconciled with data from other studies and recommendations will be made concerning the comparison or combination of data sets from different studies.

Project investigators will conduct mass balance and statistical analysis on the data. Mass balance analysis will follow standard engineering approaches as applicable to dynamic systems. Salt mass, as measured by EC, will be used as a conservative tracer for the mass balance. Examples of mass balance approaches to analysis of these types of data can be seen in reports from previous studies (Foe et al. 2002, Stringfellow and Quinn 2002). The Strawman Report (Foe et al. 2002) provided a method for evaluating the distribution of load in the upstream SJR. The analysis conducted by Foe et al. 2002 will be repeated and updated with the data collected in this study and historical data. The objective of the mass balance analysis is to address issued raised by PRR1, PRR2, PRR5, and SR5.

A complete package of statistical analysis will be performed on all the new data collected in this study and a comparison will be made with the historical data available in the IEP database and other sources. The compatibility of this study's data to prior studies will be made, in an effort to link this study to the historical record. Simple time-series analyses of the flow and water quality measurements will be executed and standard statistical evaluations will be made. More complex regression analyses with a time series component will be applied to data collected in this study and historical data to evaluate the relationships between nutrients, algal pigment concentrations, BOD, and low DO conditions in the DWSC. Other analysis will include PCA time series analysis, structural

equation modeling, and state space modeling, as recommended by Alan Jassby in the Peer Review (Cloern et al. 2002). The statistical analysis of the data is necessary to close data gaps identified by PRR2, PRR4, PRR5, SR1, SR2, and SR5.
Data integration and interpretation will also be accomplished during the model calibration (Task 6). Model development and calibration will be coordinated closely with data collection and the statistical and mass balance analysis, as recommended by the peer reviewers (PRR3). Additional analysis will be executed as described in Task 5, Task 6, and Task 7.

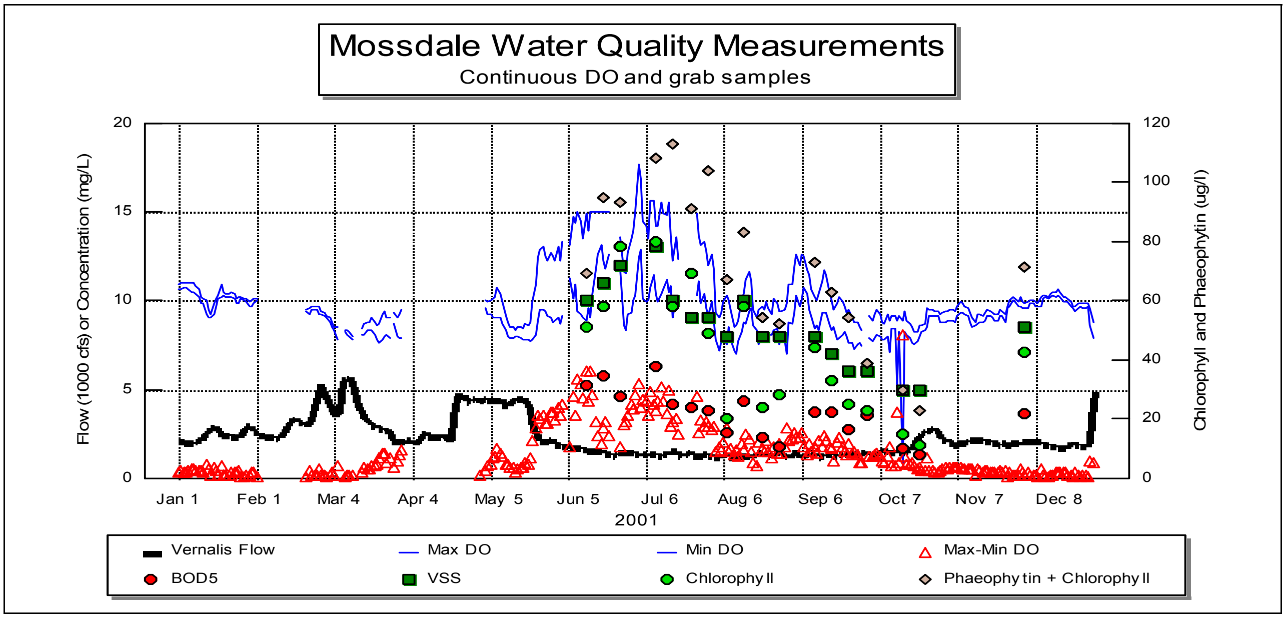

Figure B-4 SJR Flow (Vernalis) and Daily Minimum and Maximum DO Concentrations and VSS and Algae Biomass Measurements at Mossdale for 2001

Task 4 Organization

William Stringfellow will be the Principal Investigator on Task 4 and as such will be responsible for coordination of effort and the issuing of all quarterly and yearly reports. Joseph McGahan will be responsible for flow data collection (Task 4.1). William Stringfellow and Randy Dahlgren will be responsible for the grab sampling tasks (Tasks 4.2 and 4.4). William Stringfellow, Nigel Quinn, and Gary Litton will be responsible for the continuous monitoring tasks (Tasks 4.3 and 4.5). Fieldwork on this task will be a joint effort of LBNL, UCD, UOP, UCB, SJVDA, and SJRGA. Data compilation and analysis will be a joint effort among Summers Engineering, DWR-IEP, and LBNL. Outreach and training will be conducted under the direction of the SJVDA, SJRGA, and CWI.

Task 4 Deliverables

At the end of each year, a report will be prepared that includes results and analysis from the previous year and adaptive management recommendations for the coming year will be made. The adaptive management strategy is to narrow and focus each succeeding year of the project, based on the previous years results. The process is scheduled so that the adaptive management review takes place during the season of lower intensity monitoring (winter). In the winter months, the TAC will review data collected the previous season and set priorities for the coming summer. In this manner, the adaptive management plan will be instituted to narrow the focus of effort to the most critical areas in the watershed. At the end of the final year, an additional report will be issued that will recommend what stations should be included in a long-term monitoring program if such a program is needed under the DO TMDL Implementation Plan.

The adaptive management process will include, but is not limited to, the following:

If monitoring results identify tributaries or sub-watershed areas with high loads of oxygen-demanding substances, additional focused monitoring may be conducted upstream in that area to identify specific sources.

If review of monitoring results from this program, previous data, and data being collected under other programs indicate a need for additional winter monitoring, then more winter sampling events may be planned.

If coordination with other monitoring programs indicates a duplication of data collection efforts, the monitoring program will be structured so that sample collection activities, and possibly laboratory analysis and cost, will be shared. This restructuring would also require coordination of QA/QC practices.

If review of data indicates that some tributaries or sub-watershed areas contribute insignificant amounts of flow or load, elimination of those stations from future sampling efforts will be considered.

The Monitoring Reports for years 1 and 2 will include tables of all data collected during the year (as appendices), as well as a thorough evaluation of the data in terms of program objectives and the study questions posed. The Monitoring Reports for years 1 and 2 will also include recommendations for modifications to the program the following year, based on an evaluation of the results. The Comprehensive Monitoring Report issued at the end of Year 3 will include a detailed evaluation of all 3 years of data.

Task 4 Budget Justification

The overall first year budget for Task 4 is $1,752,996 (including $216,076 in matching funds). Year 2 and Year 3 budgets are adjusted for inflation (3% each year) but are less than the first year, as they do not include one time costs incurred in the first year. One-time equipment and supply expenditures in Year 1 include six SCUFA units for Task 4.5 ($ 7,910 each including extra battery and antibiofouling screens), station upgrades for Tasks 4.1 and 4.3 (see Table B-4), and a luminescence spectrophotometer ($27,000) for calibration of the SCUFA units and measurement of chl-*a*. An incubator ($15,000) for BOD analysis will be purchased with matching funds.

Task 4.1 and the collection of continuous monitoring data will be a joint effort of SJVDA, SJRGA, UCB, DWR, and LBNL. The first year budget includes flow station upgrades. Flow monitoring is the core element to the monitoring program of the project; without accurate and complete flow data, this project will be unable to provide information useful in addressing the dissolved oxygen issues of the DWSC and the SJR. These improvements include $87,500 to install stage and flow monitoring equipment at 17 locations, $75,500 to install EC and temperature probes at 25 monitoring stations, and $20,000 to install telemetry equipment to allow for remote access at five sites. EC measurements are important to the calculation of the algal mass balance and telemetry is expected to reduce labor costs. The labor to install this equipment will cost $54,000, of which $38,000 will be provided as a match share by local agencies. The total cost to the project for this work is $237,000 ($199,000 from CALFED funds, and $38,000 from local match sharing). Table B-4 summarizes the stations requiring improvements, and their associated costs.

SJVDA and SJRGA are budgeted for 1623 hours total to manage the collection and compilation of flow data. An experienced UCB technician (1280 hours) will be hired to assist Nigel Quinn in compiling and analyzing the continuous monitoring data. The DWR IEP database programming group (under the direction of Karl Jacobs) will be subcontracted for up to $30,000 the first year and $10,000 in the second year to develop the access database systems needed to coordinate the UCB/SJVDA/LBNL data collection effort and integrate the project data bases with the DWR IEP data base.

Tasks 4.2, 4.3, 4.4, and 4.5 all involve a combination of laboratory and fieldwork. It is planned to collect and analyze approximately 357 samples in Task 4.2 and 144 samples in Task 4.3. In addition, we are expecting a 20% additional sample analysis load to meet QA/QC requirements for standards, blanks, duplicates, and QA samples. Field crews will need to service, calibrate, and download data from the continuous monitors deployed in Tasks 4.4 and 4.5. To accomplish this work, we will employ two full time Field Technicians and two full time students at LBNL to collect samples and service the continuous monitors. The Field Technicians will be teamed with PIs and students to make the rounds necessary to collect the samples and service the instruments. Approximate round trip mileage is estimated to be 325 miles. Samples will be returned to LBNL and UCD by a runner if necessary to maintain holding times for chl-*a* and BOD. Expenses associated with the field sampling include truck rentals at $45 per day per truck plus gasoline and mileage for the runner (typically a student in their own vehicle) to transfer samples between the field, LBNL, and UCD. Supply costs include sampling bottles, BOD bottles, reagents, filters, filtering apparatus, ice, ice chests, and portable vacuum pumps. Sample analysis will be conducted at LBNL and UCD as described in Task 4.2 and 4.3. At UCD, salary is provided 1200 hours of technician labor and for 28% effort of a post-doctoral researcher to provide oversight, QA/QC, and data analysis. LBNL is budgeted for two full time technicians and one full time student (1280 hours) for laboratory effort, including analysis and some data entry.

Sharon Borglin is budgeted for 75% effort (1320 hours) to oversee the laboratory and fieldwork, QA/QC, supervise students and technicians, data organization, data analysis and report writing. William Stringfellow is budgeted 60% time and Nigel Quinn is budgeted 10% time to provide oversight, assist in fieldwork, analyze data, and write reports. Effort by Randy Dahlgren, Gary Litton, and Carol Kendall are being budgeted from matching funds.

DWR will be contracted for $35,000 for assistance with data management. This subcontract will provide funds to continue storing the data from the San Joaquin monitoring studies into the IEP/CALFED, Bay Delta and Tributaries Data Management System. In addition, local database development will be provided from IEP on an as needed basis, at the rate of $5,000 per year. These data will include biological, hydrodynamic, water quality, metadata and regular time series data. Data will be accessible through the Internet.

TASK 5: INDEPENDENT MEASUREMENT OF CONSTANTS USED IN ALGAL GROWTH MODELS OF IMPORTANCE TO THE LOAD ALLOCATION PROCESS

Task 5 Objectives

The purpose of Task 5 is to conduct studies to fill data gaps concerning algal and nutrient dynamics identified in the Peer Review Report (Cloern et al. 2002) and in public meetings with stakeholders, as summarized in PRR2, PRR4, and SR1.

The objectives of Task 5 are to:

1) Make independent measurements of algal biomass potential (maximum biomass yields) in different reaches of the SJR for use in the DO TMDL process and associated river models.
2) Make independent measurements of algal growth rates in different reaches of the SJR for use in the DO TMDL process and associated river models.
3) Compare experimental and literature values for algal growth constants to determine appropriate kinetic constants for use in SJR algal growth kinetic models.
4) Prove or disprove the assumption that algae growth is light-limited in the SJR.
5) Conduct preliminary experiments to measure the potential benefit of nutrient control on algal biomass accumulation in the SJR.
6) Test the assumption of a direct link between algal populations found in the upstream tributaries and the algal population entering the DWSC.
7) Determine algal decay kinetics under conditions found in BOD_{10} analyses.

Task 5 Conceptual Model

Algal biomass is not a conservative substance, but rather grows and decays in the SJR, complicating the DO TMDL load allocation process. All valid methods and models used to predict the extent of algal growth in rivers are dependent on the use of a Monod-type kinetic model coupled with a standard algal population growth model. The combined algal kinetic model is used in the SJR model to predict how fast the algae grow in the SJR (the *apparent growth rate*) and the mass balance for algae in the SJR. The apparent growth rate estimate used in the SJR model determines how the model relates upstream sources of algae and nutrients to the amount of algae entering the DWSC. The assumptions and constants used to calculate the apparent growth rate is, therefore, a key variable in determining the calculation of load allocations in the Strawman process.

Three key parameters that determine an algal growth model's estimate of apparent growth rate and, therefore, the load allocation are:

1) How fast the algae can grow (*maximum growth rate*)
2) The algal biomass potential, i.e., the maximum algal biomass concentration that can be reached in a given location on the SJR (*maximum biomass yield*)
3) The relationship between growth rate and the limiting condition or conditions for growth (*half-saturation constant*).

The current Strawman model assumes that algal growth is only limited by the amount of light available (*light-limited assumption*), that the light is essentially constant, and that the SJR has an infinite carrying capacity for algal biomass (maximum biomass yield is ignored in the model). These assumptions reduce the Strawman model to dependence on a single growth rate estimate that is a constant value for the entire river (Foe et al. 2002). The result is that the Strawman predicts a linear relationship between the algal load from the tributaries on the upper river and the amount of algal biomass entering the DWSC. In other words, the model predicts a direct link between the upper watershed and the amount of algae entering the DWSC.

Due to the importance of any assumptions made about algal growth in the SJR to the outcome of the DO TMDL load allocation process, it is important that the assumptions used in the SJR models predicting algal growth be tested. The parameters used in algal growth models (maximum growth rate, growth yield, and half-saturation constants) need to be independently verified for their use in the SJR models. Both the Peer Review Panel and the stakeholders recognized the importance of assumptions made about algal growth kinetics to the determination of load allocations and recommended that these issues be resolved (PRR2, SR1).

Task 5 Hypothesis

The hypothesis of this task is that the accuracy and reliability of models and other calculations used to predict algal biomass accumulation in the SJR can be improved by the use of algal growth rate constants (maximum growth rate, biomass yield, and half-saturation constants) that are specific for the SJR, rather than solely relying on growth rate constants developed in studies of other bodies of water. Combining more accurate kinetic estimates with results from experiments examining the propagation of algal inoculation from upstream tributaries, plankton community composition along the length of the river, and the measurement of algal decay kinetics, will provide fundamental information needed to accurately calculate the impact of the upstream tributaries on the BOD loading at the DWSC.

Task 5 Justification

The research proposed in Task 5 is needed to better understand the growth and mass balance of algae in the upstream SJR (PRR2). This task will be closely coordinated with the modeling effort (Task 6) and is directed at providing critical information needed to model algal biomass production in the SJR watershed (PRR3). The research conducted in Task 5 will test and verify assumptions concerning algal dynamics used in the Strawman (SR1). The information developed in Task 5 will be instrumental in achieving Objectives 2, 3, and 6.

In Tasks 5.1 to 5.4, a series of experiments will be conducted to measure apparent algal growth rates, maximum algal growth rates, and maximum biomass yield values. Multiple methods and approaches are necessary to insure that the growth parameter estimates are accurate and to determine natural variation that may occur in a system as large and complex as the SJR. The validity of model assumptions related to the estimation of algal growth rates will be tested, including the assumption that in no parts of the SJR or its tributaries is algal biomass production limited by factors other than available light. It will be determined how parameter estimates from direct measurements agree with estimates made from the data collected in Task 4, as analyzed in Task 5.3 and in the modeling effort (Task 6). Results from Task 5.1 to 5.5 will be compared to each other and to published values commonly used in SJR models (Bowie et al. 1985). Kinetic parameters that are valid for the SJR will be published in reports and peer review journals for use in the SJR DO TMDL models.

In Task 5.6 and 5.7, experiments will be conducted to directly test the existence of a direct link between the upstream tributary algal loads and the biomass loads propagating down the river. Statistical relations between the upstream and downstream load patterns will be examined. In Year 2 and 3, experiments will be conducted to directly perturbate the algal load from Mud Slough and evaluate the impact on algal loads downriver. The structure of the planktonic community will be compared at key points along the SJR's length between the upper tributaries and the entrance to the DWSC. A comparison will be made to determine if the community structure upriver and downriver are similar. The Peer Review Panel suggested these approaches as direct and independent methods for examining the link between algae loads in the upper watershed and the algae loads entering the DWSC (PRR2).

In Task 5.8, a direct measurement of algal decay rates will be made and related to community structure information collected in Task 5.7. The results of this task will be combined with ammonia oxidation rate data collected as part of Task 8 needed to reach Objective 2. These data will be used to resolve some of the issues related to determining the relative importance of different BOD fractions (particularly algae compared to ammonia) to the SJR loading of oxygen demanding materials (PRR4).

Task 5 Approach and Methods

Task 5.1: Quantification of Apparent Algal Growth Rates in the SJR and Tributaries Using Synoptic Surveys

In this task SCUFA sensors will be deployed on buoys along a defined distance of river or tributary to develop a "snap-shot" profile of algal concentrations. Synoptic surveys, in combination with flow and travel time measurements, will be used to calculate apparent algal growth rates for specific reaches of the SJR and tributaries. The purpose of this task is to determine how algae are actually growing in a particular reach of river, tributary, or drainage and relate that information to model assumptions. The information will also be used to assess whether the location of monitoring stations can be improved. Results from this task will be combined with results from Task 4, Tasks 5.2 to 5.5, Tasks 6 and Task 8, as described in the data analysis section, to get a complete picture of algal growth patterns in the SJR watershed.

SCUFA units together with YSI sondes, measuring EC, pH, DO, and temperature will be attached to buoys and deployed at three locations along selected tributaries and drains. The units will be deployed for a week at a time per experiment. With the SCUFA deployments, measurements of stream flow and travel time will be made with dye tests or other methods. In situ measurements of chl-*a*, pH, DO, turbidity, water temperature, water depth, and instrument depth will be combined with discrete water quality sampling for quantification of chl-*a*, pha-*a*, VSS, TSS, BOD, carbonaceous BOD (CBOD), and verification of in situ turbidity, DO, pH, and chl-*a* measurements. In situ measurements will be captured electronically with their Global Positioning System (GPS) coordinate locations. These deployments will be coordinated with the sampling effort described in Task 4 and experiments described in other parts of Task 5 and Task 8, whenever practical. Data collected in this experiment will be analyzed as described in the data interpretation section.

In Year 1, deployments will be made in summer months, when conditions for algal growth are favorable, water conditions are most predictable, and observable changes in algal concentration are likely to be greatest. In Year 1, studies will focus on Salt Slough and Mud Slough, which have been identified in previous studies as having conditions conducive to algal growth (Stringfellow and Quinn 2003, Foe et al. 2002). In Years 2 and 3, direct synoptic measurements will be made on other parts of the watershed that are demonstrated to be important to the algal mass balance and modeling conducted in Task 4 and Task 6.

Task 5.2: Quantification of Apparent Algal Growth Rates Longitudinal Along SJR's Mainstem

A conservative tracer injection study is proposed to estimate "apparent" algal growth rates between the SJR at Fremont Ford and Vernalis. In addition, this approach will allow determination of travel times (hydrologic residence time), water diversion quantities, and water inputs between sampling sites. A conservative tracer (rhodamine WT) will be injected into Salt Slough at Lander Avenue (Highway 165). The amount of tracer injected will be calculated as 10x the detection limit following the estimated dilution occurring during transport to Vernalis. Rhodamine will be injected for about 36 hours to assure that a concentration plateau will develop over the entire experimental reach. Ideally, we would like to maintain the concentration plateau for 24 hours so that we can characterize a complete diurnal cycle. Samples will be collected at the eight sites shown in Table B-5 allowing estimation of apparent algal growth rates for six increments along the SJR.

Table B-5: Sampling Sites Along the San Joaquin River for Quantification of Longitudinal Algal Growth Rates

Research Site	Sampling Site Purpose	Relationship to Major Tributaries
Salt Slough at Lander Avenue	Injection point	
SJR at Fremont Ford	Growth rate reference point	Salt Slough + SJR
SJR at Newman	Increment #1	Below Mud Slough and above Merced
SJR at Crows Landing	Increment #2	Below Merced
SJR at Patterson	Increment #3	
SJR at Grayson	Increment #4	Above Tuolumne
SJR at Maze	Increment #5	Below Tuolumne and above Stanislaus
SJR at Vernalis	Increment #6	Below Stanislaus

The stream reach above Fremont Ford will be utilized as the mixing reach to assure that the rhodamine has uniformly mixed with upstream waters. At Fremont Ford, rhodamine concentration, chl-*a,* pha-*a*, and major algal species abundance (number per liter) will be determined using methods described in the Task 5.7. In addition, nutrient, water column transparency/turbidity, temperature, etc., will be characterized throughout the experiment.

Algal cells will be concentrated by filtration through a glass fiber filter followed by rinsing with copious amounts of distilled-deionized water to remove rhodamine that could interfere with chl-*a* fluorescence. By determining the rhodamine concentration at Fremont Ford and by knowing the injection rate of rhodamine, the total stream flow at Fremont Ford can be independently calculated. Similarly, the total mass of rhodamine at each site can be calculated by knowing the flow and concentrations along the rhodamine chemograph. Samples will be collected every 2 hours to characterize the rising limb, plateau, and falling limb of the rhodamine chemograph. The ratio of the water quality parameters to Rhodamine WT concentration will be used to define the reference conditions (time zero) at Fremont Ford. All of these components will be measured at each of the sampling sites along the mainstem. The chlorophyll to rhodamine ratio will be affected by chl-*a* production (estimate of algal growth rates) and dilution from tributaries, groundwater inputs, and agricultural return flow. Dilution from the three major east-side tributaries can be independently confirmed from the gauging stations, and the excess dilution results from groundwater inputs and agricultural drainage returns can be assumed. Input of chl-*a* from agricultural drainage returns and major tributaries is expected to be minor relative to the standing crop of algae in the mainstem of the San Joaquin. However, chl-*a* imports from the major drains and tributaries will be monitored and the ratio will be corrected if necessary. Export (diversion) of water for irrigation will not affect the chlorophyll:tracer ratio directly because both chl-*a* and tracer will be removed at a constant ratio. A mass balance of rhodamine and salt (EC) will allow determination of the volume of water exported from each experimental reach. The amount of chl-*a* removed from the SJR will be corrected for based on the water diverted (calculated from the rhodamine and EC mass balance as well as direct measurements taken in Task 4) and the chl-*a* concentration at the segment's reference point. Lastly, it must be assumed that algal herbivory is negligible relative to the standing algae crop. Travel times (hydrologic residence times) will be determined from measurements of the time required for the tracer to reach each downstream sampling site. Based on the travel times, rates can be calculated as microgram chl-*a* per unit time or ±algal numbers/L per unit time. Samples will be captured for 24 hours during the rhodamine plateau to characterize diurnal algal growth patterns. Simultaneous measurements of temperature and solar radiation will allow apparent algal growth rates to be related to these important parameters. All samples would be referenced to the samples taken at the sampling site immediately upstream of the sampling site as shown in Table B-5.

This approach should provide a powerful means to quantify algal growth dynamics along the SJR. Initially, three separate rhodamine injections are proposed during the Years 1 and 2 of the study, which will allow investigation of different stream flows (hydrologic residence times), water temperatures, and potentially different algal species over the course of the summer irrigation season. Data collected in this experiment will be analyzed in the context of other experiments in Task 5 and Task 8, as described in the data interpretation section.

Task 5.3: Calculation of Apparent Algal Growth Rate and Yield Constants from Monitoring Data

Data collected along the SJR's main stem in Task 4 will be used to calculate apparent algal growth rates in the SJR. Using flow, chlorophyll, EC, and other data, a mass balance for algae biomass will be calculated and the mass balance will be related to travel time or retention time in the SJR. Separate estimates of apparent algal growth will be made using continuous data (Task 4.3) and discrete data (Task 4.2) and results will be compared. The apparent algal growth rates calculated using this method will be compared to rates predicted from models using values measured in Task 5 studies and literature values.

Task 5.4: Direct Measurement of Algal Biomass Potential (Algae Biomass Yield) and Maximum Algal Growth Rate in the SJR and Tributaries Using Combined Laboratory and Field Studies

This task will directly measure the maximum algal growth rate and algal biomass potential (algal biomass yield) for different reaches of the SJR using a combination of laboratory and field studies. In Year 1, samples will be collected during summer and fall at locations corresponding to the permanent monitoring stations along the SJR (Task 4, Table B-1). In Years 2 and 3, these experiments will be expanded to include the tributaries and drains entering the SJR.

For the laboratory studies, water samples will be collected and transported to LBNL laboratories for growth yield studies under artificial light and temperature conditions. In the field studies, water samples will be collected and tested under ambient light and temperature conditions. LBNL, UOP, UCD, and Fresno State researchers and students will conduct these field experiments.

The basic growth rate and yield test for both the field and laboratory studies will consist of a stirred batch tank reaction. Water samples collected from the SJR are placed in transparent containers, illuminated either naturally or artificially, and gently agitated, and algae are allowed to grow to completion in the reactor. The water samples may be inoculated with specific algae (for example algae from Mud Slough) or algae already present in the sample are allowed to grow. Algal biomass will be followed by fluorescence measurement, chlorophyll analysis, VSS, and direct counts. Algal growth rate constants will be estimated from growth curves generated in these experiments and algal biomass carrying capacity will be determined as the point at which no further increase in algal biomass occurs over time. Species composition in the reactor will be monitored over time and compared to species composition at the end of the reaction. Data from this experiment will be interpreted as described in Task 5.5 and the data interpretation section.

Task 5.5 Direct Determination of the Potential for Nutrient Control to Limit Algal Biomass Yield and Growth Rate.

Nutrient concentrations are high in the SJR and it is an open debate as to whether a nutrient control program would be a practical approach to controlling algal growth in the upstream areas of the SJR. In Task 5.5, the impact of nutrient limitation on algal growth and yield will be evaluated by

1) Measuring the residual nutrient and trace metal concentrations at the end of algal biomass yield experiments described in Task 5.4.
2) Measuring the effects of nutrient addition to algal growth rates and biomass yields.
3) Measuring algal growth rates and biomass yield in agricultural drainage that has been treated to remove specific nutrients, such as phosphate or iron.

These experiments will be conducted as part of and in addition to experiments described in Task 5.4 (see methods above). At the completion of the algal growth yield reaction, water samples will be collected for analysis of nutrients and trace metals. Nutrients will include soluble and total phosphorous, nitrate, and ammonia, as well as other ions. Trace metal analysis will include iron, copper, magnesium, and zinc. Nutrients will be measured in the LBNL Bioprocessing Laboratory using the standard methods described in Task 4. Trace metals will be measured at the Department of Defense's Center for Research on Oceanic Carbon Sequestration using Inductively Coupled Plasma Mass Spectrometry. The Center has a state of the art facility at LBNL run by the Ocean Biochemical Process Group capable of measuring iron and other trace metal essential to algal growth at sub-ppb concentrations. The impact of additional nutrient and trace metals will be examined using standard addition tests, where biomass yields and growth rates are compared between waters with and without nutrient or metals addition. Finally, samples of agricultural drainage will be treated to remove specific constituents and the effect of nutrient removal on algal growth under controlled (laboratory) conditions will be tested. For example, phosphate will be removed by precipitation, and treated and untreated water will be compared for the ability to support algal growth. These experiments will provide the basic information that will be needed to begin the evaluation of a nutrient control program in the SJR watershed.

Task 5.6 Algal Propagation Experiments to Directly Determine if a Link Exists Between Upstream Tributary Algal Sources and Algal Load Entering the DWSC.

In the first year of effort, continuous monitoring data collected in Task 4 will be analyzed to look for temporal patterns that would indicate a direct relationship between the algal loads entering the SJR from Mud Slough, Salt Slough, and above Lander Avenue and the algal load observed at key points in the SJR, particularly Vernalis. The most obvious temporal link would be a correlation between a rapid change in algal loading from one sub-watershed and the propagation of that flux down the river. This analysis will be followed in the second and third years by experiments to directly purturbate the algae flux and measure the resulting impact on the SJR.

In the second and third year of the project, experiments will be conducted to directly determine if there is a link between algae production in the upstream tributaries and the algal load entering the DWSC. The San Luis Drain (SLD) provides a significant fraction of the algae biomass found in Mud Slough, which in turn is a significant sources of algal biomass entering the SJR (Stringfellow and Quinn 2002). To determine the impact of reducing algal loading from this sub-watershed on the algal bloom downstream, the exit from the drain will be temporarily blocked, allowing the SLD to act as a reservoir for the algal laden drainage, thereby reducing the algal biomass entering Mud Slough and the SJR. The drainage can be retained for three days and then will be released. This will produce two signals that will be analyzed for their link to the algal load and concentration along the SJR. The first signal will be a sudden decrease in algae entering the system and the second signal will be a sudden increase in algae entering Mud Slough as the retained drainage is released. It will be determined if the perturbation in algal loading can be followed down the river and if it has a measurable impact on the algal load at Vernalis and other key points in the river. This experiment will be closely coordinated with Task

4 monitoring, Task 6 modeling, Task 8 Vernalis to Channel Point studies and the dye and synoptic studies proposed in this Task 5.1 and 5.2.

Task 5.7: Characterization of Algal Communities to Determine Linkage Between the Upper and Lower Study Area

The objective of this task is to compare upstream and downstream plankton community composition to determine if continuity exists in the community structure between the tributaries and the head of the DWSC. In Year 1, samples of water and sediments will be collected at Mud Slough at Gustine, Salt Slough at Lander Avenue, the SJR at Lander Avenue, Crows Landing, Patterson, Mossdale, and Channel Point on at three different occasions. In Year 1, samples will be taken in the summer months only. Under the adaptive management strategy for this task, other locations and more samples will be added to the study in Years 2 and 3 if results from Year 1 indicate that more sample sites are needed to fill data gaps.

In addition to the sampling described above, three locations (Channel Point, Crows Landing, and Salt Slough) will be subject to a more intensive study to determine the natural variability that can be expected at any one sampling location. This study will involve a minimum of ten sample events; however, more samples will be taken if the variability at an individual site appears to be large. The statistical study will help establish a baseline concerning the variability to be expected at any one point on the SJR. Continuity in the community structure along the length of the SJR would be supporting evidence that the upstream inoculum is leading to downstream algal biomass. Task 5.5 will also generate information on the amount of zooplankton biomass present at different locations; information needed to estimated the impact of zooplankton grazing on algal biomass loss in the SJR.

The planktonic community will be characterized by direct enumeration and speciation. Algal counts will be made on river water samples as described by Lehman (2002). Using the procedures described by Lehman (2002) for phytoplankton community analysis will allow results from this study to be directly compared to the previous data collected by the DWR in both the SJR and the DWSC. Measurements will be made to allow the determination of cells per cubic centimeter or other volumes. In the case of river water, differential counts will be conducted to enumerate the several species of algae likely to be present at a given time. To convert numbers of cells to biomass, the cell volume will be measured microscopically or dry weight and ash content from a given volume of water will be determined and the average weight of one or more cells computed.

Samples of river sediment may be more representative of the SJR's true algal community than water column samples. Comparison will be made between water column and sediment samples to determine if water column analysis is adequate for determining the SJR's species composition. Data from this section will be combined with data from other tasks as described below.

Task 5.8 Determination of Algal Decay Rates Under Dark Bottle Conditions

The objectives of Task 5.8 are to measure algae decay rates during standard BOD testing to determine how rapidly algae actually decay under BOD test conditions. This information is important for determining the relative contribution of algae to oxygen demand as compared to ammonia and non-algal detritus. This information, in combination with information from Task 8 on nitrification rates, will be used to resolve the relative importance of different BOD fractions (algae, ammonia, non-algal TOC, etc.) in various areas of the SJR.

We will directly measure algae degradation during BOD testing to find the correlation between decomposition of algae and oxygen demand. Monitoring of algal decay rates during BOD testing will establish a direct link between measured BOD and algal degradation. Monitoring of other oxygen demanding substances during testing will elucidate the relative contribution of ammonia and other organics. This direct link will be important for the development of the DO TMDL for SJR. The information developed in Task 5.8 will be coupled with the data generated at the 21 key locations in the SJR and tributaries sampled in Tasks 4 and 5 to determine the spatial and seasonal changes in BOD characteristics in the SJR. The data will be used to develop linkages between the oxygen demanding substances in the SJR and the measured BOD.

Algal decay rates will be estimated by measuring the change of concentration of chl-*a*, pha-a, algal lipids, and VSS over time. Algal lipids analysis is a direct measure of algal degradation rates (Sun et al, 2002, Rutters et al, 2002, Galois, 1996). Kinetics of degradation can be used to calculate time dependent oxygen demand from decaying algae. The rate of degradation will be examined in relation to temperature, changes in ammonia concentration over time, changes in TOC over time. TOC, which is a measure of both algal and non-algal organic matter, will be used to monitor other reduced organic compounds that contribute to the overall BOD. This task will be executed in close coordination with Task 4. Water samples from key stations along the river that will be measured for $CBOD_{10}$ and $NBOD_{10}$ in Task 4 will be used in these experiments. Algal decay rates will also be related to community analysis measures made in Task 5.7.

Task 5 Interpretation of Results

Tasks 5.1, 5.2, 5.3, and 5.4 all involve the measurement of apparent algal growth rates. Tasks 5.2 and 5.4 utilize traditional methods for measuring apparent algal growth rates. These methods are similar to methods used to generate growth data found in commonly used river modeling references (Bowie et al. 1985). Task 5.3 uses a method similar to the Strawman Report (Foe et al. 2002). Task 5.1 uses a novel approach that is expected to be rapid, reliable, and more comprehensive than more traditional dye studies (Task 5.2).

In Year 1 all four methods will be applied for the estimation of apparent algal growth rates, by fitting appropriate models (see Conceptual Model section) to the data collected in Tasks 5.1 to 5.4. The results of each task will be analyzed independently and in relation to the other experiments conducted as part of Task 5. It will be determined if the results agree and analysis will be conducted (in coordination with Task 6) to evaluate which estimates of growth rate are most representative for use in SJR models. Multiple measurements will be made using each method to determine the variability in algal growth rate observed with each method.

In the adaptive management strategy for this task, a preferred method for directly measuring the SJR's algal growth rate will be selected for further application in Years 2 and 3. Task 5.4 will, in addition, supply independent measurements of maximum algal biomass yield. This approach should provide a powerful means to quantify algal growth dynamics along the SJR. Initially three separate rhodamine injections are proposed during Years 1 and 2 of the study, allowing the investigation of different stream flows (hydrologic residence times), water temperatures, and potentially different algal species over the course of the summer irrigation season. The algal growth constants generated in Task 5 will be used as constants in models that attempt to predict biomass yield at different points in the SJR (Task 6).

Experiments executed in Task 5 will produce data on overall algal biomass changes and also information on changes that occur in dominant algal species between the beginning and end of each experiment. It will be determined whether dominant algal species are increasing, decreasing, or remaining constant along the length of the river and during the course of other experiments. Thus, we should be able to estimate growth rates of total algal biomass and the growth rate of each individual species within each reach or experiment.

Two series of experiments are planned that will directly assess the impact of upstream algae control on the algal load entering the DWSC. In Task 5.6, we will analyze data from Task 4 to look for statistical relationships between fluxes in algal and nutrient loads from tributaries at the algal load at Vernalis and other key points in out study area. In the second and third years, algal load from a major agricultural drainage will be manipulated to generate a controlled perturbation that can be measured for its impact on downriver algal loads.

Task 5.5 will provide direct evidence concerning the level of nutrients that must be reached to limit algal biomass production in the SJR. This information is critical for evaluation of nutrient control as an alternative to aeration for mitigation of the DO sag in the DWSC. If nutrient control is to be considered as an algal control option for the SJR, it is important to be sure the proper nutrient to control is identified. If nutrient control is considered impossible, these experiments are critical for demonstrating why nutrient control will not be feasible. Elimination of alternative remediation strategies is an important aspect of completing the CEQA process and gaining public approval of a DO TMDL Implementation Plan that includes aeration.

Results from this task will be interpreted in context with results from the monitoring program (Task 4), the modeling effort (Task 6), and studies examining the river between Vernalis and Channel Point (Task 8). Comparison of experimental results with monitoring data will allow an estimation of the biological status of the SJR's algae in relation to the SJR's maximum carrying capacity. These results should provide independent verification of the accuracy of growth rate studies. This task will provide information on the nutrient status of the SJR's individual sub-watersheds, and the results will allow for identification of tributaries of high algal growth potential.

Data in Task 5.6 collected in Year 1 will be analyzed to determine if the planktonic community changes along the SJR's length. The subsequent work conducted in Years 2 and 3 will depend on the results from Year 1 under the adaptive management strategy. For example, if the data are statistically different between the upper river and the entrance to the DWSC (Channel Point), studies will be conducted to determine if any specific tributaries or sources can be found to match the community "fingerprint" at

Channel Point. If the algal community profiles are consistent along the SJR's length, studies will be conducted to determine if any sources could be eliminated. These analyses will also be used to support Tasks 5 and 8 in Years 2 and 3, if the technique seems particularly informative.

Task 5 Organization

Sharon Borglin and William Stringfellow will be Co-Principal Investigators on Task 5 and will be responsible for delivering all reports. Sharon Borglin and William Stringfellow will be co-leads on Tasks 5.1. Randy Dahlgren will be the lead on the dye studies described in Task 5.2. William Stringfellow, Gary Litton and Randy Dahlgren will participate in Task 5.3. Sharon Borglin and William Oswald will be co-leads on Task 5.4 and 5.5. William Stringfellow and Joe McGahan will be responsible for leading the algal wave propagation studies (Task 5.6). Sharon Borglin and William Oswald will be responsible for Task 5.7 and 5.8. Field and laboratory work on this task will be a joint effort between LBNL, UCD, UCB, and UOP. Students from Fresno State, UCD, and UCB will be employed as part of this task.

Task 5 Deliverables

Deliverables for Task 5 include quarterly and annual reports. The annual reports include tables of all data collected during the year (as appendices), as well as a thorough evaluation of the data in terms of program objectives and the study questions posed. The Reports for Years 1 and 2 will also include recommendations for modifications to the program the following year, based on an evaluation of the results. The final annual report will include a detailed evaluation of all 3 years of data.

All deliverables listed above will be subject to a formal peer review process before finalization. PIs for each subtask will be responsible for preparing presentations for TAC meetings and peer review workshops. Results from Task 5 will be presented at scientific meetings, including the International Water Association meeting and the annual meeting of the Water Environment Federation.

Task 5 Budget Justification

The overall Task 5 budget is $328,512 for Year 1, not including matching funds of $96,440. Equipment and supplies include three buoy units and replacement parts for $36,000, $50,000 for rhodamine dye, $8,500 for an injection pump, and $3,000 for a field dye fluorometers. Laboratory and field supplies ($20,800) include analytical reagents for UCD and LBNL laboratory work, sample bottles, raft rentals, reactors for Tasks 5.4 and 5.5, computer charges, phone charges, safety equipment, and other common expenses. Travel charges are for dye studies and synoptic surveys, sample collection trips, and travel to meetings. For Tasks 5.1 and 5.2, labor charges include summer salary for a UCD postdoctoral researcher, a UCD student, a technician from LBNL, and a student from UOP. These students and technicians will work together with the Post-doc and the PIs to execute the dye studies and the synoptic surveys. Three months of salary is requested for technician labor on Tasks 5.4, 5.5, 5.7 and 5.8. These tasks will be accomplished with help from graduate and undergraduate students paid for mostly by matching funds.

Sharon Borglin will spend up to 20 % of her time on Task 5. William Stringfellow, Randy Dahlgren, Gary Litton, and William Oswald will spend up to 8% of their time (180 hours) on Task 5 each year. PI effort will include field work, oversight of experiments, analysis of data, calculation of growth constants as described in Task 5.3 and other tasks, preparation of reports, and presentation of results at meetings. SJRGA and SJVDA PI and engineers will spend up to 75 hours in each year participating in the planning and execution of experiments described in Task 5.6. Approximately 75% of costs for this task are associated with Tasks 5.1, 5.2 and 5.3. The remainder of costs is associated with Tasks 5.4 to 5.8.

The budget for Year 2 is $383,689 ($99,333 matching) and for Year 3 is $230,874 ($93,555 matching). The hourly rate of those working on this study is adjusted for inflation in years 2 and 3 (3% each year). Dye studies will be continued in Year 2 but terminated in Year 3. Synoptic surveys, laboratory studies and perturbation studies will be continued at a reduced effort through the end of the three-year project as needed.

TASK 6: RIVER MODELING

Task 6 Objective

The objective of this task is to develop a simulation and forecasting model to improve the understanding of SJR algae growth processes that create a substantial load of organic material that may contribute to episodes of DO decline in the DWSC. The task recognizes that simulation modeling can help to guide water quality management options as well as encourage monitors to make their data accessible for integration and interpretation. The task will utilize the data and help to coordinate the tributary and main river monitoring efforts described in Task 4. The goal of the modeling is to identify those aspects of the SJR algae growth dynamics (i.e., nutrients, temperature, light, residence time) that can be understood and simulated accurately.

Task 6 Conceptual Model

The conceptual model for this task is that an accurate water quality model of the SJR can be constructed from already available model components. An hourly time-step model will be required to accurately simulate temperature and light conditions and the resulting algal growth response along the SJR using 1-mile model segments. The water quality modeling is based on mass-balance and rate-limited transformations between several model variables. The water and salt budget for the SJR that is already tracked with the SJRIODAY model will become the basis for simulating the channel hydraulics and residence time with the DWR-DSM2-SJR model. Additional variables for nutrients, light, and algae biomass will be required to accurately track the observed river water quality processes. A comprehensive integration of all available water quality information will be created by model formulations that describe the interactions and consequences of each hydrological, physical, and water quality parameter. The model estimated inputs for each variable from each tributary source will provide an important tool for visualizing and evaluating the monitoring data from Task 4.

Task 6 Hypotheses

The hypothesis for this task is that an accurate SJR model can be developed from the formulations for water quality and algae dynamics that have been observed and simulated in other rivers. The SJR is unique not in basic ecological function but because it has unique watershed land use and water sources that produce the river flow and water quality dynamics. The SJR water quality will be slightly different each month of each year because a different meteorological and hydrological sequence will produce a different water quality sequence. The model will be able to be calibrated with historical water quality measurements and will be able to provide accurate forecasts of river conditions when recent water quality measurements are combined with model simulations of the recent river conditions.

Task 6 Justification

An accurate model will allow these differences to be understood and the basic features of the water quality patterns to be identified. The direct comparison of monitored river data with modeled river conditions will provide the final assessment of our current understanding of San Joaquin River water quality processes and dynamics. The calibrated SJR model will provide our most accurate tool for determining the likely effects or reduced upstream loads of nutrients and algae biomass on the resulting downstream loading of BOD materials entering the DWSC and contributing to episodes of low DO conditions. The modeling framework allows all monitored data to be integrated and allows the responses in downstream loading to be evaluated (i.e., sensitivity and reliability) for a wide range of possible upstream water quality management actions.

Task 6 Approach and Methods

This task will produce a new version of the DWR DSM2-SJR model that combines the SJR's current flow and salinity model (Pate 2001) with tributary segments that extend upstream to the diversion dams on the Stanislaus, Tuolumne, and Merced rivers. The existing Delta portion of DSM2 (without any additional development) can be used to evaluate various flow management options (i.e., south Delta tidal gates) for improving DO concentrations in the DWSC. No changes in the Delta model water quality formulations are included in this task.

The watershed runoff and groundwater hydrologic features of the SJRIODAY model will be integrated with the new DSM2-SJR model as flow and salinity inputs to enhance the model's capability for short-term forecasting of SJR flow and salinity conditions. The existing SJRIODAY graphical user interface will be expanded to include the water quality inputs for the SJR model upstream of the Delta.

The DSM2-SJR model will be calibrated for flow, EC, temperature, turbidity, TSS, VSS, nutrients, chl-*a* and pha-*a*, pH, and DO concentrations using all available data collected from 1999 to 2002 (4 years). The ability of the calibrated model to match the available data and provide short-term forecasts will be evaluated with biweekly forecasts of river algae concentrations and BOD loads at Vernalis and Mossdale during the critical periods of low-DO concerns (i.e., June through September) for each of the project study years (2003 to 2005). The interactions between the field data (samples and monitoring) and the model simulations will allow an adaptive approach to water quality forecasting and monitoring to be developed for the SJR algae and low-DO conditions.

Task 6.1: Create New Version of DSM2-SJR Water Quality Model

This task will create a new version of the DWR DSM2-SJR model that combines the current flow and salinity DSM2 model of the SJR (Pate 2001) with tributary segments that extend upstream to the diversion dams on the Stanislaus, Tuolumne, and Merced rivers. The 1-mile segments of existing DSM2–SJR will be extended to include the east-side tributary streams to the upstream diversion dams, and selected west-side tributary streams to the upstream gauge locations. The model parameters, rate constants, and other model assumptions for the water quality portion of the SJR model will be reconciled with existing Delta water quality models such as DSM2 and the DWSC water quality model developed for CALFED by Systech (Chen and Tsai 2000). Other river water quality model formulations will be reviewed and compared.

The recent available SJR measurements will be merged into a common data analysis framework (i.e., spreadsheet files arranged by day for each year) to be used for estimating the new SJR model inputs and calibration variables for the calibration period of 1999 to 2002. Similar data files were created for the DWSC portion of the SJR as part of the City of Stockton data collection and analysis for the 2000 and 2001 CALFED grants. DWR will have primary responsibility for this task.

Task 6.2: Incorporate Hydrologic Features and User Interface from SJRIODAY Model

This task will incorporate the watershed runoff and groundwater hydrologic features of the SJRIODAY model into the new DSM2-SJR model flow. The SJRIODAY estimates of runoff and groundwater salinity inputs will also be incorporated to enhance the capability for short-term forecasting of water quality variables, just like flow and salinity conditions in the SJR are currently forecast with the SJRIODAY model. The existing SJRIODAY graphical user interface will be expanded to include the necessary water quality inputs and forecast variables for the SJR model upstream of the Delta (to Mossdale). The graphical user interface and model will be available for simulations from a web-site.

The daily rainfall-runoff and groundwater flow routines in the current SJRIODAY model will be included in the new DSM2-SJR flow and water quality input formulations, thus allowing surface-water accretions and runoff quality to be calculated from forecasts of basin precipitation. Groundwater accretion estimates will be adjusted based on changes in groundwater levels adjacent to the SJR. The SJR model should allow schedules of east-side reservoir releases to be developed and used in flow, salinity, and other water quality variable forecasting. The current San Joaquin River Management Program – Water Quality Subcommittee graphical user interface for the SJRIODAY model will be extended and enhanced to cover the SJR from Bear Creek to Mossdale for flow, salinity, and water quality inputs and forecasting comparisons and adjustments. The water quality parameters that can be adjusted and compared in the user interface (flow and EC) will be expanded to include temperature, turbidity, TSS, VSS, nutrients, chl-*a* and pha-*a* (algae), pH, BOD, and DO. This list of model variables matches the tributary input and main-river monitoring variables described in Task 4. Dr. Chen will have primary responsibility for this task.

Task 6.3: Calibrate the SJR Water Quality Model

This task will calibrate the new DSM2-SJR model for flow, EC, temperature, turbidity, TSS, VSS, nutrients, chl-*a*, pha-*a*, pH, BOD, and DO using data already collected by various agencies and monitoring projects from 1999 to 2002 (4 years). The data for DSM2-SJR model inputs and calibration comparisons will be compiled in annual spreadsheets with daily measurements for interactive graphical displays. Calibration of the new DSM2-SJR model using 1999, 2000, 2001, and 2002 data from continuous monitoring and discrete sample data will cover a wide range of conditions and provide confidence in the short-term forecasting ability of the model. This task will include a complete set of model sensitivity studies for the major adjustment parameters. The sensitive model parameters will indicate specific measurements that should be included in the continuing adaptive monitoring programs. Dr. Brown will have primary responsibility for this task.

Task 6.4: Perform Biweekly Forecasts of SJR (Mossdale) Water Quality Parameters

This task will perform biweekly forecasts with the DSM2-SJR model using procedures similar to those developed by the San Joaquin River Management Program – Water

Quality Subcommittee during typical periods of high algae growth in the SJR and low DO concentrations in the DWSC (June through September). Forecasting results will be used to adaptively improve the predictive accuracy of the new DSM2-SJR flow and water quality model. A web site will be developed for public review and distribution of model calibration and forecasting results during Year 2 of the project. Dr. Quinn will have primary responsibility for this task.

Task 6 Interpretation of Results

The calibrated SJR water quality model can be used to compare alternative management strategies to control the resulting algae biomass at Mossdale. Several methods might be effective for the control of upstream discharge of nutrients and the initial "seed" of algae biomass that will affect algae growth in the SJR and the resulting low-DO concentrations in the DWSC. The existing Delta DSM2 water quality model can be used in combination with the DSM2-SJR model to evaluate various flow management options (i.e., south Delta tidal gates) for improving DO concentrations in the DWSC. The combination of the new SJR model and the existing Delta model will be a very powerful tool for the TMDL implementation process. The DSM2-SJR model will be available for Year 2 of the project to begin interpretation of results and advanced forecasting of river conditions at Mossdale as well as low-DO conditions in the DWSC. Dr. Brown will have primary responsibility for this task.

Task 6 Organization

Russ Brown will be the Principal Investigator on Task 6 and will be responsible for delivery of all reports. Management and oversight of this task will be provided by Russ Brown. Nigel Quinn will be responsible for the integration of the monitoring data and the existing SJRIODAY model components and results. DWR Modeling staff will be responsible for developing the DSM2-SJR model and making any necessary changes in the water quality formulations. Model calibration and forecasting applications will be accomplished by Jones & Stokes and Systech Engineering.

Task 6 Deliverables

All deliverables listed below will be subject to a formal peer review process before finalization. PIs for each subtask will be responsible for preparing presentations for TAC meetings and peer review workshops. The following deliverables will be submitted under Task 6:

1) Documentation for the extended DSM2-SJR model. This will include procedures for users to download the model (executable) with example input files and guidelines for preparing data files to run the model. This will be prepared by DWR staff by the end of Year 1.
2) Calibration Report for the DSM2-SJR model. This will include graphical presentation of results for the 1999-2002 initial calibration period, with sensitivity of the most important model input variables and model coefficients. This will be prepared by Jones & Stokes by the middle of Year 2.
3) Forecasting Procedures Report. This will include a description of the graphical users interface and coordination with the SJRIODAY modeling. This will be prepared by Systech Engineering by the end of Year 2.

4) Forecasting Results Report. This will include a description of the ability of the model to match the measured river conditions on an updated basis. The coordination with the SJRIODAY modeling of flow and salinity as well as the other monitored water quality variables will be described. This will be prepared by Dr. Quinn by the middle of Year 3.
5) Final Modeling Report. This will include a summary of all the modeling tasks and highlight the ability of the model to match measured conditions and the simulated response of SJR algae loads to be reduced by various upstream water quality management actions. The simulated changes in DO concentrations in the DWSC will also be described. This will be prepared by Jones & Stokes by the end of Year 3.

Task 6 Budget Justification

Each of the important model development, calibration, forecasting, and water quality management evaluation tasks will require considerable staff time to produce high quality deliverables. The model can be used by all interested stakeholder staff to evaluate the data and assess the likely success of alternative water quality management strategies for the San Joaquin River. A highly qualified and experience team has been assembled to accomplish this task with the minimum cost. Nevertheless, the modeling tasks requires a budget of $252,764 for the first year, $257,448 for the 2nd, and $261,984 for the 3rd. The annual modeling task budget represents about 2,250 hours at an average salary rate of $100/hour for the senior level modeling staff that will be developing and calibrating the model and using the model for forecasting and alternatives evaluations. Salaries are adjusted for inflation (at 3%) in years 2 and 3. The total expenditures for the 3-year modeling effort will be $772,196.

TASK 7: CHARACTERIZATION OF BOD FRACTIONS AND DETERMINATION OF THEIR SOURCES

Task 7 Objectives

The objective of Task 7 is to resolve the relative importance of different BOD fractions (algae, ammonia, non-algal TOC, etc.) in various areas of the SJR to the loads transported to Channel Point, per PRR 4. This will be achieved by:

1) characterizing the isotopic composition of the dissolved and particulate organic material (DOM and POM) and nutrients at the 21 key locations in SJR and the 33 sub-watershed sites sampled by the monitoring program described in Task 4,
2) using these isotope data, along with the chemical data generated at the monitoring sites sampled in Task 4, to determine the spatial and seasonal changes in BOD characteristics in the SJR, and
3) developing linkages between the biomass compositions in the SJR and the characteristic biogeochemical "fingerprints" of sources derived from the contributing watersheds.

The SJR Dissolved Oxygen TAC has determined that oxygen-depleting substances in the SJR at Vernalis contribute significantly to low dissolved oxygen episodes in the Stockton area during June through November. The isotope data collected in this task at the monitoring sites will be critical for evaluating the sources of oxygen demand (especially algal sources) in the SJR because the isotopic data will provide "characteristic fingerprints" of different biomass and nutrient sources. Isotopic data will help address several recommendations for future work from the recent peer review: (1) provide a useful and cost-effective adjunct to routine monitoring efforts by improving the identification of sources of biomass and nutrients, (2) link algal sources and loads in the upper watersheds with algal loads downstream, (3) provide better quantification of specific sources of biomass which will be useful for improving river modeling efforts, and (4) improve the characterization of various types of BOD sources and sinks in the SJR.

To leverage the limited resources available for characterization of BOD, all the isotope samples for this task will be piggybacked onto the monitoring program described in Task 4, and will require that (at most) an extra liter of water be collected at each site. All the isotope samples can be processed (e.g., filtered, rebottled, and/or frozen) back at the LBNL or other labs for later shipment to the USGS isotope lab in Menlo Park. Samples will be collected and archived for POM $\delta^{15}N$-$\delta^{13}C$-$\delta^{34}S$, DOM $\delta^{15}N$-$\delta^{13}C$-$\delta^{34}S$, nitrate $\delta^{15}N$-$\delta^{18}O$-$\delta^{17}O$, water $\delta^{18}O$-$\delta^{2}H$, and DOM optical property measurement. Because of funding limitations, not all samples will be analyzed for all these constituents (see specific details below). However, the entire suite will be archived and available for subsequent analysis in Years 2 or 3 if data generated during the first year of the study demonstrate that these types of auxiliary analyses provide useful characterization of BOD and nutrient sources, and additional funding becomes available.

Task 7 Conceptual Model

The major contributors to BOD in the San Joaquin River are believed to be algal biomass, ammonia, and non-algal organic carbon sources. The relative importance of each of these fractions to total BOD and short-term BOD is poorly understood for many critical areas of the watershed. For example, BOD concentrations measured in the Salt Slough watershed cannot be fully accounted for by corresponding concentrations of algal biomass and ammonia. Potential BOD contributions from algal biomass in upstream watersheds may be underestimated, and little is known about whether there are unaccounted sources of BOD (e.g., labile organic carbon from wastewater) that are contributing disproportionately to BOD in this region compared to other regions of the river. Understanding the relative importance of the BOD sources in various areas of the river and between seasons will provide more detailed composition information for the DO fate and transfer model described in Task 6. Multi-parameter BOD measurements (including algal biogeochemical fingerprints developed in task 5) will allow evaluation of key parameters that are central to understanding the relative contribution of algae, ammonium, and other oxidizable organics to oxygen demand in the river.

The conceptual model for this project uses a combined isotope and chemical mass balance approach to characterize and differentiate various sources of organic matter and nutrients from different land uses to the SJR. The basic idea is that different sources of organic matter and nutrients, and different biogeochemical processes, frequently have characteristic signatures that, when used in conjunction with relevant chemical and hydrological data generated in Task 4, allow these sources and processes to be quantified.

For decades, the isotopic composition of water, biomass, and dissolved nutrients has provided critical information in water quality studies that is difficult or impossible to obtain using other methods. Because the ratio of a heavier to lighter isotope of an element (e.g., for carbon, $^{13}C/^{12}C$) changes with biological and geochemical processes, these isotope ratios provide a powerful tool for tracing sources and processes in many environments. These ratios are typically expressed as δ (or "delta") values, where $\delta^{13}C = \{[(^{13}C/^{12}C)_{sample}/(^{13}C/^{12}C_{standard})]-1\}*1000$. A higher delta value indicates more of the heavier isotope of the element relative to the international standard.

A multi-isotope approach was successfully used recently to trace nutrients responsible for algal blooms at the mouth of the Mississippi and consequent hypoxia in the Gulf of Mexico. POM and nitrate isotopes provided vital information about nutrient sources and cycling that could not have been learned using only chemical methods, which provide information about concentrations alone (Kendall et al., 2001; Battaglin, Kendall et al., 2001). Based on these successes, and the results of a preliminary assessment of the usefulness of these isotopic techniques at a few sites in the SJR (abstracts: Silva, Kendall et al., 2001, 2002), we will apply the same approach to the larger SJR study.

This task is simplified by the fact that the POM in the upper SJR is apparently derived almost entirely from algae (and perhaps heterotrophic bacteria) during the summer and fall, with insignificant contributions from terrestrial debris except during storms. Biweekly POM samples collected during July through October 2000 from the SJR at 3 sites above Vernalis (above the Merced River, Crows Landing, Laird Park) had atomic C:N values of 6.0 ± 0.5 ($n = 50$) except during a storm event in mid October when C:N values reached 9. POM samples collected at Vernalis had a slightly higher and more variable C:N values of 7.1 ± 1.1 during this same period of time. The reported range of

C:N ratios for freshwater phytoplankton is about 5 to 8, averaging close to the Redfield ratio of 6.6 for marine phytoplankton. Hence, the isotopic, pigment, and lipid compositions of the easily collected and analyzed POM should reflect that of pure algae samples during this period. During other seasons when terrestrial loads of biomass are significant, earlier studies of POM isotope data at 40 other big river sites show that the isotopic signatures of the specific components can be estimated using a combined chemical, hydrologic, and isotopic approach (Kendall et al., 2001).

The algae (as reflected by POM) at these 4 sites showed large oscillations in $\delta^{13}C$ (from -30 to -27‰) and in $\delta^{15}N$ (+5 to +15‰) related to episodic algal blooms. These distinctive oscillations not only provide valuable information about nutrient sources and biogeochemical processes in the river and headwaters (see Kendall et al., 2001 for a fuller discussion of how to interpret POM isotope data), but demonstrate the feasibility of using isotope-specific fingerprints of algae to identify different sources. Furthermore, lipid analysis (and the pigment analyses performed in task 5) will provide additional information useful for discriminating different algal sources and BOD fractions. Figure B-5 shows the data for SJR sites upstream of the Merced River and at Laird Park. The most likely explanation for the oscillations in $\delta^{15}N$ is changes in the relative proportion of nitrate from animal waste; this could be verified with nitrate $\delta^{15}N$ data. The oscillations in $\delta^{13}C$ probably reflect changes in the $\delta^{13}C$ of dissolved inorganic carbon, the carbon source for algal biomass. If algae (POM) samples from various major sub-watersheds had been collected and analyzed (and found to be isotopically distinctive), we probably would have been able to determine if the algae found in the SJR at these dates developed in the river or was derived from some specific sub-watershed (e.g., Salt Slough).

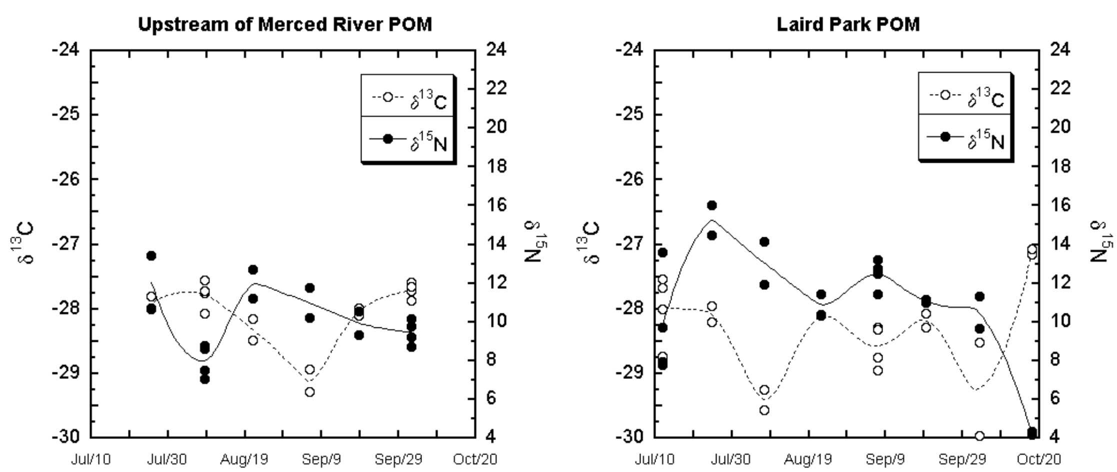

Figure B-5. The $\delta^{15}N$ and $\delta^{13}C$ of POM samples collected in 2000 from the SJR above the Merced River (A), and at Laird Park (B).

Task 7 Hypothesis

This project uses a combined isotope and chemical mass balance approach to characterize and differentiate various sources of organic matter and nutrients from different tributaries, canals, and land uses to the SJR. It is likely that there are multiple discrete sources of biomass in the SJR that vary with seasonal and spatial changes in nutrient levels and biogeochemical processes in the watersheds (such as nitrification of ammonium and denitrification). The basic hypothesis of Task 7 is that these different sources of organic matter and nutrients, and different biogeochemical processes, frequently have characteristic isotopic and optical signatures that, when used in conjunction with relevant chemical and hydrological data (such as that generated in Tasks 4 and 5), allow these sources and processes to be identified and quantified.

Task 7 Justification

The SJR Dissolved Oxygen TAC has determined that oxygen-depleting substances in the SJR at Vernalis contribute significantly to low dissolved oxygen episodes in the Stockton area during June through November. The isotope, optical, and lipid data collected in this task at the monitoring sites will be critical for evaluating the sources of oxygen demand (especially algal sources) in the SJR. These data will help address several recommendations for future work from the recent peer review: (1) provide a useful and cost-effective adjunct to routine monitoring efforts by improving the identification of sources of biomass and nutrients, (2) link algal sources and loads in the upper watersheds with algal loads downstream, (3) provide better quantification of specific sources of biomass which will be useful for improving river modeling efforts, and (4) improve the characterization of various types of BOD sources and sinks in the SJR.

Isotopes and optical techniques provide more specific information about the source of the biomass responsible for low DO than is possible with chemical methods such as BOD analysis. Isotopic and chemical tracers provide a means to directly investigate hypotheses related to BOD, nutrient sources, biomass production, and cycling because they provide both a **tracer of source** as well as an **integration of processes** along the river (Kendall, 1998; Kendall et al., 2001; Battaglin, Kendall, et al., 2001). For example, the combined use of nitrate and POM isotopes provides a way to link specific nutrient sources (e.g., wastewater or wetlands) with the algae formed in different watersheds from these nutrients.

In specific, the data collected in this project will be highly beneficial for understanding the spatial and temporal variations in sources (especially particulate sources) of oxygen-depleting substances in the SJR by developing isotopic fingerprints of different sources of organic matter and nutrients in the watersheds draining into the SJR. This characterization cannot be done with BOD and chemical measurements alone. These isotope and optical data will complement the data generated in tasks 4 and 5 since they will be made on the same samples.

Several of the stakeholder recommendations focused on how to validly assign responsibility for biomass developed in different sub-watersheds and regions, especially if the algae was "pass-through" from other sources (SR-3). Identification of specific isotopic fingerprints for algae and nutrients from different regions, sources, land uses will be of great value for the development of accurate biochemical models of seasonal and spatial variations in DO demand, and for the development of a scientific TMDL allocation plan based on linking specific types of BOD with specific geographic sources, land uses, and biogeochemical processes.

Isotopes are a very cost-effective add-on to the routine monitoring programs, requiring little additional effort by the LBNL field crews. Furthermore, compared with the costs associated with the field collections and basic chemical measurements, little additional resources are required to analyze selected constituents for isotopic composition.

Isotope methods are standard tools that have been used by watershed hydrologists and biochemists for decades. They are no longer considered esoteric. Recent advances in isotope technology were summarized in the book "Isotope Tracers in Catchment Hydrology" published by Elsevier in 1998 (edited by C. Kendall and J. J. McDonnell). See: http://wwwrcamnl.wr.usgs.gov/isoig/isopubs/ for more information on isotope applications.

Task 7 Approach and Methods

The accuracy and reliability of models and other calculations used to predict BOD in the SJR can be improved by the development of more precise geochemical tools. Improved methods for characterizing the biomass in the SJR and tributaries (i.e., isotopic fingerprints that are specific for the SJR) and the nutrients that contribute to biomass formation in the upstream watersheds can provide quantitative estimates of model parameters.

The approach to this work is based on the assumption that there are multiple discrete sources of biomass in the SJR that vary with seasonal and spatial changes in nutrient levels and biogeochemical processes in the watersheds (such as nitrification of ammonium, denitrification, and algal blooms). Isotopic techniques can frequently distinguish between several types of sources. For example, contributions of different sources of organic matter to rivers (e.g., algae, macrophytes, soil, terrestrial leaves, peat, animal waste) can be estimated using $\delta^{15}N$, $\delta^{13}C$, $\delta^{34}S$, and C:N ratios (Kendall et al., 2001). Also, nutrient sources (e.g., fertilizer, wastewater, wetlands-derived ammonium, denitrified wetlands-derived nitrate, dissolved and particulate organic phosphorus compounds) can be identified and often quantified using nitrate $\delta^{15}N$ and $\delta^{18}O$, ammonium $\delta^{15}N$, and phosphate $\delta^{18}O$ (Kendall, 1998). Characterizing the optical properties of biomass (i.e., SUVA etc) also provides significant information about its source. Nutrient isotopic composition will be also determined to provide a direct link between specific nutrient sources and the biomass fractions responsible for oxygen depletion.

Figure B-6 below provides an example of the power of isotopic techniques for providing specific information about sources of algal material to the SJR, and linkages between nutrient sources in the watersheds and the formation of algal biomass. The figure presents isotope data for samples collected at 25 sites along a transect from the San Luis Drain (SLD) to the Golden Gate during low flow conditions in mid-October 2002. The most striking feature of these data is the clearly linear nature of the various spatial trends, especially in the Bay and River parts of the system (lines were hand-drawn).

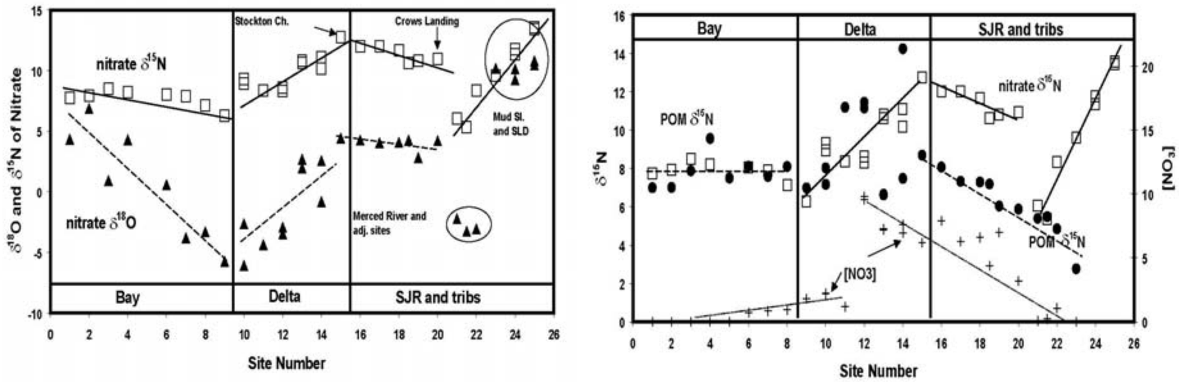

Figure B-6. Isotopic compositions of samples collected along a transect from the Golden Gate to the San Luis Drain in mid October 2002. A (left): Nitrate δ^{15}N and δ^{18}O values, B (right): Nitrate concentrations, δ^{15}N of nitrate, and δ^{15}N of POM.

The nitrate δ^{15}N and δ^{18}O values (left) show simple mixing in the Bay between ocean and Delta sources of nitrate (with very different δ^{18}O values), and mixing between a Bay and river nitrate source in the Delta. The "disconnect" between δ^{18}O and δ^{15}N values of nitrate in the SJR section clearly shows mixing of at least 3 sources of nitrate: a moderately well-mixed groundwater source that drains into the SJR river (perhaps partly via minor tributaries) that has the composition seen in the Stockton Channel, one apparently derived from groundwater feeding the Merced River, and a third related to water from the Mud Slough and the SLD.

The C:N values of the POM in the SJR upstream of Stockton averaged 7.4, clearly indicating that the POM in the SJR at this time was almost entirely algae. Note that the δ^{15}N of POM and nitrate in the Bay are almost identical, as is expected for N-limited systems. This contrasts with the ~4‰ lower δ^{15}N values of POM relative to nitrate in the SJR where nitrate concentrations are higher; isotope fractionations are known to be dependent on pool sizes (Kendall, 1998). The parallel trends of nitrate concentration, POM δ^{15}N, and nitrate δ^{15}N in the SJR part suggest that most of the POM (consisting primarily of algae) was developed in contact with nitrate δ^{15}N and concentration gradients similar to what was observed in the SJR.

With the isotope data we have generated thus far for this transect (chemistry data analysis in progress), it appears that the algae in the SJR in mid October was **not** derived from watersheds upstream of the confluence with the Merced River, and was instead developed in contact with a well-mixed shallow groundwater source of nitrate that is slightly diluted upstream by water derived from near the Merced River. More data are required to determine whether most of the algae largely grew in the SJR itself, or if some of it might be derived from tributary or drain sites downstream of the Merced River that are fed by this same shallow groundwater nitrate source. However, the strongly linear trends strongly suggest that the algae grew in or adjacent to the SJR.

The preliminary results of this related study demonstrate the value of POM and nitrate isotope data for characterizing sources and fractions of BOD, among other uses. In specific, this example shows how isotope data address PRR 2 to investigate the linkage between upper watershed algal sources and algal loads in the DWSC, and PRR 4 to resolve the relative importance of different BOD fractions to the SJR. These data would rule out the upper watersheds as a significant source of the biomass present in the SJR in mid-October 2002.

The peer panel has specifically recommended investigation of the contribution of ammonia to the SJR (PRR4). Because the influx of ammonia from wastewater and wetlands discharge may present a significant oxygen demand in the SJR when it is oxidized to form nitrate, this study will also investigate the possible contribution of nitrification to BOD. Previous studies in other regions have indicated that waste water-derived ammonium is usually isotopically distinct from ammonium derived from wetlands or fertilizer (Kendall, 1998). These isotopic differences should be maintained after nitrification and allow us to identify the relative contributions of the two pools.

Task 7.1: Tracing Sources of Organic Matter and Nutrients Responsible for Oxygen Demand in the SJR Using Isotope and Optical Techniques

The objectives of this task are to:

- Identify the major sources of biomass and nutrients to the SJR between the Grasslands area and Channel Point.
- Identify the organic matter and nutrient transformations along this reach.
- Determine if ammonia is an important contributor to oxygen demand in upstream wetlands and to the Stockton reach of the SJR.
- Characterize the temporal variability in biomass and nutrients in the SJR.
- Establish site-specific links among nutrient sources, biomass sources, and oxygen demand.

Isotopes and optical techniques provide more specific information about the source of the biomass responsible for low DO than is possible with chemical methods such as BOD analysis. Isotopic and chemical tracers provide a means to directly investigate hypotheses related to BOD, nutrient sources, biomass production, and cycling because they provide both a tracer of source as well as an integration of processes along the river (Kendall, 1998; Kendall et al., 2001; Battaglin, Kendall, et al., 2001). For example, the combined use of nitrate and POM isotopes provides a way to link specific nutrient sources (e.g., wastewater or wetlands) with the algae formed from these nutrients. This cannot be done with BOD and chemical measurements alone.

Task 7.1.1. Characterizing BOD in the SJR, its Main Tributaries, and Main Sub-Watersheds

We will use isotopic and optical measurements to enhance the characterization of BOD and nutrients at monitoring sites described in task 4. Specifically, we will obtain splits (1 L) of all the samples collected 17± times per year at 21 key SJR and tributary sites and all the samples collected 4± times per year at the 33 sub-watershed sites. Samples will be chilled and filtered within 48 hours through pre-combusted glass fibers in the lab, and the filter will be wrapped in foil, frozen, and sent to the USGS stable isotope lab in Menlo Park for isotopic analysis. In Menlo Park, POM from all samples will be freeze-dried, homogenized, acidified, and analyzed for $\delta^{15}N$, $\delta^{13}C$, $\delta^{34}S$, C:N, and C:S. All the filtered water samples will also be analyzed for (1) $\delta^{13}C$ of DOC, (2) $\delta^{13}C$ (and approximate concentration) of DIC, (3) optical properties (esp. SUVA), and (4) water $\delta^{18}O$ (for water mass budgets).

Waters will be archived to evaluate the usefulness of several other types of isotope tools for enhancing our ability to distinguish among BOD sources. In particular, filtered 20 ml water samples split from all samples collected during Task 4.2 will be frozen and archived for later possible analysis for nitrate $\delta^{18}O$, $\delta^{17}O$ and $\delta^{15}N$ (if additional funds become available). A subset of POM samples will be analyzed for ^{14}C to quantify contributions of old detrital carbon. On occasion, different size fractions of POM will also be isolated (using centrifugation and Ludox separations) and analyzed separately for $\delta^{13}C$, $\delta^{15}N$, and $\delta^{34}S$ to better characterize pure, undegraded phytoplankton when the rivers contain significant amounts of non-algal POM (i.e., during storms). We will integrate the above methods to provide a fingerprint comparison among sites in the watersheds and in the mainstem SJR.

Task 7.1.2. Determining the Sources of Nutrients Responsible for BOD in Salt Slough and Other Sub-Watersheds

The primary objective of this task is to link specific nutrient (ammonium, nitrate, and phosphate) sources in the sub-watersheds with the specific types of organic matter formed there. This will be achieved by:

1) isotopically analyzing the various end-member N and P sources important to the production of BOD sources in the sub-watersheds,

2) determining the seasonal and spatial changes in nutrient sources in the sub-watersheds,

3) comparing the isotopic compositions of the nutrients with the isotopic compositions of the resulting organic matter, and

4) correlating these isotopic fingerprints with changes in water chemistry and BOD measured as part of tasks 4 and 5.

Water samples collected from 32 sub-watersheds sampled 4± times per year will be analyzed for (1) nitrate $\delta^{15}N$ and $\delta^{18}O$, and (2) ammonium $\delta^{15}N$ and DON $\delta^{15}N$ (if concentrations permit). Waters will be archived for evaluation of the usefulness of several other types of isotope data for enhancing our ability to distinguish among BOD sources. For example, dissolved and particulate phosphate from a few selected samples will be analyzed for $\delta^{18}O$ of phosphate to provide information on the source of P incorporated in algal material in areas where phosphate limitation is suspected. Algae from P-limited sites will show a different isotope fractionation than from sites with excess P.

Various end-member N and P sources important to the production of BOD sources in the sub-watersheds (e.g., wastewater treatment plant effluent, agricultural drains with only tailwater, agricultural drains with only tile drainage, dairy waste, native soil nitrates, fertilizer) will be sampled two or more times during the first year to identify their isotopic compositions. Otherwise, all the samples in this task will be obtained from splits of samples collected in Task 4.

Task 7 Quality Assurance/Quality Control

The number of QC samples (blanks and replicates) will amount to about 20 percent of the total number of samples. A QAPP was prepared by the USGS for the CALFED-supported sampling in July through October 2000. This will be incorporated into the QAPP developed under Task 3.

Task 7 Data Handling and Storage

After the data have been quality-assured by the PI, all data will be made available to collaborators and transmitted to Karl Jacobs in an Excel spreadsheet for entry into the Bay-Delta and Tributaries Database.

Task 7 Interpretation of Results

Data collected in Year 1 will be analyzed in a forensic manner to determine if the isotopic data developed in this task, along with the chemical and hydrologic data generated at the monitoring sites, provide sufficiently unique fingerprints of seasonal and spatial changes of BOD sources (especially particulate BOD) to the SJR. The subsequent work conducted in Year 2 will depend on the results from Year 1 under the adaptive management strategy. For example, if the $\delta^{34}S$ analyses of POM do not provide sufficient discrimination of S from wetlands sources, or the $\delta^{13}C$ analyses of DOC do not provide adequate discrimination of terrestrial vs. algal (or C3 vs. C4) sources of particular components of BOD, or some types of isotope measurements show little linkage to BOD measurements, these analyses will be minimized in the second year and the funds used for more promising analyses (e.g., $\delta^{15}N$ of nitrate and/or DON).

We will archive samples for several types of promising analyses, so that samples from Year 1 will be available for analysis in Year 2 if deemed beneficial after the initial interpretation of the data. Furthermore, although funds are not requested for Year 3, we will ask the field crews to continue collecting us samples which we will archive for possible future analysis if there is future interest and funding. For example, if Years 1 and 2 turn out to be unusual years in terms of DO conditions, or if some important hydrologic event was unsampled, we will have a backup set of samples from an additional year (e.g., the archived 3rd year) that could be analyzed. Another example: based on our existing isotope data, we expect that the POM in the SJR during much of the year is dominated by algal sources. After we begin to generate data showing the spatial and seasonal changes in $\delta^{15}N$ (and $\delta^{13}C$) of the POM, we will probably want to determine how these changes relate to changes in nutrient sources and biogeochemical processes in the SJR, tributaries, and sub-watersheds. Analysis of archived nitrate samples for $\delta^{15}N$ and $\delta^{18}O$ will provide this type of critical source-related information.

The discussions above of temporal variations in $\delta^{15}N$ and $\delta^{13}C$ of POM (Figure B-5) and spatial variations in nitrate $\delta^{15}N$ and $\delta^{18}O$, nitrate concentrations, and $\delta^{15}N$ of POM (Figure B-6) provide very specific and relevant examples of how the isotope data generated in this task will be interpreted. Seasonal changes in POM data (e.g., Figure B-5) will be evaluated to calculate relative percentages of POM from different sources (e.g., terrestrial vs. algal, or tributary algae vs. in situ algae). If the POM is largely algal, or if the isotopic compositions of the algae in a mixed-source sample can be calculated to sufficient precision (which depends mainly on whether the end-member sources have distinctive compositions), the temporal variability in $\delta^{15}N$ and $\delta^{13}C$ will be interpreted in terms of temporal changes in biogeochemical processes (such as nutrient limitations, in situ algal blooms, or nitrification of ammonium), or changes in nutrient sources (fertilizer, wastewater, soil N, etc.) in the sub-watersheds, tributaries, and mainstem SJR. Spatial changes in POM and nitrate isotope data (i.e., Figure B-6) will be evaluated to identify river reaches dominated by mixing of 2 or more sources, locations where various types of isotope data (e.g., nitrate vs. POM vs. water isotopes) show inconsistencies in the mixing of various components, biomass produced from nitrification of ammonium from wetlands or sewage, or situations (like that illustrated in Figure B-6) where the isotope data clearly indicate that the algae in the SJR is not derived from upstream sites and is most likely formed in situ.

Because the isotope samples are all splits of samples collected by the monitoring program in Task 4, the isotope data will not be interpreted in isolation. As discussed in detail in somewhat similar studies of POM and nutrient isotopes in large rivers (e.g., Kendall et al, 2001; Battaglin, Kendall, et al., 2001; and Chang, Kendall, et al., 2002), isotope data are best used in conjunction with available chemical and hydrologic data (such as that generated in Task 4). For example, with information on suspended sediment loads, nitrate concentrations, and discharge measurements, the relative contributions of POM and nutrients from different tributaries and sources, as determined by isotope measurements, can be checked with other mass balance estimates. Multi-parameter statistical methods will be used to characterize sources of biomass and nutrients from different geographic regions.

Task 7 Organization

Carol Kendall will be the Principal Investigator on Task 7 and therefore responsible for delivery of all reports. Work on this task is a joint effort between USGS and LBNL, who is conducting the sampling as part of Task 4. Kendall will produce the draft and final quarterly reports. At least one of the Task 7 team will attend each PI and TAC meeting. Kendall will be responsible for producing the draft and final annual reports, and the final summary report. The budget contained funds to cover the costs of meetings and reports.

Task 7 Deliverables

Prior to beginning fieldwork, a Sampling and Analysis Plan (including QA/QC procedures for incorporation into the overall project QAPP) will be prepared and distributed to CALFED, CVRWQCB, stakeholders, and other interested parties for review. The Sampling and Analysis Plan will include details on sample collection and handling procedures, sampling locations, laboratory analysis, operations and maintenance of continuous monitoring stations, and data management.

The reports for Years 1 and 2 will include tables of all data collected during the year (as appendices), as well as a thorough evaluation of the data in terms of program objectives and the study questions posed. The reports for Years 1 and 2 will also include recommendations for modifications to the program the following year, based on an evaluation of the results. The Comprehensive Report will include a detailed evaluation of all 2 years of data.

All deliverables listed above will be subject to a formal peer review process before finalization. The schedule for deliverables and the review process is shown in the table above. PIs for each subtask will be responsible for preparing presentations for TAC meetings and peer review workshops.

Task 7 Budget Justification

First year: We have asked for 22 days (176 h) each of salary for PI Kendall and Scientist Silva to cover monthly attendance at monthly TAC and PI meetings, preparation of quarterly and annual reports, and other project coordination activities. The USGS is making a 2-month (in kind) contribution of salary for each of them to supervise the sample analyses, oversee QA/QC, interpret the data, give presentations at local and national meetings, and prepare journal articles. We have asked for 44 days (352 h) of salary for Technician II to analyze prepared samples on one of the 3 stable isotope mass spectrometers, perform data reductions, evaluate the QA/QC samples, provide data files to the PI for distribution to other team members, and help with the data interpretation, presentation, and reports. One year of salary (2088 h) is requested for USGS Technician I to provide bottles to LBNL field crews, retrieve filtered/chilled/frozen samples from the LBNL lab team, log the samples into our lab database, prepare reference materials and QA/QC samples, and prepare all the samples for isotopic analysis. The $16,200 requested for supplies covers bottles, filters, purified gases and liquid nitrogen needed to operate the mass spectrometers, reagents for the elemental analyzers and gas preparation units, and glassware. The $8,100 requested for travel covers weekly to biweekly trips to obtain samples from field crews, attendance at monthly meetings, and a few days in the field to visit the sites and collect end-member BOD samples. $6,480 was requested to write, edit and publish papers in scientific jorunals.

This budget covers the costs of analyzing filtered water and particulate organic matter from all samples collected in Task 4.2 and 4.3 by the LBNL team (and filtered and bottled at LBNL) for selected N, C, S, and O stable isotopic compositions. In specific, we will be analyzing the following number of samples (21 sites x 17 times, plus 32 sites x 4 times, plus 20% QA/QC samples, for a total of ~600 samples. Samples from the 21 main-stem and tributary sites (Task 4.2) and the 32 upstream sites (Task 4.3) will each be analyzed for $\delta^{15}N/\delta^{13}C/\delta^{34}S$ of POM, $\delta^{13}C$ of DOC, $\delta^{18}O$ of water, and SUVA, with selected samples analyzed for other optical parameters, $\delta^{13}C$ of DIC, $\delta^{15}N/\delta^{18}O$ of nitrate, $\delta^{15}N$ of ammonium, $\delta^{18}O/\delta^{17}O$ of DO, and $\delta^{2}H$ of water, as seems appropriate as the study progresses. In addition, all samples from the 32 upstream sites (32 x 4, plus 20% QA/QC samples, for a total of ~175 samples) will be analyzed for $\delta^{15}N/\delta^{18}O$ of nitrate, and when concentrations permit, for $\delta^{15}N$ of ammonium and $\delta^{15}N$ of DON. The price breakdown per sample is about $100 each for 600 samples and about $100 each for the 175 samples.

Second year: We have requested the same budget breakdown except for a 3% increase for inflation.

TASK 8: LINKING THE SJR TO THE DWSC

Task 8 Objectives

The goal of the project is to quantitatively determine the cause of the decrease in chlorophyll and other organic matter between Vernalis and the DWSC. The following objectives are proposed to meet this goal:

- Quantify oxygen demands entering the DWSC.
- Characterize the growth and decay of algae from Vernalis to the DWSC.
- Quantify losses of organic matter associated with settling and agricultural diversions.
- Estimate BOD decay and nitrification rates.
- Provide recommendations for fixed monitoring locations that best describe the loads entering the DWSC.
- Provide a comprehensive data set for model development and calibration from Vernalis to the DWSC.

While this work seeks to develop a mechanistic understanding of algal processes between Vernalis and the DWSC, utilization of a water quality model may prove necessary to fully explain the generated data. As such, development of a comprehensive data set for model algorithm development and calibration is included as one of the objectives.

Task 8 Conceptual Model

The growth and decay dynamics of algae in the SJR reach between Vernalis and the DWSC is poorly characterized, despite 2 years of intensive study. Contradictory data exist for algal growth and decay between Vernalis and the DWSC (Jones & Stokes 1998; Lehman 2001; Foe, Gowdy, and McCarthy 2002). However, the data do strongly indicate a significant loss of algal biomass downstream of Vernalis and Mossdale (Jones & Stokes 2002; Lehman 2001). Extant DWSC models rely on input data generated at Mossdale, but this model overpredicts the chlorophyll entering the DWSC by approximately 3 times and underpredicts the DO by 2 mg/L for 2001 (Jones & Stokes 2002).

The existing monitoring program has been incapable of explaining apparent losses of algal biomass between Mossdale and the DWSC. Estimates were made in 2001 of inflows and diversions to this SJR reach (Quinn and Tullock 2002). However, this work was based on scanty historic information and a boat survey – insufficient to properly characterize the algal dynamics or other mechanisms responsible for the algal decline. This SJR reach between Vernalis and the DWSC is of critical importance since it dictates the loading of live or decaying algae that directly affect oxygen removal from the water column. Tidal effects complicate the dynamics of this reach also and slow the transport of biological material to the DWSC and its passage through the DWSC.

The conceptual model for this project is a mass balance approach to characterize and differentiate the possible causes for the decline in algal biomass between Vernalis and the DWSC. This study will also yield critical input parameters for developing an accurate water quality model of the SJR and DWSC. Continuous monitoring performed over weeklong periods provides information on the diurnal fluctuations in algal loads as well as providing more accurate insight into data noise than has been possible in the past. Previous sampling in this reach has been limited to grab sampling supplemented with continuous monitoring at Mossdale.

Task 8 Hypothesis

The underlying hypotheses of the proposed studies are that (1) studies using dye tracers to measure algal transport, performed together with continuous water quality monitoring at selected sites within the dye path, are capable of providing important additional insights into the dynamics of algae growth and decay and will address unresolved mass balance questions for both algal biomass and organic matter; (2) this approach can be used to quantify the effects of (a) agricultural diversions, (b) algal settling, (c) tidal dilution (dispersion), and (d) decay associated with light reduction in the tidal prism.

Task 8 Justification

This task specifically addresses the PRR 5, the SJR between Vernalis and the DWSC is poorly understood and needs further investigation. Task 8 will address algal growth dynamics and investigate possible mechanisms for the loss of algal biomass observed within this reach. This peer review recommendation also calls specifically for establishing the location of a new station between Mossdale and Channel Point to better characterize the loads entering the DWSC.

Task 8 also addresses PRR 3 by coordinating the model development with data collection efforts. One of the investigators working on Task 8, Dr. Nigel Quinn, is also providing oversight on Task 6, River Modeling. The data generated by Task 8 will be important for modifying model algorithms, calibration, and verification. Task 8 will also generate input parameters independently of the model including algal productivity, BOD and nitrification rates between Vernalis and the DWSC. Lastly, work proposed in Task 8 will better characterize BOD in the SJR, and thus contributes to addressing PRR 4 .

Task 8 Approach and Methods

Location of Project

This component of the project is located in the SJR downstream of Vernalis and upstream of Channel Point at the DWSC.

Approach Overview

The loss of chl-*a* may be associated with agricultural diversions, diminished exposure to light as the SJR deepens in the tidal prism of the Delta, dilution (dispersion) of the SJR during flood tides with water from the DWSC that exhibits much lower chl-*a* concentrations, or settling out of the water column. Dye measurements will provide evidence of mass balance and losses and would indicate diversions from the SJR, when used in combination with current and planned flow and water quality monitoring in this reach. Additional self-contained, continuous, monitoring stations will capture additional data including chl-*a,* DO, pH, and water temperature. Light-dark bottle field tests are proposed to quantify algal DO productivity. Long-term BOD bottle tests will quantify DO decay and nitrification rates.

This task is proposed for three years of investigation. The approach is flexible to permit adaptive monitoring within the SJR between Vernalis and the DWSC. During the first year, four monitoring runs will be conducted during each month from June to September. Only two trials are scheduled for the second year, and one run is proposed for the last year of this study. The monitoring runs are designed to address extant questions about the

SJR, but the emphasis on certain study elements will be modified to attempt to resolve new questions that arise as more information becomes available.

Each monitoring run will involve four specific tasks:

Task 8.1: Deploy three continuous monitoring buoys at selected locations for extended periods (1 week). This subtask will provide a data set for modeling (PRR 3) and provide a means for interpreting the results of Task 8.2. The positioning of the monitoring buoys in the SJR is flexible in order to optimize the utility of the data collected. As new data become available, the positioning of the buoys will be tailored to answer specific questions. For example, where is the best monitoring location for predicting pollutant loads to the DWSC? When combined with Task 8.2 these subtasks will address PRR 5.

Task 8.2: Perform Lagrangian monitoring to assess mass losses of a conservative dye and reactive substances (i.e., chl-*a*, pha-*a*, BOD, ammonia). Task 8.2 facilitates Tasks 8.3 and 8.4 since these subtasks use water samples collected during this subtask. Task 8.2 is critical to addressing PRR 5 and also contributes to PRR 3 and 4.

Task 8.3: Augment fieldwork with laboratory assessment of BOD decay and nitrification kinetics. This subtask contributes to addressing PRR 3, 4, and 5.

Task 8.4: Algal species determination, enumeration, and field light/dark bottle experiments. This subtask contributes to addressing Peer Review Recommendations 3 and 5.

Continuous Water Quality Measurements

Tasks 8.1 and 8.2 will be performed with multiparameter sondes manufactured by YSI, Inc. and Turner Instrument fluorometers. These instruments were previously described in Task 4: Monitoring. Calibration will be performed per standard methods (APHA 1998) or manufacturers specifications and checked periodically in the field. The data acquisition frequency will be adjusted as appropriate. However, it is anticipated that the monitoring buoys will capture data every 15 minutes, while the frequency for the Lagrangian dye monitoring will vary from 1 second when quantifying the dye mass to as long as 5 minutes when tracking changes in chl-*a* or other parameters.

Discrete Water Sample Collection and Analysis

All the tasks will require the collection of water samples for constituent quantification. Sampling will be performed by manual grab methods or peristaltic pumps. Analysis will be performed in accordance with standard methods (AHPA 1998). TSS and VSS will be performed by SMs 2540 D and E, respectively. However, trials will be performed with filters required for chl-*a* (SM 10200H) instead of filters required by SMs 2540 D and E to obtain better correlations among VSS, chl-*a,* and BOD. Filter pore sizes for TSS and VSS can be significantly larger than pores sizes of filters specified for chl-*a* analysis. Chl-*a* and pha-*a* will be extracted using an acetone/water solution and UV absorption in accord with SM 10200H. Biochemical oxygen tests will be of a long-term nature (SM 5210 C) to facilitate determination of decay rate constants.

Task Descriptions

Task 8.1: Deployment of Continuous Recording Sensors

Three additional monitoring sites on the SJR will be chosen between Vernalis and Channel Point. A location 2-4 miles upstream of Channel Point will be included to investigate possible permanent stationary monitoring site for future management of the system. These sites are flexible and will be changed as new information becomes available. Continuous water quality sondes (YSI Inc., Yellow Springs, IL, and Turner Instruments, Sunnyvale, CA), measuring chl-*a,* turbidity, EC, pH, DO, and water temperature will be deployed at the five locations for 1 to 2 weeks at a time each month between June and November each year. The deployment will coincide with the Lagrangian dye tracking measurements. These sondes will capture the diurnal patterns of algal growth and decay allowing advective transport of algae to be separated from tidal transport and more careful mass accounting of algal loading in this SJR reach. These stations will also yield important data sets for model calibration.

Enhanced monitoring has been proposed at existing DWR stations on Old River at Head and the SJR at Lathrop to complement the Mossdale monitoring. Investments in additional monitoring are planned to enhance discharge stations at New Jerusalem Drain and on French Camp Slough to capture potential dilution effects of these sources.

Task 8.2: Lagrangian Monitoring

In addition to the in-river, continuous sensors, a slug of rhodamine WT dye will be dispersed uniformly across the SJR and tracked downstream by boat. Semimonthly injections of dye and deployment of the light-dark bottle experiments are proposed from June to October. In situ measurements of dye concentration, chl-*a,* pH, DO, turbidity, water temperature, water depth, and instrument depth will be captured electronically with their GPS coordinate location. Figure B-7 presents a photograph of the monitoring boat and a schematic diagram of the equipment required for this task. This system permits the simultaneous collection of all data from five different instruments every second. These data are processed in real-time and displayed graphically using MATLAB (MathWorks, Natick, MA). An example of the capability of this system is exhibited on Figure B-8. Over 1,200 data points were captured in the 20 minutes required to generate this cross-sectional contour view of rhodamine WT dye in the DWSC. This system permits accurate accounting of dye mass in the SJR and precise characterization of chl-*a,* DO, and other parameters in the SJR. Simultaneous graphing of concentration contours of all continuous parameters is possible. For example, bathymetry measurements will yield water depth information that may be correlated to the growth and decay of chl-*a* in the reach between Vernalis and the DWSC.

To augment the continuous monitoring, discrete water quality samples will also be periodically collected for quantification of chl-*a,* pha-*a,* VSS, TSS, BOD, CBOD, and verification of in situ turbidity, DO, pH, chl-*a* measurements. As shown on Figure B-7, discrete water samples can be collected at a prescribed water depth using 5/16-inch-inner-diameter tubing attached to a peristaltic pump (MasterFlex, Cole-Parmer Instrument Company, Vernon Hills, IL). Mass balance applied to the longitudinal measurements of inorganic solids will be used to assess net losses associated with settling. Sediment deposition traps may also be deployed if significant sediment losses are detected with the initial water quality measurements.

These simulations will be coordinated with other water tracking studies proposed in the river above Vernalis so the same dye plume and associated changes in water quality and algal populations will be followed from the upper San Joaquin River to the DWSC. It is anticipated that each full river dye tracking study will require 4 to 5 continuous days of extensive fieldwork. Water samples collected during these trials will be periodically transported to the laboratory and processed or preserved as appropriate.

Task 8.3: BOD Decay and Nitrification Rates

The BOD and CBOD tests will be performed over 20 days to determine kinetic decay rate constants of BOD, CBOD, and NBOD. The rate of NBOD decay will also be evaluated by monitoring the ammonia and nitrate concentrations in the BOD tests. Direct measurements will be made of ammonia oxidation rates as a function of time will be made using Clark-type electrodes. Nitrifying organisms in the SJR will be enumerated using a most probable number technique. The data from these experiments will be used to determine more accurately the liability of the soluble ammonia in this SJR reach. Understanding and predicting how fast ammonia is oxidized in this region is important to assigning the oxygen demand allocation between algal biomass and ammonia. These tests will be conducted with each of the Lagrangian dye tracking investigations.

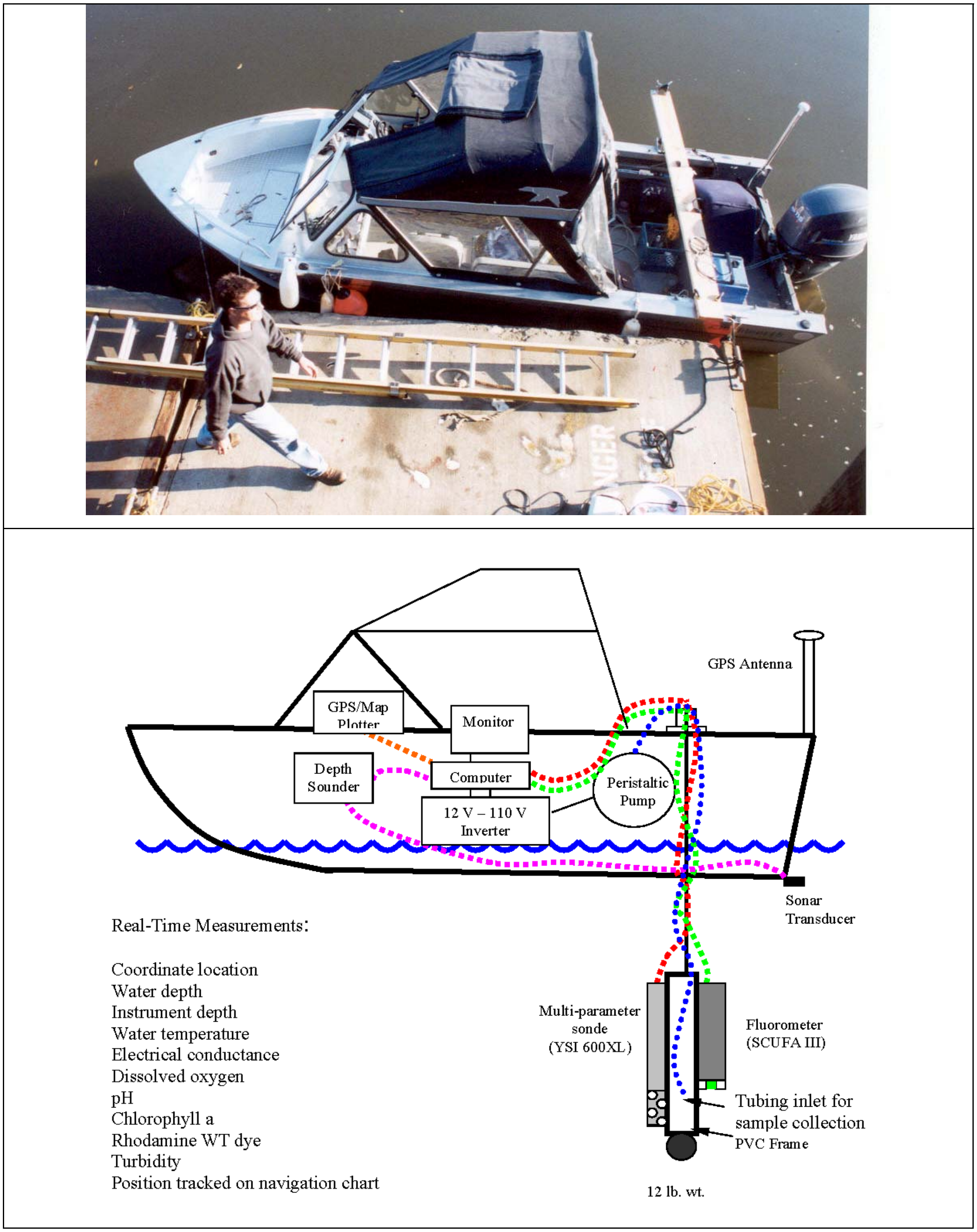

Figure B-7 Monitoring Boat and Data Acquisition System

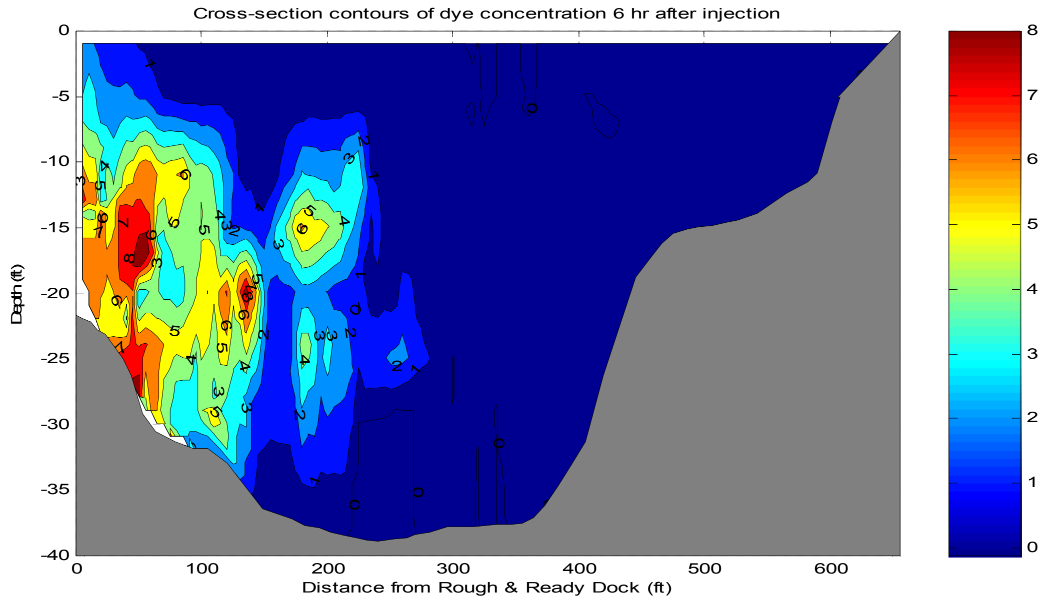

Figure B-8 Rhodamine WT Dye Contours in the DWSC Generated from Data Captured with the Data Acquisition System

Task 8.4: Algal Species Determination, Enumeration and Light-Dark Bottle Experiments

As part of the Lagrangian studies, water samples will be collected within dye plume as it is tracked from Vernalis to the DWSC. Algal counts will be made on the river water samples using a haemocytometer cell. Phytoplankton and zooplankton counts will be conducted according to Standard Methods 10200 F and 10200G, identification will be made using Standard Methods 10900 C and other appropriate keys (APHA, 1998). The algal cells per cubic centimeter or other volumes will be measured. Differential counts will be made to enumerate the several species of algae likely to be present at a given time. The conversion of cell volume to biomass will be measured microscopically or by dry weight and ash content from a given volume of water will be determined and the average weight of one or more cells computed. With these techniques, algal productivity by species in the river from Vernalis to the DWSC will be assessed. This effort will be coordinated with similar work proposed by other investigators of this proposal (Task 5). Light-dark bottle experiments are also proposed to assess whether the apparent decay of algal biomass from Mossdale to the DWSC may be associated with reduced exposure to light resulting from the deepening of the SJR within the tidal prism. These tests will be performed with the Lagrangian dye tracking. Previous studies have shown that algae collected in the SJR 1 mile above the DWSC decay extremely rapidly when kept in darkness (Litton 2002). To assess the impact of light reductions, light-dark bottle racks will be suspended from the boat at various depths while following the dye slug. Light intensity will be measured at each rack depth periodically. The pH, DO, chl-*a,* and pha-*a* concentrations will be quantified for the light-dark bottle experiments. These tests will assess whether light limitation is a significant cause of the chl-*a* decay between Mossdale and the DWSC. These tests will also yield algal productivity and DO response curves as a function of light intensity, data critical for modeling this SJR reach accurately.

Task 8 Data Interpretation

Data will be analyzed and interpreted to address Peer Review Recommendations.

- Development of a mechanistic understanding of algal growth and decay from Vernalis and the DWSC. This will include quantification of the possible causes of biomass loss historically observed from Mossdale to the DWSC. Accomplishment of these objectives will specifically address PRR 5.
- Determination of the parameters critical to accurately calculating the algal biomass and associated oxygen demands entering the DWSC. A monitoring site or reach of the SJR will be identified for acquiring data that best characterizes the constituents entering the DWSC. The data collected from this site is critical for accurately estimating the loads of dissolved oxygen demands entering the DWSC. This interpretation will address PRR 4 and 5.
- Development of a comprehensive data set to adequately calibrate (or modify existing algorithms) predictive water quality models developed by Systech Engineering, Inc., DWR, or HydroQual, Inc. These data address PRR 3 when combined with data generated from other tasks (e.g., Task 4: Upper SJR monitoring).

Task 8 Organization

Gary Litton and Nigel Quinn are Co-PI's for Task 8 and will deliver written quarterly and annual task reports. Responsible investigators by subtask are:

Task 8.1 Continuous monitoring	Nigel Quinn, LBNL
Task 8.2 Lagrangian monitoring	Gary Litton, UOP
Task 8.3 BOD and nitrification rates	Gary Litton, UOP
Task 8.4 Algal species	Gary Litton, UOP
Task 8.5 Report preparation, etc.	Gary Litton, UOP

As shown above, the project will be executed with effort from UOP and LBNL. Students from UOP and Fresno State will be employed on this project.

Task 8 Deliverables

In addition to distribution of the electronic data sets, the following deliverables will be submitted under Task 8:

- Quarterly progress reports
- Yearly written reports
- A three year summary report
- Attendance at Technical Advisory Committee meeting and presentations where appropriate.

Prior to beginning fieldwork, a Sampling and Analysis Plan (including QA/QC procedures for incorporation into the overall project QAPP) will be prepared and distributed to CALFED, CVRWQCB, stakeholders, and other interested parties for review. The Sampling and Analysis Plan will include details on sample collection and handling procedures, sampling locations, laboratory analysis, operations and maintenance of continuous monitoring stations, and data management.

The reports for Years 1 and 2 will include tables of all data collected during the year (as appendices), as well as a thorough evaluation of the data in terms of program objectives and the study questions posed. The reports for Years 1 and 2 will also include recommendations for modifications to the program the following year, based on an evaluation of the results. The Comprehensive Report will include a detailed evaluation of all 3 years of data.

All deliverables listed above will be subject to a formal peer review process before finalization. PIs for each subtask will be responsible for preparing presentations for TAC meetings and peer review workshops.

Task 8 Budget Justification

This task is proposed for three years of investigation. The approach is flexible to permit adaptive monitoring within the SJR between Vernalis and the DWSC. During the first year, four monitoring runs will be conducted during each month from June to September. Only two trials are scheduled for the second year, and one run is proposed for the last year of this study. Coordination of this effort with a similar dye study above Vernalis will be attempted so as to obtain a seamless data set for the upper SJR to the DWSC. The Task 8 budget does not include assistance with the upper SJR dye study since it is included in the Task 4 budget.

For Year 1, individual tasks are budgeted as follows: Task 8.1 $134,919; Task 8.2 $74,673; Task 8.3 $35,075; Task 8.4 $26,704; Task 8.5 $99,912.

Each monitoring run is labor intensive. The travel time of the SJR from Vernalis to the DWSC may be 4 days or longer, depending on flow. Since a slug of dye is being followed during each monthly trial, personnel must remain in the field from the discharge of the dye to its arrival at the DWSC. Several days of preparation before the dye tracking event and extensive laboratory work after each run are also required.

The monitoring runs are designed to address extant questions about the SJR, but the emphasis on certain study elements will be modified to attempt to resolve new questions that arise as more information becomes available. It is expected that follow-up monitoring runs will be necessary in subsequent years, as such a budget is proposed for all three years, but it is reduced after each year. Salaries for those involved in this task are adjusted annually by 3% for inflation.

TASK 9: SUMMARY

Task 9 Objectives

The objective of Task 9 is to produce a concise report that summarizes and explains the major findings of the overall project in a manner that is useful to stakeholders, regulators, scientists, and others who are interested in the outcome of the DO TMDL studies conducted as part of this project. The report will serve as a guide to the detailed reports issued annually as part of Tasks 4 to 8 and provide a balanced reporting of the major findings.

Task 9 Conceptual Model

The conceptual model for this task is the "literature review" found in scientific journals. In a literature review, the author or authors read all the available literature on a subject and then write a paper summarizing and discussing the findings of individual studies in the context of the overall state of knowledge that has been developed or to answer a particular scientific question. The concept of the literature review is that the sum of the whole is greater than the sum of the individual parts.

Task 9 Hypothesis

A concise Summary Report is needed to integrate the findings of separate complex tasks. Integration is required to make the information generated in these DO TMDL studies available to the people and organizations involved in the DO TMDL process.

Task 9 Justification

The production of concise annual and final Summary Reports is justified by peer review comments concerning the lack of such a document in prior DO studies (Cloern et al. 2002). Concise Summary reports are justified under the need for increased communication with stakeholders to increase confidence in the TMDL process (SR5, Objective 6). RWQCB staff have requested a Summary Report on this project.

Task 9 Approach and Methods

Task PIs will write annual reports for Task 4 to 8 that will contain a complete description of all work accomplished in the previous year. In Task 9, these reports will be reviewed and a Summary Report will be written to summarize the finding of the overall research program in a concise document convenient for reference by stakeholders, regulators, scientists, and other interested parties. Any discrepancies between study results will be examined and experiments will be suggested to resolve potential discrepancies in the subsequent year's effort (see adaptive management description above). In year three, a final Summary Report will be issued incorporating findings from all three years of study.

Task 9 Interpretation of results

The authors of the Summary Report will review their interpretation of the results from individual tasks with the task PIs and in the open forum of the TAC before the final report is issued. Differing interpretations of the same data will be noted and PIs will be given an opportunity to write dissenting opinions on the data interpretation if they so desire.

Task 9 Organization

Erwin E. Van Nieuwenhuyse and William Stringfellow will be co-PI's for Task 9 and will be the authors of the Summary Reports. Co-authors for the reports will include other

PI listed on this project and scientists from outside agencies if they make a significant contribution to writing the report. The report will be subject to peer review by the TAC and CalFed before being finalized.

Task 9 Deliverables

An Annual Summary Report will be issued in the first quarter of the year following the completion of the individual PI annual reports. In the third year, the final report will be delivered within a month of the final project ending date.

Task 9 Budget Justification

Writing the Summary Reports is a key task for transferring knowledge gained in this project to practical application in the DO TMDL implementation process. Task 9 will require reading and analyzing the Task reports; writing draft reports; presenting draft reports to the TAC, the Steering Committee, CalFed Peer Review Committees and other stakeholder and scientific groups as might be required; soliciting public comments and responding to comments; and writing a final report.

In Year 1 and Year 2, William Stringfellow will spend up to 200 hours and Lowell Ploss and Joe McGahan up to 40 hours each writing and reviewing the Summary Reports. In Year 3, it is expected that the final report will require more effort and up to 480 hours of PI time and 160 hours of Project Director time are budgeted. Salaries are adjusted 3% for inflation in years 2 and 3. In addition the budget includes clerical time, travel, supplies, and publication costs.

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Table B-6: Target Dates

Task	Date
Award Contract	June 2003
Task 1: Project Administration	
Contract Summary Form	July 2003
Award Subcontracts	July 2003
Quarterly Progress Reports	September 2003 and Quarterly thereafter
Annual Progress Reports	June 2004, 05, & 06
Task 2: CEQA/NEPA Documentation	August 2003
Task 3: QAPP	September 2003
Task 4: Monitoring Program	
Initiate Monitoring	July 2003
Quarterly Reports	September 2003 and Quarterly thereafter
Annual Reports and Adaptive Management Recommendations	December 03, 04, & 05
Final Report	June 2006
Task 5: Algal Growth Constant Measurements	
Quarterly Reports	September 2003 and Quarterly thereafter
Annual Reports and Adaptive Management Recommendations	December 03, 04, & 05
Final Report	June 2006
Task 6: River Modeling	
Quarterly Reports	September 2003 and Quarterly thereafter
Documentation for the extended DSM2-SJR model	December 2003
Calibration Report for the DSM2-SJR model	June 2004
Forecasting Procedures Report	December 2004
Forecasting Results Report	June 2005
Annual Reports	December 03, 04, & 05
Final Modeling Report	June 2006
Task 7: Characterization of BOD Fractions	
Annual Sampling and Analysis Plan	July 03, 04
Quarterly Reports	September 2003 and Quarterly thereafter
Annual Reports and Adaptive Management Recommendations	December 03, 04, & 05
Final Report	June 2006
Task 8: Linking the SJR to the DWSC	
Quarterly Reports	September 2003 and Quarterly thereafter
Annual Reports and Adaptive Management Recommendations	December 03, 04, & 05
Final Report	June 2005
Task 9: Summary Report	
Annual Summary Report	March 04, 05, & 06
Final Summary Report	September 2006

Table B-7: Schedule Flowchart

	2003												2004												2005												2006											
	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
Award Contract						X																																										
Task 1: Project Administration																																																
Contract Summary Form							X																																									
Award Subcontracts							X																																									
Quarterly Progress Reports									X			X			X			X			X			X			X			X			X			X			X			X						
Annual Progress Reports																		X												X												X						
Task 2: CEQA/NEPA Documentation								X																																								
Task 3: QAPP									X																																							
Task 4: Monitoring Program																																																
Initiate Monitoring							X																																									
Quarterly Reports									X			X			X			X			X			X			X			X			X			X			X			X						
Annual Reports and Adaptive Management Recommendations												X												X												X												
Final Report																																										X						
Task 5: Algal Growth Constant Measurements																																																
Quarterly Reports									X			X			X			X			X			X			X			X			X			X			X			X						
Annual Reports and Adaptive Management Recommendations												X												X												X												
Final Report																																										X						
Task 6: River Modeling																																																
Quarterly Reports									X			X			X			X			X			X			X			X			X			X			X			X						
Documentation for the extended DSM2-SJR model												X																																				
Calibration Report for the DSM2-SJR model																		X																														
Forecasting Procedures Report																								X																								
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Task 7: Characterization of BOD Fractions																																																
Quarterly Reports									X			X			X			X			X			X			X			X			X			X			X			X						
Sampling and Analysis Plan							X												X																													
Annual Reports and Adaptive Management Recommendations												X												X												X												
Final Report																																										X						
Task 8: Linking the SJR to the DWSC																																																
Quarterly Reports									X			X			X			X			X			X			X			X			X			X			X			X						
Annual Reports and Adaptive Management Recommendations												X												X												X												
Final Report																																										X						
Task 9: Summary Report																																																
Annual Summary Report															X												X												X									
Final Summary Report																																													X			

PART C: PROJECT BUDGET SUMMARY

Table C-1: Annual and Task Budget Summary

	CALFED Directed Action Funds	Matching Funds	Total	Task 2 - CEQA NEPA	Task 3 - QA/QC	Task 4 - Monitoring Program	Task 5 - Algal Growth	Task 6 - Modeling	Task 7 - BOD Charact.	Task 8 - Linkage	Task 9 - Summary Report
Year 1	$ 2,670,956	$ 394,275	$ 3,065,231	$ 7,383	$ 35,074	$ 1,752,996	$ 424,952	$ 252,764	$ 200,051	$ 332,695	$ 59,317
Year 2	$ 1,993,486	$ 369,492	$ 2,362,978	$ -	$ -	$ 1,297,817	$ 383,689	$ 257,448	$ 204,479	$ 159,025	$ 60,520
Year 3	$ 1,771,969	$ 319,696	$ 2,091,666	$ -	$ -	$ 1,336,043	$ 230,874	$ 261,984	$ -	$ 150,681	$ 112,083
Subtotal	$ 6,436,411	$ 1,083,463	$ 7,519,875	$ 7,383	$ 35,074	$ 4,386,856	$ 1,039,515	$ 772,196	$ 404,530	$ 642,401	$ 231,920
Administrative Charges (7%)	$ 450,549		$ 450,549	$ 517	$ 2,253	$ 263,888	$ 52,513	$ 54,054	$ 19,272	$ 44,968	$ 13,084
Total	$ 6,886,960	$ 1,083,463	$ 7,970,424	$ 7,900	$ 37,327	$ 4,650,744	$ 1,092,028	$ 826,250	$ 423,801	$ 687,369	$ 245,004

Note: Administrative Charges are calculated as 7% of the CALFED Directed Action Funds.

Table C-2: Year 1 Project Budget Summary

Labor Category	Hourly Rate	Benefits Rate	Indirect (Overhead) Rate	Hours Billed to Project	Hours Billed to Matching Funds	Labor Costs Billed to Project	Labor Costs Billed to Matching Funds	Total	Project Cost by Institution
LBNL Principal Investigator	$55.00	1.58	1.45	1476	0	$185,983	$0	$185,983	
LBNL Scientist	$41.00	1.58	1.45	1320	0	$123,989	$0	$123,989	
LBNL Technician/Clerical	$20.00	1.58	1.45	7608	0	$348,599	$0	$348,599	
LBNL/Fresno State Student	$16.00	1.58	1.45	0	5120	$0	$187,679	$187,679	$658,571
UC Davis Principal Investigator	$56.00	1.25	1.47	0	332	$0	$34,163	$34,163	
UC Davis Scientist/Post-Doctoral	$22.00	1.25	1.47	1140	0	$46,085	$0	$46,085	
UC Davis Technician/Clerical	$20.00	1.25	1.47	1200	0	$44,100	$0	$44,100	
UC Davis Student	$16.00	1.25	1.47	480	640	$14,112	$18,816	$32,928	$104,297
SJVDA Principal Investigator	$115.00	1.00	1.25	278	0	$39,963	$0	$39,963	
SJVDA Engineer	$66.00	1.00	1.25	1357	0	$111,953	$0	$111,953	
SJVDA Technician/Clerical	$58.00	1.00	1.25	254	0	$18,415	$0	$18,415	$170,330
UOP Principal Investigator	$60.00	1.22	1.41	704	208	$72,867	$21,529	$94,396	
UOP Scientist	$41.00	1.22	1.50	0	0	$0	$0	$0	
UOP Technician/Student	$20.00	1.00	1.50	1776	0	$53,280	$0	$53,280	$126,147
Jones & Stokes Principal Investigator	$120.00	1.00	1.00	310	0	$37,200	$0	$37,200	
Jones & Stokes Scientist/Engineer	$80.00	1.00	1.00	473	0	$37,840	$0	$37,840	
Jones & Stokes Technician/Clerical	$20.00	1.00	1.00	0	0	$0	$0	$0	$75,040
USGS Principal Investigator	$64.00	1.00	1.62	176	400	$18,248	$41,472	$59,720	
USGS Scientist	$48.00	1.00	1.62	176	352	$13,686	$27,372	$41,057	
USGS Technician II	$28.00	1.00	1.62	352	0	$15,967	$0	$15,967	
USGS Technician I	$17.00	1.00	1.62	2088	0	$57,504	$0	$57,504	$105,404
Systech Principal Investigator	$125.00	1.00	1.00	300	0	$37,500	$0	$37,500	
Systech Scientist/Engineer	$95.00	1.00	1.00	395	0	$37,525	$0	$37,525	
Systech Technician/Clerical	$20.00	1.00	1.00	0	0	$0	$0	$0	$75,025
SJRGA Principal Investigator	$110.00	1.00	1.25	168	0	$23,100	$0	$23,100	
SJRGA Engineer	$80.00	1.00	1.25	50	0	$5,000	$0	$5,000	
SJRGA Technician/Clerical	$40.00	1.00	1.25	0	0	$0	$0	$0	$28,100
UC Berkeley Principal Investigator	$90.00	1.58	1.45	80	80	$16,495	$16,495	$32,990	
UC Berkeley Principal Investigator/Scientist	$55.00	1.58	1.45	1398	0	$176,155	$0	$176,155	
UC Berkeley Technician/Clerical	$20.00	1.58	1.45	2708	0	$124,081	$0	$124,081	
UC Berkeley Student	$16.00	1.58	1.45	0	0	$0	$0	$0	$316,731
Sub Total Labor Costs						**$1,659,644**	**$347,525**	**$2,007,169**	

Other Costs Category	Indirect Procurement Rate	Direct Costs Billed to Project	Direct Costs Billed to Matching Funds	Cost to Project	Cost to Matching Funds	Total
Supplies	1.05	$98,161	$0	$108,769	$0	$108,769
Equipment	1.05	$558,474	$15,000	$586,398	$15,750	$602,148
Subcontract	1.00	$150,000	$15,000	$150,000	$15,000	$165,000
Subcontract	1.00	$20,000	$0	$20,000	$0	$20,000
Subcontract	1.00	$54,000	$16,000	$54,000	$16,000	$70,000
Publication costs	1.05	$20,000	$0	$23,280	$0	$23,280
Travel	1.05	$62,379	$0	$68,865	$0	$68,865
Sub Total Other Costs				**$1,011,312**	**$46,750**	**$1,058,062**

	CalFed Directed Action Funds	Matching Funds	Total Costs
Total Project Cost	**$2,670,956**	**$394,275**	**$3,065,231**

Table C-3: Year 1 Budget Summary, Task 2, CEQA/NEPA Documentation

Labor Category	Hourly Rate	Benefits Rate	Indirect (Overhead) Rate	Hours Billed to Project	Hours Billed to Matching Funds	Labor Costs Billed to Project	Labor Costs Billed to Matching Funds	Total	Project Cost by Institution
LBNL Principal Investigator	$55.00	1.58	1.45	4		$504	$0	$504	
LBNL Scientist	$41.00	1.58	1.45			$0	$0	$0	
LBNL Technician/Clerical	$20.00	1.58	1.45			$0	$0	$0	
LBNL/Fresno State Student	$16.00	1.58	1.45			$0	$0	$0	$504
UC Davis Principal Investigator	$56.00	1.25	1.47			$0	$0	$0	
UC Davis Scientist/Post-Doctoral	$22.00	1.25	1.47			$0	$0	$0	
UC Davis Technician/Clerical	$20.00	1.25	1.47			$0	$0	$0	
UC Davis Student	$16.00	1.25	1.47			$0	$0	$0	$0
SJVDA Principal Investigator	$115.00	1.00	1.25	8		$1,150	$0	$1,150	
SJVDA Engineer	$66.00	1.00	1.25	40		$3,300	$0	$3,300	
SJVDA Technician/Clerical	$58.00	1.00	1.25	8		$580	$0	$580	$5,030
UOP Principal Investigator	$60.00	1.22	1.41			$0	$0	$0	
UOP Scientist	$41.00	1.22	1.50			$0	$0	$0	
UOP Technician/Student	$20.00	1.00	1.50			$0	$0	$0	$0
Jones & Stokes Principal Investigator	$120.00	1.00	1.00			$0	$0	$0	
Jones & Stokes Scientist/Engineer	$80.00	1.00	1.00			$0	$0	$0	
Jones & Stokes Technician/Clerical	$20.00	1.00	1.00			$0	$0	$0	$0
USGS Principal Investigator	$64.00	1.00	1.62			$0	$0	$0	
USGS Scientist	$48.00	1.00	1.62			$0	$0	$0	
USGS Technician II	$28.00	1.00	1.62			$0	$0	$0	
USGS Technician I	$17.00	1.00	1.62			$0	$0	$0	$0
Systech Principal Investigator	$125.00	1.00	1.00			$0	$0	$0	
Systech Scientist/Engineer	$95.00	1.00	1.00			$0	$0	$0	
Systech Technician/Clerical	$20.00	1.00	1.00			$0	$0	$0	$0
SJRGA Principal Investigator	$110.00	1.00	1.25			$0	$0	$0	
SJRGA Engineer	$80.00	1.00	1.25			$0	$0	$0	
SJRGA Technician/Clerical	$40.00	1.00	1.25			$0	$0	$0	$0
UC Berkeley Principal Investigator	$90.00	1.58	1.45			$0	$0	$0	
UC Berkeley Principal Investigator/Scientist	$55.00	1.58	1.45			$0	$0	$0	
UC Berkeley Technician/Clerical	$20.00	1.58	1.45			$0	$0	$0	
UC Berkeley Student	$16.00	1.58	1.45			$0	$0	$0	$0
Sub Total Labor Costs						**$5,534**	**$0**	**$5,534**	

Other Costs Category	Indirect Procurement Rate	Direct Costs Billed to Project	Direct Costs Billed to Matching Funds	Cost to Project	Cost to Matching Funds	Total
Supplies	1.05	$1,761		$1,849	$0	$1,849
Equipment	1.05			$0	$0	$0
Subcontract	1.00			$0	$0	$0
Subcontract	1.00			$0	$0	$0
Subcontract	1.00			$0	$0	$0
Publication costs	1.05			$0	$0	$0
Travel	1.05			$0	$0	$0
Sub Total Other Costs				**$1,849**	**$0**	**$1,849**

	CalFed Directed Action Funds	Matching Funds	Total Costs
Total Task Cost	**$7,383**	**$0**	**$7,383**

Table C-4: Year 1 Budget Summary, Task 3, Quality Assurance Project Plan

Labor Category	Hourly Rate	Benefits Rate	Indirect (Overhead) Rate	Hours Billed to Project	Hours Billed to Matching Funds	Labor Costs Billed to Project	Labor Costs Billed to Matching Funds	Total	Project Cost by Institution
LBNL Principal Investigator	$55.00	1.58	1.45	40		$5,040	$0	$5,040	
LBNL Scientist	$41.00	1.58	1.45			$0	$0	$0	
LBNL Technician/Clerical	$20.00	1.58	1.45	8		$367	$0	$367	
LBNL/Fresno State Student	$16.00	1.58	1.45			$0	$0	$0	$5,407
UC Davis Principal Investigator	$56.00	1.25	1.47		12	$0	$1,235	$1,235	
UC Davis Scientist/Post-Doctoral	$22.00	1.25	1.47			$0	$0	$0	
UC Davis Technician/Clerical	$20.00	1.25	1.47			$0	$0	$0	
UC Davis Student	$16.00	1.25	1.47			$0	$0	$0	$0
SJVDA Principal Investigator	$115.00	1.00	1.25	20		$2,875	$0	$2,875	
SJVDA Engineer	$66.00	1.00	1.25	160		$13,200	$0	$13,200	
SJVDA Technician/Clerical	$58.00	1.00	1.25	40		$2,900	$0	$2,900	$18,975
UOP Principal Investigator	$60.00	1.22	1.41		8	$0	$828	$828	
UOP Scientist	$41.00	1.22	1.50			$0	$0	$0	
UOP Technician/Student	$20.00	1.00	1.50			$0	$0	$0	$0
Jones & Stokes Principal Investigator	$120.00	1.00	1.00			$0	$0	$0	
Jones & Stokes Scientist/Engineer	$80.00	1.00	1.00			$0	$0	$0	
Jones & Stokes Technician/Clerical	$20.00	1.00	1.00			$0	$0	$0	$0
USGS Principal Investigator	$64.00	1.00	1.62		8	$0	$829	$829	
USGS Scientist	$48.00	1.00	1.62			$0	$0	$0	
USGS Technician II	$28.00	1.00	1.62			$0	$0	$0	
USGS Technician I	$17.00	1.00	1.62			$0	$0	$0	$0
Systech Principal Investigator	$125.00	1.00	1.00			$0	$0	$0	
Systech Scientist/Engineer	$95.00	1.00	1.00			$0	$0	$0	
Systech Technician/Clerical	$20.00	1.00	1.00			$0	$0	$0	$0
SJRGA Principal Investigator	$110.00	1.00	1.25	8		$1,100	$0	$1,100	
SJRGA Engineer	$80.00	1.00	1.25	25		$2,500	$0	$2,500	
SJRGA Technician/Clerical	$40.00	1.00	1.25			$0	$0	$0	$3,600
UC Berkeley Principal Investigator	$90.00	1.58	1.45			$0	$0	$0	
UC Berkeley Principal Investigator/Scientist	$55.00	1.58	1.45			$0	$0	$0	
UC Berkeley Technician/Clerical	$20.00	1.58	1.45			$0	$0	$0	
UC Berkeley Student	$16.00	1.58	1.45			$0	$0	$0	$0
Sub Total Labor Costs						**$27,982**	**$2,892**	**$30,874**	

Other Costs Category	Indirect Procurement Rate	Direct Costs Billed to Project	Direct Costs Billed to Matching Funds	Cost to Project	Cost to Matching Funds	Total
Supplies	1.05	$2,000		$2,100	$0	$2,100
Equipment	1.05			$0	$0	$0
Subcontract	1.00			$0	$0	$0
Subcontract	1.00			$0	$0	$0
Subcontract	1.00			$0	$0	$0
Publication costs	1.05	$1,000		$1,050	$0	$1,050
Travel	1.05	$1,000		$1,050	$0	$1,050
Sub Total Other Costs				**$4,200**	**$0**	**$4,200**

	CalFed Directed Action Funds	Matching Funds	Total Costs
Total Task Cost	**$32,182**	**$2,892**	**$35,074**

Table C-5: Year 1 Budget Summary, Task 4, Monitoring Program

Labor Category	Hourly Rate	Benefits Rate	Indirect (Overhead) Rate	Hours Billed to Project	Hours Billed to Matching Funds	Labor Costs Billed to Project	Labor Costs Billed to Matching Funds	Total	Project Cost by Institution
LBNL Principal Investigator	$55.00	1.58	1.45	1056		$133,061	$0	$133,061	
LBNL Scientist	$41.00	1.58	1.45	1320		$123,989	$0	$123,989	
LBNL Technician/Clerical	$20.00	1.58	1.45	7040		$322,573	$0	$322,573	
LBNL/Fresno State Student	$16.00	1.58	1.45		3840	$0	$140,759	$140,759	$579,623
UC Davis Principal Investigator	$56.00	1.25	1.47		160	$0	$16,464	$16,464	
UC Davis Scientist/Post-Doctoral	$22.00	1.25	1.47	500		$20,213	$0	$20,213	
UC Davis Technician/Clerical	$20.00	1.25	1.47	1200		$44,100	$0	$44,100	
UC Davis Student	$16.00	1.25	1.47		640	$0	$18,816	$18,816	$64,313
SJVDA Principal Investigator	$115.00	1.00	1.25	160		$23,000	$0	$23,000	
SJVDA Engineer	$66.00	1.00	1.25	1132		$93,390	$0	$93,390	
SJVDA Technician/Clerical	$58.00	1.00	1.25	206		$14,935	$0	$14,935	$131,325
UOP Principal Investigator	$60.00	1.22	1.41		40	$0	$4,140	$4,140	
UOP Scientist	$41.00	1.22	1.50			$0	$0	$0	
UOP Technician/Student	$20.00	1.00	1.50			$0	$0	$0	$0
Jones & Stokes Principal Investigator	$120.00	1.00	1.00			$0	$0	$0	
Jones & Stokes Scientist/Engineer	$80.00	1.00	1.00			$0	$0	$0	
Jones & Stokes Technician/Clerical	$20.00	1.00	1.00			$0	$0	$0	$0
USGS Principal Investigator	$64.00	1.00	1.62		40	$0	$4,147	$4,147	
USGS Scientist	$48.00	1.00	1.62			$0	$0	$0	
USGS Technician II	$28.00	1.00	1.62			$0	$0	$0	
USGS Technician I	$17.00	1.00	1.62			$0	$0	$0	$0
Systech Principal Investigator	$125.00	1.00	1.00			$0	$0	$0	
Systech Scientist/Engineer	$95.00	1.00	1.00			$0	$0	$0	
Systech Technician/Clerical	$20.00	1.00	1.00			$0	$0	$0	$0
SJRGA Principal Investigator	$110.00	1.00	1.25	100		$13,750	$0	$13,750	
SJRGA Engineer	$80.00	1.00	1.25	25		$2,500	$0	$2,500	
SJRGA Technician/Clerical	$40.00	1.00	1.25			$0	$0	$0	$16,250
UC Berkeley Principal Investigator	$90.00	1.58	1.45			$0	$0	$0	
UC Berkeley Principal Investigator/Scientist	$55.00	1.58	1.45	176		$22,177	$0	$22,177	
UC Berkeley Technician/Clerical	$20.00	1.58	1.45	1280		$58,650	$0	$58,650	
UC Berkeley Student	$16.00	1.58	1.45			$0	$0	$0	$80,826
Sub Total Labor Costs						**$872,337**	**$184,326**	**$1,056,663**	

Other Costs Category	Indirect Procurement Rate	Direct Costs Billed to Project	Direct Costs Billed to Matching Funds	Cost to Project	Cost to Matching Funds	Total
Supplies	1.05	$50,000		$52,500	$0	$52,500
Equipment (SCUFA, Station Upgrade, BOD incubators)	1.05	$402,460	$15,000	$422,583	$15,750	$438,333
Subcontract (DWR Database & DO & pH Monitoring)	1.00	$75,000		$75,000	$0	$75,000
Subcontract (CWI/Fresno State Outreach & Training)	1.00	$20,000		$20,000	$0	$20,000
Subcontract (Local Agency Labor)	1.00	$54,000	$16,000	$54,000	$16,000	$70,000
Publication costs	1.05	$10,000		$10,500	$0	$10,500
Travel	1.05	$28,079		$30,000	$0	$30,000
Sub Total Other Costs				**$664,583**	**$31,750**	**$696,333**

	CalFed Directed Action Funds	Matching Funds	Total Costs
Total Task Cost	**$1,536,920**	**$216,076**	**$1,752,996**

Table C-6: Year 1 Budget Summary, Task 5, Algal Growth Studies

Labor Category	Hourly Rate	Benefits Rate	Indirect (Overhead) Rate	Hours Billed to Project	Hours Billed to Matching Funds	Labor Costs Billed to Project	Labor Costs Billed to Matching Funds	Total	Project Cost by Institution
LBNL Principal Investigator	$55.00	1.58	1.45	176		$22,177	$0	$22,177	
LBNL Scientist	$41.00	1.58	1.45			$0	$0	$0	
LBNL Technician/Clerical	$20.00	1.58	1.45	480		$21,994	$0	$21,994	
LBNL/Fresno State Student	$16.00	1.58	1.45		1280	$0	$46,920	$46,920	$44,170
UC Davis Principal Investigator	$56.00	1.25	1.47		160	$0	$16,464	$16,464	
UC Davis Scientist/Post-Doctoral	$22.00	1.25	1.47	640		$25,872	$0	$25,872	
UC Davis Technician/Clerical	$20.00	1.25	1.47			$0	$0	$0	
UC Davis Student	$16.00	1.25	1.47	480		$14,112	$0	$14,112	$39,984
SJVDA Principal Investigator	$115.00	1.00	1.25	50		$7,188	$0	$7,188	
SJVDA Engineer	$66.00	1.00	1.25	25		$2,063	$0	$2,063	
SJVDA Technician/Clerical	$58.00	1.00	1.25			$0	$0	$0	$9,250
UOP Principal Investigator	$60.00	1.22	1.41		160	$0	$16,561	$16,561	
UOP Scientist	$41.00	1.22	1.50			$0	$0	$0	
UOP Technician/Student	$20.00	1.00	1.50	480		$14,400	$0	$14,400	$14,400
Jones & Stokes Principal Investigator	$120.00	1.00	1.00			$0	$0	$0	
Jones & Stokes Scientist/Engineer	$80.00	1.00	1.00			$0	$0	$0	
Jones & Stokes Technician/Clerical	$20.00	1.00	1.00			$0	$0	$0	$0
USGS Principal Investigator	$64.00	1.00	1.62			$0	$0	$0	
USGS Scientist	$48.00	1.00	1.62			$0	$0	$0	
USGS Technician II	$28.00	1.00	1.62			$0	$0	$0	
USGS Technician I	$17.00	1.00	1.62			$0	$0	$0	$0
Systech Principal Investigator	$125.00	1.00	1.00			$0	$0	$0	
Systech Scientist/Engineer	$95.00	1.00	1.00			$0	$0	$0	
Systech Technician/Clerical	$20.00	1.00	1.00			$0	$0	$0	$0
SJRGA Principal Investigator	$110.00	1.00	1.25			$0	$0	$0	
SJRGA Engineer	$80.00	1.00	1.25			$0	$0	$0	
SJRGA Technician/Clerical	$40.00	1.00	1.25			$0	$0	$0	$0
UC Berkeley Principal Investigator	$90.00	1.58	1.45	80	80	$16,495	$16,495	$32,990	
UC Berkeley Principal Investigator/Scientist	$55.00	1.58	1.45	352		$44,354	$0	$44,354	
UC Berkeley Technician/Clerical	$20.00	1.58	1.45	480		$21,994	$0	$21,994	
UC Berkeley Student	$16.00	1.58	1.45			$0	$0	$0	$82,843
Sub Total Labor Costs						**$190,647**	**$96,440**	**$287,087**	

Other Costs Category	Indirect Procurement Rate	Direct Costs Billed to Project	Direct Costs Billed to Matching Funds	Cost to Project	Cost to Matching Funds	Total
Supplies	1.05	$20,800		$21,840	$0	$21,840
Equipment (dye, fluorometer, monitoring bouy units, and pumps)	1.05	$97,500		$102,375	$0	$102,375
Subcontract	1.00			$0	$0	$0
Subcontract	1.00			$0	$0	$0
Subcontract	1.00			$0	$0	$0
Publication costs	1.05	$3,000		$3,150	$0	$3,150
Travel	1.05	$10,000		$10,500	$0	$10,500
Sub Total Other Costs				**$137,865**	**$0**	**$137,865**

	CalFed Directed Action Funds	Matching Funds	Total Costs
Total Task Cost	**$328,512**	**$96,440**	**$424,952**

Table C-7: Year 1 Budget Summary, Task 6, River Modeling

Labor Category	Hourly Rate	Benefits Rate	Indirect (Overhead) Rate	Hours Billed to Project	Hours Billed to Matching Funds	Labor Costs Billed to Project	Labor Costs Billed to Matching Funds	Total	Project Cost by Institution
LBNL Principal Investigator	$55.00	1.58	1.45			$0	$0	$0	
LBNL Scientist	$41.00	1.58	1.45			$0	$0	$0	
LBNL Technician/Clerical	$20.00	1.58	1.45			$0	$0	$0	
LBNL/Fresno State Student	$16.00	1.58	1.45			$0	$0	$0	$0
UC Davis Principal Investigator	$56.00	1.25	1.47			$0	$0	$0	
UC Davis Scientist/Post-Doctoral	$22.00	1.25	1.47			$0	$0	$0	
UC Davis Technician/Clerical	$20.00	1.25	1.47			$0	$0	$0	
UC Davis Student	$16.00	1.25	1.47			$0	$0	$0	$0
SJVDA Principal Investigator	$115.00	1.00	1.25			$0	$0	$0	
SJVDA Engineer	$66.00	1.00	1.25			$0	$0	$0	
SJVDA Technician/Clerical	$58.00	1.00	1.25			$0	$0	$0	$0
UOP Principal Investigator	$60.00	1.22	1.41			$0	$0	$0	
UOP Scientist	$41.00	1.22	1.50			$0	$0	$0	
UOP Technician/Student	$20.00	1.00	1.50			$0	$0	$0	$0
Jones & Stokes Principal Investigator	$120.00	1.00	1.00	310		$37,200	$0	$37,200	
Jones & Stokes Scientist/Engineer	$80.00	1.00	1.00	473		$37,840	$0	$37,840	
Jones & Stokes Technician/Clerical	$20.00	1.00	1.00			$0	$0	$0	$75,040
USGS Principal Investigator	$64.00	1.00	1.62			$0	$0	$0	
USGS Scientist	$48.00	1.00	1.62			$0	$0	$0	
USGS Technician II	$28.00	1.00	1.62			$0	$0	$0	
USGS Technician I	$17.00	1.00	1.62			$0	$0	$0	$0
Systech Principal Investigator	$125.00	1.00	1.00	300		$37,500	$0	$37,500	
Systech Scientist/Engineer	$95.00	1.00	1.00	395		$37,525	$0	$37,525	
Systech Technician/Clerical	$20.00	1.00	1.00			$0	$0	$0	$75,025
SJRGA Principal Investigator	$110.00	1.00	1.25	20		$2,750	$0	$2,750	
SJRGA Engineer	$80.00	1.00	1.25			$0	$0	$0	
SJRGA Technician/Clerical	$40.00	1.00	1.25			$0	$0	$0	$2,750
UC Berkeley Principal Investigator	$90.00	1.58	1.45			$0	$0	$0	
UC Berkeley Principal Investigator/Scientist	$55.00	1.58	1.45	198		$24,949	$0	$24,949	
UC Berkeley Technician/Clerical	$20.00	1.58	1.45			$0	$0	$0	
UC Berkeley Student	$16.00	1.58	1.45			$0	$0	$0	$24,949
Sub Total Labor Costs						**$177,764**	**$0**	**$177,764**	

Other Costs Category	Indirect Procurement Rate	Direct Costs Billed to Project	Direct Costs Billed to Matching Funds	Cost to Project	Cost to Matching Funds	Total
Supplies	1.05			$0	$0	$0
Equipment	1.05			$0	$0	$0
Subcontract (DWR Modeling)	1.00	$75,000		$75,000	$0	$75,000
Subcontract	1.00			$0	$0	$0
Subcontract	1.00			$0	$0	$0
Publication costs	1.05			$0	$0	$0
Travel	1.05			$0	$0	$0
Sub Total Other Costs				**$75,000**	**$0**	**$75,000**

	CalFed Directed Action Funds	Matching Funds	Total Costs
Total Task Cost	**$252,764**	**$0**	**$252,764**

Table C-8: Year 1 Budget Summary, Task 7, BOD Characterization by Stable Isotropic Methods

Labor Category	Hourly Rate	Benefits Rate	Indirect (Overhead) Rate	Hours Billed to Project	Hours Billed to Matching Funds	Labor Costs Billed to Project	Labor Costs Billed to Matching Funds	Total	Project Cost by Institution
LBNL Principal Investigator	$55.00	1.58	1.45			$0	$0	$0	
LBNL Scientist	$41.00	1.58	1.45			$0	$0	$0	
LBNL Technician/Clerical	$20.00	1.58	1.45			$0	$0	$0	
LBNL/Fresno State Student	$16.00	1.58	1.45			$0	$0	$0	$0
UC Davis Principal Investigator	$56.00	1.25	1.47			$0	$0	$0	
UC Davis Scientist/Post-Doctoral	$22.00	1.25	1.47			$0	$0	$0	
UC Davis Technician/Clerical	$20.00	1.25	1.47			$0	$0	$0	
UC Davis Student	$16.00	1.25	1.47			$0	$0	$0	$0
SJVDA Principal Investigator	$115.00	1.00	1.25			$0	$0	$0	
SJVDA Engineer	$66.00	1.00	1.25			$0	$0	$0	
SJVDA Technician/Clerical	$58.00	1.00	1.25			$0	$0	$0	$0
UOP Principal Investigator	$60.00	1.22	1.41			$0	$0	$0	
UOP Scientist	$41.00	1.22	1.50			$0	$0	$0	
UOP Technician/Student	$20.00	1.00	1.50			$0	$0	$0	$0
Jones & Stokes Principal Investigator	$120.00	1.00	1.00			$0	$0	$0	
Jones & Stokes Scientist/Engineer	$80.00	1.00	1.00			$0	$0	$0	
Jones & Stokes Technician/Clerical	$20.00	1.00	1.00			$0	$0	$0	$0
USGS Principal Investigator	$64.00	1.00	1.62	176	352	$18,248	$36,495	$54,743	
USGS Scientist	$48.00	1.00	1.62	176	352	$13,686	$27,372	$41,057	
USGS Technician II	$28.00	1.00	1.62	352		$15,967	$0	$15,967	
USGS Technician I	$17.00	1.00	1.62	2088		$57,504	$0	$57,504	$105,404
Systech Principal Investigator	$125.00	1.00	1.00			$0	$0	$0	
Systech Scientist/Engineer	$95.00	1.00	1.00			$0	$0	$0	
Systech Technician/Clerical	$20.00	1.00	1.00			$0	$0	$0	$0
SJRGA Principal Investigator	$110.00	1.00	1.25			$0	$0	$0	
SJRGA Engineer	$80.00	1.00	1.25			$0	$0	$0	
SJRGA Technician/Clerical	$40.00	1.00	1.25			$0	$0	$0	$0
UC Berkeley Principal Investigator	$90.00	1.58	1.45			$0	$0	$0	
UC Berkeley Principal Investigator/Scientist	$55.00	1.58	1.45			$0	$0	$0	
UC Berkeley Technician/Clerical	$20.00	1.58	1.45			$0	$0	$0	
UC Berkeley Student	$16.00	1.58	1.45			$0	$0	$0	$0
Sub Total Labor Costs						**$105,404**	**$63,867**	**$169,271**	

Other Costs Category	Indirect Procurement Rate	Direct Costs Billed to Project	Direct Costs Billed to Matching Funds	Cost to Project	Cost to Matching Funds	Total
Supplies	1.62	$10,000		$16,200	$0	$16,200
Equipment	1.05			$0	$0	$0
Subcontract	1.00			$0	$0	$0
Subcontract	1.00			$0	$0	$0
Subcontract	1.00			$0	$0	$0
Publication costs	1.62	$4,000		$6,480	$0	$6,480
Travel	1.62	$5,000		$8,100	$0	$8,100
Sub Total Other Costs				**$30,780**	**$0**	**$30,780**

	CalFed Directed Action Funds	Matching Funds	Total Costs
Total Task Cost	**$136,184**	**$63,867**	**$200,051**

Table C-9: Year 1 Budget Summary, Task 8, Linking the SJR to the DWSC

Labor Category	Hourly Rate	Benefits Rate	Indirect (Overhead) Rate	Hours Billed to Project	Hours Billed to Matching Funds	Labor Costs Billed to Project	Labor Costs Billed to Matching Funds	Total	Project Cost by Institution
LBNL Principal Investigator	$55.00	1.58	1.45			$0	$0	$0	
LBNL Scientist	$41.00	1.58	1.45			$0	$0	$0	
LBNL Technician/Clerical	$20.00	1.58	1.45			$0	$0	$0	
LBNL/Fresno State Student	$16.00	1.58	1.45			$0	$0	$0	$0
UC Davis Principal Investigator	$56.00	1.25	1.47			$0	$0	$0	
UC Davis Scientist/Post-Doctoral	$22.00	1.25	1.47			$0	$0	$0	
UC Davis Technician/Clerical	$20.00	1.25	1.47			$0	$0	$0	
UC Davis Student	$16.00	1.25	1.47			$0	$0	$0	$0
SJVDA Principal Investigator	$115.00	1.00	1.25			$0	$0	$0	
SJVDA Engineer	$66.00	1.00	1.25			$0	$0	$0	
SJVDA Technician/Clerical	$58.00	1.00	1.25			$0	$0	$0	$0
UOP Principal Investigator	$60.00	1.22	1.41	704		$72,867	$0	$72,867	
UOP Scientist	$41.00	1.22	1.50			$0	$0	$0	
UOP Technician/Student	$20.00	1.00	1.50	1296		$38,880	$0	$38,880	$111,747
Jones & Stokes Principal Investigator	$120.00	1.00	1.00			$0	$0	$0	
Jones & Stokes Scientist/Engineer	$80.00	1.00	1.00			$0	$0	$0	
Jones & Stokes Technician/Clerical	$20.00	1.00	1.00			$0	$0	$0	$0
USGS Principal Investigator	$64.00	1.00	1.62			$0	$0	$0	
USGS Scientist	$48.00	1.00	1.62			$0	$0	$0	
USGS Technician II	$28.00	1.00	1.62			$0	$0	$0	
USGS Technician I	$17.00	1.00	1.62			$0	$0	$0	$0
Systech Principal Investigator	$125.00	1.00	1.00			$0	$0	$0	
Systech Scientist/Engineer	$95.00	1.00	1.00			$0	$0	$0	
Systech Technician/Clerical	$20.00	1.00	1.00			$0	$0	$0	$0
SJRGA Principal Investigator	$110.00	1.00	1.25			$0	$0	$0	
SJRGA Engineer	$80.00	1.00	1.25			$0	$0	$0	
SJRGA Technician/Clerical	$40.00	1.00	1.25			$0	$0	$0	$0
UC Berkeley Principal Investigator	$90.00	1.58	1.45			$0	$0	$0	
UC Berkeley Principal Investigator/Scientist	$55.00	1.58	1.45	672		$84,675	$0	$84,675	
UC Berkeley Technician/Clerical	$20.00	1.58	1.45	948		$43,437	$0	$43,437	
UC Berkeley Student	$16.00	1.58	1.45			$0	$0	$0	$128,113
Sub Total Labor Costs						**$239,860**	**$0**	**$239,860**	

Other Costs Category	Indirect Procurement Rate	Direct Costs Billed to Project	Direct Costs Billed to Matching Funds	Cost to Project	Cost to Matching Funds	Total
Supplies	1.05	$12,600		$13,230	$0	$13,230
Equipment	1.05	$58,514		$61,440	$0	$61,440
Subcontract	1.00			$0	$0	$0
Subcontract	1.00			$0	$0	$0
Subcontract	1.00			$0	$0	$0
Publication costs	1.05			$0	$0	$0
Travel	1.05	$17,300		$18,165	$0	$18,165
Sub Total Other Costs				**$92,835**	**$0**	**$92,835**

	CalFed Directed Action Funds	Matching Funds	Total Costs
Total Task Cost	**$332,695**	**$0**	**$332,695**

Table C-10: Year 1 Budget Summary, Task 9, Summary Report

Labor Category	Hourly Rate	Benefits Rate	Indirect (Overhead) Rate	Hours Billed to Project	Hours Billed to Matching Funds	Labor Costs Billed to Project	Labor Costs Billed to Matching Funds	Total	Project Cost by Institution
LBNL Principal Investigator	$55.00	1.58	1.45	200		$25,201	$0	$25,201	
LBNL Scientist	$41.00	1.58	1.45			$0	$0	$0	
LBNL Technician/Clerical	$20.00	1.58	1.45	80		$3,666	$0	$3,666	
LBNL/Fresno State Student	$16.00	1.58	1.45			$0	$0	$0	$28,867
UC Davis Principal Investigator	$56.00	1.25	1.47			$0	$0	$0	
UC Davis Scientist/Post-Doctoral	$22.00	1.25	1.47			$0	$0	$0	
UC Davis Technician/Clerical	$20.00	1.25	1.47			$0	$0	$0	
UC Davis Student	$16.00	1.25	1.47			$0	$0	$0	$0
SJVDA Principal Investigator	$115.00	1.00	1.25	40		$5,750	$0	$5,750	
SJVDA Engineer	$66.00	1.00	1.25			$0	$0	$0	
SJVDA Technician/Clerical	$58.00	1.00	1.25			$0	$0	$0	$5,750
UOP Principal Investigator	$60.00	1.22	1.41			$0	$0	$0	
UOP Scientist	$41.00	1.22	1.50			$0	$0	$0	
UOP Technician/Student	$20.00	1.00	1.50			$0	$0	$0	$0
Jones & Stokes Principal Investigator	$120.00	1.00	1.00			$0	$0	$0	
Jones & Stokes Scientist/Engineer	$80.00	1.00	1.00			$0	$0	$0	
Jones & Stokes Technician/Clerical	$20.00	1.00	1.00			$0	$0	$0	$0
USGS Principal Investigator	$64.00	1.00	1.62			$0	$0	$0	
USGS Scientist	$48.00	1.00	1.62			$0	$0	$0	
USGS Technician II	$28.00	1.00	1.62			$0	$0	$0	
USGS Technician I	$17.00	1.00	1.62			$0	$0	$0	$0
Systech Principal Investigator	$125.00	1.00	1.00			$0	$0	$0	
Systech Scientist/Engineer	$95.00	1.00	1.00			$0	$0	$0	
Systech Technician/Clerical	$20.00	1.00	1.00			$0	$0	$0	$0
SJRGA Principal Investigator	$110.00	1.00	1.25	40		$5,500	$0	$5,500	
SJRGA Engineer	$80.00	1.00	1.25			$0	$0	$0	
SJRGA Technician/Clerical	$40.00	1.00	1.25			$0	$0	$0	$5,500
UC Berkeley Principal Investigator	$90.00	1.58	1.45			$0	$0	$0	
UC Berkeley Principal Investigator/Scientist	$55.00	1.58	1.45			$0	$0	$0	
UC Berkeley Technician/Clerical	$20.00	1.58	1.45			$0	$0	$0	
UC Berkeley Student	$16.00	1.58	1.45			$0	$0	$0	$0
Sub Total Labor Costs						**$40,117**	**$0**	**$40,117**	

Other Costs Category		Indirect Procurement Rate	Direct Costs Billed to Project	Direct Costs Billed to Matching Funds	Cost to Project	Cost to Matching Funds	Total
Supplies		1.05	$1,000		$1,050	$0	$1,050
Equipment		1.05			$0	$0	$0
Subcontract	Coauthor	1.00		$15,000	$0	$15,000	$15,000
Subcontract		1.00			$0	$0	$0
Subcontract		1.00			$0	$0	$0
Publication costs		1.05	$2,000		$2,100	$0	$2,100
Travel		1.05	$1,000		$1,050	$0	$1,050
Sub Total Other Costs					**$4,200**	**$15,000**	**$19,200**

	CalFed Directed Action Funds	Matching Funds	Total Costs
Total Task Cost	**$44,317**	**$15,000**	**$59,317**

Table C-11: Year 2 Project Budget Summary

Labor Category	Hourly Rate	Benefits Rate	Indirect (Overhead) Rate	Hours Billed to Project	Hours Billed to Matching Funds	Labor Costs Billed to Project	Labor Costs Billed to Matching Funds	Total	Project Cost by Total Institution
LBNL Principal Investigator	$56.65	1.58	1.45	1432	0	$185,852	$0	$185,852	
LBNL Scientist	$42.23	1.58	1.45	1320	0	$127,709	$0	$127,709	
LBNL Technician/Clerical	$20.60	1.58	1.45	7600	0	$358,679	$0	$358,679	
LBNL/Fresno State Student	$16.48	1.58	1.45	0	5120	$0	$193,309	$193,309	$672,240
UC Davis Principal Investigator	$57.68	1.25	1.47	0	320	$0	$33,916	$33,916	
UC Davis Scientist/Post-Doctoral	$22.66	1.25	1.47	1140	0	$47,467	$0	$47,467	
UC Davis Technician/Clerical	$20.60	1.25	1.47	1200	0	$45,423	$0	$45,423	
UC Davis Student	$16.48	1.25	1.47	480	640	$14,535	$19,380	$33,916	$107,425
SJVDA Principal Investigator	$118.45	1.00	1.25	250	0	$37,016	$0	$37,016	
SJVDA Engineer	$67.98	1.00	1.25	1157	0	$98,316	$0	$98,316	
SJVDA Technician/Clerical	$59.74	1.00	1.25	206	0	$15,383	$0	$15,383	$150,715
UOP Principal Investigator	$61.80	1.22	1.41	400	200	$42,644	$21,322	$63,966	
UOP Scientist	$42.23	1.22	1.50	0	0	$0	$0	$0	
UOP Technician/Student	$20.60	1.00	1.50	1128	0	$34,855	$0	$34,855	$77,499
Jones & Stokes Principal Investigator	$123.60	1.00	1.00	310	0	$38,316	$0	$38,316	
Jones & Stokes Scientist/Engineer	$82.40	1.00	1.00	473	0	$38,975	$0	$38,975	
Jones & Stokes Technician/Clerical	$20.60	1.00	1.00	0	0	$0	$0	$0	$77,291
USGS Principal Investigator	$65.20	1.00	1.62	176	392	$18,590	$41,405	$59,994	
USGS Scientist	$49.40	1.00	1.62	176	352	$14,085	$28,170	$42,255	
USGS Technician II	$28.90	1.00	1.62	352	0	$16,480	$0	$16,480	
USGS Technician I	$17.50	1.00	1.62	2088	0	$59,195	$0	$59,195	$108,349
Systech Principal Investigator	$128.75	1.00	1.00	300	0	$38,625	$0	$38,625	
Systech Scientist/Engineer	$97.85	1.00	1.00	395	0	$38,651	$0	$38,651	
Systech Technician/Clerical	$20.60	1.00	1.00	0	0	$0	$0	$0	$77,276
SJRGA Principal Investigator	$113.30	1.00	1.25	160	0	$22,660	$0	$22,660	
SJRGA Engineer	$82.40	1.00	1.25	25	0	$2,575	$0	$2,575	
SJRGA Technician/Clerical	$41.20	1.00	1.25	0	0	$0	$0	$0	$25,235
UC Berkeley Principal Investigator	$92.70	1.58	1.45	80	80	$16,990	$16,990	$33,980	
UC Berkeley Principal Investigator/Scientist	$56.65	1.58	1.45	1105	0	$143,413	$0	$143,413	
UC Berkeley Technician/Clerical	$20.60	1.58	1.45	2234	0	$105,433	$0	$105,433	
UC Berkeley Student	$16.48	1.58	1.45	0	0	$0	$0	$0	$265,835
Sub Total Labor Costs						**$1,561,866**	**$354,492**	**$1,916,358**	

Other Costs Category	Indirect Procurement Rate	Direct Costs Billed to Project	Direct Costs Billed to Matching Funds	Cost to Project	Cost to Matching Funds	Total
Supplies	1.05	$93,400	$0	$103,770	$0	$103,770
Equipment	1.05	$80,000	$0	$84,000	$0	$84,000
Subcontract	1.00	$130,000	$15,000	$130,000	$15,000	$145,000
Subcontract	1.00	$30,000	$0	$30,000	$0	$30,000
Subcontract	1.00	$0	$0	$0	$0	$0
Publication costs	1.05	$19,000	$0	$22,230	$0	$22,230
Travel	1.05	$55,479	$0	$61,620	$0	$61,620
Sub Total Other Costs				**$431,620**	**$15,000**	**$446,620**

	CalFed Directed Action Funds	Matching Funds	Total Costs
Total Project Cost	**$1,993,486**	**$369,492**	**$2,362,978**

Table C-12: Year 2 Budget Summary, Task 2, CEQA/NEPA Documentation

Labor Category	Hourly Rate	Benefits Rate	Indirect (Overhead) Rate	Hours Billed to Project	Hours Billed to Matching Funds	Labor Costs Billed to Project	Labor Costs Billed to Matching Funds	Total	Project Cost by Institution
LBNL Principal Investigator	$56.65	1.58	1.45			$0	$0	$0	
LBNL Scientist	$42.23	1.58	1.45			$0	$0	$0	
LBNL Technician/Clerical	$20.60	1.58	1.45			$0	$0	$0	
LBNL/Fresno State Student	$16.48	1.58	1.45			$0	$0	$0	$0
UC Davis Principal Investigator	$57.68	1.25	1.47			$0	$0	$0	
UC Davis Scientist/Post-Doctoral	$22.66	1.25	1.47			$0	$0	$0	
UC Davis Technician/Clerical	$20.60	1.25	1.47			$0	$0	$0	
UC Davis Student	$16.48	1.25	1.47			$0	$0	$0	$0
SJVDA Principal Investigator	$118.45	1.00	1.25			$0	$0	$0	
SJVDA Engineer	$67.98	1.00	1.25			$0	$0	$0	
SJVDA Technician/Clerical	$59.74	1.00	1.25			$0	$0	$0	$0
UOP Principal Investigator	$61.80	1.22	1.41			$0	$0	$0	
UOP Scientist	$42.23	1.22	1.50			$0	$0	$0	
UOP Technician/Student	$20.60	1.00	1.50			$0	$0	$0	$0
Jones & Stokes Principal Investigator	$123.60	1.00	1.00			$0	$0	$0	
Jones & Stokes Scientist/Engineer	$82.40	1.00	1.00			$0	$0	$0	
Jones & Stokes Technician/Clerical	$20.60	1.00	1.00			$0	$0	$0	$0
USGS Principal Investigator	$65.20	1.00	1.62			$0	$0	$0	
USGS Scientist	$49.40	1.00	1.62			$0	$0	$0	
USGS Technician II	$28.90	1.00	1.62			$0	$0	$0	
USGS Technician I	$17.50	1.00	1.62			$0	$0	$0	$0
Systech Principal Investigator	$128.75	1.00	1.00			$0	$0	$0	
Systech Scientist/Engineer	$97.85	1.00	1.00			$0	$0	$0	
Systech Technician/Clerical	$20.60	1.00	1.00			$0	$0	$0	$0
SJRGA Principal Investigator	$113.30	1.00	1.25			$0	$0	$0	
SJRGA Engineer	$82.40	1.00	1.25			$0	$0	$0	
SJRGA Technician/Clerical	$41.20	1.00	1.25			$0	$0	$0	$0
UC Berkeley Principal Investigator	$92.70	1.58	1.45			$0	$0	$0	
UC Berkeley Principal Investigator/Scientist	$56.65	1.58	1.45			$0	$0	$0	
UC Berkeley Technician/Clerical	$20.60	1.58	1.45			$0	$0	$0	
UC Berkeley Student	$16.48	1.58	1.45			$0	$0	$0	$0
Sub Total Labor Costs						**$0**	**$0**	**$0**	

Other Costs Category	Indirect Procurement Rate	Direct Costs Billed to Project	Direct Costs Billed to Matching Funds	Cost to Project	Cost to Matching Funds	Total
Supplies	1.05			$0	$0	$0
Equipment	1.05			$0	$0	$0
Subcontract	1.00			$0	$0	$0
Subcontract	1.00			$0	$0	$0
Subcontract	1.00			$0	$0	$0
Publication costs	1.05			$0	$0	$0
Travel	1.05			$0	$0	$0
Sub Total Other Costs				**$0**	**$0**	**$0**

	CalFed Directed Action Funds	Matching Funds	Total Costs
Total Task Cost	**$0**	**$0**	**$0**

Table C-13: Year 2 Budget Summary, Task 3, Quality Assurance Project Plan

Labor Category	Hourly Rate	Benefits Rate	Indirect (Overhead) Rate	Hours Billed to Project	Hours Billed to Matching Funds	Labor Costs Billed to Project	Labor Costs Billed to Matching Funds	Total	Project Cost by Institution
LBNL Principal Investigator	$56.65	1.58	1.45			$0	$0	$0	
LBNL Scientist	$42.23	1.58	1.45			$0	$0	$0	
LBNL Technician/Clerical	$20.60	1.58	1.45			$0	$0	$0	
LBNL/Fresno State Student	$16.48	1.58	1.45			$0	$0	$0	$0
UC Davis Principal Investigator	$57.68	1.25	1.47			$0	$0	$0	
UC Davis Scientist/Post-Doctoral	$22.66	1.25	1.47			$0	$0	$0	
UC Davis Technician/Clerical	$20.60	1.25	1.47			$0	$0	$0	
UC Davis Student	$16.48	1.25	1.47			$0	$0	$0	$0
SJVDA Principal Investigator	$118.45	1.00	1.25			$0	$0	$0	
SJVDA Engineer	$67.98	1.00	1.25			$0	$0	$0	
SJVDA Technician/Clerical	$59.74	1.00	1.25			$0	$0	$0	$0
UOP Principal Investigator	$61.80	1.22	1.41			$0	$0	$0	
UOP Scientist	$42.23	1.22	1.50			$0	$0	$0	
UOP Technician/Student	$20.60	1.00	1.50			$0	$0	$0	$0
Jones & Stokes Principal Investigator	$123.60	1.00	1.00			$0	$0	$0	
Jones & Stokes Scientist/Engineer	$82.40	1.00	1.00			$0	$0	$0	
Jones & Stokes Technician/Clerical	$20.60	1.00	1.00			$0	$0	$0	$0
USGS Principal Investigator	$65.20	1.00	1.62			$0	$0	$0	
USGS Scientist	$49.40	1.00	1.62			$0	$0	$0	
USGS Technician II	$28.90	1.00	1.62			$0	$0	$0	
USGS Technician I	$17.50	1.00	1.62			$0	$0	$0	$0
Systech Principal Investigator	$128.75	1.00	1.00			$0	$0	$0	
Systech Scientist/Engineer	$97.85	1.00	1.00			$0	$0	$0	
Systech Technician/Clerical	$20.60	1.00	1.00			$0	$0	$0	$0
SJRGA Principal Investigator	$113.30	1.00	1.25			$0	$0	$0	
SJRGA Engineer	$82.40	1.00	1.25			$0	$0	$0	
SJRGA Technician/Clerical	$41.20	1.00	1.25			$0	$0	$0	$0
UC Berkeley Principal Investigator	$92.70	1.58	1.45			$0	$0	$0	
UC Berkeley Principal Investigator/Scientist	$56.65	1.58	1.45			$0	$0	$0	
UC Berkeley Technician/Clerical	$20.60	1.58	1.45			$0	$0	$0	
UC Berkeley Student	$16.48	1.58	1.45			$0	$0	$0	$0
Sub Total Labor Costs						**$0**	**$0**	**$0**	

Other Costs Category	Indirect Procurement Rate	Direct Costs Billed to Project	Direct Costs Billed to Matching Funds	Cost to Project	Cost to Matching Funds	Total
Supplies	1.05			$0	$0	$0
Equipment	1.05			$0	$0	$0
Subcontract	1.00			$0	$0	$0
Subcontract	1.00			$0	$0	$0
Subcontract	1.00			$0	$0	$0
Publication costs	1.05			$0	$0	$0
Travel	1.05			$0	$0	$0
Sub Total Other Costs				**$0**	**$0**	**$0**

	CalFed Directed Action Funds	Matching Funds	Total Costs
Total Task Cost	**$0**	**$0**	**$0**

Table C-14: Year 2 Budget Summary, Task 4, Monitoring Program

Labor Category	Hourly Rate	Benefits Rate	Indirect (Overhead) Rate	Hours Billed to Project	Hours Billed to Matching Funds	Labor Costs Billed to Project	Labor Costs Billed to Matching Funds	Total	Project Cost by Institution
LBNL Principal Investigator	$56.65	1.58	1.45	1056		$137,053	$0	$137,053	
LBNL Scientist	$42.23	1.58	1.45	1320		$127,709	$0	$127,709	
LBNL Technician/Clerical	$20.60	1.58	1.45	7040		$332,250	$0	$332,250	
LBNL/Fresno State Student	$16.48	1.58	1.45		3840	$0	$144,982	$144,982	$597,012
UC Davis Principal Investigator	$57.68	1.25	1.47		160	$0	$16,958	$16,958	
UC Davis Scientist/Post-Doctoral	$22.66	1.25	1.47	500		$20,819	$0	$20,819	
UC Davis Technician/Clerical	$20.60	1.25	1.47	1200		$45,423	$0	$45,423	
UC Davis Student	$16.48	1.25	1.47		640	$0	$19,380	$19,380	$66,242
SJVDA Principal Investigator	$118.45	1.00	1.25	160		$23,690	$0	$23,690	
SJVDA Engineer	$67.98	1.00	1.25	1132		$96,192	$0	$96,192	
SJVDA Technician/Clerical	$59.74	1.00	1.25	206		$15,383	$0	$15,383	$135,265
UOP Principal Investigator	$61.80	1.22	1.41		40	$0	$4,264	$4,264	
UOP Scientist	$42.23	1.22	1.50			$0	$0	$0	
UOP Technician/Student	$20.60	1.00	1.50			$0	$0	$0	$0
Jones & Stokes Principal Investigator	$123.60	1.00	1.00			$0	$0	$0	
Jones & Stokes Scientist/Engineer	$82.40	1.00	1.00			$0	$0	$0	
Jones & Stokes Technician/Clerical	$20.60	1.00	1.00			$0	$0	$0	$0
USGS Principal Investigator	$65.20	1.00	1.62		40	$0	$4,225	$4,225	
USGS Scientist	$49.40	1.00	1.62			$0	$0	$0	
USGS Technician II	$28.90	1.00	1.62			$0	$0	$0	
USGS Technician I	$17.50	1.00	1.62			$0	$0	$0	$0
Systech Principal Investigator	$128.75	1.00	1.00			$0	$0	$0	
Systech Scientist/Engineer	$97.85	1.00	1.00			$0	$0	$0	
Systech Technician/Clerical	$20.60	1.00	1.00			$0	$0	$0	$0
SJRGA Principal Investigator	$113.30	1.00	1.25	100		$14,163	$0	$14,163	
SJRGA Engineer	$82.40	1.00	1.25	25		$2,575	$0	$2,575	
SJRGA Technician/Clerical	$41.20	1.00	1.25			$0	$0	$0	$16,738
UC Berkeley Principal Investigator	$92.70	1.58	1.45			$0	$0	$0	
UC Berkeley Principal Investigator/Scientist	$56.65	1.58	1.45	176		$22,842	$0	$22,842	
UC Berkeley Technician/Clerical	$20.60	1.58	1.45	1280		$60,409	$0	$60,409	
UC Berkeley Student	$16.48	1.58	1.45			$0	$0	$0	$83,251
Sub Total Labor Costs						**$898,507**	**$189,810**	**$1,088,317**	

Other Costs Category	Indirect Procurement Rate	Direct Costs Billed to Project	Direct Costs Billed to Matching Funds	Cost to Project	Cost to Matching Funds	Total
Supplies	1.05	$50,000		$52,500	$0	$52,500
Equipment (SCUFA replacements)	1.05	$30,000		$31,500	$0	$31,500
Subcontract (DWR database & DO/pH Monitoring)	1.00	$55,000		$55,000	$0	$55,000
Subcontract (CWI/Fresno State Outreach & Training)	1.00	$30,000		$30,000	$0	$30,000
Subcontract	1.00			$0	$0	$0
Publication costs	1.05	$10,000		$10,500	$0	$10,500
Travel	1.05	$28,079		$30,000	$0	$30,000
Sub Total Other Costs				**$209,500**	**$0**	**$209,500**

	CalFed Directed Action Funds	Matching Funds	Total Costs
Total Task Cost	**$1,108,007**	**$189,810**	**$1,297,817**

Table C-15: Year 2 Budget Summary, Task 5, Algal Growth Studies

Labor Category	Hourly Rate	Benefits Rate	Indirect (Overhead) Rate	Hours Billed to Project	Hours Billed to Matching Funds	Labor Costs Billed to Project	Labor Costs Billed to Matching Funds	Total	Project Cost by Institution
LBNL Principal Investigator	$56.65	1.58	1.45	176		$22,842	$0	$22,842	
LBNL Scientist	$42.23	1.58	1.45			$0	$0	$0	
LBNL Technician/Clerical	$20.60	1.58	1.45	480		$22,653	$0	$22,653	
LBNL/Fresno State Student	$16.48	1.58	1.45		1280	$0	$48,327	$48,327	$45,496
UC Davis Principal Investigator	$57.68	1.25	1.47		160	$0	$16,958	$16,958	
UC Davis Scientist/Post-Doctoral	$22.66	1.25	1.47	640		$26,648	$0	$26,648	
UC Davis Technician/Clerical	$20.60	1.25	1.47			$0	$0	$0	
UC Davis Student	$16.48	1.25	1.47	480		$14,535	$0	$14,535	$41,184
SJVDA Principal Investigator	$118.45	1.00	1.25	50		$7,403	$0	$7,403	
SJVDA Engineer	$67.98	1.00	1.25	25		$2,124	$0	$2,124	
SJVDA Technician/Clerical	$59.74	1.00	1.25			$0	$0	$0	$9,528
UOP Principal Investigator	$61.80	1.22	1.41		160	$0	$17,058	$17,058	
UOP Scientist	$42.23	1.22	1.50			$0	$0	$0	
UOP Technician/Student	$20.60	1.00	1.50	480		$14,832	$0	$14,832	$14,832
Jones & Stokes Principal Investigator	$123.60	1.00	1.00			$0	$0	$0	
Jones & Stokes Scientist/Engineer	$82.40	1.00	1.00			$0	$0	$0	
Jones & Stokes Technician/Clerical	$20.60	1.00	1.00			$0	$0	$0	$0
USGS Principal Investigator	$65.20	1.00	1.62			$0	$0	$0	
USGS Scientist	$49.40	1.00	1.62			$0	$0	$0	
USGS Technician II	$28.90	1.00	1.62			$0	$0	$0	
USGS Technician I	$17.50	1.00	1.62			$0	$0	$0	$0
Systech Principal Investigator	$128.75	1.00	1.00			$0	$0	$0	
Systech Scientist/Engineer	$97.85	1.00	1.00			$0	$0	$0	
Systech Technician/Clerical	$20.60	1.00	1.00			$0	$0	$0	$0
SJRGA Principal Investigator	$113.30	1.00	1.25			$0	$0	$0	
SJRGA Engineer	$82.40	1.00	1.25			$0	$0	$0	
SJRGA Technician/Clerical	$41.20	1.00	1.25			$0	$0	$0	$0
UC Berkeley Principal Investigator	$92.70	1.58	1.45	80	80	$16,990	$16,990	$33,980	
UC Berkeley Principal Investigator/Scientist	$56.65	1.58	1.45	352		$45,684	$0	$45,684	
UC Berkeley Technician/Clerical	$20.60	1.58	1.45	480		$22,653	$0	$22,653	
UC Berkeley Student	$16.48	1.58	1.45			$0	$0	$0	$85,328
Sub Total Labor Costs						**$196,366**	**$99,333**	**$295,699**	

Other Costs Category	Indirect Procurement Rate	Direct Costs Billed to Project	Direct Costs Billed to Matching Funds	Cost to Project	Cost to Matching Funds	Total
Supplies	1.05	$20,800		$21,840	$0	$21,840
Equipment (dye, fluorometer, monitoring bouy units, and pumps)	1.05	$50,000		$52,500	$0	$52,500
Subcontract	1.00			$0	$0	$0
Subcontract	1.00			$0	$0	$0
Subcontract	1.00			$0	$0	$0
Publication costs	1.05	$3,000		$3,150	$0	$3,150
Travel	1.05	$10,000		$10,500	$0	$10,500
Sub Total Other Costs				**$87,990**	**$0**	**$87,990**

	CalFed Directed Action Funds	Matching Funds	Total Costs
Total Task Cost	**$284,356**	**$99,333**	**$383,689**

Table C-16: Year 2 Budget Summary, Task 6, River Modeling

Labor Category	Hourly Rate	Benefits Rate	Indirect (Overhead) Rate	Hours Billed to Project	Hours Billed to Matching Funds	Labor Costs Billed to Project	Labor Costs Billed to Matching Funds	Total	Project Cost by Institution
LBNL Principal Investigator	$56.65	1.58	1.45			$0	$0	$0	
LBNL Scientist	$42.23	1.58	1.45			$0	$0	$0	
LBNL Technician/Clerical	$20.60	1.58	1.45			$0	$0	$0	
LBNL/Fresno State Student	$16.48	1.58	1.45			$0	$0	$0	$0
UC Davis Principal Investigator	$57.68	1.25	1.47			$0	$0	$0	
UC Davis Scientist/Post-Doctoral	$22.66	1.25	1.47			$0	$0	$0	
UC Davis Technician/Clerical	$20.60	1.25	1.47			$0	$0	$0	
UC Davis Student	$16.48	1.25	1.47			$0	$0	$0	$0
SJVDA Principal Investigator	$118.45	1.00	1.25			$0	$0	$0	
SJVDA Engineer	$67.98	1.00	1.25			$0	$0	$0	
SJVDA Technician/Clerical	$59.74	1.00	1.25			$0	$0	$0	$0
UOP Principal Investigator	$61.80	1.22	1.41			$0	$0	$0	
UOP Scientist	$42.23	1.22	1.50			$0	$0	$0	
UOP Technician/Student	$20.60	1.00	1.50			$0	$0	$0	$0
Jones & Stokes Principal Investigator	$123.60	1.00	1.00	310		$38,316	$0	$38,316	
Jones & Stokes Scientist/Engineer	$82.40	1.00	1.00	473		$38,975	$0	$38,975	
Jones & Stokes Technician/Clerical	$20.60	1.00	1.00			$0	$0	$0	$77,291
USGS Principal Investigator	$65.20	1.00	1.62			$0	$0	$0	
USGS Scientist	$49.40	1.00	1.62			$0	$0	$0	
USGS Technician II	$28.90	1.00	1.62			$0	$0	$0	
USGS Technician I	$17.50	1.00	1.62			$0	$0	$0	$0
Systech Principal Investigator	$128.75	1.00	1.00	300		$38,625	$0	$38,625	
Systech Scientist/Engineer	$97.85	1.00	1.00	395		$38,651	$0	$38,651	
Systech Technician/Clerical	$20.60	1.00	1.00			$0	$0	$0	$77,276
SJRGA Principal Investigator	$113.30	1.00	1.25	20		$2,833	$0	$2,833	
SJRGA Engineer	$82.40	1.00	1.25			$0	$0	$0	
SJRGA Technician/Clerical	$41.20	1.00	1.25			$0	$0	$0	$2,833
UC Berkeley Principal Investigator	$92.70	1.58	1.45			$0	$0	$0	
UC Berkeley Principal Investigator/Scientist	$56.65	1.58	1.45	193		$25,049	$0	$25,049	
UC Berkeley Technician/Clerical	$20.60	1.58	1.45			$0	$0	$0	
UC Berkeley Student	$16.48	1.58	1.45			$0	$0	$0	$25,049
Sub Total Labor Costs						**$182,448**	**$0**	**$182,448**	

Other Costs Category	Indirect Procurement Rate	Direct Costs Billed to Project	Direct Costs Billed to Matching Funds	Cost to Project	Cost to Matching Funds	Total
Supplies	1.05			$0	$0	$0
Equipment	1.05			$0	$0	$0
Subcontract (DWR Modeling)	1.00	$75,000		$75,000	$0	$75,000
Subcontract	1.00			$0	$0	$0
Subcontract	1.00			$0	$0	$0
Publication costs	1.05			$0	$0	$0
Travel	1.05			$0	$0	$0
Sub Total Other Costs				**$75,000**	**$0**	**$75,000**

	CalFed Directed Action Funds	Matching Funds	Total Costs
Total Task Cost	**$257,448**	**$0**	**$257,448**

Table C-17: Year 2 Budget Summary, Task 7, BOD Characterization by Stable Isotropic Methods

Labor Category	Hourly Rate	Benefits Rate	Indirect (Overhead) Rate	Hours Billed to Project	Hours Billed to Matching Funds	Labor Costs Billed to Project	Labor Costs Billed to Matching Funds	Total	Project Cost by Institution
LBNL Principal Investigator	$56.65	1.58	1.45			$0	$0	$0	
LBNL Scientist	$42.23	1.58	1.45			$0	$0	$0	
LBNL Technician/Clerical	$20.60	1.58	1.45			$0	$0	$0	
LBNL/Fresno State Student	$16.48	1.58	1.45			$0	$0	$0	$0
UC Davis Principal Investigator	$57.68	1.25	1.47			$0	$0	$0	
UC Davis Scientist/Post-Doctoral	$22.66	1.25	1.47			$0	$0	$0	
UC Davis Technician/Clerical	$20.60	1.25	1.47			$0	$0	$0	
UC Davis Student	$16.48	1.25	1.47			$0	$0	$0	$0
SJVDA Principal Investigator	$118.45	1.00	1.25			$0	$0	$0	
SJVDA Engineer	$67.98	1.00	1.25			$0	$0	$0	
SJVDA Technician/Clerical	$59.74	1.00	1.25			$0	$0	$0	$0
UOP Principal Investigator	$61.80	1.22	1.41			$0	$0	$0	
UOP Scientist	$42.23	1.22	1.50			$0	$0	$0	
UOP Technician/Student	$20.60	1.00	1.50			$0	$0	$0	$0
Jones & Stokes Principal Investigator	$123.60	1.00	1.00			$0	$0	$0	
Jones & Stokes Scientist/Engineer	$82.40	1.00	1.00			$0	$0	$0	
Jones & Stokes Technician/Clerical	$20.60	1.00	1.00			$0	$0	$0	$0
USGS Principal Investigator	$65.20	1.00	1.62	176	352	$18,590	$37,180	$55,769	
USGS Scientist	$49.40	1.00	1.62	176	352	$14,085	$28,170	$42,255	
USGS Technician II	$28.90	1.00	1.62	352		$16,480	$0	$16,480	
USGS Technician I	$17.50	1.00	1.62	2088		$59,195	$0	$59,195	$108,349
Systech Principal Investigator	$128.75	1.00	1.00			$0	$0	$0	
Systech Scientist/Engineer	$97.85	1.00	1.00			$0	$0	$0	
Systech Technician/Clerical	$20.60	1.00	1.00			$0	$0	$0	$0
SJRGA Principal Investigator	$113.30	1.00	1.25			$0	$0	$0	
SJRGA Engineer	$82.40	1.00	1.25			$0	$0	$0	
SJRGA Technician/Clerical	$41.20	1.00	1.25			$0	$0	$0	$0
UC Berkeley Principal Investigator	$92.70	1.58	1.45			$0	$0	$0	
UC Berkeley Principal Investigator/Scientist	$56.65	1.58	1.45			$0	$0	$0	
UC Berkeley Technician/Clerical	$20.60	1.58	1.45			$0	$0	$0	
UC Berkeley Student	$16.48	1.58	1.45			$0	$0	$0	$0
Sub Total Labor Costs						**$108,349**	**$65,350**	**$173,699**	

Other Costs Category	Indirect Procurement Rate	Direct Costs Billed to Project	Direct Costs Billed to Matching Funds	Cost to Project	Cost to Matching Funds	Total
Supplies	1.62	$10,000		$16,200	$0	$16,200
Equipment	1.05			$0	$0	$0
Subcontract	1.00			$0	$0	$0
Subcontract	1.00			$0	$0	$0
Subcontract	1.00			$0	$0	$0
Publication costs	1.62	$4,000		$6,480	$0	$6,480
Travel	1.62	$5,000		$8,100	$0	$8,100
Sub Total Other Costs				**$30,780**	**$0**	**$30,780**

	CalFed Directed Action Funds	Matching Funds	Total Costs
Total Task Cost	**$139,129**	**$65,350**	**$204,479**

Table C-18: Year 2 Budget Summary, Task 8, Linking the SJR to the DWSC

Labor Category	Hourly Rate	Benefits Rate	Indirect (Overhead) Rate	Hours Billed to Project	Hours Billed to Matching Funds	Labor Costs Billed to Project	Labor Costs Billed to Matching Funds	Total	Project Cost by Institution
LBNL Principal Investigator	$56.65	1.58	1.45			$0	$0	$0	
LBNL Scientist	$42.23	1.58	1.45			$0	$0	$0	
LBNL Technician/Clerical	$20.60	1.58	1.45			$0	$0	$0	
LBNL/Fresno State Student	$16.48	1.58	1.45			$0	$0	$0	$0
UC Davis Principal Investigator	$57.68	1.25	1.47			$0	$0	$0	
UC Davis Scientist/Post-Doctoral	$22.66	1.25	1.47			$0	$0	$0	
UC Davis Technician/Clerical	$20.60	1.25	1.47			$0	$0	$0	
UC Davis Student	$16.48	1.25	1.47			$0	$0	$0	$0
SJVDA Principal Investigator	$118.45	1.00	1.25			$0	$0	$0	
SJVDA Engineer	$67.98	1.00	1.25			$0	$0	$0	
SJVDA Technician/Clerical	$59.74	1.00	1.25			$0	$0	$0	$0
UOP Principal Investigator	$61.80	1.22	1.41	400		$42,644	$0	$42,644	
UOP Scientist	$42.23	1.22	1.50			$0	$0	$0	
UOP Technician/Student	$20.60	1.00	1.50	648		$20,023	$0	$20,023	$62,667
Jones & Stokes Principal Investigator	$123.60	1.00	1.00			$0	$0	$0	
Jones & Stokes Scientist/Engineer	$82.40	1.00	1.00			$0	$0	$0	
Jones & Stokes Technician/Clerical	$20.60	1.00	1.00			$0	$0	$0	$0
USGS Principal Investigator	$65.20	1.00	1.62			$0	$0	$0	
USGS Scientist	$49.40	1.00	1.62			$0	$0	$0	
USGS Technician II	$28.90	1.00	1.62			$0	$0	$0	
USGS Technician I	$17.50	1.00	1.62			$0	$0	$0	$0
Systech Principal Investigator	$128.75	1.00	1.00			$0	$0	$0	
Systech Scientist/Engineer	$97.85	1.00	1.00			$0	$0	$0	
Systech Technician/Clerical	$20.60	1.00	1.00			$0	$0	$0	$0
SJRGA Principal Investigator	$113.30	1.00	1.25			$0	$0	$0	
SJRGA Engineer	$82.40	1.00	1.25			$0	$0	$0	
SJRGA Technician/Clerical	$41.20	1.00	1.25			$0	$0	$0	$0
UC Berkeley Principal Investigator	$92.70	1.58	1.45			$0	$0	$0	
UC Berkeley Principal Investigator/Scientist	$56.65	1.58	1.45	384		$49,837	$0	$49,837	
UC Berkeley Technician/Clerical	$20.60	1.58	1.45	474		$22,370	$0	$22,370	
UC Berkeley Student	$16.48	1.58	1.45			$0	$0	$0	$72,208
Sub Total Labor Costs						**$134,875**	**$0**	**$134,875**	

Other Costs Category	Indirect Procurement Rate	Direct Costs Billed to Project	Direct Costs Billed to Matching Funds	Cost to Project	Cost to Matching Funds	Total
Supplies	1.05	$11,600		$12,180	$0	$12,180
Equipment	1.05	$0		$0	$0	$0
Subcontract	1.00			$0	$0	$0
Subcontract	1.00			$0	$0	$0
Subcontract	1.00			$0	$0	$0
Publication costs	1.05			$0	$0	$0
Travel	1.05	$11,400		$11,970	$0	$11,970
Sub Total Other Costs				**$24,150**	**$0**	**$24,150**

	CalFed Directed Action Funds	Matching Funds	Total Costs
Total Task Cost	**$159,025**	**$0**	**$159,025**

Table C-19: Year 2 Budget Summary, Task 9, Summary Report

Labor Category	Hourly Rate	Benefits Rate	Indirect (Overhead) Rate	Hours Billed to Project	Hours Billed to Matching Funds	Labor Costs Billed to Project	Labor Costs Billed to Matching Funds	Total	Project Cost by Institution
LBNL Principal Investigator	$56.65	1.58	1.45	200		$25,957	$0	$25,957	
LBNL Scientist	$42.23	1.58	1.45			$0	$0	$0	
LBNL Technician/Clerical	$20.60	1.58	1.45	80		$3,776	$0	$3,776	
LBNL/Fresno State Student	$16.48	1.58	1.45			$0	$0	$0	$29,733
UC Davis Principal Investigator	$57.68	1.25	1.47			$0	$0	$0	
UC Davis Scientist/Post-Doctoral	$22.66	1.25	1.47			$0	$0	$0	
UC Davis Technician/Clerical	$20.60	1.25	1.47			$0	$0	$0	
UC Davis Student	$16.48	1.25	1.47			$0	$0	$0	$0
SJVDA Principal Investigator	$118.45	1.00	1.25	40		$5,923	$0	$5,923	
SJVDA Engineer	$67.98	1.00	1.25			$0	$0	$0	
SJVDA Technician/Clerical	$59.74	1.00	1.25			$0	$0	$0	$5,923
UOP Principal Investigator	$61.80	1.22	1.41			$0	$0	$0	
UOP Scientist	$42.23	1.22	1.50			$0	$0	$0	
UOP Technician/Student	$20.60	1.00	1.50			$0	$0	$0	$0
Jones & Stokes Principal Investigator	$123.60	1.00	1.00			$0	$0	$0	
Jones & Stokes Scientist/Engineer	$82.40	1.00	1.00			$0	$0	$0	
Jones & Stokes Technician/Clerical	$20.60	1.00	1.00			$0	$0	$0	$0
USGS Principal Investigator	$65.20	1.00	1.62			$0	$0	$0	
USGS Scientist	$49.40	1.00	1.62			$0	$0	$0	
USGS Technician II	$28.90	1.00	1.62			$0	$0	$0	
USGS Technician I	$17.50	1.00	1.62			$0	$0	$0	$0
Systech Principal Investigator	$128.75	1.00	1.00			$0	$0	$0	
Systech Scientist/Engineer	$97.85	1.00	1.00			$0	$0	$0	
Systech Technician/Clerical	$20.60	1.00	1.00			$0	$0	$0	$0
SJRGA Principal Investigator	$113.30	1.00	1.25	40		$5,665	$0	$5,665	
SJRGA Engineer	$82.40	1.00	1.25			$0	$0	$0	
SJRGA Technician/Clerical	$41.20	1.00	1.25			$0	$0	$0	$5,665
UC Berkeley Principal Investigator	$92.70	1.58	1.45			$0	$0	$0	
UC Berkeley Principal Investigator/Scientist	$56.65	1.58	1.45			$0	$0	$0	
UC Berkeley Technician/Clerical	$20.60	1.58	1.45			$0	$0	$0	
UC Berkeley Student	$16.48	1.58	1.45			$0	$0	$0	$0
Sub Total Labor Costs						**$41,320**	**$0**	**$41,320**	

Other Costs Category	Indirect Procurement Rate	Direct Costs Billed to Project	Direct Costs Billed to Matching Funds	Cost to Project	Cost to Matching Funds	Total
Supplies	1.05	$1,000		$1,050	$0	$1,050
Equipment	1.05			$0	$0	$0
Subcontract (Coauthor)	1.00		$15,000	$0	$15,000	$15,000
Subcontract	1.00			$0	$0	$0
Subcontract	1.00			$0	$0	$0
Publication costs	1.05	$2,000		$2,100	$0	$2,100
Travel	1.05	$1,000		$1,050	$0	$1,050
Sub Total Other Costs				**$4,200**	**$15,000**	**$19,200**

	CalFed Directed Action Funds	Matching Funds	Total Costs
Total Task Cost	**$45,520**	**$15,000**	**$60,520**

Table C-20: Year 3 Project Budget Summary

Labor Category	Hourly Rate	Benefits Rate	Indirect (Overhead) Rate	Hours Billed to Project	Hours Billed to Matching Funds	Labor Costs Billed to Project	Labor Cost to Matching Funds	Total	Project Cost by Institution
LBNL Principal Investigator	$58.36	1.58	1.45	1624	0	$217,115	$0	$217,115	
LBNL Scientist	$43.50	1.58	1.45	1320	0	$131,552	$0	$131,552	
LBNL Technician/Clerical	$21.22	1.58	1.45	7380	0	$358,779	$0	$358,779	
LBNL/Fresno State Student	$16.98	1.58	1.45	0	5120	$0	$199,127	$199,127	$707,446
UC Davis Principal Investigator	$59.42	1.25	1.47	0	320	$0	$34,937	$34,937	
UC Davis Scientist/Post-Doctoral	$23.34	1.25	1.47	820	0	$35,171	$0	$35,171	
UC Davis Technician/Clerical	$21.22	1.25	1.47	1200	0	$46,790	$0	$46,790	
UC Davis Student	$16.98	1.25	1.47	240	640	$7,486	$19,964	$27,450	$89,447
SJVDA Principal Investigator	$121.90	1.00	1.25	290	0	$44,189	$0	$44,189	
SJVDA Engineer	$69.96	1.00	1.25	1157	0	$101,180	$0	$101,180	
SJVDA Technician/Clerical	$61.48	1.00	1.25	206	0	$15,831	$0	$15,831	$161,200
UOP Principal Investigator	$63.60	1.22	1.41	368	200	$40,375	$21,943	$62,318	
UOP Scientist	$43.46	1.22	1.50	0	0	$0	$0	$0	
UOP Technician/Student	$21.20	1.00	1.50	804	0	$25,567	$0	$25,567	$65,942
Jones & Stokes Principal Investigator	$127.20	1.00	1.00	310	0	$39,432	$0	$39,432	
Jones & Stokes Scientist/Engineer	$84.80	1.00	1.00	473	0	$40,110	$0	$40,110	
Jones & Stokes Technician/Clerical	$21.20	1.00	1.00	0	0	$0	$0	$0	$79,542
USGS Principal Investigator	$65.20	1.00	1.62	0	40	$0	$4,225	$4,225	
USGS Scientist	$49.40	1.00	1.62	0	0	$0	$0	$0	
USGS Technician II	$28.90	1.00	1.62	0	0	$0	$0	$0	
USGS Technician I	$17.50	1.00	1.62	0	0	$0	$0	$0	$0
Systech Principal Investigator	$132.50	1.00	1.00	300	0	$39,750	$0	$39,750	
Systech Scientist/Engineer	$100.70	1.00	1.00	395	0	$39,777	$0	$39,777	
Systech Technician/Clerical	$21.20	1.00	1.00	0	0	$0	$0	$0	$79,527
SJRGA Principal Investigator	$116.60	1.00	1.25	200	0	$29,150	$0	$29,150	
SJRGA Engineer	$84.80	1.00	1.25	25	0	$2,650	$0	$2,650	
SJRGA Technician/Clerical	$42.40	1.00	1.25	0	0	$0	$0	$0	$31,800
UC Berkeley Principal Investigator	$95.49	1.58	1.45	40	40	$8,751	$8,751	$17,501	
UC Berkeley Principal Investigator/Scientist	$58.36	1.58	1.45	899	0	$120,188	$0	$120,188	
UC Berkeley Technician/Clerical	$21.22	1.58	1.45	1997	0	$97,084	$0	$97,084	
UC Berkeley Student	$16.98	1.58	1.45	0	0	$0	$0	$0	$226,023
Sub Total Labor Costs						**$1,440,927**	**$288,946**	**$1,729,873**	

Other Costs Category	Indirect Procurement Rate	Direct Costs Billed to Project	Direct Costs Billed to Matching Funds	Cost to Project	Cost to Matching Funds	Total
Supplies	1.05	$83,400	$0	$87,570	$0	$87,570
Equipment	1.05	$30,000	$15,000	$31,500	$15,750	$47,250
Subcontract	1.00	$120,000	$15,000	$120,000	$15,000	$135,000
Subcontract	1.00	$30,000	$0	$30,000	$0	$30,000
Subcontract	1.00	$0	$0	$0	$0	$0
Publication costs	1.05	$15,000	$0	$15,750	$0	$15,750
Travel	1.05	$43,529	$0	$46,223	$0	$46,223
Sub Total Other Costs				**$331,043**	**$30,750**	**$361,793**

	CalFed Directed Action Funds	Matching Funds	Total Costs
Total Project Cost	**$1,771,969**	**$319,696**	**$2,091,666**

Table C-21: Year 3 Budget Summary, Task 2, CEQA/NEPA Documentation

Labor Category	Hourly Rate	Benefits Rate	Indirect (Overhead) Rate	Hours Billed to Project	Hours Billed to Matching Funds	Labor Costs Billed to Project	Labor Costs Billed to Matching Funds	Project Cost by Total Institution	
LBNL Principal Investigator	$58.36	1.58	1.45			$0	$0	$0	
LBNL Scientist	$43.50	1.58	1.45			$0	$0	$0	
LBNL Technician/Clerical	$21.22	1.58	1.45			$0	$0	$0	
LBNL/Fresno State Student	$16.98	1.58	1.45			$0	$0	$0	$0
UC Davis Principal Investigator	$59.42	1.25	1.47			$0	$0	$0	
UC Davis Scientist/Post-Doctoral	$23.34	1.25	1.47			$0	$0	$0	
UC Davis Technician/Clerical	$21.22	1.25	1.47			$0	$0	$0	
UC Davis Student	$16.98	1.25	1.47			$0	$0	$0	$0
SJVDA Principal Investigator	$121.90	1.00	1.25			$0	$0	$0	
SJVDA Engineer	$69.96	1.00	1.25			$0	$0	$0	
SJVDA Technician/Clerical	$61.48	1.00	1.25			$0	$0	$0	$0
UOP Principal Investigator	$63.60	1.22	1.41			$0	$0	$0	
UOP Scientist	$43.46	1.22	1.50			$0	$0	$0	
UOP Technician/Student	$21.20	1.00	1.50			$0	$0	$0	$0
Jones & Stokes Principal Investigator	$127.20	1.00	1.00			$0	$0	$0	
Jones & Stokes Scientist/Engineer	$84.80	1.00	1.00			$0	$0	$0	
Jones & Stokes Technician/Clerical	$21.20	1.00	1.00			$0	$0	$0	$0
USGS Principal Investigator	$65.20	1.00	1.62			$0	$0	$0	
USGS Scientist	$49.40	1.00	1.62			$0	$0	$0	
USGS Technician II	$28.90	1.00	1.62			$0	$0	$0	
USGS Technician I	$17.50	1.00	1.62			$0	$0	$0	$0
Systech Principal Investigator	$132.50	1.00	1.00			$0	$0	$0	
Systech Scientist/Engineer	$100.70	1.00	1.00			$0	$0	$0	
Systech Technician/Clerical	$21.20	1.00	1.00			$0	$0	$0	$0
SJRGA Principal Investigator	$116.60	1.00	1.25			$0	$0	$0	
SJRGA Engineer	$84.80	1.00	1.25			$0	$0	$0	
SJRGA Technician/Clerical	$42.40	1.00	1.25			$0	$0	$0	$0
UC Berkeley Principal Investigator	$95.49	1.58	1.45			$0	$0	$0	
UC Berkeley Principal Investigator/Scientist	$58.36	1.58	1.45			$0	$0	$0	
UC Berkeley Technician/Clerical	$21.22	1.58	1.45			$0	$0	$0	
UC Berkeley Student	$16.98	1.58	1.45			$0	$0	$0	$0
Sub Total Labor Costs						**$0**	**$0**	**$0**	

Other Costs Category	Indirect Procurement Rate	Direct Costs Billed to Project	Direct Costs Billed to Matching Funds	Cost to Project	Cost to Matching Funds	Total
Supplies	1.05			$0	$0	$0
Equipment	1.05			$0	$0	$0
Subcontract	1.00			$0	$0	$0
Subcontract	1.00			$0	$0	$0
Subcontract	1.00			$0	$0	$0
Publication costs	1.05			$0	$0	$0
Travel	1.05			$0	$0	$0
Sub Total Other Costs				**$0**	**$0**	**$0**

	CalFed Directed Action Funds	Matching Funds	Total Costs
Total Task Cost	**$0**	**$0**	**$0**

Table C-22: Year 3 Budget Summary, Task 3, Quality Assurance Project Plan

Labor Category	Hourly Rate	Benefits Rate	Indirect (Overhead) Rate	Hours Billed to Project	Hours Billed to Matching Funds	Labor Costs Billed to Project	Labor Costs Billed to Matching Funds		Project Cost by Total Institution
LBNL Principal Investigator	$58.36	1.58	1.45			$0	$0	$0	
LBNL Scientist	$43.50	1.58	1.45			$0	$0	$0	
LBNL Technician/Clerical	$21.22	1.58	1.45			$0	$0	$0	
LBNL/Fresno State Student	$16.98	1.58	1.45			$0	$0	$0	$0
UC Davis Principal Investigator	$59.42	1.25	1.47			$0	$0	$0	
UC Davis Scientist/Post-Doctoral	$23.34	1.25	1.47			$0	$0	$0	
UC Davis Technician/Clerical	$21.22	1.25	1.47			$0	$0	$0	
UC Davis Student	$16.98	1.25	1.47			$0	$0	$0	$0
SJVDA Principal Investigator	$121.90	1.00	1.25			$0	$0	$0	
SJVDA Engineer	$69.96	1.00	1.25			$0	$0	$0	
SJVDA Technician/Clerical	$61.48	1.00	1.25			$0	$0	$0	$0
UOP Principal Investigator	$63.60	1.22	1.41			$0	$0	$0	
UOP Scientist	$43.46	1.22	1.50			$0	$0	$0	
UOP Technician/Student	$21.20	1.00	1.50			$0	$0	$0	$0
Jones & Stokes Principal Investigator	$127.20	1.00	1.00			$0	$0	$0	
Jones & Stokes Scientist/Engineer	$84.80	1.00	1.00			$0	$0	$0	
Jones & Stokes Technician/Clerical	$21.20	1.00	1.00			$0	$0	$0	$0
USGS Principal Investigator	$65.20	1.00	1.62			$0	$0	$0	
USGS Scientist	$49.40	1.00	1.62			$0	$0	$0	
USGS Technician II	$28.90	1.00	1.62			$0	$0	$0	
USGS Technician I	$17.50	1.00	1.62			$0	$0	$0	$0
Systech Principal Investigator	$132.50	1.00	1.00			$0	$0	$0	
Systech Scientist/Engineer	$100.70	1.00	1.00			$0	$0	$0	
Systech Technician/Clerical	$21.20	1.00	1.00			$0	$0	$0	$0
SJRGA Principal Investigator	$116.60	1.00	1.25			$0	$0	$0	
SJRGA Engineer	$84.80	1.00	1.25			$0	$0	$0	
SJRGA Technician/Clerical	$42.40	1.00	1.25			$0	$0	$0	$0
UC Berkeley Principal Investigator	$95.49	1.58	1.45			$0	$0	$0	
UC Berkeley Principal Investigator/Scientist	$58.36	1.58	1.45			$0	$0	$0	
UC Berkeley Technician/Clerical	$21.22	1.58	1.45			$0	$0	$0	
UC Berkeley Student	$16.98	1.58	1.45			$0	$0	$0	$0
Sub Total Labor Costs						**$0**	**$0**	**$0**	

Other Costs Category	Indirect Procurement Rate	Direct Costs Billed to Project	Direct Costs Billed to Matching Funds	Cost to Project	Cost to Matching Funds	Total
Supplies	1.05			$0	$0	$0
Equipment	1.05			$0	$0	$0
Subcontract	1.00			$0	$0	$0
Subcontract	1.00			$0	$0	$0
Subcontract	1.00			$0	$0	$0
Publication costs	1.05			$0	$0	$0
Travel	1.05			$0	$0	$0
Sub Total Other Costs				**$0**	**$0**	**$0**

	CalFed Directed Action Funds	Matching Funds	Total Costs
Total Task Cost	**$0**	**$0**	**$0**

Table C-23: Year 3 Budget Summary, Task 4, Monitoring Program

Labor Category	Hourly Rate	Benefits Rate	Indirect (Overhead) Rate	Hours Billed to Project	Hours Billed to Matching Funds	Labor Costs Billed to Project	Labor Costs Billed to Matching Funds	Project Cost by Total Institution	
LBNL Principal Investigator	$58.36	1.58	1.45	1056		$141,178	$0	$141,178	
LBNL Scientist	$43.50	1.58	1.45	1320		$131,552	$0	$131,552	
LBNL Technician/Clerical	$21.22	1.58	1.45	7040		$342,250	$0	$342,250	
LBNL/Fresno State Student	$16.98	1.58	1.45		3840	$0	$149,345	$149,345	$614,980
UC Davis Principal Investigator	$59.42	1.25	1.47		160	$0	$17,468	$17,468	
UC Davis Scientist/Post-Doctoral	$23.34	1.25	1.47	500		$21,445	$0	$21,445	
UC Davis Technician/Clerical	$21.22	1.25	1.47	1200		$46,790	$0	$46,790	
UC Davis Student	$16.98	1.25	1.47		640	$0	$19,964	$19,964	$68,236
SJVDA Principal Investigator	$121.90	1.00	1.25	160		$24,380	$0	$24,380	
SJVDA Engineer	$69.96	1.00	1.25	1132		$98,993	$0	$98,993	
SJVDA Technician/Clerical	$61.48	1.00	1.25	206		$15,831	$0	$15,831	$139,205
UOP Principal Investigator	$63.60	1.22	1.41		40	$0	$4,389	$4,389	
UOP Scientist	$43.46	1.22	1.50			$0	$0	$0	
UOP Technician/Student	$21.20	1.00	1.50			$0	$0	$0	$0
Jones & Stokes Principal Investigator	$127.20	1.00	1.00			$0	$0	$0	
Jones & Stokes Scientist/Engineer	$84.80	1.00	1.00			$0	$0	$0	
Jones & Stokes Technician/Clerical	$21.20	1.00	1.00			$0	$0	$0	$0
USGS Principal Investigator	$65.20	1.00	1.62		40	$0	$4,225	$4,225	
USGS Scientist	$49.40	1.00	1.62			$0	$0	$0	
USGS Technician II	$28.90	1.00	1.62			$0	$0	$0	
USGS Technician I	$17.50	1.00	1.62			$0	$0	$0	$0
Systech Principal Investigator	$132.50	1.00	1.00			$0	$0	$0	
Systech Scientist/Engineer	$100.70	1.00	1.00			$0	$0	$0	
Systech Technician/Clerical	$21.20	1.00	1.00			$0	$0	$0	$0
SJRGA Principal Investigator	$116.60	1.00	1.25	100		$14,575	$0	$14,575	
SJRGA Engineer	$84.80	1.00	1.25	25		$2,650	$0	$2,650	
SJRGA Technician/Clerical	$42.40	1.00	1.25			$0	$0	$0	$17,225
UC Berkeley Principal Investigator	$95.49	1.58	1.45			$0	$0	$0	
UC Berkeley Principal Investigator/Scientist	$58.36	1.58	1.45	176		$23,530	$0	$23,530	
UC Berkeley Technician/Clerical	$21.22	1.58	1.45	1280		$62,227	$0	$62,227	
UC Berkeley Student	$16.98	1.58	1.45			$0	$0	$0	$85,757
Sub Total Labor Costs						**$925,402**	**$195,391**	**$1,120,793**	

Other Costs Category	Indirect Procurement Rate	Direct Costs Billed to Project	Direct Costs Billed to Matching Funds	Cost to Project	Cost to Matching Funds	Total
Supplies	1.05	$50,000		$52,500	$0	$52,500
Equipment (SCUFA replacements)	1.05	$30,000	$15,000	$31,500	$15,750	$47,250
Subcontract (DWR database & DO/pH Monitoring)	1.00	$45,000		$45,000	$0	$45,000
Subcontract (CWI/Fresno State Outreach & Training)	1.00	$30,000		$30,000	$0	$30,000
Subcontract	1.00			$0	$0	$0
Publication costs	1.05	$10,000		$10,500	$0	$10,500
Travel	1.05	$28,079		$30,000	$0	$30,000
Sub Total Other Costs				**$199,500**	**$15,750**	**$215,250**

	CalFed Directed Action Funds	Matching Funds	Total Costs
Total Task Cost	**$1,124,902**	**$211,141**	**$1,336,043**

Table C-24: Year 3 Budget Summary, Task 5, Algal Growth Studies

Labor Category	Hourly Rate	Benefits Rate	Indirect (Overhead) Rate	Hours Billed to Project	Hours Billed to Matching Funds	Labor Costs Billed to Project	Labor Costs Billed to Matching Funds	Total	Project Cost by Institution
LBNL Principal Investigator	$58.36	1.58	1.45	88		$11,765	$0	$11,765	
LBNL Scientist	$43.50	1.58	1.45			$0	$0	$0	
LBNL Technician/Clerical	$21.22	1.58	1.45	240		$11,668	$0	$11,668	
LBNL/Fresno State Student	$16.98	1.58	1.45		1280	$0	$49,782	$49,782	$23,432
UC Davis Principal Investigator	$59.42	1.25	1.47		160	$0	$17,468	$17,468	
UC Davis Scientist/Post-Doctoral	$23.34	1.25	1.47	320		$13,725	$0	$13,725	
UC Davis Technician/Clerical	$21.22	1.25	1.47			$0	$0	$0	
UC Davis Student	$16.98	1.25	1.47	240		$7,486	$0	$7,486	$21,212
SJVDA Principal Investigator	$121.90	1.00	1.25	50		$7,619	$0	$7,619	
SJVDA Engineer	$69.96	1.00	1.25	25		$2,186	$0	$2,186	
SJVDA Technician/Clerical	$61.48	1.00	1.25			$0	$0	$0	$9,805
UOP Principal Investigator	$63.60	1.22	1.41		160	$0	$17,554	$17,554	
UOP Scientist	$43.46	1.22	1.50			$0	$0	$0	
UOP Technician/Student	$21.20	1.00	1.50	240		$7,632	$0	$7,632	$7,632
Jones & Stokes Principal Investigator	$127.20	1.00	1.00			$0	$0	$0	
Jones & Stokes Scientist/Engineer	$84.80	1.00	1.00			$0	$0	$0	
Jones & Stokes Technician/Clerical	$21.20	1.00	1.00			$0	$0	$0	$0
USGS Principal Investigator	$65.20	1.00	1.62			$0	$0	$0	
USGS Scientist	$49.40	1.00	1.62			$0	$0	$0	
USGS Technician II	$28.90	1.00	1.62			$0	$0	$0	
USGS Technician I	$17.50	1.00	1.62			$0	$0	$0	$0
Systech Principal Investigator	$132.50	1.00	1.00			$0	$0	$0	
Systech Scientist/Engineer	$100.70	1.00	1.00			$0	$0	$0	
Systech Technician/Clerical	$21.20	1.00	1.00			$0	$0	$0	$0
SJRGA Principal Investigator	$116.60	1.00	1.25			$0	$0	$0	
SJRGA Engineer	$84.80	1.00	1.25			$0	$0	$0	
SJRGA Technician/Clerical	$42.40	1.00	1.25			$0	$0	$0	$0
UC Berkeley Principal Investigator	$95.49	1.58	1.45	40	40	$8,751	$8,751	$17,501	
UC Berkeley Principal Investigator/Scientist	$58.36	1.58	1.45	176		$23,530	$0	$23,530	
UC Berkeley Technician/Clerical	$21.22	1.58	1.45	240		$11,668	$0	$11,668	
UC Berkeley Student	$16.98	1.58	1.45			$0	$0	$0	$43,948
Sub Total Labor Costs						**$106,029**	**$93,555**	**$199,584**	

Other Costs Category	Indirect Procurement Rate	Direct Costs Billed to Project	Direct Costs Billed to Matching Funds	Cost to Project	Cost to Matching Funds	Total
Supplies	1.05	$20,800		$21,840	$0	$21,840
Equipment (dye, fluorometer, monitoring bouy units, and pumps)	1.05			$0	$0	$0
Subcontract	1.00			$0	$0	$0
Subcontract	1.00			$0	$0	$0
Subcontract	1.00			$0	$0	$0
Publication costs	1.05	$3,000		$3,150	$0	$3,150
Travel	1.05	$6,000		$6,300	$0	$6,300
Sub Total Other Costs				**$31,290**	**$0**	**$31,290**

	CalFed Directed Action Funds	Matching Funds	Total Costs
Total Task Cost	**$137,319**	**$93,555**	**$230,874**

Table C-25: Year 3 Budget Summary, Task 6, River Modeling

Labor Category	Hourly Rate	Benefits Rate	Indirect (Overhead) Rate	Hours Billed to Project	Hours Billed to Matching Funds	Labor Costs Billed to Project	Labor Costs Billed to Matching Funds	Total	Project Cost by Institution
LBNL Principal Investigator	$58.36	1.58	1.45			$0	$0	$0	
LBNL Scientist	$43.50	1.58	1.45			$0	$0	$0	
LBNL Technician/Clerical	$21.22	1.58	1.45			$0	$0	$0	
LBNL/Fresno State Student	$16.98	1.58	1.45			$0	$0	$0	$0
UC Davis Principal Investigator	$59.42	1.25	1.47			$0	$0	$0	
UC Davis Scientist/Post-Doctoral	$23.34	1.25	1.47			$0	$0	$0	
UC Davis Technician/Clerical	$21.22	1.25	1.47			$0	$0	$0	
UC Davis Student	$16.98	1.25	1.47			$0	$0	$0	$0
SJVDA Principal Investigator	$121.90	1.00	1.25			$0	$0	$0	
SJVDA Engineer	$69.96	1.00	1.25			$0	$0	$0	
SJVDA Technician/Clerical	$61.48	1.00	1.25			$0	$0	$0	$0
UOP Principal Investigator	$63.60	1.22	1.41			$0	$0	$0	
UOP Scientist	$43.46	1.22	1.50			$0	$0	$0	
UOP Technician/Student	$21.20	1.00	1.50			$0	$0	$0	$0
Jones & Stokes Principal Investigator	$127.20	1.00	1.00	310		$39,432	$0	$39,432	
Jones & Stokes Scientist/Engineer	$84.80	1.00	1.00	473		$40,110	$0	$40,110	
Jones & Stokes Technician/Clerical	$21.20	1.00	1.00			$0	$0	$0	$79,542
USGS Principal Investigator	$65.20	1.00	1.62			$0	$0	$0	
USGS Scientist	$49.40	1.00	1.62			$0	$0	$0	
USGS Technician II	$28.90	1.00	1.62			$0	$0	$0	
USGS Technician I	$17.50	1.00	1.62			$0	$0	$0	$0
Systech Principal Investigator	$132.50	1.00	1.00	300		$39,750	$0	$39,750	
Systech Scientist/Engineer	$100.70	1.00	1.00	395		$39,777	$0	$39,777	
Systech Technician/Clerical	$21.20	1.00	1.00			$0	$0	$0	$79,527
SJRGA Principal Investigator	$116.60	1.00	1.25	20		$2,915	$0	$2,915	
SJRGA Engineer	$84.80	1.00	1.25			$0	$0	$0	
SJRGA Technician/Clerical	$42.40	1.00	1.25			$0	$0	$0	$2,915
UC Berkeley Principal Investigator	$95.49	1.58	1.45			$0	$0	$0	
UC Berkeley Principal Investigator/Scientist	$58.36	1.58	1.45	187		$25,000	$0	$25,000	
UC Berkeley Technician/Clerical	$21.22	1.58	1.45			$0	$0	$0	
UC Berkeley Student	$16.98	1.58	1.45			$0	$0	$0	$25,000
Sub Total Labor Costs						**$186,984**	**$0**	**$186,984**	

Other Costs Category	Indirect Procurement Rate	Direct Costs Billed to Project	Direct Costs Billed to Matching Funds	Cost to Project	Cost to Matching Funds	Total
Supplies	1.05			$0	$0	$0
Equipment	1.05			$0	$0	$0
Subcontract (DWR Modeling)	1.00	$75,000		$75,000	$0	$75,000
Subcontract	1.00			$0	$0	$0
Subcontract	1.00			$0	$0	$0
Publication costs	1.05			$0	$0	$0
Travel	1.05			$0	$0	$0
Sub Total Other Costs				**$75,000**	**$0**	**$75,000**

	CalFed Directed Action Funds	Matching Funds	Total Costs
Total Task Cost	**$261,984**	**$0**	**$261,984**

Table C-26: Year 3 Budget Summary, Task 7, BOD Characterization by Stable Isotropic Methods

Labor Category	Hourly Rate	Benefits Rate	Indirect (Overhead) Rate	Hours Billed to Project	Hours Billed to Matching Funds	Labor Costs Billed to Project	Labor Costs Billed to Matching Funds	Project Cost by Total	Institution
LBNL Principal Investigator	$58.36	1.58	1.45			$0	$0	$0	
LBNL Scientist	$43.50	1.58	1.45			$0	$0	$0	
LBNL Technician/Clerical	$21.22	1.58	1.45			$0	$0	$0	
LBNL/Fresno State Student	$16.98	1.58	1.45			$0	$0	$0	$0
UC Davis Principal Investigator	$59.42	1.25	1.47			$0	$0	$0	
UC Davis Scientist/Post-Doctoral	$23.34	1.25	1.47			$0	$0	$0	
UC Davis Technician/Clerical	$21.22	1.25	1.47			$0	$0	$0	
UC Davis Student	$16.98	1.25	1.47			$0	$0	$0	$0
SJVDA Principal Investigator	$121.90	1.00	1.25			$0	$0	$0	
SJVDA Engineer	$69.96	1.00	1.25			$0	$0	$0	
SJVDA Technician/Clerical	$61.48	1.00	1.25			$0	$0	$0	$0
UOP Principal Investigator	$63.60	1.22	1.41			$0	$0	$0	
UOP Scientist	$43.46	1.22	1.50			$0	$0	$0	
UOP Technician/Student	$21.20	1.00	1.50			$0	$0	$0	$0
Jones & Stokes Principal Investigator	$127.20	1.00	1.00			$0	$0	$0	
Jones & Stokes Scientist/Engineer	$84.80	1.00	1.00			$0	$0	$0	
Jones & Stokes Technician/Clerical	$21.20	1.00	1.00			$0	$0	$0	$0
USGS Principal Investigator	$65.20	1.00	1.62			$0	$0	$0	
USGS Scientist	$49.40	1.00	1.62			$0	$0	$0	
USGS Technician II	$28.90	1.00	1.62			$0	$0	$0	
USGS Technician I	$17.50	1.00	1.62			$0	$0	$0	$0
Systech Principal Investigator	$132.50	1.00	1.00			$0	$0	$0	
Systech Scientist/Engineer	$100.70	1.00	1.00			$0	$0	$0	
Systech Technician/Clerical	$21.20	1.00	1.00			$0	$0	$0	$0
SJRGA Principal Investigator	$116.60	1.00	1.25			$0	$0	$0	
SJRGA Engineer	$84.80	1.00	1.25			$0	$0	$0	
SJRGA Technician/Clerical	$42.40	1.00	1.25			$0	$0	$0	$0
UC Berkeley Principal Investigator	$95.49	1.58	1.45			$0	$0	$0	
UC Berkeley Principal Investigator/Scientist	$58.36	1.58	1.45			$0	$0	$0	
UC Berkeley Technician/Clerical	$21.22	1.58	1.45			$0	$0	$0	
UC Berkeley Student	$16.98	1.58	1.45			$0	$0	$0	$0
Sub Total Labor Costs						**$0**	**$0**	**$0**	

Other Costs Category	Indirect Procurement Rate	Direct Costs Billed to Project	Direct Costs Billed to Matching Funds	Cost to Project	Cost to Matching Funds	Total
Supplies	1.05			$0	$0	$0
Equipment	1.05			$0	$0	$0
Subcontract	1.00			$0	$0	$0
Subcontract	1.00			$0	$0	$0
Subcontract	1.00			$0	$0	$0
Publication costs	1.05			$0	$0	$0
Travel	1.05			$0	$0	$0
Sub Total Other Costs				**$0**	**$0**	**$0**

	CalFed Directed Action Funds	Matching Funds	Total Costs
Total Task Cost	**$0**	**$0**	**$0**

Table C-27: Year 3 Budget Summary, Task 8, Linking the SJR to the DWSC

Labor Category	Hourly Rate	Benefits Rate	Indirect (Overhead) Rate	Hours Billed to Project	Hours Billed to Matching Funds	Labor Costs Billed to Project	Labor Costs Billed to Matching Funds		Project Cost by Total Institution
LBNL Principal Investigator	$58.36	1.58	1.45			$0	$0	$0	
LBNL Scientist	$43.50	1.58	1.45			$0	$0	$0	
LBNL Technician/Clerical	$21.22	1.58	1.45			$0	$0	$0	
LBNL/Fresno State Student	$16.98	1.58	1.45			$0	$0	$0	$0
UC Davis Principal Investigator	$59.42	1.25	1.47			$0	$0	$0	
UC Davis Scientist/Post-Doctoral	$23.34	1.25	1.47			$0	$0	$0	
UC Davis Technician/Clerical	$21.22	1.25	1.47			$0	$0	$0	
UC Davis Student	$16.98	1.25	1.47			$0	$0	$0	$0
SJVDA Principal Investigator	$121.90	1.00	1.25			$0	$0	$0	
SJVDA Engineer	$69.96	1.00	1.25			$0	$0	$0	
SJVDA Technician/Clerical	$61.48	1.00	1.25			$0	$0	$0	$0
UOP Principal Investigator	$63.60	1.22	1.41	368		$40,375	$0	$40,375	
UOP Scientist	$43.46	1.22	1.50			$0	$0	$0	
UOP Technician/Student	$21.20	1.00	1.50	564		$17,935	$0	$17,935	$58,310
Jones & Stokes Principal Investigator	$127.20	1.00	1.00			$0	$0	$0	
Jones & Stokes Scientist/Engineer	$84.80	1.00	1.00			$0	$0	$0	
Jones & Stokes Technician/Clerical	$21.20	1.00	1.00			$0	$0	$0	$0
USGS Principal Investigator	$65.20	1.00	1.62			$0	$0	$0	
USGS Scientist	$49.40	1.00	1.62			$0	$0	$0	
USGS Technician II	$28.90	1.00	1.62			$0	$0	$0	
USGS Technician I	$17.50	1.00	1.62			$0	$0	$0	$0
Systech Principal Investigator	$132.50	1.00	1.00			$0	$0	$0	
Systech Scientist/Engineer	$100.70	1.00	1.00			$0	$0	$0	
Systech Technician/Clerical	$21.20	1.00	1.00			$0	$0	$0	$0
SJRGA Principal Investigator	$116.60	1.00	1.25			$0	$0	$0	
SJRGA Engineer	$84.80	1.00	1.25			$0	$0	$0	
SJRGA Technician/Clerical	$42.40	1.00	1.25			$0	$0	$0	$0
UC Berkeley Principal Investigator	$95.49	1.58	1.45			$0	$0	$0	
UC Berkeley Principal Investigator/Scientist	$58.36	1.58	1.45	360		$48,129	$0	$48,129	
UC Berkeley Technician/Clerical	$21.22	1.58	1.45	477		$23,189	$0	$23,189	
UC Berkeley Student	$16.98	1.58	1.45			$0	$0	$0	$71,318
Sub Total Labor Costs						**$129,629**	**$0**	**$129,629**	

Other Costs Category	Indirect Procurement Rate	Direct Costs Billed to Project	Direct Costs Billed to Matching Funds	Cost to Project	Cost to Matching Funds	Total
Supplies	1.05	$11,600		$12,180	$0	$12,180
Equipment	1.05	$0		$0	$0	$0
Subcontract	1.00			$0	$0	$0
Subcontract	1.00			$0	$0	$0
Subcontract	1.00			$0	$0	$0
Publication costs	1.05			$0	$0	$0
Travel	1.05	$8,450		$8,873	$0	$8,873
Sub Total Other Costs				**$21,053**	**$0**	**$21,053**

	CalFed Directed Action Funds	Matching Funds	Total Costs
Total Task Cost	**$150,681**	**$0**	**$150,681**

Table C-28: Year 3 Budget Summary, Task 9, Summary Report

Labor Category	Hourly Rate	Benefits Rate	Indirect (Overhead) Rate	Hours Billed to Project	Hours Billed to Matching Funds	Labor Costs Billed to Project	Labor Costs Billed to Matching Funds	Project Cost by Total	Institution
LBNL Principal Investigator	$58.36	1.58	1.45	480		$64,172	$0	$64,172	
LBNL Scientist	$43.50	1.58	1.45			$0	$0	$0	
LBNL Technician/Clerical	$21.22	1.58	1.45	100		$4,862	$0	$4,862	
LBNL/Fresno State Student	$16.98	1.58	1.45			$0	$0	$0	$69,033
UC Davis Principal Investigator	$59.42	1.25	1.47			$0	$0	$0	
UC Davis Scientist/Post-Doctoral	$23.34	1.25	1.47			$0	$0	$0	
UC Davis Technician/Clerical	$21.22	1.25	1.47			$0	$0	$0	
UC Davis Student	$16.98	1.25	1.47			$0	$0	$0	$0
SJVDA Principal Investigator	$121.90	1.00	1.25	80		$12,190	$0	$12,190	
SJVDA Engineer	$69.96	1.00	1.25			$0	$0	$0	
SJVDA Technician/Clerical	$61.48	1.00	1.25			$0	$0	$0	$12,190
UOP Principal Investigator	$63.60	1.22	1.41			$0	$0	$0	
UOP Scientist	$43.46	1.22	1.50			$0	$0	$0	
UOP Technician/Student	$21.20	1.00	1.50			$0	$0	$0	$0
Jones & Stokes Principal Investigator	$127.20	1.00	1.00			$0	$0	$0	
Jones & Stokes Scientist/Engineer	$84.80	1.00	1.00			$0	$0	$0	
Jones & Stokes Technician/Clerical	$21.20	1.00	1.00			$0	$0	$0	$0
USGS Principal Investigator	$65.20	1.00	1.62			$0	$0	$0	
USGS Scientist	$49.40	1.00	1.62			$0	$0	$0	
USGS Technician II	$28.90	1.00	1.62			$0	$0	$0	
USGS Technician I	$17.50	1.00	1.62			$0	$0	$0	$0
Systech Principal Investigator	$132.50	1.00	1.00			$0	$0	$0	
Systech Scientist/Engineer	$100.70	1.00	1.00			$0	$0	$0	
Systech Technician/Clerical	$21.20	1.00	1.00			$0	$0	$0	$0
SJRGA Principal Investigator	$116.60	1.00	1.25	80		$11,660	$0	$11,660	
SJRGA Engineer	$84.80	1.00	1.25			$0	$0	$0	
SJRGA Technician/Clerical	$42.40	1.00	1.25			$0	$0	$0	$11,660
UC Berkeley Principal Investigator	$95.49	1.58	1.45			$0	$0	$0	
UC Berkeley Principal Investigator/Scientist	$58.36	1.58	1.45			$0	$0	$0	
UC Berkeley Technician/Clerical	$21.22	1.58	1.45			$0	$0	$0	
UC Berkeley Student	$16.98	1.58	1.45			$0	$0	$0	$0
Sub Total Labor Costs						**$92,883**	**$0**	**$92,883**	

Other Costs Category	Indirect Procurement Rate	Direct Costs Billed to Project	Direct Costs Billed to Matching Funds	Cost to Project	Cost to Matching Funds	Total
Supplies	1.05	$1,000		$1,050	$0	$1,050
Equipment	1.05			$0	$0	$0
Subcontract (Coauthor)	1.00		$15,000	$0	$15,000	$15,000
Subcontract	1.00			$0	$0	$0
Subcontract	1.00			$0	$0	$0
Publication costs	1.05	$2,000		$2,100	$0	$2,100
Travel	1.05	$1,000		$1,050	$0	$1,050
Sub Total Other Costs				**$4,200**	**$15,000**	**$19,200**

	CalFed Directed Action Funds	Matching Funds	Total Costs
Total Task Cost	**$97,083**	**$15,000**	**$112,083**

PART D: QUESTIONNAIRE

1. DESCRIBE THE FOLLOWING ELEMENTS OF YOUR PROJECT:

a. Community involvement: How will your activity promote community and landowner/user involvement in watershed management? Please also describe any training, employment, and capacity building benefits of the proposed project.

The project is being managed in cooperation among irrigation districts and water use agencies within the San Joaquin Valley Drainage Authority (SJVDA) and the San Joaquin River Group Authority (SJRGA). Participants include Del Puerto Water District, Pacheco Water District, Panoche Drainage District, Patterson Irrigation District, Modesto Irrigation District, Turlock Irrigation District, and the San Joaquin River Exchange Contractors.

Informational and technical presentations on this research will be made in cooperation with educational programs organized by the California Water Institute and the Center for Irrigation Technology at Fresno State University. UCD and Fresno State University students will be trained in water sampling protocols and employed on this project. Employees of participating agencies will also be trained and employed to conduct water quality sampling and operate and maintain equipment.

b. CALFED Program objectives: Describe the specific goals and objectives of the CALFED Program in general that will be met through this project. Include a description of the relevance to the implementation priorities of CALFED.

The San Joaquin River and many of its tributaries are listed as impaired by the State Water Resources Control Board, and are subject to a number of existing and proposed total maximum daily loads (TMDLs) for selenium, boron, salt, pesticides, and oxygen-demanding materials. Reducing these constituents in drinking water is a recognized priority for CALFED.

The primary objective of this project is to accumulate and analyze data to develop a plan to address the dissolved oxygen (DO) issues in the San Joaquin River. In addition, the data gathered by the project could be used for the implementation of other TMDLs and regulatory issues in the San Joaquin River.

This project will provide crucial information to help address Multi-Regional Bay Delta Priority MR-5, "Ensure that restoration is not threatened by degraded environmental water quality," by collecting and analyzing data that will be used to address the DO issues (and possibly other issues) impacting the Bay/Delta and San Joaquin River. More specifically, this project will address CALFED's objectives concerning DO by identifying the cause(s) of the depletion of DO in the San Joaquin River and Delta, and help in establishing a management program to address the issue.

c. **<u>Support for community based watershed management</u>: Describe how your project will enhance decision making in local watershed management based on an existing watershed management plan. Please also describe how your project addresses environmental justice issues related to water management in the Bay-Delta watershed.**

The result of this project will be a direct benefit to water quality and ecosystem restoration in the San Joaquin River system by contributing to the development of an integrated treatment and management plan for agricultural drainage throughout the project area. Drainage from this region is subject to management under the DO TMDL allocation, as well as other existing and proposed TMDLs. The proposed project will collect and process water quality and flow data from a number of monitoring sites along the San Joaquin River, its tributaries, and diversion points for several interrelated sub-watersheds. The data will provide information to the stakeholders and allow them to make informed decisions to develop load allocations and meet discharge requirements. Additionally, the variety of monitoring locations will help to define the water quality character and interactions that occur throughout the river system and help address future TMDL requirements for other constituents.

d. **<u>Technology transfer</u>: Describe how your project will promote information exchange, including monitoring and technology transfer, among CALFED agencies and others interested in watershed management.**

The districts within the SJVDA and SJRGA are active in data collection and information exchange. Many of the districts host tours of their drainage management activities, demonstrating the operations and effectiveness of all of the management tools they are currently developing or applying. The data accumulated by this project will be used to develop a basin-wide TMDL management plan specific to DO.

The monitoring data collected in this project will be made available on the Interagency Ecological Program Website and in reports and publications. The data will also be presented at CALFED and other meetings, as requested.

Seminars, tours, class visits, and student training related to the project will be organized with UCD, Fresno State University, and the Center for Science and Engineering Education at Lawrence Berkeley National Laboratory.

2. IDENTIFY, IF APPLICABLE, THE MAJOR SOURCES OF NPS (NONPOINT SOURCE) POLLUTION THAT WILL BE ADDRESSED BY THE PROPOSED PROJECT (CHECK ALL APPROPRIATE SOURCES).

x	Agriculture
	Forestry
	Urban (Construction, Roads, Septic Systems)
x	Stormwater/Urban Runoff
	Marinas and Boating Activities

Hydromodification
Resource Extraction
x Other: Wetland Drainage Discharge

3. IDENTIFY THE NPS MANAGEMENT MEASURE(S) (SEE SECTION 6 OF THE SWRCB APPLICATION REFERENCE DOCUMENT [ARD]) THAT THE PROPOSED PROJECT WILL IMPLEMENT AND DESCRIBE HOW YOU WILL BE ABLE TO TRACK OR ACCOUNT FOR THE IMPLEMENTATION OF THESE MEASURES.

The proposed project will accumulate water quality data in the San Joaquin River and its tributaries, including agricultural and wetland drainage. In terms of the management methods listed in the ARD, this project will collect data that will help with the implementation of Management Measure 1C (nutrient management) as it pertains to the DO issues of the San Joaquin River and the Delta. Additionally, the data generated by this project may help in the future implementation of Management Measures 1A (erosion and sediment control) and 1D (pesticide management) and will assist with the implementation of 1F, as it pertains to a pollutant (surface and subsurface drainage) partially resulting from irrigation.[1]

4. IS THE PROPOSED PROJECT IDENTIFIED IN AN EXISTING WATERSHED MANAGEMENT PLAN, RESTORATION ACTION STRATEGY, OR EQUIVALENT DOCUMENT?

This project will complement the Grassland Bypass Project, which is a watershed management plan specific to selenium. The proposed project is part of an effort to integrate drainage treatment and management to meet current and future regulatory requirements. The intent of the project is to accumulate data to develop a basin-wide TMDL management program for DO for the San Joaquin River and tributaries. Much of the data generated by this project will also be helpful in developing management programs for future TMDLs and agricultural wavers.

5. INDICATE IF THIS PROJECT IS IMPLEMENTING A PROPOSED OR EXISTING TMDL (SEE SECTION 19 OF THE ARD).

The project will collect and analyze data that will be used to develop a management program to address the DO TMDL for the San Joaquin River and Delta. The water quality monitoring implemented by this project will provide crucial data in establishing the health of the river system and indicating which regions are impacted by a given group of contaminants. The data compiled by this project may also be useful in the implementation of future TMDLs.

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[1] While the management of agricultural drainage is not listed as a management method in the ARD, the Central Valley Regional Water Quality Control Board has indicated in its Watershed Management Initiative chapter and Basin Plan that reduction of pollutants associated with agricultural surface and subsurface drainage to the San Joaquin River is a high priority.

6. WILL THE PROPOSED PROJECT ACHIEVE MEASURABLE WATER QUALITY IMPROVEMENTS?

The purpose of the proposed project is to obtain and analyze water quality and flow data throughout the study area and will not, in and of itself, achieve any water quality improvements. However, the information gathered by the project will be necessary to implement the DO TMDL for the San Joaquin River and Delta.

7. LIST THE WATERSHED GROUP(S) OF WHICH THE APPLICANT IS A MEMBER.

The Grassland Drainage Basin
Middle San Joaquin – Lower Chowchilla (18040001)
Middle San Joaquin – Lower Merced, Lower Stanislaus (18040002)
San Joaquin Delta (18040003)
Panoche–San Luis Reservoir (18040014)
Ingram Creek/Hospital Creek/Del Puerto Creek Drainage

8. HAVE ANY PREVIOUS PROPOSITION 13 IMPLEMENTATION GRANTS OR GRANTS FROM OTHER AGENCIES AND OTHER FUNDING SOURCES (SUCH AS CALFED, CWA SECTION 319[H] OR 205[J], PROPOSITION 204) BEEN AWARDED FOR WORK IN THIS WATERSHED?

Yes, per the following:

- Prop 13 San Joaquin River Water Quality Improvement Project (1999)
- Prop 13 Grassland Integrated Drainage Management Project (2001)
- Prop 13 Southwest Stanislaus County Regional Drainage Water Management Program (2002)
- Prop. 204 San Joaquin River Water Quality Improvement Project In Valley Planning (2001)
- CALFED ERP Full-Scale Demonstration of Agricultural Drainage-Water Recycling Process Using Membrane Technology (2002)
- CALFED DWQ Agricultural Drainage Treatment (ABSR) (2002)
- EPA 205j Panoche/Silver Creek Coordinate Resources Management & Planning (1995)
- EPA 319h San Joaquin River TMML (1994)
- EPA 319h Implementation Economic Incentives to Improve WQ in the Grasslands Watershed and the Lower San Joaquin River (1996)
- USDA-NRCS Westside San Joaquin Valley Hydrologic Unit Area (1995)
- Combined funding San Joaquin Valley Drainage Program (1995)

9. **IS THIS A NEXT PHASE OF AN ONGOING PROJECT?** Yes _x_ (if "yes," describe) No ___

This project is, in part, a response to the Peer Review Recommendations that resulted from the CVRWQCB's Strawman Report (see Section B1.1). Many of the Peer Review

Recommendations identified regions of the San Joaquin River Drainage that are poorly understood and need further investigation. Much of monitoring efforts of this program will be aimed at filling in these gaps of missing data and improving our understanding of the character and processes of the San Joaquin River and its tributaries.

10. DESCRIBE HOW THE PROJECT WILL RESULT IN ONGOING OR WIDESPREAD IMPLEMENTATION THROUGHOUT THE PROJECT AREA, REGION, OR STATE.

This project will collect data from the San Joaquin River and tributaries that receive drainage discharges from several drainage entities, including agricultural districts, managed wetlands, and municipalities. The information this project provides will be used to develop a basin-wide TMDL management program for DO that will affect the decisions of all of these entities in the management of their discharges. Results from this project will aid in the selection and implementation of best management practices for a variety of agricultural operations including subsurface drainage management, fertilizer control, sediment and erosion management, pesticide management, and irrigation management.

11. DESCRIBE RELATED ANTICIPATED FUTURE WORK IN THE AFFECTED WATERSHED.

The future work anticipated as a result of the project will depend on drainage and water quality issues faced by each locality. Many districts within the SJVDA and the SJRGA are researching and implementing new tools to help them manage and reduce their drainwater. Future anticipated projects and programs may include tailwater and tilewater recirculation systems, drainwater reuse, drainage detention ponds, and similar projects. The results of this project will help guide each district toward the management practices that will best address the water quality issues it faces to meet the DO TMDL. The combined efforts of the drainage entities within the SJVDA and the SJRGA, as a result of this project, will improve the water quality of the San Joaquin River and its tributaries.

12. SUMMARIZE ACTIONS THAT HAVE BEEN ACCOMPLISHED TO DATE TO ADDRESS THE PROBLEM(S) (E.G., PAST MONITORING, PLANNING, IMPLEMENTATION PHASES).

Extensive monitoring has been conducted in the DO problem in the San Joaquin River. Much of the monitoring conducted over the last 3 years has been funded by CALFED through Directed Actions. However, most of the monitoring has focused on downstream locations, leaving data gaps on sources and loads from the upper watersheds.
A "Strawman" TMDL source assessment has been drafted by the CVRWQCB, and a demonstration aeration project in the Deep Water Ship Channel has been initiated. The purpose of the work to be conducted under this proposal is to provide information to determine the contributions and significance of upstream loads to the downstream DO problem.

13. IS THE PROJECT READY TO PROCEED?

The project will be ready to proceed at the point of contract execution. Laboratory and research facilities are available at Lawrence Berkeley National Laboratory, U.S. Geologic Survey, University of the Pacific, and UC Davis. Many of the field monitoring stations are installed and the remainder have been identified and are ready for installation.

14. DESCRIBE HOW THE PROJECT WILL DEMONSTRATE A CAPABILITY OF SUSTAINING WATER QUALITY BENEFITS FOR A PERIOD OF 20 YEARS AS REQUIRED BY PROPOSITION 13 (CWC SECTION 791144[B]).

The project will collect and analyze water quality and flow data for 3 consecutive years from several different monitoring sites throughout the project area. The results of the water quality analysis will provide the data necessary for the San Joaquin River stakeholders to develop and implement a long term TMDL management plan to address the DO issues of the San Joaquin River. Additionally, the information gathered by this project will be helpful in implementing future TMDLs for the region.

15. IF THERE IS AN NPDES PERMIT REQUIRED FOR THIS PROJECT AREA (CHECK WITH YOUR RWQCB), DESCRIBE THE RELATIONSHIP OF THE PROJECT TO THE PERMIT.

Not applicable.

16. WILL LAND, RIGHTS-OF-WAY, OR EASEMENTS BE PURCHASED WITH PROPOSITION 13 FUNDS? WHO WILL HOLD THE TITLE?

Not applicable.

17. PLEASE DESCRIBE ANY INTERMEDIATE IMPACTS (BENEFICIAL OR ADVERSE) OF YOUR PROPOSED PROJECT.

No negative intermediate impacts of this project will occur. Positive intermediate impacts include the training of UCD and Fresno State students in aspects of environmental science and pollution control.

PART E: MAP OF STUDY AREA

(See Figure B-1)

PART F: ENVIRONMENTAL INFORMATION FORM

NEPA/CEQA

1. **WILL THIS PROJECT REQUIRE COMPLIANCE WITH CEQA, NEPA, OR BOTH?**

   CEQA compliance in the form of a Categorical Exemption will be required to implement this project. No NEPA compliance will be required.

2. **IF YOU CHECKED "NO" TO QUESTION 1, PLEASE EXPLAIN WHY COMPLIANCE IS NOT REQUIRED FOR THE ACTIONS IN THIS PROPOSAL.**

   The lead agency for the proposed project is a non-Federal local agency and NEPA is not applicable.

3. **IF THE PROJECT WILL REQUIRE CEQA AND/OR NEPA COMPLIANCE, IDENTIFY THE LEAD AGENCY(IES).**

   CEQA Lead Agency San Joaquin Valley Drainage Authority
   NEPA Lead Agency Not Applicable

4. **PLEASE CHECK WHICH TYPE OF DOCUMENT WILL BE PREPARED.**

CEQA	**NEPA**
_x_ Categorical Exemption	__ Categorical Exclusion
__ Initial Study	__ Environmental Assessment/FONSI
__ Environmental Impact Report	__ Environment Impact Statement

5. **IF THE CEQA/NEPA PROCESS IS NOT COMPLETE, PLEASE DESCRIBE THE ESTIMATED TIMELINES AND COST FOR THE PROCESS AND THE EXPECTED DATE OF COMPLETION.**

   The proposed project consists only of data collection and research and will not result in serious or major disturbance to any environmental resource as defined by Section 15306 of the California Public Resources Code. A Categorical Exemption will be filed to comply with CEQA. The lead agency for this project is not a Federal agency and NEPA does not apply. The estimated cost for this portion of the project is $7,383 and will be completed at the execution of the project contract.

6. **IF THE CEQA/NEPA DOCUMENT HAS BEEN COMPLETED:**

   What is the name of the document? NA

   Please attach a copy of the CEQA/NEPA document cover page to the application.

   Not applicable.

7. ENVIRONMENTAL PERMITTING AND APPROVALS:

Please indicate what permits or other approvals may be required for the activities contained in your proposal and which have already been obtained. Please check all that apply.

LOCAL PERMITS AND APPROVALS	**Needed?**	**Obtained?**
Conditional use permit	no	
Variance	no	
Subdivision Map Act	no	
Grading permit	no	
General plan or Local Coastal Program amendment	no	
Specific plan approval	no	
Rezone	no	
Williamson Act Contract cancellation	no	
Local Coastal Development Permit	no	
Other: County Road Crossing Permit	no	
STATE PERMITS AND APPROVALS	**Needed?**	**Obtained?**
Scientific collecting permit	no	
CESA compliance: 2081	no	
CESA compliance: NCCP	no	
1601/03	no	
CWA 401 certification	no	
Coastal development permit	no	
Reclamation Board approval	no	
Notification of DPC or BCDC	no	
Other		
FEDERAL PERMITS AND APPROVALS	**Needed?**	**Obtained?**
ESA compliance Section 7 consultation	no	
ESA compliance Section 10 permit	no	
Rivers and Harbors Act	no	
CWA 404	no	
Other	no	
PERMISSION TO ACCESS PROPERTY		
Permission to access city, county, or other local agency land. If "yes," indicate the name of the agency: Participating Districts	yes	yes
Permission to access State land. If "yes," indicate the name of the agency: CDFG	yes	in progress
Permission to access federal land. If "yes," indicate the name of the agency: USBR, USFWS	yes	in progress
Permission to access private land. If "yes," indicate the name of the agency: various landowners	yes	in progress

PART G: LAND USE QUESTIONNAIRE

1. **Do the actions in the proposal involve construction or physical changes in the land use? Yes____ No__x__**

   If you answered "yes" to # 1, describe what actions will occur on the land involved in the proposal.

   If you answered "no" to # 1, explain what type of actions are involved in the proposal (i.e., research only, planning only).

   This project involves research and analysis only. Water samples will be collected from existing agricultural drains and other waterways.

2. **How many acres of land will be subject to a land use change under the proposal?**
   __0_____

3. **What is the current land use of the area subject to a land use change under the proposal? What is the current zoning and general plan designation(s) for the property? Does the current land use involve agricultural production?**

a)	Current land use	N/A
b)	Current zoning	N/A
c)	Current general plan designation	Varies, including agriculture, commercial, industrial and residential.

d) Does current use involve agricultural production?
   Yes____ No____
   Not applicable

4. **Is the land subject to a land use change in the proposal currently under a Williamson Act contract?**
   Yes____ No ____
   Not applicable (no land use change).

5. **What is the proposed land use of the area subject to a land use change under the proposal?**

   Not applicable.

6. **Will the applicant acquire any land under the proposal, either in fee (purchase) or through a conservation easement?**
   Yes_____ No__x___
   a) If you answered "yes" to 6, describe the number of acres that will be acquired and whether the acquisition will be of fee title or a conservation easement:
   b) Total number of acres to be acquired under proposal ______________________
   c) Number of acres to be acquired in fee ___________________________________
   d) Number of acres to be subject to conservation easement ____________________

7. For all lands subject to a land use change under the proposal, describe what entity or organization will manage the property and provide operations and maintenance services.

Not applicable

8. Will the applicant require access across public or private property that the applicant does not own to accomplish the activities in the proposal?

Yes__**x**__ No_____

Some of the monitoring points require access through private land. Permission for this access will be acquired.

9. For land acquisitions (fee title or easements), will existing water rights be acquired?

Yes_____ No_____ Not applicable

10. Does the applicant propose any modifications to the water right or change in the delivery of the water?

Yes_____ No _**x**__

If "yes" to 10, please describe the modifications or changes.

PART H: QUALIFICATIONS AND LABORATORY FACILITIES

Qualifications of Project Administrators

Joseph C. McGahan, MS, PE, is President of Summers Engineering, Inc. in Hanford, California. He holds a BS degree from California State Polytechnic University and an MS degree from the California Institute of Technology. He is a registered Civil Engineer in the State of California. He has spent over thirty years working in the field of water resources. Mr. McGahan has been responsible for irrigation and drainage water quality studies for Summers Engineering. He has also been responsible for design of potable water treatment plants, including remedial work due to trace element problems. Since 1985, he has been a consultant to agricultural districts in the Grassland area dealing with water quality issues. Currently he serves as Drainage Coordinator for the Grassland Area Farmers. Mr. McGahan is a member of the Board of Directors of the U.S. Committee on Irrigation and Drainage, a member of the American Water Works Association, and the American Society of Civil Engineers.

Lowell Ploss, Project Administrator, San Joaquin River Group Authority located in Modesto, California. He holds a BS in Civil Engineering from the University of Wisconsin and is a registered engineer in the State of Colorado. For thirty-three years he was employed by the U.S. Bureau of Reclamation last serving as the Deputy Regional Director for the Mid-Pacific Region in Sacramento, California. He has extensive experience in water resources planning and management throughout the western United States. Prior to 1985 Mr. Ploss serves at locations providing oversight and management of water projects in Colorado, Wyoming, Nebraska, and Kansas. In 1985 Mr. Ploss assumed responsibility for administration of Bureau of Reclamation interest and facilities in the Sacramento Valley. Beginning in 1993 he served as the Operations Manager to oversee and direct water operations for the entire Central Valley Project extending from Redding to Bakersfield, California. In his current position he served the San Joaquin River Group Authority, a Joint Powers Authority of the San Joaquin Valley water agencies from Manteca to Bakersfield.

Qualifications of Investigators

William T. Stringfellow, PhD, is a Research Engineer at Lawrence Berkeley National Laboratory. He received his B. S. in Environmental Health from the University of Georgia (Athens, GA) in 1980. He received his Master's Degree in Microbial Physiology and Aquatic Ecology from Virginia Tech (Blacksburg, VA) in 1984. At the completion of his M. S., he worked for Sybron Chemicals Co. as a Research Scientist, investigating the biological treatment of industrial wastes. In this capacity, he was responsible for the development of a patented technology to biologically control algae blooms in wastewater lagoons. He received his Ph.D. in Environmental Sciences and Engineering from the University of North Carolina at Chapel Hill in 1994 and worked as a Post-Doctoral Fellow in the Civil and Environmental Engineering Department at the University of California at Berkeley. Dr. Stringfellow has provided consulting concerning the biological treatment of industrial and agricultural wastes in the Eastern U. S. and Europe. His areas of expertise include biokinetics, ammonia oxidation (nitrification) and the biological treatment of food industry wastes. Currently, Dr. Stringfellow directs the Bioprocesses Laboratory at Lawrence Berkeley National Laboratory, where his research addresses microbial growth and degradation processes occurring in engineered systems and advanced techniques for water and wastewater treatment. Dr. Stringfellow has been an active member of the DO TMDL Technical Advisory Committee for over three years.

Erwin E. Van Nieuwenhuyse, Ph.D. is a senior Fisheries Biologist with the United States Bureau of Reclamation in Sacramento, California and a Visiting Research Scientist at the University of California-Davis' Land, Air and Water Resources Department. Dr. Van Nieuwenhuyse manages Reclamation's Water Quality Compliance Monitoring Program for the Sacramento-San Joaquin Delta and San Francisco Bay estuary and advises operators of the Central Valley Project on technical issues related to water quality, aquatic ecology and fish populations listed under the Endangered Species Act. His applied research focuses on improving the performance of the Bay-Delta monitoring network and on developing modeling and visualization tools that facilitate the transformation of data into useful information. Dr. Van Nieuwenhuyse chairs or serves on several committees and work groups, including the California Bay-Delta Authority (CALFED) Ecosystem Restoration Program Selection Panel, Delta Geographic Review Panel and Environmental Water Account Science Advisory Group; the Interagency Ecological Program (IEP) Water Quality, Estuarine Ecology, Delta Salmon, and Delta Cross Channel project work teams; the Mokelumne River Technical Advisory Committee; the San Joaquin River Dissolved Oxygen TMDL Technical Advisory Committee, the Interagency Instream Flow Studies Management Team, and the CVPIA Water Acquisitions Program Planning Team. He holds a Cand. Sc. (Hons) degree in Biology from the University of Louvain in Belgium, an M.S. degree in Fisheries Biology from the University of Alaska, Fairbanks and a Ph.D. in Limnology from the University of Missouri, Columbia.

Gary Litton, PhD, received a B.S. in Civil Engineering from the University of California, Irvine in 1980 and spent the first part of his career with the Regional Water Quality Control Board, Lahontan Region and Santa Ana Region. As a professional engineer he has been responsible for water quality monitoring and modeling investigations, water quality planning, pollution impact studies, acid-mine drainage abatement projects, and subsurface remediation efforts. He received his M.S. and Ph.D. in Environmental Engineering from UC Irvine, in 1990 and 1993, respectively. Dr. Litton is currently an associate professor in the Department of Civil Engineering at the University of the Pacific. He is responsible for teaching courses and conducting research in environmental engineering. Dr. Litton has been the principal investigator of numerous water quality studies in the San Joaquin River and Delta investigating sediment transport, oxygen demands, and the effects of algal photosynthesis on water quality parameters. Dr. Litton's research interests also include colloid surface chemistry interactions and the associated mass transport of radionuclides, trace metals, and strongly adsorbing pesticides in aquatic environments.

Randy Dahlgren, PhD, is a professor of Soil Science and Biogeochemistry in the Department of Land, Air and Water Resources at the University of California, Davis. He currently serves as Vice-Chair of the Soils and Biogeochemistry Program in LAWR and was Chair of the Hydrologic Sciences Graduate Group for the past four years. His research program in biogeochemistry examines the interaction of hydrological, geochemical, and biological processes in regulating surface and ground water chemistry. He is currently involved in water quality research spanning the scale from hillslopes to small headwater catchments (<10 ha) to the combined Sacramento-San Joaquin watersheds. Randy received his Ph.D. and M.S. in forest soils from the University of Washington and his B.S. in soil science from North Dakota State University. He was a post-doctoral research associate in the Department of Civil and Environmental Engineering at Syracuse University before coming to UCD in 1989.

Sharon E. Borglin, PhD, EIT, is a Scientist at Lawrence Berkeley National Laboratory. She received her B.S. in Chemistry with a minor in Environmental Toxicology in 1988 from The University of California, Davis. After receiving her B.S., Dr. Borglin worked as an analytical chemist for a contract laboratory and for Battelle PNL in Sequim, WA. Dr. Borglin received her Ph.D. in Mechanical and Environmental Engineering (1995) and a M.S. Mechanical and Environmental Engineering (1993) from the University of California, Santa Barbara. Her thesis focused on the adsorption and desorption of hydrophobic organic chemicals to river sediments. After receiving her Ph.D., she taught organic and analytical chemistry at Ventura College, and was a professor and faculty advisor at Kennedy Western University. Dr. Borglin came to LBNL in 1996, and has since worked on several projects related to water and soil pollution in the San Joaquin Valley. Dr. Borglin has conducted extensive research on the biogeochemistry of selenium in algae and sediments associated with the San Luis Drain. Her current research focus is on examining the changes in bacteria and algal community structure that occur in response to pollutant impacts and the biodegradation of pharmaceuticals and endocrine disrupting chemicals in water and river sediments.

Carol Kendall, PhD, is the chief of the Isotope Tracers Project in the National Research Program of the USGS in Menlo Park. She received her B.S. and M.S. in Geochemistry from the University of California (Riverside), and her Ph.D. in Geochemistry from the University of Maryland in 1993. Dr. Kendall has been using stable isotope techniques to trace sources of water, nutrients, and organic matter in small and large watersheds for 20 years, resulting in her editing of a 1998 textbook entitled "Isotope Tracers in Catchment Hydrology". Since 1995, her group has focused on using the isotopic composition of nitrate and organics to identify sources and biogeochemical processes in the Mississippi Basin that contribute to hypoxia in the Gulf of Mexico. She is a collaborator on three CalFed-funded studies, in collaboration with Drs. Bergamaschi and Kratzer.

Russ Brown, PhD, received a B.S. in Civil and Environmental Engineering from UC Irvine in 1972. He completed a M.S. in Ocean Engineering from MIT in 1974 and a Ph.D. in Civil Engineering & Water Resources from MIT in 1978. Dr. Brown conducted reservoir water quality modeling studies at the US Army Corps of Engineers WES for his Ph.D. research and began his applied engineering evaluations of natural water bodies. He worked for the Tennessee Valley Authority on reservoir and river water quality investigations (temperature, dissolved oxygen, sediment, algae) and developed his interest in hydrologic interpretation of water quality data. He spent five years as associate professor in the Water Center at Tennessee Technological University. He has worked for Jones & Stokes since 1989 and has conducted various modeling and impact assessment projects throughout California. He is experienced in Delta hydrodynamics and water quality modeling, daily simulation of SWP and CVP reservoir and Delta pumping operations, and reservoir and river temperature studies. He has actively participated in the SJR DO TMDL and conducted tidal exchange and aeration technology evaluations of the DWSC for CALFED.

Nigel W. T. Quinn, PhD, PE, is an Assistant Research Engineer at U. C. Berkeley and a Staff Geological Scientist at Berkeley National Laboratory. He has worked as a consultant to the US Bureau of Reclamation for the past 15 years and is currently under contract with that institution leading projects on regional groundwater model development, real-time water quality management of the San Joaquin River and managed wetlands within the Grassland Basin. He is also an adjunct faculty affiliate of the California Water Institute at California State University in Fresno. His research focuses on the application and development of watershed scale models to solve salinity, selenium and related water quality problems in the San Joaquin Valley. Dr Quinn is a principal investigator on several current CALFED-funded water quality management projects as well as an EPA-funded project on impacts of Global Climate Change on San Joaquin Basin water resources. He has a B.Sc. (Hons) degree from Cranfield Institute of Technology in England, in irrigation and drainage engineering, an MS degree in civil and agricultural engineering from Iowa State University, where he served on the teaching faculty, and a Ph.D. from Cornell University in water resource systems engineering. He is the author of over 50 publications in the area of water resource systems engineering.

Carl W. Chen received his M.S. and Ph.D. degrees in Environmental Engineering from the University of California-Berkeley. He is a registered civil engineer (CE20579) in the State of California. He has been president of Systech Engineering for the last 20 years. Prior to that, he worked as a vice president of Tetra Tech, Inc. for 10 years and a senior engineer of Water Resources Engineers, Inc. for 7 years. He has directed the development and calibration of dissolved oxygen model for the Deep Water Ship Channel of the Lower San Joaquin River, taking into account the tide, river geometry, solar radiation, river flow, and pollution loads of oxygen consuming matters from City of Stockton and river upstream. The model has been applied to calculate allowable pollution loads (TMDL) to maintain DO above 5 mg/l. Dr. Chen has developed the graphical user interface to support the real time water quality management of the upper San Joaquin River. Dr. Chen has also applied a lake eutrophication model to Camanche, Pardee, and Oroville reservoirs.

Chris Linneman, PE, is a Registered Civil Engineer in the State of California and has worked for Summers Engineering, Inc. in Hanford, California since 1996. He received his BS in Civil Engineering from Santa Clara University in 1995. Mr. Linneman has assisted in drainage coordination for the Grassland Drainage Area. Duties have included water quality analysis, calculation of selenium, salt, and boron loads; water, selenium, and salt balance studies; the design of district and farm level recirculation pipelines and pumping plants; the design irrigation and drain water conveyance systems; and infrastructure feasibility studies. He has also been actively involved in the development of drain water reuse projects in the Grassland Drainage Area. Mr. Linneman is a member of the U.S. Committee on Irrigation and Drainage.

William J. Oswald, PhD, PE, DEE, is Professor Emeritus of Environmental Engineering and Public Health at the University of California, Berkeley and Senior Staff Scientist at Lawrence Berkeley National Laboratory. His 50-year career has been devoted to understanding and controlling algae and processes that use algal-bacterial symbiosis, and engineering specialized ponds and shallow flow channels for production of algal biomass. Large-scale facilities based on Professor Oswald's engineering designs have been shown to improve the economy of wastewater reclamation while lessening the negative environmental impacts normally associated with wastewater treatment. Investigations on algae production for nutrient control in San Joaquin Valley agricultural tile drainage led to Professor Oswald receiving a Special Commendation for Excellence of Consulting Services from the Interagency Central Valley Drainage Project. His is currently Principal Investigator for projects investigating selenium and nitrate removal from both typical and highly concentrated agricultural drainage. He currently consults for the U.S. Agency for International Development on municipal wastewater infrastructure and has provided advisory, review, and consultative services for more than 35 years on water supply and waste management systems, biological engineering, and environmental control to numerous international organizations, national agencies, and foreign governments. He has written over 300 articles and research papers in reviewed journals, reports, and monographs on the subject of wastewater management and reclamation.

Bryan Bemis, PhD, is a biogeochemist with the Isotope Tracers Project at the USGS in Menlo Park. He received B.S. (1990) and M.S. (1992) degrees in Geology from the University of Wisconsin, Madison. He received his Ph.D. in Geology from the University of California, Davis in 2000. His dissertation investigated environmental controls on the isotopic composition of planktonic foraminifera. Dr. Bemis has extensive experience developing novel methods of reconstructing environmental information in aquatic systems using the isotopic chemistry of organic compounds and biogenic minerals. Since 2000, he has worked as a Post-Doctoral Fellow at the USGS on isotopic characterization of food web structure in the Florida Everglades and isotopic tracing of trihalomethane-forming DOC in the Sacramento-San Joaquin Delta.

Brian Bergamaschi, PhD, received a Ph.D. in Chemical Oceanography from the University of Washington, in Seattle, WA, where he specialized in analyzing the sources and fates of natural organic material in the environment. For that work, he received an award for an outstanding dissertation in Chemical Oceanography (ONR/NSF). He was also the recipient of the Barbara McClintock postdoctoral fellowship at the Carnegie Geophysical Laboratory. For the past 6 years, he has been working with the USGS on matters relating to the activity of natural organic material in the environment, and especially in the Sacramento-San Joaquin Delta.

Steven Silva is an isotope geochemist with the Isotope Tracers Project at the USGS in Menlo Park. He has extensive experience using POM and nitrate isotopes for tracing sources of nutrients and organic matter in large river systems. Since 1999, he has been an active team member on two CALFED-funded collaborations with colleagues in the Sacramento USGS office, first using isotope techniques to trace sources of DOC and THM in the Delta, and later to trace nutrient and POM sources in the SJR.

Donna Smith is the Director of the Environmental Measurement Laboratory at LBNL. Graduated from Northern Arizona University in 1991 with a B.S. degree in chemistry. Graduate coursework in chemistry with research focusing on organometallic chemistry in clay substrates. Twelve years of experience in environmental chemistry under EPA and Environmental Laboratory Accreditation Program (ELAP) regulatory protocol. Extensive analytical experience in fields of volatile and semivolatile organic analyses and RCRA metals analyses as well as maintaining laboratory certification with regulatory agencies, authoring standard operating procedures and implementing and maintaining QC monitoring programs. Experience in field and laboratory project management includes, QA and field sampling plan (QAP and FSP) development and implementation, documentation and validation of data and reporting and interpretation of chemical analytical data.

Parviz Nader, PhD, PE, is a Senior Engineer in the Delta Modeling Section, Department of Water Resources (DWR). He received his B.S. (1981) in Civil Engineering from the California State University, Fresno. He received his M.S. (1985), and PhD (1989) in Civil Engineering from University of California, Davis. His area of expertise is in numerical modeling. He worked for close to two years at Imbsen and Associates, as a Civil Engineer. He was in charge of conducting computer simulations in analyzing and designing various types of bridges. He started working at DWR in 1989, where he gained extensive experience in hydrodynamics and water quality modeling. He is one of the original developers of DSM2 (Delta Simulation Model 2). He supervises a group of 4 engineers in conducting historical and planning computer simulations of various alternatives designed to improve water quality and/or water supply in California. Dr. Nader has also been teaching undergraduate engineering courses at UC Davis on a part time basis since 1983.

Hari L. Rajbhandari, PhD, PE is an Engineer at the California Department of Water Resources. He has fourteen years of experience in development, application and refinement of mathematical models of hydrodynamics and water quality. He has a Bachelors degree in Civil Engineering from the Indian Institute of Technology, Kanpur in India. In 1986 he was awarded Fulbright Grant to pursue graduate study. He received MS degree in Civil Engineering in 1989 and Ph.D. in Civil and Environmental Engineering in 1995, both from University of California, Davis. Dissolved Oxygen (DO) model development was part of his Ph.D. dissertation. He incorporated DO and the related constituent simulation algorithms (including temperature, nutrients and algae) into Delta Simulation Model 2 (DSM2). He has been actively involved in the San Joaquin River DO Total Maximum Daily Load (TMDL) development process and water quality studies of the Sacramento- San Joaquin Delta system. His work at the University of California includes: modeling the effects of tidal barrier closure on water quality of Venice Lagoon, development of a model for waste load allocation and TMDL estimates in Suisun Marsh and modeling the effects of live stream discharges on water quality of San Diego River estuary. His professional activities include technical review for American Society of Civil engineers (ASCE) and the other scientific journals. Dr. Rajbhandari a Registered Professional Engineer in the state of California.

Theresa Sebasto, the California Water Institute’s Program Specialist, has 15 years experience in organizing a wide variety of successful events, from small seminars to large trade shows. She has been responsible for coordinating curricula for numerous technical education seminars, including training on the proper use and function of technical equipment. She has also been responsible for development of technical training manuals.

Tim Jacobsen, the California Water Institute’s Education Specialist (through the Central Valley Water Education Center) has been successfully organizing and conducting technical water training seminars and curriculum development for the California Water Institute for a number of years. Topics of his seminars include all aspects of irrigation technology, pumping plant efficiency testing, ground water protection, and irrigation well technology. He successfully integrates modern presentation techniques with traditional subjects in his well-received presentations.

Brian Hale is a database specialist with the DWR Interagency Ecological Program. Brian is a Senior Microsoft Access developer with over 10 years of experience working with this product to produce many database applications. As a programmer/analyst, he has created database applications that support a wide range of projects. Brian has experience creating data schemas, tables, fields, and relationships. He has a great deal of experience creating intuitive interfaces and reports. All of the functionality in these applications is provided by coding with the Visual Basic language. Brian has implemented local water quality databases for BDAT.

Kris Lightsey is a database specialist with the DWR Interagency Ecological Program. He will be the principal developer who will implement the comprehensive components of the project. Kris has a recent advanced degree in computer science and over ten years of experience working on enterprise data management systems. Kris will be working with four other BDAT staff who support the comprehensive database components of the project.

Karl Jacobs is an Environmental Specialist IV with the Dept. Water Resources in Sacramento CA. Karl received his BS at UC San Diego (1979) and a MS in Chemistry at California State.U. Sacramento (1990). Currently, Karl Jacobs is the Chair, Interagency Ecological Program Data Utilization Work Group; manager/member of the team developing the comprehensive Bay/Delta and tributaries databases for the Interagency Ecological Program, Central Valley Improvement Act and Stakeholders, CALFED and other Bay/Delta and Tributary groups; and Section Chief for the Interagency Information Systems Section.

Laboratory Facilities

Biogeochemistry Laboratory at University of California, Davis

Dr. Dahlgren's Biogeochemistry laboratory is located in the new Plant and Environmental Sciences building on the UCD campus. The lab is fully equipped for both routine and specialized plant, soil and water chemistry analyses. The laboratory is equipped with standard laboratory equipment and analytical instruments including: ultra-pure (18 megaohm) distilled-deionized water, research grade pH meters, EC meters, turbidity meters, dissolved oxygen meter, analytical balances, Dohrmann carbon analyzer (DIC & DOC), two Dionex ion chromatographs, FTIR, UV/visible spectrophotometer, conductimetric nitrogen analyzer, muffle furnace, block digestion unit, refrigerated centrifuge, and micro-computing facilities. In addition, the Department of Land, Air and Water Resources has a C/N analyzer, ICP-AES, and atomic absorption spectrophotometer available through a recharge policy. We also have ample cold storage both within our own laboratories and in departmental cold rooms. These laboratories meet all state and federal criteria for laboratory safety, seismic standards and hazardous chemical storage and disposal.

Bioprocesses Laboratory at Lawrence Berkeley National Laboratory

The Bioprocesses Laboratory is a fully equipped microbiological and environmental engineering laboratory located in Building 70 on the LBNL campus. The Bioprocesses Laboratory is a fully functional water and wastewater treatment laboratory, capable of executing bench level or pilot level testing of experimental water and wastewater treatment processes. The major research focus of the Bioprocesses Laboratory is the study of microbial growth and biodegradation kinetics in engineered systems.

Analytical capabilities at the laboratory include high performance liquid chromatography (HPLC), gas chromatography, mass-spectroscopy, UV-visible spectroscopy, organic and inorganic carbon analysis, and a complete range of techniques critical to measuring biological processes in environmental systems. Specialty capabilities of the Bioprocesses Laboratory include fatty-acid methyl ester analysis (FAME), primary and secondary metabolite analysis, algal pigment analysis by HPLC, respirometry, and many other analyses that can be used to directly or indirectly measure microbial activity or biomass. Engineering capabilities in the laboratory include reactor construction and operation.

Environmental Measurements Laboratory at Lawrence Berkeley National Laboratory

The Environmental Measurement Laboratory (EML) is an EPA/California Department of Health Services certified analytical lab at Lawrence Berkeley National Laboratory (LBNL). The EML is within the Earth Sciences Division at LBNL and provides services for researchers at DOE laboratories and the University of California. The EML has the capabilities to conduct a wide variety of analyses covering both organic and inorganic methods, including examination of air, water, soil, sediment, seawater, and wastewater samples. Some analytical equipment includes ICP-OES, ICP-MS, FLAA, Ion Chromatography, GC-MS, and GC.

Environmental Engineering Laboratory at University of the Pacific

The Environmental Engineering Laboratory at the University of the Pacific is housed in a dedicated laboratory with approximately 850 square feet of floor space. Analyses common to water and wastewater characterization are performed at the laboratory. The major research focus of the Environmental Engineering Laboratory is the quantification of biochemical oxygen demands of pollutants in water and sediments and the kinetics associated with these processes.

Analytical capabilities in the laboratory include UV-visible spectroscopy, and organic and inorganic carbon analyses. Gravimetric solids quantification, biochemical oxygen demand tests, chlorophyll a, pheophytin a, ammonia and carbon analyses are routinely performed in the laboratory. Three boats are available for field investigations that are instrumented to quantify dye concentration, chlorophyll a, pH, DO, EC, turbidity, water temperature, water depth, instrument depth, and geographic coordinate location. A data acquisition system permits the simultaneous collection of all data from five different instruments every second and displays the data graphically in real-time.

Isotope Geochemistry Laboratory at United States Geological Survey

The USGS Menlo Stable Isotope laboratory is located at 345 Middlefield Road, Building 15, Menlo Park, CA 94025. It is part of the National Research Program's Isotope Tracers Project, headed by Dr. Carol Kendall. The staff currently consists of 4 permanent full-time researchers, 2 temporary full-time post-docs, 1 full-time temporary researcher (Ph.D. student at Stanford), 2 full-time permanent technicians, 1 full-time temporary technician, 4 part-time temporary technicians, and a shared secretary.

The Menlo Park Stable Isotope and Tritium Laboratories consist of five laboratories (4 stable isotope and 1 radio-isotope labs), with 4 mass spectrometers, 4 tritium counters, and numerous preparation systems. The primary systems used for stable isotope analysis of biological, organic, and nutrient samples are 3 Micromass continuous-flow mass spectrometers capable of analyzing C, N, S, O, and H isotopes. These mass spectrometers share 4 elemental analyzers, 2 GCs, 2 gas-sampling autosamplers, an automated DIC-DOC analyzer, and a gas concentration apparatus. Specialties of the laboratory include nitrate analyses for δ18O, d15N, and d17O; dissolved and particulate organics for d15N, d13C, and d34S; and dissolved gases for δ18O, d13C and d15N.