Implementing a Collaborative Approach to Quantifying Ecosystem Flow Regime Needs for the Sacramento River

Form I - Project Information

1. **Proposal Title:**
Implementing a Collaborative Approach to Quantifying Ecosystem Flow Regime Needs for the Sacramento River

2. **Proposal applicants:**
Mike Roberts, The Nature Conservancy
Gregory Golet, The Nature Conservancy
Frank Ligon, Stillwater Sciences
Yantao Cui, Stillwater Sciences
Bruce Orr, Stillwater Sciences
David Marmorek, ESSA Technologies, Ltd.
Calvin Peters, ESSA Technologies, Ltd.
Michael Scott, United States Geological Survey
Gregory Auble, United States Geological Survey
Jonathon Friedman, United States Geological Survey
Patrick Shafroth, United States Geological Survey
William Dietrich, U. C. Berkeley
G. Matt Kondolf, U. C. Berkeley

3. **Corresponding Contact Person:**
Wendie Duron
The Nature Conservancy
500 Main Street Chico, CA. 95926
530 897-6376
wduron@tnc.org

4. **Project Keywords:**
Flow, Instream
Local and Regional Coordination
Water Resource Management

5. **Type of project:**
Research

6. **Does the project involve land acquisition, either in fee or through a conservation easement?**
No

7. **Topic Area**:
Natural Flow Regimes

8. **Type of applicant:**
Private non-profit

9. **Location - GIS coordinates:**

Latitude: 39.679
Longitude: -122.009
Datum:

Describe project location using information such as water bodies, river miles, road intersections, landmarks, and size in acres.

The project is located within the designated Sacramento River Conservation Area boundary, and between the cities of Red Bluff (river mile 244) and Colusa (river mile 144).

10. **Location - Ecozone:**
3.2 Red Bluff Diversion Dam to Chico Landing, 3.3 Chico Landing to Colusa

11. **Location - County:**
Butte, Colusa, Glenn, Tehama

12. **Location - City:**
Does your project fall within a city jurisdiction?
No

13. **Location - Tribal Lands:**
Does your project fall on or adjacent to tribal lands?
No

14. **Location - Congressional District:**
3 & 2

15. **Location:**
California State Senate District Number: 4 & 1
California Assembly District Number: 2 & 3

16. **How many years of funding are you requesting?**
3

17. **Requested Funds:**
a) Are your overhead rates different depending on whether funds are state or federal?
No

If no, list single overhead rate and total requested funds:
Single Overhead Rate: 25
Total Requested Funds: $1,640,801

b) Do you have cost share partners already identified?
No

c) Do you have potential cost share partners?
Yes
The David and Lucile Packard Foundation, $380,000

d) Are you specifically seeking non-federal cost share funds through this solicitation?
No

If the total non-federal cost share funds requested above does not match the total state funds requested in 17a, please explain the difference:

18. **Is this proposal for next-phase funding of an ongoing project funded by CALFED?**
No

Have you previously received funding from CALFED for other projects not listed above?
Yes

If yes, identify project number(s), title(s) and CALFED program.
97-NO2
Ecosystem and Natural Process Restoration on the Sacramento River: Floodplain Acquisition and Management
Ecosystem Restoration Program

97-NO3
Ecosystem and Natural Process Restoration on the Sacramento River: Active Restoration of Riparian Forest
Ecosystem Restoration Program

97-NO4
Ecosystem and Natural Process Restoration on the Sacramento River: A Meander Belt Implementation Project
Ecosystem Restoration Program

98-F18
Floodplain Acquisition, Management and Monitoring on the Sacramento River
Ecosystem Restoration Program

2000-FO3
Floodplain Acquisition and Sub-Reach/Site Specific Management Planning: Sacramento River (Red Bluff to Colusa)
Ecosystem Restoration Program

19. **Is this proposal for next-phase funding of an ongoing project funded by CVPIA?**
No

Have you previously received funding from CVPIA for other projects not listed above?
Yes

If yes, identify project number(s), title(s) and CVPIA program.

00FG200173
Acquisition of Southam Orchard Properties for Preservation of Riparian Habitat
Section 3406 (b) (1) “other”

1448113327G017
Hartley Island Acquisition
AFRP

113320G014
Singh Walnut Orchard

AFRP

114201J114
Boeger/Ward Acquisition

Section 3406 (b) (1) “other”

20. Is this proposal for next-phase funding of an ongoing project funded by an entity other than CALFED or CVPIA?
No

Please list suggested reviewers for your proposal. (optional)

21. **Comments:**

Form II - Executive Summary

Implementing a Collaborative Approach to Quantifying Ecosystem Flow Regime Needs for the Sacramento River

The Nature Conservancy proposes to quantify ecosystem flow regime needs for the Sacramento River between Red Bluff and Colusa. This is a targeted research project utilizing a collaborative workshop process, targeted field investigations, quantitative computer modeling, and a decision analysis tool to formulate linkages between the flow regime and ecosystem components. This information will aid in the recovery and restoration of many at-risk riparian species and habitats, facilitating the most effective water management and ecosystem restoration strategies for the Sacramento River. Existing efforts seeking to balance demands on river flow do not account for many ecosystem components on the main stem of the Sacramento River. This project proposes an interdisciplinary, workshop approach to develop multi-species conservation flow regime needs, to inform and coordinate with existing efforts, reduce scientific uncertainties, and improve our ability to effectively guide conservation efforts in the study area. Importantly, this project seeks to quantify key aspects of a naturalized flow regime that are compatible with flood damage reduction, agriculture, diversions, storage, and conveyance; it does not seek to return the system to its pre-regulated condition however, it is a proactive approach to avoiding future regulatory action.

Specific objectives of this project include:

1) Synthesize existing, interdisciplinary knowledge that addresses unknowns already identified during project development.
2) Provide information on ecological flow needs to other efforts seeking to balance ecosystem and human needs for river flow.
3) Develop a decision analysis tool to evaluate trade-offs among different ecological objectives.
4) Propose strategies to achieve multiple species conservation benefits.

Hypothesis: An overall hypothesis is not appropriate, as many tasks are not research. However, individual hypotheses are formulated for each of the research-oriented sub-tasks.

This project addresses many CALFED and CVPIA goals, and science program priorities. Total cost for the proposed activities is $2,020,801 however, TNC is asking for $1,640,801. Should CALFED decide to fund this project, private cost-share funds will be applied to leverage CALFED expenditures. CALFED documents point out that naturalization of critical aspects of

the flow regime would aid the recovery of at-risk species and restore natural riparian habitats dependent on natural ecosystem processes that support at-risk species. (PSP SR-1 and SR-3, ERP Strategic Goals 1, 2, and 4). Specifically, this project assists in improving our understanding of processes responsible for maintenance of habitat for anadromous fish. Project work will lead to the development of flow recommendations and the creation of a tool to evaluate integration between anadromous fish and other species and habitat flow needs (AFRP Goal 1).

Form III - Environmental Compliance Checklist

1. **CEQA or NEPA Compliance**
a) Will this project require compliance with CEQA?
No

b) Will this project require compliance with NEPA?
No

c) If neither CEQA or NEPA compliance is required, please explain why compliance is not required for the actions in this project.
This project is not an implementation project. No on-the-ground actions will occur as a result of this project.

2. **If the project will require CEQA and/or NEPA compliance, identify the lead agency(ies).** *If not applicable, put "None".*
CEQA Lead Agency: None
NEPA Lead Agency (or co-lead:) None
NEPA Co-Lead Agency (if applicable): None

3. **Please check which type of CEQA/NEPA documentation is anticipated.**
CEQA
-Categorical Exemption
-Negative Declaration or Mitigated Negative Declaration
-EIR
Xnone

NEPA
-Categorical Exclusion
-Environmental Assessment/FONSI
-EIS
X none
If you anticipate relying on either the Categorical Exemption or Categorical Exclusion for this project, please specifically identify the exemption and/or exclusion that you believe covers this project.

4. **CEQA/NEPA Process**
a) Is the CEQA/NEPA process complete?
Not Applicable

b) If the CEQA/NEPA document has been completed, please list document name(s):

5. **Environmental Permitting and Approvals** (*If a permit is not required, leave both Required? and Obtained? check boxes blank.*)

LOCAL PERMITS AND APPROVALS
Conditional use permit
Variance
Subdivision Map Act
Grading Permit
General Plan Amendment
Specific Plan Approval
Rezone
Williamson Act Contract Cancellation
Other

STATE PERMITS AND APPROVALS
Scientific Collecting Permit
CESA Compliance: 2081
CESA Compliance: NCCP
1601/03
CWA 401 certification
Coastal Development Permit
Reclamation Board Approval
Notification of DPC or BCDC
Other

FEDERAL PERMITS AND APPROVALS
ESA Compliance Section 7 Consultation
ESA Compliance Section 10 Permit
Rivers and Harbors Act
CWA 404
Other

PERMISSION TO ACCESS PROPERTY
Permission to access city, county or other local agency land.
Agency Name:
Permission to access state land.
Agency Name:
Permission to access federal land.
Agency Name:
Permission to access private land.
Landowner Name:

6. **Comments.**

Form IV - Land Use Checklist

1. **Does the project involve land acquisition, either in fee or through a conservation easement?**
No

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

3. **Do the actions in the proposal involve physical changes in the land use?**
No
If you answered no to #3, explain what type of actions are involved in the proposal (i.e., research only, planning only).
Research only

4. **Comments.**

Form V - Conflict of Interest Checklist

Please list below the full names and organizations of all individuals in the following categories:

- Applicants listed in the proposal who wrote the proposal, will be performing the tasks listed in the proposal or who will benefit financially if the proposal is funded.

- Subcontractors listed in the proposal who will perform some tasks listed in the proposal and will benefit financially if the proposal is funded.

- Individuals not listed in the proposal who helped with proposal development, for example by reviewing drafts, or by providing critical suggestions or ideas contained within the proposal.

The information provided on this form will be used to select appropriate and unbiased reviewers for your proposal.

Applicant(s):
Mike Roberts, The Nature Conservancy
Gregory Golet, The Nature Conservancy
Frank Ligon, Stillwater Sciences
Yantao Cui , Stillwater Sciences
Bruce Orr, Stillwater Sciences
David Marmorek , ESSA Technologies, Ltd.
Calvin Peters, ESSA Technologies, Ltd.
Michael Scott, United States Geological Survey
Gregory Auble, United States Geological Survey
Jonathon Friedman, United States Geological Survey
Patrick Shafroth, United States Geological Survey
William Dietrich, U. C. Berkeley
G. Matt Kondolf, U. C. Berkeley

Subcontractor(s):
Are specific subcontractors identified in this proposal? Yes
If yes, please list the name(s) and organization(s):
Frank Ligon Stillwater Sciences
Dave Marmorek ESSA Technologies
Calvin Peters ESSA Technologies
Michael Scott USGS

Greg Auble USGS
Jonathon Friedman USGS
None None
None None
None None
None None

Helped with proposal development:
Are there persons who helped with proposal development?
Yes

If yes, please list the name(s) and organization(s):

Michael Fainter	Stillwater Sciences
Matt Kondolf	UC Berkeley
William Dietrich	UC Berkeley
Eric Larsen	UC Davis
Scott McBain	McBain and Trush, Inc.
Koll Buer	Department of Water Resources

Comments:

Form VI - Budget Summary

Please provide a detailed budget for each year of requested funds, indicating on the form whether the indirect costs are based on the Federal overhead rate, State overhead rate, or are independent of fund source.

Independent of fund source

Year 1												
Task No.	Task Description	Direct Labor Hours	Salary *(per year)*	Benefits *(per year)*	Travel	Supplies & Expendables	Services or Consultants	Equipment	Other Direct Costs	Total Direct Costs	Indirect Costs	**Total Cost**
1	Workshop and decision tool development	650	19,405	7,471	1,700	200	184,615	0	4,600	217,991	54,498	**272,489**
2	Targeted research	319	9,483	3,651	700	200	472,354	0	1,100	487,488	121,872	**609,360**
3	Quantitative modeling	72	2,141	824	0	0	36,906	0	0	39,871	9,968	**49,839**
4	Hypothesis development and experimental design	0	0	0	0	0	12,600	0	0	12,600	3,150	**15,750**
5	Outreach and presentation of results	0	0	0	0	0	0	0	0	0	0	**0**
Proj Mgmt		292	9,887	3,806	0	0	0	0	0	13,693	3,423	**17,117**
		1,333	**40,916**	**15,753**	**2,400**	**400**	**706,475**	**0**	**5,700**	**771,644**	**192,911**	**964,555**

Year 2												
Task No.	Task Description	Direct Labor Hours	Salary *(per year)*	Benefits *(per year)*	Travel	Supplies & Expendables	Services or Consultants	Equipment	Other Direct Costs	Total Direct Costs	Indirect Costs	**Total Cost**
1	Workshop and decision tool development	0	0	0	0	0	0	0	0	0	0	**0**
2	Targeted research	319	9,935	3,825	900	200	311,506	0	700	327,066	81,766	**408,832**
3	Quantitative modeling	66	2,081	801	0	0	129,981	0	0	132,863	33,216	**166,079**
4	Hypothesis development and experimental design	0	0	0	0	0	37,800	0	0	37,800	9,450	**47,250**
5	Outreach and presentation of results	0	0	0	0	0	0	0	0	0	0	**0**
Proj Mgmt		129	4,469	1,721	900	0	0	0	0	6,190	1,547	**7,737**
		514	**16,485**	**6,347**	**900**	**200**	**479,287**	**0**	**700**	**503,919**	**125,980**	**629,898**

Year 3												
Task No.	Task Description	Direct Labor Hours	Salary *(per year)*	Benefits *(per year)*	Travel	Supplies & Expendables	Services or Consultants	Equipment	Other Direct Costs	Total Direct Costs	Indirect Costs	**Total Cost**
1	Workshop and decision tool development	0	0	0	0	0	0	0	0	0	0	**0**
2	Targeted research	303	9,871	3,800	1000	200	194,131	0	200	209,202	52,301	**261,503**
3	Quantitative modeling	66	2,178	839	0	0	67,245	0	0	70,262	17,565	**87,827**
4	Hypothesis development and experimental design	72	2,141	824	0	0	12,611	0	0	15,576	3,894	**19,470**
5	Outreach and presentation of results	72	2,141	824	0	0	34,675	0	0	38,840	9,710	**48,550**
Proj Mgmt		145	5,197	2,001	1200	0	0	0	0	7,198	1,799	**8,997**
		658	**21,528**	**8,288**	**2,200**	**200**	**308,662**	**0**	**200**	**341,078**	**85,270**	**426,348**

Grand Total = Total cost for the proposed activities is $2,020,801 however, TNC is asking for $1,640,801.

Comments

Final selection panel review comments suggested reducing the cost of the project, yet other comments suggested expanding aspects of the work scope. Review of costs associated within individual tasks revealed reductions were not possible. In some cases, proposed costs increased to incorporate additional scope requested in review. TNC is seeking $1,640,801 from CALFED and $380,000 from a private source to cover total project costs. Should CALFED decide to fund this project, private cost-share funds will be applied to leverage CALFED expenditures. It is anticipated that private cost share funds would be in hand prior to a contract agreement with CALFED. Therefore, TNC is seeking only the remaining $1,640,801 from CALFED.

Although all subtasks within task #2 are consistent with CALFED goals and priorities stated in the Implementation plan, Ecosystem restoration plan, and Record of decision, CALFED could further reduce costs by eliminating individual field studies based on CALFED's priorities for information needs. Total funding for individual sub-tasks is as follows:
Task 2, Sub-task 1: Quantify and Refine the Relationship Between Flows and Sediment Transport: $146,100.
Task 2, Sub-task 2:Quantify Cottonwood Root Growth Rates: $149,890.
Task 2, Sub-task 3: Quantify Fluvial Geomorphic Processes that Create and Maintain Off-Channel Habitats: $97,250.
Task 2, Sub-task 4: Pilot Characterization of Channel Substrate Composition and Permeability: $71,400.
Task 2, Sub-task 5: Assess and Compare the Effects of Bank Protection on In-Channel Habitat Conditions: $138,451.
Task 2, Sub-task 6: Refine a Meander Migration Model: Incorporation of variable hydrograph interactions $75,000, and incorporation of non-linear version of fluid and flow equations, $75,000, for a subtask total of $150,000.
Task 2, Sub-task 7: Quantify Frequency and Spatial Extent of Cottonwood Recruitment: $224,900.

We also responded to the reviewer comments of a poorly justified budget through restructuring proposal tasks. We broke tasks down into more specific subtasks in order to convey the full range of activities and job duties associated with this complex proposal.

Form VII - Budget Justification

Direct Labor Hours. Provide estimated hours proposed for each individual.

Position Hours: Project Director II-193 hrs; Science Specialist II-262 hrs; Program Director I-192 hrs; Program Director I-1,118 hrs; Conservation Planner-305 hrs; Operations Manager-166 hrs; Program Assistant II-269hrs.

Salary. Provide estimated rate of compensation proposed for each individual.

Project Director II $48/hr; Science Specialist II $31/hr; Program Director I $36/hr; Conservation Planner $22/hr; Operations Manager $27/hr; Program Assistant II $17/hr.

Benefits. Provide the overall benefit rate applicable to each category of employee proposed in the project.

38.5% for all categories.

Travel. Provide purpose and estimate costs for all non-local travel.

Tasks within this proposal require a high degree of coordination. Staff will work closely with contractors who are located in Sacramento, Berkeley, and Davis, CA; Ft. Collins, CO; and British Columbia, Canada. Travel will also cover presentations of results to stakeholders, and conferences.

Supplies & Expendables. Indicate separately the amounts proposed for office, laboratory, computing, and field supplies.

Office: $400 Computing: $400

Services or Consultants. Identify the specific tasks for which these services would be used. Estimate amount of time required and the hourly or daily rate.

- ESSA is involved in Task 1. Their estimated time required is 244.5 days. Their estimated daily rate is $811.
- Stillwater Sciences and collaborators are involved in Tasks 1, 2, 3, and 4. Their estimated time is: Task 1: 1040 hrs, $94.4/hr Task 2: 6630 hrs, $102.3/hr Task 3: 750 hrs, $149.4/hr Task 4: 480 hrs, $105/hr.
- USGS is involved in Task 2. Their estimated time is 1100 hrs. and hourly rate is $204/hr.

Equipment. Identify non-expendable personal property having a useful life of more than one (1) year and an acquisition cost of more than $5,000 per unit. If fabrication of equipment is proposed, list parts and materials required for each, and show costs separately from the other items.

None

Project Management. Describe the specific costs associated with insuring accomplishment of a specific project, such as inspection of work in progress, validation of costs, report preparation, giving presentations, response to project specific questions and necessary costs directly associated with specific project oversight.

This proposal has complex project management responsibilities associated with the coordination of many collaborators and many tasks and sub-tasks. Staff will be involved in various aspects of project management including presentations, project and deliverable tracking, reporting, fieldwork coordination, and outreach of proposal products to numerous stakeholder groups.

Other Direct Costs. Provide any other direct costs not already covered.

Other direct costs include copying, photography, postage, and workshop costs.

Indirect Costs. Explain what is encompassed in the overhead rate (indirect costs). Overhead should include costs associated with general office requirements such as rent, phones, furniture, general office staff, etc., generally distributed by a predetermined percentage (or surcharge) of specific costs. *[CORRECTION: If overhead costs are different for State and Federal funds, note the different overhead rates and corresponding total requested funds on Form I - Project Information, Question 17a. On Form VI - Budget Summary, fill out one detailed budget for each year of requested funds, indicating on the form whether you are presenting the indirect costs based on the Federal overhead rate or State overhead rate. Our assumption is that line items other than indirect costs will remain the same whether funds come from State or Federal sources. If this assumption is not true for your budget, provide an explanation on the Budget Justification form.]* Agencies should include any internal costs associated with the management of project funds.

The Nature Conservancy (TNC) has a Negotiated Indirect Cost Rate (NICRA) of 25% that was negotiated and approved by TNC's cognizant agency, USAID, and calculated in compliance with the requirements of OMB Circular A-122. TNC's indirect cost per the NICRA includes salaries, fringe benefits, fees and charges, supplies and communication, travel, occupancy, and equipment for general and administrative regional and home office staff. These costs are reflected in the Indirect Costs category of this proposal and are not reflected anywhere else in the proposal budget. Direct staff costs are reflected in the salary and benefits categories of the proposal budget. Indirect costs are not assessed on the estimated cost to acquire any real property, which cost is included in other direct costs.

Proposal

The Nature Conservancy

Implementing a Collaborative Approach to Quantifying Ecosystem Flow Regime Needs for the Sacramento River

Mike Roberts, The Nature Conservancy
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Implementing a Collaborative Approach to Quantifying Ecosystem Flow Regime Needs for the Sacramento River

A. Project Description: Project Goals and Scope of Work

A1. Problem:

The alteration of river flow regimes associated with dam operations is identified as one of three leading causes, along with non-point source pollution and invasive species, of declines in imperiled aquatic ecosystems (Richter et al. 1997, Pringle et al. 2000). Many river-dependent plants and animals are strongly influenced by and have adapted to a river's natural variation in flow, and many riparian species possess traits that allow them to tolerate or exploit certain flow conditions. There is an emerging body of literature, which supports the interconnections between a river's flow regime and the species that have adapted to live within the riverine environment. Many of these concepts are investigated and summarized in Poff and Ward (1990), Resh et al. (1994), Poff et al. (1997), Rood et al. (1998), Mahoney and Rood (1998), Richter and Richter (2000), Richter et al. (2001, in review), Collier et al. (1996), Freedman et al. (1998), Stanford et al. (1996), Ligon et al. (1995).

CALFED's Draft Stage 1 Implementation Plan reflects this emerging science and specifies "human activities have fundamentally, and irreversibly, altered hydrologic processes in the Bay-Delta ecosystem" (p. 25), including the Sacramento River. In order to address this problem the CALFED Ecosystem Restoration Plan (ERP) Strategic Goal 2 includes restoring the variability of the flow regime and associated river processes, "as an important component of restoring ecological function and supporting native habitats and species in the Bay-Delta ecosystem". In addition, other water-related planning and conservation efforts seek to balance environmental and human water supply needs. Examples of these efforts include the Environmental Water Account (EWA), the Environmental Water Program (EWP), the Central Valley Project Improvement Act (CVPIA), the Anadromous Fish Restoration Plan (AFRP), the Integrated Storage Investigation (ISI), the North of Delta Off-stream Storage investigation (NODOS), the Water Management Strategy Evaluation Framework (WMSEF), and the Phase 8 resolution of the State Water Resources Control Board's current Bay-Delta Water Rights Hearings (Phase 8).

Despite recent attention to flow regimes within CALFED and other programs, there is little quantification of critical aspects of a natural flow regime for the Sacramento River. Current attention focuses only on a minimum in-stream flow and temperature requirements for a subset of fisheries. Quantification of additional aspects of the flow regime, which maintain the ecological function of riverine systems, would facilitate the formulation of the most effective water management and ecosystem restoration strategies. It may be unrealistic to expect to meet all ecosystem and human demands on a system as complex as the Sacramento River. However, an important first step is to develop a more complete understanding of the flow regime and its relation to natural processes and species' linkages, in order to identify the critical aspects of the flow regime necessary to maintain ecosystem function.

This project seeks to quantify key aspects of a "naturalized" flow regime that are compatible with flood damage reduction, agriculture, diversions, storage, and conveyance; it does not seek to return the system to its "pre-regulated" condition. Our project also does not attempt to identify how best to allocate Sacramento River water to meet human needs. Numerous efforts (some of which are discussed below) are addressing this topic, and we have no intention of duplicating these efforts. What our project does propose to accomplish, however, is to bring critical ecological information to these decision-making forums. In this spirit, we will work with stakeholder groups to fully utilize information from existing efforts.

Restoring, or "naturalizing", the most critical components of the flow regime is a proactive approach to avoiding future regulatory action by restoring or enhancing conditions that support at-risk species. Proactively addressing regulatory action is common ground shared by all stakeholders.

Project Location

The Sacramento River flows south along the boundary between the Klamath Mountains and the Cascade Range into the Sacramento Valley of California. The Sacramento River is California's largest river draining an area of 26,000 square miles with a mean annual discharge of 22 million acre feet. The Sacramento River typically supplies 80% of Delta in-flow and the hydrology is driven both by winter storms and spring snowmelt runoff[1]. The Sacramento River corridor captures a rich mosaic of aquatic habitat, oxbow lakes, sloughs, seasonal wetlands, riparian forests, and valley oak woodlands in what amounts to the most diverse and extensive river ecosystem in the state. Supporting numerous rare and declining species, this corridor hosts critical breeding areas for neo-tropical migrant birds as well as the largest remaining populations of anadromous fish in California.

The study area for this project is the river reach between the towns of Red Bluff and Colusa in Northern California (Figure #1). This area is described as reaches 2 and 3 in the Sacramento River Conservation Area Forum (SRCAF) Handbook (Sacramento River Advisory Council, 1998) and is a meandering reach with the channel flowing through recent alluvium (Buer, 1994). The lateral extent of the study area is a portion of the floodplain of the Sacramento River mainstem and a limited distance upstream on tributary confluences where appropriate. The exact lateral extent is unknown at this time because linkages between ecosystem components to be studied and flow regime aspects are also unknown. However, preliminary analysis indicates the extent will likely be similar to the Inner River Zone (IRZ) designation of the SRCAF. The IRZ contains much of the frequently flooded lands (within the 2.5 year return interval flood) and this is the floodplain area likely to contain the most ecological linkage to the flow regime. Although work under this project is coordinated with the SRCAF, the project's study area is not directly linked to the IRZ or the previous delineation of a Sacramento River Conservation Area (SRCA). Both the IRZ and SRCA are guidelines developed by the SRCAF to evaluate changes in land use. This project does not request funding for any land use changes or acquisition.

Project Goals and Objectives

The goals of this project are to:

1) Apply an interdisciplinary workshop approach to develop and communicate multi-species conservation flow regime recommendations, and evaluate and improve these draft results.
2) Reduce key scientific uncertainties, previously identified by CALFED, and improve our ability to effectively guide conservation efforts in the study area, through completion of focused research efforts, computer based quantitative modeling, and more qualitative modeling.
3) Demonstrate the utility of a decision analysis tool by working with CALFED to develop a number of test scenarios, and evaluate tradeoffs among ecological objectives.
4) Identify additional flow regime and ecosystem uncertainties and develop experiments and monitoring plans to address these in the future.

We conducted an extensive review of similar projects to formulate the research framework, which guides these goals and objectives. The most pertinent research framework for our study area originates in the ISI report titled "Flow regime requirements for habitat restoration along the Sacramento River between Colusa and Red Bluff" (Kondolf et al. 2000). This report

[1] For a detailed description of Sacramento River hydrology see 'Flow Regime Requirements for Habitat restoration along the Sacramento River between Red Bluff and Colusa' (Kondolf et al., 2000).

represents the first attempt to compile existing knowledge and to hypothesize and evaluate linkages between channel meander, stream flow, and a number of ecosystem components such as riparian forest regeneration. The report also specified the current, key scientific uncertainties.

A second set of pertinent studies informing the goals and objectives of this project are field studies authorized by the CVPIA. The CVPIA requires the determination of instream flow needs for anadromous fishes in the Central Valley.

This project also seeks compliment the above studies with a more thorough evaluation of linkages between ecosystem components and the flow regime identified in the existing report, while also evaluating additional linkages. The research framework for this project is to address those identified key uncertainties. Figure #2 is a conceptual model of ecological linkages to the flow regime of the Sacramento River within the project area.A more thorough investigation was proposed by the ISI authors but was limited by time and budgetary constraints.

Specific objectives of this project include:

1) Synthesize existing, interdisciplinary knowledge that addresses unknowns already identified during project development.
2) Provide information on ecological flow needs to other efforts seeking to balance ecosystem and human needs for river flow.
3) Develop a decision analysis tool to evaluate trade-offs among different ecological objectives.
4) Propose strategies to achieve multiple species conservation benefits.

Hypotheses relevant to this project are identified in section A3, Task 2, the section that describes proposed research activities. The nature of this project is such that it does not lend itself to one overall testable hypothesis.

A2. Justification:

Water-related planning and conservation efforts, mentioned in section ***A1***., are seeking to balance environmental and human water supply needs, and evaluate changes to the water management system in the Central Valley of California. Most of these efforts utilize "gaming", or some other decision analysis process, to evaluate changes to the water management system. However, most previous gaming exercises did not include ecosystem water needs beyond minimum in-stream flow requirements for certain fishes within the Bay-Delta.

For example, the EWP prioritization process considers only whether there are baseflow limitations for certain fish species within our project area and the neighboring tributaries. As a consequence, our project area is not currently included in the EWP, despite CALFED's recognition that there needs to be a better identification of ecological flow requirements for the Sacramento River.

Evaluating baseflow limitations is a valid first step to initiate the very complex process of an ecosystem flow needs assessment. However, many ecosystem components depend on flow characteristics other than baseflows (Figure #3). Without completing the work proposed in this project, many important ecosystem processes will remain vaguely defined, and hence excluded from consideration in restoration and management discussions that focus on the Sacramento River.

A number of recently developed approaches to stream flow analysis go beyond minimum in-stream flow needs and incorporate many ecosystem components (Poff et al., 1997). Tharme (*in draft*) provides a review of different types of flow assessment techniques, and documents the growing application of these more system-wide approaches throughout the world. Some examples of interdisciplinary, workshop-based approaches to assessing alternative flow management strategies include: Adaptive Environmental Assessment and Management (AEAM; Holling 1978, Walters 1986, Walters et al. 2000, Trinity River Restoration Program 2001), decision analysis (Peterman and Anderson 1999, Hammond et al. 1999, Alexander et al. 2001, 2002, Peters and Marmorek 2001, Marmorek and Parnell 2002), the "Building Block Method" (BBM; Tharme and King, 1998), Downstream Response to Imposed Flow Transformations (DRIFT; Brown et al., 2000), and Ecologically Sustainable Water Management (ESWM; Richter et al., 2001 *in review*). Several of these approaches can be combined. In the most effective form of AEAM, management experiments developed from modeling workshops are implemented to test clearly formulated hypotheses about important, but uncertain, components of a system. Decision analysis is a complementary, structured approach for focusing modeling efforts on decisions in the face of significant uncertainty and competing objectives, using models to project the outcomes of alternative actions (including adaptive management experiments).

Most recently and locally, a decision analysis process was applied to Clear Creek in Northern California to evaluate ecosystem stream flow needs, and add scientific rigor to the CALFED adaptive management approach. Clear Creek is an example of one of CALFED's adaptive management forums, initiated to develop tools transferable to other sites in the CALFED region. This process created a decision analysis tool, a computer program, which evaluates tradeoffs between ecological benefits and other considerations (power generation) when naturalized flow changes are proposed (Alexander et al. 2000).

A second local example of naturalizing aspects of the flow regime comes from work on the Trinity River in Northern California. Here, multiple species conservation objectives are met with a series of proposed hydrographs. These hydrographs attempt to restore key aspects of ecosystem function yet do not attempt to duplicate pre-regulation conditions (Figure #4). These hydrographs are also developed to consider changing water availability due to natural variability in snowpack, and human water demands.

While our original project highlighted the use of BBM and DRIFT, we have shifted the original approach in response to reviewer comments. This shift in approach will help us take advantage of a decision analysis tool developed through CALFED's adaptive management forums and applicable to other rivers in the CALFED Bay Delta region. This approach will allow us to leverage existing CALFED work. There is however, an important distinction between our proposed decision analysis tool and the Clear Creek example. We will not include an analysis of supply and demands of other uses such as power generation or agricultural use in our project. Early discussions with water-use-groups revealed that these investigations were already underway within the Integrated Storage Investigation. Additional efforts were perceived as being duplicative. Therefore, our decision analysis model will evaluate trade-offs between different ecological benefits that may be derived from flow alterations. This information will be supplied to relevant efforts evaluating supply and demand to more fully inform those efforts. In order to make the exercise the most useful, the form of output from the proposed efforts will be useable as input for other processes.

We also stressed a BBM and DRIFT approach because a workshop group, which has proven effective in other areas, did not exist for the Sacramento River. Since our original project submission, the NODOS Technical Advisory Group (TAG) was formed. The TAG is a multi-stakeholder group representing, and knowledgeable on, many perspectives of the Sacramento River. Although the group's primary focus is the completion of environmental documentation for a potential large diversion from the Sacramento River, the group will generate some type of information for evaluation of flow regime changes. Participants and the facilitator of the group now recognize the significant information gaps for such an evaluation and that timeline and funding constraints preclude addressing these gaps in the NODOS TAG process. These constraints also resulted in limited, or no, participation of specialists invited to participate in the process. Regardless, the TAG has initiated some data synthesis related activities. This information will be incorporated into this project work. The increased resources available through this project will facilitate participation of the larger group of specialists originally invited to the TAG and address many of the information gaps identified by the TAG. We have re-structured the project workshop series to best leverage current progress of the NODOS TAG, and to use modeling approaches which provide a more dynamic, integrative assessment of the ecological implications of different flow scenarios.

Reviewer comments stated that the level of public involvement reflected in the original proposal was not sufficient. We responded to these concerns by reformatting the workshop series to include significant additional outreach, and to utilize members of the existing NODOS TAG as workshop participants. Other reviewer comments stated the project was duplicative of or not aligned with existing efforts. CALFED assisted in holding a meeting to re-state the scope of the project to interested parties, and ensure coordination with various efforts. Meeting attendees included David Guy (Northern California Water Association), Van Tenny (Glenn Colusa Irrigation District), Mike Welsh (ACOE, Sacramento and San Joaquin River Basins Comprehensive study), Sean Sou (DWR), Rebecca Fris (CALFED), Mark Cowin (DWR) Stacy Cepello (DWR), Peter Yolles (TNC), Gwen Buchholz (CH2Mhill), Steve Roberts (DWR), and Mike Roberts (TNC). The meeting helped us to understand where proposal points needed clarification, in particular where stakeholders concerns were involved. Meeting attendees also helped us to verify that activities were complimentary and not duplicative.

Specifically, reviewers mentioned the project was duplicative of the ACOE Comprehensive Study's Ecosystem Function Model (EFM). During project development, the EFM was carefully reviewed. Original designs of the EFM specified inclusion of many more ecosystem relationships than the current version of the EFM contains. Components of this project work compliment the EFM by evaluating components that were "deferred" by the ACOE due to funding limitations. The ACOE Hydrologic Engineering Center (HEC) has produced a graphic user interface for the EFM and that work will be reviewed for this project to avoid duplication.

Project Type

This project is a targeted research project (as defined in the CALFED Implementation Plan), composed of five primary tasks.

Task 1 is designed as a series of professionally facilitated workshops, to synthesize existing information, build on NODOS TAG work, and evaluate and improve initial estimates of ecosystem flow requirements. We will use an inclusive and collaborative workshop setting to increase the level of understanding of scientific issues among a broad group of stakeholders, to provide input to our scientific team on stakeholders' ecological concerns and objectives, and to initiate development of the decision analysis tool. We originally proposed to develop flow regime objectives within stakeholder workshops. Our experience with a number of efforts over the last year reveals increased efficiency if workshop participants are supplied with draft materials prepared by scientists to review prior to workshops, outlining preliminary flow regime hypotheses and ecological objectives. These are then reviewed and discussed by stakeholders. A second addition to this task is the development of a workshop series for modelers, which will ensure that models produced under this project will be both well integrated with each other and capable of being linked to other existing models.

Task 2 will initiate 7 *field studies* to address critical data gaps that have been identified by teams of scientific and technical experts. For example, the "Flow Regime Requirements" report identifies "bed mobility experiments, bedload transport measurements, and bedload routing models" as critical data gaps. We propose field investigations that will focus on identifying and refining estimates of flows required to initiate important fluvial geomorphic processes such as sediment transport. By initiating these studies parallel with the Task 1 workshops, we will enhance the data set available to guide initial flow recommendations. Targeted research is justified for this section of our project because scientific experts have identified these critical data gaps (Kondolf et al. 2000).

Task 3 will involve application of a *computer model,* as a decision analysis tool, to simulate the linkages between stream flow and various ecological components. Ecological components will be captured as submodels and will include channel geometry, substrate composition, riparian vegetation response, benthic community response, and fish population responses, because these relationships are some of the best documented. While the channel geometry and substrate components will use an existing quantitative submodel, the other components may use either quantitative or qualitative modeling approaches (e.g. classification of different flow regimes according to their likelihood of achieving various ecological objectives) (Figure #5). The number of these additional, more qualitative submodels is unknown and will depend in part on the outcome of Tasks 1. Additional models could be developed contingent upon resources (i.e. if other subtasks cost less money than anticipated, or if the structure of such submodels is very simple). The model will also be used to evaluate interactions between flow regimes described in Task 1 and other restoration strategies (e.g. gravel augmentation).

Task 4 addresses additional uncertainties identified during previous tasks. *Testable hypotheses* will be generated to address the key uncertainties. Experiments, and proposed monitoring of those experiments, will be designed to provide data and an adaptive feedback loop, which will refine initial functional relationships defined in Task 1. Figure #6 depicts relationships among the four tasks.

Task 5 consists of two primary activities designed to disseminate information and communicate lessons learned. The first is a series of workshops that will communicate results of the project to stakeholders; and the second is the production of a final report that summarizes the outcomes of the overall project.

A3. Approach:

Task 1: Develop initial hypotheses of ecosystem flow requirements through workshops.

Task 1 consists of four sub-tasks: 1.1) an initial set of meetings with individual stakeholders to review the proposed process, solicit their concerns and initiate dialogue, as well as a scoping meeting of the scientific team; 1.2) a synthesis of existing information on the linkages between ecosystem response and stream flow (a State of the System (SOS) report); 1.3) a stakeholder workshop to present and review the SOS report, including a review of fundamental objectives for valued ecosystem components; and 1.4) technical meetings and a workshop to design an integrated ecological model that evaluates the impacts of alternative flow management actions on ecosystem components. The technical group involved in this task will consist in part of the same participants of the current NODOS TAG, supplemented by other specialists. In addition to the model design workshop, some technical meetings may be required to ensure that the integrated ecological model produced within this effort will be compatible with existing supply and demand models and avoid duplication. A field visit through the project area, potentially a float trip, will be conducted as part of task 1.3 to familiarize interested parties with the study setting if that is desired.

<u>Task 1, Sub-task 1: Initial Meetings.</u>

Meetings will be held to brief stakeholders on the proposed process by TNC (with support from ESSA and Stillwater Sciences), and to provide input and direction to the issues considered in the SOS report. It is important that key stakeholders are consulted and offered the opportunity to participate in the process. We will also solicit recommendations from stakeholders regarding who should participating in technical meetings. This will give stakeholder groups a greater level of trust in the products generated. The scientific team will then hold a scoping meeting to ensure that future tasks can respond to most of the issues raised by stakeholders.

Task 1, Sub-task 2: Synthesize Existing Data.

Existing information (e.g. geomorphology, aquatic ecology, fisheries) will be summarized by a panel of specialists into a "State of the System" (SOS) report in technical workshops as a foundation for the stakeholder workshop in Task 1.3. Currently, the NODOS TAG is compiling relevant information, which will form the foundation for the SOS report to avoid duplication of effort. The SOS report will also build on earlier work by Kondolf et al. (2000). It will be structured so that it can be read by non-technical participants, while still containing the detailed information of interest to specialists. It will (1) present an updated conceptual model of the system, (2) describe alternative hypotheses for how flow affects ecosystem components (including potential quantitative or qualitative submodels to represent these hypotheses), (3) highlight critical uncertainties, and (4) propose a draft set of ecosystem objectives and performance measures. Early in the process, a draft Table of Contents will be circulated to stakeholders to ensure that the report covers the issues of concern. Table 1 provides examples of desired expertise and existing information to incorporate into the SOS report. The list is not exhaustive and is representative of the process until funding allows further development.

Task 1, Sub-task 3: Stakeholder Workshop on State of the System Report

We will hold a facilitated 2.5 day stakeholder workshop at which specialists will communicate their initial hypotheses regarding flow regime and ecosystem linkages. Presentations will be designed in an effort to ensure they are intelligible to non-technical audiences. This workshop will start with a trip down the river, where scientists and stakeholders can discuss relevant information right in the relevant setting. This will be followed by a meeting room session for the exchange of information, at which results from the SOS report will be presented. In particular, participants will provide feedback on a draft set of objectives and performance measures for ecosystem components (e.g. channel, riparian, aquatic invertebrates, and fish). We will revise the SOS report based on feedback from the workshop.

Task 1, Sub-task 4; Scientific Workshop to Develop a Conceptual Design for Linked Models

This task will use technical meetings and a workshop to design an integrated decision analysis model that evaluates the impacts of different flow scenarios on selected ecosystem components. A variety of existing models will be considered for each ecological component, including elements of the Clear Creek Decision Analysis Model dealing with sediment transport (EASI, Appendix A), chinook salmon and riparian vegetation (CCDAM, Alexander et al. 2000), (see Figures 5 and 7), a meander migration model (Larsen 2001), and the EFM (ACOE, 2000). We will not design submodels, within the decision analysis tool, for reservoir management or agricultural use of water. However, the model will be structured so that it could be driven by existing flow management models (e.g. CALSIM, CALSIM II) dealing with issues of water supply and demand. The model could be used in other exercises to inform the set of performance measures that are used to evaluate alternatives. Technical meetings will be held to ensure that the integrated model can be easily linked in the future to other models (e.g. using flows at gage stations that are the output of CALSIM as an input to ecological modules). These meetings will also serve to make other forums aware of the field work and modeling undertaken in this project.

The technical meetings will establish the linkages among all submodels for different ecosystem components, ensure that possible submodel designs will be responsive to a wide range of flows and channel conditions, and confirm that they will produce performance measures of interest. Figure 7 shows an example conceptual design for the Clear Creek Decision Analysis Model. This design grew out of a 3-day workshop with structured identification of linkages through a "Looking Outward Exercise". In this exercise, specialists at first focused on what they needed to know about other submodels before designing the details of their own submodels.

These detailed designs will help to refine the fieldwork in Task 2 to ensure the right information is collected to build both the submodels and the associated variables that link them together. While at some point in the future it would be ideal to combine all submodels into one decision analysis tool, this may not be possible for logistical or institutional reasons. Some models (e.g. CALSIM) run at a much larger spatial scale (i.e. most of California), and it would be both awkward and unnecessary to incorporate it into a model for this stretch of the Sacramento River. Similarly, some entities may prefer to run their own models for particular ecosystem components. The process can accommodate both these situations. The key step is defining exactly what needs to be exchanged between submodels (units, time scale, spatial scale) to permit integration. Ideally, a hierarchy of models is established, where more detailed models at finer spatial and temporal scales provide summary indicators to larger scale models.

ESSA Technologies, Ltd. (ESSA) will function in a facilitation and coordination role for Task 1 as a sub-contractor to TNC. ESSA Technologies Ltd. has been running modeling workshops for over two decades, and is very experienced in facilitating scientists in this effort. Stillwater Sciences will provide technical support for the Task 1 as a sub-contractor to TNC for the workshop process, including helping ESSA with initial data compilation, taking the lead on drafting the SOS report, and assisting the workshop specialists with data analysis and synthesis as needed. TNC will assist in stakeholder involvement such as circulating outlines produced in Task #1 for collection of stakeholder input.

Task 2: Initiate field studies to reduce critical scientific uncertainties previously identified.

In 1999, CALFED's Integrated Storage Investigation commissioned a group of scientific and technical experts to define "Flow Regime Requirements for Habitat Restoration along the Sacramento River between Colusa and Red Bluff" (Kondolf et al. 2000). The experts identified several critical data gaps and scientific uncertainties that impede the process of identifying environmental flow needs for the mainstem Sacramento River. In Task 2, we propose a series of field studies within the study area to address several of these identified data gaps and scientific uncertainties. The proposed investigations will improve our understanding of the flows required to restore fundamental fluvial geomorphic processes on the mainstem Sacramento River, as well as the biological response of salmonids, riparian vegetation, and other ecosystem components to those fluvial geomorphic processes. The data from the proposed investigations will also feed into the workshops and model development proposed for Task 1, thereby strengthening the initial flow recommendations produced through the workshops. Task 2 includes the following 7 investigations: **(Refer to Table #2 for activities, outputs, outcomes, and environmental indicators for each investigation**).

<u>Task 2, Sub-task 1: Quantify and Refine the Relationship Between Flows and Sediment Transport.</u>

The hypothesis for this subtask is Sediment transport models used in restoration planning can predict the discharge that will mobilize the bed in different channel morphologies and at different positions on a cross section.

Streambed and bar mobility are important ecosystem processes, because they help maintain the quality of spawning habitat for salmonids; maintain invertebrate communities that support higher trophic levels; and create surfaces for riparian colonization. The "Flow Regime Requirements" report states that "restoring and/or maintaining the natural frequency of bed mobilization is a first priority." However, "little empirical information is available to estimate a threshold discharge for bed mobility. Future evaluation should focus on empirical methods to estimate bed mobility thresholds, supplemented with more detailed modeling approaches to predict bed mobility thresholds" (Kondolf et al., 2000). To help determine the flows required to initiate bed and bar mobility on the Sacramento River, we propose to place and monitor sediment tracers at several sampling sites within the study area. We will select sampling sites that reflect the variability in channel conditions—channel width and morphology, particle size distribution, slope, and bank conditions—that affect the flow required to initiate bed mobility. We will use the data generated by the tracer experiments to validate and calibrate a numerical model that predicts the flow required to initiate sediment mobility. This flow-sediment transport model has been applied to several Central Valley tributaries (see Appendix A for a description of the flow-sediment mobility model). Validating and calibrating the flow-sediment transport model for the study area will provide a tool for analyzing other segments of the river that are not sampled, thereby allowing predictions of bed mobility without the time and expense of additional tracer experiments. Because the model predicts rates of gravel transport, it can also be used to assess the necessary gravel supply and the changes in the size distribution of the bed for different flow regimes.

Task 2, Sub-task 2:Quantify Cottonwood Root Growth Rates.

The hypothesis for this subtask is that cottonwood maximum root growth rates of 1 to 2.5 cm/day reported in the literature are applicable to cottonwood seedlings recruiting naturally along the Sacramento River, regardless of local variability in hydrology and substrate.

The "Flow Regime Requirement" report (Kondolf et al. 2000) identifies cottonwood root growth rates as a scientific uncertainty. While there are estimates of root growth rates established in the scientific literature (Mahoney and Rood, 1998), the published rates do not necessarily apply to the highly variable hydrologic conditions of the Sacramento River basin. Developing a better understanding of cottonwood root growth rates will help refine the water ramping rates required to support cottonwood seedling and sapling survival. Fluctuations of water surface elevation that are too rapid can cause groundwater tables to drop faster than seedlings can grow longer roots, resulting in the potential loss of an entire cohort. However, ramping rates that decrease slower than necessary may utilize more water than necessary and exacerbate conflict between environmental restoration and water supply reliability. To better quantify cottonwood root growth rates, we propose to excavate seedlings representing different age classes from selected point bars within the study reach. To correlate root growth with fluctuations in ground water elevations, we will install piezometers at sampling sites. To correlate root growth with channel bed material, we will collect and analyze bulk samples of sediment at sampling sites.

Task 2, Sub-task 3: Quantify Fluvial Geomorphic Processes that Create and Maintain Off-Channel Habitats.

The hypothesis for this subtask is that the likelihood of a meander cut-off can be predicted based on various attributes of channel planform, bank and floodplain characteristics, and hydraulic conditions during high flows.

The Sacramento River basin contains remnants of a rich mosaic of habitat types, such as oxbow lakes and side-channel habitats. These off-channel habitats are important for supporting multiple native species and species assemblages. The creation and maintenance of these off-channel habitats is driven by fluvial geomorphic processes such as channel migration and meander cutoff however, there is a relatively poor mechanistic understanding of the processes necessary to initiate meander cutoff. We propose to analyze historical aerial photos and maps of the study area to identify historical meander cutoffs and better understand the conditions related to meander cutoff. For each meander cutoff identified in the historical photo set, we will develop a case study to quantify and describe the conditions resulting in meander cutoff. Each case study will include an analysis of historical discharge records and aerial photos, and interviews with local landowners and technical experts to detect evidence of floodplain scour that preceded or initiated a meander cutoff; identify the flow that initiated or completed the meander cutoff; measure the radius of curvature of meander bends prior to cutoff; analyze the radius of curvature of meander bends relative to the vector of main flow/thalweg; assess floodplain vegetation and roughness, and bank conditions; describe human activities that may have caused or contributed to meander cutoff. This case study approach will provide the data necessary to develop an analytical tool to predict formation of oxbows and the consequent conservation of multiple native species and species assemblages associated with oxbows.

Task 2, Sub-task 4: Pilot Characterization of Channel Substrate Composition and Permeability.

This subtask involves a characterization of particle size distribution, therefore no hypothesis will be tested for this subtask.

The particle size distribution of sediment influences habitat quality for a number of species. For example, excessive fine sediment can reduce salmonid egg survival and depress the production of aquatic macroinvertebrates. To assess gravel conditions for salmonids and invertebrates (an important food source for juvenile salmonids), we propose to collect and analyze bulk samples and to measure channel bed permeability and dissolved oxygen at selected sites within the study area. Selected sites will encompass both spawning areas and potential rearing areas. Because redd excavation can clean gravels of finer sediment, some of the sample sites will include areas where there is no spawning, as control sites.

Task 2, Sub-task 5: Assess and Compare the Effects of Bank Protection on In-Channel Habitat Conditions.

The hypothesis for this subtask is that bank protection alters habitat quantity and quality for aquatic plants, invertebrates, and fish.

Geomorphic processes control the quantity, quality, and distribution of the in-channel habitats necessary to support numerous sensitive species that CALFED has committed to recover. Much of the study reach is bounded by bank protection, which can affect local hydraulics and resultant habitat conditions. There is a poor understanding of how bank protection affects in-channel habitat conditions. We propose to analyze and compare habitat conditions and complexity at study sites both with and without bank protection. The analysis will include three-dimensional mapping of channel morphology at protected and unprotected sites in the study area. Measures of habitat quality will be defined by the different life history stage requirements of a number of different species or guilds, including salmonids, centrarchids, and amphibians. Using the defined measures of habitat quality, we will compare in-channel habitat at the protected and unprotected sites.

Task 2, Sub-task 6: Refine a Meander Migration Model.

The hypothesis for this subtask is that incorporation of variable hydrology and non-linear effects will improve the performance of the Sacramento River meander migration model.

A number of ecosystem components (e.g. riparian vegetation, newly formed floodplain, bar habitat) are dependent upon complex interactions among ecological, geomorphic, and hydraulic processes, including river meandering. Researchers at UC Davis have calibrated a predictive meander migration model for a number of sites on the Sacramento River (Larsen, 2001), in order to inform long-term management strategies of these ecosystem components. The model also evaluates channel response to changes in bank protection infrastructure. The model is based on work by Johannesson and Parker (1989) and calculates channel migration using a simplified form of the governing equations for fluid flow and sediment transport. The model's current form predicts meander migration as a function of a single representative, geomorphically effective discharge. Peer reviewers of the current model identified capturing variable hydrograph effects on migration rates as an important next step, particularly for application to the Sacramento River. In addition, recent research (Imran et al. 1999) that utilized a similar version of this model demonstrated that an important next step is to capture non-linear effects currently ignored by the model, which is based on linearized governing equations. Both improvements represent a more accurate depiction of system function and greater utility as a management tool on the Sacramento River. Funding under this project will develop these improvements to the model and the improved model will be used to evaluate ecosystem response to restoration strategies. Dr. Eric Larsen, Dr. Gary Parker, and Jassim Imran have agreed to collaborate on the model's improvement dependent on funding availability.

Task 2, Sub-task 7: Quantify Frequency and Spatial Extent of Cottonwood Recruitment.

The hypothesis for this subtask is that a retrospective analysis of established cottonwood stands, using tree coring and excavation to establish age and elevation of seedling establishment, can be used to test and calibrate the "recruitment box model" (Mahoney and Rood 1998) for application to point bar sites along the Sacramento River.

The second hypothesis for this subtask is that a retrospective analysis will show that some stands have established via alternative pathways related to meander cutoffs and filling of oxbow lakes to create conditions suitable for recruitment of cottonwood cohorts, and that alternative pathways will create predictably different temporal and spatial patterns of recruitment.

There is uncertainty about which combinations of flow and geomorphic processes have produced successful cottonwood recruitment under both "pre-regulated" and current flow regimes within the project area on the Sacramento River. Improved understanding of controlling factors is critical to formulating ecologically effective "naturalized" flow regimes. Functional relationships between streamflow, channel change, and the recruitment of riparian cottonwood will be quantified by determining ages and topographic positions of existing stands in conjunction with historical flow records and channel locations. Stand mapping and intensive sampling will be conducted at four 2-3 km long reaches (approximately 2-3 km wide) within the study area. This information will yield an understanding of current and historic cottonwood population dynamics on the Sacramento River

Stillwater Sciences, Inc. and senior researchers from the United States Geological Service (USGS; G. Auble, J. Friedman, M. Scott, and P. Shafroth) will conduct and coordinate activities under Task 2 as sub-contractors. Other researchers such as G. Mathias Kondolf, William Dietrich, and Eric Larsen will subcontract to Stillwater Sciences and collaborate on targeted research tasks.

Task 3: Build and apply an integrated decision analysis model to evaluate the outcomes of example flow scenarios against objectives for different ecosystem components.

Task 3 will combine the results of the fieldwork in Task 2 with the model design in Task 1 to produce an integrated decision analysis model to evaluate example flow scenarios. It consists of four subtasks: 3.1) Development of a flow-sediment transport model; 3.2) Development of submodels for other parts of the ecosystem, including riparian, benthic and fish components; 3.3) Solicit ideas from CALFED for three illustrative flow and channel scenarios; 3.4) Evaluation of the ecological outcomes and tradeoffs for these three illustrative scenarios.

Task 3, Sub-task 1: Development of a Flow-Sediment Transport Model.

The State of the System report in Task 1 will identify or bracket the flows required to restore fluvial geomorphic processes under current channel conditions (current channel-floodplain morphology, particle size distribution, bank conditions, etc.). In Task 3.1, we propose to conduct numerical modeling to predict the flows required to restore fluvial geomorphic processes for a range of hypothesized channel conditions, simulating the application of complementary restoration strategies (e.g. alterations to gravel supply, levee re-alignment or removal where stakeholders support such actions). For example, the Task 1 workshops will suggest a flow necessary for achieving bed mobilization, assuming current channel and sediment conditions in the Sacramento River. We propose to apply a flow-sediment transport model that estimates the flows required to mobilize a range of sediment particle sizes, allowing the simulation of gravel augmentation as a complementary restoration strategy. Workshop participants can thus examine alternative restoration strategies.

Task 3, Sub-task 2: Development of Computer Submodels for Other Ecological Components.

The intent of this task is to develop the simple quantitative or qualitative submodels that were designed in Task 1.4, and integrate these into a decision analysis framework. The decision analysis framework will generate outcomes for both alternative flows and alternative hypotheses for critical (but uncertain) processes. The structure of these models will be developed in Task 1.4, and refined with the results of fieldwork in Task 2. It will be similar to the structure of the Clear Creek Decision Analysis Model (CCDAM) with the key differences already discussed (Figure 7).

Task 3, Sub-task 3: Solicit Ideas from CALFED for Three Illustrative Flow and Channel Scenarios.

We will hold two technical meetings with CALFED representatives to identify three illustrative scenarios to apply the decision analysis model. Each scenario would consider both changes in channel conditions as well as the range of expected flows under alternative restoration strategies.

Task 3, Sub-task 4: Evaluate the Ecological Outcomes and Tradeoffs for the Example Flow and Channel Scenarios.

We will run the model for a number of water years under the different scenarios, and generate performance measures for each of the ecological components. These scenarios would be rerun with alternative hypotheses for critical uncertainties. We will then assess and illustrate tradeoffs among different ecological components, and assess how the remaining uncertainties affect flow management decisions. These results will be integrated into a series of flow recommendations, including adaptive management experiments.

Task 4: Hypothesis development and design of future water-related experiments and monitoring plans.

Task 4 will focus on developing active adaptive management opportunities within the study area and producing a final report.

The workshops and data synthesis, analysis, and archival conducted as part of Task 1, and the quantitative modeling conducted as part of Task 3, will produce initial flow recommendations using the decision analysis tool. These flow recommendations are based on available data and current professional understanding of geomorphic and ecological processes in the Sacramento River. Though we expect to make considerable progress on reducing key uncertainties, some aspects of these flow recommendations may still depend heavily on untested assumptions, or be based on poorly understood processes. This project does not address all of the unknowns identified in the Flow Regime White Paper, or all of the components that were deferred in the EFM. Therefore, Task 4 will generate testable hypotheses to address the remaining key uncertainties and then design experiments that will provide data that will feed back into the integrated decision model and refine the initial flow recommendations. To facilitate timely implementation of experiments, we propose to work with the workshop participants (of Task 1) to develop study plans and to design high-priority experiments.

Task 5: Stakeholder workshops for final presentation.

Final results of the associated field studies and application of the decision analysis tool will be presented in a number of workshops. We will seek to ensure that the results of all of the above efforts are conveyed to the stakeholder audience. We will also seek to demonstrate the utility of the approaches and tools built within this project, and distribute the results to relevant efforts that may benefit from the findings.

A4. Feasibility:

Bridging the gap between longer timeframes to complete all necessary scientific studies and the shorter timeframes that often drive management is a challenge. The best management actions are fully informed by all the necessary studies however, delaying management for study completion may be impractical. In addition, declining species populations may demand more immediate efforts.

This project offers a feasible approach by addressing both time frames. Task 1 provides initial answers in the short term (1 year) based on existing data, and provides a mechanism to involve and develop buy-in among all stakeholders into potential solutions. Integrated models will be designed that use quantitative and qualitative metrics to assess the ability of different flow regimes and associated actions (e.g. gravel augmentation) to meet a set of ecological objectives jointly defined by stakeholders and scientists, and evaluate tradeoffs among these objectives. These methods have been applied successfully in British Columbia and Colorado, and more locally in Clear Creek and the Trinity River (references in section A2 above). Materials from these approaches and others will be used as guides. Where the approach is less transferable, it will be altered to fit the specific situation of the Sacramento River.

Results of this project approach will inform numerous CALFED and other system wide efforts, which are operating under relatively short time frames, such as the Environmental Water Account, the Environmental Water Program, the Integrated Storage Investigation, the Off-stream Storage Investigation, and the Phase 8 Settlement Agreement. We seek to develop initial hypotheses through Task 1, while initiating longer-term studies to better inform shorter timeline processes.

Tasks 2, 3, and 4 address the scientific uncertainty of Task 1, without precluding development of initial results. Tasks 2, 3, and 4 seek to improve the caliber of information, which has informed other river restoration efforts such as the Trinity River restoration plan. The formulation of the Trinity River plan was based on 10 years of research. Formulating balanced river flow strategies on the Sacramento River may take as long. However, we seek to inform decision points for water management, likely to occur prior to 10 years in the future, with initial investigations into ecosystem flow needs.

Task 1 activities are relatively independent of season or field conditions and therefore these have little chance of precluding completion. Directed research within Task 2 is more dependent of field conditions and season. However, the project includes two field seasons, which should be sufficient to complete necessary fieldwork. Special use permits and access permits will be acquired for field data collection from the United States Fish and Wildlife Service (USFWS) and the Department of Fish and Game, respectively. All work will take place on public land or on land owned by The Nature Conservancy. Permission for site access from public land management agencies is anticipated and will be gained before data collection activities occur on these properties.

A5. Performance Measures:

Refer to Table #2 for project activities, outputs, outcomes, and environmental indicators by task. Implementation of flow regime changes on the Sacramento River for ecosystem benefit are not a part of this project. Therefore it is not possible to measure the performance of a flow change in meeting an ecological goal. However, the baseline condition for each of the field tasks described in the project is scientific uncertainty. The successful performance measure for each task is completion of the task and the reduction of scientific uncertainty with additional data. We use the above performance measures as surrogates, in the absence of actually implementing flow changes. Numerous stakeholder review and input opportunities are structured into the project for evaluation of the completion of tasks. Task 5 was specifically included to ensure communication and distribution of the results of the proposed work to the appropriate interested groups (Environmental Water Program steering committee, or the NODOS TAG) Measuring the performance of Tasks 2, 3, and 4 results will also relate to the applicability of these tasks' outcomes to further inform the Task 1 activities as an adaptive management loop.

A6. Data Handling and Storage:

ESSA will record and organize all hypotheses and data associated with the decision analysis model. This will include field data used for model inputs or functional relationships, as well as model parameters that are derived from the literature or professional judgement. Stillwater Sciences will develop a database, which catalogues data generated from the field studies.

A7. Expected Products/Outcomes:

Table 2 provides a summary of project activities, outputs, outcomes, and environmental indicators by task. Outcomes of this project will also be presented at a future conference focused on CALFED science. Originally, we proposed presenting results to a technical review workshop specifically for the Sacramento River, which the CALFED science board has suggested it will fund and assist in organizing. A committee has recently decided not to separate Sacramento River science from other projects. It is unknown at this time whether CALFED will assist in formulation of such a group. Therefore, results will be presented at whatever science forum CALFED continues to maintain, such as a CALFED science conference.

Most importantly, we see this project advancing the CALFED goals and strategies, and reducing uncertainty related to one of the most key aspects of river restoration, the flow regime. The SRCA "Handbook" presents a set of principles and guidelines, developed by many stakeholders, for restoration of the Sacramento River ecosystem. The SRCAF decided early on to exclude flow-related issues. However, references within the CALFED documents point out the importance of working on flow related issues. The outcomes of this project provide California with a *proactive* approach to dealing with flow issues developing elsewhere.

A8. Work Schedule:

See Table #3

Regional reviewers suggested a re-evaluation, and further justification of costs. Upon re-evaluation, proposed costs have increased to accommodate requested additions to the workscope. Also, tasks were further broken down into sub-tasks and associated costs were reallocated to clarify and justify budget expenditures.

<u>Partial Funding:</u>

If partial funding is preferred by CALFED, we suggest that individual subtasks within Task #2 be removed. CALFED can decide which subtasks are lower information priorities to meet ERP goals. Individual subtask removal is preferable over partial funding of other tasks.. Tasks #1 through #5 are very interrelated and interdependent, and work quality would suffer more from removing these tasks as opposed to partially funding Task #2.

B. Applicability to CALFED ERP and Science Program Goals and Implementation Plan and CVPIA Priorities.

B1. ERP, Science Program, and CVPIA Priorities:

The primary focus of The Nature Conservancy's Sacramento River Project is to "**develop and implement management and restoration actions in collaboration with local groups such as the Sacramento River Conservation Area Non-Profit Organization.**" (SR-1).

Individual components of The Nature Conservancy's Sacramento River project address many of CALFED's Implementation Plan goals and CVPIA priorities (PSP Sacramento Region Priorities 1, 3, 4, 7, ERP Goals 1, 2, 4, 6, Key CALFED Science Program Goals and CVPIA Goals). (See Section B5 for programmatic structure and coordination with other TNC Sacramento River projects.)

This project, *Implementing a Collaborative Approach to Quantifying Ecosystem Flow Regime Needs for the Sacramento River*, addresses a subset of the above CALFED and CVPIA goals, and science program priorities. It is projected that "naturalization" of critical aspects of the flow regime would aid the recovery of at-risk species and restore natural riparian habitats that support at-risk species. (PSP SR-1 and SR-3, ERP Strategic Goals 1 and 4). Mimicking aspects of a "natural" flow regime is likely the most effective means of rehabilitating aquatic and associated terrestrial biotic communities and habitats dependent on natural ecosystem processes (ERP Strategic Goal 2). With the simulation of aspects of a more "natural" flow regime self-sustaining populations of native species will likely be favored over exotic species (ERP Strategic Goals 4 and 5). Specifically, this project sets the stage to improve habitat for all life stages of anadromous fish by proposing the development of flow recommendations and the creation of a process to evaluate how flows meeting anadromous fish needs could be integrated with other species and habitat needs (AFRP Goal 1). Title 34, Section 3406(b)(1)(B) of the CVPIA requires determination of instream flow needs for anadromous fish in the Central Valley. Studies proposed here are complimentary to these ongoing efforts.

This project explicitly addressees the Draft Stage 1 Implementation Plan Strategic Goal 2, which states "Research, monitoring, and implementation projects designed to develop a better understanding of geomorphic flow thresholds and hydrologic-biologic relationships will facilitate estimating environmental flow needs, so that environmental dedications of water are effective and efficient in achieving restoration objectives, thereby minimizing potential effects on water supply and hydropower generation." (pg. 27).

Work under this project also advances broad CALFED science program priorities. Task 1 first *takes advantage of existing data*. Flow regime and ecosystem response data is synthesized into a database, which can be queried for ecosystem response to any number of flow regime changes. This exercise functions as an *adaptive management experiment framework*, which can *advance a process understanding*, *compare relative effectiveness of different restoration strategies*, and assist the *development of population models for at-risk species*. All stakeholders participate in Task 1 workshops to synthesize existing information, which ensures *societal issues related to restoration are incorporated* and future needs are identified. Task 2 develops new information to continually inform the process. Development and incorporation of this new knowledge *advances a process understanding*, and *advances the scientific basis of regulatory actions*. Once flow recommendations are developed, their integration with many other demands can be evaluated to *understand the intertwined implications of all CALFED program actions*.

B2. Relationship to Other Ecosystem Restoration Projects:

The Nature Conservancy's Sacramento River project is part of a collaboration of public and private partners whose goal is to establish a riparian corridor within approximately 30,000 acres of the Sacramento River Conservation Area (SRCA). Over the last decade a number of projects within this partnership have worked together with local governments and organizations to protect and restore habitat and establish a limited meander along the Sacramento River between Red Bluff and Colusa. This partnership is formalized under a Memorandum of Agreement with project activities coordinated through the SRCA non-profit. Projects and organizations working in partnership toward this goal include the U. S. Fish and Wildlife Service's Sacramento River Refuge, California Department of Fish and Game, Department of Parks and Recreation, Department of Water Resources, CALFED, CVPIA, Sacramento and San Joaquin River Basins Comprehensive Study (Comp. Study), Riparian Habitat Joint Venture, Sacramento River Preservation Trust, and Sacramento River Partners. Others who support these efforts include the Wildlife Conservation Board, Environmental Protection Agency, and many private foundations and individuals.

This project is structured to foster coordination with other ongoing investigations within the ISI. These investigations are evaluating large-scale alterations to the water management infrastructure such as additional off-stream storage.

In addition, this project is directly related to cultivated restoration efforts to re-vegetate the Sacramento River floodplain. We assume cultivated restoration significantly increases habitat value on the floodplain as evident by listed species now inhabiting restoration sites. However, cultivated restoration does not replace habitat created by natural river process. It is also unknown whether current cultivated restoration strategies are maximizing ecosystem benefit and function. This broader question is the focus of a separate but coordinated project submitted by TNC's Sacramento River project in this CALFED PSP round. Therefore, it is necessary to evaluate how alterations to the flow regime would both create new natural habitat and expose restoration sites to river processes, which may enhance their ecological function. Many current restoration sites were leveled during previous agricultural practices. Field observation demonstrates that flooding of restoration sites increases topographic diversity and deposits large wood debris. Both results serve to add habitat complexity to the original planting design.

Other studies and data sources informing this project include an Indicators of Hydrologic Alteration analysis summarizing statistical differences among 32 flow characteristics (Pike 2000), a meander migration model (Larsen, 1995), a pilot study of recruitment limitations of riparian vegetation on the Sacramento River (TNC 2001), a summary of various geomorphic conditions in the project area provided in Buer (1994), a NSF Bio-complexity incubation project applied for by Karen Holl (UC Santa Cruz) and funded by an NSF grant, topographic data and potentially hydraulic modeling developed for the Comp. Study, a dissertation describing the nature of channel change correlating with changes in vegetation communities (Greco, 1999), and an Integrated Storage Investigation Report titled " Flow regime requirements for habitat restoration along the Sacramento River between Colusa and Red Bluff" (Kondolf et al. 2000).

B3. Requests for Next Phase Funding:

This funding request is not directed at the next phase of a previous CALFED grant. However, it represents the evolution of restoration on the Sacramento River, complimenting cultivated restoration with an evaluation of ecosystem effects of flow regime alterations. This effort will utilize products funded with previous CALFED grants awarded to The Nature Conservancy's Sacramento River project, which lead to a long-term management framework. This project leverages expenditures on the products which include: a pilot study investigating cottonwood recruitment limitations, two-dimensional hydraulic modeling, a geo-technical investigation, one-dimensional hydraulic modeling, meander migration modeling, ortho-rectified 1999 aerial photography and vegetation community mapping, results of a multi-disciplinary study evaluating riparian vegetation succession trajectories, further calibration of a cottonwood recruitment model, point bar sedimentology data, salmonid use of different habitats, and a benthic macroinvertebrate investigation. This project builds on information gathered during projects previously funded under CALFED grants, and incorporates the data into a decision analysis tool. Incorporation of existing study information represents a savings to this project of approximately $600,000.

B4. Previous Recipients of CALFED Program or CVPIA funding:

To date, The Nature Conservancy's Sacramento River Project (TNC) has been awarded 5 CALFED and 4 CVPIA grants to further the goals of protection and restoration within the Sacramento River Conservation Area. Two grants focused on restoration planning, and the remaining 7 grants have been used to plan and implement protection and restoration actions on approximately 3,114 acres. Project titles and numbers, specific accomplishments, and progress to date are summarized in Table #4.

B5. System-Wide Ecosystem Benefits:

TNC's Sacramento River Project is working with public agencies and private organizations to restore a riparian corridor and limited river meander within the Sacramento River Conservation Area between Red Bluff and Colusa, CA. Four programmatic phases comprise TNC's Sacramento River Project synergistic approach to conservation implementation in an adaptive management framework (Figure #8):

-integrated floodplain management planning,
-habitat acquisition and baseline assessment,
-horticultural and process restoration, and
-ecosystem response monitoring and research.

TNC projects submitted in response to the ERP represent efforts to expand our project in each of these four programmatic directions. In addition to coordinating our efforts internally, we have worked to ensure that all proposed work complements the extensive restoration activities already underway on the Sacramento River and elsewhere.

By nature, this project offers system-wide benefit by addressing a primary controlling factor of riverine systems, the flow regime, as depicted in Figure #2. Examples of these benefits include improved aquatic and terrestrial habitats, improved ecological function, restoring the viability of native species, and reducing the proliferation and adverse impacts of non-native invasives.

This project was structured after reviewing other efforts seeking to formulate "naturalized" flow regimes to avoid duplication of effort, ensure complimentary work, and facilitate exchange of information. Some examples of work reviewed include the Natural Heritage Institute (NHI) San Joaquin Flow project funded by CALFED in 1999, the San Joaquin vegetation response model, the Clear Creek Decision Analysis Model, Trinity River maintenance flow documents, the Tuolumne River Corridor restoration material, the Sacramento River Biocomplexity group efforts, initial Sub-reach planning investigations, and the work of a number of other researchers including Eric Larsen (associate professor, U.C. Davis), Steve Greco (associate professor, U.C. Davis), and Michael Singer (doctoral candidate, U.C. Santa Barbara).

We have coordinated with other researchers including Michael Singer and Tom Dunne, Matt Kondolf, John Stella (Stillwater Sciences), and John Baer (McBain and Trush) who are submitting related projects to this PSP. If multiple, related projects are funded, the researchers have committed to conducting work in a coordinated and compatible manner to ensure that the greatest degree of system-wide benefit is achieved. Michael Singer and Tom Dunne's sediment transport modeling project is closely related and complimentary to sediment transport modeling proposed in task #3. Task #3 modeling is intensive reach-scale analyses that will help calibrate Singer and Dunne's broader-scale analysis of the whole mainstem Sacramento River. Task #3 includes the use tracer particles along tightly spaced cross sections to verify or refine the calculation of the initiation of bed material motion at selected reaches and required for initiating meander migration.

This project is also related to a NHI project to develop information ranking geomorphic restoration potential of different tributaries related to conjunctive use. The Sacramento main stem already passes basic criteria in the NHI project for geomorphic restoration potential and serves as a pilot for evaluation of additional ecological linkages to flow regime components. The project also benefits from concepts developed by Stillwater Sciences to formulate ecosystem flow regime needs for different tributary types. Tasks 2, 3, and 4 of this project are fashioned after the Stillwater concepts developed to inform the Environmental Water Program. Work under this project also provides complimentary information to other local efforts including the ACOE Comprehensive Study's EFM, and various ISI and OSI studies.

B6. Land Acquisition:

This project contains no land acquisition activities.

C. Qualifications

The project will be conducted under the guidance and management of The Nature Conservancy's Sacramento River Project.

The Nature Conservancy. The Nature Conservancy is an international non-profit corporation; our mission is to preserve the plants, animals, and natural communities that represent the diversity of life on Earth by protecting the lands and waters they need to survive. Founded in 1951, The Nature Conservancy and its one million members have safeguarded more than 11.6 million acres in the United States. The Nature Conservancy's California program, headquartered in San Francisco, has 110,000 members and has protected nearly one million acres in the state.

The Nature Conservancy employs an integrated conservation framework called "Conservation By Design to fulfill its long-term vision and achieve its goals. Conservation by Design directs the organization to systematically identify the array of places around the globe that embrace the full spectrum of the Earth's natural diversity; to develop the most effective strategies to achieve tangible, lasting results; and to work collaboratively to catalyze action at a scale great enough to ensure the survival of entire ecosystems. (Conservation by Design, 2001)

Our strength and reputation are built on the policy and practice of applying the best conservation science available and of building partnerships to achieve mutual conservation goals. We respect the needs of local communities by pursuing strategies that conserve biological diversity while at the same time enabling humans to live productively and sustainably on the landscape. We know that lasting conservation success requires the active involvement of individuals from diverse backgrounds and beliefs, and we value the participation of individuals in the conservation of their communities and environments.

The Nature Conservancy's Sacramento River Project. Headquartered in Chico, California for more than ten years, The Sacramento River Project has proven track record, having helped protected more than 18,000 acres of riparian land within the Sacramento River Conservation Area, and having restored more than 2,800 of marginal agricultural land along the Sacramento River to riparian habitats. The Sacramento River Project is organized into teams focused on planning, science, restoration, acquisition, government relations and outreach, and administration. Legal, finance, and government contracting are overseen by TNC's regional office in San Francisco.

Overall project management is the responsibility of TNC's Sacramento River Project Director, Dawit Zeleke. Dr. Greg Golet, Project Ecologist; manages the planning, science, and restoration teams. The project lead for this project is Mike Roberts.

Mike Roberts has worked in the natural resource management field for 13 years, including 10 years of evaluation and restoration of aquatic and riverine ecosystems. His experience includes work on a number of California, Idaho, and Utah rivers, ranging from large alluvial rivers to small mountain streams, and eastern aquatic and wetland systems. The focus of his Master's degree at Utah State University was geomorphic and hydrologic influences on riparian ecosystems. For the last three years, he has applied a foundation of hydrology and geomorphology to large-scale restoration planning and integrated floodplain management on the Sacramento River in California.

Gregory H. Golet has degrees from Bates College (B.S. Biology 1987), and the University of California, Santa Cruz (M.S. Marine Sciences 1994, Ph.D. Biology 1999). His doctoral research focused on the behavioral and physiological adjustments that long-lived birds make during their breeding seasons, and the effects that these adjustments have on subsequent survival and future fecundity. Dr. Golet was a wildlife biologist for the U.S. Fish and Wildlife Service before joining The Nature Conservancy of California's Sacramento River Project as senior ecologist. He provides scientific input for the design of conservation strategies and studies ecosystem responses to management actions. He has 11 refereed publications, and has extensive experience coordinating and conducting research in California and Alaska.

Potential Conflicts of Interest or Problems with Availability:

The Sacramento River Project does not have any conflicts of interest or any potential problems with availability to do the proposed work within the proposed timeline.

See Appendix B for Stillwater Sciences staff and collaborator's qualifications, Appendix C for ESSA Technologies staff qualifications, and Appendix D for USGS staff qualifications and bibliography.

D. Budget

D1. Budget

Total cost for the proposed activities is $2,020,801 however, TNC is asking for $1,640,801 (See below). See webpage form for the complete budget.

D2. Cost-Sharing

Total cost for the proposed activities is $2,020,801. TNC is seeking $1,640,801 from CALFED and $380,000 from a private source to cover total project costs. Should CALFED decide to fund this project, private cost-share funds will be applied to leverage CALFED expenditures. It is anticipated that private cost share funds would be in hand prior to a contract agreement with CALFED. Therefore, TNC is seeking only the remaining $1,640,801 from CALFED.

E. Local Involvement

Refer to Section A3 Tasks 1, 4, and 5, and associated sub-task descriptions for a complete discussion on the numerous stakeholder participation and review opportunities. There are no 3rd party impacts associated with this project, as it does not involve implementation.

This project concept was presented to the SRCA Technical Advisory Committee (TAC) on 8/16/01, 9/19/02, and 10/17/02. Organizations represented at the meeting included the Family Water Alliance, Bureau of Reclamation, Northern California Water Association, Sacramento River Partners, United States Fish and Wildlife Service, Department of Fish and Game, Department of Water Resources, Reclamation Board, and local landowners. This project concept was also presented to the SRCA Board and summarized in the SRCA notes publication. We conducted a meeting with (NCWA) to provide an overview of this project and invite them to participate as co-applicants to ensure a balanced approach to the process. They declined. NCWA was also given the opportunity to review a draft of this revised project prior to submission. TNC will continue to update the SRCA TAC and Board on project progress and results.

F. Compliance with Standard Terms and Conditions

Attachment D, Section 4 *Expenditure of*	TNC requests the following language which was negotiated and approved for the CALFED 2001 agreements with TNC:

Funds	"Contractor shall expend funds in the manner described in the approved Budget. As long as the total contract amount does not increase, the Contractor may (1) decrease the Budget for any individual tasks by no more than 10% of the total task amount, on a cumulative basis, and increase the Budget for one or more task(s) by an equal dollar amount and (2) adjust the Budget between individual line items within a task by no more than 10% of the total task amount, for such task. Any other variance in the budgeted amount among tasks, or between line items within a task, requires approval in writing by CALFED or NFWF. All cumulative variances to approved Budget must be reported with each invoice submitted to NFWF for payment. The total amount to be funded to Contractor under this Agreement may not be increased except by amendment of this Agreement. Any increase in the funding for any particular Budget item shall mean a decrease in the funding for one or more other Budget items unless there is a written amendment to this Agreement."
Attachment D, Section 5 Subcontracts	TNC requests the following language which was negotiated and approved for the CALFED 2001 agreements with TNC: "Contractor is responsible for all subcontracted work. Subcontracts must include all applicable terms and conditions as presented herein. An approved sample subcontract is attached as [an exhibit]. Contractor must obtain NFWF's approval prior to entering into any subcontract that will be funded under this Agreement, which approval shall not be unreasonably withheld if (1) contracted work is consistent with the Scope of Services and the Budget; and (2) the subcontract is in writing and in the form attached to this Agreement as [an exhibit]. Contractor must subsequently provide NFWF with a copy of the signed subcontract. Contractor must (a) obtain at least 3 competitive bids for all subcontracted work, or (b) provide a written justification explaining how the services are being obtained at a competitive price and submit such justification to NFWF with copy of the signed subcontract. Notwithstanding the foregoing, the CALFED Program has acknowledged that the Contractor generally does not use a subcontract for routine land appraisals, surveys, and hazardous materials reports. For these one-time services, Contractor uses a group of vendors on a regular basis and pays no more than fair market value for such services by one-time invoice rather than written contract. Contractor will not be required to obtain competitive bidding for such services or to provide any further justification to NFWF."
Attachment D, Section 9 Rights in Data	TNC requests the following language which was negotiated and approved for the CALFED 2001 agreements with TNC: "All data and information obtained and/or received under this Agreement shall be publicly disclosed only in accordance with California law. All appraisals, purchase and sale agreements and other information regarding pending transactions shall be treated as confidential and proprietary until the transaction is closed. Contractor shall not sell or grant rights to a third party who intends to sell such data or information as a profit-making venture. Contractor shall have the right to disclose, disseminate and use, in whole or in part, any final form of data and information received, collected, and/or developed under this Agreement, subject to inclusion of appropriate acknowledgment of credit to the State, NFWF, to the CALFED Program, and to all cost-sharing partners for their financial support. Contractor must obtain prior approval from CALFED to use draft data. Permission to use draft data will not be unreasonably withheld. CALFED will not disseminate draft data, but may make draft data available to the public upon request with an explanation that the data has not been finalized."

Attachment D, Section 11 ***Indemnification***	TNC requests the following language which was negotiated and approved for the CALFED 2001 agreements with TNC be added to the end of Section 11: ", provided, that Contractor shall have no indemnification obligations under this paragraph to the extent that any claim or loss is caused by the gross negligence or willful misconduct of the party seeking indemnification.
Attachment D, Section 13 Termination Clause	TNC requests the following language which was negotiated and approved for the CALFED 2001 agreements with TNC: "Default and Remedies. In the event of Contractor's breach of any of Contractor's obligations under this Agreement, NFWF shall deliver to Contractor written notice, which shall describe the nature of such breach (the "Default Notice"). If Contractor has not cured the breach described in a Default Notice prior to the expiration of the twenty (20) day period immediately following Contractor's receipt of such Default Notice, or, in the event the breach is not curable within such twenty (20) day period, Contractor fails to commence and diligently proceed with such cure within such twenty (20) day period, then Contractor shall be deemed to be in default under this Agreement, and NFWF shall have the right, after receiving approval from CALFED, to terminate this Agreement by delivering to Contractor a written notice of termination, which shall be effective immediately upon receipt by Contractor (the "Termination Date"). Upon and following the Termination Date, NFWF

	shall be relieved of the obligation under this Agreement to process any payments to Contractor for any work that has been performed prior to the Termination Date; however, NFWF shall continue to be obligated to process any payments to Contractor for work properly performed and invoiced in accordance with the terms and conditions of this Agreement prior to the Termination Date. In no event shall Contractor be required to refund to NFWF, CALFED, the Agency or DWR any of the funds that have been forwarded to Contractor under this Agreement, except as provided below: 1) If Contractor transfers any fee simple real property interest acquired by Contractor with funds provided under this Agreement without having obtained prior approval by the Agency, which approval shall not be unreasonably withheld, Contractor shall reimburse the Agency the sum received by Contractor for such fee simple real property interest, together with interest compounded semiannually starting from the date funds were disbursed by DWR pursuant to this Agreement, and including the date of default, at a rate equivalent to that which is being earned at the time of default on deposits in the State of California's Pooled Money Investment Account. 2) In the event of Contractor's default under Section Eleven, the Agency shall be entitled to receive one of the following remedies, at the Agency's election: a) reimbursement pursuant to the terms in Section Ten.I.(1); or b) conveyance by Contractor of a conservation easement to an entity that is authorized to acquire and hold conservation easements under Section 815.3 of the California Civil Code and is selected by the Agency (the "Easement"), together with a sum to CALFED which, when combined with the fair market value of the Easement, equals the sum granted to Grantee pursuant to this Agreement, together with interest compounded semi-annually starting from the date funds for the real property interest purchase were disbursed pursuant to this agreement, and including the date of default, at a rate equivalent to that which is being earned at the time of default on deposits in the State of California's Pooled Money Investment Account. The value of the Easement shall be determined by a fair market value appraisal approved by CALFED.
Attachment D, Section 16 ***Consideration***	TNC requests the following language which was negotiated and approved for the CALFED 2001 agreements with TNC: "Consideration. The consideration to be paid Contractor as provided in this Agreement, shall be in compensation for the performance by Contractor of Contractor's obligations under this Agreement.

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Figure #1
Study Area

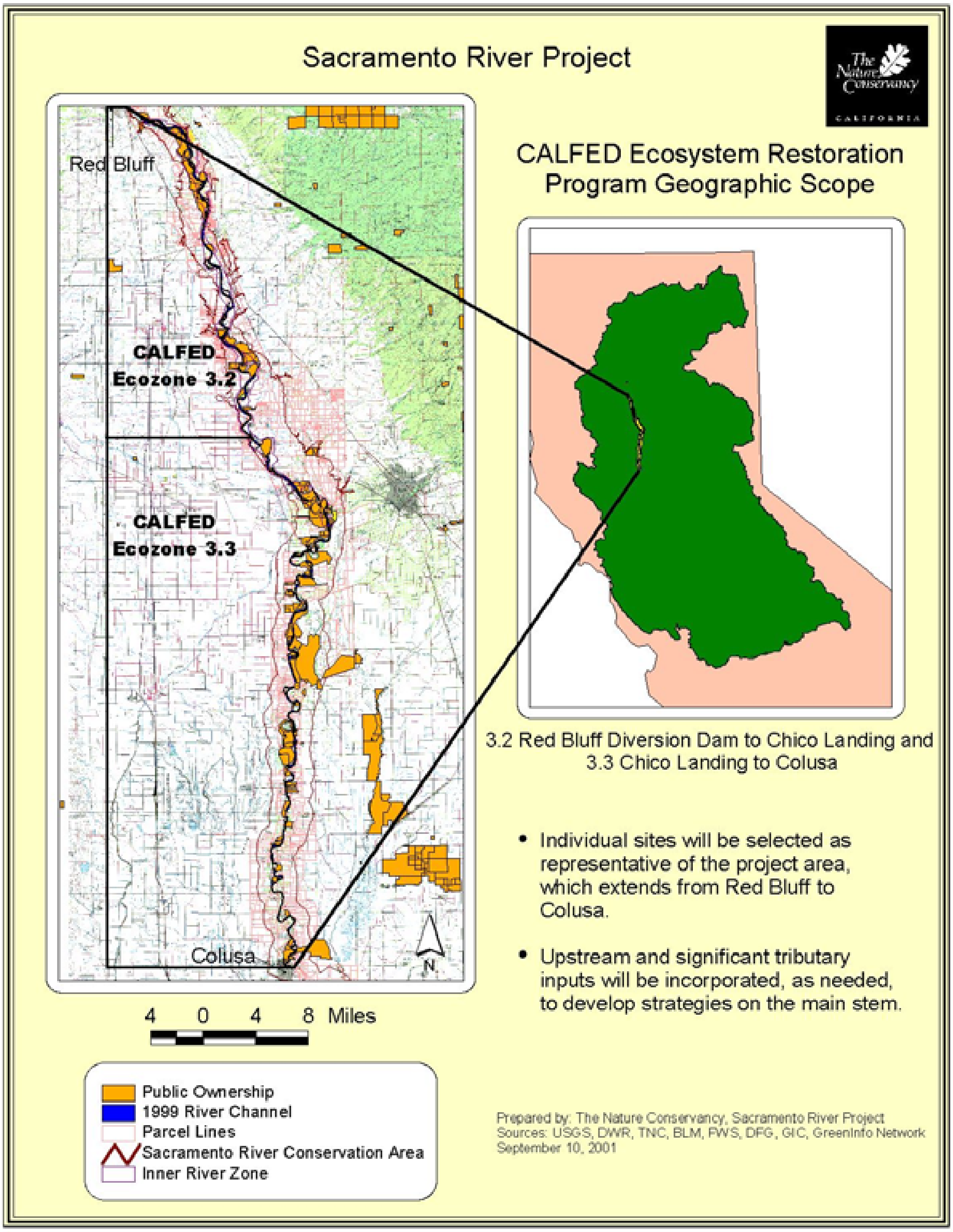


Figure #2

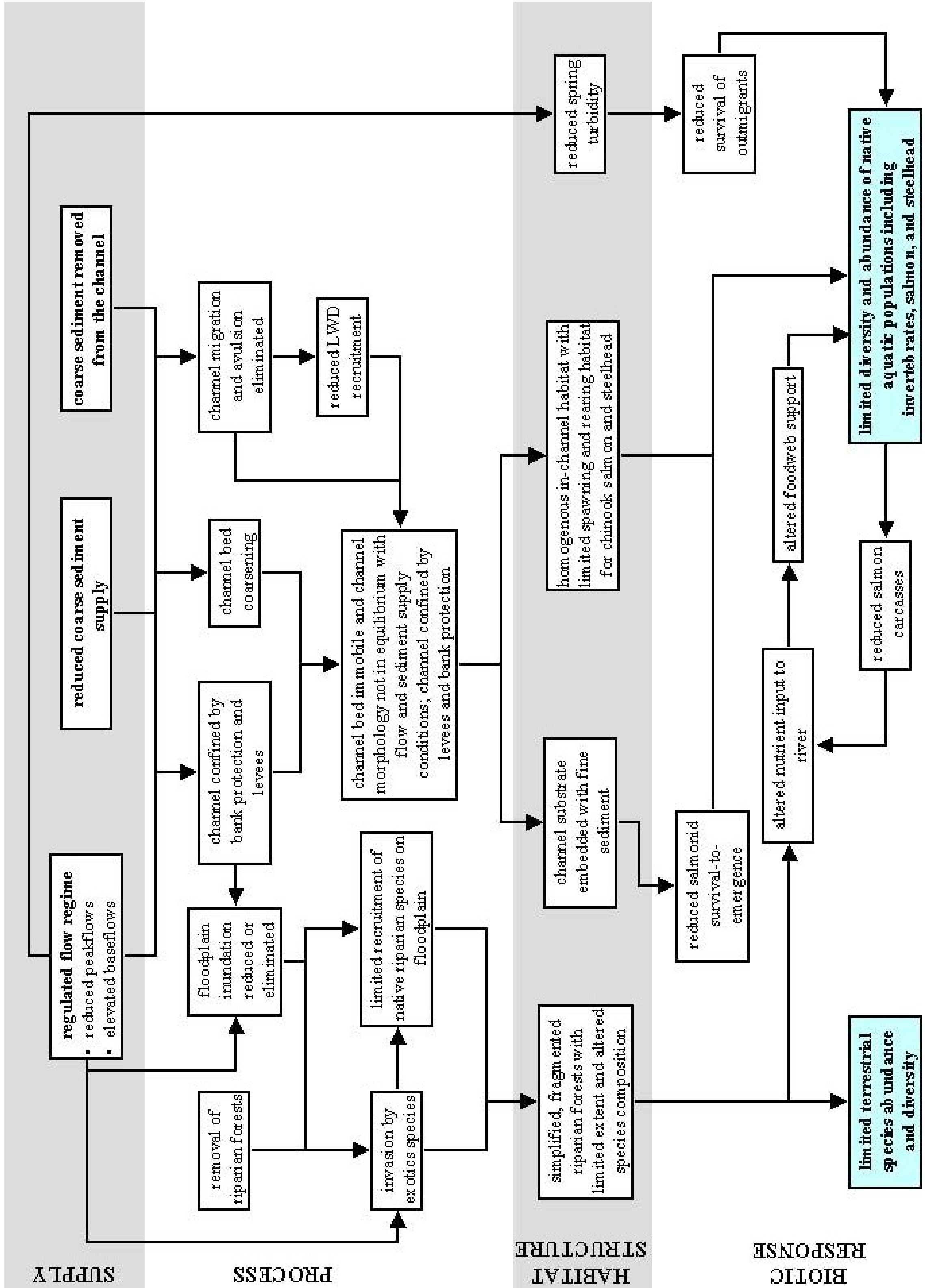
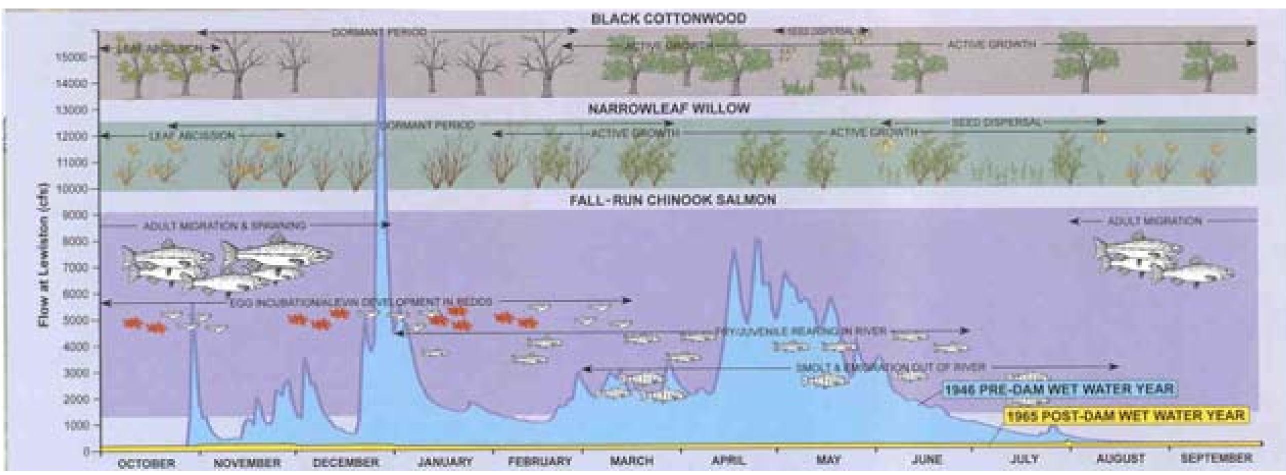


Figure 2. Conceptual model of processes and linkages in the Sacramento River From Red Bluff to Colusa.

Figure #3

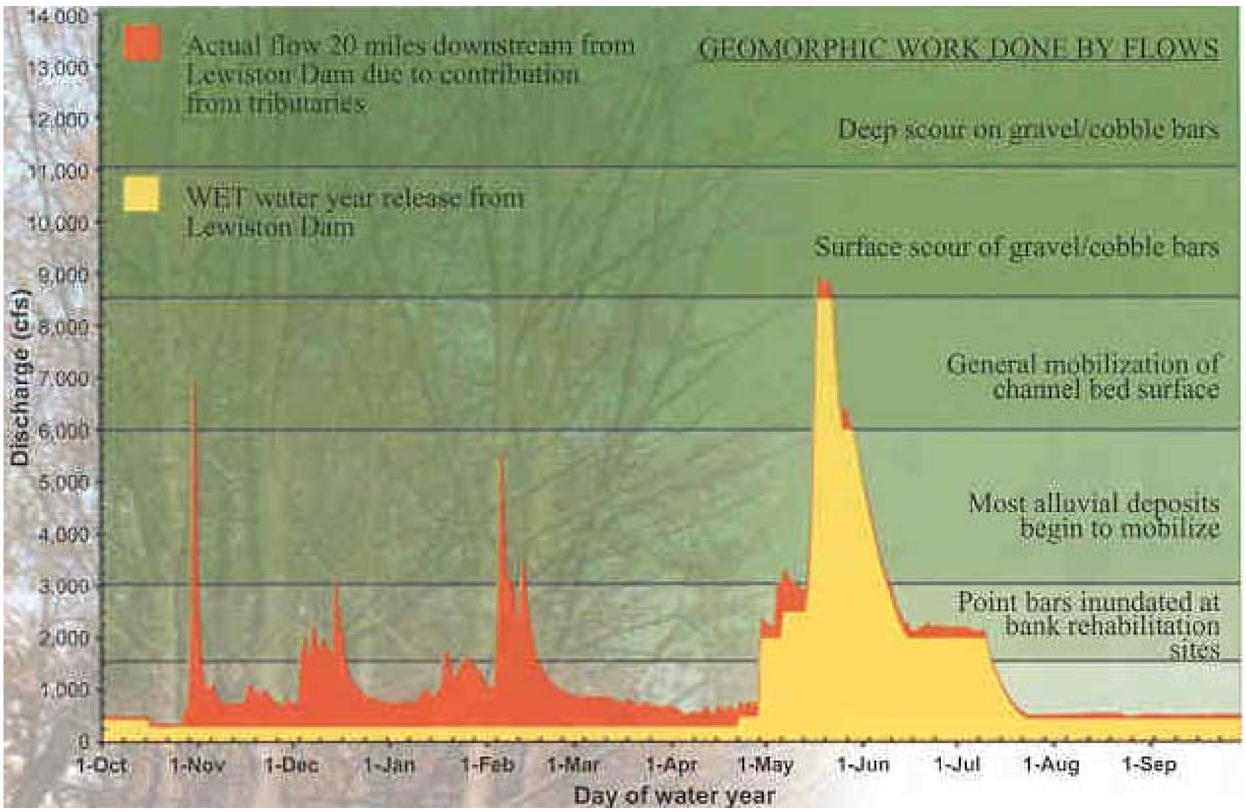
An example of multiple species' life history traits that may not be met with simple minimum instream flow prescriptions



From the Trinity River Restoration Program, 2001

Figure #4

Example: Trinity River Hydrograph and Flow Related Objectives
(WET Water Year)



From the Trinity River Restoration Program, 2001

Figure #5

Example of an ecological model.

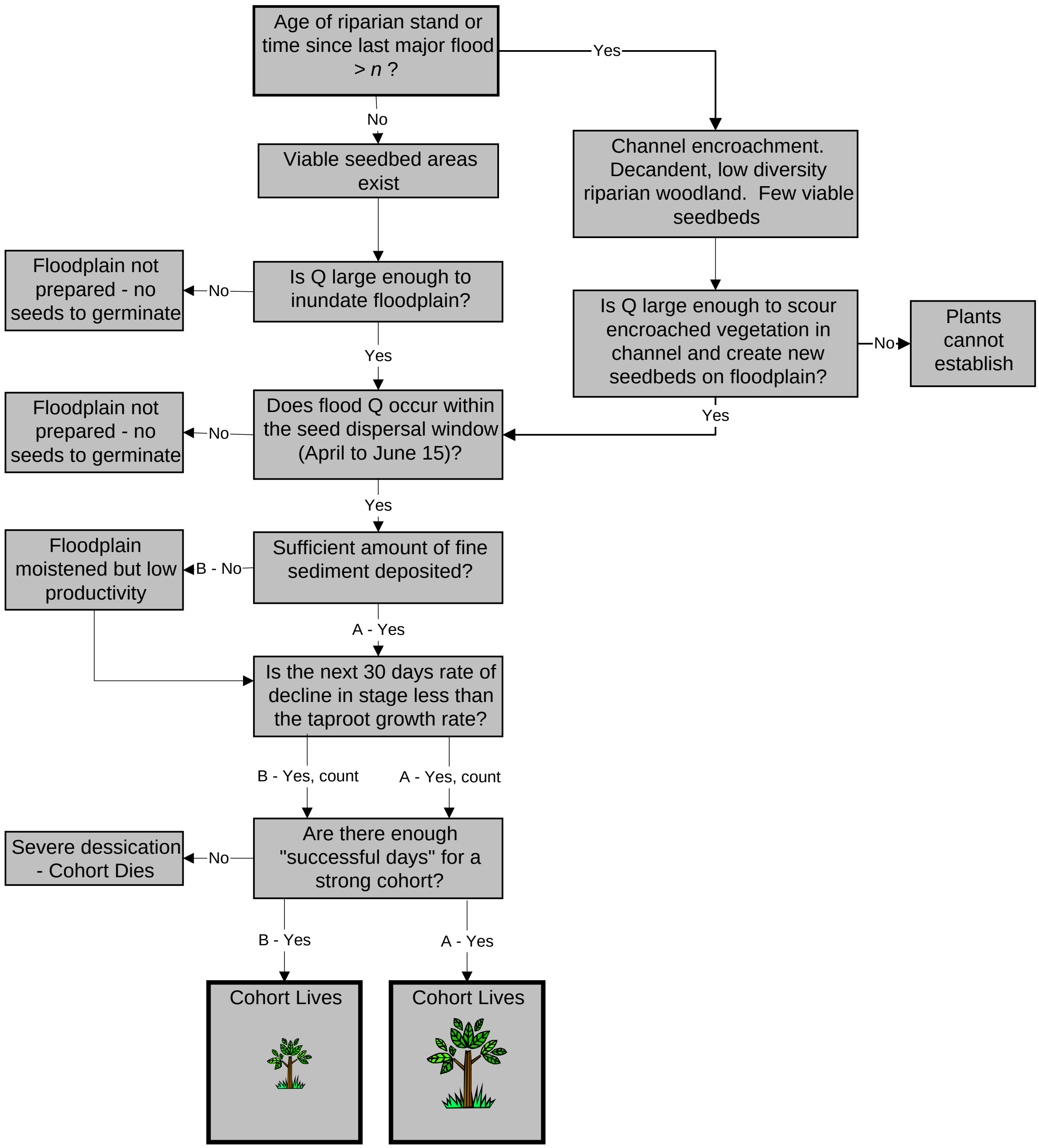


Figure #6

Conceptual model of relationships among primary tasks.

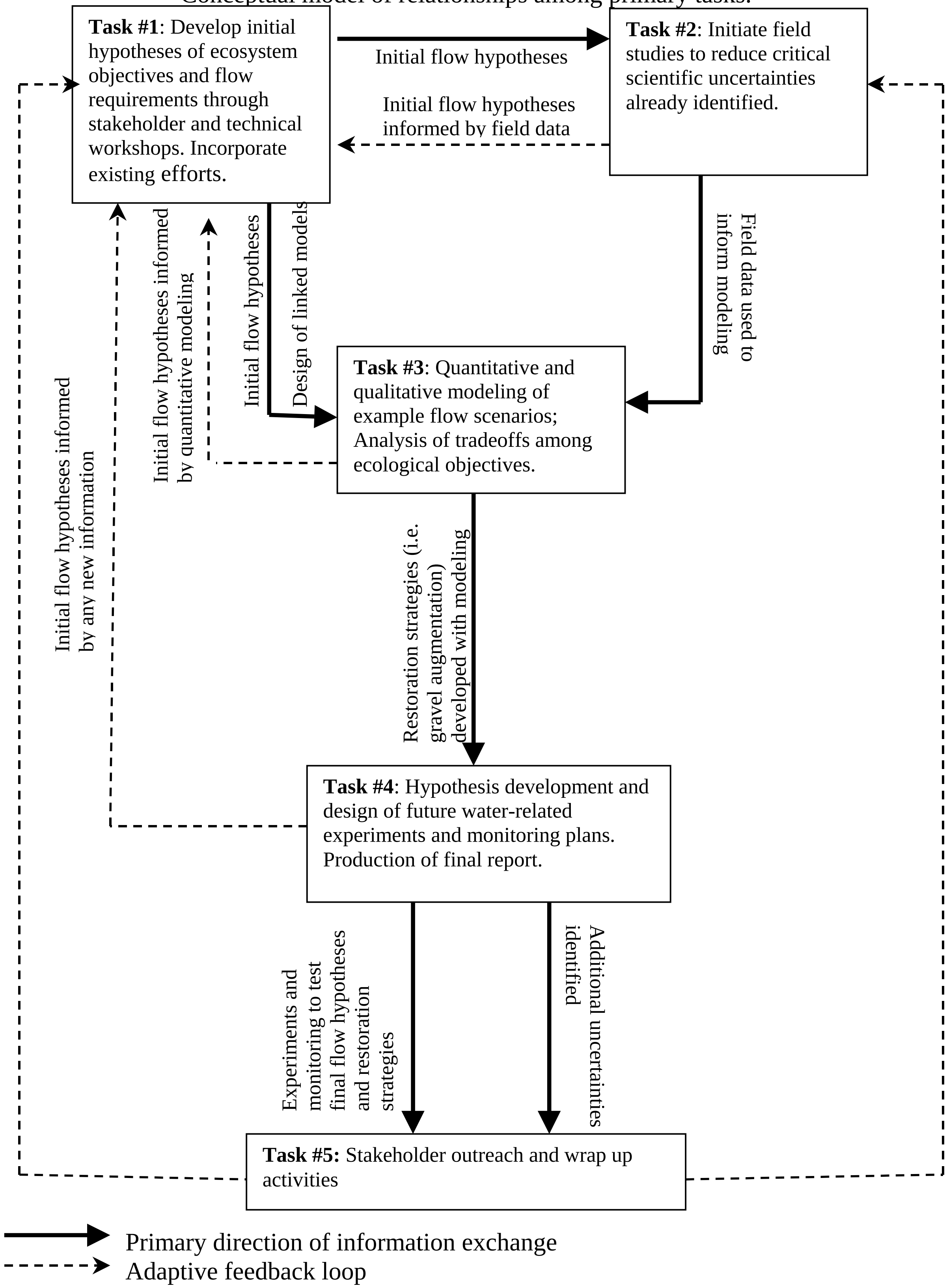


Figure #7

Structure of the Clear Creek Decision Analysis Model (CCDAM), showing linkages among actions, submodels and performance measures. The integrated decision analysis model developed for the Sacramento River would have an analogous overall structure for the channel, riparian, and fish submodels, but would not include water management actions, or performance measures for human uses (e.g. power production, flood risk, agricultural use). Flow scenarios and performance measures for human uses would be generated by other models, that would be easily linked to the decision analysis model developed in this project. The form of the riparian submodel is shown in Figure 5 however, details within the submodel will be altered for the Sacramento River.

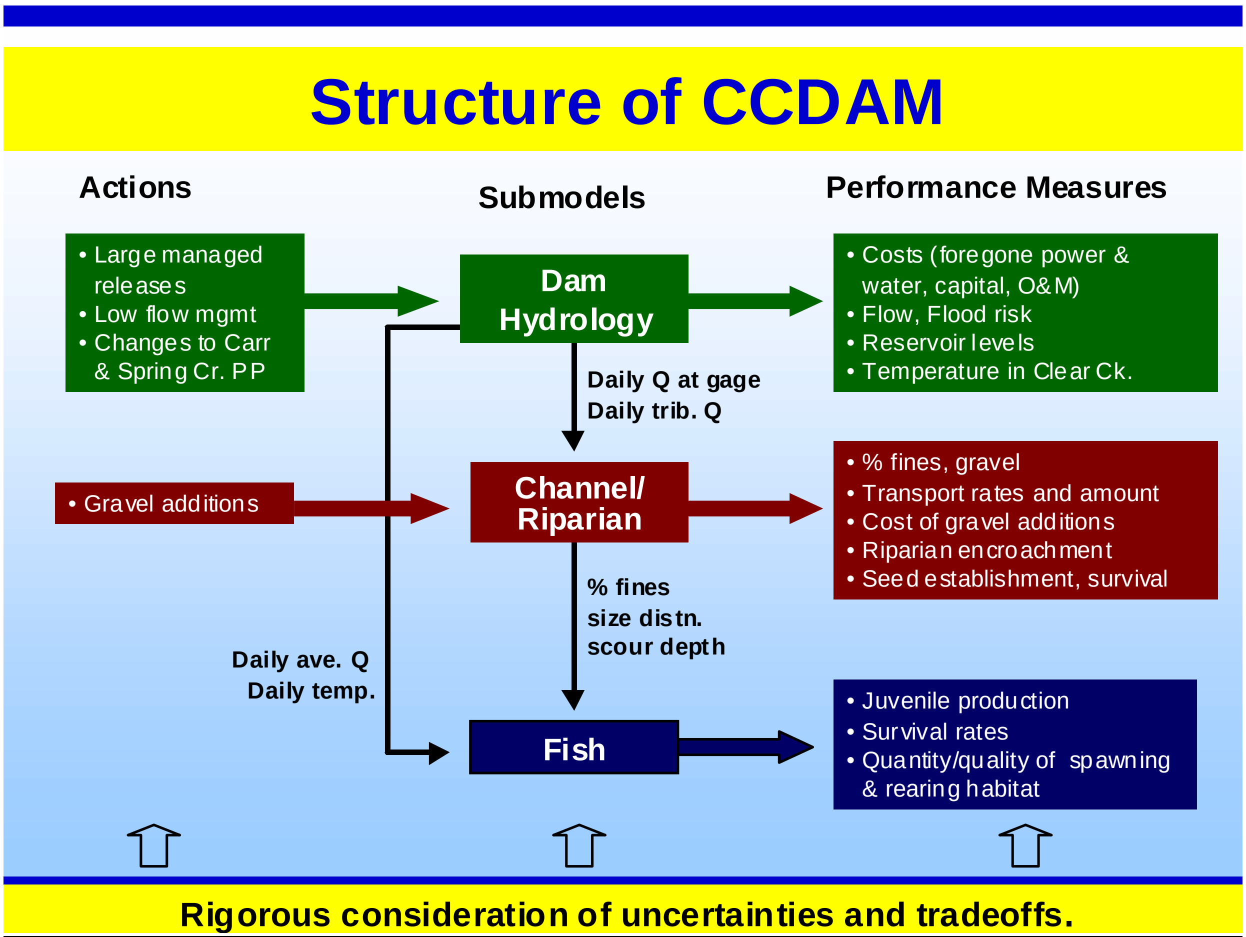
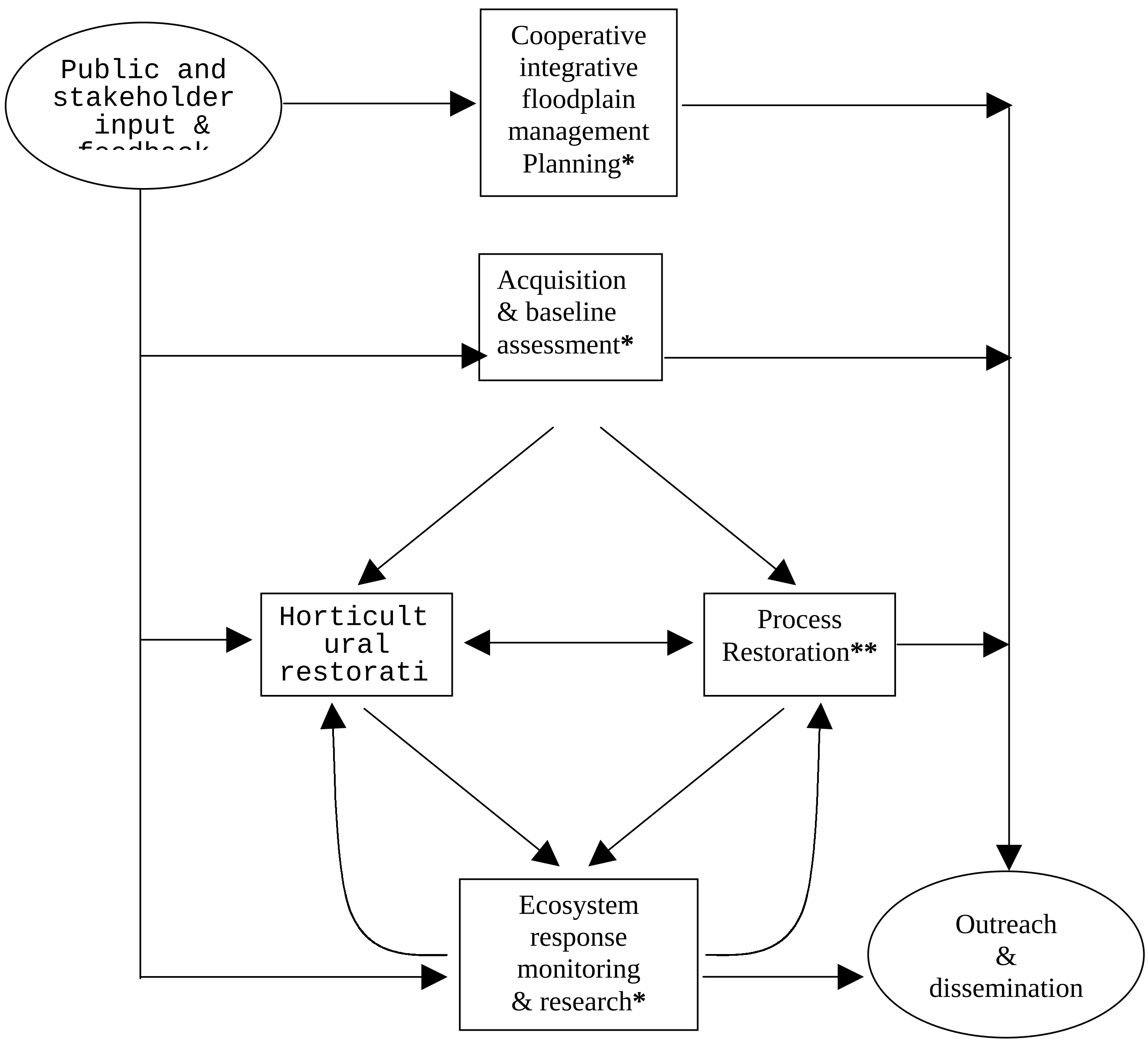


Figure #8

Conceptual Model of TNC Sacramento River Project's programmatic structure



* Indicate project component projects submitted to this PSP.
** Project component represented by this project.

Table #1

Table #1	
Discipline	Known existing data
Hydrology	Stream gage records, IHA analysis, stage discharge relationships*, ACOE Comp Study data.
Geomorphology	Historic channel and floodplain cross sections, recent channel cross sections*, suspended sediment and bedload transport data, particle size distribution data, 2 foot contour floodplain topographic data and hydrography, historic channel locations, point bar sedimentology data*
Fisheries biology	Seining data in the main stem and tributary confluences, IFIM analysis, results from study evaluating salmonid use of different habitat types*
Wildlife biology	Wildlife surveys conducted in the project area*, bat population data*, PRBO data
Riparian ecologist	Vegetation community mapping from ortho-rectified 1999 aerial photography*, recruitment pilot study*, vegetation transect data*
Invertebrate ecologist	Results from benthic macroinvertebrate study*, existing DF&G benthic macroinvertebrate data
Hydraulic modeling	1 & 2 dimensional hydraulic modeling for various river reaches*
Water quality	Regional Water Quality Control Board monitoring summaries
Water use	Water needs quantified in other efforts such as the Department of Water Resources water plan.
Engineering/Dam operation	Operating rules for water management infrastructure

*Indicates CALFED funded data collection.

Table #2

Project activities, outputs, outcomes, and environmental indicators

Table #2	
Project activities	
Task 1.1: Meetings with project team and stakeholders	• Preparation and planning, • outreach and scoping meeting, and • prepare technical memo for issues in this subtask.
Task 1.2: Synthesize existing data	• Develop draft outline • incorporate stakeholder input, • review draft chapters, • hold technical meeting for state of the system (SOS) report, and • prepare and review SOS report.
Task 1.3: Hold stakeholder workshops report	• Workshop preparation and planning, • hold workshop, and • produce workshop summary and task list.
Task 1.4:Scientific workshop to develop a conceptual design for linked models.	• Workshop preparation and planning, • hold workshop and technical meetings, and • produce design document.
Task 2.1: Quantify relationship between flows and sediment transport	• Analyze existing data to identify segments of the river that reflect significant changes in slope, channel width and morphology, bank conditions, and particle size distribution. • Select a stratified random sample of sites within the identified river segments. • Survey channel cross-sections at selected sampling sites. • Conduct sediment sampling to determine particle size distribution at sites. • Place sediment tracers across the width of the channel at sampling sites. Using cross-sectional and particle size distribution data, apply a numerical flow-sediment mobility model to predict flows required to initiate bed mobility. • Locate sediment tracers following significant flow events. • Compare the predictions of the flow-sediment transport model with observed tracer movements. • Validate and calibrate the flow-sediment transport model with tracer data.
Task2.2: Quantify Cottonwood Root Growth Rates	• Use field surveys to identify point bars with cottonwood seedling cohorts of different ages. • Select a stratified random sample of monitoring sites for identified point bars. • Install piezometers at sampling sites. • Excavate cottonwood seedlings from selected sites at various time intervals to determine root growth rates. • Collect and analyze bulk samples of sediment from the sampling sites to correlate root growth with bed material.
Task 2.3: Quantifying Fluvial Geomorphic Processes to Create and Maintain Off-Channel Habitats	• Analyze historical maps and aerial photographs to identify meander cutoffs. • Analyze stream gauge data to correlate historical flows with the meander cutoffs identified on historical aerial photographs. • Analyze historical maps and aerial photographs to assess floodplain vegetation and roughness, radius of curvature of meander bends, bank conditions, and the vector of main flow/thalweg. • Interview local landowners and technical experts to describe any human activities that may have contributed to the meander cutoffs identified in the historical photo set.

	• Using the data generated from each meander cutoff case study, develop an analytical tool to predict the flows and contributing factors required to initiate meander cutoff.
Task 2.4: Channel Substrate Composition and Permeability	• Select sample sites that represent spawning areas and non-spawning, control areas. • Measure gravel permeability and dissolved oxygen at sample sites. • Collect and analyze bulk samples at sampling sites.
Task 2.5: Assess and Compare the Effects of Bank Protection on In-Channel Habitat Conditions	• Select comparable sample sites with and without bank protection. • Conduct three-dimensional mapping of channel morphology at sample sites. • Define measures of habitat quality for the life history stage requirements of different species and guilds—including salmonids, centrarchids, and amphibians—at sample sites. • Compare habitat quality and complexity at sample sites. • Synthesize information to assess the effects of bank protection on in-channel habitat complexity and quality.
Task 2.6: Refine a Meander Migration Model	• Collect time sequence of hydrograph characteristics and related bank migration. • Develop numerical algorithm, which captures relationship between variable hydrograph and bank migration. • Code algorithm into the migration model, and calibrate and validate the model.
Task 2.7: Quantify Frequency and Spatial Extent of Cottonwood Recruitment	• Map the forest at each of four 2-3 km long reaches as mosaics of patches of distinct age classes (approximately 5-7 age classes). • Within each age class, excavate and age trees to determine establishment year, elevation, and stratigraphic history following establishment. An initial, prototype sampling at one reach will be conducted to refine methods and to investigate efficiency of collecting cores versus slabs from either the ground surface or below. • Determine mode of establishment for each forest patch using sampled site stratigraphy, historical flow records, and historical aerial photography.
Task 3.1: Development of a flow-sediment transport model	• Validate, calibrate, and apply a numerical flow-sediment transport model to predict the flows required to restore fluvial geomorphic processes for a range of restored or hypothesized channel conditions.
Task 3.2: Development of computer submodels for other ecological components	• Revise design document based on field results, • database development, • development of submodels, • and, prototype demonstration.
Task 3.3: Work with CALFED to develop 3 illustrative strategies for model application.	• Meeting preparation and planning, and • hold technical meetings with CALFED.
Task 3.4: Evaluate ecological outcomes and tradeoffs for example flow and channel scenarios.	• Run model for different scenarios, • analyze and summarize outputs, and • develop draft flow recommendations.
Task 4: Develop Experimental Designs and Study Plans	• Develop study plans, and • produce final report.
Task 5: Stakeholder workshops and presentations.	• Workshop preparation and planning, • prepare summary presentation, and • deliver presentation.
Project outputs	
Task 1	Technical memos, SOS report, workshop summary and task list, conceptual design of an ecosystem flow assessment tool capturing the state of the knowledge on functional ecological relationships.
Task 2.1	Study plan; raw data; summary reports and technical memoranda.
Task2.2	Study plan; raw data; summary reports and technical memoranda.

Task 2.3	Summary reports and technical memoranda.
Task 2.4	Study plan; Raw data; Summary reports and technical memoranda.
Task 2.5	Study plan; Raw data; Summary reports and technical memoranda.
Task 2.6	Report summarizing empirical data, developed algorithm, code, and model calibration and validation, and , sample input and output for selected sites on the Sacramento River.
Task 2.7	Revised study plan based on prototype sampling; Raw data; Summary report; Manuscript for peer-reviewed journal.
Task 3.1	Summary reports and technical memoranda; Multimedia presentations; Integrated decision analysis model.
Task 4	Study plans; Conceptual restoration designs; Statistical analyses; Monitoring plans.
Task 5	Final report and presentation.
Project outcomes	
Task 1	Increased base of knowledge to address ecosystem flow needs and a structured means to do so. Results provide an intermediate step to addressing multi-regional priorities #1 & #6, and Sacramento Region priorities #2, #3, #4, & #7. Provides a data storage and management framework to better address these priorities as new information is developed.
Task 2.1	Estimate of flows required to mobilize channel bed for a range of sites; Estimates of incipient motion thresholds for a range of particle sizes.
Task 2.2	Cottonwood root growth; Sediment distribution.
Task 2.3	Flows required to initiate floodplain scour and meander cutoff.
Task 2.4	Particle size distribution; Gravel permeability.
Task 2.5	Measures of in-channel habitat complexity and quality in the vicinity of protected and unprotected banks.
Task 2.6	Increased understanding of effect of a variable hydrograph on river migration, sample demonstrations (i.e. validation runs of the model).
Task 2.7	Characterization of cottonwood recruitment in terms of the spatial extent of suitable establishment conditions created by specific combinations of streamflow and channel change.
Task 3	Alternative restoration scenarios that identify different flow requirements.
Task 4	Study plans; conceptual restoration designs; statistical analyses; Monitoring plans.
Task 5	Increased understanding of the results of the study, and buy-in among stakeholders of the approach for evaluating flow regime changes.
Environmental Indicators	
Task 1	Initially hypothesized interactions of hydrograph changes and affects on various ecosystem metrics.
Task 2.1	Sediment tracers; Particle size distribution; discharge.
Task2.2	Cottonwood root growth rates; Sediment distribution; discharge, groundwater elevations.
Task 2.3	Meander cutoff; Radius of curvature; Meander amplitude; Discharge, Floodplain vegetation and roughness.
Task 2.4	Gravel Permeability; Dissolved Oxygen; Particle size distribution.
Task 2.5	Discharge; Depth; Channel Morphology.
Task 2.6	Meander migration rates, Hydrograph characteristics, channel width, depth, slope, velocity, roughness.
Task 2.7	Areas, ages, and fluvial geomorphic origins of cottonwood stands; streamflow requirements for cottonwood establishment.
Task 3	N/A
Task 4	N/A
Task 5	N/A

Table #3 Timeline

<table>
<tr><th>Task</th><th>3rd quarter</th><th>4th quarter</th><th>1st quarter</th><th>2nd quarter</th><th>3rd quarter</th></tr>
<tr><td colspan="6">Task 1: Develop initial hypotheses of ecosystem flow requirements through workshops.</td></tr>
<tr><td>Task 1 Subtasks:

1.1 Stakeholder / Scoping Meetings
1.2 Synthesize existing data
1.3 Stakeholder workshop
1.4 Model design workshop</td><td>Task 1.1:
- Identify specialists
- Separate meetings with stakeholders and team scoping meeting
Task 1.2:
- Compile and synthesize existing data into State of the System (SOS) report; formulate flow hypotheses (Task 1.2)</td><td>- Complete SOS report (Task 1.2)

Task 1.3:
- Stakeholder workshop on SOS report; revise objectives, performance measures, hypotheses</td><td>Task 1.4:
-Scientific workshop to develop conceptual design for linked models; document suggested revisions to Task 2</td><td></td><td></td></tr>
<tr><td colspan="6">Task 2: Initiate field studies to reduce previously identified, critical scientific uncertainties.</td></tr>
<tr><td>Subtask 2.1: Quantify / refine relationships between flows and sediment transport</td><td>- select sampling sites
- apply sediment transport model to suggest particle sizes for tracers and concomitant mobilization flows</td><td>- place tracers</td><td colspan="2">- monitor tracer movement following sufficient high flows</td><td>- validate and calibrate sediment transport model</td></tr>
<tr><td>Subtask 2.2: Quantify Cottonwood Seedling Root Growth Gates</td><td>- conduct field surveys to identify bars with different aged riparian seedlings
- select sample sites
- install and monitor peizometers/observation wells to correlate water surface elevations with groundwater table elevations</td><td>- monitor observation wells/peizometers to correlate water surface elevations with groundwater table elevations</td><td colspan="3">- excavation of riparian seedlings to correlate root growth rate with groundwater table elevations
- bulk sampling of sediment
monitor observations wells/peizometers to correlate water surface elevations with groundwater table elevations
(Task continues to the end of the grant period)</td></tr>
<tr><td>Subtask 2.3: Quantify Fluvial Geomorphic Processes that Create and Maintain Off-Channel Habitats</td><td colspan="3">- analyze aerial photos
- analyze stream gauge data
- interview local landowners and technical experts</td><td colspan="2">- develop an analytical tool to predict the flows and contributing factors necessary to initiate meander cutoff (consistent with model design in workshop from Task 1.4).</td></tr>
<tr><td>Subtask 2.4: Pilot Characterization of Channel Substrate Composition and Permeability</td><td>- identify sampling sites
- collect and analyze bulk samples</td><td></td><td></td><td></td><td>- collect and analyze bulk samples following high flows</td></tr>
</table>

Task	3rd quarter	4th quarter	1st quarter	2nd quarter	3rd quarter
Subtask 2.5: Assess and Compare the Effects of Bank Protection on In-Channel Habitat Quality and Complexity	- select sample sites	- three-dimensional mapping of channel morphology in the vicinity of protected and unprotected banks		- define measures of habitat quality by life history stage requirements of key species and guilds - quantify differences in-channel habitat complexity and quality between protected and unprotected sites	
Subtask 2.6: Refine a Meander Migration Model	- collect bank migration and flow data;		- develop algorithm to relate migration and flow; develop non-linear algorithm (consistent with Task 1.4 model design)		- integrate non-linear algorithm into numerical model
Subtask 2.7: Quantify Frequency and Spatial Extent of Cottonwood Recruitment	- preliminary site visits	- prototype cottonwood stand sampling	- sample preparation and dendrochronological analysis	- data analysis of prototype sampling, revised study plan and sampling methodology	- field sampling with revised sampling methodology (Task continues through next quarter)
Task 3: Build and apply integrated decision analysis model to evaluate the outcomes of example flow scenarios against objectives for different ecosystem components.					
Subtask 3.1: Develop flow-sediment transport model				- apply numerical flow-sediment transport model to predict the flows required to restore fluvial geomorphic processes for a range restored channel conditions - (Task continues through the next 2 quarters)	
Subtask 3.2: Develop computer submodels for other ecological components				- revise / build submodels for other ecological components identified in Task 1.4 (i.e. fish, riparian, benthos - (Task continues through the next 2 quarters)	

Table #3 continued. This section of the table begins with the 4th quarter, which follows the 3rd quarter in the table above.

Task	4th quarter	1st quarter	2nd quarter	3rd quarter	4th quarter	1st quarter	2nd quarter
Task 2: Continue field studies to reduce critical scientific uncertainties.							
Subtask 2.1: Quantify / refine relationships between flows and sediment transport		- monitor tracer movement following sufficient high flows	- validate and further calibrate flow-sediment transport model			- monitor tracer movement following sufficient high flows	
Subtask 2.2: Quantify Cottonwood Seedling Root Growth Gates	- excavation of riparian seedlings to correlate root growth rate with groundwater table elevations - bulk sampling of sediment - monitor observation wells/piezometers to correlate water surface elevations with groundwater table elevations and cottonwood root growth rates						
Subtask 2.3: Quantify Fluvial Geomorphic Processes that Create and Maintain Off-Channel Habitats	develop an analytical tool to predict the flows and contributing factors necessary to initiate meander cutoff.						
Subtask 2.4: Pilot Characterization of Channel Substrate Composition and Permeability				- collect and analyze bulk samples following high flows			
Subtask 2.5: Assess and Compare the Effects of Bank Protection on In-Channel Habitat Quality and Complexity	- integrate flow-migration algorithm in to existing model;		- collect calibration data to apply to representative sites; calibrate and validate model runs		draft report		final report
Subtask 2.6: Refine a Meander Migration Model	- assess the effects of bank protection on in-channel habitat complexity and quality						
Subtask 2.7: Quantify Frequency and Spatial Extent of Cottonwood Recruitment	- field sampling with revised sampling methodology	- sample preparation and dendrochronological analysis		- integration of field and dendrochronological data with hydrology, stratigraphy, and geospatial analysis	- analysis and writing; follow-up field sampling if necessary		

Task	**4th quarter**	**1st quarter**	**2nd quarter**	**3rd quarter**	**4th quarter**	**1st quarter**	**2nd quarter**
Task 3: Build and apply integrated decision analysis model to evaluate the outcomes of example flow scenarios against objectives for different ecosystem components.							
Subtask 3.1: Develop flow-sediment transport model	- apply numerical flow-sediment transport model to predict the flows required to restore fluvial geomorphic processes for a range restored channel conditions			- further adjustment of model parameters based on results of field studies			
Subtask 3.2: Develop computer submodels for other ecological components	- build / apply / revise submodels for other ecological components identified in Task 1.4 (i.e. fish, riparian, benthos)						
Subtask 3.3: Solicit ideas from CALFED for 3 illustrative flow and channel scenarios			- 2 technical meetings with CALFED to define 3 flow scenarios				
Subtask 3.4: Evaluate ecological outcomes for example flow and channel scenarios				- run integrated decision analysis model to evaluate ecological outcomes and tradeoffs - develop flow recommendations			
Task 4: Hypothesis development and design of future water-related experiments and monitoring plans							
Task 4: Hypothesis development and design of future water-related experiments and monitoring plans	-develop experimental design/study plan for high-priority flow hypotheses			- illustrate flow management experiments using decision analysis model	- draft report	-final report	
Task 5: Stakeholder workshops and presentations							
Task 5: Stakeholder workshops and presentations					- prepare summary presentations	- deliver presentations; - conduct joint stakeholder & scientist workshop	

Table #4 Previous Recipients of CALFED Program or CVPIA funding.

Project Title	CALFED Program/ CVPIA Project	Term	Progress and Accomplishments	Status
Ecosystem and Natural Process Restoration on the Sacramento River: Floodplain Acquisition and Management	CALFED 97-NO2	1/1/98-12/31/01	Four properties along the Sacramento River totaling approximately 1,628 acres have been purchased (Kaiser, Dead Man's Reach, Gunnhill, RX Ranch). Task orders were approved to fund portions of the purchase of two additional properties: 238-acre Ward property purchased in April 2001, and 77-acre Clendenning property purchased in October 2001. Start up stewardship activities are underway, including hydrologic and geomorphic modeling that will help identify short and long-term conservation and management actions for these properties.	The acquisition terms of this grant have been completed. Restoration of 3 of the purchased properties is the subject of a 2002 CALFED proposal. A request was approved by CALFED for an extension of the term date and the shifting of funds under the agreement from Task 1 (direct acquisition costs) to Task 3 (Startup Stewardship) in order to complete the management and monitoring plans called for under Task 3.
Ecosystem and Natural Process Restoration on the Sacramento River: Active Restoration of Riparian Forest	CALFED 97-NO3 ERP	12/1/98-6/30/02	Site preparation and planting of two sites (River Vista and Flynn) to riparian habitat totaling 264 acres, as well as maintenance and monitoring activities, are complete.	Completed.
Ecosystem and Natural Process Restoration on the Sacramento River: A Meander Belt Implementation Project	CALFED 97-NO4 ERP	2/25/98-12/1/01	The 94-acre Flynn property and adjacent levee were purchased in December 1998. The levee was subsequently removed; as a result this site now supports one of the largest bank swallow colonies recorded on the Sacramento River. Restoration was implemented under CALFED 97-NO3 and 97-NO4 and is complete.	Completed.
Floodplain Acquisition and Sub-Reach/Site Specific Management Planning: Sacramento River (Red Bluff to Colusa)	CALFED 2000-F03, FWS Agreement #11420-1-J001 ERP	6/1/01-5/31/03	Funding was awarded to implement the Sub-reach/Site Specific Planning portion of this proposal. Four tasks were identified to develop comprehensive conservation and management strategies for multiple benefits and uses of the river floodplain. Under Task 1, the Beehive Bend hydraulic analysis has been completed for RM 167-172. Under Task 2, a socioeconomic assessment for the riparian corridor of the SRCA between Red Bluff and Colusa has been drafted with involvement from SRCA, stakeholders and local governments, and will be sent out for public comment. Under Task 3, the final in a series of newsletters went out to all stakeholders; stakeholder meetings have been conducted; updates are regularly provided to the SRCA. Under Task 4, a report will be developed to inform future conservation and	During the first year of this 3-year grant, all tasks were initiated. Task 1 has been completed and other tasks are making good progress.

			management actions for the Beehive Bend sub-reach based on information developed within Tasks 1 – 3.	
Floodplain Acquisition, Management and Monitoring on the Sacramento River	CALFED 98-F18, FWS Agreement #11420-9-J074 ERP	7/20/99-6/30/02	Funding was awarded for the acquisition portion of this grant. The 104-acre Jensen property was purchased in July 2000, the 54-acre Hays property was purchased in May 2001, and partial funding was provided for the 129-acre Boeger property purchased in April 2002.	Completed.
Acquisition of Southam Orchard Properties for Preservation of Riparian Habitat	CVPIA grant, BuRec Agreement #00FG200173 (b)(1)"other"	9/12/00-9/30/02	A portion of the grant was applied to the purchase of the 76-acre Southam property, purchased in July 2000. The remainder of the funding was applied to the purchase of the 238-acre Ward property purchased in April 2001.	Completed.
Hartley Island Acquisition	CVPIA grant, FWS Agreement #1448-11332-7-G017 AFRP	8/14/97-9/30/01	Funding was used toward the purchase of two parcels on Hartley Island, including the 321-acre Sandgren parcel. The remaining funds available were applied to the purchase of the 76-acre Southam parcel.	Completed.
Singh Walnut Orchard	CVPIA grant, FWS Agreement #11332-0-G014 AFRP	9/18/00-12/31/01	All tasks were completed for this pre-acquisition and planning grant including: pre-acquisition due diligence and signed option for Singh property, baseline assessment, and local stakeholder meeting to discuss restoration plans.	Completed. A report dated December, 2001 was submitted that outlined baseline and ecological considerations with restoration alternatives. Restoration of this property is the subject of a 2002 CALFED proposal.
Acquisition of Boeger and Ward Properties	CVPIA grant, FWS Agreement #114201J114 (b)(1)"other"	9/27/01-12/31/03	Funding was used toward the purchase of the 238-acre Ward property (purchased in April 2001) and the 129-acre Boeger property (purchased April 2002).	Acquisition activities under this grant have been completed. Sub-reach planning and baseline assessment activities, as well as draft restoration plans for both parcels will be completed and provided to USFWS and BuRec.

Appendix A
The EASI Flow-Sediment Transport Model

We will use the EASI model to investigate thresholds of sediment mobility in Task 2a and Task 3. The EASI model was developed by Stillwater Sciences to provide a simple, user-friendly sediment transport assessment. The EASI model is a coarse sediment transport model that can be used to assess the average bedload transport rate and mobility thresholds based upon channel geometry, flow, and the grain size distribution of the bed. The effect of changes in the flow regime, channel geometry, and grain size distribution on the bedload transport rate can be easily assessed by varying the input parameters.

The EASI model adapts the surface-based bedload equation of Parker (1990a, b), which was developed for a wide rectangular channel, to a natural river cross section. The input parameters to the EASI model include channel cross section, channel surface grain size distribution, water discharge, floodplain Manning's n, and reach-average water surface slope. Output of the model includes bedload transport rate, bedload grain size distribution and normalized Shields stress (which can be used to assess mobility thresholds).

The EASI model has been applied to several Central Valley tributaries, including Clear Creek, the Merced River, and the Tuolumne River. Model application on both Clear Creek and the Merced River was funded by CALFED as part of the Saeltzer Dam decommissioning and a previous CALFED PSP grant, respectively.

For this proposal, we will use tracer rock experiments (proposed in Task 2a) to validate and calibrate the EASI model for the mainstem Sacramento River, testing its predictions of bed mobility for a number of different cross sections that represent a range of hydraulic and sediment transport conditions. Application of the EASI model will assist workshop participants in estimating the flows required to initiate bed mobilization (assuming current channel conditions) for a number of sites within the study reach.

In Task 3, the EASI model will be used to examine how the manipulation of other factors that influence fluvial geomorphic processes (e.g., channel-floodplain geomorphology, particle size distribution of channel bed sediments) affect environmental flow needs. For example, investigators will be able to hold channel-floodplain geomorphology as a constant, and then input a range of particle sizes (thereby simulating the addition of gravel to the channel) to predict the flows required to move the differently sized particles. In this manner, investigators can examine different combinations of flow releases, gravel augmentation, and channel-floodplain alterations to restore sediment mobilization and transport on the mainstem Sacramento River. Such simulations will be useful in the event that the flows required to initiate bed mobility under current channel conditions conflict significantly with general water supply or flood management objectives.

References

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Appendix B
Stillwater Sciences and collaborator's qualifications

Stillwater Sciences, a natural resource consulting firm specializing in riverine ecosystems and fluvial geomorphology, based in Berkeley, CA has worked on 54 different California rivers and streams. They have been involved in data collection and analysis, or coordination efforts and bring a depth of knowledge on California river systems. Primary staff involved in this project from Stillwater Sciences includes Frank Ligon, Dr. Yantao Cui, and Dr. Bruce Orr. See Appendix B for others involved in the project, which space limitations prevent listing here.

Mr. Frank Ligon has successfully managed several complex, long-term projects involving watershed analysis, salmon ecology and restoration, geomorphology and riverine ecosystem restoration. Mr. Ligon has over 20 years of experience in examining the role of fluvial processes on the ecology of stream fish, invertebrates, and plant communities in California, Oregon, Georgia, and New Zealand.

Dr. Yantao Cui has 15 years of experience in modeling sediment dynamics in regulated rivers in many areas of the Pacific Northwest, Florida, China, and Papua New Guinea. His applied research projects have involved investigation of riverbank erosion, effects of gravel extraction on fluvial geomorphic processes, and the downstream impacts of reservoir management and mines. Dr. Cui has developed models on the response of rivers to landslides and debris flows, reservoir removal, gravel extraction and addition, and participated in studies on the effects of woody debris jams on sediment transport

Dr. Bruce Orr has over 20 years of experience in population and community ecology of aquatic, terrestrial, and fresh and saltmarsh wetland environments in California and the western United States. During the past 5 years, Dr. Orr has managed a variety of complex, multi-year projects that have focused on the use of watershed analysis and ecosystem management approaches to meet a variety of regulatory needs, including TMDLs, state and federal Endangered Species Acts, and California Forest Practice Rules. He has expertise in watershed analyses, developing natural resource management plans, and analysis of flow regimes and turbidity on fish populations and riparian vegetation.

Ms. Jennifer Vick has extensive experience in geomorphic and ecological analysis and restoration planning throughout the Central Valley. She has conducted hydrologic, geomorphic and ecological analyses on the Merced, Tuolumne, and Stanislaus rivers that are being used to design and assess restoration programs.

Mr. Christian Braudrick is a geomorphologist who has conducted research on the dynamics and geomorphic role of large woody debris in streams in the Pacific Northwest and elsewhere. His current work involves assessing the geomorphology and hydrology of the lower Tuolumne and Merced rivers, as well as research on headwater stream geomorphology, assessment of habitat structure adjacent to woody debris, and various field mapping and surveying projects.

Mr. Scott Wilcox is responsible for development, implementation, evaluation, and management of environmental studies, particularly fisheries studies associated with hydroelectric and other water resource projects. His 20 years of professional experience includes project management; FERC licensing and compliance studies; environmental impact analysis for fish, wildlife, and water quality; computer modeling of stream hydraulic and temperature conditions; instream flow data collection and analysis; and technical aquatic studies. He has worked on water resource projects throughout the western United States.

Dr. Leonard Sklar is an expert in sediment transport issues, particularly in the California Coast Range, Central Valley, Oregon Coast Range, and Oregon Cascades regions. His academic and professional work has focused on his mechanistic and quantitative understanding of landscape processes and evolution, especially pertaining to river incision (river incision and valley development are a crucial link between tectonics and landscape evolution). He is an expert on bedrock channel incision by fluvial processes, including the role of sediment loading on rates of incision. As a modeler, Dr. Sklar has expertise in landscape evolution modeling, as well as event-based erosion modes.

Dr. Noah Hume is a registered California Civil and Mechanical Engineer with over 15 years experience in aquatic ecology and engineering spanning water quality, water supply and treatment. He has extensive experience in the application of laboratory, in-stream and reservoir enclosures, experimental design and data analysis of the ecological impact of contaminant and nutrient loading in urban runoff, rivers, lakes, wetlands and estuaries. Dr. Hume's areas of expertise include constructed and created wetlands for habitat and water quality improvement, reservoir and watershed management.

Mr. Martin Trso is a registered California Geologist with over 11 years of geologic mapping and interpretation experience, and over 8 years of experience in quantitative process geomorphology. Mr. Trso's work has recently included assessment of past and current stream channel conditions in forested and urban areas, assessments of potential effects of dam removal on channel morphology, constructing watershed- and reach-scale sediment budgets, and determining impacts of human activities, particularly timber harvesting and urban development, on hydrology, hillslope erosion, and channel morphology, especially with regard to landsliding. In addition, Mr.Trso has extensive experience in analyzing sediment production and its effects on coho salmon habitat.

Other collaborators:

Dr. G. Mathias Kondolf is a fluvial geomorphologist whose research concerns environmental river management; influences of land-use, mining, and dams on rivers; interactions of riparian vegetation and channel form; geomorphic influences on habitat for salmon and trout; alternative flood management strategies; and application of fluvial geomorphology to river restoration. He has published over one hundred technical journal articles, book chapters, and reports on these and related topics. Dr. Kondolf is an Associate Professor of Environmental Planning and Geography at the University of California at Berkeley, where he teaches Hydrology for Planners, Restoration of Rivers and Streams, Ecological Analysis in Urban Design, and Introduction to Environmental Sciences. He received his Ph.D. in Geography and Environmental Engineering from the Johns Hopkins University, his MS in Earth Sciences from the University of California at Santa Cruz, and his AB in Geology (*cum laude*) from Princeton University. Dr. Kondolf was an author of the Strategic Plan for the Calfed Ecosystem Restoration Program, and is currently a member of the Interim Science Board for the Calfed ERP.

Dr. William Dietrich chairs the Earth and Planetary Science Department, University of California, Berkeley. Dr. Dietrich's research has been instrumental in the development of the watershed analysis methodologies that are now being used to guide much of the planning effort for the restoration of Pacific salmon. Much of his recent work has focused on the downstream effects of dams and land use on fluvial systems, including the linkages between physical processes and aquatic biota, and the development of methods for restoring degraded rivers. Professor Dietrich's expertise in both hillslope and fluvial geomorphology has led to the development of some of the digital terrain models that underlie Stillwater Sciences' approach.

Dr. Eric Larsen received his Ph.D. in 1995 from the Environmental Water Resources Division of the Civil Engineering program at UC Berkeley. Prior to receiving his degree he worked extensively as a consultant in the field of geomorphology and river restoration. From 1997 to the present he has been an Assistant Research Geomorphologist in the Department of Geology, UC Davis. His current research interests involve applying the mechanics of sediment transport and flow hydraulics to the development of quantitative techniques for evaluating the impacts of geomorphic change on river meander migration.

Appendix C
ESSA Technologies staff qualifications

ESSA Technologies, Ltd., is a natural resource consulting firm specializing in technical facilitation of resource management exercises and development of advanced decision support methods and tools. They have extensive experience throughout North America in applying decision analysis and Adaptive Environmental Assessment and Management (AEAM) (Holling, 1978) to problems of flow management and river restoration (Alexander et al. 2001, 2002, Peters and Marmorek 2001, Marmorek and Parnell 2002)

The ESSA team will consist of David Marmorek, Calvin Peters and Clint Alexander. David Marmorek is the President of ESSA Technologies Ltd.. His 25 years of experience includes facilitation of over a hundred workshops, and development of models, monitoring designs, adaptive management approaches, and ecological risk assessments for a diverse range of resource management problems. Recent relevant experience includes leadership of a 5-year, multi-agency decision analysis of risks to endangered chinook salmon stocks in the U.S. Columbia River (PATH – the Plan for Analyzing and Testing Hypotheses, Marmorek and Peters 2001).

Calvin Peters is a systems ecologist who is highly skilled in integrating biological, economic, and social components of environmental problems into comprehensive solutions. He specializes in applying decision analysis and other quantitative and analytical tools to the evaluation of environmental policy and practices. Most recently, Mr. Peters was a member of the ESSA team that developed the Clear Creek Decision Analysis Model, a comprehensive bio-physical model and database for assessing the effects alternative flow policies on Clear Creek (California) on downstream chinook and steelhead populations.

Clint Alexander offers high level expertise in multiple-objective risk analysis and management for resource management problems. As these systems are pervaded by uncertainty, Mr. Alexander specializes in the use of quantitative methods that permit the clear identification and credible accounting of key uncertainties (e.g., probabilistic simulation modeling, decision analysis, adaptive management, and statistics). Mr. Alexander was the principal architect and software developer on several recent projects including the Clear Creek Decision Analysis and Adaptive Management (CCDAM) model for CALFED, a data management and catch estimation system (MERCI) for DFO, and the Keenleyside Decision Analysis and Adaptive Management model (KDAM) for BC Hydro.

ESSA Technologies, LTD. Qualifications

David R. Marmorek

Birthdate: **December 6, 1952**
Citizenship: **Canadian**

Post-Secondary Education

Leadership Laboratory, University of British Columbia, Vancouver, BC, 1989

M.Sc. Zoology, University of British Columbia, 1983. Thesis topic: Effects of lake acidification on zooplankton community structure and phytoplankton-zooplankton interactions: an experimental approach. 397 pp.

B.E.S. (Honors), Man-Environment Studies and Mathematics, First class honors, University of Waterloo, 1975.

Awards

Environmental Protection Agency - Bronze Medal for Commendable Service, 1987.
University of British Columbia Graduate Scholarship, 1980.
Natural Science & Engineering Research Council - Post-Graduate Scholarship, 1979.
Rene Descartes Mathematics Bursary, University of Waterloo.
Ontario Scholarship, York Mills Collegiate, Toronto.

Research Interests

applying the tools of Adaptive Environmental Assessment and Management (AEAM) to solving problems in aquatic ecosystems (e.g. fisheries management, acid deposition, environmental assessment and monitoring), particularly at a regional scale

melding my group leadership and facilitation skills with my knowledge of scientific methods (data analysis, modeling, experimental design, field monitoring and experimental management)

Professional Experience

1993 - now **Director,** ESSA Technologies Ltd.
1991 - now **Adjunct Professor,** School of Resource and Environment Management, Simon Fraser University.
1983 - 1993 **Director,** ESSA Environmental and Social Systems Analysts Ltd.
1981 - 1983 **Systems Ecologist,** ESSA Environmental and Social Systems Analysts Ltd.

Refereed Journal Articles and Book Chapters

Marmorek, David R. and Calvin Peters. In press. Finding a PATH towards scientific collaboration: insights from the Columbia River Basin. Conservation Ecology on-line journal.
Deriso, R.B., Marmorek, D.R., and Parnell, I.J. 2001. Retrospective Patterns of Differential Mortality and Common Year Effects Experienced by Spring Chinook of the Columbia River. Can. J. Fish. Aquat. Sci. (accepted, in final review)
Peters, C.N. and Marmorek, D.R. 2001. Application of decision analysis to evaluate recovery actions for threatened Snake River spring and summer chinook salmon (Oncorhynchus tshawytscha). Can. J. Fish. Aquat. Sci. (accepted, in final review).
Peters, C.N., Marmorek, D.R., and Deriso, R.B. 2001. Application of decision analysis to evaluate recovery actions for threatened Snake River fall chinook salmon (Oncorhynchus tshawytscha). Can. J. Fish. Aquat. Sci. (accepted, in final review).
More extensive qualifications and publication list available upon request.

Calvin N. Peters

Birthdate: **April 26, 1967**
Citizenship: **Canadian**

Professional Experience

1996 - now **Systems Ecologist**, ESSA Technologies Ltd., Vancouver, BC.
Responsibilities include: Data analysis, statistical and decision analysis, ecological modelling, report writing, workshop facilitation, and proposal preparation.

Jan. 01/96- Aug. 31/96 **Research Assistant**, Simon Fraser University, Burnaby, BC. (Contract position with Dr. Randall Peterman)

1994-1995 **Recreational Fisheries Policy Analyst**, Fisheries Branch, B.C. Ministry of Environment, Lands, and Parks (contract/summer position)

Post Secondary Education

Masters of Resource Management, Simon Fraser University, Burnaby, B.C. 1996
Interdisciplinary training in integrated environmental management, specialization in policy analysis and quantitative approaches to decision-making in fisheries management

B.Sc. Ecology, Simon Fraser University, Burnaby, B.C. 1992.
Specialization in evolutionary and behavioural ecology

Diploma of Technology (Honors), B.C. Institute of Technology (1988)
Professional training in financial management, capital budgeting and financing, and computer systems analysis, design, and programming.

Peer-Reviewed Publications and Reports

Marmorek, D. and Peters, C. 2001. Finding a path towards scientific collaboration: Insights from the Columbia River Basin. Conservation Ecology XX(YY): ZZ. [online] URL: http://www.consecol.org/volXX/issYY/artZZ. In press.

Peters, C., and Marmorek, D. 2001. Application of decision analysis to evaluate recovery actions for threatened Snake River spring and summer chinook salmon (Oncorhynchus tshawytscha). Can. J. Fish. Aquat. Sci. (accepted, in final review).

Peters, C., Marmorek, D., and Deriso, R. 2001. Application of decision analysis to evaluate recovery actions for threatened Snake River fall chinook salmon (Oncorhynchus tshawytscha). Can. J. Fish. Aquat. Sci. (accepted, in final review).

Peterman, R.M., C. Peters. S Frederick and C. Robb. 1998. Bayesian decision analysis and uncertainty in fisheries management. In: T. Pitcher, D. Pauly, and P.J.B. Hart (eds.). Reinventing Fisheries Management: Proceedings of a Symposium held February, 1996. Kluwer Academic Publishers, Dordrecht. 646 pp.

Peterman, R.M. and C. Peters. 1998. Decision Analysis: Taking Uncertainties into Account in Forest Resource Management. In: V. Sit and B. Taylor (eds.). Statistical Methods for Adaptive management Studies. Resource Branch, B.C. Ministry of Forests, Victoria B.C., Land Management Handbook No. 42.

Clint A.D. Alexander

Post Secondary Education

- **Master of Resource and Environmental Management**, Simon Fraser University, Burnaby, BC, 1995-1999.
- **B.Sc. (Ecology and Environmental Biology),** The University of BC, Vancouver, BC, 1991-1995.

Seminars Attended

- **Facilitation Skills for Leaders**, UBC Commerce - Centre for Management Development, Oct. 13-15, 1999.

Professional Experience

1997 -present **Systems Ecologist**, ESSA Technologies Ltd. As a member of the aquatic ecosystems, fisheries and environmental monitoring group specializing in quantitative methods, responsibilities include: design and development of computer simulation models and other decision support tools; evaluation of sampling (e.g., creel surveys) and experimental designs; development and assessment of appropriate research methods; conducting statistical analyses (using Bayesian, classical and Bootstrap methods); decision and risk analysis; statistical power analysis; technical writing (e.g., progress, model documentation, final project reports); identification of new research areas, and proposal writing; and coordination and facilitation of workshops.

1996 -1997 **Principal Researcher (contract position),** Department of Fisheries and Oceans, Burnaby, BC.

1996 **Teaching Assistant (Ecology),** School of Resource and Environmental Management, SFU, Burnaby, BC. (Sept.-Dec.)

1996 **Research Assistant,** School of Resource and Environmental Management, SFU, Burnaby, BC. (Jun.-Aug.)

1995 **Research Assistant / Technician 2,** UBC Fisheries Centre, Vancouver, BC.

Recent Publications and Reports

Alexander, C.A.D. 2002. Training Course: Management and Evaluation of River Catch and Effort Information for Lower and Mid-Fraser River Aerial-Roving-Access Creel Surveys (for MERCI 3 software system). Prepared by ESSA Technologies Ltd., Vancouver, BC. 60 pp.

Alexander, C.A.D., D.R. Marmorek, and C.N. Peters. 2000. Applying decision analyses to whitefish management in the Columbia River: Is it worth varying flows to reduce key uncertainties? Model description and preliminary results. Prepared by ESSA Technologies Ltd., Vancouver, BC for BC Hydro, Burnaby, BC. 52 pp. and appendices.

Alexander, C.A.D., D.R. Marmorek, and C.N. Peters. 2000. Clear Creek Decision Analysis and Adaptive Management Model: Results of a Model Design Workshop held January 24th-26th 2000. Draft report prepared by ESSA Technologies Ltd., Vancouver, BC for CALFED Bay-Delta Program, 1416 Ninth Street, Suite 1155 Sacramento, CA 95814, 96 pp. and appendices.

Alexander, C.A.D. 1999. Contradictory data and the application of the precautionary approach: a case study for setting escapement targets for the Early Stuart run of Fraser River sockeye salmon (*Oncorhynchus nerka*), British Columbia. Rep. No. 237. Master's thesis, School of Resource and Environmental Management, Simon Fraser University, Burnaby, BC.

Marmorek, D.R., I. Parnell, C.N. Peters, and C.A.D. Alexander (compls./eds.). 1999. PATH: Scoping of candidate research, monitoring and experimental management actions: concurrently reducing key uncertainties and recovering stocks. Working draft prepared by ESSA Technologies Ltd., Vancouver, BC. 232 pp.

Appendix D
USGS personnel qualifications and bibliography

The interdisciplinary team at the USGS Mid-continent Ecological Science Center has been collaborating for a number of years on studies aimed at defining the relations between streamflow and western riparian vegetation. The researchers involved in this proposal are among the most prominent authors of the published literature relating to their field investigation in this proposal. The primary researchers who will be involved in this project from USGS include Michael Scott, Gregory Auble, Jonathon Friedman, and Patrick Shafroth. A currently undesignated postdoctoral fellow will be added for this specific project. For more information on their qualifications and a bibliography of the team's riparian publications.

GREGOR T. AUBLE

U.S. Geological Survey, Midcontinent Ecological Science Center, Fort Collins CO

Education

1982. Ph.D., Ecology. University of Georgia. Dissertation: Biogeochemistry of Okefenokee Swamp: Litterfall, litter decomposition, and surface water dissolved cation concentrations.

1973. B.A. (Honors), Biological Sciences. Indiana University.

Work Experience

1984-present. Operations Research Analyst (Ecologist) working on wetland and riparian systems, Midcontinent Ecological Science Center, USGS, Fort Collins CO (previously NBS and FWS).

1981-1984. Systems Ecologist developing environmental simulation models, Adaptive Environmental Assessment Group, Western Energy and Land Use Team, U.S. Fish and Wildlife Service, Fort Collins CO (IPA from University of Georgia).

1979-1981. Project Manager, Okefenokee Swamp Ecosystem Research Project, University of Georgia, Athens GA.

Professional Affiliations

American Geophysical Union, Ecological Society of America, Society of Wetland Scientists, SWS Certified Professional Wetland Scientist, ESA Certified Senior Ecologist

Honors and Awards

Phi Beta Kappa, Phi Eta Sigma, Phi Kappa Phi, Sigma Xi
Special Achievement Awards, U.S. Fish and Wildlife Service (1986, 1989-1993)
Branch Chief's Quality Award, U.S. Fish and Wildlife Service (1992)
Quality Performance Award, National Biological Survey (1994)
Superior Accomplishment Award, National Biological Service (1995)
STAR Award, U.S. Geological Survey (1999, 2001)
Superior Service Award, U.S. Department of the Interior (2000)

JONATHAN M. FRIEDMAN

U.S. Geological Survey, Midcontinent Ecological Science Center, Fort Collins CO

Education

1993. Ph.D., Environmental, Population, and Organismic Biology. University of Colorado. Dissertation: Vegetation establishment and channel narrowing along a Great-Plains stream following a catastrophic flood.

1987. M.S., Oceanography and Limnology. University of Wisconsin.

1983. B.S., Biology. Massachusetts Institute of Technology.

Work Experience

1993-present. Hydrologist integrating fluvial geomorphology and riparian ecology, Midcontinent Ecological Science Center, USGS (NBS, FWS), Fort Collins CO

1994-present. Affiliate Faculty Colorado State University Earth Resources Department, University of Colorado Geography Department.

1990-92. Hydrologist, U.S. Geological Survey, Denver, CO.

1988-90. Instructor, Bellevue Community College and Olympic College, WA; and Front Range Community College, CO.

1988. Assistant Natural Area Scientist, Natural Heritage Program, Olympia, WA
1985-87. Wetland Scientist, The Nature Conservancy, Olympia, WA.

Professional Affiliations

American Geophysical Union, Ecological Society of America, Society of Wetland Scientists

Honors and Awards

Phi Beta Kappa (1983),
Graduate School Fellowship, University of Wisconsin, Madison (1983-84)
Edna Bailey Sussman Fund Grant for work at The Nature Conservancy (1987)
Special Achievement Award, National Biological Service (1994)
Superior Accomplishment Award, National Biological Service (1995)

MICHAEL L. SCOTT

U.S. Geological Survey, Midcontinent Ecological Science Center, Fort Collins CO

Education

1985. Ph.D., Department of Botany and Plant Pathology (Ecology Program), Michigan State University. Dissertation: Growth dynamics and successional trends in an old-growth, cedar-hardwood dune forest.
1974. B.S., Biology, Michigan State University.

Work Experience

1987-present. Wetlands Ecologist working on western wetland and riparian systems, Midcontinent Ecological Science Center, USGS (NBS, FWS), Fort Collins CO.
1988-present. Affiliate Faculty, Department of Biology, Colorado State University.
1986-1987. Research Associate working on ecological characterization of risks posed by toxic chemicals, Department of Botany and Plant Pathology, Oregon State University.
1984-1986. Postdoctoral Fellow working on structural and functional changes in a cypress-tupelo wetland, along a disturbance gradient, Savannah River Ecology Laboratory, University of Georgia.
1983. Research Assistant on Man and the Biosphere grant to study seasonally dry tropical forest types in northern Australia.
1979-1983. Botany Instructor, Michigan State University.

Professional Affiliations

Ecological Society of America, American Institute of Biological Sciences, Society of Wetland Scientists, Editor of Society of Wetland Scientists Bulletin (1994-present)

Honors and Awards

William G. Fields Graduate Award for Excellence in Teaching, Michigan State University (1980).
Superior Service Award (1989, 1991-1993). U.S. Fish and Wildlife Service.
Quality Performance Award, National Biological Survey (1994)
Superior Accomplishment Award, National Biological Service (1995)

PATRICK B. SHAFROTH

U.S. Geological Survey, Midcontinent Ecological Science Center, Fort Collins CO

Education

1999. Ph.D., Botany, Arizona State University. Dissertation: Downstream effects of dams on riparian vegetation: Bill Williams River, Arizona.
1993. M.S., Forest Sciences (Ecology). Colorado State University. Thesis: Reproduction of an exotic riparian willow, *Salix* x *rubens* Schrank, in Colorado.
1989. B.A. (*summa cum laude*), Environmental Studies and Geography. University of California, Santa Barbara.

Work Experience

1999-present. Ecologist (plants) Midcontinent Ecological Science Center, USGS, Fort Collins, CO.
1995-1999. Coop-Ed. Student, Midcontinent Ecological Science Center, USGS, and Research Assistant, Arizona State University.
1993-1995. Botanist, MESC, National Biological Service, Fort Collins, CO.
1991-1993. Biological Aide and Biologist, National Ecology Research Center, U.S. Fish and Wildlife Service, Fort Collins, CO.

1988-1990. Research, Intern, and Teaching Assistantships. University of California, Santa Barbara, and The Nature Conservancy.

Professional Affiliations

Ecological Society of America, Arizona Riparian Council, Society of Wetland Scientists

Honors and Awards

Graduate Fellowship, Colorado State University (1991)

Student Travel Award, Society of Wetland Scientists (1992)

Special Achievement Awards, Fish and Wildlife Service (1992) and National Biological Service (1994)

Superior Accomplishment Award, National Biological Service (1995)

Bibliography

Auble, G.T., J.M. Friedman, and M.L. Scott. 1994. Relating riparian vegetation to present and future streamflows. Ecological Applications 4: 544-554.

Auble, G.T., and M.L. Scott. 1998. Fluvial disturbance patches and cottonwood recruitment along the upper Missouri River, MT. Wetlands 18: 546-556.

Auble, G.T., M.L. Scott, J.M. Friedman, J. Back, and V.J. Lee. 1997. Constraints on establishment of plains cottonwood in an urban riparian preserve. Wetlands 17:138-148.

Bovee, K. and M.L. Scott. In Press. Effects of flow regulation on the Upper Missouri River, USA: implications for flood pulse restoration. Regulated Rivers: Research and Management.

Friedman, J.M., and G.T. Auble. 1999. Removal of riparian trees by sediment mobilization and extended inundation. Regulated Rivers: Research and Management: 15:463-476.

Friedman, J.M., and G.T. Auble. 2000. Floods, flood control, and bottomland vegetation. Pages 219-237 in E. Wohl, editor. Inland flood hazards: human, riparian and aquatic communities. Cambridge University Press.

Friedman, J.M. and V.J. Lee. In Press. Extreme floods, channel change and riparian forests along ephemeral streams. Ecology.

Friedman, J.M., W.R. Osterkamp, and W. M. Lewis, Jr. 1996. Channel narrowing and vegetation development following a Great Plains flood. Ecology 77:2167-2181.

Friedman, J.M., W.R. Osterkamp, and W. M. Lewis, Jr. 1996. The role of vegetation and bed-level fluctuations in the process of channel narrowing. Geomorphology 14:341-351.

Friedman, J.M., W.R. Osterkamp, M.L. Scott, and G.T. Auble. 1998. Downstream effects of dams: regional patterns in the Great Plains. Wetlands 18:619-633.

Friedman, J.M., M.L. Scott, and G.T. Auble. 1997. Water management and cottonwood forest dynamics along prairie streams. Ecological Studies 125:49-71.

Friedman, J.M., M.L. Scott, and W.M. Lewis, Jr. 1995. Restoration of riparian forest using irrigation, artificial disturbance, and natural seedfall. Environmental Management 19:547-557.

Katz, G.L., J.M. Friedman, and S.W. Beatty. 2001. Effects of physical disturbance and granivory on establishment of native and alien riparian trees in Colorado, U.S.A. Diversity and Distributions 7:1-14.

Richter, B. D., Mathews R., Harrison D. L., Wigington R. 2001 in review. Ecologically Sustainable Water Management: Managing River Flows for Ecological Integrity.

Scott, M.L., and G.T. Auble. In press. Conservation and Restoration of Semi-arid Riparian Forests: A Case Study From The Upper Missouri River, Montana, USA. in: Flood Pulsing and Wetland Restoration in North America, B. Middleton, (ed.), John Wiley and Sons, Inc.

Scott, M.L., G.T. Auble, and J.M. Friedman. 1997. Flood dependency of cottonwood establishment along the Missouri River, Montana, USA. Ecological Applications 7:677-690.

Scott, M.L., J.M. Friedman, and G.T. Auble. 1996. Fluvial process and the establishment of bottomland trees. Geomorphology 14:327-339.

Scott, M.L., G.C. Lines, and G.T. Auble. 2000. Channel incision and patterns of cottonwood stress and mortality along the Mojave River, California. Journal of Arid Environments 44:399-414.

Scott, M.L., P.B. Shafroth, and G.T. Auble. 1998. Response of cottonwoods to alluvial water table declines. Environmental Management 23:347-358.

Segelquist, C.A., M.L. Scott, and G.T. Auble. 1993. Establishment of *Populus deltoides* under simulated alluvial groundwater declines. American Midland Naturalist 130: 274-285.

Shafroth, P.B., G.T. Auble, and M.L. Scott. 1995. Germination and establishment of the native plains cottonwood (*Populus deltoides* marshall subsp. *monilifera*) and the exotic Russian-olive (*Elaeagnus angustifolia* L.) Conservation Biology 9:1169-1175.

Shafroth, P.B., G.T. Auble, J.C. Stromberg, and D.T. Patten. 1998. Establishment of woody riparian vegetation in relation to annual patterns of streamflow, Bill Williams River, Arizona. Wetlands 18:577-590.

Shafroth, P.B., J.M. Friedman, and L.S. Ischinger. 1995. Effects of salinity on establishment of *Populus fremontii* (cottonwood) and *Tamarix ramosissima* (saltcedar) in southwestern United States. Great Basin Naturalist 55:58-65.

Shafroth, P.B., M.L. Scott, J.M. Friedman, and R.D. Laven. 1994. Establishment, sex ratio, and breeding system of an exotic riparian willow, *Salix* x *rubens*. American Midland Naturalist 132:159-172.

Shafroth, P.B., J.C. Stromberg, and D.T. Patten. In Press. Riparian vegetation response to altered disturbance and stress regimes. Ecological Applications.

Shafroth, P.B., J.C. Stromberg, and D.T. Patten. 2000. Woody riparian vegetation response to different alluvial water table regimes. Western North American Naturalist 60:66-76.

Springer, A.E., J.M. Wright, P.B. Shafroth, J.C. Stromberg, and D.T. Patten. 1999. Coupling groundwater and riparian vegetation models to assess effects of reservoir releases. Water Resources Research 12:3621-3630.