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

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?**

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: 22

Total Requested Funds: 1,927,032

b) Do you have cost share partners already identified?

No

c) Do you have potential cost share partners?

No

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**	**b-1 other**
1448113327G017	**Hartley Island Acquisition**	**AFRP**
113320G014	**Singh Walnut Orchard**	**AFRP**

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:**

Environmental Compliance Checklist

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

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 proposal.

      This proposal is not an implementation project. No on-the-ground actions will occur as a result of this proposal.

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
   Xnone

   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.**

Land Use Checklist

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

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.**

Conflict of Interest Checklist

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

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
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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:

Budget Summary

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

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	workshops and decision tool development	650	18744	6935	1700	200	318664		4600	350843.0	77186	428029.00
2	targeted research	319.25	9442	3494	700	200	472354		1100	487290.0	107204	594494.00
3	quantitative modeling	72	2111	781			22413			25305.0	5567	30872.00
4	hypothesis development and experimental design	72	2111	781			12600			15492.0	3408	18900.00
5	project management	291.75	9442	3494						12936.0	2846	15782.00
		1405	41850.00	15485.00	2400.00	400.00	826031.00	0.00	5700.00	891866.00	196211.00	1088077.00

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	workshops and decision tool development									0.0		0.00
2	targeted research	319.25	9880	3656	900	200	311506		700	326842.0	71905	398747.00
3	quantitative modeling	66	2047	757			67238			70042.0	15409	85451.00
4	hypothesis development and experimental design	66	2047	757			37800			40604.0	8933	49537.00
5	project management	128.75	4364	1615						5979.0	1315	7294.00
		580	18338.00	6785.00	900.00	200.00	416544.00	0.00	700.00	443467.00	97562.00	541029.00

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	workshops and decision tool development									0.0		0.00
2	targeted research	303	9880	3656	1000	200	194131		200	209067.0	45995	255062.00
3	quantitative modeling	66	2139	791			22413			25343.0	5576	30919.00
4	hypothesis development and experimental design	66	2139	791						2930.0	645	3575.00
5	project management	145	5008	1853						6861.0	1509	8370.00
		580	19166.00	7091.00	1000.00	200.00	216544.00	0.00	200.00	244201.00	53725.00	297926.00

Grand Total=1927032.00

Comments.

Although all subtasks within task #2 are consistent with CALFED goals and priorities stated in the Implementation plan, Ecosystem resoration plan, and Record of decision, they may be funded seperately if partial funding is considered. 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.

Budget Justification

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

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

Position Hours Project Director III 200 Science Specialist II 270 Program Director I 200 Program Director I 870 Science Specialist I 270 Conservation Planner 315 Operations Manager 160 Program Assistant II 280

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

Position Hrly Rate Project Director III $56 Science Specialist II $31 Program Director I $36 Science Specialist I $24 Conservation Planner $22 Operations Manager $27 Program Assistant II $17

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

37% 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. Travel will also cover presentations of results to stakeholders and confernces.

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.

No equipment purchase is proposed.

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 presentatons, reponse to project specific questions and necessary costs directly associated with specific project oversight.

This proposal has complex project managment responsibility associated with the coordination of many collaborators and many tasks and sub-tasks. Staff will be invovled in various aspects of project management including presentations, project and deliverable tracking, reporting, 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.

The Nature Conservancy (TNC) has a Negotiated Indirect Cost Rate (NICRA) of 22% which was negotiated and approved by TNCs cognizant agency, USAID, and calculated in compliance with the requirements of OMB Circular A-122, and bound into our annual OMB Circular A-133 audit reports. TNCs 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.

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, and quantitative computer modeling 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 proposal 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. Objectives: 1) Synthesize existing, interdisciplinary knowledge that addresses unknowns already identified during proposal development. 2) Provide information on ecological flow needs to other efforts seeking to balance ecosystem and human river flow needs. 3) Propose strategies to achieve multiple species conservation benefits. Hypothesis: It is possible to develop flow recommendations on the Sacramento River that will improve the viability of key, at-risk species (e.g., salmon and splittail), riparian habitat communities (e.g., cottonwood forest and mixed riparian), and river processes (e.g., sediment transport and channel meander) while meeting human demands. This proposal addresses many CALFED and CVPIA goals, and science program priorities and that is proposed to cost $1,927,032. 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 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 habitat for all life stages of anadromous fish through the development of flow recommendations and the creation of a process to evaluate integration between anadromous fish and other species and habitat flow needs (AFRP Goal 1).

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 has been 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 riparian zone. 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 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 efforts such as the Environmental Water Account (EWA), Environmental Water Program (EWP), Central Valley Project Improvement Act (CVPIA), Anadromous Fish Restoration Plan (AFRP), and the Phase 8 resolution of the State Water Resources Control Board's current Bay-Delta Water Rights Hearings, seek to balance environmental and human water supply needs.

Despite recent attention to flow regimes within CALFED and other programs, little quantification of critical aspects of a natural flow regime for the Sacramento River, beyond the needs of some fisheries in the Bay-Delta, has occurred. Quantification of stream flow needs, which maintain the ecological function of riverine systems, would facilitate the formulation of the most effective water management and ecosystem restoration strategies.

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 hydrology is driven both by winter storms and spring snowmelt runoff[1]. The Sacramento River 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 proposal is the reach between the towns of Red Bluff and Colusa in Northern California (see Figure #1). This area is described as reaches 2 and 3 in the Sacramento River Conservation Area (SRCA) Handbook (Sacramento River Advisory Council, 1998) and is a meandering reach with the channel flowing through recent alluvium (Buer, 1994).

[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).

Project Goals and Objectives

The goals of this proposal are:

1) Apply an interdisciplinary workshop approach to develop and evaluate multi-species conservation flow regime recommendations.
2) Initiate focused research efforts to reduce key scientific uncertainties and improve our ability to effectively guide conservation efforts in the study area.
3) Initiate computer based quantitative modeling to also reduce key scientific uncertainties and improve our ability to effectively guide conservation efforts in the study area.
4) Identify additional unknown and develop experiments and monitoring plans to address these unknowns in the future.

A previous report that informs this proposal is an Integrated Storage Investigation (ISI) report titled "Flow regime requirements for habitat restoration along the Sacramento River between Colusa and Red Bluff" (Kondolf et. al. 2000). This report evaluated linkages between channel meander, stream flow, and a number of ecosystem components including riparian regeneration. This proposal seeks to expand on the ISI report and evaluate linkages between additional ecosystem components and the flow regime. Figure #2 is a conceptual model of ecological linkages to the flow regime of the Sacramento River within the project area.

Specific objectives of this proposal include:

1) Synthesize existing, interdisciplinary knowledge that addresses unknowns already identified during proposal development.
2) Provide information on ecological flow needs to other efforts seeking to balance ecosystem and human river flow needs.
3) Propose strategies to achieve multiple species conservation benefits.

The hypothesis to be tested is:

H: It is possible to develop flow recommendations on the Sacramento River that will improve the viability of key, at-risk species (e.g., salmon and splittail), riparian habitat communities (e.g., cottonwood forest and mixed riparian), and river processes (e.g., sediment transport and channel meander) while meeting human demands.

We do not seek to develop one flow regime that will meet all ecosystem needs. A range of variation of individual flow regime characteristics will better serve a multi-species conservation approach. Some combination of flow regime characteristics may serve multiple species benefit, thereby meeting both riverine and Bay-Delta ecosystem goals. In addition, we will not quantify human demands on the system within this proposal. Other efforts, discussed below, are currently quantifying these demands. This proposal focuses on the development of ecological flow needs to include in these other efforts.

A2. Justification:

A number of "water yield analyses" are now occurring within the Central Valley of California. These analyses apply a workshop approach to balance water supply both for ecological benefit and human demands. Within workshops, specialists develop water needs for a series of objectives and build a tool to evaluate, or "game", how infrastructure or policy changes can meet these water needs. Gaming was applied, or is considered for application, within the CALFED Environmental Water Account (EWA), CALFED Environmental Water Program (EWP), the Off-stream Storage Investigation (OSI), and the Phase 8 resolution of the State Water Resources Control Board's current Bay-Delta Water Rights Hearings (Phase 8). However, to date gaming only includes the water needs for certain fisheries within the Bay-Delta. Current gaming does not include overall riverine ecosystem needs.

In addition, these yield analysis efforts are identifying priority streams for potential water management strategies. The current prioritization process considers only baseflow limitations to fisheries habitat utilization as the primary ecosystem component. Evaluating baseflow limitations is a valid approach to initiating the very complex process of a flow needs assessment. However, many ecosystem components depend on flow characteristics other than baseflows. Also, the Sacramento River is not currently included in this analysis because baseflows are not considered a limiting factor on the Sacramento River. Without further work, many ecosystem components on the Sacramento River may remain unapprised through current analysis efforts. This proposal is structured to develop riverine ecosystem flow needs to better inform these efforts.

A number of recently developed, holistic approaches to flow analysis go beyond analysis of the typical fisheries needs outlined in many environmental flow analysis methods and incorporate many ecosystem components. Tharme (in draft) provides a review of different types of flow assessment techniques, and documents the growing application of these more system-wide approaches. Some examples of interdisciplinary, workshop-based approaches to assessing alternative management strategies include decision analysis (Peterman and Anderson 1999), Adaptive Environmental Assessment and Management (AEAM; Holling 1978), the "Building Block Method" (BBM) (Tharme and King, 1998), and Downstream Response to Imposed Flow Transformations, or DRIFT (Brown et al., 2000)

We use the BBM and DRIFT as the methodological examples and frameworks for this proposal. These approaches were developed in the 1990's when South Africa completely restructured water management at the national level. These approaches differ in their exact methodology however, preliminary evaluation of these two approaches shows they offer a structure that integrates many complex relationships. They also offer a common framework for an interdisciplinary team to distill information into an outcome that is applicable to management issues. The BBM creates a flow regime recommendation, which maintains a river's integrity as defined in structured, consensus-based workshops. Therefore, BBM is used as the methodological example for data synthesis and preparation for workshops. DRIFT evolved from and utilizes many of the same initial data preparation and analysis methods. However, DRIFT offers increased flexibility with the addition of a data archival tool and formal decision analyses of alternative flow regimes. Once flow regime needs are developed, the authors of the approach suggest including these needs into a water yield analysis, similar to those described above.

We recognize that the approach used to develop multiple species and process flow needs will need to adapt and conform to the particular challenges of the Sacramento River. This will likely require drawing elements from several different workshop approaches. This proposal is modeled after these holistic approaches and a number of examples are offered to communicate the key aspects of this more holistic approach. The strength of the holistic approach, and components built into this proposal are: synthesis of existing information, a structure to integrate this information, facilitated workshops to maximize communication and develop support among many stakeholders, development of a decision analysis and hypothesis generation tool, and the initiation of directed research to further inform initial hypotheses and reduce uncertainty.

This proposal 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. Restoring or "naturalizing" the most critical components of the flow regime is a proactive approach to avoiding future regulatory action. This is common ground shared by all stakeholders. An important aspect of this proposal approach, and future water management strategies, is the incorporation of stakeholder input. The proposed workshop structure (applied in the BBM and DRIFT) encourages stakeholders to participate. We intend to collaborate with water user groups through workshops to ensure a balanced review of products from this proposal.

Project Type

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

Task 1 is designed as a series of professionally facilitated workshops, that will be modeled after the BBM and DRIFT approaches, to develop initial estimates of ecosystem flow requirements. Several workshop-based approaches have been successfully applied in other systems, including formal decision analysis (Marmorek and Peters 2001; McDaniels et al. 1999), Adaptive Environmental Assessment and Management (Holling 1978), BBM, and DRIFT. An inclusive and collaborative workshop setting and the presentations of workshop results will increase the level of understanding of the issues among a broad group of stakeholders. This will also increase the chance of support for implementation at some future point.

Task 2 will initiate *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 proposal because scientific experts have identified these critical data gaps (Kondolf et al. 2000).

Task 3 will involve application of a *quantitative computer model,* which evaluates linkages between stream flow, channel geometry, and particle size. The modeling will serve as a tool to evaluate different restoration strategies that include these parameters. 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 will be designed to provide data and an adaptive feedback loop, which will refine initial functional relationships defined in Task 1.

Figure #3 depicts relationships among the four tasks.

A3. Approach:

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

Task 1 consists of three sub-tasks: synthesis of existing data and preparation for workshops, conducting workshops, and follow-up activities that link the workshops with planning activities. Workshops involve a broad audience in the development of linkages between ecosystem response and stream flow. The BBM manual provides an example of the structured steps to develop these results. An executive summary from the BBM manual is included as Appendix A. In summary, representative field sites are selected for which flow recommendations are constructed. We will follow this model for three sites within the study area on the Sacramento River.

<u>Task 1, Sub-task 1: Synthesize existing data.</u>

Existing data will be summarized for a panel of specialists (geomorphology, aquatic ecology, fisheries, etc.) in preparation for workshops. The specialist panel will likely be a combination of agency personnel, consultants, and academic community members. Table 1 provides examples of disciplines and existing data, which can inform the workshop process on the Sacramento River. The list is not exhaustive and is representative of the process until funding allows further development.

Task 1, Sub-task 2: Conduct workshops.

A professional facilitator conducts workshops where specialists communicate their initial hypotheses regarding flow regime and ecosystem linkages. Workshops include a field visit to representative sites, a session for the exchange of information, and a session to address any final questions prior to sub-task #3.

Task 1, Sub-task 3: Integrate information and develop data archive and decision analysis tool.

This last step is the most difficult to define until information in Sub-tasks #1 and #2 is developed. Again, DRIFT is offered as an example and an exact duplication of the process may not be appropriate. The intent is to develop a data archival mechanism and a tool that will capture hypotheses developed by workshop participants, and bracket thresholds of ecological response.

Figure #4 is an example of a functional relationship, or "consequence entry", created in workshops and entered into a database. Each consequence entry demonstrates how ecosystem responses are related to changes to the flow regime. Levels of assurance for each relationship are also characterized. Ecosystem responses are given "severity ratings" as a qualitative start to the process. The data archival and decision tool becomes increasingly quantitative as new data is generated in Tasks #2 and #3 described below. Finally, the database is used to formulate a less "severe" flow regime compared to the existing conditions. An abstract from a manuscript submitted to Regulated Rivers, which outlines DRIFT, is included as Appendix B. A document summarizing the DRIFT approach can be downloaded at http://www.southernwaters.co.za/the-company/projects/publications.html

ESSA Technologies, Ltd. (ESSA) will function in a facilitation and coordination role for Task 1 as a sub-contractor. Stillwater Sciences will provide technical support for the Task 1 workshop process, including helping ESSA with initial data compilation and assisting the workshop specialists with data analysis and synthesis as needed.

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 database development proposed for Task 1, thereby strengthening the initial flow recommendations produced through the workshops. Task 2 includes the following 6 investigations: **(Refer to Table #2 for activities, outputs, outcomes, and environmental indicators for each investigation**).

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

Bed 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 F for a description of the flow-sediment mobility model). Validating and calibrating the flow-sediment transport model for the Sacramento River 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.

<u>Task 2, Sub-task 2:Quantify Cottonwood Root Growth Rates.</u>

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.

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

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. To better understand the conditions related to meander cutoff, we propose to analyze historical aerial photos and maps of the study area to identify historical meander cutoffs. 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 consequent conservation of multiple native species and species assemblages.

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

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.

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.

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 demonstrates 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 decision tool on the Sacramento River. Funding under this proposal 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.

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: Numerical modeling of flows required to restore fluvial geomorphic processes for restored or hypothesized channel conditions.

The workshops proposed as part of Task 1 will focus on identifying or bracketing 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, 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 4: Hypothesis development and design of future water-related experiments and monitoring plans.

The workshops and database development conducted as part of Task 1, and the quantitative modeling conducted as part of Task 3, will produce initial flow recommendations. These flow recommendations are based on available data and current professional understanding of geomorphic and ecological processes in the Sacramento River. These recommendations may depend heavily on untested assumptions or be based on poorly understood processes, owing to the complexity of the Sacramento River ecosystem. Task 4 will generate testable hypotheses to address the key uncertainties and then design experiments that will provide data that will feed back into the DRIFT database 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 4 will focus on developing active adaptive management opportunities within the study area.

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, although delaying management for study completion may be impractical. In addition, declining species populations may demand more immediate efforts.

This proposal offers a feasible approach by addressing both time frames. Task 1 provides initial answers in the short term (1-2 years) based on existing data, and provides a mechanism to involve and develop buy-in among all stakeholders into potential solutions. Holistic methods, used as models for this proposal, were recently developed in South Africa and are characterized as an intermediate level of investigation, where an ecosystem approach is the goal (see Figure #5). The methods are currently undergoing revision that this proposal will benefit from. These methods have proven successful in numerous South African and Australian catchment basins and are also being considered for Federal Energy Regulatory Commission dam re-licensing in the US (Knight, pers. comm. 2001).

Materials from these approaches will be used as guides. Where the approach is less applicable, it will be altered to fit needs of the Sacramento River, which may differ from South African systems.

Tharme and King (1998) outline a few of the relevant advantages a workshop approach has to offer and these directly serve CALFED goals. These include:

- Developing methodologies, which produce credible flow recommendations within suitable time frames.
- Developing an inclusive process, which progresses by consensus rather than conflict, and involves scientists from different disciplines, planners, managers, engineers, and decision-makers at each step.
- Setting achievable environmental objectives for rivers through a process of linking specific modified flow regimes with different levels of river health.
- Making flow recommendations that reflect and are synchronized with, the natural variability of rivers.

Results of this proposal 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 develop 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 knowledge. 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 proposal includes two field seasons, which should be sufficient to complete necessary fieldwork. Special use permits will be acquired for field data collection from the United States Fish and Wildlife Service (USFWS). 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. The baseline condition for each of the tasks described in the proposal is scientific uncertainty. The successful performance measure for each task is to reduce this scientific uncertainty with additional data. In addition, measuring the performance of deliverables provided in Table 2 will occur in two forums. Draft and final proposal results will be presented to the EWP steering committee. This committee represents a diverse group of stakeholders interested in water management issues and currently struggling with development of ecosystem flow needs. Results will also be presented to a technical review workshop, which the CALFED science board has suggested that it will fund and assist in organizing. 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 generated from the workshop process. They will develop a database (either some form of DRIFT or a custom-designed database, whichever is most appropriate and efficient), which will function as the data storage and archival mechanism. Stillwater Sciences will assist in data management and coordination with ESSA.

A7. Expected Products/Outcomes:

Table 2 provides a summary of project activities, outputs, outcomes, and environmental indicators by task. Outcomes of this proposal will also be presented at a future conference focused on science on the Sacramento River. Sam Luoma of the CALFED Science Board suggested this future conference. The conference was suggested as a means to increase the focus of science on restoration of the Sacramento River. Results of this proposal are well aligned with the focus of this conference.

Most importantly, we see this proposal 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 aspects of the Sacramento River ecosystem. A decision was made early on in the formulation of the SRCA to exclude flow-related issues. It is apparent from references within the CALFED documents that work now begins to address these flow related issues. The methods communicated by the BBM and DRIFT represent a flow-related "Handbook" similar to the SRCA Handbook. The outcomes of this proposal provide California with a *proactive* approach to dealing with flow issues apparent elsewhere.

A8. Work Schedule:

See Table #3

<u>Partial Funding</u>:

Individual tasks are very inter-related, and partial funding will impact the full potential of the proposal. However, partial-funding decisions may be based on the following relationships.

Task #1 can be funded separately from Tasks #2 and #3 however, initial results will remain generally qualitative and based only on existing data. Field studies or quantitative modeling to address scientific uncertainty will not inform relationships between flow and ecosystem components.

Tasks #2, #3, and #4 can be funded separately from Task #1. However, workable solutions to balancing ecosystem and other flow needs will take the longer time period demonstrated on other rivers. Both the ecosystem and stakeholders would benefit from initial hypotheses generated within a shorter timeframe to allow the initiation of an adaptive feedback process.

Sub-tasks within Task#2 can be funded separately based on CALFED priorities to address scientific uncertainty. See the webpage budget form for individual sub-tasks' funding totals within Task #2.

Task #3 can be funded separately. However, without the inclusion of previous tasks, only a much-reduced scope of potential multi-species conservation strategies can be evaluated.

Task #4 should not be funded separately. It represents the adaptive management feedback loop to previous tasks and is closely related to all of them. If any of the previous tasks are funded, Task #4 should also be funded.

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 proposals.)

This proposal, *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).

This proposal 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 proposal 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, Sacramento and San Joaquin River Basins Comprehensive Study (Comp. Study), Riparian Habitat Joint Venture, Sacramento River Preservation Trust, and Sacramento River Partners. Numerous programs including CALFED, CVPIA, Wildlife Conservation Board, Environmental Protection Agency, and many private foundations and individuals have supported these efforts.

This proposal is structured to ensure the same degree of coordination, as described above, with other ongoing investigations within the ISI and OSI. These investigations are evaluating large-scale alterations to the water management infrastructure such as additional off-stream storage. This proposal represent an extension of the "Flow Regime Requirements for Habitat Restoration along the Sacramento River between Colusa and Red Bluff," a report funded by CALFED's Integrated Storage Investigation. That report was intended to address the scientific uncertainty related to such large-scale decisions and most of the field studies proposed in Task 2 respond directly to the high-priority research needs defined in the report.

In addition, this proposal 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 proposal 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 proposal 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 proposal 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, and salmonid use of different habitats. In addition, a study is under negotiation to develop indicators of riparian ecosystem function. This proposal builds on information gathered during projects previously funded under CALFED grants, and incorporates the data into a scenario-based assessment tool. Incorporation of this information represents a savings to this proposal 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 3 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 6 grants have been used to plan and implement protection and restoration actions on approximately 2985 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 #6):

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

TNC proposals 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 proposal 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 increased 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 proposal 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 proposal 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), John Baer (McBain and Trush) who are submitting related proposals to this PSP. If multiple, related proposals 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.

This proposal is also related to a NHI proposal 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 proposal for geomorphic restoration potential and serves as a pilot for evaluation of additional ecological linkages to flow regime components. The proposal 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 proposal are fashioned after the Stillwater concepts developed to inform the Environmental Water Program. Work under this proposal also provides complimentary information to other local efforts including the Comp. Study's ecosystem function model, various ISI and OSI studies.

B6. Land Acquisition:

This proposal contains no land acquisition activities.

C. Qualifications

TNC

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, Sam Lawson, with more than thirty years experience in community and economic development, transactional real estate, enterprise development, and organizational management. Dr. Greg Golet, Project Ecologist; manages the planning, science, and restoration teams. The project lead for this proposal 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 two 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.

Stillwater Sciences staff and identified collaborators

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 C 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 river bank 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.

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 have 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.

ESSA

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 implemented decision analysis, a process very similar to the BBM and DRIFT called Adaptive Environmental Assessment and Management (AEAM) (Holling, 1978), and other facilitated workshop approaches on many projects throughout North America, and bring a high level of technical expertise in river flow and ecosystem issues.

The ESSA team will consist of David Marmorek and Calvin Peters. Mr. Marmorek is the Director of ESSA's North America operations. 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. See Appendix D for brief resumes.

USGS

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, see Appendix E.

D. Cost

D1. Budget

See webpage form for the complete budget.

D2. Cost-Sharing

There is no cost sharing within this proposal.

E. Local Involvement

This proposal concept was presented to the SRCA Technical Advisory Committee (TAC) on 8/16/01. 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 proposal 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 proposal. TNC will continue to update the SRCA TAC and Board on proposal progress and results.

Although workshops within Task #1 primarily consist of technical specialists, results of this proposal will be presented to both a water user stakeholder group and a technical review workgroup. This provides an opportunity for stakeholders to review and understand the process. The intent is to then bring proposal results to "gaming" exercises. This ensures further review by the broader stakeholder audience involved in gaming. There are no 3rd party impacts associated with this proposal, as it does not involve implementation.

F. Compliance with Standard Terms and Conditions

Regarding Attachment D, Section 4, Expenditure of Funds, TNC requests the following language currently being negotiated for the CALFED 2001 agreements with TNC:

"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 adjust (1) the Budget between individual tasks by no more than 10% and (2) the Budget between individual line items within a task by no more than 10%. Any other variance in the budgeted amount among tasks, or between line items within a task, requires approval in writing by CALFED or NFWF. 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." For Section 5, Subcontracts, TNC requests the following language currently being negotiated 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."

For Section 9, Rights in Data, TNC requests the following language currently being negotiated 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."

For Section 13, Termination Clause, TNC requests the following language currently being negotiated for the CALFED 2001 agreements with TNC:

"Default and Remedies.

1. 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 make any payments to Contractor for any work that has been performed prior to the Termination Date; however, NFWF shall continue to be obligated to make 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 in Section 10.I.2 below.

In the event of any termination of this Agreement by NFWF pursuant to Section 10.I.1 above prior to close of escrow of Contractor's acquisition of any real property interest funded by this Agreement, NFWF's sole remedy shall be to obtain the return of those funds that have been forwarded to Contractor under this Agreement to fund Contractor's acquisition of the Property. "

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Figure #1

Study Area

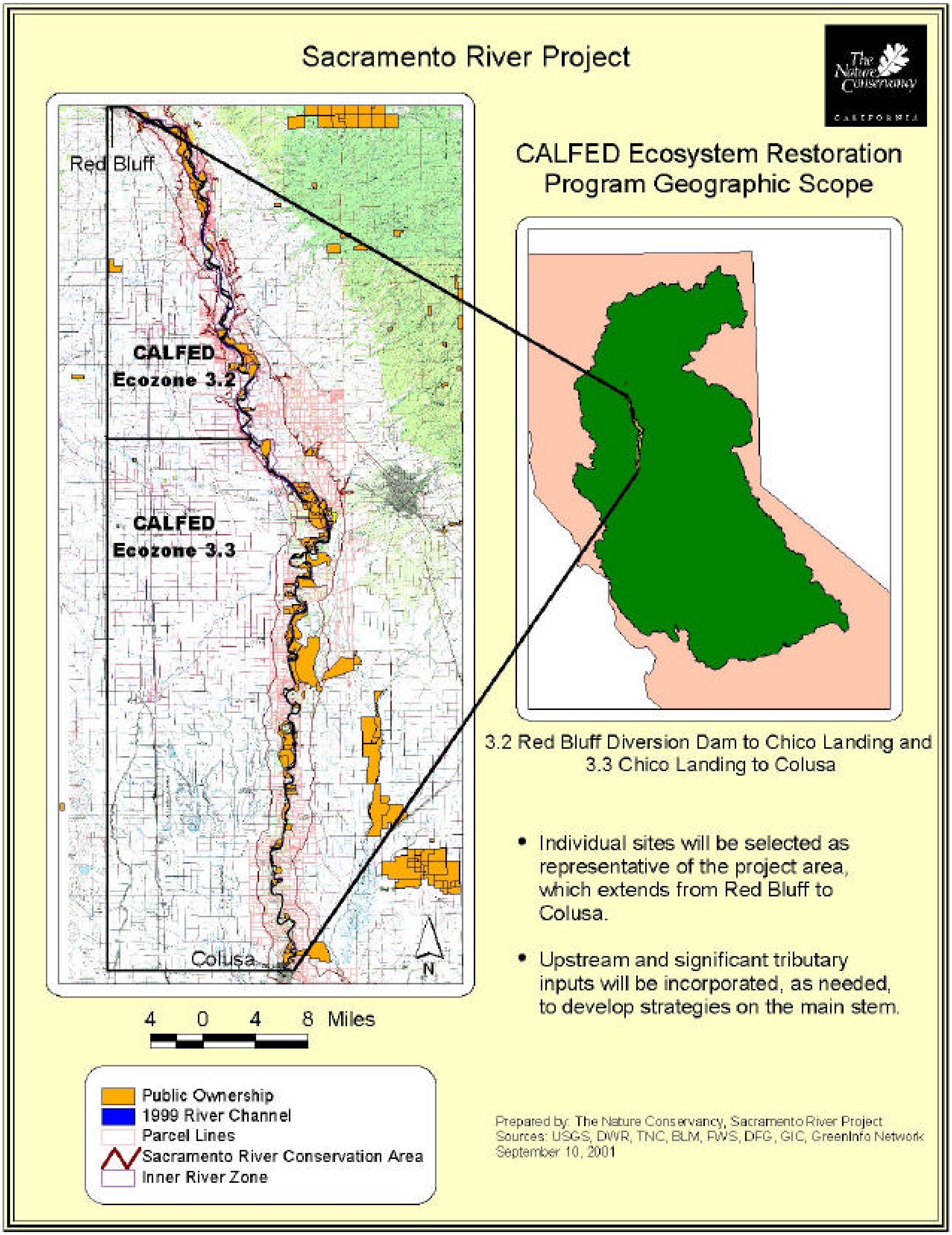


Figure #2

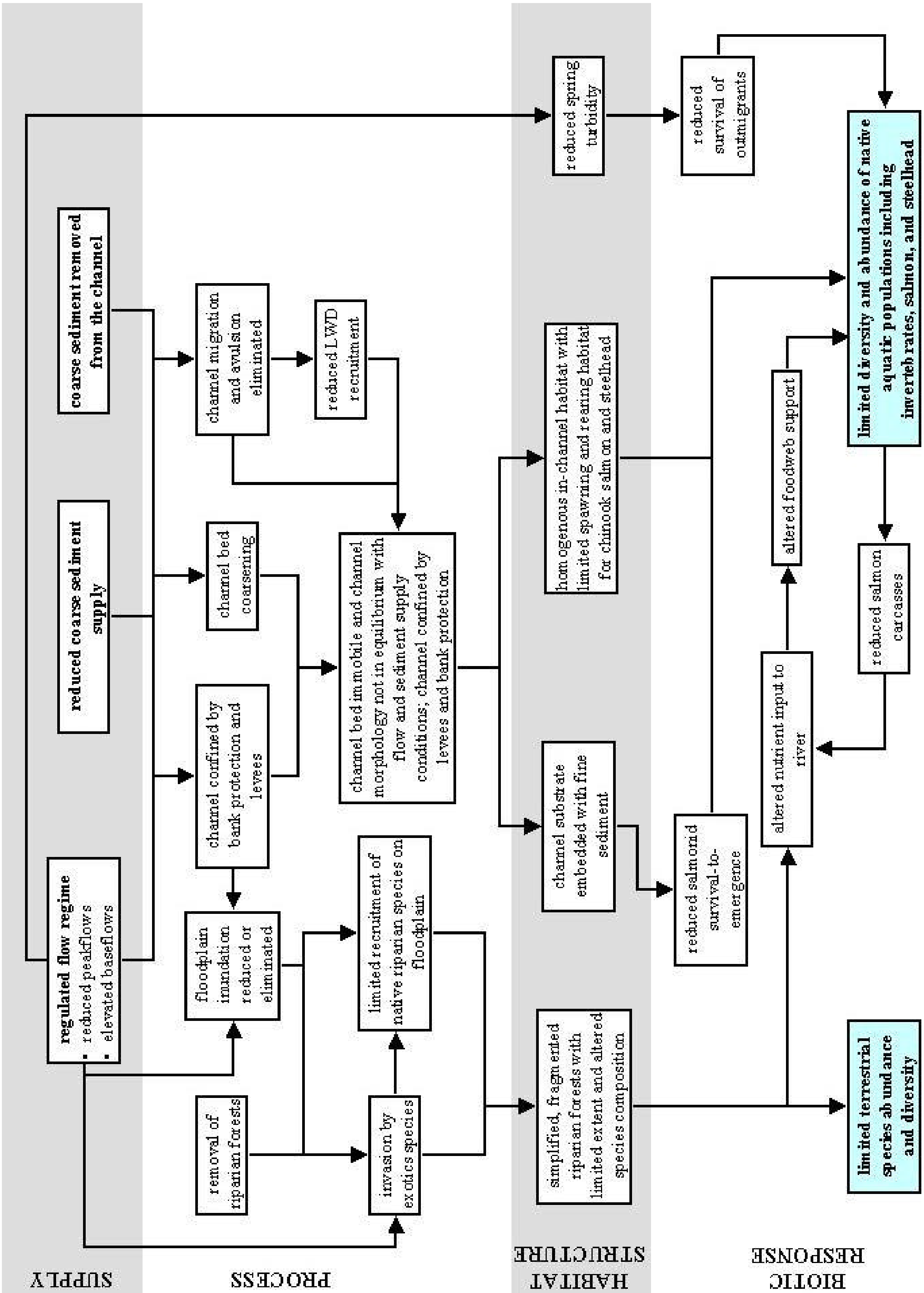


Figure 2. Conceptual model of processes and linkages in the Sacramento River From Red Bluff to Colusa.

Figure #3

Conceptual model of relationships among primary tasks.

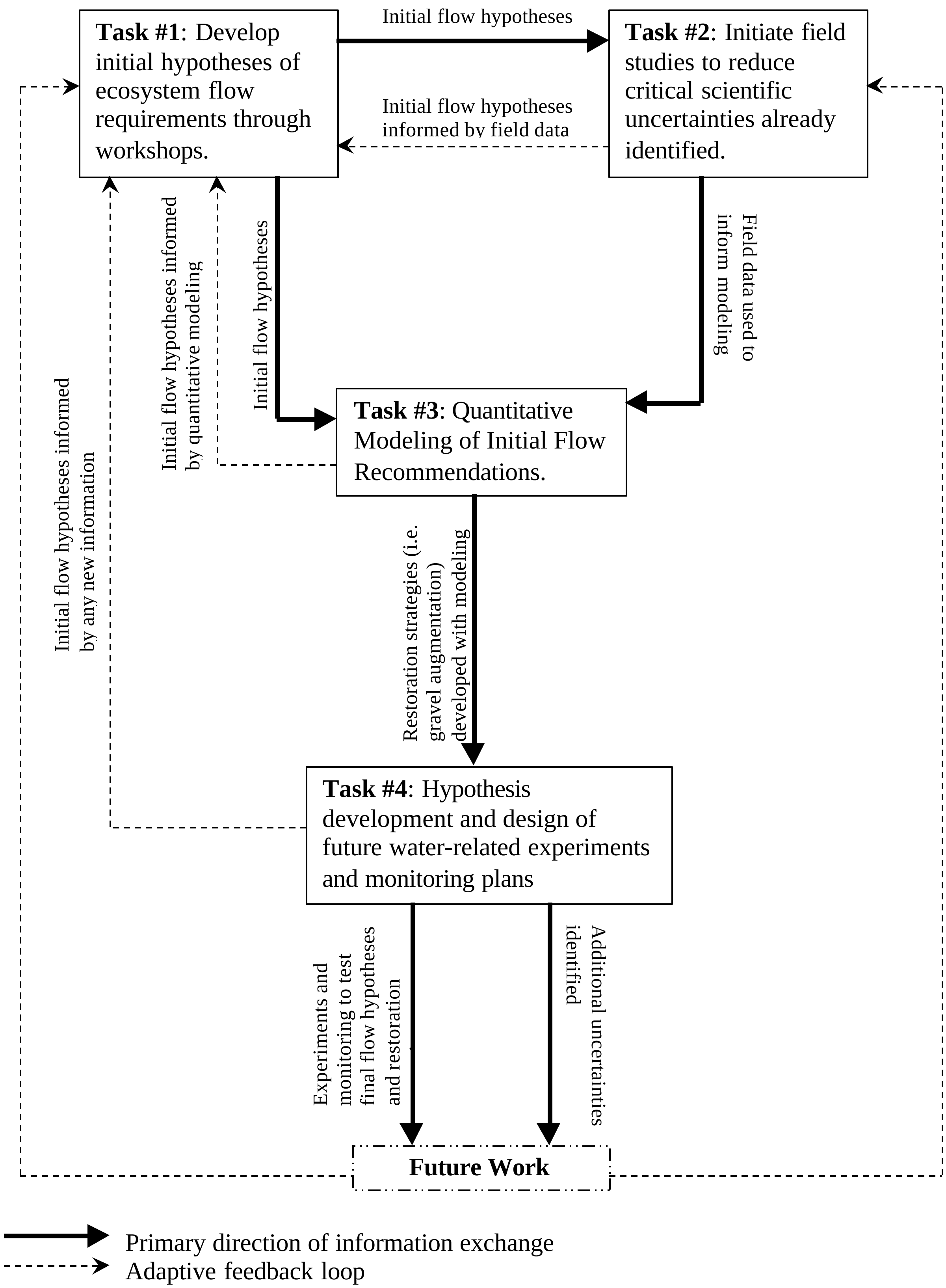


Figure #4

DRIFT database entry

A consequence entry

Each consequence described by the specialists and entered into the database links a site with a flow-reduction level, a discipline, an item from the generic list for that discipline, and the predicted direction and severity of change (Table 6). To aid interpretation of impacts, the ecological and social significance of the generic-list item are also entered.

Sequence	Category	Information
1	Site	2
2	Flow reduction level	Reduction level 4 of dry-season low flows
3	Specialist	Invertebrates
4	Generic list entry	*Simulium nigritarse*
5	Direction of change in abundance	Increase
6	Severity of change	Rating 5: critically severe
7	Conversion to percentage	500% gain or more – probable pest proportions
8	Ecological significance	Filter feeder in slow, eutrophic water
9	Social significance	Blood-sucking pest of poultry

From "A SCENARIO-BASED HOLISTIC APPROACH TO ENVIRONMENTAL FLOW ASSESSMENTS FOR REGULATED RIVERS"

JACKIE KING#, CATE BROWN# AND HOSSEIN SABET*

*Southern Waters Ecological Research and Consulting, University of Cape Town, Rondebosch 7701, South Africa.*

* *SMEC International, Private Bag A8, Maseru 100, Lesotho.*

Figure #5

Levels of Investigation

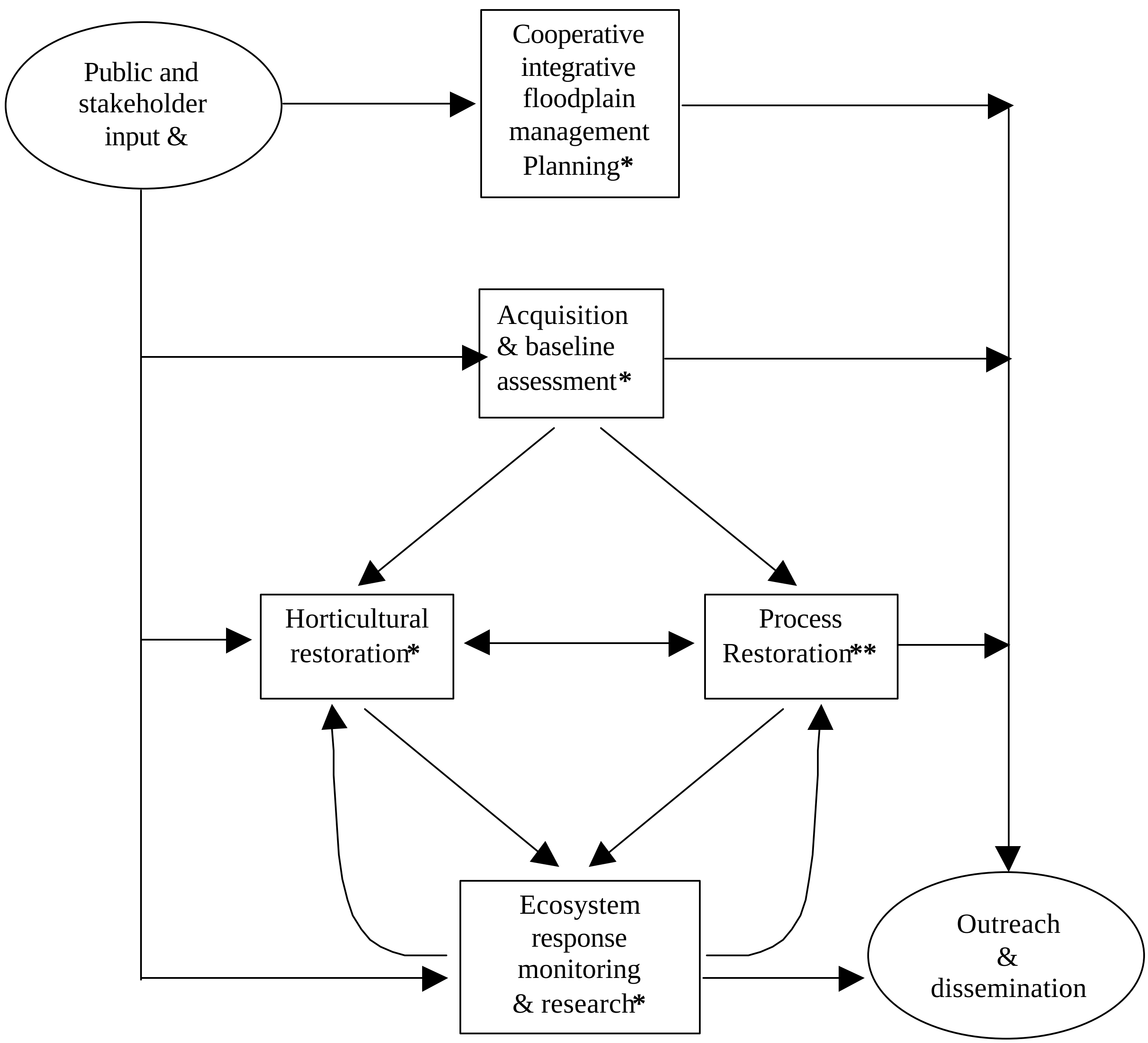
Level		
1 Reconnaissance level	**Type**	**Hydrological**
	Recommended Methodology	RVA/Tennant method/Texas method/FDCA, modified and validated for south African conditions using specialist knowledge
	Future Direction	(1) RVA and/or similar ecologically relevant hydrologic indices modified using various forms of specialist knowledge (2) Inclusion of hydrological and river ecotype regionalisation approaches.
2 Intermediate Whole Ecosystem Level	**Type**	**Holistic**
	Recommended Methodology	BBM/DRIFT/Similar
	Future Direction	(1) inclusion of ecologically relevant hydrologic indices, possibly component specific indices (2) bio-type-level modeling (3) elements of other holistic approaches (4) inputs from riparian/wildlife/water quality/ geomorphology models (5) expansion of social component (6) EFR operating rules/reservoir models
3 Species/ Component Oriented Level	**Type**	**Habitat Simulation (in addition to holistic)**
	Recommended	(1) one/more recently developed, internationally recognized methods modified for local conditions e.g. IFIM or other species level habitat modeling approach, plus holistic method above (2) advanced modeling approaches for abiotic components
	Future Direction	(1) complete and tested components of various simulation methods for instream/riparian biota and abiotic components, appropriate for local conditions

This proposal combines these two approaches within task #1 (→ level 2) and tasks #2, #3, and #4 (→ level 3) in order to formulate both short and long-term strategies

Adapted from Tharme and King (1998).

Figure #6

Conceptual Model of TNC Sacramento River Project's programmatic structure



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

Table #1

Table #1	
Discipline	Known existing data
Hydrologist	Stream gage records, IHA analysis, stage discharge relationship*
Geomorphologist	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 biologist	Seining data in the main stem and tributary confluences, helicopter video footage (as specified in the BBM manual), IFIM analysis, preliminary results from study evaluating salmonid use of different habitat types*
Wildlife biologist	Wildlife surveys conducted in the project area*
Riparian ecologist	Vegetation community mapping from ortho-rectified 1999 aerial photography*, recruitment pilot study*, vegetation transect data*
Invertebrate ecologist	?
Hydraulic modeler	1 & 2 dimensional hydraulic modeling for various river reaches*
Water quality chemist	Regional Water Quality Control Board monitoring summaries
Water user representative	Water needs quantified in other efforts such as the Department of Water Resources water plan.
Engineer/Dam operator	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 1a: Synthesize data and conduct interdisciplinary workshops to evaluate existing data and formulate initial hypotheses	Prepare for workshops, gather and synthesize existing data, hold planning meeting, conduct workshops, visit sites, present summary findings by discipline, final check.
Task 1b & 1c: Catalogue data into a database to facilitate queries regarding effects of different flow regimes	Integrate information, create and populate database, write report summarizing main results.
Task 2a: 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.
Task2b: Quantify Cottonwood Root Growth Rates	• Use field surveys to identify point bars with cottonwood seedlings 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 2c: 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 2d: 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 2e: 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 2f: 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 2g: 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 Numerical Simulation Modeling	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 4: Develop Experimental Designs and Study Plans	Work with workshop participants to develop study plans.
Project outputs	
Task 1a	A list of unknowns that preclude the formulation of a naturalized flow regime; workshop starter documents including synthesized data; draft and final summary report and presentations
Task 1b&c	An ecosystem flow assessment tool capturing the state of the knowledge on functional ecological relationships; queries of flow regime change effects; simple user interface.
Task 2a	Study plan; raw data; summary reports and technical memoranda
Task2b	Study plan; raw data; summary reports and technical memoranda
Task 2c	Summary reports and technical memoranda
Task 2d	Study plan; Raw data; Summary reports and technical memoranda
Task 2e	Study plan; Raw data; Summary reports and technical memoranda
Task 2f	Report summarizing empirical data, developed algorithm, code, and model calibration and validation, and , sample input and output for selected sties on the Sacramento River
Task 2g	Revised study plan based on prototype sampling, raw data, summary report, and manuscript for peer-reviewed journal.
Task 3	Summary reports and technical memoranda; Multimedia presentations
Task 4	Study plans; conceptual restoration designs; statistical analyses; monitoring plans
Project outcomes	
Task 1a	Increased base of knowledge to address ecosystem flow needs; Example changes to the hydrograph representing improved ecological condition, while providing a balance with human needs.

Task 1b	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. Provides a framework to evaluate and compare flow actions if used on other rivers.
Task 2a	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 2b	Cottonwood root growth; Sediment distribution
Task 2c	Flows required to initiate floodplain scour and meander cutoff;
Task 2d	Particle size distribution; Gravel permeability
Task 2e	Measures of in-channel habitat complexity and quality in the vicinity of protected and unprotected banks
Task 2f	Increased understanding of effect of a variable hydrograph on river migration, sample demonstrations (i.e. validation runs of the model).
Task 2g	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
Environmental Indicators	
Task 1a	N/A
Task 1b	Changes to characteristics of the current hydrograph and their effects on various ecosystem metrics.
Task 2a	Sediment tracers; Particle size distribution; discharge
Task2b	Cottonwood root growth rates; Sediment distribution; discharge, groundwater elevations
Task 2c	Meander cutoff; Radius of curvature; Meander amplitude; Discharge, Floodplain vegetation and roughness
Task 2d	Gravel Permeability; Dissolved Oxygen; Particle size distribution
Task 2e	Discharge; Depth; Channel Morphology;
Task 2f	Meander migration rates, Hydrograph characteristics, channel width, depth, slope, velocity, roughness
Task 2g	Areas, ages, and fluvial geomorphic origins of cottonwood stands; streamflow requirements for cottonwood establishment.
Task 3	N/A
Task 4	N/A

Table #3 Timeline

Task	3rd quarter	4th quarter	1st quarter	2nd quarter	3rdquarter
#1formulating initial hypotheses	-Identify specialists -scoping meeting compile and synthesize existing data -evaluate initial data and formulate flow hypotheses	-Initiate workshop process	-Initiate database developme nt	-Complete database development -Develop potential flow scenarios -Prepare Draft Report -Present interim findings to EWP and technical review workshop	-Finalize database/Interim final report -Present interim findings to EWP and technical review workshop
Subtask 2a: Quantifying relationships between flows and sediment transport	- select sampling sites - apply sediment transport model to suggest particle sizes for tracers and concomitant mobilization flows	- place tracers	- monitor tracer movement following sufficient high flows		- validate and calibrate sediment transport model
Subtask 2b: Quantifying Cottonwood and Willow Seedling Root Growth Gates	- 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	- monitor observation wells/peizometer s to correlate water surface elevations with groundwater table elevations	- 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)		
Subtask 2c: Quantifying Fluvial Geomorphic Processes that Create and Maintain Off-Channel Habitats	- analyze aerial photos - analyze stream gauge data - interview local landowners and technical experts			develop an analytical tool to predict the flows and contributing factors necessary to initiate meander cutoff.	
Subtask 2d: Pilot Characterization of Channel Substrate Composition and Permeability	- identify sampling sites - collect and analyze bulk samples				- collect and analyze bulk samples following high flows
Subtask 2e: 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 2f: Refine a Meander Migration Model	collect bank migration and flow data; develop non-linear algorithm		develop algorithm to relate migration and flow; develop non-linear algorithm		integrate non-linear algorithm into numerical model
Subtask 2g: 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 the next quarter)
Task 3: Numerical Modeling of Flows Required to Restore Fluvial Geomorphic Processes for a Range of Restored or Hypothesized Channel Conditions				- 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)	
Task 4: Develop Experimental Designs and Study Plans for High-Priority Flow Recommendations				-develop experimental design/study plan for high-priority flow hypotheses (Task continues through the next 3 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
#1formulating initial hypotheses				-Technical review workshop -Incorporate new information into decision analysis tool		Final report	Final presentation
Subtask 2a: Quantifying relationships between flows and sediment transport		- monitor tracer movement following sufficient high flows	- validate and calibrate flow-sediment transport model			- monitor tracer movement following sufficient high flows	
Subtask 2b: Quantifying Cottonwood and Willow Seedling Root Growth Rates	- 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 2c: Quantifying 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 2d: Pilot Characterization of Channel Substrate Composition and Permeability				- collect and analyze bulk samples following high flows			
Subtask 2f: Refine a Meander Migration Model	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 2e: Assess and Compare the Effects of Bank Protection on In-Channel Habitat Quality and Complexity	- assess the effects of bank protection on in-channel habitat complexity and quality						
Subtask 2g: 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 3: Numerical Modeling of Flows Required to Restore Fluvial Geomorphic Processes for a Range of Restored or Hypothesized Channel Conditions	apply numerical flow-sediment transport model to predict the flows required to restore fluvial geomorphic processes for a range restored channel conditions						
Task 4: Develop Experimental Designs and Study Plans for High-Priority Flow Recommendations	-develop experimental design/study plan for high-priority flow hypotheses						

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 ERP	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 are in progress to fund portions of the purchase of two additional properties: 238-acre Ward property purchased in April 2001, and 77-acre Clendenning property under option and anticipated to close in September. Start up stewardship activities are underway, including preliminary hydrologic and geomorphic modeling that will help identify short and long-term conservation and management actions for these properties.	The Clendenning property will complete the acquisition terms of this grant. Restoration of 3 of the purchased properties is the subject of a 2002 CALFED proposal. A request was recently 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 is complete.	Restoration terms of this grant are completed; monitoring is currently in progress. Maintenance will be complete fall of 2001.
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.	Acquisition and restoration terms of this grant are complete; monitoring is currently in progress. Maintenance will be complete in the fall of 2001.
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 located in Colusa County was purchased in July 2000. This property is located within the setback levees of the Sacramento River Flood Control Project. Two additional properties, totaling 183+ acres will be wholly or partially funded under this agreement upon official approval of the agency, including: the 129 acre Boeger property scheduled to close by December, and 54 acre Hays property purchased in May 2001.	The Boeger and Hays properties will complete this acquisition grant. Additional CVPIA funding has been obligated to complete the purchase of the Boeger property.

(continued next page)

B.4., continued

Project Title	**CALFED Program/ CVPIA Project**	***Term***	**Progress and Accomplishments**	***Status***
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 are currently in progress to develop comprehensive conservation and management strategies for multiple benefits and uses of the river floodplain. Under Task 1 data collection is in progress, and 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 is in progress with involvement from SRCA, stakeholders and local governments. Under Task 3 a newsletter went out to all stakeholders; stakeholder meetings have been conducted; updates are regularly provided to the SRCA.	During the first year of this 3-year grant, all tasks were initiated and are making good progress. A report to be developed under Task 4 will outline future conservation and management actions for the Beehive Bend sub-reach based on information developed within Tasks 1 – 3.
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.	The grant is complete. Additional funding was used to purchase each of these properties. CVPIA (AFRP) and private funding was used to complete the purchase of the Southam property. CALFED 97-NO2 and private funding was used to complete the Ward purchase.
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.	The grant is complete.
Singh Walnut Orchard	CVPIA grant, FWS Agreement #11332-0-G014 AFRP	9/18/00-12/31/01	Completed tasks for this pre-acquisition and planning grant includes: pre-acquisition due diligence and signed option for Singh property, baseline assessment, and local stakeholder meeting conducted to discuss restoration plans.	A report will be submitted fall 2001 that outlines baseline and ecological considerations with restoration alternatives. This will complete the terms of this grant. Acquisition and restoration of this property is the subject of a 2002 CALFED proposal.

Appendix A

BBM executive summary

Reference:
THARME, R.E. & KING, J.M. 1998. Development of the Building Block Methodology for instream flow assessments, and supporting research on the effects of different magnitude flows on riverine ecosystems. *Water Research Commission Report No.* 576/1/98. 452 pp.

Environmental (or instream) flows are flows that are left in, or released into, a river system with the specific purpose of managing some aspect of its condition. Their purpose could be as general as maintenance of a 'healthy' riverine ecosystem, or as specific as enhancing the survival chances of a threatened fish species. They could be targeting the river channel and its surface waters, groundwater, the estuary, linked wetlands or floodplains, the riparian zone, and/or any of the plant and animal species associated with any of these system components.

As the condition of river systems deteriorates globally, environmental flows are increasingly appearing on national and international political agendas, and the requirement to use them, in legislation. The science of advising on environmental flows is relatively young (about 50 years), but more than 100 methodologies and methods now exist for such assessments and at least 30 countries are using them routinely in water resource management, with the number growing annually.

South Africa formally addressed the topic in the 1980s, and during the 1990s made considerable progress at a national level. Tharme & King (1998) track the major milestones of this course. Recognizing that international approaches to environmental flow assessments did not meet South Africa's needs entirely, development of a local approach was initiated. First introduced in a workshop for the Lephalalal River in February 1992, what was to become the Building Block Methodology (BBM) was developed through application in a series of real water-resource development projects. The South African Department of Water Affairs and Forestry (SWAF) organized and partially funded the workshops, and the Water Research Commission (WRC) funded many of the river scientists who stepped forward to become involved, via their research projects. Through a decade of extraordinary cooperation and willingness to contribute, the national body of aquatic scientists, water managers and engineers developed the BBM to the point where it is now one of only a few advanced environmental flow methodologies in the world with a formal manual.

In addition, the BBM has advanced the field of environmental flow assessment in an entirely new direction being an holistic methodology that addresses the health (structure and functioning) of all components of the riverine ecosystem, rather than focusing on selected species as do many similarly resource-intensive international methodologies. This kind of approach ahs been spearheaded in Africa and Australia, in close collaboration, and because of its pragmatic and all-encompassing nature, has triggered exceptional growth in communication between many scientific disciplines, and between scientists and water managers.

During the 1990s, more than 15 BBM Workshops were held for different local rivers, as well as for the Logan River in Australia in 1996. The 1994 workshop for the Luvuvhu River was generally seen as the one in which the BBM 'came together', providing a sound template for further development of the methodology. The 1996 workshop for the Sable-Sand River System brought together the developers of the BBM and members of the Kruger National Park Rivers Research Programme, in the most data rich application of the BBM to that date. A member of DWAF's Water Law Review Team attended the Sable-Sand workshop, to assess whether or not the BBM could meet legal requirements in terms of quantifying the water required for river maintenance. As a result, an environmental flow allocation for maintaining river ecosystems was entrenched in South Africa's new National Water Act (No. 36 of 1998), as the ecological Reserve. This is one of the two components of the Reserve, the other being an allocation for basic human needs. Within the framework of Resource Directed Measures for Protection of Water Resources, established by DWAF, assessment of the Reserve is now being done for every major water body within South Africa. For various kinds of water-resource developments, Reserve determinations may be done at different levels of assessment, namely Desktop Rapid, Intermediate or Comprehensive. Requirements for Comprehensive Reserve determinations were established based on the BBM, and it is currently the methodology used in such environmental flow assessments.

The BBM is essentially a prescriptive approach, designed to construct a flow regime for maintaining a river in a predetermined condition. This manual describes its basic nature and main activities, and provides guidelines for its application. It also introduces the links between the methodology and the procedures for determination of the ecological Reserve as embodied in the Water Act. The BBM has further provided the impetus for the evolution of several alternative holistic environmental flow methodologies, notably the Downstream Response to Imposed Flow Transformations (DRIFT) methodology. The DRIFT methodology is an interactive, scenario-based approach, designed for use in negotiations, and contains a strong socio-economic component, important when quantifying subsistence use of river resources by riparian peoples.

Appendix B

Abstract from "A SCENARIO-BASED HOLISTIC APPROACH TO ENVIRONMENTAL FLOW ASSESSMENTS FOR REGULATED RIVERS"

JACKIE KING[#], CATE BROWN[#] AND HOSSEIN SABET*

Southern Waters Ecological Research and Consulting, University of Cape Town, Rondebosch 7701, South Africa.

* *SMEC International, Private Bag A8, Maseru 100, Lesotho.*

Submitted to Regulated Rivers

Environmental flows consist of specific amounts of water that are left in river systems or released into them, to manage some aspect of river condition. This paper describes a holistic approach to defining environmental flows that overcomes several shortcomings identified in earlier similar approaches. DRIFT (Downstream Response to Imposed Flow Transformation) is essentially a data-management tool, allowing data and knowledge to be used to their best advantage in a structured process. Its basic philosophy is that all major abiotic and biotic components of the river are collectively the ecosystem to be managed, and the full spectrum of flows in the river, including their spatial and temporal variability, is the flow regime to be managed. Its central rationale is that different parts of the flow regime elicit different responses from the ecosystem; that removal of one flow component will affect the river differently than removal of another; and that all of these affects can be described and quantified. DRIFT can be used to produce any chosen number of scenarios of possible future flow regimes, along with their consequences, thus providing a number of alternatives for a water-resource development and a much more comprehensive picture than usual of the implications. One of its most important and innovative features, of vital importance in developing countries, is inclusion of the socio-economic effects of changing river condition on subsistence users of the river. Each DRIFT scenario consists of a number of parts: the potential flow regime, the resulting river condition, the impacts of this changing condition on subsistence users, and the economic implications in terms of mitigation and compensation. All these parts are quantified to the extent possible.

DRIFT consists of four modules: biophysical, social, scenario-building and economic. In the first two modules, relevant specialists complete studies designed to develop predictive capacity of how their ecosystem component would change with flow changes. Specialists typically involved in the biophysical module are hydrologists, hydraulic modelers, fluvial geomorphologists, aquatic chemists, riparian and aquatic botanists, fish and invertebrate biologists and, where relevant, microbiologists and specialists in herpetofauna, water birds and river-dependent terrestrial wildlife. Specialists involved in the social link to subsistence users are sociologists, anthropologists, public-health doctors, livestock veterinarians, experts on community water supply, and resource economists. In the third module, a range of theoretical changes to the river's present flow regime is considered, and the consequences described by each specialist – first the biophysical changes to the river, then the impacts on the people. In the fourth module, the tangible impacts are costed. Where there are no subsistence users, modules 2 and 4 may be omitted.

DRIFT should ideally run in parallel with two other exercises: a macro-economic assessment of the wider implications of each scenario, and a Public Participation Process which represents the interests of people other than subsistence users. All three should be closely linked and produce a co-ordinated information package for the decision-maker.

Appendix C

Additional Stillwater Sciences staff qualifications

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.

Appendix D

ESSA Technologies, LTD. Qualifications

Calvin N. Peters

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

Professional Experience

1996 - now **Systems Ecologist**, ESSA Technologies Ltd., Vancouver, BC.
Responsibilities include: Data analysis, statis tical 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

C **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

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

X **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.

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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.

David R. Marmorek

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

Post-Secondary Education

- X **Leadership Laboratory,** University of British Columbia, Vancouver, BC, 1989
- X **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.
- X **B.E.S. (Honors), Man-Environment Studies and Mathematics,** First class honors, University of Waterloo, 1975.

Awards

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

Research Interests

- X 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

- X melding my group leadership and facilitation skills with my knowledge of scientific methods (data analysis, modelling, 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.

Appendix E

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Qualifications

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 Acomplishment 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)

Appendix F

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.

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