Adding Rigor to the CALFED Concept of Adaptive Management: Application of the Clear Creek Decision Analysis and Adaptive Management Model (CCDAM) to Tributary Restoration. Phase III.

Project Information

1. **Proposal Title:**

   Adding Rigor to the CALFED Concept of Adaptive Management: Application of the Clear Creek Decision Analysis and Adaptive Management Model (CCDAM) to Tributary Restoration. Phase III.

2. **Proposal applicants:**

   David Marmorek, ESSA Technologies Ltd.
   Frank Ligon, Stillwater Sciences

3. **Corresponding Contact Person:**

   David Marmorek
   ESSA Technologies Ltd.
   Suite 300, 1765 West 8th Avenue, Vancouver, B.C. Canada V6J 5C6
   604 733.2996
   dmarmorek@essa.com

4. **Project Keywords:**

   Flow, Instream
   Modeling
   Restoration Ecology

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 for profit

9. **Location - GIS coordinates:**

Latitude: 40.57

Longitude: -122.36

Datum:

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

The primary spatial bounds for the overall model and proposal are Whiskeytown Dam to the confluence with the Sacramento River, including lower Clear Creek tributaries. For modeling purposes, Clear Creek has been subdivided into five reaches: 1. Whiskeytown to the confluence with Paige Boulder Creek; 2. Paige Boulder Creek to the confluence with South Fork Clear Creek (slightly north of USGS Gauging station); 3. South Fork Clear Creek to the Clear Creek road bridge; 4. Clear Creek road bridge to former Saeltzer Dam; and 5. Former Saeltzer Dam to the confluence with the Sacramento River. Dam Operations, Hydrology, Power & Lake Recreation elements of the model take into account flow and temperature issues at other areas, namely: - the Sacramento River downstream of Keswick Dam (to show effects of Whiskeytown releases on temperatures, flood flows); - Clear Creek above Whiskeytown Dam (upper watershed hydrology affects ability to deliver larger flushing flows out of Whiskeytown); - outflows from the Trinity River via the Judge Francis Carr Power Plan (a major inflow to Whiskeytown Reservoir); and - outflow from Whiskeytown Reservoir to the Spring Creek Power Plant tunnel.

10. **Location - Ecozone:**

4.1 Clear Creek

11. **Location - County:**

Shasta

12. **Location - City:**

Does your project fall within a city jurisdiction?

Yes

If yes, please list the city: Redding, CA

13. **Location - Tribal Lands:**

Does your project fall on or adjacent to tribal lands?

No

14. **Location - Congressional District:**

2

15. **Location:**

California State Senate District Number: 6

California Assembly District Number: 2

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

    3

17. **Requested Funds:**

    a) Are your overhead rates different depending on whether funds are state or federal?

    No

    If no, list single overhead rate and total requested funds:

Single Overhead Rate:	133%
Total Requested Funds:	$914,616

    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?**

    Yes

    If yes, identify project number(s), title(s) and CALFED program (e.g., ERP, Watershed, WUE, Drinking Water):

Mid-Pacific Regional Office of the Bureau of Reclamation, contract #00CS202122	**Flow-Related Decision Analysis Model.**	**Ecosystem Restoration Program Strategic Planning (directed funding)**

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.

CH2M HILL delivery order #1425-98-PD-20-3041 A/043	**Scoping for Decision Analysis Framework**	**Ecosystem Restoration Program Strategic Planning (directed funding)**

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?

    No

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)

Dr. Pete Rhoads	**Metropolitan Water District (retired)**	**530 642-9931**	**Prhoads@mindspring.com**
Dr. Michael Healey	**University of British Columbia**	**604 822-4705**	**healey@ocgy.ubc.ca**
Larry Smith	**Chief, US Geological Service**		**lhsmith@s101dcascr.wr.usgs.gov**
Dr. Randall Peterman	**Simon Fraser University**	**604 291-4683**	**Randall_Peterman@sfu.ca**

21. **Comments:**

Environmental Compliance Checklist

<u>Adding Rigor to the CALFED Concept of Adaptive Management: Application of the Clear Creek Decision Analysis and Adaptive Management Model (CCDAM) to Tributary Restoration. Phase III.</u>

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 is principally a research study that uses existing and simulated data.

2. **If the project will require CEQA and/or NEPA compliance, identify the lead agency(ies).** *If not applicable, put "None".*

   <u>CEQA Lead Agency:</u> None
   <u>NEPA Lead Agency (or co-lead:)</u> None
   <u>NEPA Co-Lead Agency (if applicable):</u> 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.**

1. This project is consistent with the Environmental Compliance Checklist. For fieldwork components, any required Permits will be obtained from the appropriate State or Federal agency (e.g., CDFG permits for trapping and handling fish). In the event this project is selected for funding, access agreements shall be provided within the required time frame. Permits for similar activities have been obtained for other restoration practitioners in the system, many of which we will be collaborating with closely.

Land Use Checklist

<u>Adding Rigor to the CALFED Concept of Adaptive Management: Application of the Clear Creek Decision Analysis and Adaptive Management Model (CCDAM) to Tributary Restoration. Phase III.</u>

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?**

   No

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).

   Modeling research only. 3rd year output is a report documenting results of a facilitated process for multi-agency, multi-stakeholder consultations to build understanding of trade-offs and identify barriers and bridges to the evidence for MPFO flows generated by the rigorous analyses in years 1 and 2. Details of potential water acquisition for conservation flows/changes in land use pursuant to implementation of the MPFO recommendations would be the focus of work/negotiations to occur *after year 3.

4. **Comments.**

Conflict of Interest Checklist

<u>Adding Rigor to the CALFED Concept of Adaptive Management: Application of the Clear Creek Decision Analysis and Adaptive Management Model (CCDAM) to Tributary Restoration. Phase III.</u>

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):

David Marmorek, ESSA Technologies Ltd.
Frank Ligon, Stillwater Sciences

Subcontractor(s):

Are specific subcontractors identified in this proposal? Yes

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

Frank Ligon	Stillwater Sciences
Yantao Cui	Stillwater Sciences
Christian Braudrick	Stillwater Sciences
Dr. John Williams	Independent Consultant, Executive Director Bay-Delta Modeling Forum, other posts
Scott McBain	McBain and Trush
Dr. Tom Griggs	University Professor, Riparian ecology expert

Helped with proposal development:

Are there persons who helped with proposal development?

Yes

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

Frank Ligon **Stillwater Sciences**

Scott McBain **McBain and Trush**

Michael Fainter, reviewer **Stillwater Sciences**

Comments:

Subcontractor Misc. - for components of field sampling service contracts. One of Graham Mattews and Associates, Stillwater Sciences or McBain and Trush

Budget Summary

<u>Adding Rigor to the CALFED Concept of Adaptive Management: Application of the Clear Creek Decision Analysis and Adaptive Management Model (CCDAM) to Tributary Restoration. Phase III.</u>

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.

<u>Independent of Fund Source</u>

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**
1-20	Known model enhancements / Research / Testing	692.81	18875.13	3925.72	5259.70	377.80	34628.25			63066.6	25190.84	88257.44
21	Review relevant fieldwork	97.50	3419.82	711.27	5259.70	515.18	3823.49			13729.46	4564.11	18293.57
*22a.	Targeted field monitoring - INFILTRATION fines into spawning gravels	35.63	1177.82	244.97		85.86	203205.11			204713.76	1571.92	206285.68
*22b.	Targeted field monitoring - EMERGENCE trapping	20.63	747.33	155.43		85.86	126953.89			127942.51	997.40	128939.91
23	Preliminary analyses/Assessment of model	105.00	3307.61	687.93						3995.54	4414.36	8409.90
24	Comprehensive sensitivity analysis	127.50	3418.67	711.03						4129.7	4562.58	8692.28
25	Preliminary filtering of inapropriate actions / experiments	120.00	3230.30	671.85		343.45				4245.6	4311.17	8556.77
26	Ongoing documentation model refinements and analyses	52.50	1506.70	313.37		309.11	1234.24			3363.42	2010.85	5374.27
27	Outreach: Facilitation of 2-day review meeting	120.00	4152.54	863.66	7363.58	2060.70	10913.07			25353.55	5542.00	30895.55
28	Outreach: Year 1 Progress Report	120.00	3885.20	808.06	1373.80	7430.24				13497.3	5185.21	18682.51
*29	Outreach: Conference paper	45.00	1913.12	397.90	2629.85	686.90	1603.19			7230.96	2553.26	9784.22
30	Contingency: Foreseeable but undefined meetings	90.00	3411.80	709.60	5785.67	686.90	6844.64			17438.61	4553.40	21992.01
31	Project Management (incld. stakeholder coordination)	67.50	2351.63	489.10		343.45	1432.38			4616.56	3138.50	7755.06
		1694	51397.67	10689.89	27672.30	12925.45	390638.26	0.00	0.00	493323.57	68595.60	561919.17

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	Implement Adaptive Management components	285.00	7599.68	1580.61		156.47	3924.64			13261.4	10142.56	23403.96
2	Complete Excel Export Assistant reports	52.50	1506.70	313.37		104.31				1924.38	2010.85	3935.23
3	Contingency (foreseeable but undefined revisions/bug correction)	84.38	2276.59	473.49			981.16			3731.24	3038.35	6769.59
4	Development of AM experiments identified in Year 1	18.75	641.72	133.47						775.19	856.44	1631.63
5	Review relevant fieldwork	97.50	3419.82	711.27	6668.70	782.33	3823.49			15405.61	4564.11	19969.72
6	Formal rigorous decision analysis, AM simulations	195.00	5737.06	1193.21		886.64	2035.00			9851.91	7656.70	17508.61
7	Ongoing documentation of AM analyses	37.50	1016.10	211.33		312.93				1540.36	1356.09	2896.45
8	Package and deployment of final model	60.00	1299.60	270.30		782.33				2352.23	1734.45	4086.68
9	Outreach: Facilitation of 1 3-day workshop	127.50	4635.12	964.03	6668.70	1616.81	16369.61			30254.27	6186.05	36440.32
10	Outreach: Training session for CCDAM modules	45.00	1291.46	268.60		678.02				2238.08	1723.59	3961.67

11	Outreach: Most Promising Flow Options (MPFO) report	180.00	6021.59	1252.39		2607.75	5549.11			15430.84	8036.44	23467.28
*12	Outreach: Conference paper	37.50	1283.44	266.93	3334.35	782.33	1603.19			7270.24	1712.88	8983.12
*13	Outreach: Users Guide for complete model	116.25	2517.77	523.66		1043.10	490.58			4575.11	3360.23	7935.34
14	Contingency: Foreseeable but undefined meetings	90.00	3411.80	709.60	5557.25	260.78	6844.64			16784.07	4553.40	21337.47
15	Project Management (incld. stakeholder coordination)	67.50	2558.85	532.20		417.24	1432.38			4940.67	3415.05	8355.72
		1494	45217.30	9404.46	22229.00	10431.04	43053.80	0.00	0.00	130335.60	60347.19	190682.79

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	Review relevant fieldwork	41.25	1287.45	267.77	3991.80	1273.84	5858.49			12679.35	1718.23	14397.58
2	Facilitation of stakeholder consultations (min. 3 2-day workshops)	270.00	9820.96	2042.60	21455.93	2972.29	13255.81			49547.59	13107.09	62654.68
3	Support anlayses to verify robustness of the Year 2 MPRO	82.50	2247.44	467.43	424.61					3139.48	2999.45	6138.93
4	Study plan development for structured field monitoring	11.25	426.47	88.70		636.92	11935.00			13087.09	569.18	13656.27
5	Report - Structured Implementation of the MPFO flows: Barriers and Bridges	198.75	6603.19	1373.36		2123.07	4377.74			14477.36	8812.65	23290.01
*6	Outreach: Conference paper	37.50	1283.44	266.93	2494.88	424.61	1603.19			6073.05	1712.88	7785.93
7	Contingency: Foreseeable but undefined meetings	90.00	3411.80	709.60	5322.40	424.61	5610.41			15478.82	4553.40	20032.22
8	Project Management (incld. stakeholder coordination)	75.00	3602.97	749.36		212.31	4685.49			9250.13	4808.54	14058.67
		806	28683.72	5965.75	33689.62	8067.65	47326.13	0.00	0.00	123732.87	38281.42	162014.29

Grand Total=914616.25

Comments.

Tasks with a (*) are those that are separable/optional.

Budget Justification

Adding Rigor to the CALFED Concept of Adaptive Management: Application of the Clear Creek Decision Analysis and Adaptive Management Model (CCDAM) to Tributary Restoration. Phase III.

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

David Marmorek 609 Clint Alexander 1,409 Calvin Peters 1,275 Christine Pinkham 360 Keti Milosheva 341

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

David Marmorek $56.33 / hour Clint Alexander $28.70 / hour Calvin Peters $28.70 / hour Christine Pinkham $20.68 / hour Keti Milosheva $19.04 / hour

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

Benefits are 20.81% of salary for all employees. These benefits include employer contributions to medical plan, dental plan, disability insurance, unemployment insurance, workers compensation, vacation, sick time and statutory holidays.

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

Travel costs over 3-years ($81,792) are to cover up to 62-person trips of ESSA staff and our subcontractors, and advisory committee members (and associated accommodation, meal and incidental costs). These trips will be spread over 3 years, and will involve meetings of the project team with CALFED in Sacramento, meetings with subcontractors Stillwater Sciences, Scott McBain, and John Williams in Berkeley and Davis. Travel of ESSA staff will also be required to coordinate and conduct field program review/data gathering and lead up to 6 facilitated meetings/workshops with local agency staff and restoration groups in Redding or Sacramento California. In each year a travel allowance has also been made for public/scientific outreach via presentations of findings at CALFED conferences (e.g., Sacramento/Monterey).

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

Communications and computing costs (phone, photocopying, courier, report production, computer rentals, visuals, software distribution media) are estimated at $25,792 over the three years of the contract.

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.

Subcontract type 1 - Stillwater Sciences staff (team and roles described in section C of proposal) will be involved in tasks 1-20, 21, 22, 26 - 28, and 30 listed in Form VI (year 1). This highly specialized sediment transport and fish population modeling assistance would extend to tasks 1, 3, 5, 7, 10, and 12 - 15 in year 2, and tasks 1, 2, 4 7 in year 3. This 3-year effort adds up to a total of $82,801 over 616 hours, at an average rate of $134.27 per hour. Subcontract type 2 - This project also includes an advisory committee comprised of 3 independent experts (average rate $135.67 per hour) Dr. John Williams, Dr. Tom Griggs, and Scott McBain who will provide up to 456 hours of independent review and advice on model assumptions and analyses, and independent reviews of draft reports for tasks 1-20, 21, 27 30 (year 1); tasks 5, 6, 9, 11, 12 and 14 (year 2); and tasks 1, 2, 5, 6 and 7 (year 3); (see Form VI). This accounts for $61,813 of the total 3-year value of Services and Consultants (456 hours). Subcontract type 3 (optional) - In addition, bulk service contracts have been allowed for optional targeted and field monitoring (task 22 in year 1 only); (see Form VI). Depending on implementation details that would be devised following contract award, these service contracts would be let to one or more of Stillwater Sciences, McBain and Trush, and/or Graham Mattews and Associates at a total 1-year value of $330,159. Subcontract type 4 - A subcontract is required for an additional Visual Basic programmer, at a total value of $13,675 (paid at a rate of $65.41 per hour over a total of 209 hours, years 1 and 2 only). All said subcontracts include realistic contingency and project management amounts. The 4 types of subcontracts total the $488,448 value found in Form VI. ESSA Technologies Ltd. would be the contracting entity for this project, and Stillwater Sciences Ltd., the Advisory Committee, and any misc. subcontractors would operate through subcontracts from ESSA. Budget information is included in web forms VI and VII. As with ESSA fees, we have used rates for subcontractors consistent with average salary increases due to real and cost of living increases over a 3-year period.

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

None

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

Total ESSA Project Management costs (shown in Table VI) are estimated at $30,169, or 3.3% of the overall total cost of services (9.5% ESSA fees). In the case of subcontracts, project management tasks have been incorporated therein.

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

None

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 indirect costs are computed as 133% of salary. This includes: rent, salaries and benefits for administrative, word processing and financial staff; bank interest and service charges, office costs, depreciation on office equipment including computer hardware and furniture; office insurance; rental of office equipment; furniture; staff development; temporary staff wages, stationary, and marketing costs.

Executive Summary

Adding Rigor to the CALFED Concept of Adaptive Management: Application of the Clear Creek Decision Analysis and Adaptive Management Model (CCDAM) to Tributary Restoration. Phase III.

The goal of this next phase project is to (a) apply a previously developed prototype model (CCDAM) in the generation of evidence for the most promising flow options (MPFO) for promoting ecosystem restoration and (b) to build agency support for structured implementation of these flows with facilitated multi-stakeholder consultations. The major objectives of this model-based research project are to: 1. Complete the evaluation of the existing prototype decision analysis model (CCDAM) and improve it; 2. Use the model to assess the frequency, duration, and magnitude of flows realized from alternative Whiskeytown Reservoir (WTR) operations and quantify the impact of alternative operations to competing ecological and non-ecological values; and, 3. Determine what types of WTR operations and field monitoring programs yield the most information to reduce uncertainties. Hypotheses generated during CCDAM development that will be tested include: - Reach specific gravel transport rates for different flows; - Appropriate empirical parameter values in Tappel & Bjornn (1983) relationship between % emergence of salmon fry and grain size distributions; - Shape of functional relationship between egg survival and scour depth; - Relationship between % fry rearing in Clear Creek and flows. Approach: Our two-step decision analysis and simulated adaptive management approach is used to simulate the costs, biological effects, and information benefits of alternative WTR operations and monitoring programs. Overall, CCDAM represents a scientific advance in the generation of information that improves understanding of the interactions between reservoir operations, habitat conditions, and fish populations. In brief, the 3-year work plan includes the following: (1) YEAR 1 User Acceptance of model. - Known model enhancements, targeted field sampling for key uncertain hypotheses not addressed by other efforts, preliminary trade-off analysis, year 1 Progress report. (2) YEAR 2 Adaptive Management Modeling. - Implement adaptive management components, formal rigorous decision analysis and adaptive management experiments, Most Promising Flow Options (MPFO) report. (3) YEAR 3 - Consultations to Prepare for Structured Implementation - Process design and Facilitation of consensus-based multi-stakeholder consultations, final report - Structured Implementation of the MPFO flows: Barriers and Bridges Expected outcomes. Assist CALFED in providing: - Evidence in support of the MPFO via a rigorous analysis of trade-offs and quantification of the expected value of information from alternative WTR operations; - Facilitated process for multi-agency, multi-stakeholder consultations to build understanding of trade-offs and identify barriers and bridges to implementation. These outcomes meet specific goals of the ERP Draft Stage 1 Implementation Plan (Science Program pg. 14-15; Strategic goals SG-1,2,4,6; and Sacramento SR-3,1,2,4 and 7).

Proposal

ESSA Technologies Ltd.

Adding Rigor to the CALFED Concept of Adaptive Management: Application of the Clear Creek Decision Analysis and Adaptive Management Model (CCDAM) to Tributary Restoration. Phase III.

David Marmorek, ESSA Technologies Ltd.
Frank Ligon, Stillwater Sciences

Application of the Clear Creek Decision Analysis and Adaptive Management Model (CCDAM) to Tributary Restoration (Phase 3)

ESSA Technologies Ltd.[1] and Stillwater Sciences[2]

A. Project Description: Project Goals and Scope of Work

A.1 Problem

To address scientific uncertainties inherent in restoring and managing a system as large and complex as the Bay-Delta ecosystem, CALFED and the Ecosystem Restoration Program (ERP) have embraced adaptive management. Developing and implementing robust adaptive management experiments requires advance planning to ensure a good experimental design that optimizes learning, and to ensure that the benefits of conducting an adaptive management experiment outweigh the projected costs or trade-offs. In 1999, the ERP provided direct funding to ESSA Technologies to begin developing a model to support the design of a robust adaptive management experiment for a restoration issue that is central to the ERP—how to structure flow releases from dams in a manner that helps to restore and maintain Bay-Delta tributaries. Working with local experts in the Clear Creek basin, ESSA has developed a prototype Clear Creek Decision Analysis and Adaptive Management (CCDAM) model to support the design of potential flow-related adaptive management experiments in Clear Creek. Identifying the flows required to restore a river ecosystem is complicated by a number of uncertainties and the need to balance multiple objectives. For example, it is often unclear what **volume** of flow is required to achieve different ecological objectives (e.g., the discharge required to mobilize channel bed sediments, to provide fish passage past flow-related barriers, to inundate floodplains, to drive channel migration, etc.). The **timing** of ecological flows is often unclear as well (e.g., when to release flows to initiate gravel transport without scouring redds, to provide fish passage past barriers, to coincide with riparian vegetation seed dispersal and germination, etc.) It is often unclear what **duration** of flow is required (e.g., how long a flow is needed to route sediment an appropriate distance downstream, to provide fish passage past barriers, to support seedling establishment). Defining an ecologically beneficial flow regime requires balancing multiple ecological objectives. It also requires balancing ecological objectives with socioeconomic objectives, such as satisfying water supply, hydropower, and recreational needs. The CCDAM model is designed to assist local and regional resource managers in designing flow-related adaptive management experiments while identifying, evaluating, and balancing the trade-offs associated with different flow management scenarios.

ESSA has already completed Phases I (Scoping Functional Relationships) and II (Develop Prototype CCDAM Model). The prototype CCDAM model was demonstrated in Redding on July 12th and 13th 2001, and has already proven to be very useful in filtering out flow management alternatives that do not make ecological or economic sense. Participants at the July 2001 Redding meeting (Table D.3) were enthusiastic about the potential value of the tool, both for Clear Creek and other rivers. *This proposal* seeks phase 3 funding for the refinement and application of the CCDAM model and consultations in service of future structured implementation of the optimal adaptive management experiments identified by it.

Clear Creek is a tributary of the Sacramento River that drains the North Western slopes of the Coast Range Mountains from the northern most portion of the Sacramento River Basin. Clear Creek, the first major tributary of the Sacramento River below Shasta Dam, has been identified as one of the most promising for increasing anadromous fish runs and riparian forests (CDWR 1986). Flow in Clear Creek is regulated by Whiskeytown Dam, which since its construction in 1963, diverts most of its water supply to Keswick Dam on the Sacramento River (Figure B.1). This diversion, and its sustained low flow releases (<15% of natural flow) has resulted in reduction in the supply of spawning gravel, reduction in suitable spawning and rearing habitat, higher-than-

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suitable summer water temperatures, increased sedimentation from decomposed granite sand, and encroachment of late successional riparian woodlands. In addition to sediment starvation imposed by Whiskeytown Dam, historic gravel mining in the lower reaches of Clear Creek has further resulted in the loss of tremendous quantities of spawning gravels (CDWR 1986). These problems have reduced habitat quantity and quality and early life history survival rates of anadromous fish (Bay Institute 1998, CDWR 1986). These species are listed as CALFED "Priority Group I Species", whose management "will require substantial manipulations of the ecosystem" and for which CALFED "takes major responsibility for recovery…" (ERP Vol. I p. 32).

Suggested solutions for these physical and ecological problems on Clear Creek include:

- Flow releases to periodically mobilize the channel bed to improve the quality of spawning gravels (e.g., flush sand, improve substrate permeability and grain size distribution), to reduce summer water temperatures, to scour point bars to prevent riparian encroachment, and to provide fish passage; (Milhous 1973, Wilcock et al. 1996);
- Ongoing, gravel injection programs to improve the quality and quantity of spawning gravels (i.e., mitigate for the loss of coarse sediment trapped behind Whiskeytown Dam); and
- Producing over bank flooding to provide fine-grained substrate for seed germination and establishment of early successional riparian woodlands (Pelzman 1973, Johnson 1992 , McBain and Trush 1997).

The question central to this proposal is: "What frequency, duration, and magnitude of flows should be required to improve ecological values, and how can ecological flows be balanced with non-ecological water uses?" More specifically, "What type of flow management scenarios and monitoring programs will optimize learning to reduce key ecological uncertainties that make it difficult and time consuming to *answer* this first question?".

Goals and Objectives

The goal of this project is to: (a) refine and apply a prototype model (CCDAM) to develop the most promising flow options (MPFO) for promoting ecosystem restoration and (b) to build agency support for structured implementation of these flows with facilitated multi-stakeholder consultations. The project would combine quantitative decision analysis modeling, targeted field monitoring, and consensus-based facilitation to achieve this two-part goal. The project will help to integrate hydrologic, geomorphic, and biological information relating to the restoration of self-maintaining populations of salmon and riparian habitat in Clear Creek, and it will help to balance multiple objectives.

Our proposal strongly complements current restoration projects in Clear Creek by quantifying how the alternative flow and sediment transport regimes possible within existing and possible future reservoir operations promote the recovery and *maintenance* of salmon and riparian communities. This project would aid local tributary restoration groups by providing expected outcomes of alternative reservoir operations and gravel injection efforts for a variety of indicators. It emphasizes active adaptive management experiments as a means of reducing key physical and biological uncertainties. This will be of tremendous benefit, as the information will directly inform the prioritization of ongoing and contemplated projects and flow operation policies.

The objectives of the project are to:

1. Complete the evaluation of the existing prototype decision analysis model (CCDAM) and improve it;
2. Use the model to assess the frequency, duration, and magnitude of flows realized from alternative Whiskeytown Reservoir operation policies and how these operations improve ecological values, namely salmonid species of central concern to CALFED, CVPIA, and AFRP. Quantify the impact of alternative operations to competing non-ecological values (e.g., power production, flood control);

3. Through simulation, determine what types of Whiskeytown Reservoir operations and field monitoring programs will optimize learning to reduce key physical and biological response uncertainties. Quantify the expected net benefits of managing on the basis of this information over a range of assumptions;
4. Develop and facilitate a consensus-based multi-stakeholder process for implementing the "most promising flows". A component of this process would be the development of a formal study plan for targeted field studies under these flows to test hypotheses related to key physical and biological uncertainties that make it difficult to quantify the relationship between restoration actions and outcomes;
5. Integrate the insight and expertise of regional agency and independent, external scientists in the development and assessment of alternative adaptive management designs throughout the project; and
6. Effectively communicate the knowledge gained to local agencies and stakeholders, as well as the broader scientific community and public.

In meeting the objectives above, we will provide CALFED with a quantitatively rigorous design of a management experiment for a problem of immediate concern, to serve as a 'flagship' example of the application of decision analysis, modeling and adaptive management. The problem bounding and design process, model methodology, and lessons from this study can also be transferred and applied to other tributary restoration problems in California.

Hypotheses

Several hypotheses have been generated during CCDAM model design and development that could be tested by simulation and field studies in an adaptive management program. These include:

- Reach specific gravel transport rates for different flows (i.e., the persistently difficult problem of predicting the river discharge yielding bed shear stress for incipient motion[3]); (Wilcock et al. 1996, Wilcock 1988);
- Refinement of existing Wetted Usable Area (WUA) curves for representative reaches that summarize the effect of flows on the quality and quantity of salmon spawning habitat;
- Appropriate empirical parameter values in Tappel and Bjornn (1983) relationship between % emergence of salmon fry and % fines (currently based on lab studies; need to verify using actual field conditions);
- Shape of functional relationship between egg survival and scour depth (depth at which redd scour begins (minimum redd depth); depth at maximum redd scour (maximum redd depth));
- Relationship between % fry rearing in Clear Creek and flows (downstream emigration of juveniles is thought to be related to the magnitude of flows during the rearing period) (Vogel and Marine 1991);
- Effect of high spring flows followed by abrupt drops on cottonwood and willow seedling establishment and survival (i.e., relative rate of decline in water table vs. rate of taproot growth) (Mahoney and Rood 1998); and
- Relationship between air temperature and flows on water temperatures during summer (excessive water temperatures place stress on resident fish populations, lower survival rates);

Other hypotheses that could be tested are described in Alexander et al. 2000a (http://www.essa.com/clearcreekdesign.pdf).

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[3] Depends on local channel properties, the bed size distribution, discharge, channel geometry, and hydraulic roughness; obstacles include the large spatial variability of both flow and grain size in gravel-bed rivers, small errors in τc and related parameters lead to very large errors in calculated transport rates, and the stochastic nature of gravel transport ensures that no single value of τc exists – grain motion near τc occurs in sporadic, brief events, separated by relatively long periods of immobility.

A.2 Justification

The need to reduce uncertainties is well recognized by the ERP as it is in the professional literature on resource management (e.g., Walters 1986, Mangel et al. 1996, Hilborn and Mangel 1997, Healey 1997). Decision analysis and simulated adaptive management, the methods used by CCDAM, provide a framework to integrate a wide body of expert knowledge, help quantify trade-offs and determine the potential information gain from applied experimentation and monitoring. Given the physical and biological uncertainties clouding the choice of best flow-related restoration actions in Clear Creek (and elsewhere), and the millions of dollars of direct and indirect costs associated with implementing restorative flows, our proposed project is highly practical. The study will help meet the ERP's major challenge – providing information that assists restoration practitioners choose and prioritize restoration actions.

Figure B.2 shows a simplified conceptual model of Whiskeytown Reservoir and Clear Creek that describes the linkages between restoration actions, physical processes, and biological responses generated during CCDAM model design and development.

Basis for Conceptual Model

The basis for and details of the CCDAM model is well documented in the model design document (Alexander et al. 2000a, http://www.essa.com/clearcreekdesign.pdf[4]). These documents and subsequent work integrate numerous workshop and meeting discussions of subject matter experts from dam operations and hydrology, channel dynamics and sediment transport, riparian woodland establishment, and fish biology. Many of these individuals are leading researchers in the primary literature. Our approach continues to focus on close collaborations with these independent and local agency experts. Participation in the development of the conceptual model is summarized in Attachment D.

Degree of Scientific Uncertainty and Design for Testing Hypotheses

While some restoration actions are underway in Clear Creek, large uncertainty surrounds the ability of "contemporary flows" to maintain the conditions necessary to promote self-sustaining ecological values. There are still so few observational studies of sediment transport and fish population survival and habitat utilization for different flow regimes it is difficult to draw clear generalizations. Channels are highly variable, and sediment mobilization and deposition are affected by fine-scale phenomena such as velocity fluctuations in turbulent flow, the bed size distribution, channel geometry, and hydraulic roughness (Wilcock et al. 1996). Equally crucial uncertainties exist in relation to fish survival and habitat quality and quantity in response to flows (e.g., grain size distribution / % fines, passage capability, temperature effects, emigration triggers). This uncertainty makes it difficult to make quantitative predictions about the effects of alternative reservoir operation strategies on downstream fish populations.

Decision analysis is a method for taking uncertainties into account explicitly when evaluating management options (Raiffa 1968, Keeney and Raiffa 1976, Peterman and Anderson 1999, Hammond et al. 1999). Decision analysis is very helpful for assessing trade-offs among different objectives, and for choosing the action that best meets these objectives when uncertainties make a variety of outcomes possible. For ecosystem objectives on Clear Creek, decision analysis provides a systematic method to organize conceptual models into a rigorous framework for assessing alternative actions ***and*** evaluating the expected benefits of managing on the basis of the information gained from adaptive management experiments. Specifically, the use of water from Whiskeytown Reservoir to help restore habitat and natural salmonid populations in Clear Creek involves two basic decision questions:

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[4] Note: the memo "*Development of Modified Parker-Klingeman-McLean Gravel Transport Equation in Support of the ESSA Clear Creek Decision Model*" prepared by Stillwater Sciences (Cui and Braudrick 2000) documents the in-stream sediment transport methodology, and replaces section 4.2.9 of the draft design document. It is available from: http://www.essa.com/parkermodeldoc.pdf.

a) What is the best flow operation policy to restore and maintain channel processes, riparian habitat, and ultimately fish populations over the long-term (e.g., what magnitude, frequency and duration of flows)?; and

b) What is the optimal design and duration of a management experiment and associated monitoring to determine the answer to question “a”?

CCDAM is design to help answer these questions, with an emphasis on identifying cost-efficient, high-statistical-power, adaptive management experiments that will permit a more reliable answer to question “a”. Overall, hypotheses will be tested through:

- Using the decision analysis to filter out uncertain hypotheses that do not alter the choice of the best reservoir operation and gravel injection policies; and
- ‘Model relevant’ inventories/reviews of ongoing field programs and targeted implementation of new field studies for the most critical uncertain hypotheses identified by CCDAM simulations.

Using simulated data collection from hypothetical monitoring programs, the proposed analysis will also give information about the expected statistical probability of generating evidence in favor of the various hypotheses in the future. These analyses will be informative with respect to “pay-back” intervals – i.e., “how long does it take to reduce uncertainty sufficiently to choose different restorative flow policies, and what are the costs and benefits?”. For this and reasons above, this **research and monitoring project** fits squarely within the concept of adaptive management identified in the ERP Stage 1 Implementation Plan (Figure B.3).

A.3 Approach

Our two-step decision analysis and simulated adaptive management approach is specifically suited to accounting for and reducing uncertainties (Alexander et al. 2000b). We use the computer model to simulate the costs, biological effects, and information benefits of alternative flow experiments and monitoring. We systematically compare these results among alternative experimental designs, and evaluate the trade-offs between economic, biological, and learning objectives. Overall, CCDAM represents a scientific advance in the generation of information that improves understanding of the interactions between reservoir operations, habitat conditions, and fish populations. Through workshops and collaborations with subject matter and local agency experts we have already developed hypotheses to explain these interactions, and use these hypotheses and refinements to them to assess the biological and economic effects of alternative reservoir operations over a broad range of scientific uncertainty and objectives. The process employed is systematic and rigorous; one based on quantitative modeling and statistical techniques.

Overview

The six objectives of the proposed three-year study will be achieved sequentially[5]. **Our overall approach is summarized by Figure B.4**. The project is designed so that each year’s activities will provide useful deliverables.

We outline for each of these objectives our general approach, listing specific tasks and deliverables in the sections that follow. To set this work plan in context, we first point out the relationship between modeling and field studies that would occur in the first year of this project, and related cost options.

Relationship between modeling and targeted field investigations

Phases 1 and 2 of CCDAM development involved working with local technical experts to define the key ecological processes, biological resources, and socioeconomic activities of greatest management interest in

[5] Note: contingency line items do not necessarily occur sequentially, but are logically placed with a particular group of tasks.

Clear Creek, followed by defining the functional relationships among the identified environmental and socioeconomic variables. Many of the key variables built into CCDAM are supported by good data on Clear Creek, such as fishery escapement estimates, historical discharge data, and power production. Such data allows for the quantification of functional relationships among variables, enhancing the power of the CCDAM model. For other variables, however, there is relatively little data on Clear Creek. Local, state, and federal agencies will be addressing some of these data gaps over the next few years. For example, the U.S. Fish and Wildlife Service has submitted a proposal to CALFED entitled "*Identification of the Instream Flow Requirements for Aquatic Ecosystems in Clear Creek*," which would provide data for several environmental variables related to fluvial geomorphic processes (e.g., scour depth vs. flows). This data would greatly enhance the refinement and application of CCDAM. For this reason, we have structured our work plan to include review of new and relevant fieldwork to support model refinement. To maximize the chances of success in building agency/regulator support for structured implementation of the MPFO identified by the modeling analyses, we need the flexibility to obtain the best data available. In addition to building on knowledge gained from field monitoring, we will also track and build on other modeling work that is relevant to CCDAM (e.g., individual based models of chinook salmon by W. Kimmerer, Clear Creek temperature modeling by U.C. Davis).

Despite our plans of diligent review of existing data, it is very likely that some key data gaps will remain because the CCDAM model integrates many linkages between hydrologic, geomorphic, and biological components. Given an emphasis on user acceptance of the modeling results (i.e., credible model outputs), some of these data gaps will need to be filled. **This proposal includes two key field investigations that will provide data that contributes not only to the refinement of the CCDAM, but also to our understanding of the relationships among ecosystem processes, resultant habitats, and biotic response**. We have included these field investigations because they provide an additional means to move from expert judgments/educated guesses to model assumptions based on actual field observations. This strengthens the credibility of model analyses and may provide a more reliable ranking of options.

Table C.1 identifies the contribution of the proposed studies to components of the CCDAM.

YEAR 1 – User Acceptance

Objective 1: Complete the evaluation of the existing prototype decision analysis model and refine it.

Now that a working prototype model has been developed, the next step is to gain confidence from the numerous stakeholders that the model provides a credible (not quantitatively predictive) link between its restoration actions and economic, biological, and physical measures of performance. CCDAM output is intended to bracket the range of credible future values of indicators, not make absolutely correct predictions. At the July 12th and 13th 2001 workshop in Redding California where we unveiled the prototype decision analysis model, these stakeholders identified a number of enhancements and analyses to improve the model's acceptance by interdisciplinary specialists. We reviewed and documented these suggestions following the meeting, and they form the basis of tasks 1 – 20 listed in the work plan below:

	Task	Notes
General		
1	Complete integration/testing of run control interface	Windows interface for selecting actions, combinations of uncertain hypotheses, mode of analysis.
2	Complete Excel Export Assistant reports	Access queries and Excel template files used to generate model performance measures used in multi-objective trade-off analysis (in an Excel output format).
Dam Operations, Hydrology, Power, and Lake Recreation Submodel		
3	Complete interface	Basic validation rules, bug correction, additional functionality.
4	Develop and implement water year scenarios for model testing	Simple scenarios are needed to understand dynamics of sediment transport model (e.g., only a known number of storm events of specific magnitude).

	Task	Notes
5	Add Glory Hole discharge vs. elevation relationship (update database, interface, core algorithms)	Account for how long reservoir has been at elevation (higher discharge if reservoir has been at elevation for longer). Make this parameter adjustable by user.
6	Revise flushing flow procedure	Release flushing flows only once per X years (allow user to control the number of years between treatments), to allow for time lags in measured responses. Make flushing flow treatments dependent on anticipated flow conditions. If a wet year is anticipated, operate WT reservoir in summer mode (full pool) until target flow achieved, then draw-down to winter elevation. In dry year, just operate at winter elevation (flushing flows too difficult/expensive to achieve). Decision about winter operations would be made each November, based on anticipated flow conditions. Predict flow conditions based on carryover storage in Shasta and Trinity reservoirs, and predicted inflows to WT based on autocorrelation in historical data.
7	Make Glory Hole output vs. elevation relationship an uncertainty node in decision analysis	Perform model iterations over different hypotheses with associated degrees of belief in each.
8	Contingency	Final minor revisions, if necessary, following training session and review of revised model.
Channel Submodel		
9	Review and improve initial conditions/parameterization to address unreasonable timing/magnitude of gravel movement (communicate to experts)	Initial parameterization of channel submodel was based on professional opinion owing to general lack of data, with some elements based on lab studies or data from surrogate watersheds. Thus: Greatly reduce amount of sediment initially present, and review parameter settings to deal with concerns about timing/magnitude of modeled gravel movement (e.g., sediment movement in summer, rate & amount of reach-to-reach movement). ***Current model** has numerous parameters to make sediment transport rates more reasonable. Tasks 9-11 will together require 4 person trips (David Marmorek and Clint Alexander + 2 Advisory committee members to meet with members of project team and local agency experts).
10	Reinitiate discussions with experts and revise method of simulating %<2mm (i.e., alternative simple approach not based on modeling transport dynamics and deposition)	At present fines automatically present whenever there's space for them as relationship used is based on the standard deviation of the geometric mean grain size only (though this relationship was based on observations of a field expert) Reinitiate discussion with sediment modelers to devise a simpler approach that is not based on modeling gravel transport and deposition of fine material (e.g., so that flushing flows prone to remove fines, as in Trinity R.).
11	Revise scour depth functional relationship to depend on either shear stress or volume of larger grain sizes that are mobilized in bed load	…
12	Revise Gravel Manager (simplify)	Gravel additions occur on yearly basis, not in a state dependent way (will continue to add roughly constant amounts of gravel every year to correct existing gravel deficit). Only add gravel into top of Reaches 1, 3, 5 (areas with access). Limit amount added to 4-5000 cu. yards (easy to do via specifying appropriate annual budget limit). Turn off gravel additions when testing sediment movement submodel.
13	Complete revisions to interface/core algorithms inherent in the changes to model structure from tasks 9 - 12	Tasks 9 through 12 will require simple to moderate changes to the database, core algorithms, and graphical user interface.
14	Contingency	As task "8"

	Task	Notes
Fish Submodel		
15	Have parameter values reviewed by local fish experts	As task 9, but not expected to result in unplanned changes to functional relationships in fish submodel (significantly less effort in comparison).
16	Allow user to control emigration rates of juvenile chinook and steelhead salmon	Allow different seasonable patterns of emigration (not merely constant monthly proportion).
17	Change survival vs. scour depth relationship to reflect minimum depth of redds	Reflect fact that eggs are not laid right at beginning of surface.
18	Use post-1995 escapement data to estimate mean of distribution of spawners	…
19	Complete minor changes to interface	Correct technical scenario management/data problems, implement simple built-in validation of parameter values.
20	Contingency	As task "8"

Deliverable: Revised, user accepted, fully working **decision analysis model** ready for full-scale application to alternative Whiskeytown reservoir operation and gravel injection scenarios and uncertain hypotheses.

The other feature of the activities performed in support of objective 1 is review of relevant fieldwork already in progress and funded (task 21). This will ensure that any new information that has been generated about the key hypotheses in CCDAM is incorporated into the model analyses, and the field study component of this proposal does not duplicate any existing/future funded projects.

Objective 2: Use the model to assess the frequency, duration, and magnitude of flows realized from alternative Whiskeytown Reservoir operation policies and how these operations improve ecological values. Quantify the impact of alternative operations to competing non-ecological values.

The following tasks summarize the steps in our work plan to achieve objective 2. This set of tasks focuses on **preliminary application** of the model to alternative flow actions, rigorous sensitivity analyses to identify key uncertainties for the full decision analysis, and the elimination of possible flow management experiments that do not make sense:

	Task	Notes
21	Review relevant fieldwork already in progress and funded	Studies that generate information relevant to the key uncertain hypotheses in CCDAM. **Learn from existing studies** – look at information that can be used for *updating prior probabilities on alternative hypotheses* and *refining fixed model parameters* (e.g., WUA lookup data from IFIM, channel slope data following floodway rehabilitation, gravel transport rates at different flows, data to update Tappel and Bjornn relationships, egg survival and scour depth, % fry rearing in Clear Creek vs flows, and so on). Also looking for details on any planned or performed flushing flows and gravel injection efforts to use in *configuring simulated actions* – CCDAM projects both the short and the long-term results of these management strategies. Help guide direction of these monitoring efforts by communicating insights from preliminary modeling. **Avoid duplicating** these **programs** in 22. For efficiency reasons, this may require some members of our project team to meet with local Clear Creek Restoration groups.

	Task	Notes
22a	Targeted field investigation to obtain necessary data to fill key model data gaps **Infiltration of fine sediment into spawning gravels**	CCDAM has *many* functional relationships with a variety of required empirical parameters. We will perform sensitivity analyses to verify what model inputs and parameters are most important (i.e., alter rank order of chosen management actions). Task 21 ensures we will avoid duplication of existing/ongoing efforts. The first field investigation is targeted at quantifying the rate at which fine sediment infiltrates spawning gravels during storm events and reservoir releases. This study will assess how long the benefits of cleaning gravels (e.g., through gravel injection, riffle cleaning, or bed mobilization) will last. Because the study will also assess how fine sediment infiltration rates vary with suspended sediment concentrations, it may also provide insight into whether the control of fine sediment sources, and resultant reductions in suspended sediment concentrations, can prolong the benefits of gravel cleaning strategies. This investigation will involve cleaning patches (7 ft. x 7 ft.) of spawning riffles and deploying 12 infiltration bags at each sample site (i.e., cleaned patch). We hypothesize that sediment infiltration rates will vary in different areas of the riffle in response to different hydraulic conditions. The first step in selecting sample patches will be to stratify the riffle by those features that we expect will influence the hydraulic conditions that affect infiltration rates (e.g., gradient, particle size distribution, depth of flow, obstructions or changes in channel width that may cause eddies). We will then randomly select patches to be cleaned from each major strata. We will measure suspended sediment concentrations and sand moving as bedload for four discharge events. Following each discharge event, we will retrieve a random sample of 3 of the original 12 infiltration bags from each patch. After processing the samples, we will re-deploy three infiltration bags, covered by clean gravel, in each patch. The three re-deployed bags will be sampled following the next discharge event. The study design will allow us to isolate the rate of fine sediment infiltration in spawning gravel for each discharge event, as well as assess the cumulative infiltration of fines from multiple discharge events. The investigation will allow us to quantify relationships between discharge, suspended sediment, and spawning gravel quality. The investigation will also allow us to evaluate differences in suspended sediment concentrations and fine sediment infiltration in spawning gravels for discharge events dominated by clear water reservoir releases and discharge events dominated by more turbid tributary flows. (***See Attachment E for a description of the preliminary study design.**)
22b	Targeted field investigation to obtain necessary data to fill key model data gaps **Emergence trapping and gravel quality monitoring**	The second field investigation is targeted at quantifying the linkages among the particle size distribution of gravel, permeability, dissolved oxygen, salmonid egg survival, and fry emergence. The majority of salmonid monitoring and research in the Central Valley focuses on adult and juvenile life stages. There is comparatively little monitoring of egg and fry life stages on Bay-Delta tributaries; consequently, there is little data available to model the functional relationships among flow, spawning gravel quality, and egg/fry survival. The proposed investigation involves placing emergence traps on both natural and constructed redds for fall-run chinook salmon. The natural redds will reflect current conditions of gravel quality, while the constructed redds will be cleaned of fine sediments (to varying degrees) to represent improved gravel quality (thereby simulating such restoration strategies as the release of flushing flows and gravel injection). Particle size distribution (bulk samples will be collected after all fry have emerged), permeability, dissolved oxygen, and egg/fry survival will be monitored at each natural and constructed redd, allowing us to quantify relationships among these variables. (***See Attachment E for a description of the preliminary study design.**)
23	Preliminary analysis of trade-offs	Initial model application would focus on a preliminary, simple analysis of trade-offs for specific reservoir operations (e.g., structural change vs. current reservoir operational changes).

	Task	Notes
		Here we would assume some best guess deterministic hypotheses (i.e., parameter values for functional relationships). This would help us understand overall model behavior, and give us a simple base set of output to communicate to and review with others.
24	Complete comprehensive sensitivity analysis	A rigorous sensitivity analysis would be performed to identify the key uncertainties to include in the decision analysis, and to focus on when refining the implementation details of the field investigations in 22.
25	Begin filtering out inappropriate actions/gaming to design preliminary AM experiments	At this more detailed level of analysis, we would conduct simulations to filter out reservoir operation and gravel injection actions that – even with full uncertainty – do not make sense. A restoration action would “not make sense” if the risk/cost to a key performance measure was consistently too high, or the expected outcomes of the restoration action failed to move into an acceptable range even with heavy weighting on the extremes within the uncertain hypotheses admitted.
26	Ongoing documentation of model refinements and analyses	Ensure proper record of assumptions and results for various model analyses, to ensure there is a repository of materials for the annual report, meetings, and other communications.
27	Outreach: preparation and facilitation of two-day meeting to review model	Present results of tasks 21 – 25. Confirm critical uncertainties. Conduct group design of candidate flow management experiments to resolve these uncertainties. Summary document of meeting discussions for participants. This will require some members of our project team to meet with and facilitate meetings with local Clear Creek Restoration groups (5 person trips @ 2 nights accommodation).
28	Outreach: Year 1 Progress Report	Prepare draft report for peer review by independent and agency participants summarizing key findings from tasks 21 – 26. Include comments from participants in second draft. This would be the first major report documenting methods, analyses, and results of the application of the CCDAM model in Year 1, and lay the blue print for next steps (i.e., describe the full decision analysis and considerations for the adaptive management experiments to be performed in Year 2).
29	Outreach: present paper at IEP/Bay Delta Modeling Forum or at CALFED Adaptive Management Forum	Effectively communicate knowledge gained to local agencies and stakeholders, as well as the broader scientific community. Raise profile of the project.
30	Contingency	Foreseeable but undefined meeting(s) with stakeholders/subject matter experts. Past experience has shown that project “bottlenecks” are most effectively cleared through concentrated, face-to-face meetings. This may require some members of our project team to meet with and facilitate meetings with local Clear Creek Restoration groups.

Deliverables: see “Year 1” in section A.7

YEAR 2 – Adaptive Management Modeling

Objective 3: Through simulation, determine what types of experimental Whiskeytown Reservoir operation policies and field monitoring programs will yield the most information to reduce key physical and biological response uncertainties. Quantify the expected net benefits of managing on the basis of this information over a range of assumptions and objectives.

The steps in our work plan to achieve objective 3 are summarized below. The first set of tasks focuses on the **model implementation** of the adaptive management elements of the model identified in Year 1:

	Task	Notes
1	Implement Adaptive Management component of model	For those elements of the model for which field monitoring is possible to gain information about uncertain hypotheses, simulate the collection of this data with error (measurement and natural variation). Requires an assumed true state for the uncertain hypothesis for which data is being collected (*this assumption is a key focus in sensitivity analysis). This includes **many software development subtasks** to incorporate this mode of analysis: database additions, core algorithm additions (e.g., to simulate the gathering of data with measurement error and natural variation), output and graphical user interface development. Requires communications with field monitoring experts to properly structure these simulations (e.g., frequency of monitoring, expected level of measurement error).
2	Complete Excel Export Assistant reports	Access queries and Excel template files used to generate model performance measures. Here, focus is on performance measures on the learning value of the experimental reservoir operations and monitoring (i.e., statistical likelihood calculations for the alternative hypotheses following collection of simulated data, probability of experiment “moving in the right direction” towards identifying the assumed true hypothesis).
3	Contingency	As Year 1 task 8
4	Development of AM experiments identified in Year 1	Construct flow management experiments identified in Year 1 (i.e., set up parameters in model and database).

With full-scale decision analysis and simulated adaptive management analysis capabilities, the second set of tasks focuses on **application** of this mode of analysis to assess the ability of alternative operations and monitoring programs to reduce uncertainties:

	Task	Notes
5	As Year 1 task 21	As Year 1 task 21
6	Formal rigorous decision analysis and trade-off analysis, learning from AM experimentation for channel, fish, power, flood objectives	**Apply the model with the best parameterization and design of flow management experiments incorporating and accounting for current uncertainty.** For the initial rigorous decision analysis, the degree of belief in the alternative hypotheses would be equal, with sensitivity analyses to consider more informative weightings (building in information from reviews of ongoing research and monitoring). Would then perform simulated adaptive management experiments (i.e., assume true hypotheses for key uncertain components, simulate collection of data in field monitoring programs with measurement error and natural variability). Revise base case decision analysis probabilities with results of adaptive management (via statistical likelihood calculations – Alexander et al. 2000b gives detailed example). Update expected outcomes of all performance measures for base case decision analysis using the post-AM probabilities. Determine if you take a different action based on this information (do this for alternative management objectives). Assess monitoring and other indirect costs during experimental period and compare against long-run value of managing on the basis of this information.

	Task	Notes
7	Ongoing documentation of AM analyses	As Year 1 task 26
8	Package and deployment of final model	Generate install pack for Windows (98, 2000, NT) CCDAM application and make available for download over the Internet on ESSA's and/or CALFED's web site. This should proceed gaming and training planned for tasks 9 and 10.
9	Outreach: Preparation for and facilitation of 1 3-day workshop to discuss and select best candidate water year dependent AM experiments – given operational and other constraints	This would be the **key meeting of Year 2**, where ESSA and associates would present key findings of the modeling research over Years 1 and 2. Would seek broad multi-stakeholder participation, the workshop format would be open, with opportunities for model gaming one 1 of the 3 days. Document level of consensus, areas of disagreement. We would install the model on several computers (3-6 depending on interest) for purposes of gaming. On the first day of the workshop, we would present the results of "canned" simulations in the CCDAM database. ESSA would provide neutral facilitation of the selection of the best water year dependent experiments, given operational and other constraints, and different management objectives. Special attention would be placed on identifying strategies that were robust to uncertainties and differences in values/management objectives. Ideal output would be a consensus on the best flow related management strategy for Clear Creek, informed by the rigorous modeling evidence from Year 1-2/ input from stakeholders.
10	Outreach: Training session for AM module, including group refinement of AM experiments using AM module	The CCDAM application has been designed to be a powerful but user friendly tool that will be used by interested investigators. Familiarity with the operation of the model is best achieved through instructor led, hands-on training sessions. This strongly compliments the provision of a users guide (task 13) The model ought to be used over the next 3-5 or more years as research continues that provides data to refine CCDAM assumptions/uncertainties Aided by CCDAM, aspects of AM plans could be refined by local agency restoration groups on an ongoing basis
11	Outreach: Year 2 Progress Report documenting **Most Promising Flow Options (MPFO)**	This would be the major report documenting methods, analyses, and results of the application of the CCDAM model, and **thoroughly evaluate the weight of evidence and trade-offs for alternative flow related reservoir operations and gravel injection programs**. In essence, a document that substantiates the MPFO for Clear Creek. Prepare draft report for peer review by independent and agency participants summarizing key findings from tasks 6 and 9. Include comments from participants in second draft
12	As Year 1 task 29	As Year 1 task 29
13	Outreach: User's Guide for complete model	A comprehensive reference manual for the proper operation of the CCDAM application. This document would be made available over the Internet on ESSA's and/or CALFED's web site.
14	As Year 1 task 30	As Year 1 task 30

Deliverables: see "Year 2" in section A.7

YEAR 3 – Consultations to Prepare for Structured Implementation

Objective 4: Develop and facilitate a consensus-based multi-stakeholder process for implementing the "most promising flows".

The steps in our work plan to achieve objective 4 are summarized below. The first set of activities focuses on the **multiple stakeholder facilitation** to review the evidence in support of the MPFO identified in Year 2, and to discuss the "how to" and "who will" of implementing them. The second set of activities focuses on **study plan development** for formal implementation of targeted field monitoring studies to test hypotheses related to key uncertainties *under* the "most promising flow" regimes:

	Task	Notes
1	As Year 1 task 21	As Year 1 task 21
2	Facilitation of stakeholder negotiations	Develop a facilitated, consensus based process for negotiating the implementation of the most promising flow options. Develop participant list and distribute tech memo on process for comment. In a series of workshops designed to build shared understanding: ▪ Review evidence in support of the most promising flow regimes, ▪ Document areas of agreement and disagreement, and 'show stopper' regulatory requirements, ▪ Document prospects for regulatory flexibility, ▪ Incorporate "late breaking" information and how it may affect the Year 2 MPFO, ▪ Address issues such as "how to" implement the MPFO flows and "who will" provide them, ▪ Address who will implement the monitoring and how it will be coordinated amongst agencies, *Assume minimum of 3 2-day multi-agency workshops
3	Conduct CCDAM analyses to verify robustness of the Year 2 MPFO (if required)	Facilitation in task 2 will be staged over at least 3 meetings. Between meetings, be responsive to agency/expert suggestions and criticisms by returning with new analyses to show the consequences of these viewpoints.
4	Study plan development for structured field monitoring with MPFO flows	As part of the facilitated process, a workgroup will be devoted to study plan development for the MPFO flows. This Workgroup will be charged with development of a structured field-monitoring program to test hypotheses pertaining to key hydrology, geomorphic, and biological uncertainties under 1 or more MPFO flow regimes. *The workgroup will distinguish between development of new field monitoring that relates to key uncertain hypotheses that are not underway, and the coordination of filed monitoring with existing, ongoing programs
5	Outreach: Year 3 Progress Report **Results of Consultations on the Structured Implementation of MPFO flows: Barriers and Bridges**	Prepare draft report for peer review by independent and agency participants summarizing discussions related to tasks 2 and 3. Include comments from participants in second draft. This would be **the major report** documenting the level of consensus for the MPFO flows, as well as a structured plan for their implementation and monitoring.
6	As Year 1 task 29	As Year 1 task 29
7	As Year 1 task 30	As Year 1 task 30

Deliverables: see "Year 3" in section A.7

A.4 Feasibility

The approach presented in the previous section has been developed with careful consideration, integrating insights from this project's two previous phases. ESSA has done a lot of the work already, using previous funding support from CALFED. We have outlined the need for explicit funding for coordination with local agencies and partners, as well as for the review of information available from ongoing restoration activities. Our proposal also builds in funding flexibility to acquire information to fill key model uncertainties and data gaps. Contingency line items have also been provided both for software development tasks as well as for unforeseen stakeholder consultations/meetings. Our contingency structure and change request procedure (Attachment F) provides the necessary flexibility to address unforeseen factors and to adjust project schedules/scope.

The modeling approach developed has already been shown to be effective during preliminary simulations (July 12th and 13th 2001 prototype review meeting) and we have previously shown the methods effectiveness and feasibility in the Columbia River (Alexander et al. 2000b). Our project team has considerable expertise and experience in all the core competencies required by this project: technical facilitation, adaptive management, modeling, statistics, and field monitoring. Also working in our favor is strong local support (Attachment D), and these groups, namely the WSRCD, Clear Creek Restoration Team, and the USBR have demonstrated the ability to successfully plan and implement large-scale restoration actions. We hope to continue to earn this support through active consultations.

This project is consistent with the Environmental Compliance Checklist. Any required Permits will be obtained from the appropriate State or Federal agency (e.g., CDFG permits for trapping and handling fish). In the event this project is selected for funding, access agreements shall be provided within the required time frame.

A.5 Performance Measures

Our project performance evaluation plan and specific performance measures are listed in Table C.3.

A.6 Data Handling and Storage

A relational Access database (CCDAM.mdb) has already been developed for the CCDAM model with many placeholders to complete this project already in place. All model related data and scenario information will be stored in this database, as well as queries for generating specific outputs.

Project status reports, meeting presentations, participant lists, and annual reports would be distributed electronically in Word (draft) and PDF (secure) format. At the option of CALFED, these materials may also be made available for secure download[6] from ESSA's web-site (www.essa.com) on an "as needed" basis.

A.7 Expected Products/Outcomes

Please see Table C.4 (attached) for a detailed list of project deliverables as well as Table C.3.

A.8 Work Schedule

Figure B.5 summarizes the work schedule in each year to complete this project.

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

B.1 ERP, Science Program and CVPIA Priorities

This project has grown directly out of the priorities of the CALFED Ecosystem Restoration Program (ERP), Central Valley Project Improvement Act (CVPIA), and the Anadromous Fish Restoration Program (AFRP).

6 Would need to generate e-mail distribution list to supply user name and password information for such downloads.

ERP Goals

Table C.5 provides excerpts of the ERP Draft Stage 1 Implementation Plan demonstrating that this proposal meets several explicit CALFED priorities for the Science Program and the Sacramento Valley region.

CVPIA Priorities

Congress identifies the general purposes of the CVPIA in Section 3402(a) to protect, restore, and enhance fish, wildlife, and associated habitats in the Central Valley. Section 3406 (b) 12 describes specific actions to be implemented in Clear Creek, including development of a comprehensive program to provide flows to restore salmon and steelhead habitat below Whiskeytown Dam. The CCDAM model, provides an overall integration of key system linkages for comparing the relative effectiveness of different flow related restoration strategies.

B.2 Relationship to Other Ecosystem Restoration Projects

This project builds on many past and ongoing restoration projects completed by CALFED[7], as well as similar work funded by the Bureau of Reclamation, US Fish and Wildlife Service, and the numerous stakeholder restoration efforts initiated by the Clear Creek Coordinated Resource Management Program (CRMP) and Western Shasta RCD aimed at restoring sediment transport dynamics, salmonid populations, or riparian community health. **Overall, these efforts are an important source of data and expert knowledge on component linkages and hypotheses for the CCDAM model**. **The model itself is an integrative force used to forecast the effects of alternative flow related operation alternatives over multiple objectives while explicitly accounting for numerous uncertainties**.

B.3 Requests for Next-Phase Funding

This proposal is for phase 3 funding. ESSA and numerous state and federal participants have already completed considerable work through directed funding from CALFED for phases 1 (case study selection and scoping) and 2 (multi-stakeholder model design workshop and prototype development) and have recently unveiled and reviewed the working prototype model – CCDAM. The requested summary of the earlier 2 phases of this project is included in Attachment G.

B.4 Previous Recipients of CALFED Program or CVPIA Funding

ESSA has previously received directed funding from CALFED for two earlier phases of this project.

Name of project

1. Adding Rigor to the CALFED Concept of Adaptive management: Development of a Decision Analysis and Adaptive Management Model for Restoration Programs. Contract no. 6-CA-20-0341A. (Funded through CH2M HILL via delivery order no. 1425-98-PD-20-3041 A/043, Ecosystem Strategic Plan, Task 14c)[8].
2. Adding Rigor to the CALFED Concept of Adaptive Management: A Case Study Application to Tributary Restoration. Contract no. 00CS202122[9].

The status of these projects was summarized in section B.3 above.

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[7] Such as addition of coarse sediment, removal of Saeltzer Dam and large-scale channel and floodway restoration activities.

[8] ESSA reference: EW1060.

[9] ESSA reference: EW1134.

B.5 System-Wide Ecosystem Benefits

This project offers the following system-wide ecosystem benefits:

- Provide CALFED with a quantitatively rigorous design of a management experiment for a problem of immediate concern, to serve as a model for the application of adaptive management to other areas;
- Provide an example for how CALFED applies decision analysis and adaptive management to other program areas. In essence, a ***flagship example of the benefits of how to compare the relative effectiveness of different flow related restoration strategies*** through the development and application of mechanistic models as restoration tools; and
- Other valuable system-wide benefits are provided in the Outcomes row of Table C.3 (attached).

B.6 Additional Information for Proposals Containing Land Acquisition

This research and restoration project does not include a land acquisition component.

C. Qualifications

As illustrated in earlier phases of this project, ESSA has considerable experience in adaptive management, decision analysis, modeling, statistics and technical facilitation. We believe this experience is required, and we are very confident that we have assembled a highly capable project team with a strong mix of excellence in all five of these areas. The proposed project team organization structure is illustrated in Figure B.6.

ESSA Technologies, founded in 1979, is a 25-person firm that applies its expertise in ecological sciences, quantitative methods, and workshop facilitation to tackle both the technical and human dimensions of ecosystem problems. Resumes for key ESSA staff members available to work on this project can be found on: http://www.essa.com/resumes and key staff members that would be available to work on this project are described below:

Mr. David Marmorek is Director of ESSA's North America operations, and will manage this project. His twenty-five years of experience includes facilitation of over 100 workshops, and development of models, monitoring designs, adaptive management approaches, and ecological risk assessments for a diverse range of resource management problems. He brings considerable experience to this project, including retrospective analyses and adaptive management/monitoring designs for the restoration of both large river ecosystems (e.g., the Columbia, Fraser and San Joaquin rivers) and smaller watersheds (e.g., Clear Creek CA; Cheakamus River, Kennedy Lake, Okanagan Lake and Carnation Creek BC). He recently completed a critical review of BC's Watershed Restoration Program. Mr. Marmorek has considerable experience in managing large, interdisciplinary teams working on complex projects, including leading a 5-year, multi-agency decision analysis of risks to endangered chinook salmon stocks in the U.S. Columbia River. David has a Bachelor of Environmental Studies and Mathematics from the University of Waterloo, an M.Sc. in Zoology from UBC, and over 30 peer-reviewed publications.

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

Mr. Calvin Peters is a systems ecologist who specializes in applying decision analysis and other quantitative and analytical tools to the evaluation of environmental policy and practices. He recently developed the fisheries and DOHPLR submodels for the Clear Creek Decision Analysis Model, a comprehensive bio-physical model for assessing the effects alternative flow policies on Clear Creek (California) on downstream chinook and steelhead populations. Mr. Peters has extensive analytical experience using models and decision analysis frameworks to evaluate recovery actions for endangered salmon stocks in the Columbia Basin, lake stocking policies affecting freshwater fisheries, and the effects of Columbia River flows on Mountain Whitefish populations. Mr. Peters holds a Masters Degree in Resource and Environmental Management from Simon Fraser University.

Ms. Christine Pinkham is an Application Specialist in conducting research, technical writing (including online documentation), data manipulation and analysis, customization of data (spatial and non-spatial) for ESSA models, database design and management and model testing. Ms. Pinkham has over five years experience in the areas of forestry and aquatic sciences, adaptive management, environmental impact assessment and environmental information systems. She holds a B.Sc. and a Post-Graduate Diploma in Environmental Science.

Stillwater Sciences is a 30-person firm of biological and geological scientists that focuses on developing the highest quality scientific understanding of interdisciplinary issues in watershed analysis and river restoration. Key staff members that would be available to work on this project are described below:

Mr. Frank Ligon is an aquatic ecologist and geomorphologist specializing in investigations of the role of fluvial processes and morphology in the ecology of stream fish, invertebrates, and plant communities. His experience in the Central Valley includes designing, managing, and implementing a ten-year investigation of chinook salmon population dynamics in the Tuolumne River. This investigation formed the foundation of a Settlement Agreement among irrigation districts, resource agencies, and environmental groups that identified flow requirements and restoration and management strategies to restore the river's chinook salmon population to sustainable levels. In addition, he is currently a lead author and coordinator of the CALFED white paper process, which is an effort to compile and synthesize existing knowledge of the Central Valley ecosystem and target species and populations. The information developed in this process will be used to identify restoration strategies and prioritize restoration actions to be implemented under the CALFED program.

Dr. Yantao Cui is a civil engineer with over ten years of experience modeling sediment dynamics and hydraulic effects in regulated rivers. His applied research projects have involved investigation of riverbank erosion, effects of gravel extraction on fluvial geomorphic processes, and the downstream impacts of reservoir management.

Mr. Christian Braudrick is a fluvial geomorphologist with a Master's Degree in geology from Oregon State University. He has assessed channel morphology, sediment transport, and hydrology of fluvial systems in California, Oregon, Washington, and Utah. Mr. Braudrick has also managed projects on dam removal on Clear Creek, CA and stream restoration for the Chelan River, WA. On Clear Creek he helped develop and implement a monitoring plan to assess numerical modeling of sediment transport following the removal of Saeltzer Dam.

Advisory Committee

John Williams has a broad background in the natural sciences, and has worked on Central Valley water issues for the last nine years. He has a Ph.D. in Geography from UCLA, where he specialized in energy balance climatology and developed strong modeling skills before working as a postdoctoral scholar in physiological plant ecology. His election to the Board of Directors of the Monterey Peninsula Water Management District in 1978 prompted a change in emphasis to hydrology, fluvial geomorphology, and fisheries issues, along with work on riparian vegetation. In 1990 he was appointed Special Master to supervise the continuing jurisdiction in

Environmental Defense Fund v. East Bay Municipal Utilities District, in which capacity he supervised studies intended to clarify the flows needed to protect public trust resources in the American River. Drawing on this experience, he published several influential papers on instream flows. Dr. Williams also serves as Executive Director of the Bay-Delta Modeling Forum, a small professional group that works to improve the technical basis for decision-making regarding Central Valley water issues.

Matt Brown, Fish Biologist with USFWS, received a Bachelor of Science Degree in Biology from the University of California at Santa Cruz in 1986 and a Master of Science Degree from Arizona State University in 1990. He worked as a non-game fish biologist for the Arizona Game and Fish Department from 1990-1991and for FWS on threatened and endangered fish in New Mexico from 1991-1993. Matt began work on chinook salmon at the Northern Central Valley Fish & Wildlife Office in January, 1994. His current work focuses on habitat restoration under the CVPIA and evaluating the impacts of water development.

Scott McBain is an assistant hydraulic engineer and fluvial geomorphologist whose special interests include bed mobility, bedload transport, effects of high flows on channel morphology, watershed sediment yields, and stream restoration. He completed his Master of Science Degree in Civil Engineering at the University of California at Berkeley, studying hydraulic engineering under Dr. H.W. Shen and geomorphology under Dr. William E. Dietrich.

Dr. Tom Griggs. Academic and professional bio not available at press time (Riparian ecology expert).

Jim DeStaso, Fisheries Biologist with the Bureau of Reclamation, received a Bachelor of Science Degree in Biology from William Paterson University in 1990 and a Master of Science Degree from the University of Wyoming in 1992. He worked as a fisheries biologist with the USFWS from 1993-1995. Jim has been working with the Bureau of Reclamation at Shasta Dam since 1995 and is the program manager for the implementation of Clear Creek Restoration under the CVPIA.

D. Cost

D.1 Budget

ESSA Technologies Ltd. would be the contracting entity for this project, and Stillwater Sciences Ltd., the Advisory Committee, and any misc. subcontractors would operate through subcontracts from ESSA. However, we have project and budget flexibility to allow a substantial fraction of the field work to be done by local agencies such as USFWS and/or CDFG. As acknowledged elsewhere in this proposal, before initiating any field work we would discuss this with these agencies. Budget information is included in web forms VI and VII. We have carefully budgeted all tasks in this project based on our current understanding, including realistic contingency amounts, and have used rates consistent with average salary increases due to real and cost of living increases over a three year period (i.e., accounting for 2-year fiscal lag in initiation + duration of award). *Attachment F describes our standard procedure for change management and budget control.

Cost Options

If insufficient funds are available to support all of the proposed tasks, then CALFED has the option of bypassing the second field investigation (task 22b, Year 1), which is designed to quantify relationships between particle size distribution, permeability, dissolved oxygen, and egg/fry survival. CALFED funded a similar study on the Tuolumne River as part of a 2001 PSP proposal (2001-C208: Tuolumne River Fine Sediment Management), from which we may be able to obtain useful data for CCDAM model refinement. However, because of significant differences in the flow and sediment regimes between Clear Creek and the Tuolumne River, and because of relatively little monitoring of early life history stages of salmonids in Bay-Delta tributaries, we believe an investigation on egg-fry survival in Clear Creek would contribute both to CCDAM development and Bay-Delta science. CALFED also has the option of bypassing the first field investigation (task 22a, Year 1), which is designed to observe the infiltration of fine sediment in spawning gravels. Because there is relatively little data available to quantify the relationship between discharge, suspended sediment, and the infiltration of fine sediment in spawning gravels, bypassing the second field investigation would mean that important linkages among environmental variables in the CCDAM model will be based upon professional estimates rather than field-based monitoring. We believe, however, that the proposed field study would contribute not only to CCDAM development, but Bay-Delta science and ERP planning. CALFED has defined and funded a number of restoration actions designed to directly enhance spawning gravel quality (e.g., gravel injection, riffle cleaning), but the duration of the habitat quality benefits resulting from these restoration strategies is unclear in light of the potential for fine sediment infiltration.

If there are sufficient funds to support only one of the proposed field investigations, we would recommend that CALFED select the first field study targeted at fine sediment infiltration of spawning gravels, because little field data currently exists to relate discharge, suspended sediment, and infiltration of fine sediment in spawning gravels. Table C.2 summarizes the line items for field investigations in our work plan (details on these tasks were given in earlier sections). All potentially severable items are identified in Figure B.5 (* items).

D.2 Cost-Sharing

There are no cost-sharing arrangements in place for the work outlined in this proposal.

E. Local Involvement

This project has the support of a wide body of local agencies and stakeholders, namely representatives of the Clear Creek Restoration Team. Please consult Attachment D for a list of specific participants for phases 1 and 2. Development of this kind of model requires the support and participation of local experts in biology, geomorphology, hydrology and dam operations and economics that are familiar with the issues specific to flow management on Clear Creek. Part of ESSA's task in developing the model, therefore, is to work closely with these experts to ensure that the model adequately captures all relevant issues. To this end, ESSA is also responsible for facilitating technical meetings and formal workshops to engage local experts and solicit their inputs to the model. ESSA would also hold discussions with local agencies before initiating any field work. Though Stillwater Sciences is identified as the primary contractor for the optional field components in this proposal, we have budget flexibility to allow a substantial fraction of the field work to be done by local agencies such as USFWS and/or CDFG.

F. Compliance with Standard Terms and Conditions

We comply with the standard State and Federal contract terms described in Attachments D and E of the PSP. For purposes of meeting term 4 in Attachment D of the PSP, we have included Attachment F (herein) to describe our standard procedure for change management and budget control.

G. Literature Cited

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Attachment A: List of Figures and Tables and Cover Page

List of Figures

List of Tables

Ecosystem Restoration Program

2002 Proposal to the CALFED Bay-Delta Program

Adding Rigor to the CALFED Concept of Adaptive Management:

Application of the Clear Creek Decision Analysis and Adaptive Management Model (CCDAM) to Tributary Restoration

Phase 3

Prepared by

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Vancouver, BC V6J 5C6

And

Stillwater Sciences
2532 Durant Avenue, Suite 201
Berkeley, CA 94704

October 4, 2001

Attachment B: Figures

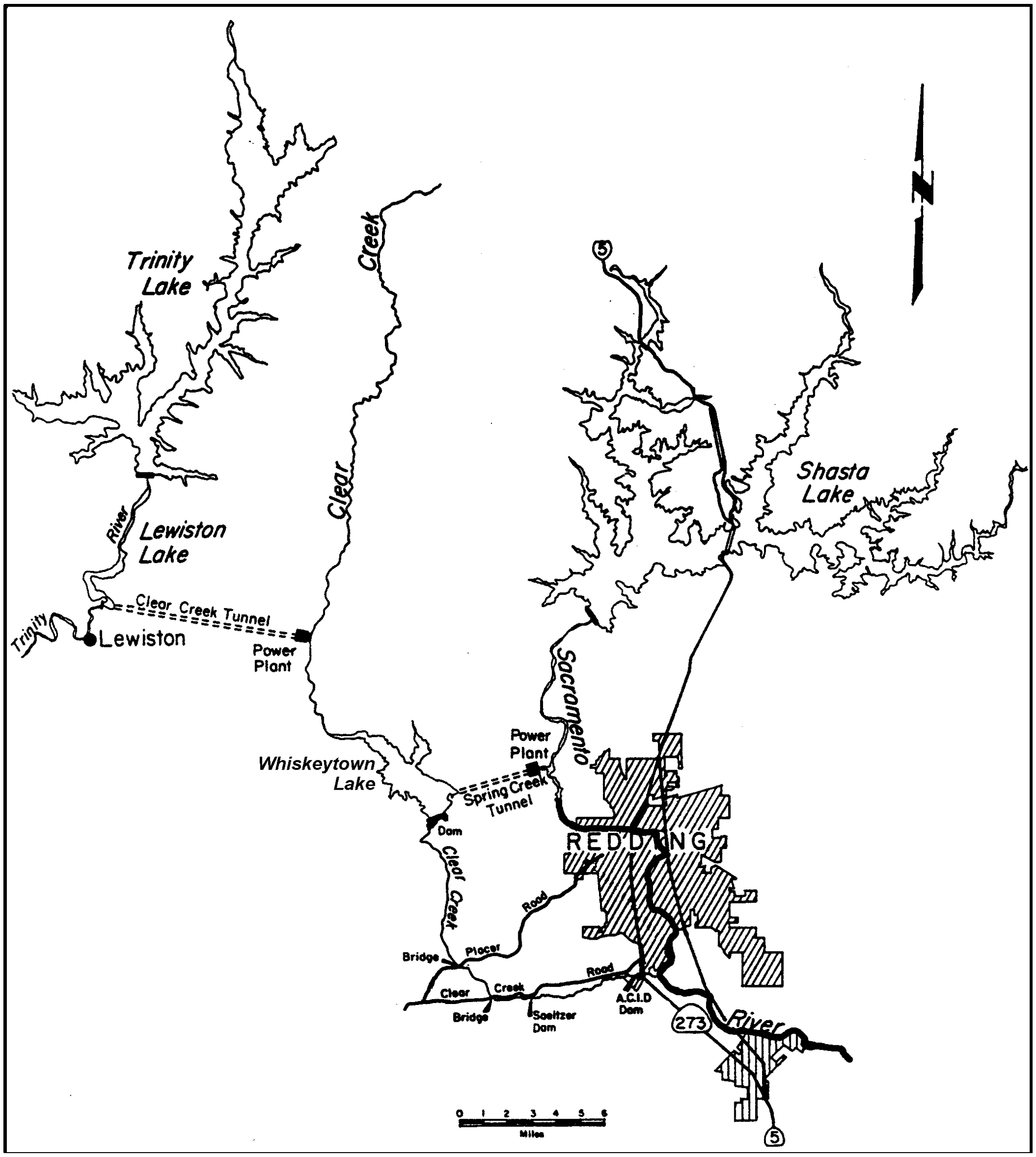

Figure B.1: Clear Creek study area (below Whiskeytown Reservoir) and major surrounding watersheds. Adapted from CDWR, 1986.

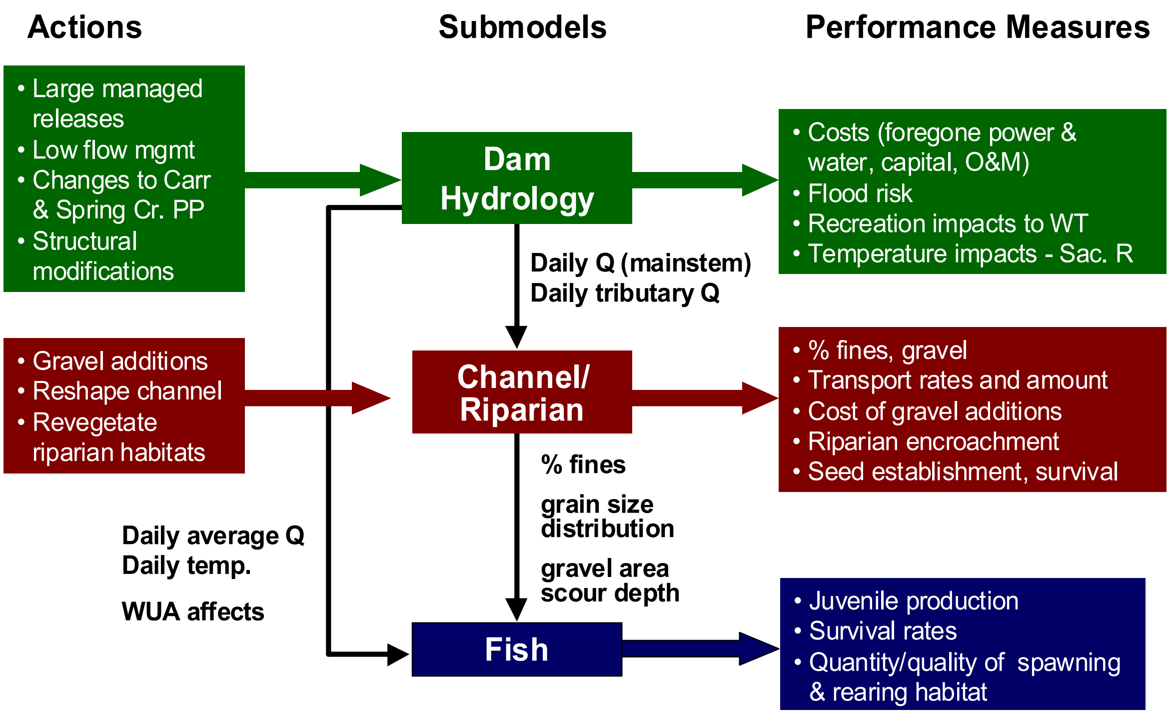

Figure B.2: Simplified conceptual model showing examples of management actions that are hypothesized to restore some of the lost habitat structure and biotic responses. The numerous functional relationships and alternative hypotheses linking actions and physical processes to biological responses in this model are set within the context of an overall decision analysis. Q = discharge; WUA = weighted usable area; WT = Whiskeytown Reservoir; Sac. R = Sacramento River.

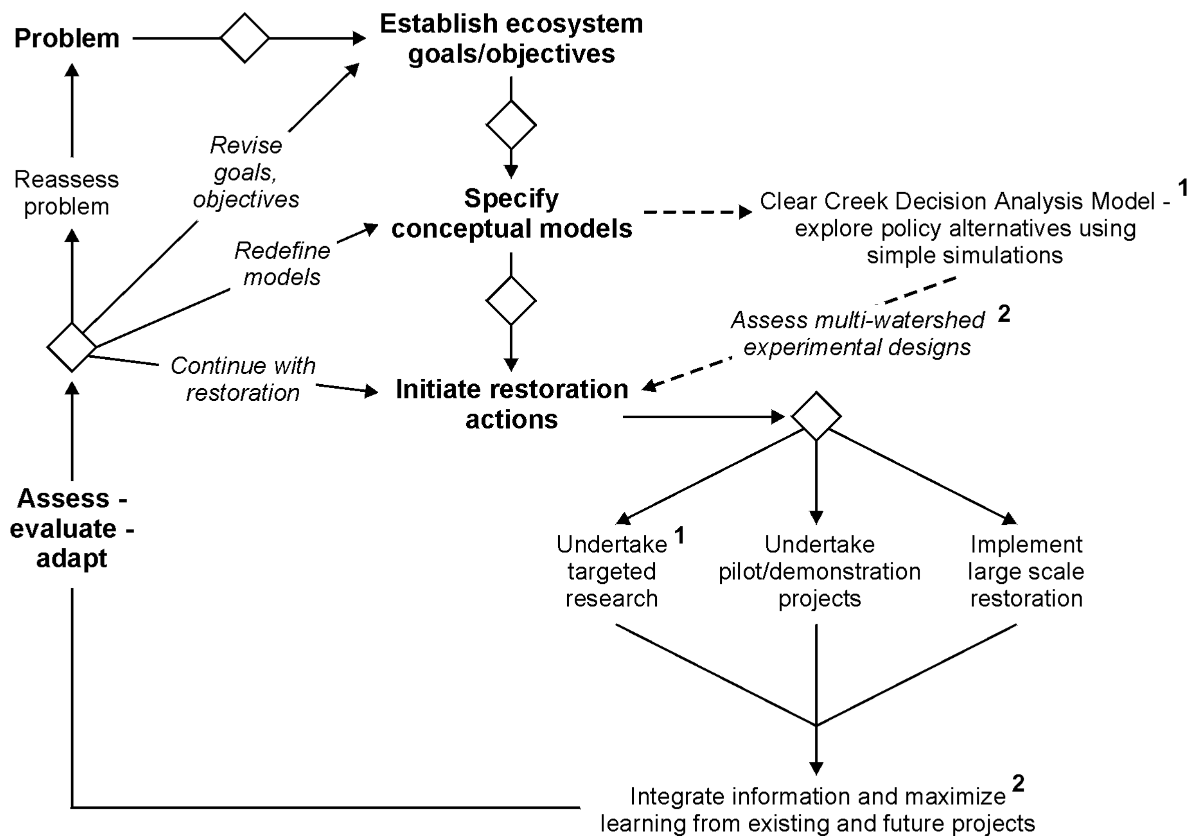

Figure B.3: Position of proposed project in the CALFED Adaptive Management process. The current proposal is one of three complementary projects initiated by ESSA Technologies and Stillwater Sciences to add rigor to CALFED's adaptive management process. Complementary projects include ESSA's Clear Creek Decision Analysis Model (#1), and ESSA's Testing Restoration Hypotheses across Multiple Watersheds project (#2).

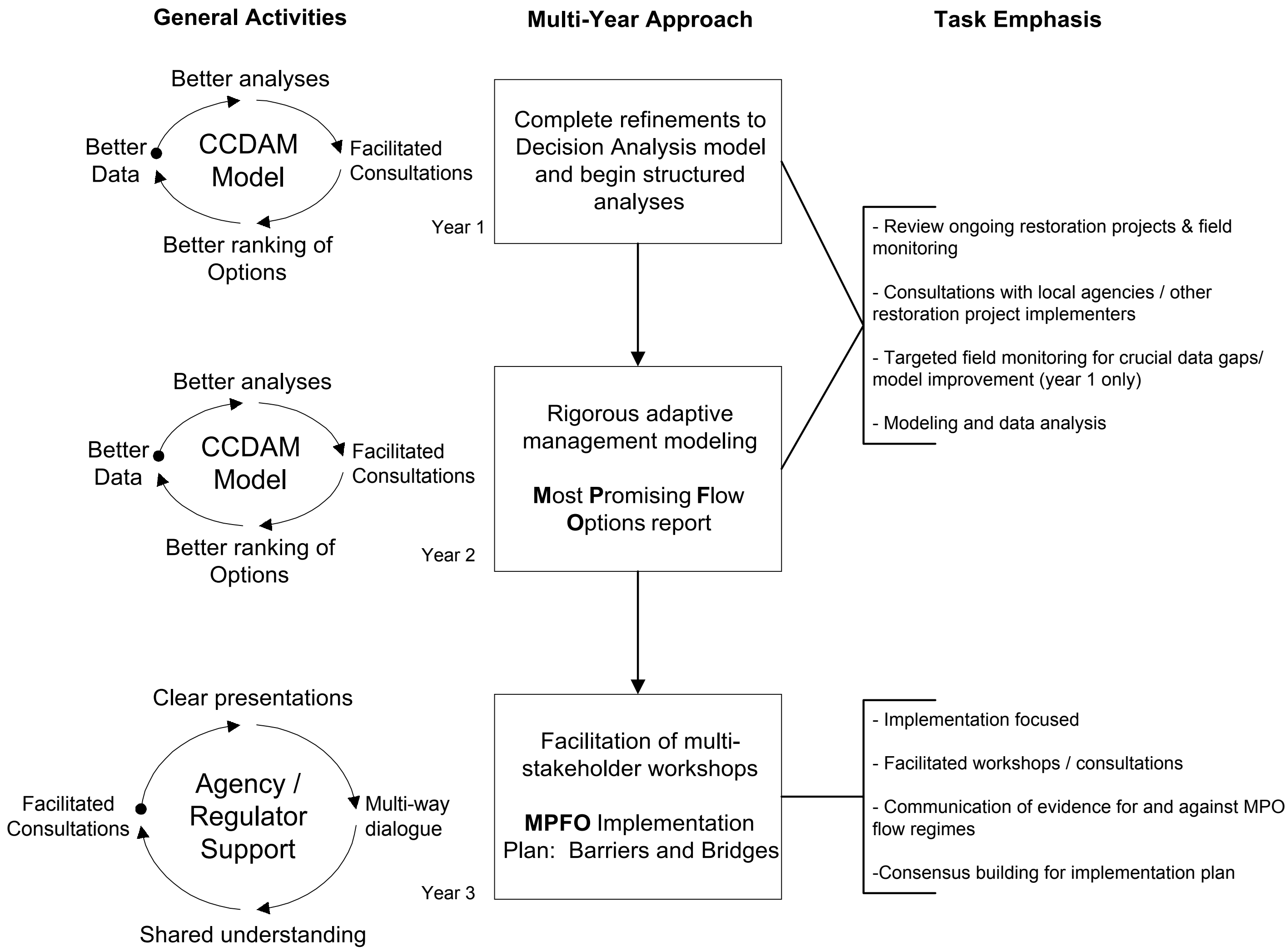

Figure B.4: Overview of approach for achieving project objectives. The overall workplan is highly adaptive – structured to maximize learning from ongoing research and monitoring in Clear Creek as well as other watersheds. Where existing monitoring programs are insufficient, flexibility is built in to allow targeted monitoring to obtain information for key data gaps that preclude the credible application of the CCDAM model.

YEAR 1 - CCDAM User Acceptance	2002			2003										
TASK	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**
1-20. Known model enhancements / Research / Testing					X									
21. Review relevant fieldwork														
* 22.a & b. Targeted field monitoring (water year independent)														
23. Preliminary analyses/Assessment of model						X								
24. Comprehensive sensitivity analysis							X							
25. Preliminary filtering of inapropriate actions / experiments									X					
26. Ongoing documentation model refinements and analyses														
27. Outreach: Facilitation of 2-day review meeting								X						
28. Outreach: Year 1 Progress Report										draft	peer review		X	
* 29. Outreach: Conference paper														
30. Contingency: Foreseeable but undefined meetings														
Project Management (incld. stakeholder coordination)														

= Hard schedule required

= Soft schedule

	YEAR 2 - Adaptive Management Modeling	2003	2004											
	TASK	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
	1. Implement Adaptive Management components				X									
	2. Complete Excel Export Assistant reports + 3. Model contingency							X						
	4. Development of AM experiments identified in Year 1													
	5. Review relevant fieldwork													
	6. Formal rigorous decision analysis, AM simulations								X					
	7. Ongoing documentation of AM analyses													
	8. Package and deployment of final model						X							
	9. Outreach: Facilitation of 1 3-day workshop							X						
	10. Outreach: Training session for CCDAM modules							X						
	11. Outreach: Most Promising Flow Options **(MPFO)** report									draft	peer review			X
*	12. Outreach: Conference paper													
*	13. Outreach: User's Guide for complete model								X					
	14. Contingency: Foreseeable but undefined meetings													
	Project Management (incld. stakeholder coordination)													

= Hard schedule required

= Soft schedule

	YEAR 3 - Consultations for Structured Implementation	2005								
	TASK	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**
	1. Review relevant fieldwork		X							
	2. Facilitation of stakeholder consultations (min. 3 2-day workshops)									
	3. Support anlayses to verify robustness of the Year 2 MPRO									
	4. Study plan development for structured field monitoring							X		
	5. Report - **Structured Implementation of the MPFO flows: Barriers and Bridges**							draft	peer rev	X
*	6. Outreach: Conference paper									
	7. Contingency: Foreseeable but undefined meetings									
	Project Management (incld. stakeholder coordination)									

= Hard schedule required

= Soft schedule

Figure B.5: Work schedule. Noting comments in Cost Options in section A.3. Tasks with a (*) are those that are separable/optional.

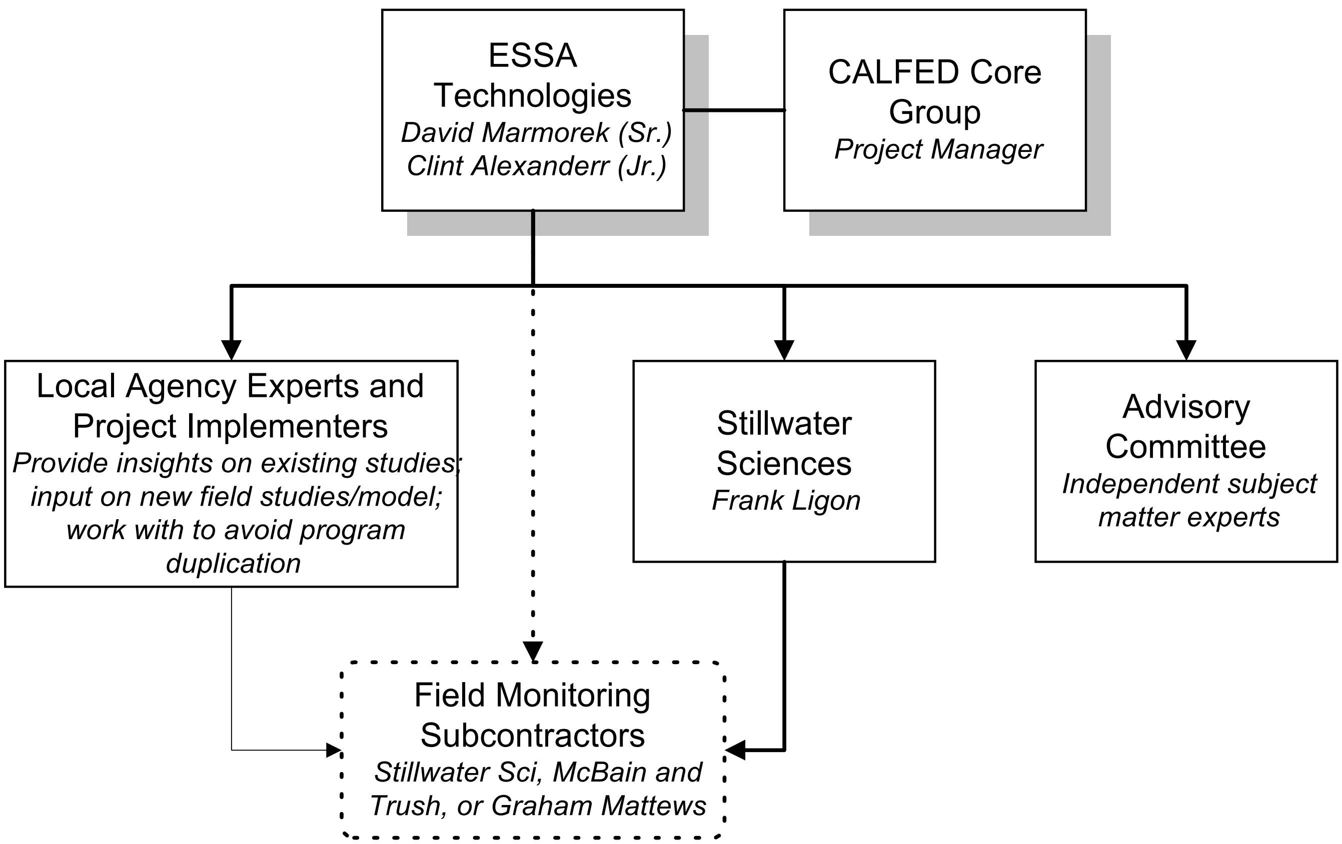

Figure B.6: Project management structure. The requirement for field monitoring subcontractors is dependent on review of other ongoing, funded field studies.

Attachment C: Tables

Table C.1: Descriptions of the contributions of the proposed field studies to the components of the CCDAM model. * These studies would facilitate quantifying the relationships between key environmental variables and basing relationships on field observations rather than professional estimates, thereby enhancing the credibility and acceptance of CCDAM model analyses.

Submodel data gap
Dam Operations, Hydrology, Power, and Lake Recreation Submodel
• relationships between tributary-dominated discharge events and downstream suspended sediment concentrations
• relationships between reservoir-release-dominated discharge events and downstream suspended sediment concentrations
Channel Riparian Submodel
• fine sediment infiltration relative to particle size distribution of framework gravels
• fine sediment infiltration of spawning gravels correlated with measured suspended sediment concentrations
• fine sediment infiltration relative to bed morphology and hydraulic conditions
Fish Submodel
• intra-gravel permeability, dissolved oxygen, and temperature relative to particle size distribution
• egg survival relative to particle size distribution
• fry emergence relative to particle size distribution

Table C.2: Field monitoring components of this proposal. Details on these tasks are given in section A.3.

Year	Task
1	22a. Targeted field investigation to obtain necessary data for key model data gaps as required. INFILTRATION of fine sediment into spawning gravels.
	22b. Targeted field investigation to obtain necessary data for key model data gaps as required. EMERGENCE TRAPPING and gravel quality monitoring.

Water year independent monitoring.

Table C.3: Plan for project performance evaluation. A list of performance measures that will be used to assess project success in relation to goals and objectives. Model analyses in Year 1 will be preliminary, Year 2 model analyses will be comprehensive. PM = Performance Measure.

<table>
<tr><th rowspan="2">PM Category</th><th colspan="4">Project Objective</th></tr>
<tr><th>1. Complete the evaluation of the existing prototype decision analysis model and improve it
(Year 1)</th><th>2. Use the model to assess flows from alternative Whiskeytown operations and how these operations improve ecological values. Quantify impacts to non-ecological values.
(Year 1)</th><th>3. Determine what types of experimental operation policies and field monitoring programs yield most information to reduce uncertainties. Quantify benefits of managing using this information
(Year 2)</th><th>4. Facilitate process for implementing “Most Promising Flows” and development of formal study plan for targeted field studies and implementation
(Year 3)</th></tr>
<tr><td>Activities: specific program actions taken</td><td colspan="2">- Software enhancements implemented that have already been identified by stakeholders to improve the model’s acceptance / credibility (metric: check-list vs. July 12th and 13th workshop summary document of July 26th 2001; yr1 work plan items 1-20)
- Degree of acceptance from interdisciplinary specialists / agencies at model review meeting (metric: end of workshop questionnaire)
- # face-to-face meetings with project implementers
- # project implementers contacted by phone / NetMeetings
- # data sets acquired and field studies reviewed
- # targeted field studies implemented which return usable new information on key data gaps / uncertainties (metric: short study plan document and Tech. Memo of results; quality control metric: studies follow sound sampling design, do not duplicate existing studies)
- # model analyses performed (namely: (a) complete comprehensive sensitivity analysis to identify crucial uncertainties / important assumptions / data gaps and (b) a preliminary analysis to filter out unsuitable actions, assess model behavior)
- Documentation (metric: Tech. Memos summarizing (a) purpose of various analyses and results (b) additional suggested enhancements by stakeholders at model review workshop and (c) First Annual Report)</td><td>- Implementation of algorithms for simulated adaptive management and monitoring along with associated software and database additions (User Interface, populate database tables); (metric: check-list for the addition of key uncertain hypotheses that were agreed to at Yr1 review workshop)
- # data sets acquired and field studies reviewed
- Development of AM experiments identified in Yr1
- # targeted field studies implemented which return usable new information on key data gaps / uncertainties (metric: as Yr1)
- # model analyses performed (namely: (a) formal rigorous decision and trade-off analysis, (b) decision analysis of alternative experimental reservoir operations and gravel injection actions)
- Degree of acceptance from interdisciplinary specialists / agencies at model review meeting (metric: end of workshop questionnaire)
- Documentation: Most Promising Flow Options Report (MPFO)</td><td>- # data sets acquired and field studies reviewed
- At least 3 2-day multi-agency workshops to review the evidence in support of the “most promising flows”, build consensus
- Ongoing consultations over the degree of acceptance from interdisciplinary specialists / agency staff of the MPFO report (metric: # face-to-face meetings with project implementers, agency staff; # project implementers /agency staff contacted by phone)
- Documentation: Results of Consultations on the Structured Implementation of MPFO flows -- the level of consensus for the MPFO flows, barriers and bridges to their immediate implementation (metric: thorough anonymous questionnaire)
- Study plan design: A structured plan for a field monitoring program under MPFO flows</td></tr>
</table>

<table>
<tr><th rowspan="2">PM Category</th><th colspan="4">Project Objective</th></tr>
<tr><th>1. Complete the evaluation of the existing prototype decision analysis model and improve it
(Year 1)</th><th>2. Use the model to assess flows from alternative Whiskeytown operations and how these operations improve ecological values. Quantify impacts to non-ecological values.
(Year 1)</th><th>3. Determine what types of experimental operation policies and field monitoring programs yield most information to reduce uncertainties. Quantify benefits of managing using this information
(Year 2)</th><th>4. Facilitate process for implementing "Most Promising Flows" and development of formal study plan for targeted field studies and implementation
(Year 3)</th></tr>
<tr><td>Outputs: direct products and services delivered</td><td colspan="2">- Revised, user accepted, fully working decision analysis model ready for full-scale application
- Tech memo summarizing review of relevant fieldwork in progress and funded
- Complete comprehensive sensitivity analysis to identify crucial uncertainties / important assumptions / data gaps
- Preliminary analysis to filter out unsuitable actions, assess model behavior
- 1-2 Tech. Memos documenting ongoing model refinements, results of analyses
- 1 to 2 facilitated meetings and related presentations to build understanding, share information, and communicate progress and conduct group design of candidate flow management experiments for year 2 analyses
- Targeted field research to provide useful new information on key model uncertainties, data gaps
- First Annual Report (see Table C.4 yr 1 for details)
- CALFED conference paper, newsletter article
- Completed Access database for CCDAM model; portions of which can be made available over the Internet (via XML formatted data tables, query results) if interest</td><td>- Revised, user accepted, fully working decision analysis & adaptive management model ready for full-scale application
- Tech memo summarizing review of relevant fieldwork in progress and funded
- Rigorous comprehensive evaluation of alternative experimental Reservoir operations, multi-objective trade-off analysis
- 1-2 Tech. Memos documenting ongoing model refinements, results of analyses
- 3-day workshop and related presentations to communicate progress and select best water year dependent operations and AM experiments
- Targeted field research to provide useful new information on key model uncertainties, data gaps
- Most Promising Flow Options Report (see Table C.4 Yr 2 for details)
- CALFED conference paper, newsletter article</td><td>- Tech memo summarizing review of relevant fieldwork in progress and funded
- Design of a multi-agency consensus based process for the structured implementation of MPFO flows
- Late breaking analyses for any as yet unperformed analyses
- Neutral technical facilitation of consensus-based multi-stakeholder process
- Formal presentations
- Report on Structured Implementation of MPFO flows (see Table C.4 Yr 3 for details)
- CALFED conference paper, newsletter article</td></tr>
<tr><td>Outcomes: intermediate and longer-term results for which program is designed</td><td colspan="4">- Provide CALFED with a quantitatively rigorous design of a management experiment for a problem of immediate concern, to serve as a model for the application of adaptive management to other areas
- Provide an example for how CALFED applies decision analysis and adaptive management to other program areas
- Comprehensive integration of linkages and uncertain hypotheses between hydrologic, geomorphic, biological, and economic components of restoration actions being performed in Clear Creek. CCDAM provides "major integrating" force for ongoing Clear Creek restoration efforts, focusing on multiple objectives, multiple trade-offs
- Generation of evidence in support of the "Most Promising" flows via a rigorous analysis of trade-offs and quantification of the expected value of information from alternative Reservoir operation polices and monitoring programs
- Blue print for how to move from "contemporary" flows to water year dependent flow regime more conducive to the maintenance of ecological values. Facilitated outreach process for multi-agency, multi-stakeholder consultations to build shared understanding of trade-offs and identify bridges and barriers to implementation of the Most Promising flows
- Provision of a user friendly model (CCDAM) for ongoing multi-objective analyses as new information is available from field monitoring programs
- Catalyst for sharing information</td></tr>
</table>

<table>
<tr><th rowspan="2">PM Category</th><th colspan="4">Project Objective</th></tr>
<tr><th>1. Complete the evaluation of the existing prototype decision analysis model and improve it
(Year 1)</th><th>2. Use the model to assess flows from alternative Whiskeytown operations and how these operations improve ecological values. Quantify impacts to non-ecological values.
(Year 1)</th><th>3. Determine what types of experimental operation policies and field monitoring programs yield most information to reduce uncertainties. Quantify benefits of managing using this information
(Year 2)</th><th>4. Facilitate process for implementing “Most Promising Flows” and development of formal study plan for targeted field studies and implementation
(Year 3)</th></tr>
<tr><td>Environmental indicators: measures of environmental change</td><td colspan="4">Examples of indicators produced by the CCDAM model:
- Hydrology: expected frequency, duration, and magnitude of flows realized from alternative Whiskeytown Reservoir operation policies, flood risks (long run perspective), estimates of Weighted Usable Area (WUA), shape of hydrograph, reservoir elevation, net flow to Sacramento River
- Recreation: reservoir elevation changes during “high demand” season
- Sediment Transport / Geomorphic: transport amounts from tributaries and reach to reach, grain size distribution including % fine material in different reaches (gravel quality, permeability), scour depth, adjustments to Weighted Usable Area (WUA) estimates according to gravel quality (grain size distrib. related)
- Fish: egg to fry, fry to smolt, egg to smolt, juvenile densities, smolt output, fish distribution (chinook and steelhead)
- Riparian Vegetation: index of floodplain fine/silt deposition, establishment success, distribution, age
- Barriers: flow related passage barriers (physical and temperature related)
- Water Quality: stream temperatures, flow
- Economic: foregone power revenues, capital costs for structural modifications to WT reservoir, capital cost for gravel injection programs, setup and ongoing operation costs for field monitoring studies to reduce uncertainties
- Learning: updated probabilities on alternative uncertain hypotheses, indices of statistical power (e.g., probability of moving “in the right direction”) for different reservoir operation policies, gravel injection actions and associated monitoring of varying sampling intensity and precision</td></tr>
</table>

Table C.4: Detailed list of project deliverables.

Year 1 Deliverables

1. Revised, user accepted and fully working **decision analysis model** ready for full-scale application to alternative Whiskeytown reservoir operation and gravel injection scenarios and uncertain hypotheses.
2. Through 1 or 2 facilitated meeting presentations, a concerted effort to communicate knowledge gained to local agencies and stakeholders, build consensus.
3. Summary report from targeted field research to provide information on key model uncertainties, data gaps (more credible model analyses).
4. **First annual report** documenting:
   - Methods and assumptions, sources of information;
   - Results: (a) the frequency, duration, and magnitude of flows realized from alternative Whiskeytown Reservoir operation policies and how these operations affect power costs, biological responses, and physical conditions over the short and long run, (b) the types of reservoir operation and gravel injection policies that "do and don't make sense", (c) as "a" and "b" but for scenarios based on the controls available through structural modifications (i.e., BoR 1999, Value Planning Study);
   - Interpretation and discussion of the evidence produced (e.g., types of restoration actions that are robust in satisfying multiple objectives, weight of evidence for alternative hypotheses); and
   - Blue print for next steps – describe the full decision analysis to be performed, as well as considerations for type of adaptive management experiments that are worthwhile.
5. Conference paper (IEP/Bay-Delta Modeling Forum or AM Forum or other appropriate conference).
6. Article for CALFED Newsletter.

Year 2 Deliverables

7. CCDAM model equipped with full-scale decision analysis and **simulated adaptive management analysis capabilities**.
8. Through meeting presentations and 3-day workshop, a concerted effort to communicate knowledge gained to local agencies and stakeholders, incorporate their knowledge and build consensus.
9. Targeted field research to provide information on key model uncertainties, data gaps (more credible model analyses).
10. 2nd Annual Report – **Most Promising Flow Options.** A report documenting:
    - Methods and assumptions, sources of information;
    - Results of numerous adaptive management experiments (learning value, multi-objective trade-offs, net benefits of managing on basis of information gained);
    - Interpretation of the evidence produced–*what are* the most promising flow options?; and
    - Blue print for next steps – outline a neutrally facilitated, multi-stakeholder consensus based process for moving towards implementation of the most promising flow options.
11. Conference paper (IEP/Bay-Delta Modeling Forum or AM Forum or other appropriate conference).
12. Article for CALFED Newsletter.
13. CCDAM training session and users guide – help interested user groups self-sufficient in the use of the model.

Year 3 Deliverables

14. Through multi-stakeholder consultative meetings, a concerted effort to communicate knowledge and build consensus.
15. 3rd Annual Report – **Structured Implementation of the MPFO flows: Barriers and Bridges.** This report would provide:
    - A short review of the evidence in support of the MPFO flows (Year 2 report will house the detailed review), and any "late breaking" developments/information that would tend to refute or support the Year 2 recommendations;
    - Documentation for the level of consensus for the MPFO flows, as well as potential barriers and bridges to their implementation; and
    - A structured plan for their implementation and field monitoring under the MPFO flow regimes.
16. Conference paper (IEP/Bay-Delta Modeling Forum or AM Forum or other appropriate conference).
17. Article for CALFED Newsletter.

Table C.5: ERP / Science Program priorities targeted by this proposal. Abbreviations in referencing reports: SP = Science Program; SG = Strategic Goal; SR = Sacramento Regional Goal. Reference document: ERP Draft Stage 1 Implementation Plan, or 2002 PSP if (PSP precedes page number).

Priority	Description
Relevant Science Program Priorities	
SP, pg. 14	"***Compare relative effectiveness of different restoration strategies.***"
SP, pg. 14	"***Conduct adaptive management experiments.*** Specific adaptive management experiments can lead to improved restoration approaches, better understanding of restoration impediments or better management…"
SP, pg. 14	"***Understand intertwined implications of all CALFED Program actions***. In a program with multiple goals some conflicts and re-directed effects among goals are inevitable. Identifying and improving understanding and resolution of re-directed effects, interconnections and/or conflicts among restoration and other goals is critical."
SP, pg. 15	"***Coordinate and extend existing monitoring.*** A strength of the CALFED Program is the monitoring systems already in place… Subsequent investments are needed to tie together the existing monitoring. New monitoring efforts are needed in some types of environments."
SP, pg. 15	"***Advance the scientific basis of regulatory activities***. Managing water and protecting at-risk species uses science to establish regulations. … the present state of knowledge is imperfect and uncertainties exist…. Addressing the uncertainties in the science used for management is an important goal of the CALFED Science Program."
SP, pg. 15	"***Take advantage of existing data***…The existing monitoring programs and science efforts have generated decades of useful data. Full advantage has not yet been taken of all this data."
SG-1, pg. 9, 23	"***At-Risk Species.*** Achieve recovery of at-risk species…first step toward establishing large, self-sustaining populations…minimize the need for future endangered species listing by reversing downward populations trends…all runs of chinook salmon, steelhead trout…" • At risk species assessments
SG-2, p.10, 25, 29	"***Ecosystem Processes and Biotic Communities.*** Rehabilitate natural processes…to support, with minimal ongoing human intervention, natural aquatic and associated terrestrial biotic communities and habitats, in ways that favor native members of those communities." • Natural flow regimes • Channel Dynamics and Sediment Transport
SG-4, p.10, 30, 34	"***Habitats***. Protect and/or restore functional habitat types…for ecological and public values such as supporting species and biotic communities, ecological processes, recreation…" • Riparian habitat • Fish passage
SG-6, p.12, 36	"***Sediment and Water Quality.*** Improve and/or maintain water and sediment quality conditions that support healthy and diverse ecosystems…" • Fine sediment • Dissolved Oxygen • Temperature
Relevant Sacramento Valley Priorities	
SR-3, PSP p.27	"***Conduct adaptive management experiments in regard to natural and modified flow regimes to promote ecosystem functions…restoration***" • **Mechanistic models as restoration tools** (*In Clear Creek, CCDAM is the pre-eminent model integrating multiple linkages between flows, sediment transport, and fish population responses over the long run while accounting for uncertain hypotheses. The model also provides information on the expected learning value of alternative flow regimes and monitoring designs)
SR-1, PSP p.25	"***Develop and implement habitat management and restoration actions in collaboration with local groups***…" • Previous phases and the proposed next steps in this proposal look to continue to foster these collaborations and earn greater local support
SR-2, PSP p. 26	"***Restore fish habitat and fish passage particularly for spring-run chinook salmon and steelhead trout***…" Among many other variables, CCDAM explicitly accounts for: • Spawning gravel • Fine sediment loads • Fish passage (temperature/flow related distribution effects)
SR-4, PSP p. 27	"***Restore geomorphic processes in stream and riparian corridors***" Among many other variables, CCDAM explicitly accounts for: • Flood flows and rates of recession
SR-7, PSP pg. 29	"***Compare conceptual models and develop restoration performance measures for tributary streams and rivers.***"

Attachment D: Local Agency and Stakeholder Participation

This project has the support of a wide body of local agencies and stakeholders, namely representatives of the Clear Creek Restoration Team who has agency representation from:

- the US Bureau of Reclamation (USBR);
- Bureau of Land Management (BLM);
- US Fish and Wildlife Service (USFWS);
- National Marine Fisheries Service (NMFS);
- Natural Resources Conservation Service (NRCS);
- California Department of Fish and Game (CDFG);
- California Department of Water Resources (CDWR); and
- the Western Shasta Resource Conservation District (WSRCD).

Lists of participants at key workshops are provided on subsequent pages of this attachment.

Table D.1: Scoping meeting participants: November 1st and 2nd 1999, Sacramento California.

Participant	Agency
Michael Fainter	CALFED
Pete Rhoads	Metropolitan Water
Larry Smith	USGS
Scott McBain$^{\delta}$	Geomorphologist consultant
John Williams	Consultant
Frank Ligon	Stillwater Sciences
Peter Baker	Stillwater Sciences
Dick Daniels$^{\delta}$	CALFED
Larry Brown	
David Marmorek*	ESSA Technologies
Clint Alexander*	ESSA Technologies
Calvin Peters*	ESSA Technologies

$^{\delta}$ Participated on the first day (November 1st) only.

* Meeting facilitators – did not vote.

Reference document: http://www.essa.com/clearcreekdesign.pdf

Table D.2: Workshop participants: 3 day model design workshop facilitated by ESSA Technologies Ltd., held January 24th – 26th 2000, Redding California.

Name	Affiliation	Phone and Fax	E-mail
David Marmorek	ESSA Technologies	ph. (604) 733-2996 fax (604) 733-4657	dmarmorek@essa.com
Michael Fainter	CALFED	ph. (916) 653-0198 fax (916) 653-5699	mfainter@water.ca.gov
Tom Griggs	CSU Chico	ph. (530) 898-5294 fax	tgriggs@jps.net
John Williams	Consultant	ph. (530) 753-7081 fax (530) 756-3784	jgwill@den.davis.ca.us
John K. Johnson	NOAA	ph. (707) 575-6081 fax	John.K.Johnson@noaa.gov
Francis Berg	BLM	ph. (530) 224-2120 fax (530) 224-2172	fberg@ca.blm.gov
Dick Daniel	CALFED	ph. (916) 657-2666 fax	ddaniel@water.ca.gov
Gerry Hubatka	NRCS	ph. (530) 246-5252 fax (530) 246-5164	gerry.hubatka@ca.usda.nrcs
Jim DeStaso	BOR	ph. (530) 275-1554 fax (530) 275-2441	jdestaso@mp.usbr.gov
Peter Baker	Stillwater Sciences	ph. (510) 848-8098 fax (510) 848-8398	pfb@stillwatersci.com
Andrew Hamilton	USFWS	ph. (916) 414-6540 fax (916) 414-6713	andrew_hamilton@fws.gov
Terry J. Mills	Calfed	ph. (916) 653-3244 fax	tmills@water.ca.gov
John Johannis	WAPA	ph. (916) 353-4076 fax (916) 985-1931	johannis@wapa.gov
Scott McBain	McBain & Trush	ph. (707) 826-7794 fax (707) 826-7795	mcbtrsh@northcoast.com
Mark Hampton	Northstate Resources	ph. (530) 222-5347 fax (530) 222-4950	hampton@nsrnet.com
Brian Rasmussen	NPS Whiskeytown	ph. (530) 242-3444 fax	brian_rasmussen@nps.gov
Morgan Hannaford	Shasta College	ph. (530) 224-4637 fax	mhannaford@shastacollege.edu
Calvin Peters	ESSA Technologies	ph. (604) 733-2996 fax (604) 733-4657	cpeters@essa.com
Clint Alexander	ESSA Technologies	ph. (604) 733-2996 fax (604) 733-4657	calexander@essa.com
Wes Crum	Alpine LIS	ph. (530) 244-8600 fax	alpine@awwwsome.com
Matt Kondolf	UC Berkeley	ph. (510) 644-8381 fax	kondolf@uclink.berkeley.edu
Harry Rectenwald	Department of Fish and Game	ph. (510) 225-2368 fax	hrectenw@dfg.ca.gov

Name	Affiliation	Phone and Fax	E-mail
Julie Clausen	Sen. Johannessen	ph. (530) 244-4706 fax	julie.rodgers@sen.ca.gov
Dave Robinson	BOR	ph. (916) 978-5050 fax (916) 978-5055	drobinson@mp.usbr.gov
Carl Weidert	Sacramento PAC and Shasta	ph. (530) 474-4300 fax (530) 474-1528	

Reference document: http://www.essa.com/clearcreekdesign.pdf

Table D.3: Meeting participants of the inaugural Clear Creek Decision Analysis and Adaptive Management model (CCDAM) review workshop, held July 12th and 13th 2001, Redding California.

Name	Organization	Phone	Fax	E-mail
Calvin Peters	ESSA	(250) 542-2973	(604) 733-4657	cpeters@essa.com
David Marmorek	ESSA	(604) 733-2996	(604) 733-4657	dmarmorek@essa.com
Matt Brown	USFWS	(530) 527-3043	(530) 529-0292	Matt_Brown@fws.gov
Wes Silverthorne	NMFS	(707) 575-6087	(707) 578-3545	
David Tomberlin	NMFS	(831) 420-3910		David.Tomberlin@noaa.gov
Paul Bratovich	SWRI	(916) 325-4044	(916) 446-0143	Bratovich@swri.net
Jeff Phipps	WAPA / NCPA	(916) 933-6425	(916) 933-7636	Jphipps@softcom.net
John Williams	BDMF	(530) 753-7081		Jgwill@dcn.davis.ca.us
Mike Roberts	The Nature Conservancy	(530) 897-6378		Mike_Roberts@TNC.org
Mike Berry	DFG	(530) 225-2131		Mberry@dfg.ca.gov
Howard Brown	NMFS	(916) 930-3068		Howard.Brown@noaa.gov
Tricia Bratcher	CDFG	(530) 225-3845		Pbratcher@dfg.ca.gov
Gerry Hubatka	NRCS	(530) 246-5252	(530) 246-5164	GerryHubatka@ca.usda.gov
Jeff Souza	WSRCD	(530) 224-3250		Jsouza@westernshastarcd.org
Andrew Hamilton	USFWS	(916) 414-6540		Andrew_hamilton@fws.gov
John Icanberry	USFWS-AFRP	(209) 946-6400 (X306)		John_Icanberry@fws.gov
Russell Smith	USBR	(530) 275-1554	(530) 275-2441	Rpsmith@mp.usbr.gov

Appendix E. Description of field methodology for Tasks 22a and 22b

The following description of the field methods to measure sediment infiltration of spawning gravels (Task 22a) and emergence (Task 22b) are preliminary study designs that will be refined and submitted for peer review.

Task 22a. Measure the infiltration of fine sediments in spawning gravel

The purpose of this task is to correlate suspended sediment concentrations and sand transported as bedload during winter storm events with fine sediment infiltration into gravel patches. This relationship is one of the key uncertainties in the CCDAM. Because the relationship between suspended sediment concentration and sediment infiltration likely varies between locations with different hydraulic characteristics, we propose to examine infiltration at 20 gravel patches to account for this variation. Additionally, because flow in Clear Creek can originate from either tributaries (which tend to have high suspended sediment concentrations) or from reservoir releases (which tend to have low suspended sediment concentrations), we can also correlate sediment infiltration into the bed with the type of high flow event. Finally, we will investigate the role of the timing of high flow events on sediment accumulation. Fine sediment deposition from initial storms can effectively fill the interstices of the surface layer and block subsequent fine sediment from infiltrating into the bed (Lisle 1989). The relationship between sediment infiltration and the timing of storm events is therefore important.

The first step in this study is to identify and clean 20 gravel patches at Reading Bar (located just downstream of Clear Creek Road Bridge). Because Reading Bar is upstream of the Saeltzer Dam site, it should reflect fine sediment dynamics in Clear Creek as a whole, rather than lingering effects of the dam removal. Each gravel patch should be approximately 50ft^2. Cleaning the gravel patches involves removing the sediment to a depth of 18-24 inches (the lower limit of egg deposits in salmonid redds), and sieving the sample to remove the fine sediment, and returning the cleaned sediment to the bed. The surface layer should be kept separate from the subsurface, because the surface layer is typically coarser than the subsurface. The McNeil sampler will have to be placed in several locations to clean an entire patch.

Once each patch is cleaned, we will characterize it based upon the grain size distribution, stream gradient, and flow depth/bed topography to account for any differences between patches. We will also note the location and extent of each patch on a map and aerial photographs.

Twelve infiltration bags will be deployed at each gravel patch. The infiltration bag methodology is reported in Lisle and Eads (1991). An infiltration bag is placed in the bed to a specified depth below the surface layer. The bag is collapsed below the surface and attached to cables that extend into the water column. When the bag is removed it contains both the surface and subsurface layers. Following high flows the bags are retrieved and the contents are sieved to extract fine sediment from the gravel.

Suspended sediment will be measured during four winter storm events at Reading bar using a DH-48 sampler to record depth integrated samples at 15-20 verticals across the channel. Bedload transport will also be measured with a Helly-Smith sampler to account for any sand transported as bedload. Water surface elevation will also be measured during the suspended sediment sampling and related to discharge using a rating curve. Following the first measured storm, we will sample three randomly selected infiltration bags at each gravel patch. The bags will be removed and the gravel will be sieved to collect accumulated fine sediment. The fine sediment from each bag will be dried, sieved, and weighed in a laboratory to correlate sediment infiltration with both suspended sediment concentration and discharge. After the fine sediment is removed, the infiltration bags and cleaned gravels will be replaced in the bed.

Following three additional high flow events, six bags will be removed from each patch. Three of the six bags will be sampled and removed and three will be cleaned and replaced. Bags not sampled during earlier storms will contain sediment deposited during earlier storms. By comparing the accumulation in clean bags with the accumulation in bags that had not been cleaned yet, we can compare fine sediment accumulation in one storm with fine sediment accumulation over several storms to investigate the effects of cumulative and single events. Because field sampling conditions can be very difficult, the number of infiltration bags and the number of sampled storm events may vary.

The data will be summarized in a report that stresses linkages between discharge, suspended sediment concentration, and infiltration rates. We will also investigate the origin of the flood (tributary versus reservoir release), and differences between cumulative and single storm accumulations. The data will also refine relationships among key environmental variables such as fine sediment transport, fine sediment deposition, and egg survival in CCDAM.

Task 22b. Quantify relationships between particle size distribution, intra-gravel permeability, dissolved oxygen, temperature, egg survival, and fry emergence

In this task we will examine the relationships between the particle size distribution, intra-gravel permeability, dissolved oxygen, water temperature, egg survival, and fry emergence for natural and constructed redds. The CCDAM prototype identified egg-fry survival as a key indicator of salmonid success in Clear Creek. An important factor on intra-gravel permeability and dissolved oxygen delivery to incubating eggs is the portion of fine sediment in the redd. This task will, therefore, link information obtained in Task 22a with egg survival and fry emergence.

Because this task relies on sampling during both egg incubation and fry emergence, predicting the duration of spawning and the timing of emergence is important. Field reconnaissance will be used to note the onset of fall-run chinook salmon spawning, which will determine when monitoring begins. Temperature modeling will also be used to predict the onset of emergence.

In consultation and coordination with USFWS and NMFS, we will select 10 natural fall-run chinook salmon redds at Corkscrew, Renshaw and Reading Bar riffles[10]. Following site selection we will install standpipes and emergence traps on the selected redds XX days after the observed onset of spawning. The standpipes will be used to assess permeability and dissolved oxygen for the duration of incubation following methods outlined by Terhune (1958).

At the same time, we will construct 10 artificial redds at Corkscrew, Renshaw, and Reading Bar riffles. These redds will be constructed from gravel with a known particle size distribution and depth. The gravel used in these artificial redds will be sieved to remove fine sediment, to maximize permeability and potential dissolved oxygen delivery. We will plant known numbers of fall-run chinook salmon eggs, ideally from Clear Creek brood stock. Similar to the natural redds, standpipes and emergence traps will be installed over the constructed redds. Additionally, we will place infiltration bags (see Task 22a) in the redds.

Throughout incubation and emergence, we will monitor stream temperature, dissolved oxygen, and permeability in the natural and constructed redds. The expected duration of monitoring is 135 days (to cover spawning, incubation, and emergence). Once emergence begins, we will also count, weigh, and measure fry 3 times per week at each redd.

Following emergence we will collect and analyze three bulk sediment samples at each of the natural redds to link emergence to sediment characteristics (i.e. fine sediment loading). We will also remove and analyze the infiltration bags from the constructed redds to assess fine sediment infiltration during spawning, incubation, and emergence.

[10] Corkscrew and Renshaw riffles currently support the majority of spawning in Clear Creek. The improved access following the removal of Saeltzer Dam could also make Reading Bar an important spawning location.

The data collected for Task 22b will be analyzed and incorporated into a report to CALFED. The data will also be used to adjust CCDAM parameterization to more accurately reflect uncertainty regarding bed characteristics and fall-run chinook salmon emergence.

References

Lisle, T.E. 1989. Sediment transport and resulting deposition in spawning gravels, North Coastal California. Water Resources Research. 25. 1303-1319.

Lisle, T.E. and R.E. Eads. 1991. Methods to measure sedimentation of spawning gravels. Res. Note PSW-411. Berkeley, CA: Pacific Southwest Research Station, Forest Service, U.S. Department of Agriculture. 7 pp.

Terhune, L.D.B. 1958. The Mark VI groundwater standpipe for measuring seepage through salmon spawning gravel. Canada Fisheries Research Board Journal. 15. 1027-1063.

Attachment F: Change Management and Budget Control

Project Management

The ESSA project manager and the CALFED project manager will be jointly responsible for controlling the scope of the project. Whether fixed-price or time and materials contracting, Change Management is a necessary and expected procedure. Following any request or evolved need[11] for extension in scope of an existing task, or addition of new unplanned tasks, the ESSA project manager will prepare a Change Request outlining the scope of the change and the impacts on the project budget, schedule, and other modules or core activities. This Change Request must be approved in writing by CALFED before any new work proceeds (see template on p. F-2).

The ESSA project manager will provide an on-going risk assessment for the project, such that the client understands the severity and status of any risks that might impact the schedule, budget, quality, and scope of the project. Risk is anything that could impede completing the project as specified in the time and budget allowed. One can generally identify the relative risk factors for every task of every project. We suggest avoiding management of small risks and focusing only on the significant and manageable risks. These risks would be summarized in quarterly Project Status reports or as needed. Those that have increased their risk will be identified as issues requiring mitigation.

Change Management and Budget Control

As CALFED is aware, providing a fixed-price on any modeling project of this scope and complexity involves not only estimating the activities, but assessing and managing our risks during project implementation. Although the spirit of the working relationship must be trust and fairness to eventually achieve a successful project, it is important to specify guidelines prior to commencing the assignment. In brief we suggest that:

> CALFED should be responsible for the cost of changes if the item was not explicitly included in a previously accepted work schedule, design document, formal memoranda, or Change Request. Our cost for researching these changes to a sufficient level to produce estimates will be built into a Change Request amount.
>
> ESSA will be responsible for the cost of items that were included in previously accepted work schedule, design document, formal memoranda or Change Request (that have not been moved out of scope by a prior approved Change Request).

In most fixed-price contracts ESSA is responsible for internally monitoring our time and costs and the client monitors the schedule and status of deliverables. Past experience has shown that a Project Status report and Change Request issuing procedure is a very prudent and helpful addition to this relationship. Of course, we recognize the limits of this procedure. Should the value of Change Requests exceed CALFED's available budget, ESSA and CALFED would jointly decide which previously included items will be reduced in scope or deferred to a subsequent project.

This change structure provides a logical mechanism to address project management uncertainties. For *example*, in reaching decisions about funding for optional elements, this approach allows for the CALFED project manager to fund these items in their entirety, and apply scope reduction orders to decrease the contract value. This way, funding support is in place if needed so that the project schedule can proceed smoothly, with a reduced chance of bottlenecks. If the funding is not needed, CALFED maintains the discretion to revoke the funds.

[11] e.g., an additional meeting with local experts needed to clear a critical project bottleneck.

ESSA
Change Request Form

Project: Contract no.	**Change Request Number:** **Request Date:**
ESSA Contact:	**Client Contact:**
Change Description:	
Change Impact: Estimated Impact on Project Costs: in dollars: **$** in person-days: Estimated Impact on Project Schedule: in days:	
Change of Status Request (check one): ☐ **Approved** ☐ **Rejected**	

Signatures:

Client Project Manager	Date	Producer	Date
Client Contracting Officer	Date		

Attachment G: Next-phase funding - summary of existing project status

Status Summary of Clear Creek Flow Related Decision Model

Project Description

The CALFED Ecosystem Restoration Program (ERP) has adopted an ecosystem-based management approach – with its attendant emphasis upon adaptive management – for restoring the Bay-Delta ecosystem. The Strategic Plan for Ecosystem Restoration describes the general adaptive management framework that CALFED will apply. Recent advances in the quantitative design and simulation of management experiments and application of decision analysis to resource management questions provide CALFED with an opportunity to refine its adaptive management approach and gain experience in these new techniques.

As a first step in exploring the benefits of decision analysis and adaptive management, CALFED contracted ESSA Technologies to conduct a project with the following objectives:

1. Provide CALFED with a quantitatively rigorous design of a management experiment for a problem of immediate concern, to serve as a useful example of the application of decision analysis, modeling and adaptive management;
2. involve regional and independent, external scientists in the development and assessment of alternative designs;
3. evaluate this example application and consider both how to improve it, and other issues appropriate for this approach; and
4. provide an example for how CALFED applies decision analysis to the design of adaptive management experiments.

Phase 1 of the project (initial scoping and conceptual model design) was completed in May 2000. Phase 2 (model development) was initiated in September of 2000.

Status

We held an initial **multi-agency scoping meeting** November 1st and 2nd 1999 in Sacramento where we selected Clear Creek as an example watershed for application of our decision analysis/adaptive management approach. Following this meeting, we held a **multi-agency workshop** to design a decision analysis framework for Clear Creek (January 24th-26th 2000, Redding California). The meeting was attended by key scientists and administrators from federal, state, and local water, power, and fisheries management agencies and advisory groups (Attachment A). The purpose of the meeting was to: 1) define the management decisions to be made, the practical constraints on these decisions, and their temporal and spatial boundaries; and 2) identify and quantitatively define the linkages between flows out of Whiskeytown Dam and resulting temperatures, physical habitat attributes downstream of the dam, and biological processes affecting spawning and survival of steelhead and chinook populations. Wherever these linkages were uncertain, we developed multiple alternative hypotheses based on interpretation of data (where available), or professional judgement (where data were unavailable).

Based on the results of the initial scoping and design meetings, we prepared a **draft design document** that laid out a preliminary structure for the modeling / decision analysis framework. In the document, we specified the spatial and temporal scale of the framework, the primary linkages between flows, habitat, and fish populations, and our data requirements for developing the framework. The document was reviewed at a subsequent meeting with key workshop participants from the design workshop, and subsequently revised. This document formed the basis for building a prototype modeling tool (Alexander et al. 2000a), (http://www.essa.com/clearcreekdesign.pdf).

After receipt of our contract September 8 2001, we initiated full-scale **architectural design and development** of the Clear Creek Decision Analysis and Adaptive Management model (CCDAM). This step involved considerable unplanned written and verbal requests for information, additional meetings with subject matter experts to revise the original design (particularly the sediment transport component).

The next step of the research program is to **improve and apply** the computer tool to evaluate potential adaptive management experiments, and generate evidence in support of the **most promising flow options** for restoration. This is the subject of this proposal.

Accomplishments

A working prototype model has been completed, and was demonstrated in Redding on July 12th -13th 2001. The model has already proven to be very useful in filtering out flow management alternatives that don't make ecological or economic sense. For example, maintaining Whiskeytown Reservoir at 1210' throughout the winter to generate flushing flows can lead to excessively high flows, scour and poor egg to fry survival, especially during a wet year such as 1995. Participants at the Redding meeting (see Attachment A, Table A.3) were enthusiastic about the potential value of the tool, both for Clear Creek and other rivers.

We are looking forward to future phases of this project that will continue collaborations with many interested agencies and stakeholders. Our focus will be on application of the model to evaluating alternative Whiskeytown reservoir operation policies over multiple objectives (hydrologic, geomorphic, fish, riparian, recreation, and economic).

Data Collection

In 2000 and part of 2001, we compiled and analyzed critical biological and physical data (e.g., temperature vs. flow data, preliminary sediment transport data), reviewed the primary literature relating to sediment transport within stream channels.

This data is summarized in various spreadsheets and in the CCDAM Microsoft Access database.

Fiscal Status

Table G.1: Fiscal status of – Adding Rigor to the CALFED Concept of Adaptive management: Development of a Decision Analysis and Adaptive Management Model for Restoration Programs (completed). Contract no. 6-CA-20-0341A. (Funded through CH2MHILL via delivery order no. 1425-98-PD-20-3041 A/043, Ecosystem Strategic Plan, Task 14c).

Planned Project Cost	Actual Project Cost
$56,715	$60,724[12]

Table G.2: Fiscal status of – Clear Creek Flow Related Decision Analysis Model Development project (completed). Contract no. 00CS202122.

Planned Project Cost	Actual Project Cost
$155,846	$187,245[13]

[12] Cost overrun absorbed by ESSA Technologies Ltd.

[13] Cost overrun absorbed by ESSA Technologies Ltd.