PART A. Cover Sheet

ERP DIRECTED ACTIONS

Complementing Water Planning Efforts for the Delta and Sacramento River: Application of the Ecological Flows Tool

For

The San Joaquin-Sacramento Bay Delta and Sacramento River

Reference
Ecosystem Restoration Program
Prop 50 Bond Funded
Project No. DFG-04####

Prepared by:
The Nature Conservancy
500 Main Street
Chico, CA 95928
(530) 897-6370, ext 213

A1. Proposal Title:
Complementing Water Planning Efforts for the Delta and Sacramento River: Application of the Ecological Flows Tool

A2. Lead Applicant or Organization:
Contact Name: Wendy Millet
Agency/Organization Affiliation: The Nature Conservancy
Address: 201 Mission St., 4th Floor, San Francisco, CA 94105
Phone Number: (415) 777−0487
Fax Number: (415) 777-0772
E-mail: wmillet@tnc.org

A3. Project Manager or Principal Investigator
Contact Name: Ryan Luster
Agency/Organization Affiliation: The Nature Conservancy
Address: 500 Main St., Chico, CA 95928
Phone Number: (530) 897-6370, ext. 213
Fax Number: (530) 342-0257
E-mail: rluster@tnc.org

A4. Cost of Project: $1,715,533
See Exhibit A for budget details.

A5. Cost Share Partners:*
None. However, we will be capitalizing on previous investments made by the CALFED ERP grant ERP-02D-P61 to The Nature Conservancy (TNC) between 2004 and 2008. Combining the ERP-02D-P61 grant with private investments made by TNC and ESSA Technologies, the total budget for developing the Sacramento River Ecological Flows Tool (SacEFT), which provides the foundation for the work outlined in this proposal, was $495,000.

A6. List of Subcontractors:*
ESSA Technologies, LTD.
1765 West 8th Avenue, Suite 300
Vancouver, B.C., V6J 5C6
Canada
(604) 733-2996

A7. Other Cooperators:*
Subcontractors to ESSA Technologies will include:

Dr. Yantao Cui
Stillwater Sciences
2855 Telegraph Ave, Suite 400
Berkeley, CA 94705
(510) 848-8098

Dr. Eric Larsen
Geology Department
University of California
Davis, CA 95616
(530) 752-8336

A8. Project Topic Area*
Primary: Environmental Water Management
Secondary: At-Risk Species Assessment

A9. Project Type*
Primary: Research
Secondary: Planning

PART B. Executive Summary

B1. Proposal Title:
Complementing Water Planning Efforts for the Delta and Sacramento River: Application of the Ecological Flows Tool.

B2. Project Description:
This proposal seeks to leverage a recently completed effort, The Sacramento River Ecological Flows Study ("the Study", grant #ERP−02D−P61 to TNC), by expanding the capability of the developed Sacramento River Ecological Flows Tool for application to the Delta. Between 2004 and 2008 TNC conducted the Study in which TNC and its project partners developed a decision analysis tool that incorporates physical models of the Sacramento River with biophysical habitat models for six Sacramento River species. The resultant tool, the Sacramento River Ecological Flows Tool (SacEFT), is a database-centered software system that links flow management actions to focal species outcomes on the mainstem Sacramento River. The SacEFT allows 1) the evaluation of ecosystem responses to alternative scenarios of discharge, water temperature, gravel augmentation, and channel revetment actions, and 2) water operations managers to significantly expand their ecological considerations when evaluating water management projects for the Sacramento River. The SacEFT software leverages considerable previous investment by utilizing data sets from commonly used models, such as CALSIM II, that evaluate statewide water management operations.

The Sacramento River Ecological Flows Study team was successful in developing the SacEFT through completion of the project for the Middle Sacramento River. Although the SacEFT is now fully operational, herein we are proposing a two-prong approach to maximize its utility to Sacramento River and Delta water management planning processes.

First, we propose to conduct a set of focused refinements which would further increase SacEFT's utility and credibility for water operations analysis on the Sacramento River. Specifically, the SacEFT "branch" of the existing software would benefit from inclusion of additional functional linkages for the focal species considered (e.g., Chinook salmon) for a more robust analysis of those targets. Additional scientific peer review could also bolster a number of aspects of the SacEFT decision analysis tool.

Second, the software architecture is now ready for inclusion of Delta specific management actions and Delta specific ecological considerations through construction of a new Delta ecological flows tool (DeltaEFT) "branch" of the software. Extending the software in order to incorporate Delta targets and management actions 1) will take advantage of previously awarded CALFED ERP funds, 2) achieve economies of scale by applying the same approach utilized to construct the SacEFT architecture, and 3) unite ecological water operations planning, by allowing for inter- and intra-regional focal species' trade-off evaluations between the Sacramento and Delta systems, and 4) further quantify specific biophysical linkages in the Delta, building on existing information (e.g., Delta Regional Ecosystem Implementation Plan conceptual models).

Much information is now available to inform Delta management efforts. Studies funded by the CALFED ERP programs, beginning in the mid 1990s, have resulted in better understanding of the relationships between inflows, water exports, water quality, and at risk fish populations. Most recently, research efforts have intensified on Delta smelt and other pelagic organisms following dramatic declines first observed in 2001 that continue today. Developments such as the Wanger Decision in September 2007, and the expectation of alternate conveyance strategies for the Delta resulting from the

Delta Vision and Bay Delta Conservation Plan efforts, highlight the need for a robust means to scientifically evaluate the effects of alternative water management actions for the Delta.

The ability to evaluate management actions in the Delta relies on quantifiable relationships between these management actions and responses of ecological targets. At a conceptual level, many of these relationships are preexisting, having been developed and refined through the Delta Regional Ecosystem Restoration Implementation Plan (DRERIP) process. DRERIP functional relationships would be reviewed for potential inclusion into the DeltaEFT, and vetted using the selection criteria developed during construction of SacEFT. The vetting process will place particular emphasis on those relationships most likely to be affected by a suite of management actions. We assume at this time that the most relevant management actions to evaluate will include alterations to Delta conveyance and geometry, alterations to inflow from the Sacramento River, and alterations to inflow from other significant sources such as the San Joaquin River (and resultant effects on transport and salinity). We also assume at this time that the DeltaEFT decision analysis tool would focus on the ability to evaluate affects on Delta Pelagic Organism Decline (POD) species (e.g., Delta smelt, longfin smelt, and salmonids) and their relationships with water quantity (e.g., Sacramento and San Joaquin River inflows), water quality (e.g., temperature, salinity), and other parameters (e.g., entrainment at pumps) that are influenced by Delta water operations. Ultimate selection of ecological targets, functional relationships, and management actions to evaluate within the newly constructed DeltaEFT is expected to be done in conjunction with Delta experts through a workshop approach.

Importantly, completion of the proposed project is expected to provide the ability to explicitly link upstream (Sacramento River) ecological responses evaluated with SacEFT to ecosystem responses in the Delta evaluated with DeltaEFT. The software architecture will be constructed such that managers and decision makers may choose to evaluate ecological responses to management actions in upstream geographies (the Middle Sacramento River), downstream geographies (the Delta), or both (Figure 1). As described above, affects of management actions will be generated through quantified species and ecological target information (Figure 2). This approach seeks to integrate the ability to evaluate ecological affects in both of these highly linked ERP ecoregions. Extending the SacEFT organizing framework to the Delta is expected to facilitate development of complementary management actions that do not jeopardize the considerable conservation progress and investment in either system. In addition, as demonstrated in SacEFT, our approach emphasizes efficient communication of complex information by providing output in various levels of aggregation and detail. Results may be presented in a multi-year "roll-up" analysis (Figure 3) as well as displaying very detailed information on assumptions and functional relationships for technical audiences (Figure 4). This type of rapid communication and synthesis is a major value added benefit of our design, receiving favorable reviews by Sacramento River water managers at both the 2004 CALFED Science Conference and the January 2008 Sacramento River Ecological Flows Study Final Presentation.

Delta and Sacramento River planning processes that are likely to derive significant value from this effort include:

1) Bay Delta Conservation Plan,
2) Delta Regional Ecosystem Restoration Implementation Plan (including ERP Implementing Agencies),
3) Delta Vision Process,
4) Interagency Ecological Program POD Study,
5) Delta Risk Management Strategy,
6) Delta Long-Term Management Strategy,
7) Delta-Suisun Status and Trends Assessment,

8) North-of-Delta Off Stream Storage Investigations (NODOS),
9) Shasta Lake Water Resources Investigations (Shasta enlargement)

The proposed project is a complex and technically challenging undertaking. However, the recent successful construction and application of the SacEFT software provides an excellent roadmap for similar construction of a new DeltaEFT branch into this ecological flows decision analysis tool.

PART C. Work Plan

C1. Project Background and Information:

A similar version of this proposal was submitted by TNC in response to the 2006 Science Program PSP. Responses to reviewer comments are incorporated in this proposal. Readers may go to the following link for the past reviews on TNC's 2006 Science PSP proposal (https://solicitation.calwater.ca.gov/solicitations/2006.01/public_proposal_reviews?proposal_id=0052). Much of that previous proposal was structured to build upon a foundation of knowledge gained from work in progress on SacEFT at that time. Specifically, we sought to structure an effort focused on Delta specific ecological targets by following the approach used and lessons learned in construction of the SacEFT decision analysis tool. Reviewers understandably conveyed difficulty gauging the success of work that was incomplete at the time. To clarify, the Sacramento River Ecological Flows Project and the SacEFT decision analysis tool and management scenario comparisons were both successfully completed and are available for review at http://www.delta.dfg.ca.gov/erp/sacriverecoflows.asp. Refinements to the first version of SacEFT were not yet identified in the 2006 Science PSP proposal and have been newly included in this proposal.

Building on Existing Progress

The following is a brief description of the recently completed SacEFT work which now provides a foundation upon which to both further refine, as well as build a Delta specific effort. The Nature Conservancy received CALFED funding in 2004 (grant #ERP-02D-P61) to expand the ecological considerations and scientific foundation of water management decisions in the Upper and Middle Sacramento River, from Keswick Reservoir to Colusa, in part through construction of the SacEFT decision analysis tool. We undertook the Sacramento River Ecological Flows Study after noting challenges facing the managing agencies within existing water management planning efforts for the Central Valley that if addressed could greatly enhance these efforts.

First, upon reviewing Sacramento River planning efforts we noted that ecological considerations included in water management planning were minimal. Ecological considerations were limited to meeting minimal in-stream flows, meeting basic temperature requirements, or limiting periods of pumping during times when sensitive species are present. Although these considerations are among the highest management priorities, they are often focused on single species management. In SacEFT, we more transparently relate additional attributes of the flow regime to multiple species' life-history needs, thereby contributing to a more effective understanding of water operations on focal species and their habitats. Prior to SacEFT, much of the important information on focal species existed in stacks of separate reports, independent conceptual models, and unconnected modeling tools. SacEFT has synthesized much of this disparate information, linking ecological submodels to existing physical planning models, and providing a major advance in the region's capabilities for assessing ecological trade-offs.

In addition to integrating disparate sources of information, the second challenge we overcame in constructing SacEFT was translating analyses of this information into easily understandable results for managers. Practical synthesis and integration is challenging when considering multiple ecological targets, complex physical models, and multiple audiences (i.e., high level managers as well as technical level staff). In keeping with the design principle of making it easy for non-specialists to understand the model's results, SacEFT creates output that can span the range from high-overview to high-resolution. The output interface makes extensive use of a "traffic light" paradigm that juxtaposes performance measure (PM) results and scenarios to provide an intuitive overview of whether a given year's PMs are healthy (green), of some concern (yellow), or of serious concern/poor (red).

Lastly, SacEFT's output interface and reports for trade-off analyses make it clear how actions implemented for the benefit of one area or focal species may affect (both positive and negative) another area or focal species. For example, we can show how altering Sacramento River flows to meet export pumping schedules in the Delta affects focal species' performance measures in the Upper and Middle Sacramento River.

The vision for SacEFT, one we believe we have achieved, is to address all of these needs with a robust decision analysis tool. SacEFT is structured as an "ecological plug-in" to existing models that are commonly used for water planning in the Central Valley. Rather than reinventing models, SacEFT utilizes output data sets from CALSIM II and other models that are already addressing water supply and other demands on the water storage and delivery system. SacEFT utilizes these data sets, which typically emphasize human demands on the system, and adds ecological calculations to evaluate effects on various ecosystem targets. Specifically, SacEFT uses predictions of change in habitat attributes from these water management planning models (e.g., flow, water, temperature, substrate composition), to generate biological responses using functional relationships for a select group of representative focal species of the Sacramento River ecosystem (chinook salmon, steelhead, green sturgeon, Freemont cottonwoods, western pond turtle, and bank swallows). These functional relationships were vetted through a multi-disciplinary workshop process, resulting in the component architecture of the SacEFT decision analysis tool depicted in Figure 5. SacEFT uses these biological inferences as performance measures against which to evaluate alternative water management scenarios. Collectively, the constituent focal species "submodels" provide 35 performance measures which vary in spatial scale, temporal scale, and levels of reliability. Multi-year rollups (Figure 3) allow users to quickly zoom in on the much smaller set of performance measures which differ significantly across management scenarios. With the completion of this work, SacEFT provides the ability to:

1. improve the basis for evaluating flow alternatives on the Sacramento River from Keswick to Colusa (e.g., North-of-Delta Off-Stream Storage Investigation, or Sites Reservoir, Shasta Lake Water Resources Investigation, or enlarged Shasta Dam, and new diversions and water transfers)
2. evaluate a variety of management actions' affects (e.g. gravel augmentation and bank protection alternatives) on ecosystem targets for the six Sacramento River focal species,
3. provide multiple levels of communication of information ranging from simplified formats for managers and decision-makers to in-depth displays of detail functional relationships and transparent assumptions for review by technical experts,
4. leverage existing systems and data sources (CALSIM, historical gauging station records, the meander migration model, and TUGS, a new sediment transport model),
5. catalyze exploration of new alternatives as data sets become available (e.g., climate change) and help promote the development of needed flexibility in the water management system.

Figure 3 is one example of value added to water planning discussions through completion of the Sacramento River Ecological Flows Study and the SacEFT branch of the decision analysis tool. The figure displays responses of a subset of the suite of focal species available for evaluation in the SacEFT in response to various management "scenarios" (Sites Reservoir, enlarged Shasta Dam). The scenarios displayed also demonstrate the ability to evaluate actions such as gravel augmentation and various bank revetment strategies developed through related studies as part of the recently completed Study. Results of the scenarios are conveyed here as categories of good (green), fair (yellow), or poor (red) conditions and the percentage of time these categories occur over the period of years evaluated. Figure 3 shows SacEFT output in its most simplified form, called "multi-year roll-up"; significantly more detail may be displayed for a technical audience (Figure 4). Another useful form of output is referred to as *flow envelopes* for targets or avoidance flows (Figure 6). These are created by querying and displaying the flow conditions for good years (target flows), whereas querying bad years produces avoidance flow envelopes for a particular target. All documents and results referred to above are available at http://www.delta.dfg.ca.gov/erp/sacriverecoflows.asp.

Early in the project development phase of SacEFT, the project team specifically excluded Delta considerations when bounding the limits of the SacEFT decision analysis tool. We sought to first achieve proof of concept in one location (e.g. the Sacramento River ERP ecoregion) prior to expanding efforts to other ERP ecoregions. We now have a significant foundation of existing work to build upon and in light of recent DRERIP progress, timing is significantly more appropriate to now address Delta specific needs in a similar fashion. Incorporation of Delta considerations into the existing framework would both provide managers the ability to better inform Delta management actions for ecological affects, as well as evaluate a management action's affects in the two inseparable ERP ecoregions of the Sacramento River and Delta.

Application to the Delta and Integration of Management Actions Across ERP Ecoregions

The Sacramento River supplies on average 80% of the Delta's inflow, which highlights the priority of coordinating management actions between these two ERP ecoregions. The Delta is the hub of California's water supply system and the Central Valley's aquatic ecosystem. It is home to 750 species found in and amongst its 57 islands where freshwater from the Sacramento and San Joaquin Rivers meets saltwater from the Pacific Ocean. Resource and water managers in the Delta are faced with a complex set of challenges with significant socio-economic ramifications and the widespread recognition that the current uses, resources, and ecosystem of the Delta are unsustainable over the next 100 years (Delta Vision Process Overview Draft, February 14, 2006). To inform these efforts, the CALFED program supported development of a wide array of research investigations beginning in the mid 1990's. These studies sought a better understanding of the relationships between inflows, water exports, water quality and at risk fish population responses. Most recently, research effort has intensified on Delta smelt and other pelagic species following the step-like decline in their abundance in 2001, though the cause of this decline, and separation of natural variability from measurement error, is a focus of considerable scrutiny (Armor et al., 2005, but see also Bertness et al., 2005). While many questions and uncertainties remain, a wealth of research and monitoring results have been generated for the Bay-Delta system that are beginning to highlight linkages between water flow and habitat characteristics and ecological targets.

Similar to initial steps on the Sacramento River effort, the project team has reviewed the many planning efforts occurring in the Delta. These include the Bay Delta Conservation Plan, Delta Vision Process, Interagency Ecological Program POD Study, Delta Regional Ecosystem Restoration Implementation Plan (DRERIP), Delta Risk Management Strategy, Delta Long-Term Management Strategy, and the Delta-Suisun Status and Trends Assessment. Regulatory agencies, charged with ensuring these programs do not conflict with one another and are instead aligned for the greatest leverage of potential management actions, are faced with a significant challenge. In addition, similar challenges face these Delta efforts as those addressed on the Sacramento River: *a significant amount of existing information spread in disparate sources and processes, difficulty in assessing multiple ecological targets at one time, and difficulty assessing the potential effects on Delta specific targets resulting from actions driven by demands in another ecoregion.*

Despite the challenges above, no single management tool, or framework, exists for the Delta system with the ability to integrate, analyze, and efficiently communicate important ecological effects of management actions. To meet these needs, this proposal focuses specifically on development of a Delta Ecological Flows Tool (DeltaEFT) *branch* of a pre-existing decision analysis tool (SacEFT). The creation of the DeltaEFT branch by no means replaces existing models, tools, and information being used and developed by Delta practitioners. Indeed, the use of established and accepted models would be a key strength of a new DeltaEFT. In the same fashion as SacEFT, the DeltaEFT decision analysis tool would synthesize vast amounts of information by linking ecological submodels to existing physical planning models used in the Delta. This increases the likelihood that important scientific and defensible information is put to practical use. Generating good information does not ensure its use in decision making. However, its use is facilitated through effective integration and communication of the information to decision makers and technical audiences alike, further increasing the scientific credibility and transparency of the decision making process.

Fortunately, recent Delta efforts have made significant progress in one of the more difficult steps in creating any decision analysis tool – articulating the linkages between species' and ecological target responses and management actions. Delta practitioners have directly addressed this challenge within the DRERIP process through creation of a set of standardized conceptual models. From the preface of the Ecosystem Conceptual Model DRERIP documents, the process has created "a suite of conceptual models which collectively articulate the current scientific understanding of important aspects of the Sacramento-San Joaquin River Delta ecosystem. The DRERIP conceptual models are designed to aid in the identification and evaluation of ecosystem restoration actions in the Delta. These models are designed to structure scientific information such that it can be used to inform sound public policy. The DRERIP Conceptual Models include both ecosystem element models (including process, habitat, and stressor models); and species life history models (Table 1). The models were prepared by teams of experts using common guidance documents developed to promote consistency in the format and terminology of the models." These models provide a critical starting point to move select conceptual linkages to more quantitative estimates of ecological target response to management actions. Given the breadth of work occurring in the Delta, there is a high likelihood that a subset of these linkages can be supported and quantified using existing data and research. Combining existing DRERIP conceptual models within a facilitated workshop approach to further quantify functional relationship sets the stage for integration of these functional relationships into the DeltaEFT branch of a decision analysis tool.

The proposed project is an effort to explicitly integrate best available information to better inform decision makers and reduce scientific uncertainties, an approach aligned with that outlined in the Delta Visioning Process (Mount et al. 2006). The Delta Visioning Process insightfully identifies three types of scientific information including: 1) high consensus understandings ready for immediate application in decision making, 2) knowledge where science is in flux, but where tools could be brought to bear quickly to provide useful advice, and 3) topics that are known to require inventory, monitoring, and research, and which irrespective of their importance, will simply not be ready for upcoming visioning efforts. The current version of SacEFT includes the first two identified types of information for Sacramento River focal species and processes, and so too would DeltaEFT. This flexible framework may be highly relevant to the ongoing scenario evaluation process identified in the Delta Visioning Process.

It is also important to understand what this proposed project is not. First, it is not currently possible to quantify *all* the linkages in *all* the DRERIP conceptual models for inclusion into DeltaEFT. Rather, as identified above, it is a highly targeted effort to improve quantification of select, key functional links between management actions, physical responses, and focal species performance measures where the state of science and expert judgment allows. In the standardized guidance developed for DRERIP conceptual model creation, these better supported linkages are referred to as "fat green arrows", and they would receive our focus when considering them for inclusion in the DeltaEFT. Quantifying some of these key linkages will provide much more informed insights for decision making. Other parts of the DRERIP conceptual models, though only evaluated qualitatively, can readily be integrated with quantified performance measures through standard methods of decision analysis (Hammond et al. 1999).

This proposal is not an attempt to generate scenarios that suggest returning the Delta to an unrealistic "pre-regulated" condition. Rather, we are seeking to develop a practical tool that could help identify how flow management and other Delta management actions best meet multiple species requirements within existing human demands for water (e.g., urban and agriculture diversions, storage, and conveyance) and scientific limitations in understanding. Accounting for ecosystem effects of Delta operations while working to restore critical habitats and components of the incoming flow regime is a proactive approach to avoiding future regulatory action.

C2. Project Goals and Objectives

Project Goals

There are three goals of the Project: first, refining SacEFT, second addressing Delta specific needs and third, combining analysis of the Delta with the Sacramento River in response to management actions:

1) Further increase the robustness of analyses and technical credibility of the SacEFT branch of the decision analysis tool for application to relevant water management planning efforts evaluating Sacramento River targets.
2) Facilitate the incorporation of the most robust and defensible findings from various Delta planning efforts and on-going studies, and incorporate them into a DeltaEFT branch of the existing decision analysis tool.
3) Integrate management actions between the strongly linked ERP ecoregions of the Delta and Sacramento River. Apply both the improved SacEFT as well as the newly built DeltaEFT to a set of relevant management scenarios to highlight the ecological trade-offs in both ecoregions.

Project Objectives

1) Complete refinements, identified through completion and stakeholder review of the SacEFT, including incorporation of additional functional linkages as well as peer review of "hazard thresholds" used to distinguish between habitat conditions for focal species' performance measures resulting from management scenarios.

2) Leverage existing CALFED and POD investments through a synthesis of existing scientific information in the Delta. Using an interdisciplinary workshop approach, facilitate the extraction of the most relevant and useful information on linkages between flow regime characteristics, habitats of the Delta, implications of alternative Delta configurations and operations, and focal species' life history requirements. Defining these relationships will facilitate inclusion of Delta specific focal species performance measures and Delta hydrodynamics into the DeltaEFT.

3) Work with relevant management forums to identify and evaluate leading water operation scenarios. With the DeltaEFT we expect to identify the trade-offs inherent in the different management strategies on the chosen focal species' performance measures.

4) Effectively communicate the knowledge gained to agency managers and stakeholders, as well as to the public. The project team will utilize a combination of facilitated workshops and web accessible reports to communicate project findings. In addition, the DeltaEFT software will be made publicly available with one to two pre-defined illustrative scenarios and a stand alone tutorial.

2. Background and Conceptual Models

The biological, political, and socio-economic complexity of the Delta is exemplified by the numerous planning processes that have arisen in the last few years attempting to guide management of this complex set of challenges. Creation of a decision analysis tool must be grounded in, and relevant to, these efforts and background. We present here a summary of existing efforts we see as beneficiaries of the proposed project with an emphasis on the most relevant goals.

Delta Vision Process (DVP)

Established by Governor Schwarzenegger's Executive Order S-17-06, the Delta Vision Blue Ribbon Task Force was to "develop a durable vision for sustainable management of the Delta" with the goal of "... managing the Delta over the long term to restore and maintain identified functions and values that are determined to be important to the environmental quality of the Delta and the economic and social wellbeing of the people of the state." The DVP has developed 12 Integrated and Linked Recommendations that are designed to guide the short- and long-term management of the Delta (http://deltavision.ca.gov/BlueRibbonTaskForce/FinalVision/Delta_Vision_Final.pdf). The proposed DeltaEFT could help guide the decision making processes necessary to address many of the 12 Integrated and Linked Recommendations, and in particular the following recommendations:

4. California's water supply is limited and must be managed with significantly more efficiency to be adequate for its future population, growing economy and vital environment.
7. A revitalized Delta ecosystem will require reduced diversions, or changes in patterns and timing of those diversions, upstream, within the Delta and exported from the Delta at critical times.
8. New facilities for conveyance and storage, and better linkage between the two, are needed to better manage California's water resources the estuary and exports.

Bay Delta Conservation Plan (BDCP)

The BDCP will evaluate approaches to conveyance and how they would likely contribute to achieving the planning goals and conservation objectives of the Planning Agreement and affect habitat restoration opportunities across the Delta pursuant to the Endangered Species Act and the Natural Community Conservation Planning Act (http://calwater.ca.gov/content/Documents/meetings/2006/12-14-06Item_3E_BDCP_Update.pdf). The BDCP is focusing its efforts on evaluating alternative water management schemes for the Delta; these include conveyance elements, operations, maintenance, and facility improvements of the State Water Project and the Central Valley Project, and ongoing operations and future projects of other water users signatory to the BDCP Agreement. The BDCP is focused on conserving aquatic ecosystems and natural communities. Potential covered species include Central Valley steelhead, Central Valley Chinook salmon (spring run and fall/late-fall runs), Sacramento River Chinook salmon (winter run), Delta smelt, green sturgeon, white sturgeon, splittail, and long-fin smelt. The proposed DeltaEFT will be an invaluable tool in analyzing the impacts of proposed changes in conveyance and water operations on a suite of focal species, in both the Delta and the Middle Sacramento River.

Delta Regional Ecosystem Restoration Implementation Plan (DRERIP)

DRERIP is the most directly related effort to the creation of a DeltaEFT because the decision analysis model can make immediate use of conceptual species models as a starting point. Beginning in 2006 the CALFED ERP Implementing Agencies (DFG, USFWS, National Marine Fisheries Service) developed a suite of ecosystem and species conceptual models for the Delta (Table 1, summarized from DCM_Peer_Review_Summary_1-24-08.PDF). These models are designed to provide a strong scientific foundation to guide management actions seeking to improve the ecological functions of the Delta and the health of the species that depend on the Delta. Through an extensive and exhaustive peer review process, the conceptual models have been developed to explore the linkages between ecosystem processes, function, and habitat needs for multiple species. We anticipate the DRERIP conceptual models will be used extensively by the Delta Vision and BDCP processes to analyze habitat restoration opportunities and hydrodynamic conditions within the Delta. The DeltaEFT could provide a framework for quantifying components of these conceptual models, and integrating multiple relationships and datasets at different spatial and temporal horizons and resolutions.

Conceptual Models

A decision analysis tool serves all of the above efforts as they all reference the goal of considering ecological information while formulating management actions. The ability to do so is a direct function of forming linkages between the two as has been accomplished in SacEFT. The first step is identifying conceptual models that lead to quantifiable linkages. The selection of the highest priority conceptual models and linkages to integrate into the existing decision analysis tool will be vetted with an emphasis on which functional relationships may most likely be affected by a suite of management actions. Other guiding criteria found to be helpful in selecting linkages in SacEFT effort were:

- *Relevance:* whether submodels were developed using data collected within the study area during recent conditions;
- *Clarity*: relationships not contested or seriously confounded by other information (e.g., not confounded by other factors not modeled in DeltaEFT);
- *Rigor:* whether evidence supporting a relationship was: 1) well established & generally accepted, 2) strong but not fully conclusive, 3) theoretical with some evidence, or 4) hypothesized based purely on theory and professional judgment; and
- *Feasibility:* recognizing our inability to "include everything", the chosen functional links do not require fundamental new research, analyses or major customizations to the software structure that would exceed project funding resources.

We assume at this time that the most relevant management actions to evaluate will include alterations to Delta conveyance and geometry, alterations to inflow patterns from the Sacramento River and other significant sources such as the San Joaquin River, and changes to export volumes and schedules.

As described above and conveyed in Table 1, the DRERIP process has made significant progress along the lines of conceptual model development. Figure 7 provides the Sacramento Splittail example emerging from this effort. The functional linkages approach we took in SacEFT, and will take in DeltaEFT, is analogous to the DLO (Drivers, Linkages, Outcomes) approach used to develop the DRERIP models. To re-emphasize, not all conceptual models in part or in whole will be integrated into the DeltaEFT decision analysis tool. Rather, a vetting process would first be conducted, and is explained in the following sections, to select only the most robust and defensible linkages.

Our review of existing information reveals that more quantified linkages are available for functional relationships between Delta outflow / salinity (Peterson et al. 1975, 1989; Jassby et al. 1995) and striped bass survival (Stevens et al. 1985; Kimmerer et al. 2001b), between the Delta Smelt summer townet abundance index and the natural log of Delta outflow (DWR and U.S. Bureau of Reclamation 1994), and between inflows and Delta smelt habitat availability (Bennet 2005). Kimmerer (2002a, 2002b) found that survival indices for most Delta fish species, as well as bay shrimp, were positively correlated with flow (negatively correlated with X2). Dr. Kimmerer and his colleagues are continuing to develop models of Delta smelt and other estuarine fishes through CLAFED Science Program funding under the 2004 PSP.

C3. Approach/Methodology

Three attributes of our approach are noteworthy. First, it links two major ecoregions (Figure 8), Sacramento River flows with Delta hydrodynamics. Second, we intend to more clearly communicate the ecological considerations inherent in flow and water delivery decisions. Third, we intend to expand the ability to efficiently communicate the ecological considerations associated with Delta water delivery and transfer decisions, utilizing a multi-species, rather than a single-species approach. All of these attributes were identified as desirable in a recent CALFED review article (Kimmerer et al. 2005).

Our approach for the development of a Delta specific decision analysis tool is to use SacEFT's underlying software architecture as the template for the DeltaEFT branch. With the DeltaEFT, we will highlight selected biological components of the Delta ecosystem (e.g., at-risk pelagic organism decline species), their relationships with water quality (e.g., temperature, salinity), hydrology (e.g., Sacramento and San Joaquin River inflows), and water management activities (e.g., transport, change in timing and magnitude of water exports) to better illuminate and communicate ecological implications of system-wide operations. Figure 5 depicts the component architecture of SacEFT which can be readily duplicated for DeltaEFT. For clarity, it is understood that new physical submodels in the figure, such as meander migration that are appropriate for Sacramento River evaluations, would be replaced by relevant Delta specific models such as the Delta Simulation Model II (DSM2).

Similar to SacEFT, DeltaEFT submodels would be integrated and centered around a single SQL Server relational database (item "1" in Figure 5) with a Graphical User Interface (item "3" in Figure 5), Model Controller & Analysis Engine (item "2" in Figure 5) and Excel Reporting Service (item "5" in Figure 5) connecting to and interacting with this database. Because a large amount of data is involved in both the SacEFT and DeltaEFT database components, they will be constructed as separate data stores connected to the same decision analysis software. Components are expected to be structured to manage this quantity of data such that users may perform SacEFT or DeltaEFT focal species analyses separately or in conjunction with one another.

As shown, the Graphical User Interface (Figure 9) is designed with a high level of flexibility. Users can chose which management scenarios to evaluate, what range of years to display, and which ecological indicators they wish to evaluate. To rapidly and visually communicate the acceptability of results and remove disparate and non-comparable units, performance measure summaries are displayed using a "traffic light" approach (i.e., red-yellow-green coding). Again, output forms are flexible as well with either summarized results (Figure 3) for high level managers, or with significantly more detail (Figure 4). Providing transparent information provides an opportunity for reviewers to gauge the credibility of functional relationships utilized to formulate management actions. The software manages metadata information on functional linkages and also provides an opportunity for the reviewer to log comments (Figure 10).

Definition of thresholds between traffic light conditions is a critical step in the ability to compare affects between management actions as well as providing confidence in the comparisons. These thresholds require and intentionally involve user definable value judgments for the specific threshold ranges (i.e., the green-to-yellow and yellow-to-red thresholds). These ranges are documented in SacEFT, and can be configured as additional data informs their ecological significance. Figure 11 provides an example of how threshold boundaries were applied to juvenile Chinook and steelhead stranding data in SacEFT, again as an example of an approach that could be adapted to the DeltaEFT effort.

We have designed SacEFT to make it easy to store external result datasets. Thus, SacEFT contains a mix of imported datasets derived from external models while other components—usually its focal species components—are embedded within SacEFT itself. Design details of the existing model are further discussed in ESSA 2007 (SacEFT Design Guidelines). A similar approach is expected to be applied to construct the DeltaEFT.

There are a number of potential models, data sets, and studies of key biophysical relationships that could be integrated into the DeltaEFT. Figure 12 depicts the approach followed to develop SacEFT. It conveys the steps from initial selection of targets all the way to final output as the example we expect to follow for DeltaEFT with an application of lessons learned from the previous effort. By no means is a comprehensive list, Table 2 lists some examples of models that we may link with or extract high-value biophysical relationships from for DeltaEFT. For example, Cramer (http://www.spcramer.com/imf/imf.htm) identifies 14 different models dealing with various parts of the life history of winter run Chinook. We plan to carefully review a wide range of existing models and literature to assess which components are most appropriate for inclusion in the DeltaEFT. Our focus is on a broad representation of the physical processes and habitats required to support a range of focal species, rather than on a very detailed representation of a single species' entire life history. This provides a more optimal compromise between understanding and complexity (risk of compounding formulation errors, and uncertainty).

The DeltaEFT would require links to one or more physical driving models (e.g., DSM2, and the 3D Tidal, Residual, Inter-tidal Mud-flat model, or TRIM3D) to predict the consequences of different rates and timing of Delta inflows and within Delta water quality and transport dynamics. We expect to consult with experts in Delta hydrodynamics and water quality to determine the best tool(s) for predicting the consequences of changes in Delta inflow, water exports, local diversions and gate/barrier/canal configurations. We expect to continue to use the CALSIM II Daily Operations Model (DOM) for determining inflow to the Delta from the Sacramento River and potentially CALSIM II for determining inflows from the San Joaquin River; we used CALSIM II DOM datasets for the current version of SacEFT. We anticipate selecting a particular physical hydrodynamic model of the Delta, and leveraging as much as possible existing model runs and their analyses. Key output variables such as cumulative flow (or density of particles) past certain points and concentrations of salt or total organic carbon under different scenarios expect to then be imported into the DeltaEFT database at the appropriate resolution, using the approach described in ESSA 2007 (SacEFT Design Guidelines).

A likely candidate for evaluation of the linkages referred to above is the DSM2 (DSM2, DWR 2005). DSM2 is a one-dimensional numerical model that simulates hydrodynamics in a network of channels. DWR has expended considerable effort developing, calibrating, and testing this model, given its use to support decisions about water project operations. Spatially, the model consists of a grid of 416 nodes or 509 links representing channels and open-water areas, which are represented as reservoirs where mixing occurs, and 17 hydraulic barriers and gates. DSM2 can also be associated with a particle tracking model (PTM), a quasi 3-dimensional extension of DSM2 (Culberson et al 2004). The PTM represents movement of particles through advection in the mean flow together with dispersion (Wilbur 2000). Each particle has a random component of movement, and its position in the channel can be tracked. This model tracks flow field velocities, allowing particles to encounter channel domains that differ substantially from the mean flow. These characteristics allow for dispersion of particles. Kimmerer and Nobriga (in prep.) have found DSM2's PTM, in its existing configuration, to provide useful results for passive and actively moving particles (e.g., fish) at the scale of the entire Delta. We expect to consider other tools during model and focal species selection (e.g., TRIM3D). It is important to point out that our focus is on re-use of existing (and easy to produce new) model runs and analyses, rather than engaging in any expensive new calibrations and runs of these sophisticated models.

Model scoping and bounding is a critical step in developing functional software as mixed spatial and temporal bounds present challenges. We expect to rely on a workshop approach and subsequent technical discussions to appropriately scope and bound DeltaEFT and create a framework for integrating multiple models and datasets that serve the needs of the chosen focal species' functional relationships. Figure 13 summarizes the mixed spatial and temporal bounds and resolution we had to overcome in SacEFT. During consultations and workshops to construct SacEFT, given decisions about where we needed to know something for a focal species relationship, we asked technical experts whether these spatial locations could be simulated using a particular physical model. We also asked, given focal species' functional relationship needs, could we model various physical processes at the required time step, given the current state of knowledge. We expect to follow an analogous approach to develop the DeltaEFT. However, in creating the DeltaEFT, we expect to be ahead of where we started with developing SacEFT in that the DRERIP conceptual models provide a stronger starting point for developing the Delta focal species' relationships and tying them to key environmental drivers.

The approach taken by our team is consistent with the advice of the Delta Science Panel, who advocates synthesizing information simply and efficiently when providing science-based advice and to focus on the science ready for immediate application (Mount et al. 2006). It may be unrealistic to wait for complete scientific certainty before making decisions and as described below in subtasks 1.1 and 2.3, we advocate using streamlined sensitivity analyses to explore how management decisions are affected by alternative hypotheses and functional relationships for a few critical uncertainties. 'Mental models' are being used to make decisions today; the DeltaEFT would enhance, not replace, managers' mental models.

C4. Tasks and Deliverables

All tasks will be completed by TNC and ESSA Technologies who will comprise the project team. See Part H (Qualifications) for descriptions of TNC and ESSA and their respective staff's qualifications to carry out this work. TNC will manage the project (Tasks 3, 4, 5). TNC will subcontract to ESSA to carry out the SacEFT model refinements and application (Task 1), and design, integration, and construction of the DeltaEFT software package (Task 2). ESSA Technologies will also manage any additional minor subcontracts associated with their needs on Task 1 and 2. Task leads are identified in parentheses after the subtask title. The proposed project is comprised of five tasks and their associated subtasks (see Exhibit B for Task Title, Deliverable, and their Estimated Completion Dates and Table 7 for the project timeline):

Task 1: SacEFT Model Refinements and Application
- Subtask 1.1: SacEFT model technical review and improvement
- Subtask 1.2: SacEFT application to relevant water management scenarios

Task 2: DeltaEFT Model Development to Evaluate Flow Requirements for Delta Species
- Subtask 2.1: DeltaEFT model design
- Subtask 2.2: DeltaEFT model construction
- Subtask 2.3: Delta water management ecological outcomes and trade-offs evaluation
- Subtask 2.4: DeltaEFT public outreach and stakeholder involvement

Task 3: Project Management and Administration
- Subtask 3.1: Internal project team coordination
- Subtask 3.2: ERP directed action project administration

Task 4: Draft and Final Report

Task 5: Project Close Out

Based on TNC's experience, the project team recognizes that communication and outreach are critical to this type of work (Golet et al. 2006). Thus, we emphasize interaction with five audiences when completing these tasks: 1) ERP staff to ensure that project deliverables are clearly aligned with CALFED ERP priorities, 2) Sacramento River resource managers and experts to ensure refinements to SacEFT meet their needs, 3) Delta water managers to ensure that the DeltaEFT is scoped correctly and relevant to their needs, 4) technical experts to provide guidance and peer review of scientific elements, and 5) stakeholders to ensure the DeltaEFT is reflective of the Delta's ecological and socio-economic values.

Task 1: SacEFT Model Refinements and Application

Subtask 1.1: SacEFT Model Technical Review and Improvement (ESSA assisted by TNC)

Possible refinements to the existing structure and capabilities of SacEFT were identified in the Sacramento River Ecological Flow Study's Final Report (TNC et al. 2008) in March 2008. Specifically, there are data available that support the inclusion of additional functional relationships within the existing database structure. There is also a need to conduct peer review of the hazard thresholds used to classify the condition of a focal species' habitat as good (green), fair (yellow), or poor (red).

Working with Sacramento River experts and managers, we intend to organize a 2-day workshop, selecting key individuals from the participants who attended the SacEFT Model Design Workshop held at UC Davis in December 2005 (Table 3). We will work openly with technical specialists in the workshop to provide a thorough familiarity with the structure, content, and output of SacEFT. Our past experience in other projects is that technical specialists gain confidence in a model when they can easily examine its assumptions and understand their consequences by exploring the effects of different water years, management actions and hypotheses (e.g. Marmorek and Peters 2001, Peters and Marmorek 2001, Alexander et al. 2006). For example, SacEFT's inclusion of historical flow and temperature for 1939-2004 allows scientists to explore the model's output under a wide range of conditions.

Prior to the workshop we expect to provide draft materials for attendees to review and prepare for the workshop. We expect to distribute relevant background materials describing SacEFT to the participants, including the SacEFT Design Guidelines (ESSA Technologies 2007), the Sacramento River Ecological Flows Study Final Report and it's Appendix F (TNC et al. 2008). At the workshop, we expect to facilitate six sessions on:

1. *A peer review of hazard thresholds* (green, yellow and red zones for each performance measure) by focal species experts, providing insights on the biological significance of changes in physical habitat conditions. In the current version of SacEFT, we determined the green, yellow and red hazard thresholds based on logical break points in a sorted list of performance measure values over the 66-year historical time series (1939-2004), as illustrated in Figure 11 for the chinook/steelhead individual stranding index. While this approach has some merit (i.e. it scales each performance measure relative to its long term historical variation), our method may under- or over-estimate the current biological significance of performance measure results, given the current state of each focal species and its habitat. We would prefer to have these hazard thresholds reviewed by a small group of knowledgeable biologists, who ideally can come to a consensus on appropriate break points and the associated caveats. This discussion could generate questions about how the output came to be what it is, which in turn could lead to a discussion of model functional relationships (session 2).
2. *A peer review of critical uncertainties in model functional relationships* that might affect flow management decisions. We have described some important assumptions and limitations of each performance measure included in SacEFT in the Sacramento Ecological Flows Study Final Report (Table 4). Table 4 is an excellent starting point for this peer review. While models generally contain many assumptions, only a small proportion of these assumptions turn out to be *critical* to flow management decisions (Marmorek and Peters 2001, Peters and Marmorek 2001, Alexander et al. 2006, Marmorek and Parnell 2002). This is because many performance measures show very little variation across the range of scenarios being simulated, and therefore do not help managers to compare alternative courses of action. This lack of sensitivity could be real (i.e. the habitat is genuinely insensitive to the types of flow changes under consideration), or could be due to an incorrect formulation of a flow-habitat linkage. Peer review can help us to distinguish between these two alternatives. That peer review is likely to lead to some suggestions for further sensitivity analyses (session 3).

3. *Suggestions for a small set of sensitivity analyses on alternative forms of critical functional relationships.* We describe the relative sensitivity of SacEFT performance measures in the Sacramento Ecological Flows Study Final Report (Table 5). For example, the Chinook/steelhead stranding index, in the current version of SacEFT based on research by Mark Gard of USFWS), was quite insensitive to the NODOS and Shasta scenarios simulated in the Sacramento River Ecological Flows Study. An alternative formulation, perhaps based on results of the off-channel habitat study described in the Study's Final Report (TNC et al. 2008), might turn out to be more sensitive (or not). If several formulations for a performance measure, each based on different evidence, all show similar sensitivity, this tends to increase the level of confidence in the model. Sometimes when the sensitivity varies across different formulations of a performance measure, it is because the more sensitive formulation zooms in on the most responsive locations and times, while the insensitive indicator averages over space and time. In these cases, it is valuable to have biologists decide what level of effect is biologically significant for the focal species.
4. *Discussion of an additional 2-4 indicators for SacEFT*, based on rationale and data provided in the Study's Linkages Report and field studies (Stillwater Sciences 2007). There are always possibilities for improving models, and the group will need to be very disciplined in focusing on the highest priority items, given their potential to contribute valuable additional information to water management decisions. Examples of potential improvements to the model include:
   - adding management actions related to operation of ACID and Red Bluff Diversion Dam to reflect the benefits of spatial segregation for certain Chinook run type,
   - adding an indicator for flow in off-channel water bodies during summer incubation for western pond turtles based on accurate site specific stage discharge information (currently lacking),
   - improving the indicator of Chinook/steelhead spawning weighted useable area to reflect the quantity and relative depth of spawning gravel, in addition to substrate grain-size suitability, and
   - adding a redd superimposition indicator for Chinook using appropriate field research that quantifies the functional details.
5. A discussion of how to *enhance Excel report model output* to show the assumptions associated with each model run (up to 6 output reports will be improved). The database contains all of the assumptions associated with each model run. We wish to discuss with technical scientists the subset of these assumptions which would be most helpful to them in the Excel output reports (e.g. for model testing, comparison, and synthesis).
6. A discussion of defensible methods for refining and automating the generation of *preferred flow envelopes* for each performance measure, which can be translated into operating rules for dam operators for different focal species. While it is likely desirable to satisfy certain ecological objectives every year (e.g. temperature criteria) other objectives may only be satisfied occasionally (e.g. cottonwood recruitment every 5-10 years). We wish to have a technical discussion on how to convert SacEFT target and avoidance flows for multiple focal species into water year specific criteria and constraints that take into account the recent history of flows. This is the ultimate product that will help water managers and dam operations personnel which ultimately should feed back directly as new constraints in future formulations of CALSIM.

After the workshop we will complete a concise technical memo describing the agreed upon improvements to SacEFT, and recommended sensitivity analyses. We will then implement these improvements and sensitivity analyses.

Key Assumptions:

- Willingness and availability of technical scientists to participate in the workshop. In our experience, this type of modeling is of great interest among biologist and modelers in the region.
- Suggestions for model improvements and sensitivity analyses must be feasibly implemented within the available budget for this task.

Subtask 1.2: SacEFT Application to Relevant Water Management Scenarios (TNC and ESSA)

We will work openly with managers and decision makers to actively and practically apply SacEFT within a water planning process in the Sacramento Basin (e.g., NODOS, Shasta Dam enlargement). SacEFT is among a suite of models that the Department of Water Resources (DWR) is considering applying in the NODOS process for development of project alternatives. We anticipate a high likelihood of applying SacEFT within the NODOS process. SacEFT has been deliberately designed to provide managers with multi-year roll-ups comparing alternative scenarios or sets of actions (Figure 3). The managers and decision makers will determine what scenarios are of interest, and provide iterative feedback on what forms of scenario comparisons are most helpful to their decision making. While managers make decisions in water planning processes, attempting to balance multiple objectives, we assume agency scientists will remain closely involved in an advisory role. Hence, completing task 1.1 and building the level of confidence of technical scientists is crucial for the success of this task.

Scenarios of possible interest may include: NODOS, Shasta enlargement, Bay Delta Conservation Plan options which have implications for upstream water management (e.g. increasing flows to have sufficient bypass flow for a Sacramento River diversion near Hood, up to 15,000 cfs), climate change scenarios, gravel augmentation options, and various combinations thereof. Given the fixed budget for this project, there is a limit to how many scenarios and options can be analyzed. There is also a tradeoff between the number of scenarios / options run through SacEFT, and the depth of analysis completed for each one. Thus there will need to be some dialogue on the best use of available resources, given both short and long range decisions (e.g. comparing various combinations of scenarios to highlight the effects of particular actions or climatic conditions). In similar past exercises we have found it informative to begin with a very wide range of scenarios (i.e. a strong contrast), and then iteratively narrow the scope of these scenarios (Marmorek and Parnell 2001). We have included a unit cost estimate in our budget, if additional runs are anticipated beyond our assumed budget.

Specifically, this subtask will involve the following six steps:

1. *Scope additional application of SacEFT.* We intend to meet with the lead facilitators or steering committees of the forums, review the objectives being considered in the forums, map the performance measures in SacEFT to these objectives (i.e. how SacEFT can help to quantify objectives that previously were only evaluated qualitatively), discuss what forms of output and analysis would be most helpful for their decisions, and discuss the management actions and other factors (e.g. climate change) under consideration.
2. *Finalize scenarios.* Work with managers and agency scientists to carefully finalize a set of 4 primary scenarios (and associated options) which can be run through SacEFT. It is most

important that these scenarios be accurately and precisely specified, so that all of the contributing models to SacEFT are run correctly. Several iterations could be required to ensure that all of the details are correct.

3. *Obtain output.* We expect to run those scenarios / options through SacEFT, summarize and synthesize the output in a format most helpful to decisions (i.e. highlighting differences and tradeoffs among scenarios), and integrate results into the Draft and Final report (Task 4). Since SacEFT has a chain of model runs feeding it, the date of delivery of the final results hinges on the timing of delivery of the first critical inputs – runs of CalSim-SRWQM-HEC5Q (or CalSim DOM if available).
4. *Present the results to the Forum*. We expect to present a detailed summary of results to agency scientists, followed on the next day by a short, carefully crafted presentation to the managers that are participating in the Forum. This 2-step process is expected to ensure that agency scientists are fully informed of the outcomes before their managers receive the results, allowing them to suggest additional comments to be added to the presentation for the forum managers.
5. *If desired (and sufficient resources are available), complete additional scenario runs.* Decision forums are generally iterative, and new 'hybrid' scenarios may be crafted after seeing the results of the first set of scenarios.

Assumptions:

- the number of scenarios and options run through SacEFT, and the depth of analysis of those options, will be determined through dialogue based both on what is desired, and what is achievable within the available budget
- we have budgeted for a maximum total of 16 model runs (e.g. 4 scenarios, each with 4 sub-options);
- flow and temperature runs from the CalSim-SRWQM-HEC5Q-TMS modeling complex (or CalSim DOM if available) will be provided to us, according to the agreed upon schedule, for each of the scenarios (and sub-options) that managers have selected for evaluation with SacEFT.

Task 1 Deliverables: 1) SacEFT Model Review Workshop, 2) SacEFT Model Review Workshop Technical Memo, 3) SacEFT v2.0 and Install Pack, 4) updated SacEFT Design Document including an appendix with the sensitivity analysis results), 5) SacEFT User's Guide.

Task 2: DeltaEFT Model Development to Evaluate Flow Requirements for Delta Species

<u>Subtask 2.1: DeltaEFT Model Design (ESSA assisted by TNC)</u>

Generate DeltaEFT Backgrounder Report

TNC and ESSA, working with Delta experts, intend to identify candidate models and focal species functional relationships for integration into the DeltaEFT based on 1) the available DRERIP conceptual models appropriate for integration (e.g., "fat green arrows"), 2) technical knowledge of the Project team and conservation partners, 3) feedback from stakeholders during a review cycle, and 4) literature reviews. The ESSA modeling team intends to then review and become familiar with these available resources (e.g., DSM2, TRIM3D, IBMs, fish-X2, etc.) to identify those physical models (and existing model runs) and focal species functional relationships that could be integrated into DeltaEFT.

The focus is expected to be on predicting changes in the biologically relevant features of the physical habitats occupied by a range of focal species.

In addition to the criteria identified earlier, suitability of candidate functional relationships and submodels is expected to be evaluated by considering a variety of criteria:

- Can a submodel (either directly or indirectly via other models) generate performance measures that relate to the management actions of interest?
- Across what spatial extent has a submodel been applied?
- What is the spatial resolution of the submodel (meters vs. kilometers)?
- Across what temporal horizon can the submodel be applied?
- What is the time step of the submodel (hourly, daily, weekly, or monthly calculations)?
- What are the input data requirements (type and source), and how do these relate to those available either empirically or via other models?
- What outputs from the submodel are available, either as inputs to other submodels or as 'bottom line' performance measures to evaluate habitat or biological responses?

In addition to reviewing available models, the project team must make decisions about which focal species to include in DeltaEFT. Focal species are expected to be selected on the basis of available DRERIP conceptual model information and other sources, their importance to managers and biologists (e.g., ESA listing, population status, sensitivity of life history traits to human disturbance), whether their habitat requirements are broadly representative of habitats found in the Delta, and whether these habitat requirements can be quantified using generally accepted functional relationships. As we did in the Sacramento River Ecological Flows Study, the project team intends to use a vetting process to select candidate focal species to propose to the stakeholder group convened in Task 2.1. The vetting process is described in Figure 14.

The project team intends to summarize its initial findings in a Draft DeltaEFT Backgrounder Report; the draft would be distributed to identified Delta experts and planners to receive guidance on leading focal species, functional relationships, data sources, and physical driving models. This guidance is expected to allow ESSA to produce the Final DeltaEFT Backgrounder Report which is expected to be distributed to the DeltaEFT Model Design Workshop invitees prior to the workshop. The DeltaEFT Backgrounder Report would prepare the Model Design Workshop invitees to be more effective participants in the workshop.

DeltaEFT Model Design Workshop

Working with Delta experts and managers, we expect to convene a 2-day DeltaEFT Model Design Workshop to elicit the essential information needed to: 1) design the DeltaEFT Model, 2) determine priority focal species, habitats and functional relationships, and 3) to define the management scenarios to apply in DeltaEFT. The Model Design Workshop is expected to include Delta biologists, modelers, and water managers who have the best knowledge of existing data sets, fish population biology, and environmental water gaming. We expect to also invite a relevant group of experts to make presentations on previous and ongoing research findings related to candidate focal species (e.g., Delta smelt, Chinook salmon). This may involve capturing findings from studies by Kimmerer et al. on Delta smelt (2004 PSP #106) and Bay-Delta estuary food web dynamics (2004 PSP #107).

Plenary discussions during the DeltaEFT Model Design Workshop are expected to also be important to share information across sub-groups pertaining to priorities for integration, and understanding critical assumptions / key uncertainties potentially affecting DeltaEFT results. As well, experience has shown that focused 1-on-1 conversations are needed following intensive model design workshops to clarify advice and suggestions provided by workshop participants.

Because the most knowledgeable individuals are often the busiest, a small stipend may be available to core experts making presentations at this workshop and potentially science advisors to the Project to offset any travel expenses, and time reimbursement if it will encourage participation at key steps in the Project. ESSA Technologies intends to function as facilitators of the DeltaEFT Model Design Workshop. ESSA has led modeling workshops for over two decades and is very experienced in facilitating scientists in similar technical interdisciplinary efforts.

In the DeltaEFT Model Design Workshop participants would be split into three sub-groups to review straw man versions developed by the project team of:

Subgroup	1. candidate functional relationships for Delta focal species and focal species habitats	2. candidate physical submodels	3. alternative Delta management scenarios
Subgroup expertise	biologists and ecologists with specific experience in the Delta (mix of modeling & field experience)	engineers and hydrologists with specific expertise in the Delta	ERP representative and Delta water managers
Subgroup objectives	refine candidate functional relationships between physical habitat performance measures and biologically relevant measures of habitat suitability identified in the Backgrounder report	provide advice on the most efficient existing models to supply the needed driving physical information identified in the Backgrounder report	review water management scenarios (e.g., conveyance, inflows, exports) identified by the Project team in the DeltaEFT Backgrounder Report
	identify a sensible spatial scope and resolution for functional relationships ("where does thing x matter the most?")	knowing where and when focal species relationships need to have driving physical data, clarify whether the existing physical models can provide that habitat information at these sites	prioritizing management actions (water supply and pumping scenarios, physical configuration of Delta)
	discuss appropriate ways to aggregate performance measures across space and time	clarify technical details around how long it takes to run these models, what scenarios are "on the shelf", provide examples of output datasets	defining three management scenarios to explore ecological implications in the DeltaEFT
	assign priorities to integrate submodel components		

DeltaEFT Design Guidelines

Based on discussions at the DeltaEFT Model Design Workshop described above and reviews of the DeltaEFT Backgrounder Report, we expect to create the DeltaEFT Design Guidelines Report, similar to the SacEFT Design Guidelines Report (ESSA 2007) to reflect Delta specific model formulation and data. The DeltaEFT Design Guidelines Report is expected to include descriptions of: external physical driving models to be used, selected focal species functional relationships, and management scenarios. This technical document is expected to serve as the blueprint and primary reference for constructing and communicating the underlying structure of DeltaEFT, including functional details of physical and focal species models (spatial and temporal details, algorithms for calculating performance measures, critical uncertainties), as well as software components (data model, user interface, format of output reports).

As part of ongoing efforts to maximize cooperation and interest of researchers and managers in the development and application of the DeltaEFT, and to ensure that we have captured advice from the DeltaEFT Model Design Workshop accurately, we expect to request that the Draft DeltaEFT Design Guidelines Report be reviewed externally. The document would be sent to all DeltaEFT Model Design Workshop participants, including Delta experts or ERP representatives who didn't participate in the workshop. This feedback would then be used to produce the Final DeltaEFT Design Guidelines Report. Recognizing that it is neither necessary nor feasible to capture *all* physical submodels and focal species relationships identified in our research and at the workshop, this task would also set the stage to finalize priorities for integration of submodel components into DeltaEFT. As well, DeltaEFT Design Guidelines would help to finalize selection of model scenarios.

The project team and relevant advisors are expected to look at the outcomes from the Model Design Workshop, consider the level of effort implied by the DeltaEFT Design Guidelines Report, and determine the most effective allocation of project funds. Priorities for integration would be based on:

- a submodel's *relevance* to the focal species and management scenarios;
- the level of *scientific confidence* in the functional relationship a submodel represents;
- the technical *feasibility* and *ease* of integrating a submodel or its outputs; and
- the *strength* and *reliability* of the source data used as a model's input.

Once the software is actually constructed, the DeltaEFT Design Guidelines Report will be updated to reflect the final as built state of the DeltaEFT decision analysis tool, truly becoming a "Design Document".

<u>Subtask 2.2 DeltaEFT Model Construction (ESSA)</u>

The component architecture of the SacEFT decision analysis tool is illustrated in Figure 5 and described in ESSA 2007. The SacEFT has been designed to be modular so that 3rd party external physical models and new focal species' performance measures can be readily included. Building the DeltaEFT is expected to involve taking the component architecture of SacEFT, creating a DeltaEFT relational database that connects with the same overall software as SacEFT, building in Delta components, and loading Delta related information (e.g., metadata describing submodel assumptions) into the database. SacEFT relational database is depicted in Figure 15 and this subtask is expected to produce a parallel DeltaEFT database. Once the database components for the DeltaEFT have been added, we expect to load and configure datasets from the selected driving physical hydrodynamic models into the DeltaEFT database. Likewise, we would also add and load initial defaults and alternative hypotheses for Delta focal species components. The SacEFT database is based on seven important types of related tables (Table 6), and described in more detail in ESSA 2007. The DeltaEFT database would follow this structure.

Next, we would translate the technical design components described in the DeltaEFT Design Guidelines into computer code. Under this subtask, ESSA would extend the existing SacEFT functionality to use Delta physical models, incorporate Delta focal species functional relationships, and related metadata. More specifically, we will write the code necessary to link physical variables and processes with focal species performance measures, develop graphical user interface components needed to work with, configure, and display the Delta extension components, and expand the reporting system responsible for providing detailed results in Excel. As with all software development, this process is iterative, involving repeated cycles of testing and error correction. Software developers will also provide at least one review of an early prototype to communicate DeltaEFT's progress with project team advisors. The final step will be to create a deployment package so the software can easily be installed and run on desktop computers. At first, other users would be able to only examine scenarios that have already been run and are included in the Sac- and DeltaEFT databases. We intend through this project to establish consistent protocols and procedures for incorporating new scenarios into DeltaEFT, which will facilitate future applications of the tool to other scenarios after the project is completed.

<u>Subtask 2.3: Delta Water Management Ecological Outcomes and Trade-offs Evaluation (TNC and ESSA)</u>

It will be critical to demonstrate how DeltaEFT can be applied in water management forums, so that water managers can see benefits to the insights that DeltaEFT can provide, by improving the ecological considerations in decision-making. We plan to apply DeltaEFT in two modes. First, we expect to use historic hydrological/hydrodynamic data to conduct a retrospective analysis of how focal species' performance measures (primarily indicators of habitat-forming processes, habitats, and survival indices) might have changed in the past. From this analysis we can selectively evaluate water years and their operational patterns that by chance had relatively higher or lower ecological performance. Secondly, we will run the model in "prospective" mode with the appropriately configured physical driving model scenarios (their datasets) defined in previous tasks. These scenarios are expected to illuminate ecological outcomes of water management given natural variation in Delta inflows and different levels and timing of Delta pumping, gate, and other potential in-Delta configurations across years. As mentioned earlier, the purpose of the tool is not to provide *absolute* predictions of biological or habitat performance. Rather we expect to use the tool to provide insights into the *relative* performance of alternative water management scenarios. Consequently, predicted focal species performance would be qualitatively compared to actual biological and habitat performance across historic years as a way of evaluating the accuracy of the DeltaEFT's relative rankings of water management scenarios. Analysis of historic data would also be useful to quantify reasonable ranges of variation in Delta inflow and pumping schedules for prospective analyses.

In both modes, graphical outputs are expected to be summarized to easily communicate ecological performance across: 1) multiple focal species, 2) multiple flow years, and 3) at locations in both the upper Sacramento and Delta. Ease of communication would be critical to facilitate comparisons of a complex array of high dimension information across management alternatives. We anticipate that the results from these analyses will highlight key ecological trade-offs associated with alternative water management decisions, and illuminate the effect of uncertainties on DeltaEFT predictions. Results of water management scenarios will be integrated into the Final Report (Task 4)

It will also be critical to consider the effects of uncertainty on the model's relative rankings of water management scenarios. We plan to conduct streamlined sensitivity analyses to evaluate the robustness of DeltaEFT's results to uncertainties. Where possible we expect to consider alternative 1) hypotheses or structural forms of underlying submodels, 2) values of submodel parameters, and/or 3) ranges of natural variation in environmental covariates (e.g., alternative future climate conditions). Such uncertainties would not be evaluated using Monte Carlo based simulations. Rather, we plan to use a discrete approach to evaluating uncertainties, defining a few scientifically defensible alternatives. Because of the volume of information expected, we are choosing ease of interpretation over rigor.

<u>Subtask 2.4: DeltaEFT Public Outreach and Stakeholder Involvement (TNC assisted by ESSA)</u>

DeltaEFT Introduction Meetings

To ensure the DeltaEFT decision analysis tool is relevant and effective, TNC and ESSA expect to make presentations at Delta planning forums such as BDCP and Delta Vision meetings at the beginning of the project to inform stakeholders of the project's goals and objectives. The presentations are expected to demonstrate results and functionality of SacEFT and brief stakeholders on the process for integrating Delta considerations into the to-be-constructed DeltaEFT.

Project Initiation Meeting

TNC and ESSA expect to convene a 2-day DeltaEFT Project Initiation Meeting by the 4th. month of the project (Table 7, Project Timeline). This Initiation Meeting would be held with the project team, key experts, and selected advisors (e.g., members of the DRERIP, Delta Vision, and BDCP processes) to:

1) familiarize key experts and advisors with the end goals and structure of the Project;
2) identify key experts and collaborators from water planning forums to invite to the DeltaEFT Model Design Workshop and subsequently help guide the Project;
3) identify key studies and datasets for review and familiarization; and
4) begin Delta focal species scoping emphasizing development of selection criteria based on the strength of linkages with physical hydrodynamic and water quality forcing.

This Project Initiation Meeting would serve to clarify a number of fundamental scoping issues and set up the definition of logical next steps for the project's ongoing outreach and coordination efforts to the broader stakeholder community. Following this meeting, a summary memo and a project summary document would be written and provided to the meeting attendees.

DeltaEFT Final Presentation

At the end of the project, TNC and ESSA are expected to make a Final Presentation of DeltaEFT results to Delta stakeholders. This would be similar to the Final Presentation made for the Sacramento River Ecological Flows Study TNC held in Sacramento on January 29, 2008. The intended audience of the Final Presentation is the broader Delta stakeholder community interested in Delta management.

DeltaEFT Presentations to Individual Agencies

Towards the end of the project, TNC and ESSA expect to present the final results of the DeltaEFT to targeted Delta water planning forums (e.g., DRERIP, BDCP, Delta Vision) using a series of focused one-on one Gaming Session Presentations. The intent of these one-on-one sessions is to demonstrate the added value of incorporating explicit ecosystem needs into an integrated planning process. These Gaming Session Meetings would provide greater detail than at the Final Presentation allowing for in-depth demonstrations and explanations of the DeltaEFT's functions and applicability. We assume that water planning forum scheduling will allow for these meetings to occur within the proposed project timeline.

A novel aspect of this proposal is its physical and integrated point of view of the mainstem Sacramento River to the Delta. Delta planning processes that are likely to derive significant value from this effort include:

1. Delta Regional Ecosystem Restoration Implementation Plan (including the ERP Implementing Agencies)
2. Delta Vision Process
3. Bay-Delta Conservation Plan
4. Delta Risk Management Strategy
5. Delta Long Term Management Strategy
6. Interagency Ecological Program POD (pelagic organism decline) Study

Online Dissemination of DeltaEFT Products

To disseminate project products and findings to a broad audience, the project team would create the following products available to the public on the web:

1) create a dedicated link on the ERP web site, similar to what has been created for the Sacramento River Ecological Flows Study http://www.delta.dfg.ca.gov/erp/sacriverecoflows.asp.
2) a simple online DeltaEFT Users Guide;
3) the DeltaEFT software install pack and software system documentation.

The DeltaEFT software is expected to be a non-licensed product. The goal would be to distribute the DeltaEFT widely, so that as water planning forums evolve, so do the scenarios and applications of DeltaEFT. Distribution to a broad audience requires thinking ahead about a deployment strategy, a subject already given considerable thought with SacEFT in the Sacramento River Ecological Flows Study (ERP-02D-P61).

Task 2 Deliverables: 1) DeltaEFT Backgrounder Report, 2) DeltaEFT Model Design Workshop, 3) DeltaEFT Design Guidelines (Design Document), 4) DeltaEFT Database and Software, 5) pre and post meeting materials, 6) a dedicated DeltaEFT web page, 7) a demonstration of the DeltaEFT software (at Final Presentation and Agency Presentations), 8) web-accessible software install pack.

Task 3: Project Management and Administration

Subtask 3.1: Internal Project Team Coordination (TNC)

Employing lessons learned from TNC's Sacramento River Ecological Flows Study (ERP-02D-P61), TNC intends to apply best practices to project management to provide the deliverables on schedule. These practices include using time tracking systems to monitor time-spent and project schedule, as well as holding regular internal project team meetings to ensure task clarity, progress and quality. Monthly conference calls are expected to provide status updates, and address issues relating to project planning and schedule alignment. TNC intends to also structure the subcontracting process in a manner that would attempt to maximize project management efficiencies. The project team intends to hold an internal project team scoping meeting at the beginning of the project to begin project coordination.

Subtask 3.2: ERP Directed Action Project Administration (TNC)
TNC would prepare semi-annual and quarterly reports and periodic invoices to the ERP. TNC would provide subcontracts for review and approval.

Task 3 Deliverables: 1) Summary of activities in semi-annual reports, 2) summary of activities in quarterly reports outlining Project Management and Administration activities necessary to completing the overall project, and 3) periodic invoices.

Task 4: Draft and Final Report
Task 4 Deliverables: TNC would provide a Draft Final Report 22 months after the Recipient Agreement is signed. TNC would provide a Final Report 24 months after the Recipient Agreement is signed.

Task 5: Project Close Out
Task 5 Deliverables: TNC would provide a Project Close Out Report 30 days after the Final Report is accepted by the ERP and a Final Invoice 30 to 60 days after the Final Report is approved.

C5. Subcontractors:
TNC expects to subcontract to ESSA Technologies to enhance SacEFT and develop the DeltaEFT. TNC subcontracted with ESSA Technologies to design the SacEFT during TNC's CALFED funded ERP-02D-P61 grant between September 2004 and March 2008. See Part H for a description of ESSA's qualifications. See Exhibit B for subcontractor costs.

C6. Work Schedule
Table 7 provides the project's timeline, summarizing deliverables by task and date.

C7. Special Equipment and Supplies Required
None.

C8. Project Impacts (beneficial or adverse):
The DeltaEFT will extend the application of the Sacramento River Ecological Flows Tool (SacEFT) through the Delta, to produce a single decision support system that integrates seamlessly with existing information (e.g., CALSIM-SRWQM-HEC5Q modeling complex, DSM2, USBR Temperature Model). The tool would not reinvent models but would function as an "eco plug-in" to existing major water-planning software to evaluate ecological outcomes of alternative flow management scenarios.

The DeltaEFT expects to make the best use of existing empirical relationships that relate flow patterns to ecological outcomes. And as an expansion of SacEFT, it is expected to allow for the simultaneous examination of the ecological impacts of water management actions in both the Middle Sacramento River and the Bay Delta area. This linkage is expected to support explorations of intra- and inter-regional ecological tradeoffs and permit researchers and water managers to work together to maximize beneficial outcomes at an unprecedented scale across a major river system.

Although the DeltaEFT is expected to be developed from the current state of the science, it is flexible and can readily incorporate new information as it becomes available. For example, if new studies identify standards that better characterize the well-being of focal species, or if functional relationships are defined that better describe relationships between physical processes and biological responses, the DeltaEFT could be updated. In this way, the DeltaEFT is expected to be highly supportive of adaptive management—it could be used to both design and evaluate flow experiments.

Finally, the DeltaEFT is expected to be designed to provide multiple levels of outcome information. These will range from simplified formats for managers to consider when making flow management decisions, to in-depth displays of detailed functional relationships for review by technical experts interested in the scientific underpinnings of the models.

C9. Stakeholders and Interested Parties:
A novel aspect of this proposal is its physical and integrated point of view of the mainstem Sacramento River to the Delta. Delta planning processes that are likely to derive significant value from this effort include:

Delta Regional Ecosystem Restoration Implementation Plan
Delta Vision Process
Delta Long Term Management Strategy
Delta Risk Management Strategy
Bay-Delta Conservation Plan
Interagency Ecological Program POD Study
Shasta Lake Water Resources Investigation
North-of-Delta Off Stream Storage Investigation

C10. Consistency with CALFED ERP Goals:*
1). Identify Project Applicability to Eco-Elements
Primary: Bay-Delta Hydrodynamics
Secondary: Central Valley Streamflow

2). Identify Project Applicability to ERP Goals and Objectives:

Goal 1. Endangered and Other At-risk Species and Native Biotic Communities.
Objectives 1-4. This project is expected to further develop a tool that allows managers to evaluate how flow management decisions affect the status of a suite of at-risk species of the Sacramento San Joaquin Bay Delta System.

Goal 2. Ecological Processes.
Objectives 1-5. This project is expected to identify those key ecological processes that must be maintained to support viable populations of a broad suite of river and Delta species and the habitats they depend upon.

Goal 4. Habitats.
Objectives 1 and 2. This project is expected to allow existing habitats to be more supportive of native species by characterizing how the flow regime influences the formation, maintenance and suitability of different riverine and Delta habitat types.

Goal 5. Non-native Invasive Species.
Objective 7. This project is expected to reduce the impact and limit the spread of non-native invasive species by prescribing flow regime patterns that support and enhance the recovery of competing native taxa and communities.

3). Identify Project Applicability to Environmental Water Quality Constituents:
Primary: Salinity
Secondary: Sediment

4) Identify Project Applicability to CALFED ERP Stage 1 Milestones.

DELTA AND EASTSIDE DELTA TRIBUTARIES
ECOLOGICAL PROCESSES
Milestone 1. This project directly supports milestone 1 in that it further develops a methodology for evaluating the effect of Sacramento River and Delta flow and hydrodynamic patterns on native aquatic resources.

SACRAMENTO BASIN
ECOLOGICAL PROCESSES
Milestone 58. This project is expected to improve our understanding of how flow management decisions influence Chinook salmon and steelhead spawning by further developing the weighted useable area indicator (to account for differences in the quantity, grain-size and relative depth of gravels), and adding a redd superimposition indicator.

STRESSORS REDUCTION
Milestone 66. This project further develops a methodology for defining adequate streamflows within the Sacramento Basin and Delta for Chinook salmon, green sturgeon and a suite of Delta species. The DeltaEFT tool is expected to provide a means for distinguishing among alternative flow regimes and identifying flow hazard thresholds.

C11. Related Projects*

1). If this project is related to another restoration project, identify other projects by number and program (e.g. CALFED, CVPIA), and if CALFED, identify that relationship by category:

Previous ERP Funding:
TNC received $1,500,000 from CALFED ERP (grant ERP-02D-P61 in 2004) for the Sacramento River Ecological Flows Study, of which $377,499 in grant funds was allocated to developing the SacEFT. TNC and ESSA also contributed an additional $136,000 in private funds to the SacEFT development. SacEFT's total budget was $513,499.

Previous ERP funding specifics (grant ERP-02D-P61):

Project Title: Implementing a Collaborative Approach to Quantifying Ecosystem Flow Regime Needs for the Sacramento River (Sacramento River Ecological Flows Study)
CALFED ERP Contract Management Organization: GCAP Services, Inc.
Amount Funded: $1,500,000
Award Term: 2/17/04 – 3/31/08
Lead Organization: The Nature Conservancy
Project Number: ERP−02D−P61

PART D. Budget Summary

D1. Budget

See Exhibit A for budget details.

Task 1: SacEFT Refinements and Application	$525,719
Task 2: DeltaEFT Model Development to Evaluate Flow Requirements for Delta Species	$1,021,029
Task 3: Project Management and Administration	$135,604
Task 4: Draft and Final Report	$31,662
Task 5: Project Close Out	$1,519
TOTAL	**$1,715,533**

PART E. Project Location Information

E1. Project Location:
Task 1: SacEFT The Sacramento River between Shasta Dam and Colusa

Task 2: DeltaEFT The San Joaquin-Sacramento Bay Delta.

E2. County or Counties Project is Located in:
Task 1: SacEFT
Shasta, Tehama, Glenn, Butte, and Colusa counties.

Task 2: DeltaEFT
El Dorado, Yolo, Sacramento, Amador, Solano, Calaveras, San Joaquin, Contra Costa, Stanislaus, and Alameda counties.

E3. ERP Eco-Region, Eco-Zone, and Eco-Unit Project is Located In:*
This is a Program-wide project targeting the Sacramento Valley and Delta ecoregions. By task, the ecogegions targeted are:

Task 1: SacEFT
Sacramento Valley ecoregion

Task 2: DeltaEFT
Delta ecoregion

E4. Project Centroid:
Task 1: SacEFT
Latitude: 39.45524
Longitude: -121.59470

Task 2: DeltaEFT
Latitude: 38.117125
Longitude: −121.57085

E5. Project Map:
See Figure 8.

E6. Digital Geographic File:*
See Figure 16.

E7. Congressional District:
Task 1: SacEFT
congressional district 2

Task 2: DeltaEFT
portions of congressional districts 1, 3, 4, 5, 7, 10, 11, 18, 19

PART F. Environmental Information

F1. CEQA/NEPA Compliance

NO NEPA OR CEQA DOCUMENTATION WILL BE REQUIRED.

1). Will this project require compliance with CEQA, NEPA, both, or neither:* Neither.

2). Is your project covered by either a Statutory or Categorical Exemption under CEQA or a Categorical Exclusion under NEPA:*

3). If your project requires additional CEQA/NEPA analysis, please indicate which type of documents will be prepared:

- Initial Study/Negative Declaration
- Environmental Assessment/FONSI
- EIR/CEQA Findings of Fact
- EIS/ Record of Decision

4). If the project will require CEQA and/or NEPA compliance, identify the lead agency(ies).

- CEQA Lead Agency:
- NEPA Lead Agency (Must be a Federal Agency):

5). If your project is not covered under items 2 or 3, and you checked no to question 1, please explain why compliance is not required for the actions in this proposal:

6). If the CEQA/NEPA process is not complete, please describe the estimated timelines for the process and the expected date of completion:

7). If the CEQA/NEPA document has been completed, what is the name of the document and provide State Clearinghouse number:

F2. Environmental Permitting and Approvals

NO PERMITS ARE REQUIRED.

Please indicate what permits or other approvals may be required for the activities contained in your proposal and which have already been obtained. Please indicate all that 1) are needed, and 2) if needed, have been obtained:

1). 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

2) State Permits and Approvals:
- Scientific collecting permit
- CESA compliance: 2081.1; Take authorization
- CESA compliance: 2080.1; Consistency determination
- CESA compliance: NCCP
- 1602: Lake or Streambed Alteration Permit
- CWA 401 certification
- Coastal development permit
- Reclamation Board approval
- Notification of DPC or BCDC
- Other

3) Federal Permits and Approvals:
- ESA compliance Section 7 consultation
- ESA compliance Section 10 permit
- Rivers and Harbors Act
- CWA 404
- Other

PART G. Land Use Questionnaire

THIS PROJECT DOES NOT INVOLVE LAND USE CHANGES.

G1. Land Use Changes

1). Do the actions in the proposal involve physical changes in the land use, or potential future changes in land use (Yes/No): NO. THIS IS A RESEARCH/PLANNING PROPOSAL.

- If yes, describe what actions will occur on the land involved in the proposal.
- If no, explain what type of actions are involved in the proposal (i.e., research only, planning only).

2). How many acres of land will be subject to a land use change under the proposal:

3). Is the land subject to a land use change in the proposal currently under a Williamson Act contract (Yes/No): No.

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

5). Does the applicant propose any modifications to the water right or change in the delivery of the water (Yes/No): NO.

- If yes, please describe the modifications or changes:

G2. Current Land Use and Zoning

1). What is the current land use of the area subject to a land use change under the proposal:

2). What is the current zoning and general plan designation(s) for the property:

3). How is the land categorized on the Important Farmland Series (IFL) maps (published by the California Department of Conservation):

G3. Land Acquisition

1). Will the applicant acquire any land under the proposal, either in fee or through a conservation easement (Yes/No): NO

- If yes, describe the number of acres that will be acquired and whether the acquisition will be of fee title or a conservation easement:
- Total number of acres to be acquired under proposal:
- Number of acres to be acquired in fee:
- Number of acres to be subject to conservation easement:

2). For land acquisitions (fee title or easements), will existing water rights be acquired (Yes/No):

G4. Land Access

1). Will the applicant require access across public or private property that the applicant does not own to accomplish the activities in the proposal (Yes/No): NO

- If yes, attach written permission for access from the relevant property owner(s).

PART H. Qualifications

H1. Qualifications

The Nature Conservancy (TNC) is a nonprofit corporation working internationally to preserve the plants, animals, and natural communities that represent the diversity of life on Earth by protecting the lands and waters they need to survive. Founded in 1951, TNC and its one million members have safeguarded more than 11.6 million acres in the United States. TNC's California program, headquartered in San Francisco, has 110,000 members and has protected nearly one million acres in the state of California. TNC employs an integrated conservation framework called "Conservation By Design" to fulfill its long-term vision and achieve its goals. Conservation by Design directs the organization to systematically identify the array of places around the globe that embrace the full spectrum of the Earth's natural diversity; to develop the most effective strategies to achieve tangible, lasting results; and to work collaboratively to catalyze action at a scale great enough to ensure the survival of entire ecosystems (Conservation by Design, 2001).

The Nature Conservancy's Sacramento River Project has been headquartered in Chico, California since 1989. TNC's Sacramento River Project has a proven track record, having helped protected more than 18,000 acres of riparian land within the Sacramento River Conservation Area, having restored more than 4,500 of land along the Sacramento River to riparian habitats, and having partnered on numerous research and study investigations to build the information base guiding management actions on the river.

Ryan Luster, Program Manger - Restoration, TNC, will be the Project Manager. Mr. Luster has degrees from Beloit College (B.A. Environmental Biology 1994) and Utah State University (M.S. Range Science 2001). Mr. Luster has worked in the natural resource management field for 12 years. Since 2001, he has applied a foundation of ecology and ecosystem restoration to large-scale restoration planning and integrated floodplain management projects on the Sacramento River with partners such as California Bay-Delta Authority, U.S. Fish and Wildlife Service, CA Departments of Fish and Game and Parks and Recreation, and the U.S. Army Corps of Engineers. Mr. Luster has received and successfully administered grants from NOAA, USFWS, CBDA, WCB, and private foundations. Mr. Luster is currently managing three Ecosystem Restoration Program grants for TNC (ERP-02-P16D, ERP-02D-P61, ERP-02D-P65) and works closely with GCAP Services to ensure that these ERP grants are successfully managed through completion.

Mike Roberts, Program Director – Hydrology, TNC, has degrees from Rutgers University (B.S. Natural Resource Management 1990) and Utah State University (M.S. Watershed Science 1999). Mr. Roberts has worked in the natural resource management field since 1990, including 14 years of evaluation and restoration of aquatic and riverine ecosystems. His experience includes work on a number of California, Idaho, and Utah rivers, ranging from large alluvial rivers to small mountain streams, and eastern aquatic and wetland systems. The focus of his Master's degree at Utah State University was geomorphic and hydrologic influences on riparian forest ecosystems. Prior to his graduate work, he focused on the implementation, planning, and management of riparian forest restoration projects on The Nature Conservancy's Kern River Preserve and the Sacramento River Project. For the last seven years, he has applied a foundation of hydrology and geomorphology to large–scale restoration planning and integrated floodplain management on the Sacramento River in

California. Much of this work entails collaboration with a wide variety of stakeholders to develop multiple use and benefit projects.

Anthony Saracino, **Director - California Freshwater Program, TNC**, has degrees from California State University, Fresno (B.A. Geology) and Colorado State University (M.S. Geology). Mr. Saracino focuses on the implementation of California statewide water policies in support of TNC projects. He also works on issues related to California Bay−Delta Authority planning efforts and is consulting on a number of TNC efforts, including groundwater planning in the watersheds of the Cosumnes and Klamath Rivers. He is a widely recognized expert in water management and the author of numerous papers and presentations on water policy, including California Groundwater Management, a reference and planning guide that he co−authored. He was a founding member of the board and past president of the Groundwater Resources Association of California and is currently on the Board of Directors of the Water Education Foundation. Before coming to TNC in 2005, Mr. Saracino was Senior Principal for Schlumberger Water Services. Prior to that, he was the founding principal of Saracino−Kirby−Snow, a water resource planning and management firm; in that position he consulted with public and private clients on water resource management issues including conjunctive use, groundwater banking, and protecting the quality of groundwater. Mr. Saracino is registered by the State of California as a Professional Geologist, Certified Hydrogeologist, and Certified Engineering Geologist.

Campbell Ingram, Program Manager - California Freshwater Program, TNC, has a degree from Humboldt State University (B.S. Natural Resource Planning 1991) and completed all but thesis at the University of Texas for a M.S. in Terrestrial Ecology. Mr. Ingram has worked in the natural resource management field for 18 years. For the past years, he been associated with the CALFED and Central Valley Project Improvement Act programs managing many large scale, water focused, restoration projects. For the proposed work, Mr. Ingram will assist with stakeholder coordination and outreach.

Dr. Maurice Hall, Hydrologist and Water Resources Engineer- California Freshwater Program, TNC, received his B.S. in chemical engineering from the University of Tennessee, Chattanooga, and his Ph.D. in watershed sciences from Colorado State University. Dr. Hall's work with TNC focuses on improving understanding of the relationship of integrated water management and hydrology with function of water-dependent ecosystems. Before joining TNC, Dr. Hall was a senior engineer/scientist and project manager with CH2M HILL and EARTHWORKS Restoration, Inc., a native habitat restoration firm, working on numerous watershed planning, stream restoration, and water resources projects in California and Oregon. Prior to consulting Dr. Hall was an assistant professor in Geology at Radford University in Virginia, where he taught courses in watershed management, water quality, and groundwater modeling. Dr. Hall is a registered Professional Engineer (Civil) in California.

Dr. Greg Golet, Ecoregional Ecologist, TNC, has degrees from Bates College (B.S. Biology 1987), and the University of California, Santa Cruz (M.S. Marine Sciences 1994, Ph.D. Biology 1999). Dr. Golet was a wildlife biologist for the U.S. Fish and Wildlife Service before joining The Nature Conservancy's Sacramento River Project as senior ecologist. He has 17 refereed publications, and has extensive experience coordinating and conducting research in California and Alaska. For the Project, Dr. Golet will manage the formulation of focal species conceptual models and liaise with external biologists and agencies to ensure our models are scientifically sound.

ESSA Technologies, Ltd. is an innovative environmental consulting company headquartered in Vancouver, Canada. Established in 1979, ESSA has grown to become a world leader in the field of environmental consulting and decision support. It has achieved this position by consistently providing clients with the information they need to make improved decisions for a more sustainable future. Our experience includes over 1,500 projects in 33 countries around the world.

The key to our success is a unique and rich combination of scientific expertise, advanced tools for systems analysis, and innovative communications techniques. We work jointly with our clients on ideas, tools, and provide disciplinary expertise; our dedicated and knowledgeable team of scientists fills a niche in the consulting field - we work together in interdisciplinary teams with our clients, applying quantitative methods and qualitative concepts to resolve complex natural resource and environmental management problems.

David Marmorek, President, ESSA Technologies Ltd, is an aquatic ecologist, and an Adjunct Professor at the School of Resource and Environmental Management at Simon Fraser University. His role in this project will be as a senior advisor and facilitator. Mr. Marmorek has spent the last 26 years combining his technical knowledge (simulation modeling, aquatic ecology, experimental design, adaptive management) with his skills and experience in the human dimension (facilitation, team leadership) to tackle complex environmental problems. In the last decade, he focused on applying decision analysis and adaptive management to the design of strategies for flow management, habitat restoration and monitoring in California (Clear Creek, Trinity River, Sacramento River, San Joaquin River), the Columbia Basin (U.S. and Canadian portions), and British Columbia (Cheakamus and Okanagan Rivers). He is the author of over 20 peer–reviewed publications, and over 100 technical reports.

Clint Alexander, Sr. Systems Ecologist / Technical Architect, ESSA Technologies Ltd, would serve as ESSA project manager and technical lead for the SacEFT modeling component of the project. Mr. Alexander is an integration specialist focused on applying appropriate methods for integrating biological, physical, and economic components of environmental problems into comprehensive decision oriented advice. He specializes in the use of quantitative methods for accounting for uncertainties (e.g., probabilistic simulation modeling, statistics, decision analysis). Focal problems for these methods have been large-scale watershed restoration programs and water management related trade-off evaluations for operational changes at dams and reservoirs in Western North America. Since joining ESSA, Mr. Alexander has served as project manager or technical lead for numerous decision support projects, including SacEFT. He has over 11 years of experience in simulation modeling, environmental information system design and trade-off analysis. In addition, Mr. Alexander is an experienced facilitator of stakeholder groups, where he emphasizes the importance of clarity in design and integrating the expert knowledge of client's working in specialized areas. Given his ability to serve as facilitator, data analyst, model developer and programmer he is uniquely positioned to perform and manage staff working in a variety of roles. Mr. Alexander holds a B.Sc. in Ecology and Environmental Biology from the University of British Columbia and a Masters in Resource and Environmental Management (MRM) from Simon Fraser University.

Donald Robinson, Senior Systems Ecologist, ESSA Technologies Ltd., would assist with workshop facilitation, model design, and model application. Over the last twenty years, Mr. Robinson has developed and applied many quantitative tools to support environmental decision-making on fish survival and habitat suitability, forest growth and yield, and forest ecosystem effects of insects, disease, and fire. Over the past two years Don has been active as part of the team designing and developing SacEFT. In this work he co-facilitated scientific workshops to develop and clarify hypotheses about physical process-habitat-focal species functional relationships, designed mathematical models and database components for the four chinook races, steelhead trout and green sturgeon; and built the part of the model that links output from a gravel transport model (TUGS) with the habitat substrate requirements of spawning salmonids. As part of the SacEFT team, Don was responsible for processing, filtering, checking and loading all physical and spatial datasets, including flow and temperature scenario data at river gauging points, simulated substrate composition from the TUGS model, and bank migration output from a meander migration model. Mr. Robinson has a B.Sc. and M.Sc. in Zoology from the University of British Columbia with an additional year of graduate studies at Cornell University. He is a Registered Professional Biologist with the BC College of Applied Biology and in 2007 received a commendation award from the USDA Forest Service for his many contributions to improving the ecological realism of the Forest Vegetation Simulator (FVS).

David Carr, Senior Systems Analyst, ESSA Technologies Ltd. would help to design and implement improvements to the existing SacEFT branch, and help to create the new DeltaEFT branch. Mr. Carr played a major role in the software development of SacEFT, including: programming many of the performance measure models; applying his SQL expertise, algorithm and optimization skills for the many large and different datasets; and drawing upon his user interface/design experience to generate performance measure output both within the application and using MS Excel as a cost-effective tool. David Carr's background is firmly rooted in software engineering and simulation, with over 15 years in application development. Prior to ESSA, he has improved and built upon a sophisticated set of orthopaedic CAD/CAM tools, and was a team lead developing a highly complex ship navigation simulator. At ESSA, he has been involved in nearly every software project, including user needs analysis and specification, design and implementation of new applications, improving existing tools, product release, installation and deployment, system documentation, training and maintenance. He excels at improving the quality and accuracy in a design, through methodical problem solving and strong math and logic skills. Mr. Carr earned his Honours B.A.Sc. in Systems Design Engineering at the University of Waterloo, Canada.

Leonardo Frid, **Senior Systems Ecologist, ESSA Technologies Ltd.** will assist with SacEFT revisions and improvements. Mr. Frid is a registered professional biologist and systems ecologist with over ten years experience in ecological research and simulation modeling. Since beginning work with ESSA Mr. Frid has worked on the development of simulation models for strategic planning in managing landscape level disturbance regimes, invasive species, and the effects of alternative flow regimes on fish habitat and survival. Recently he has worked with The Nature Conservancy in Nevada and Utah to model fire regimes and the outcome of alternative restoration and prevention scenarios for areas invaded by cheatgrass; with The Nature Conservancy of Montana modeling alternative landscape level management strategies for knapweed and leafy spurge; with Parks Canada to conduct a decision analysis of alternative strategies and budgets for the restoration of areas invaded by crested wheatgrass in Grasslands National Park; and with The Nature Conservancy of California developing models of salmonid survival and habitat on the Sacramento river as part of the SacEFT project. His scientific skills include experimental design, field sampling and simulation modeling of terrestrial and aquatic ecosystems. He has worked on and published studies on rare and endangered amphibians, insect population dynamics, plant herbivore interactions, landscape simulation models and biological control. Mr. Frid has also participated and led numerous workshop groups covering topics ranging from technical and scientific issues, to strategic planning. He has delivered various courses training participants in the use of simulation modeling tools for decision support. He holds a B.Sc. in conservation biology and a M.Sc. in zoology from the University of British Columbia. His M.Sc. research focused on simulating the interaction between weather patterns and the population dynamics of forest insects.

Literature Cited

Alexander, C. A. D., C. N. Peters, D. R. Marmorek, P. Higgins. 2006. A decision analysis of flow management experiments for Columbia River mountain whitefish (*Prosopium williamsoni*) management. Canadian Journal of Fisheries and Aquatic Science. Sci. 63: 1142-1156.

Armor, C. R., R. Baxter, M. Chotkowski, P. Coulston, B. Herbold, A. Mueller-Solger, M. Nobriga, T. Sommer. 2005. Interagency Ecological Program 2005 Workplan to Evaluate the Decline of Pelagic Species in the Upper San Francisco Estuary.

Bennet, W. A. 2005. Critical Assessment of th the Delt e Delta Smelt Population in the San Francisco Estuary, California. San Francisco Estuary and Watershed Science Vol. 3, Issue 2 [September 2005], Art. 1.

Bertness, Mark D., S. M. Bollens, J. H. Cowan, Jr., R. T. Kneib, P. MacCready, R. A. Moll, P. E. Smith, A. R. Solow, R. B. Spies. 2005. REVIEW PANEL REPORT (19 Dec 2005) San Francisco Estuary Sacramento-San Joaquin Delta Interagency Ecological Program on Pelagic Organism Decline. Prepared for IEP Agency Directors.

Collier, M., R. H. Webb, and J. C. Schmidt. 1996. Dams and rivers: a primer on the downstream effects of dams. U. S. Geological Survey Circular 1126.

Culberson, S. D., C. B. Harrison, C. Enright, M. L. Nobriga. 2004. Sensitivity of Larval Fish Transport to Location, Timing, and Behavior Using a Particle Tracking Model in Suisun Marsh, California. Pages 257-267 *in* F. Feyrer, L. R. Brown, R. L. Brown, and J. J. Orsi, editors. Early Life History of Fishes in the San Francisco Estuary and Watershed. American Fisheries Society, Bethesda MD.

DWR. 2005. DSM2 Delta Simulation Model II, California Department of Water Resources, Modeling Support Branch, Sacramento, CA, http//modeling.water.ca.gov/delta/models/dsm2/.

DWR and U.S. Bureau of Reclamation, Mid-Pacific Region. 1994. Effects of the Central Valley Project and State Water Project on delta smelt and Sacramento splittail. Sacramento, California. 230 pp.

ESSA Technologies Ltd. 2005. Sacramento River Decision Analysis Tool: Workshop Backgrounder. Prepared for The Nature Conservancy, Chico, CA. 77 pp. http://www.delta.dfg.ca.gov/erp/docs/sacriverecoflows/Task%203_SacEFT%20Backgrounder%20Report.pdf

ESSA Technologies Ltd. 2007. Sacramento River Ecological Flows Tool (SacEFT): Design Guidelines. Prepared for The Nature Conservancy, Chico, CA.75 pp http://www.delta.dfg.ca.gov/erp/docs/sacriverecoflows/Task%203_SacEFT%20Design%20Guidelines.pdf

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

Gardali, T., A. L. Holmes, S. L. Small, N. Nur, G. R. Geupel, G. H. Golet. 2006. Abundance Patterns of Landbirds in Restored and Remnant Riparian Forests on the Sacramento River, California, U.S.A. Restoration Ecology Vol. 14, No. 3, pp. 391–403.

Golet G. H., M. D. Roberts, R. A. Luster, G. Werner, E. W. Larsen, R. Unger, G. G. White. 2006. Assessing Societal Impacts When Planning Restoration of Large Alluvial Rivers: A Case Study of the Sacramento River Project, California. Environmental Management Vol. 37, No. 6, pp. 862–879

Hammond, J.S., R.L. Keeney, and H. Raiffa. 1999. Smart Choices: A practical guide to making better decisions. Harvard Business School Press. Boston, Ma.

Jassby A. D., T. M. Powell. 1994. Hydrodynamic influences on interannual chlorophyll variability in an estuary: upper San Francisco Bay-Delta (California,U.S.A.). Estuarine, Coastal, and Shelf Science 39:595-618.

Jones, M. L., R. G. Randall, D. Hayes, W. Dunlop, J. Imhof, G. Lacroix, and N.J.R. Ward. 1996. Assessing the ecological effects of habitat change: moving beyond productive capacity. Canadian Journal of Fisheries and Aquatic Sciences 53(Suppl. 1): 446–457. 21

Kimmerer, W.J. 2002a. Effects of freshwater flow on abundance of estuarine organisms: physical effects or trophic linkages? Marine Ecology Progress Series 243:39-55.

Kimmerer, W.J. 2002b. Physical, biological, and management responses to variable freshwater flow into the San Francisco Estuary. Estuaries 25:1275-1290.

Kimmerer, W. J. 2004. Open water processes of the San Francisco Estuary: from physical forcing to biological responses. San Francisco Estuary and Watershed Science [online serial]. Vol. 2, Issue 1 (February 2004), Article 1.

Kimmerer, W. J., J. H. Cowan Jr, L. W. Miller, K. A. Rose. 2000. Analysis of an estuarine striped bass population: Influence of density-dependent mortality between metamorphosis and recruitment. Canadian Journal of Fisheries and Aquatic Sciences 57:478-486.

Kimmerer, W., B. Mitchell, and A. Hamilton. 2001a. Building models and gathering data: Can we do this better? Pages 305-318 in R.L. Brown, editor. Contributions to the Biology of Central Valley Salmonids: Fish Bulletin 179, Vol. 2. State of California, The Resources Agency, Department of Fish and Game, Sacramento, CA.

Kimmerer, W.J., J.H. Cowan, Jr., L.W. Miller, and K.A. Rose. 2001b. Analysis of an estuarine striped bass population: effects of environmental conditions during early life. Estuaries 24:557- 575.

Kimmerer, W. J., Murphy DD, Angermeier PL. 2005. A landscape-level model for ecosystem restoration in the San Francisco Estuary and its watershed. San Francisco Estuary and Watershed Science. Vol. 3, Issue 1 (March 2005), Article 2.

Kimmerer, W.J. and Nobriga, M.L. *in press*. Investigating dispersal in the Sacramento-San Joaquin Delta using a particle tracking model.

Ligon F. K., W. E. Dietrich, and W. J. Trush. 1995. Downstream ecological effects of dams, a geomorphic perspective. Bioscience 45:183-192.

Mahoney, J. M., and S. B. Rood. 1998. Streamflow requirements for cottonwood seedling recruitment-an integrative model. Wetlands 18:634-645.

Marmorek, D.R. and I.J. Parnell. 2002. Cheakamus River Water Use Plan Consultative Committee Report. Prepared for the Cheakamus River Water Use Plan Consultative Committee. Prepared by ESSA Technologies Ltd. A BC Hydro project. pp 91 + appendices.

Marmorek, D. R. and C. Peters. 2001. Finding a PATH towards scientific collaboration: insights from the Columbia River Basin. Conservation Ecology 5(2): 8

Mount, J., R. Twiss, and R.M. Adams. 2006. The Role of Science in the Delta Visioning Process: A report of the Delta Science Panel of the CALFED Science Program. Public Review Draft.

Monsen, N.E. 2001. A study of sub-tidal transport in Suisun Bay and the Sacramento-San Joaquin Delta, California, PhD dissertation. Stanford University.

Murray, C. C., D. R. Marmorek. 2003. Adaptive Management and Ecological Restoration. *In* Ecological Restoration of Southwestern Ponderosa Pine Forests. P. Friederici, ed. Ecological Restoration Institute, Flagstaff, AZ. p. 417-428.

Murray, C., and D. Marmorek. 2003. Chapter 24 - Adaptive Management and Ecological Restoration. Pages 417-428 in P. Freiderici. Ecological Restoration of Southwestern Ponderosa Pine Forests. Island Press. Washington.

Oreskes, N., K. Schrader-Frechette, and K. Belitz. 1994. Verification, validation, and confirmation of numerical models in the earth sciences. Science 263: 641-646.

Peters, C. N. and Marmorek, D. R. 2001. Application of decision analysis to evaluate recovery actions for threatened Snake River spring and summer chinook salmon (*Oncorhynchus tshawytscha*). Can. J. Fish. Aquat. Sci. 58(12):2431-2446. 22

Peters, C.N. and Marmorek, D.R. 2001. Application of decision analysis to evaluate recovery actions for threatened Snake River spring and summer chinook salmon (Oncorhynchus tshawytscha). Can. J. Fish. Aquat. Sci. 58(12):2431-2446.

Peterson, D. H., D. R. Cayan, J.F. Festa, F. H. Nichols, R. A. Walters, J. V. Slack, S. E. Hager, L. E. Schemel. 1989. Climate variability in an estuary: effects of riverflow on San Francisco Bay. In: Peterson DH, editor. Aspects of climate variability in the Pacific and the western Americas. Washington: AGU. Pp. 419-442.

Peterson, D. H., J. T. Conomos, W. W. Broenkow, P.C. Doherty. 1975. Location of the non-tidal current null zone in northern San Francisco Bay. Estuarine and Coastal Marine Science 3:1-11.

Poff, L. N., J. D. Allan, M. B. Bain, J. R. Karr, K. L. Prestegaard, B. D. Richter, R. E. Sparks, and J. C. Stromberg. 1997. The natural flow regime, a paradigm for conservation and restoration. Bioscience 47:769-784.

Poff, L.N., and J.V. Ward. 1990. Physical habitat template of lotic systems: recovery in the context of spatiotemporal heterogeneity. Environmental Management 14: 629-645.Resh, V.H., Hildrew, A.G., Statzner, B., and Townsend, C.R. 1994. Theoretical habitat templates, species traits and species richness: a synthesis of long term ecological research on the upper Rhone river in the context of concurrently developed ecological theory. Freshwater Biology, 31, 539-554.

Pringle, C. M., M. C. Freeman, B. J. Freeman. 2000. Regional effects of hydrologic alterations on riverine macrobiota in the New World: tropical-temperate comparisons. Bioscience 50:807-823.

Richter, B. D., Braun, D.P. Mendelson, M.A., and Master, L.L. 1997. Threats to imperiled freshwater fauna. Conservation Biology. 11:1081-1093.

Richter, B. D. and H.E. Richter. 2000. Prescribing flood regimes to sustain riparian ecosystems along meandering rivers. Conservation Biology 14:1467-1478.

Richter, B. D., Mathews R., Harrison D. L., Wigington R. 2003. Ecologically Sustainable Water Management: Managing River Flows for Ecological Integrity. Ecological Applications 13(1): 206-224

Rood, S. B., A. R. Kalischuk, and J. M. Mahoney. 1998. Initial cottonwood seedling recruitment following the flood of the century of the Oldman River, Alberta, Canada. Wetlands 18:557-570.

Rood S. B., C. R. Gourley, E. M. Ammon, L. G. Heki, J. R. Klotz, M. L. Morrison, D. Mosley, G. G. Scoppettone, S. Swanson, P. L. Wagner. 2003. Flows for Floodplain Forests: A Successful Riparian Restoration. BioScience Vol. 53 No. 7.

Stanford, J. A., J. V. Ward, W. J. Liss, C. A. Frissel, R. N. Williams, J. A. Lichatowich, and C. C. Coutant. 1996 A general protocol for restoration of regulated rivers. Regulated Rivers: Research and Management 12:392-413

Stevens, D. E., D. W. Kohlhorst, L. W. Miller, D. W. Kelley. 1985. The decline of striped bass in the Sacramento-San Joaquin Estuary, California. Transactions of the American Fisheries Society 114:12-30.

Stillwater Sciences. 2007. Linking biological responses to river processes: Implications for conservation and management of the Sacramento River—a focal species approach. Final Report. Prepared by Stillwater Sciences, Berkeley for The Nature Conservancy, Chico, California. (http://www.delta.dfg.ca.gov/erp/docs/sacriverecoflows/Task%201_Linkages%20Report.pdf)

Trinity River Restoration Program and ESSA Technologies Ltd. 2004. Conceptual models and Hypotheses for the Trinity River Restoration Program. 133 pp.

The Nature Conservancy. 2001. Conservation by Design.

The Nature Conservancy, Stillwater Sciences, and ESSA Technologies. 2008. Sacramento River Ecological Flows Study Final Report (including Appendices A-F http://www.delta.dfg.ca.gov/erp/sacriverecoflows.asp). Prepared for The CALFED Ecosystem Restoration Program.

Wilbur, R. 2000. Validation of dispersion using the particle tracking model in the Sacramento-San Joaquin Delta. Master's Thesis. University of California, Davis.

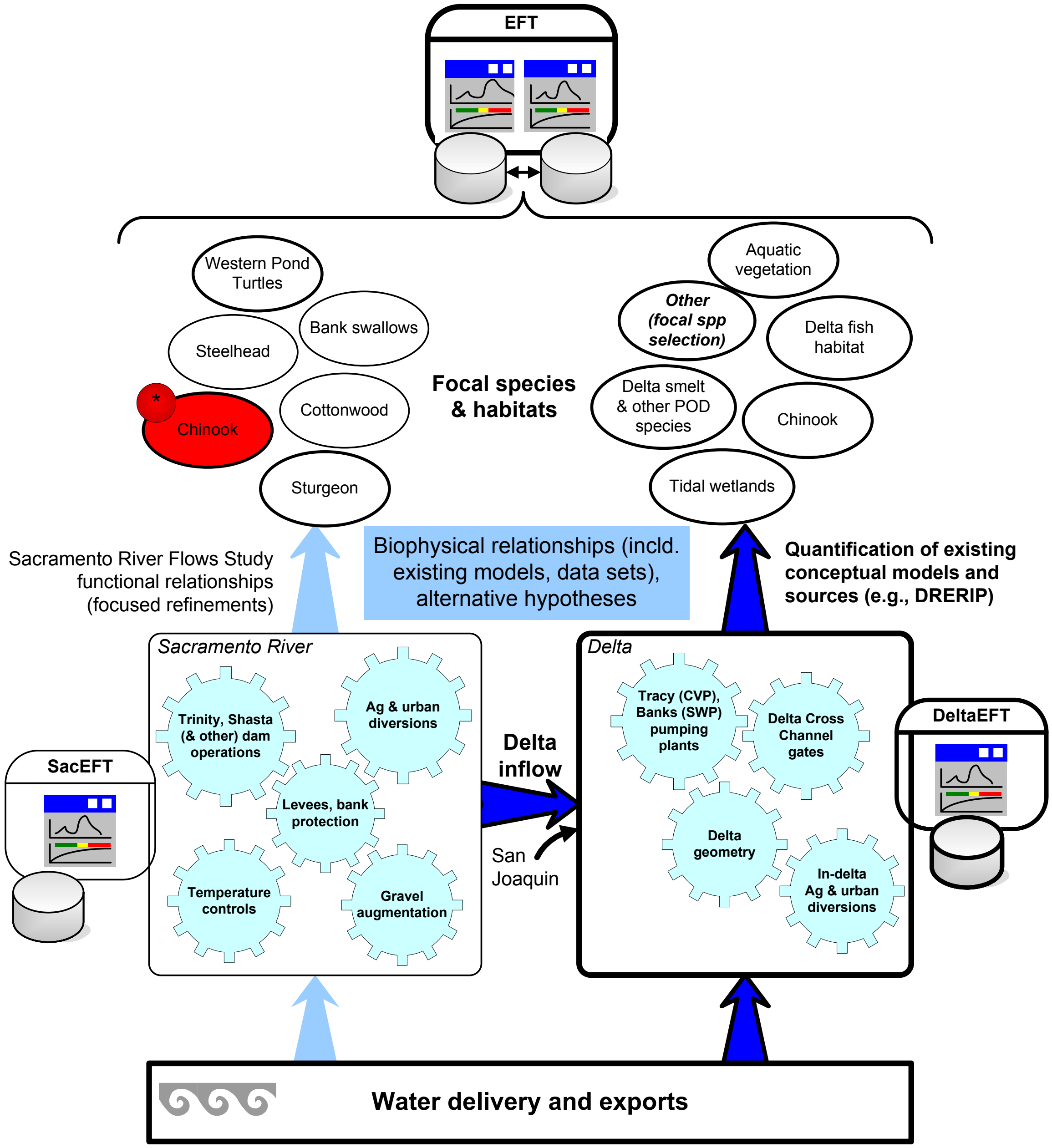


Figure 1: "50,000 foot" conceptual model for Sacramento River branch and Delta branch within the decision analysis tool software structure. The process begins with analysis of management actions as reflected by CALSIM II and other model data used for water management planning. This information feeds into "cogs" representing these management actions.. In SacEFT, all focal species have defined conceptual models (box-arrow diagrams describing hypothesized cause-effect linkages). SacEFT's other focal species specific conceptual models can be found in ESSA (2005, 2007). As done successfully in the Sacramento Flows project, this project would leverage existing research and expertise to develop quantitative and qualitative models at a level of detail appropriate for the Delta extension. Results from both branches of software are then reflected through a variety of output options within the decision analysis software architecture housing both branches.

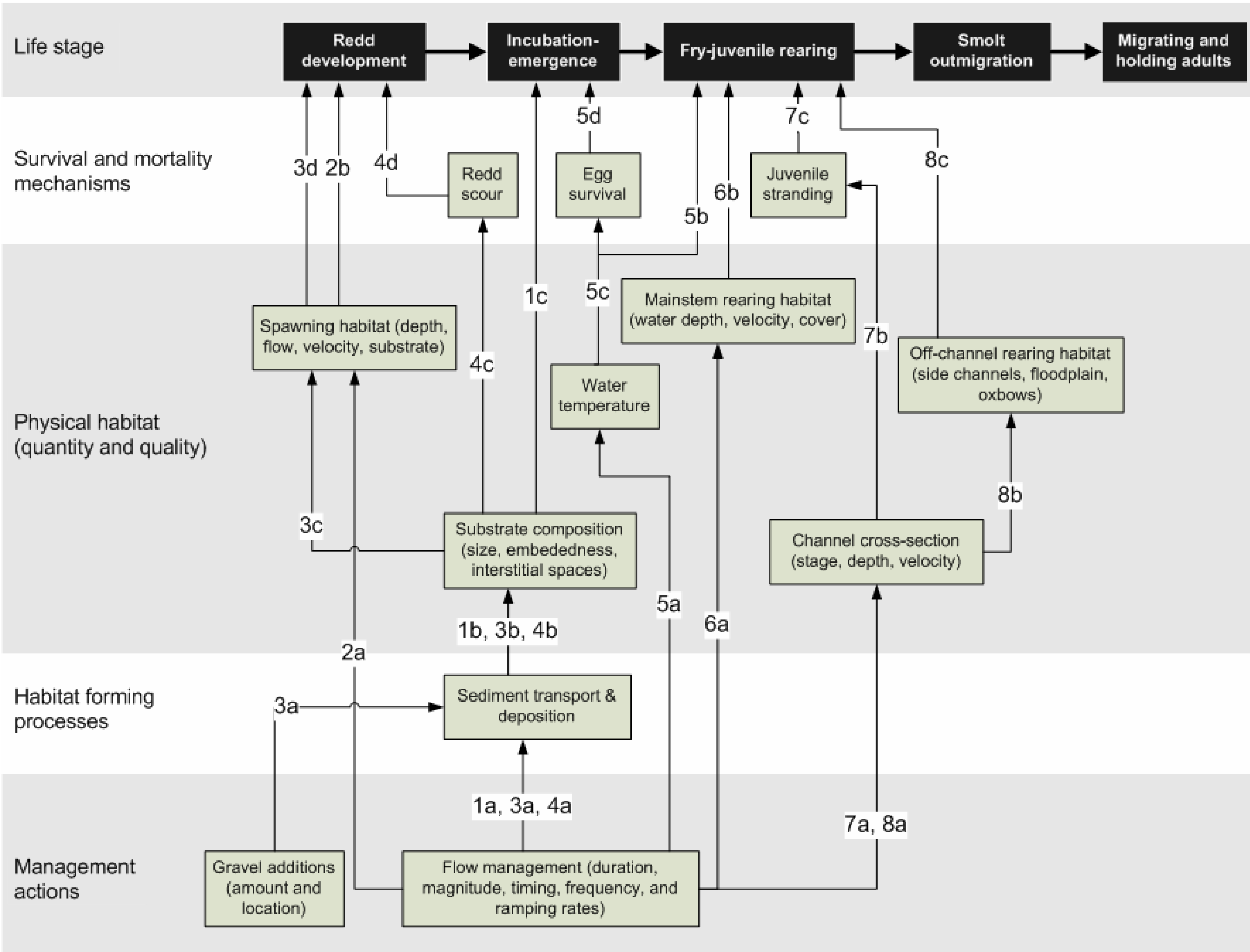
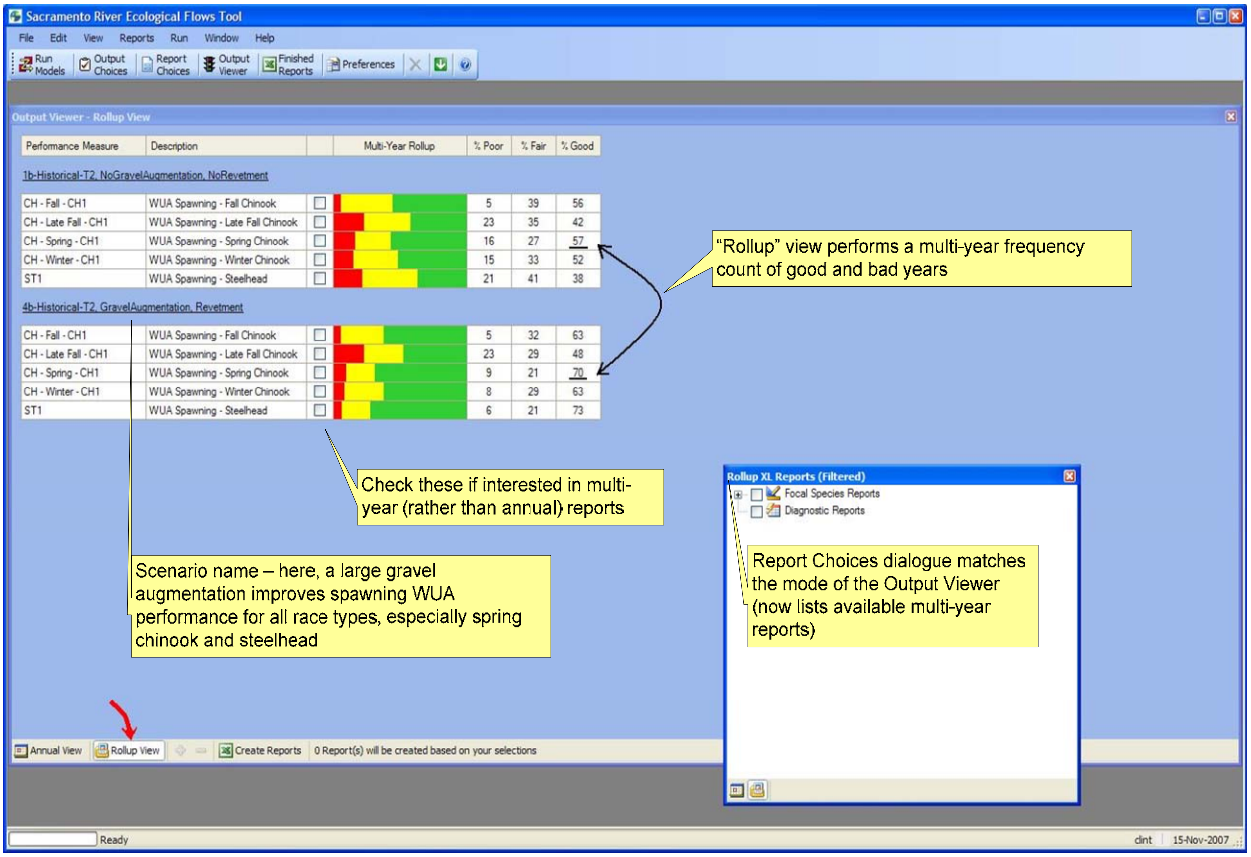


Figure 2: Conceptual diagram representing the linkages between management actions and important life stages for chinook salmon and steelhead trout, as mediated by changes in habitat forming processes, physical habitats, and survival or mortality mechanisms. Pathways represent those with the greatest potential to be quantified using available (or new) models, functional relationships, and/or data. Numbers represent pathways linking management actions to performance measures of interest. Letters represent individual and quantifiable linkages along the pathway. For more details, those interested are directed to ESSA (2005).



Performance Measure	Description	% Poor	% Fair	% Good
1b-Historical-T2, NoGravelAugmentation, NoRevetment				
CH - Fall - CH1	WUA Spawning - Fall Chinook	5	39	56
CH - Late Fall - CH1	WUA Spawning - Late Fall Chinook	23	35	42
CH - Spring - CH1	WUA Spawning - Spring Chinook	16	27	57
CH - Winter - CH1	WUA Spawning - Winter Chinook	15	33	52
ST1	WUA Spawning - Steelhead	21	41	38
4b-Historical-T2, GravelAugmentation, Revetment				
CH - Fall - CH1	WUA Spawning - Fall Chinook	5	32	63
CH - Late Fall - CH1	WUA Spawning - Late Fall Chinook	23	29	48
CH - Spring - CH1	WUA Spawning - Spring Chinook	9	21	70
CH - Winter - CH1	WUA Spawning - Winter Chinook	8	29	63
ST1	WUA Spawning - Steelhead	6	21	73

Figure 3. SacEFT's Output Viewer screen, showing the most condensed version of output for rapid review by decision makers in multi-year roll up view. The figure depicts a comparison between two different management scenarios as well as different management actions taken within those scenarios.

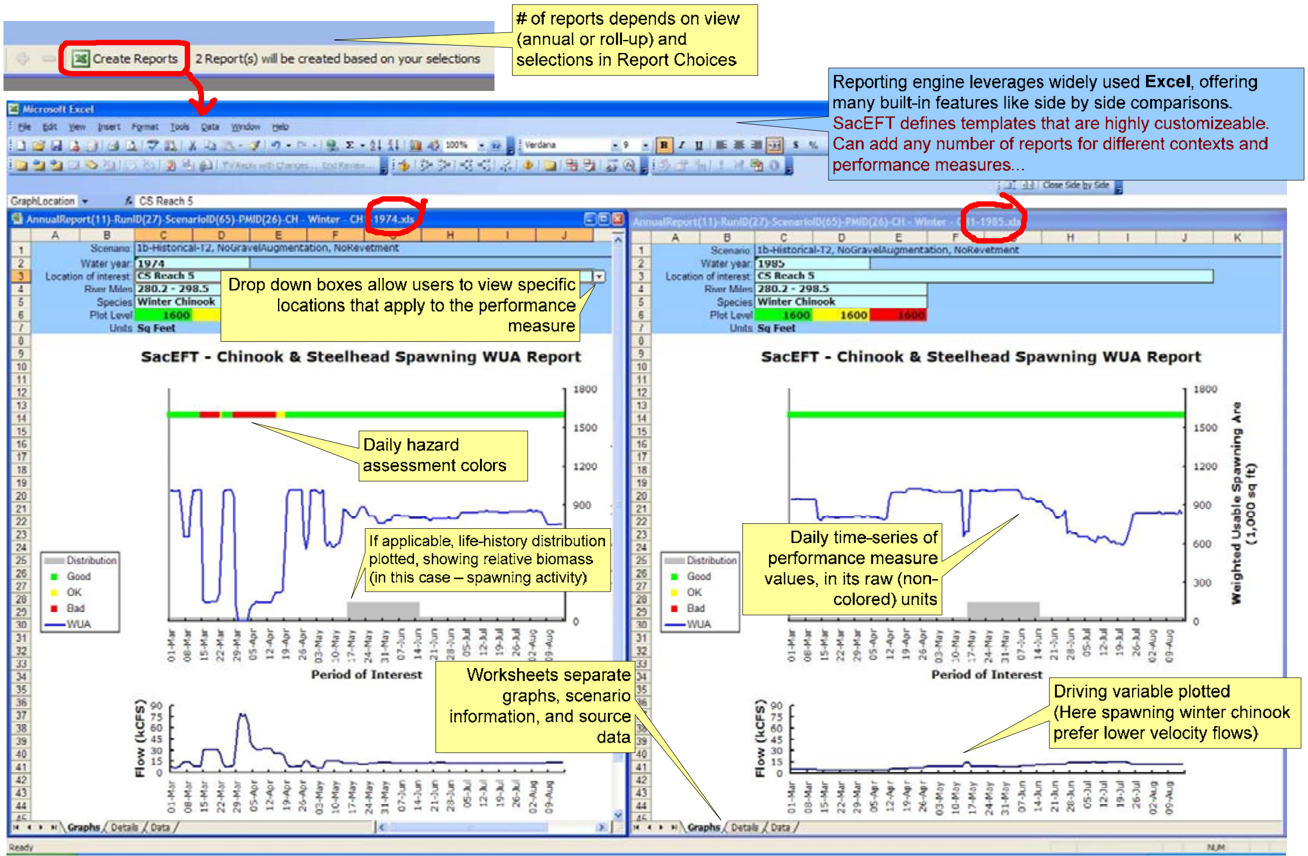


Figure 4: SacEFT also provides significantly more detailed output on a scenario × year × performance measure basis in Excel. Technical specialists can critically examine the detailed results in the performance measure's raw units, alongside its driving variables (e.g., flows), and can also log feedback and comments within the software.

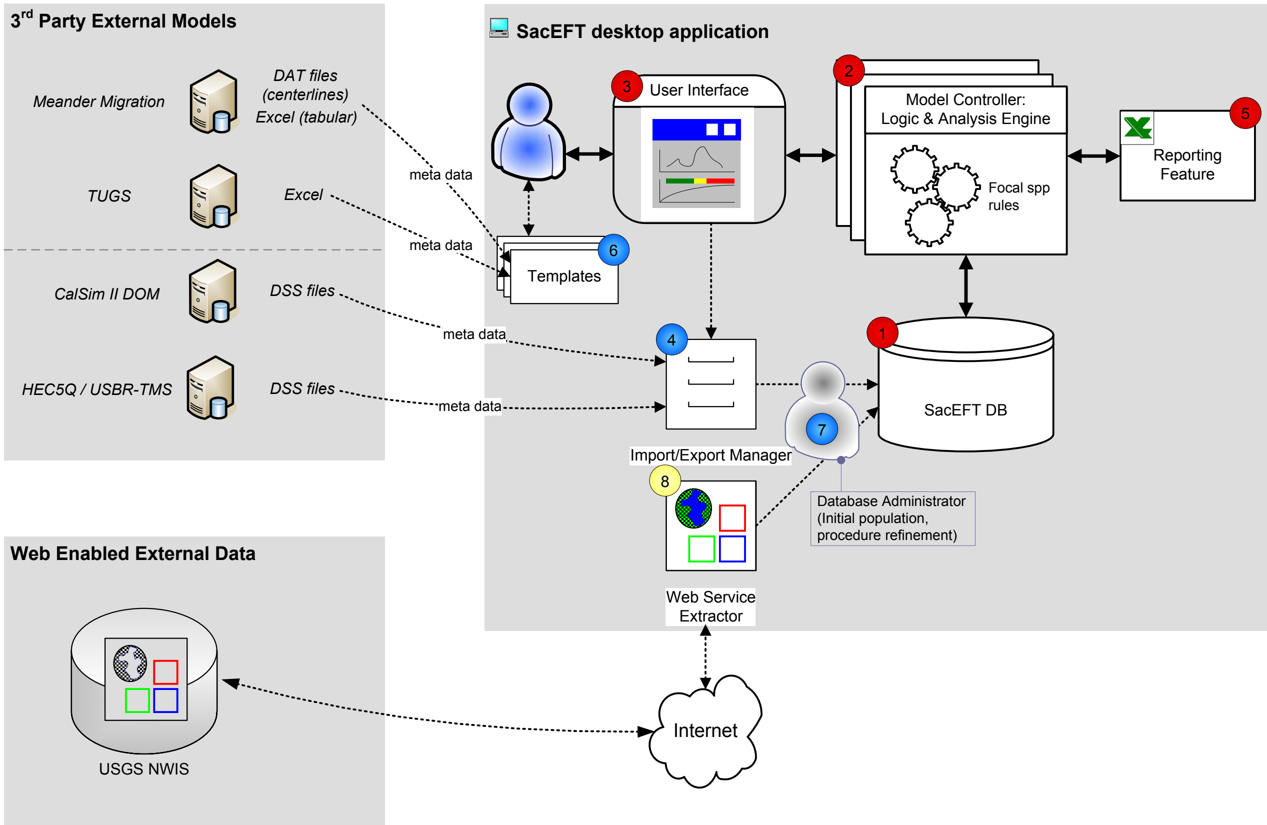


Figure 5: Illustration of the component architecture of the Sacramento River Ecological Flows Tool (SacEFT). Circled numbers are used for reference purposes in Approach and Methods Section (Section C3) of the proposal.

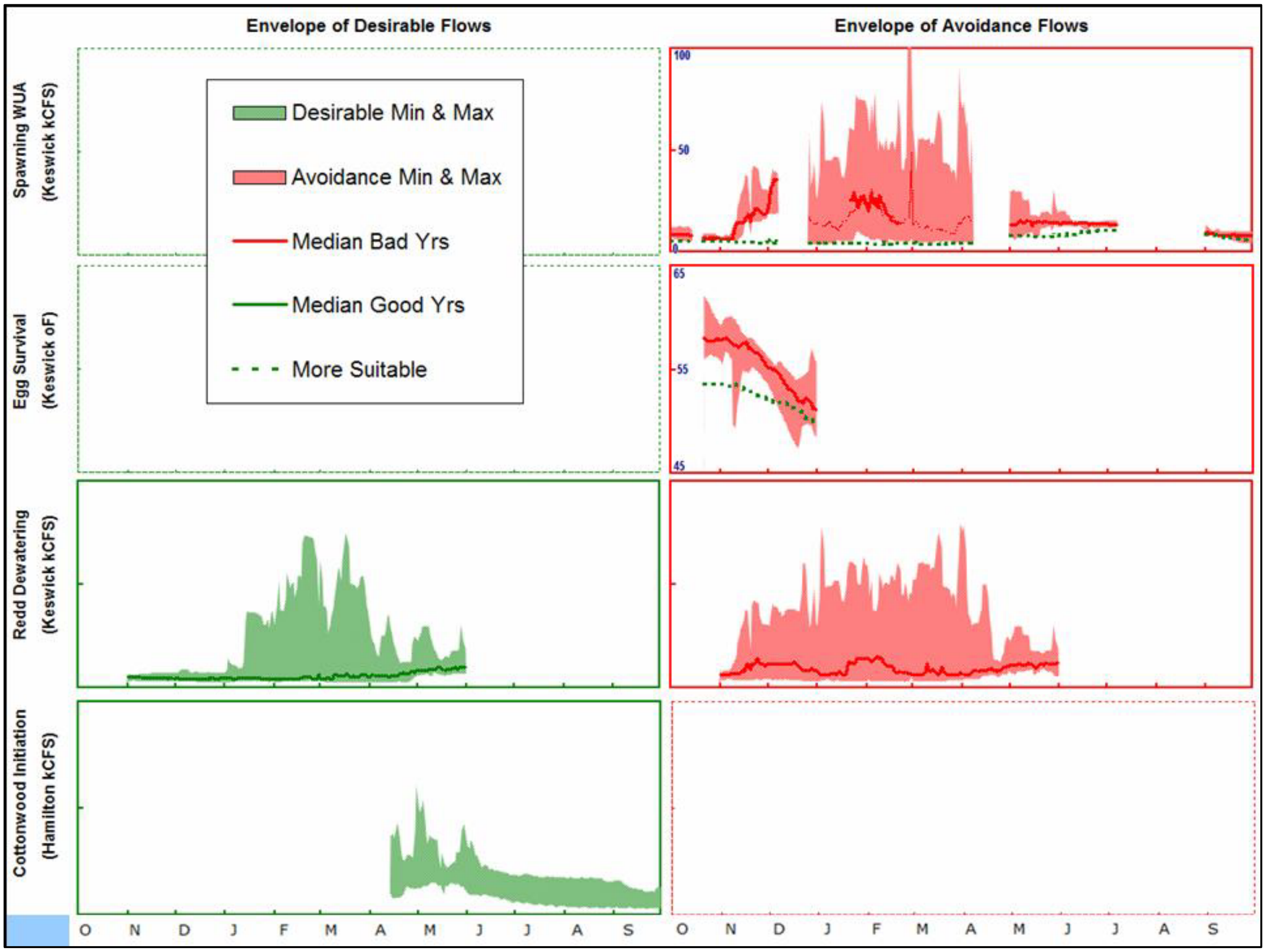


Figure 6: The figure depicts target and avoidance flow ranges emerging from initial SacEFT analyses for 4 indicators, spawning WUA, egg survival (a temperature based indicator in SacEFT at present), redd dewatering, and cottonwood initiation. These are illustrative of syntheses now available.

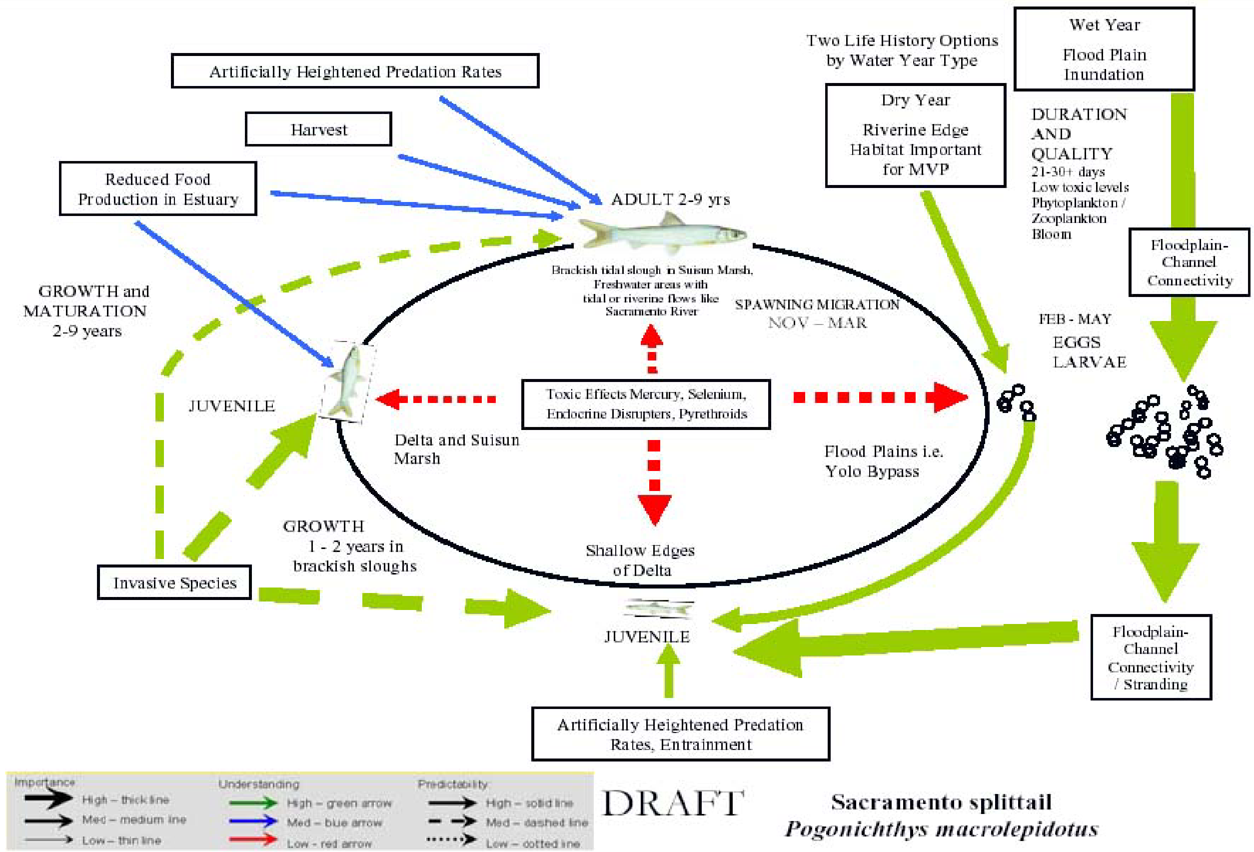


Figure 7. DRERIP conceptual model example for Sacramento splittail. (source: http://www.delta.dfg.ca.gov/erpdeltaplan/science_process.asp)

Figure 8: Project study area depicting integration and evaluation of management actions across ERP ecoregions.

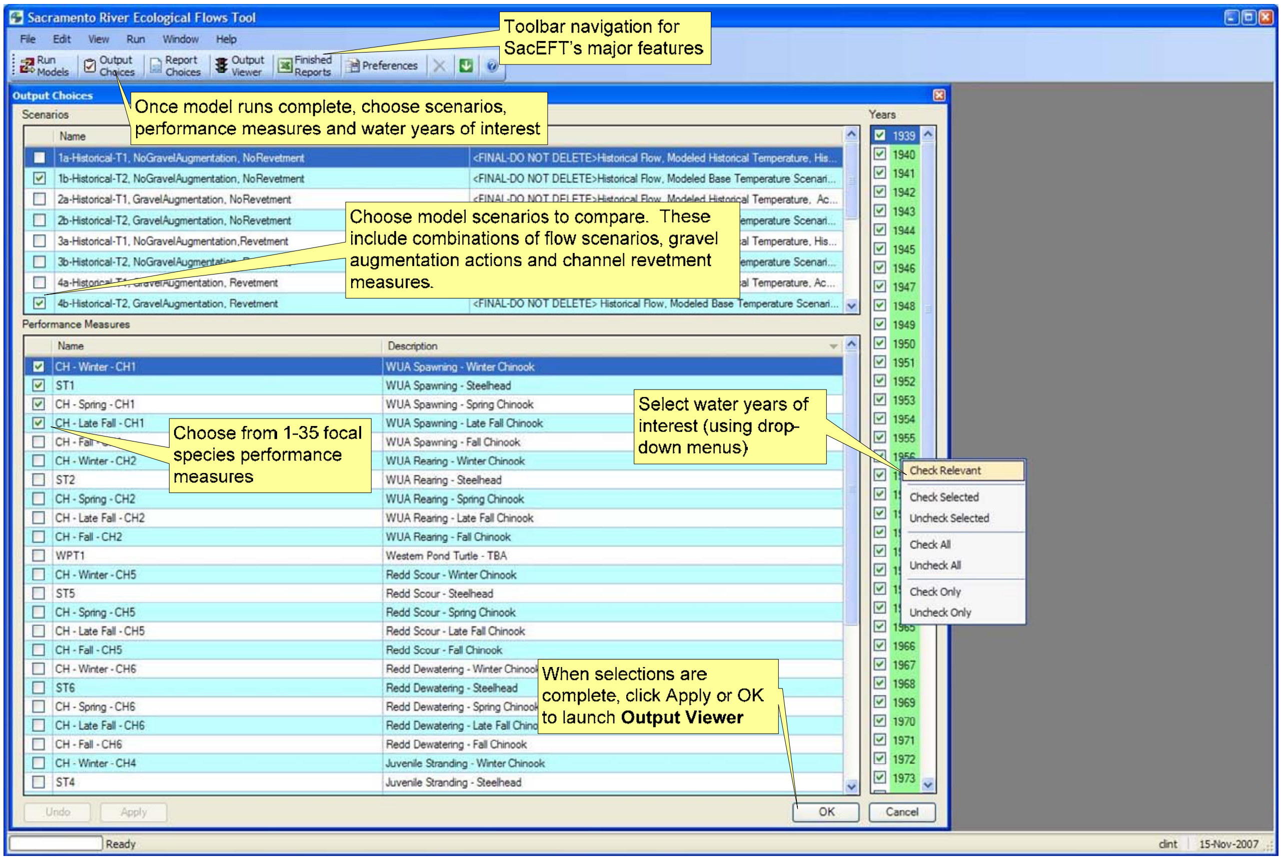


Figure 9: SacEFT's main screen, showing the Output Choices dialogue.

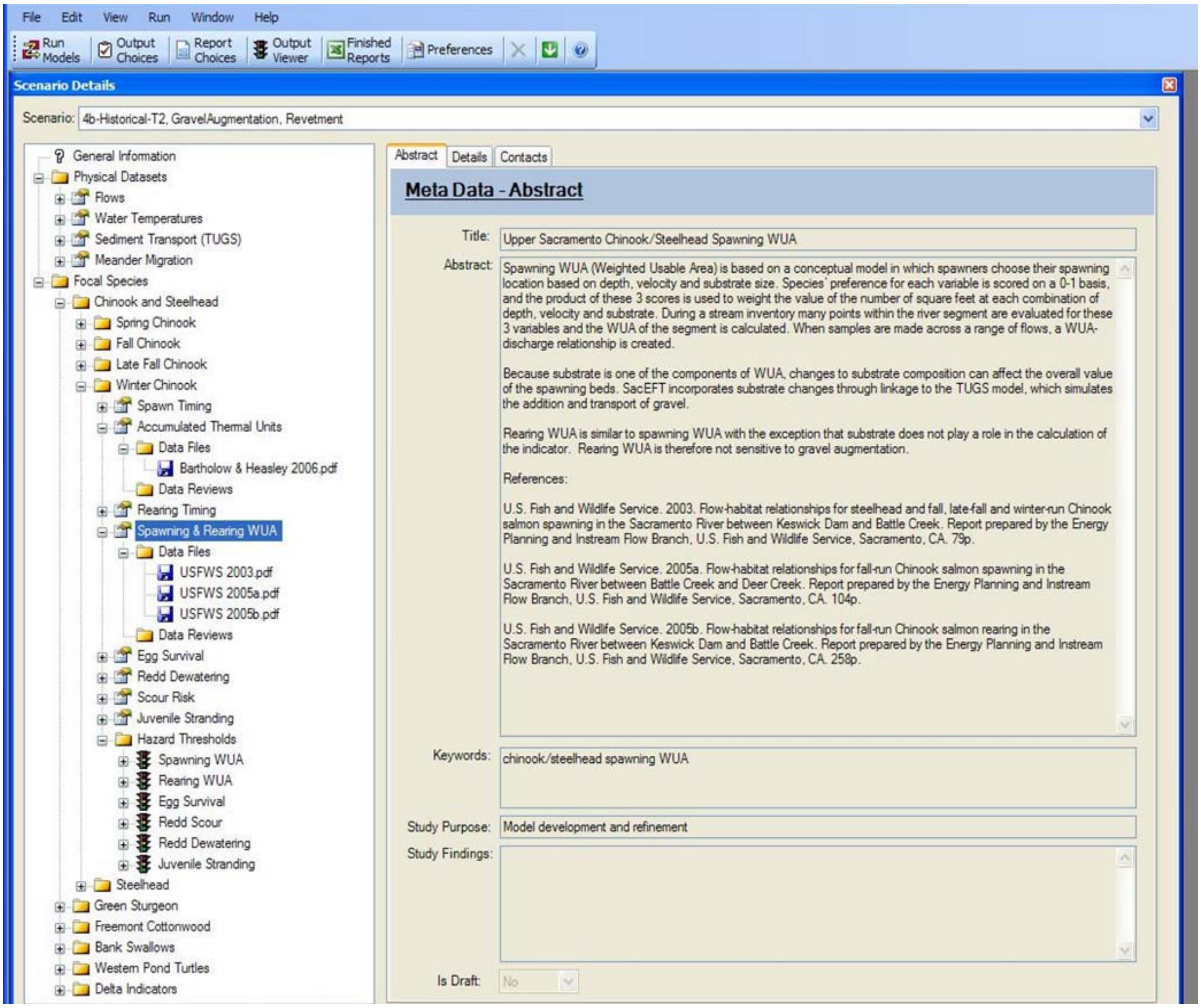


Figure 10: SacEFT's Scenario Details and Reviews dialogue for learning more about imported datasets and focal species assumptions.

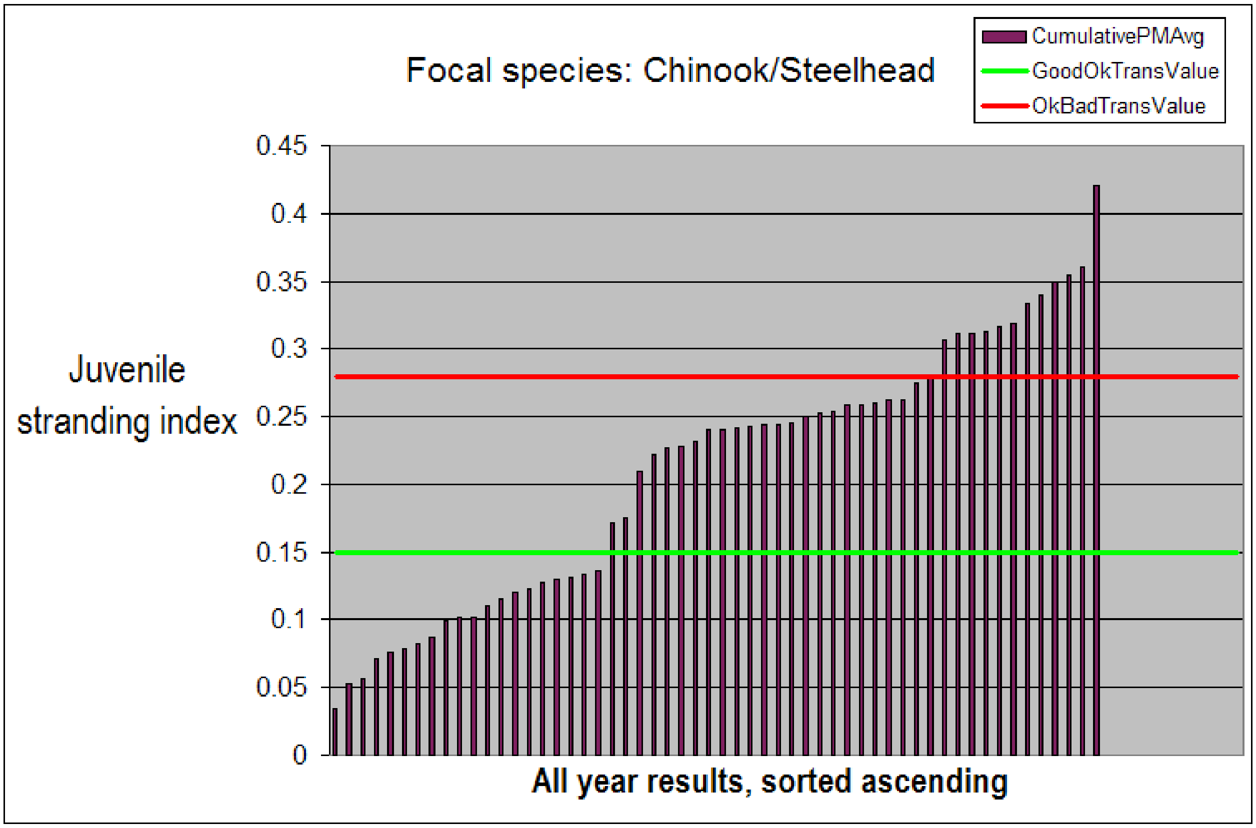


Figure 11: Method used to determine hazard threshold cutoffs in the current version of SacEFT. Example shown is for the Chinook / steelhead juvenile stranding index.

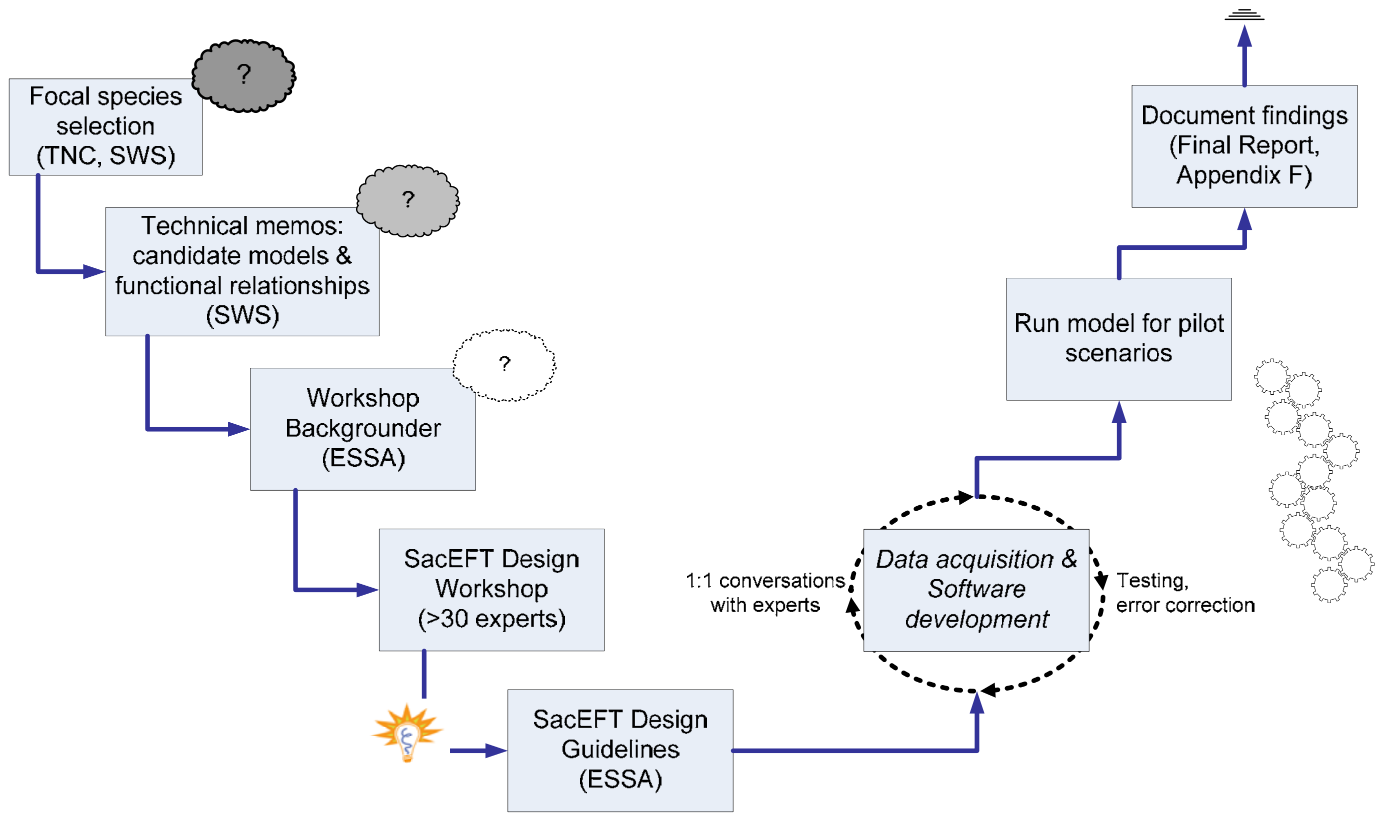


Figure 12: Process of development of SacEFT. The scope, content and structure of SacEFT was gradually defined over a series of steps. TNC = The Nature Conservancy; SWS = Stillwater Sciences; ESSA = ESSA Technologies Ltd.

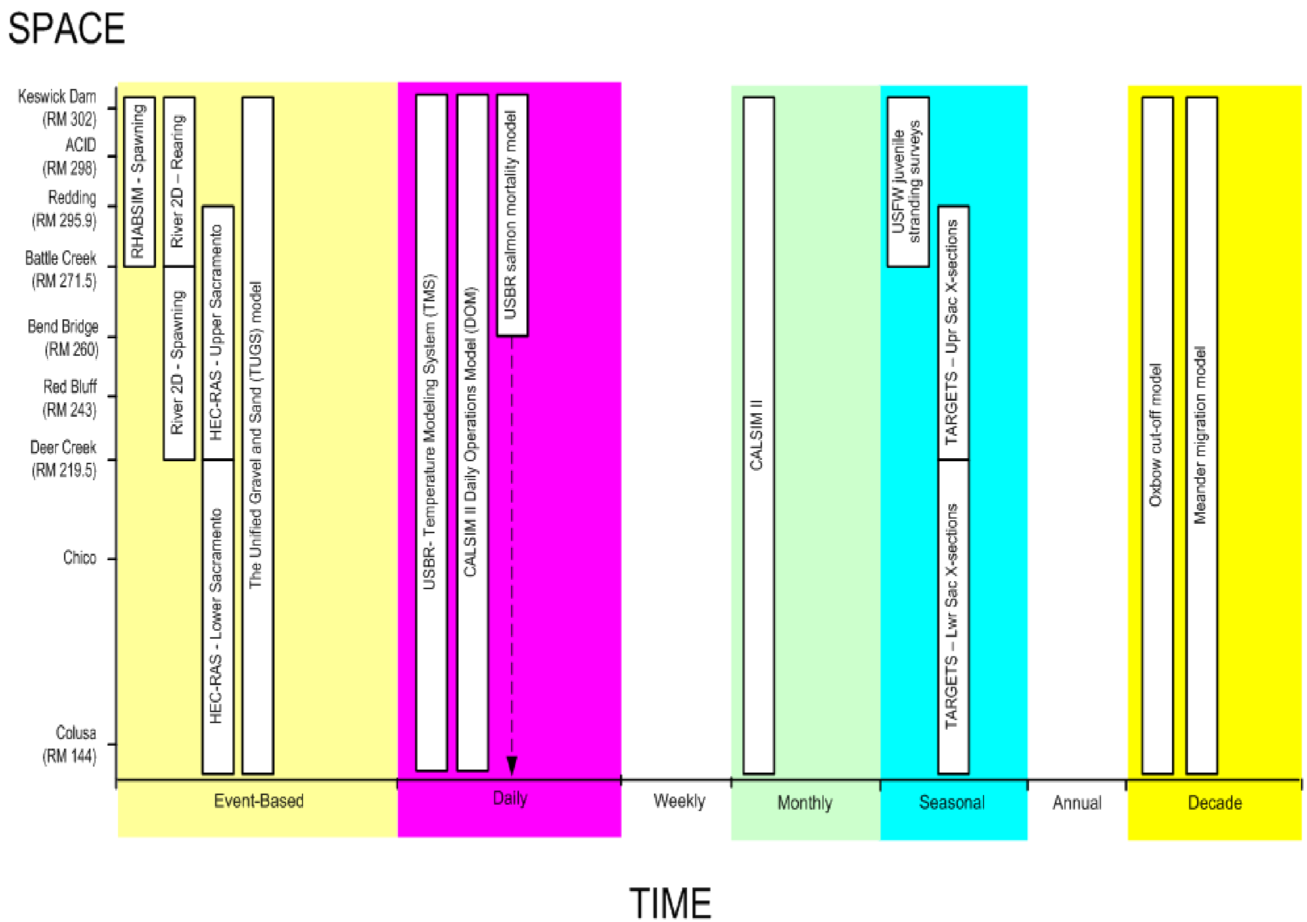


Figure 13: Spatial horizon and resolution of SacEFT's driving physical submodels. Focal species submodels not shown.

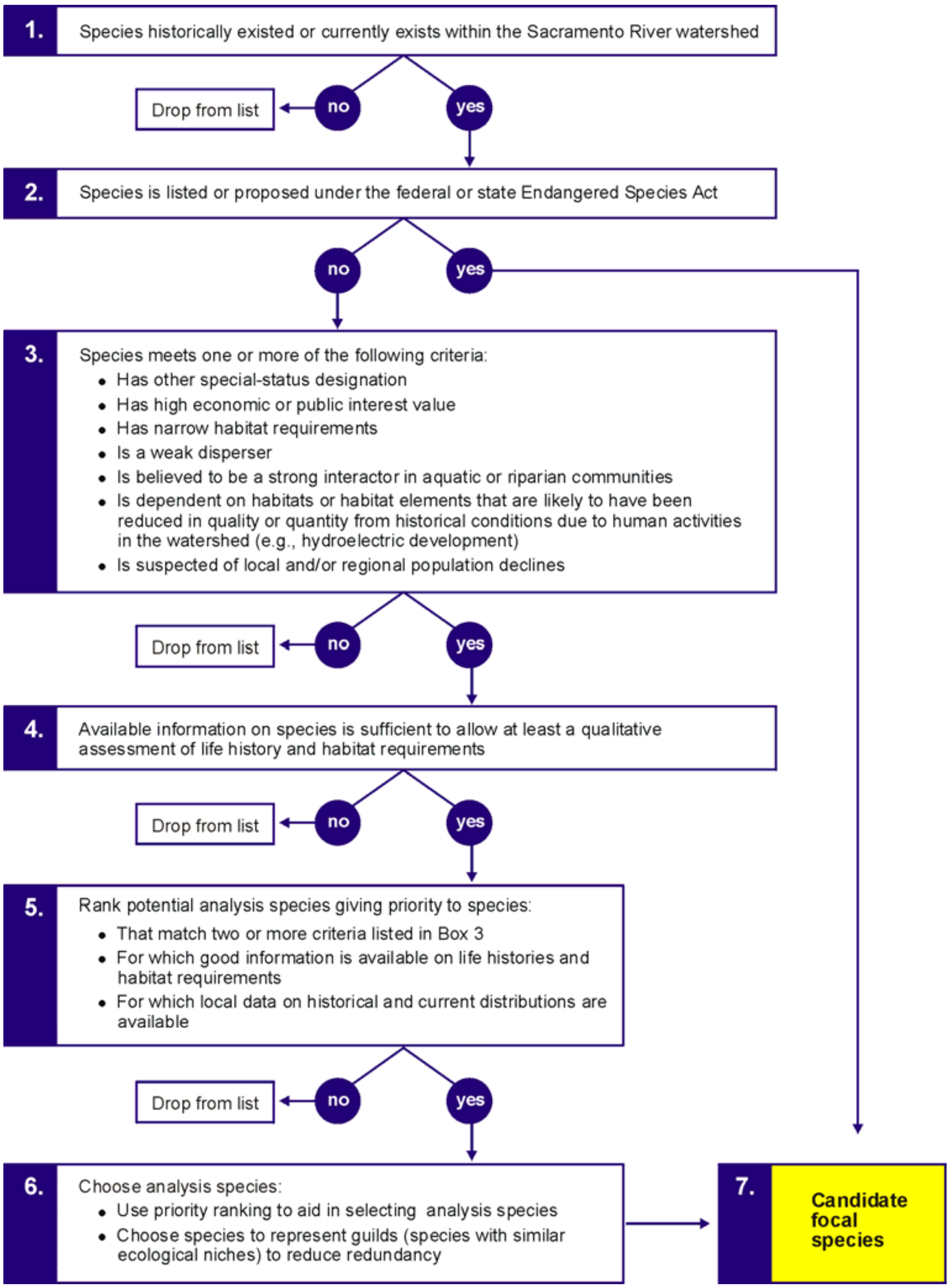


Figure 14: Focal species vetting process used for selection of Sacramento River Ecological Flows Study focal species. A similar vetting process can be applied to selecting Delta focal species in conjunction with DRERIP conceptual models.

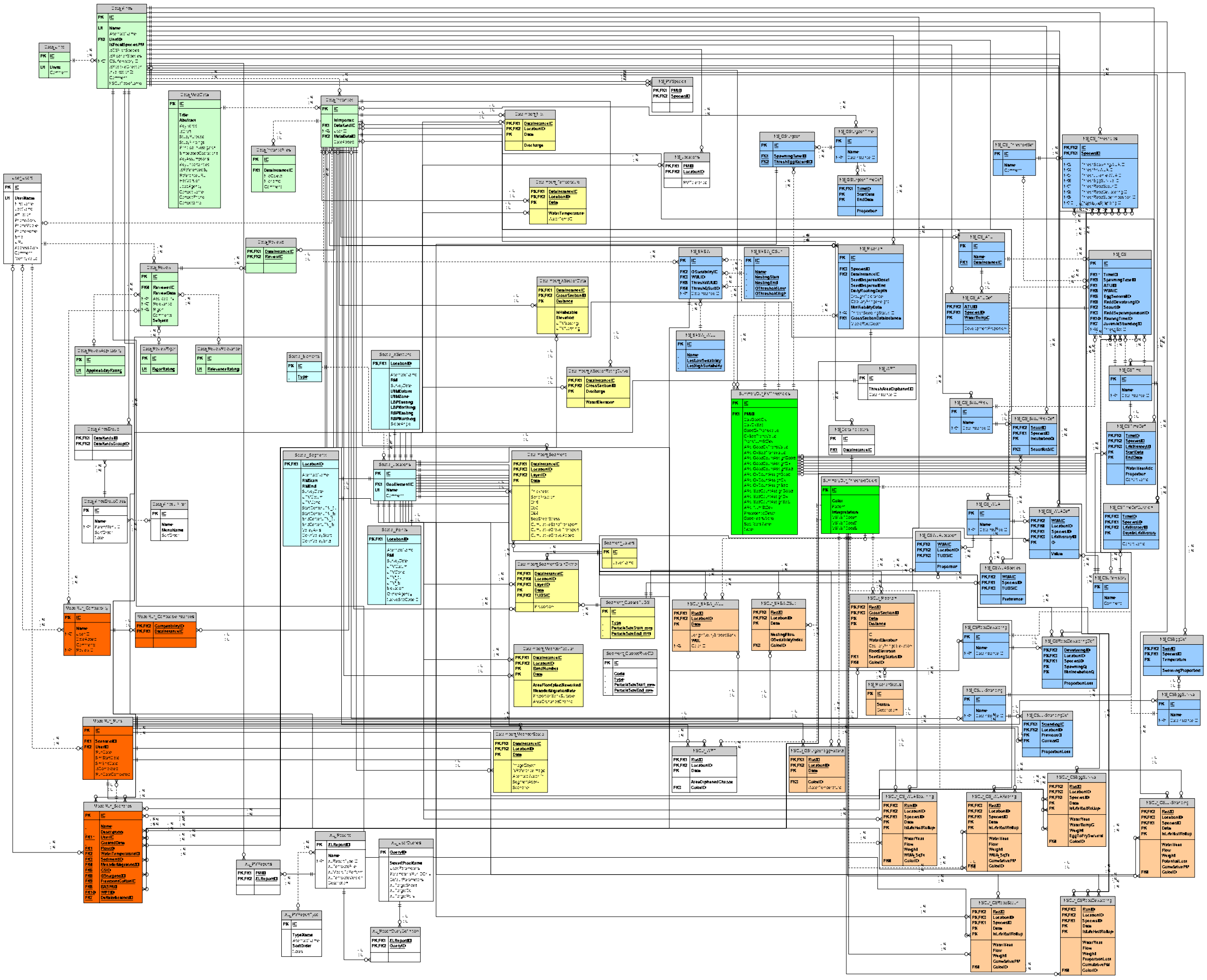


Figure 15: SacEFT relational database depicts the significant complexity involved in decision analysis modeling. The DeltaEFT will likely increase further from the level of complexity as depicted above.

Figure 16. Digital geographic file map of project area.

Table 1: DRERIP conceptual models in preparation/prepared for species and ecosystem features of the Delta.

Ecosystem Models	Species Models
Aquatic food web	Sacramento splittail
Operations	Longfin smelt
Toxicity	Chinook salmon
Pyrethroids	Steelhead
Mercury	Green sturgeon
Selenium	White sturgeon
Dissolved organic compounds	Delta smelt
Floodplains	Invasive clams
Tidal wetlands	Centarchids
Sediment	
Transport	
Aquatic vegetation	
Riparian	
Dissolved oxygen	
Delta fish habitat	

Table 2: Examples of the range of models that have been developed for species of concern that pass through the Upper Sacramento and/or the Sacramento-San Joaquin Delta.

Model / Studies / Data	Developer	Described relationship
TRIM3D – 3d hydrodynamic model	Monsen 2001	salinity (X2) and fish habitat
DSM2 – hydrodynamic model PTM – particle tracking models	DWR	track transport of passive eggs and larvae; has been used to determine the ultimate fate of delta smelt larvae and salmon smolts, and their relationship to export:inflow ratios and species timing (W. Kimmerer, pers. comm..)
Individual-based models for Chinook	EWA and VAMP studies	??
Individual-based models for Delta smelt	Wim Kimmerer	funded by CALFED; work on this is just beginning
IMF – Winter run Chinook Integrated Modeling Framework (recently re-named “IOS”)	SP Cramer & Associates	Life history model for winter run Chinook including empirical relationships to estimate survival through Delta
		Distribution of habitat features with changes in flow: salinity (X2), depth, temperature, dissolved organic carbon
		Water exports and entrainment rates
Interagency Ecological Program studies	Multiple agencies	Water operations and biological responses (see workplan documents)

Table 3: Participants Invited to SacEFT Design Workshop in December 2005

Name	**Subgroup**	**Area of Expertise**	**Organization**
Ryan Luster	Riparian / wildlife	Project Manager / habitat restoration	The Nature Conservancy
Greg Golet	Riparian / Wildlife	Focal species / functional relationships	The Nature Conservancy
Anthony Saracino	Physical	Water Policy	The Nature Conservancy
Mike Roberts	Fish	Hydrology	The Nature Conservancy
David Marmorek	Fish	DA tool, tradeoff evaluations	ESSA Technologies
Clint Alexander	Physical	DA Tool construction	ESSA Technologies
Marc Nelitz	Riparian / Wildlife	DA Tool construction	ESSA Technologies
Michael Fainter	Fish	Focal species info, SOS Report, Field Studies	Stillwater Sciences
Bruce Orr	Riparian / Wildlife	Focal species info, SOS Report, Field Studies	Stillwater Sciences
Frank Ligon	Fish	Focal species info, SOS Report, Field Studies	Stillwater Sciences
Yantao Cui	Physical	TUGS, Oxbow Cut-off models	Stillwater Sciences
Eric Larsen	Physical	Meander Migration model	UC Davis
Matt Kondolf	Physical	Oxbow studies, fluvial geomorphology	UC Berkeley
Rebecca Fris		CALFED Science Program	CALFED
Tom Morstein-Marx	Physical	CALSIM II operator	USBR
Dan Easton	Physical	CALSIM II operator	DWR
Ken Kirby	Physical	Hydrosystem consultant	Active Curiosity
Lisa Micheli	Physical	Physical / sediment transport processes	Sonoma Ecology Center
Koll Buer	Physical	Physical / sediment transport processes	DWR (retired)
Mike Singer	Physical	Physical / sediment transport processes	UC Santa Barbara
Stacey Cepello	Physical	HEC-RAS upper Sac	CDWR
Russ Yaworsky	Physical	USBR Upper Sacramento River Temperature Model	USBR
Tom Smith	Physical	HEC-RAS middle Sac	Ayres Associates
Harry Rectenwald	Fish	Chinook salmon	CDFG
Jim Smith	Fish	Chinook salmon	USFW, Red Bluff
Dennis McEwan	Fish	Steelhead	CDFG
Rob Titus	Fish	Steelhead	CDFG
Peter Klimley	Fish	Green sturgeon	UC Davis
Kurt Brown	Fish	Green sturgeon	USFWS – Coleman Hatchery
Wim Kimmerer	Fish	Chinook salmon modeling	San Francisco State Univ.
Mark Gard	Fish	PHABSIM, River 2D, juvenile stranding surveys	USFWS
Dave Germano	Riparian / Wildlife	Western pond turtle	CSU, Bakersfield
Bruce Bury	Riparian / Wildlife	Western pond turtle	USGS
Tag Engstrom	Riparian / Wildlife	Western pond turtle	California State University, Chico
Ron Schlorff	Riparian / Wildlife	Bank swallow	CDFG
Barrett Garrison	Riparian / Wildlife	Bank swallow	CDFG, Rancho Cordova
Joe Silveira	Riparian / Wildlife	Bank swallow	USFWS
Naduv Nur	Riparian / Wildlife	Riparian and songbirds	PRBO
John Bair	Riparian / Wildlife	TARGETS	McBain & Trush
Steve Greco	Riparian / Wildlife	riparian-bird community	UC Davis

Table 4: Summary of major assumptions and uncertainties in SacEFT indicators (Table F-2 from Sacramento River Ecological Flows Study Final Report Appendix F, TNC et al. 2008).

Performance measure (and key sub-component(s))	**Major assumptions and limitations**
Spawning and rearing WUA	▪ The Chinook and steelhead spawning WUA models are based on Mark Gard's habitat preference models (U.S. Fish and Wildlife Service 2003, 2005a, 2005b). Gard's results are based on the River-2D hydrodynamic model. ▪ Inherent Instream Flow Incremental Methodology (IFIM) assumptions, strengths and weaknesses. Habitat suitability curves (weighted useable area vs. discharge) for current velocity, substrate and depth accurately reflect habitat preference and these preferences truly confer differential survival (rather than summarizing a mode of differential selection that has no true significance for survival). ▪ Rearing WUA is not affected by substrate conditions. ▪ Index locations and sampling periods provide a representative snapshot of true habitat conditions and run-type preferences. ▪ The cross-sectional data used to parameterize WUA relationships are a snapshot in time of conditions in the mainstem, and mainstem habitat locations may change slowly or episodically as a result of high flow events, sediment transport and channel migration. Habitat is therefore assumed to be in an equilibrium state in which the spatial arrangement of particular habitats may change, but the segment-wide non-spatial proportions do not. ▪ Habitat preferences for spring Chinook are not available and we assumed they followed those of fall Chinook (Mark Gard, pers. comm.). ▪ Because parameterized relationships were not always available for every desired study location, relationship mapping was carried out by assuming that relationships parameterized for a race or location could be applied to another race or location (Mark Gard, pers. comm.). For example, based on USFWS (1995), the distribution of rearing habitat for spring-run Chinook is almost entirely concentrated below Battle Creek but uses fall-run rearing WUA relationships. Likewise, rearing WUA relationships are not available for downstream from Battle Creek, and currently make use of upstream WUA relationships.
Temperature-salmon egg emergence	▪ Temperature-emergence timing for Chinook/steelhead has been taken from relationships published for the SALMOD model (Bartholow and Heasley 2006). The relationship we adopted is not strictly egg-maturation, but covers the period to free swimming emergence.
Temperature-salmon egg mortality	▪ During the design of SacEFT in 2005 we anticipated using the USBR egg mortality model, but later adopted the mortality ATU models used by SALMOD, since the SALMOD formulation reports and corrects some mathematical errors that may be present in the USBR model.
Chinook/steelhead redd scour	▪ Flows above 20 kCFS trigger a fair hazard (yellow), with flows above 32 kCFS required to trigger a poor indicator rating (red). The model couples these hazard categories to each race's spawning distribution and uses a temperature-driven emergence function to create an aggregated egg distribution for each day of the egg development period. The daily proportion of redds exposed to scour incorporates the joint influence of the original spawning distribution, temperature driven egg-development distribution and the proportion of total spawning WUA available in the river segment.
Chinook/steelhead redd dewatering	▪ The model makes use of Gard's redd dewatering research (U.S. Fish and Wildlife Service 2006b), which estimates proportional decrease in redds over the period between spawning and the emergence of juveniles. Gard's results do not include time explicitly. Rather, his model estimates proportion of spawning redds lost (if any) at each location (l) between the time a day-cohort is spawned (cs) and the end of the cohort's egg development period.

Performance measure (and key sub-component(s))	**Major assumptions and limitations**
	Based on discussions with Gard, we adapted this relationship in a way that is mathematically consistent with the original results, but which can be disaggregated to the daily scale of the dewatering model. If there is no decline in flow then no loss occurs. To calculate the daily PM, the model compares the previous day's flow, Qd-l, and the flow on day Qd. If there is a drop, then some proportion of eggs are potentially dewatered: f(l,Qd-1,Qd), and bilinear interpolation is used to calculate the loss. • Gard's tabular results include fall- and winter-Chinook salmon and steelhead trout only, and relationships for spring- and late-fall Chinook salmon are mapped from fall-run Chinook.
Chinook/steelhead juvenile stranding	▪ The performance measure uses Gard's juvenile stranding research (U.S. Fish and Wildlife Service 2006b) to estimate the proportional decrease in habitat over the period between juvenile emergence and the end of the juvenile residence period. Mark Gard's raw system-level results were disaggregated to the segment level used by SacEFT. As Gard's results do not include time explicitly, we adopted a method that calculates daily losses from the day of emergence through to the end of the residency period. The model compares the previous day's flow, Qd-l, and the flow on day Qd. If there is a drop, then some proportion of juveniles are potentially stranded: f(l,Qd-1,Qd), and bilinear interpolation is used to calculate proportional losses between the tabular values found in Gard's tables (U.S. Fish and Wildlife Service 2006b). ▪ Although races are modeled separately in SacEFT, all use a single all-species flow-decline relationship.
Green sturgeon – water temperature tolerances	▪ The impact of water temperature on green sturgeon eggs/larvae is modeled using two temperature breakpoints: 17C and 20C, to mark temperature excursions into zones of moderate and high risk. Each day the model tracks spawned eggs over a fixed development period of 14 days, tracking each spawning day separately. The simplicity of the model stems from the lack of information about temperature-based mortality, referring instead to the categorical evaluation created by Cech et al. (2000, cited in (NMFS 2003)) to assign "healthy", "moderate" and "lethal" outcomes. ▪ Other important measures of green sturgeon life history (e.g., flow-habitat; juvenile entrainment; fishing and poaching, discharge-migration cues and needs) were found to be lacking in quantitative knowledge and therefore are not included in SacEFT.
Bank swallows	▪ Because the habitat model is very simplified, it has no memory of flow over time, and the BASW2 indicator does not capture the possible cumulative effects of changes in discharge, nor the role of bank height in predicting bank sloughing. ▪ The 'length of newly eroded bank' generated by $L_b = \frac{A}{W}$ using meander migration data does not account well for the **depth** of bank erosion. Lengths predicted by this formula can also in some cases be artificial, having a trivial depth of erosion along a relatively long length. ▪ Soil type is known to be a critical factor in determining whether newly eroded banks are suitable for Bank swallows. The present version of SacEFT does not implement this component of habitat suitability (as this information was not made available to our modeling team).
Fremont cottonwood initiation	▪ Standard recruitment box model ▪ Sampled cross section nodes, if non-uniform, are representative of the overall cross-sectional characteristics. ▪ Tap root growth rate = 29 mm/day

Performance measure (and key sub-component(s))	**Major assumptions and limitations**
	▪ Drought tolerance of 2 days (roots can be out of contact with water table for 2 days without being declared dead) ▪ Fixed capillary fringe height of 30 cm (a very site specific parameter based on soil type) ▪ Cottonwood seedlings whose roots reach a depth of 45cm are assumed to be successful in reaching some type of ephemeral groundwater moisture sufficient to keep them alive through the remainder of their first year (based on dialogue with John Bair, McBain and Trush, pers. comm..). ▪ **Note**: all these assumptions are fully configurable in the SacEFT database.
Western Pond turtles	▪ The lack of contrast in meander migration results did not merit calibration and implementation of Western Pond turtles in SacEFT v.1.00.018 (i.e. the key drivers did not vary sufficiently).
Chinook/steelhead: general	▪ The six performance measures are intentionally simplified and generally do not attempt to account for interactions that will naturally occur. For example, redd dewatering, temperature-driven egg mortality and redd scour risk all occur during the incubation period and the processes together would predict a different outcome than each process taken alone. ▪ SacEFT does not track movement of juveniles between reaches, and instead they are assumed to remain in the proportions occurring at the time eggs were spawned. ▪ Lengthening of the egg development and juvenile growth window via lower water temperatures also lengthens the cumulative exposure to other potential mortality sources, a set of processes not accounted for in SacEFT.
Overall	▪ Indicator ratings ("hazard ratings" or "severity ratings") represent biologically significant thresholds[1].

Table 5: Least and most sensitive focal species indicators mapped to SacEFT's major classes of actions when comparing relative change over scenarios. These results should be interpreted in the context of the flow and channel actions evaluated in the initial pilot application of SacEFT rather than as general statements (Table F-3 from Sacramento River Ecological Flows Study Final Report Appendix F, TNC et al. 2008).

Action	**Least Sensitive**	**Most Sensitive**
Water temperature	Green sturgeon egg survival risk (GS1)	Chinook and steelhead incubation and early rearing performance measures (lower water temperatures increase period of vulnerability)
	Chinook and steelhead egg-to-fry thermal mortality (CH3)	
Flow	Bank swallows - peak flows during the nesting period (BASW2)	Fremont cottonwood - initiation success (FC)
	Chinook and steelhead juvenile stranding (CH4)	Chinook and steelhead rearing weighted useable area (WUA) (CH2)
	Chinook and steelhead spawning weighted useable area (WUA) (CH1)	Chinook and steelhead redd scour risk (CH5)
	Chinook and steelhead redd dewatering (CH6)	
Revetment removal (channel migration)	Area of off-channel habitats, indexed by creation of newly orphaned channels (WPT1)*	n/a
	Bank swallow - length of newly eroded banks (BASW1)*	
Gravel augmentation	n/a	Chinook and steelhead spawning WUA (CH1)

Table 6: SacEFT database concepts and their general role. See ESSA (2007) for details and context.

Table Family	Role
(1) Spatial_	▪ Tables under the Spatial namespace are responsible for holding all information related to the spatial definition of locations. This information is managed as points, cross-sections and segments.
(2) Data_Instances	▪ The key generic concept for tracking imported datasets and their metadata ▪ Also used to (optionally) tag information on non-imported (i.e., local) generic rules/parameter values for focal species.
(3) Data_MetaData	▪ Data.Metadata will provide a standard set of fields to capture metadata for all submodels. This information, along with optional model reviews, would be inspected by users when building compatibility lists for structuring unified, "apples and apples" SacEFT model runs.
(4) Data_Review	▪ Further comments, opinions regarding Data.Instances and model results can be provided by data reviews, which characterize applicability, relevance and rigor, and allow for general comments.
(5) ModelRun._	▪ Tables under the ModelRun namespace unify the concept of a model scenario, identifying all the associated data instances (imported data sets to be used, and focal species submodel rules) that are to be used within a single model run. ▪ A key table in this family is ModelRun.Compatibility, which is tightly associated with ModelRun.CompatibleInstances. These tables will be linked with Data.Instance to list imported physical model data instances that can be defensibly grouped together, based on having sufficiently similar embedded assumptions (e.g., same flows in USBR Upper Sacramento River Temperature Model and meander migration model and TUGS). "Sufficiently similar embedded assumptions" will be determined based on inspection of metadata. ▪ Unless a data instance is found in ModelRun.CompatibleInstances as part of the same compatibility family, it cannot be added to the ModelRun.Scenario table. This is how SacEFT will ensure apples and apples result sets are used amongst imported data instances.
(6) DataImport.<Model>	▪ The DataImport namespace is used to structure how data imported from external physical models are stored. Typically, the variables of interest will be arrayed by a DataInstanceID, a LocationID and a date (at the appropriate temporal resolution). ▪ These tables store the physical data itself – the streamflow, water temperatures, model results, etc.
(7) FS_ and FSOut_	▪ This family of tables hold the lookup data, rules and parameter values for focal species and their associated model results generated internally by SacEFT code.

Table 7: Project timeline.

				Year 1 (7/1/08 - 6/30/09)												Year 2 (7/1/09 - 6/30/10)											
			Project Month	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**
Task	**Task Name**	**Deliverable Due Date (Project Month 1-24)**	**Fiscal Year Month**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**	**4**	**5**	**6**
1	SacEFT Model Refinements and Application																										
1.1	SacEFT Model Technical Review and Improvement	2 thru 12																									
1.2	SacEFT Application to Relevant Water Management Scenarios	2 thru 21																									
2	DeltaEFT Model Development to Evaluate Flow Requirements for Delta Species																										
2.1	DeltaEFT Model Design	3 and 4																									
2.2	DeltaEFT Model Construction	5 thru 19																									
2.3	Delta Water Management Ecological Outcomes and Trade-offs Evaluation	20 and 21																									
2.4	DeltaEFT Public Outreach and Stakeholder Involvement																										
3	Project Management and Administration																										
3.1	Internal Project Team Coordination	continuously																									
3.2	ERP Directed Action Project Administration	Quarterly Reports: 3, 6, 9, 12, 15, 18, 21, 24 Semi Annual Reports: 6, 12, 18																									
4	Draft and Final Report																										
	Draft Final Report	22																									
	Final Report	24																									
5	Project Close Out	24																									
	Project Close Out Report	30 days after Final Report is approved																									

EXHIBIT A - ATTACHMENT 1
PRIMARY CONTRACTOR BUDGET SUMMARY
Complementing Existing Planning Efforts in the Delta with a Decision Analysis Tool: The Delta Ecological Flows Tool (DeltaEFT) for the San Joaquin-Sacramento Bay Delta

			YEAR 1 - FISCAL YEAR 08								YEAR 2 - FISCAL YEAR 09						
	TOTAL	TOTAL	YEAR 1 TOTAL			Task 1	Task 2	Task 3	Task 4	Task 5	YEAR 2 TOTAL			Task 1	Task 2	Task 3	Task 4
	HOURS	AMOUNT	SALARY	HOURS	AMOUNT	Amount	Amount	Amount	Amount	Amount	SALARY	HOURS	AMOUNT	Amount	Amount	Amount	Amount
Personnel Services:																	
Conservation Practitioner V	1540	$51,363	$60,000	749	$24,692	$6,000	$7,385	$11,308	$0	$0	$62,100	791	$26,671	$1,672	$10,748	$9,793	$3,583
Program Director I	1351	$53,631	$71,000	672	$26,215	$7,100	$8,738	$10,377	$0	$0	$73,485	679	$27,416	$1,978	$12,719	$8,479	$4,240
Program Director IV	371	$26,350	$127,000	182	$12,700	$2,442	$5,862	$4,396	$0	$0	$131,445	189	$13,650	$1,517	$7,583	$3,539	$1,011
Director Gov Relations II	609	$30,612	$90,000	322	$15,923	$2,769	$5,538	$7,615	$0	$0	$93,150	287	$14,689	$1,075	$6,091	$5,732	$1,791
Applied Scientist IV	350	$18,954	$97,000	189	$10,073	$2,238	$4,104	$3,731	$0	$0	$100,395	161	$8,881	$772	$4,634	$2,703	$772
Applied Scientist II	812	$30,641	$68,000	581	$21,708	$4,708	$13,338	$3,662	$0	$0	$70,380	231	$8,933	$541	$3,519	$2,978	$1,895
Conservation Info Mgr II	14	$1,967	$42,000	14	$1,131	$323	$0	$808	$0	$0	$43,470	0	$836	$0	$0	$836	$0
Operations Director II	42	$0	$70,000	21	$0	$0	$0	$0	$0	$0	$70,380	21	$0	$0	$0	$0	$0
Subtotal Personnel Services	5089	$213,518		2,730	$112,442	$25,581	$44,965	$41,896	$0	$0		2,359	$101,076	$7,556	$45,293	$34,059	$13,292
Benefits @ (Rate)	41.0%	$87,542			$46,101	$10,488	$18,436	$17,177	$0	$0			$41,441	$3,098	$18,570	$13,964	$5,450
Total Personnel Services		$301,060			$158,544	$36,069	$63,401	$59,074	$0	$0			$142,517	$10,653	$63,863	$48,024	$18,741
Operating Expenses																	
Communications		$5,400			$1,950	$500	$500	$950	$0	$0			$3,450	$500	$1,000	$950	$1,000
Travel[1]		$11,250			$6,000	$2,000	$3,000	$1,000	$0	$0			$5,250	$1,000	$3,000	$250	$1,000
Meetings & Workshops (including stipends)		$27,500			$17,500	$12,500	$5,000	$0	$0	$0			$10,000	$5,000	$5,000	$0	$0
Subcontractor - Essa Technologies		$1,049,532			$527,950	$195,547	$332,403	$0	$0	$0			$521,582	$163,645	$352,937	$0	$5,000
Total Operating Expenses		$1,093,682			$553,400	$210,547	$340,903	$1,950	$0	$0			$540,282	$170,145	$361,937	$1,200	$7,000
Subtotal Personnel Services and Operating Expenses		$1,394,742			$711,944	$246,616	$404,304	$61,024	$0	$0			$682,799	$180,798	$425,800	$49,224	$25,741
Overhead Costs @ (23%) 2	23.0%	$320,791			$163,747	$56,722	$92,990	$14,035	$0	$0			$157,044	$41,584	$97,934	$11,321	$5,921
Total by Task by Fiscal Year		$1,715,533			$875,691	$303,338	$497,294	$75,059	$0	$0			$839,842	$222,382	$523,734	$60,545	$31,662
Total by Fiscal Year			**$875,691**								**$839,842**						
Total Agreement Amount			**$1,715,533**														

EXHIBIT B
SCHEDULE AND LIST OF DELIVERABALES

Complementing Water Planning Efforts for the Delta and Sacramento River: Application of the Ecological Flows Tool

Task	Task Title	Deliverable	Estimated Completion Dates
1	SacEFT Model Refinements and Application	1. Pre and post meeting materials	1. Submit with Quarterly Progress Report (Task 3) the quarter following the workshops
		2. Technical memo summarizing model refinements workshop	2. December 31, 2008
		3. Refined SacEFT software and Install Pack	3. June 30, 2010
		4. Updated SacEFT Design Document with Sensitivity Analysis Appendix	4. June 30, 2010
		5. SacEFT Users Guide	5. June 30, 2010
2	DeltaEFT Model Development to Evaluate Flow Requirements for Delta Species	1. Pre and post meeting materials	1. Submit with Quarterly Progress Report (Task 3) the quarter following the workshops
		2. DeltaEFT Backgrounder Report	2. December 31, 2008
		3. DeltaEFT Model Design Workshop	3. December 31, 2008
		4. DeltaEFT Design Guidelines	4. December 31, 2008
		5. DeltaEFT Database and Software	5. December 31, 2008
		6. DeltaEFT Webpage	6. June 30, 2010
		7. Public outreach and stakeholder involvement	7. Include information in Quarterly Progress Report (Task 5) if activities occurred during the quarter
3	Project Management and Administration	1. Semi-Annual Progress Report	1. Semi-annual report through out the project term. Due 10th of July, Jan.
		2. Quarterly Progress Reports and Periodic Invoices	2. Reports quarterly throughout the Agreement term; Invoices no more frequently than monthly throughout project term

EXHIBIT B
SCHEDULE AND LIST OF DELIVERABALES

		3. Subcontract documentation	3. Quarterly throughout the project term
4	Draft and Final Report	1. Draft Final Report 2. Final Report	1. 22 months after contract execution 2. 24 months after contract execution
5	Project Close Out	1. Project Close Out Report 2. Final Invoice	1. 30 days prior to end of the project term 2. 30 to 60 days after Final Report is approved