Summary Information

California State University, Hayward

Multdisciplinary monitoring of environmental processes in CALFED restored marshes in the Suisun Bay ecological zone. Phase Two: Importance of marsh tidal pools, algae, and other features along marsh channels.

Amount sought: $1,023,911

Duration: 36 months

Lead investigator: Dr. Christopher Kitting, California State University, Hayward

Short Description

This project would be Phase II of our mesohaline tidal marsh comparative monitoring, using non−destructive physical−chemical−biological monitoring with replication throughout each of our four recent CALFED collaborative marsh restorations and three (adjacent, ~100−yr−old, relatively natural) reference marshes. No other continued monitoring among these marsh sites is available. Central goals are to identify and improve factors that greatly enhance marsh (1) colonization, (2) productivity, (3) export, and (4) sustainability of dwindling and diverse native populations. This project will monitor and compare three reference marshes with >four replicate restored CALFED marshes both with and without pond connections, preferably including marsh maintenance as experimental field manipulations.

Executive Summary

Executive Summary

Title of Project: Multdisciplinary Monitoring of Environmental Processes in CALFED Restored Marshes in the Suisun Bay Ecological Zone. Phase Two: Importance of Rare Marsh Tidal Pools, Algae, and Other Features along Marsh Channels.

Amount requested: ~$ 1,00,100 / 3yrs, in four tasks (not including ~$300,000 match from three partner groups, plus additional in−kind expertise).

Applicant Information: California State University, Hayward (CSUH Foundation), 25800 Carlos Bee Blvd., Hayward, CA 94542−3035 Phone: (510)885−3471; FAX (510)885−4747;

contact: Chris Kitting, e−mail:ckitting@csuhayward.edu

Participants and Collaborators: Dr. Chris Kitting, Dept. of Biological Sciences, Cal State Univ. Hayward; in collaboration with McNabney Marsh Management Committee Members (East Bay Regional Park District/ Contra Costa Mosquito and Vector Control, etc.) and San Francisco Bay Wildlife Society (supporting USFWS missions), Weapons Detachment Concord, and Dr. Joy Andrews and colleagues, Chemistry, CSUH and Bay/Delta Science Consortium.

Summary Description of Project: Our CALFED marsh restoration projects over ~10 km2 are in CALFED Ecozone 2, in South Suisun Bay (east of Martinez). This would be Phase II of our mesohaline tidal marsh comparative monitoring, using non−destructive physical−chemical−biological monitoring with replication throughout each of our four recent CALFED collaborative marsh restorations and three (adjacent, ~100−yr−old, relatively natural) reference marshes. No other continued monitoring among these marsh sites is available. This work would continue with the same local ecologists who prepared for this longer−term science and helped coordinate CALFED’s multidisciplinary monitoring plan. Our central goals are to identify and improve factors that greatly enhance marsh (1) colonization, (2) productivity, (3) export, and (4) sustainability of dwindling and diverse native populations. Our central hypothesis is that virtually all these can increase dramatically in geomorphologically diverse marshes, specifically if a marsh tidal pool is present. Our additional, optional marsh maintenance task would (1) further increase tidal action where necessary (as further adaptive management,) and (2) experimentally connect several marsh ponds to channels with sills and novel sediment/aquatic animal wiers. Overall, we would monitor and thus compare our three reference marshes with our >four replicate restored CALFED marshes both with and without pond connections, preferably including marsh maintenance as experimental field manipulations. We would compare net marsh exports (or sinks) of diverse animals and plants (birds, fish, invertebrate, plant, and major algae populations,) persistent metals (Se, Hg and methyl mercury, Pb,) and water quality. We may document factors that enhance and maintain productivity, such as persistent marsh tidal pools with moderate benthic algae, and identify and remedy other limiting factors for key species and their food webs within restored marsh systems, especially for delta smelt, salmonids, splittail, and their food webs. Thus, we would improve, monitor, and maintain CALFED restored marshes and their exports through adaptive management, to improve these and other Bay/Delta restorations. Our overall hypothesis is that particular conditions in our reference and restoration marshes will yield very different population densities and exports of marsh birds, resident fishes, and their food sources. Furthermore, rates of export of larval and juvenile fishes from our marsh restorations hypothetically will tend to improve through time, with reduced methyl mercury exports, at restored marshes with suitable conditions (e.g., saline marsh tidal pools). Our project directly addresses uncertainty #10 (Shallow−water, tidal MARSH habitat) as a limiting factor in overall restoration efforts, including habitat and

water quality. Our related “marsh morphology” addresses CALFED uncertainty #’s 1 (Natural Flow regimes), #7 (Channel Dynamics, Sediment Transport, and ~Riparian Vegetation), and #9 (Bypasses as Habitat). We will present results of our work to agencies and major conferences, where colleagues provide feedback. Completing our previously planned long−term monitoring, we plan to publish this work in academic and applied management journals, and disseminate it in university lectures and outreach. Data will be available in Department of Fish and Game’s (scientific permit) electronic format, extended to include our physical and chemical factors. This proposal directly targets the following ERP strategic goals: Goal 1: At−Risk Species; Life cycle stages and habitats of delta smelt and Sacramento splittail, salmonids, and other species. Goal 2: Ecosystem Processes and Biotic Communities; Rehabilitation of natural processes and biotic communities in the Estuary. Goal 4: Habitats; Marsh habitats worldwide are recognized as refugia and nurseries for larval and juvenile fishes. Goal 5: Non−native Invasive Species; Tidal marshes have become homes for a variety of non−native invasive plant and animal species, whose effects we seek to control. Goal 6: Sediment and Water Quality; We propose to compare sediments, water, and organisms in restored and reference marshes for abundance and exports of heavy metals, especially lead, total mercury and methyl mercury, and copper, for nutrients (N and P,) and carbon flux.

Narrative and appendices for CALFED proposal:

Multdisciplinary Monitoring of Environmental Processes in CALFED Restored Marshes in the Suisun Bay Ecological Zone. Phase Two: Importance of Rare Marsh Tidal Pools, Algae, and Other Features along Marsh Channels.

By Dr. Chris Kitting, California State University, Hayward (CSUH Foundation), 25800 Carlos Bee Blvd., Hayward, CA 94542-3035 Phone: (510)885-3471; FAX (510)885-4747; contact: Chris Kitting, e-mail:ckitting@csuhayward.edu
in collaboration with others (see narrative and forms,) including McNabney Marsh Management Committee, its multi-agency members, Weapons Detachment Concord, San Francisco Bay Wildlife Society, and Dr. Joy Andrews, CSUH Chemistry and Bay/Delta Science Consortium.

 This proposal preparation was strictly on unfunded volunteer time, with little time available, particularly during CSU’s Budget Crisis.

It is in CALFED formats at almost maximum page limits.

PROJECT DESCRIPTION *1. Statement of Problem*

<u>*a. Description of Problem*</u>. Phase I. discovered that our three various marsh restorations with connected marsh pools (marsh tidal “pannes”) yielded >~20x more abundant fishes and invertebrates (largely natives) than at our two other restorations. The latter marshes yield animal abundances similar to those of our >two Suisun Bay historical marshes (~100 yr old, never diked,) which all showed few invertebrates and fishes, and lacked connections to marsh pools. Our Phase II project is designed to maintain our recent CALFED marshes with increased tidal action and to increase the size of SUITABLE aquatic animal habitat throughout ~10 km^2 by adding or connecting several MARSH TIDAL POOLS to channels (as ~large-scale field manipulation experiments,) especially near restorations that presently yield very few aquatic animals. These partner-CALFED restorations anticipated >5-10 years of monitoring, and only 2.5 were possible to contract in Phase I. Proposed comparative monitoring through 2008, including marsh functions as they develop, is critical to detect longer-term responses to marsh establishment, variable rainfall, temperature, etc. as inter-annual variables. Ongoing Dept of Fish and Game and Interagency sampling in deeper water has shown the value of longer-term monitoring.

We use integrated multidisciplinary monitoring to compare a range of ~replicate marshes to identify and improve physical, chemical, geomorphic, and biological factors most limiting in successful marsh restoration efforts in the North Bay/Suisun Bay Ecological Zone (CALFED Management Zone 2) of San Francisco Estuary, hereafter referred to as “the Estuary.” As emphasized in the CALFED mission statement and in the literature cited below, successful marsh restoration includes the creation of suitable, sustainable, low/no-maintenance habitat where both native and economically desirable non-native aquatic and terrestrial species (both species of concern and beneficial others) can successfully maintain viable populations, preferably increasing through time in restorations and surrounding areas.

Review of Relevant Studies. Ecological restoration should follow scientific principles, yet must conform to specific attributes of sites being restored. Estuarine restoration is guided by hydrodynamics common to all estuaries, and yet must address site-specifics, such as climate, geology, and the estuarine species present. In San Francisco Estuary, the "X_2" value, a distance (in km) of the 2 ppt isohaline position measured from the Golden Gate Bridge, can be estimated in past years from a kneading of physical data common to estuaries worldwide (fresh water flows, tidal fluxes, etc.), but the effects of X_2 on specific populations on Estuary species of interest (e.g. the native mysid *Neomysis mercedis*, longfin smelt) is confined only to San Francisco Estuary (Kimmerer and Monosmith, 1992; Jassby, 1992). Estuaries are difficult to model due to poorly understood linkages among the physical parameters, water chemistry, geomorphology, and the biology of the species in the given estuary (Walters, 1997). Some estuaries offer broad generalities for comparison in restoration efforts (Ogden and Davis, 1994 in Everglades restoration,) but lack the specifics of San Francisco Bay. Recent National Academy of Science reviews by Zedler and Turner show that such marsh restoration nationwide has not been adequate to keep up with habitat loss. Interdisciplinary work may be a major improvement, as the recent Am Soc of Limnology and Oceanography conference adopted the theme of "Inter-disciplinary Linkages in Aquatic Sciences and Beyond." Particular concerns for the San Francisco Estuary and its threatened and endangered fish species, have focused on environmental chemistry and animal biology, although we propose to integrate plant, algal, and avian work too. In many cases, the biology and limitations of threatened Estuary species have not been known, such as the delta smelt (Brown and Sitts, 1999). Specifically, the role of shallow-water habitats in the life history of the delta smelt, and the optimum structure and other environmental parameters of marshes that encourage healthy smelt populations, are not understood (Ibid, 1999). Brackish Suisun Bay may favor native fishes (relative to invasives, Meng et al. 1994, Matern et al. 1995) more than our freshwater Delta upstream. The approach of providing more tidal amplitude to increase fish populations and migrations is locally supported by Balling et al. (1979, 1980), and is expected to deter invasive plants (via tidal salt water) and aerate water through circulation.

Phase I suggested the direct or indirect importance of connected marsh pools here (Kitting 2001, 2002), while moderate algae from marsh tidal pools may be a more direct effect (after Van Montfrans et al. 1982, Kitting et al. 1984). Our hypothesized importance of connected marsh pools may be analogous to Sommer et al. (2001) documenting the importance of seasonal floodplains for native fishes. Grimaldo et al. (2004) also showed that in fresh water, winter and spring inundation (not continuous inundation) tends to favor native fishes upstream of our sites. West and Zedler (2000), along with our comparative sampling at their sites in San Diego, support our recent hypothesis that connected marsh tidal pools are associated with abundant animals. Collins et al. (1987) indicate how sediment may fill such pools within a decade or so, and some marshes may risk sustainability (Orr et al. 2003,) but animals and marsh tidal pools may be most abundant where marshes are EXPANDING naturally, where these animals probably evolved. Other salt marsh conditions also can minimize sedimentation naturally (Chmura and Hung, 2004.). Furthermore, our intitial coring suggests that marsh pools CAN persist over a hundred years, naturally. Perhaps periodic flood conditions scour them often enough. Alternatively, nearby sedimentation, and sealevel rise, may produce new tidal pools as old ones sediment in. Furthermore, our fish weir design (available through this project) should maintain connected tidal pools without sediment accumulation. We have found naturally analogies to such weirs, as we overall seek to provide more historical conditions for more historical, diverse populations. Increased marsh water volume and tidal currents from connected marsh pools might even minimize sedimentation in connected channels.

Objective of Proposed Study. A key to successful aquatic habitat restoration, including tidal marsh habitats, is to provide as many environmental linkages as possible. These linkages include physical, chemical, geomorphic, and biological factors that determine outcomes of restoration activities. Objectives of our proposed project within the North San Francisco/Suisun Bay ecological management zone include: (1) further increase tidal action to shores, (2) connect several marsh pools to channels with sills and novel sediment/fish weirs, (3) monitor and thus compare our reference marshes with our replicate restored marshes both with and without experimental marsh pool connections, as field manipulations. We would compare persistent metals (Se, Hg, Pb), water quality, and biotic diversity and productivity (bird, fish, invertebrate, plant, and major algae populations), and identify and improve factors that enhance productivity. The work would identify and remedy limiting factors for key species and their diverse food webs within these marsh systems, specifically with regard to delta smelt, splittail, and salmonids. Thus, we would restore, improve, monitor, maintain, and instruct others about marshes through adaptive management, to improve these and other Bay/Delta restorations and their adaptive management.

At no further cost to CALFED, we also would compare these results with our extra sampling at less accessible, ancient (>~1000-yr-old) marshes nearby (Brown Island) and estuaries north and south, such as in Mendocino, Tomales, and Elkhorn Slough, as volunteers if necessary. Our additional collaboration with the Fisheries Foundation's proposed monitoring may enable frequent, thorough sampling at additional replicate marshes just upstream in the outer Delta. Our related NSF and NIH proposals also are in prep.

b. Conceptual Model. *Technical Basis for Our Model*. Our initial, Phase I restorations, observations, and monitoring results compared both "replicate" and very different marshes, different physical and biological factors found in each, to formulate the hypothesis that a positive association exists between high population densities of most aquatic animals (including splittail and even dense HERRING in marshes) and the presence of a marsh "tidal pool" (shallow, persistent, quiet-water area) along constructed channels. By experimentally connecting several presently isolated marsh pools to channels used in most of our previous replicate restorations and monitoring them, in comparison with control/unmodified reference sites, we will use these large-scale field experimental manipulations to test for an increase in populations and diversities of zooplankton, zoobenthos, native fishes, and birds. An alternative hypothesis is that west-coast migratory fishes may be less dependent on marsh conditions in general, as west coast marshes are younger, rarer, and more isolated in comparison with better-studied estuaries on the U.S. east and south coasts (after Onuf et al. 1978).

A diagrammatic model of our project, based on our recent evidence, is shown in Figure 1 of the Appendix (Existing Project Status). Each trophic level passes the necessary nutrients and energy to the next level, but can be concentrated by a reservoir (marsh tidal pool, possibly fertilized by increased birds) increasing nutrients for enhanced primary productivity, and with a healthy secondary (zooplankton and zoobenthos) productivity as food for both resident fishes and larval and juvenile fishes whose adults inhabit deeper areas of the Estuary. If nutrients (hypothetically concentrated by marsh birds), algae, vascular plants, or zooplankton and/or zoobenthos are insufficient to sustain native larval and juvenile fishes, energy flow within the entire system is stifled, and as a result, native adult fish populations will suffer. As energy passes from one level to the next, other limiting factors come into play, described in detail under "Relevant Uncertainties," below. We have found that marshes with tidal pools have much higher densities of zooplankton (and apparently algae) than marshes with very thorough tidal flushing. The mechanism(s) for these differences are not yet known, but could relate to the "floodplain" phenomenon observed in such areas as the Yolo Bypass during wet years (see scientific uncertainty #9, "Bypasses as Habitat" of PSP, and Sommer et al. 2001) and reservoirs of productive food (Kitting et al. 1994, Miltner et al. 1995). Alternatively, we may find that previously sampled abundances near tidal pools simply are a consequence of limted export.

Source of Information for our Model. Our model of a tidal marsh habitat is based on a generalized aquatic ecosystem model, and on data gathered from Phase I of our work on tidal marshes in CALFED's Ecozone 2. Trophic levels in these marshes hypothetically can sustain higher productivity if certain conditions are improved, such as addition of marsh tidal pools along channels. We hypothesize that marsh tidal pools will act as nutrient reservoirs and as sources of food and refugia for fishes between high tides. Among our reference and restored marshes, high, dissolved nitrogen (N) and phosphorus (P) levels (or export rates each tide) may be correlated with higher population densities of zooplankton, zoobenthos, and resident fishes. Kamer et al. (2004) showed that additional N and P relieved benthic algal nutrient limitation even in a eutrophic estuary (upper Newport Bay). Recent presentations by A. Mueller-Solger further show the probable importance of pools of benthic micro algae in San Francisco Bay/Delta food webs.

Some of our larval and juvenile fishes concentrated in marshes are species whose adults are found in deeper parts of the Estuary (delta smelt, Sacramento blackfish, possibly splittail). We hypothesize that juveniles either leave these shallow-water areas and grow to adulthood in deeper parts of the Estuary, or they may generally die in marshes, due to unfavorable environmental conditions, such as temperature extremes in shallow water. As in the Gulf of Mexico, eggs and/or larval fishes may enter tidal Estuary marshes after spawning takes place just outside the marsh (Kitting et al., pers. obs.).

Relevant Uncertainties. Our simple conceptual model in Figure 1 can be related to uncertainties and limiting factors of concern in CALFED's restoration efforts in Ecological Zone 2. Our project directly addresses uncertainty #10 (Shallow-water, tidal marsh habitat) as a limiting factor in overall Estuary restoration efforts. In our model, "marsh morphology" relates to CALFED uncertainty #'s 1 (Natural Flow regimes), 7 (Channel Dynamics, Sediment Transport, and Riparian Vegetation) and 9 (Bypasses as Habitat). All three of these uncertainties may be limiting to native fish populations in our marshes. *Natural flow regimes*, our channel morphology and presence or absence of connected marsh pools in reference and restored marshes, could be critical to nutrient availability and ability of juvenile native fishes to feed and grow successfully. *Marsh channel dynamics and associated sediment transport* and emergent marsh vegetation could be critical to both nutrient availability and survival (in shade) of small native fishes. *Bypasses*, or in our case, marsh "tidal pools," areas of shallow water at low tide, we hypothesize to be crucial to buildup sufficient nutrients, as sites for increased primary and secondary productivity, and as nurseries for abundant small fishes. "Phytoplankton and emergent vegetation" and "zooplankton and zoobenthos" in our model addresses uncertainties #1 (Natural Flow Regimes), 3 (Decline in Productivity) and 6 (Non-native Invasive Species). We hypothesize that both primary and secondary productivity depend on marsh morphology, possibly the connection with marsh tidal pool. Declines in overall Estuary productivity could be tied at least in part to loss and degradation of marsh habitat, especially with connected, marsh "tidal pool" areas. We have found many native and non-native plants and animals in both our reference and restored marshes. At one site, we found non-native hydroids in very high densities, lining the pipes through which tidal action fed the marsh. The size, and probably the presence, of the pipes were undoubtedly a risk to zooplankton and larval fishes, which had to pass the gauntlet of extended stinging tentacles on the inside of the pipes. Through adaptive management, ecological bottlenecks now present in our marshes can be documented, and as appropriate, modified to remedy any marsh degradation, or design or construction flaws. Thus, we can develop and implement solutions to marsh restoration problems.

Hypotheses being Tested. *Testable Hypotheses.* Our work is based on comparisons of replicated types of marshes. Our overarching, testable hypothesis, based on our basic conceptual model, is that different conditions in our reference and restoration marshes may yield very different population densities of native fishes (including delta smelt, splittail, and salmonids) and other animals; fish abundances or export rate of our shallow-water marsh restorations may differ greatly, depending on channel connections with marsh tidal pools and local nutrients. A second hypothesis is that each of our suitably restored marshes (and adjacent reference marshes) will accrue higher habitat value of most taxa through time. In particular, we hypothesize that both the presence of intertidal vegetation and invertebrate food resources, especially near marsh tidal pools, are necessary and sufficient for fishes to colonize restored marshes. Our restorations thus may attain animal densities (or productivities) greatly exceeding those in reference and other marshes. Alternatively, marsh animal abundances may peak soon after restoration, and decline through time, explaining our presently sparse animals in ancient reference marshes. Similarly, methyl mercury or other contaminant export (or alternatively, sequestering by a marsh) may differ from better-studied freshwater systems, and change as a restored brackish tidal marsh matures.

CALFED Goals and Uncertainties Being Addressed. The following Ecosystem Restoration Plan (ERP) Strategic Goals are being addressed in our project: Goal 1: Recovery of At-Risk Species. Our project is directly addressing the recovery of two at-risk species, delta smelt and Sacramento splittail, and probably others such as Chinook salmon runs. CCMVC also has had success raising at-risk Sacramento perch, which might be used through DFG to experimentally colonize nearby marshes. We aim to answer uncertainties and improve survival of fish larvae and juveniles in our marshes, using the hypothesis that such areas of the Estuary are important (but not the sole limitation) for the recovery of healthy delta smelt populations. Our project will also address the importance of shallow water tidal marshes for establishment of healthy splittail populations in the Estuary. Goal 2: Ecosystem Processes and Biotic Communities. Through our shallow-water marsh restoration efforts we aim to achieve marshes that will persist with a minimal amount of human intervention, and will have natives as dominant species. Uncertainties addressed here in our project include the role of marsh "tidal pools" for food and larval and juvenile native species in tidal marshes. Goal 4. Estuary Habitats. We are restoring, monitoring and adaptively managing functions of tidal, mesohaline marshes. Uncertainties addressed here include whether native species will benefit as much as introduced species in such tidal marsh restorations. Goal 5: Non-native Invasive Species. Concerning non-native species, we have two goals in our adaptive management of marsh restoration:(1) the removal of non-native plant and animal colonists in our marshes, as appropriate (yellow-fin gobies, green crabs, mitten crabs, all as requested by DFG), and (2) to eliminate conditions that encourage the establishment of healthy populations of non-natives in our marshes (e.g., the role of "pipes" as conduits of water to marshes, which harbor populations of introduced hydroids), identifying and eliminating "bottlenecks" in tidal flow to marshes, such as modifying silt deposits or gates and other structures to enable fishes to pass through marshes).

d. Adaptive Management. *Relation of Our Conceptual Model to the Adaptive Management Design (Healey Ladder)*. Each trophic level in our conceptual model can be related to the "Healey Ladder" and "Healey Adaptive Management Process" of the adaptive management process. In our proposed project, restorations can be considered both as "pilot" and "large-scale" implementation projects, which will vary from 1 to 300 acres (Step 4-Healey Ladder). Through monitoring, each trophic level will be assessed for limiting factors or bottlenecks during the restoration and colonization process. Advice will be given to our colleagues as to how these limiting factors apparently can be minimized. Under "initiate restoration actions" (Step 4 of the adaptive management process), "Learning" in our Healey ladder would consist of information gleaned from Monitoring (Step 5 of the Healey ladder), and of ongoing results from each or our restoration projects being "fed-back" into each restoration (through Step 6 of the ladder) to improve habitat conditions for native species (back to Step 4). An adaptive management loop from Steps 4, through Steps 5 and 6, and back to Step 4 continually feeds information back to managers in order to continually improve the restoration process here and elsewhere.

<u>*Further Justification for the Proposed Project*</u>. As in many estuaries, San Francisco Estuary has lost many of its low-salinity marshes, known to be so important to many estuarine fish species (e.g. Schubel 1992). Tidal marsh areas have been converted for agriculture and duck clubs around the Estuary, resulting in a small remaining fraction of functioning estuarine tidal marshes connected for aquatic migrations, areas known to be highly productive and nurseries for young fishes (Wetzel 1975). The justification for our project overall is based on our increasing key areas of tidal marsh to increase the Estuary area and quality of low-salinity habitat. Our project directly addresses the uncertainty that an increase in the area of suitable low-salinity marshes *should* result in increased overall Estuary productivity and population density and habitat of threatened Estuary fish species, and other historidcal species. Our project is, in one sense, both pilot and full-scale restoration, as relatively large areas (~600 acres) are restored to increased tidal action and aquatic biological function, yet such areas are relatively small compared with the total potential Estuary tidal marsh area available for restoration. Our simultaneous monitoring of both reference and restoration marshes will enable a continuous fine-tuning and resolution of uncertainties, limiting factors, and bottlenecks in restored marshes. Testing changes in restoration design based on our adaptive management practices will support or modify our hypotheses about improved habitat for larval and juvenile native threatened species (delta smelt, splittail, salmonids), and about other CALFED ERP goals. The improvements would be used in future restoration projects, both by ourselves and others throughout the world.

The proposed project has an additional, educational objective, at no additional cost, as PI's, collaborators, student assistants, and our audiences will learn and train others throughout the duration of the project, and beyond it. We offer advanced CLASSES in Estuary and Delta restoration, integrated with our monitoring, and based at our new, nearby Contra Costa Campus of CSUH, as encouraged by Senator Tom Torlakson and CALFED. These classes would be integrated with our other proposed monitoring work, and would be open to local and visiting students and teachers, to train future generations of informed citizens and restoration scientists. At no cost to CALFED, our project partners and former grad students previously HOSTED several US senators and congressmen, plus State Senator Torlakson's Office to SHOW them our marsh restorations, including access via a boat tour near Concord. Military Base conversion is timely at our sites. The tour was very well received, focusing (then) on land acquisition for restoration and research. Our team is proposing NSF "Ecosystem Studies" funds too, for further research about mechanisms behind limiting factors at marsh restorations there. Our separately proposed biochemical and molecular assessments of mixed function oxidases can detect effects of otherwise hidden, sublethal toxins at our various sites. We already are supplying specimens to other colleagues for stable isotopic analyses of fish food webs, analogous to Kitting et al. (1984).

Our recent discovery has been especially important: Living fossil snails in our marshes with tidal pools, previously known from Central Valley ancient San Joaquin fossils only, small <u>Hydrobia andersoni</u> (first documented in Kitting and Davis 2003). It is the a closest relative of the

California brackishwater snail (on the endangered species list) and was thought to be EXTINCT for >2 million years, but we recently documented it colonizing and thriving only at three of our restoration sites with marsh tidal pools(!), where endangered/threatened fishes also colonized. Such a living fossil has important implications for the sustainability and mobility of these geologically young LOCAL habitats. Such discoveries we again propose to circulate and edit through CALFED, then colleagues, then the general public through our established outreach to diverse audiences of all ages and several languages. The present partner, SF Bay Wildlife Society, has released a successful video about Bay watersheds, narrated by Kitting.

2. Proposed scope of work

a . Location and Geographic Boundaries of the Project.

Counties Where Project is Located: Contra Costa County. Ecozone included: Suisun Marsh/San Francisco Bay (Zone 2). Suisun Bay Marsh is 2.1.
Map with Outline of Project Sites (One wide and other detailed images attached, in appendix**)**
Digital Geographic Coordinates of Project Sites*:* (A table of restoration sizes and GPS boundaries and centers, for NAD 83 datum, immediately follows the proposal. Also noted on map in appendix):
Photographs of Project Sites*:* (attached, with map in appendix)

b. Approach. Sampling; Methods and Techniques. We would improve and employ integrated, non-destructive physical-chemical-biological monitoring, with replication, throughout each restoration (and adjacent reference marshes) to evaluate and improve restoration results through adaptive management (Kitting 1993). Our restored marshes would be sampled before, during, and after any restoration maintenance to further increase tidal action. Areas nearby remain without modification for reference comparisons. These marshes include those restored to full tidal action, and others restored to increased, though still “muted” tide action. Emphasis will be placed on monitoring habitats for CALFED priority fishes, particularly delta smelt, splittail, Chinook salmon (all runs), steelhead, green and white sturgeon, and their food resources (zooplankton and zoobenthos). We also would expand bird sampling, including possible predators on young fishes, and sources of marsh nutrients. Densities of bird footprints on mud may be our best comparative indicator of bird activity. We include sampling at mouths of intertidal channels to gain unusually complete censuses of large fishes in portions of these marshes. Random number tables provide numbers of steps between each replicate sample. Our sampling protocol, schedule, and logistics are designed to minimize impacts to each site. For example, kayaks are used as access to more remote sites. Muddy equipment is washed (and misted with alcohol) to minimize any transfer, among sites, of aquatic animal pathogens present in marsh mud. Non-destructive sampling of biota is performed via standardized field photography and counting of specimens prior to returning from the field. Seasonally, sediment accumulation or net erosion in sediment traps (or with sediment “pins”) also is assessed.

Approximately monthly, zooplankton (including Ichthyoplankton) are enumerated from replicate 0.25-m^3 tows. Similarly, epibenthic sampling is performed in replicate 0.05-m^2 thrown cage samplers after Weinstein pers. comm. and Huh and Kitting (1985,) adding quantification of major algae (after Kitting et al. 1984). Sunken “minnow” traps (like crayfish traps with 2 mm mesh) as refugia (with extra 2 mm mesh inside) sometimes with white LED lights inside (as light traps for delta smelt etc.) are used for sampling larger, less abundant epibenthos and nekton, such as large crustacea (including crabs and crayfish) and certain fishes. Rates of algal overgrowth quantify benthic algal productivity. Larger fyke nets seasonally sample the above large taxa and larger fishes passing through the mouth of each marsh. The latter methods are adopted by our inter-agency wider-scale monitoring planned in North Bay CALFED marshes. Occasional mortality, and removal of common invasive species (such as yellowfin goby and mitten crab) may enable additional assessment of diets of the common fishes or invertebrates associated with marshes. If overfishing desirable species can deplete them, perhaps selectively killing invasive species can deplete THEM in our marshes, especially during our intensive sampling. Care is taken (nets extending above water) to prevent risks to air-breathing animals such as beavers, otters, muskrats, turtles, and frogs, whose presence in each area is tabulated qualitatively. Occasional specimens are preserved for reference/voucher specimens of small species, and will be maintained at the university.

Data Collection, Equipment, and Facilities. Physical, chemical, and biological data (previous and additional factors) will be gathered systematically for each reference and restoration marsh site. Sampling locations are identified and logged via Garmin WAAS GPS (wide area augmentation system global positioning system, accurate within a few meters). Other information, logged approximately monthly (see basic data table in appendix), includes site identification, date/time/tide, physical factors (below), and replicated animal abundances with 1-m^3 plankton tows, thrown cages (benthos), and fish live traps/artificial refugia (with fine mesh inside). Physical factors include approximate wind and water current, and quantitative data on physical factors of: water depth, clarity (secchi depth), and basic surface and bottom water parameters (with YSI probes and now YSI 600XL recorders, seasonally for continuous ~3-wk records of): temperature, depth, salinity/conductivity, pore water salinity/conductivity (subsurface, if different), redox, and O_2 content. Sediment accumulation or net erosion in sediment traps (and sediment "pins", and standardized photographs) also are assessed seasonally, along with analyses of large fishes (in fyke nets and sonar), plant densities (in permanent quadrats), metals (including MeHg), nutrients, and carbon flux (after Morgan and Kitting 1984) seasonally. Comparisons of carbon flux are requested by CALFED, and were begun locally by Jasby and Cloern (2000).

We use office and laboratory space at the main and Contra Costa CSUH campus, in mobile labs, and at CCMVC.

Analytical Procedures. Nutrient anions including nitrate and phosphate, cations, and dissolved transition metals will be measured using a Dionex DX 500 Ion Chromatograph. Total N, P and organic C will be measured using a microwave digestion (for orthophosphate) then Hach COD reactor and colorimetry. Total metals are determined (EPA procedures) by microwave digestion followed by atomic absorption using a Perkin Elmer Aanalyst 300. Analyses of methy mercury concentrations are to be analyzed in continued collaboration with Dr. Kenneth Coale at CSU's Moss Landing Marine Labs.

Construction Procedures (including enhancing recent restorations). In Phase I, we provided tidal amplitude to large portions of each of our restoration regions, through widening or removing physical bottlenecks. Any maintenance in Phase II would remove any silt deposits and invasive vegetation clogging channels, and stabilize the channels with other native vegetation. sometimes by hand or with small equipment, including water pressure. Native marsh vegetation threatened by these activities will be transplanted locally, to replace patches of invading plants and to stabilize sediments that slump into channels, especially near openings to tidal creeks. No threatened or endangered plants or animals would be disturbed. In particular, existing but presently isolated ponds or newly excavated ponds (resulting where invasive vegetation is removed, generally by hand) will be connected to restored channels at some restored areas.

Connections will be equipped with wiers to maintain adjustable minimum water levels in marsh tidal pools at low tide. CCMVC is donating much of their restoration and maintenance work for any more extensive excavation necessary to provide a shallow tidal pool along some channels. To prepare for future restorations, our use of reference sites (after Zedler, 1990) with and without marsh tidal pools, will enable conservation and management to proceed there and in potential restoration sites in line for future implementation**.** Additional data collection and analyses proposed here also will take place in conjunction with an array of specific restoration activities already funded through CCMVC: First, the introduction of substantial tidal action in the Peyton Slough Marsh complex will be complete in early 2006, following the completion of a mandated toxic cleanup in Peyton Slough. Second, the third restoration phase at the Point Edith marsh complex has been arranged for tidal enhancement to hundreds of acres of marsh and numerous ponds (mostly unconnected, non-tidal, but possibly some to become marsh tidal pools) soon thereafter.

Statistical Analysis and Quality Control Procedures. Biological data are tabulated with at least four replicates per sampling date, per site (usually twice that). Sampling is performed approximately once per month, more frequently if the situation dictates (e.g., presence of species of concern). Orders of magnitude differences among data sets at sites are statistically distinguishable using sets of four replicates. Pooled data provides higher resolution as necessary. In the field, data are entered into our standardized data tables (analogous to those recently adopted by DFG’s permits) from our computer database. Significant qualitative observations are noted and communicated to others of the team for confirmation as required. Consistency among team-mates and Sr. scientists is achieved through together sampling >~8 replicate samples per site (>~40 samples), or more, until observations are consistent. As each season or year of data is obtained, graphic and (often non-parametric) statistical analyses of data will be conducted, as appropriate,. Our Quality Assurance/Quality Control procedures are filed with CALFED, and include careful standardization of methods and confirmed species identification, performed by photography and experienced PI’s and their personally trained and supervised assistants. Each senior staff will continue to collect and analyze data first-hand throughout the project.

Criteria Used in Hypothesis Testing. Some of our criteria used for hypothesis testing are qualitative**:** e.g. that both emergent vegetation (shade) habitats in connected marsh pools, and invertebrate food resources, will be necessary (and that neither is sufficient, alone) for native fishes to colonize restored marshes. Subsequently, qualitatively similar replicate sites can be grouped. Other criteria are quantitative, for testing statistical differences among groups, via nonparametric statistics: e.g. that suitably restored marshes will tend to accrue increased habitat value through time, and exceed that of our historical reference marshes. A less conclusive, but useful, criterion may have to be based on intermediate probabililities (such as in weather forecasting), seeking merely increased probabilities of a successful population recruitment (analogous to Kitting and Morse 1998). Our hypothesized improvements in these restorations, through the process of adaptive management, would lead to productivities (export of zooplankton, zoobenthos, and fishes) greatly exceeding those in our reference and other Estuary marsh communities. Already, three of our four restored and reference marshes that have high animal abundances yielded herring or splittail populations over ~50x the maximum population densities reported in DFG monitoring (the latter, apparently in deeper water, where capture efficiencies may not be comparable).

c. Performance: Monitoring and Assessment Plans. Comparative, multidisciplinary monitoring, compared with historical reference marshes, forms a major focus of the project. Our separate work on relatively pristine bays north and south will provide a yardstick to assess San Francisco Bay Estuary improvements on a broader scale, too. Our attached data sheet (near the document's end) notes of field monitoring components, as is included in our QA/QC monitoring plans on file with CALFED. Feedback from our quarterly CALFED reports, colleagues at scientific and environmental management meetings, in our university course evaluations, and from our subsequent, peer-reviewed manuscripts all assess the clarity and completeness of our resulting products, including presentations. We and others have found that our monitoring will be adequate to determine the outcome of our restored marshes relative to CALFED goals (see section c :"Hypotheses being tested" in this proposal, for identification of our CALFED goals.) Emphasis will be placed on the monitoring of suitable habitats for CALFED priority fishes, particularly delta smelt and splittail, but including Chinook salmon (all runs), steelhead, and green and white sturgeon. Comparative monitoring will be essential and integral in these marsh restorations. Analysis of species colonization, migration and other environmental parameters will take place throughout the project. The monitoring and experimental design to assess the restoration outcomes will follow scientific protocols of successful biological restoration work carried out elsewhere: Zedler's PERL and CRC handbooks, Hymanson and Kingma's Coastal Conservancy Handbook, or the SFEI CMARP website (http://www.iep.water.ca.gov/ cmarp/reports/).

Water quality monitoring will be conducted to determine how these restorations may improve water quality parameters important for drinking water quality, fish viability, and suitability of fish for human consumption. Fish and invertebrate survival can be closely linked to dissolved oxygen (DO) levels (e.g. Sagasti et al. 2001). Factors affecting DO such as temperature, salinity, presence of nutrient anions (nitrate, phosphate) and particulate organic carbon will also be measured. Levels of toxic selenium, methyl mercury, copper, cadmium and zinc also will be compared in sediment, plants and common resident fish species to determine whether bioavailability and biomagnification change during the restoration process.

Sample collection procedure protocols and quality control measures will be followed to ensure lack of contamination and accurate results. Sample containers will be acid washed, and all acid preservation and digestion will be done with trace metal grade acid. Field blank and trip blanks will be taken into the field, and duplicate samples will be taken. Digestion blanks, duplicates (1 per 10 samples) and spikes (1 per 10 samples) and standardized NIST samples will be included to ensure proper sample digestion. Analytical calibration (R^2 >.995) and blanks, spikes and replicates of each measurement will ensure proper analysis.

d. Data Handling and Storage. Data are logged directly into our standardized, initialed data tables in Microsoft Excel (see sample data sheet attached). Dept. of Fish and Game has adopted such a format required for scientific permit reporting, which also served as a template for CALFED's regional multidisciplinary monitoring (led by S. Siegel). Our data are checked and analyzed/interpreted (and backed up, off campus) by the responsible PI: Kitting for physical factors, algae, and nekton (swimming animals), and an associate for plankton and epibenthos (small animals on bottom). Our data website (ftp://imctwo.csuhayward. edu/marsh) and our USFWS collaborators' websites (M\Data\SFB\WetRes\Plants\VegTI799.xls and M\Data\SFB\WetRes\Birds \Data\SBTI899.xls plus link) have been used for posting such results on the internet, as requested.

e. Expected Products/Outcomes. We will submit quarterly reports and annual reports, in a scientific paper format, to the collaborating agencies throughout the project. If desired, our drafts of major reports are available in advance to these collaborators, for their comments. Results of our work are prepared and presented to agencies, environmental managers, and major science conferences, where our oral presentations will provide feedback from colleagues. We plan to publish our work in academic and applied journals. Reprints acknowledge the collaborating agencies as appropriate.

f. Work Schedule (Also See Form)

TIME LINE and SCHEDULE MILESTONES

Year 1				Year 2				Year 3			
qrt 1	qrt 2	qrt 3	qrt 4	qrt 1	qrt 2	qrt 3	qrt 4	qrt 1	qrt 2	qrt 3	qrt 4

(Task One, administration and general reporting, throughout.)

Task 2. Marsh maintenance and vegetation/connected marsh tidal pool establishment during summer, yr 1 (qtr 3 and 4) throughout Eastern Pt. Edith Marsh Complex. Benchmarks would be reports on project completions for resource managers and for other scientists.

Task 3. Physical and biological monitoring, throughout. Performance measures would be population densities and export rates of diverse animals. Benchmarks would be formal presentations for resource managers and for other scientists, and manuscripts.

Task 4. Water chemistry monitoring and improvements, throughout. Performance measures would be MeHg concentrations and export rates in edible animals, transported sediment, and water. Benchmarks would be formal presentations for resource managers and for other scientists,
and manuscripts.

Initial deliverables often will be presentations at science and management meetings with diverse CALFED agencies. Written deliverables are semiannual, annual, and final reports that summarize, integrate, apply, and list our manuscripts from each task, which are in scientific paper formats plus databases in Excel. CALFED will be offered 60 days to comment on manuscripts before they may be submitted for publication. Alternatively, web posting is available by us if CALFED desires.

g. Feasibility. Demonstration of Project Feasibility. We have proposed a work schedule and workload that can be completed in the time allotted, thanks to major matching funds from CSUH and CCMVC. Based on the experience of the first phase of our project, the project approach for this second phase is similar to monitoring in the first phase, and we experienced very few disruptions in our monitoring schedule, laboratory work, data entry, and information dissemination through papers and meeting participation. Our Phase I progress exceeded contracted requirements. Letters of support are available.

Description of Methods. Our methods are outlined in the "Approach" section of the proposal, above, as are the references to our scientific and technical procedures used (see References). Our mobile and floating laboratories, normally kept packed and ready in their secure "hangar" make this intensive multidisciplinary field work practical. Weather has not been a major issue for completing our work in Phase I of our project, and we do not see any problems for Phase II. We have planned other contingencies and requirements, such as permitting issues, to enable the prompt start and completion of Phase II of our project.

Permits and Agreements Necessary for Project Implementation. Our partner, CCMVC, is experienced with permitting for restoration near these sites. Necessary permits and agreements are complete or in prep at all sites (see online form). An additional MOU pending for manipulation of sensitive fish species, is not critical for the proposed work, but could allow additional mesocosms to manipulate delta smelt or Sacramento perch densities experimentally within the marshes, analogous to Kitting et al. (1997 and in prep) and tidal pool experiments with snapper in cages (Guerro-Tortolero et al. 1999) sustainable at our periodically observed, high fish densities. Other scientific permits are complete, and can be renewed.

Private Property and Right of Access Issues. All property and right of access issues have been approved, and are now in effect. Property managers are our partners. Other documents are noted in required proposal forms.

APPLICABILITY TO CALFED ERP GOALS AND IMPLEMENTATION PLAN AND CVPIA PRIORITIES.

1.ERP Goals and CVPIA Priorities. This proposal targets solutions in all of the following ERP strategic goals: *Goal 1: At-Risk Species.* We are concentrating on the following species for life cycle stages and habitats: delta smelt, Sacramento splittail, white sturgeon, green sturgeon, and all runs of salmon. The habitats studied are very shallow-water tidal marshes. Our work is focusing in particular on finding and minimizing local stressors associated with larval, juvenile, and adult stages of delta smelt and splittail, especially habitat salinity, temperature, and adequate food resources. Knowledge gained from our work in these shallow-water habitats is shedding light on the role of these features in the life cycle of the delta smelt and splittail, and can enlarge and improve habitats for these and other threatened species; *Goal 2: Ecosystem Processes and Biotic Communities.* Our proposal and previous work directly addresses the rehabiliation of natural processes and biotic communities in the Estuary, specifically, how we can improve marshes to improve habitat for at risk aquatic species, again for delta smelt, splittail and salmonids, but also for other important species such as clapper rail and salt-marsh harvest mice. Our proposal directly addresses productivity in shallow-water tidal marshes and how increased productivity, through marsh modification (connected marsh pools). Removal or modification of bottlenecks (gates, pipes, silt deposits) can benefit threatened species as well as the overall health of marshes and the general Estuary; *Goal 4: Habitats.* Marsh habitats worldwide are recognized as refugia and nurseries for larval and juvenile fish. We have shown certain of our tidal marshes to harbor juvenile and adult splittail, and dense Pacific herring (the latter two at extraordinarily high population densities) and other native species also concentrate in these marshes. Our proposal and previous work directly addresses the protection and functional restoration of shallow-water tidal marshes as areas of increased general productivity and as fish nurseries; *Goal 5: Non-native Invasive Species (NIS).* Shallow-water tidal marshes, like most Estuary habitats, have become homes for a variety of non-native invasive species, including plants (which can block channels and crowd out native plants), invertebrates (hydroids, mitten crabs, green crabs) and fishes (largely yellowfin goby and chameleon etc. gobies). Some of these introductions may be of neutral benefit (introduced copepods possibly as fish food, having replaced native copepod species), while some are obviously destructive (hydroids and jellyfish capturing plankton and perhaps larval fish; introduced fishes consuming or otherwise displacing native species). We will address NIS goal II: limiting the spread, or when possible, eliminating local NIS populations through adaptive management. Hydroids can be deprived of much of their habitat (hard substrates associated with strong currents), and non-native fish species can be selectively removed locally during routine sampling procedures. Marsh vegetation appears to deplete invasive jellyfish (Rees and Kitting, 2002). *Goal 6: Sediment and Water Quality.* We propose to sample sediments, water, and organisms in selected restored and reference marshes for nutrients, carbon flux, and heavy metals, especially lead, total mercury, methyl mercury, and copper (critical in Shell Marsh, and apparently can repel fish migration; Goldstein et al. 1999). Toxicity levels will be related to other ecosystems to determine if threshold levels are exceeded, and if so, what effects heavy metals are having on higher trophic levels. Our comparisons of nutrients in and carbon flux through marshes will test for potential limitations or benefits of these brackish marsh communities.

2. Relationship to Other Ecosystem Restoration Projects. Our overall aim is to systematically improve, monitor, and compare an array of replicate reference and restored marshes throughout CALFED Ecological Zone 2, through the use of adaptive management. With CALFED ERP goals as guidelines, we seek to test conditions for increased populations of native threatened fish and other species, improve shallow-water marsh ecosystem processes through marsh modification, and improve general marsh habitat and microhabitat (after Holt, Kitting and Arnold 1983), reduce, as much as possible, the impact of non-native species, and determine the role of heavy metals or nutrients in increasing environmental stress in brackish tidal marshes and in human food webs. Phase I of our project began some of this process, and has shown that many of our tidal marshes harbor high population densities of threatened larval and juvenile fish species (see attachment of our progress to date, near the end here). We have begun to use our results to aid and advise other restoration efforts in this ecological zone, CALFED and otherwise, particularly with regard to methods of habitat improvement and sampling species non-destructively. We have worked with the US Fish and Wildlife Service, with Contra Costa Mosquito and Vector Control (Shell Marsh, Pt Edith Marshes, Weapons Detachment Concord marshes), and with East Bay Parks, all of whom have future restorations planned. Cal Department of Fish and Game manages the Point Edith Complex, encompassing much of our study region, where restoration efforts collaborate extensively with Contra Costa Mosquito and Vector Control. CSUH also collaborates with Wildlands, Inc. on plans for marsh mitigation banks and monitoring (both encouraged by Society of Wetland Scientists Policy,) and with monitoring DWR CALFED sites with the Fisheries Association, upstream in the Delta. Especially through our initial planning with CALFED's interdisciplinary regional monitoring proposals, we have coordinated our methods and data with those additional monitoring sites. However, the only Suisun site that (BREACH) team uses is on a remote island well east of our restorations, and no other monitoring is being conducted in these extensive south Suisun Marshes. (We offered to assist again in the next phase of that CALFED regional monitoring program, especially now that the fish PI has moved away.) Kathy Hieb of Cal DFG also served on that CALFED Fisheries Monitoring Plan, and DFG's Kevin Fleming (and previously Mike Rugg) coordinate methods and reports with us, based largely on Hieb and DeLeon (2000). We also have coordinated our sampling and reporting with the Interagency Ecological Program (e.g. Rees and Kitting 1999 through 2002) and IEP's annual Meetings. Our use of former military bases with relatively undisturbed buffer lands supports productive Base Conversion and new wildlands. CSUH works closely as members of the Bay/Delta Science Consortium and with Moss Landing Marine Labs, integral in the California Mercury Project. Our participation in related local, national, and international meetings assists coordination with broader ecosystem restoration efforts and other science, especially as we seek more Federal recognition of CALFED restoration science and applications.

3. Requests for Next-Phase Funding.. See the attached two-page summary of our existing project progress to date, plus Appendix tables. This proposal both continues and expands work performed in the first stage of the project, making our previous monitoring long enough to be more conclusive and publishable in major journals.

4. Previous Recipients of CALFED or CVPIA funding. Previous CALFED Project Title: Biological Restoration and Monitoring in the Suisun Marsh/North San Francisco Bay Ecological Zone: An Ecosystem Approach to Improve Effectiveness of Bay/Delta Restoration. Previous (recent) CALFED Project No. # 114209J018.
Current Project Status and Progress to Date (See Appendix: summary of our complete report)

5. System-Wide Ecosystem Benefits. *Synergistic, System-Wide Ecosystem Benefits*. Our project will improve shallow-water marsh ecosystem functioning throughout Ecological Zone 2. Improved shallow-water tidal marsh productivity and increase in populations of threatened fish species ultimately benefits productivity and threatened fish populations in the entire Estuary. Suitably increased habitats and productivity in shallow-water marshes also can improve conditions for other non-aquatic marsh biota, such as waterfowl and other marsh-dependent birds (including clapper and other rails), and mammals (otters, beaver, salt-marsh harvest mice). Our project compliments marsh restoration efforts in the Napa and Petaluma Rivers, and Northern Marin County (similar habitats). Working with Shell (McNabney) Marsh and its Marsh Management Advisory Committee, with Contra Costa Mosquito and Vector Control, Weapons Detachment Concord, Delta Science Center, EBRPD, and The Bay/Delta Science Consortium, we would apply our findings to their future habitat management and restorations. Active members of our collaborating Marsh Committee, with marsh management meetings more than quarterly, are R. Bogaert (Mt. View Sanitary District), K. Malamud-Roam (Contra Costa Mosquito and Vector Control), L. Hansen (the Watershed Nursery), K. Jennings (Cal Fish and Game Oil spill Office, plus M. Rugg, retired from DFG water quality office), S. Lusk (East Bay Regional Parks), P. Ganguli (Regional Water Board), and B. Murphy (Mt. Diablo Audubon), C. Kitting (CSUH), and others.

Qualifications and brief history of accomplishments of investigators:

Dr. Christopher L. Kitting, Professor of Biological Sciences, CSUH

A major contributor to this proposed work, Professor **Chris Kitting** earned his Biol. Sci. B.S. at University of California and Ph.D. as a Stanford University Graduate Fellow in 1979, at age 26. (Thus, he has at least ~15 more years until retirement.) After postdoctoral work with Stanford Medical School and Univ. Calif. Santa Barbara, and a faculty position at University of Texas Austin's Marine Science Institute on the Gulf of Mexico, Kitting joined the Cal State University Hayward Biological Sciences Faculty in 1985. At CSUH, he also has taught invited courses in Statistics, Marine Science, Geology, and Environmental Science Departments. He has published over 30 major works on aquatic ecology during his 27 years in academia, emphasizing nursery areas for invertebrates and fishes in shallow vegetation on diverse shores. He has been Principal Investigator on over 16 major external grants at CSUH. He also is a founding Board Member of San Francisco Bay Wildlife Society, Charter member of Ward Creek Alliance, and member of three other watershed organizations. He also is co-PI on a recent Biotechnology Field Station on Gazos Creek, with Pescadero Conservation Alliance. He has long maintained active professional membership in Society of Wetlands Scientists, Estuarine Research Federation, and

American Fisheries Society and their Chapters, and in over four related international ecological societies, where he presents new talks and posters several times each year at local and international conferences, including each CALFED Conference. He recently has served as president in two major scientific societies, and is a reviewer for major journals etc., including papers in Feyrer et al's recent Estuary Larval Fish Volume by AFS. Kitting currently serves on two editorial boards of scientific journals. Recently he was acknowledged for assistance to the National Marine Estuary Program through Louisiana State University, and locally. He also continues to serve (now State Senator) Tom Torlakson, beginning with the Program Committee of the Delta Science Center, when Kitting's "Delta Cruises for Educators" received an Environmental Achievement Award Nomination. Kitting also is a Science Advisor for Bay Area Discovery Museum's new NSF award for "Our Place by the Bay" programs. He also coordinated a major proposal for CALFED's Fish Monitoring Team for CALFED's Integrated Multidisciplinary Bay/Delta Monitoring. Kitting and his students have remained active with the Alameda County Clean Water program, which received an EPA National Excellence Award. His CSUH program is active in the Bay-Delta Science Consortium. Kitting has received over 20 major honors since the Ph.D., including nominations for Outstanding Professor Awards.   All 21 of Kitting's former M.S. and Ph.D. students, and many of his undergraduates, have remained employed and successful in their environmental profession.

His most recent papers on local work are:

- Kitting, C.C. Ouverney, and F.Canabal. Small Fishes Concentrated During the First Five Years Outside an Experimental Wastewater Marsh in San Francisco Bay. Proc. Soc.Wetl.Sci.1994. DM Kent and JJ Zentner, Eds. pp. 90-103.
- Kitting 1994. Shallow populations of small fishes in local eelgrass meadow food webs. Alameda Naval Air Station's Natural Resources and Base Closure. Audubon Society, Berkeley, CA pp 65-83.
- Kitting 1996. Comparing naturally occurring population, as field bioassays of environmental health. in D.M. Kent and J. Zentner, Eds. Proc. Soc.Wetl.Sci. II. (80-83).
- Kitting and D.E. Morse 1997. Feeding effects of postlarval red abalone, Haliotis rufescens (Mollusca: Gastropoda) on encrusting coralline algae. Molluscan Res. 18:183-196.
- Rees, J. and Kitting, 2002. "Survey of Gelatinous Zooplankton ("Jellyfish") in the San Francisco Estuary: Initial Field Survey, Annotated Species Checklist, and Illustrated Field Key."   Calif. Interagency Ecological Program Technical Report 40. 48 pp.
- Davis, C.L. and Kitting, 2002. Recruitment and abundance of unusual hydrobiid snails among restored and reference brackish marshes of San Francisco Bay Estuary. Western Society of Malacologists Annual Report 35: 7-10.
- Kitting and C. L. Davis. 2003. Distributions of Unusual Hydrobiid Snails among Restored and Reference Brackish Marshes of San Francisco Bay Estuary, versus lagoons north and south on the Central California Coast. West. Soc. Malacol. Ann. Report 42: 23-27.
- Kitting and C. C. Ouverney. 2004. Field bioassays with common fishes and invertebrate food resources near constructed and reclaimed water marshes on San Francisco Estuary. Proceedings of the American Fisheries Society, and paper in Symposium Book on Fish Toxicity Interactions, Edited by C. Wood, K. Sloman, and D. MacKindlay   pp 339-350. International Congress, American Fisheries Society, Manaus, Brazil.

- Hawkes, E. and Kitting, 2004. submitted. Lack of Genetic Diversity Within Each of Four Common Marsh Fish Species Among Central California Tidal Marshes, Based on Mitochondrial Control Region DNA Sequences.
- Davis, C. and C. Kitting, 2004. submitted. Comparing Zooplankton Abundance among Restored and Reference Marshes in Upper San Francisco Estuary, Central California.

Dr. Karl Malamud-Roam, Contra Costa Mosquito and Vector Control, is Contra Costa Mosquito & Vector Control District's Principle Investigator**,** as CCMVC's Marsh Restoration Specialist for over 11 years. He has designed and implemented eight tide marsh restoration and enhancement projects in the San Francisco Estuary, covering over 300 acres. He is the project manager for the million-dollar, 200-acre Shell Marsh Restoration Project. He is also Project Manager for the 2000-acre Point Edith Marsh Project, and has overseen implementation and evaluation of several major pilot projects to date. Currently he is developing a natural resources inventory and integrated natural resources management and restoration plan for the latter site. He also is seeking to manage vectors of the newly introoduced West Nile Virus through suitable restoration practices. Dr. Malamud-Roam earned his doctorate at UC-Berkeley, where his dissertation was on hydrology and ecology of muted-tidal marshes. His primary study sites are the marshes discussed in this proposal. He has a BA in Biology from Princeton University, an MA in Physical Geography from UC-Berkeley, and he is the author of one book chapter and four articles, plus several in press, all on the tidal hydrology and ecology of this area.

Dr. Joy Cooke Andrews, Associate Professor of Chemistry, CSUH

Dr. Andrews, an environmental chemist, received her Ph. D. in Biophysical Chemistry at the University of California, Berkeley in 1995, funded by a University Fellowship and a CSU Doctoral Incentive award. She was a Postdoctoral Associate at Lawrence Berkeley National Lab in 1995-1996. Her role in this project will be to monitor the water quality of the restored and refererence marshes throughout the project as conditions change. Dr. Andrews has taught water quality courses involving field studies, laboratory analyses and biological remediation at UC Berkeley and CSUH. She is currently supervising several graduate students in water quality analysis projects involving ion chromatography, atomic absorption spectroscopy and x-ray absorption spectroscopy, with studies in biological remediation of heavy metals, especially by plants.

While at LBNL, Dr. Andrews served on the Environmental Safety and Health Committee from 1992-1995, and won an Outstanding Graduate Instructor award in 1990. She has been a member of the American Chemical Society since 1988, with subdivision memberships in environmental chemistry and biological chemistry. Before entering the academic field she was employed at Environmental Analytical Laboratories in Richmond, CA specializing in heavy metals analysis of water, soil and air samples.

She has co-authored a book on water quality analysis, "The Chemistry of Water" (1997, University Science Books) as well as numerous papers in leading edge chemistry journals and conference proceedings on the analysis of metals, especially in plants. She has reviewed papers for Environmental Science and Technology; Water, Air and Soil Pollution; and has served on a review panel for the US EPA. She currently is Vice Chair of the Stanford Synchrotron Radiation Laboratory (for chemical structures and metals speciation) Executive Committee. She also serves as CSUH campus representative in the Bay-Delta Science Consortium (BDSC). At the

2004 CALFED conference, she chaired a session on water quality and presented poster on recent work funded by a CALFED pilot grant, through the BDSC.

Papers in review: Invited paper to Microchemical Journal, "Mercury L3 and Sulfur K-edge studies of Hg-bound thiacrowns and back-extracting agents used in mercury remediation" and paper to Environmental Science & Technology, "Using Hg L3 edges to study mercury methylation in *Eichhornia crassipes*".
Currently preparing invited chapter for Spring-Verlag book on Mercury Chemistry, edited by David Atwood.

Other Representative Publications:
"X-ray Absorption Spectroscopy of Thiacrown Complexes Used in the Remediation of Mercury Contaminated Water", by D. B. Bishop, G. D. McCool, A. J. Nelson, J. G. Reynolds, T. F. Baumann, G. A. Fox, J. G. DeWitt and **J. C. Andrews**; invited paper (2002) *Microchemical Journal 71*, 247-254.
"An X-ray Absorption Spectroscopic Investigation of the Nature of the Zinc Complex Accumulated in *Datura innoxia* Plant Tissue Culture", by R. A. Kelly, **J. C. Andrews** and J. G. DeWitt; inv. paper (2002) *Microchemical Journal 71,* 231-245.
"Field, Laboratory and X-ray Absorption Spectroscopic Studies of Mercury Accumulation by Water Hyacinths", by S. G. Riddle, H. H. Tran, J. G. DeWitt and **J. C. Andrews** (2002) *Environmental Science and Technology 36,* 1965-1970.

Collaborating Participants

Our six major collaborators from four agencies, including CSUH, are listed under "participants and collaborators" in the executive summary and in the proposal narrative. Over 20 additional, significant collaborating assistants, working under these professionals on this project, are listed in our acknowledgements of our annual reports to CALFED (on file).

See Table 1 for the organization of the staff and resources for the proposed project.
We do not foresee any conflicts of interest or insurmountable problems to complete the work within the proposed timeline.

Table 1. Organization of Staff and Resources for the Proposed Project.

Staff Member And Tasks	Technical Role	Administrative Role	Project Management Role
Chris Kitting and asst. (Tasks 1-4)	Field sampling; collection and entering of physical, algae, and fish data; its interpretation; report and paper preparation	Overseeing overall expenditures and bookkeeping	Overall Project PI. Also coordinating assistants and collaborators
Associate (e.g. C. Davis) (Tasks 1-4)	Field sampling; collection, enumeration identification, of zooplankton and zoobenthos; their data entry and interpretation; report and paper preparation	Coordinating facilities	Overseeing student assistants and technician
SFBWS (e.g. Navad Nur et al.)	Coordinating bird sampling and reporting	Oversees related bird data	Oversees his assistants
Joy Andrews, et al.	Analysis of CHEMISTRY; data		Overseeing student

Associate (Task 4)	interpretation and preparation		assistants
Karl Malamud-Roam (funded by CCMVC directly)	Shell Marsh and Pt Edith area planning and connection of marsh pools to restored channels	Overseeing expenditures and reporting for CCMVC portion	Oversees Shell Marsh and Pt Edith area restorations and staff for plant monitoring there.
Cynthia Vinson or Successor (funded by indirect costs)		Bookkeeping, billing, dispersing funds	

COST (see forms) **1. Budget.** With Totals Designated for state or federal sources.

Additional Justification of Budget:

Our proposed **Phase Two** budgets are available in a Microsoft Excel "Workbook." The tables detail each of four tasks, for each year, plus summary (Yrs1+2+3). Tasks, categories, allocations, rates, and organization are based on our previously contracted budget, for Phase 1. Task One, General Project Management, is now separated, as CALFED requests. As in the past, our partner institutions have line items where appropriate. Funds requested from CALFED are in the appendix form. Additional funds from CSUH will match faculty academic salaries and benefits (fall, winter, spring. Faculty salaries from the campus cover 3 of 4 quarters per year, so a faculty member must raise any funds for the fourth quarter, plus any release time from full-time teaching. Scientific and other permits require senior scientists present during biological sampling, which also has assisted quality control, safety, and public relations.

Moderately increased costs reflect this 2006 forecast, plus somewhat expanded effort and expenses for more reference sites, compared with Phase One funding. Our proposed +- 15% reallocation among categories, if necessary, reflected our updated agreement in our present contract, to accommodate unforeseen expenses efficiently. As noted, no changes in total cost are proposed.

This proposal cycle is our final opportunity for funding, to enable the valuable comparisons and optional (Task 2) large-scale field experimental enhancements (to add more tidal amplitude or marsh tidal pools to restorations) in Phase Two. Due to a change in CALFED funding cycles, and our rejected original proposal for our original Phase Two, a 6-year hiatus between Phase One and Phase Two will occur, allowing inexpensive, volunteered, basic monitoring to prepare for the longer-term comparisons proposed. Phase One work and funding have been completed on schedule, with the final report completion, on schedule. The major budget request is in salaries, and each staff member has a major commitment to this project, as described in the required tables. The budget is consistent with university policy, including time released from classes (matched by the university), time paid during summer, and during academic breaks ("Article 36" of current faculty agreements). California State University has pledged to close a salary gap between recent senior faculty salaries here, compared with comparable institutions nationwide. Because the resulting salary steps have become retroactive from the state (recently planned to be retroactive two years), each of these proposed salaries reflect the target amounts. Phase I salary budgets were adequate only because the PI was able to donate most of his sabbatical leave (during reduced state salary) to Phase 1. If the state eventually rejects these target amounts for academic year salaries, we propose that any salary excess be available for a new faculty member, who would then share the commitment to this project. Thus, the budget notes " associate" listed with faculty in the itemized budget. Assistants are noted with a range of salary, to reflect various degrees of expertise. Several of our graduate research assistants (e.g. H. Kingma, coauthor of a restoration monitoring handbook) are established professionals, although these state pay scales tend to remain low.

Type of Extent of Travel. All of our funded travel will be within the state of California, to restoration and monitoring sites, and to conferences within the state. Teams conduct approximately monthly trips to each pair of sites. Standard state rates are used for travel, normally in university vehicles charged at that rate. Some sites are accessible only by boat. Boat rates, established by CSUH Boat Committee, help cover the actual receipts for repairs, maintenance, supplies, and replacement equipment.

Types of Supplies. Mainly for field work (containers, boots, etc. and nets, damaged in shallows).
Service Contracts. None, other than repair costs anticipated in attached budget.
Consultants and Organizations Our partners described here have line items in our budget. CSUH Foundation again would be the contractor with CALFED. Marsh maintenance would be accomplished directly by our partner, Contra Coata Mosquito and Vector Control (CCMVC), who again is donating much of their their work in return for our much-needed, proposed assistance in improved planning and monitoring (required for permits), and reporting. Such partners bill the CSUH Foundation, where all partners are prepared to cover CALFED’s 10% holdback until a task is complete, then fully reimbursed by CALFED via CSUH Foundation. Several thousand dollars in consulting funds are included for continued advise and confirmation of any difficult specimens, by K. Fleming, S. McGinnis, and other authorities. L. Brown (USGS) also has agreed kindly to review and advise our progress.

Equipment Purchases. Proposed Yr 1 has virtually all of the “equipment” purchases. Actual equipment would be for chemical analysis. Field “equipment” would have a limited life-span, underwater. After those initial purchases, funding would be spent steadily, then invoiced to CALFED, as scheduled for the 90% reimbursement until project/report completion.
The major equipment item is a microwave digestor, which would make the numerous orthophosphate and metal analyses efficient enough to compare the range of sites, as proposed. Other grants and the university will share over half the cost. Equipment and other expenses, including expenses for remote labs for much of this work, as proposed, are justified in our methods sections, and in our report of progress.

Overhead Rate. General office and laboratory function is covered in the overhead rate, along with accounting expenses and general administration. As noted on budget, CSUH has a state overhead rate of 25% of total direct costs (=20% of total grant costs.) As noted in budget, the CSUH federally negotiated rate for indirect costs would be 47% of salaries, wages, and benefits. (The latter comes out as the cheaper total request, in this case.) The award agency is able to specify the latter.

Project Management Task. All of the senior staff noted are involved in project management. They ensure that work areas are complete, and inspect others’ work in progress. Each senior investigator is responsible for his/her area of expertise and reporting his/her part of required periodic reporting requirements. Project questions should be addressed to (1) Chris Kitting for scientific/technical questions; (2) Cynthia Vinson and/or Chris Kitting for budgets, costs, and financial allocation.

2. Cost-Sharing.

Cost Sharing Arrangements. As noted on the budget, CSU Hayward will match the faculty release time from classes. It also will help match a major equipment expense. Also during the project, Contra Costa Mosquito Vector Control District (CCMVC) again will provide much of the restoration maintenance work described near Shell Marsh, Point Edith, and Edith East, at no extra cost to CALFED. SFBWS (probably with Pt. Reyes Bird Observatory again) will manage

monitoring and comparisons of bird populations at our sites, via transects and point surveys seasonally.
Time of commitment of funds: steadily throughout contract. Phasing in additional time by personnel helps balance initial restoration maintenance/enhancement expenses and equipment purchases.

3. Long-term funding strategy.
If CALFED provides this funding (unlike in our five other recent CALFED proposals,) CSUH and CCMVC will continue basic monitoring of these restorations after these three years of CALFED funding. CSUH also has begun applying for researh funds from federal agencies (NIH and NSF) for future, focussed research that can monitor and helpmanage these sites after the present funding is complete.

Nonprofit Verification: The federal tax id number for CSUH is 94-1524922.

LOCAL INVOLVEMENT. Coordination with county and local governments. At each of our sites, land managers and neighbors are our partners in virtually every phase of the work. This relationship holds even if most of the total expenses have been donated, rather than from CALFED. The land owners generally are the managers, except on state lands and Weapons Detachment Concord, used as reference sites, and managed by our partners at CCMVC. We also are coordinating our program with A. Rockriver (DFG) and the Fisheries Foundation collaborative monitoring proposed for DWR's CALFED restorations on Decker and Twitchel Islands, and with Point Reyes Bird Observatory and Delta Science Center (and CALFED Science Consortium,) particularly with current, related proposals by the Natural Heritage Institute and State Coastal Conservancy for Marsh Creek Restoration (E Big Brk) and DWR on a study of benefits of restoration activities in West Big Break, Dutch Slough, and Lower Sherman Lake.

Our project partners in restoration have all neighboring landowner issues under control, for these restorations. CCMVC has handled permitting at our marsh restorations at south Suisun Bay, although CSUH would be able to provide them with additional, needed assistance. Colleagues at East Bay Regional Park District anticipated these fiscal needs for permitting future restorations near Antioch (near our sites, where we would provide necessary aquatic data). We have partnered with neighbors to avoid third-party negative impacts.

Public Outreach; Groups and Individuals affected by the Project.
Following agency approvals of our progress reports, we would continue public presentations largely through the university, such as at our recent Science Festival program and Bay/Delta classes for graduate students and visiting teachers. Our students and other audiences of all ages include diverse ethnic and socio-economic groups. Our employed student assistants have included high diversity too, including black and native American students who have continued in this new profession. We share information with individuals in our partners, especially through McNabney Marsh Management Committee, USF&WS and DFG (local fish monitoring, out of the Stockton office), IEP, and others. Activities of all these programs/agencies/ organizations are compatible with CALFED objectives, and may become more collaborative through expanding our very useful Marsh Management Committee. That committee began at Shell (McNabney) Marsh with our colleagues at Mt. View Sanitary District and EBRPD. Our Society of Wetlands

Scientists major meeting is scheduled for 2007 in Sacramento, where CALFED’s work and conference should be integrated with SWS, reaching diverse scientists, managers, and the public.

COMPLIANCE WITH STANDARD TERMS AND CONDITIONS

Our group of colleagues, organizations, and other associates will comply with all state and federal standard terms. Those terms are consistent with State University policy. We have reviewed all terms contained in Attachments (PSP). As a state agency, not all attachments for terms apply in our case, until a new contract will require the interagency agreements, as are in place in our previous CALFED contract and cooperative agreement.

Reporting, electronically, would be as semiannual, annual, and final reports, each with physical, biological, and fiscal data and summaries of results. Abstracts from our presentations at management and scientific meetings would summarize findings. Major annual and final reports would include summaries, management recommendations, and manuscripts suitable for journal publication. After CALFED review, they would be revised as necessary, and submitted to journals.

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Required documents are in forms, as instructed.

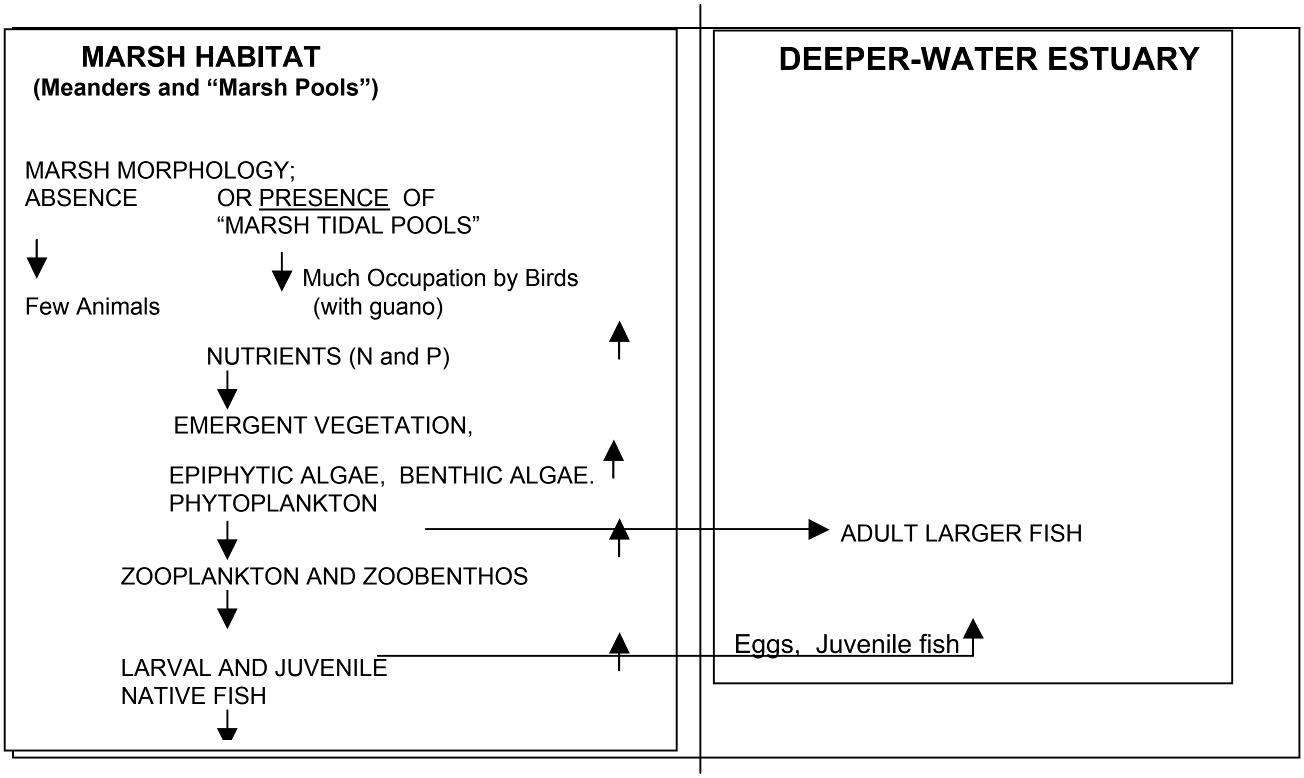
Table _. Full Digital Geographic Coordinates of Project’s multiple Sites: (NAD 83, and see map below):

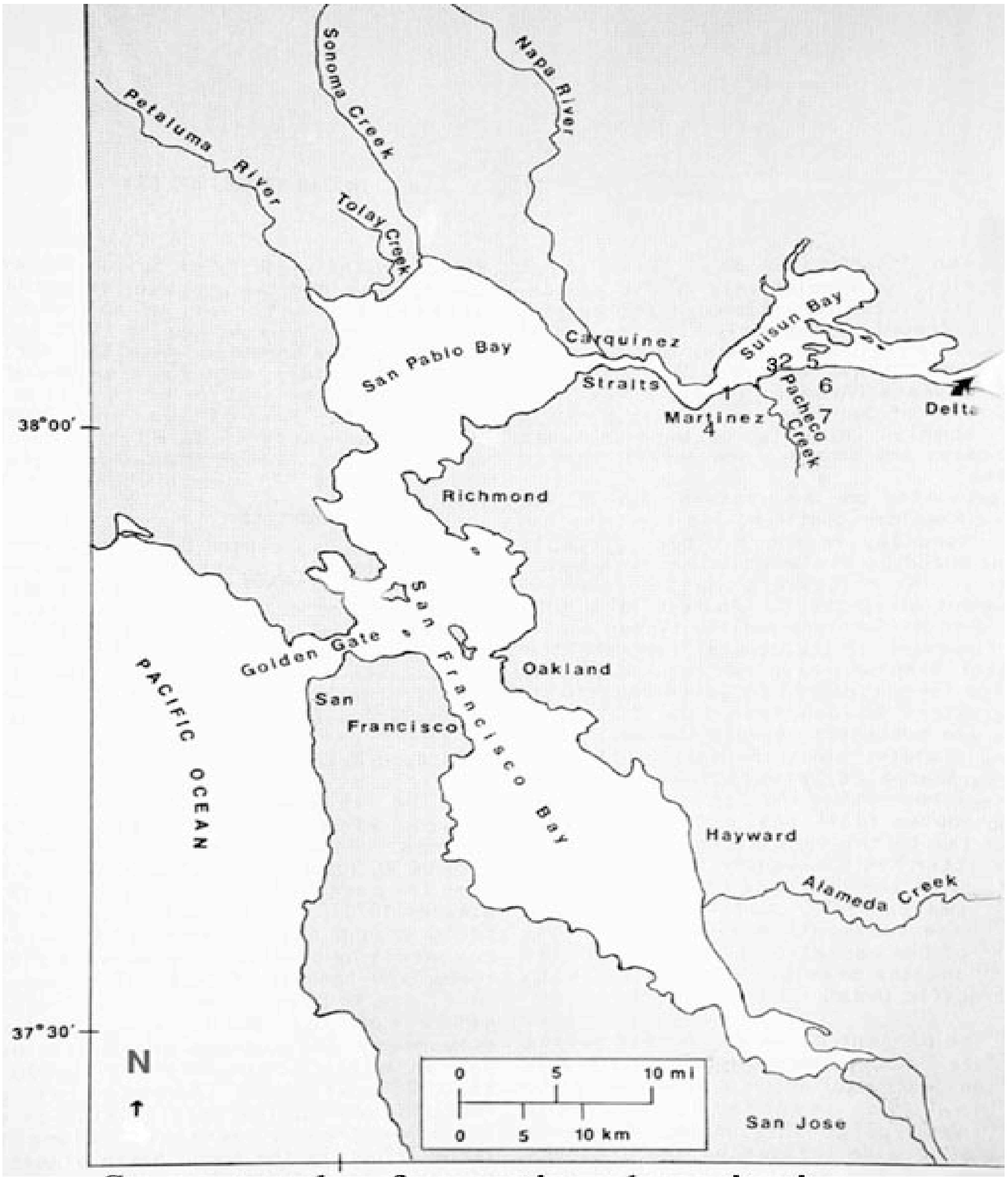
Site	Opt. Action	N edge	S Edge	W Edge	E Edge
4. Shell/ McNabney Marsh	Increase Tide Action and marsh tidal pool	N38deg 1.95’	N38deg 1.15’	W122deg 6.83’	W122deg 5.55’
5. Pt Edith	Connect Marsh Pool	N38deg 3.17’	N38deg 2.90’	W122deg 4.11’	W122deg 3.98’
6. Edith East	Major marsh pool to attach to channel:	N38deg 2.61’	N38deg 2.30’	W122deg 4.1’	W122deg 3.90’
7.“Navy”	Connect Marsh Pond	N38deg 3.15’	N38deg 3’	W122deg 3’	W122deg 2.5’
8. Waterfront Rd. Marsh	Small Marsh Tidal Pool	N38deg 2’	N38deg 1.90’	W122deg 4.51’	W122deg 1.9’

plus ref sites nearby, to remain unaltered.

Geographic Coordiates of Project Sites and map *are in appendix.*

APPENDIX. FIGURE 1. OUR CENTRAL, BASIC CONCEPTUAL MODEL, evolved from Phase 1, where habitat diversity with marsh tidal pools may accumulate guano and nutrients from associated birds, and retain nutrients and small organisms long enough to fuel increased abundances and marsh exports.

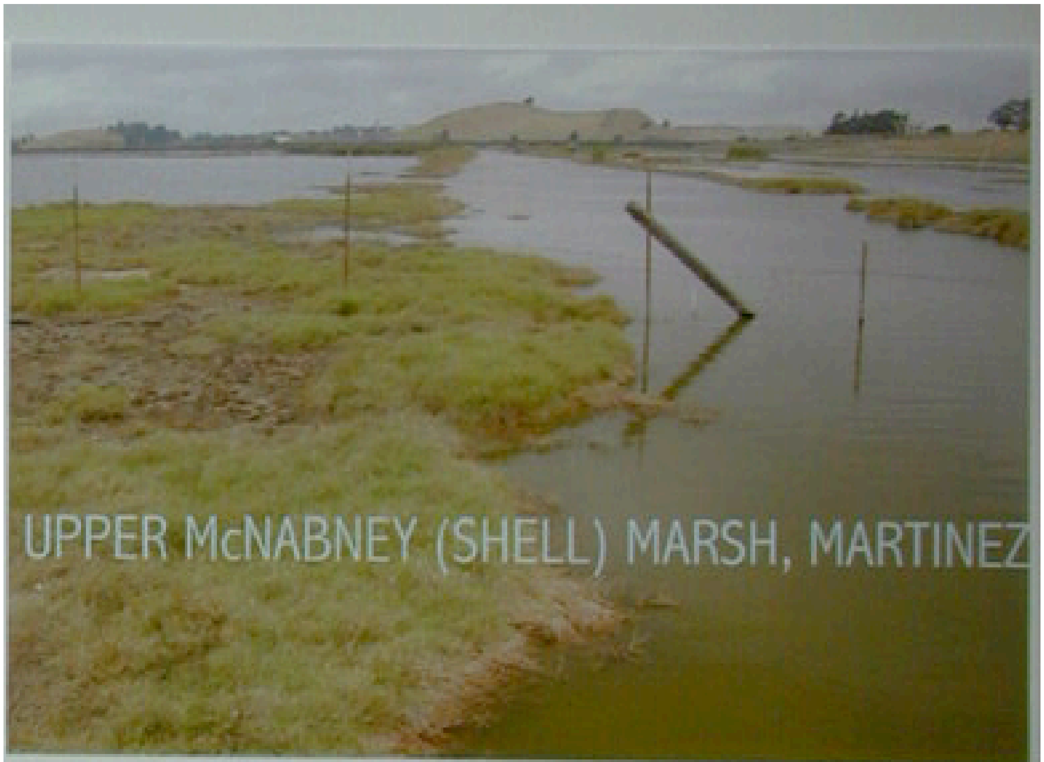


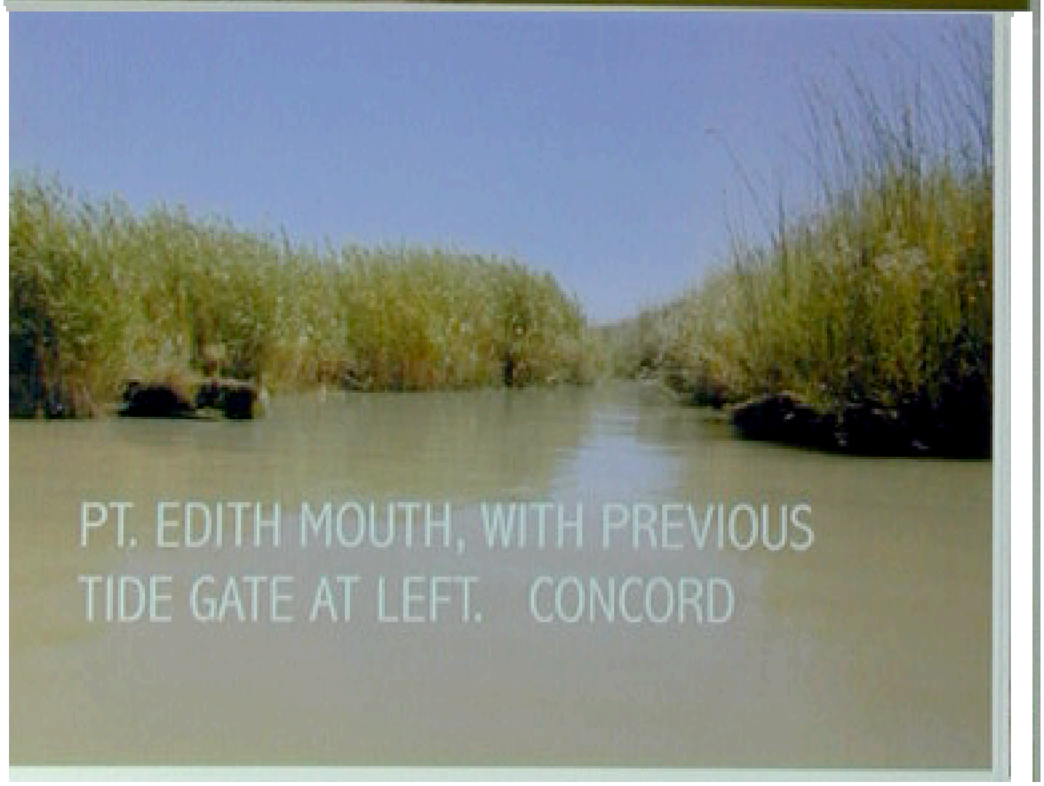


Seven marshes for continued monitoring.

#s 1-3 are historical reference marshes.
#s 4-7 are our collaborative CALFED restorations.

Figure modified from Josselyn, USFWS report.





Appendix. Two of Our Restored Marsh Study Areas

APPENDIX II. Previous Phase I PROJECT PROGRESS AND STATUS
(*CALFED* Coop Agreement # 114209J018.)

Project Description. Our Phase 1 project began to identify and improve those factors (including physical, chemical, geomorphic, and biological) which were limiting in tidal marsh restoration efforts in the North Bay/Suisun Bay Ecological Zone (CALFED Management Zone 2) of the San Francisco Estuary, particularly those that limited native fish populations. We with our collaborators at US Fish and Wildlife Service Refuge in North San Pablo Bay (Tubbs Island), and Contra Costa Mosquito and Vector Control District in Southern Suisun Bay (Pt Edith area, McNabney/Shell Marsh. Together, we restored increased tidal action to shores and monitored and compared these restored and reference marshes (see attached data sheet for items monitored). We advised and assisted our collaborators on improving restoration and maintenance/ management of marshes to increase invertebrate and native fish populations, create nurseries for native migratory fishes, and through this adaptive management, detect and correct ecological limiting factors or “bottlenecks,” both in marshes being restored and reference sites (degraded pre-restoration sites, or relatively natural marshes).

Scientific Merit of the Project. Our major hypothesis, that relatively pristine reference marshes would tend to have higher population densities of fishes and invertebrates than in analogous restored marshes, we clearly rejected thus far. Our various histical marshes to date have quite consistently shown relatively few fishes and invertebrates. A diagrammatic**,** updated conceptual model of our project is shown in Figure 1 (attached). In theory, each trophic level passes the necessary nutrients and energy to the next level, producing a “healthy” shallow-water marsh habitat, with sufficient nutrients present for primary productivity, and with a healthy primary and secondary (zooplankton and zoobenthos) productivity in place to ensure food for both resident fishes, and for larval and juvenile fish whose adults inhabit the deeper water areas of the estuary. As energy passes from one level to the next, other limiting factors may come into play, such as flow and channel dynamics. All these factors, as appropriate, are included for observation, study, and change or modification through adaptive management. Phase I suggested the direct or indirect importance of connected marsh pools here (Kitting 2001, 2002), while moderate algae from marsh pools may be a more direct effect (after Van Montfrans et al. 1982, Kitting et al. 1984).

Current Status of the Project. Completed. Our four sets of shallow-water marsh habitat sites, plus an additional deeper reference site added later (and not formally funded), spanned an array of mesohaline to oligohaline environmental conditions in CALFED Ecological Zone 2. During February-April, 2000, as we have reported to CALFED, USF&WS, and DFG, we detected relatively large population densities of our target fish species, delta smelt and splittail. *Delta smelt:* We sampled (and released live) numerous juvenile Pacific herring at the north San Pablo Bay (Tubbs Is.) in spring 2000 and 2001. This site was restored one year earlier to somewhat higher tidal action (although excavations are now silting in). Systematic, short-distance plankton tows detected ~20-mm-long herring juveniles at ~8/m^3 and <~15-mm-long postlarvae at ~32/m^3. These herring appeared in February- April for at least several weeks in upper and lower sites in the "muted marsh" on Tubbs Island, North San Pablo Bay. We also found them present, but less common, at two or our three analogous sites, only. All these sites are very shallow water (~1 m at high tide). In March-April, 1999, DFG detected numerous delta smelt juveniles (~20mm long) in the nearby Napa River, while our Tubbs Island marsh sampling yielded only ~1 individual at that time (along with higher zooplankton densities than in March, 2000). We also have been removing (and apparently reducing numbers of) a large population of invasive yellowfin goby at Tubbs Island and in other marshes. This introduced species is a potential predator on fish larvae and juveniles. Our Y2000 population densities (~8/m^3) of ~20mm-long herring juveniles at Tubbs I., ascertained with non-destructive methods, apparently exceed by >500X the maximum densities reported in DFG's Bay/Delta sampling for juvenile fishes (DFG sampled in more open, deeper water). We also sampled (and released) several herring postlarvae at our previously restored Weapons Detachment Concord site in March, 2000. *Splittail:* Near Concord in Suisun Bay, we trawled (then released) five adult splittail (per 500 m^3), and three other fish species, in our deeper reference site (a 2m-deep slough, at a creek mouth), and one adult splittail (plus one other species, per 500 m^3) in a 3-m deep slough, just outside our restored sites. Our routine fyke netting also revealed splittail at two of our three marshes with pools: one juvenile splittail at our North San Pablo Bay site (at Tubbs Island), which had received increased tidal action one year earlier) plus five adult splittail at one of our Concord marshes (with muted tides and marsh pools along the channel). As with larval fishes, our adult splittail population densities exceed previous (open water) data by ~50X (including data for juveniles). We are continually integrating and interpreting our other monitored data, including physical data, zooplankton and zoobenthos, and heavy metals data, related to our targeted fishes, their food webs, and habitats. For example, to date, marshes with higher densities of zooplankton and zoobenthos also have shown higher fish total populations, and one marsh with a large ponded, shallow-water expanse (Shell Marsh) has the highest animal population densities and diversities among all our marshes (including bird populations and species), although this marsh also has a high level of nutrient input (originating from birds *and* possibly from fully treated but reclaimed water flow from a nearby treatment plant and marsh). Some reference and restored sites sampled, particularly those without pools along channels, have yielded virtually no plankton or native fishes in our comparative sampling. Also, in our metals sampling and analysis program (previously funded at only one site), analyses of animal tissue have shown concentrations of mercury at marginally high levels (7 ppm) in adult mitten crab and yellowfin gobies sampled from northern San Pablo Bay marsh, even though the marsh sediments and water do not show correspondingly high levels of metals, including mercury. These animals may be migrating through other, mercury-contaminated regions, or biomagnifying metals up the food web. We found that some of our sites have unusually low mercury concentrations, as they have been diked for >100 yrs, since mercury increased after the gold rush in the estuary itself. Thus, those restorations can be relatively low in such contaminants.

<u>Current Status of Project, Accomplishments to Date, Information Generated.</u> The project is proceeded as planned. See CALFED accomplishments to date (Table 2, attached). A list of our major findings and resulting actions (improved restorations) is attached in the appendix, with partial bibliography, and a table of fishes (ranked by population densities) we detected in our restored marshes.

<u>Fiscal Status, Regulatory Issues</u>. Fiscally, our project proceeded as planned. In 1999, we had to increase tidal amplitude at an alternative Tubbs Island site, just west of where originally planned, to allow time to manage salt marsh harvest mouse populations prior to restoration of tidal action.

<u>Data Collection and Monitoring Program.</u> Data collected by each PI was entered into a Microsoft Excel datasheet. Monitoring and data analysis was the heart of our program (see sample data sheet attached). We present our results in team meetings, to local agencies, in CALFED quarterly and annual reports, and at management and scientific meetings. After partner and CALFED approvals or comments in our semiannual reports, more manuscripts based on this material will be submitted for publication in the refereed scientific and habitat management literature. Following this review and approval process, our first papers to come out have been in primarily rapid journals. Manuscripts are submitted to major journals, and our

previous manuscripts are in our previous CALFED final report submitted on schedule to USFWS, as planned.

Biological Restoration and Monitoring
in the Suisun Marsh/North San Francisco Bay Ecological Zone:
an Ecosystem Approach to Improve Effectiveness of Bay/Delta Restoration. Proposal # 98-C1042. Agreement # 114209J018.
Photographs of marsh construction and resulting communities are at the end of the document.

Partial bibliography (>35 different formal papers recently) for other formal CALFED progress thus far by Cal State University Hayward, acknowledging this CALFED program (mostly during that 2.7 yr project, not including numerous marsh management meeting presentations): Presentations included Partner, USFWS, and CALFED logos for an oral acknowledgement. -each meeting presentation had a different printed abstract, included in CALFED qtrly rpts. * denotes major contributions. Our collaborators' additional Ph.D. Dissertation and three previous conference presentations, plus a report on this project, also are listed here, with author affiliation.

First, numerous printed products directly from this work, thus far (not including >5 recent conference presentation abstracts since 2003):

* Andrews, J.C., S. G. Riddle, H. H. Tran, C. Kitting, J. G. DeWitt . 2001. "Field, Lab and X-ray Absorption Spectroscopic Studies of Mercury Absorbed by Water Hyacinths." Division of Environmental Chemistry Preprints of Extended Abstracts 41(1), 452-457.

*Davis, C. (2004) COMPARING ZOOPLANKTON ABUNDANCE AND MOLLUSC RECRUITMENT AMONG RESTORED AND REFERENCE MARSHES IN THE UPPER SAN FRANCISCO BAY ESTUARY, CENTRAL CALIFORNIA. M.S. Thesis, Biol. Sci. CSUH.

*Davis, C.L. and Kitting, 2002. Recruitment and abundance of unusual hydrobiid snails among restored and reference brackish marshes of San Francisco Bay Estuary. Western Society of Malacologists Annual Report 35: 7-10.

Diego, C., M. Sugiura, S.G. Riddle, J.C. Andrews. Heavy in the Tubbs Island Restoration Area. Abstract for the American Chemical Society National Meeting, San Francisco, April, 2000, with poster presentations also at CSUH and at the Am Chem Soc Student Research Conference in May, 2000.

Gill, E. and C. Kitting. 2001. Comparisons of Sedimentation Rates and Water Clarity in Historical and Restored Marshes of Upper San Francisco Bay Estuary. Western Societuy of Naturalists Annual Conference. Abstracts. (Ventura, CA 11/01)

Gill, E. (in early prep) Effects of Sedimentation on abundances of Aquatic Animals in Historic and Restored Marshes of Upper San Francisco Bay Estuary. M.S. Thesis, Special Major (Shoreline Processes), CSUH. (First abstract from thesis is below.)

*Hawkes, E. 2002. Lack of Genetic Diversity Within Each of Four Common Marsh Fish Species Among Central California Tidal Marshes, Based on Mitochondrial Control Region DNA Sequences. Biol. Sci. MS Thesis, Cal State U. Hayward.

*Hawkes, E. and Kitting, submitted. Lack of Genetic Diversity Within Each of Four Common Marsh Fish Species Among Central California Tidal Marshes, Based on Mitochondrial Control Region DNA Sequences.

Kitting, C.L. 1999. small fishes and their foods, compared among restored and reference marshes in northern San Francisco Bay. Western Society of Naturalists Abstract. Monterey, CA 12/27/99

* Kitting, C.L. 7/2000. Pulmonate mollusca persisting in California Delta marshes with high tidal and physical/chemical extremes. Oral presentation. American Malacological Society / Western Society of Malocologists Annual Conference & extended abstract in the WSM Annual Report. Vol. 33-4: 28-31.

Kitting, C.L. 8/ 2000. Epibenthic animal colonization of restored and reference marshes in San Francisco Estuary, California. for Millennium International Wetlands Conference, Quebec, with Society of Wetlands Scientists, and others.

Kitting C. , 10/2000. Physical and biological environment of dense herring and splittail populations in upper San Francisco Estuary Marshes. CALFED conference Oral Presentation , Sacramento.

Kitting et al., 10/2000. ECOLOGICAL COMPARISONS OF FOUR MARSHES NEAR SUISUN BAY, RESTORED TO INCREASED TIDE ACTION, AND REFERENCE MARSHES. CALFED conference Poster Presentation , Sacramento.

Kitting, C. 3/2001. Multidisciplinary environmental comparisons with fish abundance among six marshes in the northern San Francisco Bay Estuary. American Fisheries Society Western Conference, Santa Rosa.

Kitting, C. 11/ 2001. MULTIDISCIPLINARY ENVIRONMENTAL COMPARISONS WITH AQUATIC ANIMAL ABUNDANCES AMONG WETLANDS IN SAN FRANCISCO ESTUARY, CALIFORNIA. Estuarine Research Federation Mtg. (Conference Address) St. Petersburg, Florida

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* Koehler, J. 2004. Comparisons of Fish Abundances at Several Restored Tidal Marshes in San Francisco Estuary. Biol. Sci. MS Thesis, CSUH.

McGinnis, S. and J. Koehler. 10/'01 The Use of restored and partially restored brackish water tidal marshes by native and introduced fishes. State of the SF Estuary submitted abstract. San Francisco.

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* Webster, S. (in prep) STATISTICAL COMPARISONS OF PHYSICAL FACTORS, ASSOCIATED MARSH ZOOPLANTON, AND SMALL NEKTON COMMON IN RESTORED MARSH HABITATS THROUGHOUT THE UPPER SAN FRANCISCO BAY ESTUARY. Masters Thesis. Environmental Statistics Special Major, Cal State U. Hayward.

+Wood, J., H. Spautz, and N. Nur, with L. Vicencio. 2000. Avian Monitoring for lower Tubbs Restoration Project, San Pablo Bay National Wildlife Refuge. Annual and Final Reports.

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*Evans, K. L. 2000. Aquatic Filtering by Delta Sponges. M.S. Thesis, Cal State U Hayward Biol Sci.

* Evans, K.L. and C.L. Kitting. 2001. Particle feeding and growth in freshwater sponges discovered in the outer California Delta. (submitted for publication)

Rees, J.T. and C.L. Kitting. 1999. Pilot survey of gelatinous zooplankton in the San Francisco Estuary. Interagency Ecological Program Newsletter (and website)12(3): 4-5. (website: www.iep.ca.gov/report/newsletter/1999summer/body.html)

* Rees, J. T. 1999 Non-indigenous jellyfish in the Upper San Francisco Estuary: Potential impact on zooplankton and fish. IEP Newsletter 12(3):46-50

* Rees, J. T. and C. L. Kitting. 2000. Seasonal comparison of introduced gelatinous zooplankton from San Francisco Bay to the Delta. IEP Newsletter 13(1):9-10.

* Rees, J. T. and L. A. Gershwin, (2000). Non-indigneous hydromedusae in California’s upper San Francisco Estuary: life cycles, distribution, and potential environmental impacts. Sciencia Marina 64 (suppl): 73-86.

* Rees, J. and Kitting, 2002. “Survey of Gelatinous Zooplankton (“Jellyfish”) in the San Francisco Estuary: Initial Field Survey, Annotated Species Checklist, and Illustrated Field Key.” Calif. Interagency Ecological Program Technical Report 40. 48 pp.

* RIDDLE, S.G., H. H. TRAN, J. G. DEWITT, and J. C. ANDREWS. 2000. Field, Lab and X-ray Absorption Spectroscopic Studies of Mercury Accumulation by Water Hyacinths. Environmental Science and Technology, in press.

Sugiura, M. , J.D. Wilson, J.C. Andrews. 10/00. HEAVY METALS IN THE SHELL MARSH NEAR MARTINEZ, CALIFORNIA. American Chemical Society Western Regional Meeting.

* Sugiura, Masahiko. (in prep for Aug ‘01). "Ion Chromatography and X-ray Absorption Spectroscopy Studies of Acid Mine Drainage" . MS Thesis, CSUH Dept. of Chemistry.

* Tran, Huy Huu , March, 2001. MERCURY UPTAKE BY WATER HYACINTH (EICHHORNIA CRASSIPES) FROM THE SAN JOAQUIN RIVER. University Master of Science Thesis, California State Univ Hayward, Department of Biological Sciences.

Generally related to this project:

* Malamud-Roam, Karl. 2000. Tidal Regimes and Tide Marsh Hydroperiod in the San Francisco Estuary: Theory and Implications for Ecological Restoration. Ph.D. dissertation, Geography, UC-Berkeley, 850pp + 238 figs. (Abstract is at the end of this CALFED report.)

* "Mercury Bioaccumulation in Corbicula fluminea Associated with Water Hyacinth Beds" by James Donald Lenzen III, December 1999. MS Thesis, Biol Sci., CSUH

* “Microhabitats associated with endangered saltmarsh harvest mice following marsh restoration.” by Hope Kingma, 2003. MS Thesis, Biol. Sci., CSUH

* “Animal colonization of a restored freshwater marsh.” by S. Lee Miles, in prep. MA Thesis, Environmental Studies, CSUH

*”Its Sloughpendous!” A video production for Wetland Roundup Field Trips, Don Edwards San Francisco Bay National Wildlife Refuge. SF Bay Wildlife Society. 1999. 20 minutes. C. Kitting, script editing.and narration.

Appendix Table _2_. Results from Phase 1, cont.

Some of the Major Findings and Actions during our Phase 1, 2.5-yr CALFED PROJECT: Comparative monitoring of tidal brackish-water marshes. (Most results have been noted previously in our quarterly CALFED reports, and presented at various agency meetings.)

X indicates that the finding or action directly effects selected CALFED goals or concerns

Finding and Action	Restoration	Monitoring	Species of Concern	Contaminants	Introduced Species
1. Innovative logistics and sampling gear for sampling physical and biological features of sites makes detailed, non-destructive comparative data acquisition more efficient and practical.		**X**			
2. Flood Control Structure's debris screen was modified to allow fish to pass. More sections are proposed to be redesigned or removed.	**X**		**X**		
3. Winter rainfall following saltmarsh restoration yields colonization by more salt-tolerant native plants, with more invasive plants colonizing after a dry initial winter (based on CCMVC team, Malamud-Roam and Hanson).	**X**				**X**
4. Invasive plants begin colonizing restorations in a small enough patch to eradicate, until native vegetation can become established (based on CCMVC team). Hydrology may control some invasives.	**X**				**X**
5. Stinging estuarine hydroids, apparently introduced and harmful to small aquatic animals, overgrow various structures near swift currents, such as large pipes through levees. Hydroids are being removed frequently, pipes were replaced, but hydroids recolonize rapidly. Minimizing surface areas of structures, and using larger marsh openings (less current, less surface-to-volume ratio) may decrease the hydroid problem.	**X**	**X**			**X**
6. Stinging jellyfish in brackish water, two to three invasive spp from the Black Sea, described in Rees and Kitting (2001), occur in SF Estuary during late summer through early fall, and become very common in open water, but rarely invade local marshes. Marshes may tear jellyfish gelatinous tissues, and destroy these small (< ~3cm) jellyfish.	**X**	**X**	**X**		**X**
7. Sediments accumulate largely from sediment flow along the bottom, rather than from settlement. Thus, marsh openings to the bay should be enlarged where sediments are less likely to flow back. Any sediment removal must be widespread enough to prevent rapid sediment from sloughing back.	**X**			**X**	
8. Low metal contamination occurred in water and sediments of both marshes tested; Yellowfin goby and mitten crabs showed higher levels of contaminants.			**X**	**X**	
9. Summer fish kills were detected at both poorly circulated marsh sites (low tidal amplitude, pre-restoration), so we arranged to open channels. Fishes appear to be recovering slowly, with increased tidal flux.	**X**	**X**	**X**		
10. At a eutrophic site (from #9) isolated from tide					

action, we allowed more tidal action past contaminated sediments; because contaminants did not increase in the marsh nearby. More flow and metals monitoring is proposed.	**X**			**X**	
11. We relieved channel blockage at vulnerable petroleum pipes, covered with cattails, by opening suddenly a tide gate at high tide, using the water pressure to burst through and erode out some of the plants.					
12. Aquatic animals, including adult splittail and juvenile herring, are rarer in reference (relatively natural) or restored marshes unless marsh "pools," attached to the tidal channels, are present. We propose to connect currently isolated pools to recently restored (and natural) channels (this proposal).	**X**	**X**	**X**		
13. Minnow trap samplers on the bottom can accumulate many yellowfin goby (and small cameleon goby, native sculpin, invertebrates, etc.) live, but population densities of gobies may begin to be depleted after a year of monthly yellowfin goby removal, at least where tidal migration brings them into contact with our live fish traps.		**X**			**X**
14. We found juvenile herring on incoming and outgoing tides throughout one of our two rich marshes at 5ppt salinity during February-March, reaching very high densities; these fish taken in our routine, non-destructive, small-scale plankton samples, one year after increased tidal amplitude and yellowfin goby removal. The presence of juvenile herring both outside and inside the marsh suggest that the of *mouths* of tidal creeks, along with quiet bay inlets, are important habitats for these fish. Intensive monitoring at these locales vs. elsewhere suggests conditions attractive to herringt larvae.	**X**	**X**	**X**		
15. Adult splittail have been found in deeper water (2-3 m), so deeper marsh channels are proposed.	**X**	**X**	**X**		
16. Otters and beaver were discover and frequently observed at our Suisun Bay sites, plus additional muskrat and turtles at one site (McNabney Marsh, Martinez). The latter is our only eutrophic site, thus far. A beaver lodge elsewhere apparently blocked a restored tidal creek recently. The creek is proposed here to be re-routed (through a nearby, isolated pond, with wiers to maintain the tidal pool. Frogs also are heard near most of our marshes despite the brackish water.	**X**	**X**			
17. Patches of unusually tall pickleweed were detected at a pre-restoration site. The pickleweed will be salvaged (and placed on nearby, new levee intertidally) before levee setback and new shoreline marsh restoration.	**X**				
18. Unusually dense populations of salt marsh harvest mouse were detected before restoration to tidal action at a restoration site in North San Pablo Bay. (based on McGinnis monitoring.) Levee breach will be gradual, at night, with new intertidal habitat provided in advance, in case it is necessary to improve migration ability of the salt marsh harvest mouse population.	**X**	**X**	**X**		
19. Bird populations in a pre-restoration area are less					

abundant and diverse than in adjacent marshes restored to higher tide action (based on SPBNWR joint monitoring staff, Vicencio and Eagan).	**X**	**X**			

Appendix Table _3_. North San Francisco Bay / Outer Delta Marsh Sites: Major Species of Small (and juvenile) Fishes, in approximate order of abundance in CSUH CALFED marsh monitoring: (* indicates recruitment detected in restored marshes) - Kitting, Gaos, et al.

Ranges based on McGinnis, Samuel M. (1984). Freshwater Fishes of California. UC Berkeley Press, and Wang, Johnson C.S. (1986). Fishes of the Sacramento-San Joaquin Estuary. Technical Report 9 for Interagency Ecological Study Program. DWR.

Common Name	Species or taxon (parenth if introduced)	Reported Spawning Salinity	Reported Spawnin Temperature (C)
1.* Inland Silverside	(Menidia beryllina)	Freshwater - Brackish	13.2 - 34.2
2.* Mosqitofish	(Gambusia affinis)	Brackish, mostly Freshwater	15 (- 30)
3. Yellowfin Goby	(Acanthogobius flavimanus)	Seawater - Brackish	8 - 13
4.* Threespine Stickleback	Gasterosteus aculeatus	Freshwater - Brackish	15 – 19
5. Chameleon Goby etc.	(Tridentiger trigonecephalus +spp)	Brackish - Seawater	~ 20
6.* Prickly Sculpin	Cottus asper	Freshwater - Brackish	8 - 13
7.* Staghorn Sculpin	Leptocottus armatus	Brackish - Seawater	9 - 15.2
8.* Topsmelt	(Atherinops affinis)	Freshwater - Brackish	10 – 25
Especially Patchy:			
9. * Pacific Herring	Clupea harengus pallasi	Brackish – Seawater (8-18 ppt)	6 - 15
10.* Delta Smelt	Hypomesus transpacificus	Freshwater	7 - 15
11.* Splittail	Pogonichthys macrolepidotus	Freshwater - Brackish	9 - 20
12. Sacramento Squawfish = Pike Minnow	Ptychocheilus grandis	Freshwater	15.6 +
13. Fathead Minnow	(Pimephates promelas)	Freshwater	14 +
(isolated occurrence:)			
14. Striped Bass	(Morone saxatilis)	Brackish –Fresh, mostly Tidal	14.4 – 23.9
15.* Chinook Salmon =King Salmon	Oncorhynchus tshawytscha	Brackish - Seawater (up to 12 ppt)	10 – 14
16. Threadfin Shad	(Dorosoma petenense)	Freshwater	14 – 18
17. White Sturgeon	Acipenser transmontanus	Freshwater	8 – 22 , mostly 14-
Plus (lo salt): *Sunfishes	(Centrarchidae)	Freshwater	N/A

Appendix 3. Cooperative agreement (analogous to a subcontract) for line items in budget, for CCMVC, SFBWS, and EBRPD.

Example of our agreements with our collaborators:

CSUH Foundation
California State University
Hayward CA 94542

TO: J. Sommit, President, SF Bay Wildlife Society
(and similarly to Dr. Karl Malamud-Roam, CCMVC, etc.)

FROM: C.Kitting, Principal Investigator, CALFED grant on Improving North Estuary Restoration

SUBJECT: Agreement between our Cal State U Foundation and SFBWS for budgeted CALFED expenditures.

Thank you for your efforts in assisting in administering funds for such habitat restoration and monitoring.

All CALFED requirements described in their PSP must be adhered to. They are consistent with University policy.

I am happy to document that SFBWS will then be authorized to invoice our Cal State U Foundation, acct 51 51 152, task 3, for quarterly payments for the related bird monitoring expenses, as budgeted in the CALFED proposal, for the basic salary and the additional expenses. SFBWS is to receive 15% of the direct costs. As CALFED now specified, 90% of each invoice will be reimbursed, until the task is complete. At that time, the remaining 10% will be reimbursed from CALFED, via the CSUH Foundation.

CALFED may review results before they are publicized. Resulting publications shall acknowledge support from CALFED. Any major news is required that quarter, for Kitting's quarterly reports to CALFED. Annual reports are required in a concise scientific paper format, including EXCEL data tables and graphs, from the monitoring person. Authors are credited fully, of course.
Chris Kitting can provide the bird monitoring person templates to enable comparison with densities of other animals at these sites, through time.

The final invoice, and final report, must be received at our Cal State U Hayward Foundation before mid September, 2001.

Please contact me if further clarification becomes useful.

Thank you, again.

Tasks And Deliverables

Multdisciplinary monitoring of environmental processes in CALFED restored marshes in the Suisun Bay ecological zone. Phase Two: Importance of marsh tidal pools, algae, and other features along marsh channels.

Task ID	Task Name	Start Month	End Month	Deliverables
1	Project Management	1	36	Semiannual and final reports with summaries for managers. Periodic invoices.
2	Marsh Community Restoration Maintenance	1	30	Semiannual and final Project reports including management recommendations plus manuscripts, with above reports.
3	Physical and Biological Comparative Monitoring of Marsh Treatments	1	36	Semiannual and final Report summaries about restoration applications, including management recommendations, plus manuscripts with above reports. Presentations at CALFED and other conferences.
4	Chemical Monitoring of Water, Sediments, and Major Plants and Animals	1	36	Semiannual and final Report summaries about restoration applications and management recommendations, plus manuscripts with above reports. Presentations at CALFED and other conferences.

Comments

If you have comments about budget justification that do not fit elsewhere, enter them here.

See Proposal Forms for Budget justification and explanation of schedule.

Budget Summary

Project Totals

Labor	Benefits	Travel	Supplies And Expendables	Services And Consultants	Equipment	Lands And Rights Of Way	Other Direct Costs	Direct Total	Indirect Costs	Total
$311,819	$77,483	$4,400	$26,150	$284,485	$27,450	$0	$87,340	$819,127	$204,784	$1,023,911

Do you have cost share partners already identified?
Yes.

If yes, list partners and amount contributed by each:

CSU, Hayward: $276,037 CCMVCD: $85,000 SFBWS: $2,330

Do you have potential cost share partners?
No.

If yes, list partners and amount contributed by each:

Are you specifically seeking non−federal cost share funds through this solicitation?
No.

Multdisciplinary monitoring of environmental processes in CALFED restored marshes in the Suisun Bay ecological zone. Phase Two: Importance of marsh tidal pools, algae, and other features along marsh channels.

Multdisciplinary monitoring of environmental processes in CALFED restored marshes in the Suisun Bay ecological zone. Phase Two: Importance of marsh tidal pools, algae, and other features along marsh channels.

Year 1 (Months 1 To 12)

Task	Labor	Benefits	Travel	Supplies And Expendables	Services And Consultants	Equipment	Lands And Rights Of Way	Other Direct Costs	Direct Total	Indirect Costs	Total
1: project management (12 months)	12588	2906	800	0	0	0	0	1200	$17,494	4374	$21,868
2: Marsh Community Restoration Maintenance (12 months)	26109	5922	0	5600	57275	0	0	10730	$105,636	26409	$132,045
3: Physical and Biological Comparative Monitoring of Marsh Treatments (12 months)	31676	6527	0	0	67857	10800	0	13700	$130,560	32640	$163,200
4: Chemical Monitoring of Water, Sediments, and Major Plants and Animals (12 months)	20447	6305	0	8050	0	5450	0	1540	$41,792	10448	$52,240
Totals	**$90,820**	**$21,660**	**$800**	**$13,650**	**$125,132**	**$16,250**	**$0**	**$27,170**	**$295,482**	**$73,871**	**$369,353**

Year 2 (Months 13 To 24)

Task	Labor	Benefits	Travel	Supplies And Expendables	Services And Consultants	Equipment	Lands And	Other Direct	Direct Total	Indirect Costs	Total

							Rights Of Way	**Costs**			
1: project management (12 months)	**13218**	**3052**	**1800**	**0**	**0**	**0**	**0**	**1500**	$19,570	**4893**	$24,463
2: Marsh Community Restoration Maintenance (12 months)	**27244**	**6200**	**0**	**3600**	**4000**	**0**	**0**	**7930**	$48,974	**12244**	$61,218
3: Physical and Biological Comparative Monitoring of Marsh Treatments (12 months)	**46295**	**11365**	**0**	**0**	**73361**	**4400**	**0**	**19300**	$154,721	**38680**	$193,401
4: Chemical Monitoring of Water, Sediments, and Major Plants and Animals (12 months)	**20348**	**6512**	**0**	**3650**	**0**	**0**	**0**	**1540**	$32,050	**8013**	$40,063
Totals	**$107,105**	**$27,129**	**$1,800**	**$7,250**	**$77,361**	**$4,400**	**$0**	**$30,270**	**$255,315**	**$63,830**	**$319,145**

Year 3 (Months 25 To 36)

Task	Labor	Benefits	Travel	Supplies And Expendables	Services And Consultants	Equipment	Lands And Rights Of Way	Other Direct Costs	Direct Total	Indirect Costs	Total
	13878	**3205**	**1800**	**0**	**0**	**0**	**0**	**1500**	$20,383	**5096**	$25,479

1: project management (12 months)												
2: Marsh Community Restoration Maintenance (6 months)	**19896**	**5466**	**0**	**1600**	**3000**	**0**	**0**	**9100**	$39,062	**9766**	$48,828
3: Physical and Biological Comparative Monitoring of Marsh Treatments (12 months)	**58966**	**13206**	**0**	**0**	**78992**	**6800**	**0**	**16900**	$174,864	**43716**	$218,580
4: Chemical Monitoring of Water, Sediments, and Major Plants and Animals (12 months)	**21154**	**6817**	**0**	**3650**	**0**	**0**	**0**	**2400**	$34,021	**8505**	$42,526
Totals	**$113,894**	**$28,694**	**$1,800**	**$5,250**	**$81,992**	**$6,800**	**$0**	**$29,900**	**$268,330**	**$67,083**	**$335,413**

Budget Justification

Multdisciplinary monitoring of environmental processes in CALFED restored marshes in the Suisun Bay ecological zone. Phase Two: Importance of marsh tidal pools, algae, and other features along marsh channels.

Labor

TASK 1:

Chris Kitting, $29,904/qtr x 3qtr/yr, incl.SrFac.SalGap

Request: 16% time x 1 qtr (4 WTU) = $4,982.

Match: 16% time x 1 qtr (4 WTU) = $4,982.

0.1 time x Summer/overload/qtr breaks "= +10% holdback," (throughout, as in article 36 of CSU contract) = $2,990.

Technical Associate, $45,522/yr

6% time x 11 months = $2,504.

Office Assistance, $12/hr x 4 hr/wk x 44 weeks = $2,112.

TASK 2:

Chris Kitting, PI

Request: 33% x 1 qtr (4 WTU) = $9,968

Match: 33% time x 1 qtr (4 WTU) = $9,968

0.2 time x Summer/overload/qtr breaks = $5,981.

Technical Associate ($45,522/yr): 20% time x 9 months = $6,828.

Student Asst. 1 x $12/hr x 6.5 hr/wk x 44 weeks = $3,432

TASK 3:

Chris Kitting

Request: 33% time x 1 qtr (4 WTU) = $9,968

Match: 33% time x 1 qtr (4 WTU) = $9,968

0.2 time x Summer/overload/qtr breaks = $5,981

Technical Associate: 20% time x 10 months = $7,587

Student Assist. ~$10/hr x 6.5 hr/wk x 44 weeks = $2,860

Lab Assist. ~$12/hr x 10 hr/wk x 44 weeks = $5,280

TASK 4:

Joy Andrews, $24,541/qtr x 3 qtr

Request: 11% x 3 qtr (4 WTU) = $8,099

Match: 11% x 3 qtr (4 WTU) = $8,099

Technical Associate, $45,522/yr

5% effort x 11 months = $2,086

Chris Kitting, $29,904/qtr x 3 qtr incl.SrFacSalGap

Request: 16% time x 1 qtr (2 WTU) = $4,982

Match: 16% time x 1 qtr (2 WTU) = $4,982

Student Assistants

2 x ~$11/hr x 10 hr/wk x 24 weeks = $5,280

Benefits

Tasks 1-4:

Academic year release rate = 40.43%

Summer/overload rate = 12.4%

Non-benefitted staff rate = 12.4%

Student benefit rate = 10%

Travel

Task 1: Attend CALFED and related meetings (partial cost): $800

Supplies And Expendables

Task 2: Supplies for marsh community restoration maintenance: $3,600. Plant and animal acquisition: $2,000

Task 4: AA (metals analysis) supplies (partial cost): $2,250

Services And Consultants

Task 2:

CCMVCD Subcontract (access to restored channels): $48,000 requested, $85,000 provided as match from CCMVCD.

SFBWS Subcontract (plant salvage and transplant expenses): $4,775 requested, $80 provided as match from SFBWS.

East Bay Regional Parks or CCMVCD Subcontract (maintenance expeses - partial): $4,500

Task 3:

CCMVCD Subcontract (vegetation monitoring): $35,500

SF Bay Wildlife Society (bird monitoring): $30,600

SF Bay Wildlife Society (other hydrology monitoring): $1,757 requested, $480 provided by SFBWS as match.

Equipment

Task 3:

Field equipment (replacemenet, supplies, repairs, and safety gear): $2,400. 2 YSI underwater data loggers with 02 electrodes: $6,000. Scanner and portable computer: $2,400.

Task 4:

Hach carbon analyzer and supplies (partial cost): $5,800. Microwave digester (for metals and C, including MLML MeHg analysis): $5,450 requested, $5,450 contributed by CSUH as match.

Lands And Rights Of Way

None

Other Direct Costs

Task 1:

General publication costs, including illustrations: $1,200.

Task 2:

Repairs to equipment: $1,500.

Transportation and boat use: $2,000.

Remote lab use ($700/mo x 8 months): $5,600.

Mobile lab expenses (communications, copies): $1,300.

Publication and illustration costs: $330.

Task 3:

Transportation costs: $2,500.

Boat use, partial cost: $4,000.

Remote lab use ($700/mo x 4 months): $2,800.

Mobile lab expenses (communications, copies, modifications): $3,500.

Publication and illustration costs: $900.

Task 4:

Transportation/boat use (partial cost): $1,000.

Publication costs: $540.

Indirect Costs/Overhead

Indirect costs are calculated at the standard CSUH rate for the State of California, which is 25% of total direct costs.

Comments

The above justification is for Year 1. In Years 2–3, salaries are calculated with a 5% cost of living/merit increase. Detailed budget explanations for years 2 and 3 will be provided upon request.

Environmental Compliance

Multdisciplinary monitoring of environmental processes in CALFED restored marshes in the Suisun Bay ecological zone. Phase Two: Importance of marsh tidal pools, algae, and other features along marsh channels.

CEQA Compliance

Which type of CEQA documentation do you anticipate?
− none
X negative declaration or mitigated negative declaration
− EIR
− categorical exemption

If you are using a categorical exemption, choose all of the applicable classes below.
− Class 1. Operation, repair, maintenance, permitting, leasing, licensing, or minor alteration of existing public or private structures, facilities, mechanical equipment, or topographical features, involving negligible or no expansion of use beyond that existing at the time of the lead agency's determination. The types of "existing facilities" itemized above are not intended to be all−inclusive of the types of projects which might fall within Class 1. The key consideration is whether the project involves negligible or no expansion of an existing use.
− Class 2. Replacement or reconstruction of existing structures and facilities where the new structure will be located on the same site as the structure replaced and will have substantially the same purpose and capacity as the structure replaced.
− Class 3. Construction and location of limited numbers of new, small facilities or structures; installation of small new equipment and facilities in small structures; and the conversion of existing small structures from one use to another where only minor modifications are made in the exterior of the structure. The numbers of structures described in this section are the maximum allowable on any legal parcel, except where the project may impact on an environmental resource of hazardous or critical concern where designated, precisely mapped, and officially adopted pursuant to law by federal, state, or local agencies.
− Class 4. Minor public or private alterations in the condition of land, water, and/or vegetation which do not involve removal of healthy, mature, scenic trees except for forestry or agricultural purposes, except where the project may impact on an environmental resource of hazardous or critical concern where designated, precisely mapped, and officially adopted pursuant to law by federal, state, or local agencies.
− Class 6. Basic data collection, research, experimental management, and resource evaluation activities which do not result in a serious or major disturbance to an environmental resource, except where the project may impact on an environmental resource of hazardous or critical concern where designated, precisely mapped, and officially adopted

pursuant to law by federal, state, or local agencies. These may be strictly for information gathering purposes, or as part of a study leading to an action which a public agency has not yet approved, adopted, or funded.
– Class 11. Construction, or placement of minor structures accessory to (appurtenant to) existing commercial, industrial, or institutional facilities, except where the project may impact on an environmental resource of hazardous or critical concern where designated, precisely mapped, and officially adopted pursuant to law by federal, state, or local agencies.

Identify the lead agency.
Contra Costa Mosquito and Vector Control District

Is the CEQA environmental impact assessment complete?
Yes.

If the CEQA environmental impact assessment process is complete, provide the following information about the resulting document.

Document Name	**CCMVCD Environmental Assessment of Integrated Vector Management Program**
State Clearinghouse Number	**_**

If the CEQA environmental impact assessment process is not complete, describe the plan for completing draft and/or final CEQA documents.

NEPA Compliance

Which type of NEPA documentation do you anticipate?
X none
– environmental assessment/FONSI
– EIS
– categorical exclusion

Identify the lead agency or agencies.

If the NEPA environmental impact assessment process is complete, provide the name of the resulting document.

If the NEPA environmental impact assessment process is not complete, describe the plan for completing draft and/or final NEPA documents.

Successful applicants must tier their project's permitting from the CALFED Record of Decision and attachments providing programmatic guidance on complying with the state and federal endangered species acts, the Coastal Zone Management Act, and sections 404 and 401 of the Clean Water Act.

Please indicate what permits or other approvals may be required for the activities contained in your proposal and also which have already been obtained. Please check all that apply. If a permit is *not* required, leave both Required? and Obtained? check boxes blank.

Local Permits And Approvals	**Required?**	**Obtained?**	**Permit Number (If Applicable)**
conditional Use Permit	–	–	
variance	–	–	
Subdivision Map Act	–	–	
grading Permit	–	–	
general Plan Amendment	–	–	
specific Plan Approval	–	–	
rezone	–	–	
Williamson Act Contract Cancellation	–	–	
other (None Required)	–	–	

State Permits And Approvals	**Required?**	**Obtained?**	**Permit Number (If Applicable)**
scientific Collecting Permit	X	X	801015
CESA Compliance: 2081	–	–	
CESA Complance: NCCP	–	–	
1602	–	–	
CWA 401 Certification	X	X	

Bay Conservation And Development Commission Permit	X	X	
reclamation Board Approval	–	–	
Delta Protection Commission Notification	–	–	
state Lands Commission Lease Or Permit	–	–	
action Specific Implementation Plan	–	–	
other No Others Required	–	–	

Federal Permits And Approvals	Required?	Obtained?	Permit Number (If Applicable)
ESA Compliance Section 7 Consultation	–	–	
ESA Compliance Section 10 Permit	–	–	
Rivers And Harbors Act	–	–	
CWA 404	X	X	
other No Others Required	–	–	

Permission To Access Property	Required?	Obtained?	Permit Number (If Applicable)
permission To Access City, County Or Other Local Agency Land Agency Name Mt. View Sanitary Distr.	X	X	
permission To Access State Land Agency Name E Bay Regional Pks Distr.	X	X	
permission To Access Federal Land Agency Name	X	X	

Weapons Detachment Concord			
permission To Access Private Land Landowner Name	–	–	

If you have comments about any of these questions, enter them here.

Land Use

Multdisciplinary monitoring of environmental processes in CALFED restored marshes in the Suisun Bay ecological zone. Phase Two: Importance of marsh tidal pools, algae, and other features along marsh channels.

Does the project involve land acquisition, either in fee or through easements, to secure sites for monitoring?
X No.
– Yes.

How many acres will be acquired by fee?

How many acres will be acquired by easement?

Describe the entity or organization that will manage the property and provide operations and maintenance services.

Is there an existing plan describing how the land and water will be managed?
– No.
– Yes.

Will the applicant require access across public or private property that the applicant does not own to accomplish the activities in the proposal?
X No.
– Yes.

Describe briefly the provisions made to secure this access.

(All land owners are partners already documenting their permission for our team.)

Do the actions in the proposal involve physical changes in the current land use?
X No.
– Yes.

Describe the current zoning, including the zoning designation and the principal permitted uses permitted in the zone.

Describe the general plan land use element designation, including the purpose and uses allowed in the designation.

Describe relevant provisions in other general plan elements affecting the site, if any.

Is the land mapped as Prime Farmland, Farmland of Statewide Importance, Unique Farmland, or Farmland of Local Importance under the California Department of Conservation's Farmland Mapping and Monitoring Program?

X No.
– Yes.

Land Designation	Acres	Currently In Production?
Prime Farmland		–
Farmland Of Statewide Importance		–
Unique Farmland		–
Farmland Of Local Importance		–

Is the land affected by the project currently in an agricultural preserve established under the Williamson Act?

X No.
– Yes.

Is the land affected by the project currently under a Williamson Act contract?

X No.
– Yes.

Why is the land use proposed consistent with the contract's terms?

Describe any additional comments you have about the projects land use.

Already restored marshes, from recent collaboration between CALFED and our partners.